Datex-Ohmeda

E-Modules

Technical Reference Manual

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EEC.
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Order code for the Datex-Ohmeda E-Modules Technical Reference Manual, paper: M1065282
Order code for the S/5 Technical Reference Manuals CD: M1220141
4th edition
November 19, 2012

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Some of the products mentioned in this manual may not be available in all countries.

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Datex-Ohmeda E-Modules
M1065282

About this manual

Notes to the reader

This Technical Reference Manual is intended for service personnel and engineers who will service and maintain the Datex-Ohmeda E-Modules as well as the anesthesia record keeping keyboard, K-ARKB, remote controllers, K-REMCO and K-CREMCO, Device Interfacing Solution, N-DISxxx, keyboard interface board, B-ARK, and ARK barcode reader, N-SCAN.

This Technical Reference Manual completes the S/5 Anesthesia Monitor and S/5 Critical Care Monitor Technical Reference Manual and the S/5 Compact Anesthesia Monitor and S/5 Compact Critical Care Monitor Technical Reference Manual. Later in this manual, the monitors may be referred to as AM, CCM, CAM and CCCM.

The order code for the Datex-Ohmeda E-Modules Technical Reference Manual is M1065282.

The order code for the S/5 Technical Reference Manuals CD is M1220141. S/5 AM, CCM Technical Reference Manual, S/5 CAM, CCCM Technical Reference Manual and Datex-Ohmeda E-Modules Technical Reference Manual are included on the CD.

Each manual on the CD has an individual document number and is available for downloading from GE Common Document Library in Adobe Acrobat PDF format.

- This Technical Reference Manual contains the information needed to maintain, service and troubleshoot these products. Instructions for visual and functional inspection, disassembly and reassembly as well as calibration of the modules are included. A service check form for each product is included in the slots.
- In addition, this Technical Reference Manual contains detailed module specifications and descriptions on the technical performance and functioning of the modules.
- Read the manual through and make sure that you understand the procedures described before servicing the modules. To avoid risks concerning safety or health, strictly observe the warning indications. If you need any assistance concerning the service, please do not hesitate to contact your authorized distributor.

For information on safety precautions and symbols on equipment, installation, planned maintenance and interfacing, refer to the AM and CCM Technical Reference Manual or the CAM and CCCM Technical Reference Manual.

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Related documentation

S/5 AM, CCM Technical Reference Manual

S/5 CAM, CCCM Technical Reference Manual

For more specific information about the clinical aspects refer to:

S/5 monitor's User's Guide

S/5 monitor's User's Reference Manual

Conventions used

Throughout this manual, the following conventions are used to distinguish procedures or elements of text:

Sign the check form after performing the procedure.

Hard Keys — Hard key names on the Command Board, the Remote Controller and modules are written in the following way: **ECG**.

Menu Items — Menu items are written in bold italic: ***ECG Setup***.

'Messages' — Messages displayed on the screen are written inside single quotes: 'Please wait'.

"Sections" — When referring to different sections in the same manual, the section name is enclosed in double quotes: section "Cleaning and Service."

"Other documents" — When referring to different documents, the document name is enclosed in double quotes: refer to "User's Reference Manual".

Hypertext links — Hypertext links on PDF versions are written in blue color.

WARNING — Warnings are written in the following way:

WARNING **Make sure that the electrodes, sensor and connectors do not touch any electrically conductive material, including earth.**

CAUTION — Cautions are written in the following way:

CAUTION The module electronics can only be repaired and calibrated at the factory.

NOTE — Notes are written in following way:

NOTE: Handle all PC boards by their edges.

In this manual, the word "select" means choosing and confirming.

Revision history

Revision	Date	Comment
1st edition	10 May 2011	Initial
2nd edition	22 Sep 2011	Order code for paper manual added.
3rd edition	19 June 2012	E-PSM rev. 01, E-PSMP rev. 01, E-COP rev.01 and E-COPSv rev. 01 update.
4th edition	19 Nov 2012	Respiratory Modules E-sCAiOV, E-sCAiO, E-sCOV and E-sCO added .

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Respiratory Modules, E-sCAiOV, E-sCAiO, E-sCOV, E-sCO

Technical Reference Manual Slot

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Document number M1214853C

June 21, 2012

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Introduction

This document provides information for the maintenance and service of the CARESCAPE Respiratory modules, E-sCO, E-sCOV, E-sCAiO and E-sCAiOV. The CARESCAPE Respiratory modules are single width plug-in modules.

The CARESCAPE Respiratory modules provide airway and respiratory measurements.

Letters in the module name stand for:

C = CO_2 and N_2O, O = patient O_2, V = patient spirometry, A = anesthetic agents, and i = agent identification

Table 1 Options for CARESCAPE Respiratory modules

Modules	**Parameters / measurements**					
	CO_2	N_2O	O_2	Anesthetic agents	Agent ID	Spirometry
E-sCOV	X	X	X			X
E-sCO	X	X	X			
E-sCAiOV	X	X	X	X	X	X
E-sCAiO	X	X	X	X	X	

NOTE: Anesthetic agents and N_2O values are not displayed with ICU and ED software packages, but when present in the module they are calculated for compensation of CO_2 and O_2.

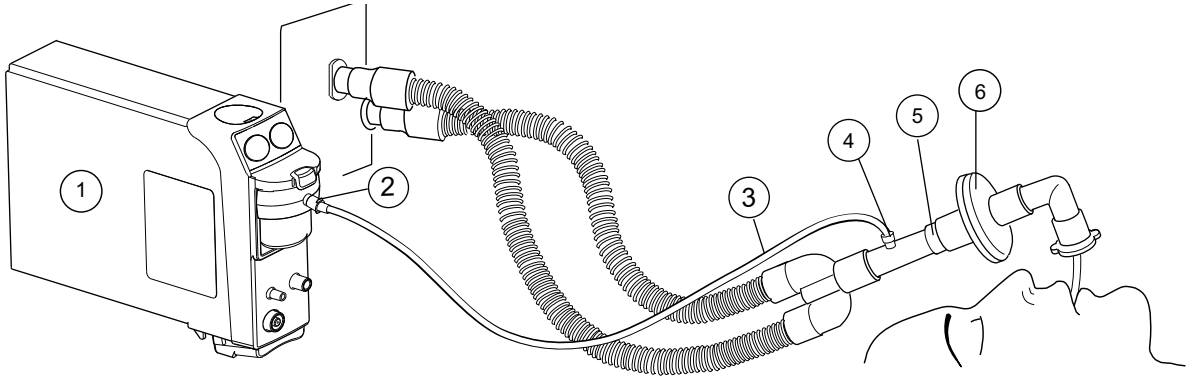


Figure 1 Airway gases measurement setup

(1) CARESCAPE Respiratory Module
(2) Gas sample, gas sampling line connector on the water trap
(3) Gas sampling line
(4) Gas sampling line connector on the airway adapter; place the connector upwards
(5) Airway adapter with sampling line connector
(6) Heat and moisture exchanger with filter (HMEF) (optional)

System compatibility

The CARESCAPE Respiratory Modules can be used for respiratory monitoring in the following S/5 monitors:

- S/5 Anesthesia Monitor, software versions L-ANE06(A) 24.1 or later
- S/5 Critical Care Monitor, software versions L-ICU06(A) 24.1 or later
- S/5 Compact Anesthesia Monitor, software versions L-CANE05(A) 19.6 or later
- S/5 Compact Critical Care Monitor, software versions L-CICU05(A) 19.6 or later

NOTE: Low sample gas flow situation is indicated with the message ***Replace D-Fend*** in the L-xxx06(A) software versions 24.1 and L-xxx05(A) software versions 19.6.

NOTE: The CARESCAPE Respiratory Modules cannot be used in the S/5 Extension Frame.

1 Technical specifications

1.1 Physical characteristics

Size (H x W x D)	112 x 37 x 205 mm (4.4 x 1.5 x 8.7 in)
Weight	0.75 kg (1.5 lb)
Power consumption	3.9 W

1.2 Operating characteristics

Warm-up time	
- CO_2, O_2 and N_2O measurements:	1 minute
-Anesthetic agent measurement and identification:	5 minutes
Gas sampling rate:	120 ±20 ml/min

Automatic compensation for ambient pressure.

Operating conditions

Ambient temperature:	+10°C to +40°C
Ambient pressure:	660 mbar to 1060 mbar
Ambient humidity:	10%RH to 98%RH, non-condensing

1.3 Airway gases

1.3.1 General characteristics

Specifications are valid at the following normal operating conditions:

Ambient temperature:	+18°C to +28°C, within ±5°C of calibration
Ambient pressure:	660 mbar to 1060 mbar, ±67 mbar of calibration
Ambient humidity:	20%RH to 80%RH, non-condensing, ±20%RH of calibration
Sampling line length:	2, 3 and 6 meters
Respiration rate:	4 to 70 breaths/minute (Halothane 4 to 50 breaths/minute)
Airway pressure:	-20 mbar to +100 mbar
Module operating time:	>20 minutes continuously

NOTE: The displayed ranges of parameter values depend on the host device. For more information, refer to the host device's user documentation.

1.3.2 Respiration rate

Breath detection:	1 vol% change in CO_2 level
Measurement range:	4 to 100 breaths/min
Accuracy	
at 4 to 20 breaths/min:	±1 breath/min
at 20 to 100 breaths/min:	±5%

RR value is updated breath-by-breath.

1.3.3 Carbon dioxide

Measurement range:	0 vol% to 15 vol%, 0 kPa to 15 kPa, 0 mmHg to 113 mmHg
Accuracy:	±(0.2 vol% +2% of reading)
Total system response time:	< 3.0 s
Rise time:	< 260 ms
CO_2 drift:	< 0.1 vol%

$EtCO_2$ and $FiCO_2$ values are updated breath-by-breath.

Description of test method, data rate, and method of ET-calculation

The module uses gas concentration waveforms with data rate of 25Hz to calculate end-tidal (ET) gas readings.

The module finds the time instant of the highest CO2 concentration in each breath. Concentration at that instant is the ET CO2 reading. Because nitrous oxide and anesthetic agents are measured by the same sensor as CO2, the ET-readings of those gases are obtained directly at the time instant of ET CO2. For calculating ET-readings of oxygen, the module synchronizes the O2-waveform with the CO2 waveform. The ET-reading of O2 is then determined as O2-concentration at the time instant of ET CO2. If no breaths are detected for a given time (20s, for example), an apnea situation is triggered. During apnea, the ET values are updated every two seconds to the current concentration of each gas.

The rated respiration rate range and the corresponding end-tidal gas reading accuracy were tested with reference gases of known concentrations. The test gases were fed to the gas sampling system of the module through an electrically actuated valve with very low internal volume. Depending on its actuation status, the valve directed either room air or a test gas to the gas sampling line. The desired respiration rates were set by the electrical actuating times of the valve.

The measurement accuracy of the end-tidal gas readings was tested using gas sampling lines of 3 meter length, connected to the gas sample port on the D-fend Pro water trap. The gas sampled to the sampling line was switched from room air to the test gases using an electrically actuated valve with low internal dead space to generate step changes in the gas concentrations. The electric actuating signal of the valve was generated using a higly accurate signal generator to accurately control the simulated respiration rate.

The electronic sampling rate of the gas sensor signals is 25Hz, equaling a new data point on the gas waveform traces every 40 milliseconds.

1.3.4 Oxygen

Measurement range:	0 vol% to 100 vol%
Accuracy:	±(1 vol% +2% of reading)
Total system response time:	< 3.0 s
Rise time:	< 260 ms
O_2 drift:	< 0.3 vol%

EtO_2 and FiO_2 values are updated breath-by-breath.

1.3.5 Nitrous oxide

Measurement range:	0 vol% to 100 vol%
Accuracy:	
at ($0 \leq N_2O < 85$ vol%)	±(2 vol% +2% of reading)
Total system response time:	< 3.0 s
Rise time:	< 320 ms
N_2O drift:	< 0.3 vol%

EtN_2O and FiN_2O values are updated breath-by-breath.

1.3.6 Anesthetic agents

Measurement range:	
Sevoflurane:	0 vol% to 8 vol%
Desflurane:	0 vol% to 20 vol%
Isoflurane, enflurane, halothane:	0 vol% to 6 vol%
Accuracy:	±(0.15 vol% +5% of reading)
Total system response time:	< 3.1 s (< 3.5 s for Halothane)
Rise time:	< 420 ms (< 800 ms for Halothane)
Hal drift:	< 0.1 vol%
Enf drift:	< 0.1 vol%
Iso drift:	< 0.1 vol%
Sev drift:	< 0.1 vol%
Des drift:	< 0.3 vol%

EtAA and FiAA values are updated breath-by-breath.

The module automatically identifies the anesthetic agent present in the sampled gas and measures the concentration of the identified agent.

Identification threshold:	0.15 vol%
Identification time:	< 20 s

The module automatically identifies mixtures of two anesthetic agents present in the sampled gas and measures the concentrations of the two identified agents.

Identification threshold for the 2nd agent	
at 1 MAC of the 1st agent:	0.2 vol% +10% of the concentration of the 1st agent

1.3.7 Non-disturbing gases

A gas is considered non-disturbing if its effects to the measured gas are as follows:

CO_2:	< 0.2 vol%
O_2, N_2O:	< 2 vol%
Anesthetic agents:	< 0.15 vol%

The following gases are non-disturbing when tested according to ISO21647(2004B):
ethanol, acetone, isopropanol, methane, nitrogen, carbon monoxide, nitric oxide, freon R134A (for CO_2, O_2 and N_2O), water vapor.

The effects caused by N_2O to the measurement of CO_2, O_2 and anesthetic agents are automatically compensated for.

The effects caused by anesthetic agents to the measurement of CO_2 and N_2O are automatically compensated for.

1.3.8 Gas cross effects

Helium (50 vol%):	Decreases CO_2 readings by less than 0.5 vol% at 5 vol% of CO_2
	Decreases O_2 readings by less than 2 vol% at 50 vol% of O_2
Xenon (80 vol%):	Decreases CO_2 readings by less than 0.5 vol% at 5 vol% of CO_2
	Decreases O_2 readings by less than 1.5 vol% at 14 vol% of O_2

1.4 Patient Spirometry

1.4.1 General characteristics

These specifications are valid in the following operating conditions:
The module has been operating continuously for 10 minutes

Airway adapter, adult:	D-lite
Airway adapter, pediatric:	Pedi-lite
Respiration rate	
- adults:	4 to 35 breaths/min
- pediatric patients:	4 to 70 breaths/min
I:E ratio:	1:4.5 to 2:1
Airway humidity:	10 %RH to 100 %RH
Ambient temperature:	+10°C to +40°C
Ambient pressure:	660 mbar to 1060 mbar
Ambient humidity:	10 %RH to 98 %RH (non-condensing)

NOTE: The displayed ranges of parameter values depend on the host device. For more information, refer to the host device's user documentation.

1.4.2 Airway pressure

Measurement range:	-20 cmH_2O to +100 cmH_2O
Accuracy:	±1 cmH_2O
Time resolution:	10 ms

Values calculated from the measured airway pressure data:

- Peak pressure (Ppeak)
- Plateau pressure (Pplat)
- Mean pressure (Pmean)
- Positive end expiratory pressure (PEEPtot, or PEEPi and PEEPe)
- Static positive end expiratory pressure (static PEEPe and static PEEPi)

1.4.3 Airway gas flow

Measurement range	
- adults:	-100 l/min to +100 l/min
- pediatic patients:	-25 l/min to +25 l/min
Time resolution:	10 ms

Flow measurement has automatic compensation for airway pressure and effects caused by variation in the concentrations of the gas components measured by the module.

1.4.4 Tidal volume

The module calculates the volume by integrating the measured gas flow over time. Tidal volumes (TVinsp and TVexp) are obtained as the change of volume during inspiration and expiration.

Measurement range	
- with D-lite:	150 ml to 2000 ml
- with Pedi-lite:	5 ml to 300 ml
Accuracy	
- with D-lite:	±6% or 30 ml (whichever is greater)
- with Pedi-lite:	±6% or 4 ml (whichever is greater)

1.4.5 Minute volume

The module calculates the inspired and expired minute volumes as the sum of inspired (MVinsp) and expired (MVexp) gas volume during one minute.

Measurement range

- with D-lite:	2 l to 20 l
- with Pedi-lite:	0.5 l to 5 l

1.4.6 Compliance

The module calculates both the compliance (Compl) and static compliance (static Compl). Compliance is calculated by dividing the expired gas volume (TVexp) by the change in the airway pressure (Pplat - PEEPtot). Static compliance is calculated by dividing TVexp by the difference of static Pplat and static PEEPtot.

Measurement range

- adults:	4 ml/cmH_2O to 100 ml/cmH_2O
- pediatric patients:	1 ml/cmH_2O to 100 ml/cmH_2O

1.4.7 Airway resistance

The module calculates the airway resistance (Raw) by solving the lung model equation *P(t) = Raw * F(t) + V(t)* / Compl + *PEEPtot*
where: *P(t), F(t)* and *V(t)* are the time dependent waveforms of pressure, flow, and volume, respectively.

Measurement range: 0 cmH_2O/l/s to 40 cmH_2O/l/s

1.4.8 Inspiration to expiration ratio

The module measures ratio of the inspiratory and expiratory time (I:E).
The inspiratory time is the time from the start of inspiration to the start of expiration. The end inspiratory pause, if one exists, is included in the inspiration. Accordingly, expiratory time is the time from the start of expiration to the start of the next inspiration.

2 Functional description

2.1 Measurement principle

2.1.1 CO_2, N_2O, and agent measurement

MiniTPX is a side stream gas analyzer, measuring real time concentrations of CO_2, N_2O, and anesthetic agents (Halothane, Enflurane, Isoflurane, Desflurane, and Sevoflurane).

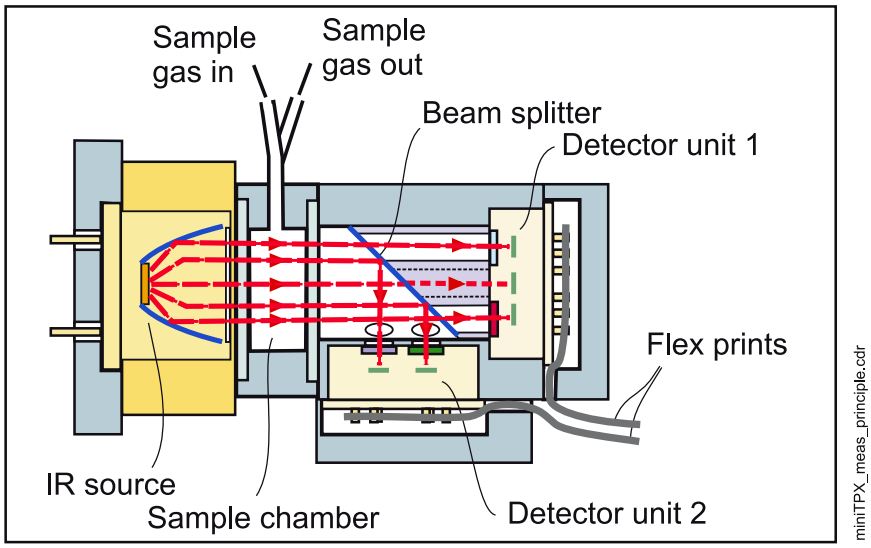


Figure 2 MiniTPX sensor principle

Anesthetic agents or mixtures of two anesthetic agents are automatically identified, and concentrations of the identified agents are measured. MiniTPX also detects mixtures of more than two agents and issues an alarm.

MiniTPX is a non-dispersive infrared analyzer, measuring absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters.

The infrared radiation detectors are thermopiles.

Concentrations of CO_2 and N_2O are calculated from absorption measured at 3-5 µm.

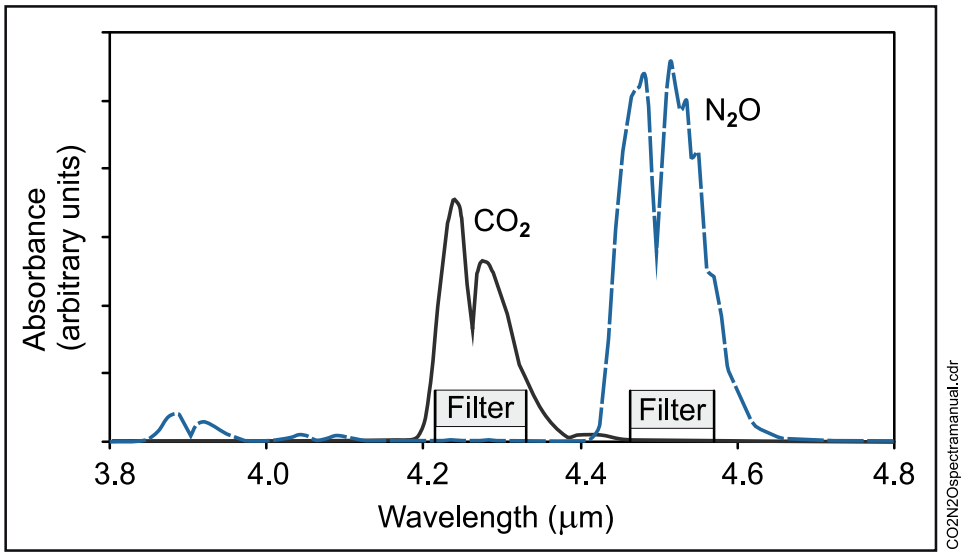


Figure 3 Absorbance of N_2O and CO_2

Identification of anesthetic agents and calculation of their concentrations is performed by measuring absorptions at five wavelengths in the 8-9 µm band and solving the concentrations from a set of equations.

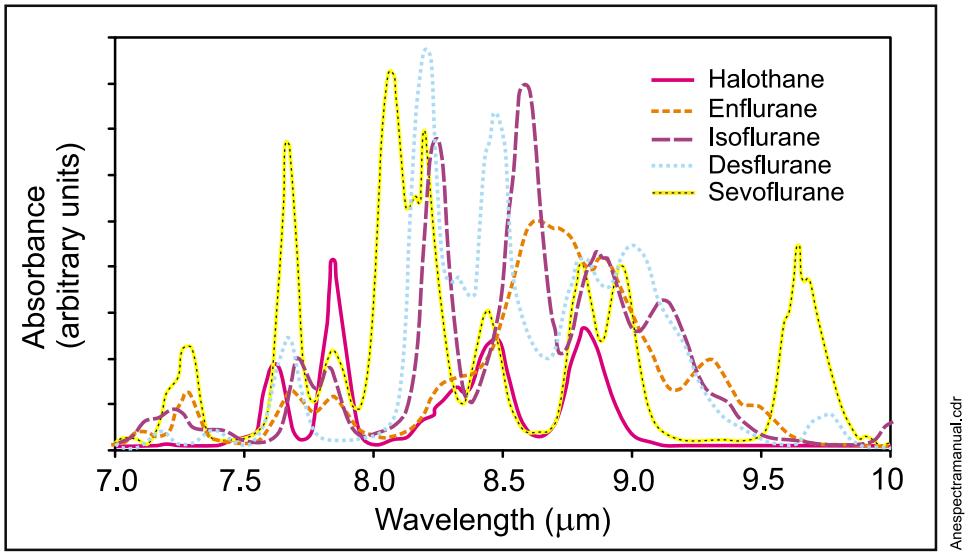


Figure 4 Infrared absorbance of AAs

The measuring accuracy is achieved utilizing numerous software compensations. The compensation parameters are determined individually for each MiniTPX during the factory calibration.

2.1.2 O_2 measurement

The differential oxygen measuring unit uses the paramagnetic principle in a pneumatic bridge configuration. The signal picked up with a differential pressure transducer unit is generated in a measuring cell with a strong magnetic field that is switched on and off at a main frequency of 164 Hz. The output signal is a DC voltage proportional to the O_2 concentration difference between the gas to be measured and the air reference.

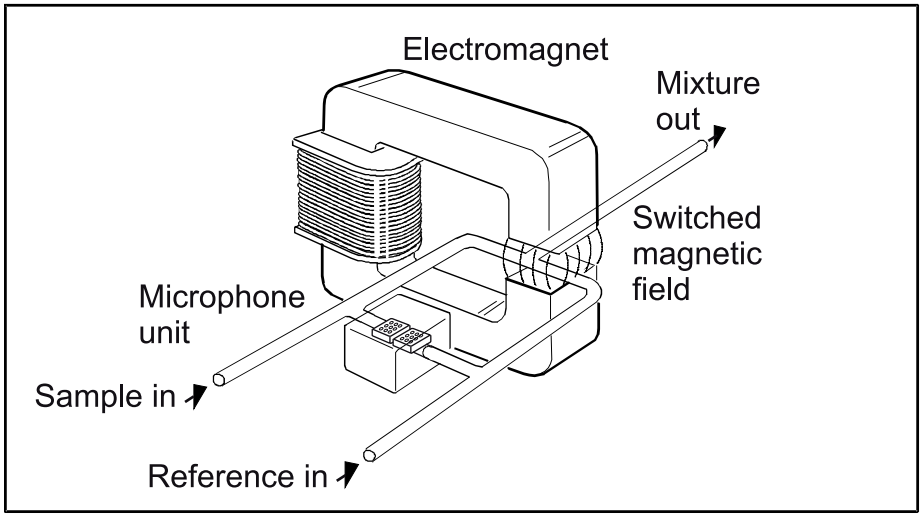


Figure 5 O_2 measurement principle

2.1.3 Patient spirometry

In mechanical ventilation, breaths are delivered to the patient by a ventilator with a proper tidal volume (TV), respiration rate (RR), and inspiration / expiration ratio in time (I:E) determined by the settings of the ventilator.

The Patient Spirometry monitors patient ventilation.

The following volume parameters are displayed:

- Expiratory and inspiratory tidal volume (TV) in ml
- Expiratory and inspiratory minute volume (MV) in l/min
- Expiratory spontaneous minute volume in l/min
- Inspiration/expiration ratio (I:E)

The following airway pressure parameters are displayed:

- Peak pressure (P_{peak})
- Mean airway pressure (P_{mean}); available only in S/5 Critical Care and Compact Critical Care monitors
- End inspiratory pressure (P_{plat})
- PEEPi, PEEPe; available only in S/5 Critical Care and Compact Critical Care monitors
- Total positive end expiratory pressure ($PEEP_{tot}$); available only in S/5 Anesthesia and Compact Anesthesia monitors
- Real time airway pressure waveform (P_{aw})
- Static Positive end expiratory pressures (Static PEEPi and Static PEEPe); available only in S/5 Critical Care and Compact Critical Care monitors
- Static Plateau pressure (Static Pplat); available only in S/5 Critical Care and Compact Critical Care monitors
- Static Compliance (Static Compl); available only in S/5 Critical Care and Compact Critical Care monitors

PEEP, P_{peak}, P_{mean}, and P_{plat} are measured by a pressure transducer on the MiniPVX board. Ambient pressure is used as a reference in measurement. The pressure measurement is made from the airway part that is closest to the patient between the patient circuit and intubation tube.

$PEEP_i$=intrinsic PEEP, $PEEP_{tot}$-$PEEP_e$

Static pressure measurement maneuvers are automatically identified based on an increased zero flow period at the end of the inspiration or expiration.

Static Compliance is calculated, if Static PEEP and Static P_{plat} measurements were made within a 2 minute period.

The following airway flow parameters are displayed:

- Real time flow waveform (V')
- Compliance (Compl)
- Airway resistance (Raw)
- Pressure volume loop
- Flow volume loop

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measure the Pitot pressure. The pressure signal obtained is linearized and corrected according to the density of the gas. Speed of flow is calculated from these pressure values and the TV value is then integrated. The MV value is calculated and averaged using TV and RR (respiratory rate) values.

D-lite

Patient Spirometry uses specific sensors called D-lite+/D-lite and Pedi-lite+/Pedi-lite flow sensors. Different types of sensors are available: adult sensor for measuring adults and pediatric sensor for children. Both are available as reusable and disposable versions.

D-lite and Pedi-lite adapters are designed to measure kinetic pressure by a two-sided Pitot tube. Velocity is calculated from pressure difference according to Bernoulli's equation. Flow is then determined using the calculated velocity.

$$v = \sqrt{\frac{2 \times dP}{\rho}}$$ (from Bernoulli's equation) Formula 1

$$V' = v \times A$$

where:

V' = flow (l/min), v = velocity (m/s), A = cross area (m^2), dP = pressure difference (cmH_2O), ρ = density (kg/m^3)

Finally, the volume information is obtained by integrating the flow signal.

Compliance and airway resistance

Compliance is calculated for each breath from the equation

$$Compl = \frac{TV_{exp}}{P_{plat} - (PEEP_i + PEEP_e)}$$ Formula 2

Compliance describes how large a pressure difference is needed to deliver a certain amount of gas to the patient.

The airway resistance, Raw, is calculated using an equation that describes the kinetics of the gas flow between the lungs and the D-lite. The equation states that the pressure at the D-lite can at any moment of the breath be approximated using the equation

$$P(t) = Raw \times V'(t) + \frac{V(t)}{Compl} + PEEP_i + PEEP_e$$ Formula 3

where P(t), V'(t) and V(t) are the pressure, flow and volume measured at the D-lite at a time t, Raw is the airway resistance, Compl is the compliance and $PEEP_e$+$PEEP_i$ is the total positive end expiratory pressure ($PEEP_{tot}$).

2.2 Main components

The respiratory modules consist of:

- Gas sampling system
- MiniTPX measuring unit
- MiniOM measuring unit
- MiniPVX measuring unit
- CPU board

2.2.1 Controls and connectors

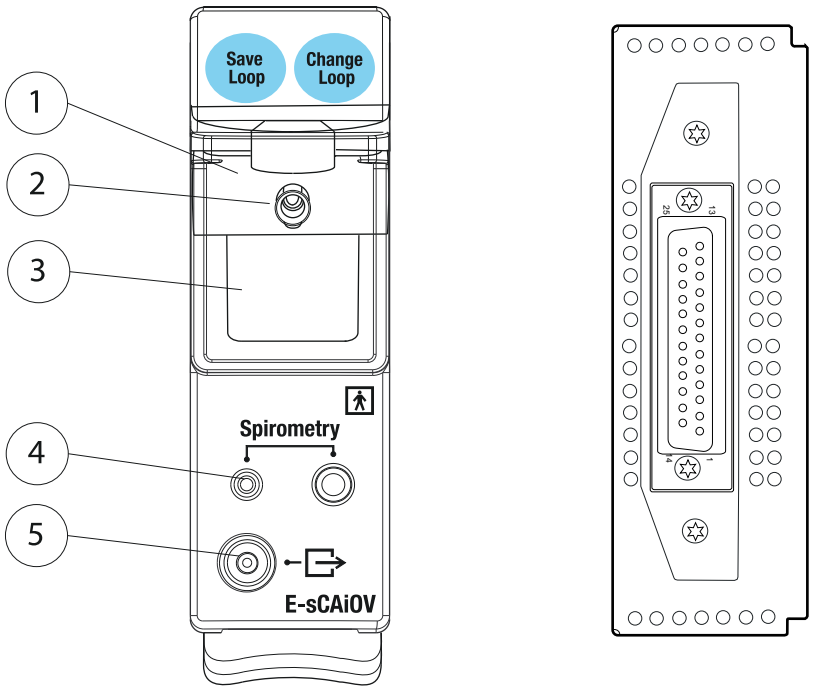


Figure 6 Front of CARESCAPE Respiratory Module, E-sCAiOV, and the back of the module

(1) D-fend Pro water trap
(2) Gas sample, sampling line connector on the water trap
(3) Water trap container
(4) Connectors for Patient Spirometry
(5) Gas exhaust, connector for the gas exhaust line (sampling gas out

Module keys	Module	Description
Save Loop	E-sCOV, E-sCAiOV	**Save Loop** saves a reference loop.
Change Loop	E-sCOV, E-sCAiOV	**Change Loop** changes a pressure/volume loop to a flow/volume loop or vice versa.
Connector	**Module**	**Description**
D25 connector	all modules	Module bus connector

2.2.2 Gas sampling system

The gas sampling system draws a 120ml/min sample from the patient's airway to the module. The sampling system also takes about 30ml/min flow of room air to the oxygen sensor. When the gas sensors are zeroed, room air is taken through the CO_2-absorber to the gas sensors instead of the sampled gas from the patient's breathing.

The gas sampling line is connected between the patient circuit and the Gas Sample port on the water trap. The water trap protects the sampling system and gas sensors from liquids and dust.

The diagram of the gas sampling system is shown in the figure below:

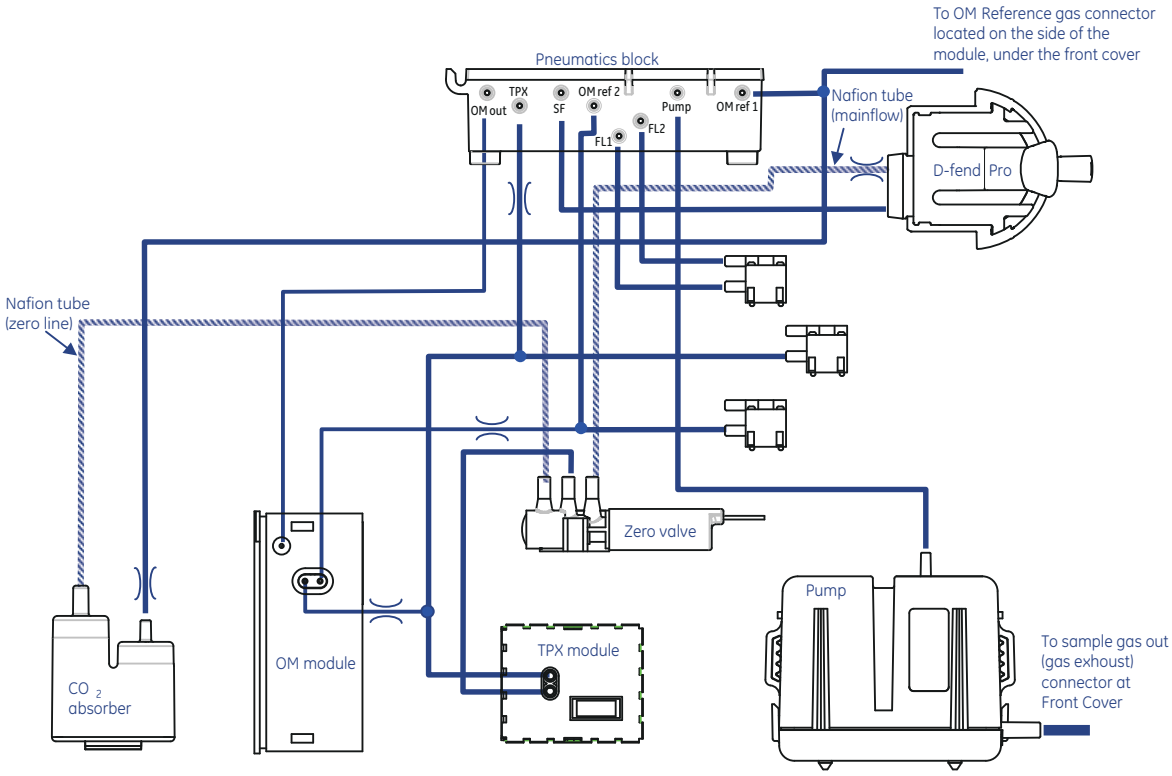


Figure 7 Gas sampling system

The sampling system has a self diagnostics that detects disturbances in the gas flow, reveals the most common reasons for disturbances, such as occluded sampling line or blocked gas exhaust line, and communicates relevant status messages to the patient monitor.

The system is designed so that gas the sampled gas will not flow from the sampling line back to the patient circuit. The parts and connections of the sampling system are streamlined for minimal dead spaces and turbulences in gas flows.

All gas inputs of the module have dust filters protecting the sampling system and gas sensors. The water trap acts as a dust filter for the sampled gas and the module should always have the water trap connected.

NOTE: It is very important to prevent dust from entering the open gas connections during service operations.

D-fend Pro(+) water trap

The gas sampling line is connected to the input of the water trap where a special membrane passes gases and vapors but stops liquids. The gas flowing through the membrane continues via the *main flow* connector of the water trap to the module. The main flow is about 90% of the sample flow.

Liquids stopped below the membrane are moved to the water container by a *side flow* that goes through the water container and the water separation membrane before entering the side flow connector of the water trap. Thus, the side flow also is free of liquids when it gets into the module. In the module, the side flow is connected directly to the pump input and it does not enter the gas sensors.

NOTE: The water trap acts as a dust filter for the sampling system and gas sensors. Thus, the module should always have the water trap connected.

Zero valve and CO_2 absorber

The zero valve is activated during gas sensor zeroing. Room air is drawn through the CO_2-absorber and the zero valve to the gas sensors, and the *main flow* of sample gas is stopped. The zero gas comes to the sensors through the CO_2-absorber that chemically absorbs CO_2. The *side flow* of the water trap flows in the gas sampling line even during zeroing.

During normal monitoring, the zero valve is not activated and the sampled gas gets through the zero valve to the gas sensors.

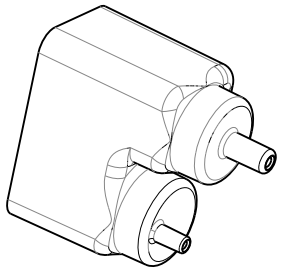


Figure 8 Absorber

Nafion tubes [1)]

The Nafion tube between the water trap and the zero valve equalizes the humidity of the sampled gas to ambient level. This will prevent calibration errors caused by the difference in humidities in the sampled breathing gas and the totally dry calibration gas.

Another Nafion tube is used between the CO_2 absorber and the zero valve to prevent condensation of water generated in the CO_2 absorber as by-product of CO_2-absorption.

1 Nafion is a registered trademark of Perma Pure Inc.

Gas sensors

After the zero valve, the gas flows trough the MiniTPX sensor that measures the concentrations of all gases but oxygen.

The oxygen concentration is measured in the MiniOM sensor that has two inputs. One input draws in a part of the main flow and the other draws in room air as reference gas for the O_2 measurement.

Sample flow differential pressure transducer

The module measures total flow at the input of the gas pump and reference flow at the OM reference line. The sample flow is the difference of these two flows.

Working pressure transducer

The working pressure transducer measures absolute working pressure near the MiniTPX unit and MiniOM unit. It is used for messages: 'Sample line blocked', 'Check D-fend', 'Replace D-fend' and 'Check sample gas out'.

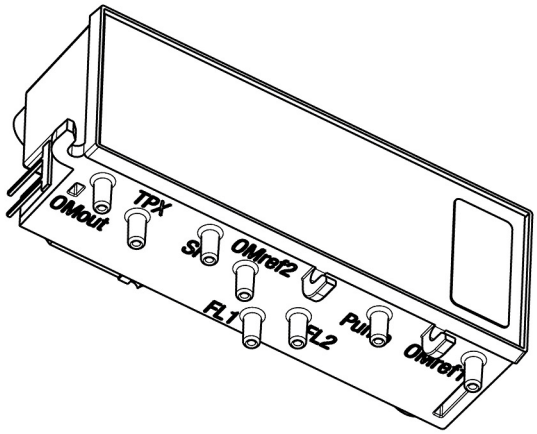
Pneumatics unit

The pneumatics unit contains the zero valve, the occlusion valve and the pneumatics block with tubing connections.

The zero valve is activated during the zero level calibrations of gas sensors. The occlusion and zero valves are activated when the sampling line or water trap is occluded. With the activated valves, the gas pump generates maximal suction trough the "side flow" connector of the water trap, thus maximizing the transfer of liquids from the wet side of the water trap to the container.

The pneumatics block contains a network of constrictions to divide the sampled gas in correct proportions to different parts in the module. The first branching takes place in the water trap where incoming flow is divided to the "main flow" and "side flow". The second branching takes place before the MiniOM sensor.

The pneumatics block also contains a pneumatic low pass filter between gas sensors and gas pump. The filter consists of constrictions (resistors) and volumes (capacitors) and it attenuates the pressure pulsation generated in the gas pump so that they do not disturb the operation of the gas sensors.



Gas pump unit

The gas pump is a membrane pump run by a brushless DC-motor. The pump is adjusted so that the sample gas flow is kept close to its nominal value even when the flow resistances in the sampling line of water trap change.

The pump is in a plastic enclosure to minimize the operating noise and mechanical vibration of the pump unit. A pneumatic damping chamber is integrated to enclosure to attenuate the pressure pulsation and noise conducted to the gas exhaust port.

Pressure measurements

The four pressure sensors on the CPU board are used to measure ambient pressure, working pressure of the MiniTPX and MiniOM sensors and pressure of the reference gas flow to the MiniOM sensor.

Sample flow control

The gas flow in the sampling line is monitored by measuring the gas flow at the input of the gas pump and the reference flow to the oxygen sensor is estimated by measuring the pressure in the reference gas flow branch. The sample flow is calculated by subtracting the reference flow from the total gas flow. A control loop adjusts the rotation speed of the pump motor so that the gas flow is kept close to 120ml/min.

Gas sampling self-diagnostics

The sample flow and the vacuum in the sampling system are used for continuous monitoring of the gas sampling system. The vacuum is calculated in real time as difference of the measured ambient and working pressures.

The self-diagnostics of the gas sampling system sends the following status data to the patient monitor when specific triggering conditions are met: ‘Check water trap’, ‘Check sample gas out’, ‘Replace water trap’, ‘Sample line blocked’ and ‘Continuous blockage’.

The gas pump is stopped when the 'Sample line blocked' has lasted for more than 1 minute. The module automatically restarts the pump to check whether the abnormal situation has been resolved so that normal gas sampling operation is possible.

The gas pump repeats 1 minute full pump, 30 seconds pump off when the ‘Continuous blockage’ message is shown.

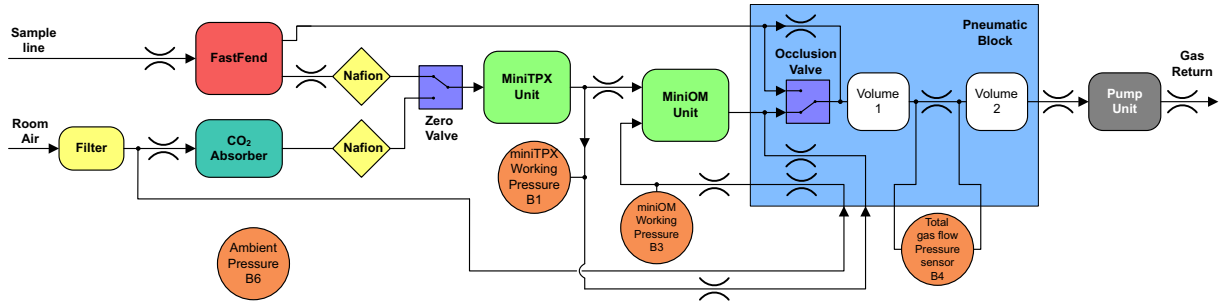


Figure 9 Gas tubing layout

2.2.3 MiniTPX measuring unit

The MiniTPX unit is a non dispersive infrared analyzer, measuring the absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters. The IR source is a micro-machined heating element with an integrated collimator. From the output of the source, the radiation is passed to a flow optimized measuring chamber.

From the sample chamber, radiation goes via a specially designed beam splitter to two detector units, each with four thermopile detectors and integrated optical filters. The miniTPX measuring unit has two detector units for redundancy purposes. A more detailed description of the measuring principle can be found in section "2.1.1. CO2, N2O, and agent measurement".

Each detector unit also measures the unit's temperature. The module CPU uses it for further processing and temperature compensation of the measured raw signals.

The miniTPX unit includes an amplifier board with the following functions:

- On-board 5V regulator and 2.5V reference source.
- Preamplifiers for the eight thermopile detectors and for the two temperature sensors. A 16 channel buffered multiplexer is used to transfer the signals to the CPU board.
- PWM controlled power for the IR source.
- An EEPROM memory for storing factory calibration coefficients of the sensor.

The input to the amplifier board comprises a 7V DC feed and CPU control signals for the PWM, the multiplexer and the EEPROM. When the module starts up, the calibration coefficients are read to the module CPU and then used for calculating the gas concentrations from the raw data received from the sensor multiplexer.

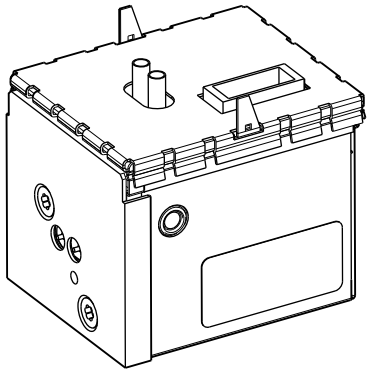


Figure 10 MiniTPX measuring unit

2.2.4 MiniOM Oxygen sensor

The miniOM sensor measures the concentration of Oxygen in the gas sample.

The measurement is based on the magnetic properties of oxygen. The sensor measures the sound pressure generated in the air gap of the magnet at the 164Hz operating frequency. Two microphones are used for detection and the Oxygen concentration is calculated from the RMS value of the difference of the microphone outputs. The measurement principle is described in more detail in section "2.1.2. O2 measurement".

The sensor consists of the following functional parts

- Pneumatic system
- Amplifier board
- MiniOM board
- Magnet

The sensor is shown in the picture below.

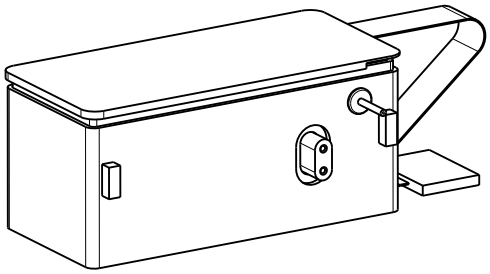


Figure 11 MiniOM oxygen sensor

NOTE: The sensor is assembled in the module using flexible suspension to prevent the mechanical vibrations of the gas pump and cooling fan from disturbing the Oxygen measurement. All gas lines to the sensor must also be carefully assembled so that they do not pick up mechanical vibrations of the module mechanics.

Pneumatic System

The pneumatic system, together with the gas sampling system of the module creates the gas flows and pressures needed for the oxygen measurement and protection of the microphones from excessive pressure. About 30 ml/min flow of sampled gas comes to the In connector on the MiniOM sensor. Room air is drawn to the Ref input of MiniOM also at 30 ml/min rate. About 75% of these flows are conducted to a pressure equalization chamber so that only about a 8 ml/min flow of the two gas streams continue into the air gap of the magnet. All the internal gas flows finally get to a volume enclosed by the sensor board and the sensor body, and then flow out through the *Out* connection of the sensor. Some of the gas channels and flow restrictors are integrated into the preamplifier electronics board utilizing the multi-layer structure of the LTCC (Low Temperature Co-fired Ceramics) circuit board technology.

NOTE: It is very important to prevent dust or liquids from getting into the pneumatic circuit of MiniOM and thus, the gas connections should always be closed with a protecting cap when the sensor is not connected to the module pneumatics.

Amplifier Board

The amplifier board located in the sensor has two electric microphones for the differential detection of pressure pulses generated in the magnet's air gap. The microphone signals are fed to two identical signal conditioning channels with a band-pass filter and a digitally controlled amplifier. The voltage gains of the amplifiers are set during factory calibration so that the responses of the microphone channels match in spite of differences in microphone's sensitivities. The amplifier board also has an amplifier for the thermistor measuring the temperature of the magnet.

MiniOM Board

The MiniOM board has five functions

- Drive the magnet coil.
- Convert the microphone and temperature signals into digital format.
- Filter digitally the microphone signals and perform the RMS-conversion.
- Communicate digitally with the module CPU.

- Store factory calibration data in permanent memory and communicate them to the module CPU.

The module CPU provides the coil drive and communication enabling signals and also clock signal for MiniOM board. The FPGA takes care of the coil drive and has also back-up clock in case of CPU clock does not work. The FPGA takes care of the A/Dconversions which are performed with a serial controlled SAR A/D-converter.

The digital band pass filtering and RMS conversion of the microphone signals is made with FPGA circuit controlled by the VHDL code stored in the circuit. In order to filter out the disturbances caused by acoustic noise, mechanical vibration and amplifier noise, the band pass filters are designed to have as narrow a pass band as possible without slowing down the filter's response to changes in the amplitude of the 164 Hz signal.

The FPGA circuit takes care of the digital communication between the miniOM sensor and the module CPU.

The factory calibration coefficients of the sensor are stored in an EEPROM memory on the miniOM board. When the module starts up, the calibration coefficients are read to the module CPU and then used for calculating the O2 concentration from the Oxygen raw data received from the sensor.

2.2.5 MiniPVX measuring unit

NOTE: Never apply the overpressure or negative pressure of more than 300 cmH_2O to the flow and volume tubing. Differential pressure max 25 cmH_2O is allowed on one port at a time e.g. when connecting tubes.

When Patient Spirometry is used, a special sensor, D-lite, replaces the normal airway adapter in the patient circuit. A double lumen tubing is attached to the two connectors on the adapter and on the module front panel.

The Patient Spirometry provides patient respiration monitoring capabilities using the D-lite and Pedi-lite flow sensors.

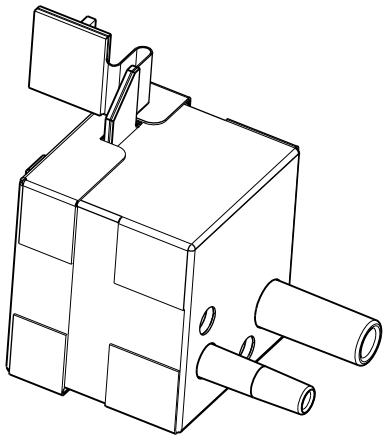


Figure 12 MiniPVX measuring unit

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measuring the Pitot pressure. The signal is then linearized and corrected according to the density of the gas. Speed of the flow is calculated from the pressure and TV is integrated from it.

Patient Spirometry consists of airway connections, two pressure transducers, valves and preamplifiers. The preamplifiers are connected to the A/D-converter on the module main CPU.

The patient's breathing flow passing through the D-lite adapter creates a pressure difference. This pressure difference is measured by a pressure transducer, B1. Overpressure and negative pressure in airways are measured by another pressure transducer, B2.

2.2.6 CPU board

The CPU board contains the processor, memories and an A/D-converter that is common to the whole module.

The CPU board also contains sensors for pressure, temperature and humidity as well as drivers for valves, the fan and the pump. The module is connected to the module bus through an RS-485 serial channel.

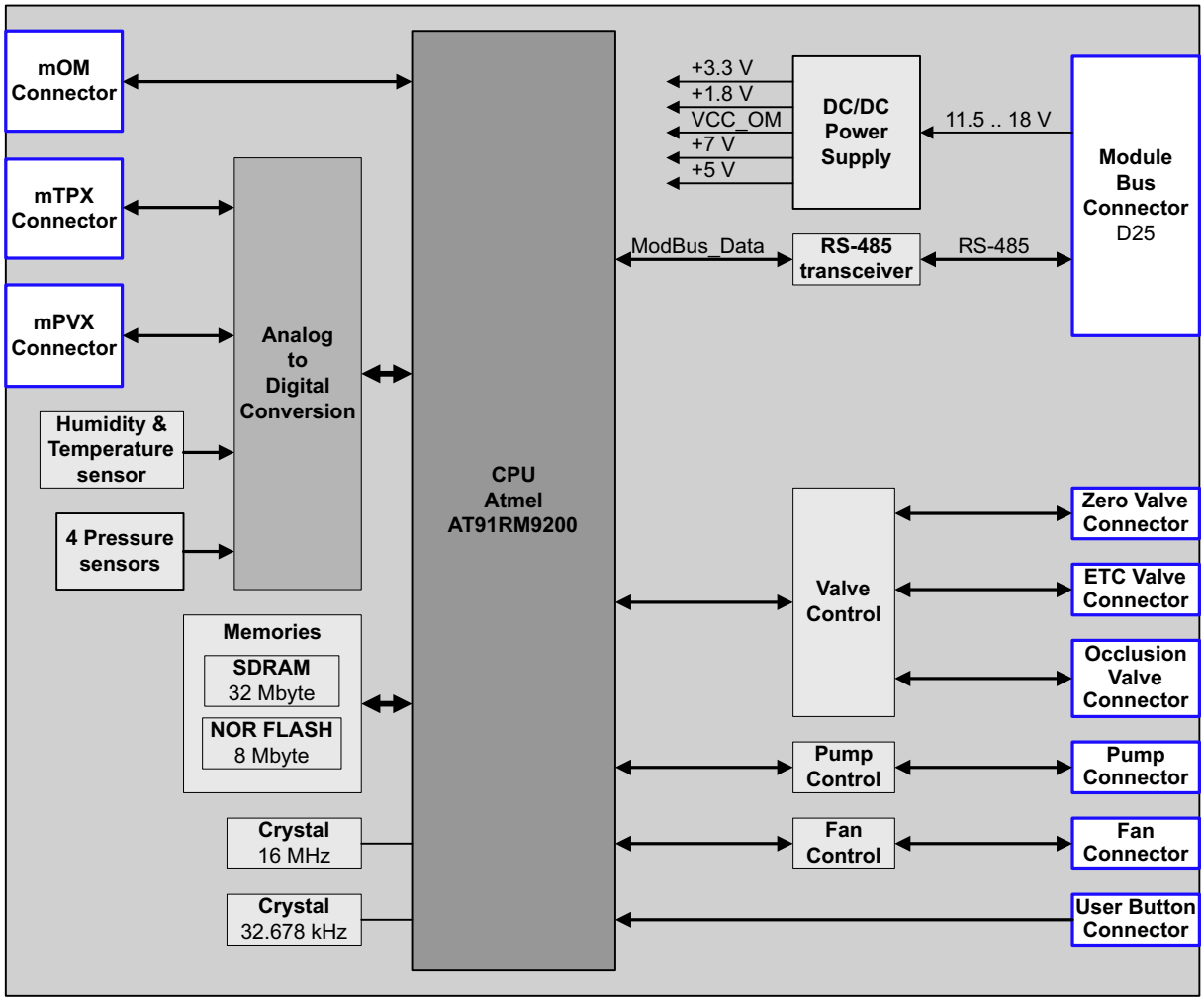


Figure 13 Signal processing on CPU board

2.2.7 MiniOM board

The miniOmM board contains electronics specific to the MiniOM sensor: FPGA circuit, coil drive, A/D-converter etc. It also contains EEPROM memory that stores calibration data of the oxygen measurement.

2.2.8 MiniPVX board

The MiniPVX board contains pressure sensors for airway pressure and flow measurement and preamplifiers for those. It also contains EEPROM memory that stores calibration data of the spirometry measurement.

2.2.9 Main Component Interactions

The figure below describes the functionality of the module and the division of tasks between different components.

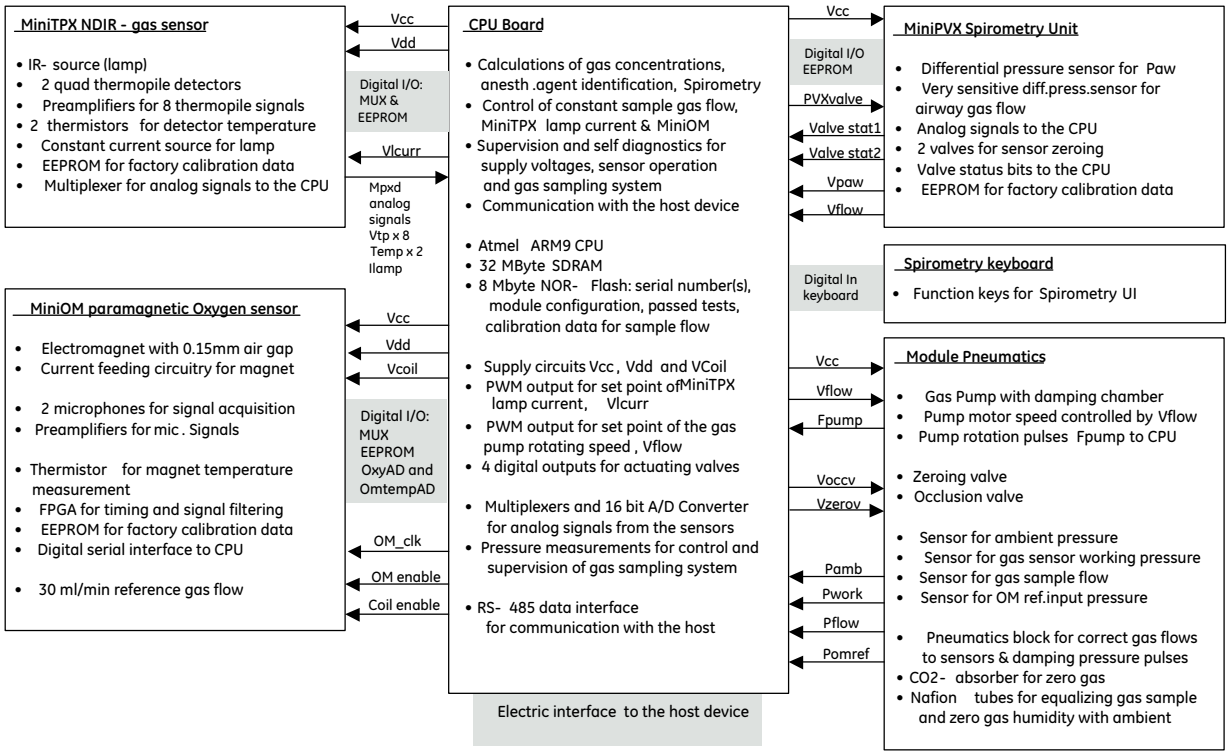


Figure 14 Block diagram

3 Service Procedures

To help ensure the equipment remains in proper operational and functional order, adhere to a good maintenance schedule.

WARNING **Only perform maintenance procedures specifically described in the manual.**

WARNING **Planned maintenance should be carried out annually. Failure to implement the recommended maintenance schedule may cause equipment failure and possible health hazards.**

CAUTION Do not apply pressurized air to any outlet or tubing connected to the module.

NOTE: The manufacturer does not, in any manner, assume the responsibility for performing the recommended maintenance schedule, unless an Equipment Maintenance Agreement exists. The sole responsibility rests with the individuals, hospitals, or institutions utilizing the device.

Corrective maintenance

Service personnel shall perform the following checkout procedure after any corrective maintenance, before taking the module back into clinical use:

Performed service activity	Required checkout procedure	
	Visual inspections (section 3.2)	**Functional check (section 3.3)**
Front panel replacement	All steps	Check "Module Keys" only
OM Reference gas filter assembly	All steps	Check "Sample Flow Rate Check"
Module case opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps

Planned maintenance

Service personnel shall perform the following checkout procedure completely every 12 months after installation:

1. 3.1. Replacement of planned maintenance parts
2. 3.2. Visual inspections
3. 3.3. Functional check

3.1 Replacement of planned maintenance parts

3.1.1 Required parts

Replace the following parts that wear in use at the recommended interval.

Description	Pieces	Replacement interval
Nafion Tube, 230 mm (mainflow)	1	Once a year
OM Reference gas filter assembly including O-ring	1	Once a year
PM sticker	1	Once a year
Nafion tube, 85 mm (zero line)	1	Once every 4 years
CO_2 absorber	1	Once every 4 years

It is also recommended to replace the D-fend Pro water trap, the gas sampling line and the spirometry tube as part of the planned maintenance procedure.

NOTE: See the supplies and accessories document delivered with the manual for compatible accessories.

3.1.2 Planned Maintenance Kits

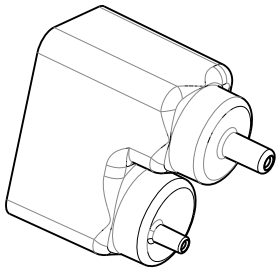
The required planned maintenance parts are included in a PM kit.

Part number	Description
M1206554	Planned Maintenance Kit for CARESCAPE E-sCxxx Respiratory modules. The PM kit includes the required Nafion tubes, the OM reference gas filter assembly with an O-ring and a PM sticker. NOTE: The PM kit does not include the CO_2 absorber. Order it separately.

3.1.3 Replacement procedures

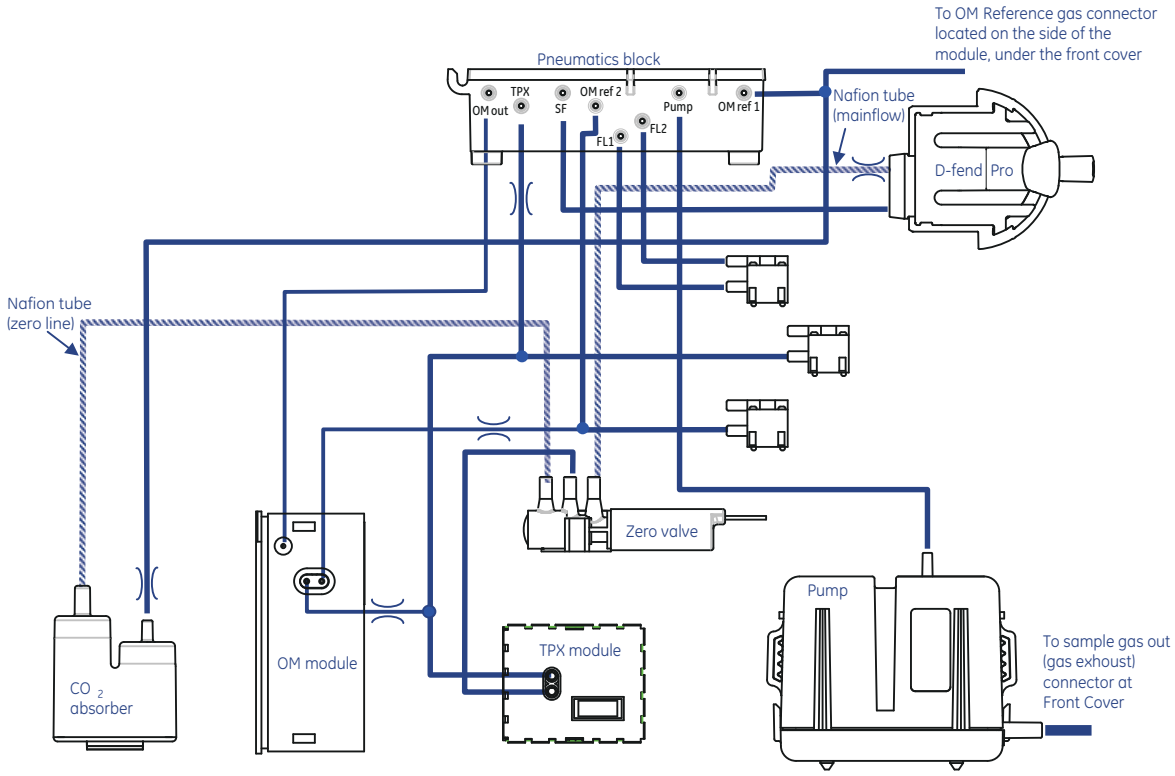
Replace the specified planned maintenance parts according to the chapter "3.4. Disassembly and reassembly".

1. Replace the CO_2 absorber every 4 years.



2. Replace the special tubes (Nafion) and check the condition of the internal tubing.
   - Check that the tubing inside the module is not contaminated. Any contamination inside the tubing may indicate that the valves or sensors are contaminated, too. This can increase a risk of faulty operation in valves or sensors. The valves or gas sensors

are not possible to clean in the field. Therefore, if you noticed any contamination in the module tubing, send the module to GE Healthcare for factory service.



NOTE: The nafion tubes do not include the silicon fittings they connect to. Use the original silicon fittings unless they are damaged or leaking.

3. Replace the OM reference gas filter assembly.
4. Check that the fan and ventilation hole are not covered in dust.

3.2 Visual inspections

Detach the module from the module slot and check that:

- the front cover is intact
- all connectors are intact and are attached properly
- the module box and latch are intact
- the D-fend Pro and its connectors are clean and intact
- the module and the applied parts are clean

The cleaning precautions, cleaning requirements, cleaning procedures, and recommended cleaning solutions for the monitor are described in the S/5 monitor user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

3.3 Functional check

Turn the monitor on. Wait until the normal monitoring screen appears.

3.3.1 Test setup

Required tools

- A barometer
- A mass flowmeter for measuring air flow, minimum measurement range from 0 to 200ml/min, accuracy 5% or better in the 0 to 200 ml/min range.
- P/N: 755534-HEL Calibration Gas Regulator
- P/N: 755583-HEL Calibration gas, CO2, O2, N2O, DESF, package of 1 can (with E-sCAiO, E-sCAiOV modules)
- P/N: 755581-HEL QUICK CAL calibration gas, CO2, O2, N2O, package of 4 cans (with E-sCO, E-sCOV modules)
- P/N: M1006864, Calibration Gas Regulator, US only
- P/N: 755571-HEL, Calibration Gas, 5% CO2, 54.5% O2, 36.0% N2O, 2.0% DESFLURANE, BAL N2 (with E-sCAiO, E-sCAiOV modules) US only
- P/N: 755587, Calibration Gas, CO2, O2, Balance, 4 cans/pkg (with E-sCO, E-sCOV modules) US only
- D-fend Pro water trap
- 3 m / 10 ft anesthesia gas sampling line
- Spirometry tube, 3 m/10 ft (with E-sCOV and E-sCAiOV modules)
- Adult D-Lite sensor
- A pressure manometer with either an integrated or a separate pressure pump
- Tubing for spirometry leak tests
- Forceps

NOTE: See the supplies and accessories document delivered with the manual for compatible accessories.

Connections

- Disconnect the module from the monitor, if connected.

Monitor configuration

1. Configure the CO_2, O_2, AA, and Flow waveform fields to the monitor screen.
2. Configure the Spiro 1 split screen to the monitor screen.
3. Select the ***Spirometry Setup*** in the ***Airway Gas*** menu and configure:
   Scaling: Auto
   Sensor Type: Adult
   TV or ***MV:*** TV

3.3.2 Procedure

Mark each task as complete on the checkout form.

1. Gas Sampling System Leak Test

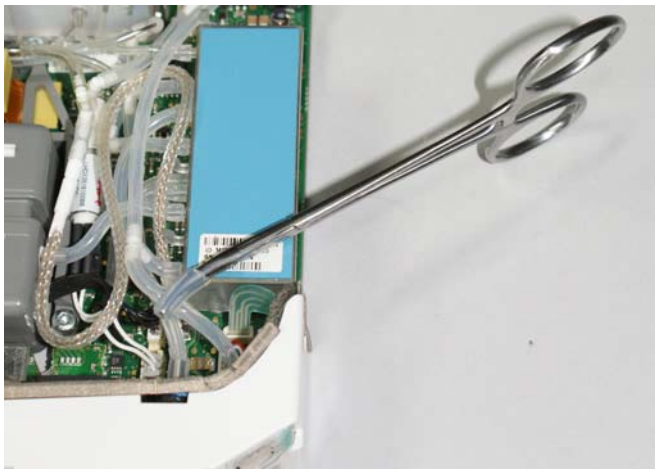
NOTE: The gas module shall be disconnected from the monitor during the leak test.

Check the gas sampling system for possible leakages.

a. Disconnect the module from the monitor.

b. Detach the module front cover and casing, see chapters"Detaching the Front Cover" on page 33 and "Detaching the Module Casing" on page 34.

c. Block the OM reference tube with the forceps. Correct positioning of the forceps is indicated by the figure below.
NOTE: Be careful when attaching the forceps to the tube and avoid stretching the tube. Short pieces of silicone tubing on the forcep jaws can be used to protect the tube from breaks that may appear when the tube is compressed between the jaws.



d. Connect a new D-fend Pro water trap to the module.

e. Connect a new gas sampling line to the sampling line connector in the water trap.

f. Connect the other end of the gas sampling line to a pressure manometer and a pressure pump.

g. Block the sample gas out (gas exhaust) connector.

h. Carefully pump 80 mmHg ± 20 mmHg pressure to the gas sampling system. Let the pressure stabilize for 10 - 20 seconds.

i. Check that the pressure reading does not drop more than 2 mmHg during 25 seconds.

j. Release the forceps, and reassemble the module casing. Make sure that the tubing fits nicely into the module casing.

2. Spirometry System Leak Test

NOTE: Perform this test only for E-sCOV and E-sCAiOV modules.

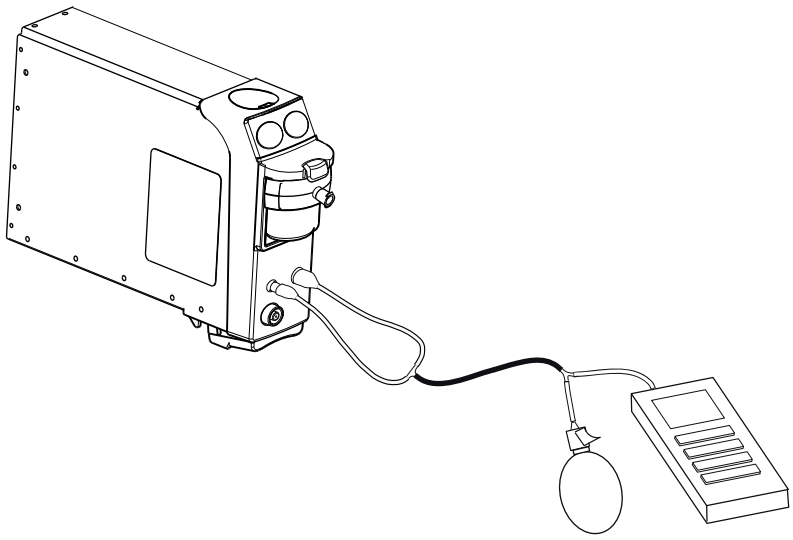
NOTE: The gas module shall be disconnected from the monitor during the leak test.

NOTE: The spirometry pressure transducers are very sensitive for differential overpressure. A momentary differential pressure between the two spirometry connectors exceeding 25 cmH_2O (18 mmHg) may damage the pressure sensors. To ensure that both pressure channels are equally pressurized, make sure that the tubing between the manometer and the two spirometry connectors is connected tightly, the tubes are equally long and thick and not kinked.

NOTE: Do not overpressure the spirometry sampling system. A static pressure exceeding 300 cmH_2O (220 mmHg) may damage the pressure sensor.

Check the spirometry sampling system for possible leakages.

a. Ensure the module is disconnected from the monitor.
b. Connect a pressure manometer to the spirometry connectors.



c. Pump ~68 cmH_2O (50 mmHg ±10 mmHg) pressure to the Spirometry sampling system. Let the pressure stabilize for approximately 10 seconds.
d. Verify that the pressure reading does not drop more than 4 cmH_2O (3 mmHg) during one minute.

3. Sample Flow Rate Check

Check the sample flow rate.

Connect the module to the monitor.

NOTE: Anesthetic gas measurement is not available during the first 1 to 5 minutes after the module is connected due to warming up. A message '***Calibrating Gas Sensor***' is shown in the waveform field. Wait until warm-up is completed before proceeding with the next steps.

NOTE: The ambient temperature and air pressure influence the flow rate measured by the flow meter. A flow meter, which has been calibrated at 21.11 °C (70 °F) and 760 mmHg (1033 cmH2O), measures the flow rate correctly under the same conditions, i.e. in room temperature at sea level. A flow rate correction as instructed by the manufacturer of the flow meter needs to be performed when measuring flow rate under other conditions, for example in high altitude.

a. Connect the gas sampling line (3 m / 10 ft with E-sCO, E-sCOV, E-sCAiO and E-sCAiOV) to the Sampling line connector.
b. Connect the other end of the gas sampling line to a flowmeter.
c. Check the sample flow rate reading from the flowmeter. The flow rate shall be within the specification limit 120 ± 20 ml/min.

NOTE: Readjustment is needed, if the measured value is not within the specification limit. Adjust the sample gas flow rate according to the instructions in section "3.5.1. Sample Flow Rate Adjustment".

4. Reference Gas Flow Rate Check

Check the flow rate in reference gas inlet:

a. Connect the module to the monitor.
b. Leave the other end of the gas sampling line open to room air.
c. Connect the flowmeter to the OM reference gas inlet on the side of the module with a piece of tubing.
d. Check that the ***Reference Flow*** is within the following range:
10 - 50 ml/min with E-sCO, E-sCOV, E-sCAiO and E-sCAiOV modules
e. Detach the water trap.
f. Attach the front cover.

5. Fan

a. Check that the gas module's fan is running behind the D-fend Pro water trap.
b. Attach the water trap.

6. Module Keys

NOTE: Perform this test only for E-sCOV and E-sCAiOV modules.

a. Press the Change Loop module key.
b. Check that the spirometry loop is changed from ***Flow / Vol*** loop to ***Paw/Vol*** loop, or vice versa.
c. Leave the ***Flow / Vol*** loop on the screen.

7. Zero Valve Operation

Test the zero valve functionality:

a. Connect the gas regulator to the calibration gas container.
b. Connect the end of the gas sampling line to the regulator on the gas container. Leave the regulator overflow port open to room air.
c. Select Monitor Setup**> *Install/Service >Service > Parameters > Gas out > Gases***
d. Start feeding the specified calibration gas. Wait until the gas values shown in the ***Gas calibration*** menu rise approximately to the level indicated in the labelling of the calibration gas container.

NOTE: The gas values in the ***Gas Calibrations*** menu is in percentages (%).

e. Open the zero valve to room air by selecting ***Zero valve Ctrl > Zero*** (zero position).
f. Check that the ***CO2***, ***N2O*** and ***anesthesia agent*** values drop back near 0% and the ***O2*** reading near 21% (room air).
g. Stop feeding the calibration gas.
h. Turn the zero valve back to the normal measurement position by selecting ***Zero valve Crtl > Meas*** (measurement position).

8. Gas Calibration

Perform gas calibration according to the instructions in section "3.5.2. Gas Calibration".

9. Agent Identification

NOTE: Perform this test only for E-sCAiO and E-sCAiOV modules.

Check agent ID unreliability:

a. Feed the specified calibration gas for at least 30 seconds.
b. Check that the anesthesia agent is identified as Desflurane and the ***ID unrel*** value (=agent ID unreliability) shown in the Monitor Setup ***> Install / Service > Service > Parameters > Gas Unit > Gases*** menu is lower than 75.

If the value is higher, repeat the gas calibration and check the value again.

10. Ambient Pressure

Use a barometer to check the operation of the absolute pressure sensor.

- Check that the ambient pressure value shown in the ***Gas Calibrations*** menu does not differ more than ± 10 mmHg from the value shown by the barometer.

NOTE: The ambient pressure value in the ***Gas Calibrations*** menu is in mmHg.

11. Occlusion detection
    a. Block the tip of the sampling line by your finger.
    b. Check that a '***Sample line blocked***' and a ***'Low sample flow'*** message appear on the screen within 30 seconds.

12. Air Leak detection
    a. Detach the D-fend Pro water trap.
    b. Check that the message '***Check Water Trap***' appears on the screen within 30 seconds.
    c. Attach the water trap.

13. Gas exhaust blockage
    a. Block the gas exhaust connector with your finger.
    b. Check that the message '***Sample gas ou***t' appears on the screen within 30 seconds.

14. Airway Gases
    a. Breathe a minimum of 5 times to the tip of the sampling line.
    b. Check that a normal ***CO2*** waveform appears and the ***EtCO2*** and ***FiCO2*** values are updated on the screen .

15. Apnea detection
    a. Stop breathing to the gas sampling line.
    b. Check that an '***Apnea***' alarm appears on the screen within 30 seconds.

16. Flow waveform

NOTE: Perform this test only for E-sCOV and E-sCAiOV modules.

    a. Connect a clean spirometry tube and D-lite to the module.
    b. Breathe through the wider side of the D-lite.
    c. Check that the flow waveform responds when you breathe in and out. The setting of the inspiratory flow may be positive or negative.

3.3.3 Test completion

- Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.
- Disconnect and reconnect the module before starting a new case.
- Complete the "Appendix A. Service check form".

3.4 Disassembly and reassembly

3.4.1 Disassembly guidelines

WARNING **Disconnect the module from any monitoring system before performing any repair.**

WARNING **Always perform gas sampling system leak test after the module cover is reassembled.**

WARNING **Always perform gas calibration after any planned or corrective maintenance.**

Field service of the module is limited to replacing the serviceable parts listed below (see also chapter "5. Spare parts"). Attempting a field repair on any other parts could jeopardize the safe and effective operation of the module, and void the warranty.

NOTE: Only a qualified service technician should perform field replacement procedures.

NOTE: Perform the checkout procedure described in chapter "3. Service Procedures" after you have disassembled and reassembled the module.

Serviceable parts

- CO_2 Absorber
- D-fend Pro
- Nafion tubes
- Front chassis unit
- MiniPVX Unit
- Pump
- OM reference filter
- Latch and spring
- Mechanical parts listed in chapter "5. Spare parts"

Service limitations

The following parts are not serviceable:

- MiniOM Measuring unit
- MiniTPX measuring unit

NOTE: Due to the complicated and sensitive mechanical construction of the oxygen measuring unit, no repairs should be attempted inside the unit. Instead, if the fault has been found in the

measuring unit itself, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.

NOTE: The MiniTPX measuring unit can only be repaired and calibrated at the factory. In case of failure, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.

ESD precautions

WARNING **Protect module from electrostatic discharge.**

All external connectors of the module are designed with protection from ESD damage. However, if the module requires service, exposed components and assemblies inside are susceptible to ESD damage. This includes human hands, non-ESD protected work stations or improperly grounded test equipment. The following guidelines may not guarantee a 100% static-free workstation, but can greatly reduce the potential for failure of any electronic assemblies being serviced:

- Discharge any static charge you may have built up before handling semiconductors or assemblies containing semiconductors.
- A grounded, antistatic wristband or heel strap should be worn at all times while handling or repairing assemblies containing semiconductors.
- Use properly grounded test equipment.
- Use a static-free work surface while handling or working on assemblies containing semiconductors.
- Do not remove semiconductors or assemblies containing semiconductors from antistatic containers until absolutely necessary.
- Do not slide semiconductors or electrical/electronic assemblies across any surface.
- Do not touch semiconductor leads unless absolutely necessary.
- Semiconductors and electronic assemblies should be stored only in antistatic bags or boxes.
- Handle all PCB assemblies by their edges.
- Do not flex or twist a circuit board.

Protection from dust

WARNING **Module must be handled to prevent dust from entering the gas sampling system.**

The gas sampling system must be protected from dust entering the tubes, valves and other components. In order to achieve this goal, the following measures must be taken:

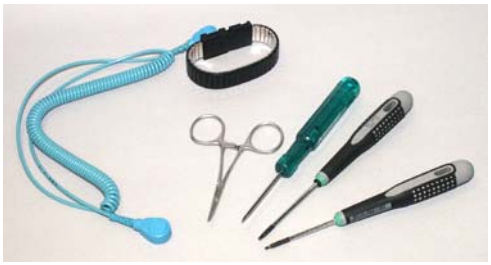
- Have the D-fend Pro water trap always connected to the module.
- Clean and dust free working environment during all service procedures.
- Minimize the times with any open connections in the gas sampling system.
- Always close the open tube connections of the sampling system when not working on the module.
- Remove the protective caps on the gas pump only immediately before assembling it to the module

- Take the CO_2-absorber out from the plastic bag only immediately before assembling it to the module.
- The clothing of the service person must be such that the dust risk is taken into account.

Before disassembly

- Note the positions of any sampling tubes, wires or cables. Mark them if necessary to ensure that they are reassembled correctly.
- Save and set aside all hardware for reassembly.

Required tools



- Torx T8 and T10 screwdrivers
- flat blade screwdriver
- forceps
- antistatic wristband

3.4.2 Disassembly and reassembly procedure

Disassembling the module (see the exploded view of the module in chapter "5. Spare parts":

Reassembling the module: reverse the order of the disassembly steps.

Check that:

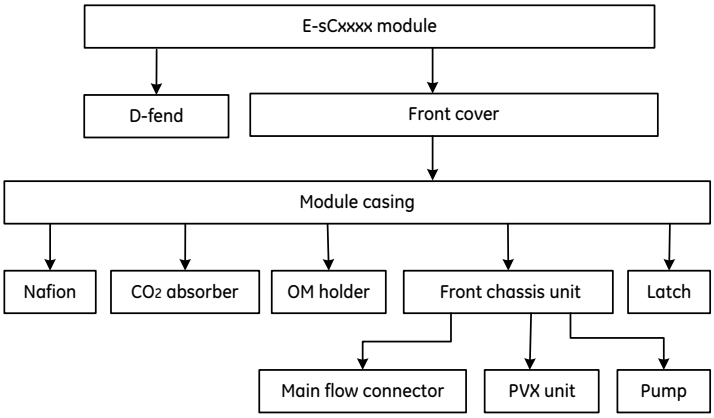
- all screws are tightened properly
- all cables are connected properly
- tubes are not pinched and there are no sharp bends on them
- all tubes are connected properly

NOTE: Make sure that the Nafion tubes are routed in such a way that they don't come near the fan, and there is no risk of the fan being obstructed by the tubes. An obstructed fan will result in degraded ventilation inside the module, and a ***'Sensor inop'*** message being displayed.

- there are no loose objects inside the module

Disassembly workflow

Use this workflow diagram to find the simplest way to disassemble the required parts of the module. Follow the arrows from the top down to the required part and disassemble the module by following the steps in between.



Detaching the Front Cover

1. Remove the D-fend Pro.
2. Release the two snaps on both sides of the module by using a flat blade screwdriver.
3. Detach the front cover.

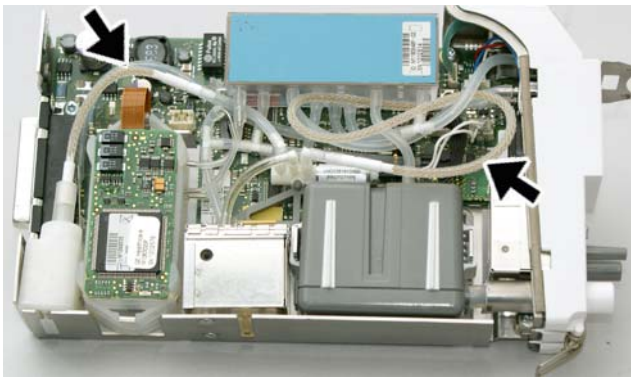
Detaching the Module Casing

1. Remove the two T8 screws mounting the D25 connector shield.
2. Detach the connector shield.
3. Remove the two T8 screws to detach the module casing.

4. Push the latch and pull the module casing.

NOTE: When reassembling ensure that the module casing does not damage the conductive sealings on the front chassis unit.

Replacement of Planned Maintenance Parts

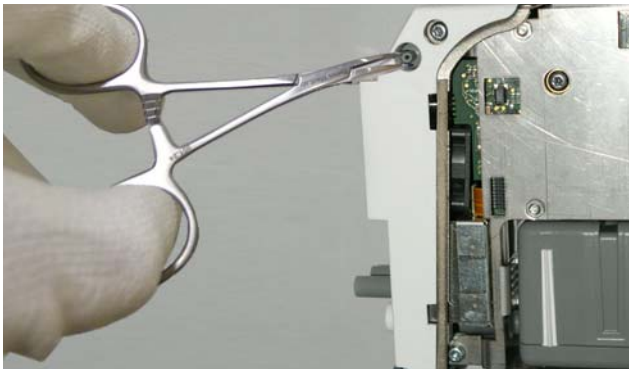


1. Carefully remove the main flow nafion tube and every 4th year the shorter zero line nafion tube.

NOTE: Remember the route of the tubes and reassemble correctly.

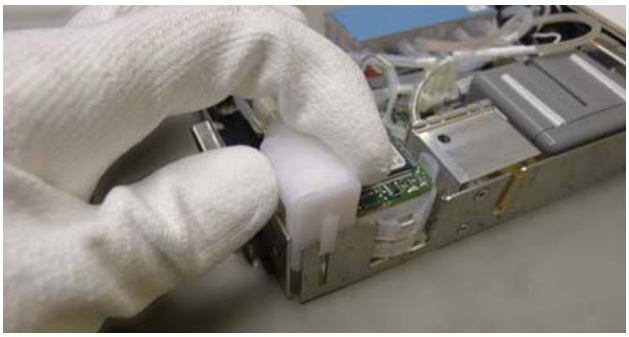
NOTE: Make sure that the Nafion tubes are routed in such a way that they don't come near the fan, and there is no risk of the fan being obstructed by the tubes. An obstructed fan will result in degraded ventilation inside the module, and sensor inop message being displayed.

NOTE: The nafion tubes do not include the silicon fittings they are connected to. Use the original silicon fittings unless they are not damaged or leaking.

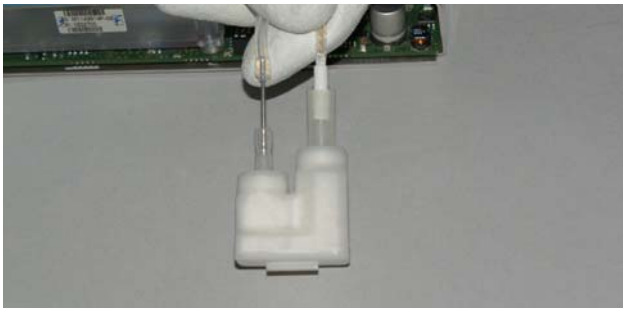


2. Pull out the OM reference filter assembly with forceps.
3. Push the new filter assembly until it is on the same level with the front chassis.

Replacement of CO_2 Absorber



1. Lift the CO_2 absorber from the slot.

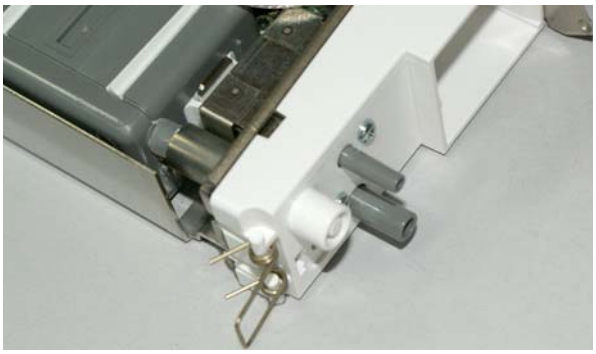


2. Detach the tubes from the absorber.
3. Connect the tubes to a new CO_2 absorber and place it to the slot.

Detaching the Latch

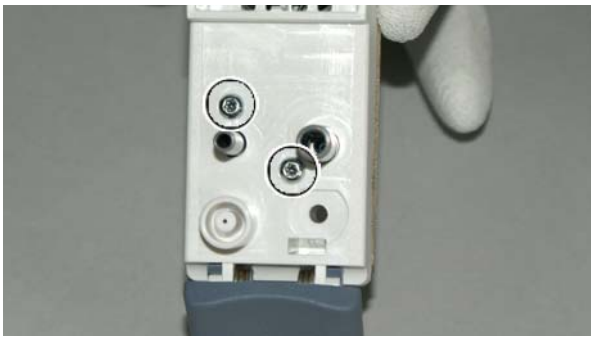
1. Pull the latch from the front chassis.

NOTE: Remember to detach the front cover first.



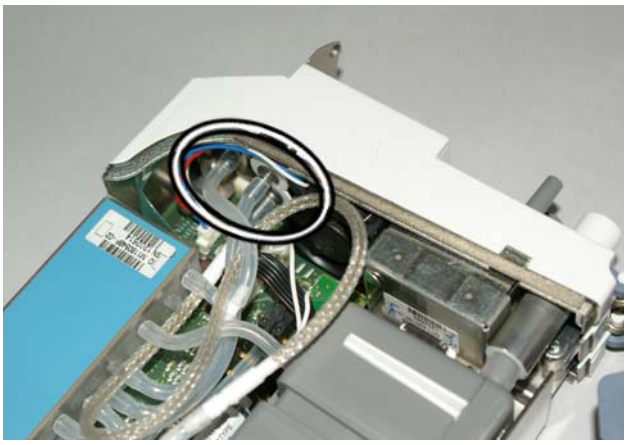
2. Remove the spring by squeezing it.

Detaching the Front Chassis Unit



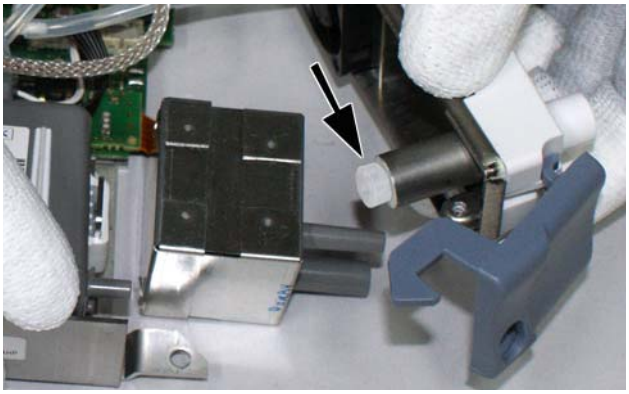
1. Remove the two T8 screws which fasten the PVX unit to the front chassis.

2. Remove the two T10 screws.



3. Carefully detach the three tubes.

4. Disconnect the fan and keypad cables.

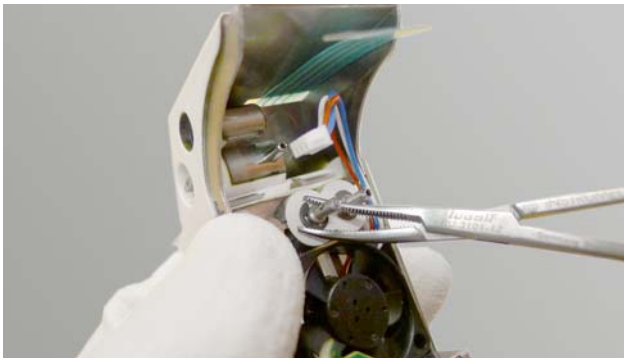


5. Detach the front chassis unit.

NOTE: When reassembling insert the pump silicone tube in the front chassis connector.

Detaching the Main Flow Connector

Original Main Flow Connector is required to maintain proper gas flow restriction in the module. When the Front Chassis Unit is replaced move the original connector to the new unit.

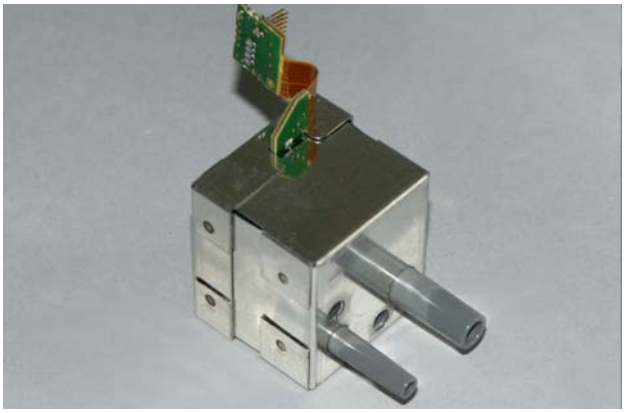


1. Carefully detach the lock pin holding the main flow connector.

2. Carefully attach the main flow connector to the new front chassis unit.

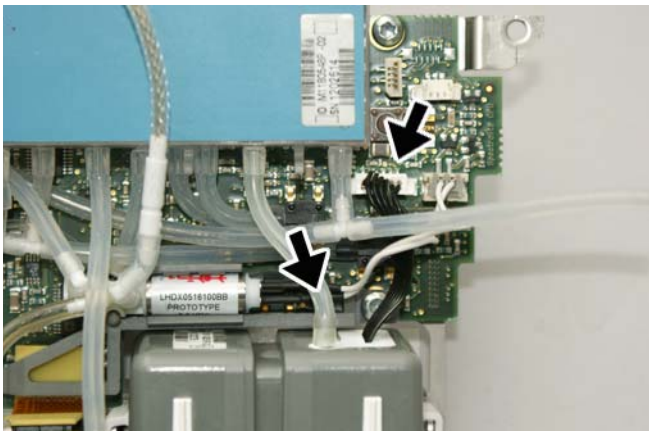
Detaching the PVX Unit

1. Carefully disconnect the PVX connector.



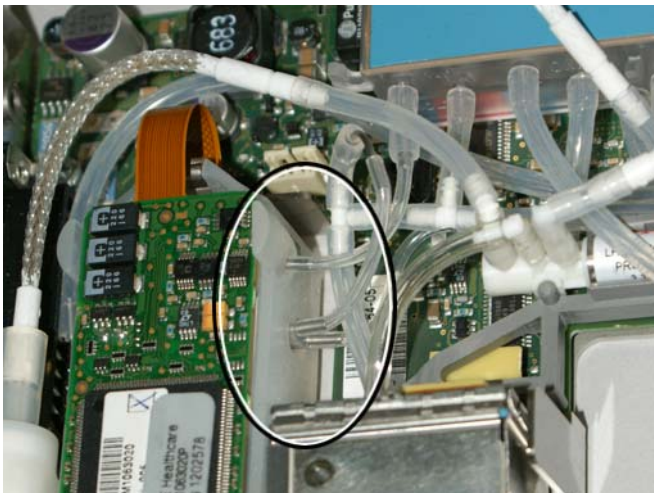
2. Detach the PVX Unit.

Detaching the Pump

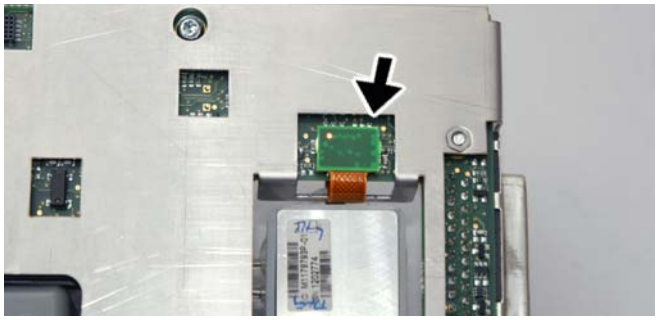


1. Carefully detach the tube from the pump.
2. Disconnect the pump cable from the CPU board.
3. Lift the pump from the metal brackets.

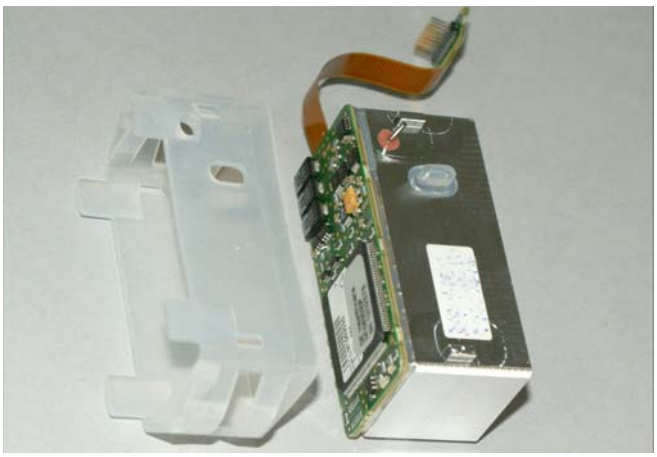
Detaching the OM holder



1. Carefully detach the three tubes from the OM unit.



2. Carefully disconnect the OM flex cable from the CPU board.
3. Carefully pass the flex cable through metal frame.



4. Lift the OM unit with the holder from the metal brackets.
5. Detach the holder.

3.5 Adjustments and calibration

3.5.1 Sample Flow Rate Adjustment

Sample flow rate shall be adjusted:

- if the sample flow rate check in section "3.3.2. Procedure" failed.

Calibration setup

Required tools

– A mass flowmeter for measuring air flow, minimum measurement range from 0 to 200ml/min, accuracy 5% or better in the 0 to 200 ml/min range.

– 3 m / 10 ft anesthesia gas sampling line.

NOTE: See the supplies and accessories document delivered with the manual for compatible accessories.

NOTE: Use only accurate, properly maintained, calibrated and traceable calibration tools for the parameter calibration to ensure measurement accuracy.

NOTE: If the flow meter unit is not ml/min, it shall be converted to ml/min according to the instructions of the flow meter manufacturer.

NOTE: Gas module sample flow rate is calibrated in the factory to ambient air conditions corresponding the flow at the end of 3 m sampling line. Make sure that your meter is also showing the flow at ambient conditions (= ATP).

NOTE: Refer to the flowmeter documentation for user instructions.

Connections

1. Ensure that the module is connected to the monitor.
2. Ensure that you have a new D-fend Pro water trap in use.
3. Connect a new gas sampling line to the sampling line connector in the water trap.
4. Connect the other end of the gas sampling line to the flow meter.

NOTE: Before checking or adjusting the sample flow, make sure there is no leakage in the sampling system.

Sample Flow Rate Adjustment

1. Select **Monitor Setup > *Install / Service > Service > Parameters > Gas Unit > Gases***
2. Select ***Sample gain adj.***
3. Adjust the sample flow to the nominal value 120 ml/min by increasing or decreasing the ***Sample Flow Gain***:

NOTE: On S/5 monitor screen the 120 ml/min flow rate is shown as 200 ml/min to be compatible with the old S/5 monitors.

   - To decrease the sample flow rate measured by the flow meter by approximately 7,5 ml / min, add gain value by 0.05.
   - To increase the sample flow rate measured by the flow meter by approximately 7,5 ml / min, lower the gain value by 0.05.

4. Press ***Confirm*** to check the effect of the gain adjustment. Wait until the sample flow value shown in the ***Calibration*** menu returns near to the nominal value 120 ml/min and then check the actual measured flow rate from the flow meter.
5. Repeat steps 3 and 4 until the flow meter shows a 120 ± 20 ml /min flow rate.

NOTE: Adjust the flow rate according to the reading in the flow meter. The flow rate reading in the ***Calibration*** menu is measured by the internal electronics and settles always back to the nominal 120 ml /min independent on the real flow rate.

3.5.2 Gas Calibration

WARNING **Failure in zeroing or calibrating gases might cause inaccurate readings.**

WARNING **Since calibration gas contains anesthetic agents, always ensure sufficient ventilation of the room during calibration.**

Gas calibration shall be performed:

- each time planned maintenance is performed.
- each time corrective maintenance is performed.

NOTE: Gas calibration is a normal user action. Refer to the monitor user's manual for the recommendation for gas calibration interval in clinical use.

Calibration setup

Required tools

– P/N: 755534-HEL Calibration Gas Regulator

– P/N: 755583-HEL Calibration gas, CO2, O2, N2O, DESF, package of 1 can (with E-sCAiO, E-sCAiOV modules)

– P/N: 755581-HEL QUICK CAL calibration gas, CO2, O2, N2O, package of 4 cans (with E-sCO, E-sCOV modules)

– P/N: M1006864, Calibration Gas Regulator, US only

– P/N: 755571-HEL, Calibration Gas, 5% CO2, 54.5% O2, 36.0% N2O, 2.0% DESFLURANE, BAL N2 (with E-sCAiO, E-sCAiOV modules) US only

– P/N: 755587, Calibration Gas, CO2, O2, Balance, 4 cans/pkg (with E-sCO, E-sCOV modules) US only

– 3 m / 10 ft anesthesia gas sampling line

NOTE: Use only the specified GE Healthcare calibration gas for the gas calibration to ensure measurement accuracy. Do not use any other calibration gases. Check the calibration gas container's labelling to ensure that the calibration gas has not expired.

NOTE: Ensure that the gas regulator is functioning properly before gas calibration. Refer to the gas regulator's "Instructions for Use" letter for the annual maintenance instructions.

Connections

1. Ensure that the module is connected to the monitor.
2. Ensure that you have a new D-fend Pro water trap in use.
3. Connect the gas regulator to the calibration gas container.
4. Connect a new gas sampling line to the sampling line connector in the water trap.
5. Connect the other end of the gas sampling line to the regulator on the gas container. Leave the regulator overflow port open to room air.

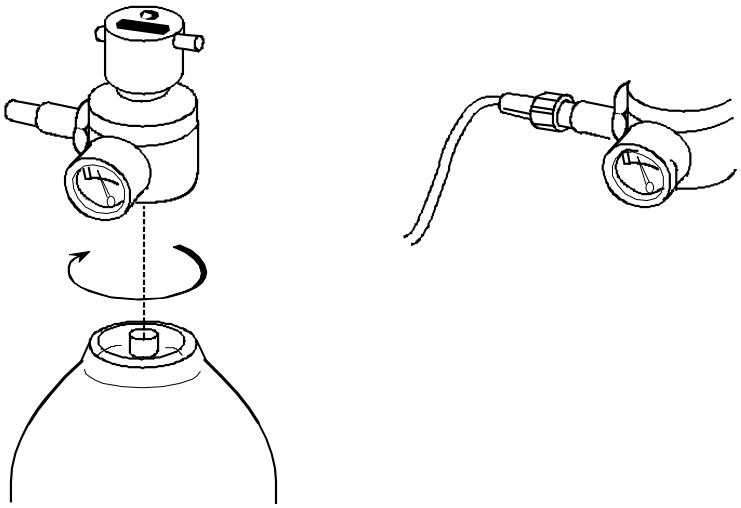


Figure 15 Connecting a gas regulator to the calibration gas container and connecting a sampling line to the gas regulator.

Procedure

NOTE: Gas calibration is not available during the first 5 minutes after the module is connected. A message '***Gas calibration is not available during first 5 minutes***' is shown in the lower left corner of the ***Calibration*** menu. For maximum accuracy, let the monitor to warm up for 30 minutes before starting calibration.

NOTE: Gas calibration is not available during a '***Sample line blocked***', '***Check Dfend***' and '***Check sample gas out***' alarm condition. A message '***Gas calibration is not available during gas sampling warning***' is shown in the lower left corner of the calibration menu. Resolve the alarm condition before starting calibration.

1. Select ***Airway Gas > Gas Calibration***
2. The monitor will start automatic zeroing of the gas sensors. Wait until the message '***Zeroing'*** is replaced by a message ***'Zero Ok'*** for all measured gases.
3. Open the regulator after a message ***'Feed gas'*** is shown for all measured gases. The measured gas concentrations are shown in real-time in the gas calibration menu. Continue feeding the calibration gas until the measured gas concentrations are stabilized and a message ***'Adjust'*** is shown for all measured gases. Close the regulator.
4. Adjust the gas readings shown in the ***Calibration*** menu to match with the gas readings in the labelling of the calibration gas container. Select ***Accept*** to accept the adjusted values when the gas readings match each other.
5. Wait until a message ***'Ok'*** is shown for all measured gases.

NOTE: A message ***'Zero Error'*** is shown in case the zeroing fails.

NOTE: A message ***'Calibration Error'*** is shown, if you do not start feeding gas within 1 minute after the automatic zeroing is completed, or if the calibration fails due to too large gain adjustment.

NOTE: If zeroing or calibration failed, select the Recalibrate button to restart the calibration procedure from the beginning.

3.5.3 Spirometry Calibration

Patient spirometry does not require regular service calibration during planned maintenance, or after the MiniPVX unit has been replaced. Calibration is only needed if there is a permanent difference between the measured inspiratory and expiratory volumes.

The MiniPVX measuring unit is calibrated at the factory and due to the unit's design, spirometry calibration is not regularly needed in the field. The calibration data is saved into the board's EEPROM.

If calibration is desired, it is recommended to perform the calibration both with adult values using the D-lite, and with pediatric values using the Pedi-lite.

Calibration setup

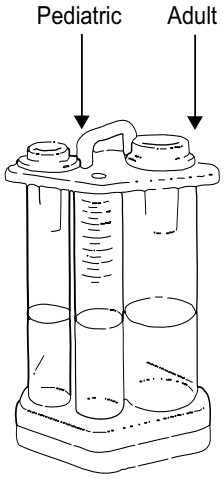
Required tools

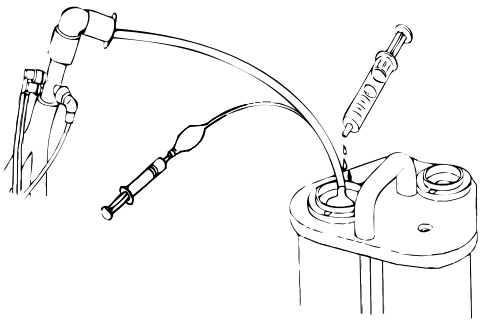
– P/N 884202-HEL Spirometry tester
– D-Lite and Pedi-lite sensors
– Spirometry tube
– Ventilator

NOTE: See the supplies and accessories document delivered with the manual for compatible accessories.

Connections

- Refer to the "Instructions for Use" -letter of the spirometry tester to see the setup.





Monitor configuration

- Configure the ***Flow*** waveform field to the monitor screen with adequate priority.
- Select the ***Spirometry Setup*** in the ***Airway Gas*** menu and configure:

  Scaling: Auto
  Sensor Type: Adult
  TV or MV: TV

Ventilator configuration

- Configure the ventilator to use air as fresh gas.
- Set the Tidal Volume (***TV***) to 500 ml/min when doing calibration check and calibration with adult sensor and 100 ml/min with pediatric sensor.
- Set the ***RR*** =15, ***I/E*** =1/2 and ***PEEP*** 0cmH2O.

Calibration check

1. Perform the calibration check according to the steps 1 through 12a in the "Instructions for Use" -letter of the spirometry tester.

NOTE: Let the gas module to warm up at least for 10 minutes before performing the calibration check or flow calibration.

2. The measured flow values are shown in real-time in the ***TV Insp*** and ***TV Exp*** fields in the Flow parameter window. Compare these measured values to the TV value reading (highest water level) in the spirometry tester.

Acceptance criteria:

- If the ***TV Insp*** and ***TV Exp*** values differ less than ± 6% of the value read from the spirometry tester, flow calibration is not needed.
- If the ***TV Insp*** and ***TV Exp*** values differ more than ± 6% of the value read from the spirometry tester, perform flow calibration according to section "Flow calibration".

Flow calibration

1. Select Monitor Setup ***> Install /Service > Service > Parameters > Gas Unit > Spirometry***
2. Ensure that the ***Sensor Type*** is correct and that ***Spirometry Zeroing*** is Enabled.
3. Wait until the MiniPVX sensor performs an automatic zeroing. It will show a message ***'zeroing'*** in the Flow parameter window when zeroing takes place.
4. Adjust the ***Exp Flow Gain*** and/or ***Insp Flow Gain*** separately to calibrate the measured ***TV Exp ml*** and ***TV Insp ml*** values:
   - To increase the ***TV Exp ml*** flow value, increase the ***Exp Flow Gain***.
   - To decrease the ***TV Exp ml*** flow value, lower the ***Exp Flow Gain***.
   - To increase the ***TV Insp ml*** flow value, increase the ***TV Flow Gain***.
   - To decrease the ***TV Insp ml*** flow value, lower the ***TV Flow Gain***.
5. Press ***Confirm*** to check the effect of the gain adjustment to the flow readings.
6. Repeat steps 3 and 4 until the flow values are within the specification.

4 Troubleshooting

The problems and solutions in this chapter represent only a few of the faults that you may encounter and are not intended to cover every possible problem that may occur.

This chapter focuses on troubleshooting technical problems. Refer also to the troubleshooting hints on the S/5 monitor user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

NOTE: Perform the checkout procedure described in chapter "3. Service Procedures" each time after you have opened the module casing.

4.1 Visual inspection

Before beginning any detailed troubleshooting, complete thorough visual inspection to be sure that:

- the front cover is intact
- the water trap connection and disconnection functions properly
- all connectors are intact, clean and are attached properly
- the module box and latch are intact
- the metal D-fend Pro connectors are clean and intact

If in doubt of having any loose parts or cable connections inside the module, detach the module box by removing the four screws from the back of the module and check that:

- all screws are tightened properly
- all cables are connected properly
- tubes are not pinched and there are no sharp bends on them
- all tubes are connected properly
- there are no loose objects inside the module

4.2 Troubleshooting checklist

The following simple troubleshooting hints may help you to localize and isolate a functional problem to the correct unit. Ensure that the monitor is turned on and all modules are connected:

- Check if there are any messages shown in the message field. Find the possible cause and solution from the "Messages" section later in the chapter.
- Check that the module in doubt is compatible with the monitor. Compatibility information can be found from the Carescape Respiratory Modules User's Manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the Carescape Respiratory Modules User's Manual.
- Connect the accessories to the module in doubt. Check that the parameters measured by the module are configured to the display (Monitor Setup **> *Screen 1 Setup***).
- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.

After troubleshooting if the problem remains, contact service. Make sure you have all necessary information of the product at hand. Describe the problem and the troubleshooting done so far. Provide Webmin Device Information and Service logs, if requested.

4.2.1 Gas sampling system troubleshooting

- Faults which can occur in the sampling system are: leaks or blockages in the tubing, failure of the sampling pump or the magnetic valves, or diminishing of the flow rates because of dirt or other matter accumulating in the internal tubing or failure of pressure sensors.
- Whenever suspecting the sampling system and always after having done any work on the sampling system, check the sampling system for leakages and check the flow rate.
- The D-fend Pro water trap should be replaced, when the ***'REPLACE D-FEND'*** message appears.
- If any liquid has entered the MiniTPX measuring unit due to water trap filter failure, contact GE Healthcare service.
- Check that the tubing inside the module is not contaminated.
  Any contamination inside the tubing may indicate that the valves or sensors are contaminated, too. This can increase a risk of faulty operation in valves or sensors. The valves or gas sensors are not possible to clean in the field. Therefore, if you noticed any contamination in the module tubing, send the module to GE Healthcare for factory service.

NOTE: All internal tubes are mechanically fragile. Sharp bends may cause leaks and occlusions.

4.2.2 MiniOM Measuring unit troubleshooting

- Due to the complicated and sensitive mechanical construction of the oxygen measuring unit, no repairs should be attempted inside the unit. Instead, if the fault has been found in the measuring unit itself, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.
- In cases of no response to O_2 or strong drift, check the tubing for loose connections, blockages, and leaks.
- Check also the OM reference gas filter assembly, and replace if needed.
- If the O_2 signal is noisy, check the measurement unit suspension and if the MiniOM tubing has tension.

NOTE: Never apply overpressure to the O_2 measuring unit, as the pressure transducer may be permanently damaged.

4.2.3 MiniTPX Measuring unit troubleshooting

- The MiniTPX measuring unit can only be repaired at the factory. In case of failure, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.

4.2.4 MiniPVX Measuring unit troubleshooting

- In case of failure, the MiniPVX unit can be replaced.
- Perform spirometry system leak test to check if there is any leakages in the internal or external spirometry tubing.

4.2.5 CPU board troubleshooting

- Due to the complexity of the large scale integrated circuitry, there are few faults in the CPU digital electronics that can be located without special equipment.
- Check that all connectors and screws are properly installed.
- In case of failure, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.

4.3 Service Interface

The monitor has a service menu, which is a useful tool to examine monitor functions and troubleshoot it in case a fault occurs.

To enter to the service menu see instructions in chapter Service Menu in the S/5 monitor's technical reference manual.

4.4 Messages

4.4.1 Gas measurements

Message	Possible causes	Possible solutions
Check water trap Check water trap and sample gas out. Wait for 30 sec. and press **Normal screen** to continue.	Water trap is not connected. Air leak inside the internal tubing.	Connect the water trap and sampling line to the module. Check the internal tubing for leakages.
Sample line blocked Continuous blockage. Check sampling line and water trap.	Gas sampling line is blocked. Water trap container is full. Water trap is occluded. Internal tubing is blocked.	Check the external gas sampling line for blockages. Replace, if needed. Empty the water trap container. Replace the water trap. Check the internal tubing for blockages.
Check sampling gas out Check water trap and sample gas out. Wait for 30 seconds and press **Normal screen** to continue.	The sample gas outflow is blocked. Internal tubing is blocked. Pump failure.	Check the sample gas out connector in the front panel and the exhaust line for gas return or scavenging for blockages. - If the sample gas is returned to the patient circuit, check that there is no occlusion in the tubing. - If the sample gas outlet is connected to a scavenging system, make sure an open system is used where gas is removed in room pressure. Check the internal tubing for blockages. Check sample pump operation by measuring the sample gas flow rate. Replace pump, if needed.
Replace water trap	Defective or contaminated D-fend Pro. Occlusion in internal tubing.	Replace the D-fend Pro water trap. Check sample and reference flows. Perform a visual check for the internal tubing. Remove the cause for occlusion.
Calibrating	Gas calibration is in progress.	Wait until the calibration is completed successfully.

Message	Possible causes	Possible solutions
Failure in Agent ID	Agent ID has failed.	Perform gas calibration. Check agent ID unreliability (see functional check). If it does not help, send the module to GE Healthcare for factory repair.
Zeroing	Zeroing is in progress.	Wait until zeroing is completed successfully.
Zero error	Autozeroing during the measurement or in the beginning of the gas calibration failed.	Check the zero valve operation. Replace the zero absorber and Nafion tube in zero line. If it does not help, send the module to GE Healthcare for factory repair.
Calibrating error	Feeding the calibration gas was not started within 1 minute after the automatic zeroing was completed. Calibration was failed due to too large gain adjustment. Wrong calibration gas is used.	Recalibrate. Recalibrate. Use the specified calibration gas.
Over range	Measured ***FiO2***>103%	Perform gas calibration.
Apnea deactivated	Apnea alarm start-up conditions are not reached.	Apnea alarm detection is activated after the 3 breaths are detected.
Sensor INOP	IR Lamp failure. Ambient pressure is too high or low. CPU failure. No response from the gas module, high temperature inside the module, or EEPROM checksum failure.	Check miniTPX flex cable connection. Check the ambient pressure from the Gas Calibrations menu. Replace CPU. Return the module to GE Healthcare for service.

Message	**Possible causes**	**Possible solutions**
Sensor INOP	MiniOM unit failure - temperature - internal supply voltages - other internal failure MiniTPX unit failure - temperature - internal supply voltages - IR lamp failure MiniPVX unit failure - pressure sensor failure - internal supply voltages CPU failure - internal supply voltages - pressure sensor failure - a/d-converter system failure Other failure - Fan failure - Pump failure - Valve (Zero, Occlusion) failure - Zeroing fails too many times - CO_2 reference signal differs too much from CO_2 signal	Check flex cable connection. Check that fan can rotate freely. Check fan, pump or valve wire connection.
Calibrating gas sensor	O_2, CO_2 and N_2O measurements are not available during the first minute after the module is connected due to warm-up. Anaesthesia agent measurement is not available during the first 5 minutes after the module is connected due to warm-up.	Wait until the warm-up is completed.
Over Scale	Incorrect waveform scale for the parameter. The waveform clipped because measured gas concentration exceeds the upper limit of the current scale.	Change to the appropriate waveform scale. For detailed instructions refer to the S/5 monitor user's manual.
Low gas sample flow	Sample flow deviates to less than 80% of the module specific nominal flow value. Gas sampling line, gas output, water trap, or internal tubing is blocked. Pump failure.	Check sample flow rate. Adjust, if needed. Check or replace the gas sampling line, water trap, or internal tubing. Replace the pump unit.
Incompatible gas module	Incompatible gas module detected by the monitor.	Check the compatibility of the gas module.
Gas measurements removed	The module is disconnected.	Reconnect the module.
Identical gas modules	The monitor detects gas measurement from two or more modules.	Remove excess modules providing gas measurement.

4.4.2 Spirometry

Message	Possible causes	Possible solutions
MVexp<<MVinsp	Expired volume is much smaller (70% or less) than inspired volume due to a leak in the spirometry system. A leaking or occluded spirometry tube. Water in tubing.	Replace the spirometry tube. Perform spirometry leak test. Replace MiniPVX, if needed. Clean the tubing.
Low volumes	I:E detection does not work. Water trap may not be properly connected, or there may be a leak in the breathing circuit. All following conditions are true for 20 s. ***No apnea***, ***Ppeak - PEEP*** <2cmH_2O, ***TVinsp*** and ***TVexp*** are DATA_INVALID.	Check the water trap and its connection. Check the breathing circuit for leaks. Check the loops on screen to locate the problem.
Zeroing error	Zero valve leaking or internal damage in the flow sensor. MiniPVX flex cable loose.	Perform spirometry leakage test. Replace MiniPVX sensor, if needed. Check MiniPVX flex cable.
Zeroing	Zeroing is in progress.	Wait until zeroing is completed successfully.
Sensor INOP	There is no response from the MiniPVX measurement board or there is an EEPROM checksum failure. MiniPVX flex cable loose. Zero valve is broken.	Replace MiniPVX unit. Check MiniPVX flex cable. Return the module to GE Healthcare for service.
Over scale	***Flow*** or ***Paw*** waveform signal exceeds the upper limit of the current scale.	Change ***Flow/Paw*** waveform scale or use autoscaling. For detailed instructions refer to the S/5 monitor user's manual.
Scale changed	Displayed for 10 seconds after autoscaling mode has changed Flow, Paw, or Vol scale.	N/A
Saving loop	Spirometry loop is being saved.	N/A
Printing loop	Spirometry loop is being printed.	N/A
Spirometry measurements removed	The module is disconnected.	Reconnect the module.

4.5 Troubleshooting charts

4.5.1 CO_2 measurement

Problem	Possible clinical cause	Possible technical cause	What to do
too low $EtCO_2$ value	- sudden decrease in circulation - pulmonary embolism - hyperventilation - very large dead-space - large shunting	- leak in sampling system - calibration error - high by-pass flow from ventilator	- check all connections - check calibration
too high $EtCO_2$	- hypoventilation - increased metabolism	- D-fend Pro contaminated - calibration error	- change D-fend Pro - check calibration
waveform clipped		- incorrect scaling	- change scale For detailed instructions refer to the S/5 monitor user's manual.
no response to breathing	- apnea - (disconnection)	- sampling line or water trap loose or blocked (air leak) - sample gas out blocked	- check all connections - check that outlet is open
$EtCO_2$ overscale >15% (>20%) Shown until 32%, specified range 0...15%	- abnormally high $EtCO_2$ (permissive hypercapnia)	- CO_2 sensor contaminated - D-fend Pro malfunction	- call service technician - change D-fend Pro
$EtCO_2$>$PaCO_2$	- unit is mmHg or kPa and $EtCO_2$ is close to arterial PCO_2	- ***Dry gas*** as default	- change to ***Wet gas*** by using ***Default Setup/ Care unit Settings / Parameters*** menu

4.5.2 Patient spirometry

Problem	Possible clinical cause	Possible technical cause	What to do
insp TV>exp TV	- leak in lungs - ET tube cuff leak	- spirometry tube leak - water inside D-lite or tubings - another side stream gas sampling between D-lite and patient - D-fend Pro leaks	- check leakages — perform leak test - change tubings and D-lite - do not use active humidification - connect gas sampling only and always to D-lite - check D-fend Pro

Problem	**Possible clinical cause**	**Possible technical cause**	**What to do**
exp TV> insp TV		- spirometry tube leak - water inside D-lite or tubings	- check leakages — perform leak test - change tubings and D-lite - do not use active humidification
Loop overscale Monitored volumes < set volumes		- wrong scale selected - wrong TV base selected - leak between ventilator and D-lite	- change scaling - Select correct TV base (ATPD / BTPS / NTPD/ STPD) - check ventilator connections

Strongly vibrating loop
 	
Too large or too small volumes
	- mucus in ET tube	- water or secretions in hoses or D-lite
		- wrong mode vs. sensor selection
		- incorrect sensor type selection
			- check the patient status
			- change dry D-lite and/or empty the water from hoses
			- check mode and sensor
			  - D-lite for adult
			  - Pedi-lite for pediatric

Fluctuating Raw	- mucus in airways or tubings - breathing effort against the ventilator - patient triggered breathes	- ventilator exp. valve causes fluctuations during exp. flow	- check the tubings and D-fend Pro - check the patient status
Too high Raw Raw value invalid	- kink in tubing - mucus - asthmatic patient - bronchospasm - spontaneous breaths - breathing efforts against the ventilator - patient triggered breaths		- check the tubing - check the patient status
Too high Ppeak	- bronchospasm - patient is coughing - patient breaths against the ventilator - obstruction in airways - HME obstructed		- check the patient status - check the patient circuit status
Compl value invalid	- spontaneous breaths		- compliance cannot be calculated

5 Spare parts

5.1 Ordering parts

To order parts, Contact GE Healthcare. Contact information is available at www.gehealthcare.com. Make sure you have all necessary information at hand.

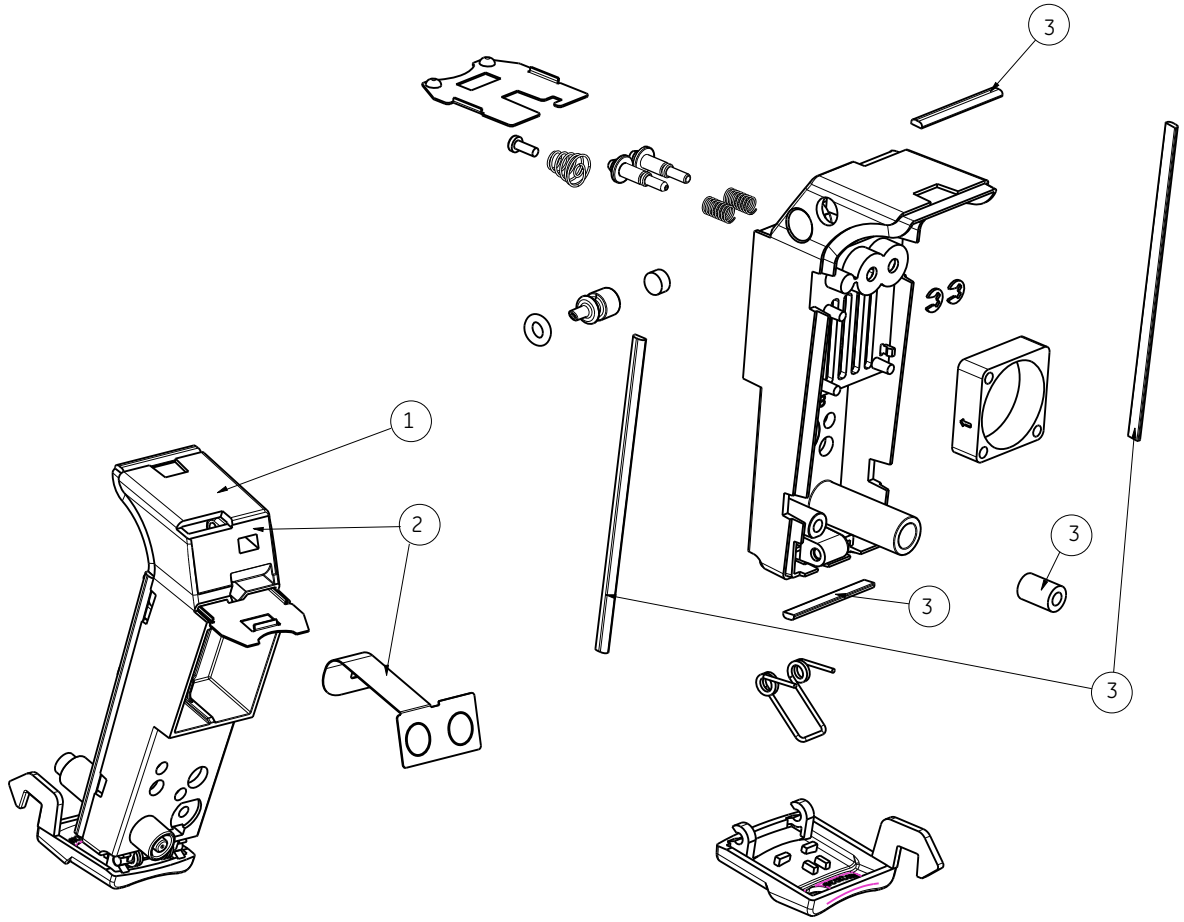
NOTE: Perform the checkout procedure described in chapter "3. Service Procedures" after you have disassembled and reassembled the module.

5.1.1 Planned Maintenance Kits

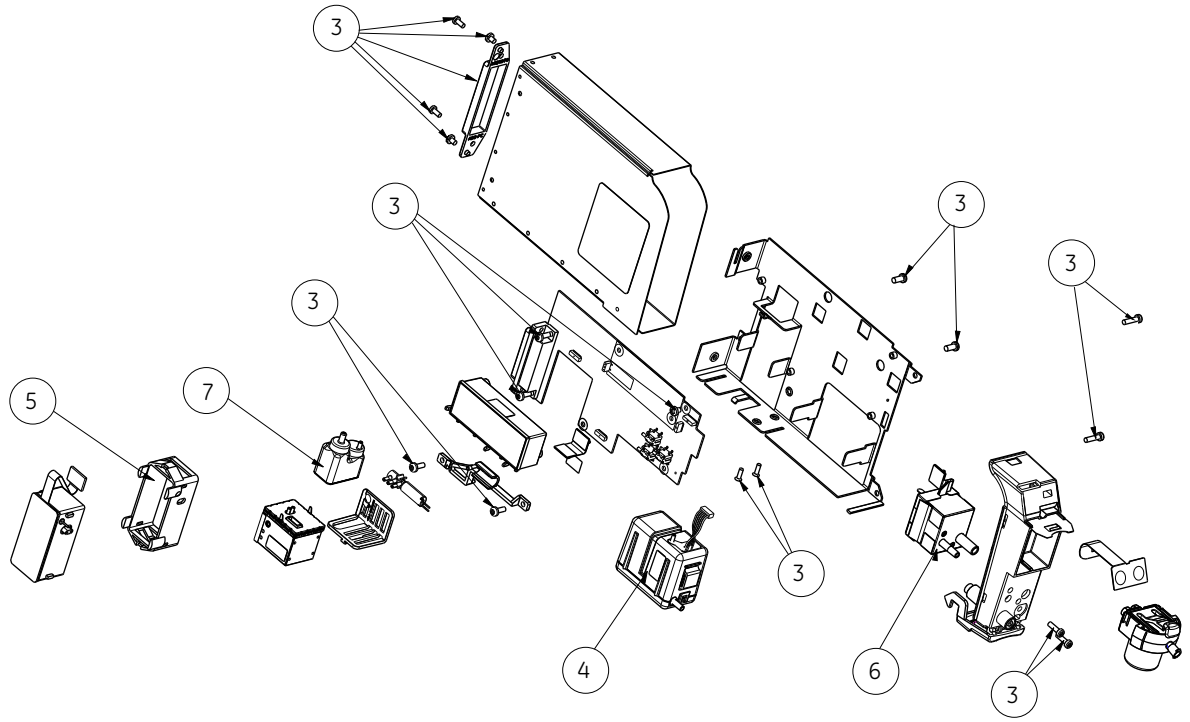
The required planned maintenance parts are included in a PM kit.

Part number	Description
M1206554	Planned Maintenance Kit for CARESCAPE E-sCxxx Respiratory modules. The PM kit includes the required Nafion tubes, OM reference filter assembly with O-ring and PM Sticker. NOTE: The PM kit does not include the CO_2 absorber. Order it separately.

5.2 Spare parts for E-sCAiOV, E-sCAiO, E-sCOV, E-sCO

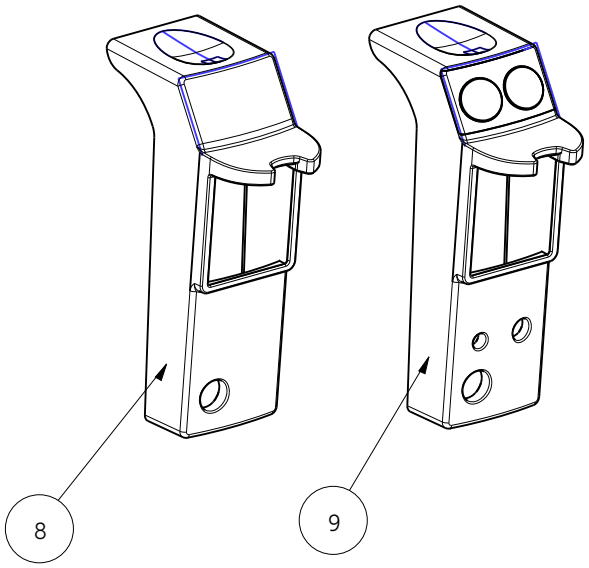


FRU#	FRU/ Item description	FRU / Item part number
1	FRU, Front Chassis Unit, E-sCAiO, E-sCO - Front Chassis Assembly	M1206530
2	FRU, Front Chassis Unit, E-sCAiOV, E-sCOV - Front Chassis Assembly including Membrane Keyboard	M1206529
3	FRU, HW Kit, E-sCxxxx - All Mounting Screws - All Conductive Sealings - Pump Connector Silicone Tube - D25 Connector Shield - Latch - Torsion Spring	M1206533



FRU#	FRU/ Item description	FRU / Item part number
4	FRU, Pump Unit, E-sCxxxx	M1206290
5	FRU, OM Holder, E-sCxxxx	M1206531
6	FRU, PVX Unit, E-sCAiOV, E-sCOV	M1206528
7	CO2 Absorber, E-sCxxxx	M1206555

5.2.1 Front covers



FRU#	FRU/ Item description	FRU / Item part number
8	FRU, Front Cover, E-sCAiO	M1206538
8	FRU, Front Cover, US, E-sCAiO	M1206558
8	FRU, Front Cover, E-sCO	M1206539
8	FRU, Front Cover, US, E-sCO	M1206559
9	FRU, Front Cover, EN, E-sCAiOV	M1207033
9	FRU, Front Cover, CS, E-sCAiOV	M1207034
9	FRU, Front Cover, DA, E-sCAiOV	M1207035
9	FRU, Front Cover, ES, E-sCAiOV	M1207036
9	FRU, Front Cover, FI, E-sCAiOV	M1207037
9	FRU, Front Cover, FR, E-sCAiOV	M1207038
9	FRU, Front Cover, HU, E-sCAiOV	M1207039
9	FRU, Front Cover, IT, E-sCAiOV	M1207040
9	FRU, Front Cover, JA, E-sCAiOV	M1207041
9	FRU, Front Cover, NL, E-sCAiOV	M1207042
9	FRU, Front Cover, NO, E-sCAiOV	M1207043
9	FRU, Front Cover, PL, E-sCAiOV	M1207044
9	FRU, Front Cover, PT, E-sCAiOV	M1207045
9	FRU, Front Cover, SV, E-sCAiOV	M1207046

FRU#	FRU/ Item description	FRU / Item part number
9	FRU, Front Cover, DE, E-sCAiOV	M1207047
9	FRU, Front Cover, RU, E-sCAiOV	M1213759
9	FRU, Front Cover, ZH, E-sCAiOV	M1213760
9	FRU, Front Cover, EN, E-sCOV	M1207048
9	FRU, Front Cover, CS, E-sCOV	M1207049
9	FRU, Front Cover, DA, E-sCOV	M1207051
9	FRU, Front Cover, ES, E-sCOV	M1207053
9	FRU, Front Cover, FI, E-sCOV	M1207055
9	FRU, Front Cover, FR, E-sCOV	M1207057
9	FRU, Front Cover, HU, E-sCOV	M1207059
9	FRU, Front Cover, IT, E-sCOV	M1207062
9	FRU, Front Cover, JA, E-sCOV	M1207064
9	FRU, Front Cover, NL, E-sCOV	M1207067
9	FRU, Front Cover, NO, E-sCOV	M1207069
9	FRU, Front Cover, PL, E-sCOV	M1207071
9	FRU, Front Cover, PT, E-sCOV	M1207073
9	FRU, Front Cover, SV, E-sCOV	M1207075
9	FRU, Front Cover, DE, E-sCOV	M1207077
9	FRU, Front Cover, RU, E-sCOV	M1213757
9	FRU, Front Cover, ZH, E-sCOV	M1213758

6 Earlier revisions

There are no earlier revisions of the CARESCAPE Respiratory Modules E-sCAiOV, E-sCAiO, E-sCOV, E-sCO.

For your notes:

APPENDIX A: Service check form

CARESCAPE Respiratory Modules, EsCAiOV, E-sCAiO, E-sCOV, E-sCO

Customer	Monitor	S/N
Service		S/N
Service engineer	Software	
Planned maintenance ☐ Corrective maintenance ☐	Module type	S/N

Prior to testing verify all equipment is calibrated via "Cal" labeling and record Cal Due Dates

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part No:	Serial Number/ID:	Cal Due Date:

PASS = Test passed **N.A. = Test not applicable** **FAIL = Test failed**

	PASS	N.A.	FAIL			PASS	N.A.	FAIL
3.2. Visual inspections						☐	☐	☐
3.3. Functional check						☐	☐	☐
3.3.2. Procedure						☐	☐	☐
1. Gas Sampling System Leak Test	☐	☐	☐	2. Spirometry System Leak Test		☐	☐	☐
3. Sample Flow Rate Check	☐	☐	☐	4. Reference Gas Flow Rate Check		☐	☐	☐
5. Fan	☐	☐	☐	6. Module Keys		☐	☐	☐
7. Zero Valve Operation	☐	☐	☐	8. Gas Calibration		☐	☐	☐
9. Agent Identification	☐	☐	☐	10. Ambient Pressure		☐	☐	☐
11. Occlusion detection	☐	☐	☐	12. Air Leak detection		☐	☐	☐
13. Gas exhaust blockage	☐	☐	☐	14. Airway Gases		☐	☐	☐
15. Apnea detection	☐	☐	☐	16. Flow waveform		☐	☐	☐
3.3.3. Test completion						☐	☐	☐

Notes

Used service parts			

Signature	Date

For your notes:

Compact Airway Modules

S/5 Compact Airway Module, E-CAiOVX (Rev. 00)
S/5 Compact Airway Module, E-CAiOV (Rev. 00)
S/5 Compact Airway Module, E-CAiO (Rev. 00)
S/5 Compact Airway Module, E-COVX (Rev.00)
S/5 Compact Airway Module, E-COV (Rev. 00)
S/5 Compact Airway Module, E-CO (Rev. 00)

Technical Reference Manual Slot

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EEC.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1027822-02

May 2, 2011

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Compact Airway modules. The Compact Airway modules are double width plug-in modules. E-CO, E-COV, E-COVX, E-CAiO, E-CAiOV, E-CAiOVX and E-CAiOVX/SERVICE/SERVICE are designed for use with the S/5 Monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The Compact Airway modules provide airway and respiratory measurements.

Letters in the module name stand for:

C = CO_2 and N_2O, O = patient O_2, V = patient spirometry, X = gas exchange, A = anesthetic agents, and i = agent identification

About E-CAiOVX/SERVICE module

The E-CAiOVX/SERVICE module is meant for service purposes only. It can be used as a loan module, if the module in the hospital should be sent to the factory for repair. The specifications that apply to the E-CAiOVX apply also to the E-CAiOVX/SERVICE module. Module differences: the color of the front mask is green, the front panel has a “SERVICE” text and there are no front panel keys equipped.

Table 1 Options for Compact Airway modules

Modules	Parameters / measurements						
	CO_2	N_2O	O_2	Anesthetic agents	Agent ID	Spirometry	Gas exchange
E-CAiOVX	X	X	X	X	X	X	X
E-CAiOV	X	X	X	X	X	X	
E-CAiO	X	X	X	X	X		
E-COV	X	X	X			X	
E-COVX	X	X	X			X	X
E-CO	X	X	X				
E-CAiOVX/SERVICE	X	X	X	X	X	X	X

NOTE: Do not use identical modules in the same monitor simultaneously.
The E-miniC, E-CO, E-COV, E-COVX, E-CAiO, E-CAiOV, E-CAiOVX and E-CAiOVX/SERVICE and the M-miniC, M-C, M-CO, M-COV, M-COVX, M-CAiO, M-CAiOV, M-CAiOVX and M-CAiOVX/SERVICE are considered identical modules.

NOTE: The Compact Airway Module or Single-Width Airway Module and Airway Module, G-XXXX, cannot be used simultaneously in the same monitor.

NOTE: The Compact Airway modules cannot be used in the Extension Frame, F-EXT4.

NOTE: Anesthetic agents and N_2O values are not displayed with Critical Care main software, but when present in the module they are calculated for compensation of CO_2 and O_2.

1 Specifications

1.1 General specifications

Module size, W x D x H	75 x 228 x 112 mm / 3.0 x 9.0 x 4.4 in
Module weight	1.6 kg / 3.5 lb.
Operating temperature	+10 to +40 °C
Storage temperature	-25 to +70 °C
Atmospheric pressure	666 to 1060 hPa / (67 to 106 kPa) (500 to 800 mmHg) (666 to 1060 mbar)
Relative humidity	10 to 95% non-condensing (in airway 0 to 100%, condensing)
Power consumption	12.6 W P_{rms}, 14.6 W momentary
Protection against electrical shock	Type BF

1.2 Typical performance

CO_2

Measurement range	0 to 15 vol% (0 to 15 kPa, 0 to 113 mmHg)
Measurement rise time	< 400 ms typical
Accuracy	(0.2 vol% +2% of the reading) e.g. Reading 5.0 % accuracy = ± (0.2 + 0.1); = ± 0.3 vol%
Gas cross effects	< 0.2 vol% (O_2, N_2O, anesthetic agents)

O_2

Measurement range	0 to 100 vol%
Measurement rise time	< 400 ms typical
Accuracy	± (1 vol% + 2% of the reading)
Gas cross effects	< 1 vol%; anesthetic agents < 2 vol%; N_2O
O_2 Fi-Et difference	resolution 0.1 vol%

N_2O

Measurement range	0 to 100%
Measurement rise time	< 400 ms typical
Accuracy	± (2 vol% + 2% of the reading) (0%<N2O<85%) ± (2 vol% + 8% of the reading) (85%<N2O<100%)
Gas cross effects	< 2 vol%; anesthetic agents

Respiration Rate (RR)

Measurement range	4 to 60 breaths/min
Detection criteria	1% variation in CO_2

Anesthetic Agents (AA)

Measuring range	
Hal, Enf, Iso	0 to 6 vol%
Sev	0 to 8 vol%
Des	0 to 20 vol%
Measurement rise time	<600 ms typical (<1000 ms for Hal, typical)
Gas cross effects	< 0.15 vol% N_2O

Resolution is two digits, when the AA concentration is below 1.0 vol%.
If AA concentration is below 0.1 vol%, 0.0% is displayed.

Agent identification

Identification threshold	0.15 vol% typical
Identification time	< 20 s (for pure agents)
Mixture identification threshold for 2. agent:	
	0.2 vol% +10% of total conc.

MAC

Range	0...9.9 MAC
Equation:	

$$MAC(AA) = \frac{\%(ETAA)}{x(AA)} + \frac{\%ETN_2O}{100}$$ Formula 1

where x(AA): Hal=0.75%, Enf=1.7%, Iso=1..15%, Sev=2.05%, Des=6.0%

1.3 Gas specifications

Airway humidity	0...100%, condensing
Sampling rate	200 ±20 ml/min. (sampling line 2-3 m, normal conditions)
Sampling delay	2.5 seconds typical with a 3 m sampling line
Total system response time	2.9 seconds typical with a 3 m sampling line, including sampling delay and rise time
Display update rate	breath-by-breath
Warm up time	2 min. for operation with CO_2, O_2, and N_2O
	5 min. for operation of anesthetic agents
	30 min. for full specifications

Gas values are measured in ATPD conditions (ambient temperature and pressure, dry). When CO2 is displayed as a partial pressure (kPa, mmHg), the value can be alternatively shown as wet (BTPS, body temperature and pressure saturated).

Automatic compensation for barometric pressure , CO_2-N_2O and CO_2-O_2 collision broadening effect.

Auto zeroing interval	Immediately after calibrating the gas sensor and 2, 5, 10, 15, 30, 45, 60 minutes after start-up, then every 60 minutes

1.3.1 Normal conditions

Accuracy specifications apply in normal conditions (after 30 minutes warm-up period):

Ambient temperature	18 to 28 °C, within ±5 °C of calibration
Ambient pressure	500 to 800 mmHg, ±50 mmHg of cal.
Ambient humidity	20 to 80% RH, ±20% RH of cal.

Non-disturbing gases	
Ethanol C_2H_5OH	< 0.3%
Acetone	< 0.3%
Methane CH_4	< 0.3%
Freon 21	< 1%
Freon R134A	<1%
Nitrogen N_2	
Carbon monoxide CO	
Nitric Oxide NO	< 200 ppm
water vapor	
Maximum effect on readings	
CO_2	< 0.2 vol%
O_2, N_2O	< 2 vol%
anesthetic agents	< 0.15 vol%
Effect of Helium	decreases CO_2 readings < 0.6 vol% typically decreases O_2 readings < 3 vol% typically
Effect of Xenon	decreases CO_2 readings < 0.4 vol% typically

1.3.2 Conditions exceeding normal

Accuracy specifications under the following conditions; ❶❷❸❹:

❶ Ambient temperature	10 to 40 °C, within ±5 °C of calibration
Ambient pressure	500 to 800 mmHg, ±50 mmHg of calibration
Ambient humidity	10 to 98% RH, ±20% RH of calibration

❷ During warm-up 2 to 10 minutes (anesthetic agents 5-10 minutes), under normal conditions

❸ During warm-up 10 to 30 minutes, under normal conditions

❹ N_2O > 85%, under normal conditions

	Accuracy under different conditions (see above)		
	Condition ❶ and ❸	Condition ❷	Condition ❹
CO_2	±(0.3 vol% + 4% of reading) (at 5 vol% error ±0.5 vol%)	±(0.4 vol% + 7% of reading) (at 5 vol% error ±0.75 vol%)	
O_2	(2 vol% + 2% of reading)	±(3 vol% + 3% of reading)	
N_2O	±(3 vol% + 3% of reading)	±(3 vol% + 5% of reading)	± (2vol% + 8% of reading)
Agents: Hal, Enf, Iso, Sev, Des	±(0.2 vol% + 10% of reading)	±(0.3 vol% + 10% of reading)	

1.4 Patient spirometry specifications

1.4.1 Normal conditions

Accuracy specifications apply in normal conditions (after 10 minutes warm-up period):

Ambient temperature	10 to 40 °C
Ambient pressure	500 to 800 mmHg
Ambient humidity	10 to 98% RH
Airway humidity	10 to 100% RH

Respiration rate	4 to 35 breaths/min (adults) 4 to 50 breaths/min (pediatric)
I:E ratio	1:4.5 to 2:1
Intubation tube	5.5 to 10 mm (adults), 3...6 mm (pediatric)

Airway pressures (P_{aw}, P_{peak}, P_{plat}, $PEEP_e$, $PEEP_{iStat}$, $PEEP_{iDyn}$, P_{mean})

Measurement range	-20 to +100 cmH_2O
Resolution	0.5 cmH_2O
Accuracy	±1 cmH_2O

Airway flow

Measurement range (for both directions)	1.5 to 100 l/min (adults) 0.25 to 25 l/min (pediatric)

Tidal volume

Measurement range	150 to 2000 ml (adults), 15...300 ml (pediatric)
Resolution	1 ml
Accuracy	±6% or 30 ml (adult), ±6% or 4 ml (pediatric)

Minute volume

Measurement range	2 to 20 l/min (adults), 0.5...5 l/min (pediatric)
Resolution	0.1 l/min

Compliance

Measurement range	4 to 100 ml/cmH_2O (adult), 1...100 ml/cmH_2O (pediatric)
Resolution	1 ml/cmH_2O (adult), 0.1 ml/cmH_2O (pediatric)

Airway resistance

Measurement range	0 to 40 cmH_2O/ l/s
Resolution	1 cmH_2O/ l/s

Other parameters

Specifications apply in conditions listed in patient spirometry specifications.

Dead space of the sensor

9.5 ml (adult), 2.5 ml (pediatric)

Resistance of the sensor

0.5 cmH_2O at 30 l/min (adult), 1.0 cmH_2O at 10 l/min (pediatric)

1.4.2 Conditions exceeding normal

Accuracy specifications under the following condition (during warm-up 2 to 10 minutes):

Airway Pressure (P_{aw})

Accuracy	±2 cmH_2O

Tidal volume

Accuracy	±10% or 100 ml (adult), ±10% or 10 ml (pediatric)

1.5 Gas exchange specifications

Mathematical integration of airway flow and gas concentration for intubated, mechanically ventilated and/or partly spontaneously breathing patients.

NOTE: These specifications apply only, when a 2 meter gas sampling line is used, and a Y-piece with a physical dead space less than 8 ml.

NOTE: These specifications only apply, if the FiO_2 level delivered to the patient is varying by less

NOTE: than 0.2% at the measurement point during the inspiratory cycle.

VO_2 and VCO_2

Measurement range	50 to 1000 ml/min
Resolution	10 ml/min
Accuracy	±10% or 10 ml/min; when FiO_2 < 65% ±15% or 15 ml/min; when 65% < FiO_2 < 85%

RQ

Measurement range	0.6...1.2
Resolution	0.05

2 Functional description

2.1 Measurement principle

2.1.1 CO_2, N_2O, and agent measurement

TPX is a side stream gas analyzer, measuring real time concentrations of CO_2, N_2O and anesthetic agents (Halothane, Enflurane, Isoflurane, Desflurane, and Sevoflurane).

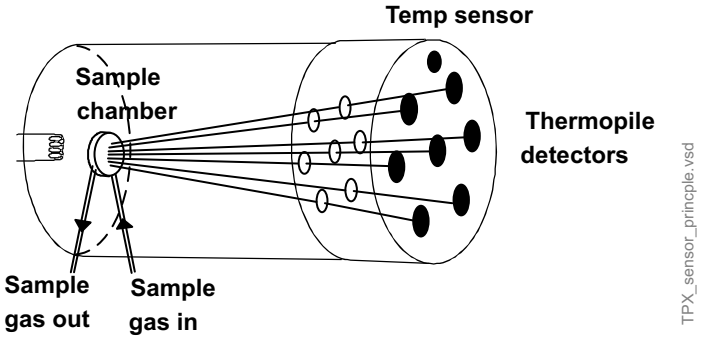


Figure 1 TPX sensor principle

Anesthetic agents or mixtures of two anesthetic agents are automatically identified and concentrations of the identified agents are measured. TPX also detects mixtures of more than two agents and issues an alarm.

TPX is a non dispersive infrared analyzer, measuring absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters.

The infrared radiation detectors are thermopiles.

Concentrations of CO_2 and N_2O are calculated from absorption measured at 3-5 μm.

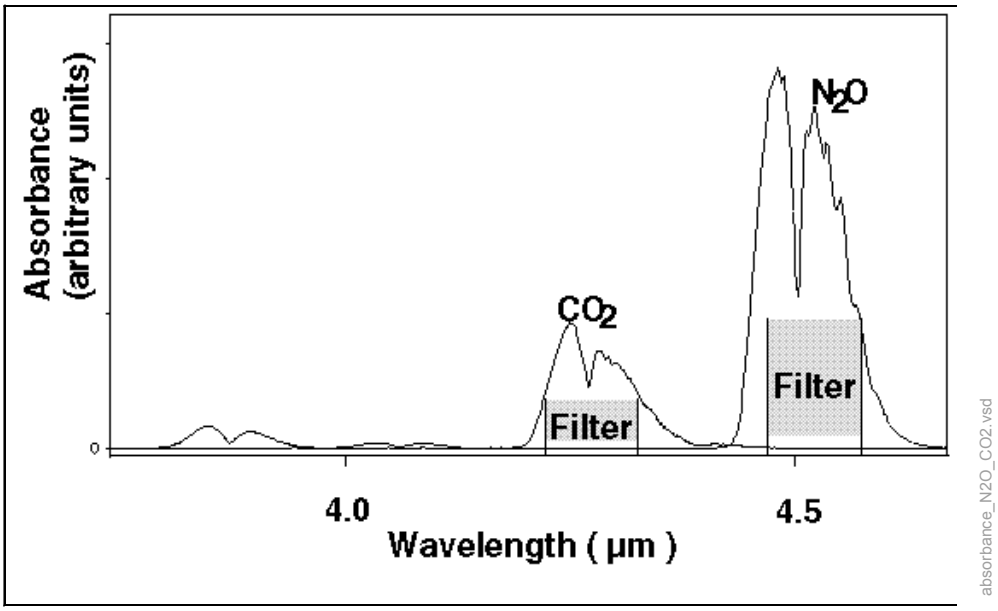


Figure 2 Absorbance of N_2O and CO_2

Identification of anesthetic agents and calculation of their concentrations is performed by measuring absorptions at five wavelengths in the 8-9 µm band and solving the concentrations from a set of five equations.

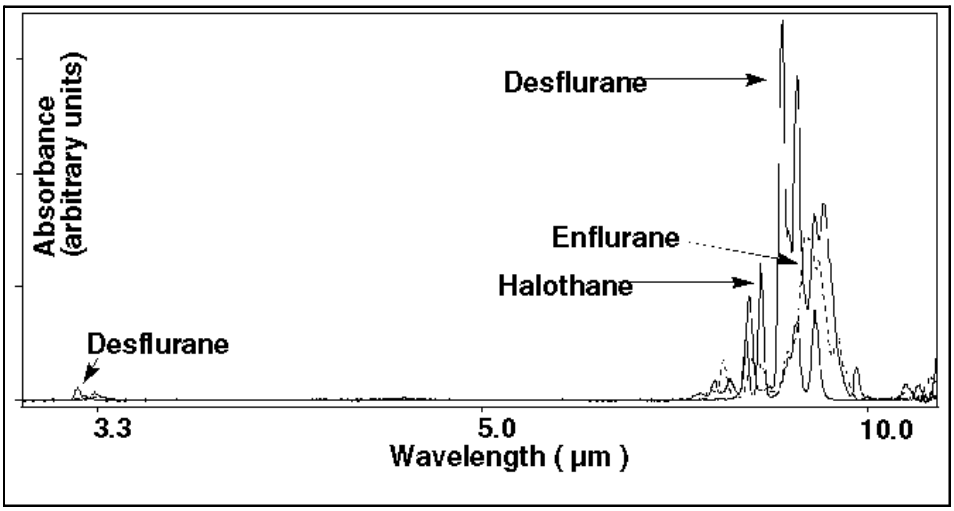


Figure 3 Infrared absorbance of AAs

The measuring accuracy is achieved utilizing numerous software compensations. The compensation parameters are determined individually for each TPX during the factory calibration.

2.1.2 O_2 measurement

The differential oxygen measuring unit uses the paramagnetic principle in a pneumatic bridge configuration. The signal picked up with a differential pressure transducer is generated in a measuring cell with a strong magnetic field that is switched on and off at a frequency of 165 Hz. The output signal is a DC voltage proportional to the O_2 concentration difference between the two gases to be measured.

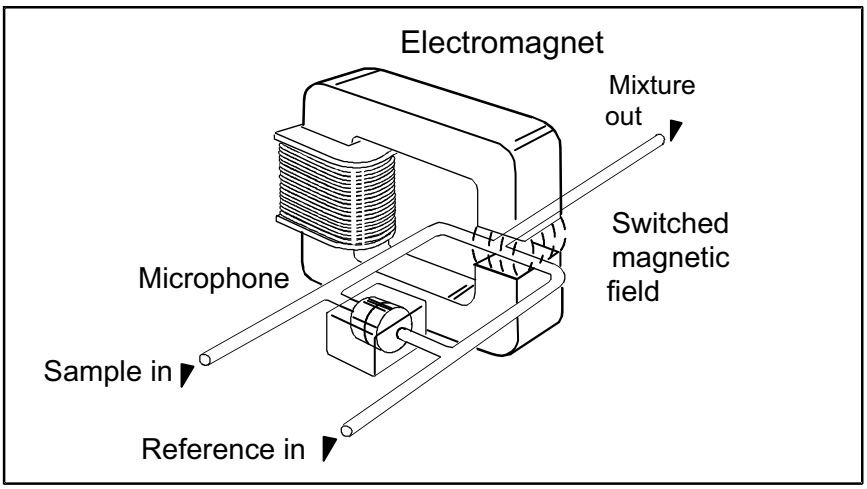


Figure 4 O_2 measurement principle

2.1.3 Patient spirometry

In mechanical ventilation, breaths are delivered to the patient by a ventilator with a proper tidal volume (TV), respiration rate (RR), and inspiration / expiration ratio in time (I:E) determined by the settings of the ventilator.

The Patient Spirometry monitors patient ventilation. The following parameters are displayed:

- Expiratory and inspiratory tidal volume (TV) in ml
- Expiratory and inspiratory minute volume (MV) in l/min
- Expiratory spontaneous minute volume in l/min
- Inspiration/expiration ratio (I:E)

Airway pressure

- Peak pressure (P_{peak})
- Mean airway pressure (P_{mean}); available only in S/5 Critical Care and Compact Critical Care monitors
- End inspiratory pressure (P_{plat})
- PEEPi, PEEPe; available only in S/5 Critical Care and Compact Critical Care monitors
- Total positive end expiratory pressure ($PEEP_{tot}$); available only in S/5 Anesthesia and Compact Anesthesia monitors
- Real time airway pressure waveform (P_{aw})
- Static Positive end expiratory pressures (Static $PEEP_i$ and Static $PEEP_e$); available only in S/5 Critical Care and Compact Critical Care monitors
- Static Plateau pressure (Static Pplat); available only in S/5 Critical Care and Compact Critical Care monitors
- Static Compliance (Static Compl); available only in S/5 Critical Care and Compact Critical Care monitors

PEEP, P_{peak}, P_{mean}, and P_{plat} are measured by a pressure transducer on the PVX board. Atmospheric pressure is used as a reference in measurement. The pressure measurement is made from the airway part that is closest to the patient between the patient circuit and intubation tube.

$PEEP_i$=intrinsic PEEP, $PEEP_{tot}$-$PEEP_e$

Static pressure measurement maneuvers are automatically identified based on an increased zero flow period at the end of the inspiration or expiration.

Static Compliance is calculated, if Static PEEP and Static P_{plat} measurements were made within a 2 minute period.

Airway flow

- Real time flow waveform (V')
- Compliance (Compl)
- Airway resistance (Raw)
- Pressure volume loop
- Flow volume loop

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measure the Pitot pressure. The pressure signal obtained is linearized and corrected according to the density of the gas. Speed of flow is calculated from these pressure values and the TV value is then integrated. The MV value is calculated and averaged using TV and RR (respiratory rate) values.

Compliance and airway resistance

Compliance is calculated for each breath from the equation

$$Compl = \frac{TV_{exp}}{P_{plat} - PEEP_i - PEEP_e}$$

Formula 2

Compliance describes how large a pressure difference is needed to deliver a certain amount of gas to the patient.

The airway resistance, Raw, is calculated using an equation that describes the kinetics of the gas flow between the lungs and the D-lite. The equation states that the pressure at the D-lite can at any moment of the breath be approximated using the equation

$$P(t) = Raw \times V'(t) + \frac{V(t)}{Compl} + PEEP_i + PEEP_e$$ Formula 3

where P(t), V'(t) and V(t) are the pressure, flow and volume measured at the D-lite at a time t, Raw is the airway resistance, Compl is the compliance and $PEEP_e$+$PEEP_i$ is the total positive end expiratory pressure ($PEEP_{tot}$).

D-lite

Patient Spirometry uses specific sensors called D-lite+/D-lite and Pedi-lite+/Pedi-lite flow sensors. Different types of sensors are available: adult sensor for measuring adults and pediatric sensor for children. Both are available as reusable and disposable versions.

D-lite and Pedi-lite adapters are designed to measure kinetic pressure by a two-sided Pitot tube. Velocity is calculated from pressure difference according to Bernoulli's equation. Flow is then determined using the calculated velocity.

$$v = \sqrt{\frac{2 \times dP}{\rho}}$$ (from Bernoulli's equation) Formula 4

$$F = v \times A$$

where:

F = flow (l/min), v = velocity (m/s), A = cross area (m^2), dP = pressure difference (cmH_2O), ρ = density (kg/m^3)

Finally the volume information is obtained by integrating the flow signal.

2.1.4 Gas exchange measurement

The gas exchange measurement uses the D-lite flow sensor and the gas sampler.

The basic data which is needed to obtain O_2 consumption and CO_2 production are volumes and concentrations.

Concentrations have been corrected for delay and deformation during the transport of the gas sample in a sidestream gas measurement sensor.

To obtain the amount of O_2 consumed in ml/min, the amount which is exhaled is subtracted from the amount that is inhaled.

To obtain the amount of CO_2 produced in ml/min, the amount which is inhaled is subtracted from the amount that is exhaled.

These amounts can be obtained by multiplying each measured volume piece (dv) by the corresponding gas concentration:

$$VO_2 = \int_{insp} f_{O_2} dv - \int_{exp} f_{O_2} dv$$ Formula 5

and

$$VCO_2 = \int_{exp} f_{CO_2} dv - \int_{insp} f_{CO_2} dv$$ Formula 6

Using inspiratory and expiratory minute volumes MV_i and MV_e and volume-weighted inspiratory concentrations fi and fe, these equations can be rewritten as:

$$VO_2 = fi_{O_2} \times MV_i - fe_{O_2} \times MV_e \quad [ml/min]$$ Formula 7

$$VCO_2 = fe_{CO_2} \times MV_e - fi_{CO_2} \times MV_i \quad [ml/min]$$ Formula 8

To obtain results which are less sensitive to errors in volume measurements, the so-called *Haldane transformation* is used. This means taking advantage of the fact that the patient is not consuming nor producing nitrogen: the amount of nitrogen inhaled is equal to the amount exhaled $fi_{N2} \times MV_i = fe_{N2} \times MV_e$.
VO_2 and VCO_2 can then be written as:

$$VO_2 = (fi_{O_2} - f_{Hald} \times fe_{O_2}) MV_i \quad [ml/min]$$ Formula 9

$$VCO_2 = (f_{Hald} \times fe_{CO_2} - fi_{CO_2}) MV_i \quad [ml/min]$$ Formula 10

with

$f_{Hald} = (1-fi_{CO2} - fi_{O2} - fi_{N2O} - fi_{Ane1} - fi_{Ane2}) / (1-fe_{CO2} - fe_{O2} - fe_{N2O} - fe_{Ane1} - fe_{Ane2})$

$$EE_{adult} = 5.50 \times VO_2 + 1.76 \times VCO_2 - 1.99 \times Un \quad [kcal/day]$$ Formula 11

with Un=Urea Nitrogen Excretion = 13 g/day (for adults only).

2.2 Main components

The compact airway modules consist of:

- Gas sampling system
- TPX measuring unit
- OM measuring unit
- PVX measuring unit
- CPU board
- OM board
- PVX board

2.2.1 Controls and connectors

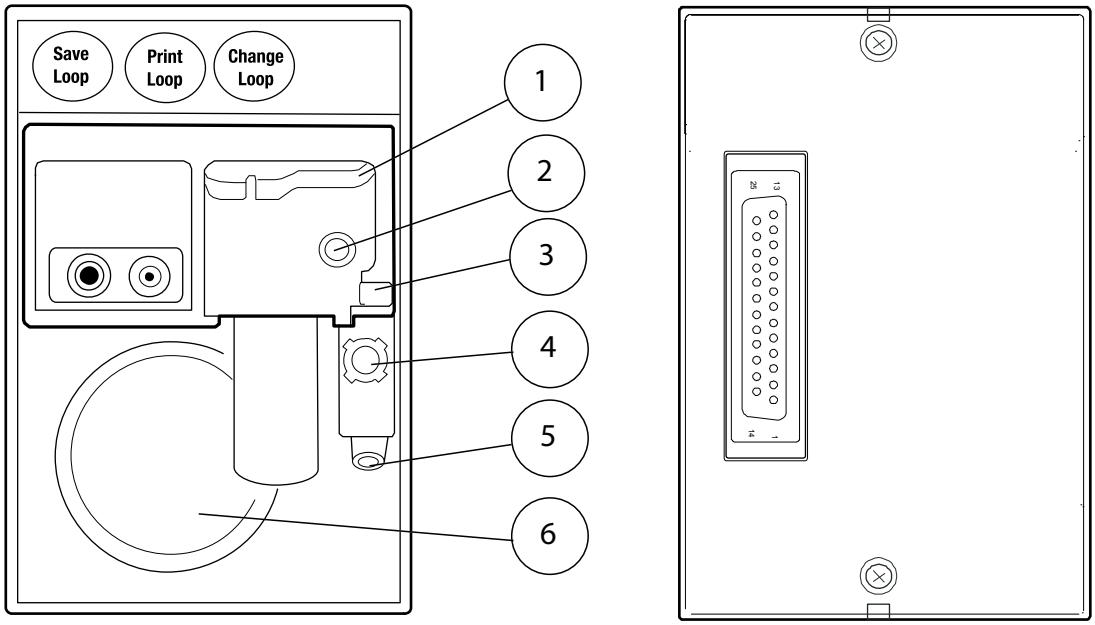


Figure 5 Front of Compact Airway Module, E-CAiOVX, and the back of the module

(1) D-fend water trap
(2) Sampling line connector
(3) Water trap latch
(4) Oxygen reference gas inlet
(5) Sample gas outlet
(6) Cooling fan with dust filter

Module keys	**Module**	**Description**
Save Loop	E-COV, E-COVX, E-CAiOV, E-CAiOVX	**Save Loop** saves a reference loop.
Print Loop	E-COV, E-COVX, E-CAiOV, E-CAiOVX	**Print Loop** prints the reference loop.
Change Loop	E-COV, E-COVX, E-CAiOV, E-CAiOVX	**Change Loop** changes a pressure/volume loop to a flow/volume loop or vice versa.
Connector	**Module**	**Description**
D25 connector	all modules	Module bus connector

2.2.2 Gas sampling system

The sampling system takes care of drawing a gas sample into the analyzers at a fixed rate.

The gas sampling system samples the measured air to the module, and removes water and impurities from it. A sampling line is connected to the water trap. The pump draws gas through the sampling line to gas measuring units. After the measurements, the gas is exhausted from the sample gas out connector.

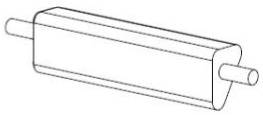
The E-COVX and E-CAiOVX modules have a different gas sampling system compared to the other modules. A number of flow restrictors have been changed to create a bigger pressure difference between ambient pressure and the gas sampling system in the gas sensors. The sample flow is, however, about the same (200 ml/min).

A larger pressure difference makes the deformations of the gas concentration curves less sensitive to high variations of the airway pressures, thus also meeting the accuracy requirements of gas exchange for these applications.

D-fend™

The sample is drawn through a sampling line. Then gas enters the monitor through the water trap, where it is divided into two flows, a main flow and a side flow. The main flow goes into the analyzers. This flow is separated from the patient side by a hydrophobic filter. The side flow creates a slight subatmospheric pressure within the D-fend water trap, which causes fluid removed by the hydrophobic filter to collect in the bottle.

Zero valve and absorber



The main flow passes through a magnetic valve before proceeding to the analyzers. This valve is activated to establish the zero points for the TPX and OM units. When the valve is activated, room air is drawn through the absorber into the internal system and the gas sensors. Paralyme is used as an absorbent.

Figure 6 Absorber

Nafion® tubes [1)]

A Nafion tube is used between the water trap and the zero valve to balance the sample gas humidity with that of ambient air. The tube will prevent errors caused by the effect of water vapor on gas partial pressure, when humid gases are measured after calibration with dry gases. Another Nafion tube is used between the absorber and the pneumatic unit to prevent humidity caused by the absorption of CO_2.

Gas analyzers

After the zero valve and Nafion tube, the gas passes through the TPX and OM units. The oxygen sensor has two inputs. One input accepts the main flow and the other draws in room air for reference. Both gas flows exit from a single port.

Sample flow differential pressure transducer

The sample flow differential pressure transducer measures pressure drop across an OM inlet restrictor and calculates sample flow from the pressure difference.

1 Nafion is a registered trademark of Perma Pure Inc.

Working pressure transducer

The working pressure transducer measures absolute working pressure between the TPX unit and OM unit. It is used for messages: 'Sample line blocked', 'Check D-fend', 'Replace D-fend' and 'Check sample gas outlet'.

Pneumatic unit

The pneumatic unit contains a zeroing valve, occlusion valve and tubing connections. There is a series of restrictors and chambers forming a pneumatic filter to prevent pressure oscillations from the pump to reach the measuring units. The occlusion valve connection to room air includes a dust filter and the zero valve connection to room air includes an absorber.

Connection block

The connection block contains a sample gas outlet connector and an OM unit reference gas inlet. The inlet is equipped with a dust filter.

Occlusion valve

The valve is activated, when the sampling line gets occluded. The main flow is then diverted to the side flow of the D-fend water trap to faster remove the occlusion.

Sampling pump and damping chamber

The gas sampling pump is a membrane pump that is run by a brushless DC-motor. Sample flow is measured with a differential pressure transducer across a known restriction. The motor is automatically controlled to maintain a constant flow, even when the D-fend water trap ages and starts to get occluded. It also enables use of sample tubes with varying lengths and diameters.

The damping chamber is used to even out the pulsating flow and silence the exhaust flow.

NOTE: In no occasion is the flow reversed towards the patient.

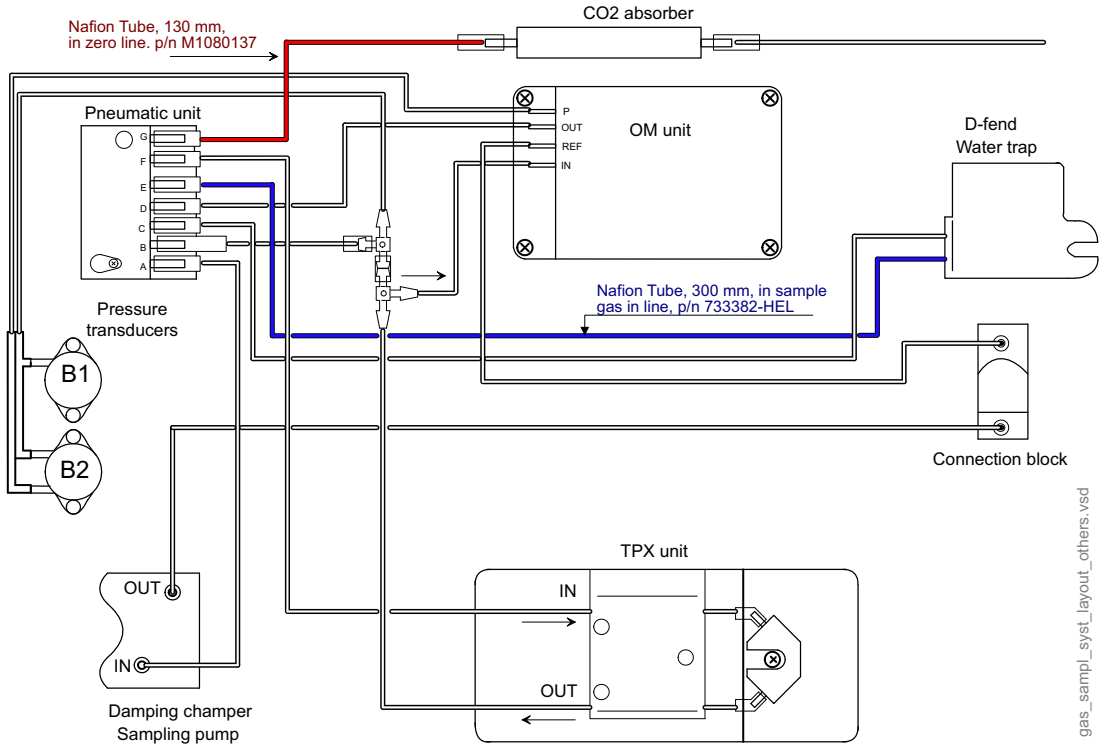
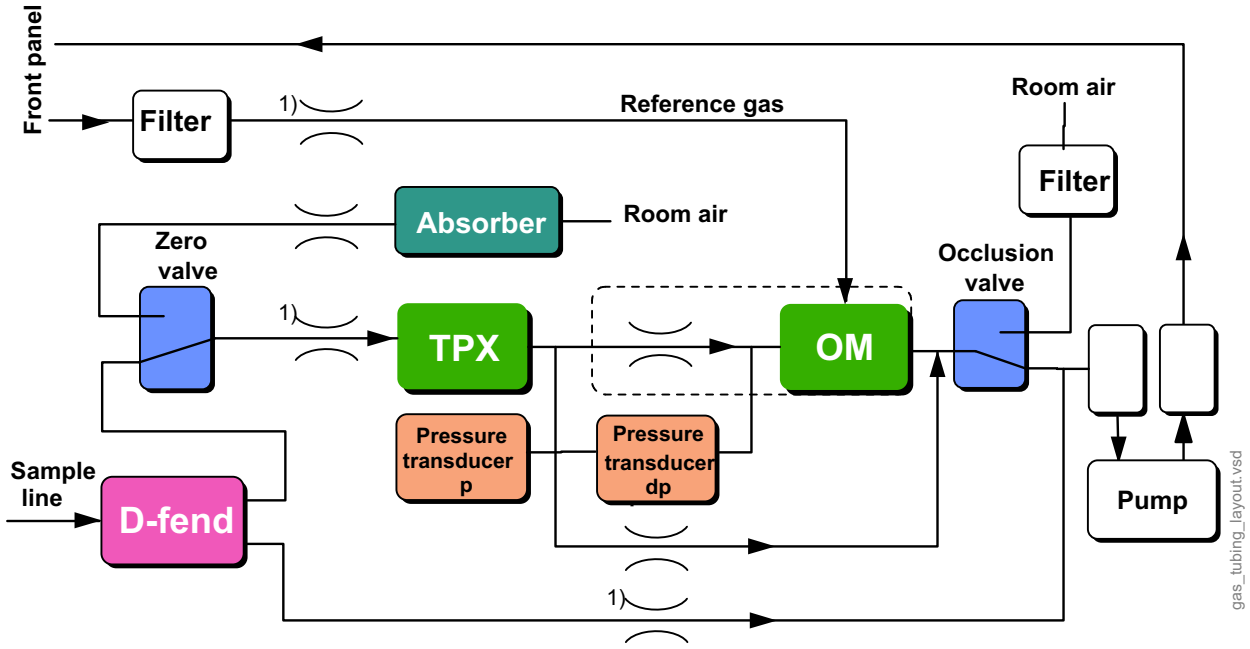


Figure 7 Gas sampling system layout



Tubing marked with 1) is thinner in E-CAiOVX and E-COVX module.

Figure 8 Gas tubing layout

2.2.3 TPX measuring unit

The TPX unit is a non dispersive infrared analyzer, measuring absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters. The IR lamp is a 4 W filament, surrounded by thermal isolation. There is a hole in the isolation, passing the radiation to a conical measuring chamber with 4 mm length.

From the sample chamber, radiation goes into seven tubular light guides with reflective inner surfaces. At the other end of each light guide, there is a thermopile detector with an optical filter in front of it.

The Temp sensor measures the TPX units' temperature and it is used for temperature compensation.

The TPX unit includes a TPX board located at the end of the unit. Its function is to connect the 7 thermopile signals and the temperature sensor signal to the CPU board.

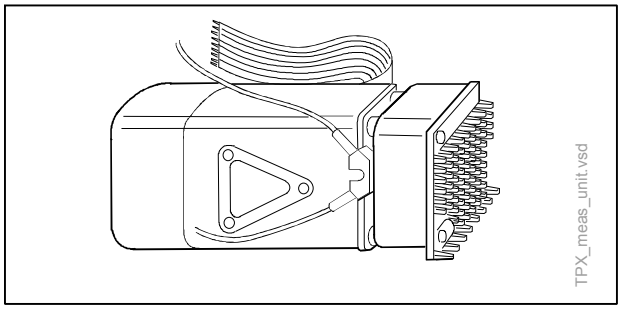


Figure 9 TPX measuring unit

OM measuring unit

The oxygen measurement is based on paramagnetic susceptibility. The gas and the reference gas, which usually is room air, are conducted into a gap in an electromagnet with a strong magnetic field switched on and off at a frequency of approximately 165 Hz.

An alternating differential pressure is generated between the sample and reference inputs due to forces acting to the oxygen molecules in a magnetic field gradient.

The pressure is measured with a sensitive differential transducer, rectified with a synchronous detector and amplified to produce a DC voltage proportional to the oxygen partial pressure difference of the two gases.

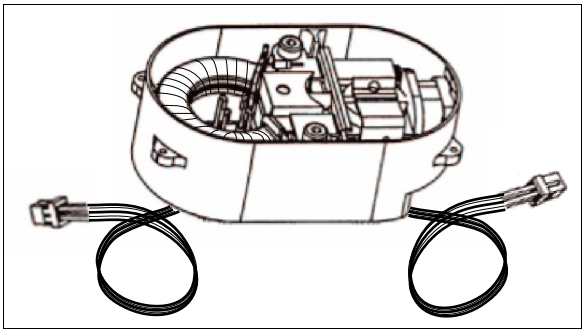


Figure 10 OM measuring unit

2.2.4 PVX measuring unit

NOTE: Never apply overpressure or negative pressure of more than 300 cmH_2O to the flow and volume tubing. Differential pressure max 25 cmH_2O on one port at a time e.g. when connecting tubes.

When Patient Spirometry is used, a special sensor, D-lite, replaces the normal airway adapter in the patient circuit. A double lumen tubing is attached to the two connectors on the adapter and on the module front panel.

The Patient Spirometry provides patient respiration monitoring capabilities using the D-lite and Pedi-lite flow sensors.

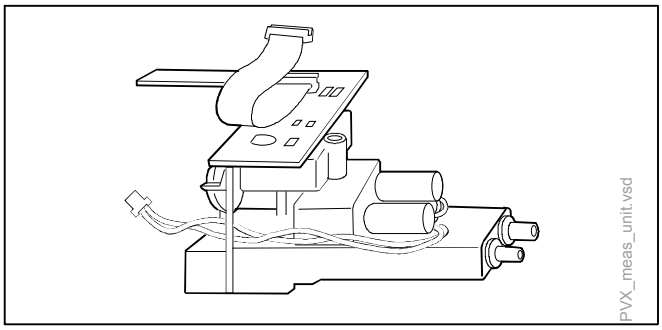


Figure 11 PVX measuring unit

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measure the Pitot pressure. The signal is then linearized and corrected according to the density of the gas. Speed of the flow is calculated from the pressure and TV is integrated from it.

Patient Spirometry consists of airway connections, two pressure transducers, valves and preamplifiers. The preamplifiers are connected to the A/D-converter on the module main CPU.

The breathing flow of a patient passing through the D-lite adapter creates a pressure difference. This pressure difference is measured by a pressure transducer, B1. Overpressure and negative pressure in airways are measured by another pressure transducer, B2.

Gas exchange

The gas exchange measurement uses the concentrations measured by the TPX measurement unit and the O_2 measurement unit, in combination with the flow from the PVX measurement unit. The gas exchange calculation is done by software.

CAUTION The gas exchange measurement in the E-CAiOVX and E-COVX modules works accurately only with 2-meter gas sampling lines.

2.2.5 CPU board

The CPU board contains the processor and memories and A/D-converters that are common to the whole module. The CPU board also contains preamplifiers of TPX-sensor and drivers for valves, fan, pump and lamp. The module is connected to the module bus through an RS-485 serial channel.

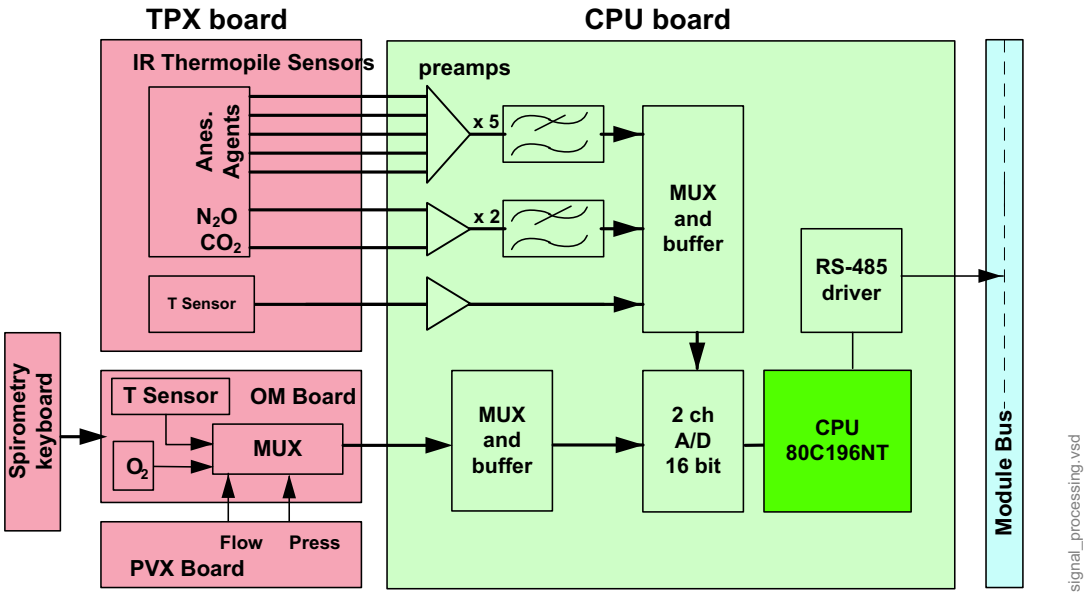


Figure 12 Signal processing

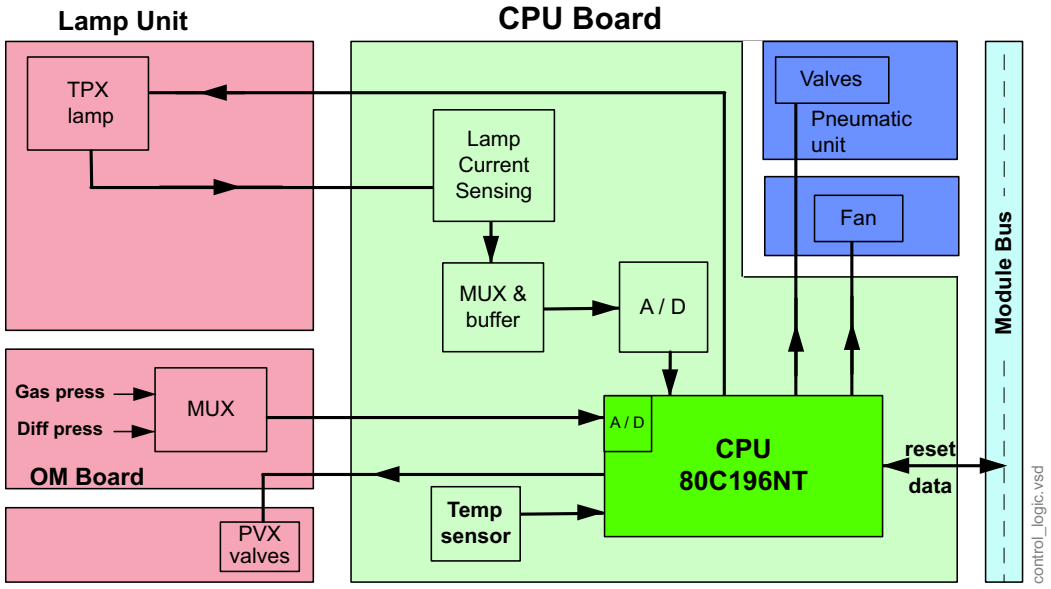


Figure 13 Control logic

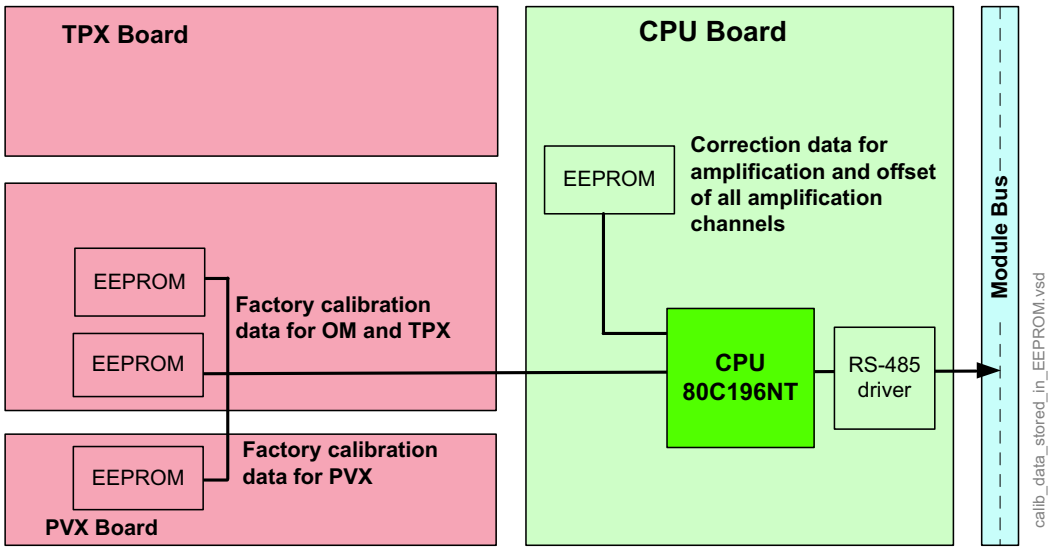


Figure 14 Calibration data stored in EEPROM

2.2.6 OM board

The Oxygen board contains the specific electronics for the oxygen sensor. Sample flow measurement and sampling system pressure sensors are on this board. It also contains EEPROMs that store calibration data of both TPX and OM sensors. The spirometry keyboard connection is on this board.

PVX board

The Spirometry board is connected to the oxygen board. It contains pressure sensors for airway pressure and flow measurement differential pressure and preamplifiers for those. Calibration data of spirometry is stored on its own EEPROM.

3 Service procedures

3.1 General service information

The field service of the compact airway modules is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

WARNING **Handle the water trap and its contents as you would any body fluid. Infectious hazard may be present.**

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

NOTE: Wear a static control wrist strap when handling PC boards. Electrostatic discharge may damage components on the board.

3.1.1 OM measuring unit

CAUTION Due to the complicated and sensitive mechanical construction of the O_2 measuring unit, no repairs should be attempted inside the unit.

3.1.2 TPX measuring unit

CAUTION The TPX photometer and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit. The information provided is for reference only.

3.1.3 OM, TPX, and PVX measuring unit

CAUTION The OM, TPX, and PVX measuring units can be repaired only at the factory.

3.1.4 Serviceable parts

- Absorber
- D-fend
- Nafion tubes
- Fan filter
- Fan
- CPU board
- CPU software
- PVX Unit including PVX board
- Pump

NOTE: After any component replacement, see chapter *3.4. Adjustments and calibrations*.

3.2 Service check

These instructions include complete procedures for a service check. The service check is mandatory after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which may be used when performing the procedures.

The symbol  in the instructions means that the check form contains space to record the results of the particular procedure.

3.2.1 Recommended tools

NOTE: Use only calibrated and traceable measuring equipment.

- A barometer
- A mass flowmeter for measuring air flow, minimum measurement range 100-300ml/min, accuracy 5% or better in the 100-300ml/min range.
- P/N: 755534-HEL Calibration Gas Regulator
- P/N: 755583-HEL Calibration gas, CO2, O2, N2O, DESF, package of 1 can (with E-CAiO, E-CAiOV, E-CAiOVX modules)
- P/N: 755581-HEL QUICK CAL calibration gas, CO2, O2, N2O, package of 4 cans (with E-CO, E-COV and E-COVX modules)
- P/N: M1006864, Calibration Gas Regulator, US only
- P/N: 755571-HEL, Calibration Gas, 5% CO2, 54.5% O2, 36.0% N2O, 2.0% DESFLURANE, BAL N2 (with E-CAiO, E-CAiOV, E-CAiOVX modules) US only
- P/N: 755587, Calibration Gas, CO2, O2, Balance, 4 cans/pkg (with E-CO, E-COV and E-COVX modules) US only
- D-Fend water trap
- 3 m / 10 ft anesthesia gas sampling line (with E-CO, E-COV, E-CAiO and E-CAiOV modules)
- 2 m / 7 ft anesthesia gas sampling line (with E-COVX and E-CAiOVX modules)
- Spirometry tube, 3 m/10 ft (with E-CO, E-COV, E-CAiO and E-CAiOV modules)
- Spirometry tube, 2 m/7 ft (with E-COVX and E-CAiOVX modules)
- Adult D-Lite sensor
- A pressure manometer with either an integrated or a separate pressure pump
- Tubing for spirometry leak tests

NOTE: Ensure that the calibration gas and the regulator are functioning properly before calibration. Perform annual maintenance on the regulator as required, see "Calibration gas regulator flow check" page 33.

3.2.2 Recommended parts

Replace the following parts that wear in use at the recommended interval.

Part number	Description	Pieces	Replacement interval
733382-HEL	Nafion Tube, 300 mm	1	Once a year
M1080137	Nafion tube, 130 mm	1	Once a year
886136-HEL	Occlusion filter for pneumatic unit	1	Once a year
M1028983	Reference gas filter assembly	1	Once a year
65340	O-ring for reference gas filter assembly	1	Once a year
M1130739	Ref gas sticker	1	Once a year
65312-HEL	D-Fend O-ring	2	Once a year
M1028987	Fan filter	1	Once a year
895933	CO2 zero absorber	1	Once every 4 years

It is also recommended to replace the D-fend water trap, the gas sampling line and the spirometry tube as part of the planned maintenance procedure.

Part number	Description	Notes
876446-HEL	D-Fend Water Trap	
881319-HEL	D-Fend+ Water Trap	for E-COVX
73319-HEL	Sampling line 3 m/10 ft	anesthesia gas sampling line
73318-HEL	Sampling line 2 m/7 ft	for E-CAiOVX/E-COVX
890031	Spirometry tube 2 m	
884101	Spirometry tube 3 m	
733950/73393	D-lite / Pedi-lite	
896952	D-lite+	for condensing active humidification circuits

3.2.3 Planned Maintenance Kits

The required planned maintenance parts are included in a PM kit.

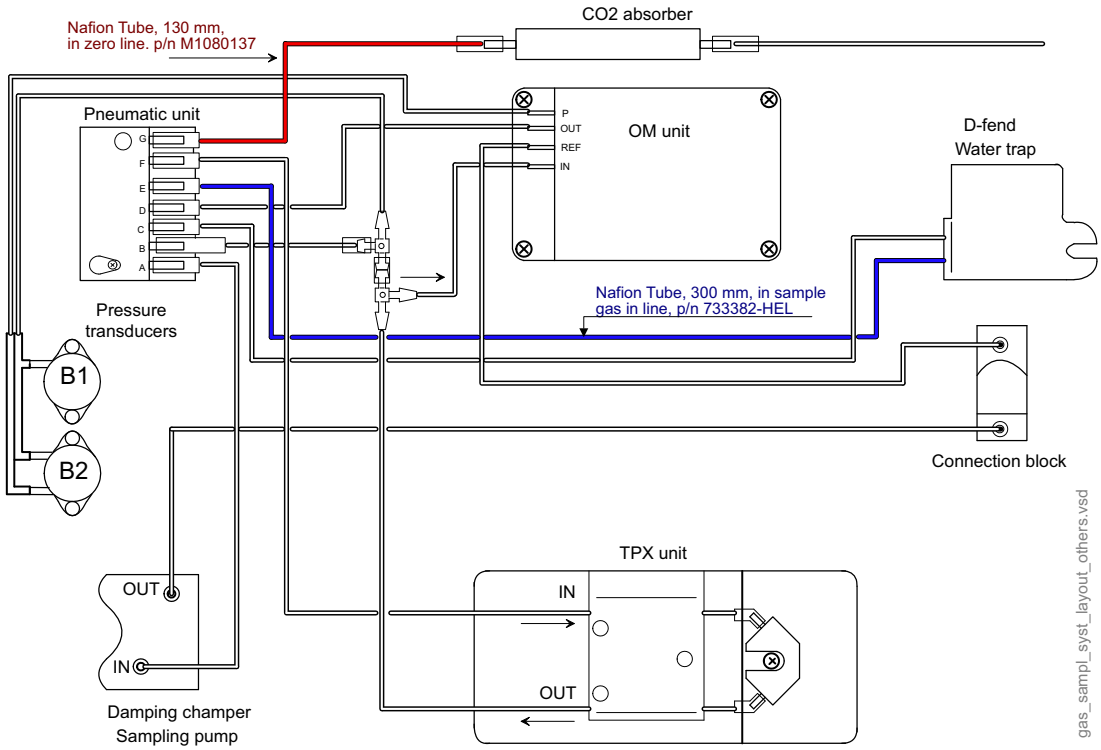
Part number	Description
8001760-HEL	Planned Maintenance Kit for Compact Airway modules. The PM kit includes the required Nafion tubes, the occlusion filter for the pneumatic unit, the reference gas filter assembly with an O-ring and a new sticker, the D-fend O-rings and the fan filter. NOTE: The PM kit does not include the CO2 zero absorber. Order it separately.

3.2.4 Replacement procedures

Replace the specified planned maintenance parts according to the following procedure. Refer to chapter "3.3. Disassembly and reassembly" and chapter "E-Modules, Spare Parts slot" for additional information.

1. Replace the CO2 absorber every 4 years.

2. Replace the special tubes (Nafion) and check the condition of the internal tubing.
   - Replace the 130 mm Nafion tube in the zero line between the CO2 absorber and the pneumatic unit.
   - Replace the 300 mm Nafion tube in the sample gas line between the D-fend water trap and the pneumatic unit.
   - Check that the tubing inside the module is not contaminated. Any contamination inside the tubing may indicate that the valves or sensors are contaminated, too. This can increase a risk of faulty operation in valves or sensors. The valves or gas sensors are not possible to clean in the field. Therefore, if you noticed any contamination in the module tubing, send the module to GE Healthcare for factory service.



NOTE: The nafion tubes do not include the silicon fittings they connect to. Use the original silicon fittings unless they are not damaged or leaking.

NOTE: Some older versions of Compact Airway modules were equipped with a longer 300 mm nafion tube in the zero line. You can replace it with the shorter 130 mm nafion tube.

3. Replace the occlusion filter in the pneumatic unit:

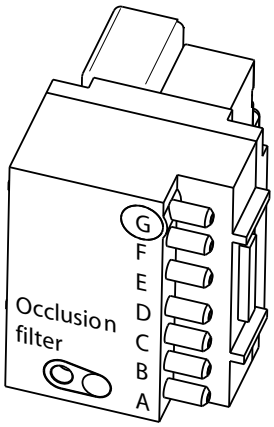
a. Open the screw that holds the black filter cover to the pneumatic unit.

b. Detach the filter cover e.g. using a small flat blade screwdriver.

c. Detach the white occlusion filter e.g. by turning the module upside-down so that the filter drops.

d. Attach a new occlusion filter to the pneumatic unit.

e. Attach the filter cover back and fasten the screw.



4. Replace the reference gas filter assembly:

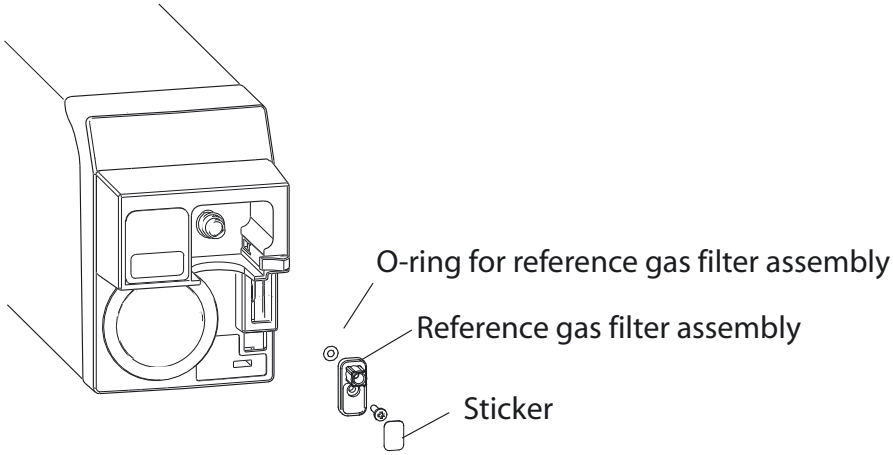
a. Detach the reference gas sticker.

b. Open the screw that holds the reference gas filter assembly to the front cover. Pull out the reference gas filter assembly and discard it.

c. Attach a new O-ring into the new reference gas filter assembly.

d. Attach the new reference gas filter assembly with the O-ring to the front cover.

e. Attach a new reference gas sticker to the reference gas filter assembly. Use the original labelling language. .

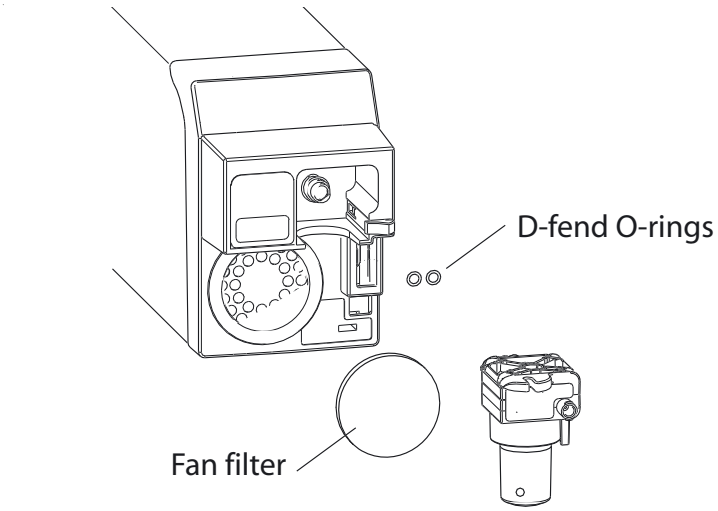


5. Replace the D-Fend O-rings:

a. Detach the D-fend.

b. Detach the old rubber O-rings that are around the metal D-fend connectors e.g. using a small flat blade screwdriver. Pay special attention not to scratch the metal D-fend connectors and thus causing leaking.

c. Set the new rubber O-rings into place and attach a new D-fend.



6. Replace the fan filter in the front of the module.

3.2.5 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts
   Check that:
   - all screws are tightened properly
   - all cables are connected properly
   - tubes are not pinched and there are no sharp bends on them
   - all tubes are connected properly
   - the front cover grounding pins are not bent against the CPU board
   - there are no loose objects inside the module

NOTE: Make sure not to press too deep the tubes that are connected to the Oxygen board pressure transducers, i.e. the pressure transducer port must not touch the back wall of the L-shaped tube connector.

NOTE: Make sure that tubes are not in contact with the sampling pump or the O_2 sensor, or its springs.

2. External parts
   Check that:
   - the front cover and the front panel stickers are intact
   - all connectors are intact and attached properly
   - the D-fend latch is moving properly
   - the module box and latch are intact

3.2.6 Functional inspection

3. Fan filter

   Clean or replace the fan filter.

4. D-fend O-rings

   Detach the D-fend. Check the condition of the rubber O-rings on the metal D-fend connectors, located in the Compact Airway Module front cover.

   If necessary, detach the connectors by first disconnecting the tubes, then removing the locking rings from the back of the front cover.

NOTE: The O-rings are recommended to be replaced annually.

5. Other filters

   Check that the flow of air through the filters in the reference gas connection block (1 pc) and in the pneumatic unit (1 or 2 pcs) is not obstructed.

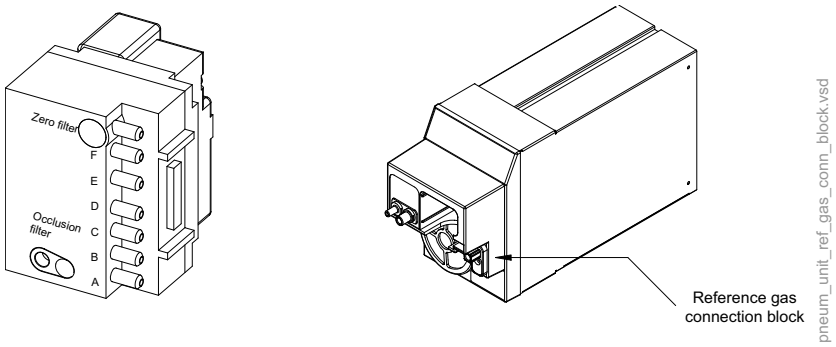


Figure 15 Pneumatic unit and reference gas connection block

NOTE: The filters should be replaced annually.

Replace the old D-fend and sampling line with new ones.

NOTE: Use only GE Healthcare sampling lines in order to ensure proper function.
2 m/7 ft. sampling line should be used with E-COVX and E-CAiOVX.

Connect the Compact Airway Module to the Central Unit's Module motherboard using the Gas interface cable (the grounding plates of the cable should be removed).

Turn the monitor on.

Configure the monitor screen so that all the needed parameters are shown, for example as follows:

Monitor Setup - ***Screen 1 Setup - Waveform fields - Field 1 - Paw***
Field 2 - Flow
Field 3 - Off
Field 4 - O2
Field 5 - AA
Field 6 - CO2
Digit Fields
Lower Field 1 - Gases

6. Fan

   Check that the fan is running.

7. Module software

   Wait until the message 'Calibrating gas sensor' disappears from the screen, then enter the ***Service*** menu.

   Monitor Setup - *Install/Service* (password 16-4-34) **- *Service*** (password 26-23-8)

   Take down the information regarding Compact Airway Module software.

8. Module configuration

   Enter the Compact Airway Module service menu.

   Parameters - Gas Unit - General

   Check that the shown module configuration corresponds with the used Compact Airway Module type.

9. Module bus communication

   Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second.

   If one of the values is increasing faster, it indicates a failure in module bus communication.

10. Flow measurement offset

    Enter the service menu ***Gases***:

    Gas Unit - Gases

    Check that the flow measurement offset, i.e. the shown sample Zero value is within ±10 ml/min.

11. Ambient pressure

    Check that the shown Ambient value corresponds with the current ambient pressure (±20 mmHg).

12. Zero valve

    Feed calibration gas and check that the gas readings in the service menu correspond with the values on the gas bottle sticker. Keep feeding gas, then activate the zero valve from the menu. The CO_2 (N_2O, AA) reading should drop back near 0%, the O_2 reading near 21%.

13. Special tubes

    Perform the steam test for the Nafion tubes, or replace those by new.

    Replace the CO_2 absorber, if necessary.

NOTE: The Nafion tubes should be replaced annually. If you replace the absorber, you should also replace the Nafion tube.

NOTE: The CO_2 absorber should be replaced once every four years.

14. Leak test

    Check the gas sampling system for possible leakages.

a. Disconnect the module from the monitor.
b. Connect a new D-Fend water trap to the module.
c. Connect a new gas sampling line to the sampling line connector in the water trap.
d. Connect the other end of the gas sampling line to a pressure manometer and a pressure pump.
e. Block the "Ref Gas In" and "Sample Gas Out" connectors.
f. Pump 100 mmHg ± 20 mmHg pressure to the gas sampling system. Let the pressure stabilize for approximately 10 seconds.
g. Check that the pressure reading does not drop more than 4 mmHg during one minute.

NOTE: The gas module shall be disconnected from the monitor during the leak test.

15. Flow rates

    Wait until the Sample Flow value is back near 200 ml/min.

    Connect a flowmeter to the 3 meter sampling line (use a 2 meter sampling line for E-CAiOVX and E-COVX) and check that the flow (the flowmeter reading) is within the following range:

Sampling flow (ml/min)	180...220

    If necessary, readjust the sampling flow:

    Select ***Sample gain adj*** from the menu. To increase the sampling flow, turn the ComWheel counterclockwise, to decrease the flow, turn the ComWheel clockwise.

    A change of 0.050 in the Gain value changes the flow approximately 10 ml/min.

    After you have changed the gain, wait until the Sample Flow value on the screen gets back near the original, then check the flowmeter reading again.

    Connect the flowmeter to the reference gas connector, check that the flow is within the following range:

Reference flow (ml/min)	E-CAiOVX/E-COVX	Others
	27...40	31...45
	(with 2m sampling line)	(with 3m sampling line)

Activate the zero valve on from the service menu. The Sample Flow value should not change more than 20 ml/min. If the absorber is connected, the value is 30 ml/min.

16. Working pressure

    Check that the Amb-Work value in the service menu is within the following range:

Amb-Work (mmHg)	E-CAiOVX/E-COVX	Others
	70...115	40...75

17. Gas calibration

    Perform the gas calibration.

    Airway Gas - ***Gas Calibration***

NOTE: Calibration is not recommended until 30 minutes warm-up time has elapsed.

Use calibration gas 755587 (5% CO_2, 95% O_2) for calibrating Airway Module, E-COVX, and calibration gas 755583-HEL (2% Desflurane, 5% CO_2, 33% N_2O, 55% O_2, balance N_2) for E-CAiOVX/E-CAiOV/E-CAiO, and calibration gas 755581 (5% CO_2, 40% N_2O, 55% O_2) for calibrating E-COV/E-CO.

NOTE: You can calibrate the modules E-CO and E-COV with the same calibration gas as the E-COVX module.

NOTE: For correct measurement values, modules need different amounts of oxygen in the calibration mixture. Use only recommended calibration gases to ensure a successful calibration.

18. Fall time measurement

    Perform the fall time measurement in the ***Gases*** service menu.

    Monitor Setup - *Install/Service* (password 16-4-34) **- *Service*** (password 26-23-8) **- *Parameters - Gas Unit - Gases***

    Activate the measurement by selecting ***Fall Time Meas*** from the service menu. Feed calibration gas until the message 'Feed' near the fall time values changes to 'READY'. If necessary, repeat the same procedure to get all the values on the screen.

    Check that the measured values are within the following ranges:

    CO_2 fall time < 400 ms
    O_2 fall time < 400 ms
    CO_2-O_2 delay < 800 ms

Anesthesia Agent measurement

19. ID unrel.

    Agent ID reliability.

    Feed calibration gas (order code 755583-HEL) continuously for at least 30 seconds and check that the ID in the service menu shows DES and that the value for ID unrel. is lower than 70.

If the value is higher, repeat the gas calibration and check the value again.

Patient Spirometry measurement

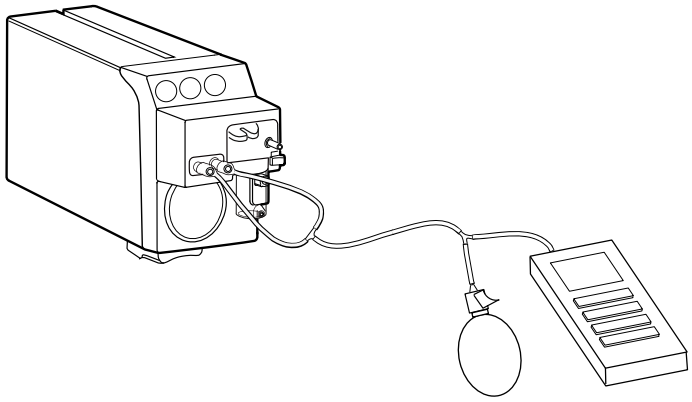
20. Spirometry System Leak Test

NOTE: Perform this test only for E-COV, E-COVX, E-CAiOV and E-CAiOVX modules.

Check the spirometry sampling system for possible leakages.

a. Ensure the module is disconnected from the monitor.

b. Connect a pressure manometer to the spirometry connectors.



c. Pump 50 mmHg ±10 mmHg (~68 cmH_2O) pressure to the Spirometry sampling system. Let the pressure stabilize for approximately 10 seconds.

d. Verify that the pressure reading does not drop more than 3 mmHg during one minute.

NOTE: The gas module shall be disconnected from the monitor during the leak test.

NOTE: The spirometry pressure transducers are very sensitive for differential overpressure. A momentary differential pressure between the two spirometry connectors exceeding 25 cmH_2O (18 mmHg) may damage the pressure sensors. To ensure that both pressure channels are equally pressurized, make sure that the tubing between the manometer and the two spirometry connectors is connected tightly, the tubes are equally long and thick and not kinked.

NOTE: Do not overpressure the spirometry sampling system. A static pressure exceeding 300 cmH_2O (220 mmHg) may damage the pressure sensor.

21. Flow waveform

Remove the blockage from the sampling line port and connect the sampling line. Breathe through the wider side of the D-lite. Check that the flow waveform moves downwards when you breathe in, and upwards when you breathe out.

22. Spirometry tester

    If possible, check the Side Stream Spirometry measurement also with the Spirometry Tester (order code 884202-HEL). Follow the instructions that are supplied with the tester.

All modules

Turn the monitor off, disconnect the Gas interface cable and reassemble the module. Remember to attach the plastic cover against the CPU board before installing the module box.

NOTE: When reassembling the module, make sure that the tubes are not pinched between the module box and internal parts.

Install the Compact Airway Module into the Central Unit, turn the monitor on and wait until the message 'Calibrating gas sensor' disappears from the screen.

23. Occlusion detection

    Block the tip of the sampling line with your finger and check that the message 'Sample line blocked' appears on the monitor screen within 60 seconds.

24. Air leak detection

    Detach the D-fend and check that the message 'Check D-fend' appears on the monitor screen within 30 seconds.

    Reattach the D-fend. Simulate at least 5 breaths by feeding calibration gas into the sampling line. Check that the shown gas information is correct.

25. Apnea detection

    Check that the monitor shows the message 'Apnea' within 30 seconds after you have stopped feeding gas.

26. Final cleaning

    Turn the monitor off, disconnect and clean the module.

- Fill in all necessary documents.

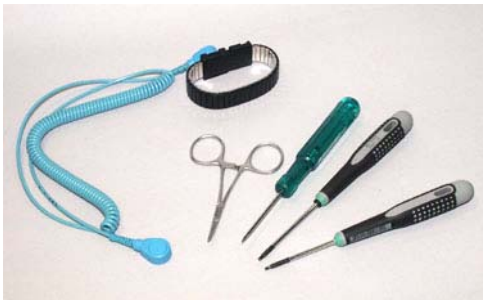
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Required tools



- pozidrive screwdrivers
- flat blade screwdriver
- pincers
- antistatic wristband

To disassemble the compact airway module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. Press the release latch. Pull the module box slowly backwards and remove it from the main body.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

Always perform the "Service check" after reassembling the module.

3.3.3 PVX unit

1. Remove the module box.
2. Detach the CPU board and OM board from the module chassis (4 screws).
3. Disconnect the pump cable, pneumatics unit cable, fan cable, and the other cable of the TPX unit from CPU board.
4. Disconnect the OM unit's cables, spirometry keyboard cable and PVX unit's cables from the OM board.
5. Detach the front panel from the module chassis (1 screw).
6. Detach the PVX unit from the front panel (1 screw).

To reassemble the module, reverse the order of the disassembly steps.

3.3.4 Pump unit

1. Remove the module box.
2. Cut off the pump's clamp (panduit).
3. Unplug the hoses of the pump.

4. Disconnect the pump's cable from the CPU board. Pass the cable under the pneumatic unit by lifting it.

To reassemble the module, reverse the order of the disassembly steps.

3.3.5 CPU board

1. Remove the module box.
2. Detach the CPU board and OM board from the module chassis (4 screws).
3. Disconnect the pump cable, pneumatics unit cable, fan cable, and both cables of the TPX unit from the CPU board.
4. Detach the CPU board from the OM board.

To reassemble the module, reverse the order of the disassembly steps.

3.3.6 Software of CPU board

1. Remove the module box.
2. Detach the CPU board and OM board from the module chassis (4 screws).
3. Disconnect the pump cable, pneumatics unit cable, fan cable, and the other cable of the TPX unit from the CPU board.
4. Detach the CPU board from the OM board.
5. Detach the software from the CPU board.

To reassemble the module, reverse the order of the disassembly steps.

3.3.7 Instructions after replacing software or CPU board

After replacing the software or CPU board:

- perform the sampling system leak test
- perform the occlusion test
- perform the gas calibration
- perform the fall time measurement

3.4 Adjustments and calibrations

See “User’s Reference Manual” for normal gas calibration instructions.

3.4.1 Gas sampling flow rate measurement

NOTE: Let the monitor run for 15 minutes before measuring flow rates.

For the flow rate measurements, a flowmeter with a low flow resistance and capability to measure the specified air flow measurement range is required. Use recommended sampling lines, because the length of the sampling line has a considerable effect on the flow.

If any flow rates are not correct, first replace the D-fend water trap. Then recheck the incorrect flows.

The sampling flow rate is measured by a rotameter at the sampling line. The rate should be between 180 and 220 ml/min. The flow rate is adjusted in the ***Gases*** service menu with ***Sample gain adj***.

The reference flow of the oxygen measuring unit is checked as follows:

Connect the rotameter to the Gas Ref. inlet on the front panel. The flow rate should be between 31 and 45 ml/min (E-CAiOVX/E-COVX: 27-40 ml/min). The flow rate is not adjustable.

3.4.2 Gas sampling flow rate adjustment

NOTE: Before adjusting the sampling flow, make sure there is no leakage in the sampling system.

Refer to chapter 3.2. Service check, step 15; “Flow rates”.

3.4.3 Gas calibration

NOTE: Ensure that the calibration gas and the regulator are functioning properly before calibration. Perform annual maintenance on the regulator as required.

WARNING **Calibration gas bottles and their regulators contain ferrous material. Perform the calibration outside the MR environment.**

The gas calibration is performed in the ***Airway Gas*** menu. See “User’s Guide” for gas calibration instructions.

Calibration gas regulator flow check

Interval: every 12 months

Regulator flow specification:

REF 755583-HEL & 755534-HEL: 260 – 410 ml/min at 1-10 bar cylinder pressure
REF 755530-HEL: 260 – 410ml/min at 5-7psi cylinder pressure

Tools needed: calibration gas can, regulator, piece of silicon hose and flow meter. GE Healthcare recommends use of TSI 4140 or 41403 flow Meter.

Attach the calibration gas regulator to the gas cylinder. Connect a silicon hose between the regulator and the flow meter. Block the regulator overflow port and open the regulator. Check the flow rate from the flow meter and verify that the flow is within the specification.

Flow calibration

The PVX measuring unit is calibrated at the factory and due to the unit’s design, calibration is not regularly needed. The calibration data is saved into the board’s EEPROM. In case calibration is needed, it is recommended to perform the calibration both with adult values using the D-lite, and with pediatric values using the Pedi-lite.

1. Connect a spirometry tube with a D-lite sensor to the compact airway module. To improve the accuracy, the endotracheal tube and all accessories which normally are in use should be attached also during the calibration.
2. Enter the ***Gas Unit*** service menu: **Monitor Setup - *Install Service - Service - Parameters***. Enter the ***Spirometry*** menu.
3. After the flow is zeroed ('Zero OK' message displayed), attach a spirometry tester to the flow sensor (D-lite or Pedi-lite). Select the sensor type.
4. Perform the calibration according to the tester instructions. Observe the values of inspired and expired tidal volumes.
5. Adjust the reading to match the calibration volume (about 1000 ml for the D-lite and 300 ml for the Pedi-lite). Adjust ***Exp Flow Gain*** and ***Insp Flow Gain*** values in proportion to the difference between the measured values and the spirometry tester reading.

4 Troubleshooting

4.1 Troubleshooting charts

Problem	Cause / What to do
No response to breathing	Sampling line or water trap blocked or loose, or improperly attached. Water trap container full. See the gas sampling system troubleshooting.
'SENSOR INOP.' message	The temperature is too high, check fan and filter at the front panel. Communication error, check timeout and bad checksum values at the service menu.
'xx ZEROING ERROR' message	Gas zeroing failed. Condensation or residual gases are affecting zero measurement. Allow module to run drawing room air for half an hour and calibrate again.
'CHECK D-FEND' message ('Air leak' message)[1)]	Probably the water trap or the sampling line is not attached properly. Gas zero valve failure. Pump failure or gas outlet blockage.
'REPLACE D-FEND' message ('Replace water trap' message)[1)]	Indicates residue build-up on the water trap membrane. This decreases air flow. Replace the D-fend.
'REBREATHING' message ('FiCO_2 high' message)[1)]	CO_2 concentration in inspiratory air is too high. CO_2 absorber in ventilation may be saturated. Change the ventilation absorber.
'SAMPLE LINE BLOCKED' message ('Air leak' message)[1)]	Sampling line or water trap is occluded. Water trap container is full. If occlusion persists, check internal tubings for blockages.
('SELECT AGENT' message)[1)]	No anesthetic agent is selected though delivery is started. Vaporizer valve is broken, or traces of cleaning or disinfecting agent in the water trap container affecting the readouts. Let the container dry properly after disinfection before use.
No response to any gas	Sampling line, water trap or internal tubing blocked or loose, or improperly attached. Occlusion or zero valve malfunction. Pump failure. Supply voltage missing. Serial communication error.
Sudden increase in gas display	Water trap malfunction. Check all internal tubings and the interior of the water trap for occlusions or leaks. Replace water trap. Check flow rates.
Abnormally high response to all gases (or abnormally low) or sudden occlusion warning	Pressure transducer failure.

Problem	Cause / What to do
Strong drift in all gases	Leak in sampling line or internal tubings (especially in conjunction with too low readings).
'MVexp << MVinsp' message	Leak in patient circuit between patient and D-lite or in the patient's lungs, or leak in tubes from D-lite to module. Check D-lite connection and D-lite tubings.
(Disconnection)[1)] (MVexp < 0.5 l/min message)[1)] Low volumes	Too small tidal volumes for accurate measurement (not shown during Apnea). Gas sampling is working correctly. Check D-lite connections and D-lite tubing.

1) with earlier software versions

4.1.1 CO_2 measurement

Problem	Possible clinical cause	Possible technical cause	What to do
too low $ETCO_2$ value	• sudden decrease in circulation • pulmonary embolism • hyperventilation • very large dead-space • large shunting	• leak in sampling system • calibration error • high by-pass flow from ventilator	• check all connections • check calibration
too high $ETCO_2$	• hypoventilation • increased metabolism	• D-fend contaminated • calibration error	• change D-fend • check calibration
waveform clipped		• incorrect scaling	• change scale
no response to breathing	• apnea • (disconnection)	• sampling line or water trap loose or blocked (air leak) • sample gas outlet blocked	• check all connections • check that outlet is open
$ETCO_2$ overscale >15% (>20%) Shown until 32%, specified range 0...15%	• abnormally high $ETCO_2$ (permissive hypercapnia)	• CO_2 sensor contaminated • D-fend malfunction	• call service technician • change D-fend
$ETCO_2$>$PaCO_2$	• unit is mmHg or kPa and $ETCO_2$ is close to arterial PCO_2	• Dry gas as default	• change to Wet gas by using ***Install/Service*** menu

4.1.2 Patient spirometry

Problem	Possible clinical cause	Possible technical cause	What to do
insp TV>exp TV	• leak in lungs • ET tube cuff leak	• spirometry tube leak • water inside D-lite or tubings • another side stream gas sampling between D-lite and patient • D-fend leaks	• check leakages -- perform leak test • change tubings and D-lite • do not use active humidification • connect gas sampling only and always to D-lite • check D-fend
exp TV> insp TV		• spirometry tube leak	• check leakages -- perform leak test
		• water inside D-lite or tubings	• change tubings and D-lite • do not use active humidification
loop overscale monitored volumes < set volumes		• wrong scale selected • leak between ventilator and D-lite	• change scaling • check ventilator connections
strongly vibrating loop too large or too small volumes	• mucus in ET tube	• - • water or secretions in hoses or D-lite • wrong mode vs. sensor selection • incorrect sensor type selection	• check the patient status • change dry D-lite and/or empty the water from hoses • check mode and sensor - D-lite for adult - Pedi-lite for pediatric

Problem	Possible clinical cause	Possible technical cause	What to do
fluctuating Raw	• mucus in airways or tubings • breathing effort against the ventilator • patient triggered breathes	• ventilator exp. valve causes fluctuations during exp. flow	• check the tubings and D-fend • check the patient status
too high Raw Raw value invalid	• kink in tubing • mucus • asthmatic patient • bronchospasm • spontaneous breaths • breathing efforts against the ventilator • patient triggered breaths		• check the tubing • check the patient status
too high Ppeak	• bronchospasm • patient is coughing • patient breaths against the ventilator • obstruction in airways • HME obstructed		• check the patient status • check the patient circuit status
Compl value invalid	• spontaneous breaths		• compliance cannot be calculated

4.1.3 Gas exchange

Problem	Possible clinical cause	Possible technical cause	What to do
"Strange" values	• ventilation mode: BiPaP, CPAP with high continuous by-pass flow • presence of N_2O or anesthetic agents in ICU applications		• gas exchange not measurable • do not use N_2O or AA in ICU, or use a E-CAiOVX module
Non physiological VO_2 readings	• unstable O_2 delivery - gas mixer		• select oxygram and verify the stableness of the curve
	• RR over 35/min	• reference gas inlet port blocked	• check reference port
		• gas sampling line longer than 2 m	• change 2 m sampling line
		• dead space of Y-piece > 8 ml	• check the dead space of Y-piece
		• gas sampling line connected to HME	• gas sampling line should ALWAYS be connected to D-lite
		• D-lite incorrectly placed	• do not connect anything between D-lite and Y-piece • ALWAYS connect D-lite between the HME and Y-piece
VO_2 value invalid, no VO_2, FiO_2 > 85%, (FiO_2+FiN_2O) > 85%	• over range • no VO_2 value • 0 ml/min < VO2 < 999 ml/min	• after changing the FiO_2 setting on the ventilator, VO_2 may be out of the specified range for several minutes	• VO_2 cannot be calculated without significant presence of N_2

4.2 Gas sampling system troubleshooting

Faults that may occur in the sampling system include: leaks or blockages in the tubings, failure of the sampling pump or the magnetic valves or diminishing of the flow rates because of dirt or other matter accumulating in the internal tubing.

The following checks should help in locating the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system, check and adjust the flow rate, if necessary.

CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

NOTE: The D-fend water trap should be replaced when the 'REPLACE D-FEND' message appears during monitor startup.

NOTE: If any liquid has entered the TPX measuring unit due to water trap filter failure, contact GE Healthcare Technical Services.

Perform sampling system leak test to check if there is any leakages in the tubing.

4.3 OM measuring unit troubleshooting

CAUTION Due to the complicated and sensitive mechanical construction of the oxygen measuring unit, no repairs should be attempted inside the unit. Instead, if the fault has been found in the measuring unit itself, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.

In cases of no response to O_2 or strong drift, check the tubing for loose connections, blockages and leaks.

CAUTION Never apply overpressure to the O_2 measuring unit, as the pressure transducer may be permanently damaged.

If the O_2 signal is noisy, check the measurement unit suspension.

– TPX measuring unit troubleshooting

CAUTION The TPX measuring unit can only be repaired and calibrated at the factory. In case of failure, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.

4.4 PVX measuring unit troubleshooting

In case of failure, the PVX unit can be replaced.

NOTE: Never apply overpressure or negative pressure of more than 300 cmH_2O to the flow and volume tubing. Also never apply differential pressure of more than 25 mmHg on one PVX connection at a time.

Perform spirometry system leak test to check if there is any leakages in the internal or external spirometry tubing.

4.5 CPU board troubleshooting

Due to the complexity of the large scale integrated circuitry, there are few faults in the CPU digital electronics that can be located without special equipment.

Check only that RAM, EPROM, CPU, and other socketed ICs are properly installed.

4.6 Error messages

Message	Cause
Occlusion or Sample Line Blocked	The sample tube inside or outside the monitor is blocked or water trap is occluded. If occlusion persists, measured gas values disappear.
Continuous occlusion. Check sampling line and D-fend.	Occlusion over 40 seconds.
Check D-fend	-The water trap is not connected -There is a leak in the sampling line inside the module. If air leak persists, measured gas values disappear.
Air leak detected. Check water trap and sample gas out-flow. Press normal screen to continue.	Air leak over 40 seconds.
Replace D-fend (replace water trap)[1)]	Indicates residue build-up on the water trap membrane. This decreases air flow.
Gas calibration is not available during the first 5 minutes/during occlusion/during air leak	Entering calibration is not allowed during 5 minutes after power up and during occlusion or air leak.
Gas out blocked	- Gas out connector on the front panel, or the exhaust line connected to it, is blocked. - If the sample gas is returned to patient circuit, the filter in the return kit may be occluded. - Make sure the sample gas outlet is connected to an open scavenging system only where gas is removed in room pressure.
Select agent[1)]	No agent selected.
Select agent[1)]	Mixture of agent is detected, but no agent is selected.
Check agent[1)]	Agent is selected manually, but it differs from the identified one.
Failure in Agent ID (unknown agent)	The agent ID has failed (due to a third agent).
Overrange	FiO_2 >100% measured.
Recalibration	Time out, fluctivating gases, gain adjusted “over”.
CO2, O2, AA, N2O	
Zero error	Unsuccessful zeroing.
Unstable, Calibr error	Unsuccessful calibration.
Menu messages during calibration:	
Zero error	Unsuccessful zeroing.
Adjust	Calibration gas accepted and monitor is ready for adjusting the gas values to match the calibration gas concentration.
Unstable	Unsuccessful calibration.

1) only with earlier monitor software versions

5 Earlier revisions

There are no earlier revisions of the S/5 Compact Airway Modules, E-CAiOVX, E-CAiOV, E-CAiO, E-COVX or E-CO.

APPENDIX A: Service check form, Compact Airway Modules

Customer		
Service	Module type	S/N
Service engineer		Date

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Fan filter	☐	☐	☐	4. D-fend O-rings	☐	☐	☐
5. Other filters	☐	☐	☐				
Notes							
6. Fan	☐	☐	☐				
7. Module software	GAS						
8. Module configuration	☐	☐	☐	9. Module bus communication	☐	☐	☐
10. Flow measurement offset					±10 ml/min		

	OK	N.A.	Fail		OK	N.A.	Fail
11. Ambient pressure	☐	☐	☐	12. Zero valve	☐	☐	☐
13. Special tubes	☐	☐	☐				
14. Leak test					≤6 mmHg/min		
Notes							
15. Flow rates				Measured value	Allowed range		
Sampling flow (E-CAiOVX/E-COVX)					180...220 ml/min		
Reference flow (E-CAiOVX/E-COVX)					27...40 ml/min		
Reference flow (E-CAiOVX/E-COVX)					27...40 ml/min		
Reference flow (others)					31...45 ml/min		
Zeroing flow					±20 ml/min		
16. Working pressure				Measured value	Allowed range		
Amb-Work					40...75 ml/min		
Amb-Work (E-CAiOVX/E-COVX)					70...115 ml/min		
Notes							
	OK	N.A.	Fail				
17. Gas calibration	☐	☐	☐				
18. Fall time measurement				Measured value	Allowed range		
CO2 fall time					< 400 ms		
O2 fall time					< 400 ms		
CO2-N2O delay					< 800 ms		

AA option		S/N
19. ID unrel.		< 70

Patient spirometry option					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
20. Spirometry System Leak Test	☐	☐	☐	21. Flow waveform	☐	☐	☐
22. Spirometry tester	☐	☐	☐				
Notes							

All modules	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
23. Occlusion detection	☐	☐	☐	24. Air leak detection	☐	☐	☐
25. Apnea detection	☐	☐	☐	26. Final cleaning	☐	☐	☐

Notes

Used spare parts			

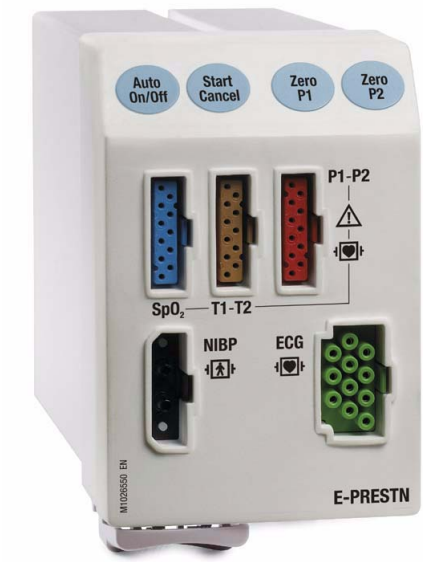
Signature

For Your notes:

Datex-Ohmeda

S/5 Hemodynamic Modules, E-PRESTN, E-RESTN, E-PRETN

Technical Reference Manual Slot



Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EC.

CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner. Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1027824-02

January 19, 2011

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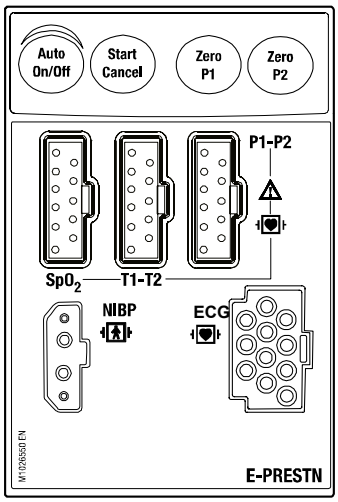
Introduction

This Technical Reference Manual Slot provides information for the maintenance and service of the hemodynamic modules S/5 E-PRESTN/-RESTN/-PRETN. The modules are double width modules designed for use with S/5 monitors. Later in this manual modules may be referred to without S/5 for simplicity.

Please also refer to "Technical Reference Manual" of the monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The E-PRESTN/-RESTN/-PRETN modules provide general hemodynamic parameters.



NOTE: Do not use identical modules in the same monitor simultaneously. All the following modules are considered identical:

E-PRESTN/ -RESTN/ -PRETN,
E-PSM(P)

M-PRESTN/ -RESTN/ -PRETN,
M-NE(12)STPR/ -NE(12)STR/ -NE(12)TPR,
M-ESTPR/ -ESTR/ -ETPR,
M-ESTP/-EST/-ETP

Figure 1 S/5 Hemodynamic Module, E-PRESTN

Table 1 Options of S/5 Hemodynamic modules

	Parameter	PRESTN	RESTN	PRETN
P	Two invasive blood pressures	x		x
R	Impedance respiration	x	x	x
E	ECG	x	x	x
S	Pulse oximetry	x	x	
T	Two temperatures	x	x	x
N	NIBP	x	x	x

NOTE: 12-lead ECG measurement requires Display Controller, B-DISP or B-DISPX.

Intended purpose (Indications for use)

The Datex-Ohmeda PRESTN module (model family E-PRESTN) and accessories are indicated for the monitoring of hemodynamic parameters of all hospital patients. The hemodynamic parameters of the module comprise ECG including ST-segment and arrhythmia, Impedance respiration, NIBP, Temperature, SpO2 (including monitoring during conditions of clinical patient motion), and invasive blood pressure.

Impedance respiration measurement is indicated for patients aged 3 and up. The NIBP measurement is indicated for patients who weigh 5kg (11 lb.) and up. This device is indicated for use by qualified medical personnel only.

Monitor software compatibility

Datex-Ohmeda E-PRESTN Rev. 00 module is designed for use with Datex-Ohmeda monitors using software as follows:
AM: L-ANE04(A) or later versions
CCM: L-ICU04(A) or later versions
CAM: L-CANE04(A) or later versions
CCCM: L-CICU04(A) or later versions

Equipment safety symbols

When displayed on the **E-PRESTN, E-PRETN, E-RESTN** module, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO_2), temperature (T) and invasive pressure (P) measurement

1 Specifications

1.1 General specifications

Module size	75 x 186 x 112 mm
W x D x H	3.0 x 7.3 x 4.4 in
Module weight	0.7 kg / 1.5 lb.
Power consumption	about 6 W
Operation temperature	10 to 40°C / 50 to 104°F

1.2 Typical performance

1.2.1 NIBP

NOTE: Non-invasive blood pressure measurement is intended for patients weighing over 5 kg (11 lb.)

Oscillometric measurement principle.

Measurement range	adult	25 to 260 mmHg
	child	25 to 195 mmHg
	infant	15 to 140 mmHg
Pulse rate range accepted	30 to 250 bpm	
Measurement interval	from 1 min. to 4h	
Typical measuring time	adult	23 s
	infant	20 s
Initial inflation pressure	adult	170 ±10 mmHg
	child	150 ±10 mmHg
	infant	120 ±10 mmHg
Venous stasis	adult	80 ±5 mmHg / 2 min.
	child	60 ±5 mmHg / 2 min.
	infant	40 ±5 mmHg / 1 min.
Cuff widths	see User's Guide	

Venous stasis pressure may be lower than the values above if the patient has low blood pressure. The venous stasis pressure adapts to the measured mean pressure being the same as mean pressure but always at least the following:

	Infant 20 ± 5 mmHg
	Child 30 ± 5 mmHg
	Adult 40 ± 5 mmHg
Overall system accuracy:	Meets or exceeds SP10-2002 AAMI standards[1]

1.2.2 ECG

Lead selection	I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6
Sweep speeds	12.5, 25, 50 mm/sec.

Display filter

Diagnostic	0.05 to 150 Hz
Monitoring	0.5 to 30 Hz (-3 dB, with 50 Hz reject filter) 0.5 to 40 Hz (-3 dB, with 60 Hz reject filter)

1 (According to SP10-2002 AAMI 4.4.5.2.B, Intra-arterial method as the reference standard, mean difference of the test system and the comparison system shall be ± 5 mmHg or less with standard deviation of 8 mmHg or less).

ST filter	0.05 to 30 Hz (-3 dB, with 50 Hz reject filter) 0.05 to 40 Hz (-3 dB, with 60 Hz reject filter)

Heart rate from ECG

Range	30 to 250 bpm
Accuracy	±5 bpm or ±5%, whichever is greater
Resolution	1 bpm
Update interval	5 s
Averaging time	5 s

ST levels (in main software)

ST level range	-9 to +9 mm (-0.9 to +0.9 mV)
Resolution	0.1 mm (0.01 mV)
Averaging	calculated from 8 QRS complexes

Pacemaker pulse detection

Detection level	2 to 700 mV
Pulse duration	0.5 to 2 ms

The monitor is specified for both of the methods A and B in ANSI/AAMI EC13 4.1.4.2.

Synchronization- signal to the module bus

Direct ECG	analog output of ECG, 1 V/1 mV
Pacer	5 V and 0.5 to 2.5 ms pulse, < 30 ms after pacer peak
Defibrillator	5 V and 10 ms pulse, < 35 ms after R-point synchronization

1.2.3 Pulse oximetry

Measurement range	0 to 100%
Calibration range	70 to 100%
Accuracy[1]	100 to 70%, ±2 digits ±3 digits during clinical patient motion 69 to 0%, unspecified
Display resolution	1 digit = 1% of SpO_2
Display averaging time	Slow, Normal, beat-to-beat
Pulse beep pitch	varies with SpO_2 level

The monitor is calibrated against functional oxygen saturation SpO_2 func.

Pulse rate from Pleth

Measurement range	30 to 250 bpm
Accuracy	30 to 100, ±5 bpm, 100 to 250, ±5%
Resolution	1 bpm
Display averaging	10 s

Adjustable pulse beep volume.

Pleth waveform

Scales	2, 5, 10, 20, 50 mod%, Auto

Start up scale is 20 mod% if AUTO is not selected to be the default setting.

1.2.4 Temperature

Measurement range	10 to 45 °C (50 to 113 °F)
Measurement accuracy	±0.1 °C (25 to 45.0 °C) ±0.2 °C (10 to 24.9 °C)
Display resolution	0.1 °C (0.1 °F)
Temperature test	automatic (every 10 min.)

1 Accuracy is based on deep hypoxia studies with volunteered subjects during motion and non-motion conditions over a wide range of arterial blood oxygen saturation as compared to arterial blood CO-Oximetry. Accuracy may depend on the sensor used, please refer to the instructions for use in the accessory package.

Probe type	compatible with YSI 400 series
Single use sensors	±0.3 °C (25 to 45.0 °C) ±0.4 °C (10 to 24.9 °C)

1.2.5 Invasive blood pressure

Measurement range	-40 to 320 mmHg
Measurement accuracy	±5% or ±2 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±25%
Scales	upper limit is adjustable between 10 and 300 mmHg in steps or 10. Lower limit is 10% of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s

Digital display

Range	-40 to 320 mmHg
Resolution	±1 mmHg

Waveform display

Range	-30 to 300 mmHg

Pulse rate from arterial pressure

Measurement range	30 to 250 bpm
Resolution	1 bpm
Accuracy	±5 bpm or ±5% whichever is greater

1.2.6 Respiration

The EMC immunity of the respiration measurement has been tested with 1 Vrms and 1 V/m. This level has been used for optimizing the immunity of the respiration measurement to damp the operating frequency of the electrosurgery equipment.

NOTE: Impedation respiration measurement is intended for patients over three years old.

Measurement range	4 to 120 breath/min
Accuracy	±5 breath/min or ±5%
Resolution	1 breath/min
Averaging time	30 s
Update interval	10 s

Respiration waveform

Sweep Speeds	6.25 mm/s and 0.625 mm/s

1.3 Technical specifications

1.3.1 NIBP

Deflation rate, PR dep.	3 to 8 mmHg/s
Inflation time	20 to 185 mmHg, 1 to 5 s

Automatic software control, max. inflation pressure

adult	280 ±10 mmHg
child	200 ±10 mmHg
infant	140 ±5 mmHg

Over pressure limit, stops measurement after 2 seconds

adult	320 mmHg
child	220 mmHg
infant	160 mmHg

The safety circuit limits the maximum cuff pressure to 320 mmHg in adult/child mode or to 160 mmHg in infant mode. Independent timing circuit limits the pressurizing (>15 mmHg) time to 3 minutes maximum in adult/child mode, and to 90 seconds at (>5mmHg) in infant mode.

Zeroing to ambient pressure is done automatically.

Inflation pressure is adjusted according to the previous systolic pressure, typically 40 mmHg above. If the systolic pressure is not found, the inflation pressure is increased typically 50 mmHg.

Max. measurement time	adult	120 s
	child	120 s
	infant	75 s

Pressure transducer accuracy is better than ±3 mmHg or ±2% whichever is greater.

Max. error	±4 mmHg.
Protection against electrical shock	Type BF defibrillator-proof

1.3.2 ECG

Defibrillation protection	5000 V, 360 J
Recovery time	5 s
Input impedance	>2.5 MΩ (10 Hz)
CMRR	>100 dB (ST)
System noise	<30 mV (p-p, RTI)
Allowable offset	±1VDC
Gain range	0.2 to 5.0 cm/mV
Pacemaker pulse detection	2 to 700 mV, 0.5 to 2 ms pulses
Protection against electrical shock	Type CF defibrillator-proof

1.3.3 Pulse oximetry

Protection against electrical shock	Type CF defibrillator-proof

1.3.4 Temperature

Measurement accuracy	±0.1 °C (25.0 to 45.0 °C) ±0.2 °C (10.0 to 24.9 °C)
Protection against electrical shock	Type CF defibrillator-proof

NOTE: The accuracy of the measurement may be different from the specified, depending on the transducer/probe used. Please refer to the transducer/probe specification.

1.3.5 Invasive blood pressure

Digital display averaging

Digital displays Art and P1 are averaged over 5 seconds and updated at 5 seconds intervals. All other pressures have respiration artifact rejection.

Accuracy	±5% or ±2 mmHg, whichever is greater
Transducer and input sensitivity	5 µV/V/mmHg
Filter	0 to 4 - 22 Hz adjustable
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg
Zero time	less than 15 s
Protection against electrical shock	Type CF defibrillator-proof

NOTE: The accuracy of the measurement may be different from the specified, depending on the transducer/probe used. Please refer to the transducer/probe specification.

1.3.6 Respiration

Excitation frequency, 12-lead ECG	31.25 kHz
Breath detection	automatic, manually adjustable minimum detection: 0.2, 0.4, 0.6, 0.8, 1.0
Input dynamic range	0.2 to 20 Ω
Input impedance range	100 to 5000 Ω
Respiration Rate	min. 4 breath/min max. 120 breath/min
Lead off detection	>3 MΩ

2 Functional description

2.1 Measurement principle

2.1.1 NIBP

NIBP (Non-Invasive Blood Pressure) is an indirect method for measuring blood pressure.

The NIBP measurement is performed according to the oscillometric measuring principle. The cuff is inflated with a pressure slightly higher than the presumed systolic pressure, and deflated at a speed based on the patient's pulse, collecting data from the oscillations caused by the pulsating artery. Based on these oscillations, values for systolic, mean, and diastolic pressures are calculated.

The following parts are necessary for the NIBP measurement:

- a multiparameter hemodynamic module
- twin hose (adult or infant model)
- blood pressure cuffs (various sizes)

2.1.2 ECG

Electrocardiography analyzes the electrical activity of the heart by measuring the electrical potential produced with electrodes placed on the surface of the body.

ECG reflects:

- electrical activity of the heart
- normal/abnormal function of the heart
- effects of anesthesia on heart function
- effects of surgery on heart function

See the "User's Guide" or the "User's Reference Manual" for electrodes' positions and other information.

2.1.3 Pulse oximetry

A pulse oximeter measures the light absorption of blood at two wavelengths, one in the near infrared (about 940 nm) and the other in the red region (about 660 nm) of the light spectrum. These wavelengths are emitted by LEDs in the SpO_2 probe, the light is transmitted through peripheral tissue and is finally detected by a PIN-diode opposite the LEDs in the probe. The pulse oximeter derives the oxygen saturation (SpO_2) using an empirically determined relationship between the relative absorption at the two wavelengths and the arterial oxygen saturation SaO_2.

In order to measure the arterial saturation accurately, pulse oximeters use the component of light absorption giving variations synchronous with heart beat as primary information on the arterial saturation.

A general limitation of pulse oximetry is that due to the use of only two wavelengths, only two hemoglobin species can be discriminated by the measurement.

The modern pulse oximeters are empirically calibrated either against fractional saturation SaO_2frac;

$$SaO2frac = \frac{HbO2}{HbO2 + Hb + Dyshemoglobin}$$ Formula 1

or against functional saturation SaO_2func;

$$SaO2func = \frac{HbO2}{HbO2 + Hb}$$ Formula 2

Functional saturation is more insensitive to changes of carboxyhemoglobin and methemoglobin concentrations in blood.

The oxygen saturation percentage SpO_2 measured by the Datex-Ohmeda module is calibrated against functional saturation SaO_2func. The advantage of this method is that the accuracy of SpO_2 measurement relative to SaO_2func can be maintained even at rather high concentrations of carboxyhemoglobin in blood. Independent of the calibration method, pulse oximeters are not able to correctly measure oxygen content of the arterial blood at elevated carboxyhemoglobin or methemoglobin levels.

Plethysmographic pulse wave

The plethysmographic waveform is derived from the IR signal and reflects the blood pulsation at the measuring site. Thus the amplitude of the waveform represents the perfusion.

Pulse rate

The pulse rate calculation is done by peak detection of the plethysmographic pulse wave. The signals are filtered to reduce noise and checked to separate artifacts.

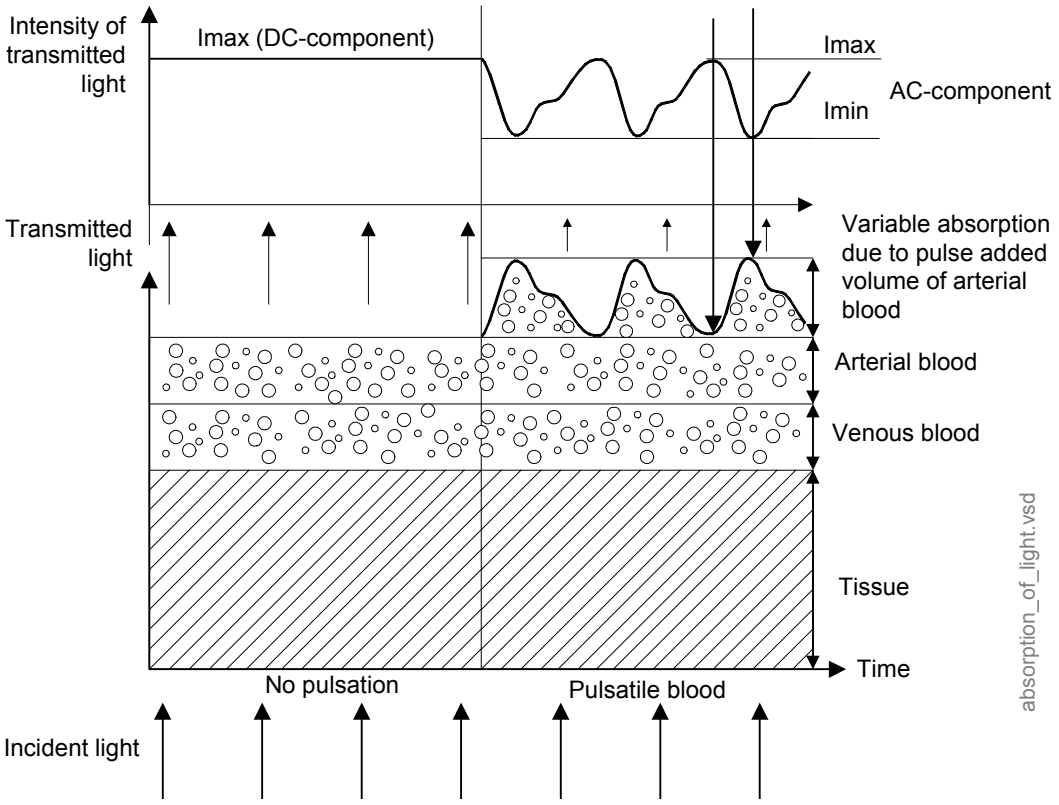


Figure 2 Absorption of infrared light in the finger

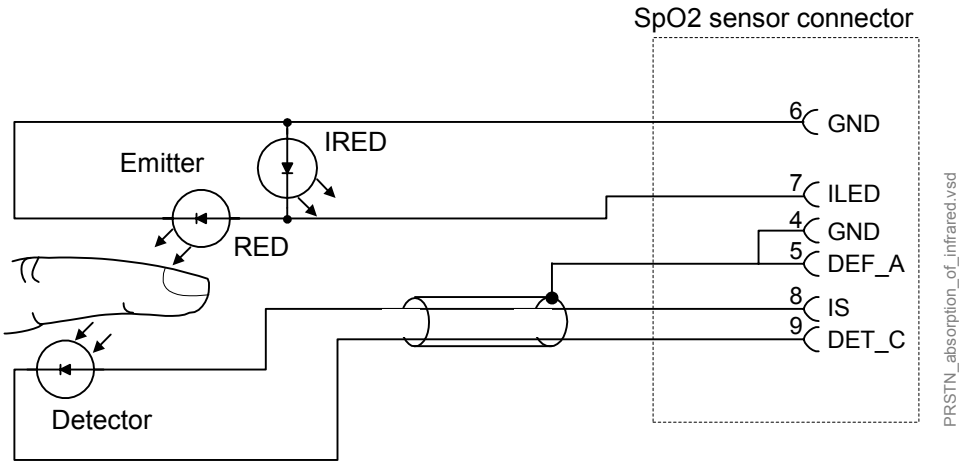


Figure 3 Pulse oximetry probe parts layout and schematic diagram

The standard probe is a finger clamp probe which contains the light source LEDs in one half and the photodiode detector in the other half. Different kinds of probes are available from GE Healthcare.

2.1.4 Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called NTC (Negative Temperature Coefficient) resistor.

The resistance can be measured by two complementary methods:

- Applying a constant voltage across the resistor and measuring the current that flows through it.
- Applying a constant current through the resistor and measuring the voltage that is generated across it.

In Datex-Ohmeda modules the two methods are combined in the form of a voltage divider. The NTC-resistor is connected in series with a normal resistor and a constant voltage is applied across them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

2.1.5 Invasive blood pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of a connecting tubing, a pressure transducer, an intravenous bag of normal saline, all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

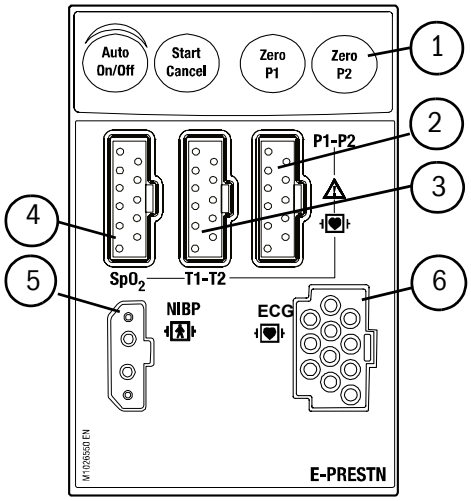
The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

2.1.6 Respiration

Impedance respiration is measured across the thorax between ECG electrodes. The respiration signal is made by supplying current between the electrodes and by measuring the differential current from the electrodes. The signal measured is the impedance change caused by breathing. The respiration rate is calculated from these impedance changes, and the respiration waveform is displayed on the screen.

2.2 Main components

2.2.1 E-PRESTN/-RESTN/-PRETN modules



1. Module keys
2. InvBP connector in E-PRESTN, E-PRETN
3. Temperature connector
4. SpO_2 connector in E-PRESTN, E-RESTN
5. NIBP connector
6. ECG and impedance respiration connector

Figure 4 Front panel of E-PRESTN

The E-PRESTN, E-RESTN and E-PRETN modules contain three main PC boards, the STP board, the ECG board, and the NIBP board. Each of these boards contain a processor and software in the processor flash memory. The boards produce their own supply voltages from the Vmod 13.8-16 V line that is available via the module bus connector. One exception, the NIBP board provides +5V for the ECG and STP board non-isolated side components. The NIBP board provides also the synchronization signal for the ECG and STP board power supplies.

There are two input boards; the STP input board attached to the front panel of the module and the ECG input board in its own housing. The front panel has five connectors and four keys. There is one connector for two temperature measurements, one for two invasive blood pressure measurements, one for ECG, one for NIBP, and one for SpO_2 measurement. The NIBP connector includes two plungers for NIBP hose identification. The keys are for NIBP Auto On/Off, NIBP Start/Cancel, P1 zero, and P2 zero.

2.2.2 NIBP board

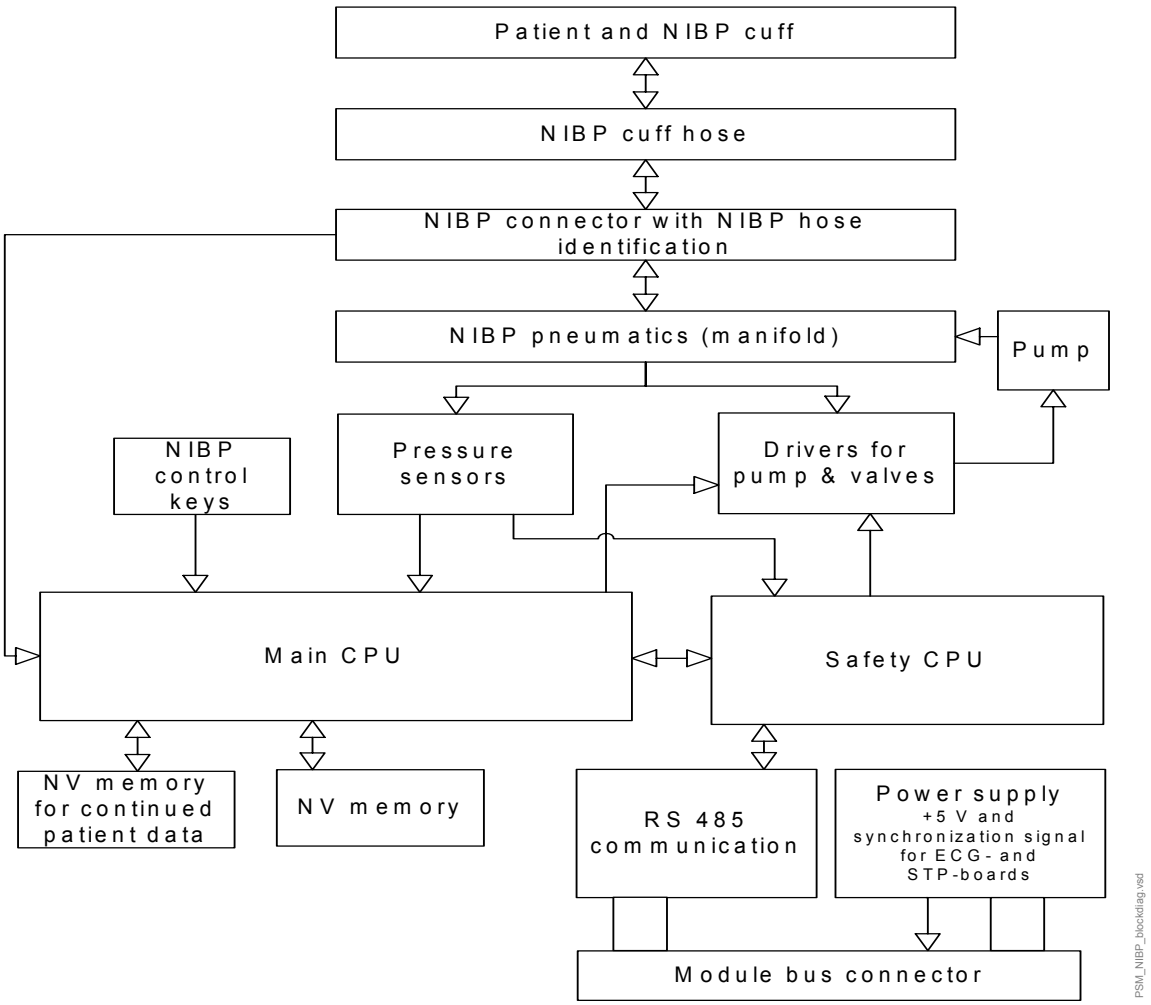


Figure 5 NIBP board functional block diagram

Signal processing

Two signals from the pressure transducers are amplified and sent to the A/D converter. After the converter, digitized signals are sent to the microprocessor for data processing.

The NIBP board is controlled with an H8/3052 microprocessor at 16 MHz oscillator frequency.

Memory

The NIBP program memory (processor flash memory) size is 512k x 8. The processor has 4 kBytes RAM and there is also an external RAM memory, the size of which is 128k x 8. Variable values of the NIBP measurement are stored into the external RAM. The EEPROM size is 512 x 8 and it is used to store the calibration values for the pressure transducers, the pulse valve constants gained during measurements, the PC board identification, and the module serial number.

Software control

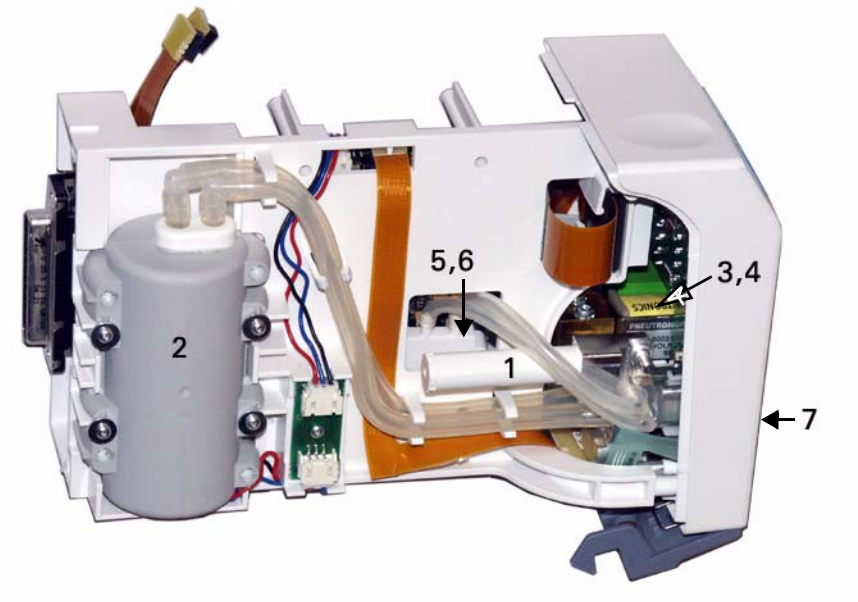
The software controls valves and a pump. In addition to the individual on/off signals for each component there is a common power switch for the valves and the pump that can be used at pump/valve failures.

In addition to external RS485 reset line, the microprocessor system is equipped with its own power-up reset. See the section in the ECG board's description: "RS485 communication"

Safety circuit

The NIBP board is equipped with an independent safety circuit to disconnect supply voltages from the pump and the valves if the cuff has been pressurized longer than the preset maximum measurement time, or if the pressure of the cuff is inflated over the specified pressure limit. The maximum measurement time values and pressure limits for different measurement modes have been specified in the technical specification section of this manual.

Pneumatics



The module has the following pneumatics parts:

1. **Intake air filter**; for preventing dust and other parts from entering the air pump and the valves.
2. **Air pump**; for pumping the measuring pressure of the cuff.
3. **(Pulse) Valve**; for producing a linear pressure fall (bleeding) in order to measure the blood pressure of the patient.
   Note that in the service menu also names **Valve** and **Set valve** have been used for this valve.
4. **Safety valve**; The safety valve is intended to be used for deflating the cuff in single fault case, i.e. to prevent too long a measurement time or too high an inflation pressure of the cuff.
   Note that lso **Exh2 valve** has been used to designate the **Safety valve** in service menu.
5. **Main pressure sensor**; for measuring the pressure of the blood pressure cuff and the pressure fluctuations caused by arterial wall movement.
6. **Safety pressure sensor;** for detecting the , cuff loose, cuff occlusion situations, etc. and for recognizing the pressure sensor fault.
7. **Cuff connector;** for connection and hose identification.

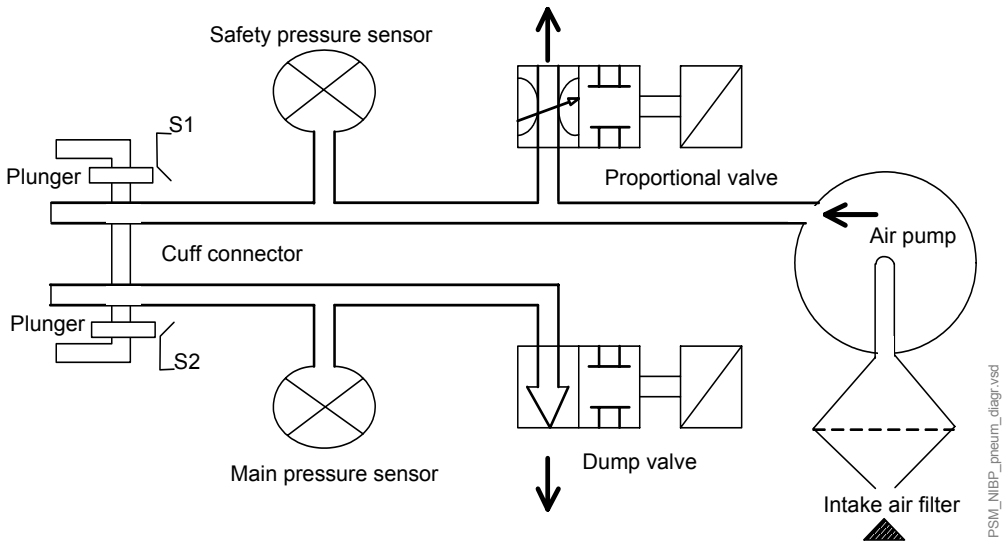


Figure 6 NIBP pneumatics diagram

Power supply section of the NIBP board

All connections are established via a 25-pin connector (D-type, female). The module needs a +15 V (dirty) power supply to operate. The supply voltage (+15V) is generated in the power supply section of the S/5 monitor. The other voltages needed for the operation of the NIBP measurement are made on the NIBP board.

2.2.3 ECG board in 12-lead measurement

The 12-lead ECG measurement consists of the functions shown in Figure 7 on page 15. All functions are located in the ECG board except the ECG input unit.

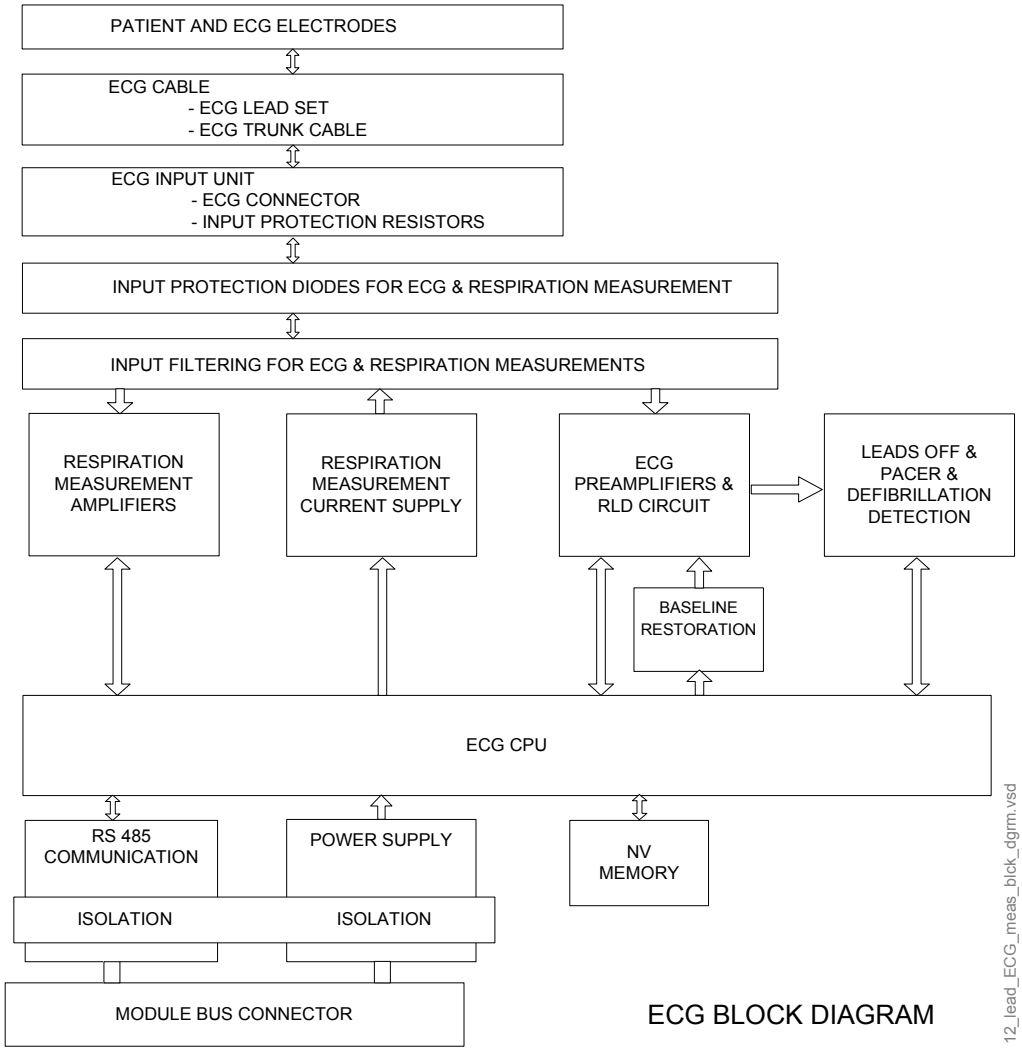


Figure 7 12-lead ECG measurement block diagram

ECG input unit

The ECG input unit consists of the front panel connector and the ECG input connector board with the high voltage protection resistors. The connector for the 12-lead ECG cable is a green 11-pin rectangle shaped connector.

Input protection and filtering

The input protection is implemented with high voltage protection resistors in the ECG input unit and with protection diodes in the ECG board. The input filtering for ECG measurement is done with passive RC filtering.

ECG preamplifiers

The buffer amplifiers are used for each lead. The “Leads off” detection is implemented by measuring the output level of the input buffer amplifiers with the A/D converter of the CPU. The ECG signals are measured using differential amplifiers.

ECG amplifiers and baseline restoration

The function of the ECG amplifiers and baseline restoration is to amplify the signal and to restore the baseline of the signal in the middle of the display after the change of the signal level, e.g. after the change of the DC offset voltage.

Pacer detection

Pacer detection has been made by using four slew rate detector circuits. The pacer detection amplifiers have been realized at the front of the slew rate detectors independently of the ECG measuring channels.

Respiration impedance supply

The 31.25 kHz sine wave generator is used as the respiration measurement signal supply. Analog switches are used for connecting the sine wave to the ECG leads to be measured.

Respiration impedance amplifiers

Buffer amplifiers are used in respiration measurement. Analog switches are used for selecting the measurement leads. There are also additional amplifiers for increasing the respiration signal gain. When ECG measurement is 5/12-lead, the respiration measurement is always done between R and F, independently on the ECG lead selection. When ECG measurement is 3-lead, then the respiration measurement is happened at the same lead as the ECG measurement (I, II or III).

ECG CPU

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

RS485 communication

The communication to the CPU board of the monitor uses RS485 protocol. The RS485 driver circuits are optically isolated from the processor of the module.

Power supply

The ECG board has a driver-controlled half-bridge switching power supply with 5 kV isolation. The supply voltages have been regulated with linear regulators.

2.2.4 ECG filtering

Datex-Ohmeda S/5 monitors have three ECG filtering modes:

MONITORING	0.5 to 30 Hz (with 50 Hz reject filter) 0.5 to 40 Hz (with 60 Hz reject filter)
DIAGNOSTIC 12-lead ECG	0.05 to 150 Hz
ST FILTER	0.05 to 30 Hz (with 50 Hz reject filter) 0.05 to 40 Hz (with 60 Hz reject filter)

The purpose of filtering is to reduce high frequency noise and low frequency (e.g. respiratory) movement artifacts.

The monitor filter is used in normal monitoring. The diagnostic filter is used if more accurate diagnostic information is needed. The ST filter gives more accurate information of ST segment, but reduces high frequency noise.

The high-pass filters 0.5 Hz and 0.05 Hz are done with software. The monitor sends a command to the hemodynamic module determining which of the corner frequencies 0.5 Hz or 0.05 Hz is to be used.

The 50 Hz and 60 Hz reject filters are both low-pass filters with zero at 50 Hz or 60 Hz correspondingly. They are software based filters used for the mains supply filtering. With these filters the 3 dB value for low-pass filter is 30 Hz or 40 Hz.

In diagnostic mode the upper frequency is 150 Hz and it is limited by software.

2.2.5 STP board

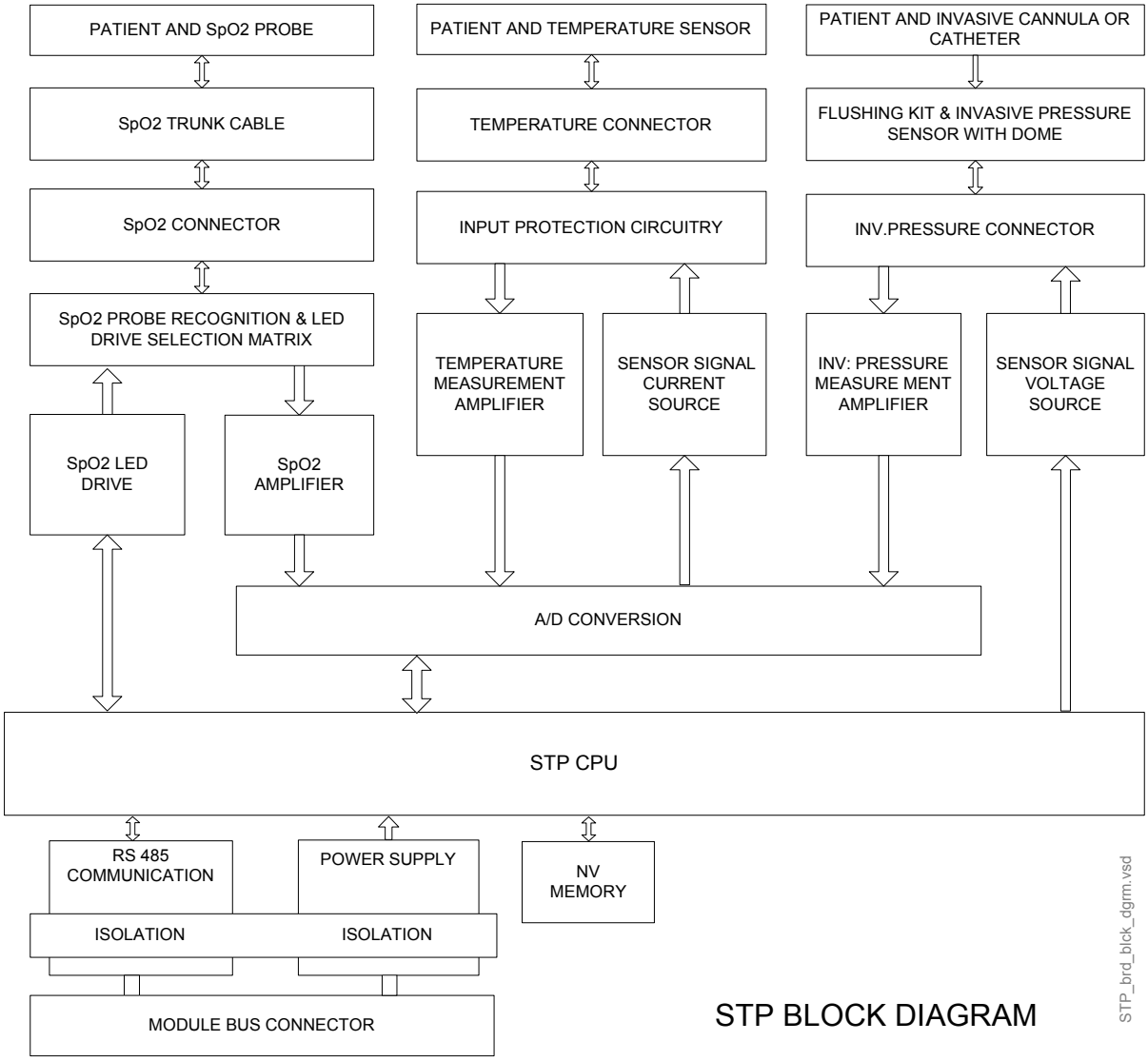


Figure 8 STP board block diagram

Microprocessor unit

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

High speed I/O is used to obtain a pulse control sequence necessary for pulse oximetry measurement. Timing for the clock is from the oscillator.

Temperature measurement unit

The NTC-resistor value in the probe depends on the patient's temperature. It is measured with the following principle described below.

The constant current source is supplied about 38 μA current through the temperature sensor (YSI 400-series NTC resistor). The constant current is caused a voltage over the temperature sensor (NTC resistor). The voltage over the temperature sensor is amplified in a differential amplifier stage. The amplified voltage is transferred to a controller of the STP board through an A/D converter.

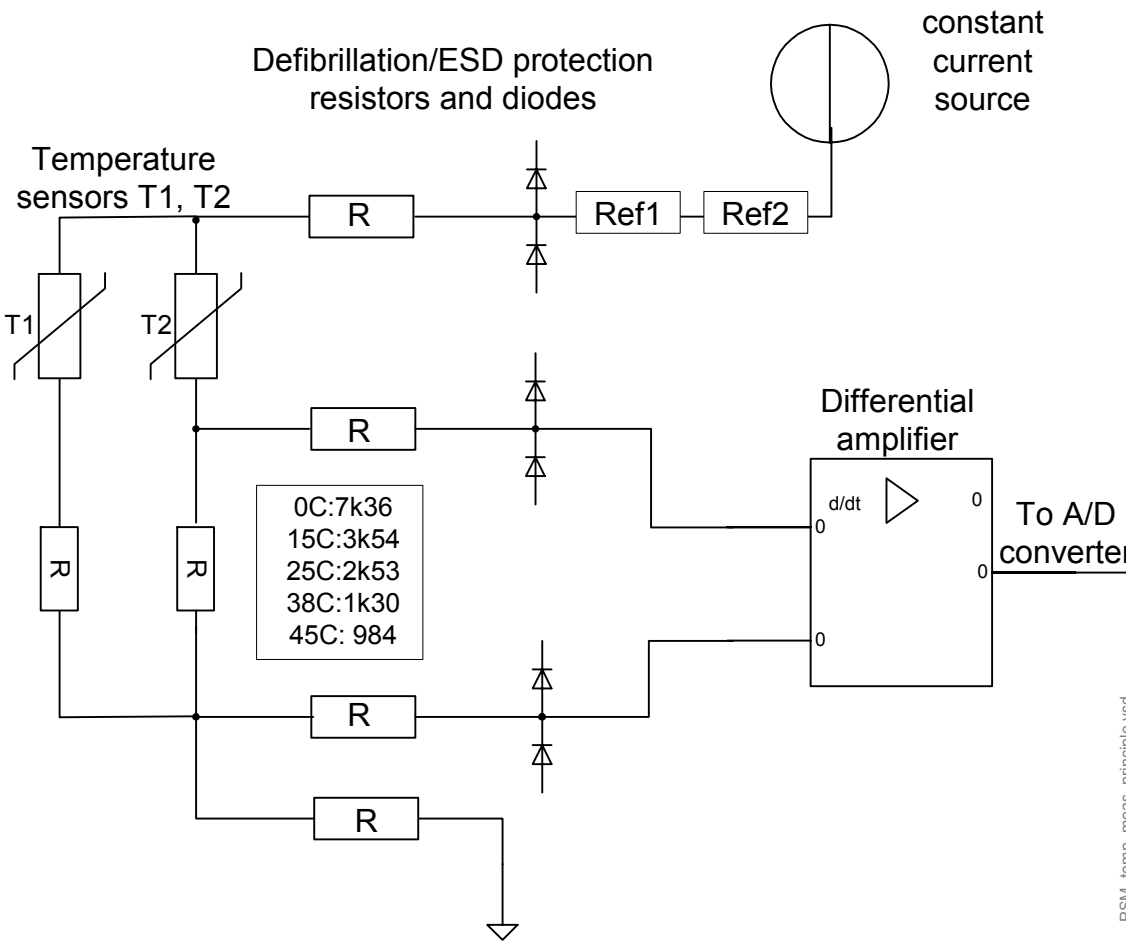


Figure 9 Temperature measurement principle

Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. The differential voltage, which depends on the pressure and the supplied voltage, is calculated from the bridge connection (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\ \mu V$, where U_{in} is 5 V

$\Rightarrow U_{out} = 25\ \mu V \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set to keep the level of the signal transferred to the A/D converter within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

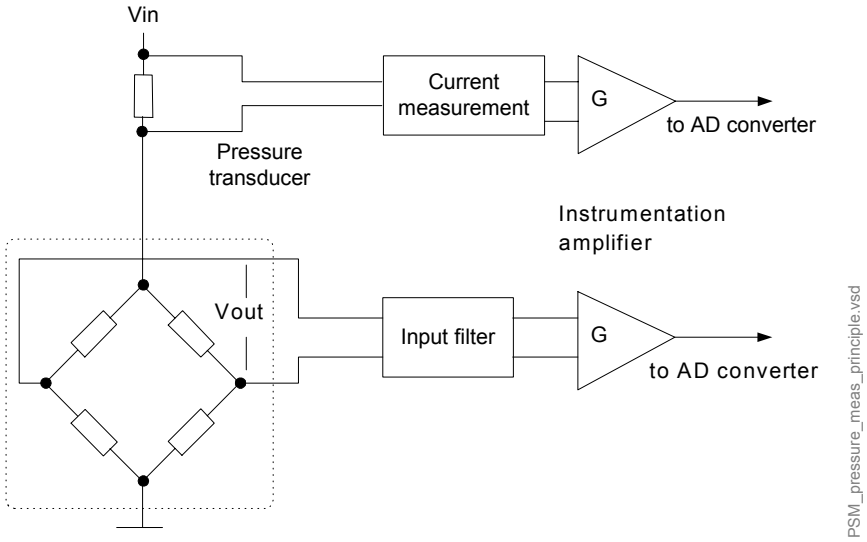


Figure 10 Pressure measurement principle

Pulse oximetry measurement section

LED control signals

The D/A converters of the microcontroller on the STP board set the LED intensity adjustment values for the infrared and red LEDs of the SpO_2 probe. The microcontroller on the STP board switches ON (to the adjusted intensity) and OFF the SpO_2 probe LEDs according to the predetermined sequence.

LED driving circuit

Differential amplifiers measure the LED currents (LED current indication) of the SpO_2 probe over the shunt resistors placed in the LED current paths. The LED driving voltages (LED voltage indication) are measured from the driver circuitry. The LED driving circuits also have MOSFET transistor matrix to enable the use of different probe configurations.

Measured signal preamplification

The preamplifier is a bipolar/single-ended current-to-voltage converter with adjustable gain. A higher gain is used for measuring thin tissue. The preamplification stage has also ambient light reduction and a second amplifier stage.

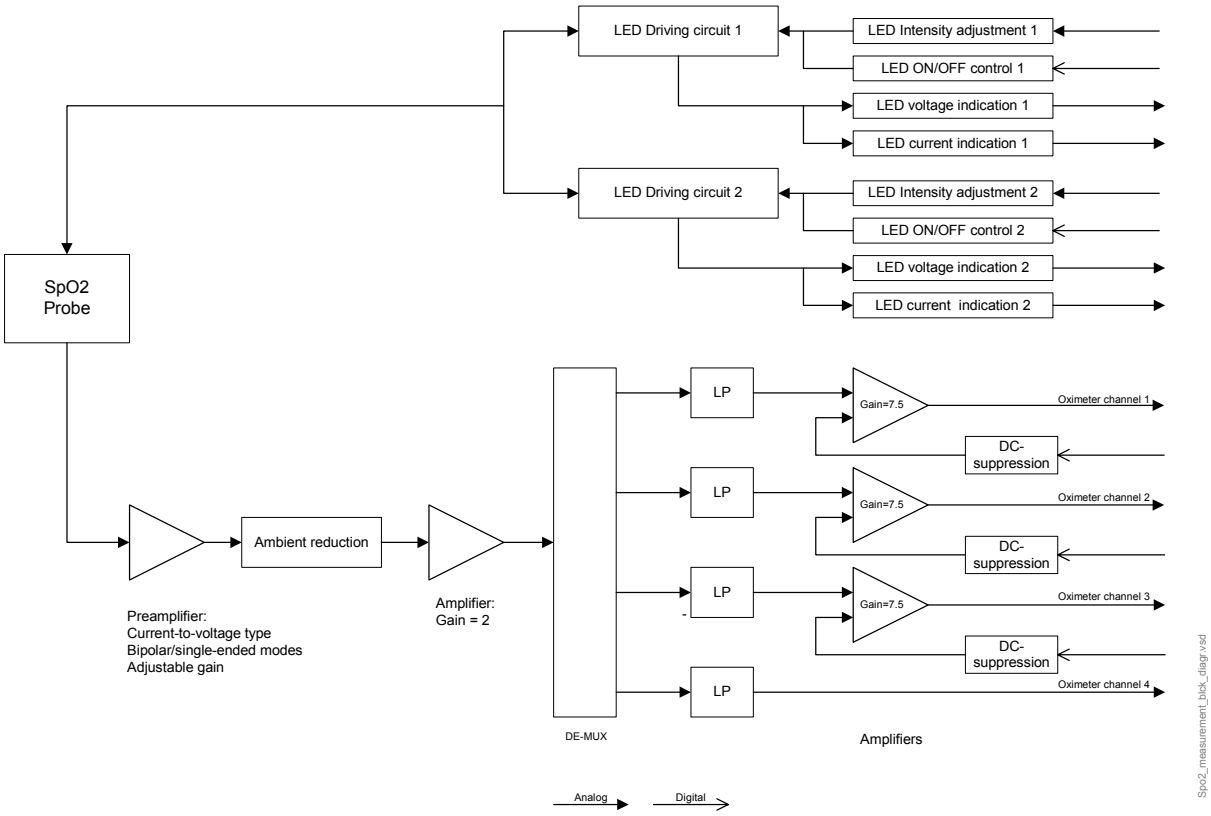


Figure 11 Pulse oximetry measurement block diagram

Red and infrared channel separation

It is possible to multiplex the detector signal to four different channels depending on the content of the signal. The detector signal must at least multiplex into infrared and red signals. Other channels are e.g. for diagnostic purposes.

Serial communication

An RS485 type bus driver makes the serial communication between the module and the frame. The data transmission rate is 500kbps.

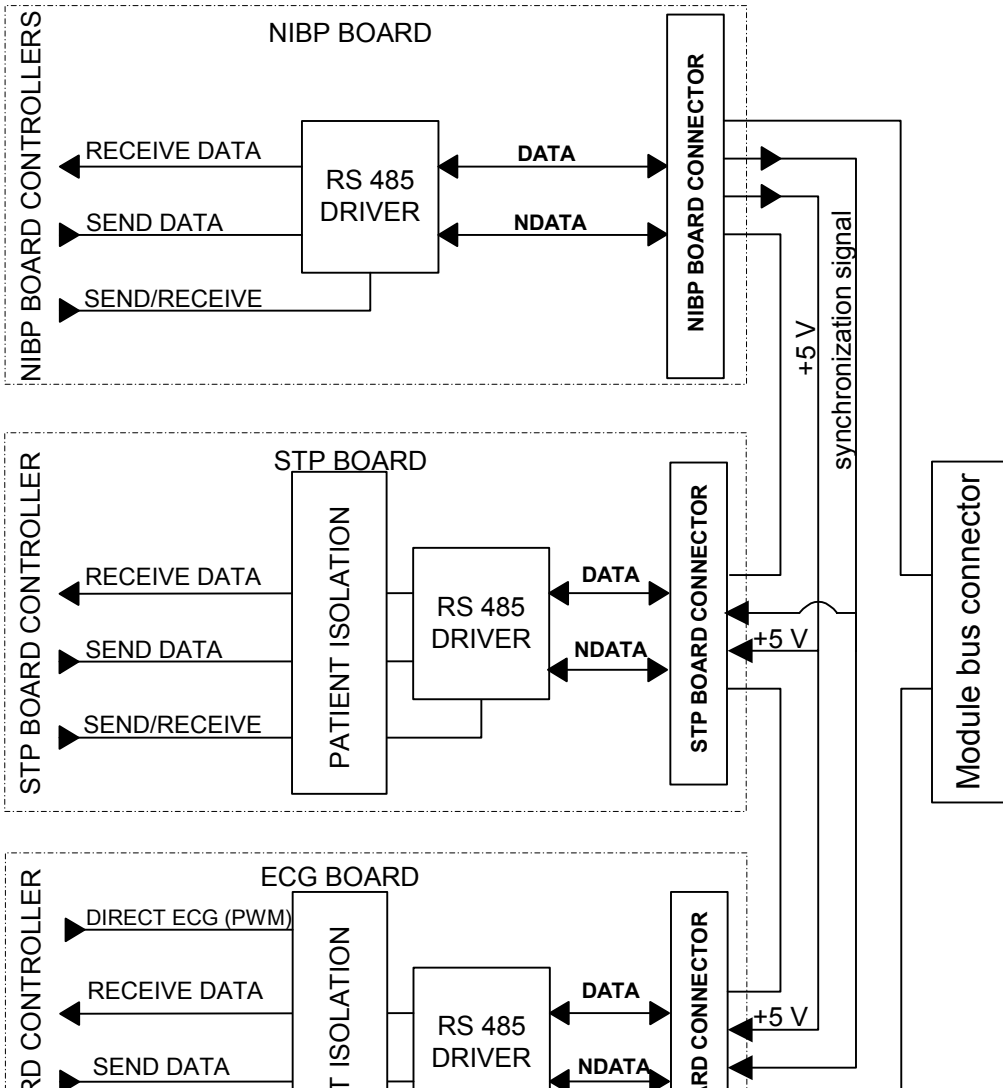


Figure 12 Serial communication of E-PRESTN module

Signals and isolation barrier

The communication signals transfer over the isolation barrier by using high isolation voltage (6kV) opto isolators.

Power supply section

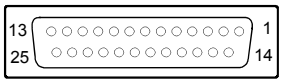
The power for the electronics on the floating part of the STP and the ECG boards is made on each board with the switching power supplies connected to a high voltage isolated transformer. The switching power supplies on the STP and ECG boards are synchronized to the frequency, about 340kHz of the switching power supply on the NIBP board. The NIBP board supplies non-isolated 5 V to the ECG and STP boards. The module uses only Vmod 13.8 - 16 V voltage of the frame. The other voltages of the measuring boards are made by the switching power supplies and regulators or the linear regulators. Each measuring board is protected against overloading with PTC type automatic fuses.

2.3 Connectors and signals

2.3.1 Module bus connector

Only the shaded signals of the table below are valid for the PRESTN module

Table 7 Module bus connector description

Module bus connector (X1)	Pin No.	I/O	Signal	Note
	1	I	RESET_RS485	
	2	I	-15 VDC	
	3	I	+15 VDIRTY	
	4	I	+15 VDC	
	5	I/O	NDATA_RS485	
	6	I/O	DATA_RS485	
	7		Ground & Shield	
	8	I	-RESET_RS485	
	9	I	CTSB	
	10	O	RTSB	
	11	I	RXDB	
	12	O	TXDB	
	13		Ground & Shield	
	14	I	+32 VDIRTY	
	15	I	GroundDIRTY	
	16	I	CTSC	
	17	O	RTSC	
	18	I	RXDC	
	19	O	TXDC	
	20		ON/STANDBY	
	21	O	PWM_ECG	
	22		RXDD_RS232	
	23		TXDD_RS232	
	24	I	+5 VDC	
	25	I	+5 VDC	

2.3.2 Front panel connectors

Table 8 ECG connector

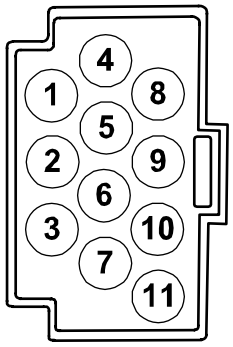
ECG Connector	Pin No.	Signal Name
	1 2 3 4 5 6 7 8 9 10 11	R/RA; Right arm electrode C2/V2; Chest electrode C3/V3; Chest electrode L/LA; Left arm electrode N/RL; Neutral/Right Leg Drive electrode C1/V1; Chest electrode C4/V4; Chest electrode F/LL; Left Leg electrode C6/V6; Chest electrode C5/V5; Chest electrode Cable Shield

Table 9 SpO_2 connector

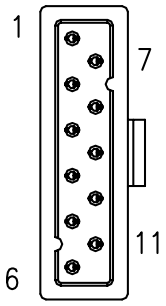
SpO_2 connector	Pin No.	Signal	Description
	1	DET_A	Photodiode anode
	2	DET_C	Photodiode cathode
	3	DATA-	
	4	Wire 1/3	LED connection
	5	IR_C	IR LED cathode
	6	OUTER SHIELD	
	7	DET_SHIELD	
	8	PRB_ID	Bin/ID Resistor+
	9	Wire 3/5	LED Connection
	10	RED_C	RED LED cathode
	11	DATA+	

Table 10 Invasive blood pressure connectors (P1, P2)

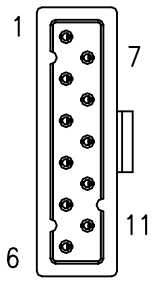
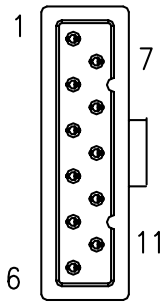
Invasive blood pressure connectors (Dual BP)	Pin No.	Signal	Description
	1	BP_+V_{REF}	BP transducer excitation voltage, channel 1
	2	BP SIG+	BP transducer signal positive (+), channel 1
	3	BP_+V_{REF}	BP transducer excitation voltage, channel 2
	4	AGND	Analog ground
	5	BP SIG+	BP transducer signal positive (+), channel 2
	6	SHIELD	BP cable shield
	7	AGND	Analog ground
	8	BP SIG1	BP transducer signal negative (-), channel 1
	9	BP SIG2	BP transducer signal negative (-), channel 2
	10	BP1_ID	BP1 probe identification
	11	NC	Not connected

Table 11 Temp connector (T1, T2)

Temp connector	Pin No	Signal
	1	Sensor drive current
	2	Input from temperature sensor, channel 1
	3	Not connected
	4	Not connected
	5	Thermistor ID (LOW= Temperature error, HIGH=YSI 400 series)
	6	Cable shield
	7	Analog ground
	8	Input from temperature sensor, channel 2
	9	Not connected
	10	Temperature probe presence identification signal
	11	Digital ground

3 Service procedures

3.1 General service information

The field service of the hemodynamic modules is limited to replacing faulty printed circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair, Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

NOTE: Use only properly maintained, calibrated and traceable measurement equipment for the specified calibrations and adjustments to ensure accuracy.

Table 12 Recommended tools

Tool	Order No.	For product(s)
Hemodynamic patient simulator	M1010831	Hemodynamic modules
Adapter cables for simulators		
- Dual temperature adapter cable	402015-004	Hemodynamic patient simulator and Medsim
- Dual Inv.BP adapter cable	2005772-001	Hemodynamic patient simulator
- Temperature adapter cable	M1010832	Medsim
- Inv.BP adapter cable	M1010858	Medsim
- Temperature adapter cable	M1010846	Lionheart & MPS450
- Inv.BP adapter cable	M1010862	Lionheart & MPS450
Pressure manometer		Hemodynamic modules w/ (P)

Tool	Order No.	For product(s)
Accessories:		
Temperature test set	884515	Hemodynamic modules w/ (T)
Multi-Link ECG accessories, IEC:		
- Multi-link 3-leadwire set	412682-003	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set	412681-003	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set, C2-C6	416467-004	Hemodynamic modules w/ (E)
- Multi-link 12-lead ECG trunk cable	416035-002	Hemodynamic modules w/ (E12)
Multi-Link ECG accessories, AHA:		
- Multi-link 3-leadwire set	412682-001	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set	416681-001	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set, V2-V6	416467-003	Hemodynamic modules w/ (E)
- Multi-link 12-lead ECG trunk cable	416035-001	Hemodynamic modules w/ (E12)
SpO_2 finger probe	OXY-F-UN	Hemodynamic modules w/ (S)
SpO_2 Interconnect Cable	OXY-ES3	Hemodynamic modules w/ (S)
InvBP transducer	70077-001	Hemodynamic modules w/ (P)
Adult NIBP cuff hose with cuff ID	2021285-001	Hemodynamic modules w/ (NIBP)
Adult NIBP cuff	2753E	Hemodynamic modules w/ (NIBP)
Infant cuff hose without cuff ID	414874-001	Hemodynamic modules w/ (NIBP)
Screwdriver		

3.2.2 Recommended parts

Table 13 Recommended parts

Part	Order No.	Notes
NIBP pump filter	57142	

3.2.3 Visual inspection

Detach the module box by removing the two screws from the back of the module.

Check:

1. Internal parts
   - screws are tightened properly
   - connectors are connected properly
   - NIBP tubing is attached properly

– there are no loose objects inside the module

2. External parts
   – the front cover and the front panel sticker are intact
   – all connectors are intact and attached properly
   – the module box and latch are intact

3.2.4 Functional inspection

3. NIBP pump filter

   Replace the NIBP pump filter, if necessary.

   Reattach the module cover and check that the latch is moving properly.

   Switch the monitor on and wait until the monitoring screen appears. Configure the monitor screen so that all the needed parameters are shown, for example as follows:

   Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 1 - ECG1***
   Field 2 - ECG2
   Field 3 - P1
   Field 4 - P2
   Field 5 - Pleth
   Field 6 - Resp
   Digit Fields - Lower Field 2 - NIBP
   Lower Field 3 - T1+T2

4. Module installation

   Plug in the module. Check that it goes in smoothly and locks up properly

5. Module recognition

   Check that the module is recognized, i.e. all the needed parameter information, except invasive blood pressure, starts to show on the screen.

   Preset ECG, Respiration, InvBP and SpO_2 measurement settings:

   ECG - ***ECG Setup - Hr Source - Auto***
   Pacemaker - Show

   Others - ***Resp&Temp Setup - Resp Setup***
   Resp Rate Source - Auto
   Measurement - On
   Detection Limit - Auto

   Invasive Pressures - ***P1 'Art' Setup - Label - Art***
   P2 'Cvp' Setup - Label - Cvp

   PulseOximetry - ***Pleth Scale - Auto***

ECG measurement

6. Module software (serial numbers)

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) -
   Service (password 26-23-8)

   Take down the information regarding the module software by selecting ***Scroll Vers*** and turning the ComWheel.

7. Communication and memories

   Enter the ***Parameters - ESTP:ECG*** service menu.

   Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the ECG/RESP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM state all OK.

8. Power frequency

   Check that the power frequency value is set according to the current mains power frequency. Change the setting by selecting ***Power Freq***, if necessary.

9. Cable recognition

   Connect a 12-lead ECG trunk cable without a lead set to the module. Check that the message 'Leads off' is displayed on the screen.

10. Lead detection

    Connect both 5-leadwire sets to the trunk cable. Connect all the leads together, for example to a suitable screwdriver. Check that all the electrodes show ON and the message 'Asystole' appears. Check that the Cable type shows 10 lead.

    Connect the 10-leadwire set to the simulator. Disconnect one of the leads and check that the corresponding electrode in the service menu shows OFF within 10 seconds of the disconnection, and then reconnect the lead. Check the rest of the leads using the same method. Disconnect the trunk cable.

    Connect a 3-leadwire set to a trunk cable and connect it to the module. Connect all the leads together, for example to a suitable screwdriver. Check that the cable type shows 3 lead.

    NOTE: When any of the limb leads is disconnected, the measurement will automatically change to 3 electrode ECG measurement.

    NOTE: The asystole and different leads off messages are shown using certain priority, Even though one of the leads is disconnected, the related leads off message may not appear on the screen.

    NOTE: When RA, LA , LL or RL electrode is disconnected, all six V electrodes show OFF.

    NOTE: With PRESTN/RESTN/PRETN modules and 5 lead cable, the state of the V electrode is displayed only for the selected V Lead (***ECG Setup - V Lead: V1 - V6)***.

11. Test with the patient simulator

    Connect the leads to a patient simulator.

    Perform the settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    ECG - BASE - BPM - 160
    PACE - WAVE - NSR

    Check that a normal ECG waveform is shown, the HR value is 160 (±5) and the 'Pacer count' -value is not increasing in the service menu.

    ECG - PACE - WAVE - ASNC

    Check that pacemaker spikes are shown on the ECG waveform, the HR value changes to 75 (±5) and the Pacer count value is increasing according to the shown pacemaker spikes.

    Set the pacemaker option off:

    ECG - PACE - WAVE - NSR

Respiration measurement

12. RESP measurement recognition

    Check that Resp Available and RESP Measurement both show ON in the ESTP: ECG service menu.

13. Test with patient simulator

    Check the respiration measurement with a patient simulator.

    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    BASELINE IMPEDANCE -switch - 500
    LEAD SELECT-switch - II/RL-LL

    RESP - WAVE - NORM
    RATE - 20
    OHMS - 1.0
    RATIO - 1/1
    APNEA - OFF
    SHIFT - OFF

    Check that the RESP waveform is shown and the RR value is 20 (±5). Change the position of the BASELINE IMPEDANCE switch and check that appropriate RESP waveform and RR value are shown again within 30 seconds.

    RESP - APNEA - 32 S

    Check that the monitor activates the APNEA alarm.

    NOTE: Make sure that only the ECG leads are connected to the simulator during the apnea test. If other cables are connected at the same time, the respiration signal from the simulator may be disturbed, and therefore, the APNEA alarm may not be activated.

    NOTE: When you have the ECG service menu open, spikes will appear on the respiration waveform. These spikes represent the threshold level for detecting inspiration and expiration.

Temperature measurement

14. Communication and memories

    Enter the ESTP: STP service menu:

    Parameters - ESTP : STP

    Check that the Time-outs, Bad checksums and Bad c-s by mod values do not increase faster than by 5 per second. Check also that the STP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

15. Temperature probe detection

    Check that the 'Cable' and 'Probe' show OFF for both channels, T1 and T2, when no probes are connected.

    Connect the temperature adapter cable to the module temperature connector and a temperature test plug to the adapter cable. Check that the Cable and Probe for T1 show ON and the corresponding temperature value appears on the monitor screen.

16. Calibration check

    Check the temperature calibrations using temperature test plugs.

    If the deviation on a temperature reading on the screen is more than 0.1°C, calibrate the temperature channels according to the instructions in chapter "Temperature calibration" on page 45."

17. Temp test

    Activate the temperature test by selecting ***Temp Test*** from the menu and pressing the ComWheel twice. When the message 'Performing temp test' disappears from the digit field, check that no error messages appear and Temp error shows OFF for both channels in the service menu.

18. Module configuration

    Check that the module configuration has been set correctly. The configuration in use is shown beside the text Configuration in the service menu and it can be either STP, ST or TP. Change the configuration in the ***Calibrations - Set Config*** menu, if necessary. To activate the change, reset the module communication by removing and inserting the module.

Invasive blood pressure measurement

19. Membrane keys

    Check the front panel membrane keys that are related to the InvBP measurement.

    Press each of the keys for at least one second. Check that the pressed key is identified, i.e. one of the texts for Buttons changes from OFF to ON in the service menu.

20. Cable and transducer detection

    Check that the Cable and Probe for P1 show OFF. Connect the InvBP adapter cable to the module, connect a cable with an invasive blood pressure transducer to the adapter cable and check that the Cable and Probe show ON and the corresponding pressure waveform appears on the screen.

    Perform the same check also for the InvBP channel P2.

21. Calibration

    Calibrate the InvBP channels P1 and P2 according to the instructions in chapter "Invasive pressure calibration" on page 46."

22. Test with patient simulator

    Check the InvBP channels with a patient simulator.

    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    SENSITIVITY - switch - 5 µV/V/mmHg

    ECG - BASE - BPM - 60 - BP - 1 - WAVE - ATM

    2 - WAVE - ATM

    Restore the normal monitoring screen by pressing the key **Normal Screen**.

    Connect cables from the channels BP1 and BP2 to the module connectors. Zero the InvBP channels by pressing the keys ZERO P1 and ZERO P2 on the module front panel.

    BP - 1 - WAVE - ART
    2 - WAVE - CVP

    Check that appropriate InvBP waveforms are shown and the InvBP values are approximately 120/80 (±3 mmHg) for the channel P1 and 15/10 (±2 mmHg) for the channel P2.

    Check that the HR value is calculated from P1, when ECG is not measured (ECG cable disconnected).

SpO_2 measurement

23. SpO_2 probe detection

    Check that the message 'No probe' is shown, when no SpO_2 sensor is connected to the module. Connect an SpO_2 finger probe to the module (with the interconnection cable, if needed). Check that the message 'Probe off' is shown when the probe is not connected to a finger.

24. Test measurement

    Connect the SpO_2 probe onto your finger. Check that the reading of 95-99 and SpO_2 waveform appears. Check that the HR value is calculated from SpO_2 when ECG and InvBP (P1) are not measured.

Non Invasive Blood Pressure measurement

25. Communication and memories

    Enter the NIBP module service menu:

    Parameters - NIBP

    Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the NIBP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

26. Membrane keys

    Check the front panel membrane keys.

    Select ***Buttons/Leds***.

    Press each of the two NIBP related membrane keys for at least one second. Check that the pressed key is identified, i.e. the corresponding text changes from OFF to ON in the menu, when the key is released back up again.

27. Pump and valves

    Check the pump and valves.

    Select ***Pneumatics*** from the NIBP menu. Connect a pressure manometer to the NIBP module cuff connector.

    Select ***Start Pump*** and press the ComWheel. Check that the pump turns on and the pressure inside the tubing system starts to increase. Stop the pump by pressing the ComWheel again when the pressure reaches 280 mmHg.

    Select ***Open Exh2***. Press the ComWheel and check that the pressure inside the tubing system starts to drop, then press the ComWheel again. If necessary, turn the pump on again for a moment to increase the pressure inside the tubing system.

    Select ***Set Valve***. Press the ComWheel and set the value under the text Pulse Valve to number 150 by turning the ComWheel. Press the ComWheel again and check that the pressure inside the tubing system starts to drop. Finish the test by selecting ***Previous Menu***.

28. Leak test

    Check the NIBP tubing system for leakages.

    Select ***Calibrations*** from the NIBP service menu.

    Connect the pressure manometer to the NIBP module cuff connector. Start the active leak test from the menu by pressing the ComWheel. The module pumps a pressure of about 290 mmHg and then the pump stops. The max pressure in Adult mode is about 290 mmHg, but in Infant mode only 140mmHg.

    Wait for 15 seconds for the pressure to stabilize then check that the pressure does not drop more than 6 mmHg per one minute. Release the pressure by pressing the ComWheel once more.

29. Calibration check

    Recalibrate the NIBP measurement according to the instructions in chapter "NIBP calibrations" on page 3-44. Remember to set the calibration protection back on after the calibration.

    Disconnect the pressure manometer. Select ***Calibrations*** - ***Calibration Check***. Press the ComWheel and take down the zero offset values for both pressure transducers, B1 and B2. The values should be within ±20 mmHg.

    Connect the pressure manometer to the cuff connector and check the calibration with pressures 100 mmHg, 200 mmHg and 260 mmHg. The zero offset value must be added to the displayed pressure value in order to determine the real pressure.

30. Safety valve functions

    Select ***Safety Valve*** from the NIBP service menu.

    Disconnect the pressure manometer from the NIBP module cuff connector. Connect the NIBP hose and cuff to the NIBP module cuff connector.

    Perform the check with a standard adult cuff that is connected around some round object, for example a calibration gas bottle.

    Select ***Start Test***. Start the adult safety valve test by pressing the ComWheel. Wait until the pump stops and the pressure is deflated.

    Open the cuff connector or disconnect and connect the cuff connector from the module.

    Check the pressure values 'Max press' and '2 s after stop' for both transducers. All the values should be within 270 - 330 mmHg.

    Select ***ADULT***. Press the ComWheel and check that the text changes now to ***INFANT***.

    Select ***Start Test*** and wait until the pump stops and the pressure values on the screen have been updated.

    Open the cuff connector or disconnect and connect the cuff connector from the module.

    Check that the values 'Max press' and '2 s after stop' are all now within 135 to 165 mmHg.

    Return to the normal monitoring mode by pressing **Normal Screen**.

31. Cuff related messages

    Connect an adult NIBP cuff to the cuff connector and disconnect one of its hoses.

    Start NIBP measurement by pressing the key **Start/Cancel** on the module and check that the message 'Cuff loose' appears on the screen within 70 seconds.

    Reconnect the hose and then bend it with your fingers. Restart the measurement and check that the message 'Cuff occlusion' appears on the screen within 70 seconds.

32. Test measurement

    Check that the automatic inflation limits are in use:

    NIBP - ***NIBP Setup - Inflation Limits - Auto - Previous Menu***

    Connect the cuff onto your arm, select ***Start Ven.Stasis*** in the NIBP menu and press the ComWheel. Check that the module identifies the cuff, i.e. the text Adult appears in the NIBP digit field for a short moment.

Keep the pressure inside the cuff for about half a minute in order to find out that the cuff is not leaking, then press the ComWheel again. Select **Normal Screen**.

Disconnect the cuff hose.

33. NIBP hose detection

    Press the **Start/ Cancel** module or side panel key and check that the 'Cuff loose' message appears in the NIBP digit field.
    Attach a NIBP cuff hose without cuff identification and check that the module identifies the hose:

    – The message 'Select inflation limits' appears in the NIBP digit field.
    – When you try to start the measurement, the monitor automatically opens the selections ***NIBP Setup - Inflation Limits.***

All modules

34. Electrical safety check

    Perform an electrical safety check and a leakage current test.

35. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

36. Final cleaning

    Clean the module with suitable detergent.

    Fill in all necessary documents.

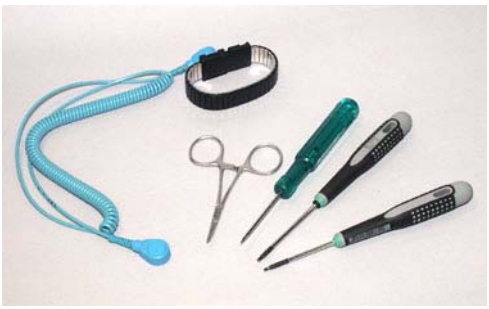
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



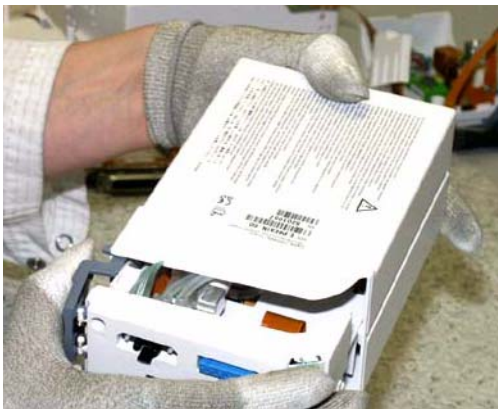
- torx screwdrivers; T6, T8
- flat blade screwdriver
- pincers
- antistatic wristband

CAUTION When reassembling the module, make sure that all cables are reconnected properly.

3.3.3 To disassemble the module

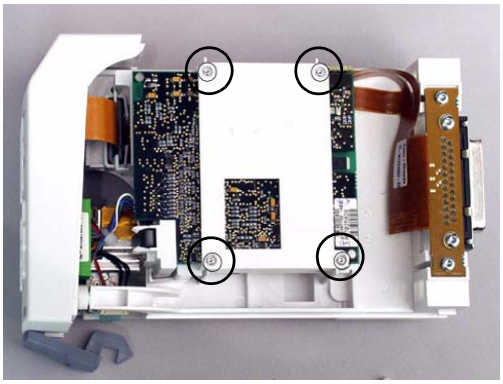
In case you are replacing either the Front chassis unit or the manifold, start by removing the Module Front Cover from the module by releasing the snaps that hold the front cover to the front chassis. Then follow the disassemle instructions

1. Remove the two screws (T8) holding the module cover to the module frame from the back of the module.



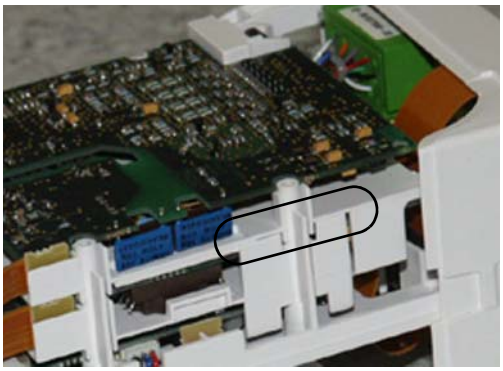
2. While pressing the release latch, pull the module cover slowly backwards and remove it from the main body.

NOTE: When reassembling, be carefull not to damage the membrane keyboard flex. Guide the flex inside the frame and the module casing.

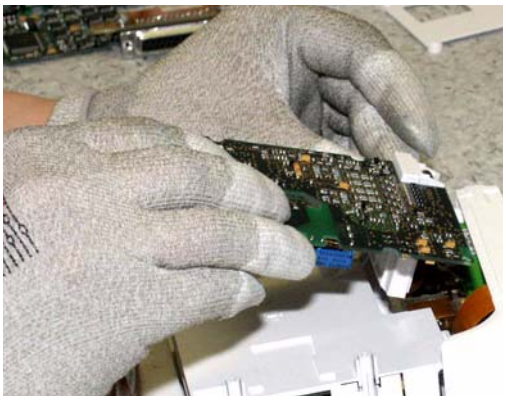


3. To remove the ECG board

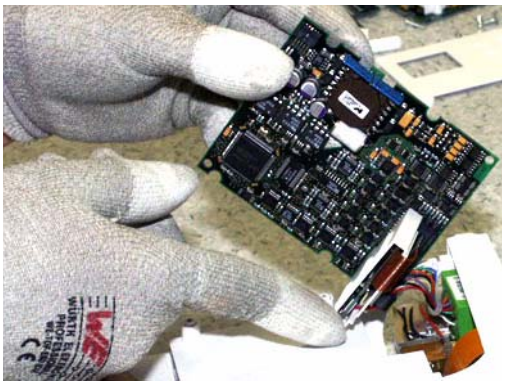
- Remove the four screws (T6) holding the insulator cover and lift the cover up.



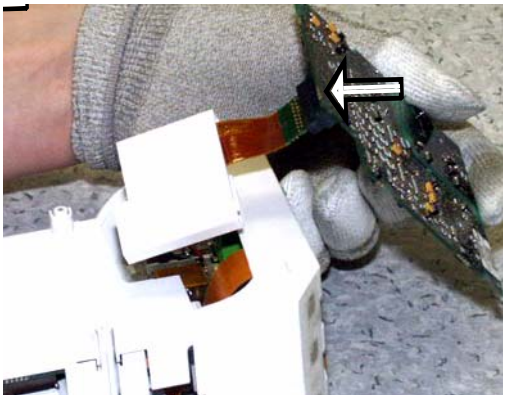
NOTE: When reassembling, push the ECG board a little to ensure that the insulator plates are correctly reassembled. Guide the upper plate inside the lips of the lower plate.



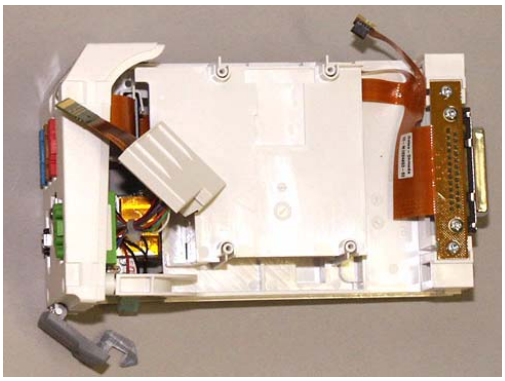
- Lift the ECG board a little and disconnect the module bus connector from the ECG board.
- Carefully lift the board together with the ECG input unit up.



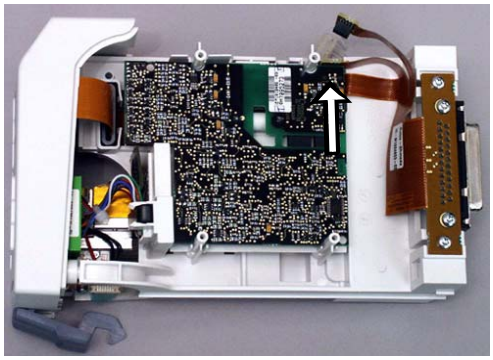
- Turn the ECG board 180 degrees around the input unit.



- Disconnect the ECG input flex connector from the ECG board. Be carefull not to damage the flex.



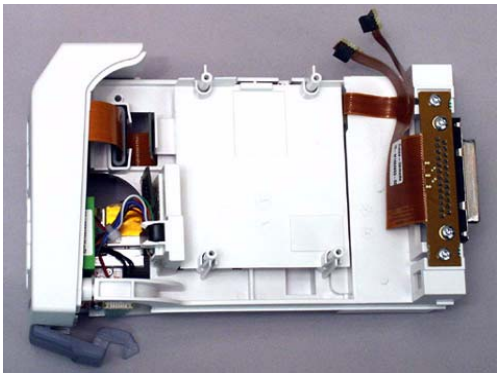
4. To remove the STP board.
- Lift the ECG-STP board insulator plate up.



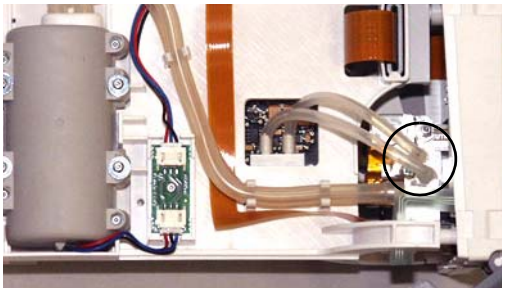
- Disconnect the module bus connector from the STP board.

- Flip the module upside down and disconnect the STP input flex connector through the hole in the module frame. Flip the module over again
- Remove the STP board.

NOTE: When reassembling, be carefull not to damage the STP input flex. Make sure the STP input flex connector is properly connected.

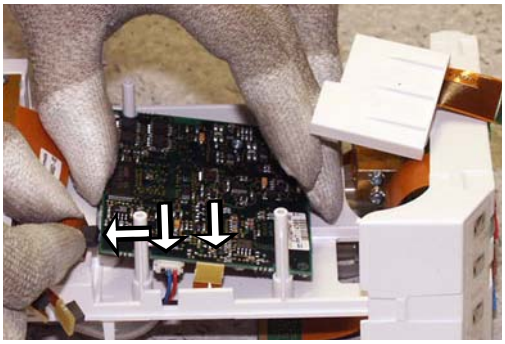


5. To remove the NIBP board:
- Lift the STP-NIBP board insulator plate up.

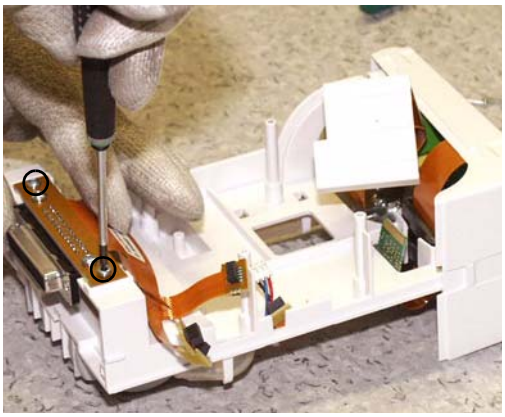


- Flip the module over and disconnect the hoses (2 pcs) coming from the manifold.

NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.



- Flip the module over again. Lift the NIBP board carefully and disconnect the module bus connector, pump connector and NIBP flex connector from the NIBP board.
- Remove the NIBP board.



6. To remove the module bus connector:

- Remove the two screws (T8) holding the connector to the frame.

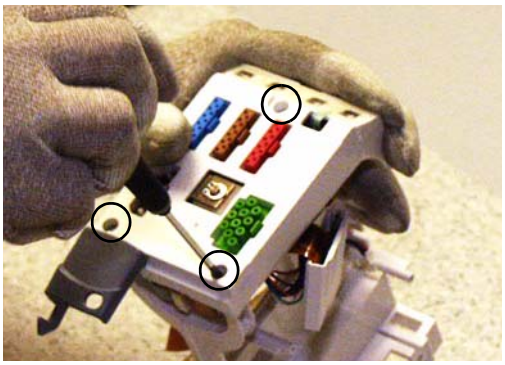
7. To remove the Front Chassis Unit:

- Carefully push/ pull the STP input flex connector through the ferrittes to the other side of the frame. The ferrites should stay in place, if not, remember to reassemble them.

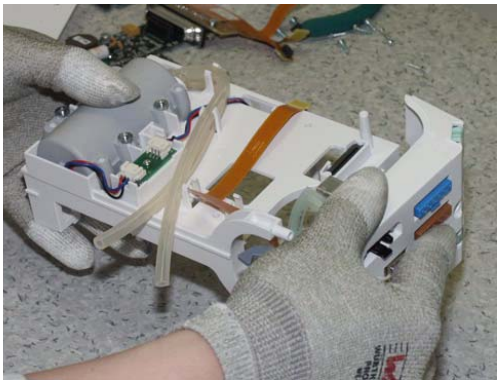
- To release the NIBP flex board:
- Disconnect the hoses (2 pcs) from the manifold and lift them up from the holders to release the NIBP flex board.

NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

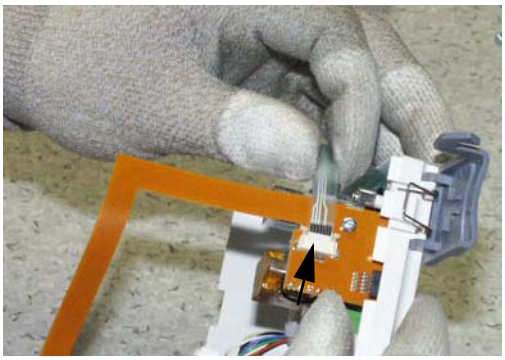
- Pull the NIBP flex board through the frame.



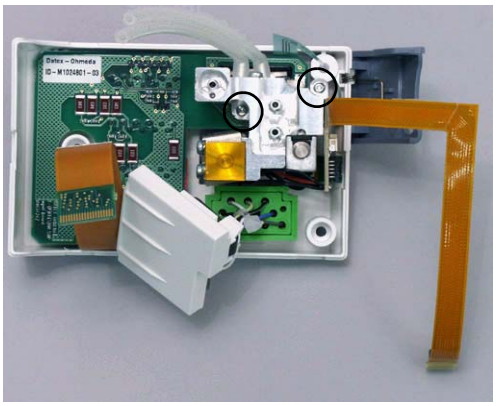
- Remove the three screws (T8) holding the front chassis to the module frame.



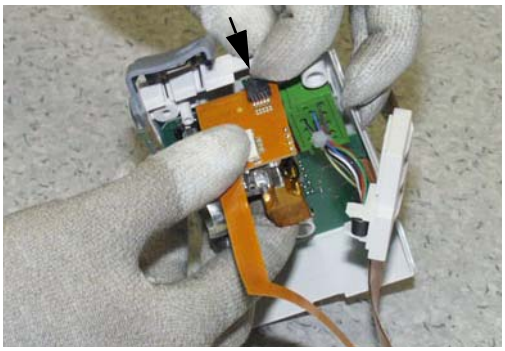
- Detach the front chassis unit from the module frame. Be carefull not to damage the NIBP flex board.



8. To remove the manifold:
- Open the connector lock from the NIBP flex board and disconnect the membrane keyboard flex.

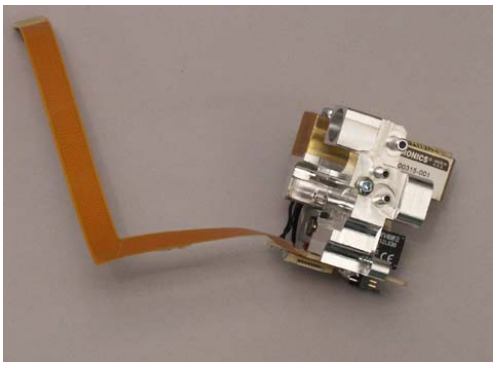


- Remove the two (T6) screws holding the manifold to the Front chassis.



- Disconnect the NIBP flex board connector from the STP input board. Lift the manifold carefully aside. Be careful not to damage the NIBP flex board.

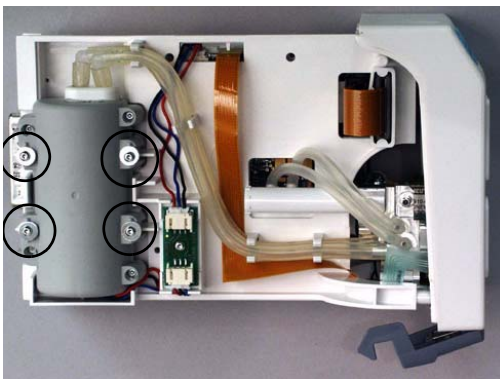
  NOTE: When reassembling, make sure that the NIBP flex board is properly connected (all pins connected) to the STP input board.



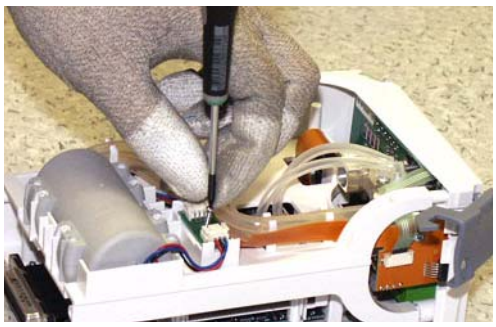
To reassemble the module, reverse the order of the disassembly steps. Pay special attention to the NOTES during the reassembling.

Always perform the "Service check" after reassembling the module.

To remove the pump unit



1. Follow the disassemble instruction steps 1 and 2.
2. Remove the four screws (T6) with washers holding the NIBP pump to the frame.



3. Remove the screw (T6) holding the pump connector board to the insulator plate and lift the board up. Disconnect the pump connector.

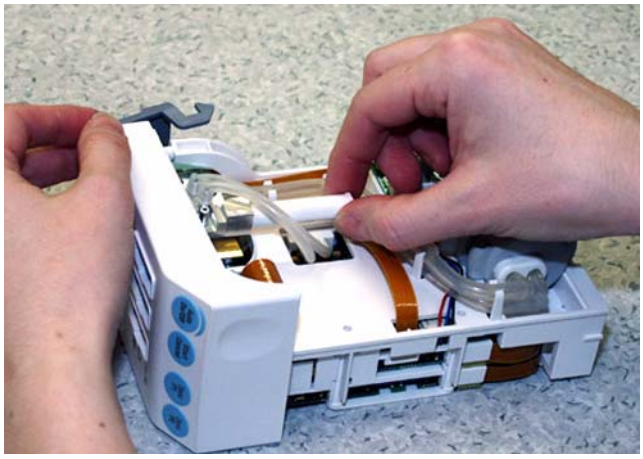
4. Disconnect the hoses and remove the the pump unit.

NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

3.3.4 To replace the NIBP filter:



1. Follow the disassemble instruction steps 1and 2.
2. Remove the NIBP filter cover and replace the filter.

Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

3.4 Adjustments and calibrations

NOTE: Use only properly maintained, calibrated and traceable measurement equipment for the specified calibrations and adjustments to ensure accuracy.

3.4.1 NIBP calibrations

The electronics of the NIBP pressure measurement is calibrated at the factory. The processor automatically maintains the zeroing pressure. If the zero point of the pressure transducer drifts more than specified, an error message is given and the NIBP board should be recalibrated or replaced.

Recalibrate the NIBP measurement once a year. The checking and recalibration can be done in the NIBP service menu.

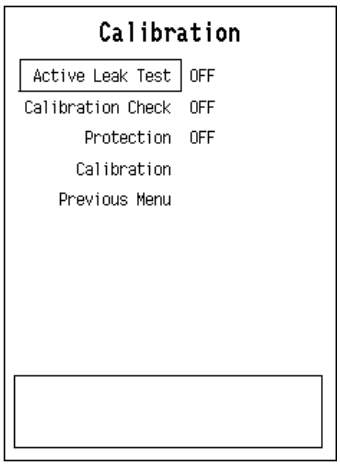
The calibration of the primary pressure channel can also be checked from the NIBP setup menu (***NIBP - NIBP Setup - Calibration Check***). In this case, the auto zeroing is performed at start - remove the hose before entering to ensure atmospheric pressure to the pressure transducers - the primary pressure is displayed. The zero-offset value should then be zero.

Check the intake air filter as part of the calibration check. Change the filter if it is visibly dirty.

Calibration check

1. Enter ***Calibration*** menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) -***Service*** (26-23-8) - ***Parameters - NIBP - Calibrations***



2. Select ***Calibration Check*** and push the ComWheel.
3. Connect an external precision manometer to the module.
4. Pump the following pressures to manometer and check the difference between the manometer and monitor pressure display (The zeroing offset is automatically subtracted from the pressure readings).

Table 3 NIBP calibration check pressures

Pressure	Max. error	Example
0 mmHg	±5 mmHg (=zero offset)	-1
100 mmHg	100 ±2 mmHg	100 ±2
200 mmHg	200 ±3 mmHg	200 ±3

If the error of pressure channel B1 is larger than specified above, the module should be recalibrated. The error of B2 is allowed to be even twice as large because it has no effect on blood pressure measurement accuracy. However, we recommend recalibrating the module when the error of B2 is larger than specified above to ensure best possible operation.

Calibration

1. Enter ***Calibration*** menu.
2. Remove the hoses from the front panel connector to enable proper zeroing.
3. Select ***Calibration***. If it is not available, perform the steps a, b, and c.

NOTE: Do not pull out the hemodynamic module from the monitor frame. The module must be in the frame during the whole procedure.

a. Press the hemodynamic module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds to enable the calibration. This enables menu selection ***Protection***. The message 'Calibration switch ON!' is displayed.
b. Select ***Protection OFF*** in the ***Calibration*** menu and push the ComWheel.
c. Press the buttons again for 3 seconds. Menu selection ***Calibration*** is now enabled, and ***Protection*** is disabled. When the calibration is enabled, a message 'Calibration not protected' is displayed.

- Start calibration by pushing the ComWheel. Messages 'Zeroing' and 'Zeroed' will be displayed in the NIBP message field. After this, a pressure bar and text 'Calibrating' will be displayed.
- Connect an external mercury manometer with a pump to the module through the both tubes of the hose - both transducers B1 and B2 must be calibrated simultaneously. Pump up to a pressure of about 200 mmHg according to the manometer. Calibration is possible in the range of 150 to 250 mmHg.
- Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel. When the values of the pressure bar and the manometer are equal, push the ComWheel to confirm the calibration. The message 'Calibrated' will be displayed on the NIBP digit field after a few seconds, which means that the calibration succeeded, and the new calibration data is saved in EEPROM.

NOTE: When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct. For example, change the value one step higher and then back one step lower. 'Calibrated' text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.

- To set the protection on:
  Press NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds. Select ***Protection ON*** and push the ComWheel. Then press the buttons again for three seconds.
- Remove the module from the frame and plug it back again. Then perform "Calibration check" (see the preceding page) to verify the new calibration.

3.4.2 Temperature calibration

NOTE: For the temperature calibration, separate, accurate test plugs (25 °C and 45 °C) are needed. A test set of two plugs is available from GE Healthcare, order code 884515.A Dual temperature adapter cable, order code 402015-004 is also required for the temperature calibration.

Calibrate the temperature, when the measured test values differ for more than ±0.1 °C, and always after STP board replacement.

1. Enter ESTPR: STP service menu.

   (**Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8) - ***Parameters***).
2. Enter ***Calibrations*** menu.
3. Choose ***Protection OFF*** in protect mode.
4. Select ***Calibrate T1/Calibrate T2***.
5. Insert calibration plug (25 °C) into T1/T2 connector.
6. Push the ComWheel.
7. Insert calibration plug (45 °C) into T1/T2 connector.
8. Push the ComWheel.
9. Choose ***Protection ON*** in protect mode.

3.4.3 Invasive pressure calibration

NOTE: Before starting invasive pressure calibration, disconnect all patient cables and discharge the patient.

Calibrate the invasive pressure when the pressure transducer (probe) is replaced with a different type of transducer, and when the STP board is replaced.

1. Enter ESTPR: the STP service menu.

   (**Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8) - ***Parameters***).
2. Enter ***Calibrations*** menu.
3. Connect a pressure transducer with a pressure manometer to the P1/P2 connector. Choose ***Calibrate P1*** or ***Calibrate P2***. Leave the transducer to room air pressure.
4. Push the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and push the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The message ‘Calibrated’ will be displayed on the display.

4 Troubleshooting

4.1 Troubleshooting charts

See also the “User’s Reference Manual” for more troubleshooting procedures.

4.1.1 NIBP

Problem	Cause	What to do
No NIBP value displayed	NIBP not selected on screen.	Check monitor setup.
NIBP menu fading	No PRESTN module, module not properly connected or NIBP and PRESTN module connected at the same time.	Plug in the module.
‘Artifacts’ message	Unsuccessful measurement due to patient movement, shivering, external artifact or weak signal.	Check the patient status.
‘Weak pulsation’ message	Weak or unstable oscillation pulses due to: • artifacts • weak pulse pressure due to arrhythmias • improper cuff position or attachment • too few pulses detected • weak or unusual blood circulation • obese patient	Check patient condition and retry. Check any leaks and retry. Use proper size of cuff. Check attachment.
Call service ‘Error X’ message	NIBP hardware error. X = error number.	See the description of the error message code, the causes and the solutions listed in the “NIBP error code explanation” chapter.

Problem	Cause	What to do
'Cuff loose' message	1. Hose and/or cuff not connected.	1. Connect the hose and the cuff.
	2. Hose and cuff connected. Reasons:	
	- cuff loosely wrapped	- Tighten the cuff.
	- leakage inside the shield, in the Patient connector panel or tubings connecting to the module	- Check the tubings inside the shield and Patient connector panel, fix if necessary.
	- leakage in cuff or hose	- Replace cuff/hose.
	- leakage inside module	- Check internal tubing and fix if necessary.
	- pump does not work	- Check pump connector; if OK, replace the NIBP Pump Unit.
Cuff ID not working	1. Defective cuff ID holes in the NIBP cuff hose	- Replace NIBP cuff hose.
	2. NIBP flex board connector wrongly connected	- Check that the NIBP flex board connector is properly connected to the STP input board: all pins have to be connected.
	3. Cuff ID switches defective	- To check the switches, attach a NIBP cuff hose without the cuff ID and check that the message 'Select inflation limit' appears. If not, replace the Front Panel Unit.
'Air leakage' message	1. Hose or cuff leaking. Reasons:	1. Replace cuff
	- cuff damaged	- Replace cuff.
	- cuff connector damaged	- Replace cuff connector (if the fault is in hose connector).
	- O-ring damaged or missing	- Replace O-ring.
	- hose double connector damaged	- Replace NIBP cuff hose.
	2. Hose and cuff OK. Reasons:	2. Connect or replace tube
	- leakage in the tubes connecting the patient connector panel and the module	- Check the tubes.
	- leakage inside the module	- Replace the whole tubing.
	- tube disconnected or damaged	- Fix connections.
	- manifold leaking	- Replace the manifold.
	- tubes or valve(s) damaged	- Replace tubes/valve(s).
'Unable to measure Sys' message	Systolic blood pressure probably higher than the inflation pressure or artifacts.	Automatic retrial with increased pressure.

Problem	**Cause**	**What to do**
'Cuff occlusion' message	1. Cuff and/or hose occluded. Reason:	
	- cuff tube kinked	- Straighten tube.
	- tubes inside the shield kinked	- Straighten tubes.
	- tubes inside module kinked	- Straighten tubes.
	- occlusion inside/outside module	- Remove occlusion.
	2. Cuff, hose, and tubes OK. Reason:	
	- fault in pressure transducer	- Replace the NIBP board.
	- fault in A/D converter	- Replace the NIBP board.
	- faulty calibration	- Check calibration.
'Calibration switch on' message	EEPROM protection has been handled by pressing module buttons **Auto ON/OFF** and **Start/Cancel** simultaneously for 3 seconds.	Enables setting the protection OFF in the ***Calibration*** menu. Press the buttons again if you are not going to calibrate.
'Calibration not protected' message.	Calibration protection is set to OFF.	Set the protection ON in the NIBP ***Calibration*** menu.

4.1.2 NIBP error code explanation

Code	Problem	What to do
0	RAM failure; memory failure	Change the NIBP board.
1	ROM checksum error; memory failure	Change the NIBP board.
2	Pump current failure	Check short circuits. Change the NIBP board.
3	Safety CPU internal test failure or pressure sensor reference voltage failure	Change the NIBP board.
4	EEPROM protection error	Press module buttons **Auto ON/OFF** and **Start/ Cancel** simultaneously for 3 seconds.
5	Calibration not protected	Protect calibration by selecting Protection ON in the NIBP calibration menu.
6	Pressure sensors give different readings	Try to remeasure. If the problem persists, recalibrate. If the problem still persists, change the NIPB board.
7	Calibration failure	Reset the module and recalibrate. If this does not help, change the NIBP board.
8	Exhaust Valve occlusion	Check and clean the tubing and air chamber. If this does not help, change the NIBP board.
9	Measurement related error	Automatic recovery.
10	EEPROM checksum error; memory failure	Change the NIBP board.
11	Auto zero range exceeded	Calibrate the NIBP.
12	Communication break; temporal break down of communication from monitor detected	Automatic recovery.
13	Illegal neonate cuff with identifying magnet connected	Remove the cuff.
14	Not in use	Not in use
15	Safety CPU pressure calibration error	Recalibrate. If this does not help, change the NIBP board.
16	Communication error between CPUs	Change the NIBP board.
17	Safety CPU has cut down power from pneumatics due to repeating safety limit violations	Reset the module. If the problem persists, change the NIBP board.

4.1.3 ECG

Problem	Cause	What to do
HR numerical display shows '---'	No heart rate available.	If no ECG waveform, check LEADS OFF message and connect the leads.
		If ECG waveform exists, check heart rate source e.g. in the ECG Setup menu behind ECG key.
Unacceptable ECG waveform	Poor electrode or poor electrode skin contact.	Electrodes from different manufacturers are used. /Too much/little gel is used.
	Poor electrode condition.	Electrodes are dried out.
	Improper site of electrodes.	Check that electrodes are not placed over bones, active muscles, or layers of fat.
	Improper skin preparation.	Remove body hair. Clean attachment site carefully with alcohol.
	Improper bandwidth filter.	Check filter.
	Faulty/ dirty ECG cable.	Change new cable.
No ECG trace	Waveform not selected on screen.	Press the **Monitor Setup** key and make adjustments.
	Module not plugged in correctly.	Plug in.
Noise-message	High frequency or 50/60 Hz noise.	Isolate noise source.

4.1.4 Impedance respiration

Problem	Cause	What to do
No resp trace	Waveform not selected on the screen	Press the Monitor Setup key and make adjustments.
	Module not plugged in correctly	Re-plug the module.
Unacceptable resp waveform	Poor electrode or poor electrode skin contact	Electrodes from different manufacturers are used. Too much/ little gel is used.
	Poor electrode condition	Electrodes are dried out.
	Improper site of electrodes	Check that electrodes are not placed over bones, active muscles, or layers of fat.
	Improper skin preparation	Remove body hair. Clean attachment site carefully with alcohol.
	Faulty/ dirty ECG cable.	Change new cable.
Message: 'SMALL RESP CURVE'	Respiration signal is very small	With 3-lead cable try another lead connection I, II, III or try 5-lead cable.
Message: 'APNEA ALARM', and respiration waveform normal	Respiration source is CO_2	Check respiration source and change it to correct one.

4.1.5 Pulse oximetry (SpO_2)

Problem	Cause	What to do
Message 'NO PROBE'	No sensor connected to the .	Check sensor connections.
	Sensor faulty.	Change the sensor.
	Flat cable connecting the loosen or broken.	Check the Flat cable, replace if necessary.
Message 'PROBE OFF' though sensor properly attached to the patient	Unsuitable site.	Try another site.
	Sensor faulty.	Try another sensor.
	Sensor connection cable not connected to sensor.	Connect the cable to sensor.
Finger sensor falls off	Sensor is slippery.	Wipe with 70% isopropyl alcohol and allow drying.
	Finger is too thin or thick.	Try other fingers, or other sensor types.
Weak signal artifacts	Poor perfusion.	Try another place.
	Movement artifacts.	
	Shivering.	
Message 'NO PULSE'	Pulse search > 20 sec. and low SpO_2 or low pulse rate.	Try other fingers.
Message 'ARTIFACT'	Pulse modulation exceeds the present scale.	Try another place or another sensor.
Message 'CHECK PROBE'	DC value not in balance.	Try another sensor.
Message 'POOR SIGNAL'	Poor perfusion. Modulation (Red or Ired) < 0.25%	Check that the sensor is positioned correctly to the patient.
Message 'FAULTY PROBE'	Sensor is faulty.	Change the sensor.
No SpO_2	No waveform selected on screen.	Check the selected SpO_2 waveforms by pressing **Monitor Setup** key and selecting ***Screen 1 Setup - Waveform Fields***.
	Wrong configuration setting.	Check the configuration settings from the ESTPR:STP/Calibrations menu (**Monitor Setup – *Install/Service - Service - Parameters***)

4.1.6 Temperature

Problem	Cause	What to do
Message 'TEMPERATURE ERROR'	Faulty calibration.	Perform calibration. If it does not help, check that front panel connector is properly connected to STP board.

Problem	**Cause**	**What to do**
No temperature displayed	Wrong type of probe.	Use correct probe.
	Temperature out of measurable range.	The range is between 10 and 45 °C.
	Temperature calibration not protected.	Set the protection ON in the Service Menu.

4.1.7 Invasive blood pressure

Problem	Cause	What to do
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer.	Check transducer.
	No pressure module plugged in.	Check the module.
	No waveform selected on screen.	Check the selected pressure waveforms by pressing **Monitor Setup** key and selecting ***Screen 1 Setup - Waveform Fields***.
		Check that the pressure transducer is open to the patient.
	Wrong configuration setting	Check the configuration setting from the ESTP:STP/Calibrations menu (**Monitor Setup - *Install/Service - Service - Parameters***).
'Not zeroed' message	Measurement on, channel not zeroed.	Zero the channel.
'Zeroing failed' message	Unsuccessful zeroing of P1 /P2 (number field).	Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel.
		Offset is > 150 mmHg. Open the transducer to air and zero the channel.
		Defective transducer. Replace it and zero the channel.
'Calibration failed' message	Unsuccessful calibration of P1/P2 (number field), possibly due to a pulsating waveform	Turn the transducer to sphygmomanometer and try again (zeroing takes place first).
		Gain is beyond the limits (± 20% of the default gain). Replace the transducer.
Out of range < 40 mmHg	Measurement pressure is beyond the measurement range.	Check the transducer level. Zero the channel.
Out of range > 320 mmHg	Measurement pressure is beyond the measurement range.	Check the transducer level. Zero the channel. The patient may also have high pressure.
Zero adj. > 100 mmHg	Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain).	Check the transducer. The waveform may hit the top and the numeric display not shown.
Out of range	Measured pressure is beyond the internal measurement range of the module.	The waveform hits the top and the numeric display not shown. Check the transducer and its level. Zero the channel.

4.2 Troubleshooting flowcharts

4.2.1 Troubleshooting for NIBP parameter

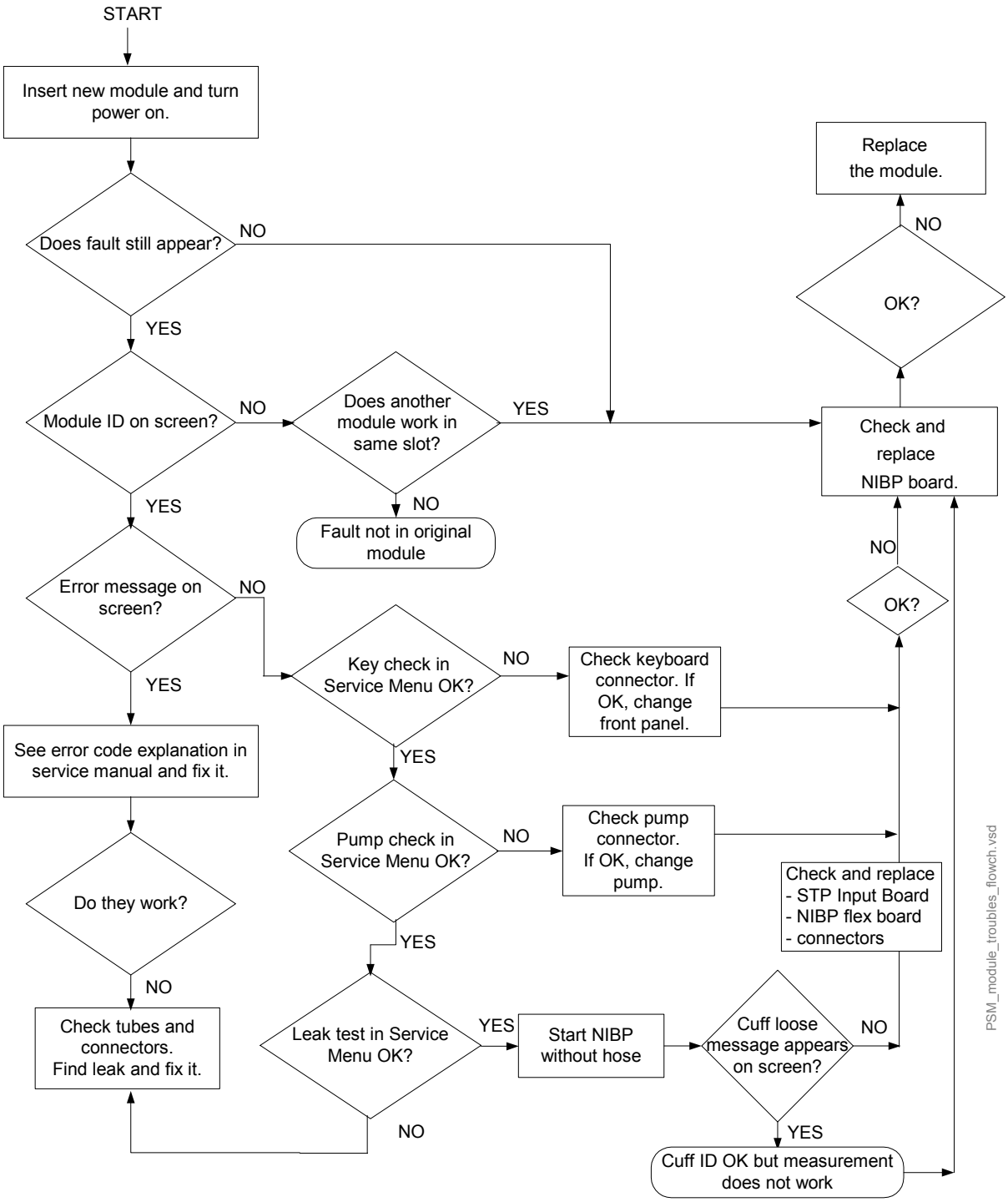


Figure 13 Troubleshooting flowchart for NIBP parameter

4.2.2 Troubleshooting for ESP parameters

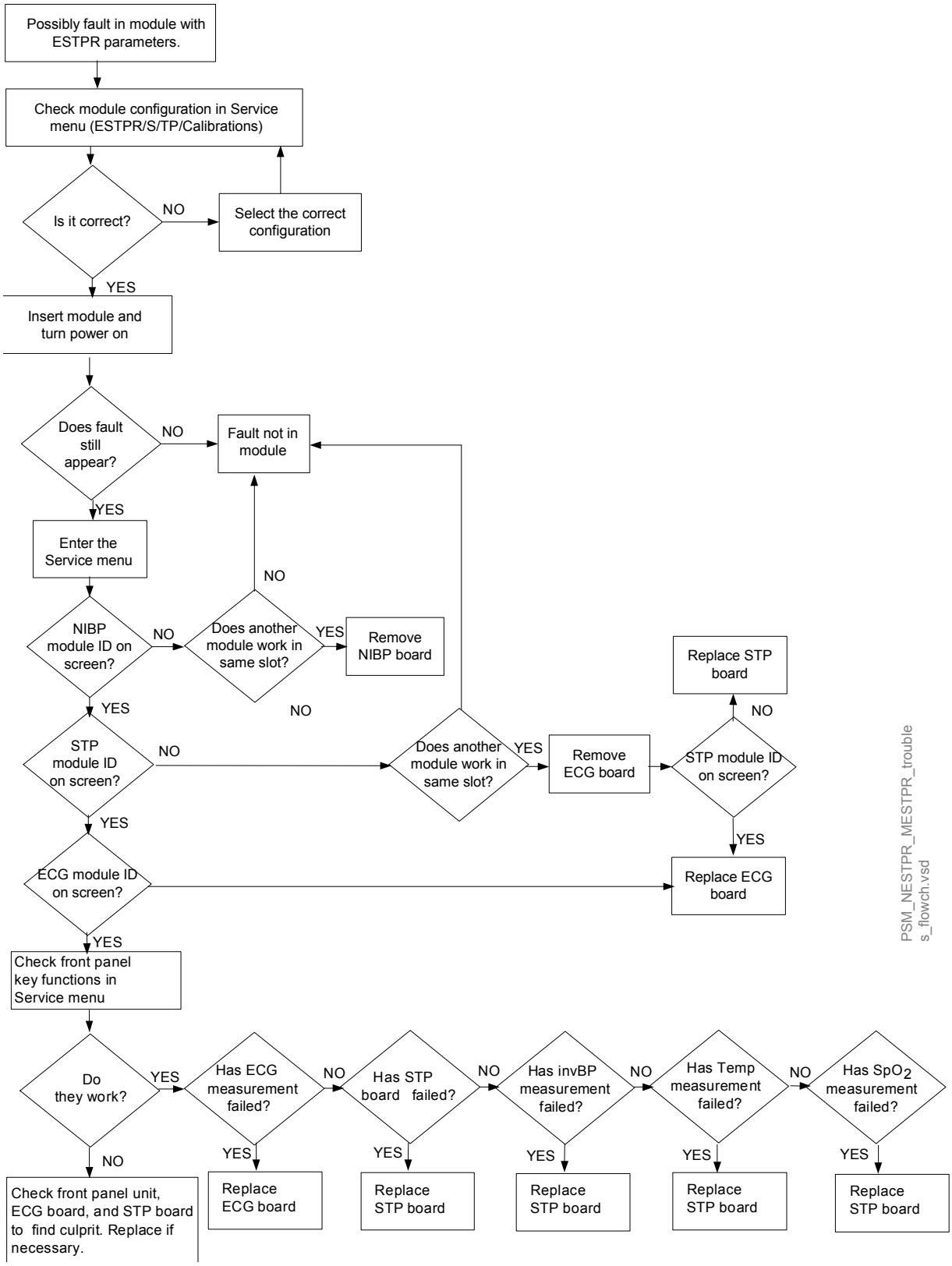


Figure 14 Troubleshooting flowchart for ESP Parameters

5 Earlier revisions

There are no earlier revisions of the S/5 Hemodynamic Module, E-PRESTN.

For your notes:

APPENDIX A: Service check form, S/5 Hemodynamic Modules, E-PRESTN, E-RESTN, E-PRETN (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

Visual inspection	OK	N.A.	Fail		OK	N.A.	Fail
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. NIBP pump filter	☐	☐	☐	4. Module installation	☐	☐	☐
5. Module recognition	☐	☐	☐				
Notes							

. ECG measurement	S/N
6. Module software (serial numbers)	
ECG/RESP	
STP	
NIBP	

. ECG measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
7. Communication and memories	☐	☐	☐	8. Power frequency	☐	☐	☐
9. Cable recognition	☐	☐	☐	10. Lead detection	☐	☐	☐
11. Test with the patient simulator	☐	☐	☐				
Notes							

RESP measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
12. RESP measurement recognition	☐	☐	☐	13. Test with patient simulator	☐	☐	☐
Notes							

TEMP measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
14. Communication and memories	☐	☐	☐	15. Temperature probe detection	☐	☐	☐
16. Calibration check	☐	☐	☐	17. Temp test	☐	☐	☐
18. Module configuration	☐	☐	☐				
Notes							

InvBP measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
19. Membrane keys	☐	☐	☐	20. Cable and transducer detection	☐	☐	☐
21. Calibration	☐	☐	☐	22. Test with patient simulator	☐	☐	☐
Notes							

SpO2 measurement				S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
23. SpO2 probe detection	☐	☐	☐	24. Test measurement	☐	☐	☐
Notes							

NIBP measurement				S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
25. Communication and memories	☐	☐	☐	26. Membrane keys	☐	☐	☐
27. Pump and valves	☐	☐	☐	28. Leak test	☐	☐	☐
29. Calibration check		Measured B1		Measured B2		Allowed range	
0 mmHg						±9 mmHg	
100 mmHg						100 ±2 mmHg	
200 mmHg						200 ±3 mmHg	
260 mmHg						260 ±4 mmHg	
30. Safety valve functions		Measured B1		Measured B2		Allowed range	
						270...330 mmHg	
						270...330 mmHg	
						130...165 mmHg	
						130...165 mmHg	
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
31. Cuff related messages	☐	☐	☐	32. Test measurement	☐	☐	☐
33. NIBP hose detection	☐	☐	☐				
Notes							

Final checks	OK	N.A.	Fail		OK	N.A.	Fail
34. Electrical safety check	☐	☐	☐	35. Functioning after electrical safety check	☐	☐	☐
36. Final cleaning	☐	☐	☐				
Notes							

Notes

Used spare parts			

Signature

Patient Side Module, E-PSM, E-PSMP (Rev. 01)

Technical Reference Manual Slot

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EC

CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner. Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1215098-002

12 August, 2011

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Introduction

This Technical Reference Manual Slot provides information for the maintenance and service of the Patient Side Modules E-PSMP and E-PSM.

Please also refer to "Technical Reference Manual" of the monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The E-PSMP and E-PSM modules provide general hemodynamic parameters.

Figure 1 Patient Side Module, E-PSMP

Table 1 Patient Side Module options

Parameter	E-PSMP	E-PSM
Two invasive blood pressures	x	
Impedance respiration	x	x
ECG	x	x
Pulse oximetry	x	x
Two temperatures	x	x
NIBP	x	x

Intended purpose (Indications for use)

The Patient Side Module (model family E-PSM(P)) and accessories are indicated for the monitoring of hemodynamic parameters of all hospital patients. The hemodynamic parameters of the module comprise ECG including ST-segment and arrhythmia, Impedance respiration, NIBP, Temperature, SpO_2 (including monitoring during conditions of clinical patient motion), and invasive blood pressure.

Impedance respiration measurement is indicated for patients aged 3 and up. The NIBP measurement is indicated for patients who weigh 5 kg (11 lb.) and up. This device is indicated for use by qualified medical personnel only.

Monitor software compatibility

Patient Side Module, E-PSM(P) Rev. 00 and 01 are designed for use with Datex-Ohmeda monitors as follows:

- S/5 FM monitors using software L-FICU04(A) or later.
- S/5 Anesthesia Monitors using software L-ANE04(A) or later equipped with 5-Module Frame, F-CU5(P) or with S/5 8-Module Frame, F-CU8. With the F-CU8, the E-INTPSM interface module is needed.
- S/5 Critical Care Monitors using software L-ICU04(A) or later equipped with 5-Module Frame, F-CU5(P) or with S/5 8-Module Frame, F-CU8. With the F-CU8, the E-INTPSM interface module is needed.

Equipment safety symbols

When displayed on the **E-PSM, E-PSMP** module, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO_2), temperature (T) and invasive pressure (P) measurement.

1 Specifications

1.1 General specifications

Module size	51 x 132 (171 w/ tab) x 140 mm
W x D x H	2 x 5.2 (67 w/ tab) x 5.5 in
Module weight	0.6 kg /1.4 lb.
Power consumption	2.3 W typical (NIBP pump off)
	7.5 W typical (NIBP pump on)
Operation temperature	10 to 40°C / 50 to 104°F

1.2 Typical performance

1.2.1 NIBP

WARNING **Non-invasive blood pressure measurement is intended for patients weighing over 5 kg (11 lb.)**

Oscillometric measurement principle.

Measurement range	adult	25 to 260 mmHg
	child	25 to 195 mmHg
	infant	15 to 140 mmHg
Pulse rate range accepted	30 to 250 bpm	
Measurement interval	from 1 min. to 4h	
Typical measuring time	adult	23 s
	infant	20 s
Initial inflation pressure	adult	170 ±10 mmHg
	child	150 ±10 mmHg
	infant	120 ±10 mmHg
Venous stasis	adult	80 ±5 mmHg / 2 min.
	child	60 ±5 mmHg / 2 min.
	infant	40 ±5 mmHg / 1 min.
Cuff widths	see User's Guide	

Venous stasis pressure may be lower than the values above if the patient has low blood pressure. The venous stasis pressure adapts to the measured mean pressure being the same as mean pressure but always at least the following:

	Infant 20 ± 5 mmHg
	Child 30 ± 5 mmHg
	Adult 40 ± 5 mmHg
Overall system accuracy:	Meets or exceeds SP10-2002 AAMI standards[1]

1 (According to SP10-2002 AAMI 4.4.5.2.B, Intra-arterial method as the reference standard, mean difference of the test system and the comparison system shall be ± 5 mmHg or less with standard deviation of 8 mmHg or less).

1.2.2 ECG

Lead selection	I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6
Sweep speeds	12.5, 25, 50 mm/sec.

Display filter

Diagnostic	0.05 to 150 Hz
Monitoring	0.5 to 30 Hz (-3 dB, with 50 Hz reject filter) 0.5 to 40 Hz (-3 dB, with 60 Hz reject filter)
ST filter	0.05 to 30 Hz (-3 dB, with 50 Hz reject filter) 0.05 to 40 Hz (-3 dB, with 60 Hz reject filter)

Heart rate from ECG

Range	30 to 250 bpm
Accuracy	±5 bpm or ±5%, whichever is greater
Resolution	1 bpm
Update interval	5 s
Averaging time	5 s

ST levels (in main software)

ST level range	-9 to +9 mm (-0.9 to +0.9 mV)
Resolution	0.1 mm (0.01 mV)
Averaging	calculated from 8 QRS complexes

Pacemaker pulse detection

Detection level	2 to 700 mV
Pulse duration	0.5 to 2 ms

The monitor is specified for both of the methods A and B in ANSI/AAMI EC13 4.1.4.2.

Direct ECG and Synchronization

for specifications see section “Specifications” in the “Frame for FM Technical Reference Manual Slot”

1.2.3 Pulse oximetry

Measurement range	0 to 100%
Calibration range	70 to 100%
Accuracy[1]	100 to 70%, ±2 digits ±3 digits during clinical patient motion 69 to 0%, unspecified
Display resolution	1 digit = 1% of SpO_2
Display averaging time	Slow, Normal, beat-to-beat
Pulse beep pitch	varies with SpO_2 level

The monitor is calibrated against functional oxygen saturation SpO_2 func.

Pulse rate from Pleth

Measurement range	30 to 250 bpm
Accuracy	30 to 100, ±5 bpm, 100 to 250, ±5%
Resolution	1 bpm
Display averaging	10 s

Adjustable pulse beep volume.

Pleth waveform

Scales	2, 5, 10, 20, 50 mod%, Auto

Start up scale is 20 mod% if AUTO is not selected to be the default setting.

1 Accuracy is based on deep hypoxia studies with volunteered subjects during motion and non-motion conditions over a wide range of arterial blood oxygen saturation as compared to arterial blood CO-Oximetry. Accuracy may depend on the sensor used, please refer to the instructions for use in the accessory package.

1.2.4 Temperature

Measurement range	10 to 45 °C (50 to 113 °F)
Measurement accuracy	±0.1 °C (25 to 45.0 °C) ±0.2 °C (10 to 24.9 °C)
Display resolution	0.1 °C (0.1 °F)
Temperature test	automatic (every 10 min.)
Probe type	compatible with YSI 400 series
Single use sensors	±0.3 °C (25 to 45.0 °C) ±0.4 °C (10 to 24.9 °C)

1.2.5 Invasive blood pressure

Measurement range	-40 to 320 mmHg
Measurement accuracy	±5% or ±2 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±25%
Scales	upper limit is adjustable between 10 and 300 mmHg in steps of 10 mmHg. Lower limit is 10% of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s

Digital display

Range	-40 to 320 mmHg
Resolution	±1 mmHg

Waveform display

Range	-30 to 300 mmHg

Pulse rate from arterial pressure

Measurement range	30 to 250 bpm
Resolution	1 bpm
Accuracy	±5 bpm or ±5% whichever is greater

1.2.6 Respiration

The EMC immunity of the respiration measurement has been tested with 1 Vrms and 1 V/m. This level has been used for optimizing the immunity of the respiration measurement to damp the operating frequency of the electrosurgery equipment.

WARNING **Impedance respiration measurement is intended for patients over three years old.**

Measurement range	4 to 120 breath/min
Accuracy	±5 breath/min or ±5%
Resolution	1 breath/min
Averaging time	30 s
Update interval	10 s

Respiration waveform

Sweep Speeds	6.25 mm/s and 0.625 mm/s

1.3 Technical specifications

1.3.1 NIBP

Deflation rate, PR dep.	3 to 8 mmHg/s	
Inflation time	20 to 185 mmHg, 1 to 5 s	
Automatic software control, max. inflation pressure		
	adult	280 ±10 mmHg
	child	200 ±10 mmHg
	infant	145 ±5 mmHg
Over pressure limit, stops measurement after 2 seconds		
	adult	320 mmHg
	child	220 mmHg
	infant	160 mmHg

The safety circuit limits the maximum cuff pressure to 320 mmHg in adult/child mode or to 160 mmHg in infant mode. Independent timing circuit limits the pressurizing (>15 mmHg) time to 3 minutes maximum in adult/child mode, and to 90 seconds at (>5mmHg) in infant mode.

Zeroing to ambient pressure is done automatically.

Inflation pressure is adjusted according to the previous systolic pressure, typically 40 mmHg above. If the systolic pressure is not found, the inflation pressure is increased typically 50 mmHg.

Max. measurement time	adult	120 s
	child	120 s
	infant	75 s

Pressure transducer accuracy is better than ±3 mmHg or ±2% whichever is greater.

Max. error	±4 mmHg.
Protection against electrical shock	Type BF defibrillator-proof

1.3.2 ECG

Defibrillation protection	5000 V, 360 J
Recovery time	5 s
Input impedance	>2.5 MΩ (10 Hz)
CMRR	>100 dB (ST)
System noise	<30 mV (p-p, RTI)
Allowable offset	±1VDC
Gain range	0.2 to 5.0 cm/mV
Pacemaker pulse detection	2 to 700 mV, 0.5 to 2 ms pulses
Protection against electrical shock	Type CF defibrillator-proof

1.3.3 Pulse oximetry

Protection against electrical shock	Type CF defibrillator-proof

1.3.4 Temperature

Measurement accuracy	±0.1 °C (25.0 to 45.0 °C) ±0.2 °C (10.0 to 24.9 °C)
Protection against electrical shock	Type CF defibrillator-proof

NOTE: The accuracy of the measurement may be different from the specified, depending on the transducer/probe used. Please refer to the transducer/probe specification.

1.3.5 Invasive blood pressure

Digital display averaging

Digital displays Art and P1 are averaged over 5 seconds and updated at 5 seconds intervals. All other pressures have respiration artifact rejection.

Accuracy	±5% or ±2 mmHg, whichever is greater
Transducer and input sensitivity	5 µV/V/mmHg
Filter	0 to 4 - 22 Hz adjustable
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg
Zero time	less than 15 s
Protection against electrical shock	Type CF defibrillator-proof

NOTE: The accuracy of the measurement may be different from the specified, depending on the transducer/probe used. Please refer to the transducer/probe specification.

1.3.6 Respiration

Excitation frequency, 12-lead ECG	31.25 kHz
Breath detection	automatic, manually adjustable minimum detection: 0.2, 0.4, 0.6, 0.8, 1.0
Input dynamic range	0.2 to 20 Ω
Input impedance range	100 to 5000 Ω
Respiration Rate	min. 4 breath/min max. 120 breath/min
Lead off detection	>3 MΩ

2 Functional description

2.1 Measurement principle

2.1.1 NIBP

NIBP (Non-Invasive Blood Pressure) is an indirect method for measuring blood pressure.

The NIBP measurement is performed according to the oscillometric measuring principle. The cuff is inflated with a pressure slightly higher than the presumed systolic pressure, and deflated at a speed based on the patient's pulse, collecting data from the oscillations caused by the pulsating artery. Based on these oscillations, values for systolic, mean, and diastolic pressures are calculated.

The following parts are necessary for the NIBP measurement:

- E-PSMP/E-PSM module
- twin hose (adult or infant model)
- blood pressure cuffs (various sizes)

2.1.2 ECG

Electrocardiography analyzes the electrical activity of the heart by measuring the electrical potential produced with electrodes placed on the surface of the body.

ECG reflects:

- electrical activity of the heart
- normal/abnormal function of the heart
- effects of anesthesia on heart function
- effects of surgery on heart function

See the "User's Guide" or the "User's Reference Manual" for electrodes' positions and other information.

2.1.3 Pulse oximetry

A pulse oximeter measures the light absorption of blood at two wavelengths, one in the near infrared (about 940 nm) and the other in the red region (about 660 nm) of the light spectrum. These wavelengths are emitted by LEDs in the SpO_2 probe, the light is transmitted through peripheral tissue and is finally detected by a PIN-diode opposite the LEDs in the probe. The pulse oximeter derives the oxygen saturation (SpO_2) using an empirically determined relationship between the relative absorption at the two wavelengths and the arterial oxygen saturation SaO_2.

In order to measure the arterial saturation accurately, pulse oximeters use the component of light absorption giving variations synchronous with heart beat as primary information on the arterial saturation.

A general limitation of pulse oximetry is that due to the use of only two wavelengths, only two hemoglobin species can be discriminated by the measurement.

The modern pulse oximeters are empirically calibrated either against fractional saturation SaO_2frac;

$$SaO_2frac = \frac{HbO_2}{HbO_2 + Hb + Dyshemoglobin}$$

Formula 1

or against functional saturation SaO_2func;

$$SaO_2func = \frac{HbO_2}{HbO_2 + Hb}$$

Formula 2

Functional saturation is more insensitive to changes of carboxyhemoglobin and methemoglobin concentrations in blood.

The oxygen saturation percentage SpO_2 measured by the module is calibrated against functional saturation SaO_2func. The advantage of this method is that the accuracy of SpO_2 measurement relative to SaO_2func can be maintained even at rather high concentrations of carboxyhemoglobin in blood. Independent of the calibration method, pulse oximeters are not able to correctly measure oxygen content of the arterial blood at elevated carboxyhemoglobin or methemoglobin levels.

Plethysmographic pulse wave

The plethysmographic waveform is derived from the IR signal and reflects the blood pulsation at the measuring site. Thus the amplitude of the waveform represents the perfusion.

Pulse rate

The pulse rate calculation is done by peak detection of the plethysmographic pulse wave. The signals are filtered to reduce noise and checked to separate artifacts.

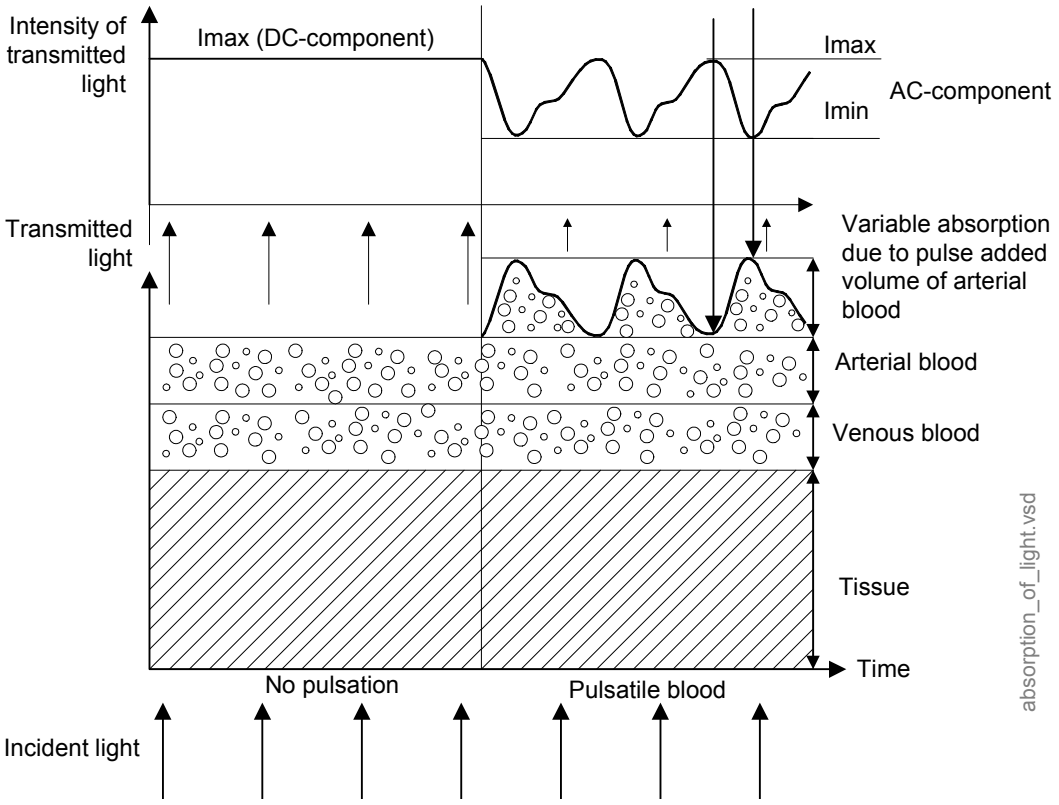


Figure 2 Absorption of infrared light in the finger

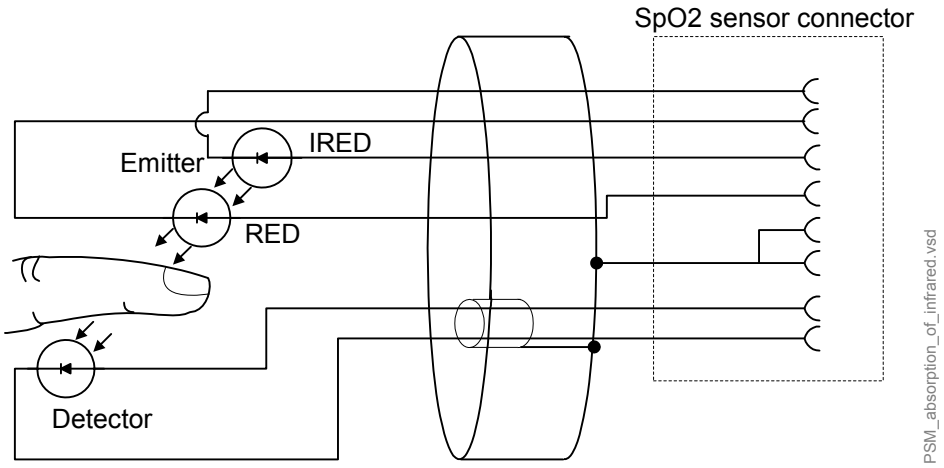


Figure 3 Pulse oximetry probe parts layout and schematic diagram

The standard probe is a finger clamp probe which contains the light source LEDs in one half and the photodiode detector in the other half. Different kinds of probes are available from GE Healthcare.

2.1.4 Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called NTC (Negative Temperature Coefficient) resistor.

The resistance can be measured by two complementary methods:

- Applying a constant voltage across the resistor and measuring the current that flows through it.
- Applying a constant current through the resistor and measuring the voltage that is generated across it.

The E-PSM(P) module uses the constant current method. The NTC-resistor is connected in series with a normal resistor and a constant current is applied through them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

2.1.5 Invasive blood pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of a connecting tubing, a pressure transducer, an intravenous bag of normal saline, all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

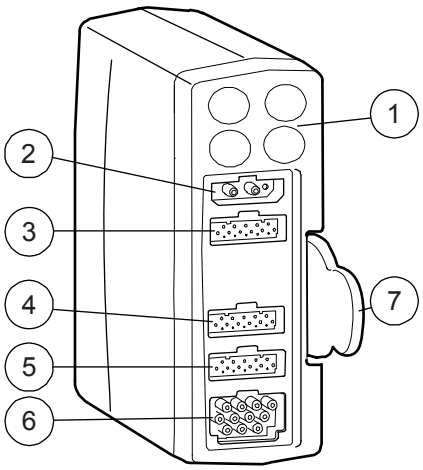
The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

2.1.6 Respiration

Impedance respiration is measured across the thorax between ECG electrodes. The respiration signal is made by supplying current between the electrodes and by measuring the differential current from the electrodes. The signal measured is the impedance change caused by breathing. The respiration rate is calculated from these impedance changes, and the respiration waveform is displayed on the screen.

2.2 Main components

2.2.1 E-PSMP/E-PSM



1. Module keys
2. NIBP connector
3. InvBP connector in E-PSMP only
4. Temperature connector
5. SpO_2 connector
6. ECG and impedance respiration connector
7. Tab for removing the module

Figure 4 Front panel of E-PSMP

The E-PSMP and E-PSM modules contain three main PC boards, the STP board, the ECG board, and the NIBP board. Each of these boards contain a processor and software in the processor flash memory. The boards produce their own supply voltages from the Vmod 13.8-16 V line that is available via the module bus connector. In addition to this, the NIBP board provides +5V for the ECG and STP board non-isolated side components. The NIBP board provides also the synchronization signal for the ECG and STP board power supplies.

There are two input boards; the STP input board and the ECG input board attached to the front panel of the module. The front panel has five connectors and four keys. There is one connector for two temperature measurements, one for two invasive blood pressure measurements, one for ECG, one for NIBP, and one for SpO_2 measurement. The NIBP connector includes two plungers for NIBP hose identification. The keys are for NIBP Auto On/Off, NIBP Start/Cancel, P1 zero, and P2 zero.

NOTE: The connectors and keys depend on the module variant, and some variants may not have all the mentioned connectors and keys.

2.2.2 NIBP board

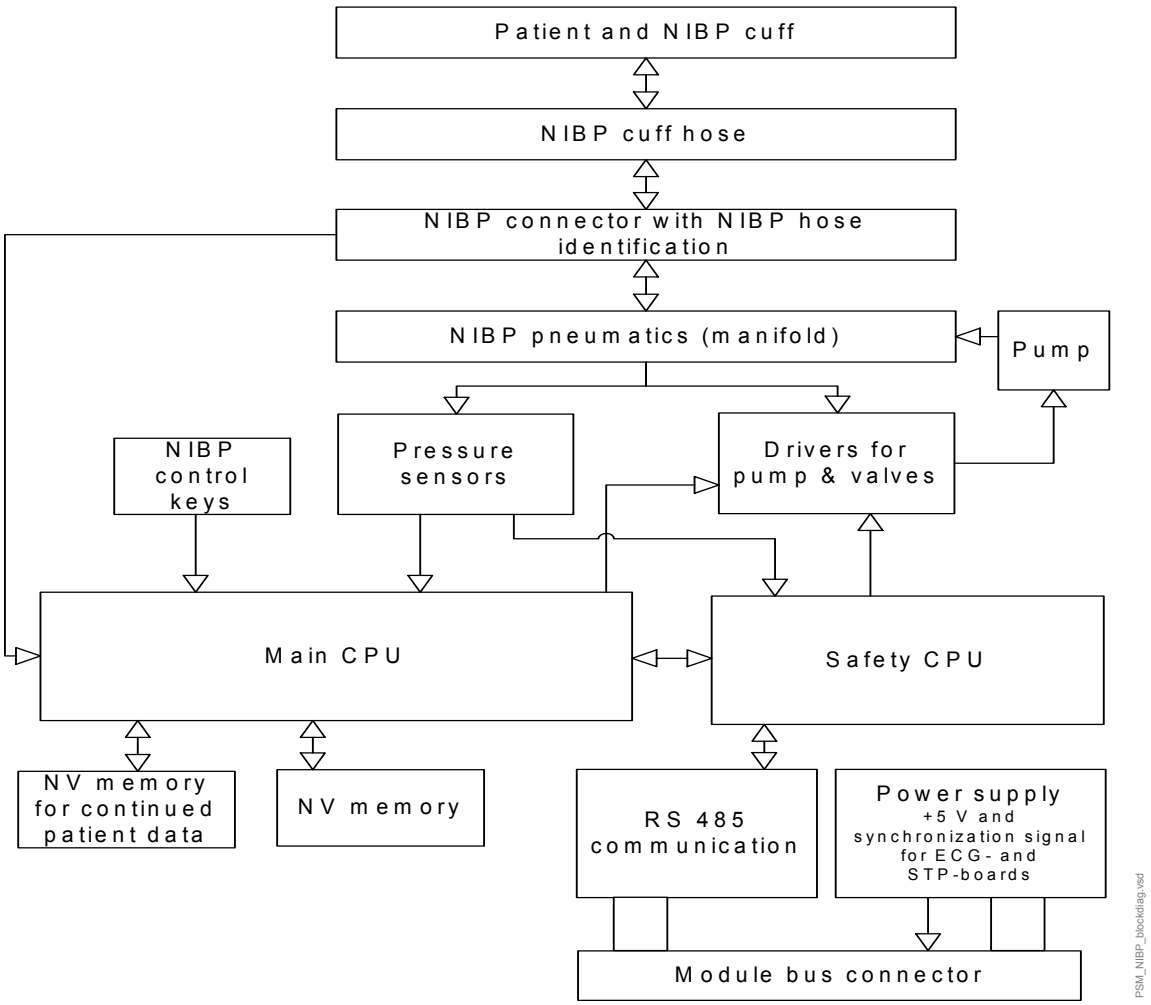


Figure 5 NIBP board functional block diagram

Signal processing

Two signals from the pressure transducers are amplified and sent to the A/D converter. After the converter, digitized signals are sent to the microprocessor for data processing.

The NIBP board is controlled with an H8/3052 microprocessor at 16 MHz oscillator frequency.

Memory

The NIBP program memory (processor flash memory) size is 512k x 8. The processor has 4 kBytes RAM and there is also an external RAM memory, the size of which is 128k x 8. Variable values of the NIBP measurement are stored into the external RAM. The EEPROM size is 512 x 8 and it is used to store the calibration values for the pressure transducers, the pulse valve constants gained during measurements, the PC board identification, and the module serial number.

Software control

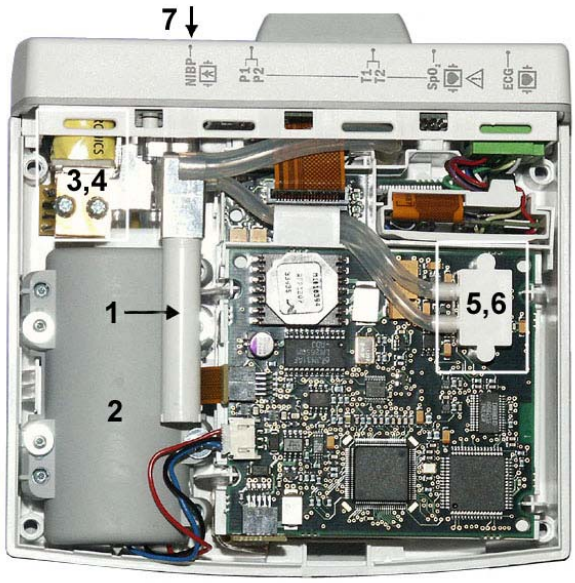
The software controls valves and a pump. In addition to the individual on/off signals for each component there is a common power switch for the valves and the pump that can be used at pump/valve failures.

In addition to external RS485 reset line, the microprocessor system is equipped with its own power-up reset. See the section in the ECG board's description: "RS485 communication."

Safety circuit

The NIBP board is equipped with an independent safety circuit to disconnect supply voltages from the pump and the valves if the cuff has been pressurized longer than the preset maximum measurement time, or if the pressure of the cuff is inflated over the specified pressure limit. The maximum measurement time values and pressure limits for different measurement modes have been specified in the technical specification section of this manual.

Pneumatics



The module has the following pneumatics parts:

1. **Intake air filter**; for preventing dust and other parts from entering the air pump and the valves.
2. **Air pump**; for pumping the measuring pressure of the cuff.
3. **(Pulse) Valve**; for producing a linear pressure fall (bleeding) in order to measure the blood pressure of the patient.
   Note that in the service menu also names **Valve** and **Set valve** have been used for this valve.
4. **Safety valve**; The safety valve is intended to be used for deflating the cuff in single fault case, i.e. to prevent too long a measurement time or too high an inflation pressure of the cuff.
   Note that also **Exh2 valve** has been used to designate the **Safety valve** in service menu.
5. **Main pressure sensor**; for measuring the pressure of the blood pressure cuff and the pressure fluctuations caused by arterial wall movement.
6. **Safety pressure sensor;** for detecting the cuff loose, cuff occlusion situations, etc. and for recognizing the pressure sensor fault.
7. **Cuff connector;** for connection and hose identification.

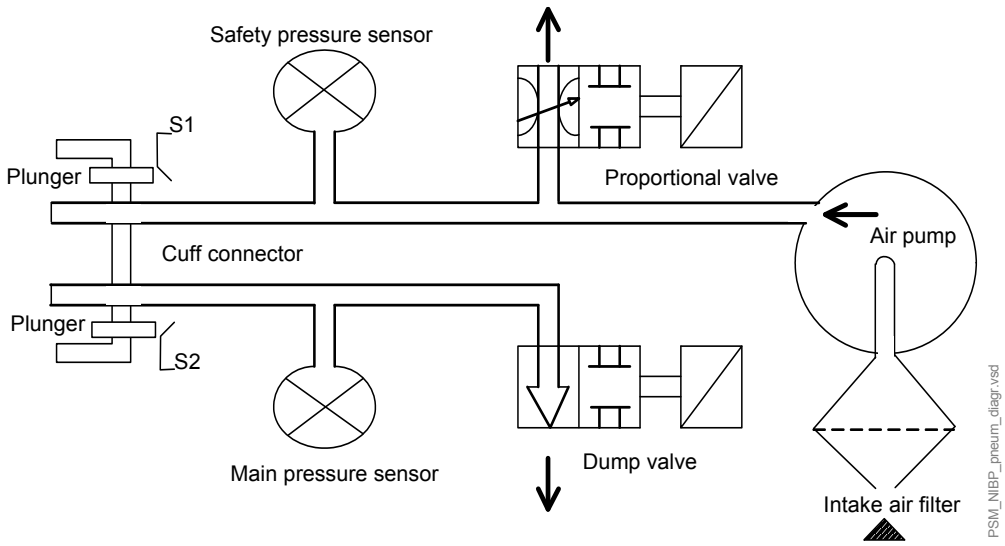


Figure 6 NIBP pneumatics diagram

Power supply section of the NIBP board

All connections are established via a 5-pin connector (female). The module needs a +15 V (dirty) power supply to operate. The supply voltage Vmod 13.8- 16 V is generated in the power supply section of the monitor. The other voltages needed for the operation of the NIBP measurement are made on the NIBP board.

The NIBP power supply synchronizes the ECG and STP isolation power and supplies non-isolated 5 V to the ECG and STP board.

2.2.3 ECG board in 12-lead measurement

The 12-lead ECG measurement consists of the functions shown in Figure 7 on page 15. All functions are located in the ECG board except the ECG input unit.

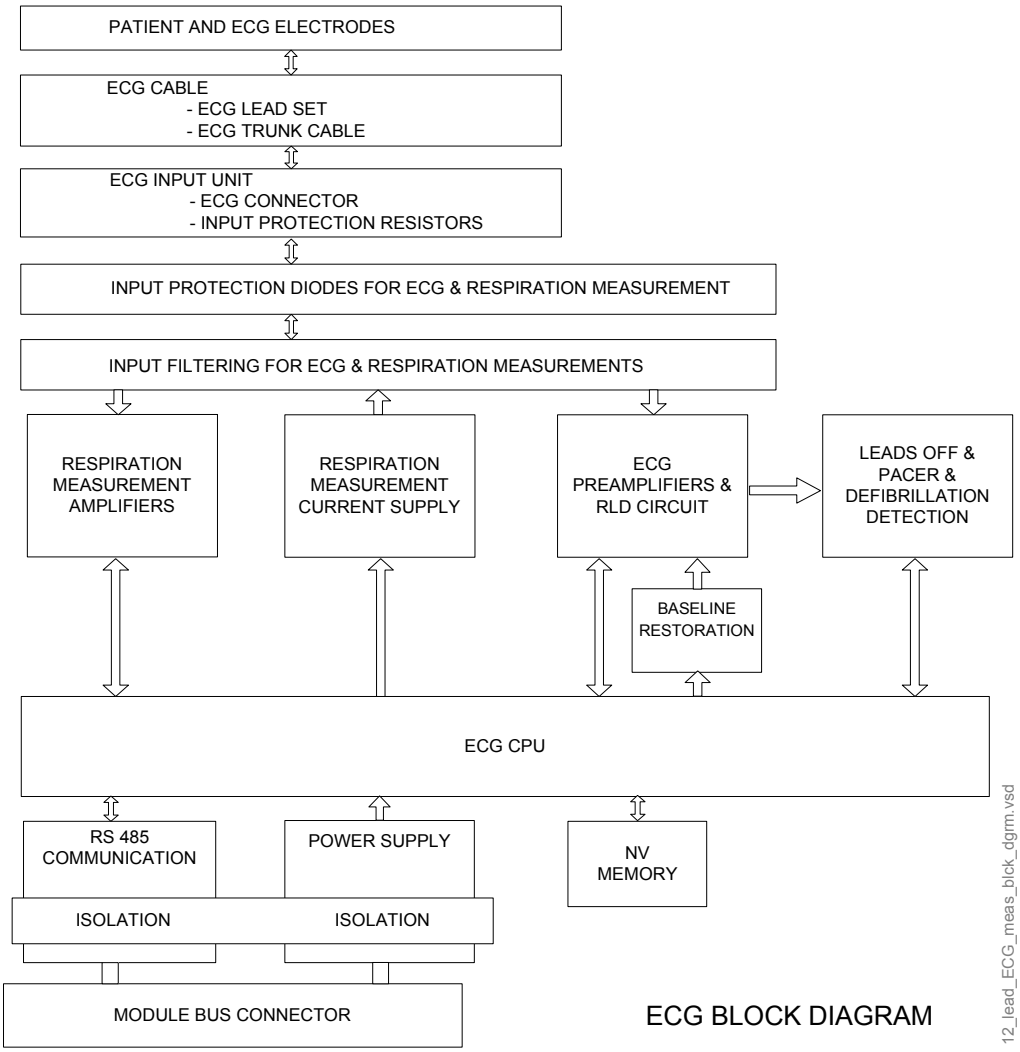


Figure 7 12-lead ECG measurement block diagram

ECG input unit

The ECG input unit consists of the front panel connector and the ECG input connector board with the high voltage protection resistors. The connector for the 12-lead ECG cable is a green 11-pin rectangle shaped connector.

Input protection and filtering

The input protection is implemented with high voltage protection resistors in the ECG input unit and with protection diodes in the ECG board. The input filtering for ECG measurement is done with passive RC filtering.

ECG preamplifiers

The buffer amplifiers are used for each lead. The “Leads off” detection is implemented by measuring the output level of the input buffer amplifiers with the A/D converter of the CPU. The ECG signals are measured using differential amplifiers.

ECG amplifiers and baseline restoration

The function of the ECG amplifiers and baseline restoration is to amplify the signal and to restore the baseline of the signal in the middle of the display after the change of the signal level, e.g. after the change of the DC offset voltage.

Pacer detection

Pacer detection has been made by using four slew rate detector circuits. The pacer detection amplifiers have been realized at the front of the slew rate detectors independently of the ECG measuring channels.

Respiration impedance supply

The 31.25 kHz sine wave generator is used as the respiration measurement signal supply. Analog switches are used for connecting the sine wave to the ECG leads to be measured.

Respiration impedance amplifiers

Buffer amplifiers are used in respiration measurement. Analog switches are used for selecting the measurement leads. There are also additional amplifiers for increasing the respiration signal gain. When ECG measurement is 5/12-lead, the respiration measurement is always done between R and F, independently on the ECG lead selection. When ECG measurement is 3-lead, then the respiration measurement happens at the same lead as the ECG measurement (I, II or III).

ECG CPU

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

RS485 communication

The communication to the CPU board of the monitor uses RS485 protocol. The RS485 driver circuits are optically isolated from the processor of the module.

Power supply

The ECG board has a driver-controlled half-bridge switching power supply with 5 kV isolation. The supply voltages have been regulated with linear regulators.

2.2.4 ECG filtering

Datex-Ohmeda S/5 monitors have three ECG filtering modes:

MONITORING	0.5 to 30 Hz (with 50 Hz reject filter) 0.5 to 40 Hz (with 60 Hz reject filter)
DIAGNOSTIC 12-lead ECG	0.05 to 150 Hz
ST FILTER	0.05 to 30 Hz (with 50 Hz reject filter) 0.05 to 40 Hz (with 60 Hz reject filter)

The purpose of filtering is to reduce high frequency noise and low frequency (e.g. respiratory) movement artifacts.

The monitor filter is used in normal monitoring. The diagnostic filter is used if more accurate diagnostic information is needed. The ST filter gives more accurate information of ST segment, but reduces high frequency noise.

The high-pass filters 0.5 Hz and 0.05 Hz are done with software. The monitor sends a command to the hemodynamic module determining which of the corner frequencies 0.5 Hz or 0.05 Hz is to be used.

The 50 Hz and 60 Hz reject filters are both low-pass filters with zero at 50 Hz or 60 Hz correspondingly. They are software based filters used for the mains supply filtering. With these filters the 3 dB value for low-pass filter is 30 Hz or 40 Hz.

In diagnostic mode the upper frequency is 150 Hz and it is limited by software.

2.2.5 STP board

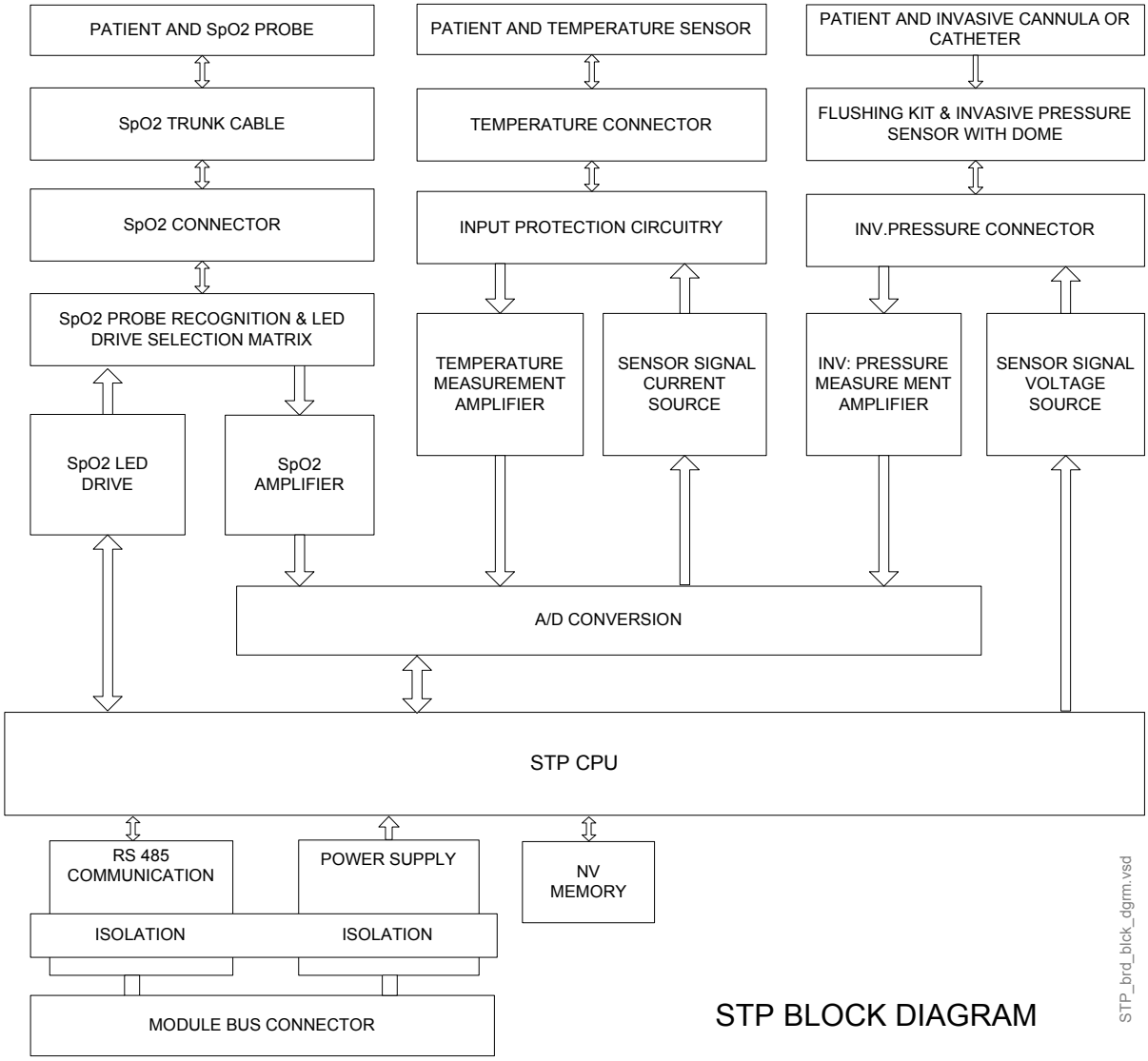


Figure 8 STP board block diagram

Microprocessor unit

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

High speed I/O is used to obtain a pulse control sequence necessary for pulse oximetry measurement. Timing for the clock is from the oscillator.

Temperature measurement unit

The NTC-resistor value in the probe depends on the patient's temperature. It is measured with the following principle described below.

The constant current source is supplied about 38 μA current through the temperature sensor (YSI 400-series NTC resistor). The constant current is caused a voltage over the temperature sensor (NTC resistor). The voltage over the temperature sensor is amplified in a differential amplifier stage. The amplified voltage is transferred to a controller of the STP board through an A/D converter.

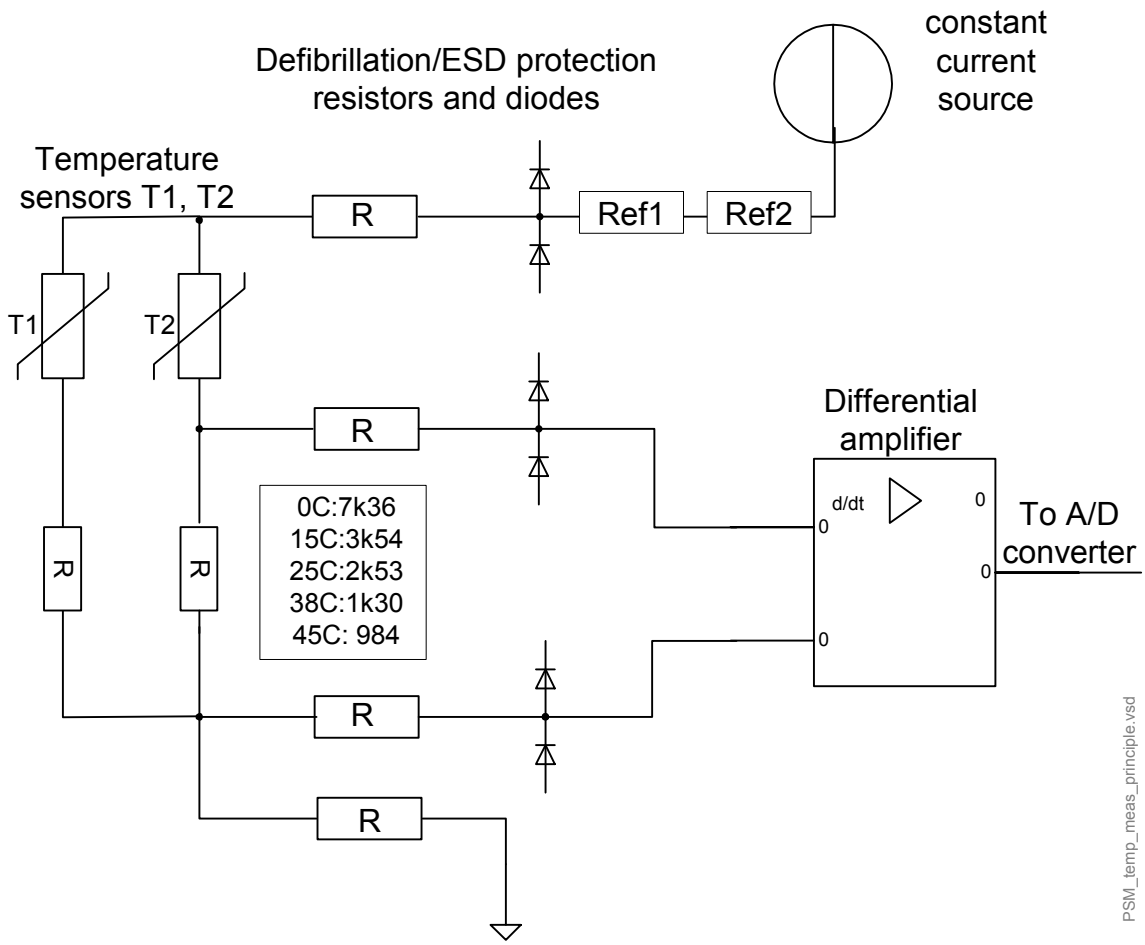


Figure 9 Temperature measurement principle

Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. The differential voltage, which depends on the pressure and the supplied voltage, is calculated from the bridge connection (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\ \mu V$, where U_{in} is 5 V

$\Rightarrow U_{out} = 25\ \mu V \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set to keep the level of the signal transferred to the A/D converter within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

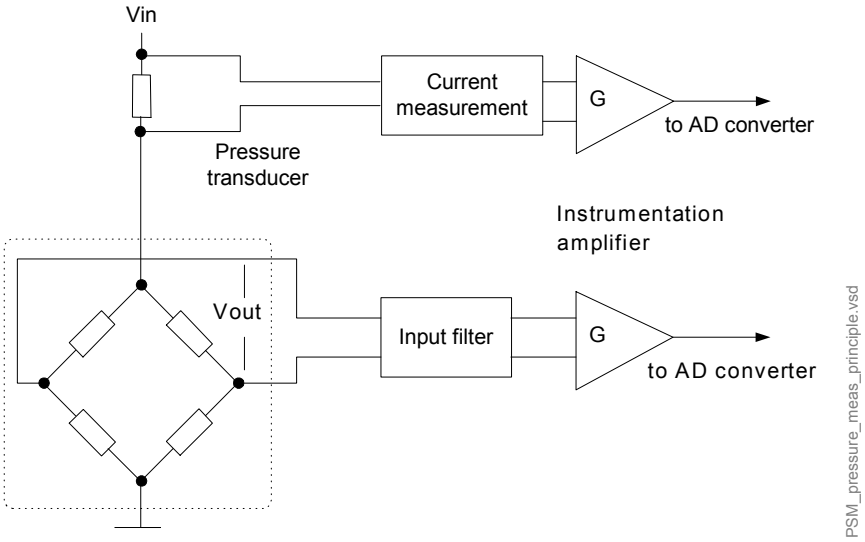


Figure 10 Pressure measurement principle

Pulse oximetry measurement section

LED control signals

The D/A converters of the microcontroller on the STP board set the LED intensity adjustment values for the infrared and red LEDs of the SpO_2 probe. The microcontroller on the STP board switches ON (to the adjusted intensity) and OFF the SpO_2 probe LEDs according to the predetermined sequence.

LED driving circuit

Differential amplifiers measure the LED currents (LED current indication) of the SpO_2 probe over the shunt resistors placed in the LED current paths. The LED driving voltages (LED voltage indication) are measured from the driver circuitry. The LED driving circuits also have MOSFET transistor matrix to enable the use of different probe configurations.

Measured signal preamplification

The preamplifier is a bipolar/single-ended current-to-voltage converter with adjustable gain. A higher gain is used for measuring thin tissue. The preamplification stage has also ambient light reduction and a second amplifier stage.

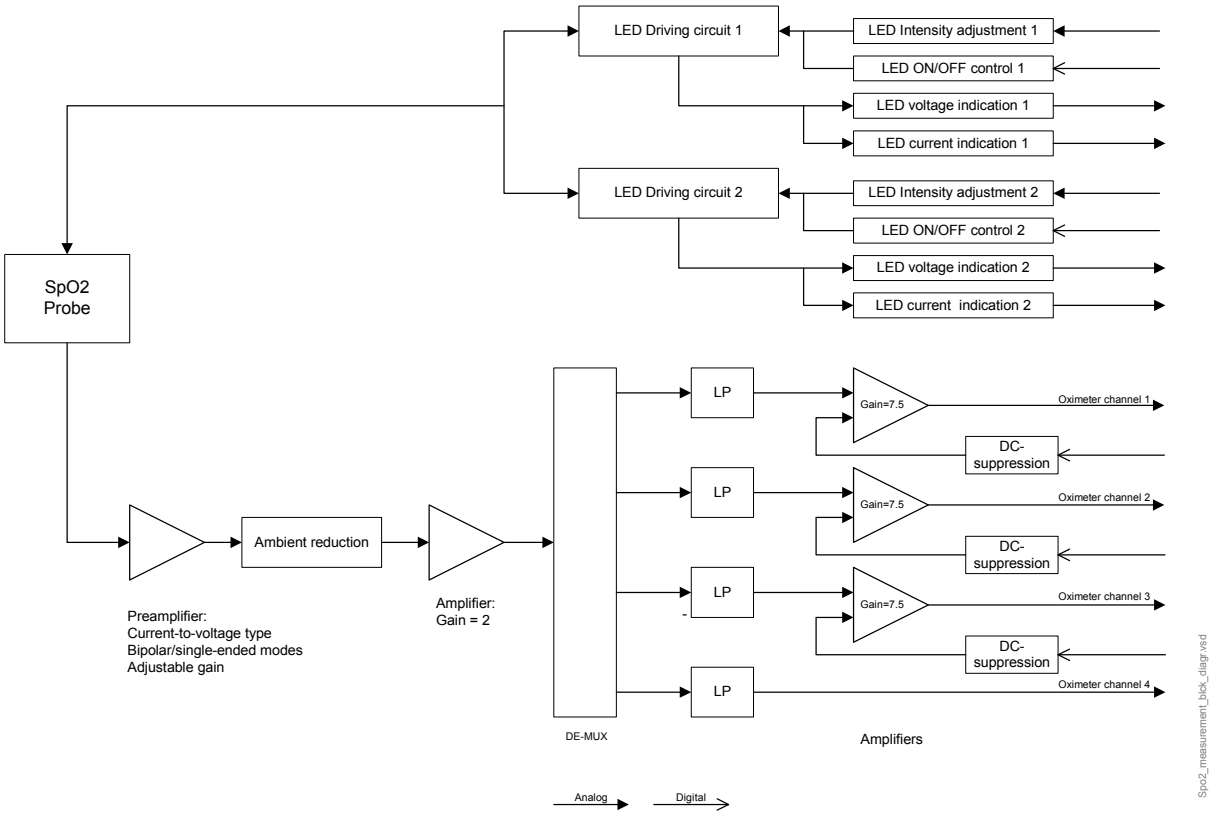


Figure 11 Pulse oximetry measurement block diagram

Red and infrared channel separation

It is possible to multiplex the detector signal to four different channels depending on the content of the signal. The detector signal must at least multiplex into infrared and red signals. Other channels are e.g. for diagnostic purposes.

Serial communication

An RS485 type bus driver makes the serial communication between the module and the frame. The data transmission rate is 500kbps.

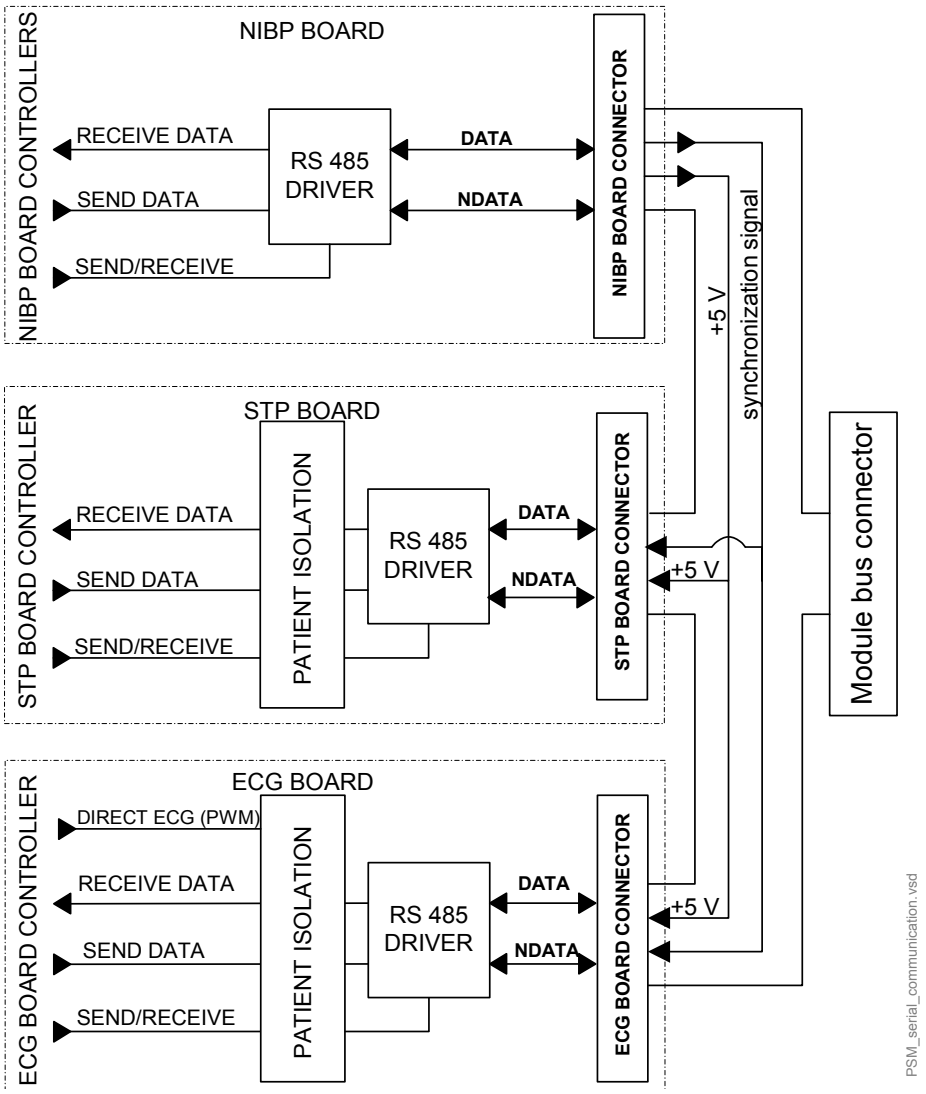


Figure 12 Serial communication of E-PSM(P) module

Signals and isolation barrier

The communication signals transfer over the isolation barrier by using high isolation voltage (6kV) opto isolators.

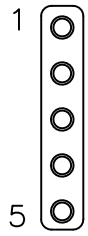
Power supply section

The power for the electronics on the floating part of the STP and the ECG boards is made on each board with the switching power supplies connected to a high voltage isolated transformer. The switching power supplies on the STP and ECG boards are synchronized to the frequency, about 340kHz of the switching power supply on the NIBP board. The NIBP board supplies non-isolated 5 V to the ECG and STP boards. The module uses only Vmod 13.8 - 16 V voltage of the frame. The other voltages of the measuring boards are made by the switching power supplies and regulators or the linear regulators. Each measuring board is protected against overloading with PTC type automatic fuses.

2.3 Connectors and signals

2.3.1 Module bus connector

Table 8 Module bus connector description

5 pin connector	Pin No.	Signal
	1 2 3 4 5	GND Vmod 13.8 - 16 V Data + Data - Shield

2.3.2 Front panel connectors

Table 9 ECG connector

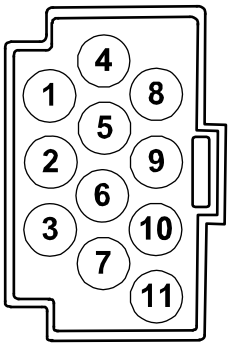
ECG Connector	Pin No.	Signal Name
	1 2 3 4 5 6 7 8 9 10 11	R/RA; Right arm electrode C2/V2; Chest electrode C3/V3; Chest electrode L/LA; Left arm electrode N/RL; Neutral/Right Leg Drive electrode C1/V1; Chest electrode C4/V4; Chest electrode F/LL; Left Leg electrode C6/V6; Chest electrode C5/V5; Chest electrode Cable Shield

Table 10 SpO_2 connector

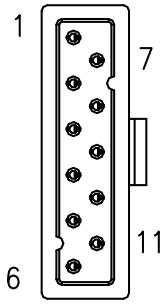
SpO_2 connector	Pin No.	Signal	Description
	1	DET_A	Photodiode anode
	2	DET_C	Photodiode cathode
	3	DATA-	
	4	Wire 1/3	LED connection
	5	IR_C	IR LED cathode
	6	OUTER SHIELD	
	7	DET_SHIELD	
	8	PRB_ID	Bin/ID Resistor+
	9	Wire 3/5	LED Connection
	10	RED_C	RED LED cathode
	11	DATA+	

Table 11 Invasive blood pressure connectors (P1, P2)

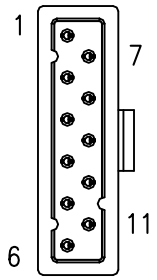
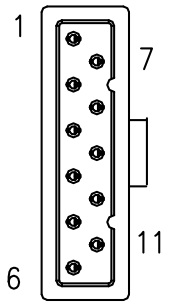
Invasive blood pressure connectors (Dual BP)	Pin No.	Signal	Description
	1	BP_+V_{REF}	BP transducer excitation voltage, channel 1
	2	BP SIG+	BP transducer signal positive (+), channel 1
	3	BP_+V_{REF}	BP transducer excitation voltage, channel 2
	4	AGND	Analog ground
	5	BP SIG+	BP transducer signal positive (+), channel 2
	6	SHIELD	BP cable shield
	7	AGND	Analog ground
	8	BP SIG1	BP transducer signal negative (-), channel 1
	9	BP SIG2	BP transducer signal negative (-), channel 2
	10	BP1_ID	BP1 probe identification
	11	NC	Not connected

Table 12 Temp connector (T1, T2)

Temp connector	Pin No	Signal
	1	Sensor drive current
	2	Input from temperature sensor, channel 1
	3	Not connected
	4	Not connected
	5	Thermistor ID (LOW= Temperature error, HIGH=YSI 400 series)
	6	Cable shield
	7	Analog ground
	8	Input from temperature sensor, channel 2
	9	Not connected
	10	Not connected
	11	Digital ground

3 Service procedures

3.1 General service information

The field service of the hemodynamic modules is limited to replacing faulty printed circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

WARNING **Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.**

3.2 Service check

These instructions include complete procedures for a service check. The service check is mandatory after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which may be used when performing the procedures.

The symbol  in the instructions indicates that the check form contains space to record the results of the particular procedure.

3.2.1 Recommended tools

NOTE: Use only properly maintained, calibrated and traceable measurement equipment for the specified calibrations and adjustments to ensure accuracy.

Table 13 Recommended tools

Tool	Order No.	For product(s)
Hemodynamic patient simulator	M1010831	E-PSM(P)
Adapter cables for simulators		
- Dual temperature adapter cable	2016998-001	Hemodynamic patient simulator and Medsim
- Dual Inv.BP adapter cable	2005772-001	Hemodynamic patient simulator
- Temperature adapter cable	M1010832	Medsim
- Inv.BP adapter cable	M1010858	Medsim
- Temperature adapter cable	M1010846	Lionheart & MPS450
- Inv.BP adapter cable	M1010862	Lionheart & MPS450
Pressure manometer		E-PSMP
Accessories:		
Temperature test set	884515-HEL	E-PSM(P)

Tool	Order No.	For product(s)
Multi-Link ECG accessories, IEC:		
- Multi-link 3-leadwire set	412682-003	E-PSM(P)
- Multi-link 5-leadwire set	412681-003	E-PSM(P)
- Multi-link 5-leadwire set, C2-C6	416467-004	E-PSM(P)
- Multi-link 12-lead ECG trunk cable	416035-002	E-PSM(P)
Multi-Link ECG accessories, AHA:		
- Multi-link 3-leadwire set	412682-001	E-PSM(P)
- Multi-link 5-leadwire set	416681-001	E-PSM(P)
- Multi-link 5-leadwire set, V2-V6	416467-003	E-PSM(P)
- Multi-link 12-lead ECG trunk cable	416035-001	E-PSM(P)
SpO_2 finger probe	OXY-F-UN	E-PSM(P)
SpO_2 Interconnect Cable	OXY-ES3	E-PSM(P)
InvBP transducer	70077-001	E-PSMP
Adult NIBP cuff hose with cuff ID	2021285-001	E-PSM(P)
Adult NIBP cuff	2753E	E-PSM(P)
Infant cuff hose without cuff ID	414874-001	E-PSM(P)
Screwdriver		

3.2.2 Recommended parts

Table 14 Recommended parts

Part	Order No.	Notes
E-PSM(P), Air Filter, FRU	M1221481	Replace every 3 years

3.2.3 Visual inspection

Detach the module cover by removing the four screws from the bottom of the module.

Check:

1. Internal parts
   - screws are tightened properly
   - connectors are connected properly
   - NIBP tubing is attached properly
   - there are no loose objects inside the module

2. External parts
   - the front cover and the front panel sticker are intact

– all connectors are intact and attached properly
– the module box and latch are intact

3.2.4 Functional inspection

3. NIBP pump filter

   Replace the NIBP pump filter, if necessary.

   Reattach the module cover and check that the latch is moving properly.

   Switch the monitor on and wait until the monitoring screen appears. Configure the monitor screen so that all the needed parameters are shown, for example as follows:

   Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 1 - ECG1***
   Field 2 - ECG2
   Field 3 - P1
   Field 4 - P2
   Field 5 - Pleth
   Field 6 - Resp
   Digit Fields - Lower Field 2 - NIBP
   Lower Field 3 - T1+T2

4. Module installation

   Plug in the module. Check that it goes in smoothly and locks up properly.

5. Module recognition

   Check that the module is recognized, i.e. all the needed parameter information, except invasive blood pressure, starts to show on the screen.

   Preset ECG, Respiration, InvBP and SpO_2 measurement settings:

   ECG - ***ECG Setup - Hr Source - Auto***
   Pacemaker - Show

   Others - ***Resp Setup - Size - 1.0***
   Resp Rate Source - Auto
   Measurement - On
   Detection Limit - Auto

   Invasive Pressures - ***P1 'Art' Setup - Label - Art***
   P2 'Cvp' Setup - Label - Cvp

   PulseOximetry - ***Pleth Scale - Auto***

ECG measurement

6. Module software (serial numbers)

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) -
   Service (password 26-23-8)

   Take down the information regarding the module software by selecting ***Scroll Vers*** and turning the ComWheel.

7. Communication and memories

   Enter the ***Parameters - ECG*** service menu.

   Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the ECG/RESP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM state all OK.

8. Power frequency

   Check that the power frequency value is set according to the current mains power frequency. Change the setting by selecting ***Power Freq***, if necessary.

9. Cable recognition

   Connect a 12-lead ECG trunk cable without a lead set to the module. Check that the message 'Leads off' is displayed on the screen.

10. Lead detection

    Connect both 5-leadwire sets to the trunk cable. Connect all the leads together, for example to a suitable screwdriver. Check that all the electrodes show ON and the message 'Asystole' appears. Check that the Cable type shows 10 lead.

    Connect the 10-leadwire set to the simulator. Disconnect one of the leads and check that the corresponding electrode in the service menu shows OFF within 10 seconds of the disconnection, and then reconnect the lead. Check the rest of the leads using the same method. Disconnect the trunk cable.

    Connect a 3-leadwire set to a trunk cable and connect it to the module. Connect all the leads together, for example to a suitable screwdriver. Check that the cable type shows 3 lead.

    NOTE: When any of the limb leads is disconnected, the measurement will automatically change to 3 electrode ECG measurement.

    NOTE: The asystole and different leads off messages are shown using certain priority. Even though one of the leads is disconnected, the related leads off message may not appear on the screen.

    NOTE: When RA, LA, LL or RL electrode is disconnected, all six V electrodes show OFF.

11. Test with the patient simulator

    Connect the leads to a patient simulator.

    Perform the settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    ECG - BASE - BPM - 160
    PACE - WAVE - NSR

    Check that a normal ECG waveform is shown, the HR value is 160 (±5) and the 'Pacer count' value is not increasing in the service menu.

    ECG - PACE - WAVE - ASNC

    Check that pacemaker spikes are shown on the ECG waveform, the HR value changes to 75 (±5) and the Pacer count value is increasing according to the shown pacemaker spikes.

    Set the pacemaker option off:

    ECG - PACE - WAVE - NSR

Respiration measurement

12. RESP measurement recognition

    Check that Resp Available and RESP Measurement both show ON in the ESTP: ECG service menu.

13. Test with patient simulator

    Check the respiration measurement with a patient simulator.

    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    Simulator Cover:

    BASELINE IMPEDANCE -switch - 500
    LEAD SELECT-switch - II/RL-LL

    Simulator Menu:

    RESP - WAVE - NORM
    RATE - 20
    OHMS - 1.0
    RATIO - 1/1
    APNEA - OFF
    SHIFT - OFF

    Check that the RESP waveform is shown and the RR value is 20 (±5). Change the position of the BASELINE IMPEDANCE switch and check that appropriate RESP waveform and RR value are shown again within 30 seconds.

    RESP - APNEA - 32 S

    Check that the monitor activates the APNEA alarm.

    NOTE: Make sure that only the ECG leads are connected to the simulator during the apnea test. If other cables are connected at the same time, the respiration signal from the simulator may be disturbed, and therefore, the APNEA alarm may not be activated.

    NOTE: When you have the ECG service menu open, spikes will appear on the respiration waveform. These spikes represent the threshold level for detecting inspiration and expiration.

Temperature measurement

14. Communication and memories

    Enter the ESTP: STP service menu:

    Parameters - ESTP : STP

    Check that the Time-outs, Bad checksums and Bad c-s by mod values do not increase faster than by 5 per second. Check also that the STP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

15. Temperature probe detection

    Check that the 'Cable' and 'Probe' show OFF for both channels, T1 and T2, when no probes are connected.

    Connect the temperature adapter cable to the module temperature connector and a temperature test plug to the adapter cable. Check that the Cable and Probe for T1 show ON and the corresponding temperature value appears on the monitor screen.

    Perform the same check also for the channel T2.

16. Calibration check

    Check the temperature calibrations using temperature test plugs.

    If the deviation on a temperature reading on the screen is more than 0.1°C, calibrate the temperature channels according to the instructions in chapter "Temperature calibration" on page 45."

17. Temp test

    Activate the temperature test by selecting ***Temp Test*** from the menu and pressing the ComWheel twice. When the message 'Performing temp test' disappears from the digit field, check that no error messages appear and Temp error shows OFF for both channels in the service menu.

18. Module configuration

    Check that the module configuration has been set correctly. The configuration in use is shown beside the text Configuration in the service menu and it can be either STP or ST. Change the configuration in the ***Calibrations - Set Config*** menu, if necessary. To activate the change, reset the module communication by removing and inserting the module.

Invasive blood pressure measurement

19. Membrane keys

    Check the front panel membrane keys that are related to the InvBP measurement.

    Press each of the keys for at least one second. Check that the pressed key is identified, i.e. one of the texts for Buttons changes from OFF to ON in the service menu.

20. Cable and transducer detection

    Check that the Cable and Probe for P1 show OFF. Connect the InvBP adapter cable to the module, connect a cable with an invasive blood pressure transducer to the adapter cable and check that the Cable and Probe show ON and the corresponding pressure waveform appears on the screen.

    Perform the same check also for the InvBP channel P2.

21. Calibration

    Calibrate the InvBP channels P1 and P2 according to the instructions in chapter "Invasive pressure calibration" on page 45."

22. Test with patient simulator

    Check the InvBP channels with a patient simulator.

    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    SENSITIVITY - switch - 5 µV/V/mmHg

    ECG - BASE - BPM - 60 - BP - 1 - WAVE - ATM

    2 - WAVE - ATM

    Restore the normal monitoring screen by pressing the key **Normal Screen**.

    Connect cables from the channels BP1 and BP2 to the module connectors. Zero the InvBP channels by pressing the keys ZERO P1 and ZERO P2 on the module front panel.

    BP - 1 - WAVE - ART
    2 - WAVE - CVP

    Check that appropriate InvBP waveforms are shown and the InvBP values are approximately 120/80 (±3 mmHg) for the channel P1 and 15/10 (±2 mmHg) for the channel P2.

    Check that the HR value is calculated from P1, when ECG is not measured (ECG cable disconnected).

SpO_2 measurement

23. SpO_2 probe detection

    Check that the message 'No probe' is shown, when no SpO_2 sensor is connected to the module. Connect an SpO_2 finger probe to the module (with the interconnection cable, if needed). Check that the message 'Probe off' is shown when the probe is not connected to a finger.

24. Test measurement

    Connect the SpO_2 probe onto your finger. Check that the reading of 95-99 and SpO_2 waveform appears. Check that the HR value is calculated from SpO_2 when ECG and InvBP (P1) are not measured.

Non Invasive Blood Pressure measurement

25. Communication and memories

    Enter the NIBP module service menu:

    Parameters - NIBP

    Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the NIBP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

26. Membrane keys

    Check the front panel membrane keys.

    Select ***Buttons/Leds***.

    Press each of the two NIBP related membrane keys for at least one second. Check that the pressed key is identified, i.e. the corresponding text changes from OFF to ON in the menu, when the key is released back up again.

27. Pump and valves

    Check the pump and valves.

    Select ***Pneumatics*** from the NIBP menu. Connect a pressure manometer to the NIBP module cuff connector.

    Select ***Start Pump*** and press the ComWheel. Check that the pump turns on and the pressure inside the tubing system starts to increase. Stop the pump by pressing the ComWheel again when the pressure reaches 280 mmHg.

    Select ***Open Exh2***. Press the ComWheel and check that the pressure inside the tubing system starts to drop, then press the ComWheel again. If necessary, turn the pump on again for a moment to increase the pressure inside the tubing system.

    Select ***Set Valve***. Press the ComWheel and set the value under the text Pulse Valve to number 150 by turning the ComWheel. Press the ComWheel again and check that the pressure inside the tubing system starts to drop. Finish the test by selecting ***Previous Menu***.

28. Leak test

    Check the NIBP tubing system for leakages.

    Select ***Calibrations*** from the NIBP service menu.

    Connect the pressure manometer to the NIBP module cuff connector. Start the active leak test from the menu by pressing the ComWheel. The module pumps a pressure of about 290 mmHg and then the pump stops. The max pressure in Adult mode is about 290 mmHg, but in Infant mode only 140mmHg.

Wait for 15 seconds for the pressure to stabilize then check that the pressure does not drop more than 6 mmHg per one minute. Release the pressure by pressing the ComWheel once more.

29. Calibration check

    Recalibrate the NIBP measurement according to the instructions in section "NIBP calibrations" on page 44. Remember to set the calibration protection back on after the calibration.

    Disconnect the pressure manometer. Select ***Calibrations*** - ***Calibration Check***. Press the ComWheel and take down the zero offset values for both pressure transducers, B1 and B2. The values should be within ±20 mmHg.

    Connect the pressure manometer to the cuff connector and check the calibration with pressures 100 mmHg, 200 mmHg and 260 mmHg. The zero offset value must be added to the displayed pressure value in order to determine the real pressure.

30. Safety valve functions

    Select ***Safety Valve*** from the NIBP service menu.

    Disconnect the pressure manometer from the NIBP module cuff connector. Connect the NIBP hose and cuff to the NIBP module cuff connector. Perform the check with a standard adult cuff that is connected around some round object, for example a calibration gas bottle.

    Select ***Start Test***. Start the adult safety valve test by pressing the ComWheel. Wait until the pump stops and the pressure is deflated.

    Open cuff connector or disconnect and connect cuff connector from module

    Check the pressure values 'Max press' and '2 s after stop' for both transducers. All the values should be within 270 - 330 mmHg.

    Select ***ADULT***. Press the ComWheel and check that the text changes now to ***INFANT***.

    Select ***Start Test*** and wait until the pump stops and the pressure values on the screen have been updated.

    Open cuff connector or disconnect and connect cuff connector from module

    Check that the values 'Max press' and '2 s after stop' are all now within 135 to 165 mmHg.

    Return to the normal monitoring mode by pressing **Normal Screen**.

31. Cuff related messages

    Connect an adult NIBP cuff to the cuff connector and disconnect one of its hoses.

    Start NIBP measurement by pressing the key **Start/Cancel** on the module and check that the message 'Cuff loose' appears on the screen within 70 seconds.

    Reconnect the hose and then bend it with your fingers. Restart the measurement and check that the message 'Cuff occlusion' appears on the screen within 70 seconds.

32. Test measurement

    Check that the automatic inflation limits are in use:

    NIBP - ***NIBP Setup - Inflation Limits - Auto - Previous Menu***

    Connect the cuff onto your arm, select ***Start Ven.Stasis*** in the NIBP menu and press the ComWheel. Check that the module identifies the cuff, i.e. the text Adult appears in the NIBP digit field for a short moment.

    Keep the pressure inside the cuff for about half a minute in order to find out that the cuff is not leaking, then press the ComWheel again. Select **Normal Screen**.

    Disconnect the cuff hose.

33. NIBP hose detection

    Press the **Start/ Cancel** module or side panel key and check that the 'Cuff loose' message appears in the NIBP digit field.
    Attach a NIBP cuff hose without cuff identification and check that the module identifies the hose:

    – The message 'Select inflation limits' appears in the NIBP digit field.
    – When you try to start the measurement, the monitor automatically opens the selections ***NIBP Setup - Inflation Limits.***

All modules

34. Electrical safety check

    Perform an electrical safety check and a leakage current test.

35. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

36. Final cleaning

    Clean the module with suitable detergent.

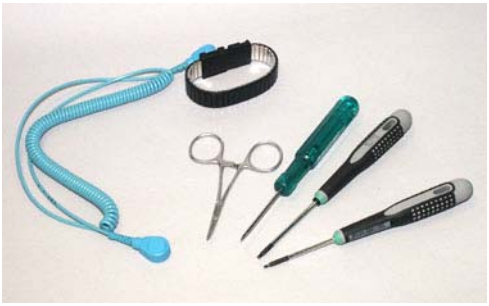
    Fill in all necessary documents.

3.3 Disassembly and reassembly

3.3.1 Before disassembly

WARNING **Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board. Handle all PC boards by their edges.**

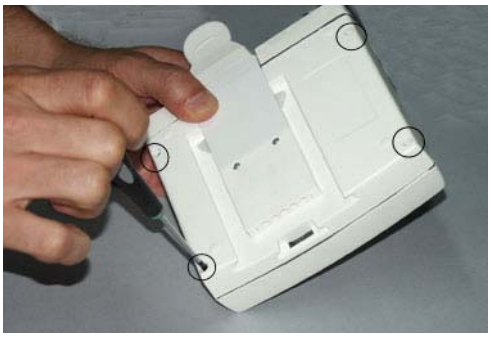
3.3.2 Tools needed



- torx screwdrivers; T6, T8
- flat blade screwdriver
- pincers
- antistatic wristband

CAUTION When reassembling the module, make sure to reconnect all cables properly.

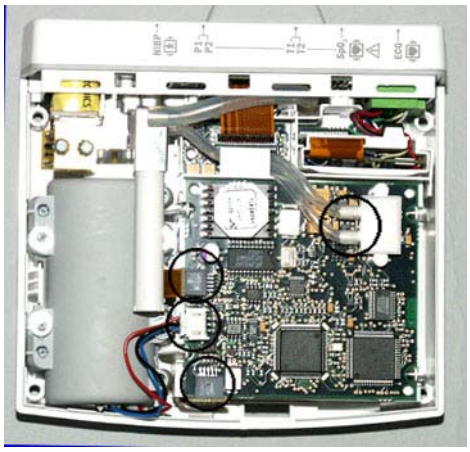
3.3.3 To disassemble the module



1. Remove the four screws (T8) holding the module cover to the frame from the bottom of the module.

2. Hold the cover from the back corners, lift it about 45° to unlock the snaps from the front unit and pull the cover out backwards.

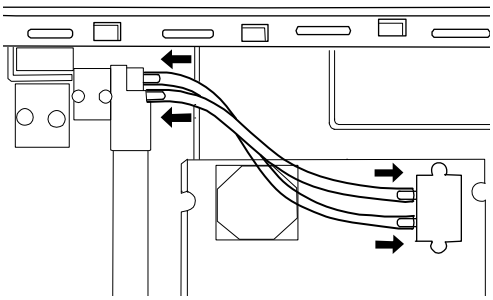
NOTE: Be careful not to damage the seal. When reassembling the seal may stick to the cover.



3. To remove the NIBP board:

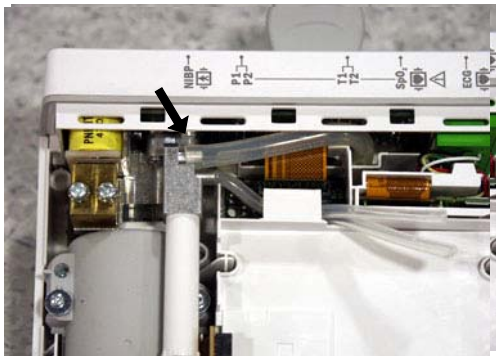
NOTE: You may remove the NIBP filter cover and the filter before disconnecting the flex cable.

- Disconnect the module bus connector, pump connector and NIBP flex connector.
- Disconnect the hoses (2 pcs) coming from the manifold.

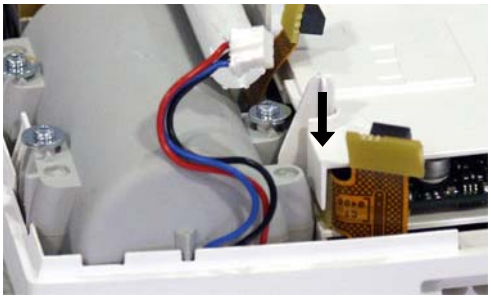


NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

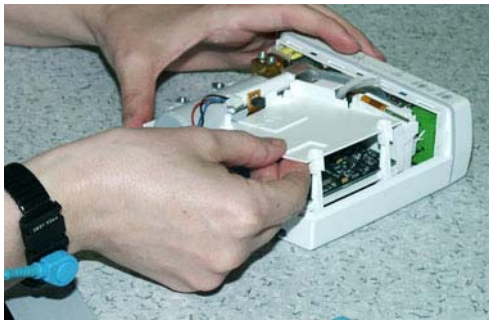
- Remove the NIBP board.



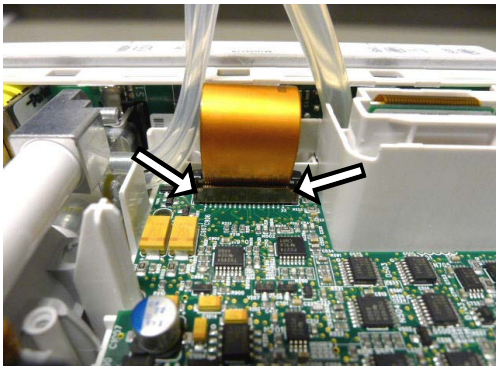
4. Disconnect the air intake hose from the NIBP manifold.



NOTE: The lips of the insulator plates secure the module bus connectors. While reassembling the insulator plates, ensure that the connector secure lips support the connectors correctly.



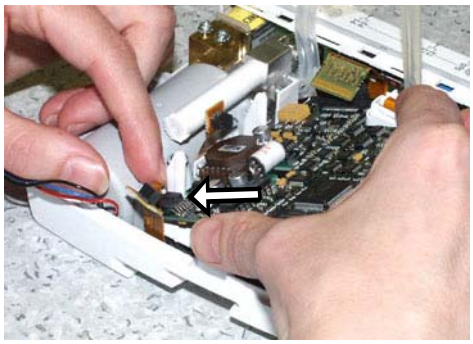
5. Lift the NIBP-STP insulator plate carefully up.



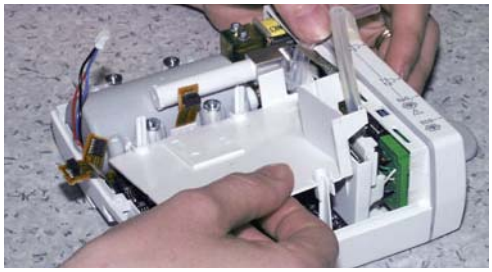
6. To remove the STP board

- Carefully open the connector lock and then disconnect the STP input flex cable from the STP board.

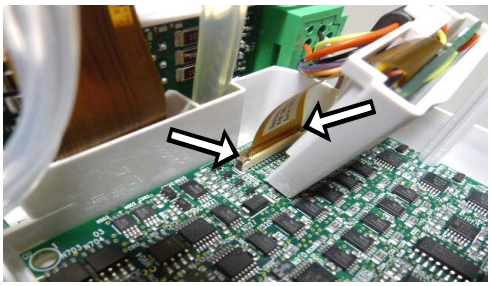
NOTE: When reassembling, ensure that the flex cable is aligned properly and the connector is locked.



- Lift the STP board a little to disconnect the module bus connector. Remove the STP board.

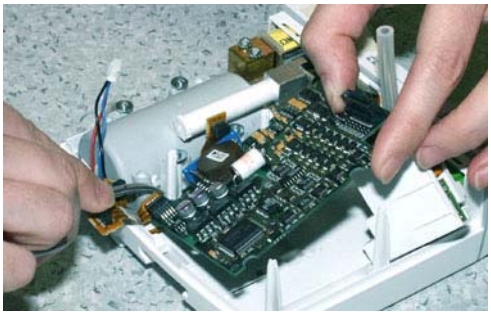


7. Remove the STP-ECG insulator plate. Be careful not to damage the NIBP hoses.



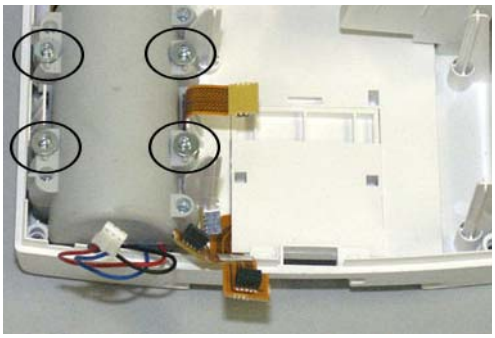
8. Hold down the ECG board. Carefully open the connector lock and then disconnect the ECG input flex cable from the ECG board.

NOTE: When reassembling, ensure that the flex cable is aligned properly and the connector is locked.



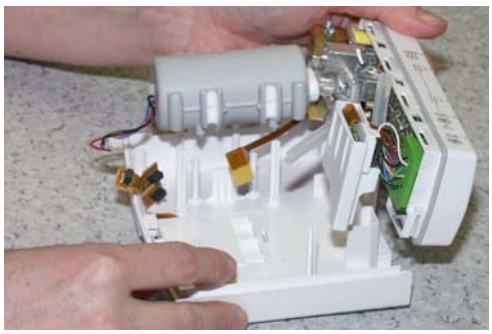
9. To remove the ECG board
- While holding the ECG input unit out of the way, lift the ECG board a little and disconnect the module bus connector.
- Remove the ECG board.

10. Remove the NIBP filter cover and the filter. (If not removed already.)



11. Remove the four screws (T6) with washers holding the NIBP pump to the frame.

12. Flip the module over and remove the two (T6) screws holding the lock unit to the frame. While pulling the tab push the lockers with a screwdriver to remove the lock unit.



13. Carefully lift up the front unit together with the NIBP pump.

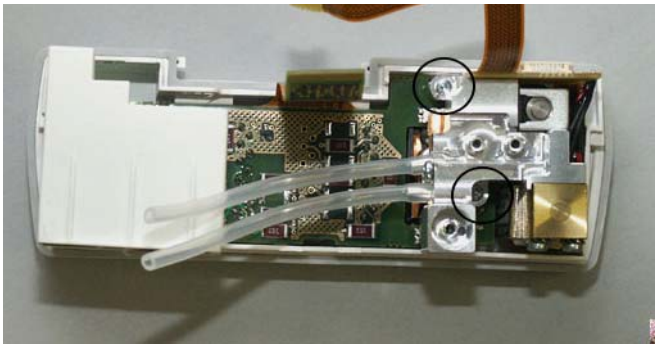
Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

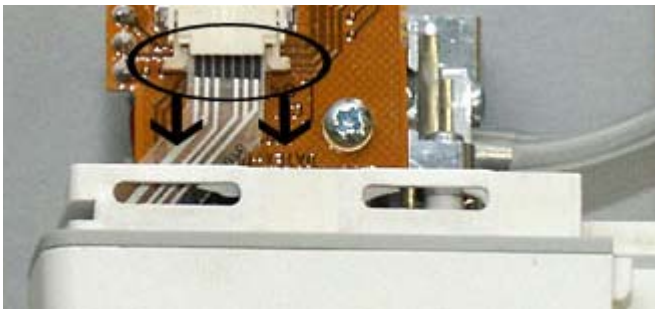
To remove the pump unit

14. Disconnect the hoses from the manifold. The hoses follow the pump.

3.3.4 To remove the manifold unit



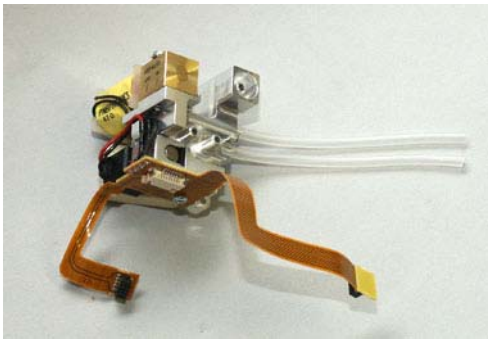
15. Disconnect the two (T6) screws holding the manifold to the front cover unit.



16. Open the connector lock from the NIBP flex board and disconnect the membrane keyboard flex.

17. Lift the manifold carefully aside. Be careful not to damage the NIBP flex board. Disconnect the NIBP flex board connector from the STP input board.

NOTE: When reassembling, make sure that the NIBP flex board connector is connected properly (all pins connected) to the STP input board.



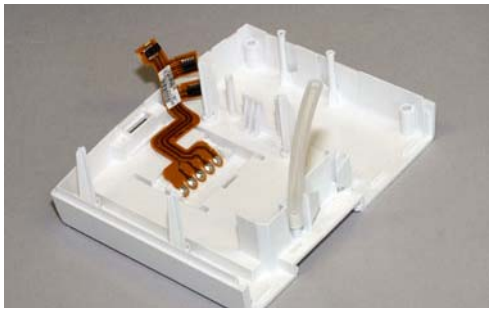
Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

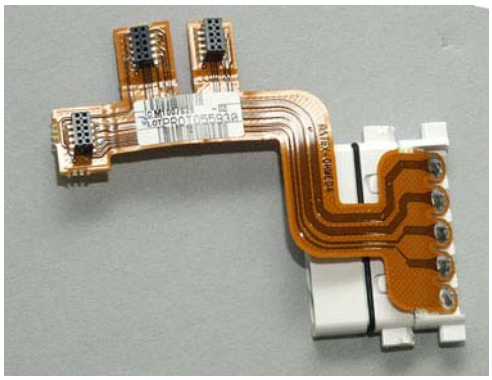
3.3.5 To remove the module bus connector

18. Use a flat blade screwdriver to unlock the module bus connector insulator cover.

    Put the screwdriver in the hole and move the blade backwards (away from the flex cable) until the insulator cover unlocks.



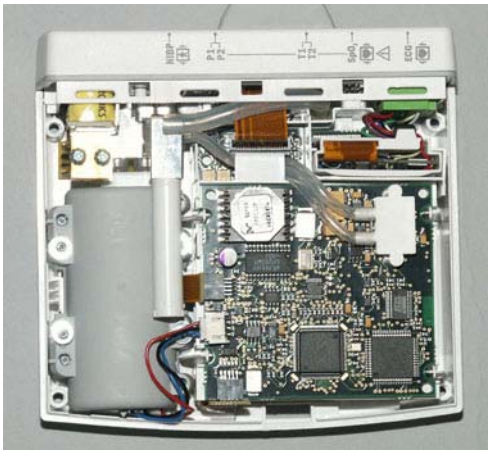
19. Pull the module bus connector carefully through the hole in the frame.



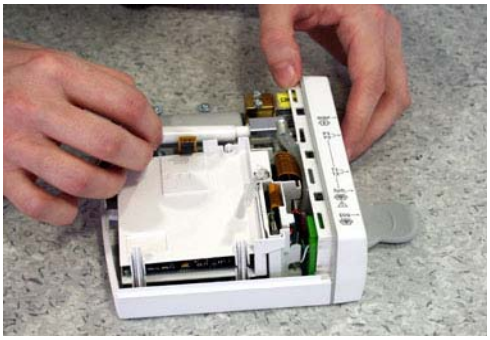
Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

3.3.6 To replace the NIBP filter



1. Follow the disassemble instruction steps 1 and 2.



2. Remove the NIBP filter cover and replace the filter.

Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

3.4 Adjustments and calibrations

NOTE: Use only properly maintained, calibrated and traceable measurement equipment for the specified calibrations and adjustments to ensure accuracy.

3.4.1 NIBP calibrations

The electronics of the NIBP pressure measurement is calibrated at the factory. The processor automatically maintains the zeroing pressure. If the zero point of the pressure transducer drifts more than specified, an error message is given and the NIBP board should be recalibrated or replaced.

Recalibrate the NIBP measurement once a year. The checking and recalibration can be done in the NIBP service menu.

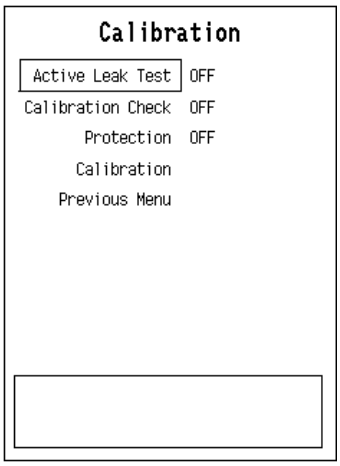
The calibration of the primary pressure channel can also be checked from the NIBP setup menu (***NIBP - NIBP Setup - Calibration Check***). In this case, the auto zeroing is performed at start - remove the hose before entering to ensure atmospheric pressure to the pressure transducers - the primary pressure is displayed. The zero-offset value should then be zero.

Check the intake air filter as part of the calibration check. Change the filter if it is visibly dirty.

Calibration check

1. Enter ***Calibration*** menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) -***Service*** (26-23-8) - ***Parameters - NIBP - Calibrations***



2. Select ***Calibration Check*** and push the ComWheel.
3. Connect an external precision manometer to the module.
4. Pump the following pressures to manometer and check the difference between the manometer and monitor pressure display (The zeroing offset is automatically subtracted from the pressure readings).

Table 3 NIBP calibration check pressures

Pressure	Max. error	Example
0 mmHg	±5 mmHg (=zero offset)	-1
100 mmHg	100 ±2 mmHg	100 ±2
200 mmHg	200 ±3 mmHg	200 ±3
260 mmHg	260 +/-3 mmHg	200 ±3

If the error of pressure channel B1 is larger than specified above, the module should be recalibrated. The error of B2 is allowed to be even twice as large because it has no effect on blood pressure measurement accuracy. However, we recommend recalibrating the module when the error of B2 is larger than specified above to ensure best possible operation.

Calibration

1. Enter ***Calibration*** menu.
2. Remove the hoses from the front panel connector to enable proper zeroing.
3. Select ***Calibration***. If it is not available, perform the steps a, b, and c.

NOTE: Do not pull out the hemodynamic module from the monitor frame. The module must be in the frame during the whole procedure.

a. Press the hemodynamic module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds to enable the calibration. This enables menu selection ***Protection***. The message 'Calibration switch ON!' is displayed.

b. Select ***Protection OFF*** in the ***Calibration*** menu and push the ComWheel.

c. Press the buttons again for 3 seconds. Menu selection ***Calibration*** is now enabled, and ***Protection*** is disabled. When the calibration is enabled, a message 'Calibration not protected' is displayed.

- Start calibration by pushing the ComWheel. Messages 'Zeroing' and 'Zeroed' will be displayed in the NIBP message field. After this, a pressure bar and text 'Calibrating' will be displayed.
- Connect an external mercury manometer with a pump to the module through the both tubes of the hose - both transducers B1 and B2 must be calibrated simultaneously. Pump up to a pressure of about 200 mmHg according to the manometer. Calibration is possible in the range of 150 to 250 mmHg.
- Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel. When the values of the pressure bar and the manometer are equal, push the ComWheel to confirm the calibration. The message 'Calibrated' will be displayed on the NIBP digit field after a few seconds, which means that the calibration succeeded, and the new calibration data is saved in EEPROM.

NOTE: When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct. For example, change the value one step higher and then back one step lower. 'Calibrated' text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.

- To set the protection on:
  Press NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds. Select ***Protection ON*** and push the ComWheel. Then press the buttons again for three seconds.

- Remove the module from the frame and plug it back again. Then perform "Calibration check" (see the preceding page) to verify the new calibration.

3.4.2 Temperature calibration

NOTE: For the temperature calibration, separate, accurate test plugs (25 °C and 45 °C) are needed. A test set of two plugs is available from GE Healthcare, order code 884515-HEL.

A Dual temperature adapter cable, order code 2016998-001 is also required for the temperature calibration.

Calibrate the temperature, when the measured test values differ for more than ±0.1 °C, and always after STP board replacement.

1. Enter the STP service menu.

   (**Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8) - ***Parameters***).
2. Enter ***Calibrations*** menu.
3. Choose ***Protection OFF*** in protect mode.
4. Select ***Calibrate T1/Calibrate T2***.
5. Insert calibration plug (25 °C) into T1/T2 connector.
6. Push the ComWheel.
7. Insert calibration plug (45 °C) into T1/T2 connector.
8. Push the ComWheel.
9. Choose ***Protection ON*** in protect mode.

3.4.3 Invasive pressure calibration

NOTE: Before starting invasive pressure calibration, disconnect all patient cables and discharge the patient.

NOTE: For the Invasive pressure calibration a Dual InvBP adapter cable, order code 2005722-001, is needed.

Calibrate the invasive pressure when the pressure transducer (probe) is replaced with a different type of transducer, and when the STP board is replaced.

1. Enter the STP service menu.

   (**Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8) - ***Parameters***).
2. Enter ***Calibrations*** menu.
3. Connect a pressure transducer with a pressure manometer to the P1/P2 connector. Choose ***Calibrate P1*** or ***Calibrate P2***. Leave the transducer to room air pressure.
4. Push the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and push the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The message 'Calibrated' will be displayed on the display.

4 Troubleshooting

4.1 Troubleshooting charts

See also the “User’s Reference Manual” for more troubleshooting procedures.

4.1.1 NIBP

Problem	Cause	What to do
No NIBP value displayed	NIBP not selected on screen.	Check monitor setup.
NIBP menu fading	No E-PSM(P) module, module not properly connected.	Plug in the module.
‘Artifacts’ message	Unsuccessful measurement due to patient movement, shivering, external artifact or weak signal.	Check the patient status.
‘Weak pulsation’ message	Weak or unstable oscillation pulses due to: • artifacts • weak pulse pressure due to arrhythmias • improper cuff position or attachment • too few pulses detected • weak or unusual blood circulation • obese patient	Check patient condition and retry. Check any leaks and retry. Use proper size of cuff. Check attachment.
Call service ‘Error X’ message	NIBP hardware error. X = error number.	See the description of the error message code, the causes and the solutions listed in the “NIBP error code explanation” chapter.
‘Cuff loose’ message	1. Hose and/or cuff not connected.	1. Connect the hose and the cuff.
	2. Hose and cuff connected. Reasons:	
	- cuff loosely wrapped	- Tighten the cuff.
	- leakage inside the shield, in the Patient connector panel or tubings connecting to the module	- Check the tubings inside the shield and Patient connector panel, fix if necessary.
	- leakage in cuff or hose	- Replace cuff/hose.
	- leakage inside module	- Check internal tubing and fix if necessary.
	- pump does not work	- Check pump connector; if OK, replace the NIBP Pump Unit.

Problem	**Cause**	**What to do**
Cuff ID not working	1. Defective cuff ID holes in the NIBP cuff hose	- Replace NIBP cuff hose.
	2. NIBP flex board connector wrongly connected	- Check that the NIBP flex board connector is properly connected to the STP input board: all pins have to be connected.
	3. Cuff ID switches defective	- To check the switches, attach a NIBP cuff hose without the cuff ID and check that the message 'Select inflation limit' appears. If not, replace the Front Panel Unit.
	4. NIBP ID switch cable (between patient connector panel and the module) broken or poorly connected	- Check the cable, fix if necessary.
'Air leakage' message	1. Hose or cuff leaking. Reasons:	1. Replace cuff
	- cuff damaged	- Replace cuff.
	- cuff connector damaged	- Replace cuff connector (if the fault is in hose connector).
	- O-ring damaged or missing	- Replace O-ring.
	- hose double connector damaged	- Replace NIBP cuff hose.
	2. Hose and cuff OK. Reasons:	2. Connect or replace tube
	- leakage in the tubes connecting the patient connector panel and the module	- Check the tubes.
	- leakage inside the module	- Replace the whole tubing.
	- tube disconnected or damaged	- Fix connections.
	- manifold leaking	- Replace the manifold.
	- tubes or valve(s) damaged	- Replace tubes/valve(s).
'Unable to measure Sys' message	Systolic blood pressure probably higher than the inflation pressure or artifacts.	Automatic retrial with increased pressure.

Problem	**Cause**	**What to do**
'Cuff occlusion' message	1. Cuff and/or hose occluded. Reason:	
	- cuff tube kinked	- Straighten tube.
	- tubes inside the shield kinked	- Straighten tubes.
	- tubes inside module kinked	- Straighten tubes.
	- occlusion inside/outside module	- Remove occlusion.
	2. Cuff, hose, and tubes OK. Reason:	
	- fault in pressure transducer	- Replace the NIBP board.
	- fault in A/D converter	- Replace the NIBP board.
	- faulty calibration	- Check calibration.
'Calibration switch on' message	EEPROM protection has been handled by pressing module buttons **Auto ON/OFF** and **Start/Cancel** simultaneously for 3 seconds.	Enables setting the protection OFF in the ***Calibration*** menu. Press the buttons again if you are not going to calibrate.
'Calibration not protected' message.	Calibration protection is set to OFF.	Set the protection ON in the NIBP ***Calibration*** menu.

4.1.2 NIBP error code explanation

Code	Problem	What to do
0	RAM failure; memory failure	Change the NIBP board.
1	ROM checksum error; memory failure	Change the NIBP board.
2	Pump current failure	Check short circuits. Change the NIBP board.
3	Safety CPU internal test failure or pressure sensor reference voltage failure	Change the NIBP board.
4	EEPROM protection error	Press module buttons **Auto ON/OFF** and **Start/ Cancel** simultaneously for 3 seconds.
5	Calibration not protected	Protect calibration by selecting Protection ON in the NIBP calibration menu.
6	Pressure sensors give different readings	Try to remeasure. If the problem persists, recalibrate. If the problem still persists, change the NIPB board.
7	Calibration failure	Reset the module and recalibrate. If this does not help, change the NIBP board.
8	Exhaust Valve occlusion	Check and clean the tubing and air chamber. If this does not help, change the NIBP board.
9	Measurement related error	Automatic recovery.
10	EEPROM checksum error; memory failure	Change the NIBP board.
11	Auto zero range exceeded	Calibrate the NIBP.
12	Communication break; temporal break down of communication from monitor detected	Automatic recovery.
13	Illegal neonate cuff with identifying magnet connected	Remove the cuff.
14	Not in use	Not in use
15	Safety CPU pressure calibration error	Recalibrate. If this does not help, change the NIBP board.
16	Communication error between CPUs	Change the NIBP board.
17	Safety CPU has cut down power from pneumatics due to repeating safety limit violations	Reset the module. If the problem persists, change the NIBP board.

4.1.3 Pulse oximetry (SpO_2)

Problem	Cause	What to do
Message 'NO PROBE'	No sensor connected to the module SpO2 connector.	Check sensor connections.
	Sensor faulty.	Change the sensor.
	Flat cable connecting the SpO2 connector to the STP board loosen or broken.	Check the Flat cable, replace if necessary.
Message 'PROBE OFF' though sensor properly attached to the patient	Unsuitable site.	Try another site.
	Sensor faulty.	Try another sensor.
	Sensor connection cable not connected to sensor.	Connect the cable to sensor.
Finger sensor falls off	Sensor is slippery.	Wipe with 70% isopropyl alcohol and allow drying.
	Finger is too thin or thick.	Try other fingers, or other sensor types.
Weak signal artifacts	Poor perfusion.	Try another place.
	Movement artifacts.	
	Shivering.	
Message 'NO PULSE'	Pulse search > 20 sec. and low SpO_2 or low pulse rate.	Try other fingers.
Message 'ARTIFACT'	Pulse modulation exceeds the present scale.	Try another place or another sensor.
Message 'CHECK PROBE'	DC value not in balance.	Try another sensor.
Message 'POOR SIGNAL'	Poor perfusion. Modulation (Red or Ired) < 0.25%	Check that the sensor is positioned correctly to the patient.
Message 'FAULTY PROBE'	Sensor is faulty.	Change the sensor.
No SpO_2	No waveform selected on screen.	Check the selected SpO_2 waveforms by pressing **Monitor Setup** key and selecting ***Screen 1 Setup - Waveform Fields***.
	Wrong configuration setting.	Check the configuration settings from the STP/Calibrations menu (**Monitor Setup - *Install/Service - Service - Parameters***)

4.1.4 Invasive blood pressure

Problem	Cause	What to do
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer.	Check transducer.
	No pressure module plugged in.	Check the module.
	No waveform selected on screen.	Check the selected pressure waveforms by pressing **Monitor Setup** key and selecting ***Screen 1 Setup - Waveform Fields***.
		Check that the pressure transducer is open to the patient.
	Wrong configuration setting	Check the configuration setting from the STP/Calibrations menu (**Monitor Setup - *Install/Service - Service - Parameters***).
	Flat cable connecting the patient connector panel to the module loosen or broken.	Check the Flat cable, replace if necessary.
'Not zeroed' message	Measurement on, channel not zeroed.	Zero the channel.
'Zeroing failed' message	Unsuccessful zeroing of P1 /P2 (number field).	Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel.
		Offset is > 150 mmHg. Open the transducer to air and zero the channel.
		Defective transducer. Replace it and zero the channel.
'Calibration failed' message	Unsuccessful calibration of P1/P2 (number field), possibly due to a pulsating waveform	Turn the transducer to sphygmomanometer and try again (zeroing takes place first).
		Gain is beyond the limits (± 20% of the default gain). Replace the transducer.
Out of range < 40 mmHg	Measurement pressure is beyond the measurement range.	Check the transducer level. Zero the channel.
Out of range > 320 mmHg	Measurement pressure is beyond the measurement range.	Check the transducer level. Zero the channel. The patient may also have high pressure.
Zero adj. > 100 mmHg	Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain).	Check the transducer. The waveform may hit the top and the numeric display not shown.
Out of range	Measured pressure is beyond the internal measurement range of the module.	The waveform hits the top and the numeric display not shown. Check the transducer and its level. Zero the channel.

4.2 Troubleshooting flowcharts

4.2.1 Troubleshooting for NIBP parameter

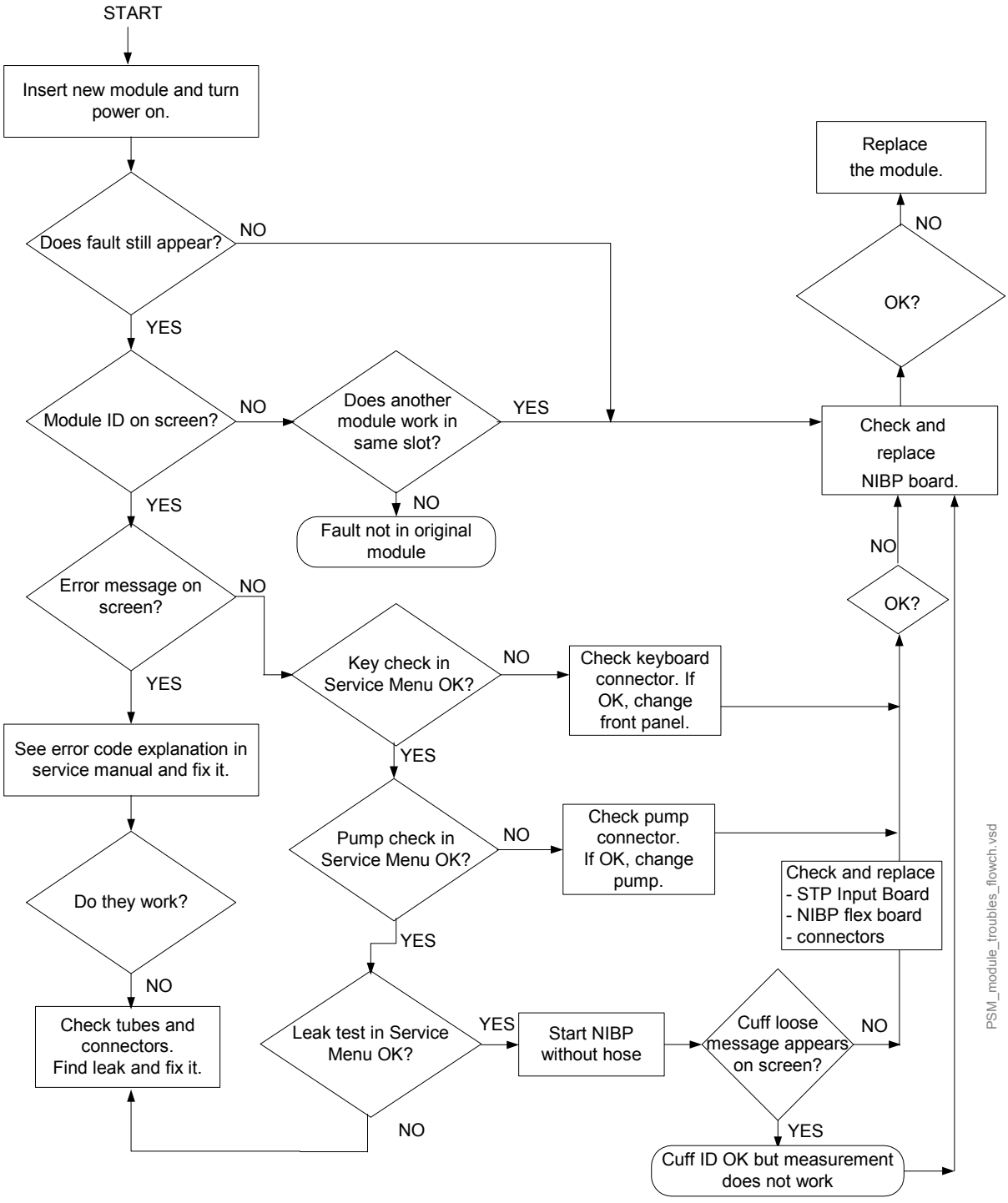


Figure 13 Troubleshooting flowchart for NIBP parameter

4.2.2 Troubleshooting for ESP parameters

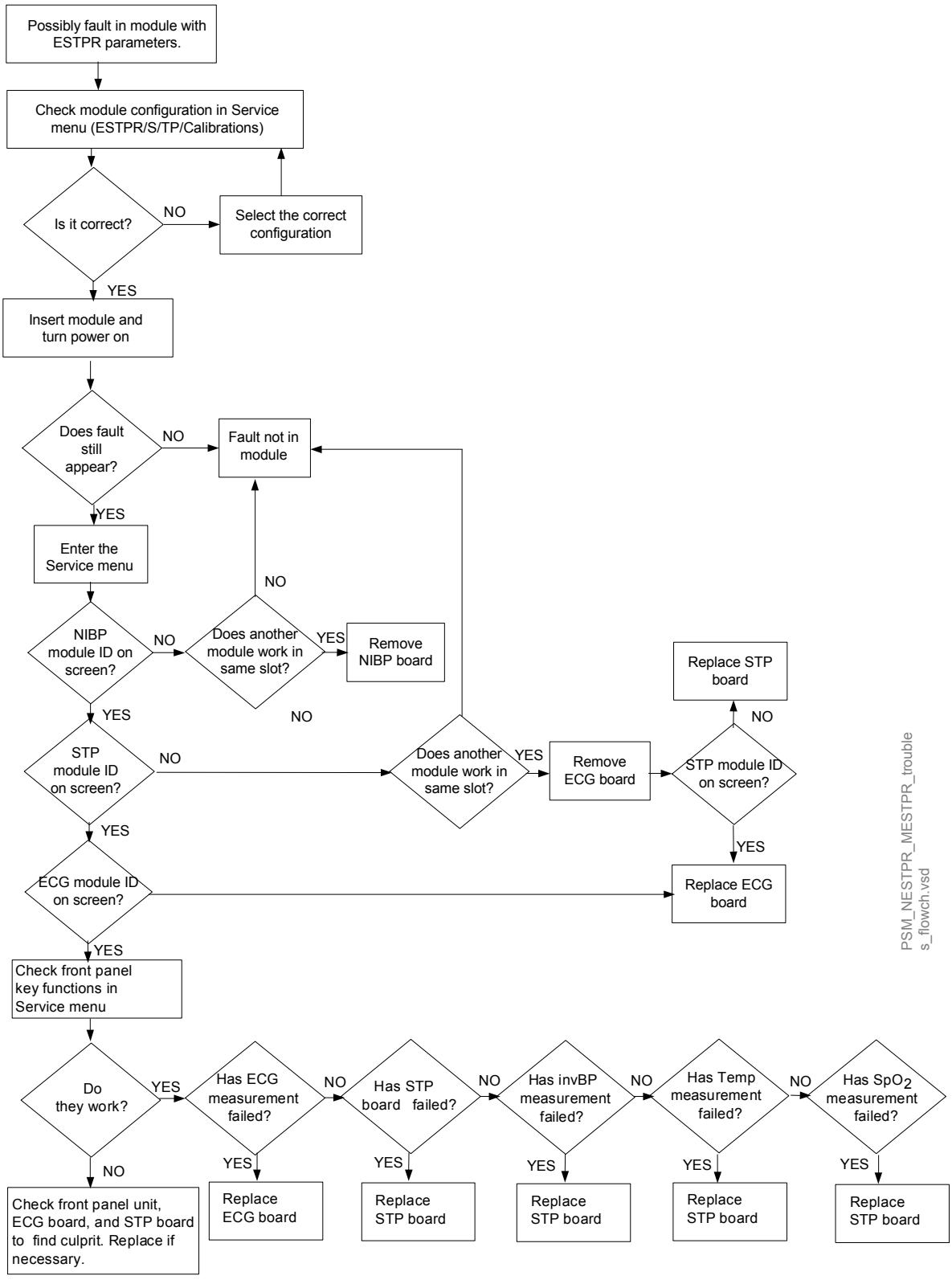


Figure 14 Troubleshooting flowchart for ESP Parameters

5 Earlier revisions

Patient Side Modules E-PSM, E-PSMP (Rev. 00)

APPENDIX A: Service check form, Patient Side Module, E-PSM, E-PSMP (Rev. 01)

Customer		
Service	Module type	S/N
Service engineer		Date

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. NIBP pump filter	☐	☐	☐	4. Module installation	☐	☐	☐
5. Module recognition	☐	☐	☐				
Notes							

ECG measurement	S/N
6. Module software (serial numbers)	
ECG/RESP	
STP	
NIBP	

	OK	N.A.	Fail		OK	N.A.	Fail
7. Communication and memories	☐	☐	☐	8. Power frequency	☐	☐	☐
9. Cable recognition	☐	☐	☐	10. Lead detection	☐	☐	☐
11. Test with the patient simulator	☐	☐	☐				
Notes							

RESP measurement				S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
12. RESP measurement recognition	☐	☐	☐	13. Test with patient simulator	☐	☐	☐
Notes							

TEMP measurement				S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
14. Communication and memories	☐	☐	☐	15. Temperature probe detection	☐	☐	☐
16. Calibration check	☐	☐	☐	17. Temp test	☐	☐	☐
18. Module configuration	☐	☐	☐				
Notes							

InvBP measurement				S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
19. Membrane keys	☐	☐	☐	20. Cable and transducer detection	☐	☐	☐
21. Calibration	☐	☐	☐	22. Test with patient simulator	☐	☐	☐
Notes							

SpO2 measurement				S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
23. SpO2 probe detection	☐	☐	☐	24. Test measurement	☐	☐	☐
Notes							

NIBP measurement				S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
25. Communication and memories	☐	☐	☐	26. Membrane keys	☐	☐	☐
27. Pump and valves	☐	☐	☐	28. Leak test	☐	☐	☐
29. Calibration check		Measured B1		Measured B2		Allowed range	
0 mmHg						±9 mmHg	
100 mmHg						100 ±2 mmHg	
200 mmHg						200 ±3 mmHg	
260 mmHg						260 ±4 mmHg	
30. Safety valve functions		Measured B1		Measured B2		Allowed range	
						270...330 mmHg	
						270...330 mmHg	
						130...165 mmHg	
						130...165 mmHg	
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
31. Cuff related messages	☐	☐	☐	32. Test measurement	☐	☐	☐
33. NIBP hose detection	☐	☐	☐				
Notes							

All modules	OK	N.A.	Fail		OK	N.A.	Fail
34. Electrical safety check	☐	☐	☐	35. Functioning after electrical safety check	☐	☐	☐
36. Final cleaning	☐	☐	☐				
Notes							

Notes

Used spare parts			

Signature

GE Healthcare

Cardiac Output Modules

Cardiac Output and SvO_2 Module, E-COPSv (Rev. 01)
Cardiac Output Module, E-COP (Rev. 01)

Technical Reference Manual Slot

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices

CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner. Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1214854-002

October 27, 2010

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Introduction

This document provides information for the maintenance and service of single width plug-in Cardiac Output Modules, E-COP-01 and E-COPSv-01.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

Both modules E-COP and E-COPSv provide

- Cardiac output (C.O.)
- Right ventricular ejection fraction (REF)
- Invasive blood pressure (InvBP) measurement

Additionally, the COPSv module provides venous oxygen saturation (SvO_2) measurement.

NOTE: Do not use identical modules in the same monitor simultaneously. The modules E-COP/M-COP and E-COPSv/M-COPSv are considered as identical and would cause communication errors if used in the same system.

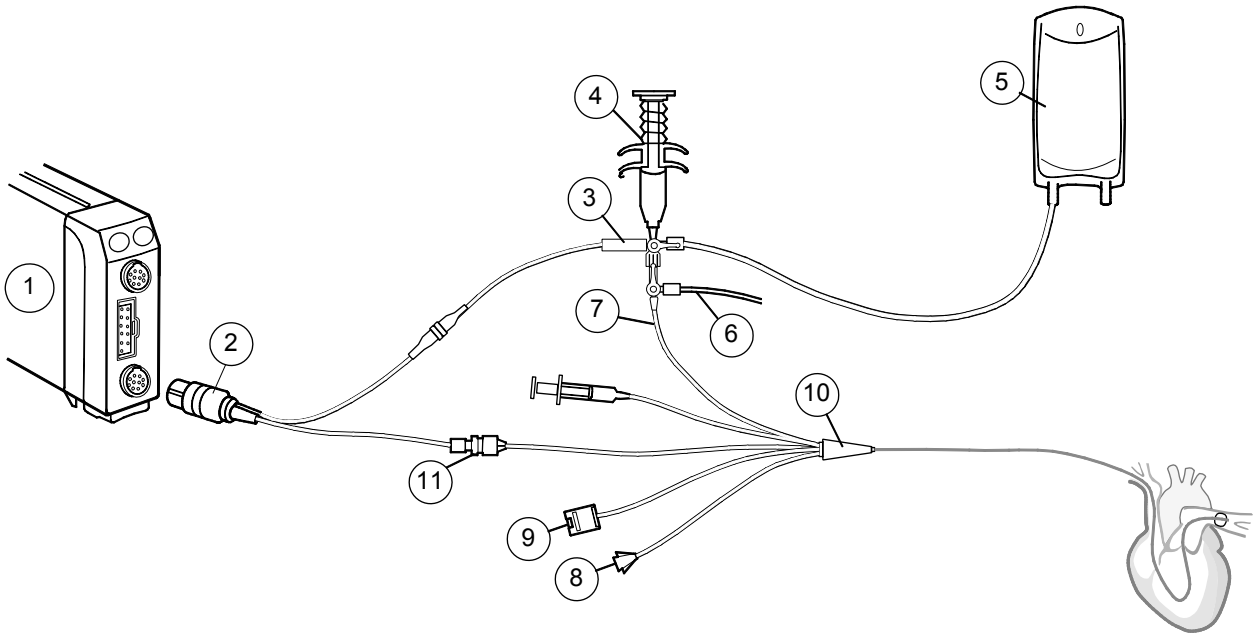


Figure 1 Cardiac output setup with closed injectate delivery system

(1) Module with C.O. measurement capability
(2) Catheter connecting cable
(3) Injectate temperature probe
(4) Injectate syringe
(5) Injectate: 5% dextrose or physiological saline at 0 to 27 °C (32 to 77 °F)
(6) CVP line to InvBP transducer
(7) Proximal
(8) Distal
(9) Optical connector
(10) Thermodilution catheter (Edwards Lifesciences corp. compatible)

(11) Catheter's termistor

Monitor software compatibility

The E-COP-01 and E-COPSv-01 module functions with monitor software version 02 or later.

Equipment safety symbols

When displayed on the E-COP and E-COPSv modules, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO2), temperature (T) and invasive pressure (P) measurement.

1 Specifications

1.1 General specifications

Module size (W × D × H)	37 x 187 x 112 mm / 1.5 x 7.4 x 4.4 in
Module weight	0.35 kg / 0.8 lb.
Power consumption, E-COP	Approximately 3.5 W
Power consumption, E-COPSv	Approximately 5 W

1.2 Typical performance

1.2.1 C.O.

Measurement range	0.1...20 l/min
Display resolution	0.01 l/min
Repeatability	±2% or ±0.02 l/min
Injectate temp range (with Edward Lifesciences Corp. tempearture probes) and accuracy	
	0...25.5 °C ±0.3 °C (32...77.9 °F ±0.5 °F)
	25.5...27.0 °C ±0.5 °C (77.9...80.6 °F ±0.9 °F)
Blood temp range (with Edward Lifesciences Corp. catheters) and accuracy	
	17.5...31 °C ±0.5°C (63.5...87.8 °F ±0.9 °F)
	31.0...43.0 °C ±0.3°C (87.8...109.4 °F ±0.5 °F)
Protection against electric shock	type CF defibrillation proof

1.2.2 REF

Repeatability	±2% as measured by electronically generated pulsatile curves for range 10 % - 60 %. For other ranges accuracy is unspecified.

1.2.3 SvO_2

Measurement range	1% to 98%
Measurement accuracy	±2% SvO_2 equals 1 standard deviation for range of 30% to 95% SvO_2 and 6.7 to 16.7 g/dl Hb when using in vivo calibration.
Display resolution	1%
Catheters	Edward Lifesciences Corp. SvO_2 catheter and optical module (OM-2E)

1.2.4 InvBP

Measurement range	-40...+320 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±20%
Scales	Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10% of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s
Numerical display	
Range	-40...+320 mmHg
Resolution	1 mmHg

Waveform display

Range	-30...+300 mmHg

Pulse rate

Measurement range	30...250 bpm
Resolution	1 bpm
Accuracy	±5% or ±5 bpm
Respiration artifact rejection	

1.3 Technical specifications

The numerical display is averaged over 5 seconds and updated at 5 second intervals.

Measurement accuracy	±5% or ±2 mmHg
Transducer sensitivity	5 μV/V/mmHg
Input voltage	5 VDC
Max current	20 mA
Nonlinearity	<1%, 0 to 200 mmHg
	<2%, -40 to 0 and 200 to 320 mmHg
Frequency response, waveform filter	DC...Upper limit
adjustable upper limit	4...22 Hz (-3 dB)
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg
Zero time	< 15 sec.
Protection against electric shock	type CF defibrillation proof

NOTE: The accuracy of the measurement may be different from the specified accuracy, depending on the transducer/probe used. Please check the transducer/probe specification.

2 Functional description

2.1 Measurement principle

2.1.1 Cardiac output and REF

Cardiac output measurement is performed using the principle of thermodilution. During measurement, the catheter lies in the heart, with an injection port in the right atrium (RA) and a thermistor, which is to monitor blood temperature, in the pulmonary artery (PA). A small, known amount of thermal indicator is injected into the RA and mixed with the blood on its way to the PA. The catheter thermistor measures the decrease in blood temperature as the blood flows past the thermistor in the PA.

The information is stored in the module and the cardiac output is calculated from the area beneath the time-temperature Cardiac Output Measurement Curve, as shown in figure 2.

The area under the time-temperature curve is inversely proportional to the flow rate which corresponds to cardiac output.

The cardiac output is calculated from the equation:

$C.O.= (1.08\ C_T\ 60\ V_i(T_B-T_i))/(T_B dt + C)$

where:

C.O. =Cardiac output in liters/minute
1.08 =Factor comparing the density and specific heat of 5% dextrose solution in water to those of blood
C_T =Correction factor for the injectate temperature rise as it passes through the catheter and its dead space
60 =Seconds/minute
V_i =Injectate volume in liters
T_B =Baseline blood temperature (°C)
Ti =Injectate temperature
$T_B dt$ =Area under time-temperature curve between time o and x, where x is the time when the curve has dropped to 30% of its peak value
C = Area beneath time-temperature curve between x and the end of the curve

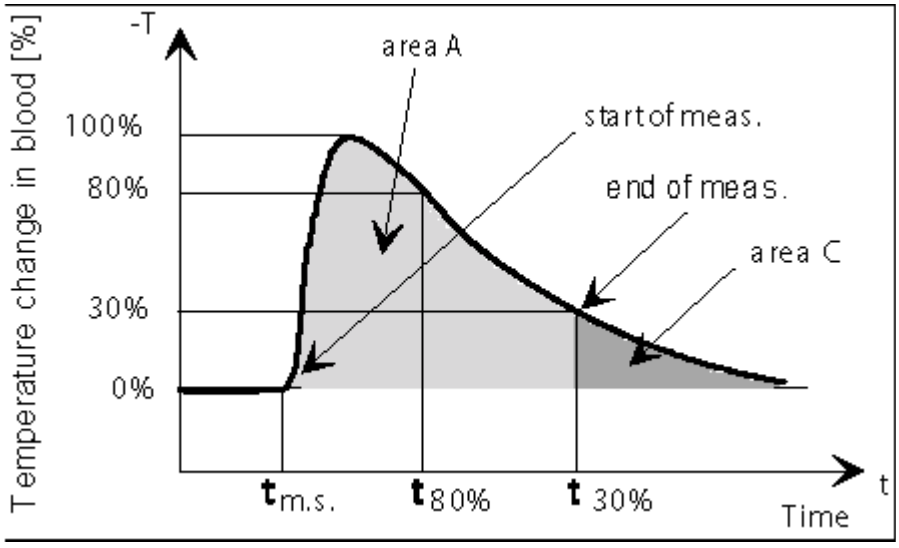


Figure 2 Cardiac output measurement curve

A = area derived by integration of the time-temperature curve

C = area beneath the time-temperature curve between t_{30}% and end of the curve. Computation based on an exponential fit to the curve between t_{80}% of the peak and t_{30}%.

REF (right ventricular ejection fraction) measurement is a part of the time-temperature (thermodilution) cardiac output measurement. Ejection fraction is determined using an exponential technique by synchronizing sensed R-waves with points of temperature changes on the time-temperature curve. Once ejection fraction, cardiac output, and heart rate are known, right ventricular volumes may be calculated. The measurement requires a Baxter-Edwards fast response thermistor catheter and an ECG module to synchronize R-wave detection to the time-temperature curves.

2.1.2 SvO_2 measurement

The COPSv module measures SvO_2 when coupled with a Baxter-Edwards OM-2E optical module and a Swan-Ganz oximetry catheter. To measure SvO_2, the system utilizes a spectrophotometric technique involving the use of light emitting diodes (LEDs) that produce red (660 nm) and infrared (810 nm) light. The light is transmitted to the blood through a single plastic optical fiber in the oximetry catheter and reflected back through a separate optical fiber to a photodetector in the optical module. The light is electrically transmitted to the COPSv module and analyzed to determine SvO_2.

The oximetry portion of the system measures SvO_2 in the pulmonary artery by detecting color changes in the red blood cells. When pulses of red and infrared light are transmitted through the oximetry catheter, the light is reflected from the red blood cells and transmitted back through the catheter to the optical module. The amount of light reflected at each wavelength depends primarily on the color of the blood and the number of red blood cells. Since the number of red blood cells in the blood affects the amount of reflected light, the differences are compensated for when the patient's total hemoglobin value is entered. The optical module stores and transfers SvO_2 calibration data. SvO_2 values can be affected by the presence of methemeglobin or carboxyhemoglobin which imitate the absorption characteristics of HbO_2. Large concentrations of methemoglobin or carboxyhemoglobin could then cause a falsely elevated SvO_2. In cases where dysfunctional hemoglobins are suspected, SvO_2 should be interpreted with caution.

2.1.3 Invasive blood pressure measurement

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The pressure transducer is placed at the same level with the heart, and electrically zeroed.

The pressure transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that blood pressure data and blood pressure waveforms can be displayed.

2.2 Main components

2.2.1 Controls and connectors

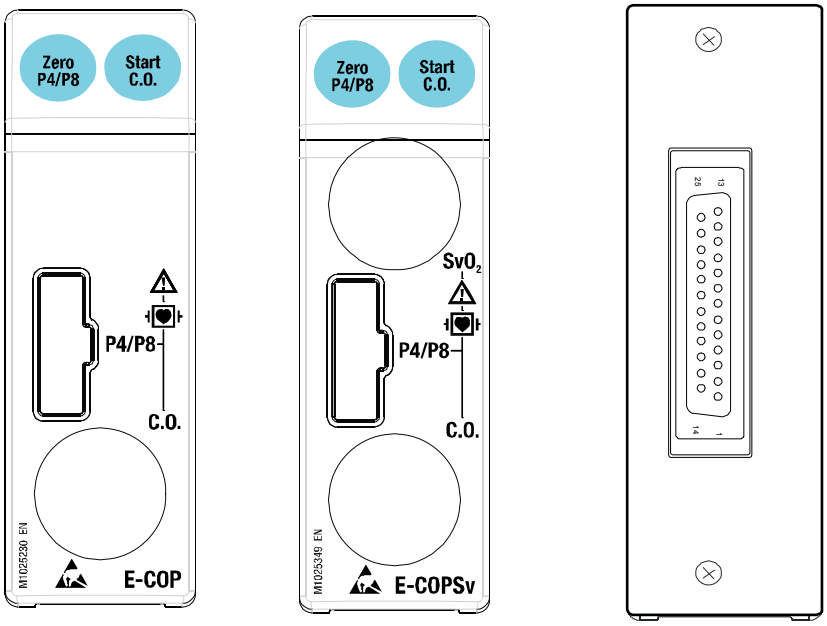


Figure 3 Front panels of Cardiac Output Modules, E-COP and E-COPSv, and the back of the module

NOTE: The invasive pressure connector in the E-COP and the E-COPSv module is labelled either as a P4 or as a P4/P8. However, the monitor software always identifies this invasive pressure port as a P8 channel.

Module key	Module	Description
Zero P4/P8	E-COP, E-COPSv	Key for pressure zeroing
Start C.O.	E-COP, E-COPSv	Key for cardiac output measurement

Connector	Module	Description
SvO2	E-COPSv	Connector for SvO_2 measurement
C.O.	E-COP, E-COPSv	Connector for C.O. measurement
P4 or P4/P8	E-COP, E-COPSv	Connector for invasive blood pressure measurement
D25 connector	E-COP, E-COPSv	Module bus connector

2.2.2 E-COP and E-COPSv modules

The Cardiac Output Module, E-COP, consists of a COP circuit board and two input boards: a CO input board and a P input board, attached to the front chassis unit.

The Cardiac Output and SvO_2 Module, E-COPSv, consist of a COPSv circuit board and three input boards: a CO input board, a SvO_2 input board, and a P input board, attached to the front chassis unit.

2.2.3 Measurement board

The measurement board consists of the following functional sections.

- Processor
- Cardiac output measurement
- Invasive blood pressure measurement
- SvO2 measurement (available only in E-COPSv)
- Serial communication
- Isolation
- Power supply

Processor section

The CPU has a 32-bit high-speed H8SX single-chip microcomputer. It contains 768 Kbytes of flash memory and 24 Kbytes of RAM. The clock frequency is 35 MHz.

Cardiac output measurement section

The catheter and the probe contain an NTC resistor that reacts to temperature change.

The temperature dependent voltage across the NTC resistor is amplified and an offset value is added to it. The resultant signal is then regulated into a ±5 V range by voltage slicing and sent to an A/D converter.

Because the temperature measurements are calibrated digitally and non-linearity of catheter/probe is compensated for by software, ambient temperature change after calibration is the only factor that may influence the measurement.

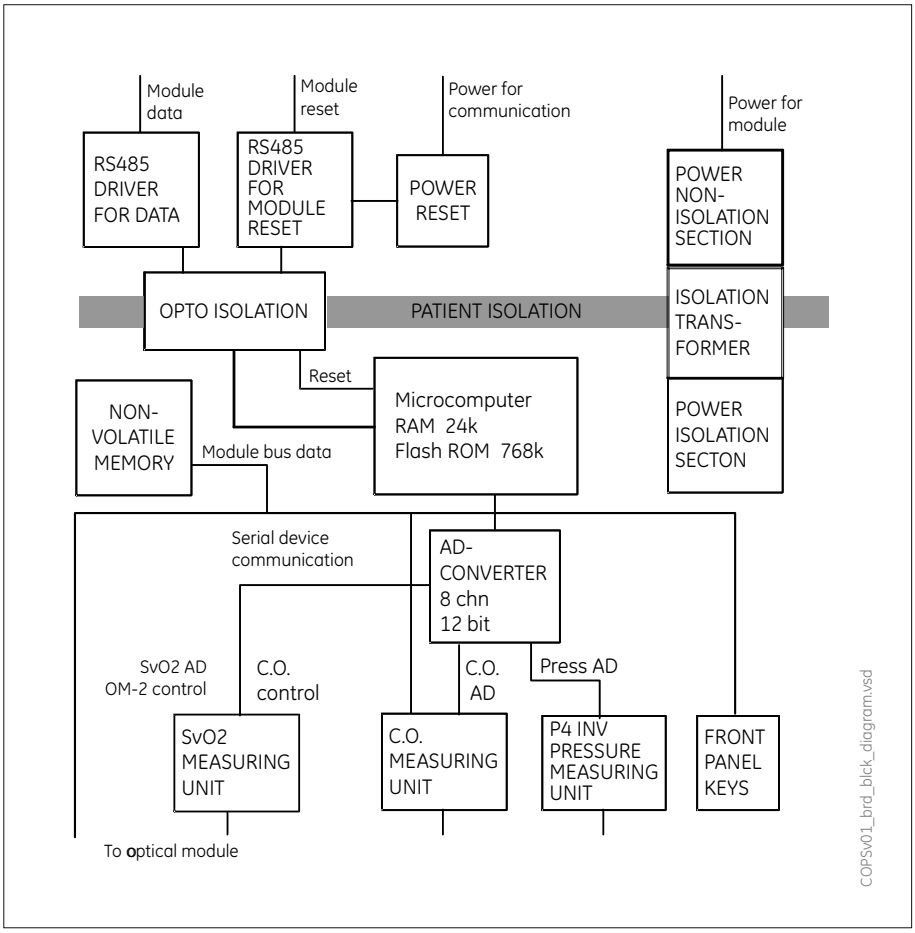


Figure 4 **Measurment board block diagram. In E-COP module the SvO_2 section is excluded**

Invasive blood pressure measurement section

An isolated +5 V supply is connected to the input of the pressure transducer bridge circuit. A differential voltage, which depends on blood pressure and input supply voltage, is calculated from the bridge circuit output using the following formula:

Uout = Uin x Pressure x 5 V, where Uin = 5 V ⇒ Uout = 25 V x Pressure [mmHg]

Pressure amplification is performed by the instrumentation amplifier. The gain of the amplifier is set so that the level of the signal transferred to the A/D converter stays within the measurement range even when there are circumstantial offsets or offsets caused by the pressure transducer. The input filter before the amplifier attenuates high frequency disturbances.

A FET switch cuts the measurement current and detects the existence of the pressure transducer. The existence of the pressure transducer is also checked digitally by a jumper next to the connector.

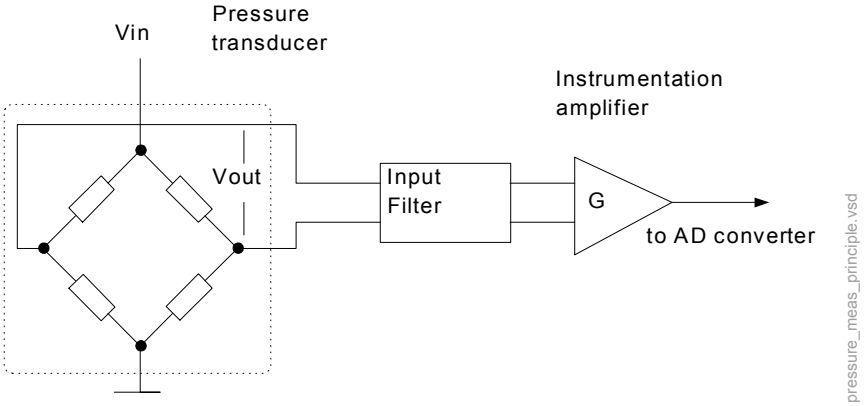


Figure 5 Pressure transducer principle of operation

SvO_2 measurement section

The SvO_2 algorithm is part of the measurement board software. The algorithm consists of five different parts: initialization, calibration, signal processing and SvO_2 calculation, automatic gain control, and signal quality analysis.

Initialization

When the optical module is connected to the COPSv module, a number of start-up procedures are performed prior to normal operation. These procedures include transfer of calibration factors from the optical module to the COPSv module and initialization of LED currents.

Calibration

The system is calibrated according to either in-vitro or in-vivo calibration. In-vitro calibration is performed before the oximetry catheter is removed from the package with the catheter tip still inside the calibration cup. The resulting calibration factor is calculated on the basis of the measured ratio of red and infrared signals and the ideal ratio for the calibration cup. In-vivo calibration is performed when the catheter is inserted into the patient's pulmonary artery. The resulting calibration factor is based on the measured ratio of red and infrared signal and the Hgb and SvO_2 values measured in a laboratory. If the calibration is skipped, the result of an old calibration is used instead and the 'Not calibrated' message is displayed in the SvO_2 parameter window.

Signal processing and SvO_2 calculation

The reflected red and infrared signals transferred from the optical module to the COPSv module are filtered, and SvO_2 is calculated on the basis of the ratio of the two signals.

Automatic gain control

The intensity of the red and infrared signals can be amplified by four different gains. The gain is selected automatically to achieve optimal signal levels.

Signal quality

The reflected red and infrared signals are checked for wall contact artifacts, pulsatility, and intensity shifts. An index is calculated to indicate the signal quality.

Serial communication

Serial communication between the Cardiac Output Module and the Central Unit Frame is established via an RS485 type bus. The communication bus drivers are powered from the Module Bus. The module isolation section is powered (+5 V) from the isolated power supply.

The communication drivers are controlled by a reset signal so that when the reset is active, the drivers do not transfer data.

In addition to the RS485 reset, there is a logic power-up reset, which holds for approximately 500 ms regardless of the state of the RS485 reset. A time constant determines the power-up reset time. The power-up reset also prevents the module from sending data to the Module Bus. The data transmission rate is 500 kbps.

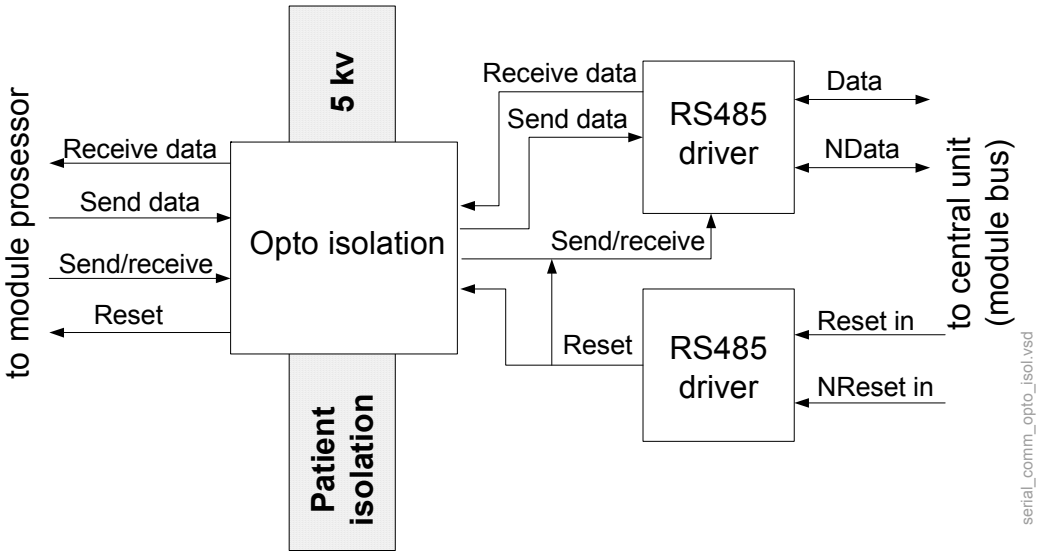


Figure 6 Serial communication and opto isolation

Isolation section

There are two opto isolators, one for data and one for the reset signal. Signals are processed on logical high-low levels even though the outputs of the opto isolators in the isolation section are analog signals.

The reset line is an open collector type with a pull-up resistor, so that the microprocessor is able to use its internal watchdog function.

Power supply section

The module isolated power supply is developed from the +15 V (non-isolated) supply received from the module bus. The isolated power supply is a switched-mode circuit where a FET switch is controlled by an oscillator using a bipolar timer. The frequency of the oscillator is approximately 30 kHz with a pulse ratio of 50%: switching of the FET is slow to suppress spurious interference. A special isolation pulse transformer is used in the circuit. The transformer secondary circuit uses normal linear regulators, except for +5 V which uses a low drop type linear regulator.

3 Service procedures

3.1 General service information

The field service of the E-COP and E-COPSv modules is limited to replacing faulty mechanical parts.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

NOTE: Use only calibrated and traceable measuring equipment.

Tool	Order No.	Notes
Patient simulator with c.o.		Medsim
SvO_2 simulator	890121	
Pressure manometer		
InvBP transducer		
Appropriate catheter connecting cable		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts
   Check that
   - screws are tightened properly
   - cables are connected properly

- there are no loose objects inside the module

2. External parts

   Check that

   - the front cover and the front panel sticker are intact
   - all connectors are intact and are attached properly
   - the module box and latch are intact

Reattach the module box and check that the latch moves properly.

3.2.3 Functional inspection

Turn the monitor on and wait until the monitoring screen appears.

Configure the monitor screen so that all the required parameters are shown, for example:

Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 4 - P4***
Digit Fields - Field 4 - SvO2

Preset the C.O., SvO_2 and InvBP measurement settings:

Others - ***C.O. - C.O. Setup - Scale - 1.0 °C***
Injectate Volume - 10 ml
Measurement Mode - SET
SvO2 - Update Hb - 115 g/l
Invasive Pressures - ***P4 Setup - Label - PA***

3. Installation

   Plug in the module. Check that it goes in smoothly and locks up properly.

4. Recognition

   Check that the module is recognized by entering the ***C.O.*** menu:

   Others - ***C.O.***

   Check that the message 'No Catheter' is shown in the middle of the menu. In the case of the E-COPSv module, also check that the message 'No cable' is shown in the digit field for SvO_2.

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) **-** ***Service*** (password 26-23-8)

Take down the information regarding COP software by selecting ***Scroll vers*** and turning the ComWheel.

6. Communication and memories

   Enter the ***COP*** module service menu:

   Parameters - COP

   Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the module memories have passed the internal memory test, i.e. RAM, ROM and EEPROM all show OK.

Invasive blood pressure measurement

7. Membrane key

   Check the front panel membrane key **ZERO P4**.

   Press the key for at least one second. Check that the key being pressed is identified, i.e. the information in the Service Data field under Button - P4 changes from OFF to ON.

8. Cable and transducer detection

   Check that Cable and Probe for P4 show OFF. Plug a cable with an invasive blood pressure transducer into the front panel connector P4 and check that Cable and Probe show ON and the corresponding pressure waveform appears on the screen.

9. Calibration

   Calibrate InvBP channel P4 according to the instructions in section "Invasive pressure calibration".

10. Test with patient simulator

    Return to the normal monitoring screen by pressing the **Normal Screen** key on the Command Board. Check the InvBP channel with a patient simulator.

    The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

    SENSITIVITY switch; 5 µV/V/mmHg
    ECG - BASE - BPM - 60
    BP - 3 - WAVE - ATM

    Connect the cable from channel BP3 to module connector P4. Zero the InvBP channel P4 by pressing the **ZERO P4** key on the module front panel.

    BP - 3 - WAVE - PA

Check that appropriate InvBP waveforms are shown and the InvBP value is approximately 25/10 (±2 mmHg) for channel P4 (PA).

SvO_2 measurement

11. Measurement state

    Enter the ***COP*** module service menu. Check that the SvO_2 values Meas. state, OM fail and OM temp. all show NO OM.

    Turn the SvO_2 simulator's pulsation switch to Medium and the range switch to Normal pulse. Connect the simulator to the module and check that the following messages appear in the digit field for SvO_2:

    Initializing, please wait --> Warming up --> Not calibrated

    Check that Meas. state has changed to NORMAL and OM fail and OM temp. show OK.

NOTE: OM temp. may show UNSTABLE at first, but the message should change to OK within half a minute.

12. Calibration

    Perform an In-Vitro calibration. Keep the SvO_2 simulator connected to the module and turn the pulsation switch to No pulse.

    Enter the ***SvO2*** menu:

    Others - *SvO2*

    Select ***Calibrate in Vitro*** to start the calibration. Wait until the text Start SvO_2 appears in the menu.

    Turn the SvO_2 simulator pulsation switch to Normal Pulse and complete the calibration by pressing the ComWheel again. Wait until the text Calibrating disappears from the digit field for SvO_2.

    Check that the calibration date for In-Vitro calibration was updated correctly and the SvO_2 reading on the screen is 81% (±2).

13. SvO_2 messages

    Turn the SvO_2 simulator pulsation switch to No pulse and check that the message 'Check cath. position' appears in the digit field for SvO_2 and the message 'SvO_2 poor signal' appears in the message field within one minute.

    Turn the pulsation switch to High pulse and check that the two messages remain on the screen.

Turn the pulsation switch back to Normal pulse and check that the messages disappear within one minute.

Cardiac Output measurement

14. Membrane key

    Check the front panel **START C.O.** membrane key.

    Enter the ***COP*** module service menu. Press the key for at least one second and check that it is identified, i.e. the information on the service menu under Button - C.O. changes from OFF to ON.

    Enter the ***C.O.*** menu:

    Others - ***C.O.***

    Connect a catheter connecting cable to module connector C.O.

15. Test with patient simulator

    Check the C.O. measurement with a patient simulator.

    The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

    C.O. - BASE - 37 °
    WAVE

    Leave the WAVE menu open on the simulator. Connect the catheter connecting cable (both connectors) to the simulator's C.O. box. Select the text START C.O. SET on the ***C.O.*** menu.

    Press the ComWheel to start the measurement. When the text 'Inject now!' appears on the menu, select the setting 5 l/min (F3) from the medSim 300 simulator. Check that the thermodilution curve displayed returns to the base level on the screen. Complete all 6 measurements.

NOTE: The medSim 300 simulator may give an inaccurate C.O. signal immediately after it has been turned on and after each new simulator setting. This property of the simulator must be taken into account when interpreting the C.O. results.

When the set is complete, exclude the first measurement from the average using the ***C.O.*** menu functions:

Edit Average - Exclude Curves - 1

Press the ComWheel to exclude the first curve. Check that each of the remaining results is within ±2% of the new average.

All modules

16. Electrical safety check

    Perform an electrical safety check and a leakage current test.

17. Functioning after electrical safety check
    Check that the module functions normally after performing the electrical safety check.

18. Final cleaning
    Clean the module with suitable detergent.

- Fill in all necessary documents.

3.3 Disassembly and reassembly

3.3.1 Disassembly guidelines

CAUTION Field service of the module is limited to replacing faulty mechanical parts only (see chapter "5. Service parts" for details). Attempting a field repair on a PCB or a factory sealed component or assembly could jeopardize the safe and effective operation of the module, and void the warranty.

NOTE: Only a qualified service technician should perform field replacement procedures.

NOTE: Perform the checkout procedure described in chapter "3. Service procedures" each time after you have opened the module casing.

3.3.2 ESD precautions

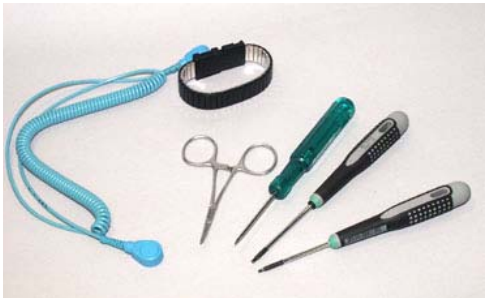
All external connectors of the module are designed with protection from ESD damage. However, if the module requires service, exposed components and assemblies inside are susceptible to ESD damage. This includes human hands, non-ESD protected work stations or improperly grounded test equipment. The following guidelines may not guarantee a 100% static-free workstation, but can greatly reduce the potential for failure of any electronic assemblies being serviced:

- Discharge any static charge you may have built up before handling semiconductors or assemblies containing semiconductors.
- A grounded antistatic wristband or heel strap should be worn at all times while handling or repairing assemblies containing semiconductors.
- Use properly grounded test equipment.
- Use a static-free work surface while handling or working on assemblies containing semiconductors.
- Do not remove semiconductors or assemblies containing semiconductors from antistatic containers until absolutely necessary.
- Do not slide semiconductors or electrical/electronic assemblies across any surface.
- Do not touch semiconductor leads unless absolutely necessary.
- Semiconductors and electronic assemblies should be stored only in antistatic bags or boxes.
- Handle all PCB assemblies by their edges.
- Do not flex or twist a circuit board.

3.3.3 Before disassembly

- Note the positions of any wires or cables. Mark them if necessary to ensure that they are re-assembled correctly.
- Save and set aside all hardware for reassembly.

3.3.4 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.5 To replace the front cover

1. Detach the front cover of the module by releasing the snaps that hold the front cover to the front chassis unit by using a small flat blade screwdriver. There are 2 snaps on both sides of the module and 1 snap on the top.

3.3.6 To disassemble the module

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module casing slowly backwards and remove it from the main body.
3. Detach the front cover (see 3.3.5).

NOTE: The COP(Sv) measurement board and input boards are not field replaceable separately. Therefore in case of faulty COP(Sv) measurement board or input board the module must be repaired by using FRUs listed in chapter "5. Service parts".

3.3.7 Reassembling the module

Reverse the order of the disassembly steps.

Check that:

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module

3.4 Adjustments and calibrations

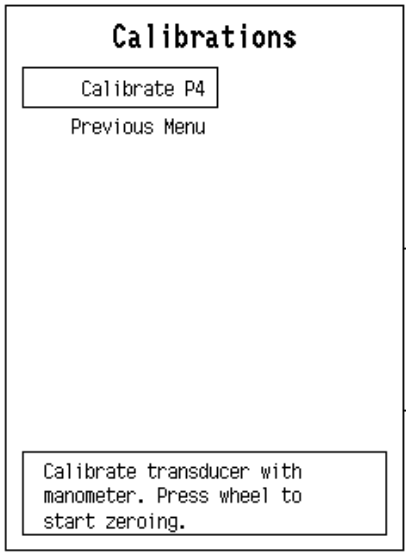
3.4.1 Cardiac output calibration

The cardiac output calibration can be performed only at the factory.

3.4.2 Invasive pressure calibration

Calibrate invasive pressure when the pressure transducer (probe) is replaced with a different type of transducer.

1. Enter the ***COP*** service menu (**Monitor Setup - *Install/Service - Service - Parameters***)
2. Enter the ***Calibrations*** menu.



3. Connect a pressure transducer with a pressure manometer to the P4 connector. Select ***Calibrate P4*** from the menu. Leave the transducer at room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel.

   A tolerance of ±1 mmHg is allowed.
7. The text 'calibrated' appears on the display.

4 Troubleshooting

4.1 Troubleshooting charts

4.1.1 Cardiac Output

Problem	Cause	What to do
'NO CATHETER' message	Catheter or cable not connected.	Connect catheter (cable).
	Catheter or cable faulty.	Change catheter or cable.
	Blood temp out of range.	Check blood temp is within range.
'Tinj OFF' message	No injectate temp probe.	Connect probe.
	Probe faulty.	Change probe.
	Wrong type of probe.	Use Baxter compatible inj. temp probe.
	Temp out of range.	Check blood temp is within range.

4.1.2 SvO_2

Problem	Cause	What to do
Faulty cable	Factory calibration of the optical module corrupted. Red or infrared transmit error, currents cannot be adjusted to factory defaults.	Replace optical module.
No cable	No optical module connected.	Connect optical module.
Insufficient signal	Loose catheter connection. Optical module failure. Catheter kinked or damaged.	Check connection. Replace optical module. Calibrate In vivo or replace catheter if necessary.
Warming up	Temperature of the optical module has not yet reached the optimum value or optical module failure or COPSv module failure.	Please wait. If it takes longer than 20 minutes replace optical module or COPSv module.
Poor SvO_2 signal	Signal pulsatility, wall contact or intensity shift signal quality level at 3.	Check number field message for problem 'Check catheter position' or 'Intensity shift'.

4.1.3 InvBP

Problem	Cause	What to do
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer. No pressure module plugged in. No waveform selected on screen.	Check transducer. Check the module. To select the desired pressure waveforms, press **Monitor Setup** key and select modify waveforms. Check that the pressure transducer is open to the patient.
'Not zeroed' message	Measurement on, channel not zeroed.	Zero the channel.
'Zeroing failed' message	Unsuccessful zeroing of P4 (number field).	Possibly due to pulsating pressure waveform. Open the transducer to room air and zero the channel. Offset is > 150 mmHg. Open the transducer to room air and zero the channel. Defective transducer. Replace and zero the channel.
'Calibration failed' message	Unsuccessful calibrating of P4 (number field).	Pulsating waveform. Turn the transducer to sphygmomanometer and try again (zeroing takes place first). Gain is beyond the limits (±20% of the default gain) of the module. Replace the transducer.
Out of range ≤ 40 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel.
Out of range > 320 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel. The patient may also have high blood pressure.
Zero adj. > 100 mmHg	Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain).	Check transducer. The waveform may hit the top and the numeric display not shown.
Out of range	Measured pressure is beyond the internal measurement range of the module.	The waveform hits the top and the numeric display not shown. Check transducer and its level. Zero the channel.

See also the troubleshooting flowchart on the next page.

4.2 Troubleshooting flowchart

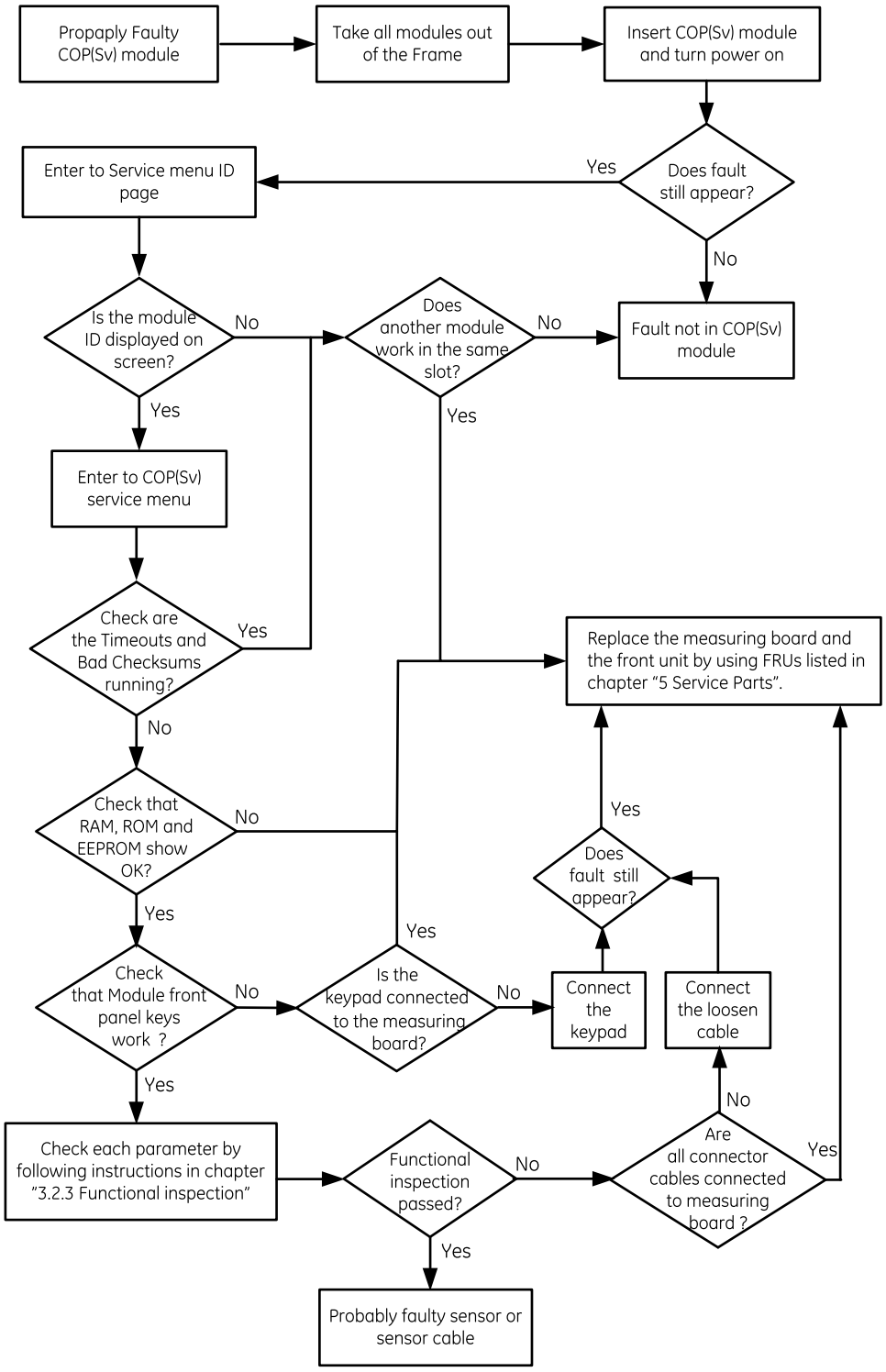


Figure 7 Cardiac Output Module troubleshooting flowchart

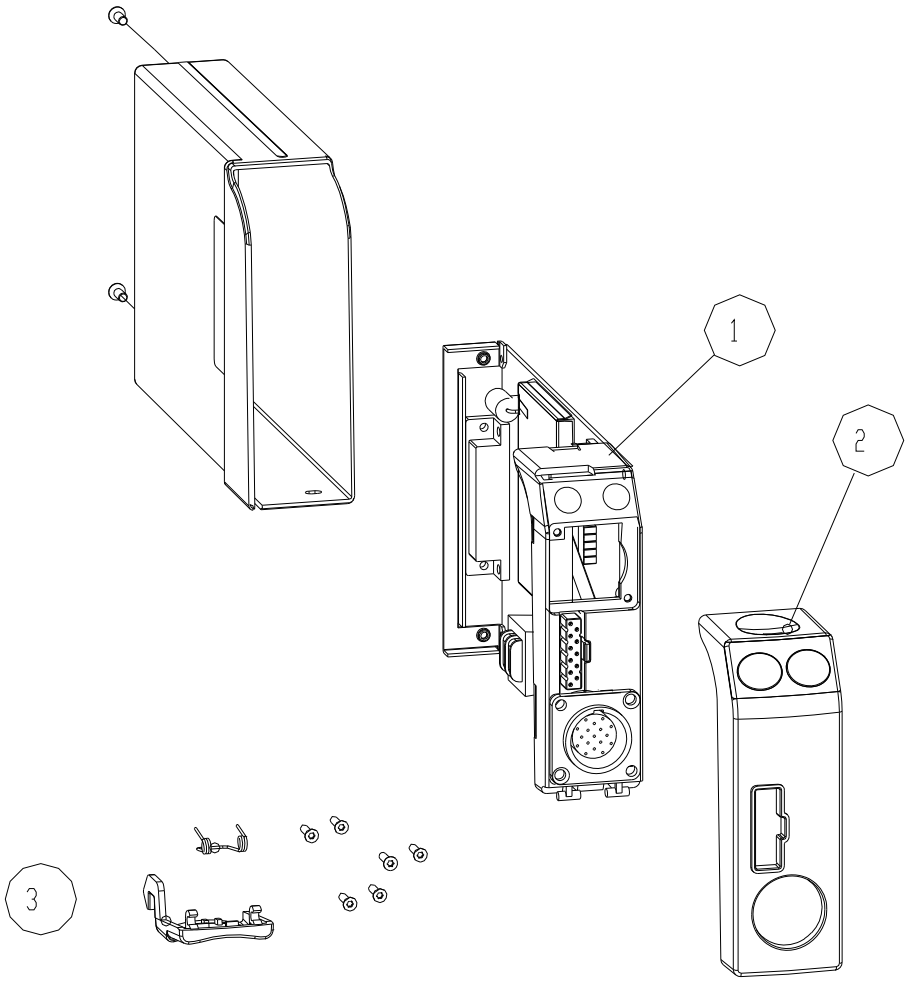
5 Service parts

5.1 Ordering parts

To order parts, contact GE Healthcare. Contact information is available at www.gehealthcare.com. Make sure you have all necessary information at hand.

NOTE: Perform the checkout procedure described in chapter "3. Service procedures" each time after you have opened the module casing.

5.2 Cardiac Output Module, E-COP

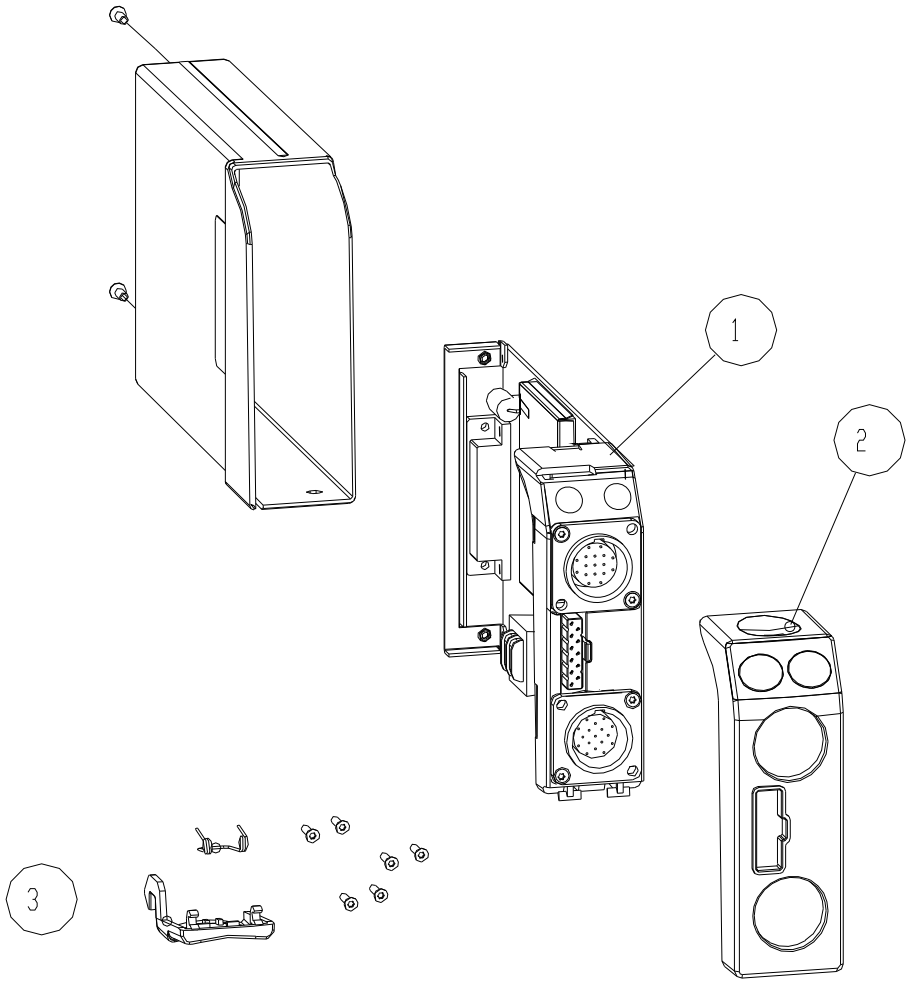


Item	Description	Order No.
1	E-COP module unit, FRU - Front chassis unit, FRU (incl. front chassis, membrane keyboard, connector unit, latch, torsion spring) - Measurement board, FRU (incl. Measurement board, metal frame, mounting screws)	M1194048

Item	Description	Order No.
2	Front Cover, CS, E-COP	M1063534
2	Front Cover, DA, E-COP	M1025568
2	Front Cover, DE, E-COP	M1025569
2	Front Cover, EN, E-COP	M1025570
2	Front Cover, ES, E-COP	M1025571
2	Front Cover, FI, E-COP	M1025572
2	Front Cover, FR, E-COP	M1025573
2	Front Cover, HU, E-COP	M1046293
2	Front Cover, IT, E-COP	M1025574
2	Front Cover, JA, E-COP	M1025575
2	Front Cover, NL, E-COP	M1025576
2	Front Cover, NO, E-COP	M1025577
2	Front Cover, PL, E-COP	M1025578
2	Front Cover, PT, E-COP	M1025579
2	Front Cover, SV, E-COP	M1025580
3	Module Hardware kit, FRU - 2 mounting screws for metal frame - 2 mounting screws for front chassis unit - 2 mounting screws for module casing - Latch - Torsion spring	M1206392

NOTE: The parts listed in the table above are also compatible with the E-COP-00 modules.

5.3 Cardiac Output Module, E-COPSv



Item	Description	Order No.
1	E-COPSv module unit, FRU - Front chassis unit, FRU (incl. front chassis, membrane keyboard, connector unit, latch, torsion spring) - Measurement board, FRU (incl. Measurement board, metal frame, mounting screws))	M1194084
2	Front Cover Unit, CS, E-COPSV	M1063536
2	Front Cover Unit, DA, E-COPSV	M1027002
2	Front Cover Unit, DE, E-COPSV	M1027003
2	Front Cover Unit, EN, E-COPSV	M1027004
2	Front Cover Unit, ES, E-COPSV	M1027005
2	Front Cover Unit, FI, E-COPSV	M1027006
2	Front Cover Unit, FR, E-COPSV	M1027007

Item	Description	Order No.
2	Front Cover Unit, HU, E-COPSV	M1046297
2	Front Cover Unit, IT, E-COPSV	M1027008
2	Front Cover Unit, JA, E-COPSV	M1027009
2	Front Cover Unit, NL, E-COPSV	M1027010
2	Front Cover Unit, NO, E-COPSV	M1027011
2	Front Cover Unit, PL, E-COPSV	M1027012
2	Front Cover Unit, PT, E-COPSV	M1027013
2	Front Cover Unit, SV, E-COPSV	M1027014
3	Module Hardware kit, FRU - 2 mounting screws for metal frame - 2 mounting screws for front chassis unit - 2 mounting screws for module casing - Latch - Torsion spring	M1206392

NOTE: The parts listed in the table above are also compatible with the E-COPSv-00 modules.

6 Earlier revisions

S/5 Cardiac Output and SvO2 Module, E-COPSv (rev.00)
S/5 Cardiac Output Module, E-COP (rev 00)

APPENDIX A: Service check form, Cardiac Output Modules, E-COP and E-COPSv (Rev. 01)

Customer		
Service	Module type	S/N
Service engineer		Date

Prior to testing verify all equipment is calibrated via "Cal" labeling and record Cal Due Dates

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Installation	☐	☐	☐	4. Recognition	☐	☐	☐
5. Module software	☐	☐	☐	6. Communication and memories	☐	☐	☐
Notes							

InvBP measurement	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
7. Membrane key	☐	☐	☐	8. Cable and transducer detection	☐	☐	☐
9. Calibration	☐	☐	☐	10. Test with patient simulator	☐	☐	☐
Notes							

SvO_2 measurement							
11. Measurement state	☐	☐	☐	12. Calibration	☐	☐	☐
13. SvO2 messages	☐	☐	☐				
Notes							

C.O. measurement							
14. Membrane key	☐	☐	☐	15. Test with patient simulator	☐	☐	☐
Notes							

All modules							
16. Electrical safety check	☐	☐	☐	17. Functioning after electrical safety check	☐	☐	☐
18. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

Signature

Datex-Ohmeda

Pressure Temp Module

S/5™ Pressure Temp Module, E-PT (Rev. 00)
S/5™ Pressure Module, E-P (Rev. 00)

Technical Reference Manual Slot

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027826-1
November, 2005

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda Pressure Module, E-P, and Pressure Temp Module, E-PT. The E-P and E-PT modules are single width plug-in modules designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

Both modules provide invasive pressure measurement. Additionally, the E-PT-module provides temperature measurement.

NOTE: Do not use identical modules in the same monitoring system. The modules E-P/M-P and E-PT/M-PT are considered as identical modules.

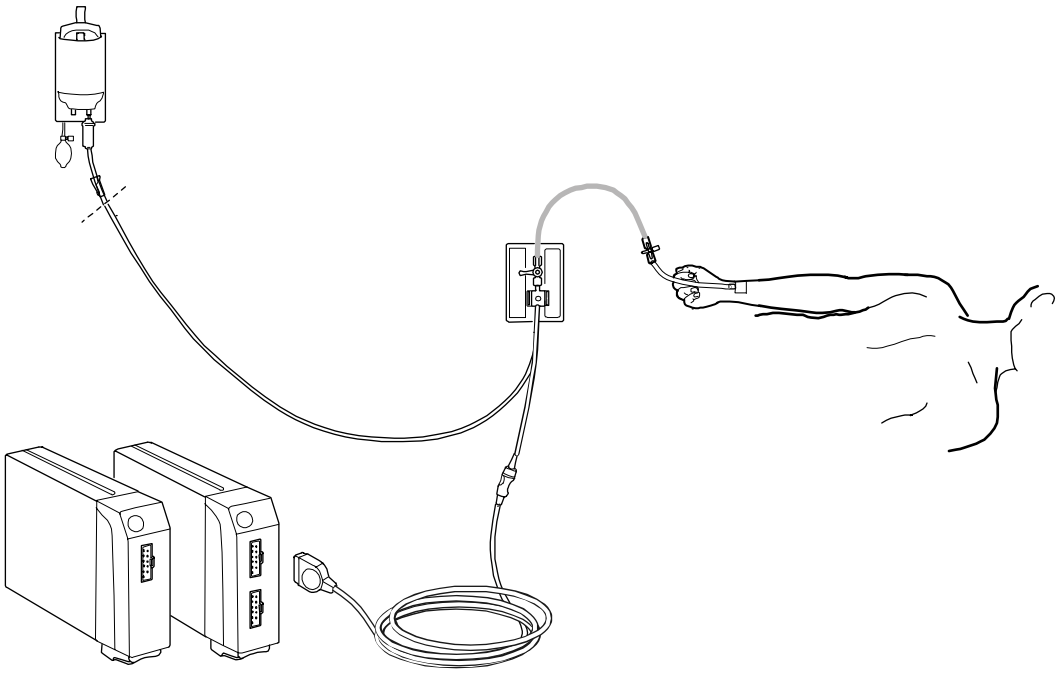


Figure 1 Invasive blood pressure setup

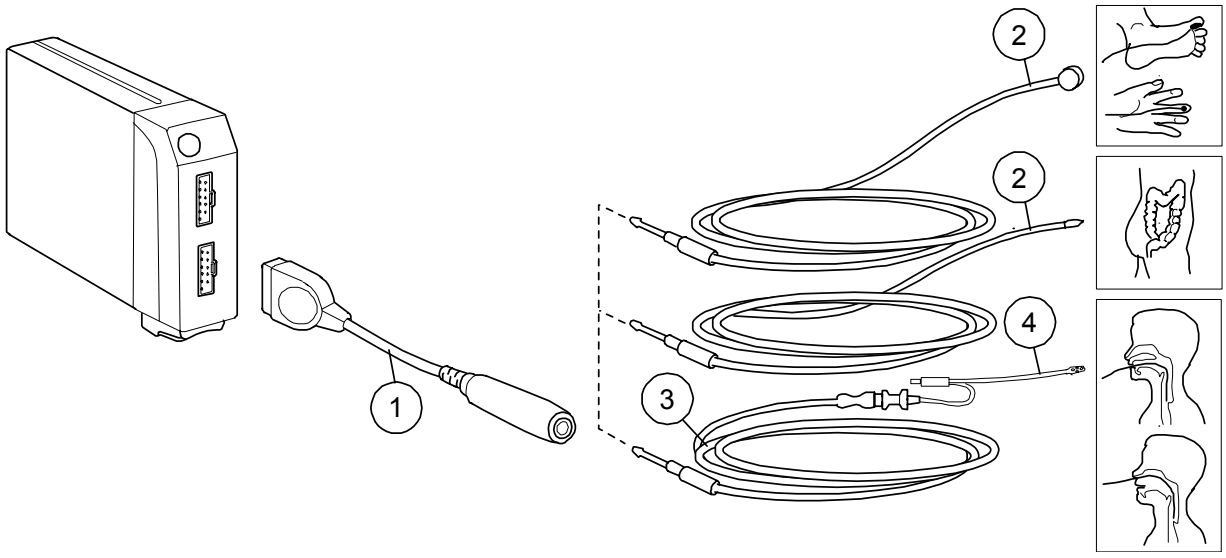


Figure 2 Temperature measurement setup

(1) Adapter cable for temperature probes
(2) Reusable temperature probe
(3) Adapter cable for disposable temperature probe
(4) Disposable temperature probe

Equipment safety symbols

When displayed on the E-P and E-PT modules, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO2), temperature (T) and invasive pressure (P) measurement.

1 Specifications

1.1 General specifications

E-P	
Module size, W × D × H	37 × 186 × 112 mm / 1.5 × 7.3 × 4.4 in
Module weight	0.3 kg / 0.7 lb.
Power consumption	Approximately 3.5 W
E-PT	
Module size, W × D × H	37 × 187 × 112 mm / 1.5 × 7.4 × 4.4 in
Module weight	0.4 kg / 0.9 lb.
Power consumption	Approximately 3.5 W

1.2 Typical performance

1.2.1 InvBP

Measurement range	-40 to +320 mmHg
Measurement accuracy	±5% or ±2 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±25%
Numerical display	
Range	-40 to +320 mmHg
Resolution	1 mmHg
Averaging	over 5 s, updated every 5 s, or end-expiratory filtering
Waveform display	
Range	-30 to +300 mmHg
Scales	Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10% of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s
Pulse rate	
Measurement range	30 to 250 bpm
Resolution	1 bpm
Accuracy	±5% or ±5 bpm

1.2.2 Temperature

Measurement range	10 to 45 °C (50 to 113 °F)
Measurement accuracy	±0.1 °C (25 to 45.0 °C)
	±0.2 °C (10 to 24.9 °C)
Measurement accuracy with single-use probes	
	±0.3 °C (25 to 45.0 °C)
	±0.4 °C (10 to 24.9 °C)
Display resolution	0.1 °C (0.2 °F)
Temperature self-check	at measurement start-up and then every 10 minutes

Probe type	Use only GE Healthcare temperature probes or defibrallator-proof YSI 400 series probes

1.3 Technical specifications

1.3.1 InvBP

Measurement accuracy	±5% or ±2 mmHg
Transducer sensitivity	5 μV/V/mmHg
Input voltage	5VDC
Max current	20 mA
Filter	4 to 22 Hz adjustable (-3 dB)
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg
Zero time	less than 15 sec.
Protection against electrical shock	type CF defibrillation proof

Numerical display averaging

Art and P1 numerical displays are averaged over 5 seconds and updated at 5 second intervals. All other pressures have respiration artifact rejection.

NOTE: The accuracy of the measurement may be different from that specified, depending on the transducer/probe being used. Please check the transducer/probe specification.

1.3.2 Temperature

Measurement accuracy	±0.1 °C (25.0 to 45.0 °C) ±0.2 °C (10.0 to 24.9 °C)
Protection against electrical shock	Type CF

NOTE: The accuracy of the measurement may be different from the specified, depending on transducer/probe used. Please check the transducer/probe specification.

2 Functional description

2.1 Measurement principle

2.1.1 Invasive blood pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

2.1.2 Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called Negative Temperature Coefficient (NTC) resistor.

The resistance can be measured by two complementary methods:

- Applying a constant voltage across the resistor and measuring the current that flows through it.
- Applying a constant current to flow through the resistor and measuring the voltage that is generated across it.

In the S/5 module, the two methods are combined in the form of a voltage divider. The NTC resistor is connected in series with a normal resistor and a constant voltage is applied across them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

2.2 Main components

The E-PT module consists of the following main parts:

- PT board
- Connector for temperature probes; temperature channels T3 and T4.
- Connector for an invasive blood pressure sensor; invasive blood pressure channel P3.
- Key for pressure zeroing.

The E-P module consists of the following main parts:

- PT board
- Connector for an invasive blood pressure sensor; invasive blood pressure channel P3.
- Key for pressure zeroing.

Communication between the module and the central unit is established through RS485 serial interface.

The power supply voltages to the module are generated in the power supply section of the monitor's Central Unit. All electrical connections between the module and the Central Unit are established via 25-pin D-type connector at the back of the module.

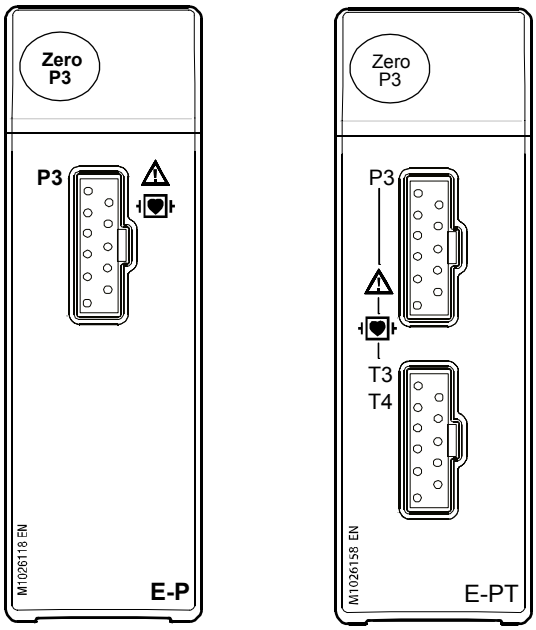


Figure 3 Front panel of E-P and E-PT Module

2.2.1 PT board

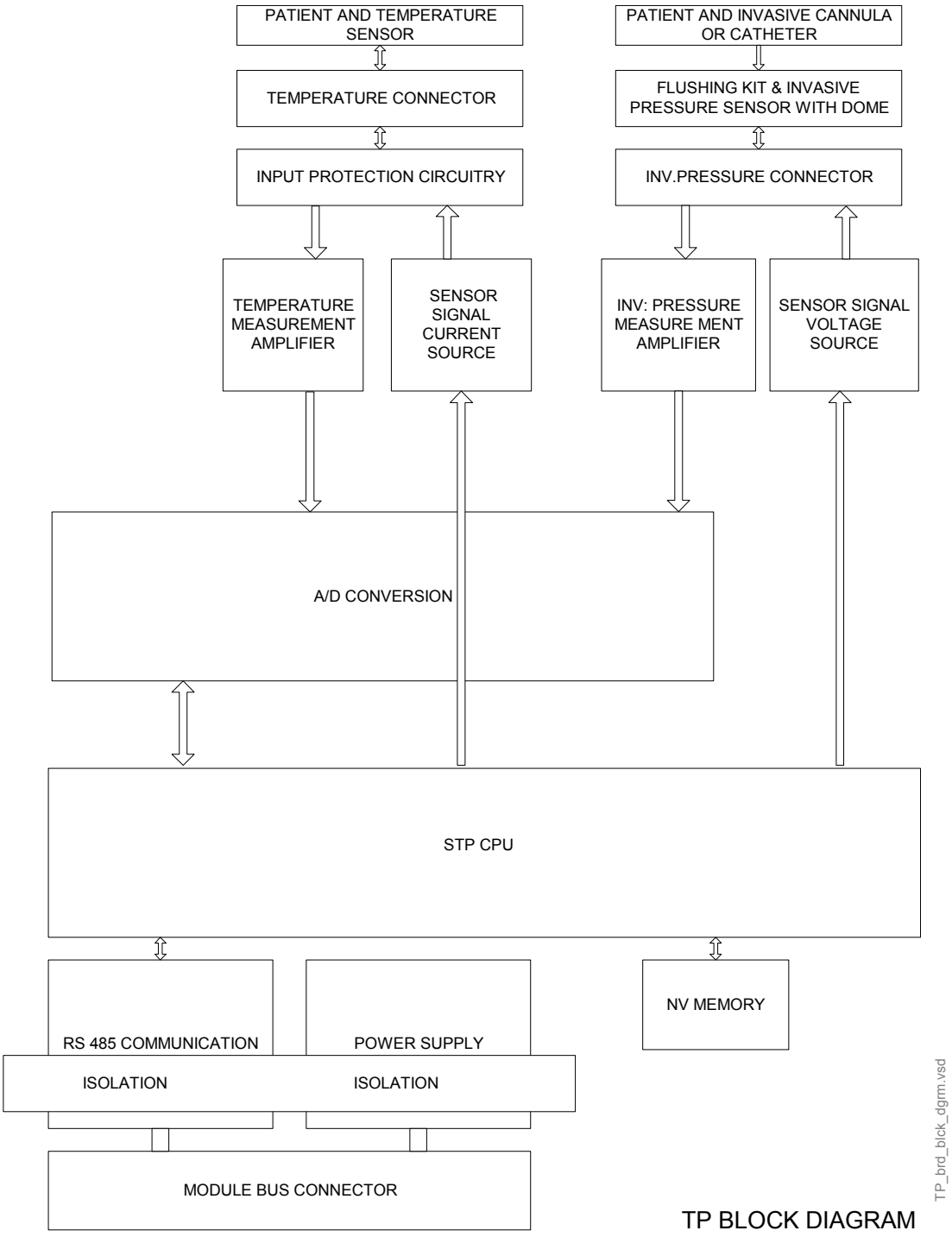


Figure 4 PT board block diagram

Microprocessor unit

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

High speed I/O is used to obtain pulse control sequence necessary for pulse oximetry measurement. Timing for the clock is from the oscillator.

Temperature measurement unit

The NTC-resistor value in the probe depends on the patient's temperature. It is measured with the following principle described below.

The constant current source is supplied about current through the temperature sensor (YSI 400-series NTC resistor). The constant current is caused a voltage over the temperature sensor (NTC resistor). The voltage over the temperature sensor is amplified in a differential amplifier stage. The amplified voltage is transferred to a controller of the PT board through an A/D converter.

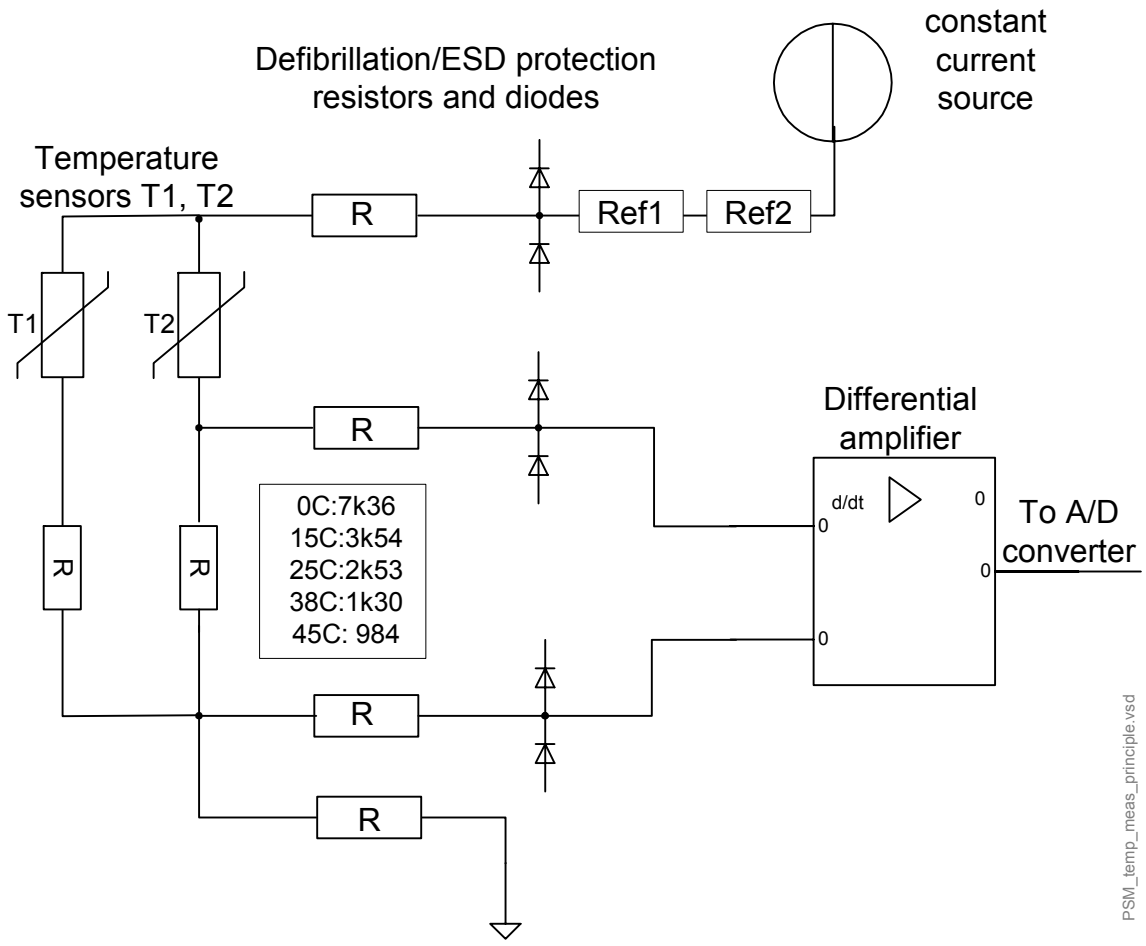


Figure 5 Temperature measurement principle

Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. The differential voltage, which depends on the pressure and the supplied voltage, is calculated from the bridge connection (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\ \mu V$, where U_{in} is 5 V

$\Rightarrow U_{out} = 25\ \mu V \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set to keep the level of the signal transferred to A/D converter within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

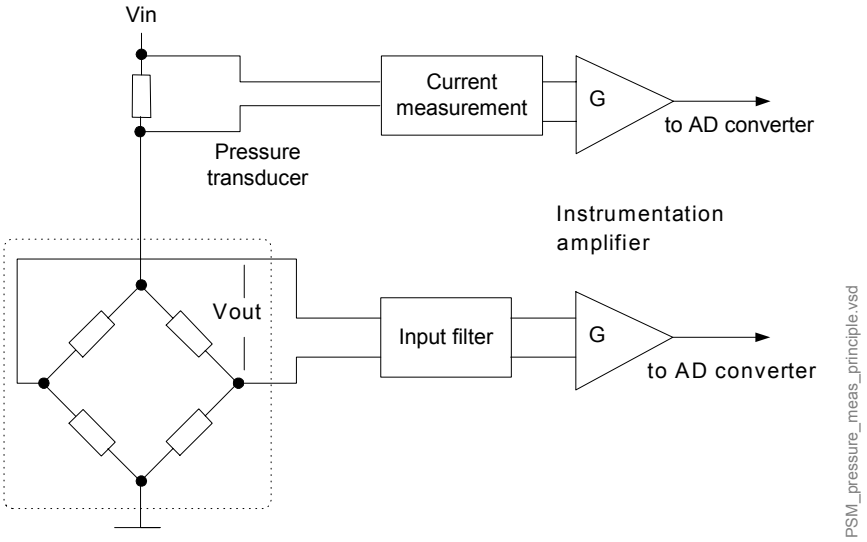


Figure 6 Pressure measurement principle

Serial communication

An RS485 type bus driver makes the serial communication between the module and the frame. Data transmission rate is 500kbps.

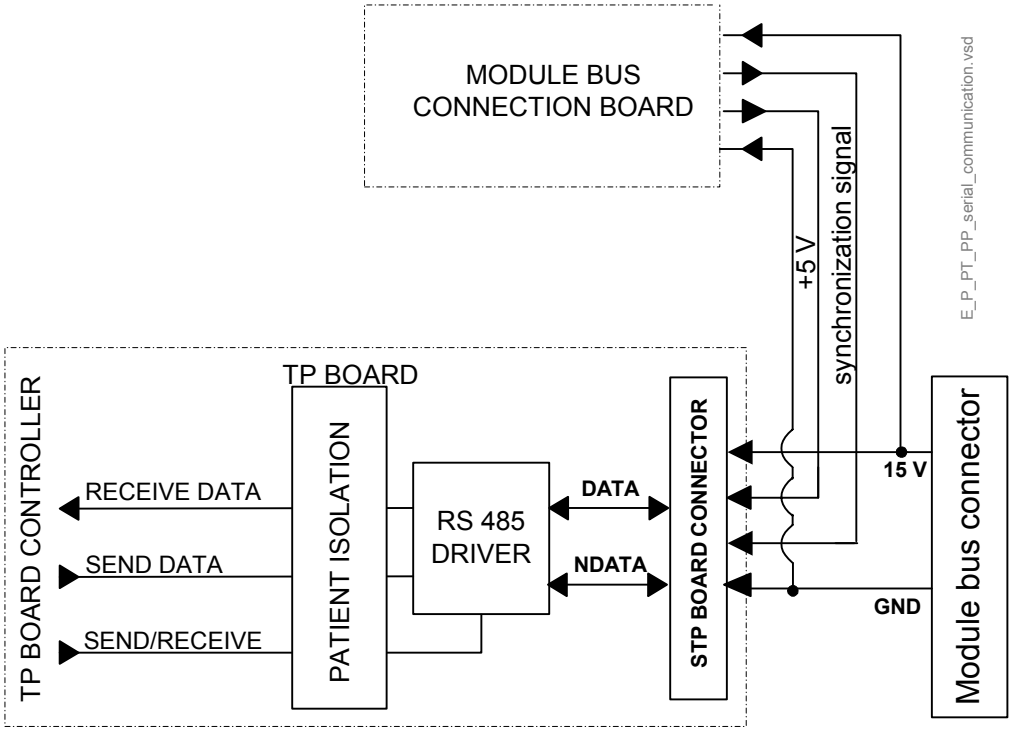


Figure 7 Serial communication of P/PT module

Signals and isolation barrier

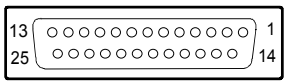
The communication signals transfer over the isolation barrier by using high isolation voltage (6kV) opto isolators.

Power supply section

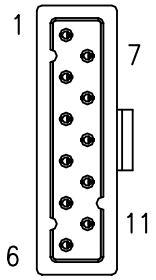
The power for the electronics on the floating part of the PT/P board is made with the switching power supply connected to a high voltage isolated transformer. The switching power supply on the PT board is synchronized to the frequency, about 340kHz of the switching power supply on the Module bus connection board. The Module bus connection board supplies non-isolated 5 V to the PT board. The module uses only Vmod 13.8 - 16 V voltage of the frame. The other voltages of the measuring boards are made by the switching power supplies and regulators or the linear regulators. The measuring board is protected against overloading with PTC type automatic fuses.

2.3 Connectors and signals

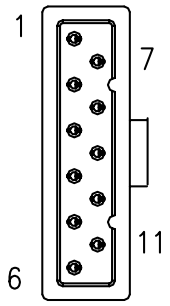
2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	3	I	+15 VD
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	GND
	13		GND
	15	I	GND
	21	O	PWM_ECG
	Other	NC	Not Connected

2.3.2 Invasive blood pressure connector

Invasive blood pressure connector (P3)	Pin No.	Signal	Description
	1	BP_+V_{REF}	BP transducer excitation voltage
	2	BP SIG+	BP transducer signal positive (+)
	3	NC	Not connected
	4	AGND	Analog ground
	5	NC	Not connected
	6	SHIELD	BP cable shield
	7	AGND	Analog ground
	8	BP SIG1	BP transducer signal negative (-)
	9	NC	Not connected
	10	BP1_ID	BP1 probe identification
	11	NC	Not connected

2.3.3 Temp connector

Temp connector (T1, T2)	Pin No.	Signal
	1	Sensor drive current
	2	Input from temperature sensor, channel 1
	3	Not connected
	4	Not connected
	5	Thermistor ID (LOW= Temperature error, HIGH=YSI 400 series)
	6	Cable shield
	7	Analog ground
	8	Input from temperature sensor, channel 2
	9	Not connected
	10	Not connected
	11	

3 Service procedures

3.1 General service information

The field service of the E-P and E-PT modules is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (“APPENDIX A”) which should be filled in when performing the procedures.

The symbol  in the instructions means that the check list should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**For product(s)**
Patient simulator		
Adapter cables for simulators:		
- Dual temperature adapter cable	402015-004	Hemodynamic patient simulator and Medsim
- Dual Inv.BP adapter cable	2005772-001	Hemodynamic patient simulator
- Temperature adapter cable	M1010832	Medsim
- Inv.BP adapter cable	M1010858	Medsim
- Temperature adapter cable	M1010846	Lionheart & MPS450
- Inv.BP adapter cable	M1010862	Lionheart & MPS450
Accessories:		
Pressure manometer		Hemodynamic modules w/ (P)
Temperature test set	884515	Hemodynamic modules w/ (T)
InvBP transducer		
Oscilloscope		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - there are no loose objects inside the module

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - all connectors are intact and are attached properly
   - the module box and latch are intact

   Reattach the module box and check that the latch is moving properly.

3.2.3 Functional inspection

Switch the monitor on and wait until the monitoring screen appears.

Configure the monitor screen so that all the needed parameters are shown, for example as follows:

Monitor Setup - ***Screen 1 Setup*** - ***Waveform Fields*** - ***Field 1*** - ***ECG1***
Field 2 - ***P1***
Field 3 - ***P3***
Field 4 - ***P5***
Digit Fields
Field 4 - ***T3+T4***

3. Installation

   Plug in the module. Check that it goes in smoothly and locks up properly.

   Preset InvBP measurement settings:

   Invasive Pressures - ***P1 'Art' Setup*** - ***Label*** - ***Art***
   P3 Setup - ***Label – PA***

4. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** - (password 26-23-8)

Take down the information regarding module software by selecting ***Scroll vers*** and turning the ComWheel.

5. Communication and memories

   Enter the ***P/PT*** service menu (according to the tested module):

   Parameters - P/PT

   Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the module memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

Invasive blood pressure measurement

6. Membrane key

   Check the front panel membrane key **Zero P3**.

   Press the key at least for one second. Check that the pressed key is identified, i.e. the text for Button changes from OFF to ON in the service menu.

7. Cable and transducer detection

   Check that the Cable and Probe show OFF.

   Plug a cable with an invasive blood pressure transducer into the front panel connector P3.

   Check that Cable and Probe show ON and the corresponding pressure waveform field appears on the monitor screen.

NOTE: Test both invasive blood pressure channels with E-PP.

8. Calibration

   Calibrate the InvBP channel according to the instructions in section “Invasive pressure calibration”.

9. Configuration BP/PT

   Check that the module configuration is correct with P and PT modules.

   The configuration in use is shown beside the text Configuration in the service menu and it can be either BP or PT.

   Change the configuration in the ***Calibrations*** menu, if necessary.

10. Test with patient simulator

    Check the InvBP channels with a patient simulator.

The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

SENSITIVITY switch position: 5 µV/V/mmHg
ECG - BASE - BPM - 60
BP - 3 - WAVE - PA

Connect a cable from the channel BP2 to the connector P3.

Check that appropriate InvBP waveform is shown and the InvBP value is approximately 25/10 (±2 mmHg).

Modules with temperature measurement

11. Temperature probe detection

    Check that the Cable and Probe show OFF for the channels T3 and T4 when no probes are connected.

    Connect a temperature test plug into the connector T3. Check that the Cable and Probe for T3 show ON and the corresponding temperature value appears on the screen.

    Perform the same check also for the channel T4.

12. Calibration check

    Check the temperature calibrations using temperature test plugs.

    If the deviation on a temperature reading on the screen is more then 0.1 °C, calibrate the temperature channels according to the instructions in section “Temperature calibration”.

13. Temp test function

    Activate the temperature test by selecting ***Temp Test*** from the menu and pressing the ComWheel twice. When the message ‘Performing temp test’ disappears from the digit field for T3+T4, check that no error messages appear and Temp error shows OFF for both channels in the menu.

All modules

14. Electrical safety check

    Perform an electrical safety check and a leakage current test.

15. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

16. Final cleaning
    Clean the module with suitable detergent.

- Fill in all necessary documents.

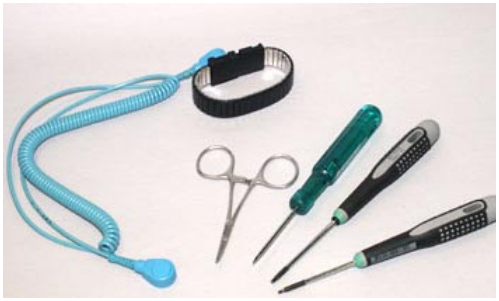
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the E-P and E-PT modules (see the exploded view of the module in the “E-Modules Spare parts” slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. To remove the PT board: remove the four screws (T10) with nylon washers holding the board to the body. Disconnect the PT input connector and the internal module bus connector.
4. To remove the Module bus connection board: remove the two screws (T10) with nylon washers holding the PC board to the body plate and the two screws (T10) holding the module bus connector to the body plate.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

NOTE: Remember to reassemble the nylon washers.

CAUTION When reassembling the module, make sure that all cables are connected properly.

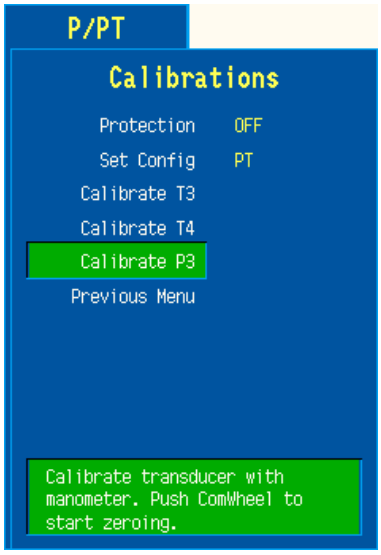
Always perform the “Service check ” after reassembling the module.

3.4 Adjustments and calibrations

3.4.1 Invasive pressure calibration

Perform pressure calibration whenever the pressure transducer (probe) is replaced with a different type of transducer.

1. Enter ***P/PT*** service menu: **Monitor Setup** - ***Install/Service*** - ***Service*** - ***Parameters***
2. Enter ***Calibrations*** menu.



3. Connect a pressure transducer with a pressure manometer to the P3 connector. Select ***Calibrate P3***. Leave the transducer to room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg...300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The text 'calibrated' appears on the display.

3.4.2 Temperature calibration

NOTE: For the temperature calibration, separate calibration plugs (25 °C and 45 °C) are necessary. A test set of two plugs is available from GE Healthcare, order code 884515.

Perform temperature calibration whenever the measured values deviate more than ±0.1.

1. Enter ***P/PT*** service menu (**Monitor Setup**, ***Install/Service, Service, Parameters***).
2. Enter ***Calibrations*** menu.
3. Select ***Protection*** OFF.
4. Select ***Calibrate T3/Calibrate T4***.
5. Insert the calibration plug (25 °C) into T3/T4 connector.
6. Press the ComWheel.
7. Insert the calibration plug (45 °C) into T3/T4 connector.

8. Press the ComWheel.
9. Select ***Protection*** ON.

4 Troubleshooting

4.1 Troubleshooting chart

See also the “User's Reference Manual” for more troubleshooting procedures.

4.1.1 Invasive blood pressure

Problem	**Cause**	**What to do**
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer.	Check transducer.
	No pressure module plugged in.	Check the module.
	No waveform selected on screen.	Check selected pressure waveforms by pressing **Monitor Setup** key and selecting modify waveforms. Check that pressure transducer open to patient.
‘Not zeroed’ message	Measurement on, channel not zeroed.	Zero the channel.
‘Zeroing failed’ message	Unsuccessful zeroing of P3 (number field).	Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel. Offset is > 150 mmHg. Open the transducer to air and zero the channel. Defective transducer. Replace it and zero the channel.
‘Calibration failed’ message	Unsuccessful calibrating of P3 (number field), possibly due to pulsating waveform.	Turn the transducer to sphygmomanometer and try again (zeroing takes place first). Gain is beyond the limits (±20% of the default gain). Replace the transducer.
Out of range ≤40 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel.
Out of range >320 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel. The patient may also have high pressure.
Zero adj. >100 mmHg	Offset when zeroing is >100 mmHg (but <150 mmHg) from the absolute zero of the module (with default gain).	Check transducer. The waveform may hit the top and the numeric display not shown.
Out of range	Measured pressure is beyond the internal measurement range of the module.	The waveform hits the top and the numeric display not shown. Check transducer and its level. Zero the channel.

4.1.2 Temperature

Problem	Cause	What to do
'Temperature error' message	Faulty calibration.	Perform calibration. If it does not help, check that front panel connectors are properly connected to PT board.
No temperature displayed	Wrong type of probe. Temperature out of measurable range. Temperature calibration not protected.	Use correct probe. The range is between 10 and 45 °C. Select ***Protection*** ON in the service menu.

4.2 Troubleshooting flowchart

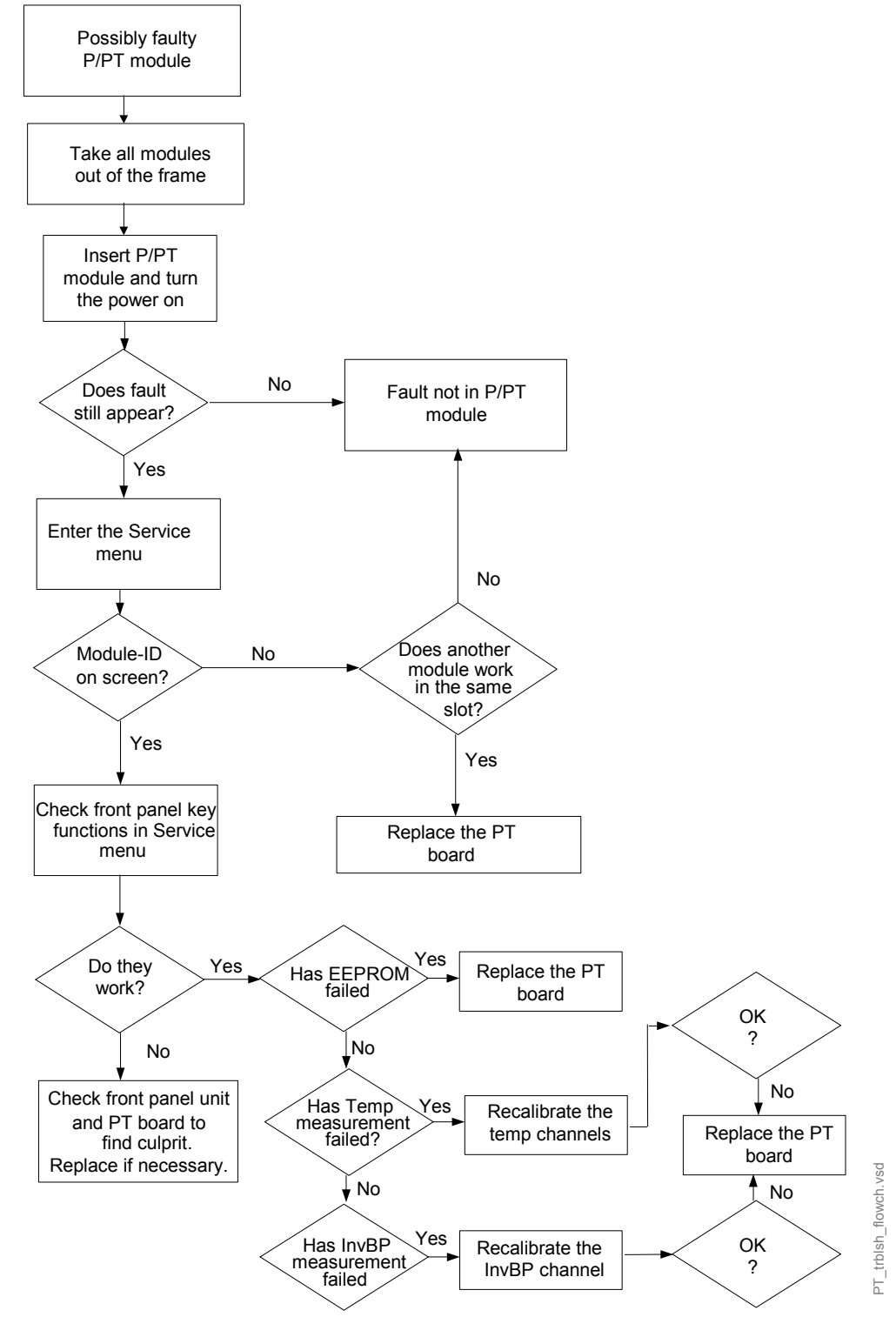


Figure 8 Troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5™ Pressure Temp Module, E-PT, and/or the S/5™ Pressure Module, E-P.

APPENDIX A Service check form, Pressure Temp Module, E-PT and Pressure Module, E-P (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Installation	☐	☐	☐				
4. Module software	P						
	PT						
5. Communication and memories	☐	☐	☐				
Notes							
InvBP measurement							
6. Membrane key	☐	☐	☐	7. Cable and transducer detection	☐	☐	☐
8. Calibration	☐	☐	☐	9. Configuration BP/PT	☐	☐	☐
10. Test with patient simulator	☐	☐	☐				
Notes							

TEMP measurement	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
11. Temperature probe detection	☐	☐	☐	12. Calibration check	☐	☐	☐
13. Temp test function	☐	☐	☐				
Notes							

All modules							
14. Electrical safety check	☐	☐	☐	15. Functioning after electrical safety check	☐	☐	☐
16. Final cleaning	☐	☐	☐				
Notes							

Notes

Used spare parts			

Signature

Datex-Ohmeda

S/5™ Dual Pressure Module, E-PP (Rev. 00)

Technical Reference Manual Slot

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027827
November, 2005

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Table of contents

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Dual Pressure Module, E-PP. The E-PP module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. The Dual Pressure Module provides invasive blood pressure (InvBP) measurement. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

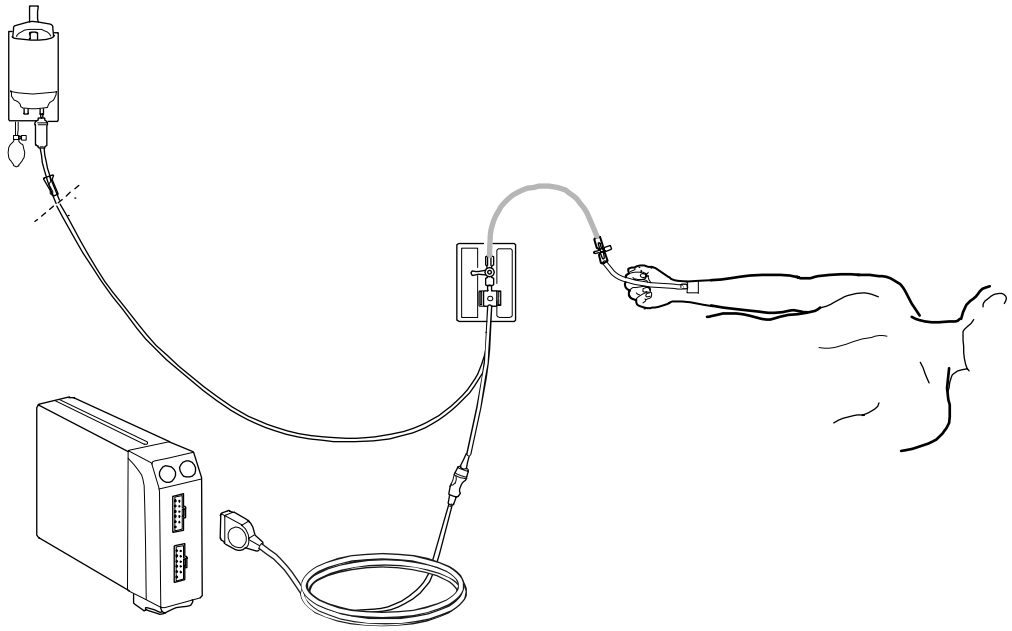


Figure 1 Invasive blood pressure setup

Monitor software compatibility

The Dual Pressure Module, E-PP, functions only with monitor software of level 97 and later.

Equipment safety symbols

When displayed on the E-PP module, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO2), temperature (T) and invasive pressure (P) measurement.

1 Specifications

1.1 General specifications

Module size, W × D × H	37 x 186 x 112 mm / 1.5 x 7.3 x 4.4 in
Module weight	0.3 kg / 0.7 lb.
Power consumption	approximately 3.5 W

1.2 Typical performance

Measurement range	-40 to +320 mmHg
Measurement accuracy	±5% or ±2 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±25%
Numerical display	
Range	-40 to +320 mmHg
Resolution	1 mmHg
Averaging	over 5 s, updated every 5 s, or end-expiratory filtering
Waveform display	
Range	-30 to +300 mmHg
Scales	Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10% of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s
Pulse rate	
Measurement range	30 to 250 bpm
Resolution	1 bpm
Accuracy	±5% or ±5 bpm

1.2.1 Technical specifications

Accuracy	±5% or ±2 mmHg
Transducer sensitivity	5 μV/V/mmHg
Filter	4 to 22 Hz adjustable (-3 dB)
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg
Zero time	< 15 s
Protection against electrical shock	type CF defibrillation proof

Numerical display averaging

Art and P1 numerical displays are averaged over 5 seconds and updated at 5 second intervals. All other pressures have respiration artifact rejection.

NOTE: The accuracy of the measurement may be different from that specified, depending on the transducer/probe being used. Please check the transducer/probe specification.

2 Functional description

2.1 Measurement principle

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

2.2 Main components

The main components of the Dual Pressure Module, E-PP, are an STP circuit board, a front panel and a box. The front panel includes two connectors, P5 and P6, and two direct function keys, **Zero P5** and **Zero P6** for pressure zeroing.

Communication between the Dual Pressure Module and the Central Unit is established via an RS485 serial interface.

The power supply voltages to the Dual Pressure Module are generated in the power supply section of the Central Unit. All electrical connections between the Dual Pressure Module and the Central Unit are provided via a 25-pin D-connector at the back of the module.

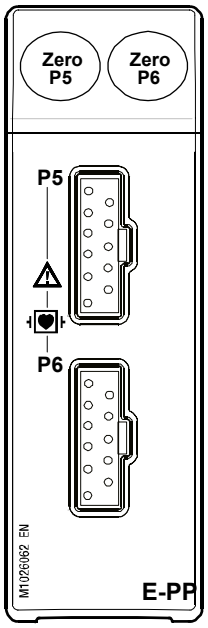


Figure 2 Front panel of the Dual Pressure Module, E-PP

2.2.1 STP board

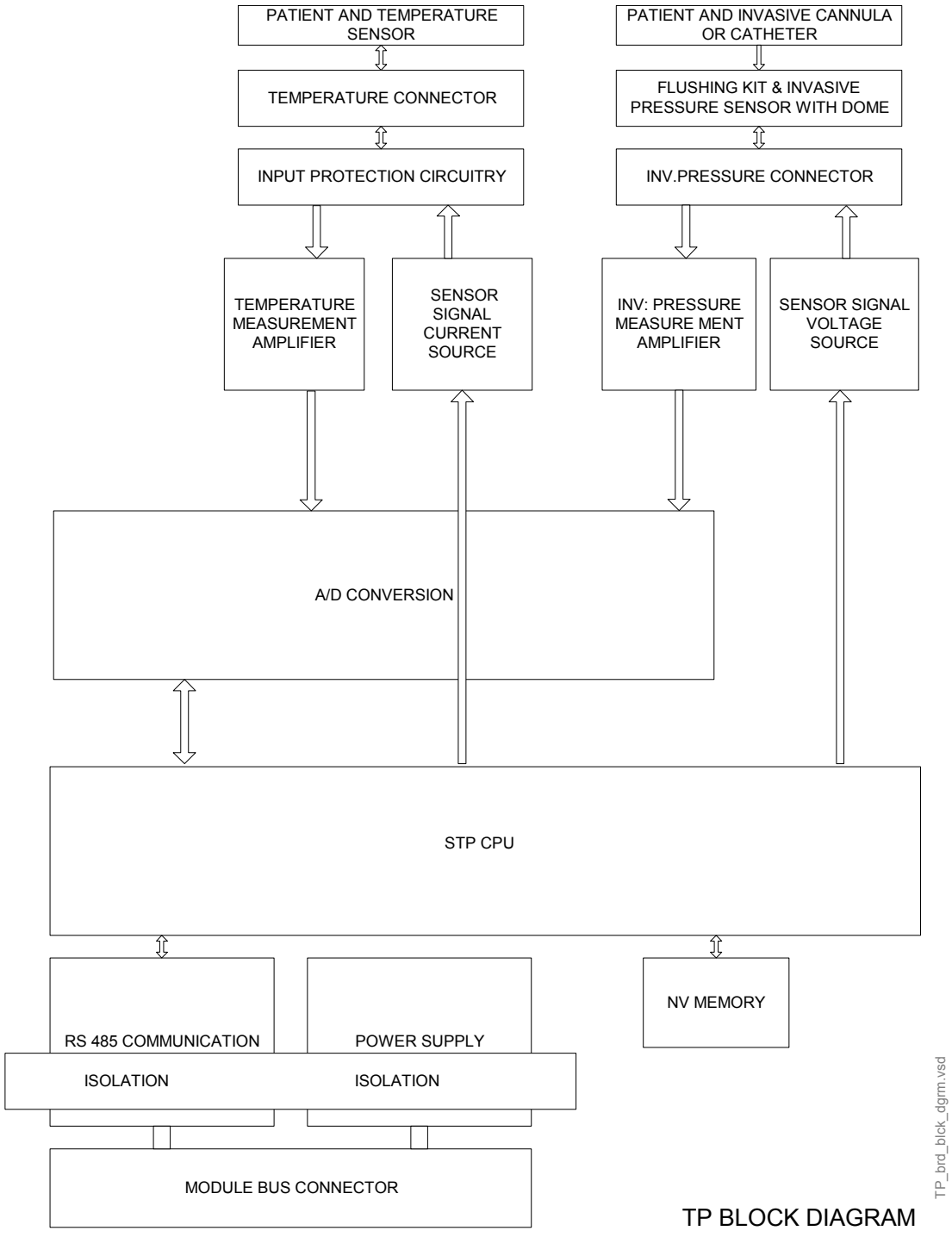


Figure 3 Temperature and invasive pressure measurements on STP board

Microprocessor unit

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

High speed I/O is used to obtain pulse control sequence necessary for pulse oximetry measurement. Timing for the clock is from the oscillator.

Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. The differential voltage, which depends on the pressure and the supplied voltage, is calculated from the bridge connection (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\ \mu V$, where U_{in} is 5 V

$\Rightarrow U_{out} = 25\ \mu V \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set to keep the level of the signal transferred to A/D converter within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

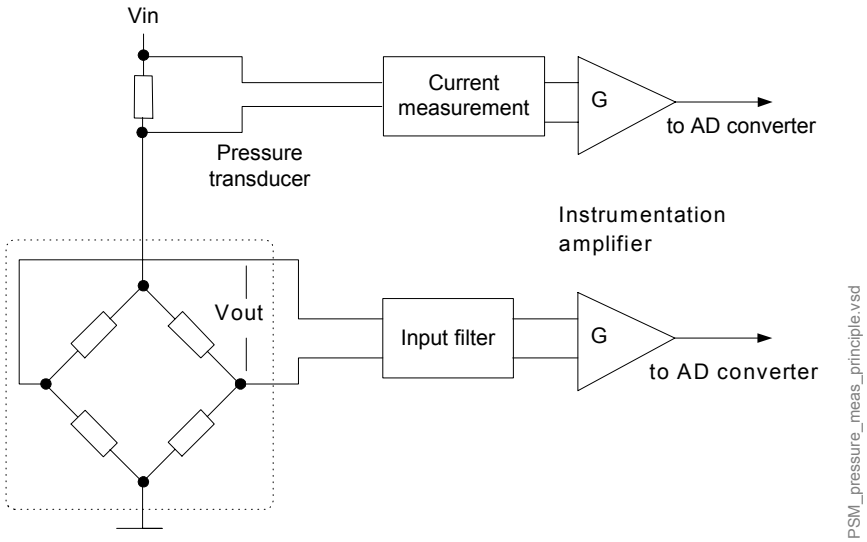


Figure 4 Pressure measurement principle

Serial communication

An RS485 type bus driver makes the serial communication between the module and the frame. Data transmission rate is 500kbps.

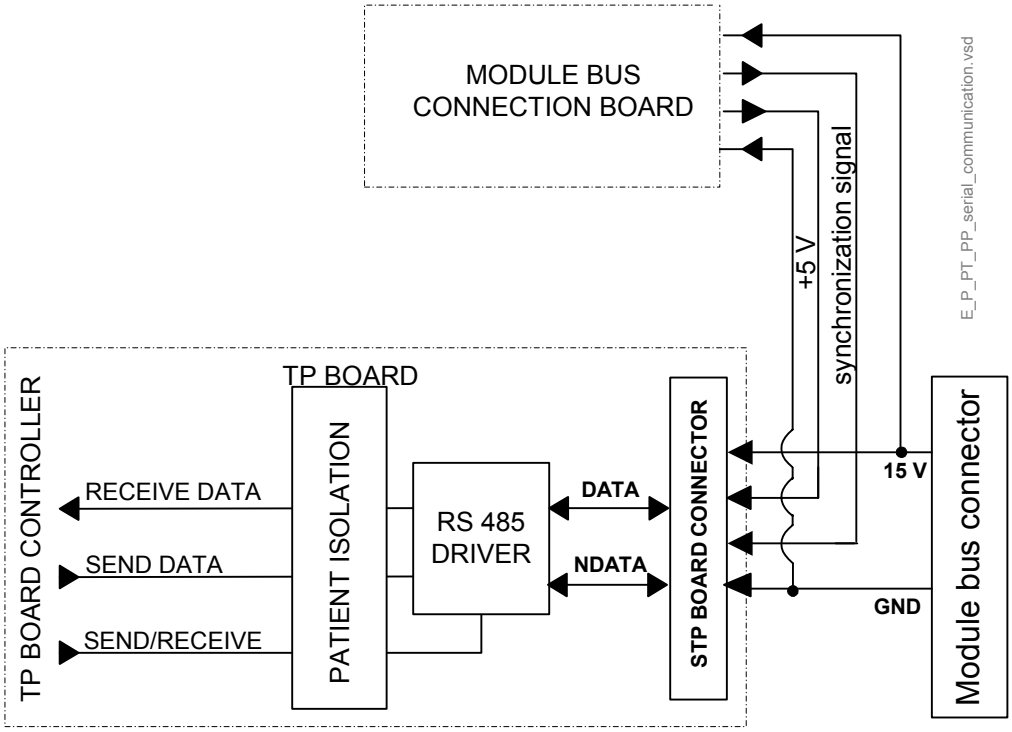


Figure 5 Serial communication of PP module

Signals and isolation barrier

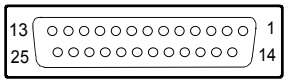
The communication signals transfer over the isolation barrier by using high isolation voltage (6kV) opto isolators.

Power supply section

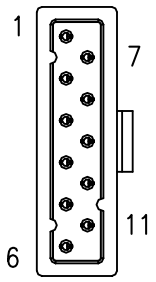
The power for the electronics on the floating part of the STP board is made with the switching power supply connected to a high voltage isolated transformer. The switching power supply on the PT board is synchronized to the frequency, about 340kHz of the switching power supply on the Module bus connection board. The Module bus connection board supplies non-isolated 5 V to the PT board. The module uses only Vmod 13.8 - 16 V voltage of the frame. The other voltages of the measuring boards are made by the switching power supplies and regulators or the linear regulators. The measuring board is protected against overloading with PTC type automatic fuses.

2.3 Connectors and signals

2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	3	I	+15 VD
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	GND
	13		GND
	15		GND
	21	O	PWM_ECG
	Other	NC	Not Connected

2.3.2 Invasive blood pressure connectors

Invasive blood pressure connectors (P5, P6)	Pin No.	Signal	Description
	1	BP_+V_{REF}	BP transducer excitation voltage
	2	BP SIG+	BP transducer signal positive (+)
	3	NC	Not connected
	4	AGND	Analog ground
	5	NC	Not connected
	6	SHIELD	BP cable shield
	7	AGND	Analog ground
	8	BP SIG1	BP transducer signal negative (-)
	9	NC	Not connected
	10	BP1_ID	BP1 probe identification
	11	NC	Not connected

3 Service procedures

3.1 General service information

The field service of the Dual Pressure Module, E-PP, is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**For product(s)**
Patient simulator		
Adapter cables for simulators		
- Dual Inv.BP adapter cable	2005772-001	Hemodynamic patient simulator
- Inv.BP adapter cable	M1010858	Medsim
- Inv.BP adapter cable	M1010862	Lionheart & MPS450
Accessories:		
Pressure manometer		Hemodynamic modules w/ (P)
InvBP transducer		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts
   Check that:

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - all connectors are intact and are attached properly
   - the module box and latch are intact

Reattach the module box and check that the latch is moving properly.

3.2.3 Functional inspection

Turn the monitor on and wait until the monitoring screen appears.

Configure the monitor screen so that all the required parameters are shown, for example:

Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 4 - P5***
Field 5 - P6

3. Installation

   Plug in the module, E-PP. Check that it goes in smoothly and locks up properly.

Preset the InvBP measurement settings:

Invasive Pressures - ***P5 Setup - Label - P5***
P6 Setup - Label - P6

4. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service (password 16-4-34) - Service View (password 26-23-8)***

   Take down the information regarding the PP module software by selecting ***Scroll vers*** and turning the ComWheel.

5. Communication and memories

   Enter the PP module service menu:

   Modules - PP

Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the module memories have passed the internal memory test, i.e. RAM, ROM and EEPROM all show OK.

6. Membrane keys

   Check the front panel membrane keys **Zero P5** and **Zero P6**.

   Press each of the keys for at least one second. Check that the key being pressed is identified, i.e. the text on the service menu for Button changes from OFF to ON.

7. Cable and transducer detection

   Check that Cable and Probe show OFF.

   Plug the cable from an invasive blood pressure transducer into the front panel connector P5. Check that Cable and Probe show ON and the corresponding pressure waveform field appears on the monitor screen.

8. Calibration

   Calibrate the InvBP channels according to the instructions in section “Invasive pressure calibration”.

9. Test with patient simulation

   Check the InvBP channels with a patient simulator.

   The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

   SENSITIVITY switch position: 5 µV/V/mmHg
   ECG - BASE - BPM - 60
   BP - 2 - WAVE - ATM
   3 - WAVE - ATM

   Connect channel BP2 to connector P5 and channel BP3 to connector P6.

   Zero the InvBP channels by pressing the zeroing keys on the module front panel.

   BP - 2 - WAVE - CVP
   3 - WAVE - PA

   Check that appropriate InvBP waveforms are shown and the InvBP values are approximately 15/10 mmHg (±2 mmHg) for channel P5 and 25/10 (±2 mmHg) for channel P6.

10. Electrical safety check

    Perform an electrical safety check and a leakage current test.

11. Functioning after electrical safety check
    Check that the module functions normally after performing the electrical safety check.

12. Final cleaning
    Clean the module with suitable detergent.

- Fill in all necessary documents.

3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the Dual Pressure Module, E-PP (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. To remove the SPT board: remove the four screws (T10) with nylon washers holding the board to the body. Disconnect the TP input connector and the internal module bus connector.
4. To remove the Module bus connection board: remove the two screws (T10) with nylon washers holding the PC board to the body plate and the two screws (T10) holding the module bus connector to the body plate.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

NOTE: Remember to reassemble the nylon washers.

CAUTION When reassembling the module, make sure that all cables are connected properly.

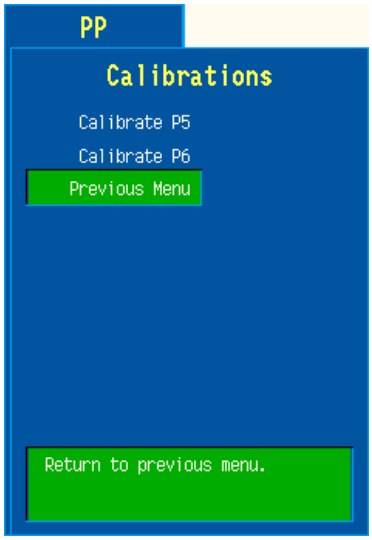
Always perform the "Service check" after reassembling the module.

3.4 Adjustments and calibrations

3.4.1 Invasive pressure calibration

Perform a pressure calibration whenever the pressure transducer (probe) is replaced with a different type of transducer.

1. Enter the ***PP*** service menu (**Monitor Setup** - ***Install/Service*** - ***Service*** - ***Parameters***).
2. Enter the ***Calibrations*** menu.



3. Connect a pressure transducer with a pressure manometer to the P5/P6 connector. Select ***Calibrate P5*** or ***Calibrate P6*** from the menu. Leave the transducer at room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg...300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel. A tolerance of 1 mmHg is allowed.
7. The text 'calibrated' appears on the display.

4 Troubleshooting

See also the “User's Reference Manual” for more troubleshooting procedures.

4.1 Troubleshooting chart

Problem	Cause	What to do
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer.	Check the transducer.
	No pressure module plugged in.	Check the module.
	No selected waveform on screen.	Check selected pressure waveforms by pressing **Monitor Setup** key and selecting modify waveforms. Check that pressure transducer open to patient.
‘Not zeroed’ message	Measurement on, channel not zeroed.	Zero the channel.
‘Zeroing failed’ message	Unsuccessful zeroing of P5/P6 (number field), possibly due to pulsating pressure waveform. Offset is > 150 mmHg. Defective transducer.	Open the transducer to air and zero the channel. Open the transducer to air and zero the channel. Replace the transducer and zero the channel.
‘Calibration failed’ message	Unsuccessful calibration of P5/P6 (number field), possibly due to pulsating waveform. Gain is beyond the limits (± 20% of the default gain).	Turn the transducer to sphygmomanometer and try again (zeroing takes place first). Replace the transducer.
Out of range ≤ 40 mmHg	Pressure measurement is beyond measurement range.	Check the transducer level. Zero the channel.
Out of range > 320 mmHg	Pressure measurement is beyond measurement range.	Check the transducer level. Zero the channel. The patient may also have high blood pressure.
Zero adj. > 100 mmHg	Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain). The waveform may hit the top of the screen and the numeric display not shown.	Check the transducer.
Out of range	Measured pressure is beyond the internal measurement range of the module. The waveform may hit the top of the screen and the numeric display not shown.	Check the transducer and its level. Zero the channel.

4.2 Troubleshooting flowchart

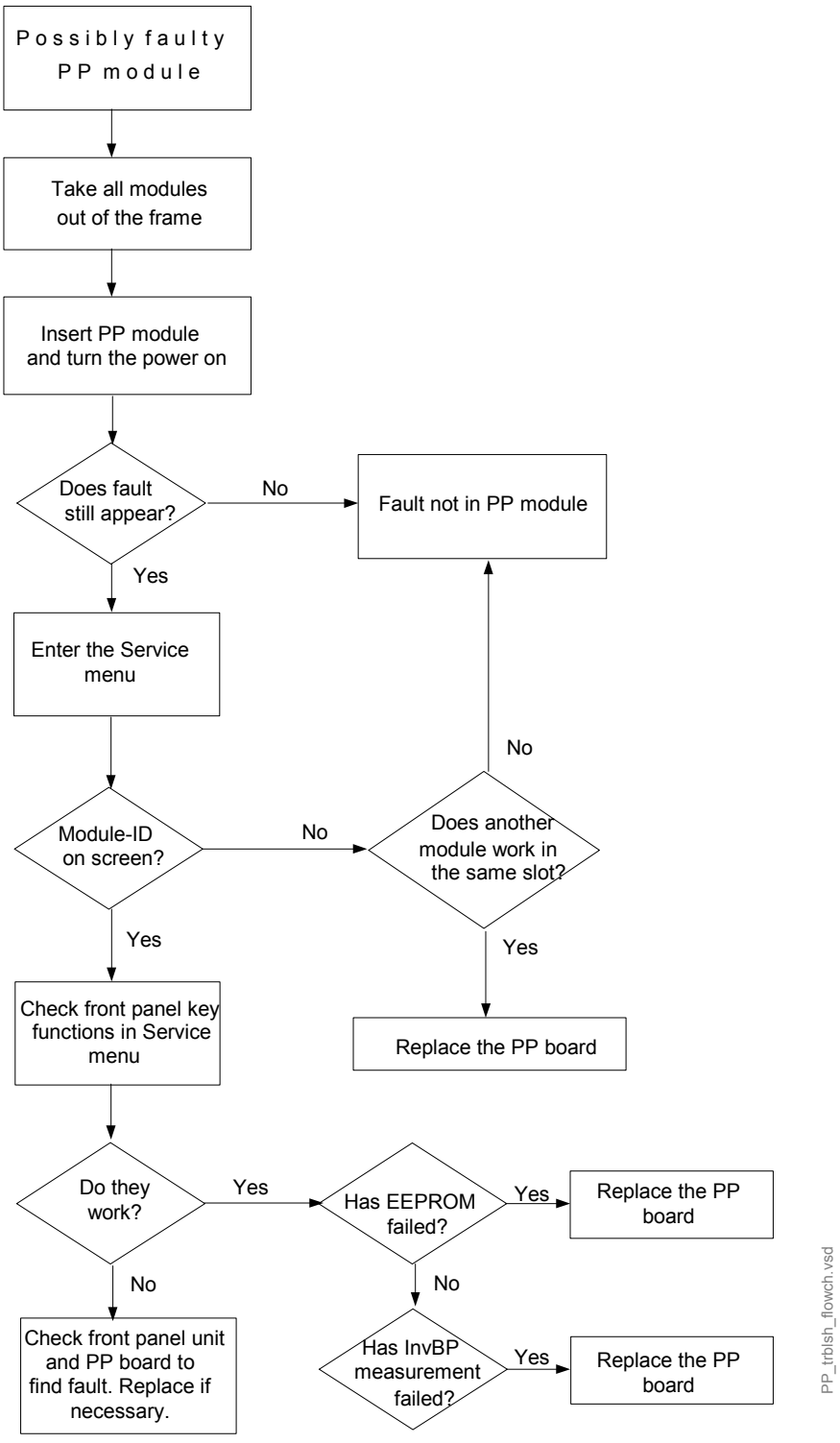


Figure 6 E-PP troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5™ Dual Pressure Module, E-PP.

APPENDIX A Service check form, Dual Pressure Module, E-PP (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Functional inspection							
3. Installation	☐	☐	☐				
4. Module software	PP						
5. Communication and memories	☐	☐	☐				
6. Membrane keys	☐	☐	☐	7. Cable and transducer detection	☐	☐	☐
8. Calibration	☐	☐	☐	9. Test with patient simulation	☐	☐	☐
10. Electrical safety check	☐	☐	☐	11. Functioning after electrical safety check	☐	☐	☐
12. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

Signature

Masimo compatible Saturation Module, E-MASIMO

Technical Reference Manual Slot

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices

CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner. Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1137270-02

June 16, 2008

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Table of contents

1 Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Masimo Compatible Saturation Module, E-MASIMO. The E-MASIMO is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors.

The service menu is described in the monitor manual in a separate “Service Menu” slot and the spare part lists in the “E-Modules Spare Parts” slot.

NOTE: E-MASIMO can be used with E-PSM(P)/E-PRESTN/E-RESTN/ M-PRESTN/M-RESTN/ M-NE(12)STPR/ M-NE(12)STR/M-ESTPR/ M-ESTR/M-ESTP/M-EST/E-NSATX modules. The SpO_2 measurement in E-MASIMO automatically overrides the SpO_2 measurement in these modules. Use only MASIMO SET sensors with the E-MASIMO module.

Masimo SET is a licensed trademark of Masimo Corporation.

WARNING **The operator is responsible for checking the compatibility of the pulse oximetry monitor, sensor, and patient cable prior to use. Incompatible components can result in degraded performance and/or device malfunction.**

WARNING **Change measuring site frequently. Change sensor site and check skin and circulatory status every 2 to 4 hours with adults and every hour with small children.**

WARNING **To prevent erroneous readings, do not use physically damaged sensors or modules. Discard a damaged sensor immediately. Do not repair a damaged sensor or use a sensor repaired by others. A damaged sensor or a sensor soaked in liquid may cause burns during electrosurgery.**

WARNING **Inaccurate SpO_2 data can result if a sensor is past its useful life. Therefore, re-evaluate the measurement periodically by performing additional assessment of the patient and equipment, including consideration of use of alternate monitoring methods such as direct measurement of arterial oxyhemoglobin saturation (SaO_2).**

WARNING **Pulse rate measurement is based on the optical detection of a peripheral flow pulse and therefore may not detect certain arrhythmias. The pulse oximeter should not be used as a replacement or substitute for ECG based arrhythmia analysis.**

NOTE: Accuracy during motion is not specified for MasimoSET(R) sensors LNOP TC-I, LNCS TC-I and LNCS TF-I.

Monitor software compatibility

The E-MASIMO is a single-width plug-in module designed for use with the Datex-Ohmeda AS/3, CS/3 and S/5 monitors using software licenses S-STD-94, S-ARK94, S-ANE97, S-ICU97 or later versions.

2 Specifications

Module size (WxDxH):	37 x 188 x 112 mm/1.5 x 7.4 x 4.4 in
Module weight	0.3 kg/ 0.7 lbs
Power consumption	1.5 W typical
Wavelength range and optical output power	appr. 400 nm and 1000 nm, less than15 mW
Radiant power at 50mA pulse	<15 mW
Degree of protection	Type BF
Pleth waveform	automatic scaling

SpO_2

Measurement and display range	1 to 100 %
Calibration range	70 to 100 %
Accuracy[1 2 3]	
70 to 100% (Arms)[4]	±2 to ±4% (from non-motion to motion and low perfusion, depends on the sensor used)
1 to 69%	unspecified
Resolution	1 digit = 1 % SpO_2
Data update period	1 second

The module is calibrated to display functional saturation.

1. Masimo SET Technology with LNOP and LNCS sensors have been validated for no motion accuracy in human blood studies on healthy adult volunteers with light to dark skin pigmentation in induced hypoxia studies in the range of 70-100% against a laboratory co-oximeter and ECG monitor. One percent was added to accuracies for neonatal/infant sensors to account for accuracy variation due to properties of fetal hemoglobin. The variation equals plus or minus one standard deviation, which encompasses 68% of the population. Refer to the directions for use of the Masimo SET Sensors.
2. Masimo SET Technology with LNOP and LNCS sensors have been validated for motion accuracy in human blood studies on healthy adult volunteers in induced hypoxia studies while performing rubbing and tapping motions, at 2 to 4 Hz an amplitude of 1 to 2 cm and non-repetitive motion with 1 to 5 Hz at an amplitude of 2 to 3 cm in the range of of 70% to 100% SpO2 compared against a laboratory CO-oximeter and ECG monitor. One percent was added to accuracies for neonatal/infant sensors to account for accuracy variation due to properties of fetal hemoglobin. The variation equals plus or minus one standard deviation, which encompasses 68% of the population. NOTE: Accuracy during motion has not been specified for Masimo SET sensors LNOP TC-I, LNCS TC-I and LNCS TF-I
3. The variation of the given accuracies is dependent on the motion and sensors being used. Refer to the directions for use of the Masimo SET Sensors. Accuracy during motion has not been specified for Masimo SET sensors LNOP TC-I, LNCS TC-I and LNCS TF-I.
4. About two-thirds of pulse oximeter equipment measurements can be expected to fall within ± Arms of the value measured by a CO-oximeter.

Pulse rate

Measurement and display range	30 to 240 bpm
Accuracy(Arms)[1 2 3 4]	±3 to ±5 bpm (from non-motion to motion and low perfusion, depends on the sensor used)
Resolution	1 bpm
Data update period	1 second
Alarms	adjustable high and low alarm limits; adjustable pulse beep sound volume

Alarms

High alarm	adjustable 51 to 100% and OFF
Low alarm	adjustable 50 to 100%
Alarm default limits	
high alarm	OFF
low alarm	90%

Alarms for no probe (No SpO2 probe) and for sensor off patient/ poor signal/interference/incompatible or defective sensor (Check SpO2 probe).

Due to the SpO_2 averaging, signal processing and data transmission the overall alarm generation delay of SpO_2 is typically less than 28 seconds from the actual SpO_2 value in the patient. The delay consists of the alarm condition and alarm generation delay, being typically <10 seconds and <18 seconds, respectively. For pulse rate the alarm generation delay is typically less than 11 seconds, in which the alarm signal delay is less than a second. The SpO_2 and Pulse rate data is updated every second.

1. About two-thirds of pulse oximeter equipment measurements can be expected to fall within ± Arms of the value measured by a CO-oximeter.
2. Masimo SET Technology with LNOP and LNCS sensors have been validated for low perfusion accuracy in bench top testing against Biotek Index 2 Simulator and Masimo's simulator with signal strength setting of greater than 0.02% and a % transmission of greater than 5% for saturation ranging from 70%-100%. One percent was added to accuracies for neonatal/infant sensors to account for accuracy variation due to properties of fetal hemoglobin. The variation equals plus or minus one standard deviation, which encompasses 68% of the population.
3. Masimo SET Technology with LNOP and LNCS sensors have been validated for pulse rate accuracy for the range of 25-240 bpm in bench top testing against a Biotek Index 2 simulator. The variation equals plus or minus one standard deviation, which encompasses 68% of the population. Monitor display range is 30 to 240 bpm.
4. The variation of the given accuracies is dependent on the motion and sensors being used. Refer to the directions for use of the Masimo SET Sensors. Accuracy during motion has not been specified for Masimo SET sensors LNOP TC-I, LNCS TC-I and LNCS TF-I.

3 Functional description

3.1 Main components of E-MASIMO

The E-MASIMO module consists of the following parts

- SpO_2 pre-amplifier board, MS-11
- Sensor connector interface cable
- E-MASIMO interface board

Figure 1 Front panel of Masimo Compatible Saturation Module, E-MASIMO

Sensors can be plugged into the E-MASIMO module using the MasimoSAT(R) Spo2 interconnect cable. MasimoSAT(R) has two types of sensors: LNOP and LNCS.

- 2027263-002 LNC-10 Cable with GE Compatible Connector LNCS (3 m /10 ft)
- 2017002-001 Interconnect cable, Masimo LNOP (3,6 m /11.8 ft)
- 2017002-003 Interconnect cable, Masimo LNOP (2,4 m / 7.8 ft)

The interconnect cable is plugged into a 11-pin connector on the front panel of the module. The Masimo MS-11 is a surface mounted PC board manufactured by Masimo. It contains the signal processing electronics and software that are based on Masimo stand-alone pulse oximeters.

The measured SpO2 and pulse rate values, as well as status information, are transferred from the MS-11 to the E-MASIMO interface board. Communication between the MS-11 and E-MASIMO interface board is established through an RS232C serial interface. The E-MASIMO interface board, in turn, transmits the measurement information to the module bus of the monitor through RS485 serial interface.

3.1.1 E-MASIMO Interface board

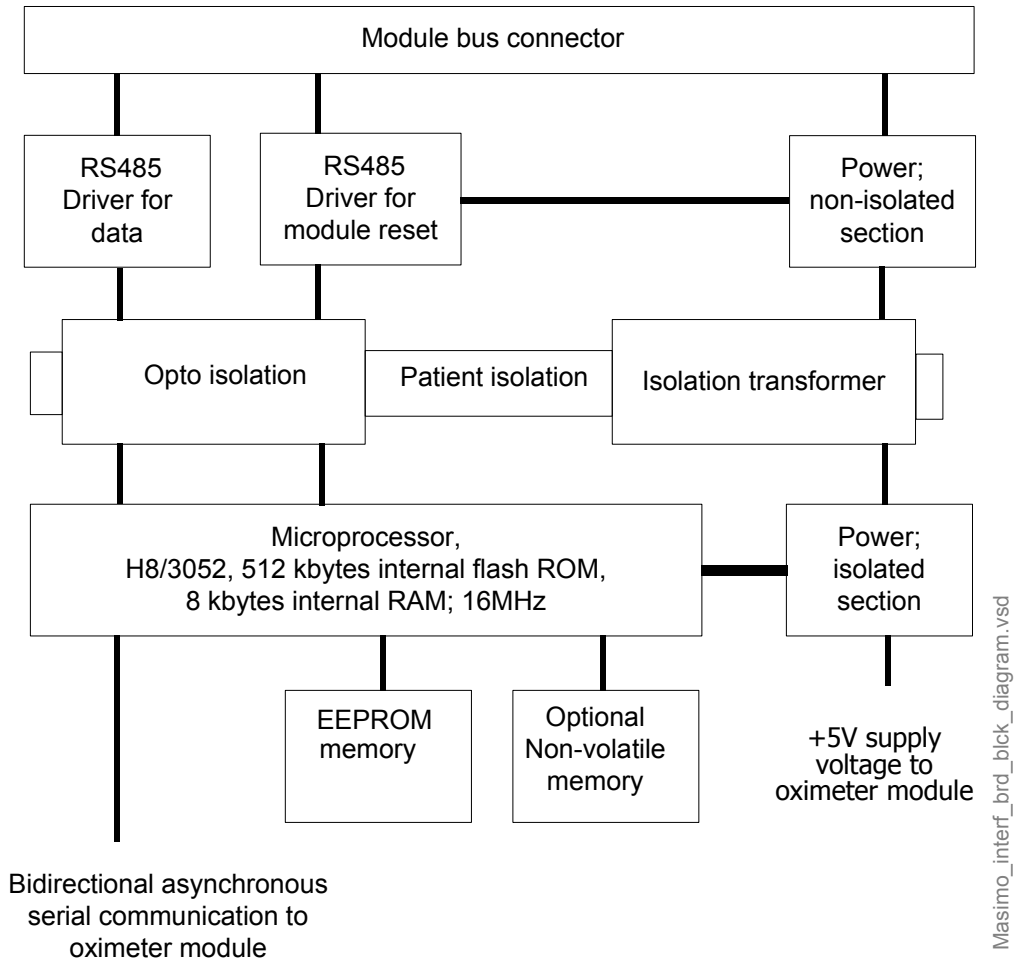


Figure 2 E-MASIMO Interface board block diagram

RS485 drivers

There are drivers for data and for optional module reset function. These drivers are used for driving the RS485 type serial communication bus between the module and the Central Unit. Data transmission speed of the bus is 500 kbps.

Power supply, non-isolated section

The power supply is a switched mode circuit, where the driver circuit is controlled by a quartz oscillator. The voltage, +15 Vdirty from the Central Unit is used as the supply voltage of the switched mode circuit.

Power supply, isolated section

The secondary voltages of the isolation transformer are rectified, filtered and regulated. Special attention is paid for the Masimo +5V supply voltage where low noise regulator is used.

Opto isolation

The signals of the serial communication bus between the E-MASIMO Interface board and the Central Unit are transferred through the patient isolation by high speed opto couplers.

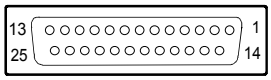
Microprocessor, non-volatile memory

The microprocessor with on-chip memory has been used to convert and transfer data from Masimo pulse oximeter module MS-11 to the monitor. The communication between MS-11 and the CPU of E-MASIMO Interface board is realized with bi-directional asynchronous serial communication.

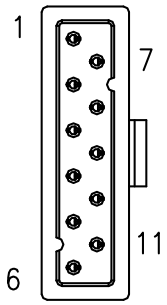
The non-volatile memory has been used to store identification information such as a serial number, control number, date, etc.

3.2 Connectors and signals

3.2.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	1	I	RESET_RS485
	3	I	+15 VDIRTY
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	Ground & Shield
	8	I	-RESET_RS485
	13	-	Ground & Shield
	15	I	GroundDIRTY
	Other	NC	Not Connected

3.2.2 SpO_2 connector, E-MASIMO

SpO_2 connector	Pin No.	Signal	Description
	1	DET_A	Photodiode anode
	2	DET_C	Photodiode cathode
	3	NC	Not connected
	4	NC	Not connected
	5	IR_C	IR LED cathode
	6	OUTER SHIELD	
	7	INNER_SHIELD	
	8	NC	Not connected
	9	NC	Not connected
	10	RED_C	RED LED cathode
	11	NC	Not connected

4 Service procedures

4.1 General service information

The field service of the E-MASIMO module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

4.2 Service check

These instructions include complete procedures for a service check**.** The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

4.2.1 Recommended tools

Tool	Order No.	Notes
Another Datex-Ohmeda hemodynamic module		
Masimo SpO2 finger probe with interconnect cable		
Torx screwdriver, T10		

Detach the module box by removing the two screws from the back of the module.

4.2.2 Visual inspection

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - all IC's that are on sockets are attached properly
   - there are no loose objects inside the module
   - Ferrite of the flex cable is attached properly

2. External parts

   Check that:

   - the front cover and the front chassis is intact
   - the probe connector and the cable are intact and attached properly
   - the module box and latch are intact

   Reattach the module box and check that the latch is moving properly.

4.2.3 Functional inspection

Switch the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that all the needed parameters are shown, for example as follows:

Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 1 - ECG1***
Field 2 - ECG2
Field 3 - P1
Field 4 - P2
Field 5 - PLETH
Field 6 - OFF
Monitor Setup - ***Interfacing - SpO2 - Module***

Make sure that the other hemodynamic module is connected, and the SpO_2 waveform field is shown on the screen.

Connect the finger probe to the module and attach the probe onto your finger. Check that the SpO_2 waveform appears on the screen.

3. Installation

   Plug in the E-MASIMO module. Check that it goes in smoothly and locks up properly.

4. Recognition

   Check that the E-MASIMO module is recognized, i.e. the SpO_2 waveform with related values disappears from the screen within 30 seconds. The empty SpO_2 waveform field should remain with the message 'No probe'.

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) **-** ***Service*** (password 26-23-8)

   Take down the information regarding MASIMO software by selecting ***Scroll Vers*** and turning the ComWheel.

6. Communication and memories

   Enter the E-MASIMO service menu:

   Parameters - M-SAT

Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the module's ROM memory has passed the internal memory test, i.e. the ROM shows OK.

7. SpO_2 probe status

   The status information in the Service Data field is not valid for the E-MASIMO. Check that the message 'No Probe' is displayed on the screen when no probe is connected.

8. Error status

   Check that all three error indicators, Preamp Error, QUART Error and I/O Error show NO.

9. SpO_2 probe detection

   Connect a SpO_2 finger probe to the module.

   Check that the message 'No Probe' changes to 'Check Probe' on the monitor screen.

   Check that the corresponding status information is updated correctly in the Service Data field.

10. Test measurement

    Connect the SpO_2 probe onto your finger. Check that a reading of 95-100 and proper SpO_2 waveform appear.

11. Electrical safety check

    Perform an electrical safety check and a leakage current test.

12. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

13. Final cleaning

    Clean the module with suitable detergent.

- Fill in all necessary documents.

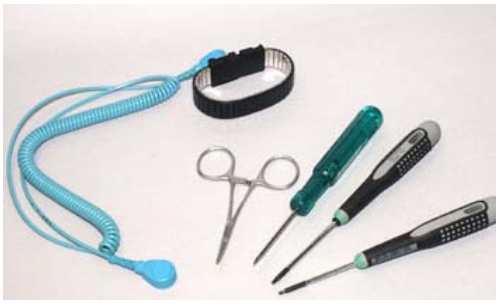
4.3 Disassembly and reassembly

4.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

4.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

4.3.3 To disassemble the module

To disassemble the E-MASIMO module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Remove the screw that secure the SpO_2 measurement board to the Interface board.
4. Unlock the three nylonposts that secure the SpO2 measurement board and lift the board up carefully.
5. Disconnect the flex cable that comes from the front chassis unit.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

NOTE: When installing the SpO_2 measurement board, make sure that the pin connector on the SpO_2 measurement board connects properly with the connector on the Interface board underneath.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

5 Troubleshooting

5.1 Troubleshooting chart

Problem	Cause	What to do
'No SpO2 probe' message	1. No probe connected to the module 2. Probe faulty 3. Wrong type of probe (not specified to be used with this module)	1. Check probe connections 2. Change probe 3. Change probe (see possible probe types: "User's Reference Manual")
'Check probe' message	1. No probe attached to the patient 2. The extension cable not connected to the probe 3. Unsuitable site 4. Probe faulty 5. Wrong type of probe (not specified to be used with this module) 6. Interference	1. See that the probe is properly attached to the patient 2. Check that the probe is connected to the cable 3. Try another place 4. Change probe 5. Change probe (see possible probe types in "User's Reference Manual") 6. See that the probe is properly attached to the patient
Finger probe falls off	1. Probe is slippery 2. Finger is too thin or thick	1. For proper sensor positioning, see the "Instructions for use" accompanying each sensor 2. Try other fingers or other probe types
Weak signal artifacts	1. Poor perfusion 2. Movement artifacts 3. Shivering	Try another place

5.2 Troubleshooting flowchart

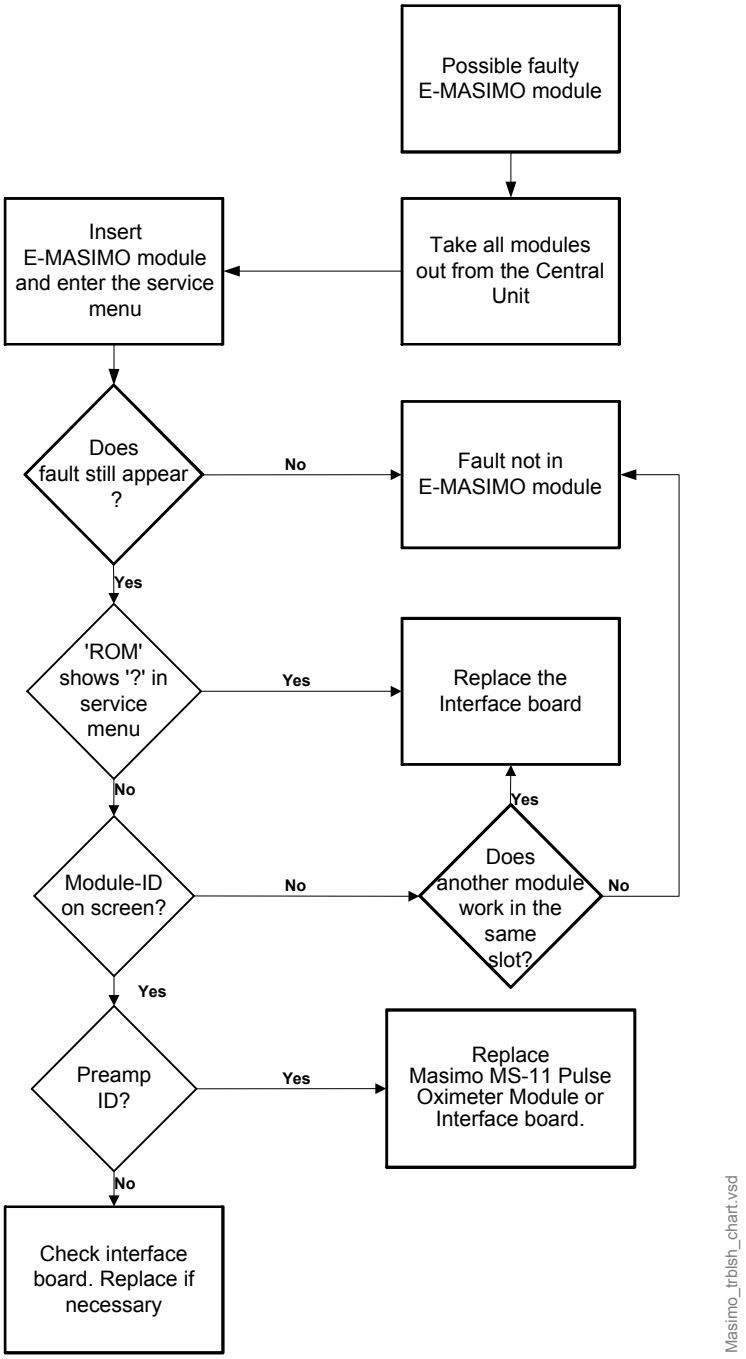


Figure 3 Module troubleshooting flowchart

6 Earlier revisions

There are no earlier revisions of the Masimo Module, E-MASIMO.

APPENDIX A: Service check form, Masimo Compatible Saturation Module, E-MASIMO (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Functional inspection							
3. Installation	☐	☐	☐	4. Recognition	☐	☐	☐
5. Module software	Masimo						
6. Communication and memories	☐	☐	☐	7. SpO2 probe status	☐	☐	☐
8. Error status	☐	☐	☐	9. SpO2 probe detection	☐	☐	☐
10. Test measurement	☐	☐	☐	11. Electrical safety check	☐	☐	☐
12. Functioning after electrical safety check	☐	☐	☐	13. Final cleaning	☐	☐	☐

Notes

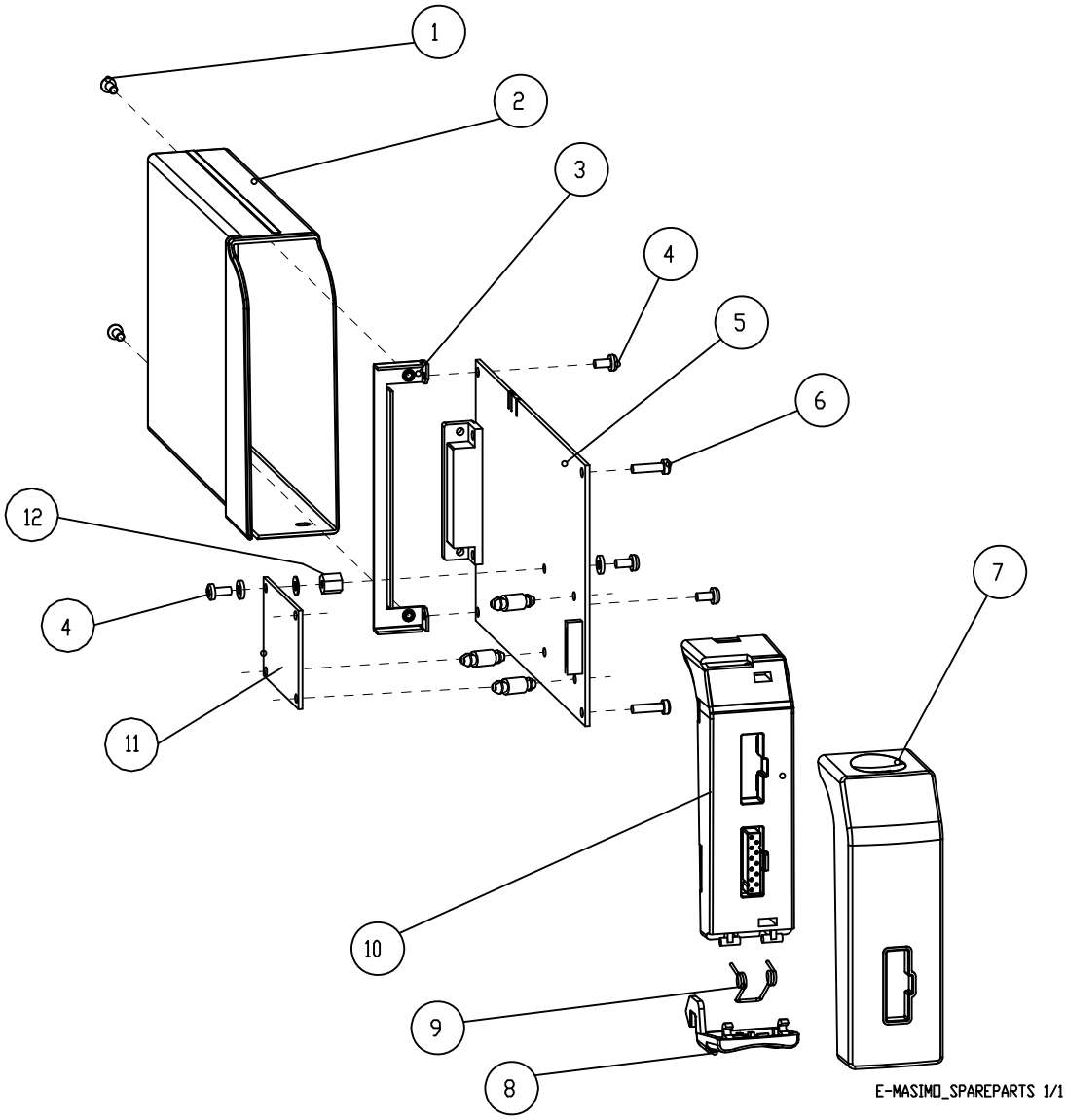
Used spare parts			

Signature

For your notes:

APPENDIX B: E-MASIMO Spare Parts

Masimo compatible Saturation Module, E-MASIMO



Item	Description	Order No.	Replaced
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel, zinc coated	606024	
2	Module Casing, Single *)	M1021035	
2*)	order with Module Casing: Patent Sticker, E-MASIMO	M1121761	
3	Metal frame	879184	
4	SCREW,machine screw, 3x6, DIN7985, ISO7045, TORX	605000-HEL	

Item	Description	Order No.	Replaced
5	Masimo Interface board, E-MASIMO	M1122843	
6	SCREW, screw for plastic,3.0 x12mm, torx head,	628729	
7	Front Cover, E-MASIMO	M1121205	
8	Latch, Injection molded	M1021039	
9	Torsion Spring, Machined	M1020935	
10	Front Chassis Unit, E-MASIMO (includes the connector and flex cable)	M1125298	
11	OEM-ITEM, Masimo MS-11 SpO2 board	M1125175	
12	MOUNTING, M3 threaded hexagonal spacer, L 7mm, D max 5.5mm, brass	640409-HEL	

Datex-Ohmeda

S/5 Nellcor Compatible Saturation Module, E-NSAT, E-NSATX

Technical Reference Manual Slot

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EEC.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1085565-003

January 21, 2011

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda Nellcor Compatible Saturation Module, E-NSAT/E-NSATX. The E-NSAT/E-NSATX is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The E-NSAT/E-NSATX module utilizes Nellcor pulse oximetry algorithm and it should only be used with Nellcor pulse oximetry sensors specified in the "Instructions for use" sheet accompanying the module.

NOTE: E-NSAT/E-NSATX can be used with E-PRESTN/E-PRETN/E-RESTN or M-PRESTN/M-PRETN/M-RESTN or E-PSM/E-PSMP or M-NE(12)STPR/M-NE(12)STR/M-ESTPR/M-ESTR. The SpO_2 measurement in E-NSAT/E-NSATX/M-NSAT/M-OSAT automatically overrides the SpO_2 measurement in these modules.

WARNING **To prevent erroneous readings, do not use physically damaged sensors or modules. Discard a damaged sensor immediately. Do not repair a damaged sensor or use a sensor repaired by others. A damaged sensor or a sensor soaked in liquid may cause burns during electrosurgery.**

WARNING **Inaccurate SpO_2 data can result if a sensor is past its useful life. Therefore, re-evaluate the measurement periodically by performing additional assessment of the patient and equipment, including consideration of use of alternate monitoring methods such as direct measurement of arterial oxyhemoglobin saturation (SaO_2).**

WARNING **Allow sensor and cable to dry completely after cleaning. Moisture and dirt on the connector may affect the measurement accuracy.**

WARNING **Data validity. Conditions that may cause inaccurate readings and impact alarms include interfering substances, excessive ambient light, electrical interference, ventricular septal defects (VSD), excessive motion, low perfusion, low signal strength, incorrect sensor placement, poor sensor fit, and/or movement of the sensor on the patient.**

Monitor software compatibility

The E-NSAT/E-NSATX module functions with Datex-Ohmeda AS/3, CS/3 and S/5 modular monitors using monitor software versions 94 or later.

1 Specifications

1.1 General specifications, E-NSAT

Module size, (W × D ×H)	37 x 188 x 112 mm/1.5 x 7.4 x 4.4 in
Module weight	0.3 kg/0.7 lb.
Power consumption	3 W
Wavelength range and energies of the light	approx. 660 nm to 890 nm

1.2 Typical performance of E-NSAT

Measurement and display range	20 to 100%
Calibration range	70 to 100%
Accuracy	70 to 100% (±1 standard deviation)
	±2 to ±3.5 digits (depends on the sensor used)
Display resolution	1 digit = 1% SpO_2
Display averaging	5...7 s
Display update	5 s
Pulse beep pitch	Varies with SpO_2 level

The monitor is calibrated over the measurement range against functional saturation SpO_2 (func).

Alarm

Alarm default limits	
high alarm	OFF
low alarm	90%

Heart rate from pleth

Measurement range	20 to 300 bpm
Accuracy	±3 bpm
Resolution	1 bpm
Display averaging	5...7 s
Adjustable pulse beep volume	

Pleth waveform

Scales	Automatic scaling
Protection against electrical shock	Type BF

1.3 Specifications, E-NSATX

Module size, (W × D ×H)	37 x 188 x 112 mm/1.5 x 7.4 x 4.4 in
Module weight	0.3 kg/0.7 lb.
Power consumption	3 W
Wavelength range and optical output power	660 nm and 900 nm, less than 15 mW

SpO_2

Measurement and display range	20 to 100%
Calibration range	70 to 100%
Accuracy 70 to 100% (A_{rms})[1]	±2 to ±3.5 digits (depends on the sensor used)
Resolution	1 digit = 1% SpO_2

Data update period	5 to 7 seconds
Display update period	5 seconds
Pulse beep pitch	Varies with SpO_2 level

The module is calibrated over the measurement range against functional saturation.

Alarms

Alarm default limitshigh	OFF, low	90%
high alarm	adjustable 51 to 100% and OFF	
low alarm	adjustable 50 to 100%	
Alarm default limits		
high alarm	OFF	
low alarm	90%	

Alarms for loss of pulse (Check SpO^2 probe) and no probe (No SpO^2 probe).

Pulse rate

Measurement and display range	20 to 300 bpm	
Accuracy	20 to 250 bpm (A_{rms})[1]	± 3 bpm
	251 to 300 bpm	unspecified
Resolution	1 bpm	
Data update period	5 to 7 seconds	
Dispaly update period	5 seconds	
Alarms	adjustable high and low alarm limits;	
Pulse beep volume	adjustable	

Pleth waveform

Scale	Automatic scaling
Degree of protection	Type BF

NOTE: You can verify the functionality of a pulse oximeter probe and monitor with a functional SpO2 tester, but you cannot evaluate their accuracy with such a device. However, if a particular calibration curve is accurate for the combination of a pulse oximeter monitor and probe, a functional tester can measure the contribution of a monitor to the total error of a monitor/probe system. The functional tester can then measure how accurately a particular pulse oximeter monitor is reproducing that calibration curve.

1. **Sensor accuracy** (MAX-A, MAX-N, MAX-FAST) was established in a controlled setting at the Nellcor Puritan Bennett Inc. performance testing laboratory in Pleasanton, CA., using the N-600 as the testing device and arterial blood SaO_2 as a CO oximetry reference. Sensor Accuracy Grids can be viewed online at www.nellcor.com. During the study, healthy adult volunteers (3 male, 9 female, aged 19 to 48 years, skin pigmentation light (3), medium (7), dark (2)) had more than 300 arterial blood samples drawn (SaO_2 53.3 to 99.5%) and A_{rms} values were calculated for the system based on these results.

   E-NSATX module accuracy was established for two modules (with Datex- Ohmeda S/5 Anesthesia Monitor and S/5 Critical Care Monitor) using a PS II simulator at Nellcor Puritan Bennett Inc., Pleasanton, CA. During the test, 70 datapoints were taken in the 70 to 100% saturation range. The RMSD for set and displayed SpO_2 values was calculated.

2 Functional description

2.1 Main components of E-NSAT

The E-NSAT module consists of the following parts

- SpO_2 pre-amplifier board
- Sensor connector cable
- Nellcor Pulse Oximeter Module MP-100
- NSAT interface board (NIO)

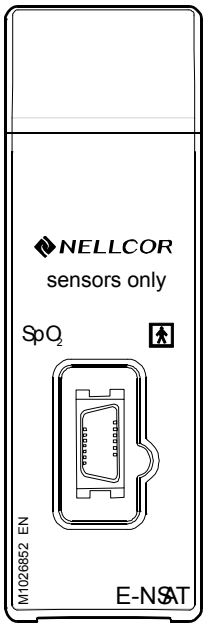


Figure 1 Front panel of Nellcor Compatible Saturation Module, E-NSAT

Sensors can be plugged into the E-NSAT module using the sensor extension cable DOC-10 available from Nellcor. Sensors are plugged into a 9-pin female connector (D-type) on the end of the extension cable DOC-10. The extension cable is plugged into a 14-pin connector on the front panel of the module.

The MP-100 is a surface mounted PC board manufactured by Nellcor. It contains the signal processing electronics and software that are based on Nellcor's stand-alone pulse oximeters.

The measured SpO_2 and pulse rate values, as well as status information, are transferred from the MP-100 to the NIO interface board. Communication between the MP-100 and NIO interface board is established through an RS232C serial interface. The NIO interface board, in turn, transmits the measurement information to the module bus of the monitor through RS485 serial interface.

2.1.1 NIO Interface board

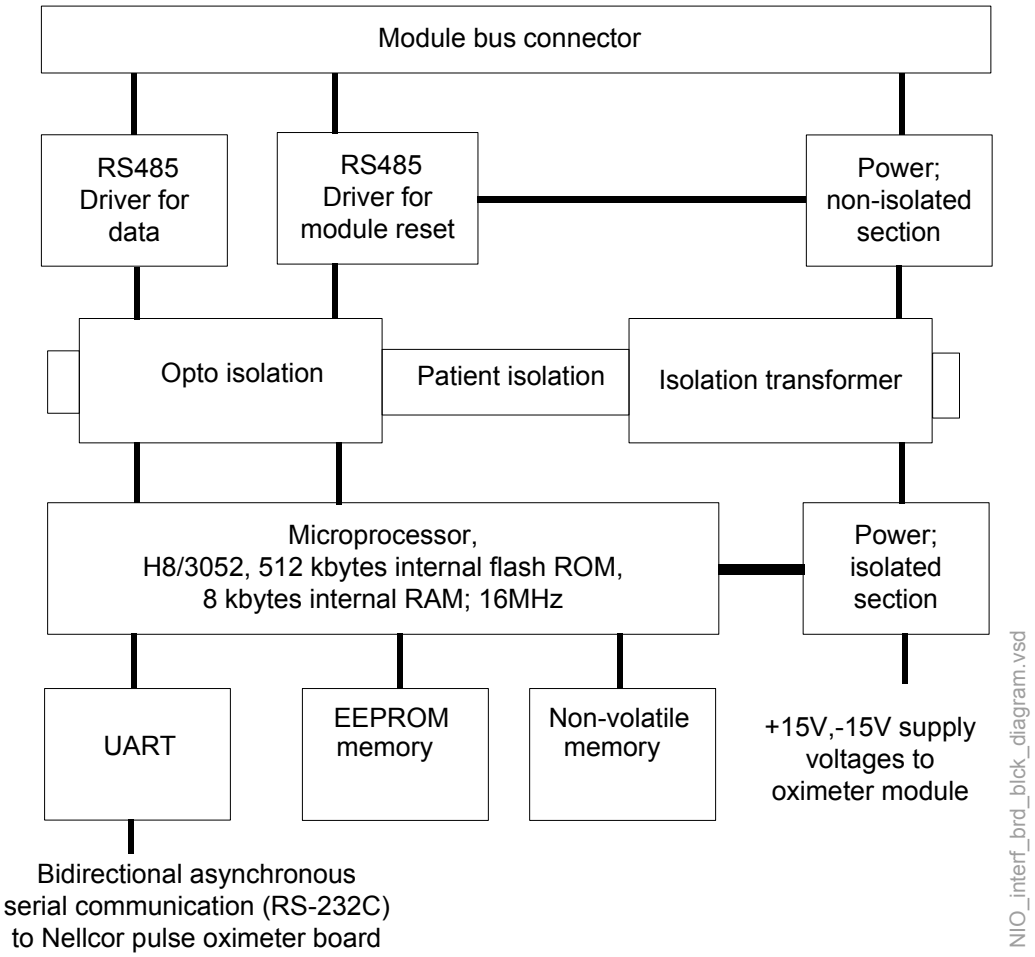


Figure 2 NIO Interface board block diagram

RS485 drivers

There are drivers for data and for module reset functions.

These drivers are used for driving the RS485 type serial communication bus between the module and the Central Unit. Data transmission speed of the bus is 500 kbps.

Power supply, non-isolated section

The power supply is a half bridge type switched mode circuit, where the driver FETs are controlled by a quartz oscillator. The load of the half bridge is the primary of the isolation transformer. The voltage, +15 Vdirty from the Central Unit is used as the supply voltage of the switched mode circuit.

Power supply, isolated section

The secondary voltages of the isolation transformer are rectified, filtered and regulated. The voltages can be measured from the test connector X11. See chapter “Other connectors”.

Opto isolation

The signals of the serial communication bus between the NIO Interface board and the Central Unit are transferred through the patient isolation by high speed opto couplers.

Microprocessor, UART, non-volatile memory

The microprocessor with on-chip memory has been used to convert and transfer data from Nellcor pulse oximeter module MP-100 to the monitor.

The communication between MP-100 and the CPU of NIO Interface board is realized with bi-directional asynchronous serial communication via the UART.

The non-volatile memory has been used to store identification information such as a serial number, control number, date, etc.

2.2 Main components of E-NSATX

The E-NSATX module consists of the following parts:

- SpO_2 pre-amplifier board
- Sensor connector cable
- Nellcor Pulse Oximeter Module NELL1GE
- NSAT interface board (NIO)

Figure 3 Figure 1 Front panel of Nellcor Compatible Saturation Module, E-NSATX

Sensors can be plugged into the E-NSATX module using the Nellcor OxiMax Spo2 interconnect cable, 2021406-001. Sensors are plugged into a 9-pin female connector (D-type) on the end of the extension cable. The extension cable is plugged into a 11-pin connector on the front panel of the module.

The NELL1GE is a surface mounted PC board manufactured by Nellcor. It contains the signal processing electronics and software that are based on Nellcor's stand-alone pulse oximeters.

The measured SpO_2 and pulse rate values, as well as status information, are transferred from the NELL1GE to the NIO interface board. Communication between the NELL1GE and NIO interface board is established through an RS232C serial interface. The NIO interface board, in turn, transmits the measurement information to the module bus of the monitor through RS485 serial interface.

2.2.1 NIO Interface board

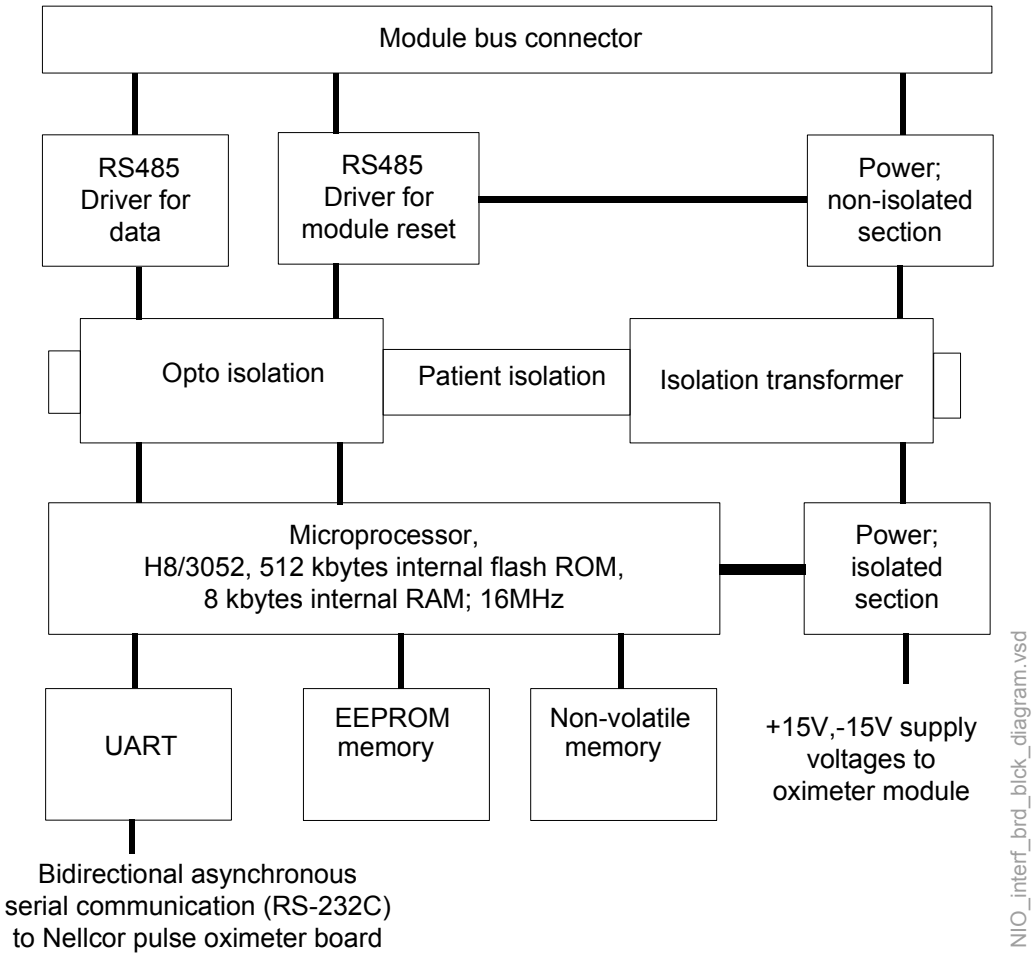


Figure 4 Figure 2 NIO Interface board block diagram

RS485 drivers

There are drivers for data and for module reset functions.

These drivers are used for driving the RS485 type serial communication bus between the module and the Central Unit. Data transmission speed of the bus is 500 kbps.

Power supply, non-isolated section

The power supply is a half bridge type switched mode circuit, where the driver FETs are controlled by a quartz oscillator. The load of the half bridge is the primary of the isolation transformer. The voltage, +15 Vdirty from the Central Unit is used as the supply voltage of the switched mode circuit.

Power supply, isolated section

The secondary voltages of the isolation transformer are rectified, filtered and regulated. The voltages can be measured from the test connector X11. See chapter “Other connectors”.

Opto isolation

The signals of the serial communication bus between the NIO Interface board and the Central Unit are transferred through the patient isolation by high speed opto couplers.

Microprocessor, UART, non-volatile memory

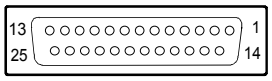
The microprocessor with on-chip memory has been used to convert and transfer data from Nellcor pulse oximeter module NELL1GE to the monitor.

The communication between NELL1GE and the CPU of NIO Interface board is realized with bi-directional asynchronous serial communication via the UART.

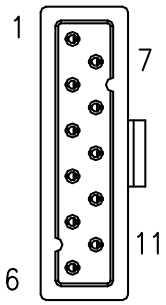
The non-volatile memory has been used to store identification information such as a serial number, control number, date, etc.

2.3 Connectors and signals

2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	1	I	RESET_RS485
	3	I	+15 VDIRTY
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	Ground & Shield
	8	I	-RESET_RS485
	13	-	Ground & Shield
	15	I	GroundDIRTY
	Other	NC	Not Connected

2.3.2 SpO_2 connector, E-NSATX

SpO_2 connector	Pin No.	Signal	Description
	1	DET_A	Photodiode anode
	2	DET_C	Photodiode cathode
	3	DATA-	
	4	Wire 1/3	LED connection
	5	IR_C	IR LED cathode
	6	OUTER SHIELD	
	7	DET_SHIELD	
	8	PRB_ID	Bin/ID Resistor+
	9	Wire 3/5	LED Connection
	10	RED_C	RED LED cathode
	11	DATA+	

2.3.3 Test connector (X11)

Pin No.	Voltage	Name	Note
1	+5V	+5VTEST	Supply voltage to the NSAT-board (NIO)
2	+5V	+5Vn	Supply voltage to the MP-100 board
3	+14...17V	+15Vn	Supply voltage to the MP-100 board

Pin No.	Voltage	Name	Note
4	-	GND	FGND
5	--14...-17	-15V	-15Vn
6	-	-	N/C

3 Service procedures

3.1 General service information

The field service of the E-NSAT/E-NSATX module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check**.** The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

NOTE: Use only calibrated and traceable measuring equipment.

Tool	Order No.	Notes
Another Datex-Ohmeda hemodynamic module		
Nellcor SpO_2 finger probe with DOC-10 cable		for E-NSAT module
40xxxxx-001Nellcor OxiMax Spo2 interconnect cable		for E-NSATX module
Torx screwdriver, T10		

Detach the module box by removing the two screws from the back of the module.

3.2.2 Visual inspection

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - all IC's that are on sockets are attached properly
   - EMC covers are attached properly

- there are no loose objects inside the module
- E-NSAT/E-NSATX ferrite of the cable sets are attached properly

2. External parts
   Check that:
   - the front cover and the front panel sticker are intact
   - the probe connector and the cable lock are intact and attached properly
   - the module box and latch are intact

Reattach the module box and check that the latch is moving properly.

3.2.3 Functional inspection

Switch the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that all the needed parameters are shown, for example as follows:

Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 1 - ECG1***
Field 2 - ECG2
Field 3 - P1
Field 4 - P2
Field 5 - PLETH
Field 6 - OFF

Monitor Setup - ***Install/Service*** (password 16-4-34) **- *Installation - Interfacing - SpO2 - Module***

Make sure that the other hemodynamic module is connected, and the SpO_2 waveform field is shown on the screen.

Connect the finger probe to the module and attach the probe onto your finger. Check that the SpO_2 waveform appears on the screen.

3. Installation
   Plug in the E-NSAT/E-NSATX module. Check that it goes in smoothly and locks up properly.

4. Recognition
   Check that the E-NSAT/E-NSATX module is recognized, i.e. the SpO_2 waveform with related values disappears from the screen within 30 seconds. The empty SpO_2 waveform field should remain with the message 'No probe'.

5. Module software
   Enter the service menu:
   Monitor Setup - ***Install/Service*** (password 16-4-34) **- *Service*** (password 26-23-8)

Take down the information regarding NSAT software by selecting ***Scroll vers*** and turning the ComWheel.

6. Communication and memories

   Enter the E-NSAT service menu:

   Parameters - M-SAT

   Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the module's ROM memory has passed the internal memory test, i.e. the ROM shows OK.

7. SpO_2 probe status

   Check that the SpO_2 probe related status information in the Service Data field is correct. Only the NoProbe should be active (1) when no probe is connected.

   E-NSAT: The status information in the Service Data field is not valid for the E-NSAT. Check that the message 'No Probe' is displayed on the screen when no probe is connected.

8. Error status

   Check that all three error indicators, Preamp Error, QUART Error and I/O Error show NO.

9. SpO_2 probe detection

   Connect a SpO_2 finger probe to the module.

   Check that the message 'No Probe' changes to 'Check Probe' on the monitor screen.

10. Test measurement

    Connect the SpO_2 probe onto your finger. Check that a reading of 95-100 and proper SpO_2 waveform appear.

11. Electrical safety check

    Perform an electrical safety check and a leakage current test.

12. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

13. Final cleaning
    Clean the module with suitable detergent.

- Fill in all necessary documents.

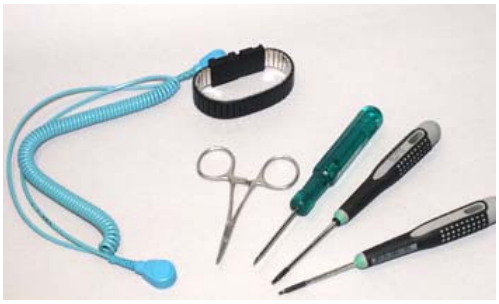
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the E-NSAT/E-NSATX module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Bend the metal tabs that hold the EMC-cover to an upright position and lift the cover off.
4. Remove the three screws that secure the SpO_2 measurement board to the Interface board.
5. Hold the SpO_2 measurement board as near the module bus connector as possible and lift the board up carefully.
6. Disconnect the cable that comes from the front panel unit and the flat cable that comes from the Interface board.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

NOTE: When installing the SpO_2 measurement board, make sure that the pin connector on the SpO_2 measurement board connects properly with the connector on the Interface board underneath.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	Cause	What to do
'No probe' message	1. No probe connected to the module 2. Probe faulty 3. Wrong type of probe (not specified to be used with this module)	1. Check probe connections 2. Change probe 3. Change probe (see possible probe types: "User's Reference Manual")
'Check probe' message	1. No probe attached to the patient 2. The extension cable not connected to the probe 3. Unsuitable site 4. Probe faulty 5. Wrong type of probe (not specified to be used with this module)	1. See that the probe is properly attached to the patient 2. Check that the probe is connected to the cable 3. Try another place 4. Change probe 5. Change probe (see possible probe types in "User's Reference Manual")
Finger probe falls off	1. Probe is slippery 2. Finger is too thin or thick	1. For proper sensor positioning, see the "Instructions for use" accompanying each sensor 2. Try other fingers or other probe types
Weak signal artifacts	1. Poor perfusion 2. Movement artifacts 3. Shivering	Try another place
'No pulse' message	Acceptable pulses were present but have now ceased for 10 seconds	Try other fingers

4.2 Troubleshooting flowchart

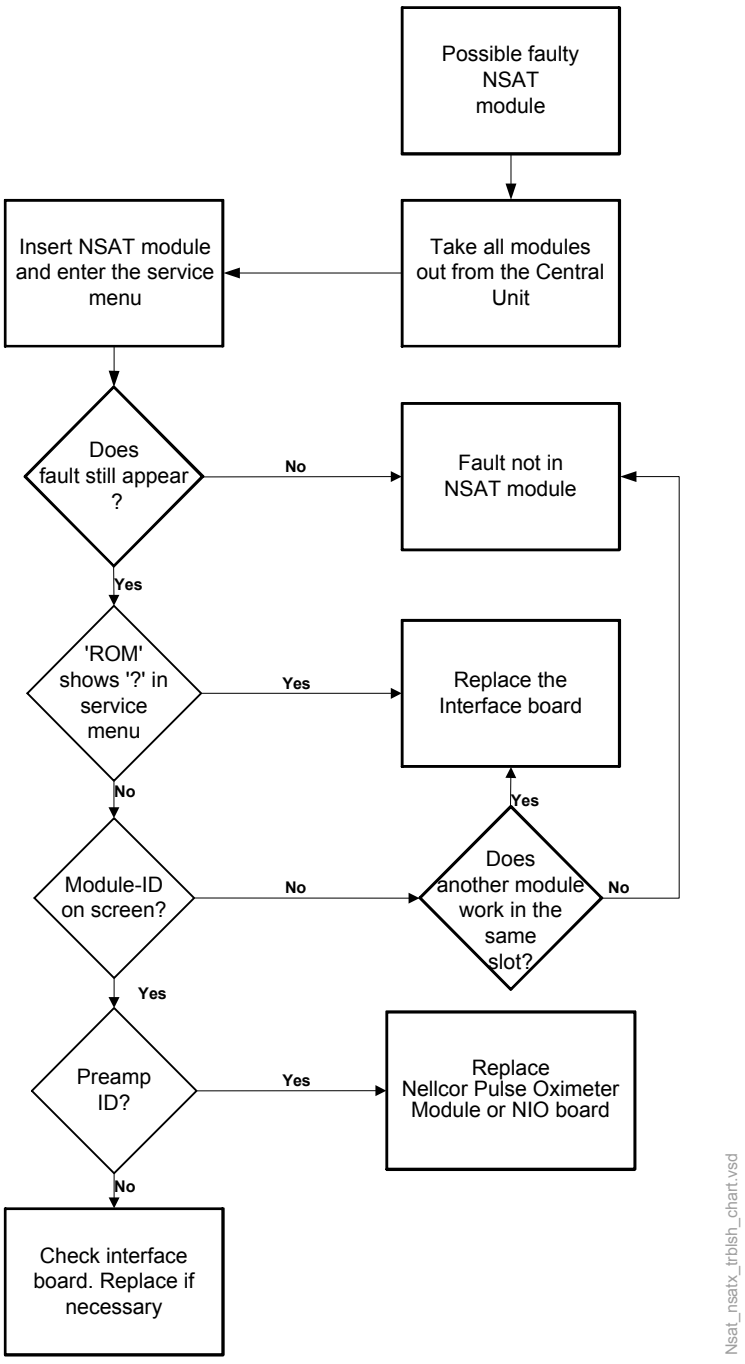


Figure 5 Module troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5 Nellcor Compatible Saturation Module, E-NSAT/E-NSATX.

APPENDIX A: Service check form, Nellcor Compatible Saturation Module, E-NSAT /E-NSATX (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	N.A.	Fail		OK	N.A.	Fail
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Functional inspection							
3. Installation	☐	☐	☐	4. Recognition	☐	☐	☐
5. Module software	NIO						
	Nellcor Prologue						
6. Communication and memories	☐	☐	☐	7. SpO2 probe status	☐	☐	☐
8. Error status	☐	☐	☐	9. SpO2 probe detection	☐	☐	☐
10. Test measurement	☐	☐	☐	11. Electrical safety check	☐	☐	☐
12. Functioning after electrical safety check	☐	☐	☐	13. Final cleaning	☐	☐	☐

Notes

Used spare parts			

Signature

Datex-Ohmeda

S/5 Single-width Airway Module, E-miniC (Rev. 00)

Technical Reference Manual Slot

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Document number M1027829-02

May 2, 2011

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Single-width Airway Module, E-miniC. The Single-width Airway Module is a single-width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual the module may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The Single-width Airway Module provides airway and respiratory measurements.

Letter C in the module name stands for CO_2.

NOTE: Do not use identical modules in the same monitor simultaneously. The E-CO, E-COV, E-COVX, E-CAiO, E-CAiOV, E-CAiOVX, E-CAiOVX/SERVICE, E-miniC, and M-C, M-CO, M-COV, M-COVX, M-CAiO, M-CAiOV, M-CAiOVX, M-CAiOVX/SERVICE and M-miniC are considered identical modules.

NOTE: The Single-width Airway Module or Compact Airway Module and Airway Module, G-XXXX, cannot be used simultaneously in the same monitor.

NOTE: E-miniC is intended for patients weighing over 5kg (11lb).

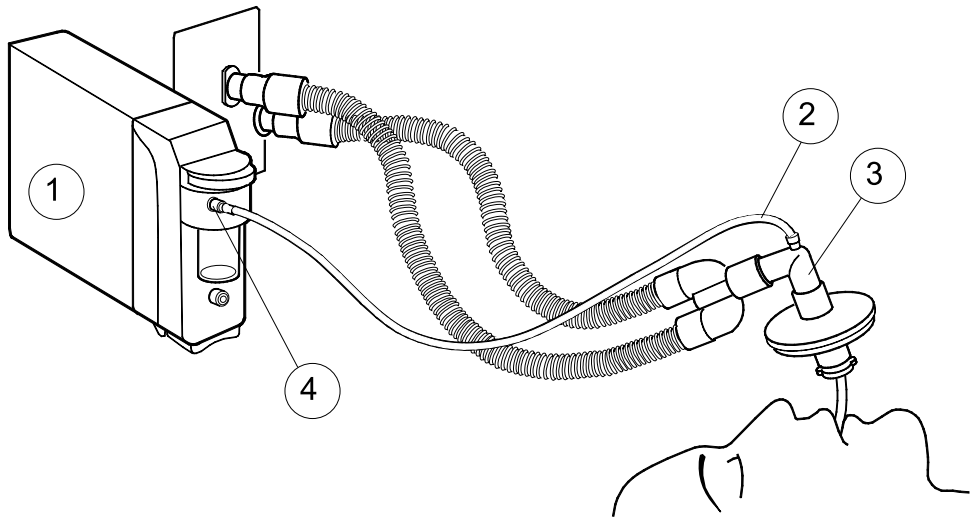


Figure 1 Airway gases setup with Compact Airway Module

1. Module for measuring airway gases
2. Anesthesia gas sampling line
3. Airway adapter with sampling line connector
4. Sampling line connector

Monitor software compatibility

The Single-width Airway Module, E-miniC, is designed for use with L-ANE02(A), L-ICU02(A), L-CANE02(A), L-CICU02(A) or later versions respectively.

Equipment safety symbols

- When displayed on the E-miniC module, indicates that airway gases should be calibrated every six months in normal use and every two months in continuous use.

1 Specifications

1.1 General specifications

E-MINIC

Module size, W × D× H	37 × 209 × 112 mm, 1.5 × 8.2 × 4.4 in
Module weight	0.4 kg/0.9 lb.

1.1.1 Environmental specifications

Operating temperature	+10 to +40 °C (+50 to 104 °F)
Storage temperature	-20 to +60 °C (-4 to +140 °F)
Atmospheric pressure	666 to 1060 hPa / (67 to 106 kPa) (500 to 800 mmHg) (666 to 1060 mbar)
Relative humidity	10 to 95% non-condensing (in airway 0 to 100%, condensing)
Protection against electrical shock	Type BF

1.1.2 Functional alarms

Functional alarms for

- Blocked sample line
- D-Fend replacement
- D-Fend check

1.2 CO_2 measurement

1.2.1 Typical performance

$EtCO_2$	End-tidal CO_2 concentration
$FiCO_2$	Inspired CO_2 concentration
Measurement range	0 to 20 vol% (0 to 20 kPa, 0 to 150 mmHg)
Accuracy	CO_2 concentration 0 to 15 vol% ±(0.2 vol% +2% of the reading) CO_2 concentration 15 to 20 vol% ±(0.7 vol% +2% of the reading)
Measurement rise time	< 300 ms with nominal flow

Adjustable low and high limits for $EtCO_2$ and $FiCO_2$.

1.2.2 Technical specifications

Airway humidity	0 to 100%, condensing
Sampling rate	150 ±25ml/min (sampling line 2 to 3 m, normal conditions)
Sampling delay	2.1 seconds typical with a 3-m sampling line
Total system response time	2.4 seconds typical with a 3-m sampling line, including sampling delay and rise time (typically 3.7 seconds with a 6-m sampling line).

Automatic compensation for barometric pressure, CO_2-NO_2 and CO_2-O_2 collision broadening effect compensation selectable from menu.

Warm-up time	1 min for operation with CO_2, 30 min for full specification
Zeroing interval	4, 15, 30 and 60 minutes after start-up, then every 60 minutes.

1.2.3 Normal conditions

Accuracy specifications apply in normal conditions (after 30 minutes warm-up period):

Ambient temperature	18 to 28 °C, within ±5°C of calibration
Ambient pressure	500 to 800mmHg, ±50mmHg of cal.
Ambient humidity	20 to 80% RH, ±20% RH of cal.

Automatic compensation for barometric pressure.

Non-disturbing gases are those with a maximum effect on the CO_2 reading <0.2 vol%. The effect is valid for specific concentrations shown in parentheses of the non-disturbing gas:

- Ethanol C_2H_5OH (<0.3%)
- Acetone (<0.1%)
- Methane CH_4 (0.2%)
- Nitrogen N_2
- Water vapor
- Dichlorofluromethane (<1%)
- Tetrafluoroethane (<1%)

Disturbing gases and their effect on the CO_2 reading at 5.0 vol% CO_2 are shown below. Errors listed reflect the effect of specific concentrations (shown in parentheses) of an individual disturbing gas and should be combined when estimating the effect of gas mixtures:

- Halotane (4%) increases < 0.3 vol%
- Isoflurane (5%) increases < 0.4 vol%
- Enflurane (5%) increases < 0.4 vol%
- Desflurane (24%) increases < 1.2 vol%
- Sevoflurane (6%) increases < 0.4 vol%
- Helium (50%) decreases < 0.3 vol%
- If O_2 compensation is not activated: O_2 (40 ... 95%) decreases < 0.3 vol%
- If O_2 compensation is activated: O_2 (40 ... 95%) error < 0.15 vol%
- If N_2O compensation is not activated: N_2O (40%) increases < 0.4 vol%
- N_2O (40 to 80%) increases < 0.8 vol%
- If N_2O compensation is activated: N_2O (40 to 80%) error < 0.3 vol%

1.2.4 Conditions exceeding normal

Accuracy specifications under the following conditions ❶❷❸:

❶ Ambient temperature	10 to 40 °C, within ±5 °C of calibration
Ambient pressure	500 to 800 mmHg, ±50 mmHg of calibration
Ambient humidity	10 to 98% RH, ±20% RH of calibration

❷ During warm-up 1 to 10 minutes, under normal conditions

❸ During warm-up 10 to 30 minutes, under normal conditions

	Accuracy under different conditions (see above)	
	Conditions ❶ and ❸	Condition ❷
CO_2 (0 to 15 vol%)	±(0.3 vol% + 4% of reading) (at 5 vol% error ±0.5 vol%)	±(0.4 vol% + 7% of reading) (at 5 vol% error ±0.75 vol%)
CO_2 (15 to 20 vol%)	±(0.8 vol% + 4% of reading) (at 5 vol% error ±0.5 vol%)	±(0.9 vol% + 7% of reading) (at 5 vol% error ±0.75 vol%)

1.3 Respiration Rate (RR)

Measurement range	4 to 80 breaths /min
Breath detection	1% change in CO_2 level
Accuracy	±1/min in the range 4 to 20 l/min
	±5% in the range 20 to 80 l/min
Resolution	1/min

Adjustable low and high limits for respiration rate; alarm for apnea.

2 Functional description

2.1 Measurement principle

2.1.1 CO_2 measurement

MiniC is a side stream gas analyzer, measuring real time concentrations of CO_2. It is a non dispersive infrared analyzer, measuring absorption of the gas sample using an optical narrow band filter.

The infrared radiation detector is thermopile.

Concentration of CO_2 is calculated from absorption measured at 4.2 to 4.3 μm.

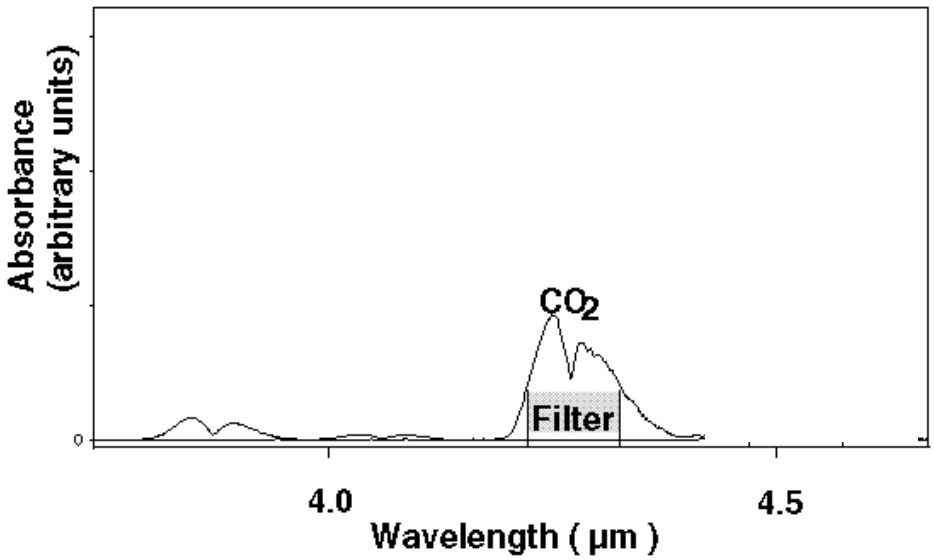


Figure 1 Absorbance of CO_2

2.2 Main components

- Gas sampling system
- MiniC measuring unit
- CPU board

2.2.1 Gas sampling system

The sampling system draws a gas sample to the analyzer at a fixed rate.

The gas sampling system samples the measured air to the module, and removes water and impurities from it. A sampling line is connected to the water trap. The pump draws gas through the sampling line to the gas measuring unit. After the measurement, the gas is exhausted from the sample gas out connector.

The sample flow is nominally 150 ml/min.

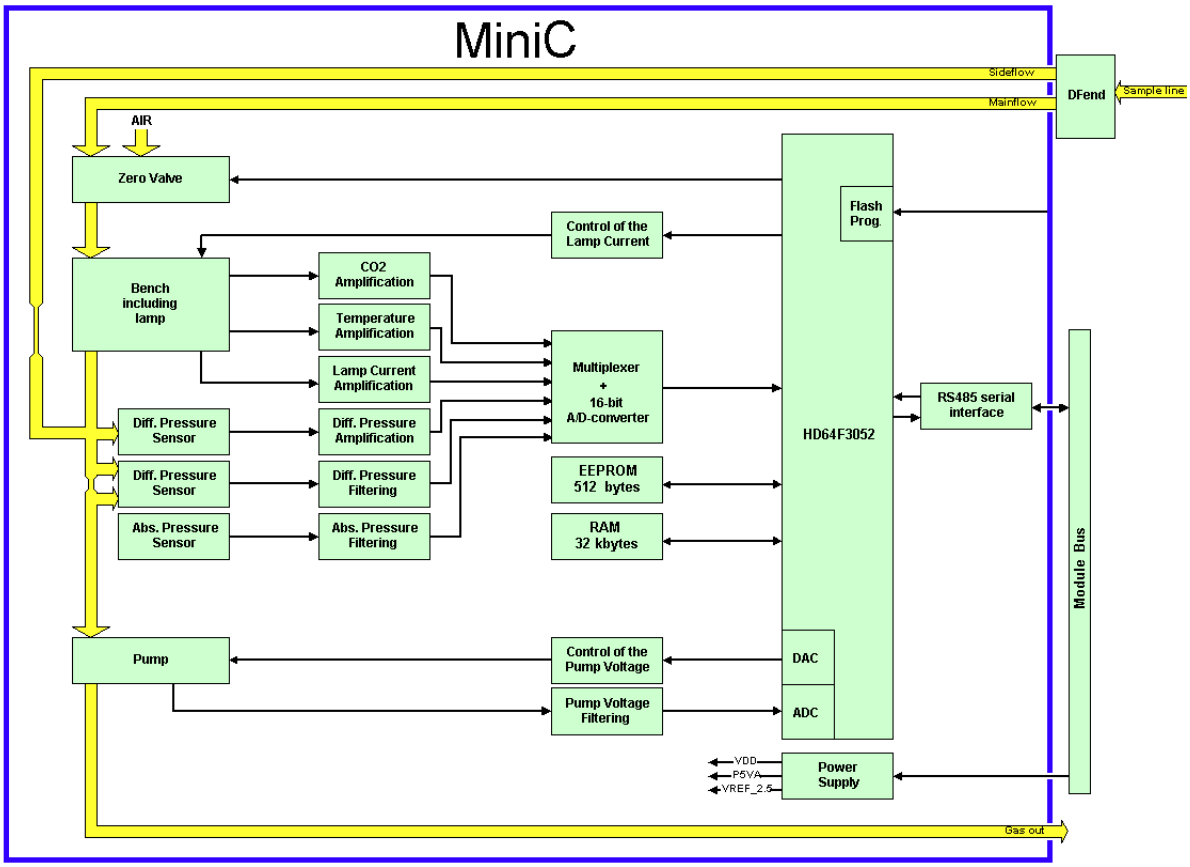


Figure 2 MiniC block diagram

Mini D-fend™

The sample is drawn through the sampling line. The gas then enters the module through the water trap, where it is divided into two flows, a main flow and a side flow. The main flow goes into the analyzer. This flow is separated from the patient side by a hydrophobic filter. The side flow creates a slight subatmospheric pressure within the Mini D-fend water trap which causes fluid removed by the hydrophobic filter to collect in the bottle.

Zero valve

The main flow passes through a magnetic valve before proceeding to the analyzer. This valve is activated to establish the zero point for the MiniC measuring unit. When the valve is activated, room air is drawn through a filter into the internal system and the gas sensor.

Nafion™ tube [1)]

A Nafion tube is used between the water trap and the zero valve to balance the sample gas humidity with that of ambient air. The tube prevents errors caused by the effect of water vapor on gas partial pressure when humid gases are measured after calibration with dry gases.

Gas analyzers

After the zero valve and Nafion tube, the gas passes through the miniC measuring unit.

Sample flow differential pressure transducer

The sample flow differential pressure transducer measures pressure drop across a restrictor and calculates the sample flow from the pressure difference.

Working pressure transducer

The working pressure transducer measures differential pressure between the tubing and ambient air near the miniC measuring unit.

Atmospheric pressure transducer

The atmospheric pressure transducer measures real-time atmospheric pressure. The following messages are based on the obtained pressure values: ‘sample line blocked’, ‘check D-fend’, ‘replace D-fend’ and ‘check sample gas outlet’.

Sampling pump and damping chamber

The gas sampling pump is a membrane pump run by a DC-motor. Sample flow is measured with a differential pressure transducer across a known restriction. The motor is automatically controlled to maintain a constant flow even when the D-fend water trap ages and starts to get occluded. It also enables the use of sample tubes with varying lengths and diameters.

NOTE: In no occasion is the flow reversed towards the patient.

1. [1)] Nafion is a trademark of Perma Pure Inc.

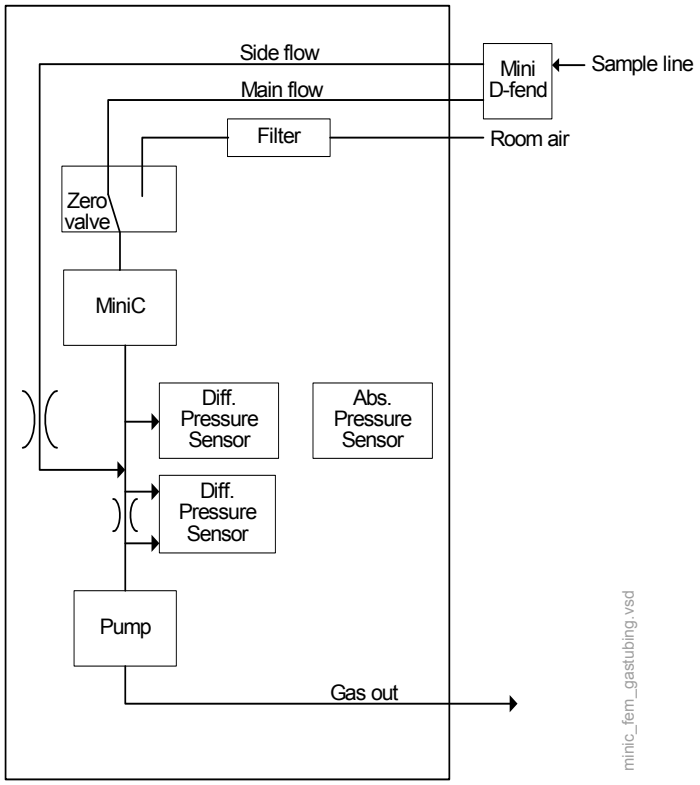


Figure 3 Gas tubing layout

2.2.2 MiniC measuring unit

The miniC measuring unit is a non-dispersive infrared analyzer measuring absorption of the gas sample at 4.2 to 4.3 μm infrared wavelength, which is selected using an optical narrow band filter. The IR lamp is a filament surrounded by thermal isolation. There is a hole in the isolation, passing the radiation to a conical measuring chamber with 3 mm length. From the sample chamber, the radiation goes into a thermopile detector with an optical filter in front of it.

The temperature sensor measures the miniC measuring unit's temperature and it is used for temperature compensation.

The miniC measuring unit includes a miniC flexible board, which connects the thermopile signal and the temperature sensor signal to the CPU board.

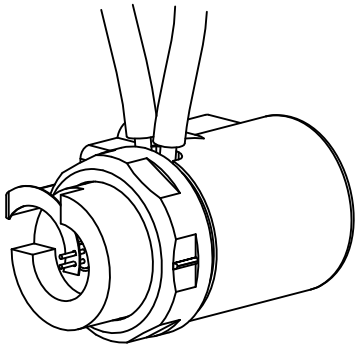


Figure 4 MiniC measuring unit

2.2.3 CPU board

The CPU board contains a processor, memories and all the analog signal processing needed. A MiniC measuring unit is attached to the board with a flexible PCB. Also supply voltage and an RS485 serial channel are connected to the CPU board using another flexible PCB.

Analog signals (CO_2, temperature, absolute and differential pressures and lamp current signals) are fed to the 16-bit A/D converter. The processor controls the A/D converter and calculates the CO_2 percentage and respiration rate from this data.

The processor controls sample flow by adjusting the pump voltage based on the differential pressure signal. The processor also controls the current of the IR source and keeps it constant.

Calibration data is stored on the EEPROM.

3 Service procedures

3.1 General service information

The field service of the E-miniC module is limited to replacing parts that are available as spare parts. For available spare parts, refer to the "E-Modules Spare Parts" slot.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

CAUTION The module electronics can only be repaired and calibrated at the factory.

3.1.1 MiniC measuring unit

WARNING **The miniC measuring unit and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit. The information provided is for reference only.**

Serviceable parts

- Mini D-fend
- Mini D-fend O-rings
- Nafion tube
- Air filter
- Pump

NOTE: After any component replacement, see chapter "Adjustments and calibrations".

Calibration interval six months. Preventive maintenance once a year including the change of Nafion tube and the O-rings of water separator, pump check and calibration, leak test and absolute pressure sensor check.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Required tools

NOTE: Use only calibrated and traceable measuring equipment.

– A barometer

- A mass flowmeter for measuring air flow, minimum measurement range 100-300ml/min, accuracy 5% or better in the 100-300ml/min range.
- P/N: 755534-HEL Calibration Gas Regulator
- P/N M1006864 Calibration Gas Regulator, (US only)
- P/N: 755580 Calibration gas 5% CO2 and air, package of 4 cans
- P/N 755587 QUICK CAL calibration gas, (US only)
- 3 m / 10 ft gas sampling line
- A pressure manometer with either an integrated or a separate pressure pump

3.2.2 Required parts

Replace the following parts that wear in use at the recommended interval.

Part number	Description	Pieces	Replacement interval
733382-HEL	Nafion Tube	1	Once a year
656565	Mini D-fend™ O-ring	2	Once a year
M1011471	Zero valve air filter	1	Once every 3 years

It is also recommended to replace the Mini D-fend water trap and the gas sampling line as part of the planned maintenance procedure.

NOTE: See the supplies and accessories document delivered with the manual for compatible accessories.

3.2.3 Inspection

General

1. Check internal parts
   - all screws are tightened properly
   - all cables are connected properly
   - tubes are not pinched and there are no sharp bends on them
   - all tubes are connected properly
   - there are no loose objects inside the module

2. Check external parts
   - the front cover and the front panel stickers are intact
   - the Mini D-fend latch is moving properly
   - all connectors are intact and attached properly

Reattach the module and check that the locking system moves properly.

3. Check Mini D-Fend

   Detach the Mini D-fend. Check the condition of the rubber O-rings on the metal Mini D-fend connectors, located in the module front cover.

   If necessary, detach the connectors by first disconnecting the tubes, then removing the locking rings from the back of the front cover.

   Replace the Mini D-fend and sampling line with new ones.

NOTE: Use only Datex-Ohmeda sampling lines in order to ensure proper functioning.

   Turn on the monitor.

   Configure the monitor screen so that the CO_2 curve is shown, for example as follows:

   Monitor Setup - ***Screen 1 Setup - Waveform fields -***
   Field 6 - CO2
   Digit Fields
   Lower Field 1 - Gases

4. Module software

   Wait until the message 'Calibrating gas sensor' disappears from the screen, then enter the service menu.

   Monitor Setup - ***Install/Service*** (password 16-4-34) **-** ***Service*** (password 26-23-8).

   Write down the information regarding the Module software.

   If one of the values is increasing faster, it indicates a failure in module bus communication.

5. Flow measurement offset

   Enter the service menu ***Gases***:

   Gas Unit - Gases

   Check that the flow measurement offset, i.e. the shown sample Zero value is within ±10 ml/min.

6. Ambient pressure

   Check that the shown Ambient value corresponds with the current ambient pressure (±20 mmHg).

7. Zero valve check

   Feed calibration gas and check that the gas readings in the service menu correspond with the values on the gas bottle sticker. Keep feeding gas, then activate the zero valve from the menu. The CO_2 reading should drop back to near 0%.

8. Nafion tube

   Replace the Nafion tube, if necessary.

NOTE: The Nafion tube should be replaced annually.

9. Gas sampling system leak test

   Check the gas sampling system for possible leakages.

   a. Disconnect the module from the monitor.
   b. Connect a new Mini D-fend water trap to the module.
   c. Connect a new gas sampling line to the sampling line connector in the water trap.
   d. Connect the other end of the gas sampling line to a pressure manometer and a pressure pump.
   e. Block the "Sample Gas Out" connector.
   f. Pump 100 mmHg ± 20 mmHg pressure to the gas sampling system. Let the pressure stabilize for approximately 10 seconds.
   g. Check that the pressure reading does not drop more than 6 mmHg during 1 minute.

NOTE: The gas module shall be disconnected from the monitor during the leak test.

10. Check the flow rates

    Wait until the Sample Flow value returns close to 150 ml/min.

    Connect a flow meter to the 3 meter sampling line and check that the flow (the flow meter reading) is within the following range:

    Sampling flow (ml/min) 150 ± 25 ml/min

    If necessary, readjust the sampling flow:

    Select ***Sample gain adj*** from the menu.

    To increase the sampling flow, turn the ComWheel counterclockwise. To decrease the flow, turn the ComWheel clockwise.

    A change of 0.050 in the Gain value changes the flow approximately 7.5 ml/min.

    After you have changed the gain, wait until the Sample Flow value on the screen returns near to the original, then check the flow meter reading again.

11. Working pressure

    Check that the Amb-Work value in the service menu is within the following range:

    Amb-Work (mmHg) 20...50

12. Gas calibration

    Airway Gas - ***Gas Calibration***

NOTE: The calibration should not be performed before 30 minutes warm-up time.
Use calibration gas 755580 (5% CO_2, about 20% O_2) for calibrating the E-miniC.

13. Occlusion detection

    Block the tip of the sampling line with your finger and check that the message 'Sample line blocked' appears on the monitor screen within 60 seconds.

14. Check D-fend

    Detach the mini D-fend and check that the message 'Check D-fend' appears on the monitor screen within 30 seconds.

15. Apnea detection

    Reattach the mini D-fend. Simulate at least 5 breaths by feeding calibration gas into the sampling line. Check that the shown gas information is correct.

    Check that the monitor shows the message 'Apnea' within 30 seconds after you have stopped feeding the gas.

16. Final cleaning

    Turn off the monitor, disconnect and clean the module.

- Fill in all necessary documents.

3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed

- torx screwdrivers; T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.4 To disassemble the module

To disassemble the airway module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

3.4.1 Pump unit

1. Remove the module cover.
2. Remove the mask.
3. Unplug the hose of the pump.
4. Disconnect the pump's cable from the CPU board.
5. Remove the three screws that connect the pump unit to the board.

To reassemble the module, reverse the order of the disassembly steps.

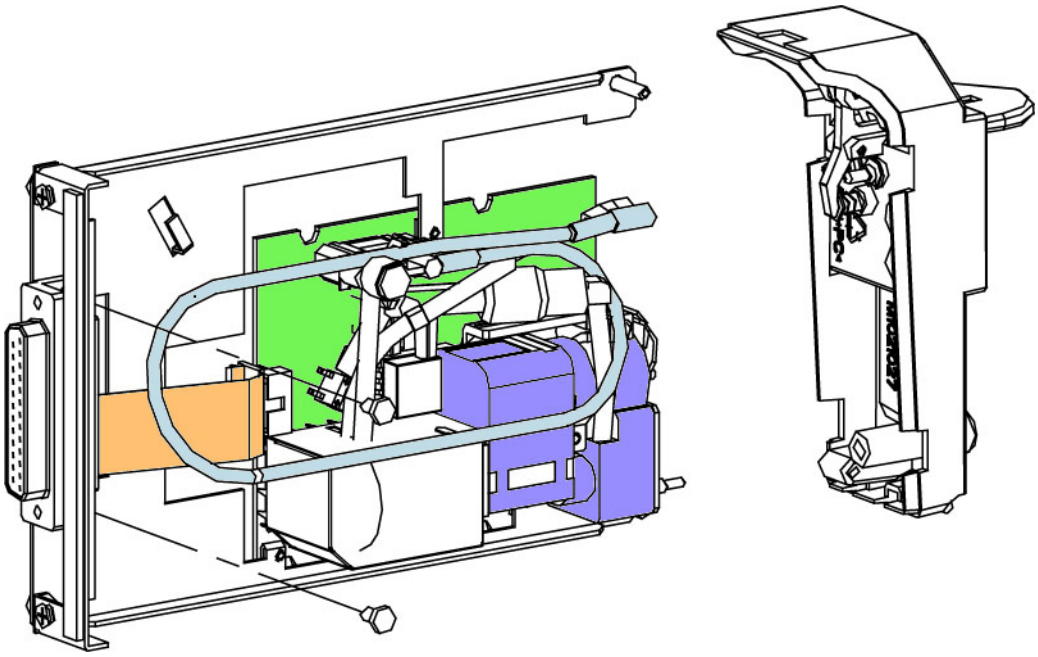


Figure 5 Uncovered E-miniC module

3.4.2 MiniCO$_2$ assy

1. Remove the module cover.
2. Unplug two tubes from the back of the mask.
3. Remove the mask.
4. Detach the miniCO$_2$ assy from the frame plate by removing the three screws.
5. Disconnect the FM board from the miniCO$_2$ assy.

To reassemble the module, reverse the order of the disassembly steps.

3.4.3 Instructions after replacing MiniCO$_2$ assy

After replacing the MiniCO$_2$ assy:

- perform the sampling system leak test
- perform the occlusion test
- perform the gas calibration

3.5 Adjustments and calibrations

3.5.1 Calibrating

Required tools

– P/N: 755534-HEL Calibration Gas Regulator
– P/N M1006864 Calibration Gas Regulator, (US only)
– P/N: 755580 Calibration gas 5% CO2 and air, package of 4 cans
– 3 m / 10 ft Gas sampling line
– P/N 755587 QUICK CAL calibration gas, (US only)
–

NOTE: See the supplies and accessories document delivered with the manual for compatible accessories.

NOTE: Use only the specified GE Healthcare calibration gas for the gas calibration to ensure measurement accuracy. Do not use any other calibration gases. Check the calibration gas container's labelling to ensure that the calibration gas has not expired.

NOTE: Ensure that the gas regulator is functioning properly before gas calibration. Refer to the gas regulator's "Instructions for Use" letter for the annual maintenance instructions.

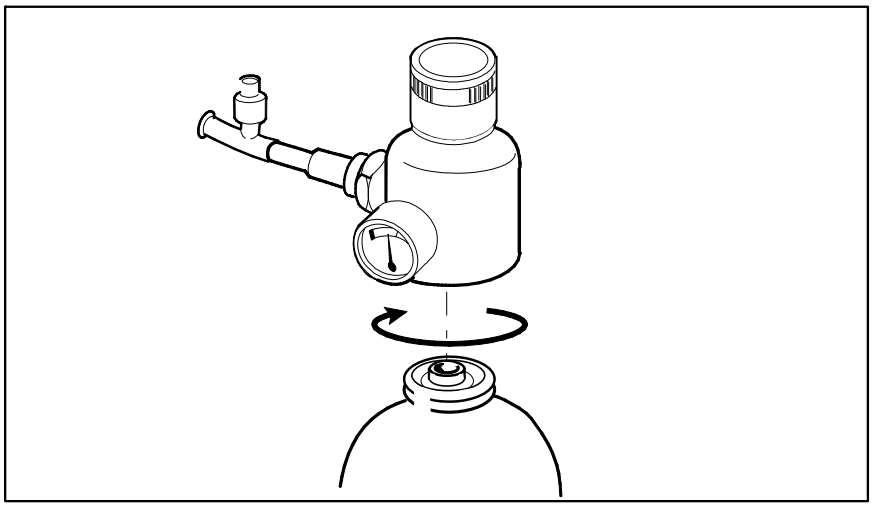


Figure 6 Attaching regulator to the calibration can

1. Attach the regulator to the gas container.
2. Attach a new sampling line to the water trap. Connect the loose end of the sampling line to the regulator on the gas container.

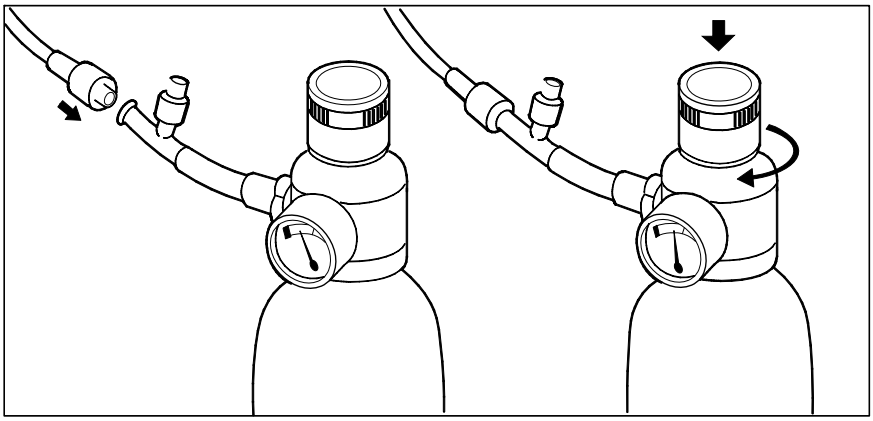


Figure 7 Connecting sampling line to the gas valve and feeding gas

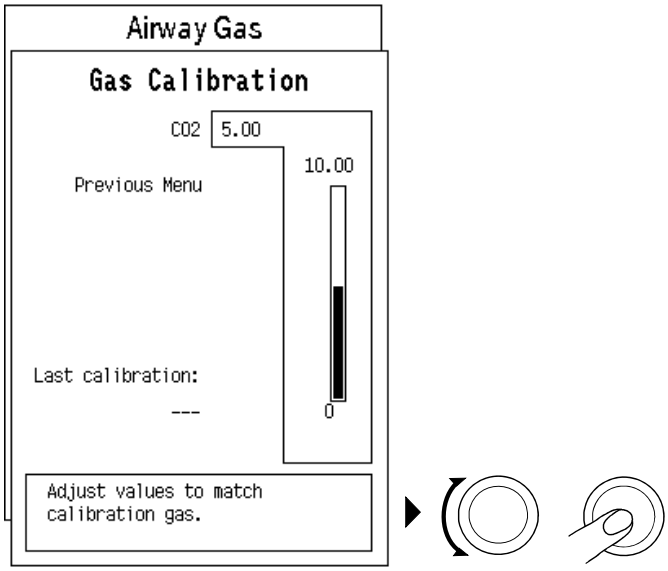
3. Turn on the power. For maximum accuracy, let the monitor warm up for 30 minutes. The menu item ***Gas calibration*** remains gray as long as the message 'Calibrating gas sensor' is displayed.
4. Press the **Airway Gas** key and select ***Gas calibration***.
5. Wait until the 'Zero ok' and then the 'Feed gas' messages appear after each gas on the screen.
6. Open the regulator and feed calibration gas until the message 'Adjust' appears, then close the valve. If you use an older brass regulator, the feeding pressure should be adjusted between 5 and 7 psi.
7. Check that the displayed gas value matches the value on the calibration gas container.

NOTE: When calibrating the E-miniC module, set the O_2 level according to the gas, for example with 755580, set the FiO_2 level in the CO2 setup menu to 21-40% and the ***AIRWAY GAS - CO2 SETUP*** O_2 level to 20%. Adjust the O_2 percentage according to the calibration gas (for 755580 the right O2 value is 20%).

NOTE: If an error occurs during calibration or if no gas is fed, the highlighting goes automatically over the item ***Recalibrate*** and the text 'Calibr. error' appears. Push the ComWheel to perform a new calibration.

If adjustments are required:

- Turn the ComWheel to highlight the first gas to be adjusted and then push the ComWheel.
- Turn the ComWheel until the displayed value matches the desired value in the gas bottle and push it again.



If the message 'Zero error' is displayed, press the **Normal Screen** key and repeat the calibration procedure.

The time of the last calibration is shown at the bottom of the menu page.

3.5.2 Gas sampling system adjustment

For flow rate measurements, a flow meter with a low flow resistance and the capability to measure low flow rates is required. A sampling line of normal length has to be connected to the monitor as it has a considerable effect on the flow.

3.5.3 Flow rate measurement

If any flow rates are not correct, first replace the Mini D-Fend water trap, then recheck the flows.

The sampling flow rate is measured by a flow meter at the sampling line. The flow rate should be 150 ± 25 ml/min. The flow rate is adjusted in the ***Gases*** service menu with ***Sample gain adj***.

3.5.4 Flow rate adjustment

NOTE: Before adjusting the sampling flow, make sure there is no leakage in the sampling system.

Refer to chapter *3.2 Service check,* step 12. Gas calibration.

Wait until the Sample Flow value is back to near 150 ml/min.

Connect a flow meter to the 3 meter sampling line and check that the flow (the flow meter reading) is within the following range:

Sampling flow (ml/min) 150 ± 25 ml/min

If necessary, readjust the sampling flow:

Select ***Sample gain adj*** from the menu.

To increase the sampling flow, turn the ComWheel counterclockwise.

To decrease the flow, turn the ComWheel clockwise.

A change of 0.050 in the Gain value changes the flow approximately 7.5 ml/min.

After you have changed the gain, wait until the Sample Flow value on the screen returns near to the original, then check the flow meter reading again.

3.5.5 Gas calibration

Gas calibration is performed in the ***Airway Gas*** menu.

Calibration gas regulator flow check

Interval: every 12 months

Regulator flow specification:

REF 755533 & 755534: 260 – 410 ml/min at 1-10 bar cylinder pressure
REF 755530: 260 – 410ml/min at 5-7psi cylinder pressure

Tools needed: calibration gas can, regulator, piece of silicon hose and flow meter. Datex-Ohmeda recommends use of TSI 4140 Flow Meter.

Insert the calibration gas regulator on the gas cylinder. Connect a silicon hose between the regulator and the flow meter. Block the regulator overflow port and open the regulator. Check the flow rate from the flow meter and verify that the flow is within the specification.

4 Troubleshooting

4.1 Troubleshooting chart for CO_2 measurement

Problem	Cause/What to do
No response to breathing	Sampling line or water trap blocked or loose, or improperly attached. Water trap container full. See the gas sampling system troubleshooting.
'SENSOR INOP.' message	The temperature is too low or high, check the temperature in the service menu. Supply voltage is too low or high, IR source current or voltage is too low or high, check current in the service menu. Pump is not working properly, check sample flow and pump voltage in the service menu. Ambient pressure too low or high, check the ambient pressure in the service menu. Zero valve not working properly, check the functionality by switching zero valve on and off in the service menu.
'ZEROING ERROR' message	Gas zeroing failed. Condensation or residual gases are affecting the zero measurement. Allow the module to run drawing room air for half an hour and calibrate again.
'CHECK D-FEND' message	Amb – Work pressure difference too small. Probably water trap or the sampling line is not attached properly. Gas zero valve failure. Pump failure or gas outlet blockage.
'REPLACE D-FEND' message	Amb – Work pressure difference too big. Indicates residue build-up on the water trap membrane. This decreases air flow. Replace the D-fend.
'SAMPLE LINE BLOCKED' message	Amb – Work pressure difference too big. Sampling line or water trap is occluded. Water trap container is full. If occlusion persists, check internal tubing for blockages.
No response to any gas	Check Sample Gas Out. Amb - Work pressure low, flow too small and pump voltage too high. Sampling line, water trap, or internal tubing is blocked or loose, or improperly attached. Gas out connector or tubing is blocked. Zero valve malfunction. Pump failure or pump is worn. Supply voltage missing. Serial communication error.
Sudden increase in gas display	Water trap malfunction. Check all internal tubing and the interior of the water trap for occlusions or leaks. Replace water trap. Check flow rates.
Abnormally high (or abnormally low) response to CO_2 or sudden occlusion warning	Pressure transducer failure. Check the Ambient and Amb – Work pressures in ***Gases*** service menu.
Strong drift in all gases	Leak in sampling line or internal tubing (especially in conjunction with too low readings).

4.1.1 CO_2 measurement

Problem	Cause	What to do
Action too low $ETCO_2$ value	• sudden decrease in circulation • pulmonary embolism • hyperventilation • very large dead-space • large shunting • leak in sampling system • calibration error • high by-pass flow from ventilator	• check all connections • check calibration
too high $ETCO_2$	• hypoventilation • increased metabolism • D-fend contaminated • calibration error	• change D-fend • check calibration
waveform clipped	• incorrect scaling	• change scale
no response to breathing	• apnea • (disconnection) • sampling line or water trap loose or blocked (air leak)	• check all connections
	• sample gas outlet blocked	• check that outlet is open
$ETCO_2$ over scale >20% Shown until 32%, specified range 0 to 20%	• abnormally high $ETCO_2$ (permissive hypercapnia) • CO_2 sensor contaminated • D-fend malfunction	• let the module run without a sampling line until the CO_2 sensor has dried out • change D-fend
$ETCO_2$>$PaCO_2$	• unit is mmHg or kPa and $ETCO_2$ is close to arterial PCO_2 • “dry gas” as default	• change to “wet gas” by using install/service menu

4.2 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or blockages in the tubing, failure of the sampling pump or the magnetic valves, or diminishing of the flow rates because of dirt accumulating in the internal tubing.

The following checks should help in localizing the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system, check and if necessary adjust the flow rate.

CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

NOTE: D-fend water trap should be replaced, when the 'REPLACE D-FEND' message appears during the monitor startup.

NOTE: If any liquid has entered the miniC measuring unit due to water trap filter failure, leave the module running without a sampling line for several hours and check the functions after it has dried out.

4.2.1 Sampling system leak test

1. Connect a flow cassette with a high flow resistance value (50/1.1) to the end of the sampling line and start following the 'Amb-Work' value in the service menu. When the value exceeds 130 mmHg, connect the other port of the flow cassette to the sample gas out connector and switch off the pump.
2. Wait until the pressure inside the sampling system is stabilized, then observe the shown Amb-Work value. The value, i.e. the pressure inside the sampling system, should not drop more than 6 mmHg in 20 seconds.
3. If the pressure drops more, first ensure the connections you have made and repeat the test.

4.3 MiniC unit troubleshooting

CAUTION The miniC measuring sensor can only be repaired and calibrated at the factory. In case of failure, the complete miniC unit should be sent to Datex-Ohmeda for factory exchange.

4.4 Error messages

Message	Explanation
Occlusion or Sample Line Blocked	The sample tube inside or outside the monitor is blocked or water trap is occluded. If occlusion persists, measured gas values disappear.
Continuous occlusion. Check sample line and D-fend.	Occlusion over 40 seconds.
Check D-fend	- The water trap is not connected - There is a leak in the sampling line inside the module. If air leak persists, measured gas values disappear. Check sample gas out.
(Air leak detected.) Check water trap and sample gas out-flow. Press normal screen to continue.	Air leak over 40 seconds.
Replace D-fend (replace water trap)	Indicates residue build-up on the water trap membrane. This decreases air flow.
Gas calibration is not available during first 5 minutes/during occlusion/during air leak	Entering calibration is not allowed during 5 minutes after power up and during occlusion or air leak.

Message	**Explanation**
Gas out blocked	- Gas out connector on the front panel, or the exhaust line connected to it, is blocked. - If the sample gas is returned to the patient circuit, the filter in the return kit may be occluded. - Make sure the sample gas outlet is connected to an open scavenging system only where gas is removed in room pressure.
Recalibration	Time out, fluctuating gases, gain adjusted "over".
Zero error	Unsuccessful zeroing.
Unstable, Calibr error	Unsuccessful calibration.
Menu messages during calibration:	
Zero error	Unsuccessful zeroing.
Adjust	Calibration gas accepted and monitor is ready for adjusting the gas values to match the calibration gas concentration.
Unstable	Unsuccessful calibration.

5 Earlier revisions

There are no earlier revisions of S/5 Single-width Airway Module E-miniC.

APPENDIX A: Service check form, Single-width Airway Module E-miniC (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

General	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Check internal parts	☐	☐	☐	2. Check external parts	☐	☐	☐
Notes							
CO_2 measurement							
3. Check Mini D-Fend	☐	☐	☐				
4. Module software	GAS						
5. Flow measurement offset					±10 ml/min		
6. Ambient pressure	☐	☐	☐	7. Zero valve check	☐	☐	☐
8. Nafion tube	☐	☐	☐				
9. Gas sampling system leak test					≤6 mmHg/20 sec.		
10. Check the flow rates							
Sampling flow					150 ± 25 ml/min		
11. Working pressure							
Amb-Work					20...50 mmHg		

General	OK	N.A.	Fail		OK	N.A.	Fail
12. Gas calibration	☐	☐	☐	13. Occlusion detection	☐	☐	☐
14. Check D-fend	☐	☐	☐	15. Apnea detection	☐	☐	☐
Notes							

General	OK	N.A.	Fail		OK	N.A.	Fail
16. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

Signature

Datex-Ohmeda

S/5™ Tonometry Module, E-TONO (Rev. 00)

Technical Reference Manual

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027830-1
November, 2005

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Tonometry Module, E-TONO. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The S/5 Tonometry Module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. The module provides gastric tonometry measurement, i.e. it measures the gastrointestinal CO_2 concentration, $PgCO_2$.

The Tonometry Module contains the CO_2 gas concentration sensor and a gas sampling system to move gas between the patient’s gastrointestinal tract and the sensors. The patient is connected to the module with a Tonometrics™ Catheter, which is inserted into the gastrointestinal tract.

A sample is taken at regular intervals to determine the CO_2 concentration of the gas.

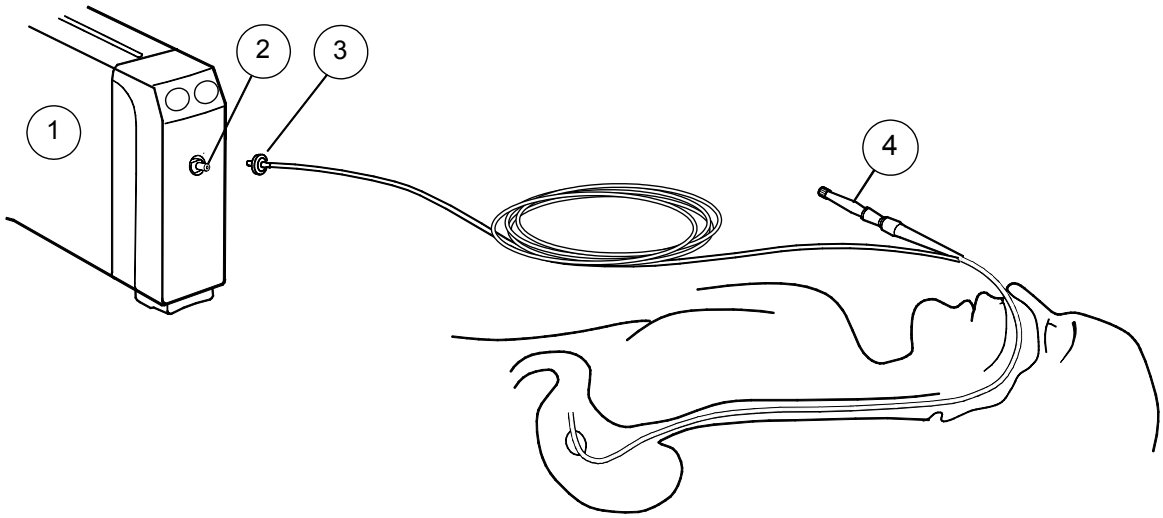


Figure 1 Patient connections

(1) Tonometry Module, E-TONO
(2) Catheter connector
(3) Biofilter
(4) Tonometrics catheter

Monitor software compatibility

The S/5 Tonometry Module, E-TONO, functions only with monitor software of level 99 or later.

Equipment safety symbols

- When displayed on the E-TONO module, indicates that the module should be used only with Tonometrics catheters.

1 Specifications

1.1 General specifications

Module size, W × D × H	37 × 193 × 112 mm, 1.5 × 7.6 × 4.4 in
Module weight	0.55 kg / 1.2 lbs.
Operating temperature	+10...+40 °C
Storage temperature	-25...+70 °C
Atmospheric pressure	666...1060 hPa (67...106 kPa/500...800 mmHg/666...1060 mbar)
Humidity	10...90% RH non-condensing
Power consumption	0.7 W Prms, 9.0 W momentary
Protection against electrical shock	type BF (IEC-60601-1) defibrillator-proof protection against electric shock

1.2 Parameter specifications

Measurement interval is 10 minutes.

1.2.1 $PgCO_2$

Measurement range	0...30 kPa (0...228 mmHg)
Accuracy[1]	
in range 0...15 kPa (0...113 mmHg)	±(0.5 kPa +5% of reading) ±(4 mmHg +5% of reading)
in range 15...30 kPa (113...228 mmHg)	±(1.5 kPa ±15% of reading) ±(12 mmHg ±15% of reading)

NOTE: Accuracy specifications apply in normal conditions:

- Measurement is done at least 30 minutes after catheter initialization
- Calibration has been checked within 2 weeks.
- Ambient temperature: 10...40 °C, within ±5 °C of calibration
- Ambient pressure: 500...800 mmHg, ±50 mmHg of calibration
- Ambient humidity: 10...90% RH, ±20% RH of calibration

1. These specifications only apply when TONO-8F, TONO-14F, TONO-16F, TONO-18F catheters with 13 mm biofilter are used.

2 Functional description

2.1 Measurement principle

2.1.1 CO_2 measurement

The CO_2 sensor measurement is based on the infrared (IR) absorption technique. CO_2 molecules absorb IR-light that has a certain wave length (4.26 µm). This wavelength is selected from the incoming IR-light with a special optical bandpass filter. The IR-light passed through the measurement chamber and the filter, and the signal is then detected with a thermopile.

The calculation of CO_2 concentration needs also the determination of the signal level, when there is no CO_2 in the measured gas. This procedure is the zeroing of the sensor. The zeroing is done with room air and it is always performed before measuring the sample gas.

The CO_2 and zeroing gas measurements are performed by pulsing the IR-lamp 3 times (lamp is on for 2 seconds and off for 2 seconds) and by measuring the thermopile signal during pulsing. The CO_2 concentration is defined then from these signals. In the definition of CO_2 partial pressure ($PgCO_2$), the influence of sensor temperature, measurement pressure, catheter pressure, gas mixing in tubings and the drop in water vapor pressure on the measurement result are compensated.

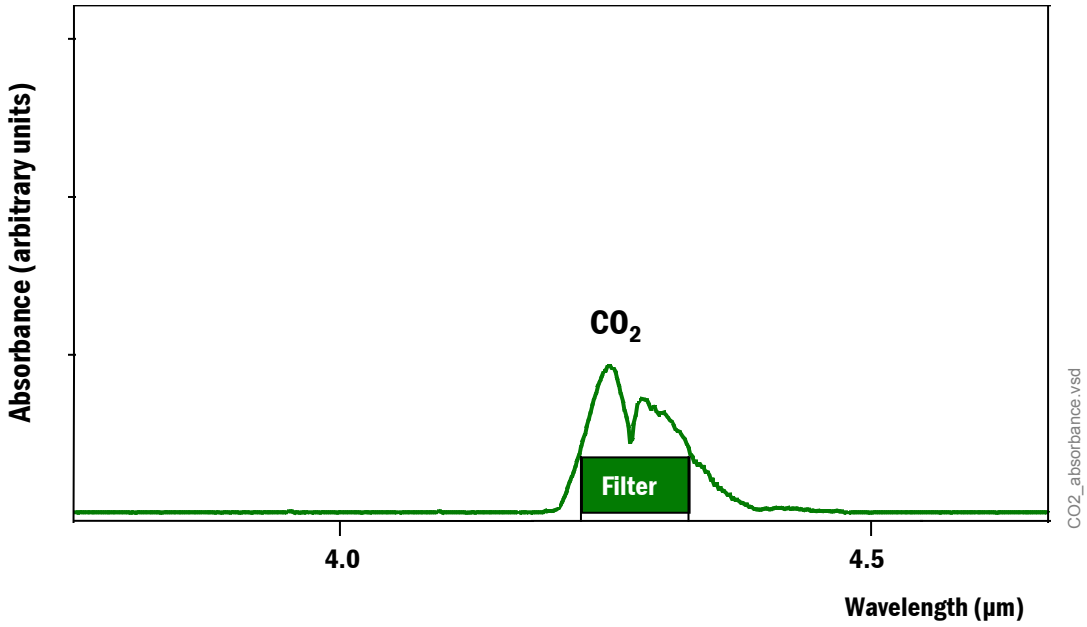
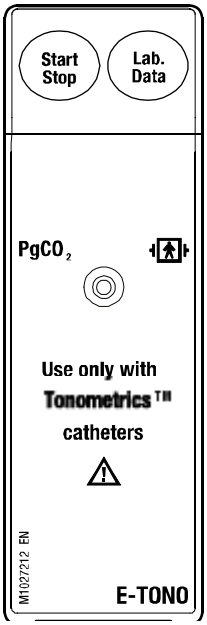


Figure 2 Absorbance of CO_2

2.2 Main components



Start Stop Starts/Stops the $PgCO_2$ measurement cycle.

Lab. Data Takes you to Lab Data menu to enter the blood gas values.

Figure 3 Front panel of Tonometry Module, E-TONO

The tonometry module consists of:

- gas sampling system
- CO_2 measuring unit
- CPU board.

2.2.1 Gas sampling system

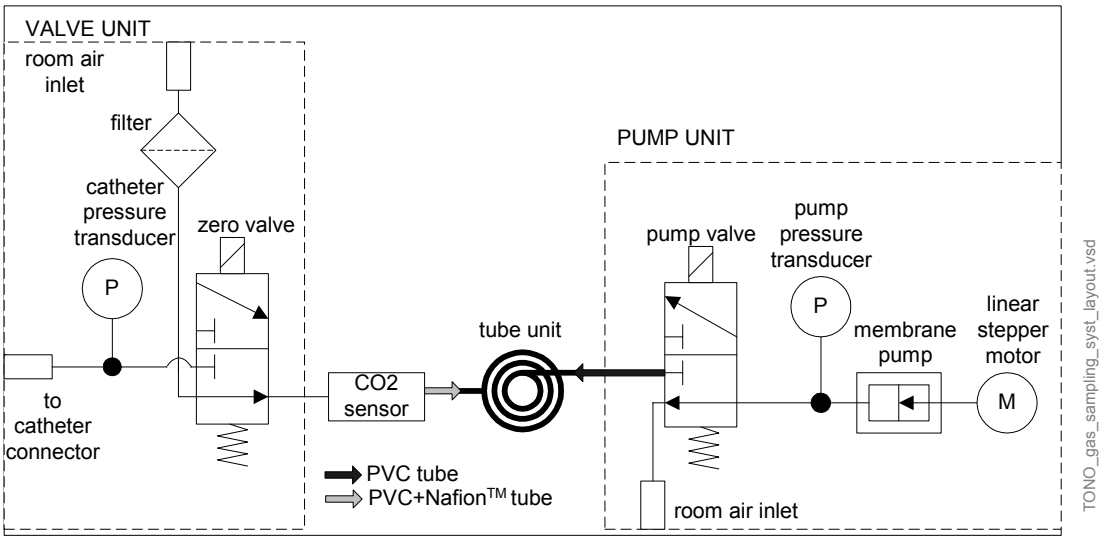


Figure 4 Gas sampling system layout

The tonometry measurement is done at regular intervals of 10 minutes. The measurement cycle starts with CO_2 sensor zeroing. Zeroing means flushing the gas measurement chamber with room air and measuring the signal level of IR-light passed through the room air. Right after zeroing the sensor, sample gas is aspirated from the tonometry catheter and the IR-signal passed through the sample gas is measured. The actual CO_2 concentration is determined from the measured zero signal and the CO_2 signal. After determining the catheter gas CO_2, the system ensures the catheter is emptied by creating a vacuum to empty any residual gas. After generating the vacuum, the tubing system is equilibrated close to the ambient pressure by switching the pump valve on and off. Thus, the catheter is always filled with the same amount of gas. The catheter is refilled with measured sample gas.

Catheter pressure transducer

The catheter pressure transducer measures absolute catheter pressure.

Zero valve

The valve is normally open to room air. When sample gas is measured from the catheter, the zero valve becomes active.

Sensor

After the zero valve, the gas passes through the CO_2 sensor.

Nafion™ tube [1)]

A Nafion tube is used between the CO_2 sensor and tube unit to balance the sample gas humidity with that of ambient air. The CO_2 sensor measures humid gas and Nafion tube prevents humidity from increasing in the tubes.

Tube unit

The tube unit is used between the Nafion tube and pump unit to store the sample gas.

Pump valve

The valve is normally open to room air. When CO_2 concentration is measured from the sample gas or from room air, the pump valve becomes active.

Pump pressure transducer

The working pressure transducer measures absolute pump pressure. It is used for the ‘Catheter empty’ message, ‘Catheter leakage’ message and ‘Unable to fill’ catheter message.

Membrane pump and linear stepper motor

The gas sampling pump is a membrane pump that is run by a linear stepper motor. Sample volume is 4 ml.

1. [1)] Nafion is a trademark of Perma Pure Inc.

2.2.2 CO_2 sensor

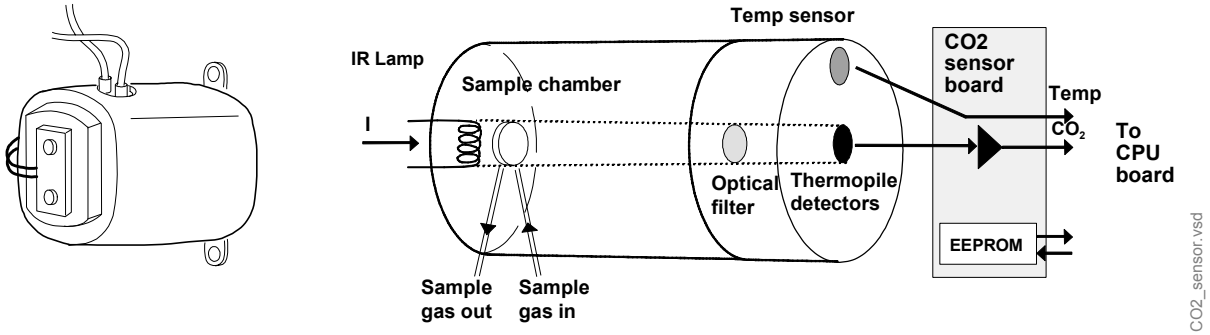


Figure 5 CO_2 sensor

The CO_2 sensor is a non-dispersive infrared analyzer, measuring absorption of the gas sample at CO_2 infrared wavelength, which is selected using an optical narrow band filter. The IR lamp is a 500 mW filament, surrounded by thermal isolation. There is a hole in the isolation, passing the radiation to a conical measuring chamber with 3 mm length.

The CO_2 sensor contains its own preamplifier board, which amplifies the thermopile signal. The preamplifier board also contains EEPROMs that store calibration data of the CO_2 sensor.

The Temp sensor measures the temperature of the CO_2 unit and it is used for temperature compensation.

CPU board

The CPU board contains the processor, memory and AD-converter that are common to the whole module. The CPU board also contains preamplifiers of pressure sensors and drivers for valves, a linear stepper motor and a lamp. The module is connected to the module bus through an RS-485 serial channel.

The CO_2 sensor preamplifier board contains the EEPROM, preamplifier of IR thermopile sensors and temp sensor.

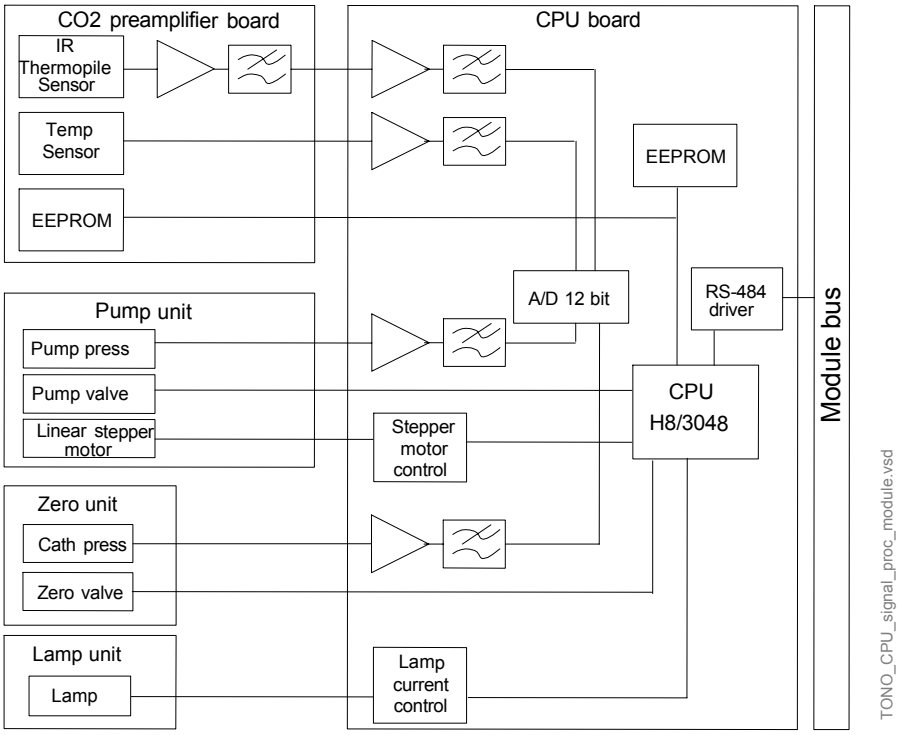


Figure 6 Signal processing of the module

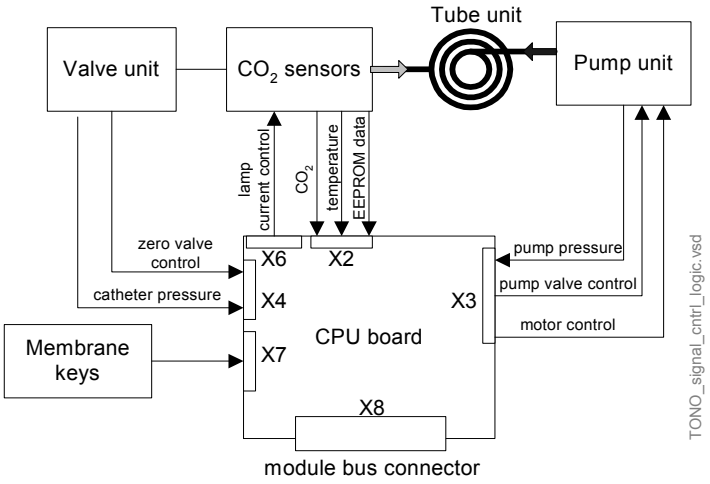
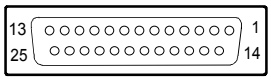


Figure 7 Signal and control logic

2.3 Connectors and signals

2.3.1 Module bus connector

Module bus connector	Pin No.	I/O	Signal
	1	I	RESET RS485
	2	I	-15 VDC (not used)
	3	I	+15 VDIRTY
	4	I	+15VDC
	5	I/O	-DATA RS485
	6	I/O	DATA RS485
	7		Ground and Shield
	8	I	-RESET RS485
	13		Ground and Shield
	14	I	+24/+32 VDIRTY Depends on power supply (not used)
	15	I	Ground DIRTY
	20	I	GASFR (not used)
	21	I	CTSD (not used)
	22	I	TXDD (not used)
	23	O	RXDD (not used)
	24	I	+5 VDC
	25	I	+5 VDC

3 Service procedures

3.1 General service information

The field service of the Tonometry module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

CAUTION The module electronics can only be repaired and calibrated at the factory.

3.1.1 CO_2 sensor

CAUTION The CO_2 sensor can only be repaired at the factory. Attempts to repair the sensor elsewhere will adversely affect operation of the sensor. The information provided is for reference only.

3.1.2 Factory calibration data

CAUTION If there is any fault in the CPU board, pump unit, valve unit or CO_2 sensor, the module should be sent to the factory for repair. The CPU board contains calibration data for the pressure transducers in the pump unit and valve unit. The CO_2 sensor preamplifier board contains calibration data for the sensor itself and for gas measurement electronics on the CPU board.

3.1.3 Serviceable or exchangeable parts

- Nafion tube
- other tubings
- tube unit
- mechanical parts

NOTE: After any component replacement see section “Adjustments and calibrations”

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (“APPENDIX A”) which should be filled in when performing the procedures.

The symbol  in the instructions means that the checklist should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
Torx screwdriver, T10	-	
Pressure manometer	-	
Silicon tube	73373	Available in meters.
Calibration gas Calibration gas regulator Calibration sampling line	755580 755534 733251	
Air pressure gauge	-	
Luer plug		
Tonometrics™ catheter	TONO-14F	or another TONO-_F catheter

See order numbers for accessories in the *Patient Monitor Supplies and Accessories* catalogue.

3.2.2 Recommended parts

Part	Order No.	Notes
Special tube, (Nafion) 300 mm	733382	

3.2.3 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts
   Check that:
   - all screws are tightened properly
   - all cables are connected properly
   - tubes are not pinched and there are no sharp bends on them
   - all tubes are connected properly

   
2. External parts
   Check that:
   - the front cover and the front panel sticker are intact
   - connectors are intact and attached properly

- the module box and latch are intact

3. Nafion tube

   Replace the Nafion tube.

NOTE: The Nafion tube should be replaced annually.

3.2.4 Functional inspection

4. Recognition

   Reattach the module box and check that the latch moves properly.

   Plug in the module. Check that it goes in smoothly and locks up properly.

   Turn the monitor on and wait until the normal monitoring screen appears.

   Configure the monitoring screen so that information regarding the tonometric measurement is shown, for example:

   Monitor Setup - ***Screen 1 Setup - Digit Fields -Lower Field 4 - PgCO2***

   Check that the module is recognized, i.e. the $PgCO_2$ header with related information appears in the chosen digit field.

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) **-** ***Service*** (password 26-23-8)

   Record the information regarding the software of the tonometry module by selecting ***Scroll Vers*** and turning the ComWheel.

6. Communication and memories

   Enter the tonometric module service menu:

   ...***Parameters - More... - TONO***

   Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the module memories have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK. Check that the general error status, module pneumatics error status, module hardware error status and testbit status are zero.

7. Membrane keys

   Check the front panel **Start-Stop** and **Lab. Data** membrane keys.

Press each key for at least one second and check that the key being pressed is identified, i.e. the keyboard status changes.

8. Pressure sensor calibration

   Perform the pressure sensor calibration (***TONO - PressSensCal***), see instructions in section "Pressure sensor calibration".

9. System test

   Perform the system test (***TONO - System Test***).

a. Block the catheter port of the module airtight e.g. with a plug that is made for closing a syringe.

b. Select ***Start Test***.

c. Wait until the automatic test procedure is over. The results are given in the data field and descriptions of the tested parts are listed in the "Service Menu" slot of the Monitor "Technical Reference Manual".

   The test can be interrupted at any time by selecting ***Stop Test***.

NOTE: The system test takes about one minute to carry out.

NOTE: Use a plug with very small volume to block the catheter port.

10. Gas calibration

    Perform the gas calibration (***TONO - Tonometry - PgCO2 - Calibration***).

11. Measurement

    Connect the catheter to the tonometry module. Start the tonometric measurement by pressing the **Start-Stop** key on the module.

    If the measurement is turned on $PgCO_2$ time bat replaces the Meas Off text. Check that the catheter fills up. Stop the measurement by pressing the **Start-Stop** key.

12. Electrical safety check

    Perform an electrical safety check and a leakage current test.

13. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

14. Final cleaning
    Clean the module with suitable detergent.

- Fill in all necessary documents.

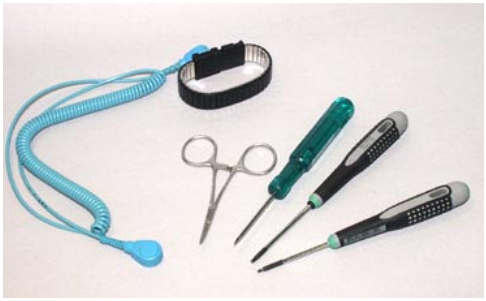
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the tonometry module (see the exploded view of the module in the “E-Modules Spare parts” slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the “Service check” after reassembling the module.

3.3.4 Instructions after replacing tubings

After replacing any part of the tubings:

- perform the “System test”
- perform the “PgCO2 calibration”

3.4 Adjustments and calibrations

3.4.1 Pressure sensor calibration

Before the procedure:

- Find out what the ambient pressure is at the moment in [mmHg] or [mbar].
- Find a device with which you can apply a known pressure of about 100 mmHg to the catheter port. There are e.g. suitable blood pressure gauges. Make sure that it can be connected to a male luer connector.

1. The monitor prompts: 'Make sure that catheter connector is open to room air and start calibration.'
   - Remove the catheter, plug, pressure gauge or anything that is connected to the catheter port of the module.
   - Select ***Start Calib***
2. The monitor prompts: 'Calib started. Make sure that the catheter connector is open to room air.'
   - Remove the catheter, plug, pressure gauge or anything that is connected to the catheter port of the module, if you haven't done so already.
   - Wait a moment.
3. The monitor prompts 'Adjust ambient pressure.'
   - Turn ComWheel to match the highlighted pressure value (or the corresponding value in mbar to the right of the mmHg reading) to the known ambient pressure.
   - Press ComWheel.
4. The monitor prompts: 'Pump approximately 100 mmHg pressure and adjust cal. press. to match.'
   - Connect the blood pressure gauge to the catheter port.
   - Pump in pressure between 95 and 105 mmHg.
   - Turn ComWheel to match the highlighted pressure value to the applied pressure.
   - Press ComWheel.
5. The monitor prompts 'Store or discard new sensor gains and offsets.'
   - Turn ComWheel to display ***YES*** if you want to store the calibration factors or ***NO*** if you do not want to store them.
   - Press ComWheel.
6. The monitor prompts 'Calibration finished.'
   - Everything went OK and the calibration is finished.
   - OR
   - The monitor prompts: 'Calibration pressure too close to ambient pressure.'
   - The applied pressure was too low and you have to redo the calibration.

3.4.2 System test

1. Plug the catheter port of the module airtight e.g. with a plug that is made for closing a syringe.
2. Select ***Start Test***.
3. Wait till the automatic test procedure is over. The results are given in the data field and descriptions of the tested parts are listed in the Service Menu slot of the Monitor “Technical Reference Manual”.

The test can be interrupted at any time by selecting ***Stop Test***.

NOTE: The system test takes about one minute to perform.

NOTE: Use a plug with very small volume to block the catheter port.

3.4.3 $PgCO_2$ calibration

The gas calibration is performed in the **Others** - ***Tonometry*** or ...***Service - Parameters - More... - TONO - Tonometry*** submenu.

1. Connect the calibration gas sampling line to the regulator and to the module’s catheter connector.
2. Press the **Others** key on the monitor keyboard.
3. Select ***Tonometry - PgCO2 Calibration***.
4. Wait until the text ‘Start feeding gas and press ComWheel. Feed gas until Adjust message is displayed’ appears. Open the regulator and start feeding gas. Press ComWheel and continue feeding gas until the text ‘Adjust’ appears on the display.
5. Check that the displayed values match the values on the calibration gas container. Adjust with ComWheel if necessary.
6. It is recommended that the airway gases be calibrated at the same time.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	Cause/What to do
Tonometry module HW error.	Module hardware error. Return the module to the factory for repair.
Tonometrics catheter empty.	There is no gas in the tonometry catheter. It will be filled automatically during the next measurement. Occlusion in the catheter, or leak in the catheter or connector in the module. Check catheter.
Tonometrics catheter leakage.	The tonometry catheter is disconnected, the tubes are leaking inside the module or the catheter is leaking. Ensure proper catheter connection and have the internal leak repaired.
Unable to fill tonometrics catheter.	Occlusion in the catheter or the balloon is squeezed. Check catheter.

4.2 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or blockages in the tubing, fault in pressure sensors, failure of the sampling pump or the magnetic valves.

The system test should help in localizing the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system, check and if necessary adjust the pressure sensors.

CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

CAUTION If there is any fault in the CPU board, pump unit, valve unit or CO_2 sensor, the module should be sent to factory for repair. The CPU board contains calibration data for the pressure transducers in the pump unit and valve unit.

NOTE: If any liquid has entered the module, contact GE Healthcare Technical Services.

5 Earlier revisions

There are no earlier revisions of the S/5™ Tonometry Module, E-TONO.

APPENDIX A Service check form, Tonometry Module, E-TONO (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
3. Nafion tube	☐	☐	☐				
Functional inspection							
4. Recognition	☐	☐	☐				
5. Module software	TONO						
6. Communication and memories	☐	☐	☐	7. Membrane keys	☐	☐	☐
8. Pressure sensor calibration	☐	☐	☐	9. System test	☐	☐	☐
10. Gas calibration	☐	☐	☐	11. Measurement	☐	☐	☐
12. Electrical safety check	☐	☐	☐	13. Functioning after electrical safety check			
14. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

Signature

Datex-Ohmeda

S/5 Entropy Module, E-ENTROPY

Technical Reference Manual Slot

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EEC.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.
All specifications subject to change without notice.

Document number M1027831-02

May 18, 2011

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Entropy Module, E-ENTROPY. The Entropy module is a single width plug-in module designed for use with the Datex-Ohmeda Anesthesia Monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The Datex-Ohmeda S/5 Entropy Module, E-ENTROPY, and accessories are indicated for monitoring the state of the central nervous system (CNS) by data acquisition of electroencephalograph (EEG) and frontal electromyograph (FEMG) signals in the anesthesia environment. The spectral entropies, State Entropy (SE) and Response Entropy (RE), are processed EEG and FEMG variables, and may be used as an aid in monitoring the effects of certain anesthetic agents.

The Entropy module uses an electroencephalography (EEG) signal, together with spontaneous facial muscular activity with a frontal electromyography (FEMG) signal to measure:

- Response Entropy (RE)
- State Entropy (SE)
- Burst Suppression Ratio (BSR)

The Entropy module is responsible for EEG and FEMG signal acquisition, amplification, filtering and digitization and electrode impedance measurement. All the calculated parameters can be selected on the display, and trended.

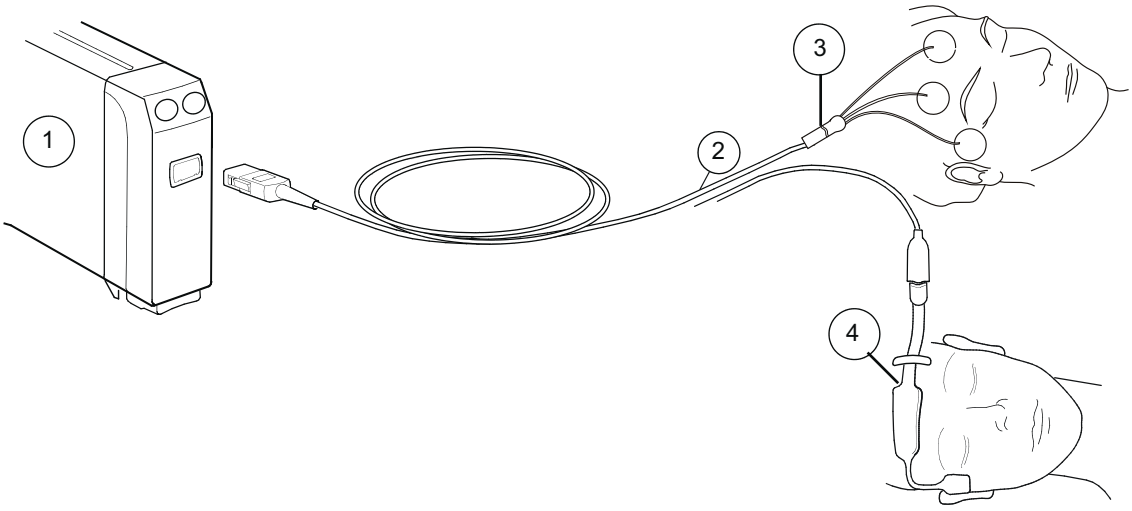


Figure 1 Measurement setup

(1) Entropy module
(2) Entropy sensor cable
(3) GE Entropy sensor
(4) Entropy sensor

Monitor software compatibility

The Entropy Module, E-ENTROPY requires monitor software version 03 or greater.

1 Specifications

1.1 General specifications

Module size (W x D x H)	37 x 186 x 112 mm/1.5 x 7.3 x 4.4 in
Module weight	0.35 kg/0.8 lb.
Power consumption	2.6 W

1.2 Technical specifications

1.2.1 Entropy

Amplifier

Amplification	10 000
Input dynamic range	±500 µV
Input offset	±300 mV
Frequency range	0.5 - 118 Hz
Noise level	<0.5 µV @ 0.5 - 118 Hz
Input impedance	1 MΩ @ 50 Hz
CMRR	>100 dB
Defibrillation protection	3000V, 130 J

A/D conversion

Sampling frequency	1600 Hz
Resolution	60 nV

Waveform display (One channel of raw EEG)

Range	800 μV_{pp}
Scales	±25/50/100/250/400 µV
Sweep speed	12.5/25/50 mm/s

Numeric display (RE, SE and BSR)

Range	RE 0 - 100
	SE 0 - 91
	BSR 0 - 100%
Accuracy	±1 or ±1%
Display resolution	1 digit
Display update	1 s

Impedance measurement

Measurement frequency	75 Hz
Current	10 µA
Range	0...30 kΩ
Resolution	0.1 kΩ
Accuracy	±1 kΩ or ±10%
Measurement time, all leads	5 s
Start of measurement	manual/automatic
Leads off detection	> 3 MΩ, continuous

2 Functional description

2.1 Measurement principle

The hypnotic component of anesthesia is most reliably monitored by measuring cortical electrical activity. Electroencephalography (EEG) changes from irregular to more regular patterns when anesthesia deepens. Similarly, frontalis EMG (FEMG) quiets down as the deeper parts of the brain are increasingly saturated with anesthetics. Entropy measures irregularity of EEG and FEMG.

Entropy parameters and BSR are calculated from EEG and FEMG signals acquired with a sensor which is attached to the patient's forehead. The sensor consists of three electrodes. This referential measurement yields one channel of raw EntrEEG.

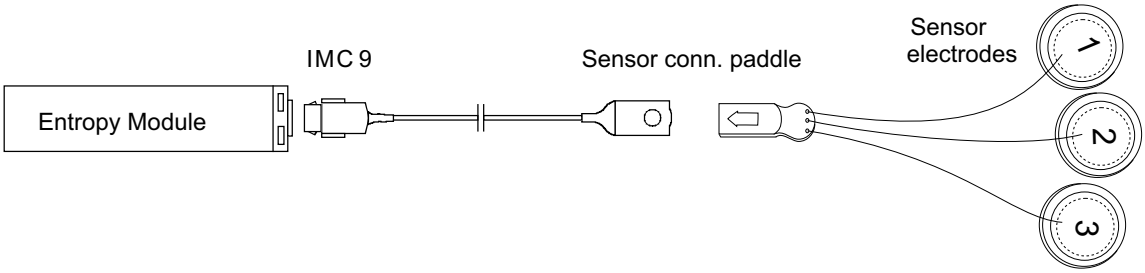


Figure 2 A general view of the cable connections

2.1.1 EntrEEG

EEG is a differential voltage signal measured from electrodes attached the patient's skin. EEG measures the spontaneous electrical activity of the brain. This electrical activity reflects the state of the brain. In referential measurement, the referential electrode delivers its potential to every channel's minus-input. The signal is the potential difference between this common reference electrode (electrode #3) and the electrode connected to the plus input (electrode #1). The purpose of the ground electrode (electrode #2) is to reduce common mode noise.

The EntrEEG signal is amplified, antialias filtered, digitized and software filtered. After that, the EntrEEG signal is shown on the screen and the RE, SE and BSR characteristics are calculated from it.

2.1.2 FEMG

FEMG is an electrical signal originating from facial muscles. The FEMG signal has much broader spectrum than EEG and it overlaps with EEG at low frequencies. The FEMG signal gives its contribution to the RE values (see chapter 2.1.3). Mains power frequency and its harmonics are digitally filtered away to reject interference noise from power lines.

2.1.3 RE and SE

Entropy numbers range from 100 to zero (RE 0-100, SE 0 – 91), correlating to the patient's anesthetic state. High values of Entropy indicate high irregularity of the signal, signifying that the patient is awake. There are two Entropy parameters: the fast-reacting **Response Entropy** and the more steady and robust **State Entropy**. State Entropy consists of the entropy of EEG signal calculated up to 32 Hz. Response Entropy includes additional high frequencies up to 47 Hz and, consequently, the fast frontalis EMG (FEMG) signals enable a fast response time.

Table 1 Frequency ranges for Entropy calculation

Response Entropy, RE	0 < f < 47 Hz
State Entropy, SE	0 < f < 32 Hz

2.1.4 Impedance measurement

The impedance measurement is performed for all leads at the same time and the EntrEEG is stopped for no longer than 5 seconds during the impedance measurement.

Differences in the electrode impedance of the electrodes cause common mode noise coupling to the measured signal. To minimize this, the electrode impedance is measured and a warning of an unsatisfactory impedance level is generated when necessary. The impedance of an electrode is measured by applying a known current through the electrode and measuring the voltage drop over the electrode. This way the impedance of a single electrode can be resolved.

2.2 Main components

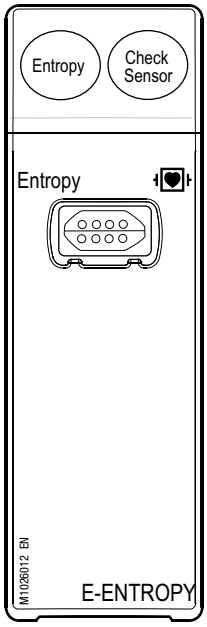


Figure 3 Front panel of Entropy Module, E-ENTROPY

- **Entropy:** Opens the ***Entropy*** menu on the screen
- **Check Sensor**: Starts the manual sensor check

The Entropy board consists of the following functional sections:

- Microprocessor for measurement control, and for processing the measurement signal
- Digital I/O circuit for smart chip communication (the chip is located in the entropy sensor)
- Serial communication driver for module bus communication

The serial bus speed to the monitor is 500 kbps and the bus itself is half duplex, i.e. data can be transferred to both directions but only one way at a time.

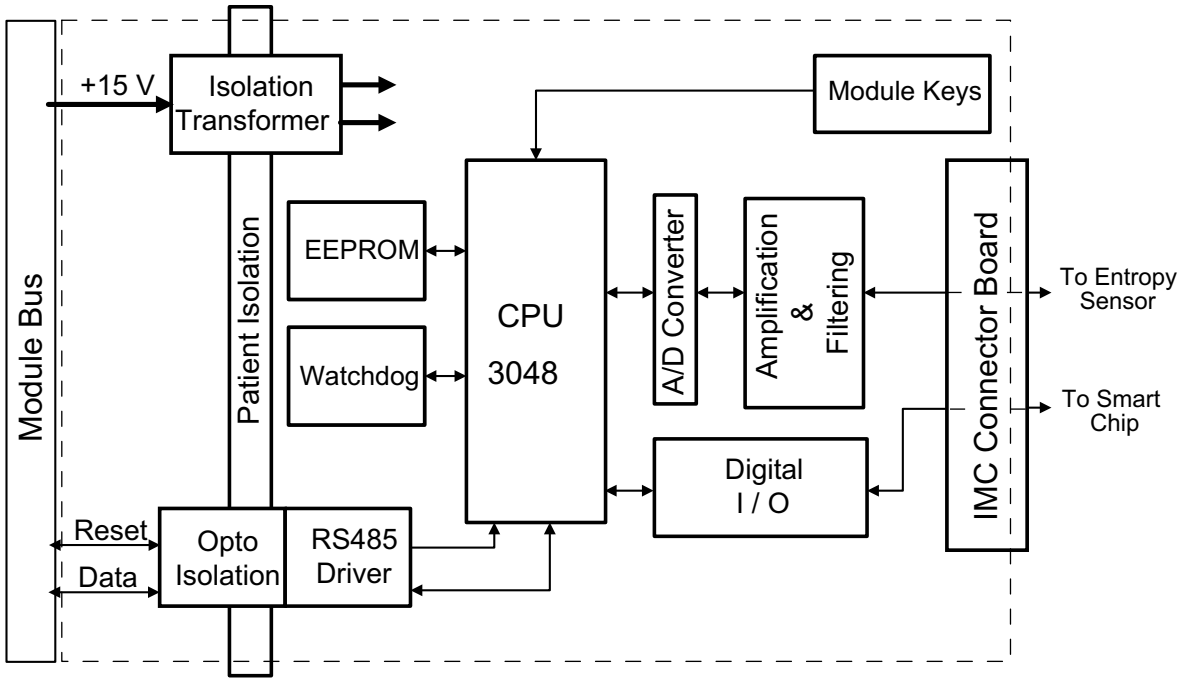
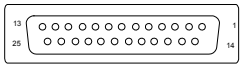


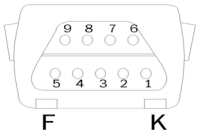
Figure 4 Entropy measurement system block diagram

2.3 Connectors and signals

2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	Name	Despcription
Female D25 	1	Reset_ RS485	Module Bus Reset +
	3	+15VD	+15V Supply voltage
	5	Ndata_ RS485	Module Bus Data -
	6	Data_ RS485	Module Bus Data +
	7	GND	Ground
	8	Nreset_ RS485	Module Bus Reset -
	13	GND	Ground
	Other	NC	Not Connected

2.3.2 Module front panel connector

Module front panel connector	Pin No.	Name	Color	Description
	1	VCC	PURPLE	Supply voltage
	2	I/O	WHITE	Bi-directional data line (open drain)
	3	CLOCK	BLUE	Clock input
	4	RESET	YELLOW	Control input (reset)
	5	GND	GREY	Smartchip ground
	6	Screen	-	Cable screen
	7	Electrode 2 (N)	GREEN	EEG channel neutral
	8	Electrode 3 (-)	RED	EEG channel -
	9	Electrode 1 (+)	BROWN	EEG channel +

3 Service procedures

3.1 General service information

The field service of the E-ENTROPY module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

The simulator for E-ENTROPY (order code N-ES) is recommended for functional checks.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") Service check form, which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
Simulator for E-ENTROPY	N-ES	
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts of the module
   Check that:
   - screws are tightened properly
   - cables are connected properly
   - the EMC cover is attached properly in the module
   - there are no loose objects inside the module

2. External parts of the module

   Check that:

   - the front cover and the front panel sticker are intact
   - connectors are intact and attached properly
   - the module box and latch are intact

   Reattach the module box.

3.2.3 Functional inspection

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that information regarding the Entropy measurement is shown:

Monitor Setup - *Screen 1 Setup - Waveform Fields - Field 1 - EntrEG*

Others - ***Entropy - Entr.EEG Scale - 250 µV***
Others - ***Entropy - Display format - All***
Others - ***Entropy - Automatic check - OFF***

3. Installation

   Plug in the module. Check that it goes in smoothly and locks up properly.

4. Recognition of module

   Check that the module is recognized, i.e. the EntrEEG header with related information appears in the chosen waveform fields and 'Cable off' message is shown on the field.

5. Recognition of sensor

   Connect the cable to the module. Check that the cable is recognized i.e. message 'No sensor' is shown on the waveform field. If the Entropy sensor is connected, 'Sensor off' message appears.

6. Module software

   Enter the service menu:

   Monitor Setup - *Install/Service* (password 16-4-34) **- *Service*** (password 26-23-8)

   Record the information regarding the software of E-ENTROPY by selecting ***Scroll vers*** and turning the ComWheel.

7. Communication and memories of module

   Enter the Entropy module service menu:

   Parameters - More... - Entropy

Check that the Time-outs, Bad checksums and Bad c-s by mod values in the module view are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK.

8. Membrane keys

   Check the **Entropy** and **Check Sensor** membrane keys of the module. Go to the module view and press each key for at least one second and check that the key being pressed is identified, i.e. the Check Sensor text is highlighted in the service menu and that pressing the **Entropy** key brings up the Entropy menu.

9. Impedances

   Connect the Entropy simulator (N-ES) to the cable. Go to the ***Entropy*** service menu and select ***Check Sensor*.** In the Sensor view, check that the impedances in all three leads are 0 kΩ.

10. Checks with simulator

    Keep the Entropy simulator connected and check that the EntrEEG waveform and RE and SE values appear on the monitor screen. The RE and SE values start to decrease after a couple of minutes.

11. Electrical safety check

    Perform an electrical safety check and a leakage current test.

12. Functioning after electrical safety check

    Check that the module functions normally after performing the electrical safety check.

13. Final cleaning

    Clean the module with suitable detergent.

- Fill in all necessary documents.

3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.4 To disassemble the module

To disassemble the E-ENTROPY module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Detach the Entropy board by removing the two screws located near the front panel frame, disconnect the cable and pull out the front panel frame.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check " after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Trouble	Cause	What to do
No EntrEEG waveform on screen.	EntrEEG waveform not selected on screen.	Press **Monitor Setup** key and select EntrEEG waveform on the screen.
No EntrEEG waveform on screen and 'Sensor off' message shown in the number field.	Entropy sensor not attached to skin.	Attach sensor to patient.
Number field shows '- - -' and message 'Sensor check failed' is displayed in number field.	Module could not accomplish a successful sensor check.	Check the sensor connection to skin and initiate a new check by pressing **Check sensor** module key or from ***Entropy*** menu.
EntrEEG signal looks noisy and 'Noise' message is displayed in the number field and waveform field	High frequency electrical interference (i.e. electrocautery) is coupling to the sensor.	Remove noise sources if possible. Check the sensor and electrode impedances.
Sensor check measurement is not available on menus.	Measurement is off because sensor is not connected to cable and to patient.	Sensor check starts immediately when sensor is connected to the patient and first Entropy values should appear 15 seconds after successful sensor check.
Electrode impedances show 'Fail'and 'Press electrodes' message is displayed on number fields after impedance measurement.	One or more of sensor electrodes is poorly connected to patient.	Check the sensor contact and cable. If the sensor electrodes have too high impedance (>7.5k), the measurement fails even if the sensor seems properly attached. Cure for this is to prepare the skin better, check that the sensor is not dried out or outdated and try again.

4.2 Troubleshooting flowcharts

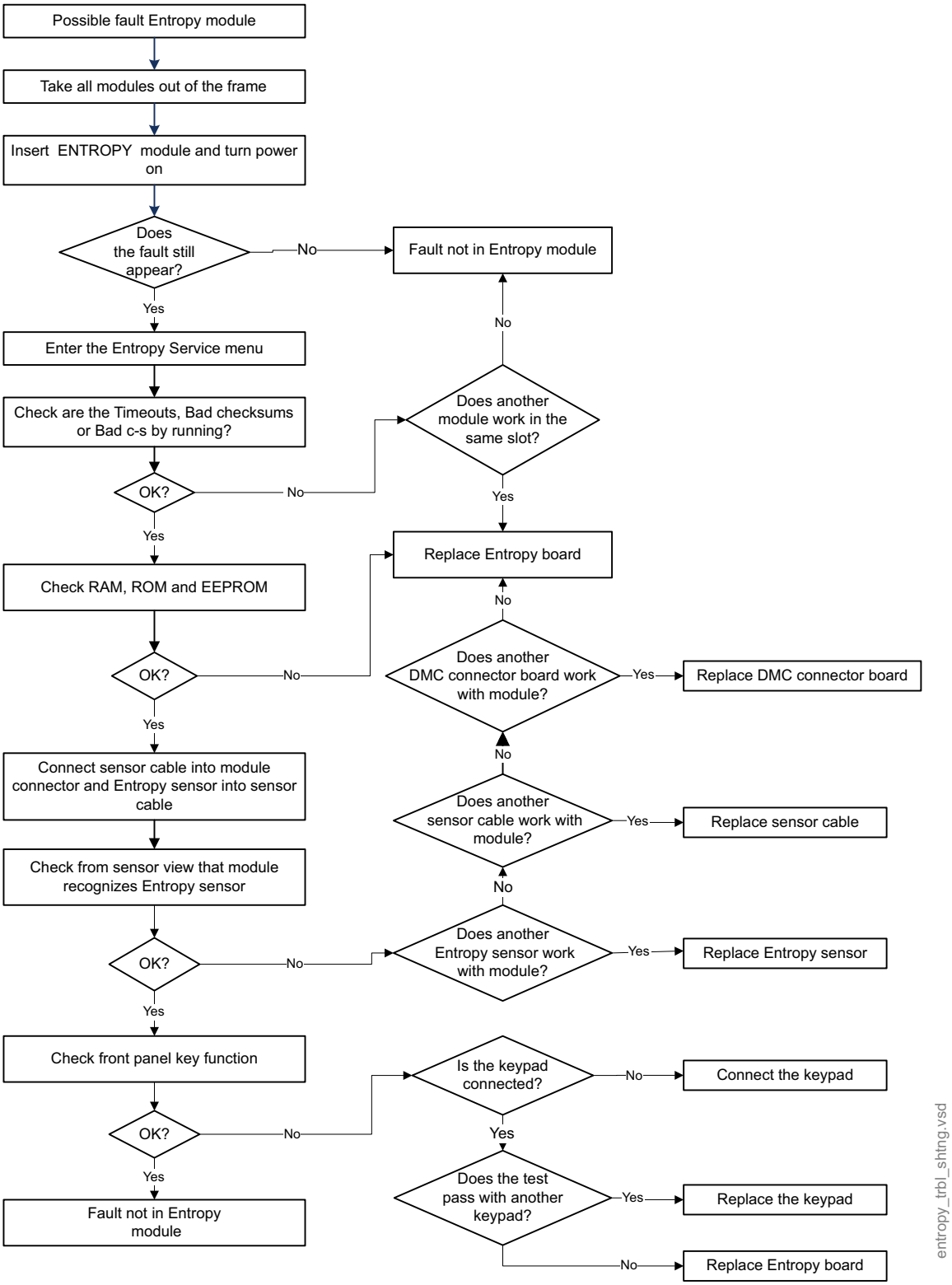


Figure 5 Entropy module troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5™ Entropy Module, E-ENTROPY.

APPENDIX A: Service check form, Entropy Module, E-ENTROPY (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts of the module	☐	☐	☐	2. External parts of the module	☐	☐	☐
Notes							

Functional inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
3. Installation	☐	☐	☐	4. Recognition of module	☐	☐	☐
5. Recognition of sensor	☐	☐	☐				
Notes							
6. Module software	E-ENTROPY						
7. Communication and memories of module	☐	☐	☐	8. Membrane keys	☐	☐	☐
9. Impedances				+	-		
Lead 1						0 kΩ	
Lead 2						0 kΩ	
Lead 3						0 kΩ	

10. Checks with simulator	+	-	OK	N.A.	Fail
EntrEEG waveforms			☐	☐	☐
RE value			☐	☐	☐
SE value			☐	☐	☐
Notes					

	OK	N.A.	Fail		OK	N.A.	Fail
11. Electrical safety check	☐	☐	☐	12. Functioning after electrical safety check	☐	☐	☐
13. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

Signature

Datex-Ohmeda

EEG Module

S/5™ EEG Module, E-EEG (Rev. 00)
S/5™ EEG Headbox, N-EEG (Rev. 01)

Technical Reference Manual Slot

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027832-1
November, 2005

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 EEG Module, E-EEG, and the Datex-Ohmeda S/5 EEG Headbox, N-EEG. The EEG module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The EEG module and the EEG headbox together measure:

- electroencephalography (EEG)
- spontaneous facial muscular activity with frontal electromyography (FEMG)
- auditory evoked potentials (AEP)

The EEG Headbox, N-EEG, is responsible for EEG and FEMG signal amplification, filtering and digitization and electrode impedance measurement. It is situated close to the patient’s head. The Headbox has connectors for the EEG leads, either for a referential or a bipolar montage, and for the AEP stimulation earphones.

The EEG module E-EEG creates auditory stimulus pulses and takes care of AEP signal processing. It has one connector for the EEG headbox.

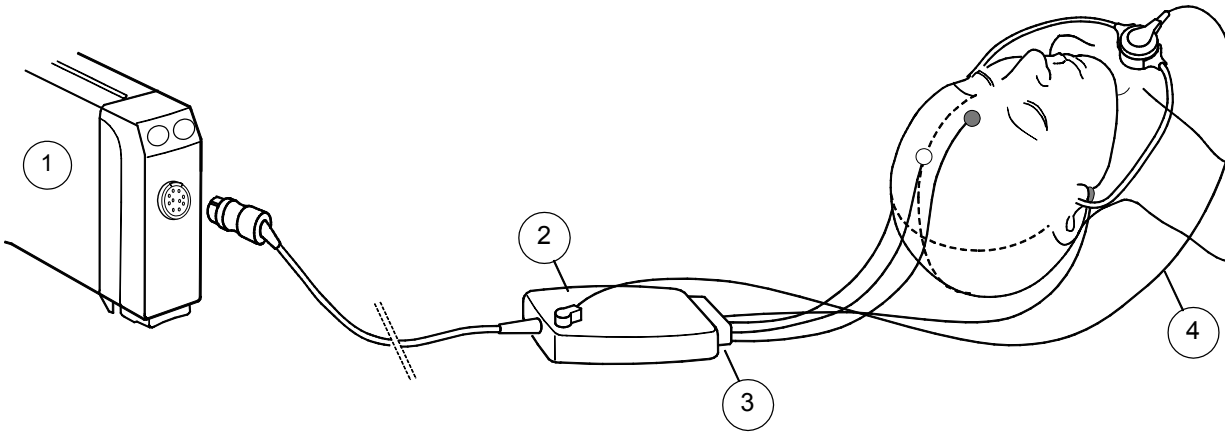


Figure 1 Measurement setup

(1) Module EEG, EP and FEMG measurement capability, E-EEG

(2) EEG Headbox and cable, N-EEG

(3) EEG leadset: preconfigured or own montage
- EEG electrodes (cup, needle or stick-on)

(4) Earphones (for AEP, earphones (4) are required)

Monitor software compatibility

The S/5 EEG Module, E-EEG and Headbox N-EEG function only with monitor software of level 99 or later.

1 Specifications

1.1 General specifications

1.1.1 Headbox

Box size, W × D × H	97 × 174 × 34 mm/3.8 × 6.9 × 1.3 in
Box weight	0.4 kg/0.9 lb.
Power consumption	1.9 W

1.1.2 Module

Module size, W × D × H	37 × 186 × 112 mm/1.5 × 7.3 × 4.4 in
Module weight	0.3 kg/0.7 lb.
Power consumption	3.1 W

1.2 Technical specifications

1.2.1 EEG

Amplification	10 000
Resolution	60 nV
Max amplitude	800 μV_{pp}
Sampling frequency	100 Hz per channel
Range	±400 μV
Frequency range	0.5...30 Hz
Input impedance	8 MΩ @ 10 Hz
Noise level	< 0.5 μV rms from 0.5 Hz to 30 Hz
CMRR	>100 dB @ 50 Hz
Parameters from power spectrum	SEF, MF, relative power in frequency bands
Burst suppression	calculated burst-suppression ratio (BSR)
Defibrillation protection	5000V, 360 J
Allowable Input Offset	±300 mV

1.2.2 AEP

Amplification	10 000
Resolution	60 nV
Max amplitude	1000 μV_{pp}
Stimulation	
Click (condensating)	duration 100 μs
Frequency	1.1...9.1 Hz (1 Hz steps) @ 10 ms measurement
	1.1...8.1 Hz (1 Hz steps) @ 100 ms measurement
Intensity	10...90 dB nHL, 10 dB steps

Measurement	
Sampling frequency	2400 Hz for MLAEP/ 4800 Hz for BAEP
Frequency range	0.5...1000 Hz
Highpass filter	off/10/30/50/75/100/150 Hz
Single average:	
Averaged responses	100...2000
Moving average:	
Gross average	100...2000
Update interval	after every 100 stimuli (200, when gross average is 2000)

1.2.3 EMG

Amplification	50 000
Resolution	100 nV
Max amplitude	100 μV_{pp}
Frequency range	60...300 Hz
Amplitude	Root Mean Square (RMS)

1.2.4 Impedance measurement

Measurement frequency	75 Hz
Current	10 μA
Range	0...30 kΩ
Resolution	100
Accuracy	$\pm$1k or $\pm$10% whichever is greater
Measurement time, all leads	3 s
Start of measurement	manual/automatic
Leads off detection	>3 MΩ, continuous

2 Functional description

2.1 Measurement principle

2.1.1 EEG

EEG is a differential voltage signal measured from electrodes attached to the patient's skin. EEG measures the spontaneous electrical activity of the brain. This electrical activity reflects the state of the brain.

Electrode connections can be made with two different principles: bipolar or referential montage. In bipolar montage, every channel has two electrodes and the signal is the potential difference between these two electrodes. In referential montage, the referential electrode delivers its potential to every channel's minus-input. The signal is the potential difference between this common reference electrode and the electrode connected to the plus input. The purpose of the ground electrode is to reduce common mode noise. It cannot be used as referential electrode.

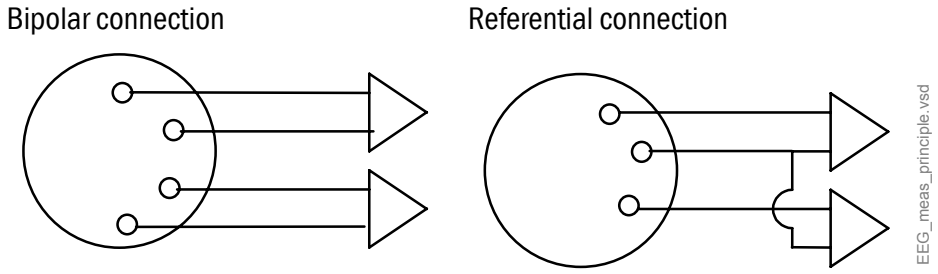


Figure 2 EEG measuring principle

The EEG signal is amplified, antialias filtered, digitized and software filtered. After that the EEG signal is displayed on the screen and various characteristics are calculated from it. These include spectrum, rms amplitude, spectral edge frequency, median frequency, burst-suppression ratio and percentage of total power in four different bands: theta (1...4 Hz), delta (5...9 Hz), alpha (9...13 Hz) and beta (>13 Hz).

2.1.2 FEMG

FEMG is an electrical signal originating from facial muscles. In the headbox, the signal of channel 1 is divided into two different amplification and filtering paths. One is the EEG path and the other is the FEMG path. The FEMG signal has a much broader spectrum than the EEG and it overlaps with the EEG at low frequencies. Because of this, the rms amplitude of FEMG signal is calculated from the frequency band 60...300 Hz. The mains power frequency and its harmonics are digitally filtered away to reject noise interference from power lines.

2.1.3 AEP

AEP is an electrical response of the nervous system to external auditory stimulus. It is measured using the same electrodes as in the EEG measurement, but the sampling frequency and bandwidth are different. The electrical signal resulting from one stimulus is weaker than the spontaneous activity of the brain. To overcome this, the stimulus is repeated several times (100...2000), and an average of all responses is calculated. Responses containing large artefacts are removed from the average to improve the signal to noise ratio.

2.1.4 Impedance measurement

The impedance measurement is performed from one channel at a time and the EEG or EP measurement is stopped during the impedance measurement.

Differences in electrode impedance cause common mode noise coupling to the measured signal. To minimize this, the electrode impedance is measured and a warning of unsatisfactory impedance level is generated when necessary. The impedance of an electrode is measured by applying a known current through the electrode and measuring the voltage drop over the electrode. This way the impedance of a single electrode can be resolved instead of a sum impedance of an electrode pair.

2.2 Main components

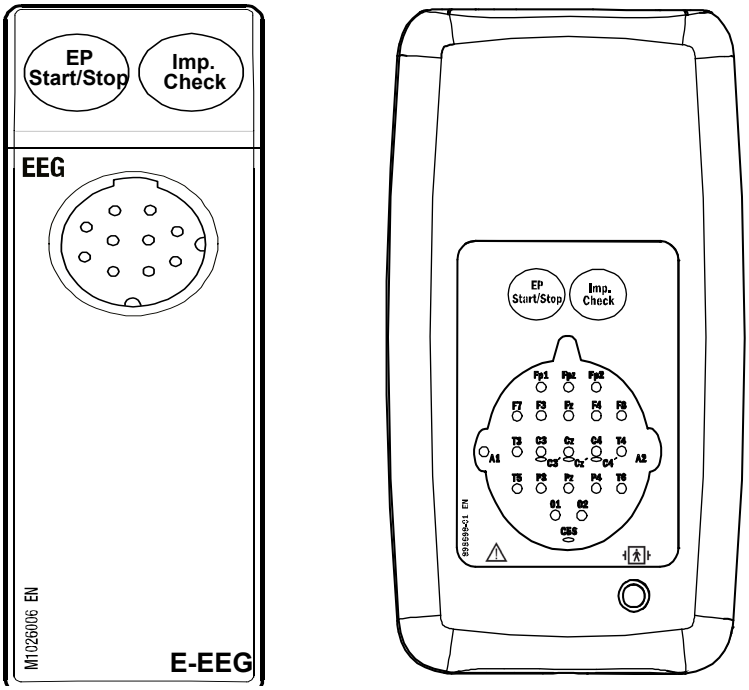


Figure 3 Front panel of EEG Module, E-EEG, and of EEG Headbox, N-EEG

EP Start/Stop Starts/stops evoked potential measurement with the defined settings.

Imp. Check Starts the manual measuring of the electrode impedance.

Headbox

The headbox, N-EEG, amplifies and digitizes the EEG signal. It has connectors for the EEG electrode leads and AEP simulation headphones. There are the same two keys as on the E-EEG: **EP Start/Stop** and **Imp. Check**. The headbox is situated close to the patient's head.

2.2.1 Neuro board

The Neuro board consists of the following functional sections:

- audio stimulator
- microprocessor for stimulation and measurement control, and for counting the measurement results

- two serial communication drivers

The serial bus speed to the monitor is 500 kbps and the bus itself is half duplex, i.e. data can be transferred to both directions but only one way at a time.

The serial bus speed to the headbox is 500 kbps and the bus is full duplex i.e. data can be transferred to both directions at the same time.

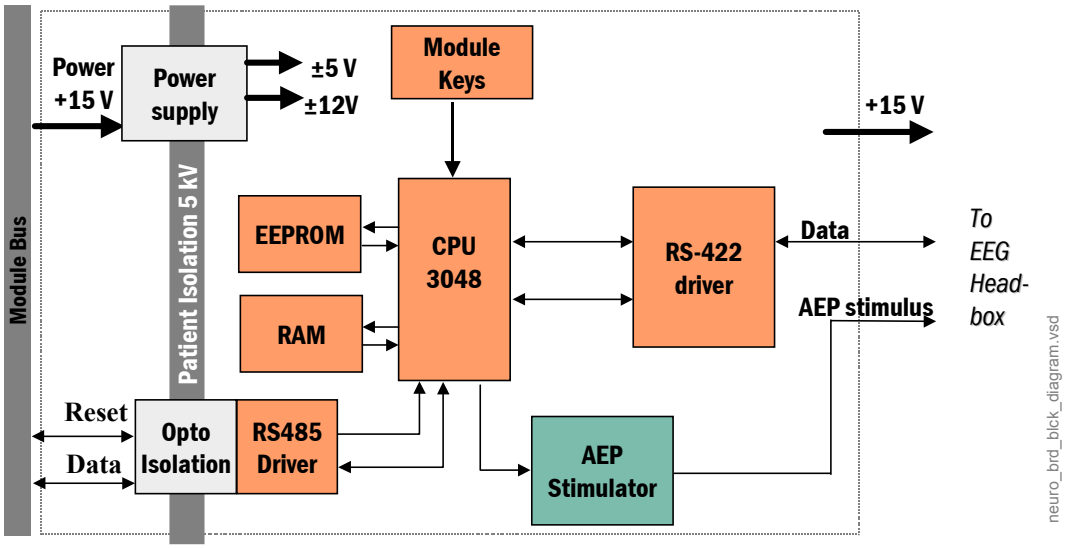


Figure 4 Neuro board block diagram

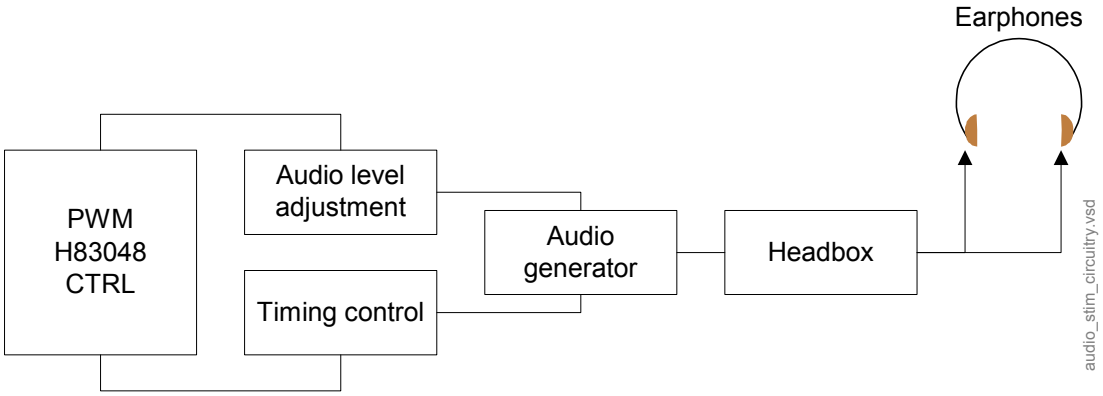


Figure 5 Audio stimulator circuitry

2.2.2 Headbox board

The Headbox board consists of the following functional sections:

- input protection
- EEG amplifiers and filters
- FEMG amplifier and filter
- current feeding circuitry and amplifiers for impedance measurement

- microprocessor
- serial communication

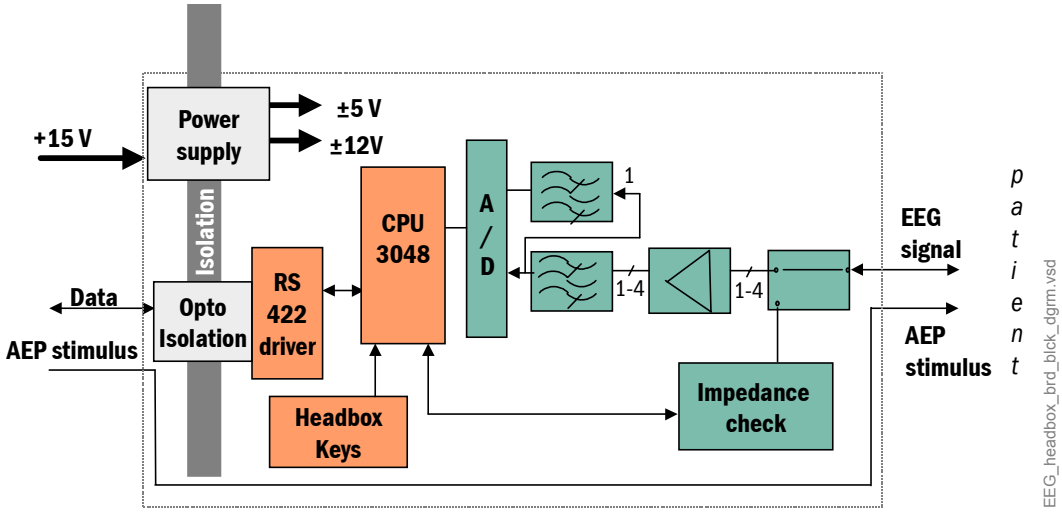
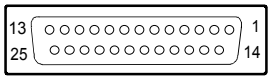


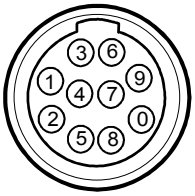
Figure 6 EEG headbox board block diagram

2.3 Connectors and signals

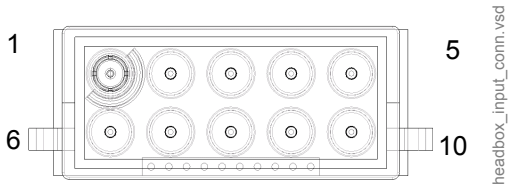
2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	1	I	RESET_RS485
	2	I	-15 VDC
	3	I	+15 VDIRTY
	4	I	+15 VDC
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	Ground & Shield
	8	I	-RESET_RS485
	9	I	CTSB
	10	O	RTSB
	11	I	RXDB
	12	O	TXDB
	13	-	Ground & Shield
	14	I	+32 VDIRTY
	15	I	GroundDIRTY
	16	I	CTSC
	17	O	RTSC
	18	I	RXDC
	19	O	TXDC
	20	-	ON/STANDBY
	21	-	PWM_ECG
	22	-	RXDD_RS232
	23	-	TXDD_RS232
	24	I	+5 VDC
	25	I	+5 VDC

2.3.2 Headbox connector

Headbox connector	Pin No.	Signal
	1	Ground
	2	Ground
	3	+15 V
	4	TXD+
	5	EP Audio
	6	Power sync 43 kHz
	7	RXD+
	8	EP Sync
	9	RXD-
	0	TXD-

2.3.3 Headbox input connector

Headbox input connector	Pin No.	Signal
	1	Lead set id
	2	1+
	3	2+
	4	3+
	5	4+
	6	Ground
	7	1- / Ref
	8	2-
	9	3-
	10	4-

3 Service procedures

3.1 General service information

The field service of the E-EEG module and N-EEG headbox is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (“APPENDIX A”) which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
EEG simulator	90502	No longer available *
Torx screwdriver, T10		
Earphones		

* In case no EEG simulator is available for checking, skip over the steps referring to the simulator.

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

Detach also the cover of the EEG headbox by removing the four screws from the bottom of the box. Be careful with the two wired connectors in the circuit board attached to the cover.

1. Internal parts of the module and the headbox:

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - the EMC cover is attached properly in the module

- there are no loose objects inside the module or the headbox

2. External parts of the module

   Check that:

   - the front cover and the front panel sticker are intact
   - connectors are intact and attached properly
   - the module box and latch are intact

3. External parts of the headbox

   Check that:

   - cover and the base of the headbox are intact
   - the headbox sticker is intact
   - connectors are intact and attached properly

Reattach the module box and the cover of the EEG headbox.

3.2.3 Functional inspection

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that information regarding the EEG measurement is shown:

Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 1 - EEG1***
Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 2 - EEG2***
Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 3 - EEG3***
Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 4 - EEG4***

Others - ***EEG - Montage - EEG Channels - 4***
Others - ***EEG - Montage - Montage type - Bip***
Others - ***EEG - EEG Setup - Numeric 1 - M****F*
Others - ***EEG - EEG Setup - Numeric 2 - Ampl****.*

4. Installation

   Plug in the module. Check that it goes in smoothly and locks up properly

5. Recognition of module

   Check that the module is recognized, i.e. the EEG header with related information appears in the chosen waveform fields and ‘Headbox off’ message is shown on the four fields.

6. Recognition of headbox

   Connect the headbox to the module. Check that the headbox is recognized i.e. message 'EEG measurement off' is shown on the four waveform fields. If the EEG leads are connected, 'EEG measurement off' message disappears after 15 seconds.

7. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) **-** ***Service*** (password 26-23-8)

   Record the information regarding the software of E-EEG and N-EEG by selecting ***Scroll vers*** and turning the ComWheel.

8. Communication and memories of module

   Enter the EEG module service menu:

   Parameters - More... - EEG & EP

   Check that the Timeouts, Bad checksums and Bad c-s by mod values in the module view are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK.

9. Communication and memories of headbox

   Check that the HB Mod Timeouts, HB Mod Bad Checksum and Mod HB Bad Checksum values are not increasing faster than by 5 per second. Check that the memory of the headbox has passed the internal memory test, i.e. HB Rom Error in the headbox view states 0.

10. Membrane keys

    Check the **EP Start/Stop** and **Imp. Check** membrane keys both of the module and the headbox. Go to the module view and press each key for at least one second and check that the key being pressed is identified, i.e. the corresponding text is highlighted in the service menu. Repeat in the headbox view with the headbox keys.

11. Impedances

    Select 10 kΩ as imped. pos. and imped. neg. value on the simulator. Go to the ***EEG & EP*** service menu and select ***Check Electr.*** In the headbox view, check that the impedances in all four channels are 10 kΩ ±1 k.

12. Checks with simulator

    Connect the EEG simulator to the headbox. Select 2 kΩ as imped. pos. and imped. neg. value on the simulator. Select 10 Hz 200 μV sinewave on the simulator and check that all the four waveforms have the same form. Check that the size of the waveforms is 200 μV_{pp} ±5 μV. Check that the MF value is 10 ±0.5 Hz. Check that the amp value is 71 μV 3 μV.

13. FEMG value

    Select 75 Hz 50 μV signal on the simulator. Check that the FEMG value is 16 ±3 μV.

Preset the AEP measurement settings:

Others

EP - Cycle - Cont.
EP - AEP Setup - AEP Channels - 2
EP - AEP Setup - Responses -100
EP - AEP Setup - Stim. Frequency - 1.1Hz
EP - AEP Setup - Stim. Intensity - 60 dB
EP - AEP Setup - Sweep length - 100 ms

14. AEP stimulation

    Plug in the earphones to the headbox. Be careful with load stimulation from the earphones when starting AEP stimulation. Start AEP stimulation by pressing the **EP Start/Stop** button on the module. Check that the clicking sound comes from the earphones in 1.1 Hz frequency. Stop the stimulation by pressing again the **EP Start/Stop** button on the module. Check that the clicking stopped.

Modify the AEP measurement settings:

Others

EP - AEP Setup - Stim. Frequency - 8.1Hz
EP - AEP Setup - Stim. Intensity - 90 dB
EP - EP Size - 1

15. AEP response

    Connect the AEP testing cable between the simulator and the headbox. Select 2 kΩ as imped. pos. and imped. neg. value on the simulator. Select 40 μV amplitude in the ***EP*** waves menu on the simulator and start AEP measurement in the **Others** - ***EP*** menu. Wait until you get the response on the display. Check that the shape of the response is one period of a sine wave. Save ***EP*** and adjust the markers to the minimum and maximum level of the response curve in both channels. Check that the amplitude is 40 V ±5 μV.

16. Electrical safety check
    Perform an electrical safety check and a leakage current test.

17. Functioning after electrical safety check
    Check that the module functions normally after performing the electrical safety check.

18. Final cleaning
    Clean the module with suitable detergent.

- Fill in all necessary documents.

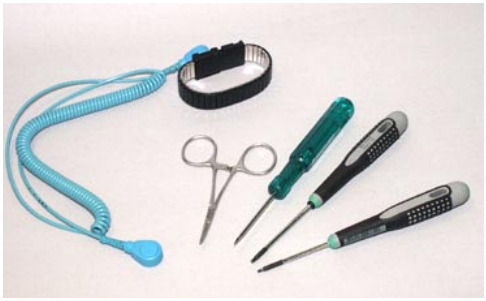
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

3.3.4 E-EEG

To disassemble the E-EEG module (see the exploded view of the EEG module in the “E-Modules Spare parts” slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Detach the Neuro board by removing the two screws located near the front panel frame, disconnect the cable and pull out the front panel frame.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the “Service check” after reassembling the module.

3.3.5 N-EEG

To disassemble the N-EEG headbox (see the exploded view of the headbox in the “E-Modules Spare parts” slot):

1. Remove the four screws from the bottom of the headbox.
2. Lift off the cover and disconnect the two cables connected to the EEG headbox board.
3. Disconnect the module-headbox cable and the headbox input unit connectors from the EEG headbox board.

4. Remove the four screws on the corners of the EEG headbox board and detach the EEG headbox board.

To reassemble the N-EEG, reverse the order of the disassembly steps.

CAUTION When reassembling the headbox, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the headbox.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	Cause	What to do
No EEG waveforms on screen.	EEG waveforms not selected on screen.	Press **Monitor Setup** key and select EEG waveforms on the screen.
No EEG waveforms on screen and 'EEG measurement off' message shown in the number field.	Electrodes not attached properly to skin or electrode cables not connected to headbox.	Check electrodes and electrode cables.
All EEG waveforms not drawn on screen even if electrodes and cables are OK.	The number of channels chosen on montage setup is smaller than the number of channels connected to patient.	Check that the number of channels in menu **Others** -***EEG*** - ***Montage*** is the same as the number of channels connected to patient.
Number fields show '---' and message 'High EMG' is displayed.	Patient has high muscle activity in the head region or noise from some equipment is coupling to electrode cables.	Wait until the patient is relaxated or remove the noise source.
EEG signal looks noisy and artefact message is displayed in the number fields.	Electrodes are poorly connected or electrical interference is coupling to electrode cables.	Check the electrodes and electrode impedances. Remove noise sources if necessary.
'Leads off' message is shown on other channels than channel 1 in referential connection.	The montage chosen in monitor is not referential.	Change the montage to referential from monitor menu **Others** -***EEG*** - ***Montage***.
Electrode impedance measurement is not available on menus.	EEG measurement is off.	EEG measurement starts 15 seconds after first electrode pair is connected.
Electrode impedance measurement is not available on menus.	EP measurement is on.	Wait until EP measurement ends or stop EP measurement.
Electrode impedances show '---' and 'Check ground electrode' message is displayed on number fields after impedance measurement.	Ground electrode is poorly connected to patient or ground electrode cable is not connected to headbox.	Check the electrode and cable. If the electrode has too high impedance (>50k), the measurement fails even if the electrode is properly attached. Cure for this is to use better electrodes or prepare the skin better.
Electrode impedances show '---'	The electrode impedances are too high and out of measurement range.	Prepare the skin better or use better electrodes.
Start EP measurement not available on EP menu.	The EEG measurement is off.	Connect electrodes and wait 15 seconds and the measurement starts.
EP measurement parameters cannot be changed.	The EP measurement is on.	Stop EP measurement.
All or most of the EP epochs are rejected (Rej. counter on EP screen increases more rapidly than Ave. counter).	The signal has too much noise/artefacts in EP measurement band. Especially coupled 50/60 Hz is not shown on EEG waveform because of filtering, but may be present in EP signal.	Check that electrode impedances are below 5k and the impedances of the same channel are close to one another. If this does not help, then try to remove noise sources.
EP wave is shown only on one channel even if two channels EP measurement is selected.	Leads are off in the channel where the EP wave is not shown.	Check the electrodes and electrode cables.
No clicks can be heard from earphones.	The earphones connector is not in place.	Check that the earphones plug is firmly pushed into the headbox's earphone connector.

4.2 Troubleshooting flowcharts

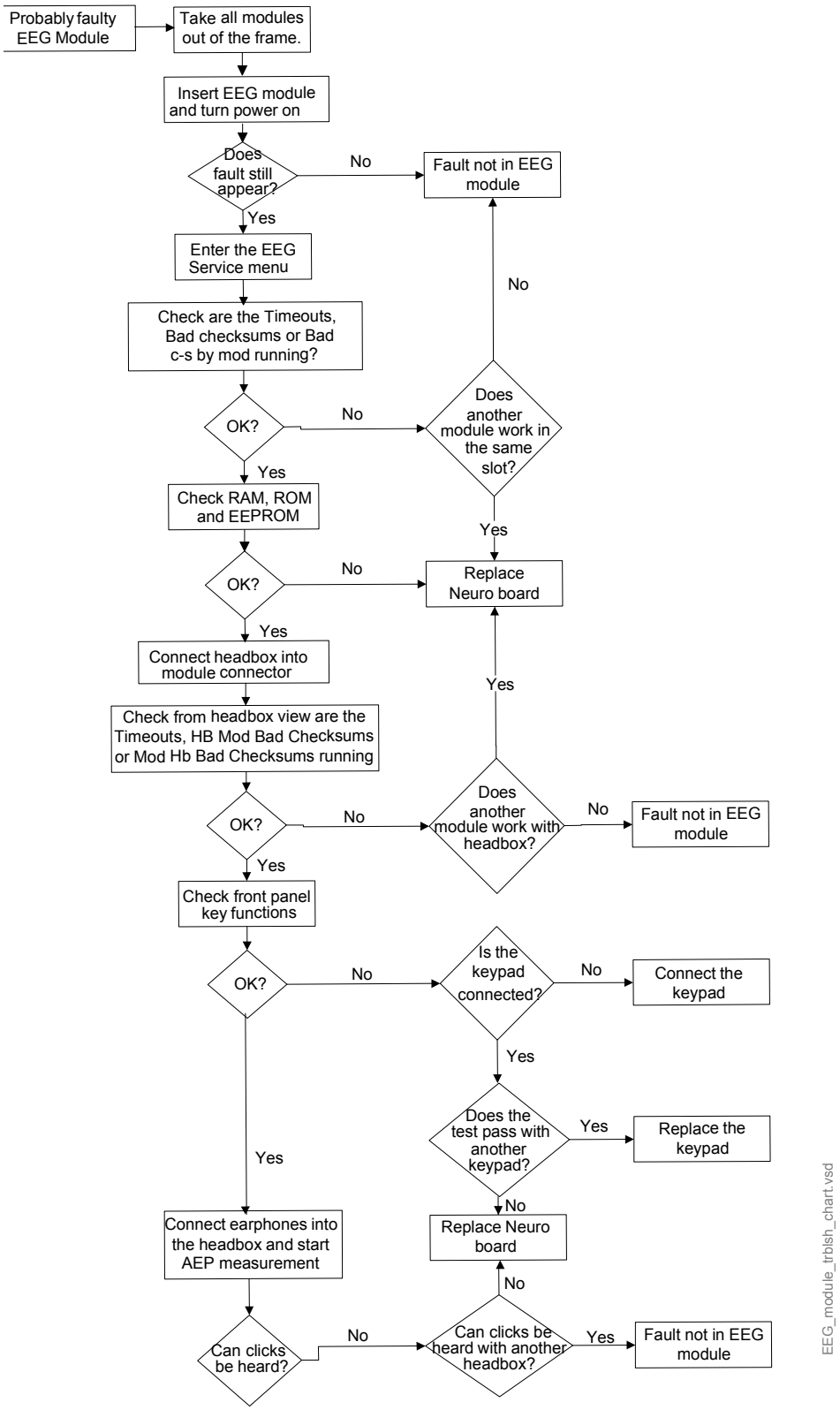


Figure 7 EEG module troubleshooting flowchart

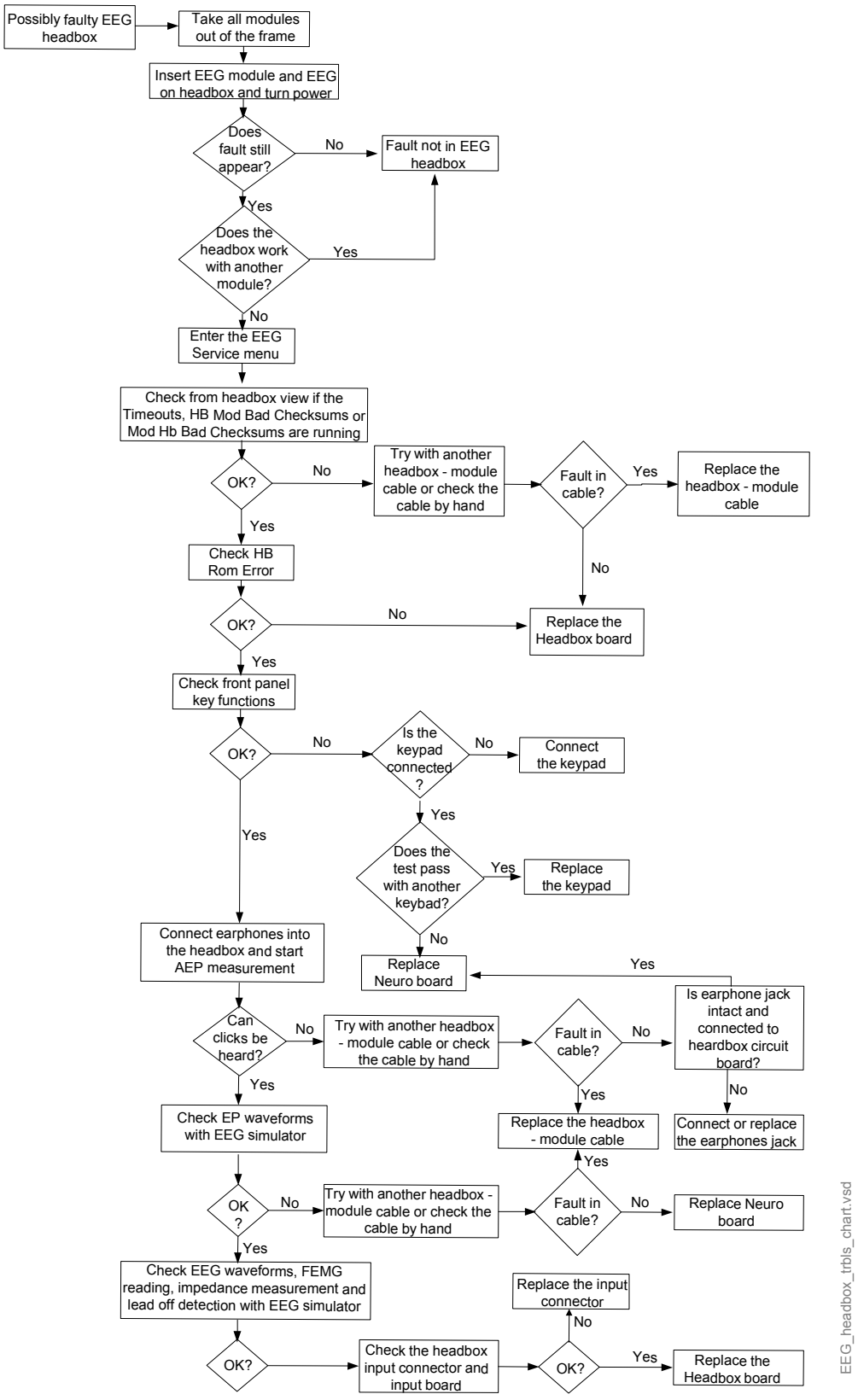


Figure 8 Headbox troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5™ EEG Module, E-EEG. This manual supports the earlier revisions of the S/5™ EEG Headbox, N-EEG.

APPENDIX A Service check form, EEG Module, E-EEG (Rev. 00) and EEG Headbox, N-EEG (Rev. 01)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts of the module and the headbox:	☐	☐	☐	2. External parts of the module	☐	☐	☐
3. External parts of the headbox	☐	☐	☐	4. Installation	☐	☐	☐
Notes							

Functional inspection							
4. Installation	☐	☐	☐	5. Recognition of module	☐	☐	☐
6. Recognition of headbox	☐	☐	☐				
7. Module software	E-EEG						
	N-EEG						
8. Communication and memories of module	☐	☐	☐	9. Communication and memories of headbox	☐	☐	☐
10. Membrane keys	☐	☐	☐				
11. Impedances				Measured value	Allowed range		
Channel 1					9...11 kOhm		
Channel 2					9...11 kOhm		
Channel 3					9...11 kOhm		
Channel 4					9...11 kOhm		
Notes							

12. Checks with simulator		Measured value	Allowed range
Waveforms			195...205 μV_{pp}
MF			9.5...10.5 Hz
Amp value			68...74 µV
13. FEMG value		Measured value	Allowed range
	FEMG		13...19 µV
	OK **N.A.** **Fail**		**OK** **N.A.** **Fail**
14. AEP stimulation	☐ ☐ ☐		
15. AEP response		Measured value	Allowed range
Channel 1			35...45 µV
Channel 2			35...45 µV
16. Electrical safety check	☐ ☐ ☐	17. Functioning after electrical safety check	☐ ☐ ☐
18. Final cleaning	☐ ☐ ☐		

Notes

Used spare parts			

Signature

BIS Module, E-BIS (Rev. 01)

Technical Reference Manual Slot

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EC

CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner. Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1208507-005

May 18, 2011

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the BIS Module, E-BIS. The BIS module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

BIS and the BIS logo are trademarks of Aspect Medical Systems Inc., and are registered in the USA, EU and other countries. Later in this manual Aspect Medical Systems Inc. will be referred to as Aspect.

The BIS module is indicated for monitoring the state of the brain by data acquisition of EEG signals. BIS may be used as an aid in monitoring the effects of certain anesthetic agents. The raw EEG signals are processed to produce a single number, ranging from 100 for a patient being wide awake to 0 in the absence of brain activity.

Calculated parameters are:

- Bispectral Index, BIS
- Suppression Ratio, SR
- Electromyograph EMG
- Signal Quality Index, SQI

The calculated parameters can be selected on the display, and trended (excluding SQI).

The module has two user keys,  for ***BIS*** menu and  for sensor check.

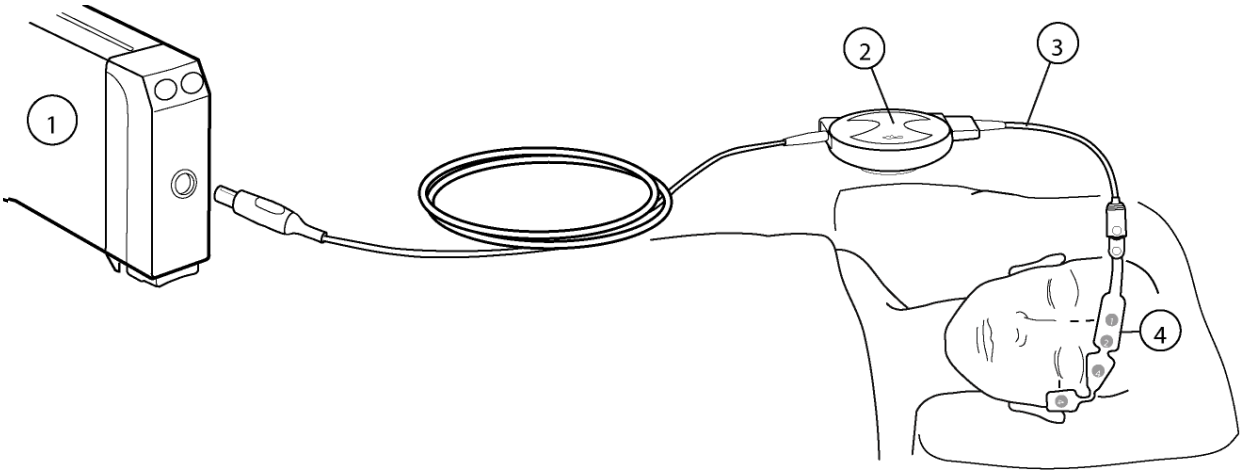


Figure 1 Measurement setup

(1) Module with BIS measurement capability, E-BIS
(2) Digital Signal Processing Unit, BISx
(3) Patient Interface Cable, PIC plus
(4) BIS Sensor

Monitor software compatibility

E-BIS module requires monitor software version 02 or later.

Accessories

The BIS measurement is based on Aspect Medical Systems Inc. technology, and all accessories are developed and manufactured by Aspect.

NOTE: Only Aspect accessories can be used with the E-BIS module.

1 Specifications

1.1 General specifications

1.1.1 BIS Module

Module size, W × D × H	37 × 189 × 112 mm / 1.5 × 7.4 × 4.4 in
Module weight	0.3 kg / 0.7 lb.
Power consumption typical	2.3 W

1.1.2 BISx Digital Signal Processing Unit

Dimensions (diameter, thickness)	95 mm, 63 mm (3.75 in, 2.5 in)
Weight	0.284 kg / 0.6 lb
Integral BISx unit Cable length	2.7 m / 9 ft
Patient Interface Cable (PIC Plus) length	1.4 m / 4.5 ft

1.1.3 Environmental specifications

Operating temperature	+10 to +40°C
Storage temperature	-25 to +70°C
Relative humidity	10 to 95%, non-condensing
Atmospheric pressure	700 to 1060 mbar
Protection against electrical shock	Type BF (BISx)

1.2 Technical specifications

1.2.1 Parameter specifications

BIS EEG

Epoch duration	2 s
Artifact rejection	automatic
EEG scales	25 to 400 μV
EEG sweep speeds	12.5 / 25 / 50 mm/s
Bispectral index (BIS)	0 to 100
Signal quality index (SQI)	0 to 100
EMG	30 to 80 db (70 to 110 Hz)
Suppression ratio (SR)	0 to 100%
Update rate	1 s for BIS index
Filters	ON (2 to 70 Hz with notch), OFF (0.25 to 100 Hz)
Smoothing rate	15 s, default in S/5 AM and CAM 30 s, default in S/5 CCM and CCCM

BISx Digital Signal Processing Unit

Analog to digital converter	noise-shaped sigma-delta
Sampling rate	16 384 samples/second
Resolution	16 bits at 256 samples/second
Input impedance	> 50 Mohms typical
Noise	< 0.3 μV RMS (2.0 μV peak-to-peak) 0.25 to 50 Hz

Common mode rejection	110 dB at 50/60 Hz to earth ground (isolation mode)
Bandwidth	0.25 to 100 Hz (-3 dB)

2 Functional description

2.1 Measurement principle

The BIS measurement is based on EEG signals, these are processed as the BIS index. The BIS sensor is placed on the patient's forehead to acquire the high-resolution signals required. These EEG signals are transferred to the BISx Digital Signal Processing Unit that amplifies and digitizes the EEG signal. The BISx unit calculates the BIS index and sends the signal and the index to the module. Then the module sends both the signal and the index to the monitor via MBUS.

2.1.1 BIS measurement on the monitor screen

The waveform field shows the BIS EEG waveform. The following BIS related data appears in digit fields and graphical trends (except SQI):

BIS number indicates the patient's level of hypnosis, ranging from 100 for wide awake to 0 in the absence of brain activity.

Signal Quality Index (SQI) bar graph indicates the quality of the EEG signal in the range of 0 to 100.

Electromyograph (EMG) bar graph represents the absolute power in the 70 to 110 Hz frequency band and ranges from 30 to 55 dB. This frequency band contains power from muscle activity (electromyograph) as well as power from high frequency artifacts.

Suppression ratio (SR) number indicates the percentage of suppressed (flat line) EEG detected over the last 63 seconds. It ranges from 0 to 100%.

2.2 Sensor check

Sensor check is performed automatically at the beginning of each case when the sensor is attached to the patient interface cable (monitor). An initial 'Checking sensor' message is shown in the digit field together with an appropriate sensor picture. The information on the passed or failed sensor check is shown on this picture at each electrode's location. The BIS measurement cannot continue if the first sensor check fails. In such a case a message 'Sensor check failed' is shown in the digit and waveform field.

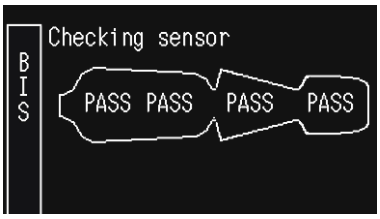


Figure 2 BIS sensor check

Continuous checking of the reference and signal electrodes and periodic checking of the ground electrode are performed by default. The automatic check can be switched off by selecting OFF in the BIS Setup menu, and the message 'Automatic check off' appears on the screen. Sensor check can be started manually by pushing a module key or selecting the appropriate command from the menu. Manual sensor check can be useful e.g. when AEP's are being monitored at the same time, as continuous sensor check might disturb the AEP measurement.

During periodic ground checks, the signal disappears momentarily and the message 'Checking sensor' is displayed in the digit and waveform fields. Also, all BIS calculation stops during this check, and no measurement values are shown.

CAUTION Continuous impedance check may need to be disabled if the 1 nA 128 Hz impedance check signal interferes with other equipment such as evoked potential.

WARNING **Make sure that the electrodes, sensor and connectors do not touch any electrically conductive material, including earth.**

2.3 Main components

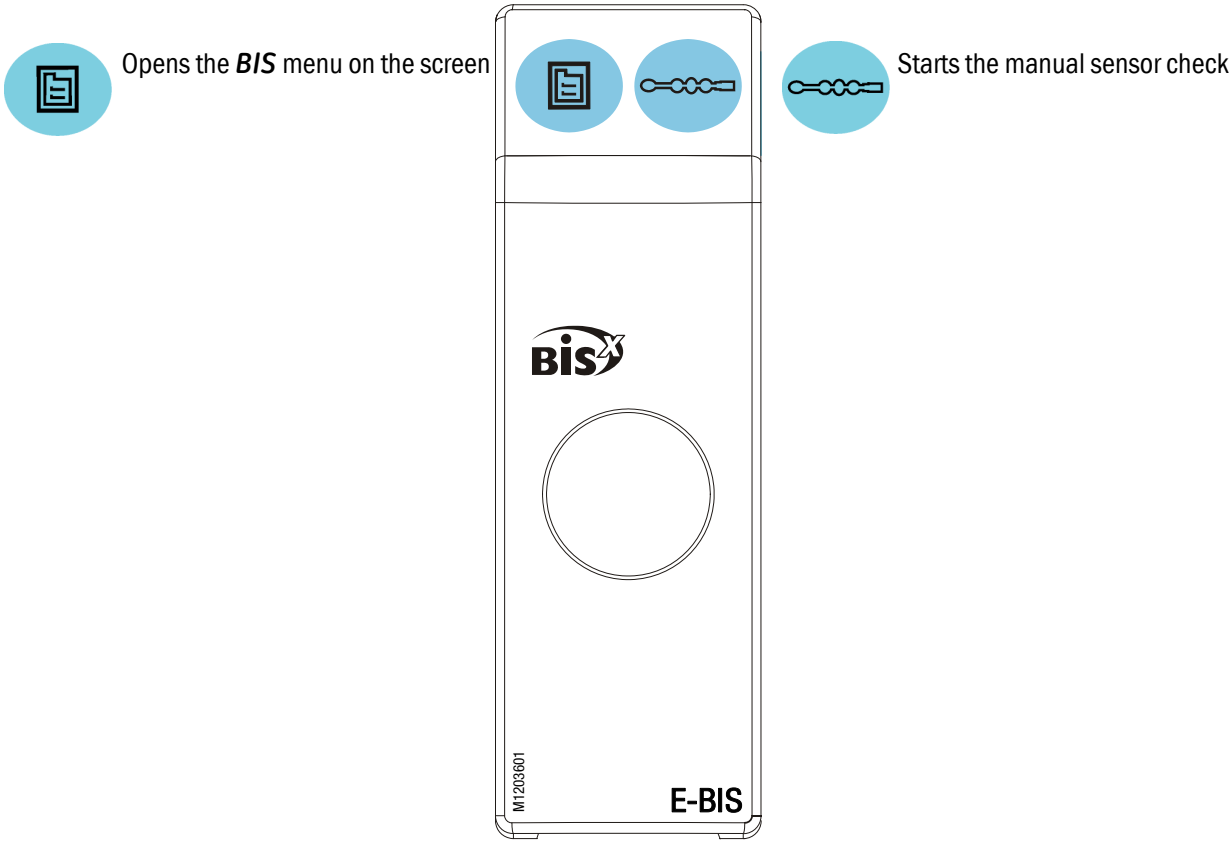


Figure 3 Front panel of BIS Module, E-BIS

The BIS measurement chain is composed of BIS sensor, BISx Digital Signal Processing Unit, E-BIS module containing an interfacing board, and a host monitor. A block diagram of the system is shown below.

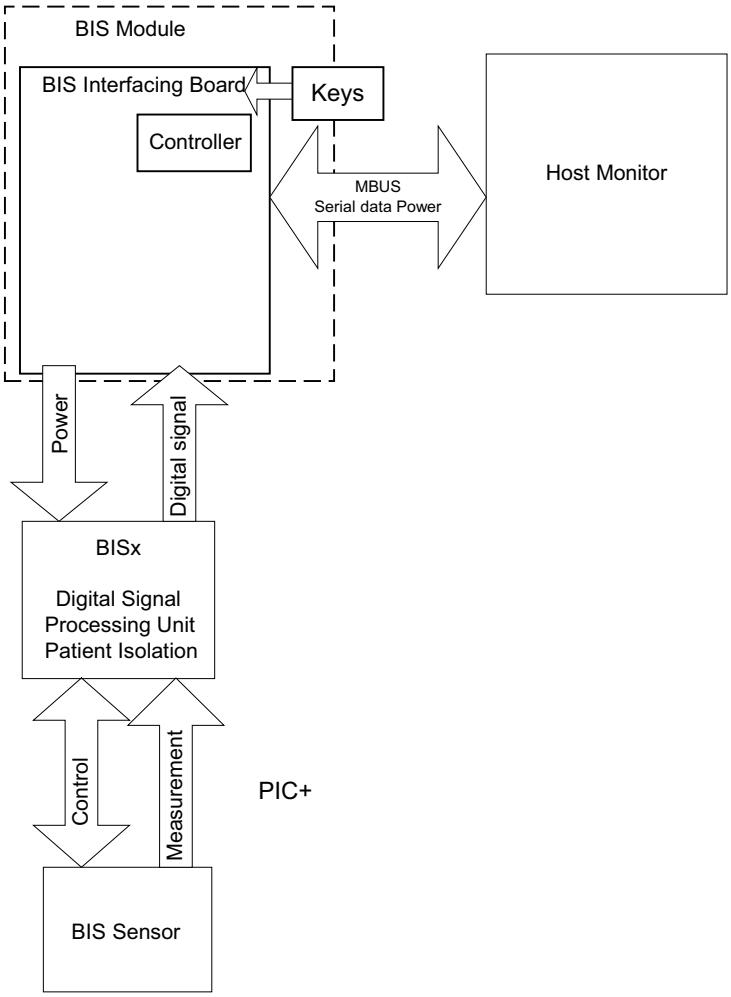


Figure 4 BIS measurement system block diagram

2.3.1 BISx Digital Signal Processing Unit

BISx Digital Signal Processing Unit receives, amplifies and digitizes patient EEG signals. It is placed close to the patient's head where the EEG signal is less subject to interference from other medical equipment. The digital signal converter is connected to the module with a 2.7 m long shielded cable and to the BIS sensor with a 1.2 m long patient interface cable, see Measurement setup. For BIS Sensor related documentation refer to BIS documentation by Aspect, Inc.

WARNING **Do not autoclave the BISx Digital Signal Processing Unit with steam or sterilize with ethylene oxide. Do not open it for any reason.**

WARNING **When using the electrosurgery unit, ensure proper contact of the ESU return electrode to the patient to avoid burns at monitor measurement sites. Also ensure that the ESU return electrode is near the operating area.**

WARNING **Radiated field strengths above 1V/m may cause erroneous measurements at various frequencies. Do not use electrical radiating equipment close to the BISx Digital Signal Processing Unit.**

2.3.2 BIS Module

BIS interfacing board

The BIS interfacing board supplies data from the BISx Digital Signal Processing Unit to the monitor via a module bus. In addition, the module accepts commands from the monitor via the module bus. The module also provides supply voltages and all the required control signals to the BISx Digital Signal Processing Unit.

The controller H8 has on-chip RAM and FLASH ROM, external SRAM and EEPROM.

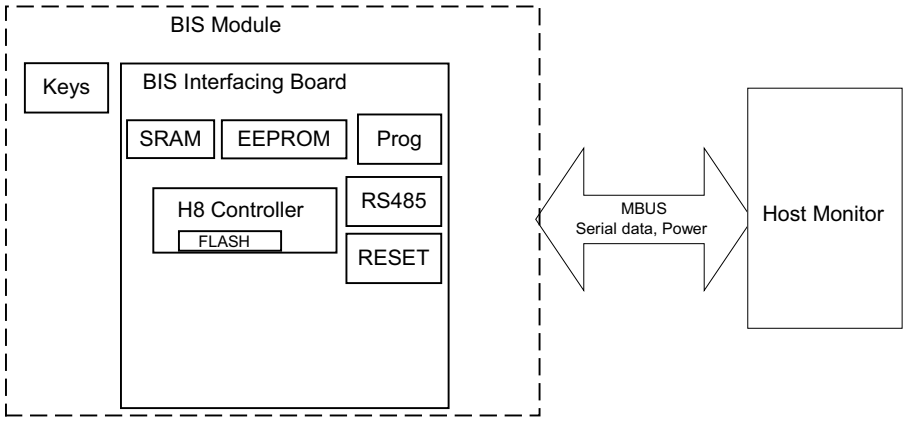
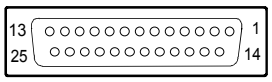


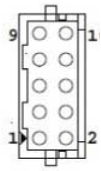
Figure 5 Block diagram of setup

2.4 Connectors and signals

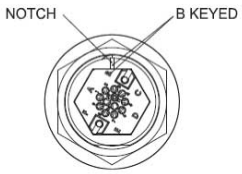
2.4.1 Module bus connector

Module bus connector (X1)	Pin No.	Name	Description
	6	Data_ RS485	Module Bus Data +
	5	Ndata_ RS485	Module Bus Data -
	3	+15VD	+15V Supply voltage
	7	GND	Ground
	13	GND	Ground
	15	GND	Ground
	Other	NC	Not Connected

2.4.2 BISx communication connector

Connector	Pin No.	Name
	1	GND
	2	PWR +5V
	3	PWR +5V
	4	PWR +5V
	5	RXD / USB+
	6	TXD / USB-
	7	Reset
	8	Baud Select
	9	Monitor Select
	10	GND

2.4.3 BISx Digital Signal Processing Unit connector

Connector	Pin No.	Name
	1	GND
	2	PWR +5V
	3	PWR +5V
	4	PWR +5V
	5	RXD / USB+
	6	TXD / USB-
	7	Reset
	8	Baud Select
	9	Monitor Select
	10-12	GND

3 Service procedures

3.1 General service information

The field service of the E-BIS is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

The BIS Simulator (order No. 900509) is recommended for functional checks.

WARNING **Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.**

3.2 Service check

These instructions include complete procedures for a service check. The service check is mandatory after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which may be used when performing the procedures.

The symbol  in the instructions indicates that the check form contains space to record the results of the particular procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
BIS Simulator or BIS Sensor simulator	900509 900508	
Torx screwdriver, T10		

3.2.2 Visual inspection

1. External parts

   Check that:

   - the front cover is intact
   - connectors are intact and attached properly
   - the module box and latch are intact

2. Check the external parts of BISx unit
   - the cover and the panel stickers are intact
   - cables and their connections are intact

   Do not connect the BISx unit to the module yet.

3.2.3 Functional inspection

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that information regarding the BIS measurement is shown:

Monitor Setup - ***Screen 1 Setup – Waveform Fields – Field1 – BIS EEG***
Others – ***BIS – Scale - 100uV***
Others – ***BIS – Smoothing Rate 15s***

3. Installation

   Plug in the module. Check that it goes in smoothly and engages properly.

4. Recognition of BISx unit

   Connect the PIC+ cable to the BISx unit.

   Connect the BISx unit to the module.
   - Check that the BISx unit is recognized (BISx unit related data appears on the page)
   - Check that 'No sensor' appears in the selected waveform field.

5. Module software

   Enter the service menu:

   Monitor Setup - *Install/Service* (password 16-4-34) **- *Service*** (password 26-23-8)

   Record the information regarding the module software of E-BIS by selecting ***Scroll vers*** and turning the ComWheel.

NOTE: BISx unit related data will appear only when the BISx unit is connected for the first time after start-up.

6. Communication and memories of module

   Enter the BIS module service menu:

   Parameters - More... - BIS

   Check that the Mod Mon Time-outs, Mon Mod Bad checksums, Mod Mon Bad Checksums, Bad Checksums from BIS values in the module view are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK.

7. Membrane keys

   Check the membrane keys of the module. Stay in the module view and press each key for at least one second and check that the key being pressed is identified, i.e. the corresponding 'PUSHED' text appears in the BIS module service menu.

8. Message from BE

   Check that Messages from BE are increasing steadily.

9. Sensor ID

   Go to the Sensor page.

   Check that:

   - no sensor is identified
   - mains frequency is set correctly
   - check that BE power-up test, DSC selftest Ch1 and DSC selftest Ch2 all show PASS
   - (if not, go to BIS Setup page, perform DSC Test and check the results again)

10. Sensor check

    Connect the BIS simulator to the PIC+ cable. See that 'Checking sensor' text and an image appear. Wait for a while and check that all sensors show PASS. Check that the Sensor type shows Demo Sensor.

11. Checks with simulator

    Check that the BIS, SQI and SR values are between 0 to 1000, and the EMG value between 0 to 10000.

NOTE: If Sensor simulator 900508 is used, the values can be out of the given range.

12. Sensor check

    Perform sensor check by pressing  and verify that the sensor shows PASS.

13. Electrical safety check

    Perform an electrical safety check and a leakage current test.

14. Functioning after electrical safety check

    Check that the module functions normally after performing the electrical safety check.

15. Final cleaning

    Clean the module with suitable detergent.

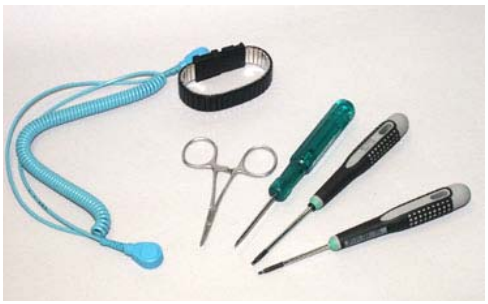
- Fill in all necessary documents.

3.3 Disassembly and reassembly

3.3.1 Before disassembly

WARNING **Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board. Handle all PC boards by their edges.**

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the E-BIS module (see the exploded view of the module in the "E-Modules Spare Parts" slot):

1. To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.
2. Remove the two screws (T10) from the back of the module.
3. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
4. Detach the interface board by removing the two screws located near the front panel frame, disconnect the cable and pull out the front panel frame.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure to reconnect all cables properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	Cause	What to do
No BIS waveforms on screen.	BIS waveforms not selected on screen.	Press **Monitor Setup** key and select BIS waveforms on the screen.
Sensor check is not available on menus.	Sensor is not connected to the BISx unit or BISx unit is not connected to the module.	Connect the sensor and the BISx unit.
Sensor check fails.	Sensor poorly attached.	Attach the sensor by following the sensor instructions.

4.2 Messages

The messages below appear in the BIS digit field (DF), BIS waveform field (WF) or the message field (MF) at the upper section of the patient monitor display.

Message	Location	Cause	What to do
No Sensor No BIS Sensor	DF MF	Sensor is not connected to PIC+ cable or PIC+ cable is not connected to the BISx unit.	Connect the sensor to the PIC+ cable. Connect the PIC+ cable to the BISx unit. Replace sensor and then PIC+ cable.
Incompatible sensor	DF	Sensor is not recognized. Sensor is not a BIS sensor.	Connect correct type of sensor. Make sure PIC connector is clean and dry.
Incompatible DSC	DF	Current module hw/sw is incompatible with the BISx Digital Processing Unit.	Connect correct type of BISx unit.
Sensor check failed BIS sensor check failed	DF MF	Sensor check failed, one or more of the electrode impedances exceeds the threshold.	Reattach the sensor to the patient by following the sensor instructions. Replace the sensor. Check PIC+ cable and then BISx unit.
Poor signal	DF	Artifacts, or the amount of EMG activity prevents calculating BIS, data excluded. SQI < 50	Check the sensor, then the PIC cable. Reattach the sensor to the patient by following the sensor instructions.
Checking sensor		Sensor check in progress. Can be either the initial sensor check, manual check or the periodic check.	Wait until the check has been performed.
'Checking sensor' message stays more than 2 min.	DF	Sensor check fails, the sensor is not attached to the patient while connected to the PIC+ cable.	Attach the sensor to the patient and press the Check Sensor button on the module front panel.

Message	Location	Cause	What to do
Automatic check off	DF	Continuous sensor checking has been turned off.	Turn the check on from the BIS menu.
Replace Sensor	DF	The sensor has passed its use by date. The sensor has been used for 24h.	Replace with a new sensor.
High BIS impedance	DF	Sensor is not attached properly to the patient.	Check the cable connections. Reattach the sensor to the patient by following the sensor instructions.
Artifact	DF	Non-EEG data such as EMG, eye blinks or shivering present.	Wait for good data.
Module error	DF	BISx unit failure. For more information see service page description.	Replace the BISx unit.
DSC Error	DF MF	The BISx unit is not communicating or operating properly. This may occur during the use of electrocautery device. For more information see service page description.	Replace the BISx unit.
Demo data	MF	BIS simulator is connected.	Disconnect the BIS simulator.

4.3 Troubleshooting flowchart

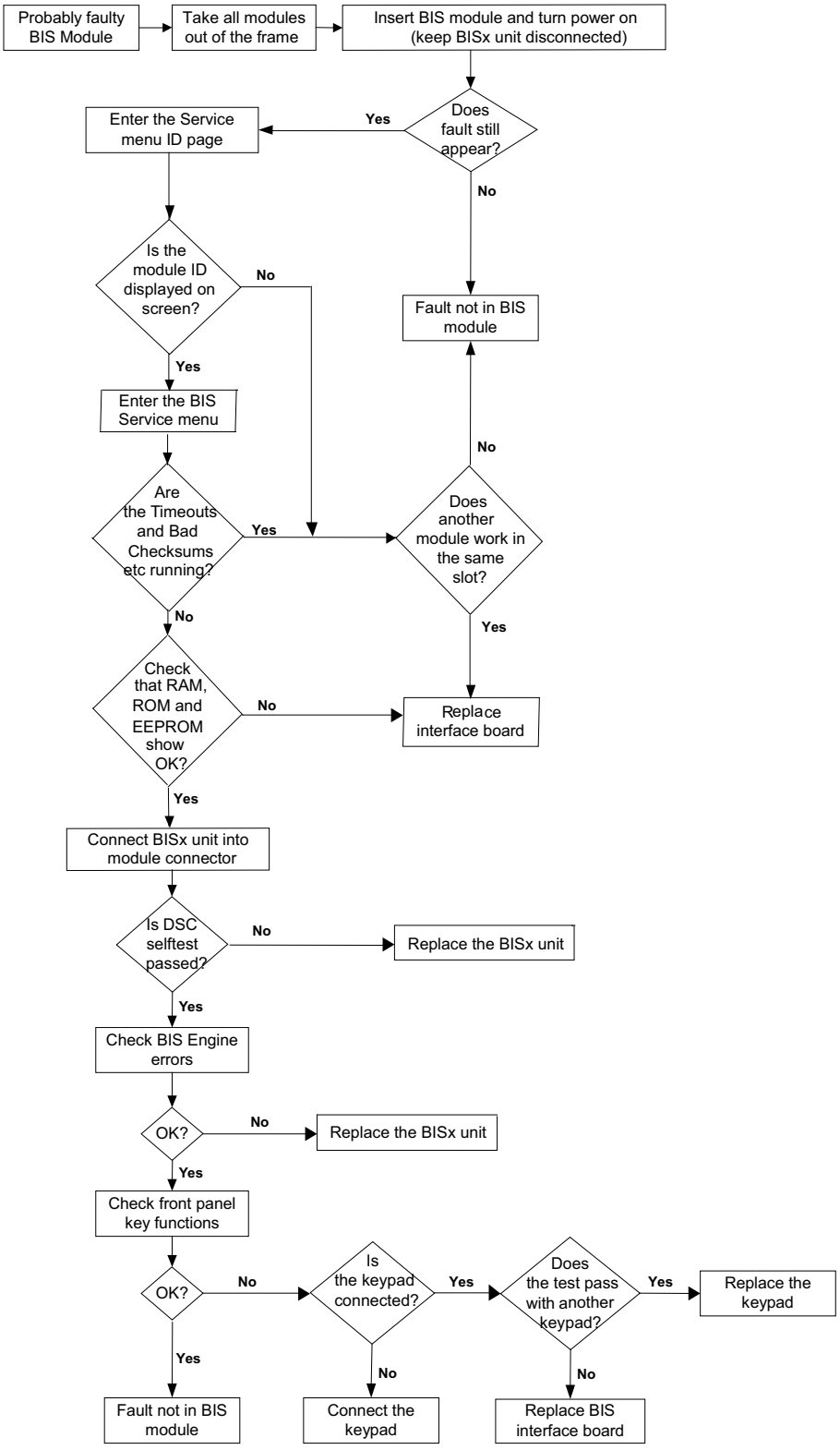


Figure 6 BIS module troubleshooting flowchart

5 Earlier revisions

BIS Module, E-BIS (Rev. 00)

APPENDIX A: Service check form, BIS Module, E-BIS (Rev. 01)

Customer		
Service	Module type	S/N
Service engineer		Date

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. External parts	☐	☐	☐	2. Check the external parts of BISx unit	☐	☐	☐
Notes							
Functional inspection							
3. Installation	☐	☐	☐	4. Recognition of BISx unit	☐	☐	☐
5. Module software	E-BIS						
6. Communication and memories of module	☐	☐	☐	7. Membrane keys	☐	☐	☐
8. Message from BE	☐	☐	☐	9. Sensor ID	☐	☐	☐
10. Sensor check	☐	☐	☐				
Notes							

Functional inspection		
11. Checks with simulator	Measured value	Allowed range
BIS		0 to 1000
SQI		0 to 1000
SR		0 to 1000
EMG		0 to 10000

	OK	N.A.	Fail		OK	N.A.	Fail
12. Sensor check	☐	☐	☐	13. Electrical safety check	☐	☐	☐
14. Functioning after electrical safety check	☐	☐	☐	15. Final cleaning	☐	☐	☐

Notes

Used spare parts			

Signature

Datex-Ohmeda

S/5 NeuroMuscular Transmission Module, E-NMT (Rev. 00)

Technical Reference Manual Slot

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EEC.

CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner. Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1027834-02

January 21, 2011

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the NeuroMuscular Transmission Module, E-NMT. The E-NMT module is a single width plug-in module designed for use with the Datex-Ohmeda Anesthesia and Compact Anesthesia Monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The module contains peripheral nerve stimulation and response measurement, which supports electromyography EMG. The module can also be used as a nerve locator for regional nerve blocking with a regional block cable. However, in this case there is no response measurement.

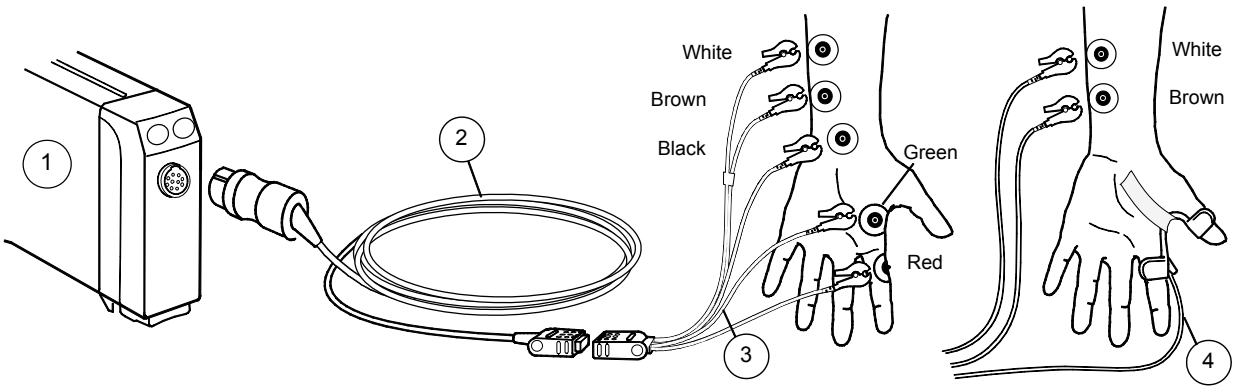


Figure 1 NMT Setup

(1) Module measuring NMT
(2) NMT sensor cable
(3) ElectroSensor
(4) MechanoSensor

Monitor software compatibility

The E-NMT requires monitor software S-xxx95 or later.

From the M-NMT rev.01 onwards, NMT modules have contained a memory for storing stimulus current and reference response data. The memory function requires monitor software S-xxx97 or later.

Equipment safety symbols

When displayed on the E-NMT module, indicates the following warnings:

- Do not place the NMT stimulating electrodes on the patient's chest.
- Always stop the NMT measurement before handling the stimulating electrodes.
- Never subject a patient with an implanted electronic device to electrical stimulation without consulting a medical specialist first.

1 Specifications

1.1 General specifications

Module size, W × D × H	37 x 186 x 112 mm / 1.5 x 7.3 x 4.4 in
Module weight	0.35 kg /0.8 lb.
Power consumption	3.3 W

1.2 Technical specifications

1.2.1 NMT

Stimulation modes	Train of four (TOF)
	Double burst (3.3) (DBS)
	Single twitch (ST)
	50 Hz tetanic + post tetanic count (PTC)
Measurement intervals for TOF / DBS	
	Manual; 10 s, 12 s, 15 s, 20 s, 1 min, 5 min, 15 min in AM and CAM
	Manual; 20 s, 1 min, 5 min, 15 min, 30 min, 60 min, 120 min in CCM and CCCM
Measurement intervals for ST	Manual; 1 s, 10 s, 20 s

1.2.2 Stimulator

Stimulus pulse	Square wave, constant current
Pulse width	100, 200 or 300 μs
Stimulus current range	supramax 10...70 mA, manual 10...70 mA with 5 mA steps
Stimulus current accuracy	10% or ±3 mA
Max. load	3 kΩ
Max. voltage	300 V

1.2.3 Regional block mode

Stimulation modes	Single twitch
Intervals	1 s, 2 s, 3 s
Stimulus pulse	Square wave, constant current
Pulse width	40 μs
Stimulus current range	0...5.0 mA with 0.1 mA steps
Stimulus current accuracy	20% or ±0.3 mA

2 Functional description

2.1 Measurement principle

2.1.1 Nerve stimulation

There are three stimulus modes in the NeuroMuscular Transmission Module: Train of Four (TOF), Double Burst 3,3 (DBS) and Single Twitch (ST).

In the Train of Four stimulus mode, four stimulation pulses are generated at 0.5 second intervals. The response is measured after each stimulus and the ratio of the fourth and first response of the TOF sequence is calculated (TOF%).

NOTE: If the first response does not exceed a certain signal level, TOF% is not calculated due to poor accuracy.

Double burst (3,3) stimulation includes two bursts with a 750 ms interval. Both bursts consist of three pulses separated by 20 ms intervals. The responses of both bursts are measured, and the ratio of the second and first response is calculated (DBS%). EMG responses are measured immediately after the first stimulus pulse of both bursts.

In Single Twitch stimulation, one stimulation pulse is generated. The response is measured after the stimulus. In order to prevent decurarization of the stimulated area, the measurement is automatically stopped after 5 minutes stimulation in 1 sec. cycle time.

Tetanic/PTC

Tetanic/PTC (Post Tetanic Count) can measure deeper relaxation than TOF. The tetanic stimulation is produced when Start is chosen under Tetanic/PTC. The length of stimulation is 5 seconds. The stimulation generates pulses with a frequency of 50 Hz and with a selected pulse width and current. After tetanic stimulation and a three second delay, Single Twitch stimulation is produced to detect the post tetanic count (PTC). PTC describes the number of responses detected after tetanic stimulation. If there is no response, the measurement will be stopped. If responses will not fade away, a maximum of 20 responses will be calculated. If more can be detected, the PTC value is displayed only as '> 20' and measurement will be stopped. If the TOF, DBS or ST measurement cycle was on when tetanic stimulation started, the cycle will continue after the PTC. After completing the PTC measurement during 1 minute TOF, DBS or another PTC measurement is not possible. This is to avoid erroneous readings due to post tetanic potentiation.

2.1.2 Response

Before each stimulation, the sequence offset, noise and threshold for the response detection are measured. Offset is a baseline of the noise measurement. Noise is calculated by the same algorithm as the response signal itself. The response detection threshold is calculated based on the noise, and if the response is not greater than the threshold then it is interpreted as no response.

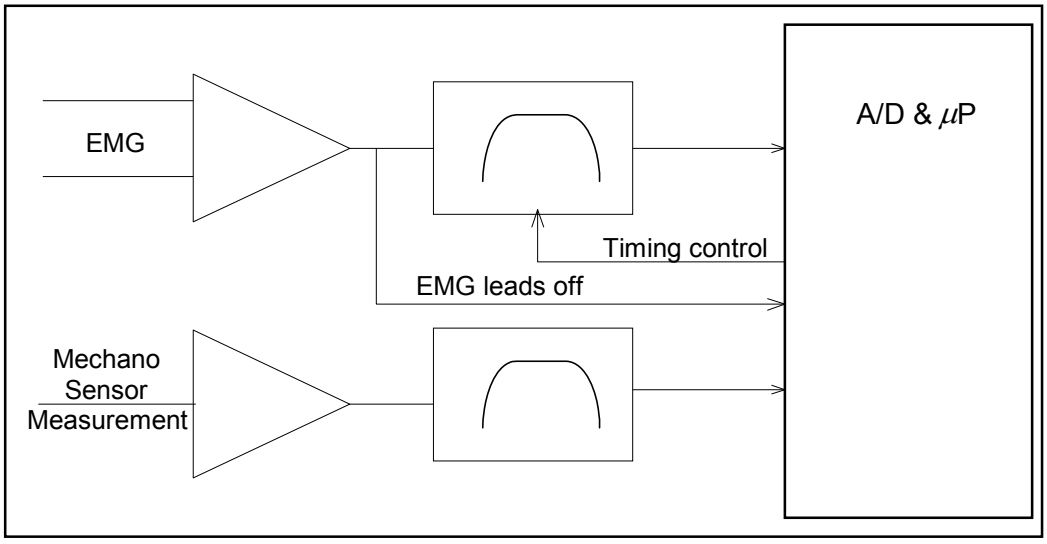


Figure 2 Principle of response measurement

EMG measurement

The EMG response is measured as integrated muscle activity. The EMG measurement starts 3 ms after the stimulation and lasts 15 ms. The 3 ms delay helps to prevent the effect of stimulation artifact.

Mechano sensor measurement

Response is measured as movement of the thumb, which is the area of positive signal.

2.1.3 Regional block

A regional block cable can be used as a nerve locator in local anesthesia. A maximum current of 5.0 mA is given every, every other or every 3rd second. The response measurement is ocular.

2.2 Main components

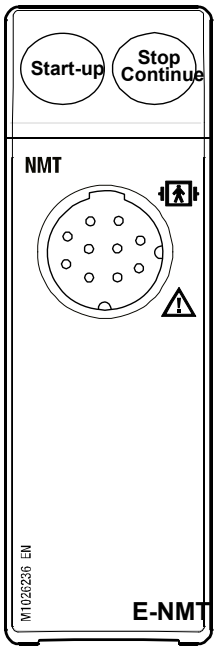


Figure 3 Front panel of NeuroMuscular Transmission Module, E-NMT

Start-up **starts the search of supramaximal current and reference level and proceeds with the selected measurement cycle.**

Stop/Continue **interrupts monitoring and restarts monitoring of the same patient.**

2.2.1 NMT board

The NMT board consists of the following functional sections:

- constant current stimulator
- measuring electronics for the EMG signals
- microprocessor for the stimulation and measuring control, and for counting the measuring results
- serial communication

The serial bus speed is 500 kbps and the bus itself is half duplex, i.e. data can be transferred in both directions but only one way at a time.

Serial communication

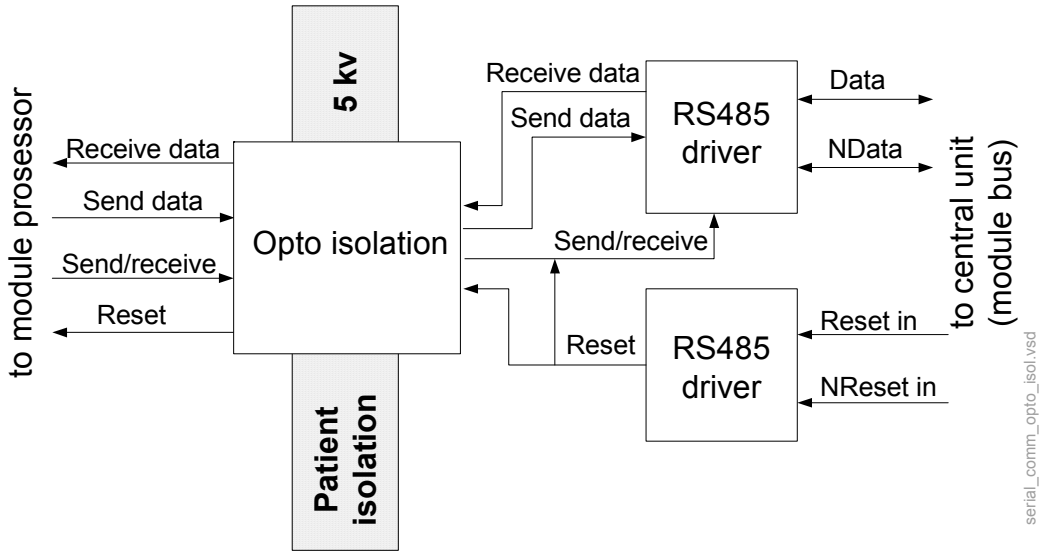


Figure 4 Serial communication and opto isolation

Stimulator

The constant current stimulator generates pulses whose amplitude is independent of the load. The main components of the stimulator are a transformer, capacitor and transistor. The transformer produces a high voltage which charges the capacitor and the transistor adjusts the pulse width and amplitude of the current.

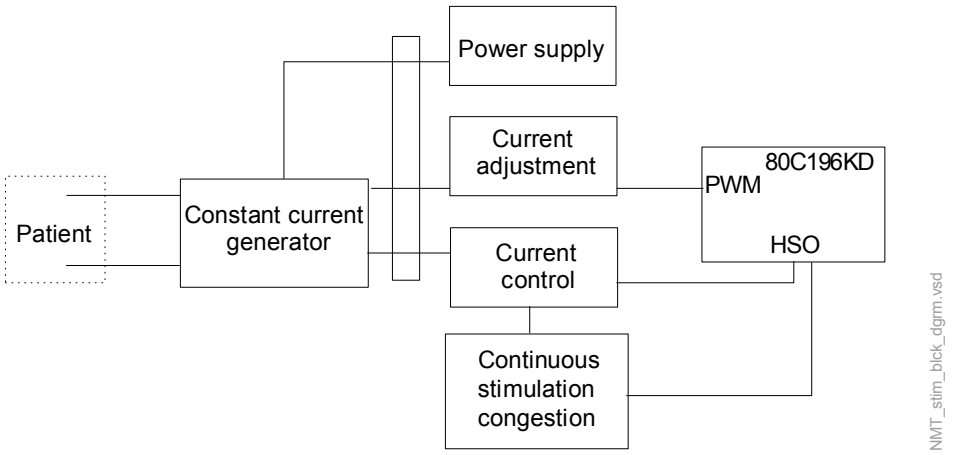
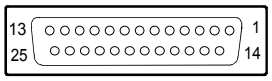


Figure 5 Stimulator block diagram

2.3 Connectors and signals

2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	1	I	RESET_RS485
	2	I	-15 VDC
	3	I	+15 VDIRTY
	4	I	+15 VDC
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	Ground & Shield
	8	I	-RESET_RS485
	9	I	CTSB
	10	O	RTSB
	11	I	RXDB
	12	O	TXDB
	13	-	Ground & Shield
	14	I	+32 VDIRTY
	15	I	GroundDIRTY
	16	I	CTSC
	17	O	RTSC
	18	I	RXDC
	19	O	TXDC
	20	-	ON/STANDBY
	21	-	PWM_ECG
	22	-	RXDD_RS232
	23	-	TXDD_RS232
	24	I	+5 VDC
	25	I	+5 VDC

2.3.2 NMT connector (NMT)

Front panel connector	Pin No.	Signal
	1	EMG Signal +
	2	EMG Signal -
	3	Not Used
	4	Stimulus +
	5	Stimulus -
	6	Ground
	8	Sensor Identification
	9	+5 V
	10	Mechanical Signal

3 Service procedures

3.1 General service information

The field service of the NeuroMuscular Transmission Module, E-NMT, is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

The NMT Simulator (order code 871251) is recommended for functional checks.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

NOTE: Use only calibrated and traceable measuring equipment.

Tool	Order No.	Notes
NMT simulator	871251	
E-NMT ElectroSensor		
E-NMT MechanoSensor		
E-NMT Sensor Cable		
3 kΩ resistor		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts
   Check that:
   - screws are tightened properly
   - cables are connected properly

- the EMC cover is attached properly
- there are no loose objects inside the module

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - connectors are intact and attached properly
   - the module box and latch are intact

   Reattach the module box and check that the latch moves properly.

3.2.3 Functional inspection

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that information regarding the NMT measurement is shown, for example:

Monitor Setup - ***Screen 1 Setup - Digit Fields - Field 4 - NMT***

Preset the NMT measurement settings:

Others - ***NMT - Stimulus Mode - TOF***
Set Cycle Time - 10 sec.
NMT Setup - Current - S(70 mA)
Pulse Width - 200 mS
Stim. Beep Volume - 2

3. Installation

   Plug in the module. Check that it goes in smoothly and locks up properly

4. Recognition

   Check that the module is recognized, i.e. the NMT header with related information appear in the chosen digit field.

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service (password 16-4-34) - Service (password 26-23-8)***

   Take down the information regarding the NMT software by selecting ***SCROLL VERS*** and turning the ComWheel.

6. Communication and memories

   Enter the NMT module service menu:

   Parameters - NMT

Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the module's memories have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK.

7. ElectroSensor recognition

   Check that the message 'Cable off' is shown in the digit field and that Cable in the Service Data field states OFF.

   Plug the E-NMT Sensor Cable with the E-NMT ElectroSensor into the front panel connector NMT. Check that the message in the digit field changes to 'Measurement OFF' and Cable in the Service Data field states EMG and ELECTR. OFF.

8. Stimulus current test

   Perform the stimulus current test.

   Connect a 3 kΩ resistor between the ElectroSensor's stimulus electrode leads (brown and white).

   Start the test by selecting ***START CURR. TEST*** on the service menu and pressing the ComWheel. Check that the test was successful with all three test currents, i.e. the ***Current test (mA):*** in the Service Data field states 30 OK, 50 OK and 70 OK.

   Connect the E-NMT ElectroSensor leads to the NMT simulator. Set the switch on the simulator to Fade off and turn the knob to max. Check that Cable in the Service Data field now states only EMG.

9. Supramaximal current

   Start NMT measurement (TOF) by pressing the **START-UP** key on the module.

   When the message 'Supramax search' changes to 'Setting reference' in the digit field, check that the supramaximal current detected is less than 70 mA, i.e. the Current set value in the Service Data field is less than 700.

10. TOF measurement with NMT simulator

    Check that the module gives four successive stimulus pulses with 10 second intervals. A small asterisk (\) should be shown in the digit field during each of the stimulus pulses and simultaneous sound signals should be heard from the loudspeaker.

    Check that in the Service Data field the values for T1%, T2%, T3%, T4% and Ratio% are all within 950-1059.

    Check also that in the digit field the TOF% value is within 95-105, Count is 4 and T1% is within 95-105.

11. Noise

    Check that the Noise value in the Service Data field stays under 100.

12. Stimulus pulse width

    Change the stimulus pulse width to 100 μs through the NMT service menu:

    NMT Setup - Pulse Width - 100 mS

    Check that the TOF% value is still within 95-105, Count is 4 and T1% is within 95-105 in the digit field.

    Check the same parameters with a stimulus pulse width of 300 s.

13. No response

    Turn the knob on the NMT simulator to 0.

    Check that in the Service Data field the values for T1%, T2%, T3%, T4% turn to 0 and the Ratio% states - - -. In the digit field TOF% should also state - - -, and Count and T1% should show 0.

    Turn the NMT simulator knob back to max.

14. DBS measurement with NMT simulator

    Change the stimulus mode to Double Burst Stimulation (DBS) through the service menu:

    NMT Setup - Stimulus Mode - DBS

    Check that the module now gives only two stimulus pulses with a 10 seconds interval.

    Check that in the Service Data field the values for T1%, T2%, and Ratio% are still within 950-1059. In the digit field the DBS% value should be within 95-105, Count is 2 and T1% is within 95-105.

15. ST measurement with NMT simulator

    Change the stimulus mode to Single Twitch Stimulation (ST):

    NMT Setup - Stimulus Mode - ST

    Check that the module starts to give only one stimulus pulse with a 1 second interval. Note the time when the ST stimulation started.

    Check that in the Service Data field the value for T1% is within 950-1059. In the digit field, the Count value should be 1 and T1% within 95-105.

    Let the monitor continue to give single twitch stimulation.

16. Automatic measurement off

    Check that the NMT measurement stops and the message 'Measurement OFF' appears in the digit field for NMT five minutes after the start of the ST stimulation.

17. MechanoSensor recognition

    Replace the E-NMT ElectroSensor with the E-NMT MechanoSensor and check that Cable in the Service Data field states PIEZO.

18. Electrical safety check
    Perform an electrical safety check and a leakage current test.

19. Functioning after electrical safety check
    Check that the module functions normally after performing the electrical safety check.

20. Final cleaning
    Clean the module with suitable detergent.

- Fill in all necessary documents.

3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.4 To disassemble the module

To disassemble the NeuroMuscular Transmission Module, E-NMT (see the exploded view of the NMT Module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Detach the NMT board by removing the two screws located near the front panel frame, disconnect the cables and pull out the front panel frame.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

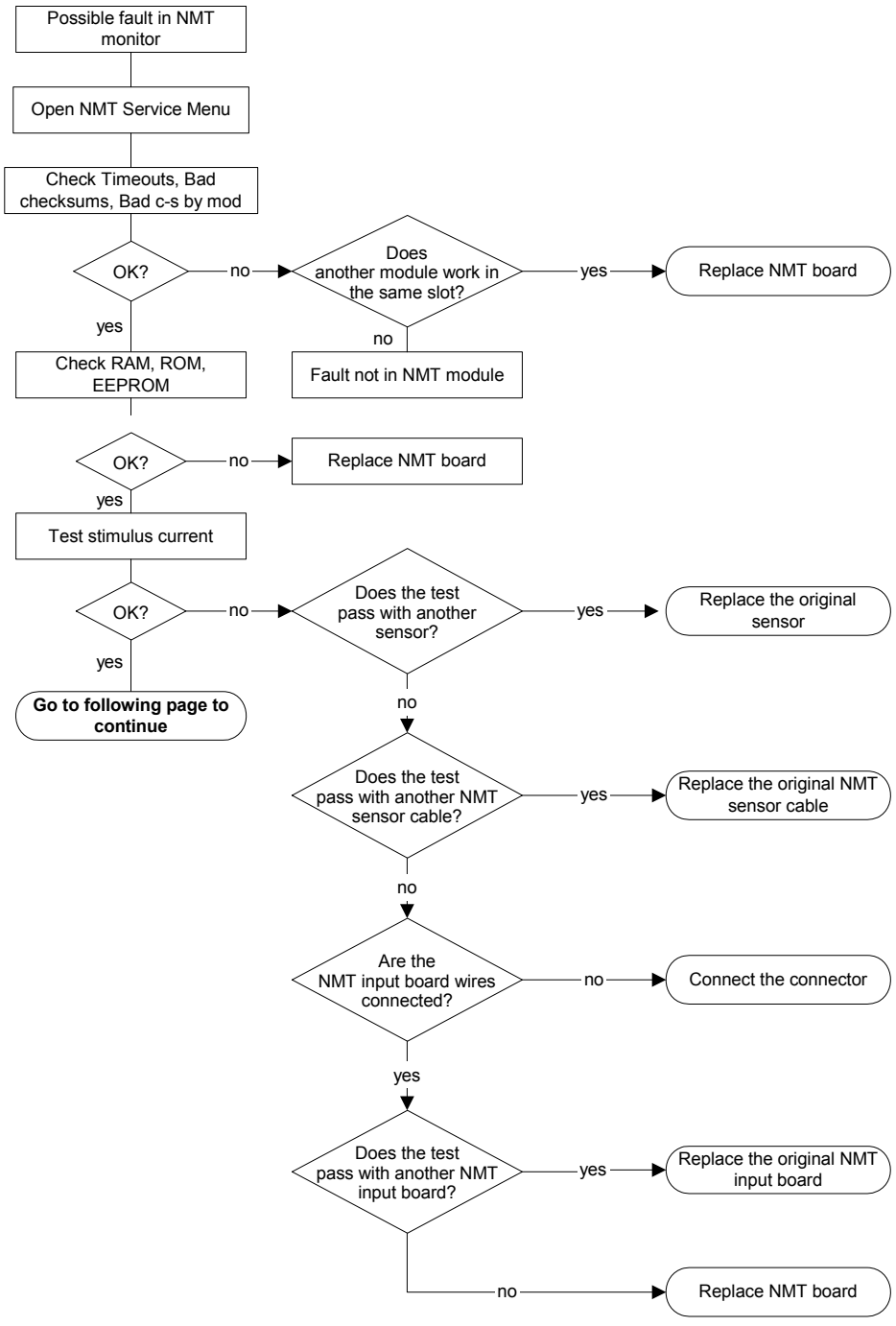
Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	Cause	What to do
Check the stimulus electrodes. EMG electrode off.	Loose electrodes or loose stimulus clip.	Change or attach the electrodes or clip.
Supramax. not found.	Loose electrodes or loose stimulus clip. Stimulus electrodes attached to wrong place. Patient is relaxated.	Change or attach the electrodes or clip. Change the place of the stimulus electrode.
Response too weak.	Loose stimulus electrodes. Measuring electrodes attached to wrong place. Patient is relaxated.	Change or attach the electrodes. Change the place of the meas. electrodes.
Ref. not stable.	Patient is relaxated. Movement artifact.	Start measurement with fixed current without reference measurement.

4.2 Troubleshooting flowchart



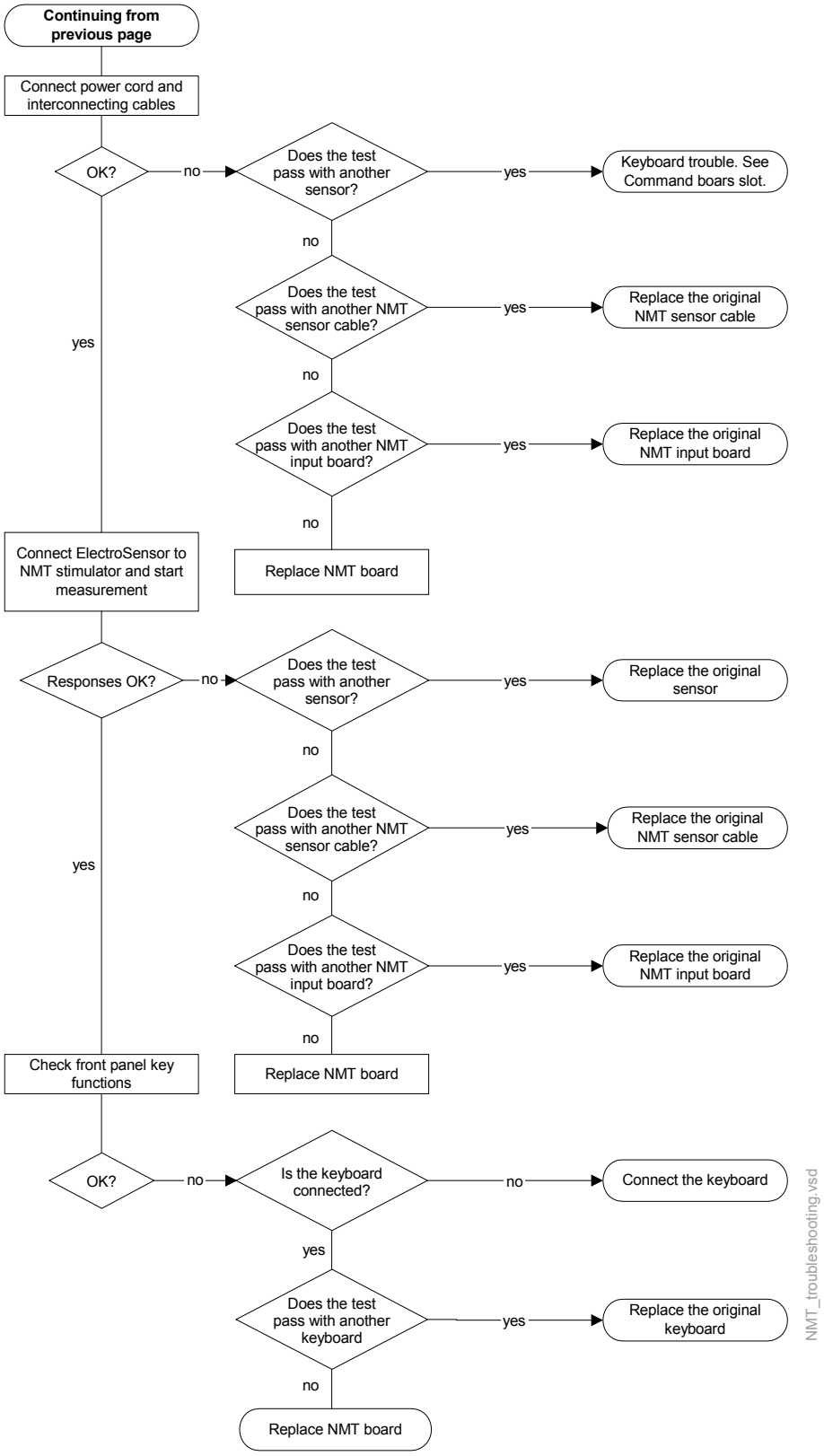


Figure 6 Module troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5 NeuroMuscular Transmission Module, E-NMT.

APPENDIX A: Service check form, NeuroMuscular Transmission Module, E-NMT

Customer		
Service	Module type	S/N
Service engineer		Date

Measuring equipment / test gases used:				
Equipment / tool / gas:	Manufacturer:	Model/Type/Part Number:	Serial Number / ID:	Calibration Date:

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Functional inspection							
3. Installation	☐	☐	☐	4. Recognition	☐	☐	☐
5. Module software	NMT						
6. Communication and memories	☐	☐	☐	7. ElectroSensor recognition	☐	☐	☐
8. Stimulus current test	☐	☐	☐				
9. Supramaximal current					<70 mA		
10. TOF measurement with NMT simulator				Measured value	Allowed range		
T1%					950...1059		
T2%					950...1059		
T3%					950...1059		
T4%					950...1059		
Ratio%					950...1059		
TOF%					95...105		
Count					4		
T1%					95...105		

				Measured value	Allowed range		
11. Noise					<100		
12. Stimulus pulse width		100		300	Allowed range		
TOF%					95...105		
Count					4		
T1%					95...105		
		OK	**N.A.**	**Fail**			
13. No response		☐	☐	☐			
14. DBS measurement with NMT simulator				Measured value	Allowed range		
T1%					950...1059		
T2%					950...1059		
Ratio%					950...1059		
DBS%					95...105		
Count					2		
T1%					95...105		
15. ST measurement with NMT simulator				Measured value	Allowed range		
T1%					950...1059		
Count					1		
T1%					95...105		
		OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
16. Automatic measurement off		☐	☐	☐	17. MechanoSensor recognition	☐	☐	☐
18. Electrical safety check		☐	☐	☐	19. Functioning after electrical safety check	☐	☐	☐
20. Final cleaning		☐	☐	☐				

Notes

Used spare parts			

Signature

Datex-Ohmeda

S/5™ Device Interfacing Solution, N-DISxxx (Rev. 00)

S/5™ Device Interfacing Solution, N-DISxxx (Rev. 01)

Technical Reference Manual

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027835
December, 2005

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Introduction

This “Technical Reference Manual” slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Device Interfacing Solution, N-DISxxx. Later in this manual modules may be referred to without S/5 for simplicity.

Please also refer to the “Installation Guide” accompanying each module.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The purpose of the Device Interfacing Solution is to produce a data connection between an external bedside device and a Datex-Ohmeda modular monitor.

The N-DISxxx is a new interfacing solution and it works beside the previous interface solutions, E-INT, M-INT and B-INT that are still available.

Up to 10 devices can be connected simultaneously via device specific N-DISxxx modules. No Device Interfacing Solution is called N-DISxxx, but the xxx are replaced with a device specific ending such as N-DISQVUE and N-DISOPT.

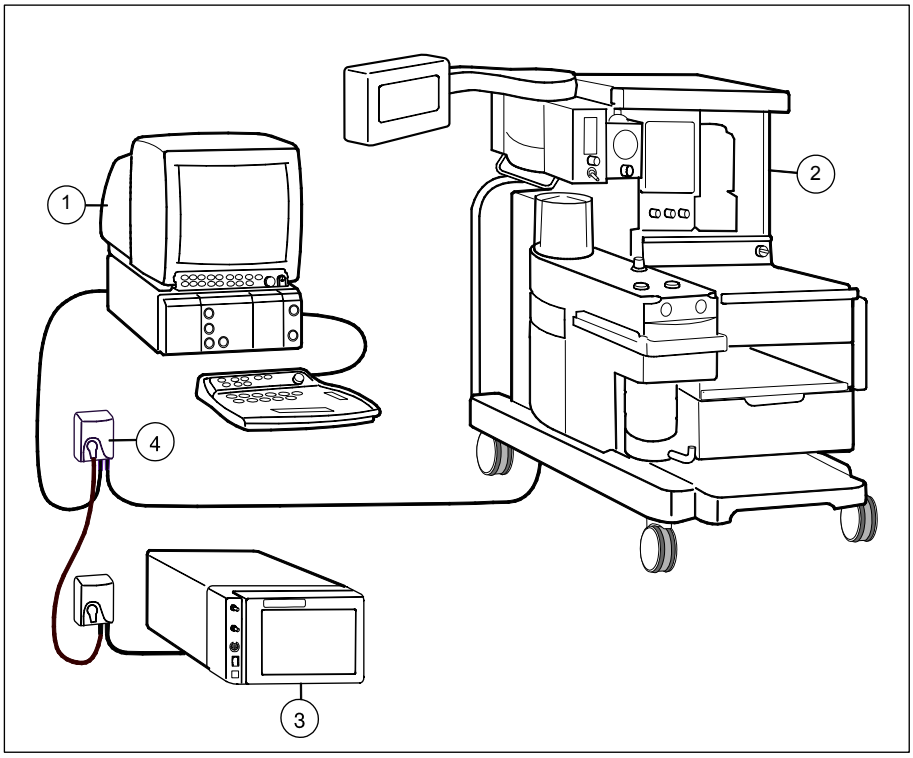


Figure 1 An example of interfacing external devices with Device Interfacing Solution

(1) Datex-Ohmeda S/5 Anesthesia Monitor (with software L-ANE01(A) or later)

(2) Aestiva3000 Anesthesia machine

(3) RGM monitor

(4) DIS module (max. 10 pcs)

Monitor compatibility

The Device Interfacing Solution requires the following monitor software versions:

- S/5 Anesthesia Monitor with software version L-ANE01 or later
- S/5 Critical Care Monitor with software version L-ICU01 or later
- S/5 Compact Anesthesia Monitor with software version L-CANE02 or later
- S/5 Compact Critical Care Monitor with software version L-CICU02 or later

The Device Interfacing Solution requires B-UPI4(NET) or later.

1 Specifications

1.1 Environmental specification

Operating temperature	+10...+35 °C (50...95 °F)
Storage and transport temperature	-10...+50 °C (14...122 °F)
Relative humidity	10...90% (non condensing)
Atmospheric pressure	660...1060 hPa (66...106 kPa/660...1060 mbar/500...800 mmHg)

1.1.1 Protection against ingress of liquids

According to IEC/EN 60592 class IPX 1.

The DIS module must always be used in vertical position to prevent water from entering the module.

1.2 Technical specifications

1.2.1 General

Max 10 DIS modules or 10 m (33 ft) cable length.

Module

Size (W × D × H)	60 × 27 × 85 mm/2.4 × 1.1 × 3.4 in
Weight	0.1 kg/0.2 lb.

Bus cables

8-pin Hirose HR12/HR212 connector

Material	black PVC
Length/Weight	1 m/47 g (39 in/3.3 ft./0.104 lb.) 2 m/85 g (79 in/6.6 ft./0.187 lb.) 6 m/220 g (236 in/19.7 ft./0.485 lb.)

Device cables

Depends on device.

Material	elastollan
Length	0.5...1 m (19...39 in/1.6...3.3 ft.)
Weight	40...70 g (0.088...0.154 lbs.)

1.3 Electrical specification

There is no isolation in the DIS module. The interfaced device, DIS module and the monitor must be situated in the same patient environment (as defined in IEC 60601-1-1).

WARNING **Connecting electrical equipment together or using the same extension cord for more than one device may cause their leakage currents to exceed the limit specified in relevant safety standards. Always make sure that the entire combination complies with the international safety standard IEC 60601-1-1 for medical electrical systems and with the requirements of local authorities.**

1.4 Maximum power consumption

450 mW (30 mA @ 15 V) 900mW peak.

1.5 Module communication

Bus communication speed is 500 kbps. RS422 implementation.

Device communication speed depends on the interfaced external device. RS232 implementation.

2 Functional description

The S/5™ Device Interfacing Solution provides a seamless link between external patient care devices and the Datex-Ohmeda S/5 Monitoring system. You can interface simultaneously up to ten external devices: monitors, ventilators, blood gas analyzers, etc.

The Device Interfacing Solution is designed for use with the S/5 Anesthesia Monitor and Compact Anesthesia Monitor, and S/5 Critical Care Monitor and Compact Critical Care Monitor. The Device Interfacing Solution (DIS) is only compatible with the S/5 Anesthesia and S/5 Critical Care Monitor, when the monitor has B-UPI4(NET) and B-CPU4 boards installed. Also, DIS is only compatible with the S/5 version (i.e. F-CM(REC)1 frame) of the Compact Anesthesia and Compact Critical Care monitor. In addition, the S/5 Monitors must be equipped with DIS compatible main software. The Device Interfacing Solution, N-DISxxx, cannot be used with AS/3 and CS/3 Compact Monitors.

WARNING **The manufacturer guarantees a reliable functioning of the devices with tested software versions only. Always refer to the Installation guide accompanying the DIS module and verify the compatibility before use.**

2.1 Main components

The implementation of Device Interfacing Solution can be divided into five parts:

- Device specific software
- Device specific module
- Device specific cable
- Bus cables
- Software in Datex-Ohmeda Monitor

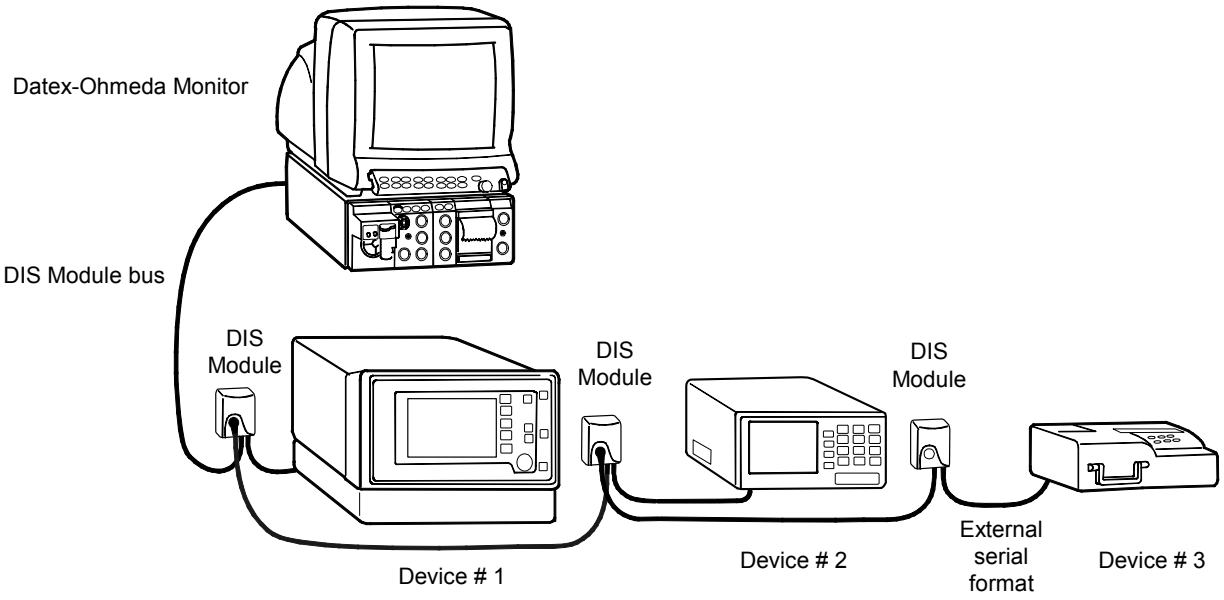


Figure 2 Implementation of Device Interfacing Solution

2.2 DIS module

A DIS module receives data from an external device, converts the data to a suitable format for the monitor and then sends the data to the monitor. The main board contains the power supply with a current limiter, microcontroller, reset circuits, memory and serial communication buffers. The board communicates with the Datex-Ohmeda Monitor through the DIS bus.

A DIS module consists of:

- Power supply with current limiter and reset circuit parts
- Microcontroller H8, internal and external RAM, non volatile memory, etc.
- Programming connection
- Device communication connection and RS232 driver
- Bus communication connection and RS422 driver
- LEDs that indicate the status of the communication
- Device specific software

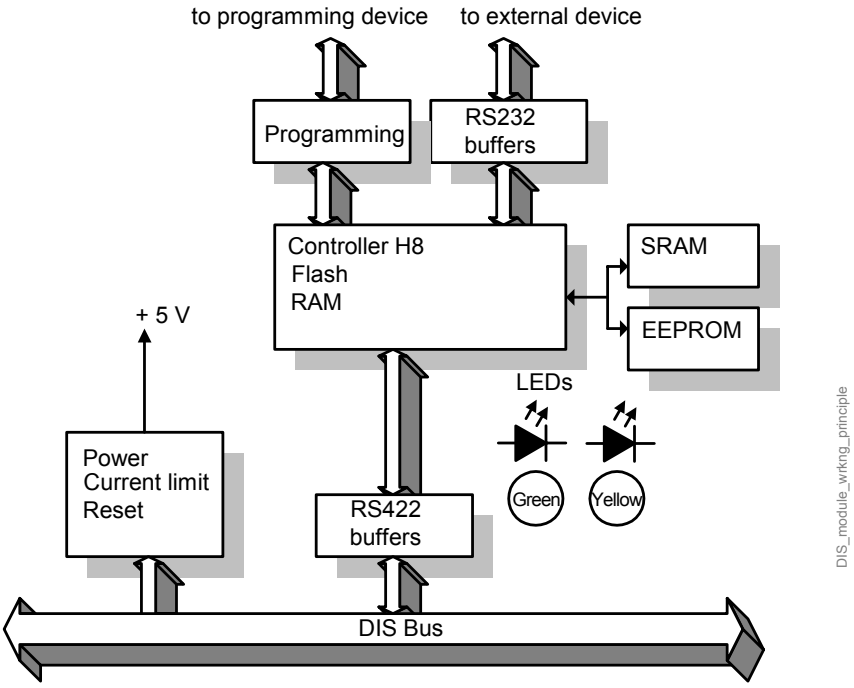
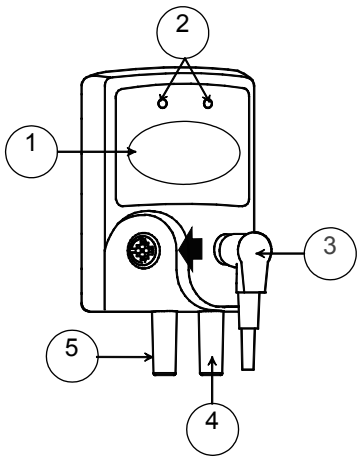


Figure 3 DIS module working principle diagram

2.3 Connections

Connect the device specific cable to the external device and the bus cable to the Datex-Ohmeda Monitor's DIS connector, B-UPI4(NET) board, or to another DIS module.



(1) label specifying the external device

(2) LED indicators

(3) black bus cable from another interfacing module, if needed

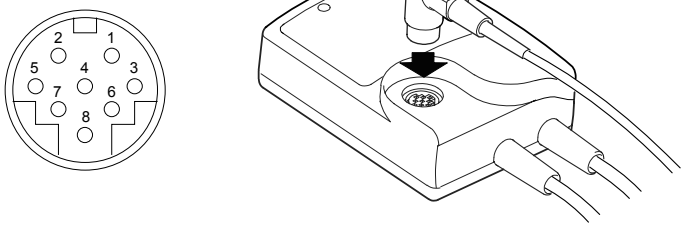
(4) grey device specific cable to the communication port of the external device

(5) black bus cable to the monitor's DIS connector (or to another interfacing module)

Figure 4 Connection cables and LED indicators

2.4 Connectors and signals

2.4.1 Male bus cable connector



Pin No.	Signal	Color
1	Data from UPI +	brown
2	Data from UPI -	red
3	VDD 9 V to 18 V (max 1 A)	orange
4	GND	yellow
5	VCC 7 V to 8 V (max 1 A)	blue
6	GND	grey
7	Data to UPI +	white
8	Data to UPI -	black

2.5 Interfaced devices

See the following table of DIS modules and devices that you can interface with the Device Interfacing Solution.

For specific information on parameters transferred from the interfaced device to the Datex-Ohmeda Monitor and the applicable software versions of the device, refer to the Installation guide accompanying each DIS module.

Table 1 DIS modules and interfaced devices

	Device Ventilators
N-DISEV4	Evita 4[a]
N-DISPRIM	Primus[a.] NOTE: Not available in the US
N-DIS7200	7200 Series Ventilator System[b]
N-DIS840	840 Ventilator System[b.]
N-DISS300	Servo Ventilator 300[c]
N-DIS7900	7900 SmartVent Ventilator[d]

N-DISAEST [e]	Aestiva/5[d.]
N-DISVENT	S/5 Aespire[d.] Aestiva/5[d.] Aisys Carestation[d.] S/5 Avance[d.] Centiva/5[d.] Engström Carestation[d.]

a. Trademark of Dräger Medical AG & Co
b. Trademark of Nellcor Puritan Bennet Inc
c. Trademark of Maquet Critical Care AB part of the Getinge Group (previously trademark of Siemens)
d. Trademark of GE Healthcare Finland Oy
e. Replaced by N-DISVENT

	Device Monitors
N-DISOXIM3	Oximetrix 3[a]
N-DISQVUE	QVue /Q2[a.]
N-DISA2000	A-2000 Bispectral Index Monitoring System[b]
N-DISVIGIL	Baxter-Vigilance[c]
N-DISPICCO	PiCCO-Technology[d] NOTE: Not available in the US
N-DISRGM	RGM Monitor[e]
N-DISTONO	Tonocap[e.]
N-DISWHITE	Capnomac, Capnomac II[e.] Multicap, Normocap, CD2-02[e.] Capnomac Ultima[e.] Normocap CD-200[e.] Oscar Oxy, Cardiocap 1GS, Cardiocap 2GS[e.] Satlite, Satlite Trans, Satlite Plus[e.]

a. Trademark of Hospira Inc. (previously trademark of Abbott Laboratories)
b. Trademark of Aspect Medical Systems
c. Trademark of Edwards Lifesciences Corporation
d. Trademark of Pulsion Medical Systems
e. Trademark of GE Healthcare Finland Oy

	Device Blood gas analyzers
N-DISOPT	AVL Opti CCA[a]
	Device Heart-lung machines
N-DISHL20	Jostra HL-20[b]

a. Trademark of Diamond Diagnostics Inc
b. Trademark of MAQUET GmbH & Co. KG part of the Getinge Group

3 Service procedures

3.1 General service information

The field service of the Device Interfacing Solution is limited to replacing faulty cables or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (“APPENDIX A”) which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
Screwdrivers		

3.2.2 Recommended parts

No recommended parts.

3.2.3 Visual inspection

Disconnect the DIS module from the DIS bus and from the interfaced external device.

1. Internal check
   - Disassemble the DIS module.
   - Make sure that there are no loose parts inside the DIS module.
   - Check that the screws holding the PC board are tightened properly.
   - Check that the cables are attached properly and the connectors are intact.

2. External check

   - Check that the DIS module case and label are clean and intact.
   - Reassemble the DIS module.
   - Check that the screws for the DIS module case are secured properly.
   - Check that the bus cable connector is intact.
   - Check that the DIS bus and device specific cables are intact.

3.2.4 Functional inspection

3. DIS module interface status

   Connect the DIS module to the DIS bus and to the external device that is specified in the DIS module label. Turn on the interfaced external device.

   Check that no error messages are displayed on the monitor screen.

   Check via the Interfacing menu that the connected DIS module status is correct:

   Monitor Setup - ***Interfacing*** - ***Status Page***

   Check that the waveforms and numeric fields are transferred to the monitor according to the configuration.

4. Recognition of interface

   Disconnect the DIS bus cable and check that the '[device name] module removed' message appears on the monitor screen. Reconnect the cable.

   Turn off the external device (if possible) and check that the '[device name] disconnected from module' message appears on the screen. Turn the external device back on again.

5. DIS module service menu

   Enter the service menu:

   Monitor Setup – ***Install/Service*** (password 16-4-34) –
   Service (password 26-23-8) –
   Parameters – More – DIS Interfacing

   Check that the menu displays submenus for all connected DIS modules.

   Enter the corresponding DIS module service menu and check that the displayed information corresponds with the information on the DIS module labels.

   Check that the DIS bus voltage is between 6.00 ...8.00 V or 10.00... 12.00 V (depending on the N-DISxxx version and the host monitor).

   Check that the DIS module time-out and checksum error values do not increase more than by 5 per second.

   Check that the status of each DIS module memory indicates OK.

6. Electrical safety check
   Perform the electrical safety test and leakage current test.

7. Functioning after electrical safety check
   Check that the DIS module functions normally after the tests.

8. Final cleaning
   Clean the DIS module, bus cable and device specific cable with suitable detergent.

- Fill up all the necessary documents.

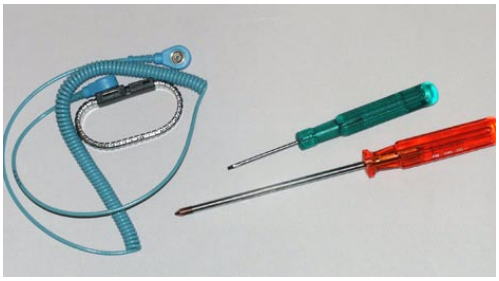
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- screwdriver
- flat blade screwdriver
- antistatic wristband

3.4 To disassemble the module

To disassemble the N-DISxxx module (see the exploded view of the module in the “E-Modules Spare parts” slot):

1. Remove the two screws from the back of the module.
2. Loosen the two strain-relief threads and after that disconnect the cables from the connectors.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the “Service check” after reassembling the module.

4 Troubleshooting

4.1 LED indicators

Figure 5 LED indicators

4.1.1 Green LED

The meaning of the green LED is to indicate that the communication between the monitor and DIS module and the communication between the DIS module and external device is working properly. When allcables are connected and the connected devices are on, the green LED should be lit continuously.

4.1.2 Yellow LED

The meaning of the yellow LED is to alert the user. The yellow LED is lit when any of the following conditions becomes true:

1. The DIS module is connected to the DIS bus, but the external device is not connected.
2. The external device is in power off state.
3. The external device is not selected from the interfacing menu as an active source of data.

NOTE: The meaning of the yellow LED varies with some external devices. See the “Installation Guide” delivered with the DIS module.

4.2 Quick functional check

You have two ways for checking the function of the Device Interfacing Solution:

- Press the **Monitor Setup** key, select ***Interfacing*** and open the ***Status Page*** menu. The status page shows you the current communication status of the interfacing modules connected to the bus (1...10 pcs).

NOTE: The status message 'Connected' appears on the monitor screen after you have connected the external device to the DIS module and turned it on, if the monitor and DIS module have already been initialized.

- Check the LED indicators on the DIS module (the green LED indicates the physical connections, the yellow LED software selections):

GREEN	YELLOW	INDICATION
lit ●	dark ○	Physical connections between the monitor, DIS module and external device are in order and the device has been selected in the menu.
dark ○	lit ●	There is something wrong with the physical connections between the monitor, interfacing module and external device. The external device has not been selected in the menu.
lit ●	lit ●	Physical connections between the monitor, DIS module and external device are in order, but the external device has not been selected in the menu (see the "User's Reference Manual" of the monitor).
dark ○	dark ○	The DIS module is not connected to the monitor.

5 Earlier revisions

This manual supports all earlier N-DISxxx revisions.

APPENDIX A Service check form, Device Interfacing Solution, N-DISxxx (Rev. 00 and Rev. 01)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal check	☐	☐	☐	2. External check	☐	☐	☐
Notes							
Functional inspection							
3. DIS module interface status	☐	☐	☐	4. Recognition of interface	☐	☐	☐
5. DIS module service menu	☐	☐	☐	6. Electrical safety check	☐	☐	☐
7. Functioning after electrical safety check	☐	☐	☐	8. Final cleaning	☐	☐	☐

Notes

Used spare parts			

Signature

Datex-Ohmeda

S/5™ Interface Module, E-INT (Rev. 00)

Technical Reference Manual Slot

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027836-1
November, 2005

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Table of contents

Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Interface Module, E-INT. The Interface module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The Interface Module, E-INT, provides an interface between the S/5 Monitors and other external monitors such as Datex-Ohmeda Cardiocap and Capnomac Ultima, Criticon Dinamap 1846 SX, and Abbott Oximetrix 3.

NOTE: The Interface Board, B-INT, and Interface Module, E-INT, cannot be used simultaneously in the same monitor.

1 Specifications

1.1 General specifications

Module size (W × D × H)	37 x 190 x 112 mm / 1.5 x 7.5 x 4.4 in
Module weight	0.35 kg / 0.8 lb.

1.2 Serial I/O definitions

- RS-232 buffered (channels 1-2)
- All standard baud rates are possible from 300 to 115200
- Each interfaced device has a fixed baud rate.

1.3 Analog definitions

- There are four analog inputs available on channel 1 and four on channel 2.
- All analog inputs are Op-Amp buffered, with an input impedance of 1 M. Each analog input is also equipped with a 1 MΩ pull-down resistor to -12 V for NC detection.
- Sampling rate: 10 ms/sample/channel
- Input range: -10 V...+10 V
- Resolution: 10 bits → 1024 voltage levels in input range

2 Functional description

The Interface Module, E-INT, detects and identifies the external monitors connected to the module. The identification is made by a serial string, sent by the external monitor.

When an external monitor is connected to the Interface Module, numeric data is always displayed on the monitor screen. Also, analog real time waveforms are displayed, if the external monitor is able to send them.

Connections from the Interface Module to external monitors are isolated from the S/5 Monitor.

2.1 Main components

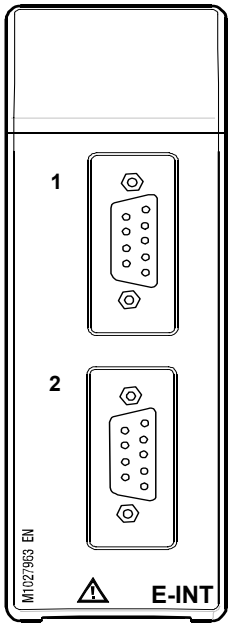


Figure 1 Front panel of Interface Module, E-INT

1. Serial/analog connector (X2) CH1
2. Serial/analog connector (X3) CH2

2.1.1 External connections

The connectors on the Interface Module are:

- One 25-pin D-connector X1 for the module bus.
- Two 9-pin connectors, X2 and X3, for external monitors. These are internally connected to two 9-pin female D-connectors via ribbon cables.

Each X2 and X3 connector has an RS-232 serial communication channel and four analog inputs.

2.1.2 RS-485 Serial communication

The Interface Module uses RS485 signal levels when communicating with the external monitor. The RS485 signals are transformed to digital signal levels and fed via an opto-isolator to the microprocessor. The communication signals for transmitting (TxD) and receiving (RxD) data are sent to

the microprocessor ports. The direction of the communication is controlled by REC/SND signals, generated by the microprocessor, via the opto-isolator. When the module bus is reset, the communication is always set to the receiving state.

2.1.3 Reset

The interface board resets when the module bus is reset. The RESET signal is converted from an RS-485 signal level to a digital signal level and then fed to an opto-isolator. The RESET signal is renamed to POWEROK signal. The POWEROK signal resets the microprocessor and the GAL circuit.

2.1.4 RS-232 Serial communication

A QUART is used to provide four serial communication channels with external monitors. However, only two channels are used. The microprocessor controls resetting of the QUART during normal operation. When the microprocessor is reset the QUART is also reset.

2.1.5 Memories

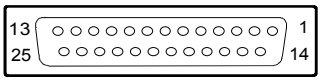
There are static RAM, ROM, EEPROM memories in the Interface Module. The memory decoding is done with the GAL circuit. The microprocessor communicates with the EEPROM memory in serial mode.

Analog inputs

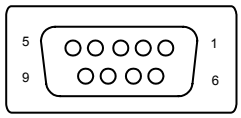
Eight analog inputs from the serial/analog connectors are connected to eight low pass filters. The frequency limit (-3 dB) is set to 35 Hz. The input signal levels are between -10 V and +10 V, and the output signals are scaled between 0 V and 5 V. The output signals are then fed to the microprocessor A/D inputs.

2.2 Connectors and signals

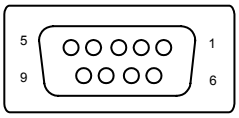
2.2.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	1	O	RESET_RS485
	2	O	-15 VDC
	3	O	+15 VDIRTY
	4	O	+15 VDC
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7		Ground & Shield
	8	O	-RESET_RS485
	9	O	CTSB
	10	I	RTSB
	11	O	RXDB
	12	I	TXDB
	13		Ground & Shield
	14	O	+32 VDIRTY
	15	O	GroundDIRTY
	16	O	CTSC
	17	I	RTSC
	18	O	RXDC
	19	I	TXDC
	20		ON/STANDBY
	21		BITOIN
	22		RXDD_RS232
	23		TXDD_RS232
	24	O	+5 VDC
	25	O	+5 VDC

2.2.2 Serial/analog connector CH1

Serial/analog connector (X2) CH 1 (floating, off-board)	Pin No.	Definition
	1	A0 analog input
	2	RXD
	3	TXD
	4	A1 analog input
	5	GND
	6	A2 analog input
	7	RTS
	8	CTS
	9	A3 analog input

2.2.3 Serial/analog connector CH 2

Serial/analog connector (X3) CH 2 (floating)	Pin No.	Definition
	1	A4 analog input
	2	RXD
	3	TXD
	4	A5 analog input
	5	GND
	6	A6 analog input
	7	RTS
	8	CTS
	9	A7 analog input

3 Service procedures

3.1 General service information

The field service of the Interface Module, E-INT, is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
Datex-Ohmeda gas monitor with the SpO_2 measurement		e.g. ULT-S
INT Interface cable	892377	
Calibration gas	755582	
SpO_2 probe		e.g. OXY-F4-M
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal check

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - all socket mounted IC's are inserted properly

- the EMC cover is attached properly
- there are no loose objects inside the module

2. External check

   Check that:

   - the front cover and the front panel sticker are intact
   - the block screws for cables are in place and tightened properly
   - the block screw threads are intact
   - all connectors are intact and attached properly
   - the module box and latch are intact

Reattach the module box and check that the latch moves properly.

3.2.3 Functional inspection

3. Installation

   Plug the Interface Module into the monitor Central Unit. Check that it goes in smoothly and locks up properly.

4. Interface selection

   Connect the Datex-Ohmeda gas monitor with the interface cable (order code 892377) to Interface Module, E-INT, connector 1. Lock the cable properly.

   Turn both monitors on.

   Make sure the serial output mode of the Datex-Ohmeda gas monitor being used is set to NUMERIC.

   Configure the S/5 Monitor screen so that all required parameters are shown, for example:

   Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 5 - Pleth***
   Field 6 - Co2

   Set the interface for the Datex-Ohmeda gas monitor being used:

   Monitor Setup - ***Install/Service (password 16-4-34) - Installation - Interfacing - Gases/Spiro - XXX***
   SpO2 - XXX

   XXX = the gas monitor being used

   Check that the menus ***NIBP*** and ***SvO2/C.O***. are selectable from the menu.

5. Module software

   Enter the service menu:

Monitor Setup - ***Install/Service (password 16-4-34)*** - ***Service (password 26-23-8)***

Take down the information regarding the Interface Module, E-INT, software by selecting ***Scroll vers*** and turning the ComWheel.

6. Communication and memories

   Enter the Interface service menu:

   Parameters - More - Interface

   Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the Interface Module E-INT memories have passed the internal memory test, i.e. RAM and ROM state OK.

7. Recognition of connection

   Check that the interfaced gas monitor is identified, i.e. the required waveform fields are shown on the screen and the gas monitor type is shown correctly on the service menu.

   Check that the communication state is online.

8. Gas interface (1)

   Select ***Gases*** from the Interface service menu.

   Check that id: states the correct monitor and interface type, Active states YES and Time-out NO.

   Check that the numeric values on the service menu are reasonable.

   Simulate breathing by feeding calibration gas into the Datex-Ohmeda gas monitor sampling line and check that the values on the service menu correspond with the values on the gas monitor screen.

   Check that the values in the S/5 Monitor gas waveform field are correct and a proper CO_2 waveform is shown.

   Stop feeding the calibration gas. Check that the message 'Apnea' appears in the S/5 Monitor waveform field, and in the message field, if the selected interface type is ULT/al.

9. SpO_2 interface (1)

   Select ***SpO2*** from the Interface service menu.

   Check that id: states the correct monitor and interface type, Active states YES and Time-out NO.

   Check that ProbeOff shows 1 when no SpO_2 probe is connected to the interfaced gas monitor. Connect the SpO_2 probe and check that the NoProbe shows 1.

   Attach the SpO_2 probe to your finger and check that the values on the menu correspond with the values on the gas monitor screen.

   Check that the values in the S/5 Monitor pleth waveform field are correct and a proper pleth waveform is shown.

Disconnect the SpO_2 probe. Check that the message 'Probe off' appears in the S/5 Monitor waveform field, and 'SpO_2 probe off' appears in the message field, if the interface type is ULT/al.

10. Recognition of disconnection

    Turn the gas monitor off. Check that the messages 'Interfaced Gas monitor removed' and 'Interfaced SpO_2 monitor removed' appear on the S/5 Monitor screen.

11. Interface (2)

    Turn the S/5 Monitor off. Connect the gas monitor with interface cable to Interface Module, E-INT connector 2.

    Turn the monitors on and check that the necessary numerics and waveforms are still interfaced, together with the alarms, if the interface type is ULT/al.

12. Restarting

    Disconnect the Interface Module, E-INT, for a moment, then plug the module back into the monitor.

    Check that interfacing with the gas monitor is restored.

13. Electrical safety check

    Perform an electrical safety check and a leakage current test.

14. Functioning after electrical safety check

    Check that the Interface Module, E-INT, functions normally after performing the electrical safety check.

    Set the interface back for modules:

    Monitor Setup - ***Install/Service (password 16-4-34)*** - ***Installation*** - ***Interfacing*** - ***Gases/Spiro*** - ***Module***
    SpO2 - ***Module***

15. Final cleaning

    Clean the module with suitable detergent.

- Fill in all necessary documents.

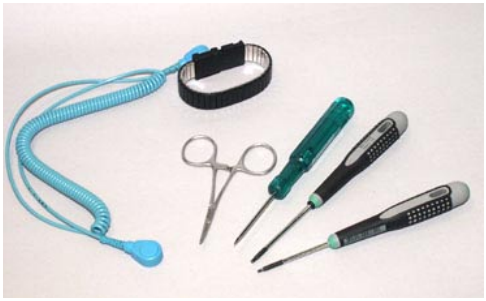
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

To disassemble the module

To disassemble the Interface Module, E-INT (see the exploded view of the module box and E-INT in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. To detach the circuit board, remove the four screws and disconnect the two ribbon cables from the front panel.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

Enter the Service Menu (see the “Service Menu” slot of the Monitor “Technical Reference Manual”). Select ***Scroll vers*** and scroll down the SW version/Unit id list. Make sure that the software code and level, control and serial numbers of the Interface Module, E-INT, are displayed under INT.

If they are not displayed, the Interface Module, E-INT, is faulty.

4.1 Troubleshooting chart

Problem	Cause	What to do
Interface menu item not active in the Service Menu. Software version and ID data are not available in the Service Data field.	Module is not connected properly. E-INT is faulty	Check that the module is firmly pushed into the module slot. Replace E-INT Interface board.
Measured values from the interfaced monitor do not appear on the display after approximately one minute.	Monitor not selected for interface. Poor contact in the interface cables. Wrong interface cable.	Select the right monitor from the Interfacing menu. Check the cables and connections. Change the cable to another connector. Check cable type and change if necessary.

Earlier revisions

There are no earlier revisions of the S/5™ Interface Module, E-INT.

APPENDIX A Service check form, Interface Module, E-INT (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal check	☐	☐	☐	2. External check	☐	☐	☐
Functional inspection							
3. Installation	☐	☐	☐				
4. Interface selection	☐	☐	☐				
5. Module software	E-INT						
6. Communication and memories	☐	☐	☐	7. Recognition of connection	☐	☐	☐
8. Gas interface (1)	☐	☐	☐	9. SpO2 interface (1)	☐	☐	☐
10. Recognition of disconnection	☐	☐	☐	11. Interface (2)	☐	☐	☐
12. Restarting	☐	☐	☐				
13. Electrical safety check	☐	☐	☐	14. Functioning after electrical safety check	☐	☐	☐
15. Final cleaning	☐	☐	☐				

Notes			

Used spare parts			

Signature

Datex-Ohmeda

S/5™ Recorder Module, E-REC (Rev. 00)

Technical Reference Manual Slot

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027837-1
November, 2005

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Table of contents

Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Recorder Module, E-REC. The REC module is a double width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual the module may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The Recorder Module, E-REC, provides real time printing of waveform and numerical data, and trend data.

The S/5 Compact Monitors may include a built-in recorder. The built-in recorder is technically the same as the Recorder Module.

NOTE: Printings on thermal paper may be destroyed when exposed to light, heat, alcohol, etc. Take a photocopy for archive.

NOTE: The Recorder Module, E-REC, cannot be used in the Extension Frame, F-EXT4.

NOTE: The Recorder Module, E-REC, functions with all monitor software versions.

NOTE: The Recorder Module, E-REC, is not compatible with the Compact Monitor frames that contain the built-in recorder (F-CMREC, F-CMCREC, F-CMREC1 and F-CMCREC1).

1 Specifications

Module size, W x D x H	75 x 192 x 112 mm / 3.0 x 7.6 x 4.4 in
Module weight	0.85 kg/ 1.9 lb.
Power consumption	3 W
Principle	Thermal array
Print resolution	
Vertical	8 dots/mm (200 dots/inch)
Horizontal	32 dots/mm (800 dots/inch) at a speed of 25 mm/s and slower
Paper width	50 mm, printing width 48 mm
Traces	Selectable 1, 2, or 3 traces
Print speed	1, 6.25, 12.5, 25 mm/s

2 Functional description

2.1 Main components

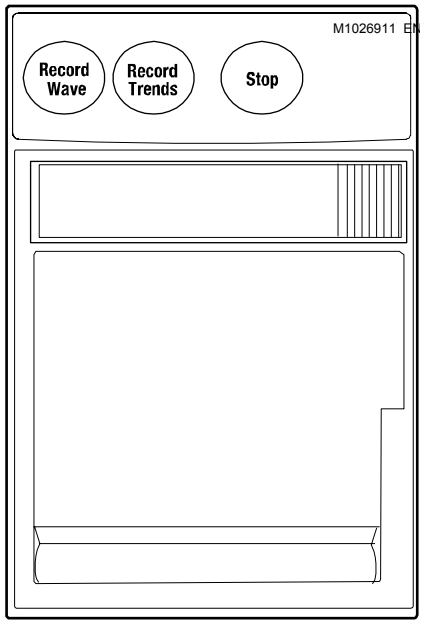


Figure 1 Front panel of Recorder Module, E-REC

Record Wave key — records selected real-time waveforms. Recording time depends on the recording length.

Record Trends key — prints numerical, graphical or tabular trends. Recording time depends on the recording length and trend resolution.

Stop key — stops recording or trend printing.

2.1.1 Recorder board

The function of the recorder board is to establish an interface between the recorder unit and main CPU board in the monitor. The three front panel keys are connected to the recorder unit via the recorder board. The recorder unit and the recorder board are connected together with a small connector board and a 12-pin flex-strip cable.

External communication

Communication with the main CPU board is established via a +5 V CMOS level RS232 serial interface, with an RS485 reset.

Reset The differential RS485 reset from the module bus generates a Recorder Unit reset signal on the Recorder Board. The Recorder Board also generates a power-up-reset, whose time constant is approximately 0.1 second. The Recorder Unit reset signal is therefore active when either the Module Bus RS485-reset or the power-up-reset is active.

+5 V priority The recorder unit supply voltage, +15 VREC, is switched on after +5 V is present.

Front panel keys The recorder board can read the three front panel keys and pass their status on to the main CPU board.

To protect the keypad signals from static discharges, zener diodes and series resistors are used. Separate pull-up resistors are not needed, because pull-up resistors connecting the keypad input signals to +5 V are inside the recorder.

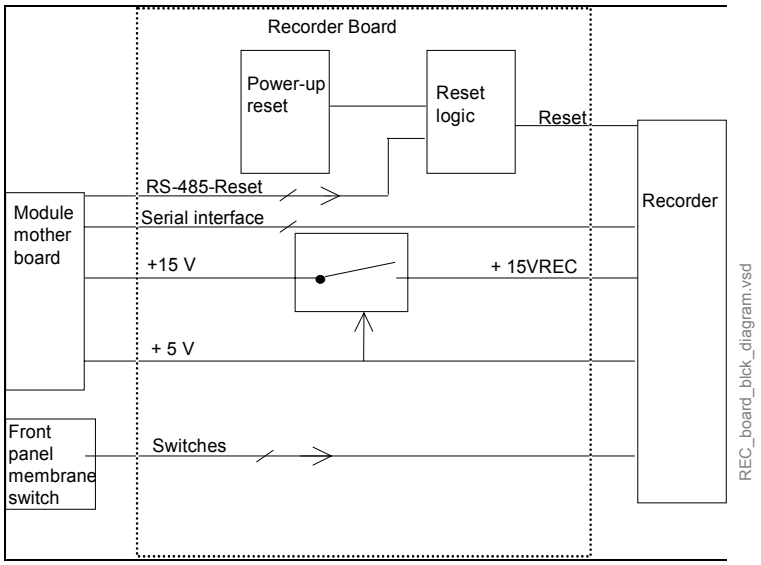
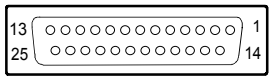


Figure 2 Recorder board block diagram

2.2 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	1	I	RESET_RS485
	3	I	+15 VDIRTY
	7	-	Ground & Shield
	8	I	-RESET_RS485
	9	O	CTSB
	10	I	RTSB
	11	O	RXDB
	12	I	TXDB
	13	-	Ground & Shield
	15	I	GroundDIRTY
	24	I	+5 VDC
	25	I	+5 VDC

3 Service procedures

3.1 General service information

The field service of the Recorder Module, E-REC, is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
Multiparameter hemodynamic module		
Patient simulator		
Torx screwdriver, T10		

3.2.2 Recommended parts

Part	Order No.	Notes
Recorder paper	74205	

3.2.3 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly

- there are no loose objects inside the module

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - the module box and latch are intact

Reattach the module box and check that the latch moves properly.

3.2.4 Functional inspection

3. Paper compartment cleaning

   Open the paper compartment hatch and take out the paper roll, if installed.

   Remove any paper chaff from the paper compartment.

   Clean the thermal printhead and the small glass window in front of the static brush with a cotton swab dipped in isopropyl alcohol. Avoid contact with the rubber paper roller.

NOTE: Be careful to limit the application of alcohol to the thermal printhead and the window.

Leave the paper compartment empty and close the hatch.

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that all required parameters are shown, for example:

Monitor Setup - ***Screen 1 Setup*** - ***Waveform Fields*** - ***Field 1 - ECG1***
Field 2 - ECG2
Field 3 - P1
Field 4 - P2
Field 5 - PLETH
Field 6 - OFF

Insert the Hemodynamic Module into a module slot. Connect a patient simulator to the module and check that all connected parameters are shown on the screen.

Preset recording settings:

Record/Print - ***Record Waveforms*** - ***Waveform 1 - ECG1***
Waveform 2 - P1
Waveform 3 - P2
Delay - Off
Paper Speed - 6.25 Mm/S
Length --> 30 S

Record Trends - Graphic Trend 1 - Hr
Graphic Trend 2 - P1

Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Installation - Printer & Recorder - Default Trend - Graph.***

Display Trends - Time Scale - 2 h

4. Installation

   Plug in the Recorder Module. Check that the module goes in smoothly and locks up properly.

5. Paper recognition

   Press the **RECORD WAVE** key on the module front panel. Check that the message 'Recorder: Out of paper' appears on the screen.

6. Cover state recognition

   Open the paper compartment cover. Check that the previous message changes to 'Recorder: Cover open'.

   Install a paper roll and close the cover. Check that the message 'Recorder: Cover open' disappears from the screen.

7. Front panel membrane keys

   Press the **RECORD WAVE** key again and check that the module starts recording the selected waveforms. Press the **STOP** key on the module front panel to stop recording.

NOTE: If no recording appears, check that the paper roll is installed correctly - only one side of the paper is printable.

Press the **PRINT TRENDS** key and check that the module starts recording graphical trends. Wait until the recording stops.

8. Quality of recording

   Check that the quality of the recordings is acceptable.

9. Recording speed

   Press the **RECORD WAVE** key again and this time wait until the recording stops. Check that the length of the recorded waveform scale is 18.7 cm (±1.5 cm).

   Change the paper speed setting to 1 mm/s:

   Record/Print - ***Record Waveforms - Paper Speed - 1 mm/s***

Press the **RECORD WAVE** key and wait until the recording stops. Check that the length of the scale is now 3.0 cm (±0.5 cm).

10. Electrical safety check
    Perform an electrical safety check and a leakage current test.

11. Functioning after electrical safety check
    Check that the module functions normally after performing the electrical safety check.

12. Final cleaning
    Clean the module with suitable detergent.

- Fill in all necessary documents.

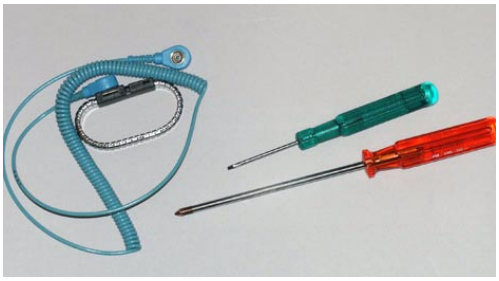
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver; T10
- flat blade screwdriver
- antistatic wristband

3.3.3 To disassemble the module

To dissassemble the Recorder Module, E-REC (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Open the recorder unit paper loading hatch. Loosen the two screws at the bottom of the recorder unit housing with a long blade screwdriver.
4. Disconnect the 50-pin connector from the back of the recorder unit and the 5-pin ribbon keypad connector from the recorder board.

The recorder unit and front panel frame can now be pulled out of the main body. The front panel frame is pulled out of the recorder by pulling backward.

The recorder board is attached to the metal chassis with four screws.

CAUTION The recorder board is fixed to the metal chassis at the factory in a specific position. The recorder board and chassis must therefore not be separated.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	Cause	What to do
Module not responding to front panel keys, but operates through **Recorder** key in ***Record*** menu.	Membrane switch cable loose or broken.	Check the cable. Replace the front panel if necessary.
	E-REC: Flex-strip cable broken.	Check the cable. Replace if necessary.
	E-REC: Bad contact on connector board.	Check contact.
Recorder will not start. No error messages shown.	E-REC: Module not properly inserted.	Re-insert the module properly.
	E-REC: Flex-strip cable broken.	Check the cable. Replace if necessary.
	E-REC: Connector board loose.	Check connector board connections.
	Recorder board faulty.	Replace the recorder board.
	Recorder unit faulty.	Replace the recorder unit.
Recorder works but nothing appears on the paper.	Active side of the paper downwards.	Turn the paper roll over. To test which side is active: Place the paper on a hard surface and draw a line with a fingernail - a dark line will appear on the active (thermal) side.
	Recorder unit faulty.	Replace the recorder unit.

4.2 Messages

Problem	What to do
Recorder: out of paper	Release paper jam or insert a roll of paper into the recorder.
Recorder: cover open	Close the recorder cover correctly.
Recorder: thermal array overheat	Recorder overheated. Stop using and allow it to cool down.
Recorder: input voltage low	+15 Vrec is too low. Check flex-strip cable and connector board.
Recorder: input voltage high	+15 Vrec is too high. Check flex-strip cable and connector board.
Recorder system error 1, 2, 3	System error. Remove the recorder module and re-insert it. If the problem persists, replace the recorder unit.
Recorder: module removed	The module not in place, or a communication error due to a fault in the module or in the main CPU board.

5 Earlier revisions

There are no earlier revisions of the S/5™ Recorder Module, E-REC.

APPENDIX A Service check form, Recorder Module, E-REC (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Paper compartment cleaning	☐	☐	☐	4. Installation	☐	☐	☐
5. Paper recognition	☐	☐	☐	6. Cover state recognition	☐	☐	☐
7. Front panel membrane keys	☐	☐	☐	8. Quality of recording	☐	☐	☐
9. Recording speed				Measured value	Allowed range		
6.25 mm/s					17.2...20.2 cm		
1.0 mm/s					2.5...3.5 cm		
10. Electrical safety check	☐	☐	☐	11. Functioning after electrical safety check	☐	☐	☐
12. Final cleaning	☐	☐	☐				
Notes							

Used spare parts			

Signature

Datex-Ohmeda

S/5™ Memory Module, E-MEM (Rev. 00)

Technical Reference Slot

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027817
June, 2005

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Table of contents

Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 MEM Module, E-MEM. The Memory Module, E-MEM, is an optional data storage single width module designed for Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The Memory Module is used for storing patient related physiological data, discrete record keeping events, menu configurations and user defined monitor configurations in removable PCMCIA[1] compatible memory cards.

The memory module can be utilized in the following applications:

- As a backup media for patient related physiological and record keeping data.
- As a local menu server for the monitor it is attached to.
- A memory card with its previously recorded patient data can be transported to a new monitor location with the patient, enabling continuous data collection.
- To save and load user defined monitor configurations.

The memory module is available in one version:

- Single width external plug-in Memory Module, E-MEM, for S/5 Critical Care and Anesthesia monitors.

The memory module has two card slots, which use rewritable PCMCIA-ATA specification compatible memory cards: Data and Menu Cards.

The data card is used for storing patient related data and record keeping events, and the menu card is used as a storage media for pre-recorded menu configurations and user defined monitor configurations. If the module is used only for data backup and transportation, the Menu card is not necessarily required. Similarly, if only record keeping configurations are needed, the data card does not have to be present. In the latter case, however, no physiological or event data can be stored in a memory card.

Module software runs under MS-DOS[2] compatible operating system provided by Datalight[3]. The files created in Data and Menu MemCards are MS-DOS compatible.

[1] PCMCIA = Personal Computer Memory Card International Association

[2] MS-DOS is a trademark of Microsoft Corporation

[3] Datalight is a trademark of Datalight, Inc.

The communication between the monitor CPU and the memory module is performed with a high-speed internal TTL level RS-232 serial interface. Data transfer rate is 76.8 kbps.

Compatibility

NOTE: Memory Module, E-MEM, cannot be used in the **Extension Frame, F-EXT4** and in the **S/5 Compact Monitors**.

1 Specifications

1.1 General specifications

1.1.1 E-MEM

Module size (W × D × H)	37 x 187 x 112 mm/1.5 x 7.4 x 4.4 in
Module weight	0.35 kg/0.8 lb.
Total power consumption	2 W maximum

1.2 Technical specifications

MemCard capacity	32 MB
Data storage capacity	2 days of continuous physiological data trends
Operating system	Datalight ROM-DOS
File system	MS-DOS compatible
MemCards	PCMCIA-ATA compatible memory cards

2 Functional description

The Memory Module, E-MEM, contains a memory board and a LED (Light Emitting Diode) board attached to the front panel.

The front panel has a dual PCMCIA card connector for two MemCards. There are two push buttons above the card slots for removing the MemCards from the module, and two memory card specific LEDs. The LEDs are on during memory card read and write operations to notify the user not to remove them until the operation is complete.

2.1 Main components

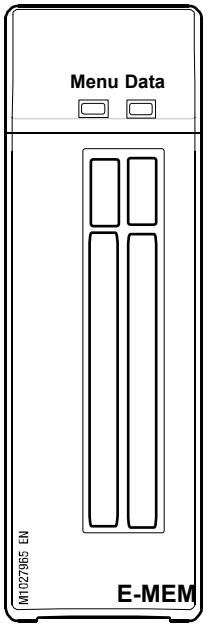


Figure 1 Front panel of Memory Module, E-MEM

2.1.1 Memory board

Processor section

Basically, the memory module is a single board PC with any unnecessary I/O functions removed. The processor is Intel 80C186 compatible and the software runs under the DOS operating system. Operating frequency is 16 MHz. The board has 512 kB RAM, 448 KB ROM, 128 kB EEPROM and associated buffer circuits for memory operations.

The Intel 82365SL compatible PC Card Interface Controller (PCIC) provides all the functions needed in MemCard operations. Serial communication, EEPROM read and write operations and LED control is accomplished through a QUART circuit. In addition, the processor board contains a circuitry to control reset signals and MemCard programming voltages.

The memory module board block diagram is shown in Figure 2.

PCMCIA card interface

E-MEM has PCMCIA compatible card sockets for two MemCards. Both sockets consist of 60 signal and 8 power connections. MemCards are PCMCIA-ATA compatible, and their memory capacity is 6 MB.

All MemCard read and write operations as well as card power management are controlled by a PCIC interface controller.

Card removals and insertions are also detected by the interface controller.

MemCard files are MS-DOS compatible and they can be copied for archiving with any MS-DOS compatible computer equipped with any PCMCIA-ATA specification compatible card drive.

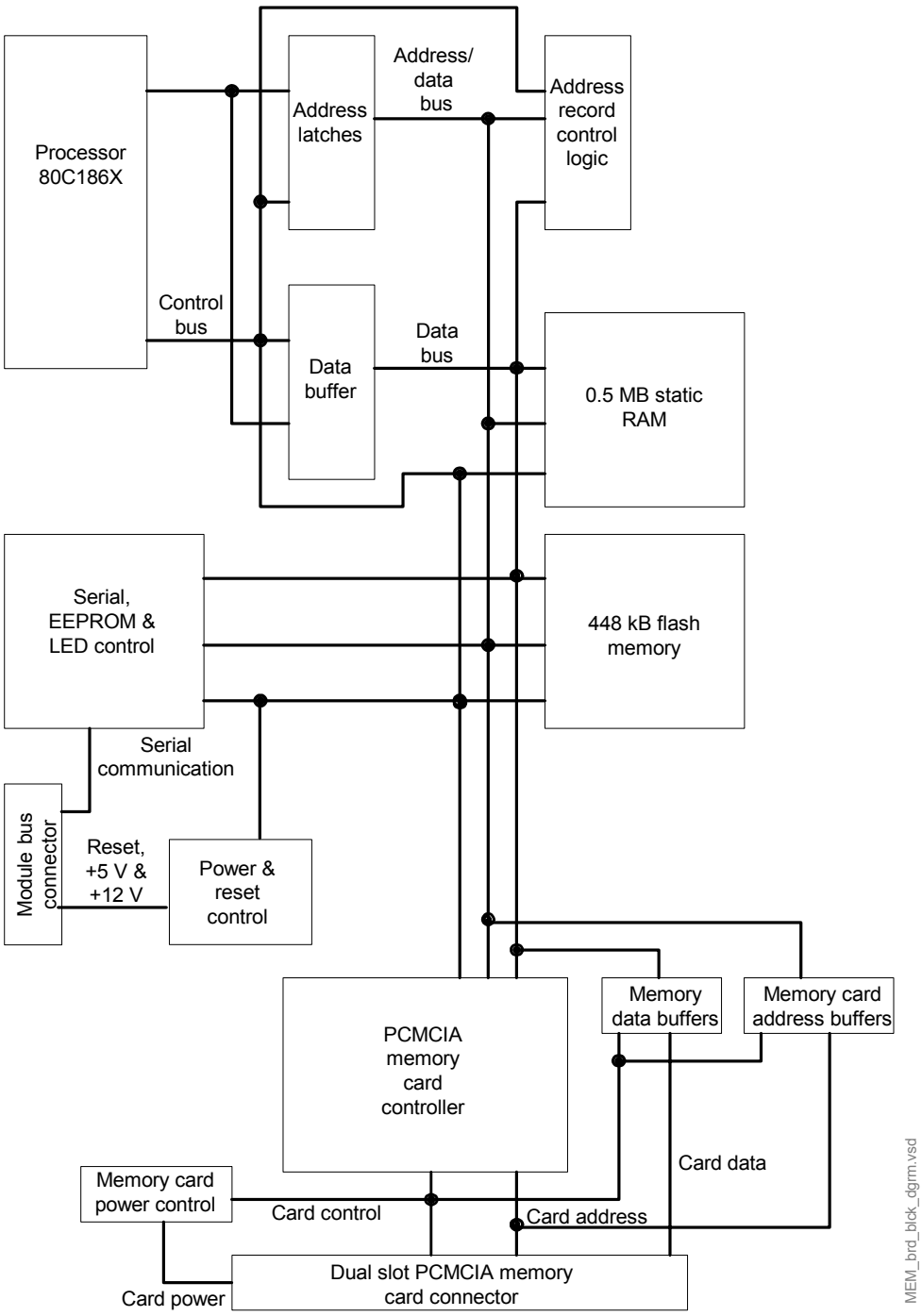


Figure 2 Memory board block diagram

Serial communication

Serial communication between the module and main CPU board is performed through a module bus TTL-level RS-232 interface. The data transfer rate is 76.8 kbps.

An RS485 type monitor reset signal is converted to module reset by an interface transceiver, and power reset is generated by a reset circuit.

Power supply

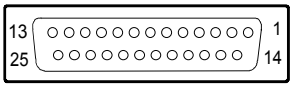
The module receives its power (+5 V, +15 V) from the monitor. The PCMCIA card programming voltage +12 V is generated from +15 V by voltage regulators. Card programming voltage is controlled by an interface controller. Otherwise, only +5 V power is used in the module. Maximum power consumption is 2 W.

LED board

The LED board contains only two yellow light emitting diodes and a three-lead cable to the memory board.

2.2 Connectors and signals

2.2.1 Module bus connector

Module bus connector	Pin No.	I/O	Signal
	1	I	RESET_RS485
	4	I	+15 VDC
	7	-	Ground & Shield
	8	I	-RESET_RS485
	13	-	Ground & Shield
	16	O	CTSC
	17	I	RTSC
	18	O	RXDC
	19	I	TXDC
	24	I	+5 VDC
	25	I	+5 VDC

2.2.2 LED board connector (X5)

Pin No.	I/O	Signal
1	O	+5 V
2	O	LED1 control
3	O	LED2 control

2.2.3 Connector board connector (X1)

Pin No.	I/O	Signal
1	I	Ground & Shield
2	I	Ground & Shield
3	I	-RESET_RS485
4	I	+15 VDC
5	I	RESET_RS485
6	O	CTSC
7	I	RTSC
8	O	RXDC
9	I	TXDC
13	I	+5 VDC
14	I	+5 VDC

3 Service procedures

3.1 General service information

The field service of the memory module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (“APPENDIX A”) which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
MemCard - Menu (PCMCIA-ATA)		
MemCard - Data (PCMCIA-ATA)		
Hemodynamic module		
Patient simulator		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - all IC’s that are on sockets are attached properly
   - EMC covers are attached properly

- there are no loose objects inside the module

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - the memory card housing frame is intact
   - the module box and latch are intact

Reattach the module box and check that the latch is moving properly.

3.2.3 Functional inspection

Switch the monitor on and wait until the monitoring screen appears.

Configure the monitor screen so that all the needed parameters are shown, for example as follows:

Monitor Setup - ***Screen 1 Setup*** - ***Waveform Fields*** - ***Field 1 - ECG1***
Field 2 - ECG2
Field 3 - P1
Field 4 - P2
Field 5 - PLETH
Field 6 - OFF

Insert the hemodynamic module. Connect a patient simulator to the module and check that all connected parameters are shown on the screen.

3. Installation

   Plug in the Memory Module without memory cards. Check that the module goes in smoothly and locks up properly.

4. Front panel LEDs

   Check that both LEDs on the module's front panel light up briefly, when the module is connected.

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) **-** ***Service*** (password 26-23-8)

   Take down the information regarding the MEM software by selecting ***Scroll Vers*** and turning the ComWheel.

6. Module recognition

   Enter the memory module service menu:

   ...***Frame - MemCards***

   Check that the module is recognized properly, i.e. Module present and Module active state YES.

7. Memories and PCMCIA controller

   Check that the Memory board memories and the PCMCIA controller have passed their tests. The status for each should be OK.

8. Communication

   Enter the memory cards ***Communication*** menu:

   Select ***...Frame - Communication***.

   Check that the Interface status states continuously ACTIVE and the error counter values on the bottom part of the menu are stable.

9. Menu-card recognition

   Enter the memory module service menu:

   Select ***...Frame - MemCards***

   Insert a Memory card labelled Menu in the left hand side memory card slot. Check that the message 'Menu Card inserted' appears on the message field and the white menu card symbol on the upper right hand corner of the screen within 1 minute.

NOTE: The battery symbol overrides the memory card symbols in the Compact Monitor.

   Wait until the information regarding SLOT1 is fully updated in the service menu, then check that the Card type states MENU and the File system ATA.

   Check that the rest of the information for SLOT1 is reliable and no errors have been detected.

10. Data-card recognition

    Insert a Memory card labelled Data in the right hand side memory card slot. Check that the message 'Data Card inserted' appears on the message field and the green menu card symbol on the upper right hand corner of the screen within 1 minute.

    Wait until the information regarding SLOT2 is fully updated in the service menu, then check that the Card type states DATA and the File system ATA.

    Check that the rest of the information for SLOT2 is reliable and no errors have been detected.

    Enter the ***Save Modes*** menu:

    Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Save Modes*** (password 13-20-31)

Save the current modes into the Menu card by selecting LOAD MODES and then TO MEMORY CARD --> SAVE. Wait until the text 'Saved' appears, then return to the previous menu.

Change the name for the mode number 1:

Highlight the mode number 1, press the ComWheel and select NAME. Select suitable characters from the list by turning and pressing the ComWheel, then confirm the new name by selecting END.

11. Menu-card functions

    Load the original modes from the Menu card by selecting LOAD MODES and then FROM MEMORY CARD --> LOAD. Wait until the text 'Loading' changes to 'Loaded', then return to the previous menu.

    Check that the mode number 1 has got back its original name.

    Press the membrane key **Display Trends**. Check that there are enough trend information available for the monitored parameters.

    Erase the trends:

    Reset Case - ***Reset All*** - ***Yes***

    Check that the trends have been erased by pressing the key **Display Trends** again.

12. Data-card functions

    Reload the trends from the Data card by pressing the key **Patient Data**, selecting ***Patient From Card***, pressing the ComWheel on the last saved file (the file information is shown at the bottom of the menu) and selecting ***Load***.

    Wait until the message 'Loading from Mem. Module' disappears, then check that the original trends are available again by pressing the key **Display Trends**.

13. Electrical safety check

    Perform an electrical safety check and a leakage current test.

14. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

15. Final cleaning

    Clean the module with suitable detergent.

- Fill in all necessary documents.

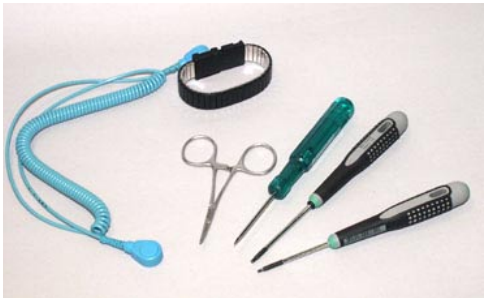
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver; T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the memory module (see the exploded view of the module in the “E-Modules Spare parts” slot):

1. To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.
2. Remove the two screws (T10) from the back of the module.
3. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
4. Remove the two screws that are located on the module bus connector and the screws that connect the front panel frame to the Memory board.
5. Disconnect the LED board cable and remove the front panel frame.
6. Remove the EMC cover carefully from around the Memory board.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables, especially the LED board cable, are reconnected properly.

Always perform the “Service check” after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting charts

4.1.1 Memory module

Problem	Cause	What to do
'Memory module removed' message	Module removed from monitor frame. Possible error in data communication between the module and the monitor.	Insert module in the module frame. Remove module briefly from the monitor. Insert module back to monitor frame. If the message persists, replace the memory board or the main CPU board.
'Memory module error' message	Module has detected an error condition.	If message persists, remove module for repair.
'Memory module comm. error' message	Module not properly attached to monitor frame.	Check module attachment.

4.1.2 Memory cards

Problem	Cause	What to do
'Two Data Cards in mem. module' message	Two Data cards detected.	Remove MemCard from the left hand side slot of the module.
'Two Menu Cards in mem. module' message	Two Menu cards detected.	Remove MemCard from the right hand side slot of the module.
'No menus in Menu Card' message	There are no menus in the Menu card.	Insert a Menu card with valid menu configuration files in the module.
'Faulty Data Card - change card' message	An error has occurred during Data card read/write operation.	Change Data card.
'Faulty Menu Card - change card' message	An error has occurred during Menu card read/write operation.	Change Menu card.

5 Earlier revisions

There are no earlier revisions of the S/5™ Memory Module, E-MEM.

APPENDIX A Service check form, Memory Module, E-MEM (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Installation	☐	☐	☐				
4. Front panel LEDs	☐	☐	☐				
5. Module software	MEM						
6. Module recognition	☐	☐	☐	7. Memories and PCMCIA controller	☐	☐	☐
8. Communication	☐	☐	☐	9. Menu-card recognition	☐	☐	☐
10. Data-card recognition	☐	☐	☐	11. Menu-card functions	☐	☐	☐
12. Data-card functions	☐	☐	☐				
13. Electrical safety check	☐	☐	☐	14. Functioning after electrical safety check	☐	☐	☐
15. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

Signature

Datex-Ohmeda

Remote Controller

S/5™ Remote Controller, K-REMCO (Rev. 01)
S/5™ Remote Controller, K-CREMCO (Rev. 00)

Technical Reference Manual Slot

Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EC

CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner. Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1187342-004

February 3, 2010

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Remote Controllers, K-REMCO and K-CREMCO. The Remote Controllers are designed for use with the Datex-Ohmeda modular monitors. Later in this manual the remote controllers may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “Spare Parts” slot .

The Remote Controller, K-REMCO/K-CREMCO, brings the Command Bar/ monitor keyboard functions near to the user and allows access to the same menus as the Command Bar/ monitor keyboard.

- Remote Controller, K-REMCO for Anesthesia Monitor and Critical Care Monitor
- Remote Controller, K-CREMCO for Compact Monitors, S/5 FM and FM Light.

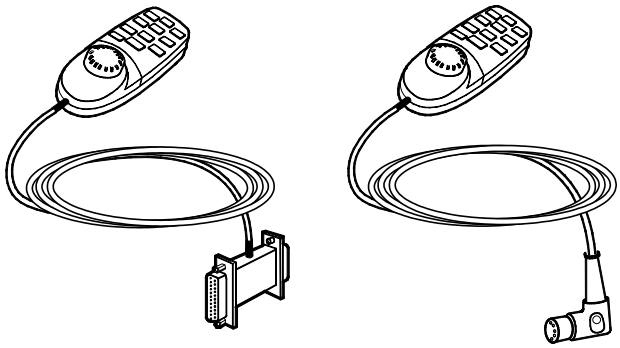


Figure 1 K-REMCO and K-CREMCO

Monitor software compatibility

K-REMCO and K-CREMCO require monitor software version 97 or later.

1 Specifications

1.1 Remote Controller, K-REMCO, K-CREMCO

Dimensions (without cable)	150 × 60 × 50 mm
Weight (incl. cable)	0.5 kg
Cable length	6 m
Input voltage	5 V
Power consumption	180 mW
Communication protocol	RS-232

NOTE: Power supply from the monitor only.

2 Functional description

2.1 Remote Controller, K-REMCO/ K-CREMCO

The Remote Controller consists of 12 direct function keys and the ComWheel.

2.1.1 K-REMCO/ K-CREMCO PCBs

The K-REMCO/ K-CREMCO has two PCBs located inside the Remote Controller. One board has only the push button switches of the keys. The other board reads the status of the keys and the ComWheel and forwards the information to the CPU board.

2.1.2 External communication

K-REMCO Rev. 00-01

Two signals, TXD and RXD in RS232 format are in use. No handshaking is used. Serial communication speed is 19.2 kbps. The 26-pin subminiature D-connector of the Remote Controller is connected to the Display Controller Board, B-DISP.

K-REMCO Rev. 00 with optional Remote Controller - Compact Monitor cable or K-CREMCO Rev. 00

Two signals, TXD and RXD in RS232 format are in use. No handshaking is used. Serial communication speed is 19.2 kbps.

In Compact Monitors, the DIN 5 connector is connected to the keyboard connector X9.

In S/5 FM and FM Light, the DIN 5 connector is connected to Multi IO adapter X7.

2.1.3 ComWheel

The ComWheel is used for menu selection.

3 Service procedures

3.1 General service information

The field service of the remote controllers is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

WARNING **Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.**

3.2 Service check

These instructions include complete procedures for a service check. The service check is mandatory after any service repair. However, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A:") which may be used when performing the procedures.

The symbol  in the instructions indicates that the check form contains space to record the results of the particular procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
Screwdriver		

3.2.2 Visual inspection

Turn the monitor to STBY.

Disconnect the remote controller cable from the monitor.

Detach the remote controller upper cover and the keypad cover by removing the screws (7 pcs) from the bottom.

1. Internal parts

   Check that:

   - cables are connected properly
   - the remote controller cable is fastened to the bottom cover with screws
   - the keypad switches are intact
   - the software EPROM under the keypad is attached properly

2. External parts

   Check that:

   - the upper and bottom covers are intact
   - the keypad cover is intact
   - the ComWheel cover is intact and attached properly

   Reassemble the remote controller.

3. Cable

   Check the remote controller cable:

   - the cable is intact
   - the cable connector is intact
   - the connector pins are clean, straight and at about the same height
   - the locking screws inside the connector case are intact

3.2.3 Functional inspection

Reconnect the cable to the monitor and turn the monitor ON.

4. Command board software

   Enter the service menu:

   Menu (on the remote controller keypad) **- Monitor Setup** - ***Install/Service*** (password 16-4-34) **-** ***Service*** (password 26-23-8)

   Take down the information regarding the remote controller software.

   Select the menu ***KEYBOARD***:

   Service - Keyboard

5. Remote controller keys

   Press the keys one by one. Check that each key generates a sound from the loudspeaker.

6. ComWheel

   Turn the ComWheel clockwise and counterclockwise and check that each step generates a sound and the corresponding values at the bottom of the menu increase.

   Select DUMMY PRESS. Push the ComWheel and check that the push generates a sound and the corresponding value in the menu increases.

7. Electrical safety check
   Perform an electrical safety check and a leakage current test.

8. Functioning after electrical safety check
   Check that the remote controller functions normally after the electrical safety check.

9. Final cleaning
   Clean the remote controller and the cable.

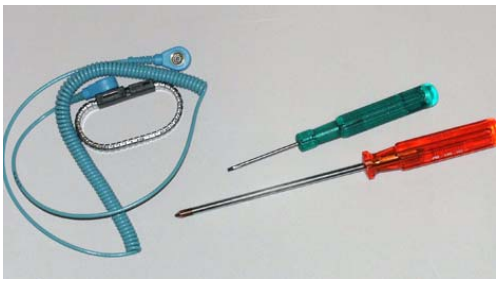
- Fill in all necessary documents.

3.3 Disassembly and reassembly

3.3.1 Before disassembly

WARNING **Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board. Handle all PC boards by their edges.**

3.3.2 Tools needed



- screwdriver
- flat blade screwdriver
- antistatic wristband

3.3.3 To disassemble Remote Controller K-REMCO / K-CREMCO

To disassemble the Remote Controller (see Figure 2):

1. Disconnect the K-REMCO/ K-CREMCO cable from the monitor.
2. Pull out the knob of the ComWheel.
3. Open the nut on the shaft of the ComWheel.
4. Open the three cross head screws on the bottom of the K-REMCO/ K-CREMCO.
5. Remove the top cover.
6. Open the four screws on the bottom of the K-REMCO/ K-CREMCO.
7. Remove the keyboard cover.
8. Disconnect the K-REMCO/ K-CREMCO cable and the wire set from the Comwheel.
9. Remove the PCBs.

For more information on the spare parts, see the “Spare parts” slot.

In reassembly, remember to put the reinforcing cord of the cable around the screw on the metal bridge before tightening the screw.

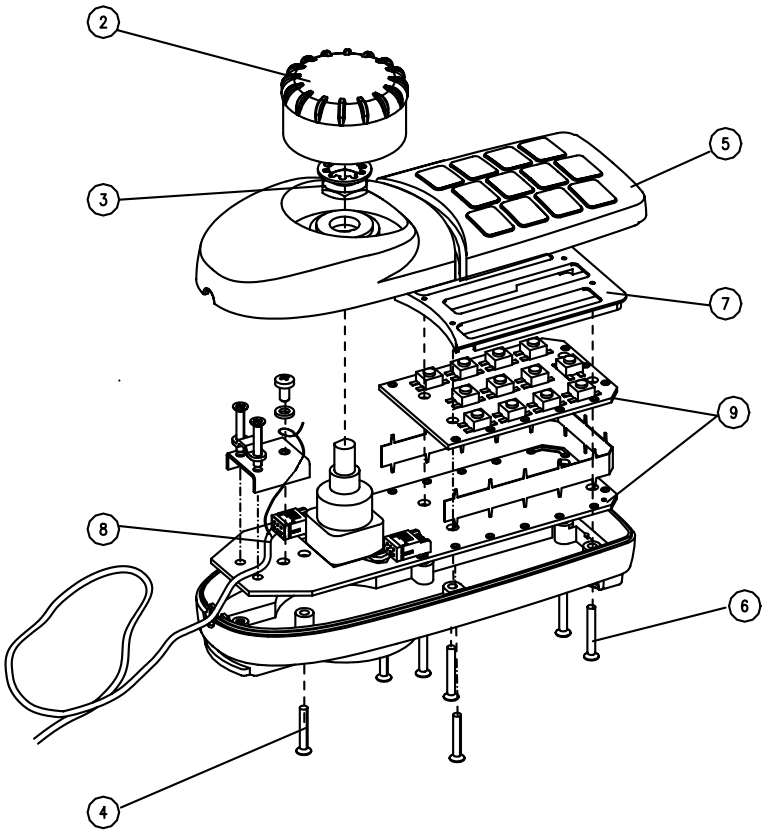


Figure 2 K-REMCO, K-CREMCO disassembly and reassembly

To reassemble the module, reverse the order of the disassembly steps.

In reassembly, remember to put the reinforcing cord of the cable around the screw on the metal bridge before tightening the screw.

CAUTION When reassembling the remote controller make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the remote controller.

4 Troubleshooting

4.1 K-REMCO, K-CREMCO

See Keyboard Service Menu in the “Service Menu“ slot and perform tests available. If any of the tests fail, see explanation below.

Problem	**Cause**	**What to do**
ComWheel not working	ComWheel leads broken or connector loose. ComWheel faulty.	Check the items. Replace the ComWheel if necessary.
Membrane key not working	Switch cable loose or broken. Keyboard cable loose or broken. Cable connector pin failure. RS232 communication failure on CPU board.	Check the items. Replace them if necessary.

For your notes:

APPENDIX A: Service check form, Remote Controllers K-REMCO (Rev. 01) and K-CREMCO (Rev. 00)

Customer		
Service	Keyboard type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
3. Cable	☐	☐	☐				
Notes							
Functional inspection							
4. Command board software	KB						
5. Remote controller keys	☐	☐	☐	6. ComWheel	☐	☐	☐
7. Electrical safety check	☐	☐	☐	8. Functioning after electrical safety check	☐	☐	☐
9. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

Signature

For your notes:

Datex-Ohmeda

Anesthesia Record Keeping Keyboard, K-ARKB (Rev. 00)

S/5™ Keyboard Interface Board, B-ARK (Rev. 00)

ARK Barcode Reader, N-SCAN (Rev. 00)

Technical Reference Manual Slot

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027839
June, 2005

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Table of contents

Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Anesthesia Record Keeping Keyboard, K-ARKB, the S/5 Keyboard Interface Board, B-ARK, and the ARK Barcode Reader, N-SCAN. The information is applicable for the current production revisions of the devices. Later in this manual the board may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

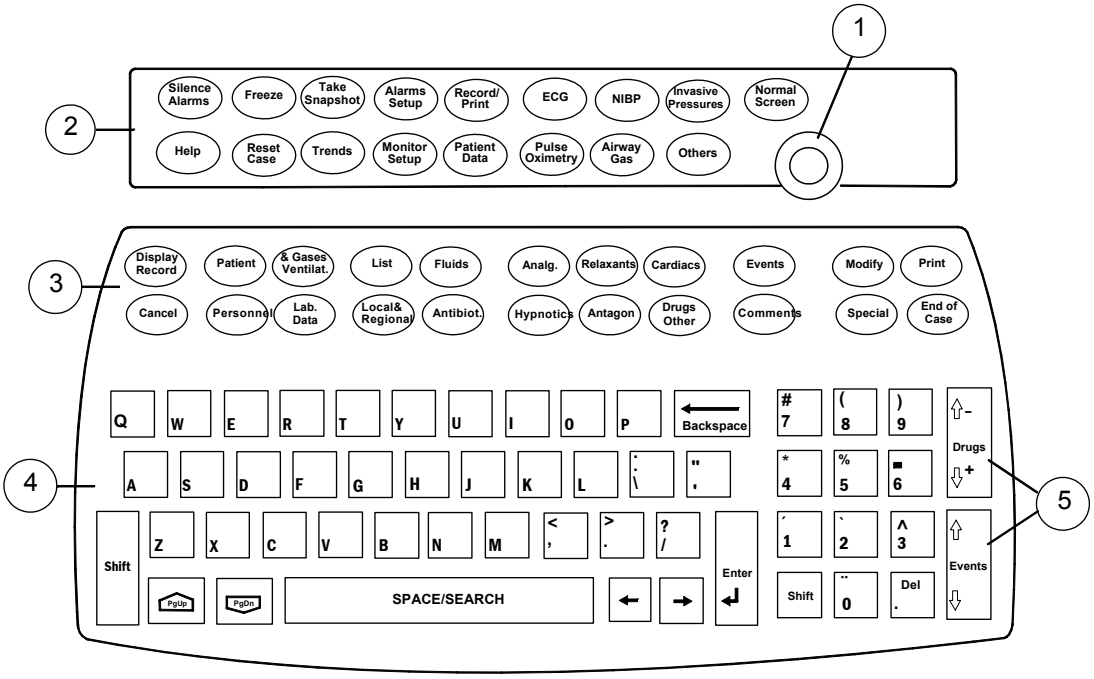


Figure 1 Anesthesia Record Keeping Keyboard, K-ARKB (English version)

(1) The ComWheel

(2) Keys that function as the S/5 Monitor’s command bar. The power switch is in the monitor’s Command Bar.

(3) Keys for record keeping control.

(4) Letter and number keys for typing in information that is not listed in the menus.

(5) Arrow keys (Drugs, Events) for moving up or down the Event list and Event trend when the record is on the display.

NOTE: The S/5 Keyboard Interface Board, B-ARK, can only be used with the S/5 Anesthesia Monitor and the AS/3 Anesthesia Monitor.

Monitor software compatibility

The K-ARK and K-ARKB keyboards are compatible with monitor software versions:
S-ARK94 and later, L-ARK99(A), L-00A03/04, L-00A07/08 and L-ANE01(A) and later.

Related documents

For more information about...	See
Technical issues	“Technical Reference Manual” of the S/5 Monitor, Part I
Configuration	Anesthesia Record Keeping Solution, user documentation
Contents of the menus in your hospital	Contact the personnel responsible for the menu configurations in the hospital
Monitor, parameters, physiological trends, general messages and symbols on the display	“Datex-Ohmeda S/5 Anesthesia Monitor, User’s Guide” and “User’s Reference Manual”
Printer	The printer manual
Barcode Reader	The Barcode Reader manual

1 Specifications

1.1 General specifications

1.1.1 Keyboard, K-ARKB

Dimensions (W × D × H)	328 × 232 × 61 mm/12.9 × 9.1 × 2.4 in
Weight	1.3 kg/3.8 lbs.
Power	+5 V DC ±10%, 70 mA max, supplied from S/5 AM or S/5 CM
Character set	ASCII
Communication interface	PC compatible serial line plus S/5 type serial line
Environmental requirements:	
Operating temperature	+10...+35 °C/+50...+95 °F
Storage temperature	-10...+45 °C/+14...+113 °F
Humidity	10...90% non-condensing

1.1.2 ARK Barcode Reader, N-SCAN

Dimensions (W × L × H)	7.1 12.7 × 16 cm/2.8 × 5 ×6.3 in
Weight approx.	170 g/5.98 oz. (w/o cable)
Power	supplied from S/5 Monitor or AS/3 AM or AS/3 CM
Light source	675 nm laser diode
Laser classifications	CDRH Class II, IEC Class 1, IEC 825 Class 2
Environmental requirements:	
Operating temperature	0...+40 °C/+32...+104 °F
Storage temperature	-40...+60 °C/-40...+140 °F
Humidity	5...95% non-condensing
Durability	withstands 1.2 m drop to concrete

2 Functional description

2.1 Introduction

The Anesthesia Record Keeping Solution is an automated anesthesia documentation system. For the Anesthesia Record Keeping Solution, the record keeping configurations from the network and a memory module, and optionally the keyboard, K-ARKB, are needed.

The Anesthesia Record Keeping Solution is connected to the network, and runs in S/5 AM or S/5 CAM. The Memory Module, E-MEM (N-CMMEM), is needed for backup data storage.

The Anesthesia Record Keeping Solution combines the physiological data measured by the monitor, information automatically integrated from external devices such as S/5 ADU, and the information manually entered into a printable anesthesia record using the menus. The record can be stored in electronic format for later review/printing and for statistical analysis.

2.2 Anesthesia Record Keeping Keyboard, K-ARKB

The Anesthesia Record Keeping Keyboard, K-ARKB, consists of a controller board, alphanumeric keyboard and membrane keyboard.

2.2.1 Controller board

The controller board reads the status of the keyboard keys and the ComWheel, and forwards the information to the CPU board in the monitor through an RS232 serial interface.

Additionally, the board controls the LEDs on the K-ARKB front panel.

External communication

Communication with the CPU board takes place in the RS232 serial communication channel which is available on the CPU bus. There are also two bidirectional signals (Data and Clock) for PCKB format communication.

For serial communication, the Anesthesia Record Keeping Keyboard, K-ARKB, is connected to the S/5 Anesthesia Monitor central unit by a 9-pin-26-pin interface cable. The cable is connected to Keyboard Interface Board, B-ARK, or to Display Controller Board, B-DISP in the F-CU8 or F-CPU.

In case of PCKB type communication, the Keyboard can be connected to the S/5 LCD Display, D-LCC10A, D-LCC12A or to the S/5 Compact Monitor.

CPU

The CPU on the controller board is of type 80C51FA and the oscillator frequency is 11.059 Mhz. There is a power-up-reset whose time constant is about 1 second.

Serial communication

The RS232 serial communication IC needs only +5 V supply voltage, because it chops the necessary RS-level supply voltages to its external capacitors. A diode allows the use of two keyboards, and a pull-down resistor on the CPU board is used for pulling the corresponding line to the negative RS-level. The speed rate of the serial communication is 19.2 kbps.

LEDs

The CPU on the controller board controls the alarm LEDs according to commands received from the main CPU board.

2.2.2 Alpha-numeric keyboard

The controller board reads the status of the keys on the alphanumeric keyboard. The boards are connected together with a 26-pin ribbon cable.

2.2.3 Membrane keyboard

The controller board reads the status of the keys on the membrane keyboards. The membrane keyboard and the controller board are connected together with a ribbon cable.

2.3 Keyboard Interface Board, B-ARK

The Keyboard Interface Board, B-ARK, is installed in the central unit of the S/5 Anesthesia Monitor. It has a 26-pin D-connector to which the Anesthesia Record Keeping Keyboard, K-ARKB, is connected. The board passes the keyboard signals to the central unit.

2.4 ARK Barcode Reader, N-SCAN

The ARK Barcode Reader, N-SCAN, is an optional device to make record keeping faster by using bar codes. With the Barcode Reader, the user has direct access to a menu item by reading a bar code mapped to the menu item. Barcodes can also be used for pushing and turning the ComWheel and opening the main menus (L-ARK99(A) or later).

WARNING **When using the ARK Barcode Reader, N-SCAN, do not stare into beam. The ARK Barcode Reader, N-SCAN, is a Class 2 laser product.**

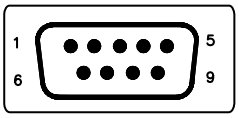
2.5 Connectors and signals

2.5.1 Connectors on the Anesthesia Record Keeping Keyboard, K-ARKB

Barcode Reader 5-pin connector

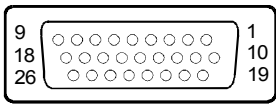
Pin No.	Signal
1	PC-CLOCK
2	PC-DATA
3	N.C.
4	GND
5	+5 V

Anesthesia Record Keeping Keyboard 9-pin connector

	Pin No.	I/O	Signal
	1	I/O	PC-DATA
	2	I	RX
	3	O	TX
	4	I	+5 V
	5		GND
	6	I	RESET
	7	-	GND
	8	-	N.C.
	9	I/O	PC-CLOCK

2.5.2 Connectors on the Keyboard Interface Board, B-ARK

26-pin connector (X3)



Pin No.	I/O	Signal
1		N/C
2		N/C
3		N/C
4		N/C
5		N/C
6	O	Ground
7		N/C
8		N/C
9		N/C
10		N/C
11		N/C
12		N/C
13		N/C
14		N/C
15	O	+ 5 V
16		N/C
17		N/C
18		N/C
19	I	RxD RS232
20	O	TxD RS232
21		N/C
22		N/C
23		N/C
24		N/C
25		N/C
26		N/C

CPU bus connector (X1)

Pin No.	a	b	c
1	+15 V	AGND	DGND
2	-15 V	BALE	DGND
3	SA0	SA1	DGND
4	SA2	SA3	RESET_RS485
5	SA4	SA5	-RESET_RS485
6	SA6	SA7	DATA_RS485
7	SA8	SA9	-DATA_RS485
8	SA10	SA11	TXDD_RS232
9	SA12	SA13	RXDD_RS232
10	SA14	SA15	BITOIN
11	SA16	SA17	BIT1IN
12	SA18	SA19	TXDC
13	SA20	SA21	RXDC
14	SA22	SA23	RTSC
15	-SMEMR	-SMEMW	CTSC
16	-IOR	-IOW	TXDB
17	CLK	-RESET	RXDB
18	-IOCHRDY	IRQ10	RTSB
19	N/C_1	IRQ11	CTSB
20	N/C_2	IRQ12	TXDA
21	-SBHE	IRQ15	RXDA
22	SD0	SD1	RTSA
23	SD2	SD3	CTSA
24	SD4	SD5	LOUDSPEAKER
25	SD6	SD7	+5 V
26	SD8	SD9	+5 V
27	SD10	SD11	+5 V
28	SD12	SD13	+5 V
29	SD14	SD15	ON/STBY
30	+15 VD	-RESET_CPU	+5 V_CPU
31	+15 VD	+32 VD	REFRESH_WD
32	GNDD	GNDD	POWER_FAIL

3 Service procedures

3.1 General service information

The field service of the K-ARKB Keyboard is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol  in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
B-ARK		with AM
Screwdriver		

3.2.2 Visual inspection

1. Cable

   Disconnect the interface cable from the Anesthesia Record Keeping Keyboard, K-ARKB, and check the cable:

   - the connector pins are clean and straight and at about the same height
   - the locking screws are intact
   - the cable is intact

   Leave the cable disconnected.

2. Internal check

   Detach the bottom cover and check internal parts:

- all screws are tightened properly
- the block screws for the interface cable are in place and tightened properly
- the block screw threads are intact
- the interface cable connector is clean and intact
- all internal cables are connected properly
- all IC's that are on sockets are attached properly
- there are no loose objects inside

Reattach the bottom cover, reconnect and lock the interface cable to the Anesthesia Record Keeping Keyboard, K-ARKB.

3. External check

   Check that:

   - the Anesthesia Record Keeping Keyboard, K-ARKB, plastic frame is intact
   - the front panel stickers are intact
   - the ComWheel cover is intact and attached properly
   - all four rubber pads are in place on the bottom cover

Install the B-ARK into the Central Unit. Connect and lock the interface cable to the B-ARK rear panel connector.

3.2.3 Functional inspection

4. ON LED

   Switch the monitor on. Check that the LED on the upper right hand corner of the Anesthesia Record Keeping Keyboard, K-ARKB, is lit up.

5. Software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) **-** ***Service*** (password 26-23-8)

   Take down the information regarding the Anesthesia Record Keeping Keyboard, K-ARKB, software.

6. Alarm LEDs

   Select the menu ***Keyboard*** with the ComWheel.

   Highlight the text ***Upper Led***. Check that the red alarm LED is turning on and off on the Anesthesia Record Keeping Keyboard, K-ARKB, when pressing the ComWheel.

Check also the yellow alarm LED by selecting ***Lower Led*** from the menu.

7. ComWheel

   Check the ComWheel.

   Turn the ComWheel clockwise and counterclockwise and check that each step generates a sound from the loudspeaker and the corresponding values at the bottom of the menu increase.

   Select ***Dummy Press***. Press the ComWheel and check that the press generates a sound and the corresponding value in the menu increases.

8. Membrane keys

   Check the membrane keys of the Anesthesia Record Keeping Keyboard, K-ARKB.

   Press the keys on the upper part of the Anesthesia Record Keeping Keyboard, K-ARKB, one by one. Check that each key generates a sound from the loudspeaker and the corresponding text in the menu changes from yellow to red.

   Press the keys on the lower part, all except the keys **Modify** and **Print**. Check that each key generates a sound from the loudspeaker, or at least the Message count value increases in the service menu.

   Press the keys **Modify** and **Print** and check that the corresponding menus open on the screen.

9. Electrical safety check

   Perform an electrical safety check and aleakage current test.

10. Functioning after electrical safety check

    Check that the Anesthesia Record Keeping Keyboard, K-ARKB, functions normally after the performed electrical safety check.

11. Final cleaning

    Clean the Anesthesia Record Keeping Keyboard, K-ARKB, with suitable detergent.

- Fill in all necessary documents.

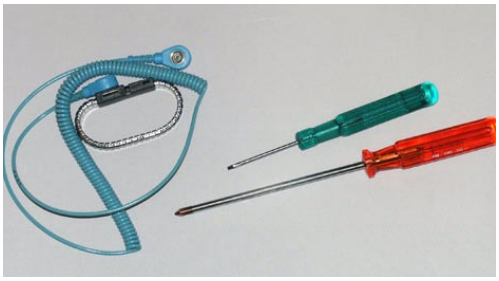
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- screwdriver
- flat blade screwdriver
- antistatic wristband

3.4 To disassemble the keyboard

To disassemble the Anesthesia Record Keeping Keyboard, K-ARKB (see the exploded view of the K-ARKB keyboard in the “E-Modules Spare parts” slot):

1. Disconnect the ARK keyboard - monitor cable (ARK keyboard - LCD display cable).
2. Remove the four screws from the bottom of the keyboard, and detach the cover plate from the bottom plate.

4 Troubleshooting

4.1 Troubleshooting charts

4.1.1 Anesthesia Record Keeping Keyboard, K-ARKB

Problem	Cause	What to do
Keys have no effect on the display.	Cable is not connected or broken. Wrong type of cable is connected. Loose connector inside. Component failure inside.	Connect right type of cable properly (see above). Detach the bottom plate and check connectors and components.
Membrane key not working.	Ribbon cable loose or broken. Keyboard cable loose or broken. D-connector pin failure. IC failure on the Controller board. RS232 communication failure on the main CPU board. NOTE: The cancel key does not respond if the menu is closed. The modify key may not work if there is no selection.	Check the items. Replace them if necessary.
Led does not light at alarm or stays lit after alarm is over.	Cable loose or broken. LED broken. Component failure on the Controller board.	Check the items. Replace them if necessary.

See more troubleshooting items in “User’s Reference Manual”.

4.1.2 Barcode Reader

Problem	Cause	What to do
Barcode Reader does not give a beep sound	Beep sound is OFF.	Contact personnel responsible for installing and configuring the monitors. ***Bar Code Beep*** should be ***ON*** in **Monitor Setup - *Install/Service - Installation - Monitor Settings*** menu. Password is required for the selection.
Nothing happens when trying to use the Barcode Reader.	Cable connections are not properly connected.	Confirm that the cables are properly connected.

Problem	**Cause**	**What to do**
Barcode Reader opens a ***Search*** menu but nothing else happens.	Menu directory does not have a Barcode Reader file.	Contact personnel responsible for installing and configuring the monitors.
Barcode Reader led flashes and you may hear a beep sound, but nothing else happens.	1. Barcodes are not included in the configuration. 2. Barcode Reader is not correctly programmed. 3. Monitor is not connected to the network and the memory module does not have a menu card inside. 4. Monitor has an old configuration which is not updated. 5. Old software version on monitor.	1. Contact personnel responsible for installing and configuring the monitors. 2. Contact personnel responsible for installing and configuring the monitors. The Barcode Reader should be reprogrammed. See the instructions following the Barcode Reader. 3. Connect the monitor to the network or insert a menu card into the memory module. 4. Contact personnel responsible for installing and configuring the monitors. 5. Please upgrade your monitor. 6. NOTE: Possible connecting cables are 881152 and Y-piece or 8001117.
Search result seems to mix different menu items.	Menu files have been modified after which they have not been recompiled with the map files.	Contact personnel responsible for installing and configuring the monitors. The menu files have to be recompiled together with the map files.

See more troubleshooting items in the Barcode Reader manual.

5 Earlier revisions

Information on Anesthesia Keyboard, K-ARK rev. 00, see Service Manual 885 941.
Information on Anesthesia Keyboard, K-ARK rev. 02, see Technical Reference Manual 896 624.
Previous Bar Code Reader (by HP) rev. 00, see Technical Reference Manual 895 585.

APPENDIX A Service check form, Anesthesia Record Keeping Keyboard, K-ARKB (Rev. 00)

Customer		
Service	Keyboard type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Cable	☐	☐	☐	2. Internal check	☐	☐	☐
3. External check	☐	☐	☐				
Functional inspection							
4. ON LED	☐	☐	☐				
5. Software	KB						
6. Alarm LEDs	☐	☐	☐	7. ComWheel	☐	☐	☐
8. Membrane keys	☐	☐	☐				
9. Electrical safety check	☐	☐	☐	10. Functioning after electrical safety check	☐	☐	☐
11. Final cleaning	☐	☐	☐				

Notes

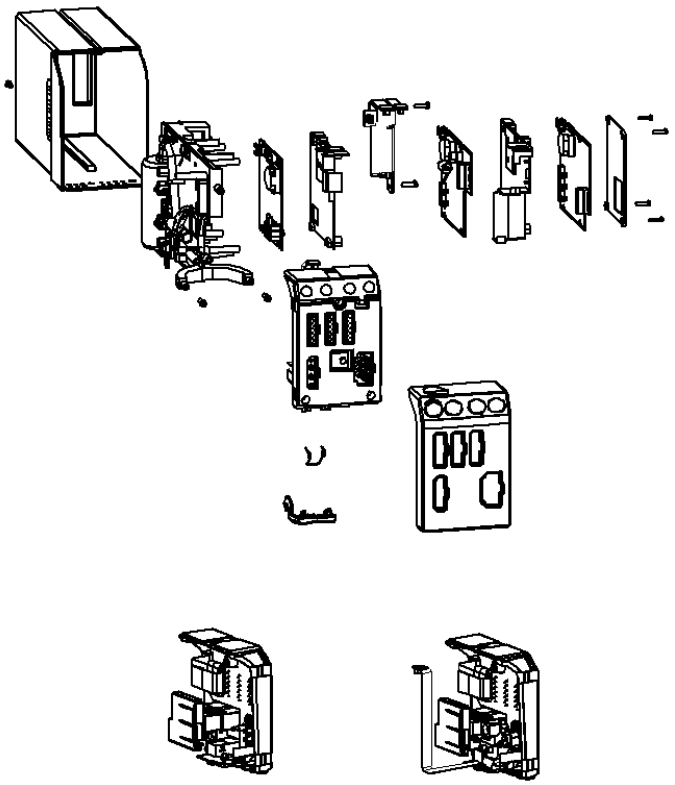
Used spare parts			

Signature

Datex-Ohmeda

E-Modules

Spare Parts



Conformity according to the Council Directive 93/42/EEC concerning Medical Devices amended by 2007/47/EEC.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

All specifications subject to change without notice.

Document number M1044469A

June 1, 2012

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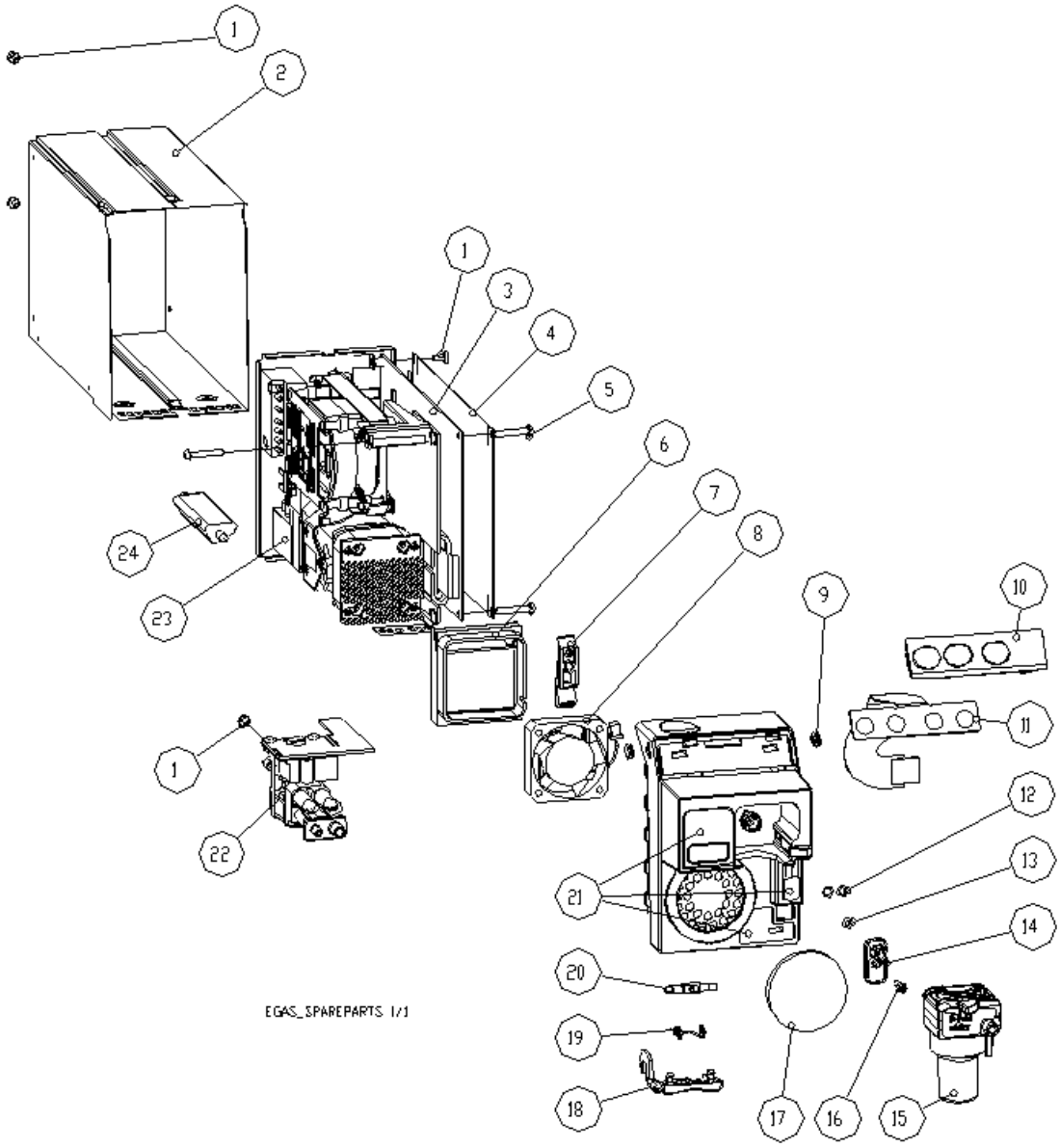
Table of contents

1 Compact Airway Module, E-CAiOVX, E-CAiOV, E-CAiO, E-COVX, E-COV, E-CO



Item	Description	Order No.
	Nafion tubing 300mm	733382
1	SCREW, machine screw, M3x6mm, DIN7985 ISO7045, Pozidrive, pan head, steel, zinc	61721
2	Casing, E-GAS	M1023095
3	CPU BOARD, M-CAiOVX	8001806

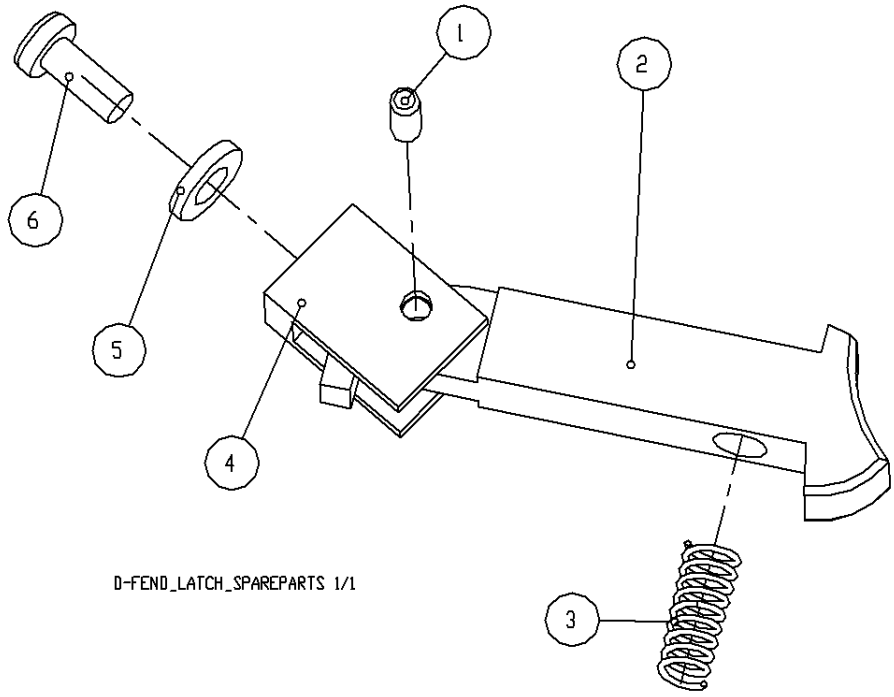
Item	Description	Order No.
4	Cover Plate for Gas Units	M1029000
5	SCREW, machine screw, M3x18mm, DIN7985, ISO7045, Pozidrive, pan head, steel, zinc, STZn	61739
6	Air deflector M-CAiOV	886239
7	Filter Base, E-GAS	M1021041
8	M-CAiOV Fan	886213
9	Filler Plug, E-GAS	M1024364
10	Front Cover, DA, E-COV(X), E-CAiOV(X)	M1029150
10	Front Cover, DE, E-COV(X), E-CAiOV(X)	M1029151
10	Front Cover, EN, E-COV(X), E-CAiOV(X)	M1029152
10	Front Cover, ES, E-COV(X), E-CAiOV(X)	M1029153
10	Front Cover, FI, E-COV(X), E-CAiOV(X)	M1029154
10	Front Cover, FR, E-COV(X), E-CAiOV(X)	M1029155
10	Front Cover, HU, E-COV(X), E-CiAOV(X)	M1046325
10	Front Cover, IT, E-COV(X), E-CAiOV(X)	M1029156
10	Front Cover, JA, E-COV(X), E-CAiOV(X)	M1029157
10	Front Cover, NL, E-COV(X), E-CAiOV(X)	M1029158
10	Front Cover, NO, E-COV(X), E-CAiOV(X)	M1029159
10	Front Cover, PL, E-COV(X), E-CAiOV(X)	M1029160
10	Front Cover, PT, E-COV(X), E-CAiOV(X)	M1029161
10	Front Cover, SV, E-COV(X), E-CAiOV(X)	M1029162
10	Keyplate (no buttons), E-CO, E-CAiO	M1024362
11	Membrane Keyboard, E-GAS	M1024354
12	O-RING, O-RING, 4.0x1.0, NBR, SHORE 70	653125
13	O-ring, 2.8x1.6	65340
14	Ref. Gas Filter and Frame, E-CAIOV	M1028983
15	D-FEND water trap (replacement part), black	875055
15	D-FEND+ water trap (once), green	893200
16	SCREW, machine screw, M2.5x10mm, DIN7985, ISO7045, Pozidrive, pan head, steel	61715
17	Fan filter, E-CAiOV	M1028987
18	Latch	M1021039

Item	Description	Order No.
19	Torsion Spring, E-REC, E-GAS	M1024356
20	Joint, E-GAS, Turned	M1023087
21	Front Panel Sticker, E-CAiO, DA (A, B, D)	M1035122
21	Front Panel Sticker, E-CAiO, DE (A, B, D)	M1035045
21	Front Panel Sticker, E-CAiO, EN (A, B, D)	M1031237
21	Front Panel Sticker, E-CAiO, ES (A, B, D)	M1035054
21	Front Panel Sticker, E-CAiO, FI (A, B, D)	M1035116
21	Front Panel Sticker, E-CAiO, FR (A, B, D)	M1035047
21	Front Panel Sticker, E-CAiO, HU (A, B, D)	M1042368
21	Front Panel Sticker, E-CAiO, IT (A, B, D)	M1035110
21	Front Panel Sticker, E-CAiO, JA (A, B, D)	M1035125
21	Front Panel Sticker, E-CAiO, NL (A, B, D)	M1035049
21	Front Panel Sticker, E-CAiO, NO (A, B, D)	M1035120
21	Front Panel Sticker, E-CAiO, PL (A, B, D)	M1035127
21	Front Panel Sticker, E-CAiO, PT (A, B, D)	M1035112
21	Front Panel Sticker, E-CAiO, SV (A, B, D)	M1035118
21	Front Panel Sticker, E-CAiOV, DA (A,B,C)	M1035840
21	Front Panel Sticker, E-CAiOV, DE (A,B,C)	M1035821
21	Front Panel Sticker, E-CAiOV, EN (A, B, C)	M1031245
21	Front Panel Sticker, E-CAiOV, ES (A,B,C)	M1035828
21	Front Panel Sticker, E-CAiOV, FI (A,B,C)	M1035834
21	Front Panel Sticker, E-CAiOV, FR (A,B,C)	M1035823
21	Front Panel Sticker, E-CAiOV, HU (A, B, C)	M1042371
21	Front Panel Sticker, E-CAiOV, IT (A,B,C)	M1035830
21	Front Panel Sticker, E-CAiOV, JA (A,B,C)	M1035842
21	Front Panel Sticker, E-CAiOV, NL (A,B,C)	M1035826
21	Front Panel Sticker, E-CAiOV, NO (A,B,C)	M1035838
21	Front Panel Sticker, E-CAiOV, PL (A,B,C)	M1035844
21	Front Panel Sticker, E-CAiOV, PT (A,B,C)	M1035832
21	Front Panel Sticker, E-CAiOV, SV (A,B,C)	M1035836
21	Front Panel Sticker, E-CAiOVX, DA (A,B,C)	M1035943

Item	Description	Order No.
21	Front Panel Sticker, E-CAiOVX, DE (A,B,C)	M1035921
21	Front Panel Sticker, E-CAiOVX, EN (A, B, C)	M1031248
21	Front Panel Sticker, E-CAiOVX, ES (A,B,C)	M1035928
21	Front Panel Sticker, E-CAiOVX, FI (A,B,C)	M1035936
21	Front Panel Sticker, E-CAiOVX, FR (A,B,C)	M1035924
21	Front Panel Sticker, E-CAiOVX, HU (A, B, C)	M1042375
21	Front Panel Sticker, E-CAiOVX, IT (A,B,C)	M1035930
21	Front Panel Sticker, E-CAiOVX, JA (A,B,C)	M1035945
21	Front Panel Sticker, E-CAiOVX, NL (A,B,C)	M1035926
21	Front Panel Sticker, E-CAiOVX, NO (A,B,C)	M1035941
21	Front Panel Sticker, E-CAiOVX, PL (A,B,C)	M1035947
21	Front Panel Sticker, E-CAiOVX, PT (A,B,C)	M1035934
21	Front Panel Sticker, E-CAiOVX, SV (A,B,C)	M1035938
21	Front Panel Sticker, E-CO, DA (A,B,D)	M1036193
21	Front Panel Sticker, E-CO, DE (A,B,D)	M1036169
21	Front Panel Sticker, E-CO, EN (A, B, D)	M1031240
21	Front Panel Sticker, E-CO, ES (A,B,D)	M1036179
21	Front Panel Sticker, E-CO, FI (A,B,D)	M1036186
21	Front Panel Sticker, E-CO, FR (A,B,D)	M1036172
21	Front Panel Sticker, E-CO, HU (A, B, D)	M1042377
21	Front Panel Sticker, E-CO, IT (A,B,D)	M1036181
21	Front Panel Sticker, E-CO, JA (A,B,D)	M1036196
21	Front Panel Sticker, E-CO, NL (A,B,D)	M1036175
21	Front Panel Sticker, E-CO, NO (A,B,D)	M1036190
21	Front Panel Sticker, E-CO, PL (A,B,D)	M1036200
21	Front Panel Sticker, E-CO, PT (A,B,D)	M1036184
21	Front Panel Sticker, E-CO, SV (A,B,D)	M1036188
21	Front Panel Sticker, E-COV, (A,B,C), DE	M1036299
21	Front Panel Sticker, E-COV, DA (A,B,C)	M1036330
21	Front Panel Sticker, E-COV, EN (A, B, C)	M1029566
21	Front Panel Sticker, E-COV, ES (A,B,C)	M1036317

Item	Description	Order No.
21	Front Panel Sticker, E-COV, FI (A,B,C)	M1036323
21	Front Panel Sticker, E-COV, FR (A,B,C)	M1036313
21	Front Panel Sticker, E-COV, HU (A, B, C)	M1042380
21	Front Panel Sticker, E-COV, IT (A,B,C)	M1036319
21	Front Panel Sticker, E-COV, JA (A,B,C)	M1036332
21	Front Panel Sticker, E-COV, NL (A,B,C)	M1036315
21	Front Panel Sticker, E-COV, NO (A,B,C)	M1036328
21	Front Panel Sticker, E-COV, PL (A,B,C)	M1036334
21	Front Panel Sticker, E-COV, PT (A,B,C)	M1036321
21	Front Panel Sticker, E-COV, SV (A,B,C)	M1036326
21	Front Panel Sticker, E-COVX, DA (A,B,C)	M1036440
21	Front Panel Sticker, E-COVX, DE (A,B,C)	M1036418
21	Front Panel Sticker, E-COVX, EN (A, B, C)	M1029575
21	Front Panel Sticker, E-COVX, ES (A,B,C)	M1036427
21	Front Panel Sticker, E-COVX, FI (A,B,C)	M1036433
21	Front Panel Sticker, E-COVX, FR (A,B,C)	M1036420
21	Front Panel Sticker, E-COVX, HU (A, B, C)	M1042382
21	Front Panel Sticker, E-COVX, IT (A,B,C)	M1036429
21	Front Panel Sticker, E-COVX, JA (A,B,C)	M1036443
21	Front Panel Sticker, E-COVX, NL (A,B,C)	M1036423
21	Front Panel Sticker, E-COVX, NO (A,B,C)	M1036437
21	Front Panel Sticker, E-COVX, PL (A,B,C)	M1036446
21	Front Panel Sticker, E-COVX, PT (A,B,C)	M1036431
21	Front Panel Sticker, E-COVX, SV (A,B,C)	M1036435
22	PVX Unit, E-CAiOV	M1029209
23	PUMP, 0V, 10V, Air pump, max 0.39l/min, 10VDC, EPDM	57313
24	Zero absorber, M-Cxxx	895933

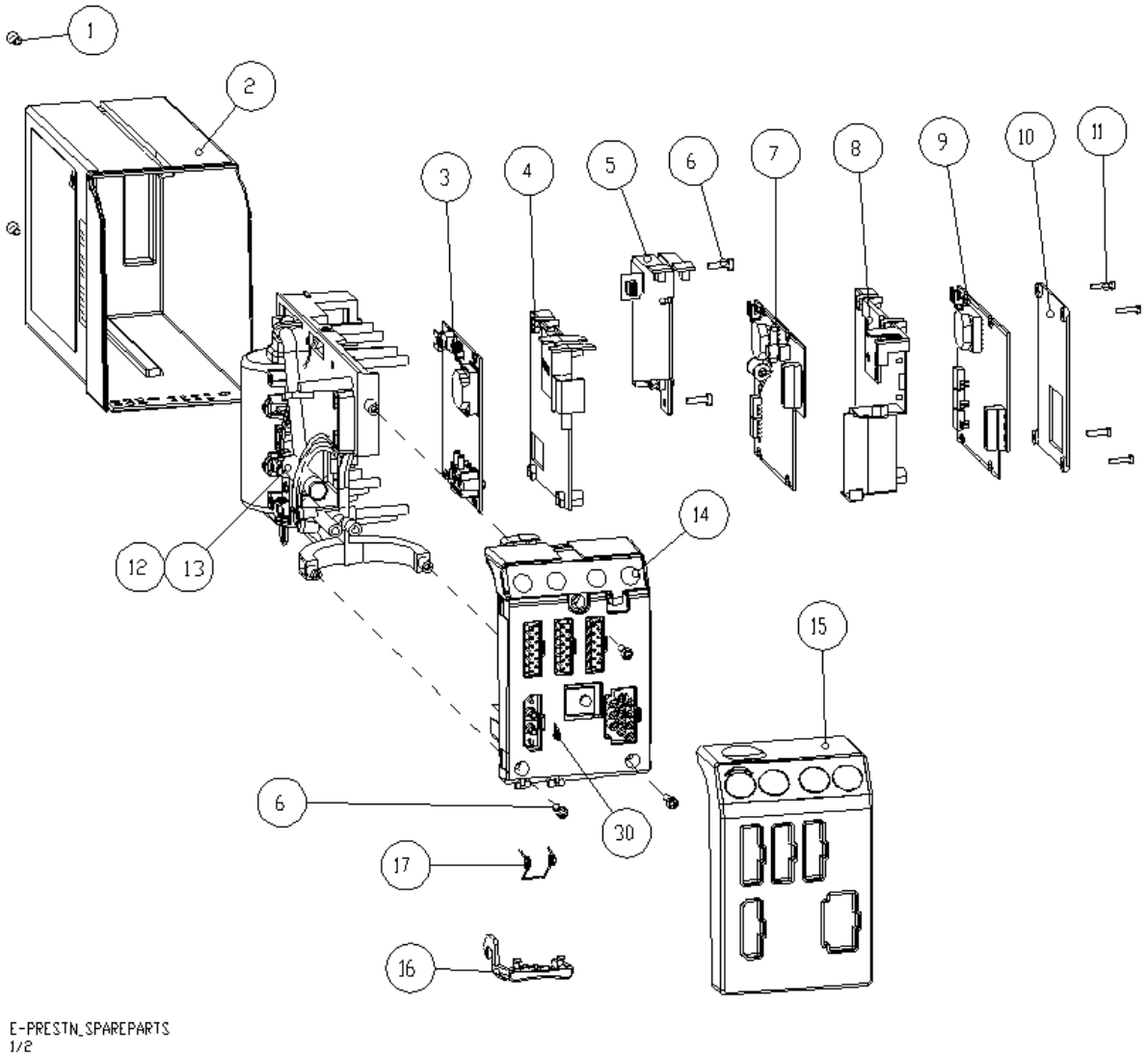
1.1 D-FEND latch



Item	Description	Order No.
	D-fend Latch Assembly, Spare Part Assembly	M1039037
1	Pin, M-CAiOV	887005
2	Latch, D-Fend	M1028985
3	Spring 0.4x2.5x10	64242
4	Hinge, M-CAiOV	886235
5	Washer STZN, M 2.7	63608
6	Screw M2.5x6 mm, DIN7985 ISO7045, Pozidrive	617120-HEL

2 Hemodynamic Modules

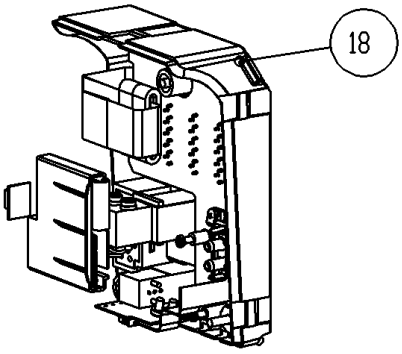
2.1 E-PRESTN, E-PRETN, E-RESTN

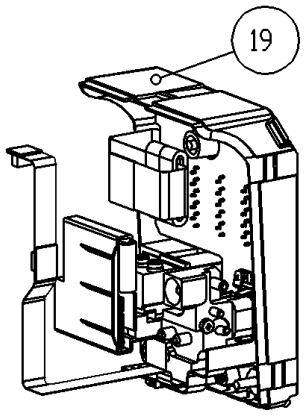


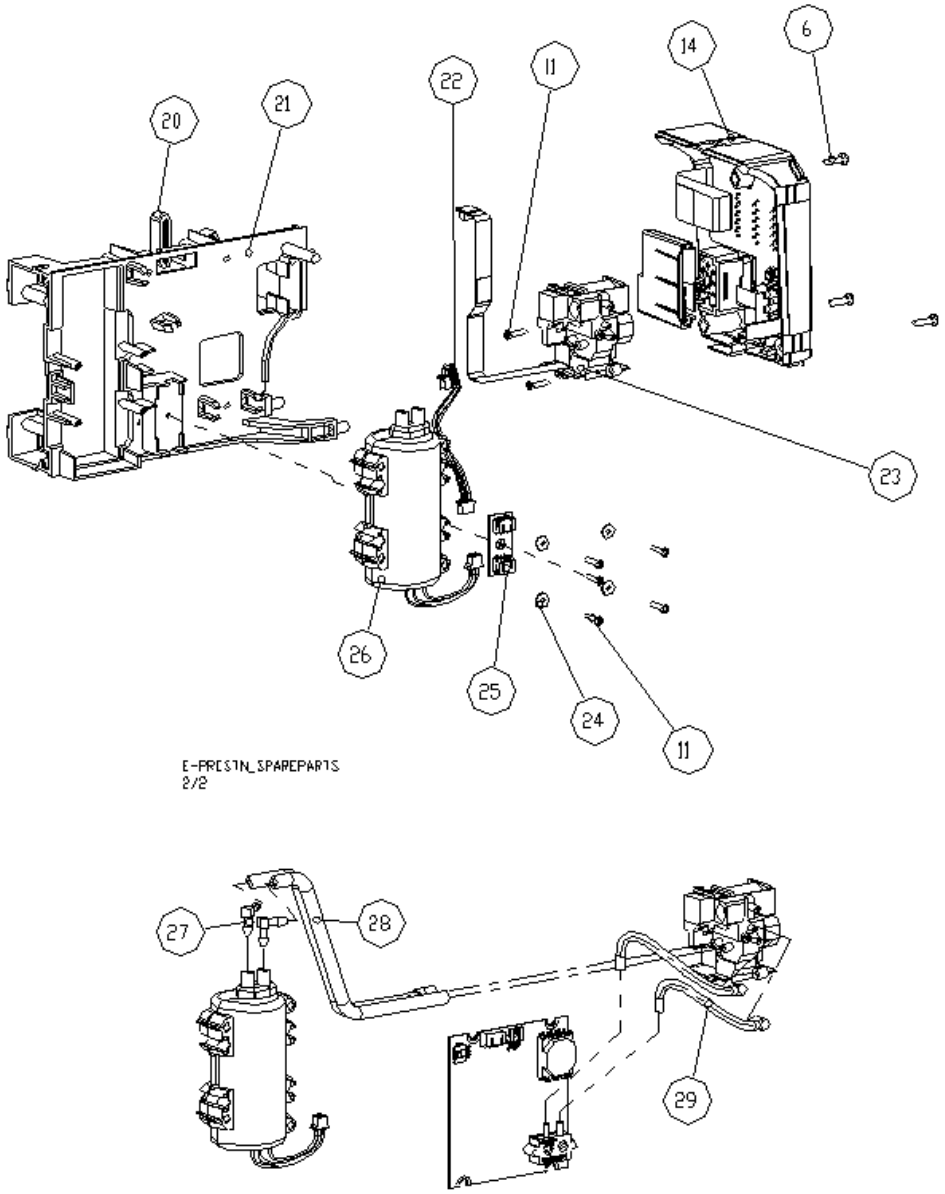
Item	Description	Order No.
1	SCREW, thread forming, M3x8mm, WN1423, torx head, flat countersunk head, steel	M1027118
2	Module Casing, Double	M1021037
3	NIBP Board PSM	M1007747
4	STP - NIBP insulator	M1008207
5	E-PRESTN Module bus connection board	M1024653
6	SCREW, for plastic PT, 3x10mm, WN1452, pan head, steel, zinc, head Torx 8, head max 5mm	628728

Item	Description	Order No.
7	STP-CO board, PSM	M1018406
8	ECG STP insulator	M1008205
9	ECG Board, PSM	M1007722
10	Board Cover, E-(P)RE(S)TN	M1038754
11	SCREW, PT, 2.2mmx10mm, torx head, pan head, steel	M1010187
12	FILTER, air filter, 30um, HDPE, D=6.5mm, d=3.3mm, L=46mm	M1221481
13	Filter cover	M1020996
14	Membrane Keyboard, E-(P)RE(S)TN	M1023085
15	Front Cover, DA, E-PRESTN	M1027792
15	Front Cover, DE, E-PRESTN	M1027793
15	Front Cover, EN, E-PRESTN	M1027794
15	Front Cover, ES, E-PRESTN	M1027795
15	Front Cover, FI, E-PRESTN	M1027796
15	Front Cover, HU, E-PRESTN	M1046280
15	Front Cover, IT, E-PRESTN	M1027797
15	Front Cover, JA, E-PRESTN	M1027798
15	Front Cover, FR, E-PRESTN	M1027799
15	Front Cover, NO, E-PRESTN	M1027801
15	Front Cover, NL, E-PRESTN	M1027800
15	Front Cover, PL, E-PRESTN	M1027802
15	Front Cover, PT, E-PRESTN	M1027803
15	Front Cover, SV, E-PRESTN	M1027804
15	Front Cover, DA, E-PRETN	M1027845
15	Front Cover, DE, E-PRETN	M1027846
15	Front Cover, EN, E-PRETN	M1027848
15	Front Cover, ES, E-PRETN	M1027851
15	Front Cover, FI, E-PRETN	M1027852
15	Front Cover, HU, E-PRETN	M1046282
15	Front Cover, IT, E-PRETN	M1027854
15	Front Cover, FR, E-PRETN	M1027853
15	Front Cover, JA, E-PRETN	M1027855
15	Front Cover, NL, E-PRETN	M1027856
15	Front Cover, PL, E-PRETN	M1027858
15	Front Cover, NO, E-PRETN	M1027857

Item	Description	Order No.
15	Front Cover, PT, E-PRETN	M1027859
15	Front Cover, SV, E-PRETN	M1027860
15	Front Cover, DA, E-RESTN	M1027866
15	Front Cover, DE, E-RESTN	M1027867
15	Front Cover, EN, E-RESTN	M1027868
15	Front Cover, ES, E-RESTN	M1027869
15	Front Cover, FI, E-RESTN	M1027870
15	Front Cover, FR, E-RESTN	M1027871
15	Front Cover, HU, E-RESTN	M1046289
15	Front Cover, IT, E-RESTN	M1027880
15	Front Cover, JA, E-RESTN	M1027881
15	Front Cover, NL, E-RESTN	M1027882
15	Front Cover, NO, E-RESTN	M1027883
15	Front Cover, PL, E-RESTN	M1027884
15	Front Cover, PT, E-RESTN	M1027885
15	Front Cover, SV, E-RESTN	M1027886
16	Latch	M1021039
17	Torsion Spring	M1020935
18	Front Chassis including connectors, E-(P)RE(S)TN, Spare Part	M1033420
19	Front Chassis Unit, E-PRESTN	M1027514



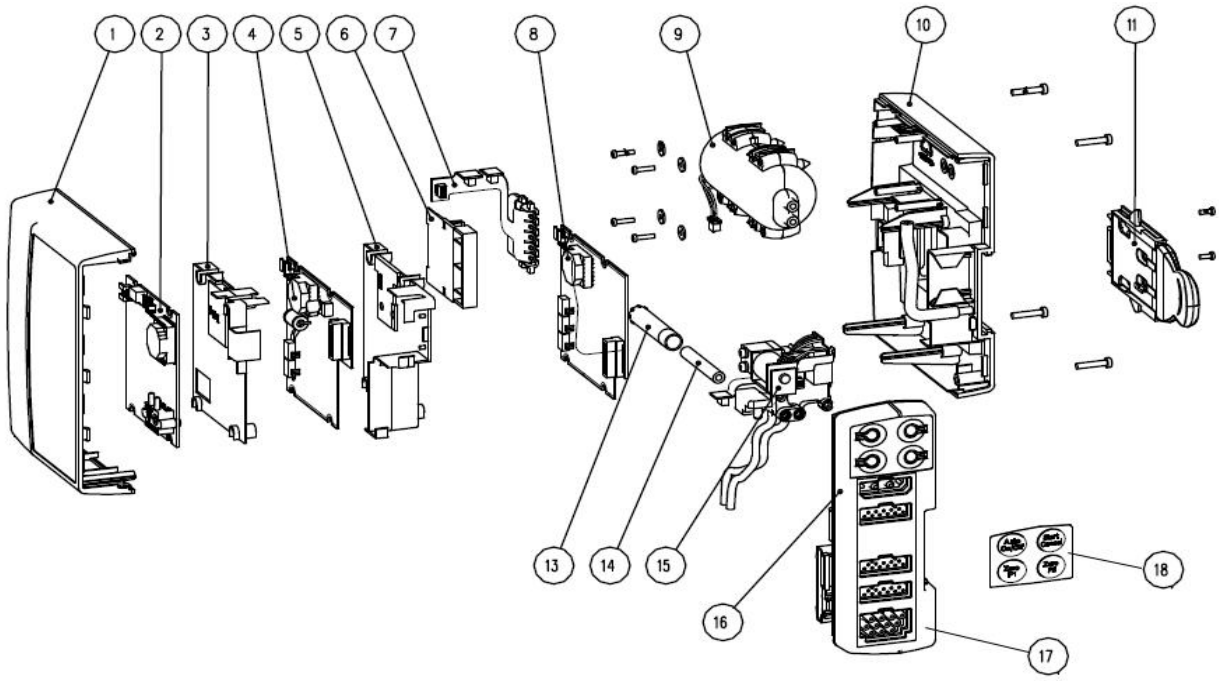




Item	Description	Order No.
20	FILT-EMI, low pass, soft ferrite for 16way flat cable, solid	304508
21	Frame, E-(P)RE(S)TN	M1023076
22	NIBP Pump Extension Wires, E-PRESTN	M1027664
23	NIBP Manifold Unit, E-PRESTN	M1027676
24	Washer 2.5x7.5x1 mm	M1010176
25	E-PRESTN NIBP pump connection board	M1024369
26	NIBP Pump Unit, E-PSM(P)	M1011858
27	Tube connector, L-piece 3mm, white	73381

Item	Description	Order No.
28	Tube silicon 3,18x6,35	73375
29	Angled hose, E-(P)RE(S)TN	M1023083
30	Snap spring	M1036967

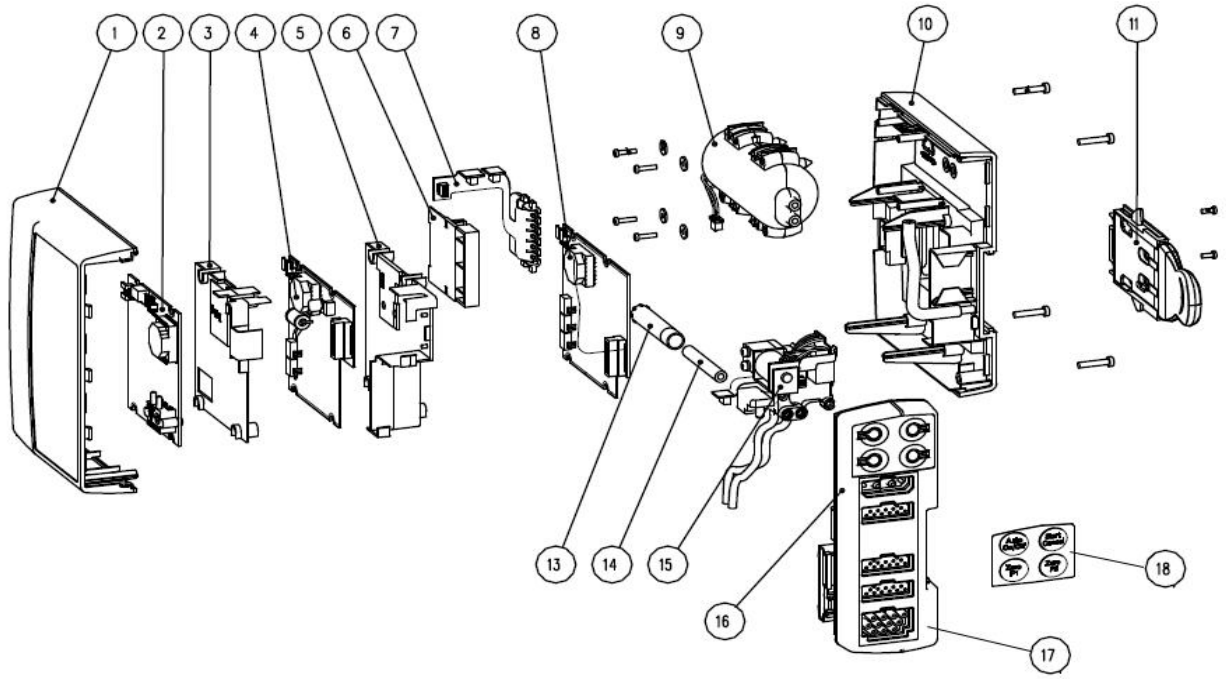
2.2 Patient Side Modules, E-PSM, E-PSMP (Rev. 01)



FRU Description	Parts Included	Order No.
E-PSM(P)-01, NIBP Board, FRU	2) NIPB Board	M1221544
E-PSM(P)-01, STP Board, FRU	4) STP Board	M1221543
E-PSM(P)-01, Module Bus Connector Board, FRU	7) Module Bus Connector 6) Module Bus Insulator	M1221542
E-PSM(P)-01, ECG Board, FRU	8) ECG Board	M1221541
E-PSM(P), NIPB Pump, FRU	9) NIPB Pump, screws and washers	M1221540
E-PSM(P)-01, NIPB Manifold Unit, FRU	15) NIPB Manifold Unit 14) Filter 13) Filter Cover	M1221539
E-PSM(P), Plastic Parts, FRU	1) Cover 3) STP NIPB Insulator 5) ECG STP Insulator 6) Module Bus Insulator	M1221538
E-PSM(P), Frame, FRU	10) Frame	M1221537
E-PSM(P), Screws and Washers, FRU	All screws and washers	M1221482
E-PSM(P), Air Filter, FRU	14) Filter 13) Filter Cover	M1221481
E-PSM(P), Lock Unit, FRU	11) Lock Unit and screws	M1221394

FRU Description	Parts Included	Order No.
E-PSM-01, Front Panel Unit - DE, FRU	16) Front Panel Unit 17) Front Mask - DE 18) Front Panel Stickers: DE	M1213585
E-PSM-01, Front Panel Unit - EN, NL, IT, FRU	16) Front Panel Unit 17) Front Mask - EN, NL, IT 18) Front Panel Stickers: EN, NL, IT	M1213586
E-PSM-01, Front Panel Unit - ES, FRU	16) Front Panel Unit 17) Front Mask - ES 18) Front Panel Stickers: ES	M1213587
E-PSM-01, Front Panel Unit - CS, DA, FI, NO, PL, SV, FRU	16) Front Panel Unit 17) Front Mask - CS, DA, FI, NO, PL, SV 18) Front Panel Stickers: CS, DA, FI, NO, PL, SV	M1213588
E-PSM-01, Front Panel Unit - FR, PT, FRU	16) Front Panel Unit 17) Front Mask - FR, PT 18) Front Panel Stickers: FR, PT	M1213589
E-PSM-01, Front Panel Unit - HU, FRU	16) Front Panel Unit 17) Front Mask - HU 18) Front Panel Stickers: HU	M1213590
E-PSMP-01, Front Panel Unit - DE, FRU	16) Front Panel Unit 17) Front Mask - DE 18) Front Panel Stickers: DE	M1213591
E-PSMP-01, Front Panel Unit - EN, NL, IT, FRU	16) Front Panel Unit 17) Front Mask - EN, NL, IT 18) Front Panel Stickers: EN, NL, IT	M1213592
E-PSMP-01, Front Panel Unit - ES, FRU	16) Front Panel Unit 17) Front Mask - ES 18) Front Panel Stickers: ES	M1213593
E-PSMP-01, Front Panel Unit - CS, DA, FI, NO, PL, FRU	16) Front Panel Unit 17) Front Mask - CS, DA, FI, NO, PL 18) Front Panel Stickers: CS, DA, FI, NO, PL	M1213594
E-PSMP-01, Front Panel Unit - FR, PT, FRU	16) Front Panel Unit 17) Front Mask - FR, PT 18) Front Panel Stickers: FR, PT	M1213595
E-PSMP-01, Front Panel Unit - HU, FRU	16) Front Panel Unit 17) Front Mask - HU 18) Front Panel Stickers: HU	M1213596
E-PSMP-01, Front Panel Unit - SV, FRU	16) Front Panel Unit 17) Front Mask - SV 18) Front Panel Stickers: SV	M1213597

2.3 Patient Side Modules, E-PSM, E-PSMP (Rev. 00)



FRU / Item Description	Parts Included	Order No.
NIBP Board, E-PSM(P)	2) NIPB Board	M1007747
STP-CO Board, E-PSM(P)	4) STP Board	M1018406
Module Flex Board Unit, E-PSM(P)	7) Module Bus Connector	M1012191
ECG Board, E-PSM(P)	8) ECG Board	M1007722
E-PSM(P), NIPB Pump, FRU	9) NIPB Pump, screws and washers	M1221540
NIBP Manifold Unit, E-PSM(P)	15) NIPB Manifold Unit	M1020158
E-PSM(P), Plastic Parts, FRU	1) Cover 3) STP NIPB Insulator 5) ECG STP Insulator 6) Module Bus Insulator	M1221538
E-PSM(P), Frame, FRU	10) Frame	M1221537
E-PSM(P), Screws and Washers, FRU	All screws and washers	M1221482
E-PSM(P), Air Filter, FRU	14) Filter 13) Filter Cover	M1221481
E-PSM(P), Lock Unit, FRU	11) Lock Unit and screws	M1221394
Front Panel Unit, E-PSM - DE	16) Front Panel Unit 17) Front Mask - DE	M1027533

FRU / Item Description	Parts Included	Order No.
Front Panel Unit, E-PSM - EN, NL, IT	16) Front Panel Unit 17) Front Mask - EN, NL, IT	M1027530
Front Panel Unit, E-PSM - ES	16) Front Panel Unit 17) Front Mask - ES	M1027534
Front Panel Unit, E-PSM - FI, DA, NO, PL, SV, CS	16) Front Panel Unit 17) Front Mask - CS, DA, FI, NO, PL, SV	M1027531
Front Panel Unit, E-PSM - FR, PT	16) Front Panel Unit 17) Front Mask - FR, PT	M1027532
Front Panel Unit, E-PSM - HU	16) Front Panel Unit 17) Front Mask - HU	M1050791
Front Panel Unit, E-PSMP - DE	16) Front Panel Unit 17) Front Mask - DE	M1027524
Front Panel Unit, E-PSMP - EN, NL, IT	16) Front Panel Unit 17) Front Mask - EN, NL, IT	M1027528
Front Panel Unit, E-PSMP - ES	16) Front Panel Unit 17) Front Mask - ES	M1027529
Front Panel Unit, E-PSMP - FI, DA, NO, PL, CS	16) Front Panel Unit 17) Front Mask - CS, DA, FI, NO, PL	M1027523
Front Panel Unit, E-PSMP - FR, PT	16) Front Panel Unit 17) Front Mask - FR, PT	M1027525
Front Panel Unit, E-PSMP - HU	16) Front Panel Unit 17) Front Mask - HU	M1050790
Front Panel Unit, E-PSMP - SV	16) Front Panel Unit 17) Front Mask - SV	M1027526

2.3.1 Front panel labeling, E-PSM(P) (Rev. 00 and 01)

Item	Description	Order No.
	Front Panel Sticker, E-PSM - CS	M1063619
	Front Panel Sticker, E-PSM - DA	M1023749
	Front Panel Sticker, E-PSM - DE	M1023740
	Front Panel Sticker, E-PSM - EN	M1023739
	Front Panel Sticker, E-PSM - ES	M1023743
	Front Panel Sticker, E-PSM - FI	M1023746
	Front Panel Sticker, E-PSM - FR	M1023741
	Front Panel Sticker, E-PSM - HU	M1042359
	Front Panel Sticker, E-PSM - IT	M1023744
	Front Panel Sticker, E-PSM - NL	M1023742
	Front Panel Sticker, E-PSM - NO	M1023748

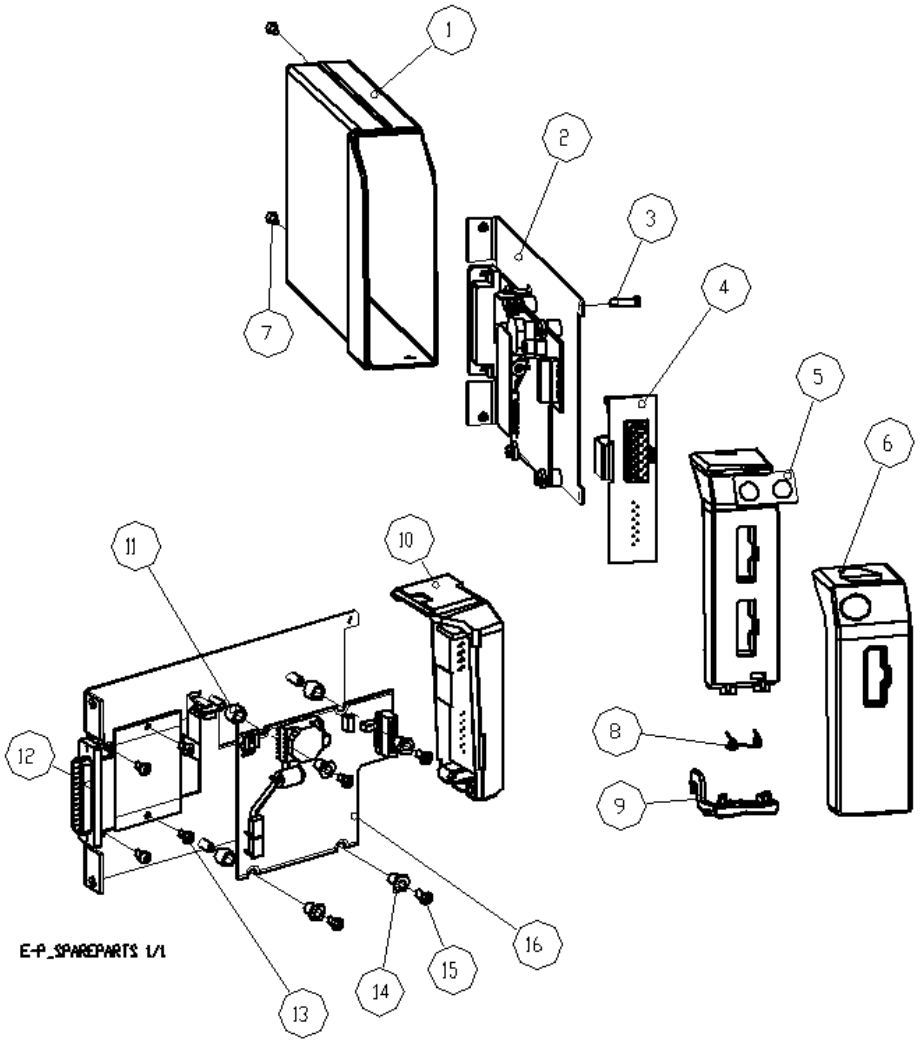
Item	Description	Order No.
	Front Panel Sticker, E-PSM - PL	M1023750
	Front Panel Sticker, E-PSM - PT	M1023745
	Front Panel Sticker, E-PSM - SV	M1023747
	Front Panel Sticker, E-PSMP - CS	M1063611
	Front Panel Sticker, E-PSMP - DA	M1021379
	Front Panel Sticker, E-PSMP - DE	M1021348
	Front Panel Sticker, E-PSMP - EN	M1020271
	Front Panel Sticker, E-PSMP - ES	M1021358
	Front Panel Sticker, E-PSMP - FI	M1021369
	Front Panel Sticker, E-PSMP - FR	M1021352
	Front Panel Sticker, E-PSMP - HU	M1042356
	Front Panel Sticker, E-PSMP - IT	M1021362
	Front Panel Sticker, E-PSMP - NL	M1021355
	Front Panel Sticker, E-PSMP - NO	M1021375
	Front Panel Sticker, E-PSMP - PL	M1021386
	Front Panel Sticker, E-PSMP - PT	M1021366
	Front Panel Sticker, E-PSMP - SV	M1021372

2.3.2 Spare parts for PSM mounts

Item	Description	Order No.
	Pole Mount for PSM, long	M1051023-S
	Frame Mount for PSM	M1051021-S
	Pole Mount for PSM, short	M1049197-S

3 Pressure Modules, E-P, E-PP, E-PT

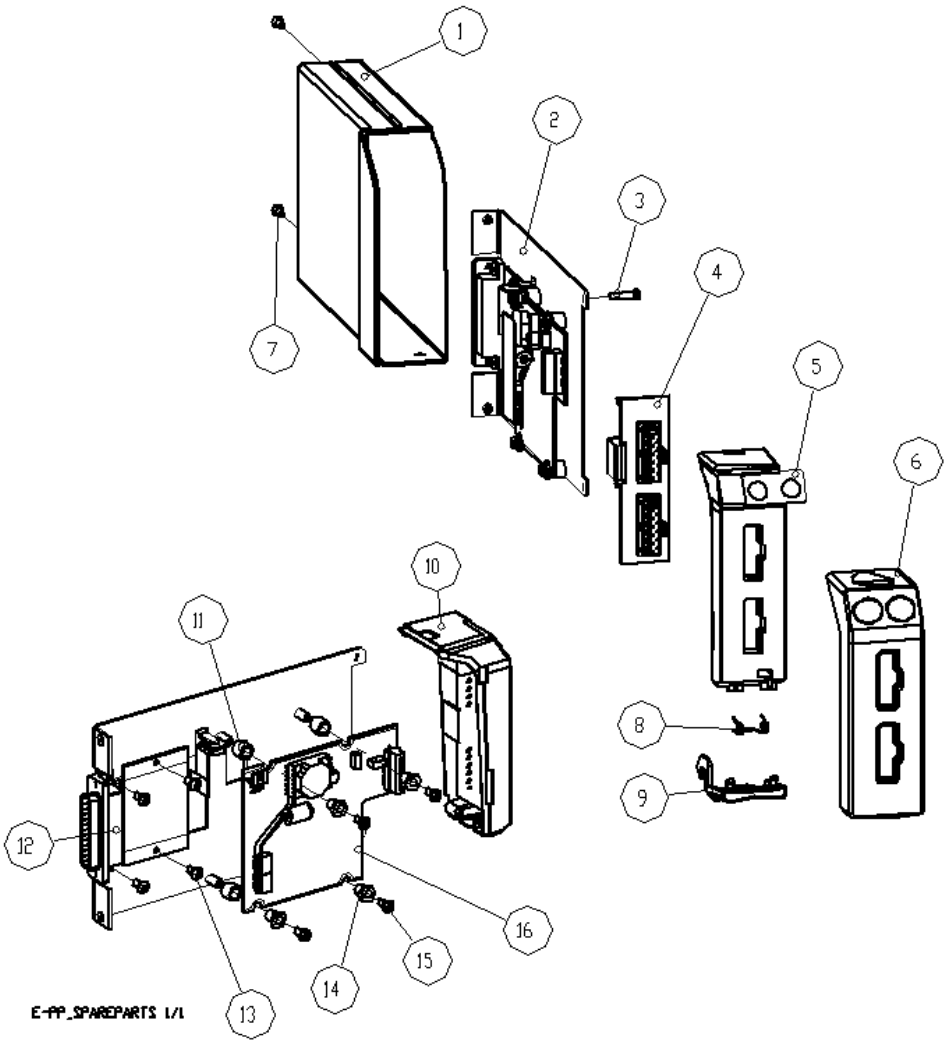
3.1 Pressure Module, E-P



Item	Description	Order No.
1	Module Casing, Single	M1021035
2	Body Plate, E-P, E-PP, E-PT	M1012033
3	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
4	E-P Input board	M1025766
5	Membrane Keyboard	M1012126
6	Front Cover, DA, E-P	M1027188
6	Front Cover, DE, E-P	M1027189
6	Front Cover, ES, E-P	M1027191

Item	Description	Order No.
6	Front Cover, EN, E-P	M1027190
6	Front Cover, FI, E-P	M1027192
6	Front Cover, HU, E-P	M1046310
6	Front Cover, IT, E-P	M1027194
6	Front Cover, FR, E-P	M1027193
6	Front Cover, JA, E-P	M1027195
6	Front Cover, NL, E-P	M1027196
6	Front Cover, NO, E-P	M1027197
6	Front Cover, PL, E-P	M1027198
6	Front Cover, PT, E-P	M1027199
6	Front Cover, SV, E-P	M1027200
7	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
8	Torsion Spring	M1020935
9	Latch	M1021039
10	Front Chassis Unit, E-P	M1027137
11	Bushing, E-P, E-PT, E-PP	M103976
12	Module bus connection board for E-PT	M1021462
13	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000-HEL
14	Std Bushing nylon, D flange = 8.7 mm	M1046004
15	Screw	61123
16	STP Main Assembly for E-P, E-PPand E-PT	M1024765

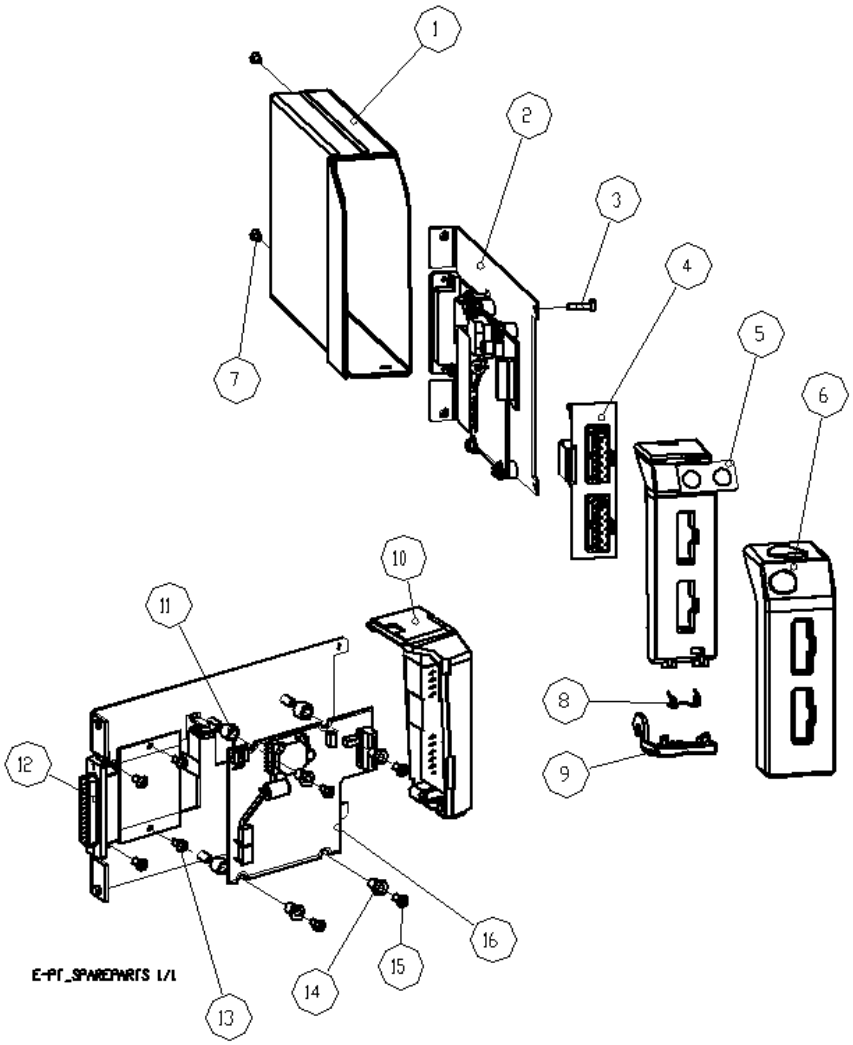
3.2 Dual Pressure Module, E-PP



Item	Description	Order No.
1	Module Casing, Single	M1021035
2	Body Plate, E-P, E-PP, E-PT	M1012033
3	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
4	E-PP Input board	M1022749
5	Membrane Keyboard	M1012126
6	Front Cover, DA, E-PP	M1027172
6	Front Cover, DE, E-PP	M1027173
6	Front Cover, EN, E-PP	M1027174
6	Front Cover, ES, E-PP	M1027175
6	Front Cover, FI, E-PP	M1027176

Item	Description	Order No.
6	Front Cover, FR, E-PP	M1027177
6	Front Cover, HU, E-PP	M1046274
6	Front Cover, IT, E-PP	M1027178
6	Front Cover, JA, E-PP	M1027179
6	Front Cover, NL, E-PP	M1027180
6	Front Cover, NO, E-PP	M1027181
6	Front Cover, PL, E-PP	M1027182
6	Front Cover, PT, E-PP	M1027183
6	Front Cover, SV, E-PP	M1027184
7	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
8	Torsion Spring	M1020935
9	Latch	M1021039
10	Front Chassis Unit, E-PP	M1027000
11	Bushing, E-P, E-PT, E-PP	M103976
12	Module bus connection board for E-PT	M1021462
13	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000-HEL
14	Std Bushing nylon, D flange = 8.7 mm	M1046004
15	Screw	61123
16	STP Main Assembly for E-P, E-PPand E-PT	M1024765

3.3 Pressure Temp Module, E-PT

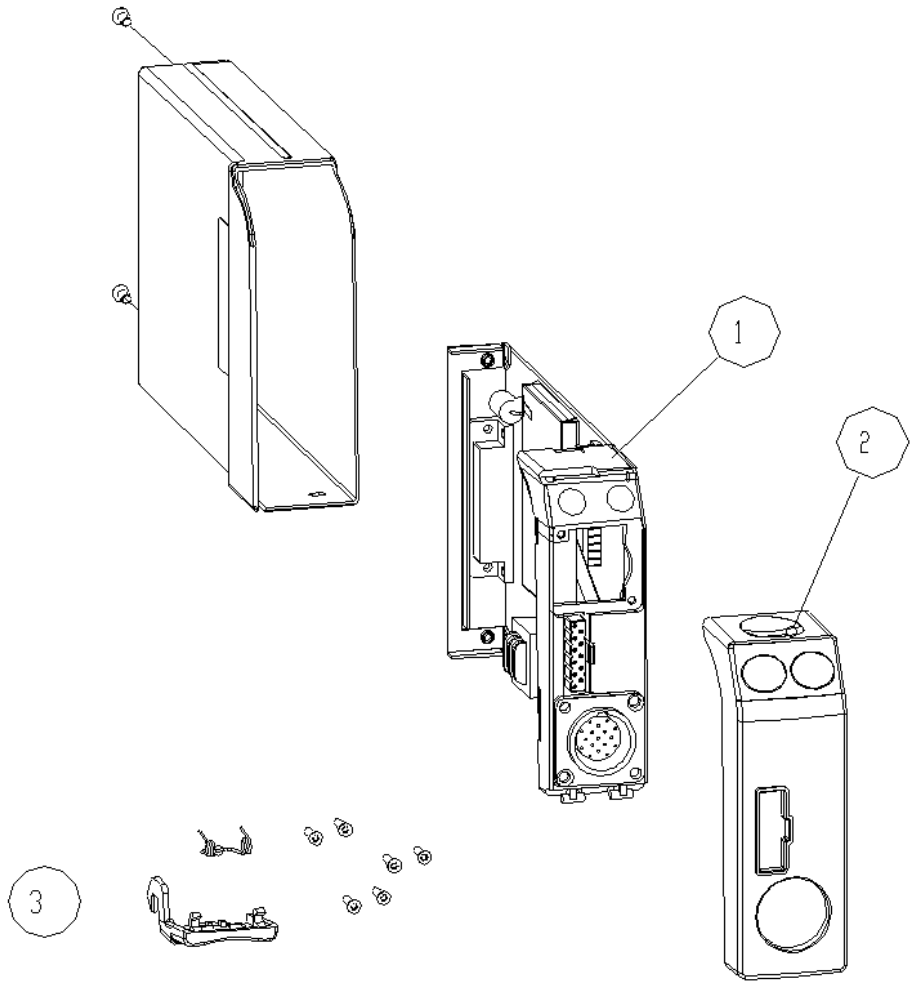


Item	Description	Order No.
1	Module Casing, Single	M1021035
2	Body Plate, E-P, E-PP, E-PT	M1012033
3	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
4	Input board, E-PT	M1021461
5	Membrane Keyboard	M1012126
6	Front Cover, DA, E-PT	M1027157
6	Front Cover, DE, E-PT	M1027158
6	Front Cover, EN, E-PT	M1027159
6	Front Cover, ES, E-PT	M1027160

Item	Description	Order No.
6	Front Cover, FI, E-PT	M1027161
6	Front Cover, FR, E-PT	M1027162
6	Front Cover, HU, E-PT	M1046321
6	Front Cover, IT, E-PT	M1027163
6	Front Cover, JA, E-PT	M1027164
6	Front Cover, NL, E-PT	M1027165
6	Front Cover, NO, E-PT	M1027166
6	Front Cover, PL, E-PT	M1027167
6	Front Cover, PT, E-PT	M1027168
6	Front Cover, SV, E-PT	M1027169
7	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
8	Torsion Spring	M1020935
9	Latch	M1021039
10	Front Chassis Unit, E-PT	M1027140
11	Bushing, E-P, E-PT, E-PP	M103976
12	Module bus connection board for E-PT	M1021462
13	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000-HEL
14	Std Bushing nylon, D flange = 8.7 mm	M1046004
15	Screw	61123
16	STP Main Assembly for E-P, E-PP and E-PT	M1024765

4 Cardiac Output Modules E-COP, E-COPSv

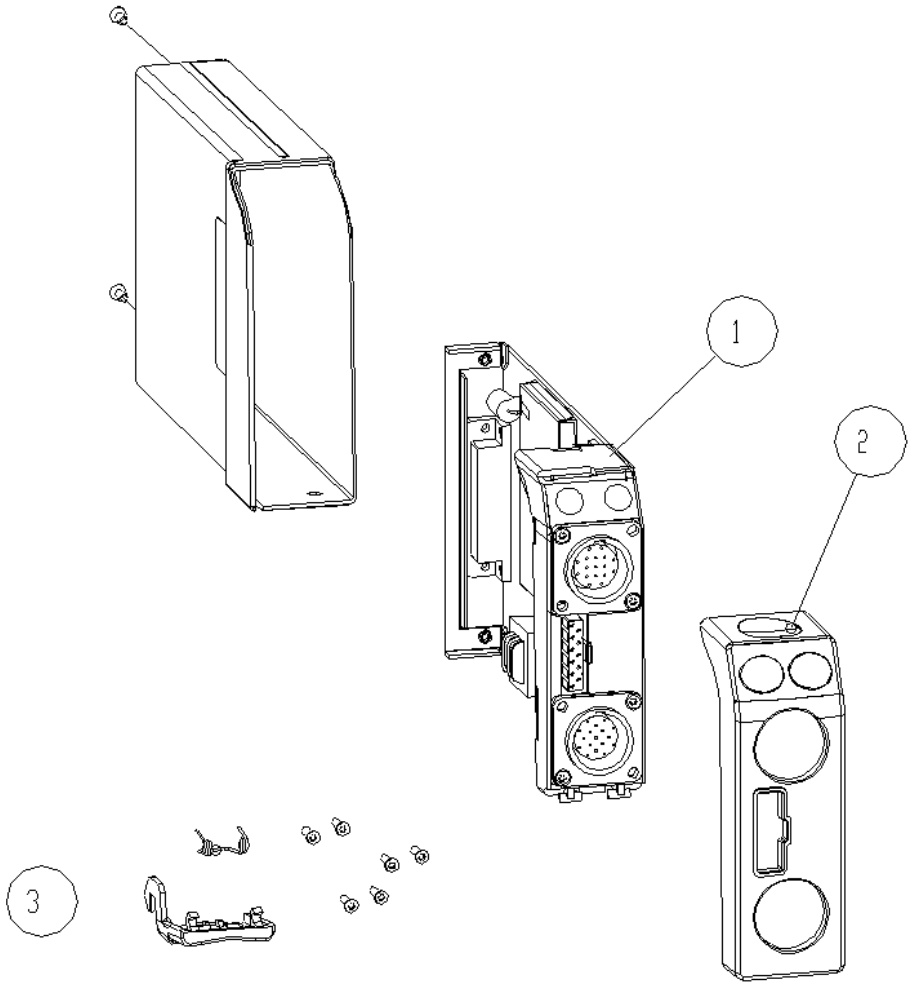
4.1 Cardiac Output Module, E-COP- 00, -01



Item	Description	Order No.
1	E-COP module unit, FRU - Front chassis unit, FRU (inc. front chassis, membrane keyboard, connector unit, latch, torsion spring) - Measurement board, FRU (inc. Measurement board, metal frame, mounting screws)	M1194048
2	Front Cover, CS, E-COP	M1063534
2	Front Cover, DA, E-COP	M1025568
2	Front Cover, DE, E-COP	M1025569
2	Front Cover, EN, E-COP	M1025570
2	Front Cover, ES, E-COP	M1025571

Item	Description	Order No.
2	Front Cover, FI, E-COP	M1025572
2	Front Cover, FR, E-COP	M1025573
2	Front Cover, HU, E-COP	M1046293
2	Front Cover, IT, E-COP	M1025574
2	Front Cover, JA, E-COP	M1025575
2	Front Cover, NL, E-COP	M1025576
2	Front Cover, NO, E-COP	M1025577
2	Front Cover, PL, E-COP	M1025578
2	Front Cover, PT, E-COP	M1025579
2	Front Cover, SV, E-COP	M1025580
3	Module Hardware kit, FRU - 2 mounting screws for metal frame - 2 mounting screws for front chassis unit - 2 mounting screws for module casing - Latch - Torsion spring	M1206392

4.2 Cardiac Output Module, E-COPSv -00, -01

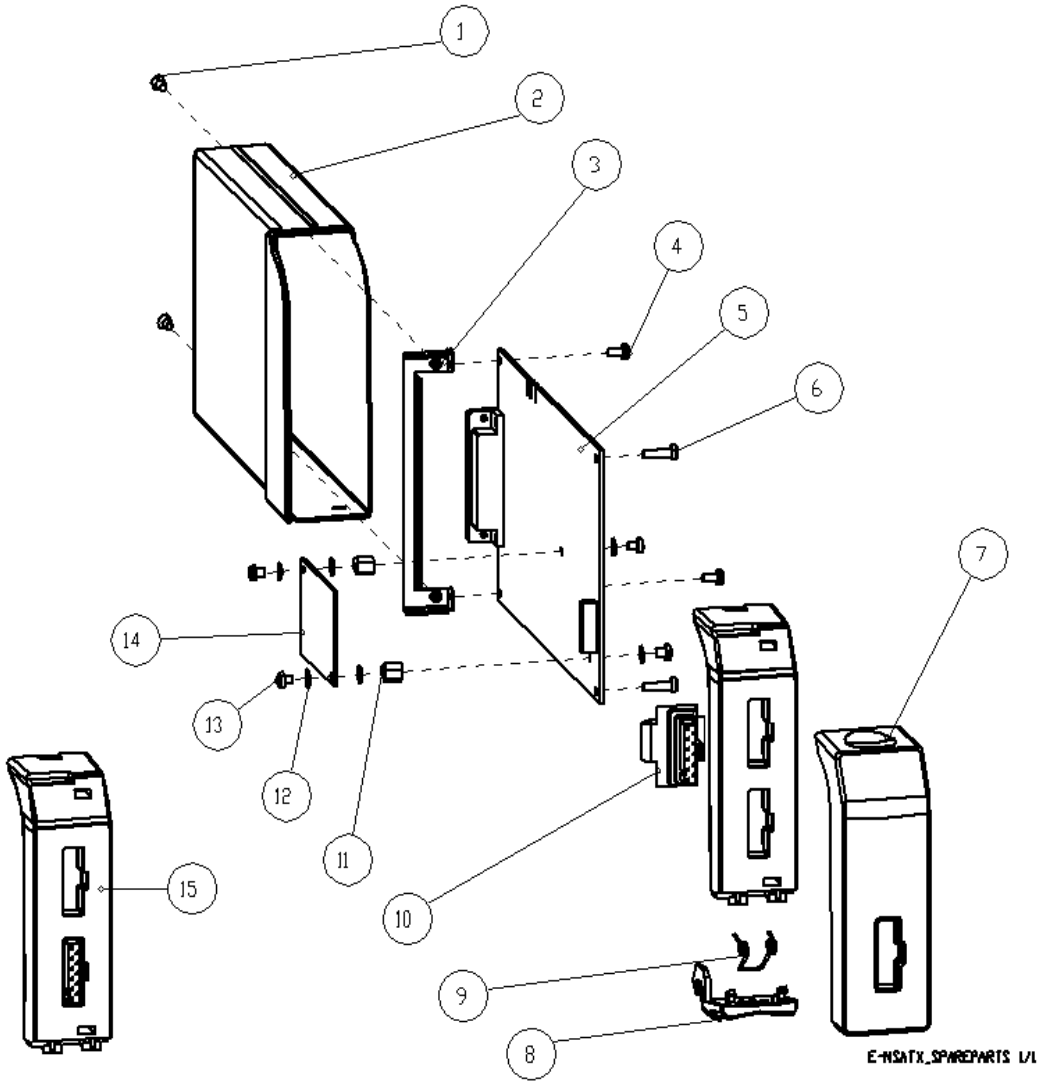


Item	Description	Order No.
1	E-COPSv module unit, FRU - Front chassis unit, FRU (inc. front chassis, membrane keyboard, connector unit, latch, torsion spring) - Measurement board, FRU (inc. Measurement board, metal frame, mounting screws))	M1194084
2	Front Cover Unit, CS, E-COPSV	M1063536
2	Front Cover Unit, DA, E-COPSV	M1027002
2	Front Cover Unit, DE, E-COPSV	M1027003
2	Front Cover Unit, EN, E-COPSV	M1027004
2	Front Cover Unit, ES, E-COPSV	M1027005
2	Front Cover Unit, FI, E-COPSV	M1027006
2	Front Cover Unit, FR, E-COPSV	M1027007

Item	Description	Order No.
2	Front Cover Unit, HU, E-COPSV	M1046297
2	Front Cover Unit, IT, E-COPSV	M1027008
2	Front Cover Unit, JA, E-COPSV	M1027009
2	Front Cover Unit, NL, E-COPSV	M1027010
2	Front Cover Unit, NO, E-COPSV	M1027011
2	Front Cover Unit, PL, E-COPSV	M1027012
2	Front Cover Unit, PT, E-COPSV	M1027013
2	Front Cover Unit, SV, E-COPSV	M1027014
3	Module Hardware kit, FRU - 2 mounting screws for metal frame - 2 mounting screws for front chassis unit - 2 mounting screws for module casing - Latch - Torsion spring	M1206392

5 Oxygen Saturation Modules

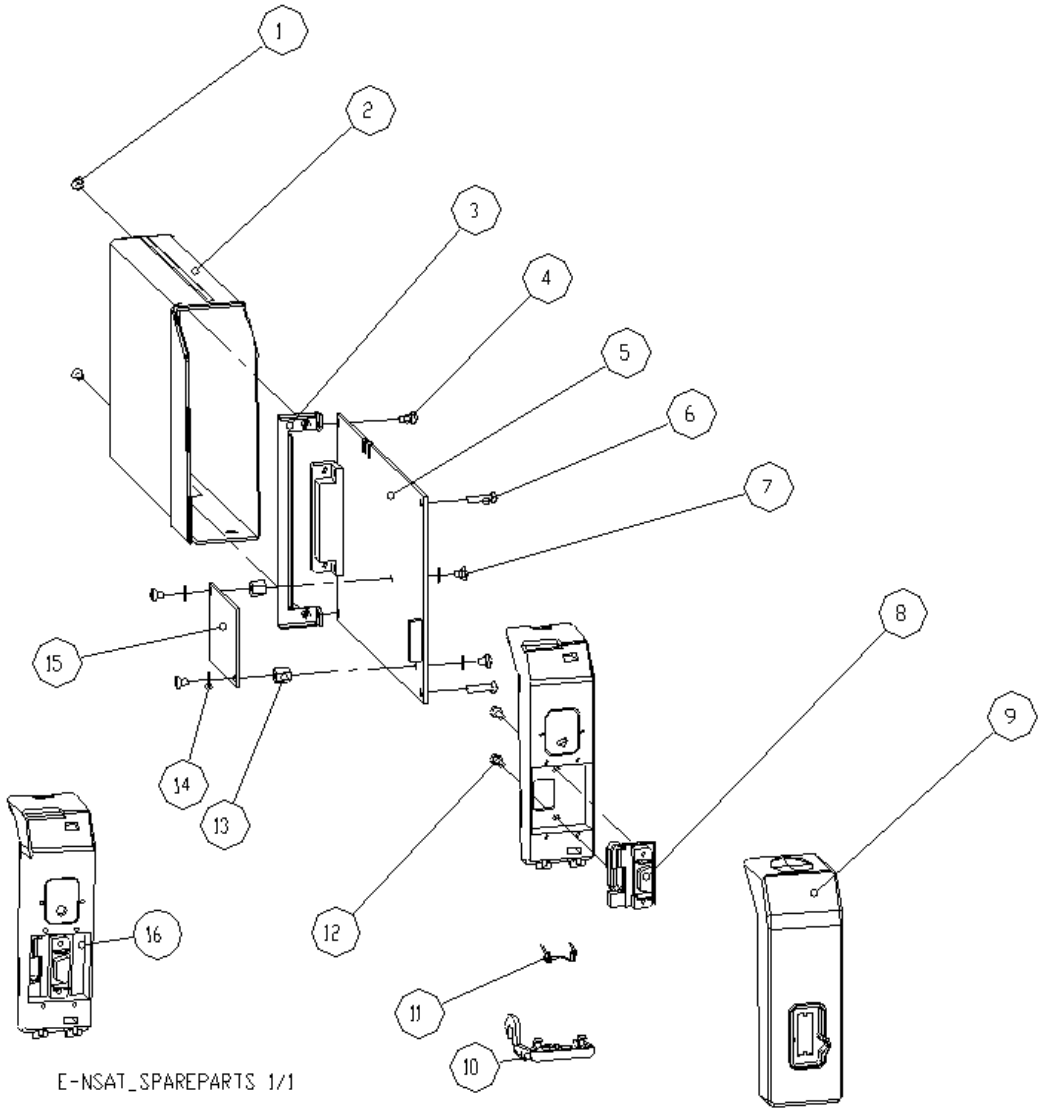
5.1 Nellcor compatible Saturation Module, E-NSATX



Item	Description	Order No.	Replaced
1	SCREW, machine, M3x8mm, DIN965, torx head, flat	606024	
2	Module Casing, Single	M1021035	
3	Metal Frame	879184	
4	SCREW, machine screw, 3x6mm, DIN7985, ISO7045, torx	605000-HEL	
5	NELL1GE Interface board, E-NSATX	M1080561	
6	SCREW, screw for plastic, 3x12mm, WN1452, torx head, pan	628729	

Item	Description	Order No.	Replaced
7	Front Cover, CS, E-NSATX	M1063523	
7	Front Cover, DA, E-NSATX	M1071156	
7	Front Cover, DE, E-NSATX	M1071159	
7	Front Cover, EN, E-NSATX	M1071160	
7	Front Cover, ES, E-NSATX	M1071162	
7	Front Cover, FI, E-NSATX	M1071163	
7	Front Cover, FR, E-NSATX	M1071164	
7	Front Cover, HU, E-NSATX	M1071174	
7	Front Cover, IT, E-NSATX	M1071166	
7	Front Cover, JA, E-NSATX	M1071169	
7	Front Cover, NL, E-NSATX	M1071167	
7	Front Cover, NO, E-NSATX	M1071168	
7	Front Cover, PL, E-NSATX	M1086342	
7	Front Cover, PT, E-NSATX	M1071171	
7	Front Cover, SV, E-NSATX	M1071172	
8	Latch, E-Modules	M1021039	
9	Torsion Spring, E-Modules,	M1020935	
10	Flex board, E-NSATX	M1076223	
11	MOUNTING, M3 threaded hexagonal spacer, L 7mm, brass	M1035473	
12	WASHER, 3.2x7.0x0.5mm, nylon-6 (PA-6), DIN125	M1028526	
13	SCREW, machine, M3x4mm, DIN7985, torx head, pan	M1025320	
14	OEM-ITEM, Nellcor NELL-1GE Pulse Oximetry Module	M1069914	
15	Front Chassis Unit, E-NSATX	M1072325	
	NELL1GE Interface Board, E-NSATX	M1080561	

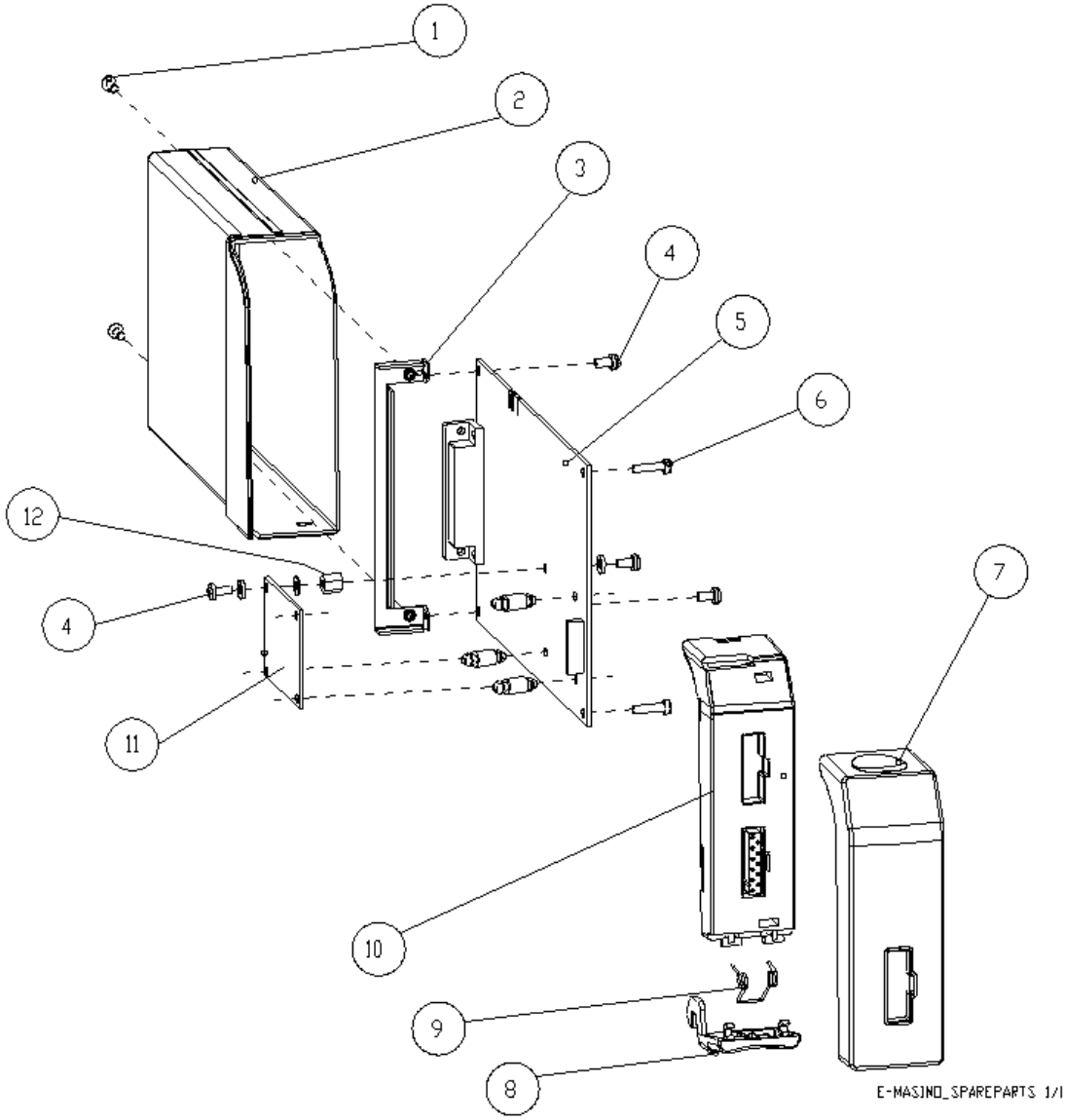
5.2 Oxygen Saturation Module, E-NSAT



Item	Description	Order No.	Replaced
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel, zinc coated	606024	
2	Module Casing, Single, Injection molded	M1021035	
3	Metal frame	879184	
4	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	61721	
5	Interface board E-NSAT for MP100, Printed Circuit Assembly	M1026771	
6	SCREW, screw for plastic,3.0 x12mm, torx head,	628729	

Item	Description	Order No.	Replaced
7	SCREW, machine, M3x4mm, DIN7985, torx head, pan head, steel, zinc coated	M1025320	
8	E-NSAT flex board, Printed Circuit Assembly	M1035951	
9	Front Cover, CS, E-NSAT	M1063523	
9	Front Cover, EN, E-NSAT	M1024919	
9	Front Cover, DA, E-NSAT	M1025070	
9	Front Cover, DE, E-NSAT	M1025073	
9	Front Cover, ES, E-NSAT	M1025075	
9	Front Cover, FI, E-NSAT	M1025077	
9	Front Cover, HU, E-NSAT	M1046302	
9	Front Cover, IT, E-NSAT	M1025079	
9	Front Cover, FR, E-NSAT	M1025082	
9	Front Cover, NL, E-NSAT	M1025083	
9	Front Cover, NO, E-NSAT	M1025084	
9	Front Cover, JA, E-NSAT	M1025085	
9	Front Cover, PT, E-NSAT	M1025086	
9	Front Cover, SV, E-NSAT	M1025087	
10	Latch, Injection molded	M1021039	
11	Torsion Spring, Machined	M1020935	
12	SCREW, machine, M2.5x10mm, DIN7985, torx head, pan head, steel, zinc coated	M1026605	
13	M3 threaded hexagonal spacer, L 7mm, D max 5.5mm, brass	M1035473	
14	WASHER, 3.2x7.0x0.5mm, nylon-6 (PA-6), DIN125	M1028526	
15	Nellcor MP100 oximetry board	M1037711	
16	Front Chassis Unit, E-NSAT	M1025088	

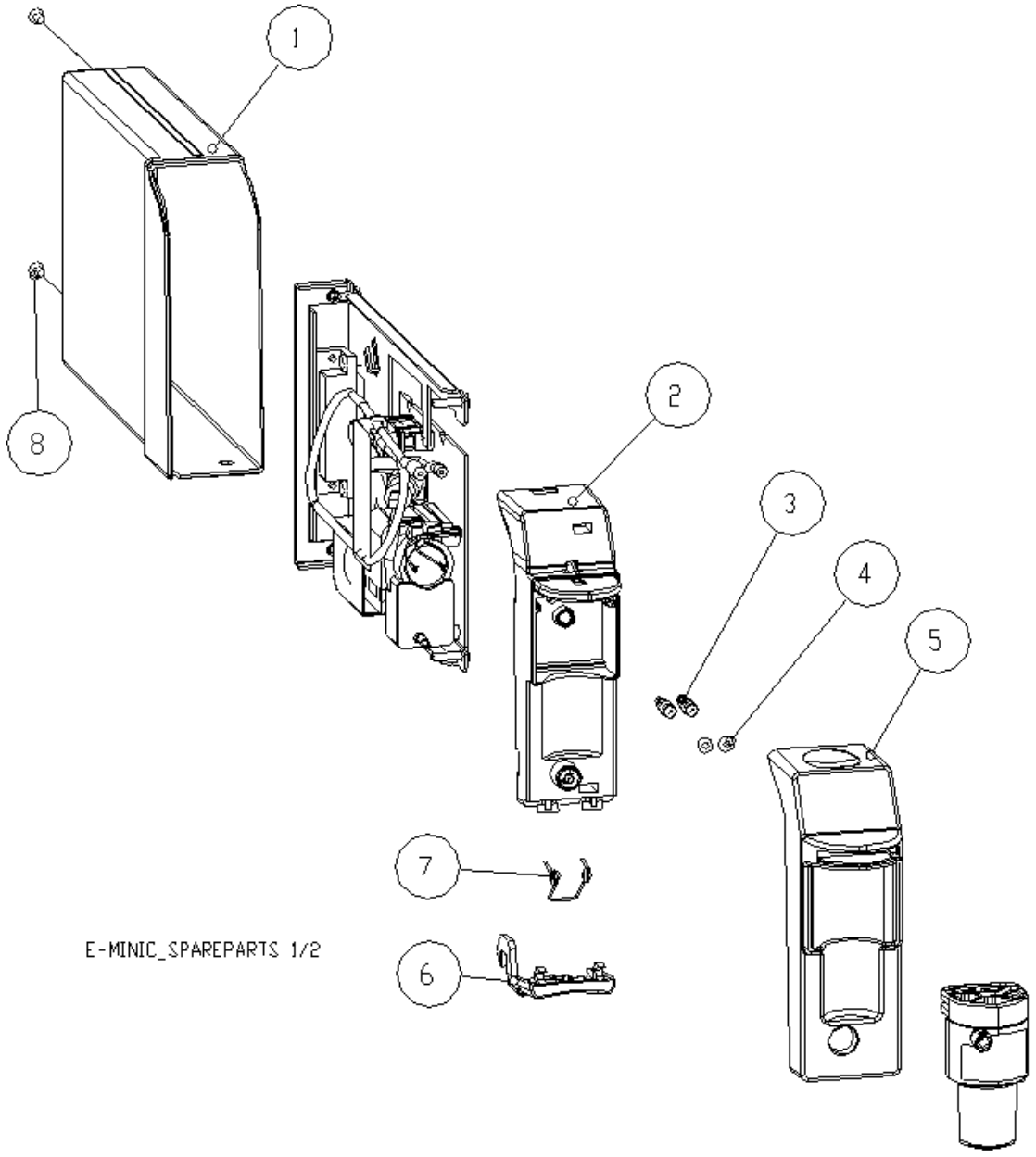
5.3 Masimo compatible Saturation Module, E-MASIMO



Item	Description	Order No.	Replaced
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel, zinc coated	606024	
2	Module Casing, Single *)	M1021035	
2*)	order with Module Casing: Patent Sticker, E-MASIMO	M1121761	
3	Metal frame	879184	
4	SCREW,machine screw, 3x6, DIN7985, ISO7045, TORX	605000-HEL	
5	Masimo Interface board, E-MASIMO	M1122843	
6	SCREW, screw for plastic,3.0 x12mm, torx head,	628729	
7	Front Cover, E-MASIMO	M1121205	

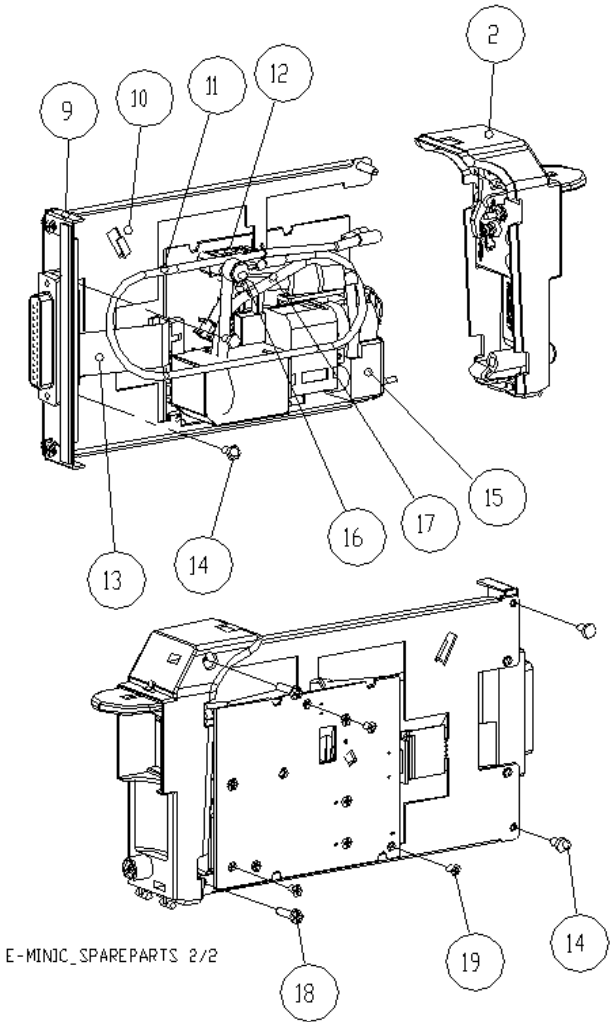
Item	Description	Order No.	Replaced
8	Latch, Injection molded	M1021039	
9	Torsion Spring, Machined	M1020935	
10	Front Chassis Unit, E-MASIMO (includes the connector and flex cable)	M1125298	
11	OEM-ITEM, Masimo MS-11 SpO2 board	M1125175	
12	MOUNTING, M3 threaded hexagonal spacer, L 7mm, D max 5.5mm, brass	640409-HEL	

6 Single-width Airway Module, E-miniC



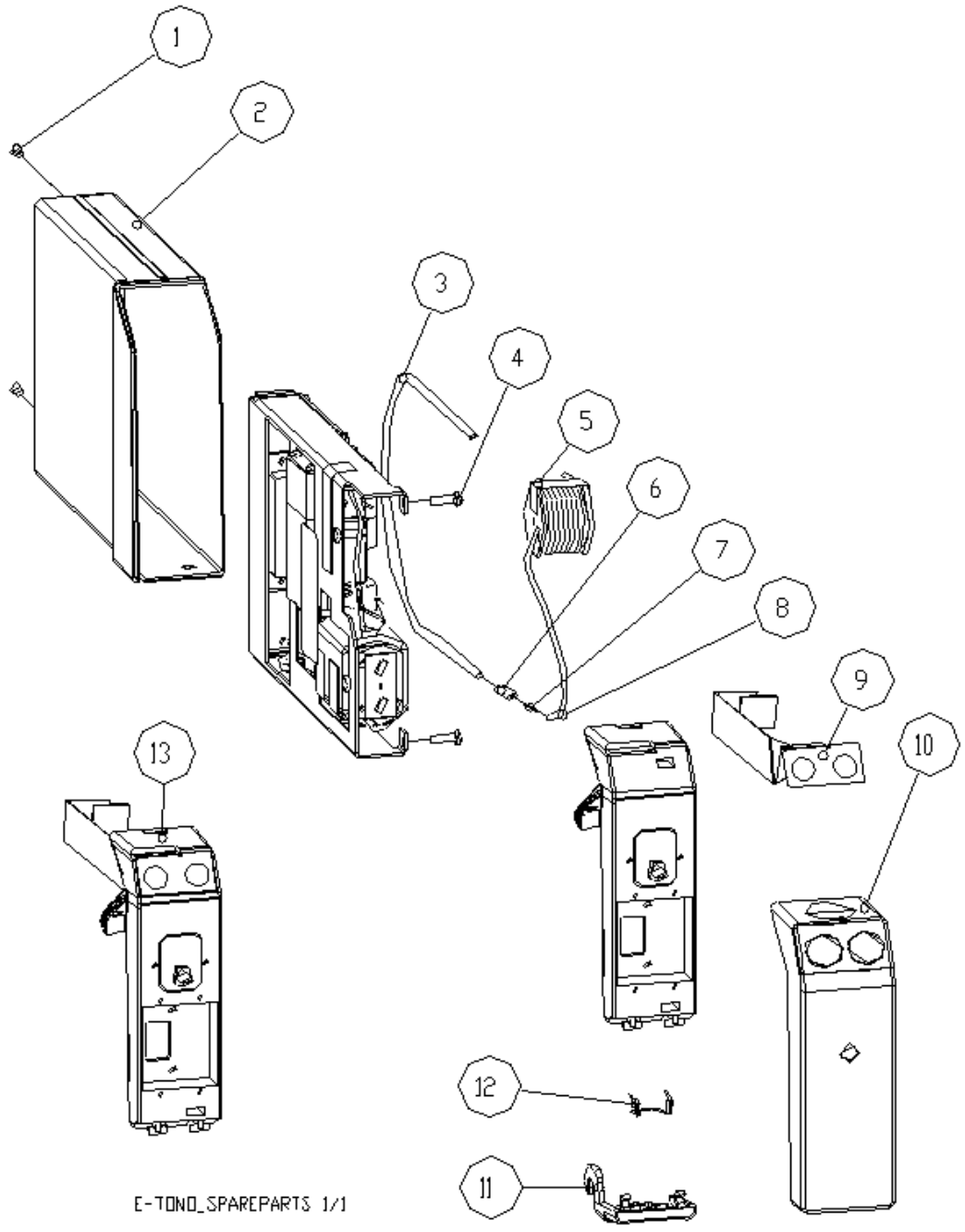
Item	Description	Order No.
	Mini D-Fend, pkg of 10 pcs	8002174
1	Module Casing, Single	M1021035
2	Front Chassis Unit, E-MINIC	M1027134
3	M-miniCO2, CONNECTOR FOR D-FEND, MINI CO2	8002173
4	O-RING, O-RING, 2.5x1.6, VITON, SHORE70, BLACK	656565
5	Front Cover, USA, E-MINIC	M1026941

Item	Description	Order No.
5	Front Cover, E-MINIC	M1026943
6	Latch	M1021039
7	Torsion Spring	M1020935
8	Screw-cross rec. c/s h, stzn, m3x6	61620



Item	Description	Order No.
9	Metal frame	879184
10	Frame, E-MINIC	M1024360
11	Nafion tubing 300mm	733382
12	MAGN-VALVE, N.O. valve, 3/2, 5VDC, 0.55W, includes seal	585714
13	Module Connection Flex, E-MINIC	M1027744
14	Cross cylinder head screw M3x6	61621
15	Pump Unit for miniC	M1013716
16	Air filter, M-MiniC	M1011471
17	Tubing Unit for miniC	M1013717
18	Cross cylinder head screw M3x10	628703
19	Screw-cross rec.c/s h,m3x8,acidproof	61609

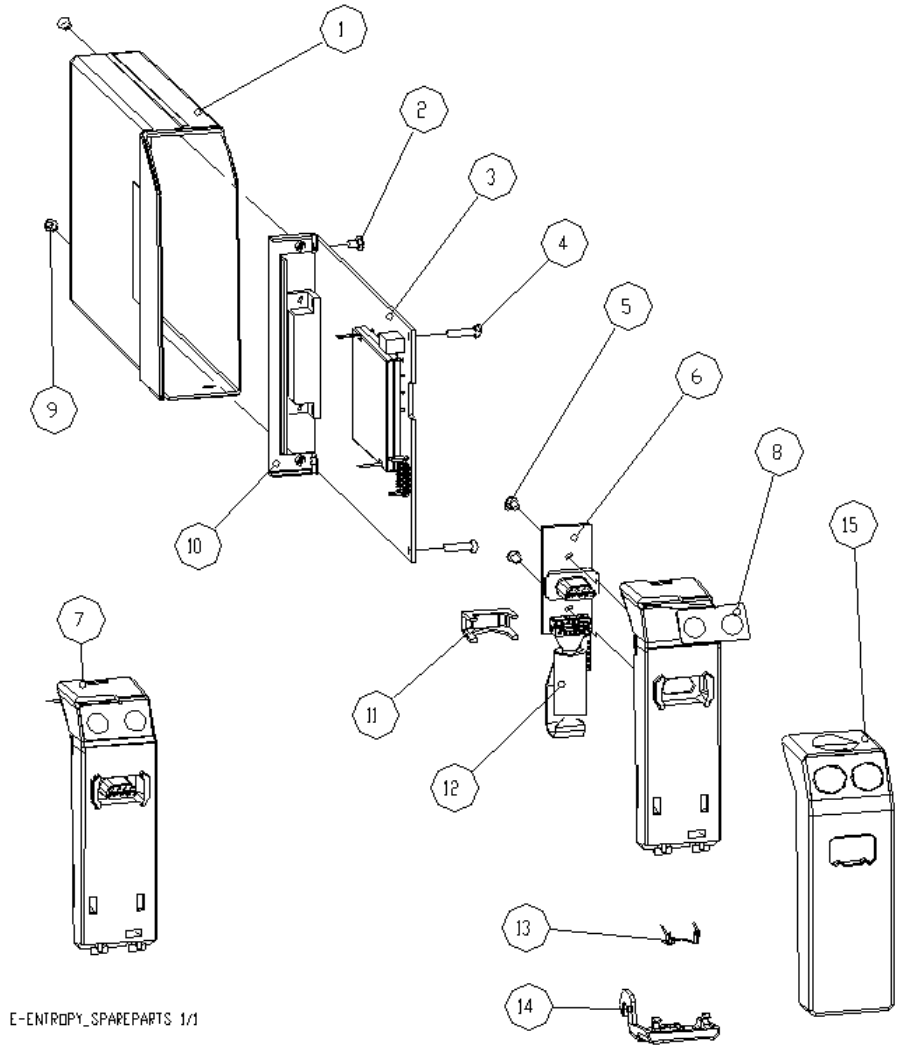
7 Tonometry Module, E-TONO



Item	Description	Order No.
1	Screw-cross rec. c/s h, stzn, m3x6	61620
2	Module Casing, Single	M1021035
3	Nafion tubing 300mm	733382

Item	Description	Order No.
4	Cross cylinder head screw M3x10	628703
5	TUBE UNIT, M-TONO	896981
6	INSUL-TUBE, ID= 1.7 +/-0.2mm, Wall= 1.05 +/-0.2mm, SIK.8128	73373
7	Pipe 10mm	871925
8	Hose-plastic,d=2/hole 1,transluc.vin	73341
9	Membrane Keyboard, E-TONO	M1012121
10	Front Cover, DA, E-TONO	M1026193
10	Front Cover, DE, E-TONO	M1026196
10	Front Cover, EN, E-TONO	M1026197
10	Front Cover, ES, E-TONO	M1026198
10	Front Cover, FI, E-TONO	M1026199
10	Front Cover, FR, E-TONO	M1026201
10	Front Cover, HU, E-TONO	M1046314
10	Front Cover, IT, E-TONO	M1026202
10	Front Cover, JA, E-TONO	M1026203
10	Front Cover, NL, E-TONO	M1026204
10	Front Cover, NO, E-TONO	M1026206
10	Front Cover, PL, E-TONO	M1026207
10	Front Cover, PT, E-TONO	M1026208
10	Front Cover, SV, E-TONO	M1026209
11	Latch	M1021039
12	Torsion Spring	M1020935
13	Front Chassis Unit, E-TONO	M1026527

8 Entropy Module, E-ENTROPY

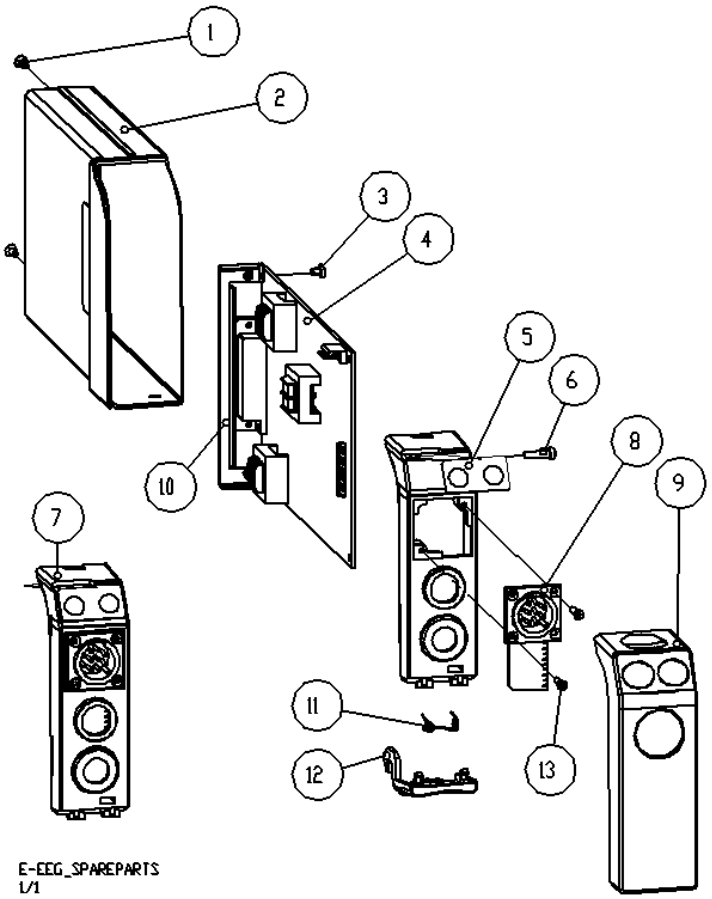


Item	Description	Order No.
1	Module Casing, Single	M1021035
2	SCREW, machine, M3x4mm, DIN7985, torx head, pan head, steel	M1025320
3	Entropy Board, M-ENTROPY	8004787
4	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
5	SCREW, screw for plastic, x8mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x8mm, ST-ZN, WN1452	628727
6	IMC CONNECTOR BOARD, M-ENTROPY	8004791
7	Front Chassis Unit, E-ENTROPY	M1024285
8	Membrane Keyboard	M1012126

Item	Description	Order No.
9	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
10	Metal frame	879184
11	Ferrite holder, M-ENTROPY, Investment cast	M1002842
12	CONNECTOR CABLE, M-ENTROPY..01	8005305
13	Torsion Spring	M1020935
14	Latch	M1021039
15	Front Cover, EN, E-ENTROPY	M1021097
15	Front Cover, DA, E-ENTROPY	M1024882
15	Front Cover, ES, E-ENTROPY	M1024939
15	Front Cover, FI, E-ENTROPY	M1024941
15	Front Cover, FR, E-ENTROPY	M1024942
15	Front Cover, HU, E-ENTROPY	M1046108
15	Front Cover, IT, E-ENTROPY	M1024943
15	Front Cover, JA, E-ENTROPY	M1024944
15	Front Cover, NL, E-ENTROPY	M1024945
15	Front Cover, NO, E-ENTROPY	M1024946
15	Front Cover, PL, E-ENTROPY	M1024947
15	Front Cover, PT, E-ENTROPY	M1024948
15	Front Cover, SV, E-ENTROPY	M1024949
15	Front Cover, DE, E-ENTROPY	M1020825

9 EEG Module and EEG Headbox

9.1 EEG Module, E-EEG



Item	Description	Order No.	Replaced by
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel, zinc coated	606024	
2	Module Casing, Single, Injection molded	M1021035	
3	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	61721	
4	NEURO BOARD, M-EEG, Printed Circuit Assembly	898806	
5	Membrane Keyboard, Sheet metal	M1012126	
6	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628700	
7	Front Chassis Unit, E-EEG, Manufacturing assembly	M1025223	
8	EEG Input board, E-EEG, Printed Circuit Assembly	M1021394	
	Front Cover, CS, E-EEG	M1063545	

Item	Description	Order No.	Replaced by
9	Front Cover, DE, E-EEG	M1025171	
9	Front Cover, EN, E-EEG	M1025172	
9	Front Cover, ES, E-EEG	M1025173	
9	Front Cover, FI, E-EEG	M1025174	
9	Front Cover, FR, E-EEG	M1025175	
9	Front Cover, HU, E-EEG	M1046299	
9	Front Cover, JA, E-EEG	M1025177	
9	Front Cover, NL, E-EEG	M1025178	
9	Front Cover, NO, E-EEG	M1025180	
9	Front Cover, PL, E-EEG	M1025181	
9	Front Cover, PT, E-EEG	M1025182	
9	Front Cover, SV, E-EEG	M1025183	
10	Metal frame	879184	
11	Torsion Spring, Machined	M1020935	
12	Latch, Injection molded	M1021039	
13	SCREW, thread forming, M2.5x10mm, WN1423, torx head, flat countersunk head, steel, zinc coated	M1025318	

9.2 EEG Headbox, N-EEG rev. 00, 01

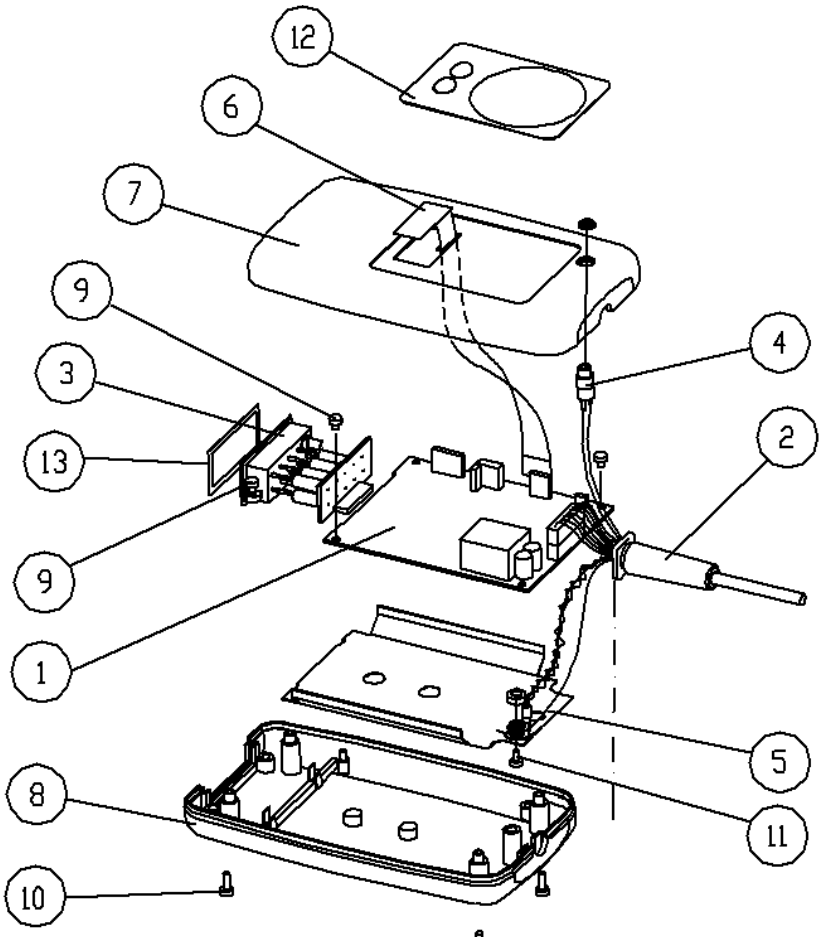


Figure 1 Exploded view of headbox

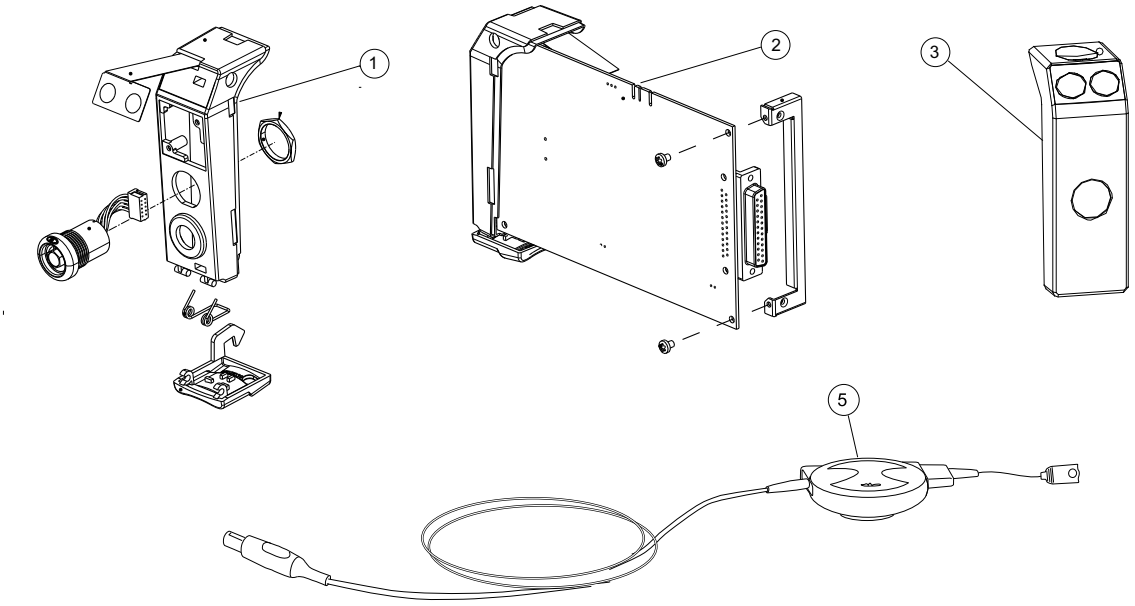
Item	Description	Order No.	Replaced by
1	EEG headbox board, N-EEG	898805	
2	Module-headbox cable, N-EEG	895610	
3	Headbox input unit	896558	
4	AEP-connector, N-EEG	896461	895610
5	EMC cover	898276	
6	Membrane keypad	880101	
7	Cover	896457	
8	Bottom side of N-EEG	896557	
9	Cross cyl. head screw M3x6	61515	
10	Cross cylinder head screw M3x12	61736	
11	Cross cylinder head screw M3x12 zinc-coated	61721	
12	HEADBOX STCIKER, CS, N-EEG	M1062572	

Item	Description	Order No.	Replaced by
12	Front Panel sticker, DA; N-EEG (rev.01); S/5	898708	
12	Front Panel sticker, DE; N-EEG (rev.01); S/5	898699	
12	Front Panel sticker, EN; N-EEG (rev.01); S/5	898698	
12	Front Panel sticker, ES; N-EEG (rev.01); S/5	898702	
12	Front Panel sticker, FI; N-EEG (rev.01); S/5	898705	
12	Front Panel sticker, FR; N-EEG (rev.01); S/5	898700	
12	Front Panel sticker, IT; N-EEG (rev.01); S/5	898703	
12	Front Panel sticker, HU; N-EEG (rev.01); S/5	M1042346	
12	Front Panel sticker, JA; N-EEG (rev.01); S/5	8000382	
12	Front Panel sticker, NL; N-EEG (rev.01); S/5	898701	
12	Front Panel sticker, NO; N-EEG (rev.01); S/5	898707	
12	Front Panel sticker, PT; N-EEG (rev.01); S/5	898704	
12	Front Panel sticker, SV; N-EEG (rev.01); S/5	898706	
12	Headbox sticker, DA; N-EEG (rev.00)	897266	
12	Headbox sticker, DE; N-EEG (rev.00)	897267	
12	Headbox sticker, EN; N-EEG (rev.00)	896512	
12	Headbox sticker, ES; N-EEG (rev.00)	897268	
12	Headbox sticker, FI; N-EEG (rev.00)	897269	
12	Headbox sticker, FR; N-EEG (rev.00)	897270	
12	Headbox sticker, IT; N-EEG (rev.00)	897271	
12	Headbox sticker, NL; N-EEG (rev.00)	897272	
12	Headbox sticker, NO; N-EEG (rev.00)	897273	
12	Headbox sticker, PT; N-EEG (rev.00)	897274	
12	Headbox sticker, SV N-EEG (rev.00)	897275	
13	ELECTRODE STICKER, CS, N-EEG	M1062575	
13	Electrode sticker, DA; N-EEG (rev.01); S/5	898207	
13	Electrode sticker, DE, EN, FI,; N-EEG (rev.01); S/5	897858	
13	Electrode sticker, ES; N-EEG (rev.01); S/5	898203	
13	Electrode sticker, FR; N-EEG (rev.01); S/5	898201	
13	Electrode sticker, HU; N-EEG (rev.01); S/5	M1042351	
13	Electrode sticker, IT; N-EEG (rev.01); S/5	898204	
13	Electrode sticker, JA; N-EEG (rev.01); S/5	8000393	
13	Electrode sticker, NL; N-EEG (rev.01); S/5	898202	

Item	Description	Order No.	Replaced by
13	Electrode sticker, NO; N-EEG (rev.01); S/5	898208	
13	Electrode sticker, PT; N-EEG (rev.01); S/5	898205	
13	Electrode sticker, SV; N-EEG (rev.01); S/5	898206	

10 BIS Module, E-BIS

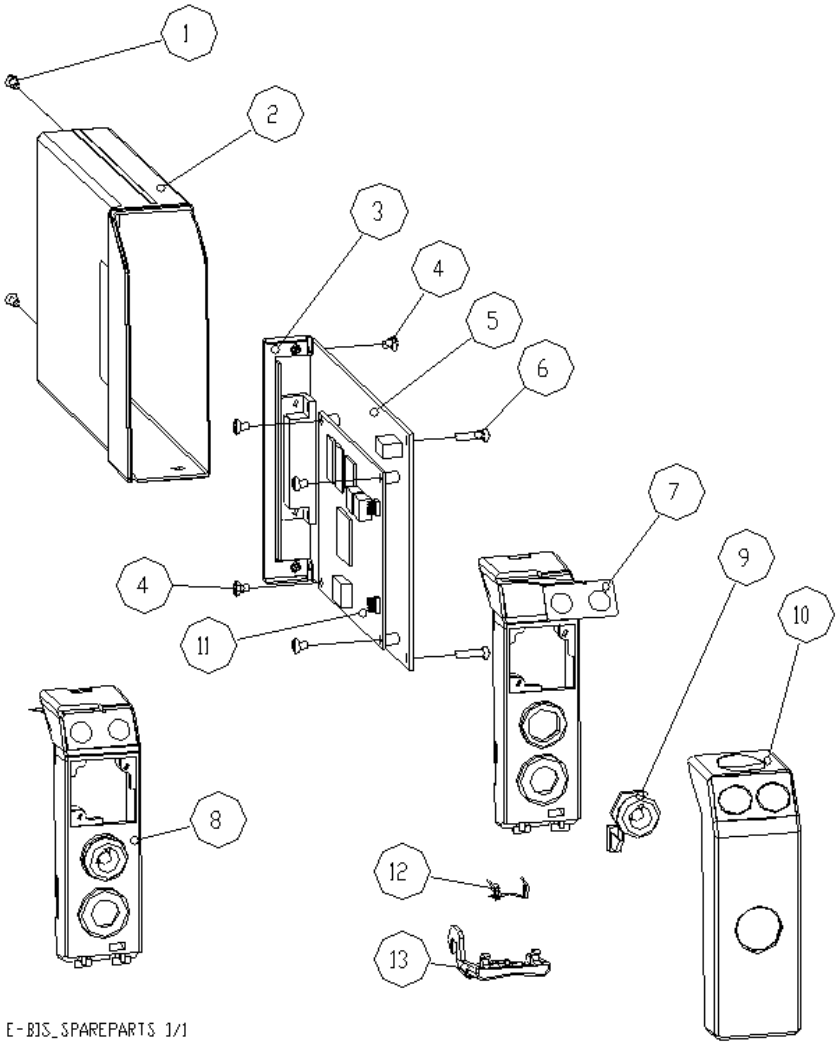
10.1 BIS Module, E-BIS-01



Item	Description	Order No.
1	E-BIS-01, Front Chassis Kit, FRU - Front Chassis - Membrane Keyboard - Connector Unit - Latch - Torsion Spring	M1206390
2	E-BIS-01, Interface Board, FRU - Interface Board - Metal Frame - 2 mounting screws	M1206391
3	E-BIS-01, Front Cover, FRU - Front Cover	M1203601-S
4	E-Modules, Hardware Kit, FRU - 2 mounting screws for Metal Frame - 2 mounting screws for Interface Board - 2 mounting screws for Module Casing - Latch - Torsion Spring - Membrane Keyboard	M1206392

Item	Description	Order No.
5	BISx Digital Signal Processing Unit - Patient Interface Cable, PIC plus - Integral BISx unit cable	M1206545

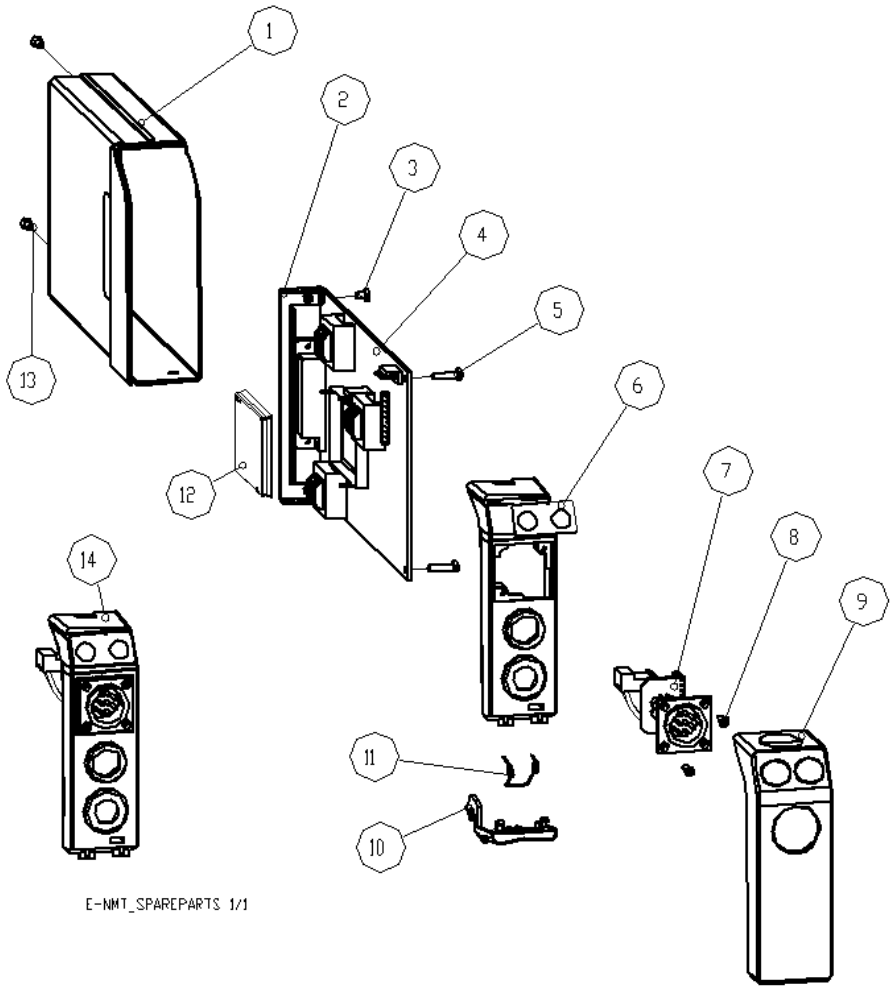
10.2 BIS Module, E-BIS-00



Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Single	M1021035
3	Metal frame	879184
4	SCREW, machine, M3x4mm, DIN7985, torx head, pan head, steel	M1025320
5	Interface Board, M-BIS, Product assembly	M1029851
6	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729

Item	Description	Order No.
7	Membrane Keyboard	M1012126
8	Front Chassis Unit, E-BIS	M1024772
9	BIS CONNECTOR UNIT, M-BIS	8002480
10	Front Cover, CS, E-BIS	M1063521
10	Front Cover, DA, E-BIS	M1024768
10	Front Cover, ES, E-BIS	M1024915
10	Front Cover, DE, E-BIS	M1024924
10	Front Cover, EN, E-BIS	M1024925
10	Front Cover, FI, E-BIS	M1024926
10	Front Cover, FR, E-BIS	M1024928
10	Front Cover, HU, E-BIS	M1046286
10	Front Cover, IT, E-BIS	M1024929
10	Front Cover, JA, E-BIS	M1024930
10	Front Cover, NL, E-BIS	M1024931
10	Front Cover, NO, E-BIS	M1024932
10	Front Cover, PL, E-BIS	M1024933
10	Front Cover, PT, E-BIS	M1024934
10	Front Cover, SV, E-BIS	M1024935
11	OEM-ITEM, BIS-Engine Board, BIS-Engine Board	900505
12	Torsion Spring	M1020935
13	Latch	M1021039

11 NMT Module, E-NMT



Item	Description	Order No.
1	Module Casing, Single	M1021035
2	Metal frame	879184
3	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000
4	NMT BOARD, M-NMT	887487
5	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
6	Membrane Keyboard	M1012126
7	NMT Connector Board, E-NMT	M1024116
8	SCREW, thread forming, M2.5x10mm, WN1423, torx head, flat countersunk head, steel	M1025318
9	Front Cover, CS, E-NMT	M1063527
9	Front Cover, DE, E-NMT	M1025669

Item	Description	Order No.
9	Front Cover, EN, E-NMT	M1025671
9	Front Cover, ES, E-NMT	M1025672
9	Front Cover, FI, E-NMT	M1025673
9	Front Cover, FR, E-NMT	M1025674
9	Front Cover, HU, E-NMT	M1046307
9	Front Cover, IT, E-NMT	M1025675
9	Front Cover, JA, E-NMT	M1025676
9	Front Cover, NL, E-NMT	M1025677
9	Front Cover, NO, E-NMT	M1025678
9	Front Cover, PL, E-NMT	M1025679
9	Front Cover, PT, E-NMT	M1025680
9	Front Cover, SV, E-NMT	M1025681
9	Front Cover, DA, E-NMT	M1024266
10	Latch	M1021039
11	Torsion Spring	M1020935
12	EMC cover	886320
13	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
14	Front Chassis Unit, E-NMT	M1024188

12 Device Interfacing Solution, N-DISxxx(rev.01... 02)

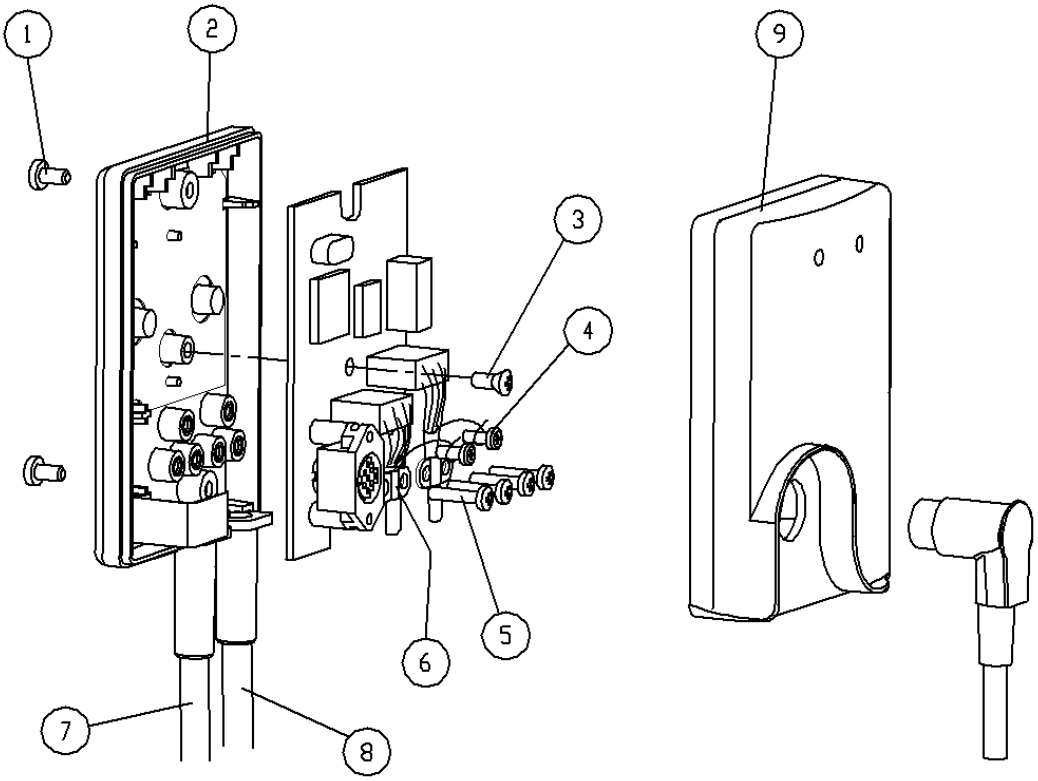
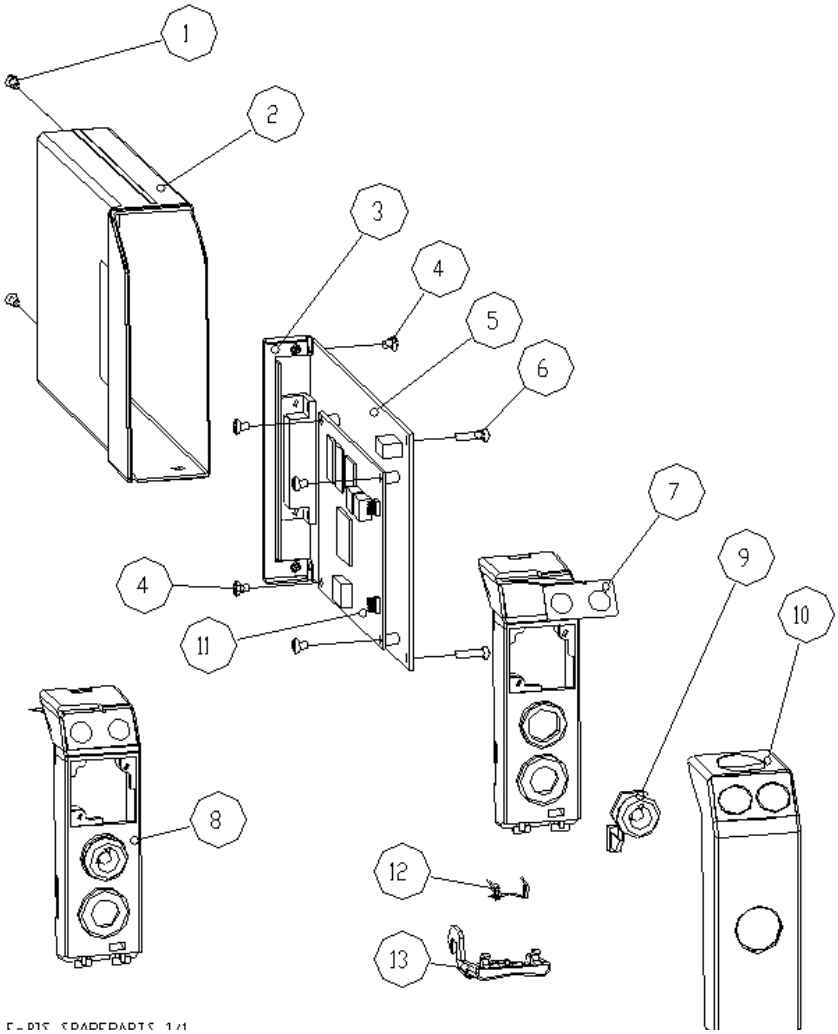


Figure 2 Exploded view of the Device Interfacing module

Item	Description		Order No.
1	Screw for the DIS module case		617210
2	DIS module case, rear		896930
3	Screw for the PC board, MFX M2.5X5 STZN		61209
4	Screw, STZN M3x6 TUFFLOCK		617120
5	SCREW, machine screw, M2.5x10mm, DIN7985, ISO7045, Pozidrive, pan head, steel, zinc coated		61715
6	Strain relief, N-DIS		897443
7	Bus cable, 1 m		900501
7	Bus cable, 2 m		900502
7	Bus cable, 6 m		900503
	Device specific cables:		
8	Cable for Abbot Oximetrix 3	N-DISOXIM3	M1034676

Item	Description		Order No.
8	Cable for Abbot Q-Vue/Q2	N-DISQVUE	897230
8	Cable for AVL Opticca	N-DISOPT	M1034675
8	Cable for Baxter Vigilance	N-DISVIGIL	8002841
8	Cable for Datex-Ohmeda anesthesia systems and critical care ventilators	N-DISVENT	M1023823
	DIS module case with labeling:		
9	Front cover for Abbot Oximetrix 3	N-DISOXIM3	M1057869
9	Front cover for Abbot Q-Vue/Q2	N-DISQVUE	M1057870
9	Front cover for AVL Opticca	N-DISOPT	M1057867
9	Front cover for Baxter Vigilance	N-DISVIGIL	M1057872
9	Front cover for Datex-Ohmeda anesthesia systems and critical care ventilators	N-DISVENT	M1057871
	DIS Extension Cable for AM and CCM		M1159125

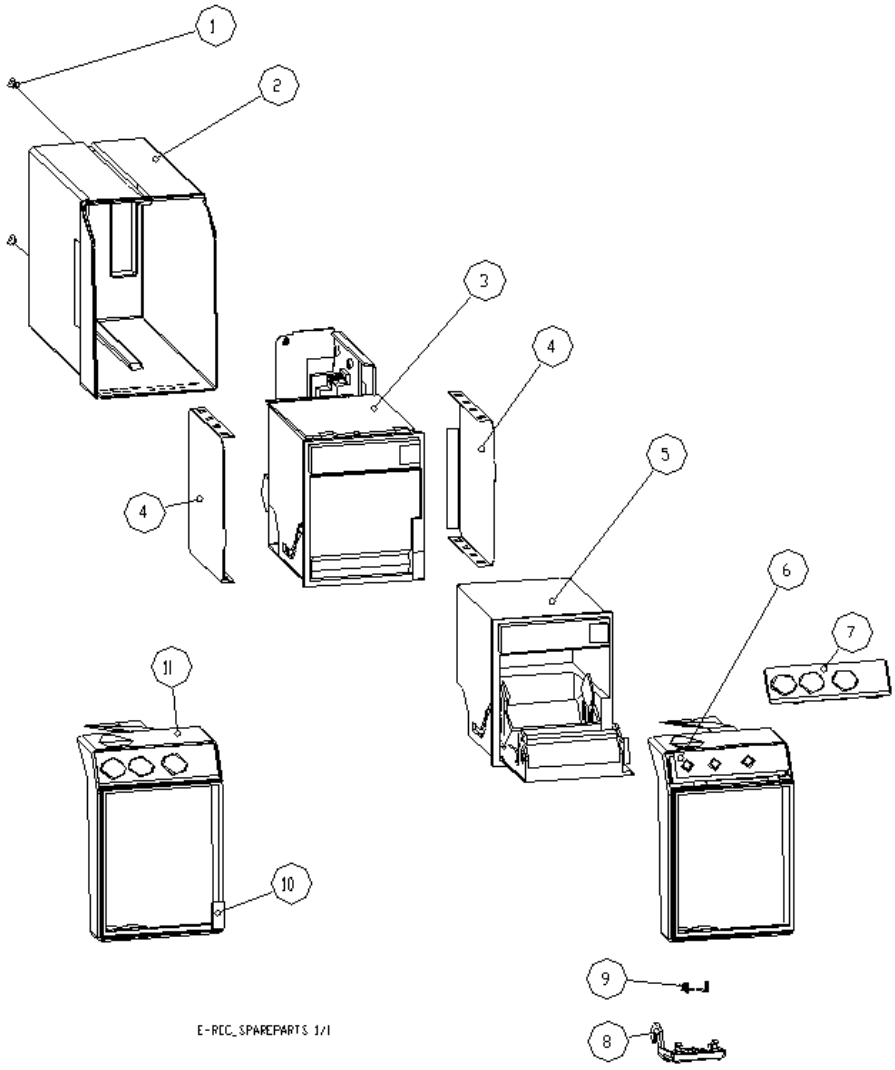
13 Interface Module, E-INT



Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Single	M1021035
3	EMC cover	884099
4	Metal frame	879184
5	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000
6	Interface board, M-INT	890843
7	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
8	NUT M3 STZN	63116
9	Front Chassis, E-INT, E-MEM	M1021025
10	Connector Plate, E-INT	M1012031

Item	Description	Order No.
11	SCREW, thread forming, M2.5x10mm, WN1423, torx head, flat countersunk head, steel	M1025318
12	Flat Cable, E-INT, Cable assembly	M1025419
13	Block screw for cables, M-INT	891033
14	Front Cover, E-INT	M1025582
15	Latch	M1021039
16	Torsion Spring	M1020935
17	Front Chassis Unit, E-INT	M1025416

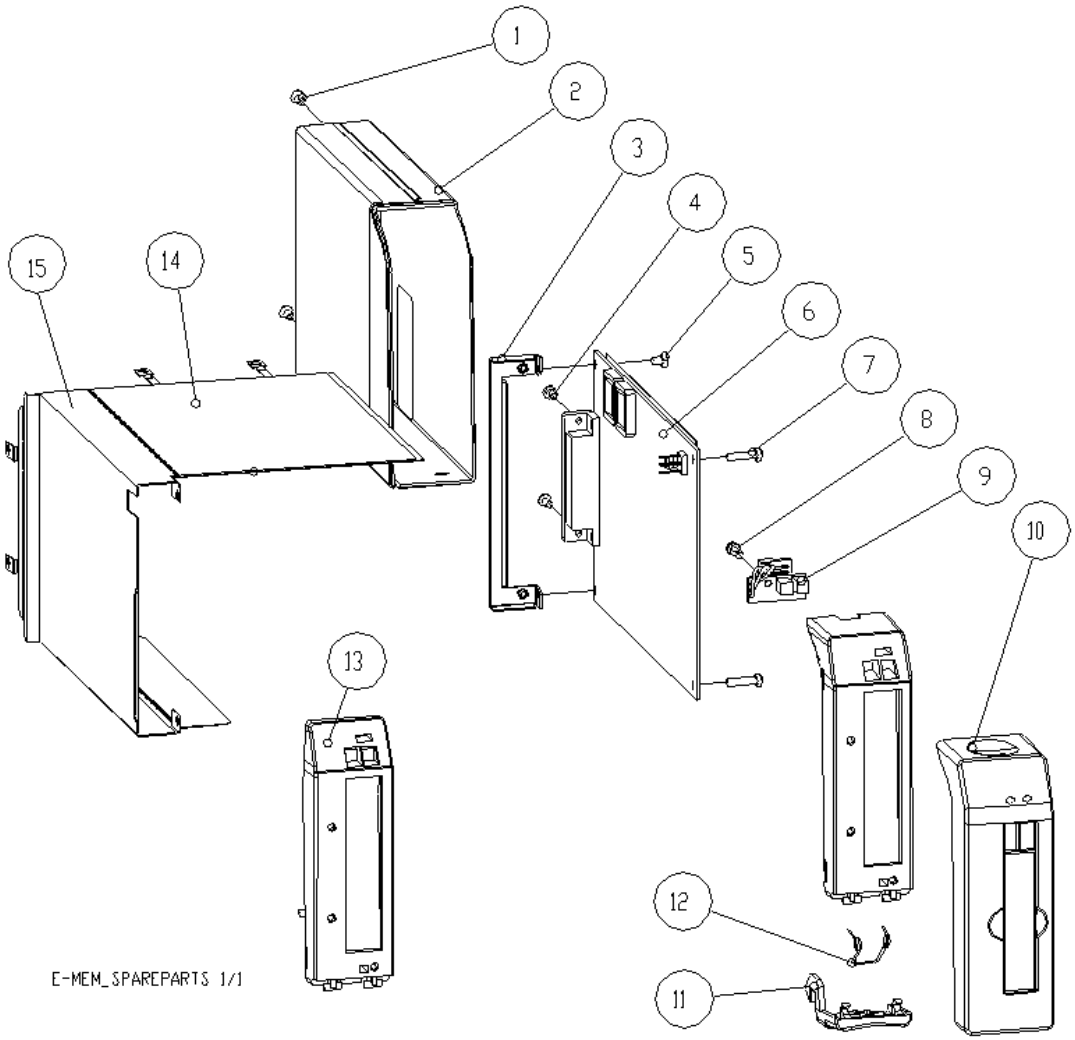
14 Recorder Module, E-REC



Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Double	M1021037
3	Recorder Board with Body Plate, E-REC, Spare Product assembly	M1029379
4	Side Plate, E-REC	M1021055
5	OEM-ITEM, Thermal printer 50mm, AR42A, Serial connection 76.8 KBaud, White	M1028145
6	Membrane Keyboard, E-REC	M1021051
7	Front Cover, cs, E-REC	M1063532
7	Front Cover, DA, E-REC	M1025398
7	Front Cover, DE, E-REC	M1025399

Item	Description	Order No.
7	Front Cover, EN, E-REC	M1025400
7	Front Cover, ES, E-REC	M1025401
7	Front Cover, FR, E-REC	M1025402
7	Front Cover, HU, E-REC	M1046413
7	Front Cover, IT, E-REC	M1025403
7	Front Cover, JA, E-REC	M1025404
7	Front Cover, NL, E-REC	M1025405
7	Front Cover, NO, E-REC	M1025406
7	Front Cover, PL, E-REC	M1025407
7	Front Cover, PT, E-REC	M1025408
7	Front Cover, SV, E-REC	M1025409
7	Front Cover, FI, E-REC	M1025410
8	Latch	M1021039
9	Torsion Spring, E-REC, E-GAS	M1024356
10	PANEL, Name sticker for E-REC	M1032491
11	Front Chassis Unit, E-REC	M1026338

15 Memory Module, E-MEM



Item	Description	Order No.
	AS/3 MemCard, Menu, EN	893860
	AS/3 MemCard, Data, EN	887045
	AS/3 MemCard, Menu, FR	893861
	AS/3 MemCard, Data, FR	887047
	AS/3 MemCard, Menu, JA	893862
	AS/3 MemCard, Data, JA	890349
	AS/3 MemCard, Menu, DE	895880
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Single	M1021035
3	Metal frame	879184

Item	Description	Order No.
4	Cross recess screw UNC 4-40	61841
5	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000
6	MEMORY BOARD, E-MEM	M1028886
7	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
8	SCREW, screw for plastic, x8mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x8mm, ST-ZN, WN1452	628727
9	LED board, M-MEM	885252
10	Front Cover, DE, E-MEM	M1027457
10	Front Cover, EN, E-MEM	M1027456
10	Front Cover, FR, E-MEM	M1027458
10	Front Cover, JA, E-MEM	M1027459
11	Latch	M1021039
12	Torsion Spring	M1020935
13	Front Chassis Unit, E-MEM	M1027451
14	Insulation plate, M-MEM	886656
15	EMC cover, M-MEM	885860

16 Remote controller, K-REMCO, K-CREMCO, rev. 00, 01

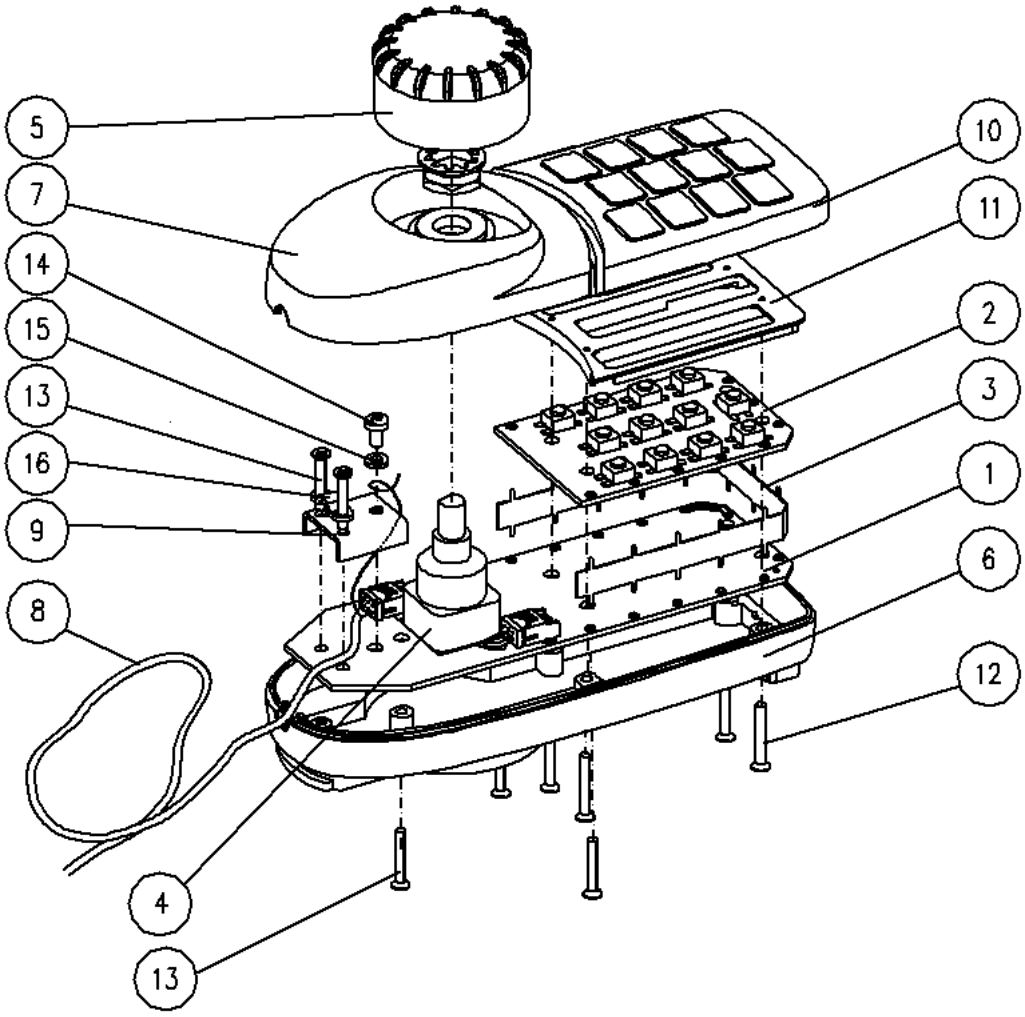


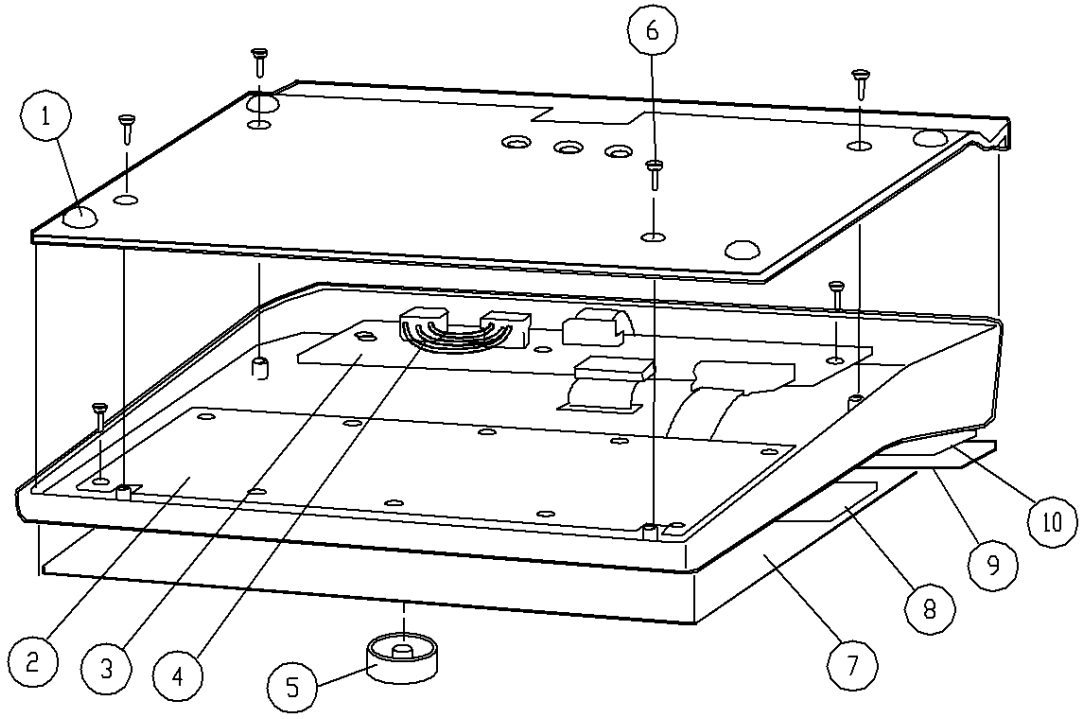
Figure 3 Exploded view of the Remote Controller

Item	Description	Order No.	Replaced by
1	CPU board, K-REMCO	890368	
2	Keyboard PCB, K-REMCO	890371	
3	Connecting plate	891427	
4	Rotary wheel	891036	
5	ComWheel (green); K-REMCO; S/5	898940	
6	Bottom (Munsell N9); K-REMCO; S/5	898938	
7	Cover (Munsell N9); K-REMCO; S/5	898939	

Item	Description	Order No.	Replaced by
8	Remote Controller Cable, K-REMCO	891813	
8	K-REMCO - CM cable (for K-CREMCO)	891965	
9	Bridge for cable	893235	
10	Printing of the keyboard, CS; K-REMCO	M1063588	
10	Front Panel sticker, DA; K-REMCO (rev.00), (rev.01; S/5)	892203	
10	Front Panel sticker, DE; K-REMCO (rev.00), (rev.01; S/5)	892312	
10	Front Panel sticker, EN; K-REMCO (rev.00), (rev.01; S/5)	891425	
10	Front Panel sticker, ES; K-REMCO	892315	
10	Front Panel sticker, FI; K-REMCO (rev.00), (rev.01; S/5)	892317	
10	Front Panel sticker, FR; K-REMCO (rev.00), (rev.01; S/5)	892313	
10	Front Panel sticker, IT; K-REMCO (rev.00), (rev.01; S/5)	892316	
10	Front Panel sticker, JA; K-REMCO (rev.01) S/5	894962	
10	Front Panel sticker, NL; K-REMCO (rev.00), (rev.01; S/5)	892314	
10	Front Panel sticker, NO; K-REMCO (rev.00), (rev.01; S/5)	893553	
10	Front Panel sticker, PL; K-(C)REMCO (rev.01); S/5	8004786	
10	Front Panel sticker, PT; K-REMCO (rev.01); S/5	895233	
10	Front Panel sticker; SV; K-REMCO (rev.00), (rev.01; S/5)	892318	
10	Printing of the keyboard, K-REMCO, HU	M1060080	
11	Front panel framework	891426	
12	Slotted recess screw M2.5x22	61218	
13	Cross recess PT-screw M2.5x16	628719	
14	Cross cylinder-head screw M3x6	61721	
15	Shake proof washer m3.2	63611	
16	Cable binder	546454	

17 Anesthesia keyboards, K-ARK, K-ARKB

17.1 K-ARK rev. 00, 01, 02



Item	Description	Order No.	Replaced by
1	Sticker-pad,diam 16,height 8	65142	
2	Alpha-numeric Keyboard PC-board, K-ARK (rev.00-01), K-CENTRALB	884178	
3	Command board PCB, K-ARK (rev.01-02)	893944	
3	Controller board, K-ARK (rev.00), K-CENTRALB	884177	
4	Rotary wheel	879872	
5	ComWheel cover and spring	879191	
6	Cross cylinder-head screw M3x6	61721	
7	Lower Front Panel sticker, IT; K-ARK (rev.02)	893608	
7	Lower Front Panel sticker, SCA; K-ARK (rev.00-01)	884632	893807
7	Lower Front Panel sticker, DA; K-ARK (rev.02)	893611	
7	Lower Front Panel sticker, DE; K-ARK (rev.00-01)	885133	893604
7	Lower Front Panel sticker, DE; K-ARK (rev.02)	893604	
7	Lower Front Panel sticker, EN; K-ARK (rev.00-01)	884017	893603
7	Lower Front Panel sticker, EN; K-ARK (rev.02)	893603	
7	Lower Front Panel sticker, ES; K-ARK (rev.00-01)	886198	893607

Item	Description	Order No.	Replaced by
7	Lower Front Panel sticker, ES; K-ARK (rev.02)	893607	
7	Lower Front Panel sticker, FI; K-ARK (rev.00-01)	888862	893609
7	Lower Front Panel sticker, FI; K-ARK (rev.02)	893609	
7	Lower Front Panel sticker, FLE; K-ARK (rev.00-01)	886161	893114
7	Lower Front Panel sticker, FLE; K-ARK (rev.02)	893114	
7	Lower Front Panel sticker, FR; K-ARK (rev.00-01)	884406	893605
7	Lower Front Panel sticker, FR; K-ARK (rev.02)	893605	
7	Lower Front Panel sticker, IT; K-ARK (rev.00-01)	886911	893608
7	Lower Front Panel sticker, NL; K-ARK (rev.00-01)	886282	893606
7	Lower Front Panel sticker, NL; K-ARK (rev.00-01)	892200	893611
7	Lower Front Panel sticker, NL; K-ARK (rev.02)	893606	
7	Lower Front Panel sticker, NO; K-ARK (rev.02)	893552	
7	Lower Front Panel sticker, PT; K-ARK (rev02)	895261	
7	Lower Front Panel sticker, SCA; K-ARK (rev.02)	893807	
7	Lower Front Panel sticker, SV; K-ARK (rev.00-01)	885916	893610
7	Lower Front Panel sticker, SV; K-ARK (rev.02)	893610	
8	Membrane keypad, lower, K-ARK	879964	
9	Upper Fro Panel sticker, ES; K-ARK (rev.01)	892329	893598
9	Upper Fro Panel sticker, FI; K-ARK (rev.01)	892331	893600
9	Upper Front Panel sticker, DE; K-ARK (rev.01)	892326	893595
9	Upper Front Panel sticker, ES; K-ARK (rev.00)	886200	
9	Upper Front Panel sticker, FR; K-ARK (rev.00)	884731	
9	Upper Front Panel sticker, FR; K-ARK (rev.01)	892327	893596
9	Upper Front Panel sticker, DA; K-ARK (rev.01)	892199	893602
9	Upper Front Panel sticker, DA; K-ARK (rev.01)	892199	893602
9	Upper Front Panel sticker, DA; K-ARK (rev.02)	893602	
9	Upper Front Panel sticker, DE; K-ARK (rev.00)	885140	
9	Upper Front Panel sticker, DE; K-ARK (rev.02)	893595	
9	Upper Front Panel sticker, EN, SCA; K-ARK (rev.00)	881648	
9	Upper Front Panel sticker, EN, SCA; K-ARK (rev.01)	892350	893594
9	Upper Front Panel sticker, EN, SCA; K-ARK (rev.02)	893594	
9	Upper Front Panel sticker, ES; K-ARK (rev.02)	893598	
9	Upper Front Panel sticker, FI; K-ARK (rev.00)	888861	
9	Upper Front Panel sticker, FI; K-ARK (rev.02)	893600	

Item	Description	Order No.	Replaced by
9	Upper Front Panel sticker, FR; K-ARK (rev.02)	893596	
9	Upper Front Panel sticker, IT; K-ARK (rev.00)	886910	
9	Upper Front Panel sticker, IT; K-ARK (rev.01)	892330	893599
9	Upper Front Panel sticker, IT; K-ARK (rev.02)	893599	
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.00)	886162	
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.00)	886162	
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.01)	892328	893597
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.01)	892328	893597
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.02)	893597	
9	Upper Front Panel sticker, NO; K-ARK (rev.02)	893551	
9	Upper Front Panel sticker, PT; K-ARK (rev.02)	895260	
9	Upper Front Panel sticker, SV; K-ARK (rev.00)	885915	
9	Upper Front Panel sticker, SV; K-ARK (rev.01)	892332	893601
9	Upper Front Panel sticker, SV; K-ARK (rev.02)	893601	
10	Membrane keypad, K-VHC14	879373	

17.2 Anesthesia recordkeeping keyboard, K-ARKB rev. 00

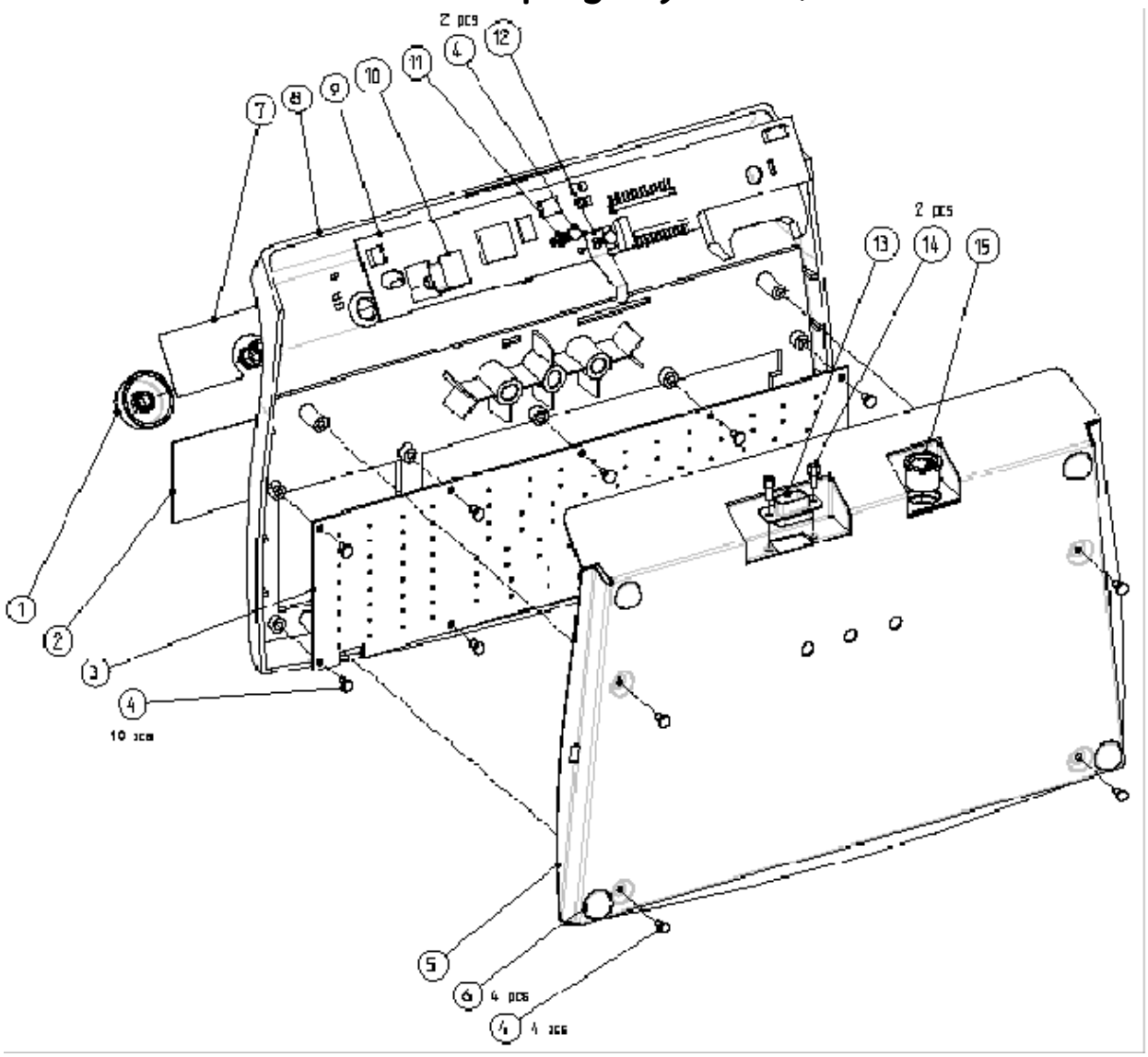


Figure 4 Exploded view of the Anesthesia Record Keeping Keyboard

Item	Description	Order No.	Replaced by
1	ComWheel; S/5	898794	
2	Membrane keypad, lower, K-ARKB; S/5	8000006	
3	Alpha-numeric Keyboard PC-board, K-ARK (rev.00-01), K-CENTRALB	884178	
4	Cross cylinder-head screw M3x6	61721	
5	Bottom plate, K-ARKB; S/5	898392	
6	Sticker-pad,diam 16,height 8	65142	
7	Membrane keypad, K-ARKB; S/5	8000050	
8	Keyboard casing, K-ARKB; S/5	898391	

Item	Description	Order No.	Replaced by
9	Command bar board, K-ARKB; S/5	8000054	
10	Opto-encoder, rotary switch,16-positions, push button, metal shaft, 4inch ribbon cable and connector	113291	
11	Shake proof washer m3.2	63611	
12	Emc plate, K-ARKB; S/5	8000960	
13	Output connector cable, K-ARKB; S/5	8000098	
14	D-female screw lock	640624	
15	Connection cable PC-KB, K-ARKB;S/5	8000097	

17.2.1 S/5 front panel stickers

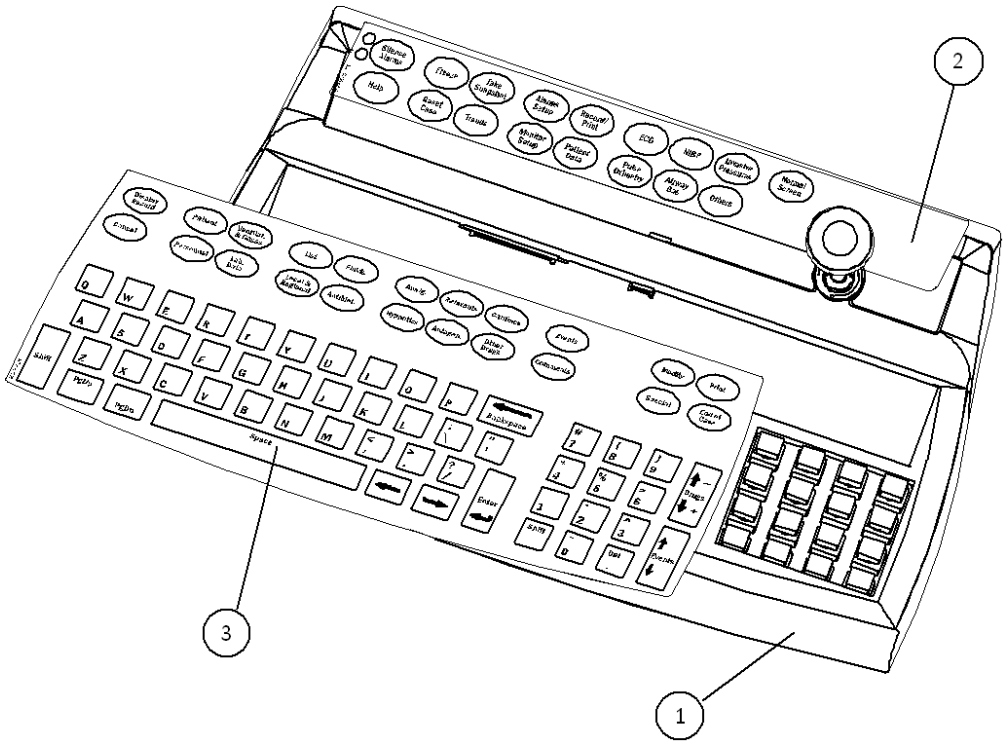


Figure 5 K-ARKB S/5 front panel stickers

Item	Description	Order No.	Replaced by
1	Keyboard casing, K-ARKB; S/5	898391	
2	Upper Front Panel sticker, DA; K-ARKB (rev.00); S/5	898369	
2	Upper Front Panel sticker, DE; K-ARKB (rev.00); S/5	898378	
2	Upper Front Panel sticker, EN; K-ARKB (rev.00); S/5	898368	
2	Upper Front Panel sticker, EN; K-ARKB (rev.00); S/5	898368	
2	Upper Front Panel sticker, ES; K-ARKB (rev.00); S/5	898372	
2	Upper Front Panel sticker, FI; K-ARKB (rev.00); S/5	898375	

2	Upper Front Panel sticker, FR; K-ARKB (rev.00); S/5	898370	
2	Upper Front Panel sticker, IT; K-ARKB (rev.00); S/5	898373	
2	Upper Front Panel sticker, JA; K-ARKB (rev.00); S/5	8000373	
2	Upper Front Panel sticker, NL; K-ARKB (rev.00); S/5	898371	
2	Upper Front Panel sticker, NL; K-ARKB (rev.00); S/5	898371	
2	Upper Front Panel sticker, NO; K-ARKB (rev.00); S/5	898377	
2	Upper Front Panel sticker, PT; K-ARKB (rev.00); S/5	898374	
2	Upper Front Panel sticker, SV; K-ARKB (rev.00); S/5	898376	
3	Front Panel sticker, lower, BE, NL; K-ARKB; S/5	898797	
3	Front Panel sticker, lower, DA; K-ARKB (rev.00); S/5	898390	
3	Front Panel sticker, lower, DE; K-ARKB (rev.00); S/5	898381	
3	Front Panel sticker, lower, EN; K-ARKB (rev.00); S/5	898380	
3	Front Panel sticker, lower, ES; K-ARKB (rev.00); S/5	898384	
3	Front Panel sticker, lower, FI; K-ARKB (rev.00); S/5	898387	
3	Front Panel sticker, lower, FR; K-ARKB (rev.00); S/5	898382	
3	Front Panel sticker, lower, IT; K-ARKB (rev.00); S/5	898385	
3	Front Panel sticker, lower, JA; K-ARKB (00); S/5	8000374	
3	Front Panel sticker, lower, NL; K-ARKB (rev.00); S/5	898383	
3	Front Panel sticker, lower, NO; K-ARKB (rev.00); S/5	898389	
3	Front Panel sticker, lower, PT; K-ARKB (rev.00); S/5	898386	
3	Front Panel sticker, lower, SKAND; K-ARKB; S/5	898796	
3	Front Panel sticker, lower, SV; K-ARKB (rev.00); S/5	898388	

17.3 Keyboard Interface Board, B-ARK

Item	Item description	Order No.
	Grounding plate, blank/narrow	885198
	Block screw for cables	546096

For your notes:

GE Healthcare

Service Manual Language Information

WARNING (EN)	This service manual is available in English only. • If a customer's service provider requires a language other than English, it is the customer's responsibility to provide translation services. • Do not attempt to service the equipment unless this service manual has been consulted and is understood. • Failure to heed this warning may result in injury to the service provider, operator, or patient, from electric shock, mechanical or other hazards.
ПРЕДУПРЕЖДЕНИЕ (BG)	Това упътване за работа е налично само на английски език. • Ако доставчикът на услугата на клиента изиска друг език, задължение на клиента е да осигури превод. • Не използвайте оборудването, преди да сте се консултирали и разбрали упътването за работа. • Неспазването на това предупреждение може да доведе до нараняване на доставчика на услугата, оператора или пациент в резултат на токов удар или механична или друга опасност.
VAROVÁNÍ (CS)	Tento provozní návod existuje pouze v anglickém jazyce. • V případě, že externí služba zákazníkům potřebuje návod v jiném jazyce, je zajištění překladu do odpovídajícího jazyka úkolem zákazníka. • Nesnažte se o údržbu tohoto zařízení, aniž byste si přečetli tento provozní návod a pochopili jeho obsah. • V případě nedodržování této varování může dojít k poranění pracovníka prodejního servisu, obslužného personálu nebo pacientů vlivem elektrického proudu, respektive vlivem mechanických či jiných rizik.
ADVARSEL (DA)	Denne servicemanual findes kun på engelsk. • Hvis en kundes tekniker har brug for et andet sprog end engelsk, er det kundens ansvar at sørge for oversættelse. • Forsøg ikke at servicere udstyret medmindre denne servicemanual har været konsulteret og er forstået. • Manglende overholdelse af denne advarsel kan medføre skade på grund af elektrisk, mekanisk eller anden fare for teknikeren, operatøren eller patienten.
WARNUNG (DE)	Diese Serviceanleitung ist nur in englischer Sprache verfügbar. • Falls der Kundendienst eine andere Sprache benötigt, muss er für eine entsprechende Übersetzung sorgen. • Keine Wartung durchführen, ohne diese Serviceanleitung gelesen und verstanden zu haben. • Bei Zuwiderhandlung kann es zu Verletzungen des Kundendiensttechnikers, des Anwenders oder des Patienten durch Stromschläge, mechanische oder sonstige gefahren kommen.
ΠΡΟΕΙΔΟΠΟΙΗΣΗ (EL)	Το παρόν εγχειρίδιο σέρβις διατίθεται στα αγγλικά μόνο. • Εάν το άτομο παροχής σέρβις ενός πελάτη απαιτεί το παρόν εγχειρίδιο σε γλώσσα εκτός των αγγλικών, αποτελεί ευθύνη του πελάτη να παρέχει υπηρεσίες μετάφρασης. • Μην επιχειρήσετε την εκτέλεση εργασιών σέρβις στον εξοπλισμό εκτός εαν έχετε συμβουλευτεί και έχετε κατανοήσει το παρόν εγχειρίδιο σέρβις. • Εαν δε λάβετε υπόψη την προειδοποίηση αυτή, ενδέχεται να προκληθεί τραυματισμός στο άτομο παροχής σέρβις, στο χειριστή ή στον ασθενή από ηλεκτροπληξία, μηχανικούς ή άλλους κινδύνους.
ADVERTENCIA (ES)	Este manual de servicio sólo existe en inglés. • Si el encargado de mantenimiento de un cliente necesita un idioma que no sea el inglés, el cliente deberá encargarse de la traducción del manual. • No se deberá dar servicio técnico al equipo, sin haber consultado y comprendido este manual de servicio. • La no observancia del presente aviso puede dar lugar a que el proveedor de servicios, el operador o el paciente sufran lesiones provocadas por causas eléctricas, mecánicas o de otra naturaleza.

HOIATUS (ET)	Käesolev teenindusjuhend on saadaval ainult inglise keeles. • Kui klienditeeninduse osutaja nõuab juhendit inglise keelest erinevas keeles, vastutab klient tõlketeenuse osutamise eest. • Ärge üritage seadmeid teenindada enne eelnevalt käesoleva teenindusjuhendiga tutvumist ja sellest aru saamist. • Käesoleva hoiatuse eiramine võib põhjustada teenuseosutaja, operaatori või patsiendi vigastamist elektrilöögi, mehaanilise või muu ohu tagajärjel.
VAROITUS (FI)	Tämä huolto-ohje on saatavilla vain englanniksi. • Jos asiakkaan huoltohenkilöstö vaatii muuta kuin englanninkielistä materiaalia, tarvittavan käännöksen hankkiminen on asiakkaan vastuulla. • Älä yritä korjata laitteistoa ennen kuin olet varmasti lukenut ja ymmärtänyt tämän huolto-ohjeen. • Mikäli tätä varoitusta ei noudateta, seurauksena voi olla huoltohenkilöstön, laitteiston käyttäjän tai potilaan vahingoittuminen sähköiskun, mekaanisen vian tai muun vaaratilanteen vuoksi.
ATTENTION (FR)	Ce manuel technique n'est disponible qu'en anglais. • Si un service technique client souhaite obtenir ce manuel dans une autre langue que l'anglais, il devra prendre en charge la traduction et la responsabilité du contenu. • Ne pas tenter d'intervenir sur les équipements tant que le manuel technique n'a pas été consulté et compris. • Le non-respect de cet avertissement peut entraîner chez le technicien, l'opérateur ou le patient des blessures dues à des dangers électriques, mécaniques ou autres.
UPOZORENJE (HR)	Ove upute za servisiranje dostupne su samo na engleskom jeziku. • Ukoliko korisnički servis zahtijeva neki drugi jezik, korisnikova je odgovornost osigurati odgovarajući prijevod. • Nemojte pokušavati servisirati opremu ukoliko niste konzultirali i razumjeli ove upute. • Nepoštivanje ovog upozorenja može rezultirati ozljedama servisnog osoblja, korisnika ili pacijenta prouzročenim električnim udarom te mehaničkim ili nekih drugih opasnostima.
FIGYELMEZTETÉS (HU)	Ez a szerviz kézikönyv kizárólag angol nyelven érhető el. • Ha a vevő szerviz ellátója angoltól eltérő nyelvre tart igényt, akkor a vevő felelőssége a fordítás elkészíttetése. • Ne próbálja elkezdeni használni a berendezést, amíg a szerviz kézikönyvben leírtakat nem értelmezték és értették meg. • Ezen figyelmeztetés figyelmen kívül hagyása a szerviz ellátó, a működtető vagy a páciens áramütés, mechanikai vagy egyéb veszélyhelyzet miatti sérülését eredményezheti.
PERINGATAN (ID)	Manual servis ini hanya tersedia dalam Bahasa Inggris. • Jika penyedia jasa servis pelanggan memerlukan bahasa lain selain dari Bahasa Inggris, merupakan tanggung jawab dari penyedia jasa servis tersebut untuk menyediakan terjemahannya. • Jangan mencoba melakukan servis pada perlengkapan kecuali telah membaca dan memahami manual servis ini. • Mengabaikan peringatan ini bisa berakibat cedera pada penyedia servis, operator, atau pasien, karena terkena kejut listrik, bahaya mekanis atau bahaya lainnya.
AÐVÖRUN (IS)	Þessi þjónustuhandbók er eingöngu fáanleg á ensku. • Ef að þjónustuveitandi viðskiptamanns þarfnast annas tungumáls en ensku, er það skylda viðskiptamanns að skaffa tungumálaþjónustu. • Reynið ekki að afgreiða tækið nema að þessi þjónustuhandbók hefur verið skoðuð og skilin. • Brot á sinna þessari aðvörun getur leitt til meiðsla á þjónustuveitanda, stjórnanda eða sjúklings frá raflosti, vélrænu eða öðrum áhættum.
AVVERTENZA (IT)	Il presente manuale di manutenzione è disponibile soltanto in Inglese. • Se un addetto alla manutenzione richiede il manuale in una lingua diversa, il cliente è tenuto a provvedere direttamente alla traduzione. • Si proceda alla manutenzione dell'apparecchiatura solo dopo aver consultato il presente manuale ed averne compreso il contenuto. • Il non rispetto della presente avvertenza potrebbe far compiere operazioni da cui derivino lesioni all'addetto, alla manutenzione, all'utilizzatore ed al paziente per folgorazione elettrica, per urti meccanici od altri rischi.

警告 (JA)	このサービスマニュアルは英語版しかありません。 ・ サービスを担当される業者が英語以外の言語を要求される場合、翻訳作業はその業者の責任で行うものとさせていただきます。 ・ このサービスマニュアルを熟読し、十分に理解した上で装置のサービスを行ってください。 ・ この警告に従わない場合、サービスを担当される方、操作員あるいは患者が、感電や機械的又はその他の危険により負傷する可能性があります。
경고 (KO)	본 서비스 지침서는 영어로만 이용하실 수 있습니다 . • 고객의 서비스 제공자가 영어 이외의 언어를 요구할 경우 , 번역 서비스를 제공하는 것은 고객의 책임입니다 . • 본 서비스 지침서를 참고했고 이해하지 않는 한은 해당 장비를 수리하려고 시도하지 마십시오 . • 이 경고에 유의하지 않으면 전기 쇼크 , 기계상의 혹은 다른 위험으로부터 서비스 제공자 , 운영자 혹은 환자에게 위해를 가할 수 있습니다 .
ĮSPĖJIMAS (LT)	Šis eksploatavimo vadovas yra prieinamas tik anglų kalba. • Jei kliento paslaugų tiekėjas reikalauja vadovo kita kalba – ne anglų, numatyti vertimo paslaugas yra kliento atsakomybė. • Nemėginkite atlikti įrangos techninės priežiūros, nebent atsižvelgėte į šį eksploatavimo vadovą ir jį supratote. • Jei neatkreipsite dėmesio į šį perspėjimą, galimi sužalojimai dėl elektros šoko, mechaninių ar kitų pavojų paslaugų tiekėjui, operatoriui ar pacientui.
BRĪDINĀJUMS (LV)	Šī apkalpotāju rokasgrāmata ir pieejama tikai angļu valodā. • Ja apkalpošanas sniedzējam nepieciešama informācija citā, nevis angļu, valodā, klienta pienākums ir nodrošināt tās tulkošanu. • Neveiciet aprīkojuma apkopi, neizlasot un nesaprotot apkalpotāju rokasgrāmatu. • Šī brīdinājuma neievērošana var radīt elektriskās strāvas trieciena, mehānisku vai citu risku izraisītu traumu apkopes sniedzējam, operatoram vai pacientam.
WAARSCHUWING (NL)	Deze service manual is alleen in het Engels verkrijgbaar. • Indien het onderhoudspersoneel een andere taal nodig heeft, dan is de klant verantwoordelijk voor de vertaling ervan. • Probeer de apparatuur niet te onderhouden voordat deze service manual geraadpleegd en begrepen is. • Indien deze waarschuwing niet wordt opgevolgd, zou het onderhoudspersoneel, de gebruiker of een patiënt gewond kunnen raken als gevolg van een elektrische schok, mechanische of andere gevaren.
ADVARSEL (NO)	Denne servicehåndboken finnes bare på engelsk. • Hvis kundens serviceleverandør trenger et annet språk, er det kundens ansvar å sørge for oversettelse. • Ikke forsøk å reparere utstyret uten at denne servicehåndboken er lest og forstått. • Manglende hensyn til denne advarselen kan føre til at serviceleverandøren, operatøren eller pasienten skades på grunn av elektrisk støt, mekaniske eller andre farer.
OSTRZEŻENIE (PL)	Niniejszy podręcznik serwisowy dostępny jest jedynie w języku angielskim. • Jeśli dostawca usług klienta wymaga języka innego niż angielski, zapewnienie usługi tłumaczenia jest obowiązkiem klienta. • Nie należy serwisować wyposażenia bez zapoznania się i zrozumienia niniejszego podręcznika serwisowego. • Niezastosowanie się do tego ostrzeżenia może spowodować urazy dostawcy usług, operatora lub pacjenta w wyniku porażenia elektrycznego, zagrożenia mechanicznego bądź innego.
AVISO (PT-BR)	Este manual de assistência técnica só se encontra disponível em inglês. • Se o serviço de assistência técnica do cliente não for GE, e precisar de outro idioma, será da responsabilidade do cliente fornecer os serviços de tradução. • Não tente reparar o equipamento sem ter consultado e compreendido este manual de assistência técnica. • O não cumprimento deste aviso pode por em perigo a segurança do técnico, operador ou paciente devido a choques elétricos, mecânicos ou outros.

AVISO (PT-PT)	Este manual técnico só se encontra disponível em inglês. • Se a assistência técnica do cliente solicitar estes manuais noutro idioma, é da responsabilidade do cliente fornecer os serviços de tradução. • Não tente reparar o equipamento sem ter consultado e compreendido este manual técnico. • O não cumprimento deste aviso pode provocar lesões ao técnico, ao utilizador ou ao paciente devido a choques eléctricos, mecânicos ou outros.
AVERTISMENT (RO)	Acest manual de service este disponibil numai în limba engleză. • Dacă un furnizor de servicii pentru clienți necesită o altă limbă decât cea engleză, este de datoria clientului să furnizeze o traducere. • Nu încercați să reparați echipamentul decât ulterior consultării şi înțelegerii acestui manual de service. • Ignorarea acestui avertisment ar putea duce la rănirea depanatorului, operatorului sau pacientului în urma pericolelor de electrocutare, mecanice sau de altă natură.
ПРЕДУПРЕЖДЕНИЕ (RU)	Настоящее руководство по обслуживанию предлагается только на английском языке. • Если сервисному персоналу клиента необходимо руководство не на английском, а на каком-то другом языке, клиенту следует обеспечить перевод самостоятельно. • Прежде чем приступать к обслуживанию оборудования, обязательно обратитесь к настоящему руководству и внимательно изучите изложенные в нем сведения. • Несоблюдение требований данного предупреждения может привести к тому, что специалисты по обслуживанию, операторы или пациенты получат удар электрическим током, механическую травму или другое повреждение.
VAROVANIE (SK)	Tento návod na obsluhu je k dispozícii len v angličtine. • Ak zákazníkov poskytovateľ služieb vyžaduje iný jazyk ako angličtinu, poskytnutie prekladateľských služieb je zodpovednosťou zákazníka. • Nepokúšajte sa o obsluhu zariadenia skôr, ako si neprečítate návod na obsluhu a neporozumiete mu. • Zanedbanie tohto varovania môže vyústiť do zranenia poskytovateľa služieb, obsluhujúcej osoby alebo pacienta elektrickým prúdom, mechanickým alebo iným nebezpečenstvom.
OPOZORILO (SL)	Ta servisni priročnik je na voljo samo v angleškem jeziku. • Če ponudnik storitve stranke potrebuje prirocnik v drugem jeziku, mora stranka zagotoviti prevod. • Ne poskušajte servisirati opreme, če tega prirocnika niste v celoti prebrali in razumeli. • Če tega opozorila ne upoštevate, se lahko zaradi elektricnega udara, mehanskih ali drugih nevarnosti poškoduje ponudnik storitev, operater ali bolnik.
UPOZORENJE (SR)	Ovo servisno uputstvo je dostupno samo na engleskom jeziku. • Ako klijentov serviser zahteva neki drugi jezik, klijent je dužan da obezbedi prevodilacke usluge. • Ne pokušavajte da opravite uredaj ako niste procitali i razumeli ovo servisno uputstvo. • Zanemarivanje ovog upozorenja može dovesti do povredivanja servisera, rukovaoca ili pacijenta usled strujnog udara ili mehanickih i drugih opasnosti.
VARNING (SV)	Den här servicehandboken finns bara tillgänglig på engelska. • Om en kunds servicetekniker har behov av ett annat språk än engelska ansvarar kunden för att tillhandahålla översättningstjänster. • Försök inte utföra service på utrustningen om du inte har läst och förstår den här servicehandboken. • Om du inte tar hänsyn till den här varningen kan det resultera i skador på serviceteknikern, operatören eller patienten till följd av elektriska stötar, mekaniska faror eller andra faror.
UYARI (TR)	Bu servis kilavuzunun sadece ingilizcesi mevcuttur. • Eğer müşteri teknisyeni bu kilavuzu ingilizce dişinda bir başka lisandan talep ederse, bunu tercüme ettirmek müşteriye düşer. • Servis kilavuzunu okuyup anlamadan ekipmanlara müdahale etmeyiniz. • Bu uyariya uyulmamasi, elektrik, mekanik veya diğer tehlikelerden dolayi teknisyen, operatör veya hastanin yaralanmasina yol açabilir.

ЗАСТЕРЕЖЕННЯ (UK)	Дане керівництво з сервісного обслуговування постачається виключно англійською мовою. • Якщо сервісний інженер потребує керівництво іншою мовою, користувач забов'язаний забезпечити послуги перекладача. • Не намагайтеся здійснювати технічне обслуговування даного обладнання, якщо ви не читали, або не зрозуміли інформацію, надану в керівництві з сервісного обслуговування. • Недотримання цього застереження може призвести до травмування сервісного інженера, користувача даного обладнання або пацієнта внаслідок електричного шоку, механічного ушкодження або з інших причин невірного обслуговування обладнання.
CẢNH BÁO (VI)	Tài Liệu Hướng Dẫn Sửa Chữa chỉ có bản tiếng Anh. • Nếu các đơn vị cung cấp dịch vụ cho khách hàng yêu cầu một ngôn ngữ nào khác tiếng Anh, thì khách hàng sẽ có trách nhiệm cung cấp các dịch vụ dịch thuật. • Không được sửa chữa thiết bị trừ khi đã tham khảo và hiểu Tài liệu Hướng dẫn Sửa chữa. • Không tuân thủ những cảnh báo này có thể dẫn đến các tổn thương cho người thực hiện sửa chữa, người vận hành hay bệnh nhân, do sốc điện, các rủi ro về cơ khí hay các rủi ro khác.
警告 (ZH-CN)	本维修手册仅提供英文版本。 • 如果维修服务提供商需要非英文版本，客户需自行提供翻译服务。 • 未详细阅读和完全理解本维修手册之前，不得进行维修。 • 忽略本警告可能对维修人员，操作员或患者造成触电、机械伤害或其他形式的伤害。
警告 (ZH-TW)	本維修手冊只提供英文版。 • 如果客戶的維修人員有英語以外的其他語言版本需求，則由該客戶負責提供翻譯服務。 • 除非您已詳閱本維修手冊並了解其內容，否則切勿嘗試對本設備進行維修。 • 不重視本警告可能導致維修人員、操作人員或病患因電擊、機械因素或其他因素而受到傷害。