GE Healthcare

Module Frames and Modules

Technical Manual

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.

English

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Module Frames and Modules
Technical Manual

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1 About this manual

1.1 Intended use of the manual

This Module Frames and Modules Technical Manual must be used in conjunction with the CARESCAPE modular monitor's technical manual for important safety information.

This manual contains instructions necessary to perform planned and corrective maintenance to the parameter modules and module frames. Use it as a guide for maintenance and repairs considered field repairable.

Where necessary the manual identifies additional sources of relevant information and technical assistance.

See the patient monitor's technical manual for an overview of the patient monitoring system, information needed for system installation and for planned and corrective maintenance.

See the supplemental information manual for the technical specifications, default settings and compatibility information, including electromagnetic compatibility.

See the patient monitor's user's manual for the instructions necessary to operate the device safely in accordance with its function and intended use.

1.2 Intended audience of the manual

This manual is intended for service representatives and technical personnel who install, maintain, troubleshoot, or repair this device.

1.3 Third party trademarks

All other product and company names are the property of their respective owners.

1.4 ESD awareness

The system complies with IEC 60601-1-2:2001 + A:2004.

In accordance with IEC 60601-1-2, modules marked with the ESD warning symbol (IEC 60417-5134) require user training in ESD awareness and prevention as follows:

- The contents of the training are specified in the local ESD Control Program Plan, issued in accordance with IEC 61340-5-1. The training should at least include an introduction to ESD and its impacts on electrical devices and how to prevent it by using appropriate personal protection equipment, proper work practices and tools.

1.5 Service requirements

General service requirements and qualification requirements for the service personnel.

Follow the service requirements listed below.

– Refer equipment servicing to GE authorized service personnel only.

– Any unauthorized attempt to repair equipment under warranty voids that warranty.

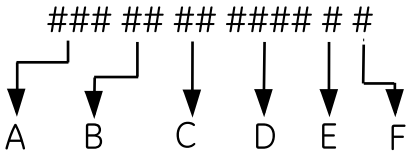
– It is the user's responsibility to report the need for service to GE or to one of their authorized agents.

– Failure on the part of the responsible individual, hospital, or institution using this equipment to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards.

– Regular maintenance, irrespective of usage, is essential to ensure that the equipment will always be functional when required.

1.5.1 Equipment identification

Every GE device has a unique serial number for identification. A sample of the information found on a serial number label is shown below.



	Description
A	product code
B	year manufactured
C	fiscal week manufactured
D	production sequence number
E	manufacturing site
F	miscellaneous characteristic

1.5.2 Serial number label

An example of a serial number label of an E-module is shown below.

	Description
TYPE	Device type e.g. E-NMT
SN	Serial number

1.5.3 Device plate location

The device plate is located between the docking rails of the PDM module and on the inside of the module frames F5 and F7.

Figure 1 Device plate location, Patient Data Module and module frames

The device plate is located beside the docking rails of the E-PSM and E-PSMP modules and on the left side of the plug-in E-modules.

Figure 2 Device plate location, E-PSM and E-modules

1.5.4 Access to Webmin

Webmin can be accessed locally through the CARESCAPE monitor or remotely from a configured service laptop connected to the CARESCAPE monitor.

For information about Webmin, see the CARESCAPE monitor's technical manual.

For your notes:

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Hemodynamic Modules
E-PRESTN, E-RESTN, E-PRETN (Rev. 00)
E-PSMP, E-PSM (Rev. 01)

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the Patient Side Modules E-PSMP and E-PSM, and the double-width plug-in hemodynamic modules, E-PRETN, E-PRESTN and E-RESTN.

These modules provide general hemodynamic parameters.

Figure 1 Patient Side Module, E-PSMP, and Hemodynamic Module, E-PRESTN.

Parameter	E-PSMP	E-PSM	E-PRESTN	E-RESTN	E-PRETN
ECG	X	X	X	X	X
Impedance respiration	X	X	X	X	X
Two invasive blood pressures	X		X		X
Two temperatures	X	X	X	X	X
Pulse oximetry	X	X	X	X	
NIBP	X	X	X	X	X

Equipment safety symbols

Safety symbol for the E-PSMP and E-PSM modules:

This symbol on the module refers to defibrillator precautions. To ensure protection against the effects of cardiac defibrillator discharge, always use the recommended cables and leadwires only (see the supplemental information manual). Using other cables or leadwires may result in damage to the equipment and compromise patient and/or user safety.

Safety symbol for the E-PRESTN, E-RESTN, and E-PRETN modules:

When displayed on the 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.

1.2 Measurement principle

1.2.1 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 patient monitor's user's manual for electrodes' positions and other information.

1.2.2 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.

1.2.3 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.

1.2.4 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.

These modules use the constant current method. 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.

1.2.5 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.

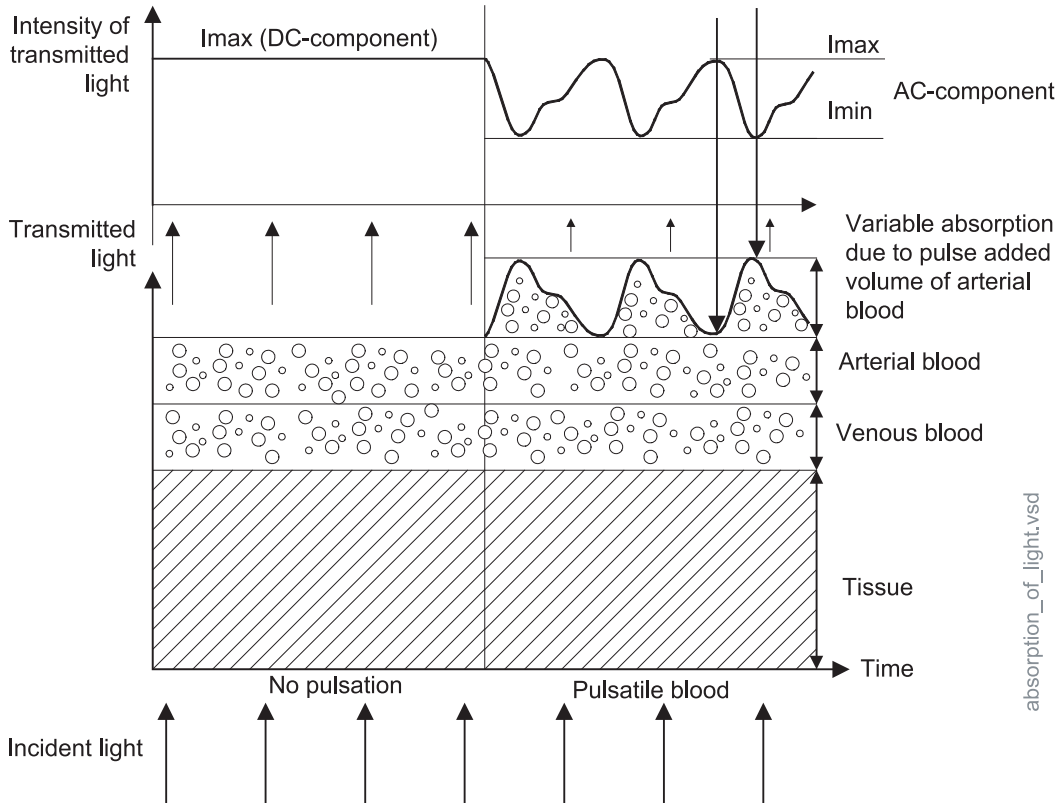


Figure 2 Absorption of infrared light in the finger

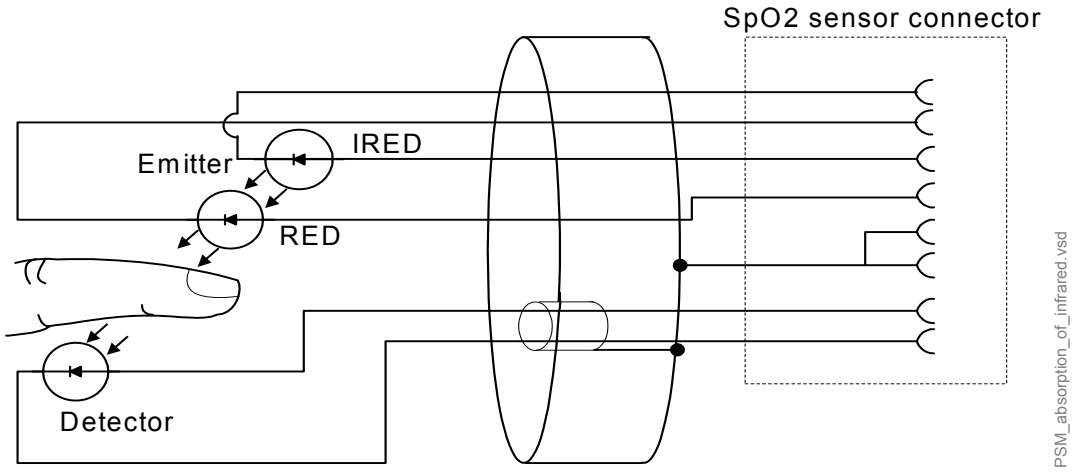


Figure 3 Pulse oximetry probe parts layout and schematic diagram

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.

1.2.6 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 parameter module
- twin hose (adult or infant model)
- blood pressure cuffs (various sizes)

1.3 Main components

1.3.1 Controls and connectors

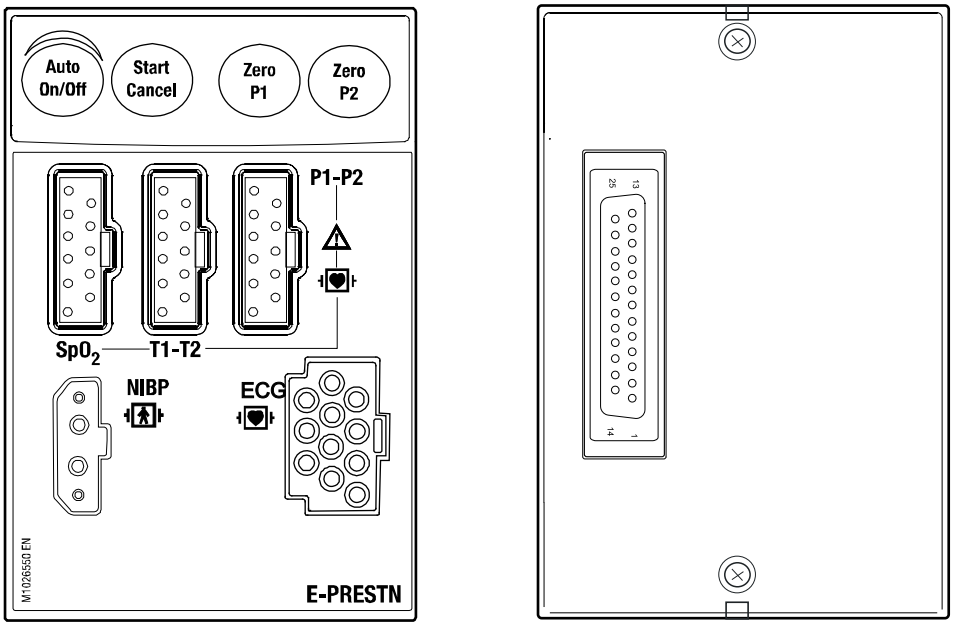


Figure 4 Front and back panel connectors of E-PRESTN module

Module keys	Module	Description
Auto On/Off	E-PRESTN, E-PRETN, E-RESTN	Starts and stops autocycling NIBP measurements
Start Cancel		Starts a single NIBP measurement, and cancels any measurement.
Zero P1	E-PRESTN, E-PRETN	Zeroes P1
Zero P2		Zeroes P2

Connector	Module	Description
NIBP	E-PRESTN, E-PRETN, E-RESTN	NIBP connector (black)
P1-P2	E-PRESTN, E-PRETN	InvBP connector (red)
T1-T2	E-PRESTN, E-PRETN, E-RESTN	Temperature connector (brown)
SpO_2	E-PRESTN, E-RESTN	SpO_2 connector (blue)
ECG	E-PRESTN, E-PRETN, E-RESTN	ECG and impedance respiration connector (green)
D25 connector	E-PRESTN, E-PRETN, E-RESTN	Module bus connector

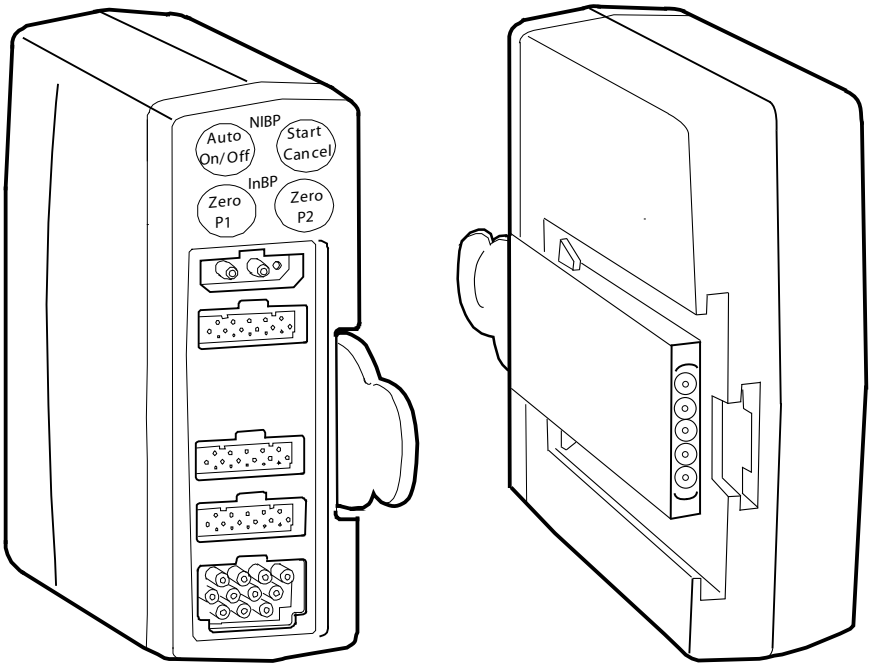


Figure 5 Front panel and connectors of E-PSMP module and the back of the module

Module keys	Module	Description
Auto On/Off	E-PSM, E-PSMP	Starts and stops autocycling NIBP measurements
Start Cancel		Starts a single NIBP measurement, and cancels any measurement.
Zero P1	E-PSMP	Zeroes P1
Zero P2		Zeroes P2

Connector	Module	Description
NIBP	E-PSM, E-PSMP	NIBP connector (black)
P1-P2	E-PSMP	InvBP connector (red)
T1-T2	E-PSM, E-PSMP	Temperature connector (brown)
SpO_2	E-PSM, E-PSMP	SpO_2 connector (blue)
ECG	E-PSM, E-PSMP	ECG and impedance respiration connector (green)
Tab for removing the module	E-PSM, E-PSMP	Detachment tab (gray)
5 pin connector	E-PSM, E-PSMP	Module bus connector

1.3.2 E-PSM(P) and E-(P)RE(S)TN modules

The 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 SpO2 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.

1.3.3 ECG board

The ECG measurement consists of the functions shown in the figure6. All functions are located in the ECG board except the ECG input unit.

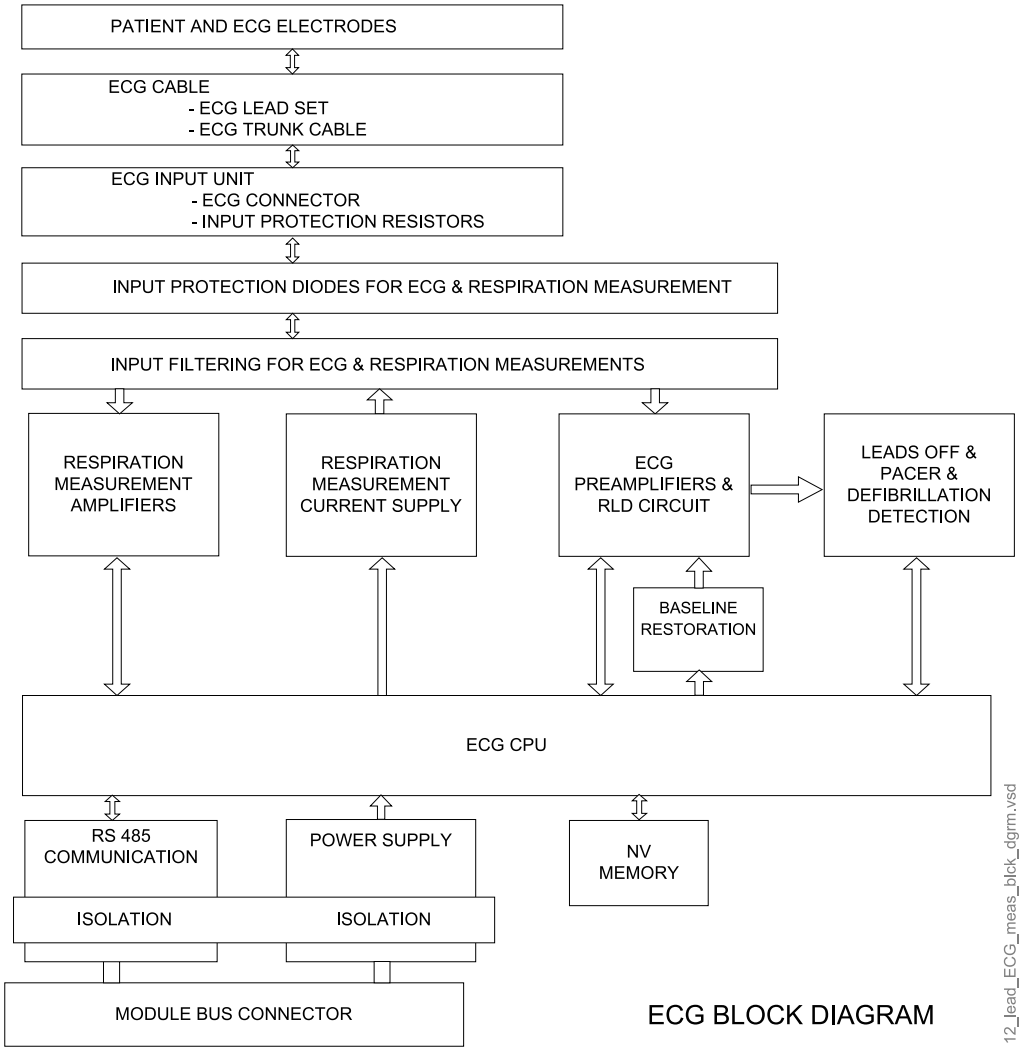


Figure 6 ECG measurement block diagram

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 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-lead5/12-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.

ECG filtering

There are 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.

1.3.4 STP board

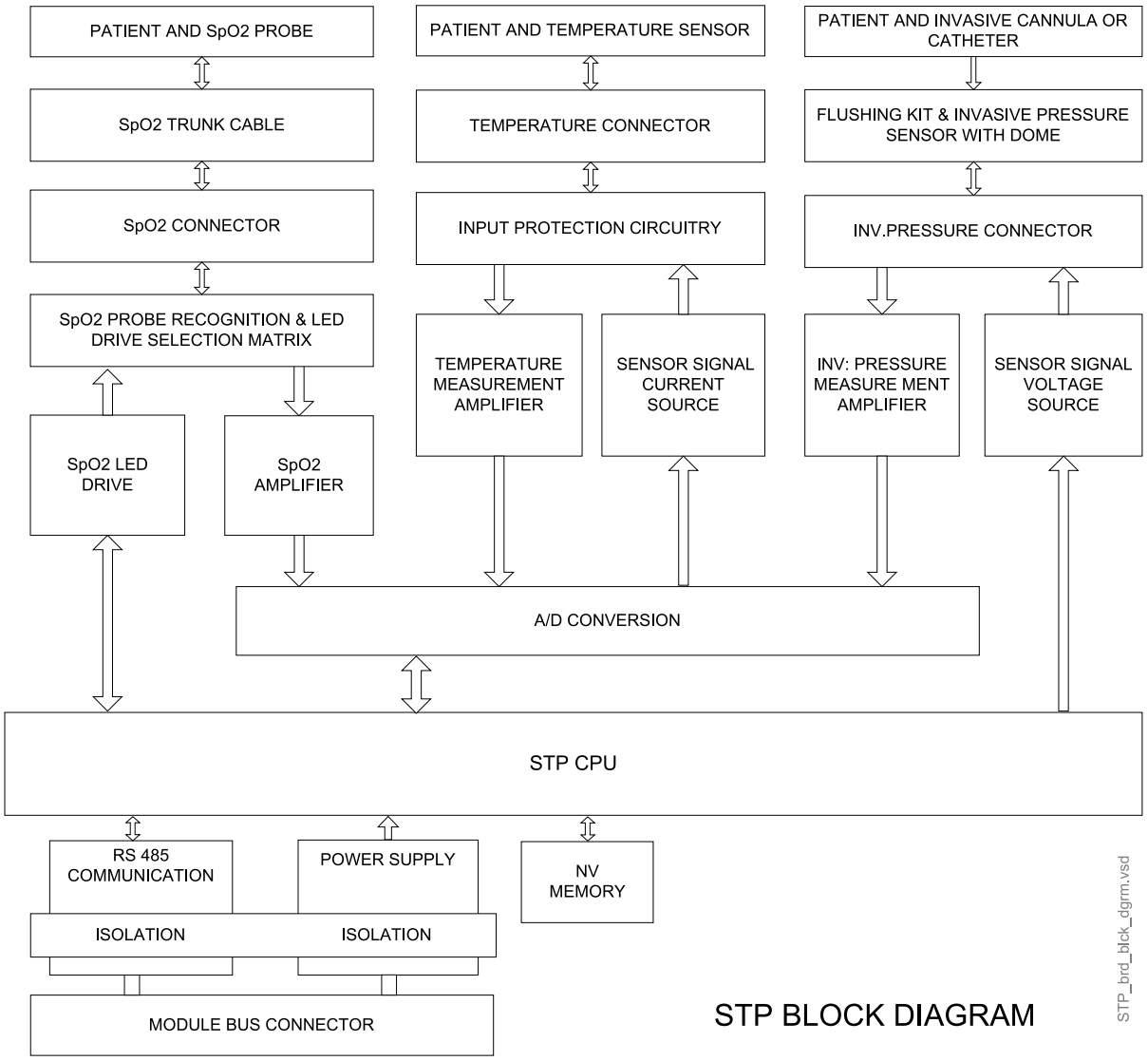


Figure 7 STP board block diagram

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.

The constant current source supplies about 38 µA current through the temperature sensor (400 series NTC resistor). The constant current causes 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.

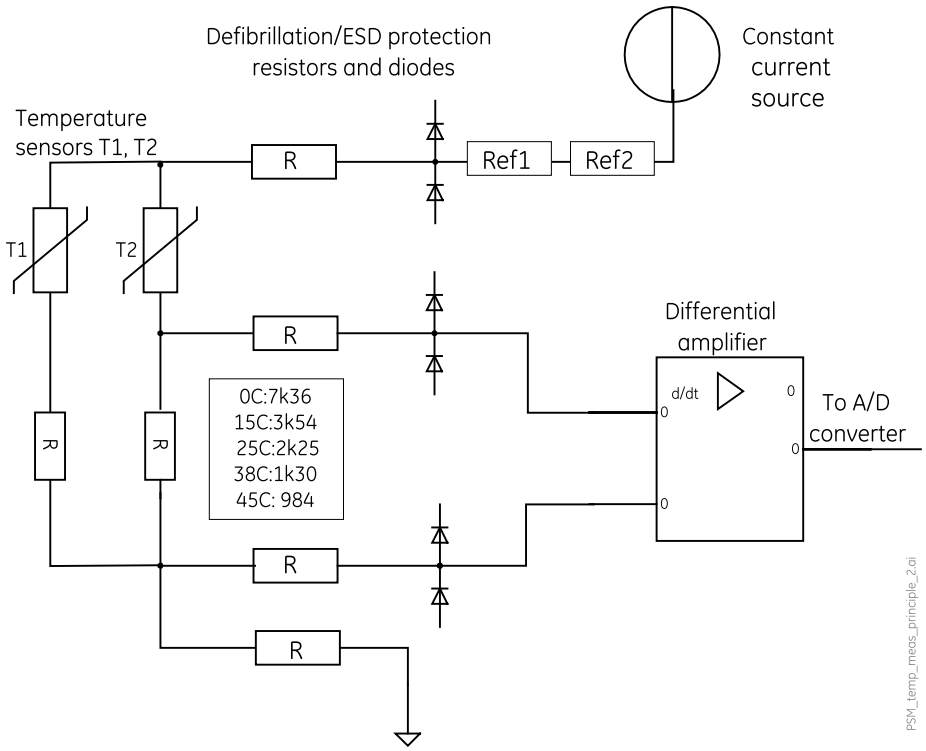


Figure 8 Temperature measurement principle

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.

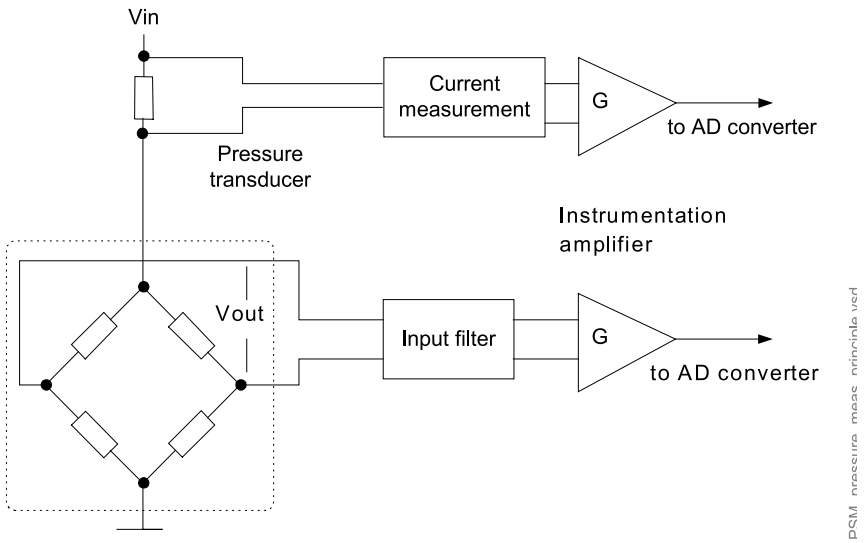


Figure 9 Pressure measurement principle

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 the SpO_2 probe LEDs ON (to the adjusted intensity) and OFF 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.

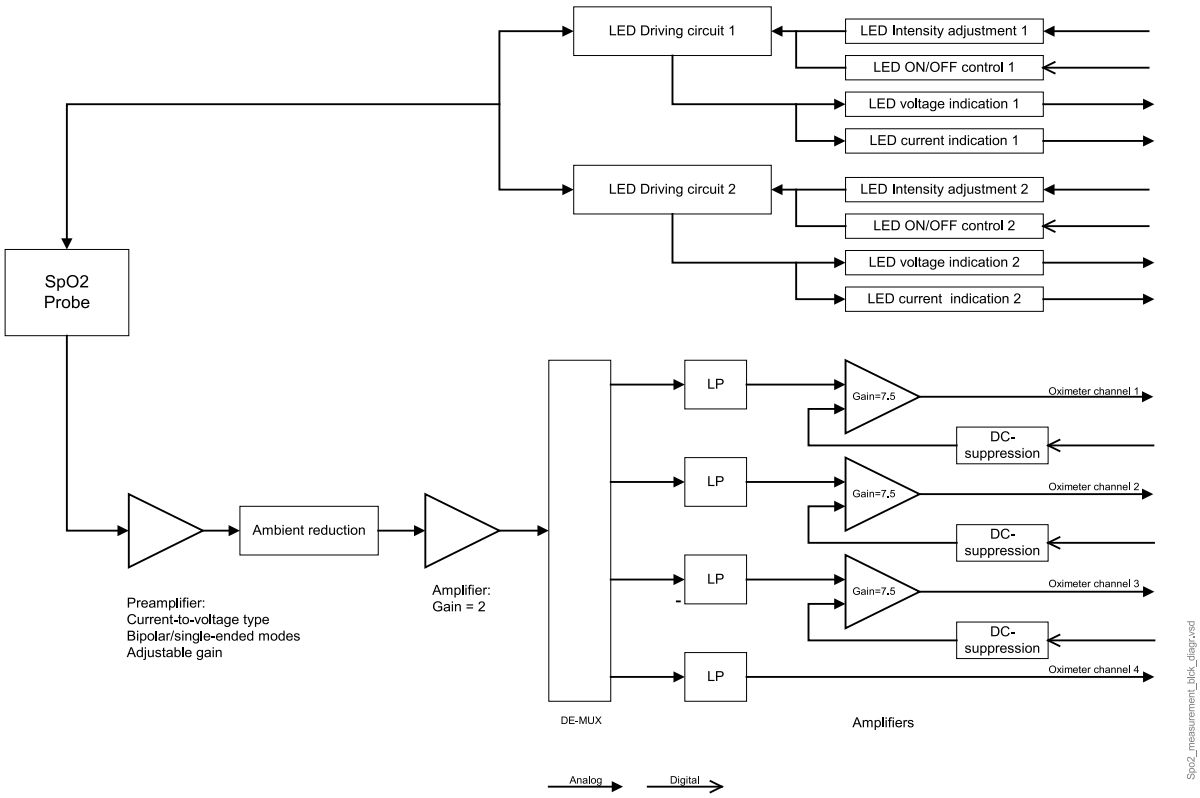


Figure 10 Pulse oximetry measurement block diagram

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.

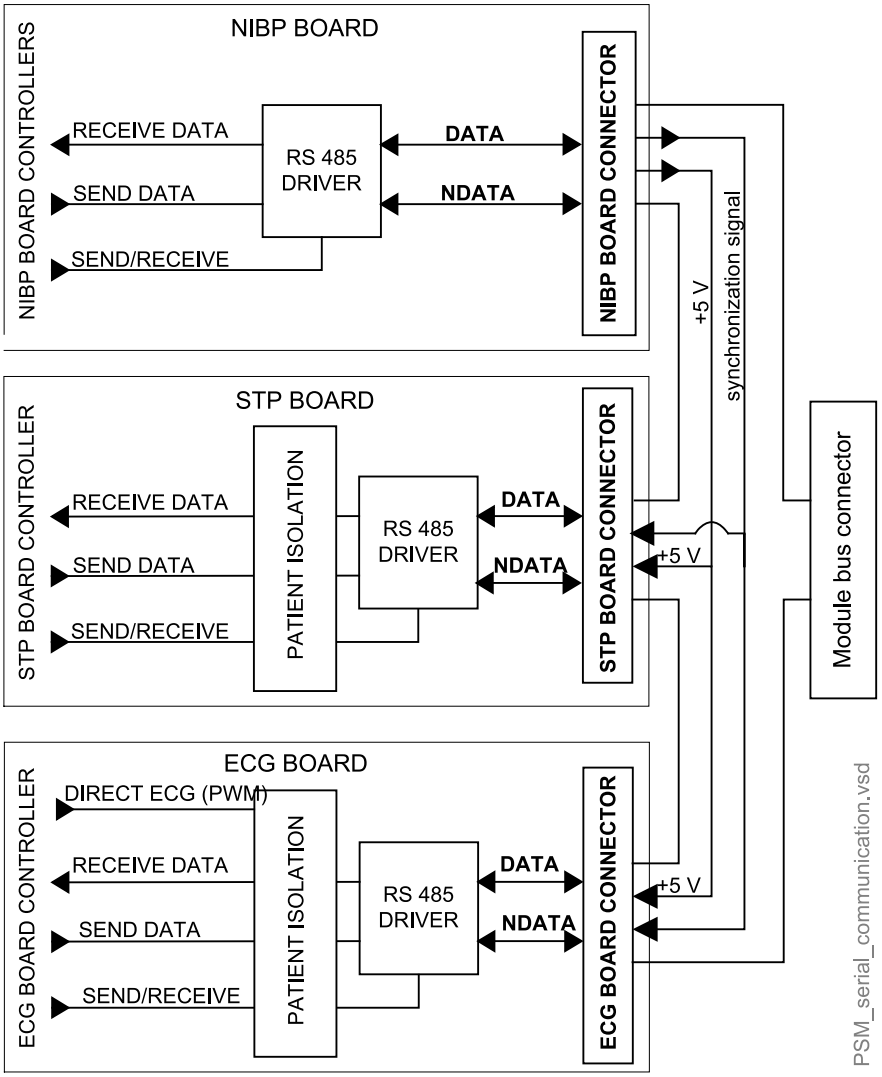


Figure 11 Serial communication of E-PSM(P) and E-(P)RE(S)TN module

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.

1.3.5 NIBP board

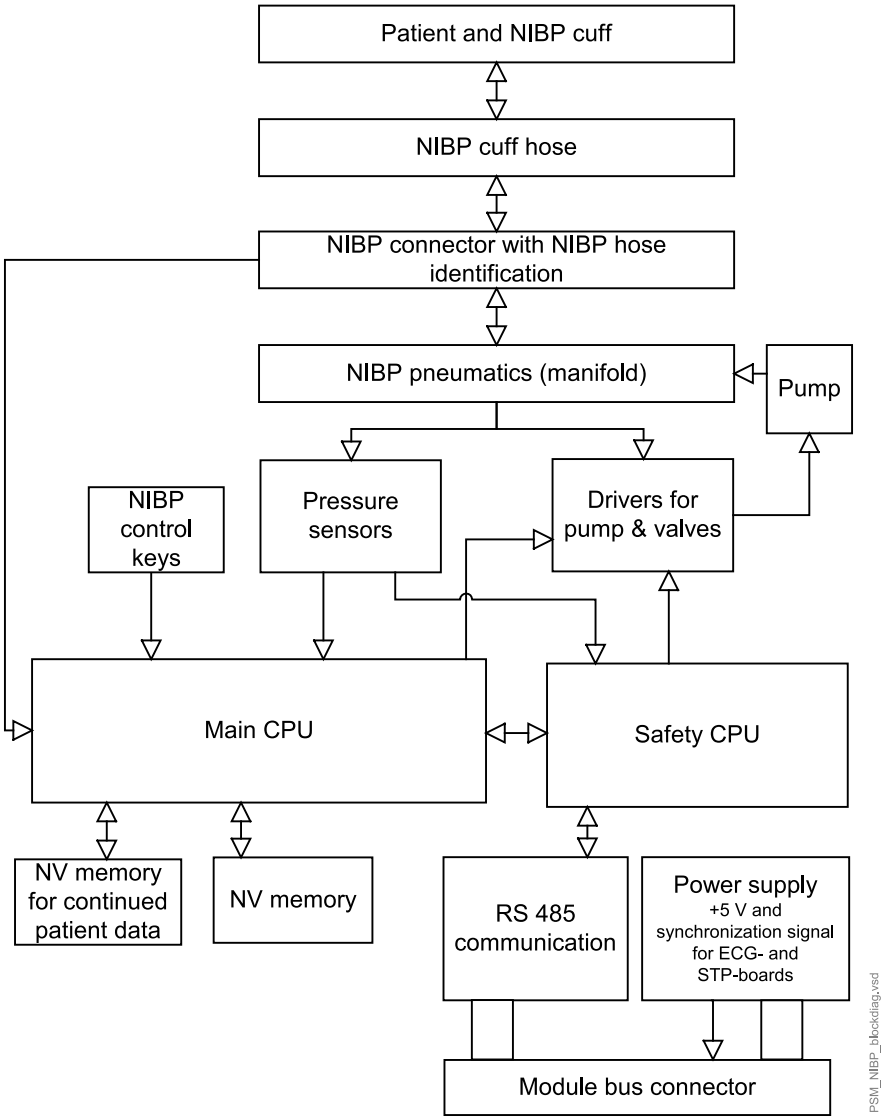


Figure 12 NIBP board functional block diagram

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 specifications.

Pneumatics

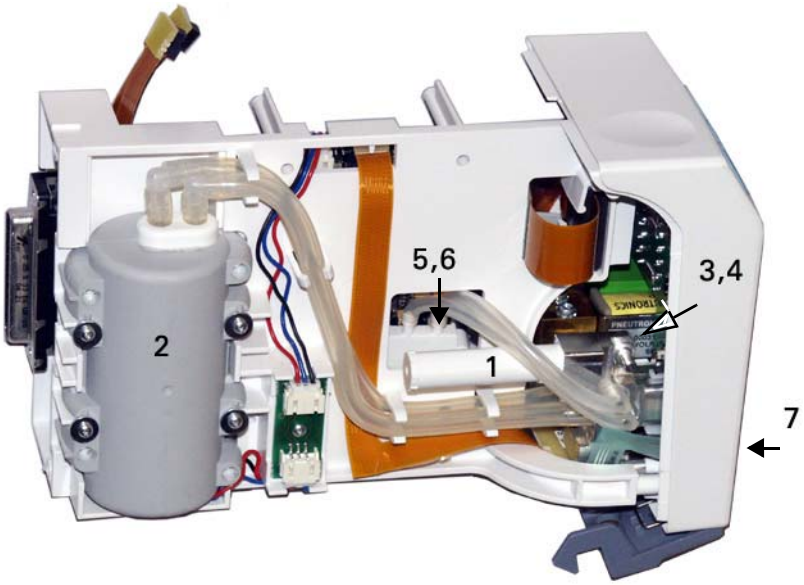


Figure 13 E-PRESTN pneumatics

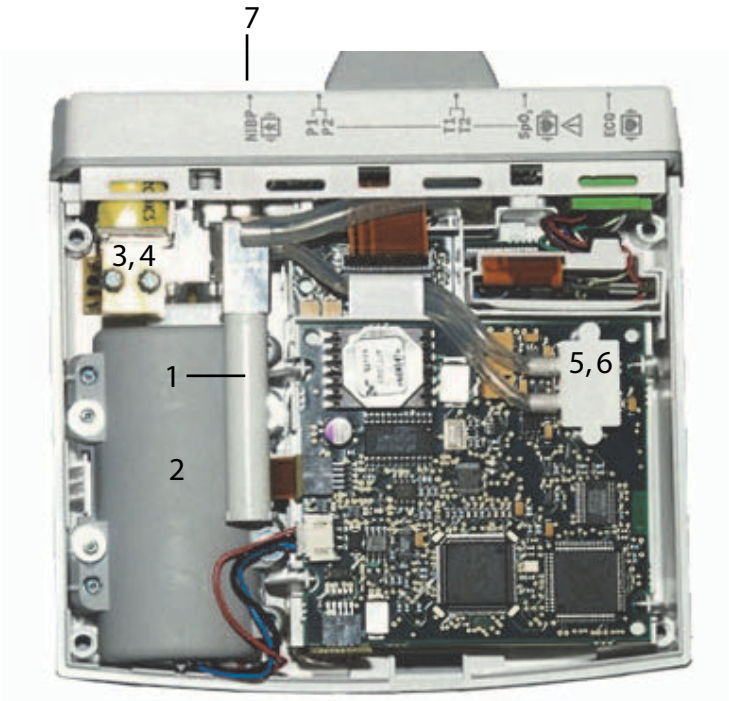


Figure 14 E-PSMP pneumatics

The modules have the following pneumatics parts:

(1) **NIBP 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.

(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.

(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.

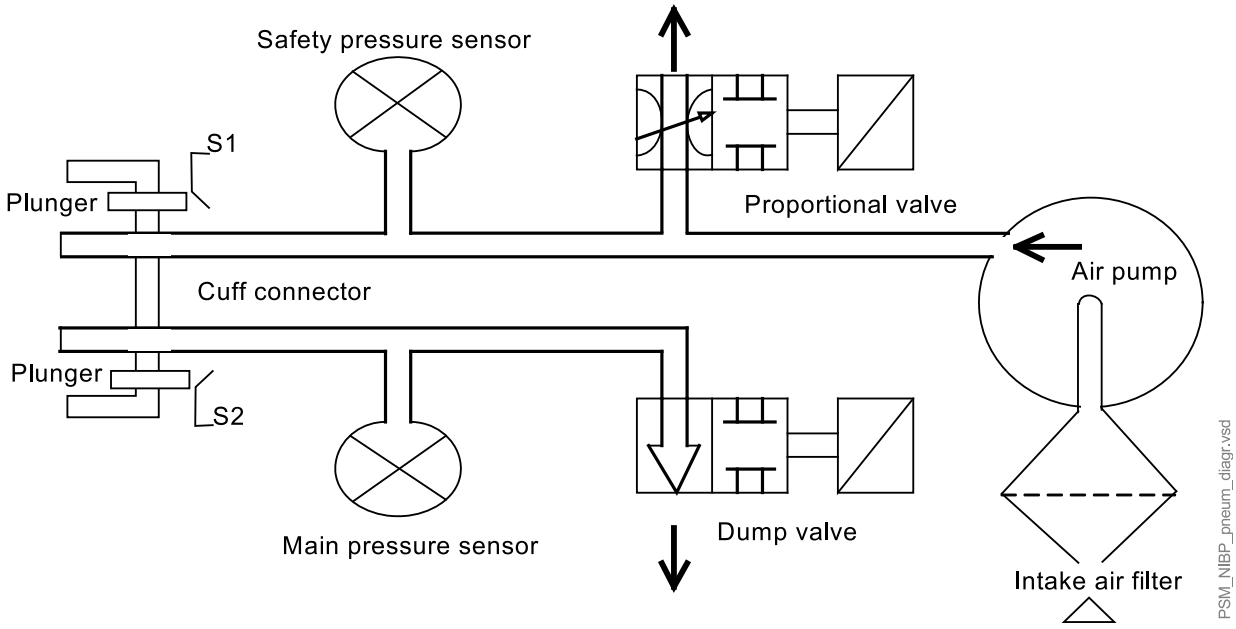


Figure 15 NIBP pneumatics diagram

Power supply section of the NIBP board

All connections are established via a module bus connector. The module needs a +15 V power supply to operate. The supply voltage (+15V) 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.

2 Configuration

2.1 STP/TP /ST-Settings

The E-PRESTN, E-PRETN, E-RESTN, E-PSM and E-PSMP modules include the STP board and software. The STP/TP/ST setting defines the parameter set the module is capable of measuring. This setting is stored into the permanent memory of the module.

STP/TP/ST setting should be always checked and, if necessary, reconfigured after the STP board has been replaced.

WARNING **Incorrect STP/TP/ST setting may cause erroneous operation of the module.**

2.1.1 Configuration

1. Disconnect all other parameter modules from the monitor, except the one you are configuring.

NOTE: The STP/TP/ST setting can be configured only for one module at a time. Presence of several modules may cause the configuration to fail.

2. Log on to the Webmin application.
3. Select the ***Configuration tab***.
4. Select ***Modules > STP/TP/ST setting***.
5. Check the current configuration for the PRESTN/PRETN/RESTN/PSM/PSMP modules. If the current configuration is incorrect, proceed to the next step and reconfigure it. Otherwise, leave the STP/TP/ST setting menu without changes.
6. Select the correct ***new configuration*** from the drop-down menu according to the following table.

NOTE: The picture may be slightly different compared to the monitor screen.

Module	New configuration
E-PRESTN, E-PSMP	STP
E-PRETN	TP
E-RESTN, E-PSM	ST

7. Select ***Submit***.

Activation and verification

The new STP/TP/ST setting will come into effect only after the module is restarted. To restart the module:

1. Disconnect the configured module and wait for approximately 5 seconds.
2. Reconnect the configured module.
3. Refresh the web browser to update the Webmin page.
4. Check that the current configuration is now correct for the module.
5. Reconnect all other modules.

3 Maintenance and checkout

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

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)	Electrical safety test (section 3.3)	Functional check (section 3.4)
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

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. Electrical safety tests
4. 3.4. Functional check

3.1 Replacement of planned maintenance parts

3.1.1 Required parts

Part number	Description	Pieces	Replacement interval
M1221481	E-PSM(P), Air Filter, FRU	1	Once every 3 years

3.1.2 Replacement procedures

Replace the air intake filter according to the procedure described in section 6.2.2. Replacing the NIBP air filter (E-PRESTN, E-PRETN and E-RESTN) and section 6.3.4. Replacing the NIBP air filter (E-PSMP and E-PSM).

3.2 Visual inspections

Detach the module from the module slot and check:

- that the front cover is intact
- that all connectors are intact and are attached properly
- that the module box and latch are intact

- the module and applied parts are clean

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

NOTE: Mark this task as complete on the checkout form.

3.3 Electrical safety tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual", Installation checkout" chapter. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 2-79

3.4 Functional check

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

3.4.1 Setup

Required tools

ECG & Impedance respiration:

– A multiparameter patient simulator
– Multi-Link 12-lead ECG trunk cable, IEC, or AHA
– Multi-Link 5-leadwire set, IEC, or AHA
– Multi-Link 5-leadwire set, C2-C6, IEC, or AHA

Invasive pressure:

– A multiparameter patient simulator with invasive pressure adapter cables to GE invasive pressure connectors.
– Dual invasive pressure adapter cable

Temperature:

– Dual temperature adapter cable
– A multiparameter patient simulator with temperature adapter cables to GE temperature connectors.

SpO2:

– GE SpO2 interconnection cable
– GE SpO2 finger probe

NIBP:

– Adult NIBP hose (with cuff id)
– Adult NIBP cuff
– Infant NIBP cuff hose (without cuff id)
– a rigid cylinder or pipe

NOTE: The diameter of a a rigid cylinder should be correct for the cuff selected. A too small or big cylinder may impact NIBP calibration check result. See CARESCAPE monitor's user's manual for details about Cuff Positioning.

– Tubing parts to connect a manometer and a pump to the NIPB cuff and hose.

NOTE: See CARESCAPE monitor supplemental information manual for compatible accessories.

Connections

Ensure that the module is connected to the monitor.

ECG & Impedance respiration:

1. Connect the 12-lead ECG trunk cable to the green ECG connector in the module.
2. Connect both 5-leadwire sets to the trunk cable and to the simulator.

Invasive pressure:

1. Connect the dual invasive pressure adapter cable to the red invasive pressure connector in the module.
2. Connect the multiparameter patient simulator with its invasive pressure adapter cables to the dual invasive pressure adapter cable.

NOTE: Pay attention to the invasive pressure connector places in the dual connector of the adapter cable.

Temperature:

1. Connect the dual temperature adapter cable to the brown temperature connector in the module.
2. Connect the multiparameter patient simulator with its temperature adapter cables to the dual temperature adapter cable.
3. Check that it is configured for 400 series probes.

SpO2:

1. Connect the SpO2 interconnection cable to the blue SpO2 connector in the module.
2. Connect the SpO2 finger probe to the SpO2 interconnection cable.

NIBP:

1. Connect an adult NIBP hose to the black NIBP module connector.
2. Connect an adult NIBP cuff to the adult NIBP hose.
3. Wrap the NIBP cuff around a rigid cylinder or pipe.
4. Connect the pressure manometer with either an integrated or separate pressure pump to the NIBP hose and NIBP cuff with a piece of tubing (see picture below).
5. Ensure that all the connections made are leak-proof.

Monitor configuration

ECG:

1. Configure the ECG1, ECG2 and ECG3 waveform fields to the monitor screen with adequate priority.
2. Select the ***Setup*** tab in the ***ECG*** menu and configure:
   ECG1 Lead: II
   ECG2 lead: V1
   ECG3 lead: aVL
   Beat volume: 1 or greater
   Size: 1x
3. Select the ***Advanced*** tab in the ***ECG*** menu and configure:
   Pacemaker Detection: Show
   Primary HR source: Auto

Impedance respiration:

1. Configure the Resp waveform field to the monitor screen with adequate priority.
2. Select the ***Setup*** tab in the ***Impedance Respiration*** menu and configure:
   Respiration Measurement: On
   Resp Rate Source: Impedance

NOTE: To select these settings, the module must be connected, the Resp waveform must be displayed and the ECG leads must be connected to a simulator with an impedance respiration source.

Invasive pressure:

1. Configure the P1 and P2 waveform fields to the monitor screen with adequate priority.

2. Select the ***P1*** tab in the ***Invasive Pressure*** menu and configure:
   Label: P1
   Scale (mmHg): 0-200 mmHg
   Parameter Format: Sys/Dia (Mean)
3. Select the ***P2*** tab in the ***Invasive Pressure*** menu and configure:
   Label: P2
   Scale (mmHg): 0-200 mmHg
   Parameter Format: Sys/Dia (Mean)

Temperature:

1. Configure the T1 and T2 parameter windows to the monitor screen with adequate priority.
2. Select the ***T1,T2*** tab in the ***Temperatures*** menu and configure:
   T1 Measurement: On
   T2 Measurement: On

SpO2:

- Configure the SpO2 waveform field to the monitor screen with adequate priority.

NIBP:

1. Configure the NIBP parameter window to the monitor screen with adequate priority.
2. Select the ***Setup*** tab in the ***Non-Invasive Blood Pressure*** menu and configure:
   Inflation Limits: Auto

Simulator configuration

NOTE: Refer to the simulator documentation for details on how to use and configure the simulator.

ECG

- Configure ECG settings as follows:
  ECG rhythm: a normal sinus rhythm
  heart rate: 80 bpm
  Amplitude: 1 mV

Impedance respiration

- Configure impedance respiration settings as follows:
  Baseline impedance: 1000
  Amplitude: 1
  Respiration rate: 20 breaths per minute
  Lead selection: II (or LL)

Invasive pressure

- Configure the simulator's invasive pressure channels as follows:
  Sensitivity: 5 μV/V/mmHg

InvBP outputs: " 0 mmHg static pressure" or "atmosphere"

Temperature

- Configure the simulator's temperature channels as follows:

  Temperature: 37 °C /98.6 °F

3.4.2 ECG tests

1. Normal Sinus Rhythm
   a. Check that the monitor displays the ECG leads II, V1 & aVL and the waveforms are noise-free. The monitor shall display a 80±5 bpm heart rate and an audible QRS tone sounds with each QRS complex.
   b. Select the ***All ECG Waveforms*** view from the ***ECG-Setup*** tab in the ***ECG*** menu. Check that all 12 ECG leads are available and they are noise free.
   c. Close the ***All ECG Waveform***s view and the ***ECG Setup*** menu.

2. Pacemaker Detection
   a. Configure the simulator to output "Asynchronous Pacemaker Pulse"
   b. Check that pacemaker spikes are shown on the ECG waveform.

3. Asystole Detection
   a. Configure the simulator to output "Asystole".
   b. Check that the 'Asystole' alarm appears to the monitor screen.
   c. Configure the simulator to show "80 beats per minute, Normal Sinus Rhythm".

4. Leads Off Detection
   a. Detach the RA/R leadwire from the simulator.
   b. Check that the Lead II waveform disappears from the ECG1 waveform field and a message 'RA/R lead off'' is shown momentarily.
   c. Check that Lead II is replaced by Lead III in the ECG1 waveform field after a while and a message 'Lead changed' is followed by a message 'Learning'.
   d. Reconnect the RA/R leadwire to the simulator.
   e. Check that Lead III is replaced back to Lead II in the ECG waveform field.
5. Mark this task as complete on the checkout form.

3.4.3 Impedance respiration tests

6. Respiration Rate
   a. Check that the RESP waveform is shown and the RR value is 20 (±5).
   b. Configure the simulator's Apnea Simulation to "32 sec".

7. Apnea Detection
   a. Check that the monitor activates the APNEA alarm.
   b. Configure the simulator's Apnea Simulation to "OFF"
8. Mark this task as complete on the checkout form.

3.4.4 Invasive pressure tests

Perform the following test steps to both to the P1 and to the P2 invasive pressure channels.

NOTE: The 'x' in the PX refers to the invasive pressure channel being tested.

9. Zeroing
   a. Ensure that the simulator InvBP output channel is configured to " 0 mmHg static pressure" or "atmosphere"
   b. Zero the tested invasive pressure channel by pressing the related **Zero Px** module key.
   c. Check that a message "Zeroing" followed by a message "Zeroed" is shown in the Px parameter window.

10. Static Pressure
    a. Configure the simulator's InvBP output channel to "200 mmHg static pressure".
    b. Check that the flat pressure line appears on the related waveform field. The reading in the parameter window shall be 200 ±10 mmHg.

NOTE: Recalibration is needed, if the measured value is not within the specification limits. Calibrate the invasive pressure channels according to the instructions in 4.1. Invasive pressure calibration" section.

11. Pressure Waveforms
    a. Configure the simulator's InvBP output channel to "Arterial 120/80".
    b. Check that the pressure waveform for tested invasive pressure channel appears in the Px waveform field and the Sys/Dia (Mean) pressure values are shown in the related parameter window.
12. Mark this task as complete on the checkout form.

3.4.5 Temperature tests

Perform the following test step both to the T1 and to the T2 temperature channels.

NOTE: The 'x' in the Tx refers to the temperature channel being tested

13. Temperature test
    a. Check that reading in the Tx temperature channel is 37 ± 0.1 °C and that no error messages are shown.

NOTE: Recalibration is needed, if the measured value is not within the specification limits. Calibrate the temperature channels according to the instructions in 4.2. Temperature calibration" section.

NOTE: You can alternatively perform the above test using a "temperature test set", P/N 884515-HEL. Test each temperature channel with both test plugs. The reading in the Tx temperature channel shall be within ± 0.1°C of the nominal value.

    b. Mark this task as complete on the checkout form.

3.4.6 SpO2 tests

14. SpO2 test
    a. Connect the SpO2 finger probe to your finger. Wait until a pulse is found.

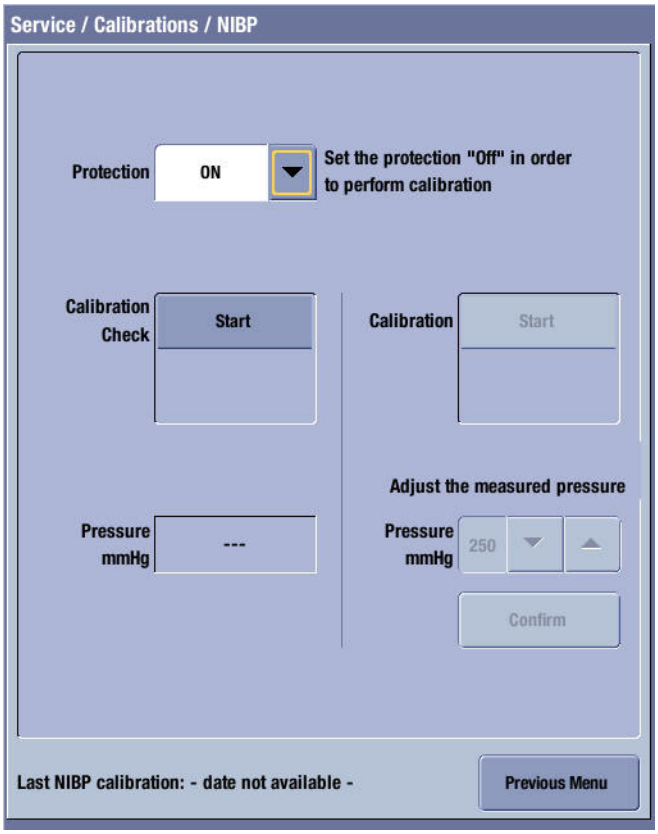
b. Check that the SpO2 reading in the parameter window is between 90-100 and the plethysmographic waveform appears on the screen.

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.

c. Mark this task as complete on the checkout form.

3.4.7 NIBP tests

15. NIBP Leak Test
    a. Check the NIBP tubing system for leakages.
    b. Select ***Monitor Setup > Service Calibrations***.
    c. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
    d. Select ***NIBP***.
    e. Select ***Start*** to start the "Calibration Check". This will close the safety and pulse valves.



f. Pump a 250 mmHg (100-300 mmHg) static pressure with the pressure pump when a message 'Apply 250 mmHg pressure and check the value' is shown. The pressure measured by the module is updated in real-time to the calibration menu. Wait for a while until the pressure stabilizes. Check that the pressure does not drop more than 6 mmHg per one minute.

16. NIBP calibration
    a. Calibrate the Non-invasive blood pressure (NIBP) channel according to the instructions in 4.3. NIBP calibration" section.

17. NIBP hose detection
    a. Disconnect the calibration setup
    b. Attach an infant NIBP cuff hose without cuff identification to the module and check that the module identifies the hose by showing a 'Select inflation limits' message in the NIBP field.
    c. Press the **Start/Cancel** module key in the module to start a NIBP measurement. The monitor shall automatically open the ***NIBP Setup Menu*** and ask the user to manually select the inflation limits.
18. Mark this task as complete on the checkout form.

3.4.8 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

19. Complete on the "Maintenance check form" on page 2-79.

4 Calibration and adjustments

4.1 Invasive pressure calibration

Invasive pressure calibration shall be performed:

- whenever the pressure transducer in use is replaced with a new type of transducer
- if the invasive pressure calibration check in section "3.4.4" failed.
- if the measured value is not within the specification limits.

4.1.1 Setup

Required tools

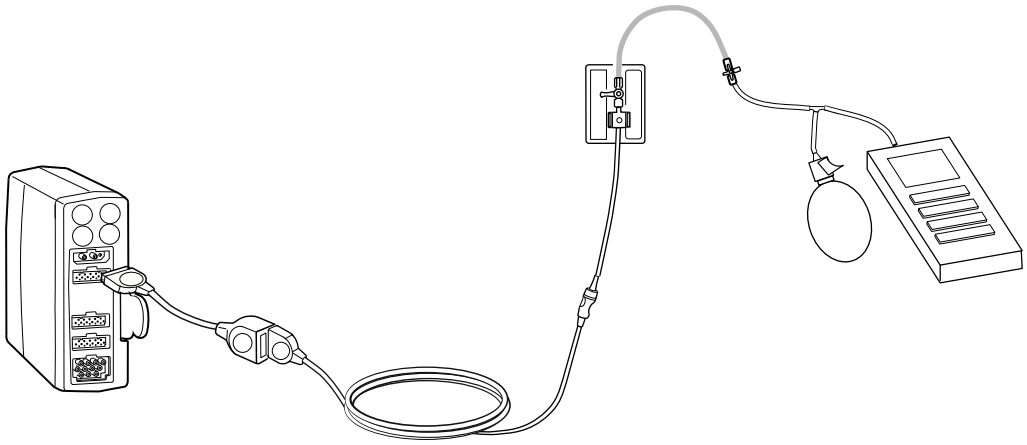
– a pressure manometer with a pressure pump
– a transducer adapter cable
– an invasive pressure transducer

NOTE: See the CARESCAPE monitor supplemental information manual delivered with the manual for compatible accessories.

NOTE: Pressure transducer is a key component in the measurement setup. If possible, perform the invasive pressure calibration with the same type of pressure transducer that is used in daily clinical use.

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

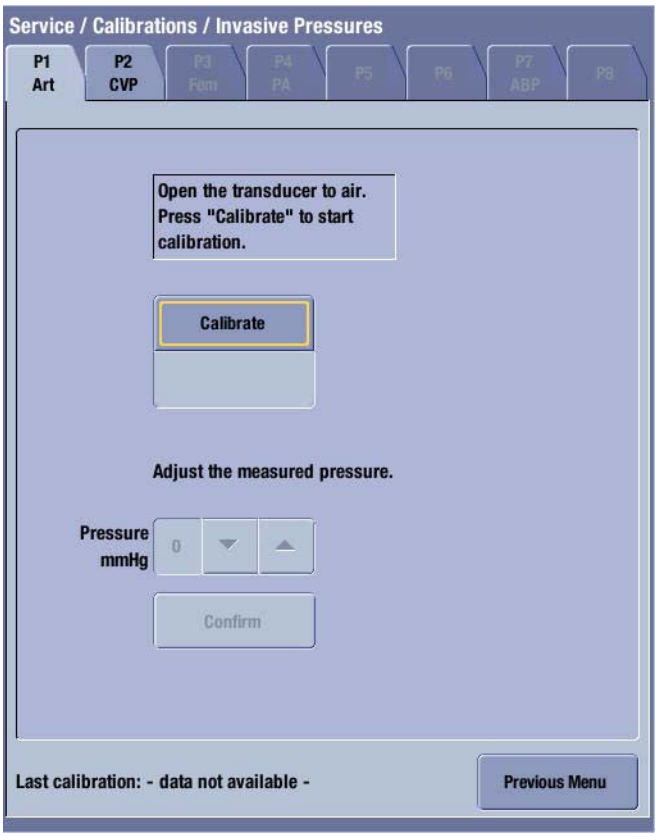
Connections



- Ensure that the module is connected to the monitor.
- Connect the transducer adapter cable to the red Inv BP connector in the module.
- Connect the invasive pressure transducer to the transducer adapter cable.
- Connect the pressure manometer with a pressure pump to the transducer's pressure line with a piece of tubing.

4.1.2 Procedure

1. Select **Monitor Setup > *Service Calibrations***.
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Invasive Pressures***.
4. Select the tab of the invasive pressure channel, P1 or P2, you want to calibrate.



5. Prepare the transducer for the zeroing by opening the dome stopcock to room air.
6. Select ***Calibrate***.
7. The monitor will start automatic zeroing of the invasive pressure channel. Wait until the message '*Zeroing*' is replaced by a message '*Zero Ok*'.
8. Pump a 200 mmHg ± 100 mmHg static pressure with the pressure pump when a message '*Create 200 mmHg pressure*' is shown. The pressure measured by the module is updated in real-time to the calibration menu.
9. When the pressure is stabilized, check the pressure reading from the manometer.
10. Use the up-down spinner control in the calibration menu to adjust the reading measured by the module to match with the manometer reading. Select ***Confirm*** to complete the calibration when the 2 readings match each other.
11. Wait until a message '*calibrated*' is shown.

Repeat the above procedure, steps 4 through 11, for the other invasive pressure channel in the module.

NOTE: 'Zero Failure' message is shown if the zeroing fails.

NOTE: 'Calibration Error' message is shown, if you do not start inflating the pressure within 45 seconds after the automatic zeroing is completed, or if the calibration fails.

4.2 Temperature calibration

Temperature calibration shall be performed:

- if the temperature calibration check in section "3.4.5" failed.
- if the measured value is not within the specification limits.

4.2.1 Setup

Required tools

– P/N 884515-HEL Temperature calibration plugs

– Dual temperature adapter cable

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

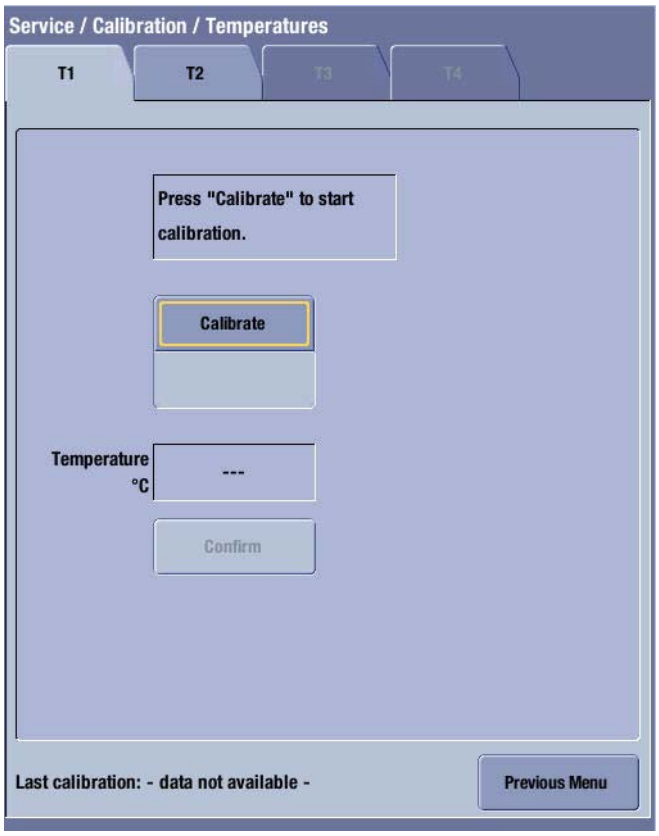
NOTE: See the CARESCAPE monitor supplemental information manual for compatible accessories.

Connections

- Ensure that the module is connected to the monitor.
- Connect the dual temperature adapter cable to the brown temperature connector in the module.
- Check that the dual temperature adapter cable is configured for 400 series probes.

4.2.2 Procedure

1. Select **Monitor Setup > *Service Calibrations***.
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Temperatures***.
4. Select tab for the temperature channel, T1 or T2, you want to calibrate.



5. Select ***Calibrate*** to start the calibration procedure.
6. Wait until '*Plug in 25 °C*' message is shown. Plug in the temperature calibration plug labelled with TEMP 25°C/77°F to the dual temperature adapter cable connector T1 (=temperature channel T1) or T2 (=temperature channel T2).
7. Wait until the value is shown in the Temperature °C field and select ***Confirm***.
8. Wait until a message 'Plug in 45 °C' is shown. Plug in the temperature calibration plug labelled with TEMP 45°C/113°F to the dual temperature adapter cable connector T1 (=temperature channel T1) or T2 (=temperature channel T2).
9. Wait until the value is shown in the Temperature °C field and select ***Confirm***.
10. Wait until '*calibrated*" message is shown.

Repeat the above procedure, steps 3 through 10, for the other temperature channel in the module.

NOTE: If calibration is not preceded within 30 seconds, the calibration is stopped automatically.

4.3 NIBP calibration

NIBP calibration shall be performed:

- each time planned maintenance is performed.
- each time corrective maintenance is performed.
- if the measured value is not within the specification limits.

4.3.1 Setup

Required tools

– A pressure manometer with either an integrated or a separate pressure pump
– Adult NIBP hose (with cuff id)
– Adult NIBP cuff
– a rigid cylinder or pipe
– Tubing parts to connect a manometer and a pump to the NIPB cuff and hose

NOTE: See the CARESCAPE monitor supplemental information manual for compatible accessories.

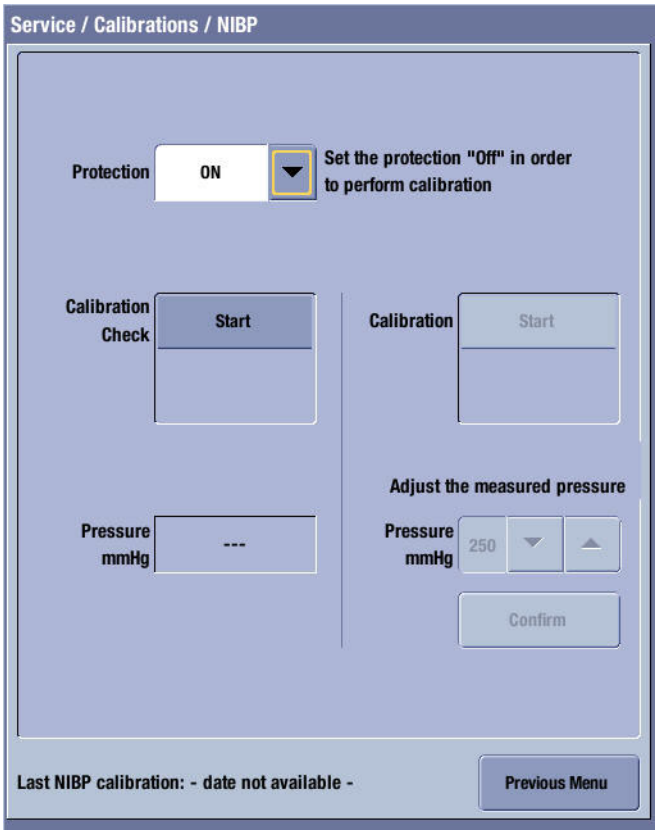
NOTE: Use only accurate, properly maintained, calibrated and traceable calibration tools for the parameter calibration to ensure measurement accuracy.

Connections

- Ensure that the NIBP measurement module is connected to the monitor.
- Connect an adult NIBP hose to the black NIBP module connector.
- Connect an adult NIBP cuff to the adult NIBP hose.
- Wrap the NIBP cuff around a rigid cylinder or pipe.
- Connect the pressure manometer with either an integrated or separate pressure pump to the NIBP hose and NIBP cuff with a piece of tubing (see picture below)
- Ensure that all the connections made are leak-proof.

4.3.2 Procedure

1. Select **Monitor Setup >** ***Service Calibrations***.
2. Enter the User Name and the Password and press Enter to get into the Calibrations menu.
3. Select ***NIBP***.



4. Set the NIBP calibration protection "Off" to enable NIBP calibration:
   - Press the module buttons **Auto On/Off** and **Start Cancel** simultaneously for 3 seconds to activate the Protection drop-down menu.
   - Select Protection "Off".
5. Select ***Start*** to start Calibration. NIBP calibration sequence starts with automatic zeroing. Wait until the message 'Zeroing' is replaced by a message 'Zero Ok'.
6. Pump a 250 mmHg (100-300 mmHg) static pressure with the pressure pump when a message 'Create 250 mmHg pressure' is shown. The pressure measured by the module is updated in real-time to the calibration menu.
7. When the pressure is stabilized, check the pressure reading from the manometer.
8. Use the up-down spinner control in the calibration menu to adjust the reading measured by the module to match with the manometer reading.
9. Select ***Confirm*** to complete the calibration when the 2 readings match each other.

NOTE: Use the up-down spinner controls even if the reading measured by the module matches the manometer reading and adjustment is not required. For example, change the value one step higher and then one step lower. This is done to ensure that the NIBP zero offset drift is cleared.

10. Wait until a message 'calibrated' is shown.
11. Set the NIBP calibration protection back on:
    a. Select Protection "On"

b. Press the module buttons **Auto On/Off** and **Start Cancel** simultaneously for 3 seconds to inactivate the Protection drop-down menu.

NOTE: Calibration protection is set automatically "On" after 30 seconds of inactivity, after the NIBP calibration menu is closed, and after zeroing or calibration failure. Set the calibration protection "Off" to restart the calibration.

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

NOTE: The NIBP calibration protection selection must be inactivated with the module buttons Auto On/Off and Start Cancel before NIBP measurement is re-enabled.

NOTE: A message 'Calibration Error' is shown, if you do not start inflating the pressure within 45 seconds after the automatic zeroing is completed, or if the calibration fails.

NOTE: You can use the calibration check function to verify the calibration after the calibration is completed.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

NOTE: Perform the checkout procedure described in section 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

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

- the front cover and the front panel sticker are intact
- all connectors are intact, clean, and attached properly
- the module box and latch are intact

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

- screws are tightened properly
- NIBP tubing is attached properly
- cables are connected properly
- there are no loose objects inside the module

5.2 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 is 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.
- Connect the accessories with a simulator to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (***Monitor Setup > Screen Setup > Upper Parameter Area***).
- Press a module key. Check that the related menu is opened or activity is started. Inoperatibility may refer to a loose keypad cable or other problem in the module.

- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.
- If only part of the parameters are working, ensure the STP/TP/ST setting is correct.
- 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.

5.3 Service Interface

Use the Webmin service interface to access configuration information, device information and service logs.

5.3.1 Configuration Information

The Configuration Information module shows the current service configuration of the system and the modules. Disconnect all other modules from the monitor, except the E-PRESTN, E-PRETN, E-RESTN, E-PSMP or E-PSM module.

To view configuration information:

1. Log on to the Webmin application.
2. Select the ***Information*** tab.
3. Select ***Config Information.***
4. Check that the STP/TP/ST setting for the module is correct.

5.3.2 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information*** tab.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.3 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the E-PRESTN, E-PRETN, E-RESTN, E-PSMP and E-PSM module.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs.

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin:

1. Log on to the Webmin application.
2. Select the ***Diagnostics*** tab.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media:

1. Log on to the Webmin application.
2. Select the ***Diagnostics*** tab.
3. Select ***Download Logs.***
4. Select one of the log files for downloading.

NOTE: Depending on the CARESCAPE Monitor type, the log file downloading may be enabled only through remote Webmin access with a service laptop.

5.4 Messages

5.4.1 ECG

The messages below appear in the ECG parameter window (PW), ECG waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Remove one ECG module	MF	More than one ECG measurement module is connected to the monitor at the same time.	Ensure that only one ECG measurement module is connected to the monitor at a time. Disconnect additional ECG measurement modules from the monitor.
ECG module error	MF	ECG module recognizes an internal communication problem.	Disconnect and reconnect the module. Replace the ECG measurement module, if repeated.
ECG measurements removed	MF	ECG measurement module is disconnected.	Reconnect the ECG measurement module.
Faulty ECG cable	MF, WF	The ECG cable is defective. The cable may be electrically damaged, or the connectors are wet.	Change the ECG cable and the lead set. Change the ECG module if the module connector is wet. Keep the connectors dry. Avoid excessive use of liquids when cleaning the cables and connectors.

Message	Location	Possible causes	Possible solutions
Artifact	WF	Motion artifact. Unreliable HR calculation or distorted waveform, possibly during defibrillation or because of motion artifacts.	Check the patient status. Check the electrodes. Ensure that the patient is not shivering. Incorrect ECG filter. Poor electrode quality or positioning. Check the electrodes and cables and their placement. Change the lead. Remove the ECG cable from the connector and reinsert it.
Noise Noisy ECG	WF MF	High frequency noise. Unreliable HR calculation or distorted waveform, possibly during defibrillation or because of motion artifacts.	See above.
XX/YY lead off. NOTE: XX/YY refers to IEC/AAMI color and letter coding for electrodes.	MF, WF	One or more lead wires or electrodes are disconnected. Other ECG leads are available for arrhythmia detection.	Check lead wire and electrode connections.
Leads off	MF, WF	One or more lead wires or electrodes are disconnected. There are no ECG leads available for arrhythmia detection.	Check lead wire and electrode connections.

5.4.2 Impedance respiration

The messages below appear in the Resp parameter window (PW), ImpResp waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Measurement off	WF, PW	ECG cable is disconnected. Module is disconnected. Impedance respiration PW or WF is not configured on the screen. One or more leads required for impedance measurement are disconnected. Impedance Respiration Measurement is “Off”.	Connect the ECG cable. Connect the module. Configure either the ImpResp waveform or Resp parameter window on the monitor screen. Connect any disconnected lead wires and/or electrodes. Set Impedance Respiration Measurement “On” from the Setup tab in the Impedance respiration menu.
RA/R lead off LA/L lead off LL/F lead off	WF, PW	One of the following lead wires or electrodes is disconnected: RA, LA, or LL.	Check lead wire and electrode connections.
Small resp curve	PW	Signal amplitude < 0,4 Ohm	Check lead wire and electrode connections.
Apnea deactivated	PW	Apnea alarm start-up conditions are not reached.	Apnea alarm detection is activated after the 5 breaths are detected.

5.4.3 Invasive Pressure

The messages below appear in the InvBP parameter window (PW), InvBP waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
No Px transducer NOTE: The 'x' in Px refers to the InvBP channel number.	MF	Pressure transducer and/or transducer adapter cable is/are disconnected from the module.	Connect pressure transducer and/or transducer adapter cable to the module.
Not zeroed IPs not zeroed	PW, WF MF	There is at least one invasive pressure channel, which is not zeroed.	Zero all invasive pressure channels.
Px over range >320mmHg' or '>43 kPa NOTE: The 'x' in Px refers to the InvBP channel number.	MF PW	Measured pressure exceeds 320 mmHg / 43 kPa upper specification limit. Transducer is not zeroed correctly.	The measurement range is between -40 mmHg and 320 mmHg. Zero the invasive pressure channel x.

Message	Location	Possible causes	Possible solutions
Px under range <-40 mmHg' or '<-5 kPa NOTE: The 'x' in Px refers to the InvBP channel number.	MF PW	Measured pressure is under -40 mmHg /-5 kPa lower specification limit. Transducer is not zeroed correctly.	The measurement range is between -40 mmHg and 320 mmHg. Zero the invasive pressure channel.
Identical IP1 modules Identical IP2 modules	MF	Identical IP modules. The monitor detects the same IP channel from two or more modules.	Remove one of the modules providing identical IP channel.
Calibrating	PW	Calibration of an invasive pressure channel is in progress.	Wait until calibration is completed successfully.
Calibration failed	PW	Pressure calibration failure due to time-out. Pulsating waveform detected during calibration. Gain is beyond the limits (± 20% of the default gain)-	Re-calibrate. Start inflating the pressure within 45 seconds after the automatic zeroing is completed. Check the manometer reading to ensure that a static 100-300 mmHg pressure is present for calibration. Replace the transducer and re-calibrate.
Calibrated	PW	Calibration of an invasive pressure channel is completed successfully.	No actions.
Zeroing	PW	Zeroing of an invasive pressure channel is in progress.	Wait until zeroing is completed successfully.
Zeroing failed	PW	Pulsating waveform detected. Offset is > 150 mmHg. Defective transducer.	Open the transducer to air and zero the channel. Replace the transducer, open it to air and zero the channel.
Zero adj > 100 mmHg	PW	Offset when zeroing is > 100 mmHg (but <150 mmHg) from the absolute zero of the module (with default gain).	Check transducer. Re-zero the pressure channel.
Zeroed	PW	Zeroing of an invasive pressure channel is completed successfully.	No actions.
Zero ICP separately	MF	ICP is an active IP channel and Zero All is performed.	Zero the ICP channel separately.
Pressure measurement removed	MF	Measurement module has been removed.	Reconnect the module if you want to restart the measurement.

5.4.4 Temperature

The messages below appear in the Temperature parameter window (PW) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Identical temperature module	MF	Identical temperature modules. The module detects the same temperature channel from two or more modules.	Remove one of the modules providing identical temperature channel.
Tx temperature error Temperature error [x] refers to the temperature channel number.	MF PW	Calibration failure. Hardware failure.	Perform calibration. Replace STP board.
Performing temp test	PW	Automatic self-check is in progress.	Wait until temperature self-check is completed. Check that no error messages appear to the screen.
Temperature measurement removed	MF	The module is disconnected.	Reconnect the module.

5.4.5 SpO2

The messages below appear in the SpO2 parameter window (PW), Pleth waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Probe off SpO2 probe off	PW MF	SpO2 probe is not connected to the patient.	Connect the SpO2 probe to the patient.
No probe No SpO2 probe	PW MF	SpO2 probe is not connected to the module.	Connect the SpO2 probe to the module.
Check probe Check SpO2 probe	PW MF	Red and infrared signals are not in balance.	Check the SpO2 probe and replace it, if needed.
Faulty probe Faulty SpO2 probe	PW MF	Probe is identified, but red and infrared leds take no current.	Replace the SpO2 probe.
Incompatible probe	PW	Incompatible SpO2 probe is detected by the monitor.	Replace the SpO2 probe with a compatible one.
Pulse search	PW	Searching pulse.	Wait until pulse is found.
Low perfusion	PW	Low perfusion at the measurement point.	Try another measurement site.
Check device	PW	Module malfunction.	Check the module operation. Repair, if needed.
SpO2 measurement removed	MF	SpO2 module is disconnected form the module slot.	Reconnect the SpO2 module to the module slot.

5.4.6 NIBP

The messages below appear in the NIBP parameter window (PW) or the message field (MF).

Message	Location	Possible causes	Possible solutions
NIBP measurement removed	MF	The module is disconnected.	Reconnect the module.
NIBP cuff occlusion Cuff occlusion	PW PW	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.
NIBP cuff loose Cuff loose	MF PW	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.

Message	Location	Possible causes	Possible solutions
NIBP air leakage Air leakage	MF PW	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).
Check NIBP	MF	Systolic and/or diastolic result is missing at the end of the entire measurement. (E/M-PRESTN and E-PSM: Maximum number of repeated inflations during a measurement is not displayed if there is one of the following alarms: cuff loose, cuff occlusion or air leakage.)	
Select inflation limits	PW, MF	NIBP: Cuff does not have an automatically detectable cuff ID.	Select an inflation limit from the NIBP setup menu.
Artifacts	PW	Artifacts normally visible for the user, either from the patient itself or from the other parameter signals like ECG, Pleth. Unsuccessful NIBP due to: movements shivering deep breathing marked arrhythmia or irregular beats.	Non-technical. No need for any measures, except to calm down the patient.

Message	Location	Possible causes	Possible solutions
Weak pulsation	PW	All invisible reasons, weak oscillation, or poor performance like algorithm etc. technically related reasons. Weak or unstable oscillation signal due to: improper cuff position or attachment weak or abnormal blood circulation slow heart rate associated with artifacts problems with measurement of diastolic pressure small air leakage insufficient data due to artifacts.	Requires immediate correction i.e. changed cuff position etc.
Cuff overpressure	PW	Cuff squeezed during measurement and exceeding pressure safety limits.	Check cuff and tubes. Restart the measurement.
Unable to measure Sys	PW	Systolic pressure probably higher than maximum inflation pressure or artifacts in systolic area.	Automatic retrial with increased pressure.
Unable to measure Dia Unable to meas.	PW	Inflation pressure incorrect or artifact preventing measurement. Message indicates failed measurement (***Sys***, ***Dia***).	Non-Technical. Check the patient status and cuff placement. Perform a new measurement
Unstable zero pressure	PW	NIBP: Unstable zero pressure when cuff inflated.	Retry the measurement. If the problem persists, check the internal tubing and recalibrate NIBP.
Incorrect infl. limits	PW	Adult or child cuff is used, but the selected infant mode restricts the inflation pressure too low to be able to measure the blood pressure.	Adjust NIBP setup.
Long measurement time	PW	Measurement time over 2 min (adult and child mode) and 1 min 15 s – 1 min 20 s (infant mode).	New NIBP measurement is started automatically.
Control measurement	PW	Pressure alarm limit has been violated. New measurement is performed automatically to check the blood pressure.	New NIBP measurement is started automatically.

Message	Location	Possible causes	Possible solutions
Call Service: Error x	PW	NIBP hardware error. Contact authorized service personnel. x = error number 1 - 99. x = 0: RAM failure x = 1: ROM checksum failure x = 2: +15V failure x = 3: -15V failure x = 6: ADC error x = 7: Watchdog time too short x = 8: Watchdog time too long x = 9: Watchdog activated x = 10 EEPROM checksum error x = 11 Autozero range exceeded x = 12 Communication watchdog activated x = 13 Not in use x = 14 Too early autocycle start	Message stays on screen until the problem is fixed. Replace module and contact authorized service personnel.
Zero ok	PW	Zeroing of the NIBP modules pressure sensor has completed successfully.	No actions.
Calibrated	PW	NIBP calibration has completed successfully.	No actions.
Zero error	PW	Zeroing of the modules pressure sensors has failed.	Restart the measurement. If problem persists, recalibrate NIBP.
Calibration error	PW	NIBP calibration failed.	Recalibrate NIBP.
Zeroing	PW	Module is zeroing the pressure sensors.	Wait until zeroing is completed.
Calibrating	PW	Calibration process is ongoing.	See section 4.3. NIBP calibration.
Calibration switch ON	PW	The ***Protection*** drop-down menu in the ***NIBP Calibration*** menu has been left active after the NIBP calibration was completed. Note: NIBP measurement is disabled until the ***Protection*** drop-down menu is disabled	Press the module buttons **Auto On/Off** and **Start Cancel** simultaneously for 3 seconds to inactivate the ***Protection*** drop-down menu and to enable normal NIBP measurement. See NIBP calibration for more details

5.5 Troubleshooting chart

5.5.1 Invasive Pressure

Problem	Possible causes	Possible solutions
Abnormally low pressure.	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure.	Defective transducer. Module not connected. Transducer adapter cable not connected to the module. Invasive pressure channel not configured to the screen (with adequate priority).	Check or replace transducer. Connect module. Connect the transducer adapter cable with the transducer to the module. Configure the invasive pressure channel to the screen (***Monitor Setup/Screen Setup***) with adequate priority and check that it is active.

5.5.2 Temperature

Problem	Possible causes	Possible solutions
No temperature displayed.	Temperature channel not configured to the screen (with adequate priority). Incompatible temperature probe. STP/TP/ST setting incorrect. Faulty temperature probe. Temperature out of measurable range.	Configure the temperature channel to the screen (***Monitor Setup/Screen Setup***) with adequate priority and check that it is active. Use correct probe (400 series). Check the STP/TP/ST setting and configure, if needed. Replace temperature probe. The measurement range is between 10 and 45 °C.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module is limited to replacing faulty circuit boards and mechanical parts only (see chapter 7. Service parts for details).

WARNING **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. Maintenance and checkout each time after you have opened the module casing.

6.1.1 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.
- Wear a grounded, antistatic wristband or heel strap 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.
- Store the semiconductors and electronic assemblies only in antistatic bags or boxes.
- Handle all PCB assemblies by their edges.
- Do not flex or twist a circuit board.

6.1.2 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.

6.1.3 Required tools

- antistatic wristband
- pincers
- flat blade screwdriver
- torx screwdrivers; T6, T8 and T10

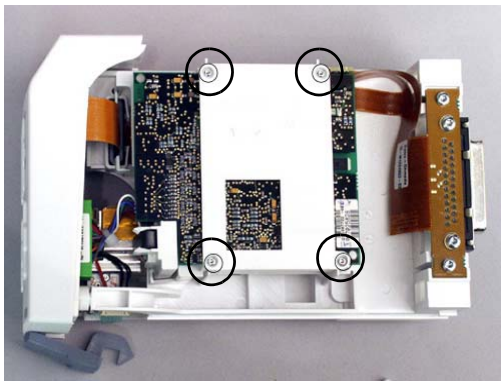
6.2 Disassembling and reassembling procedure, E-PRESTN, E-PRETN, E-RESTN

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 disassembly instructions.

1. Remove the two screws (T10) holding the module cover to the module frame from the back of the module.

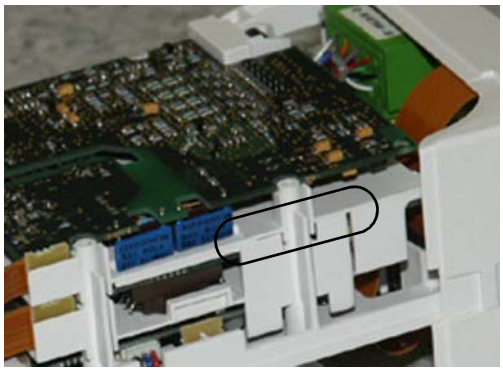
2. While pressing the release latch, pull the module cover slowly backwards and remove it from the main body.

NOTE: When reassembling, be careful not to damage the membrane keyboard flex. Guide the flex inside the frame and the module casing.

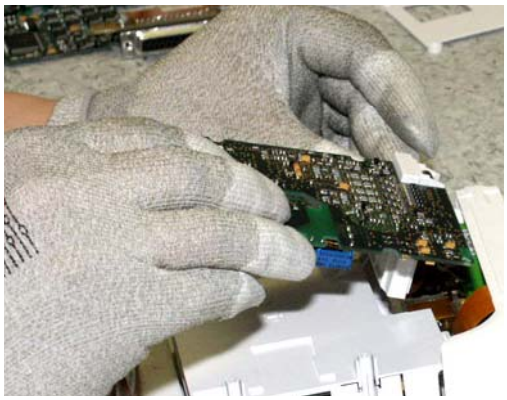


3. Removing the ECG board

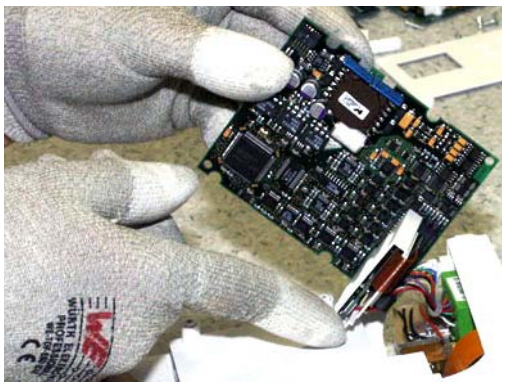
- Remove the four screws (T6) holding the insulator cover and lift the cover up.



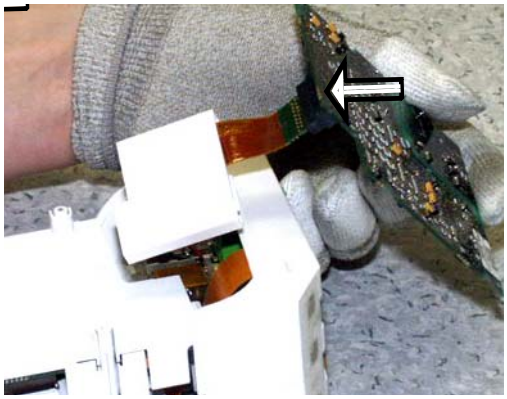
NOTE: When reassembling, push the ECG board a little to ensure that the insulator plates are correctly reassembled. Guide the upper plate inside the lips of the lower plate.



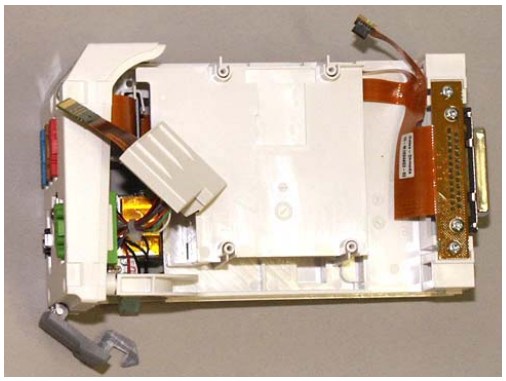
- Lift the ECG board a little and disconnect the module bus connector from the ECG board.
- Carefully lift the board together with the ECG input unit up.



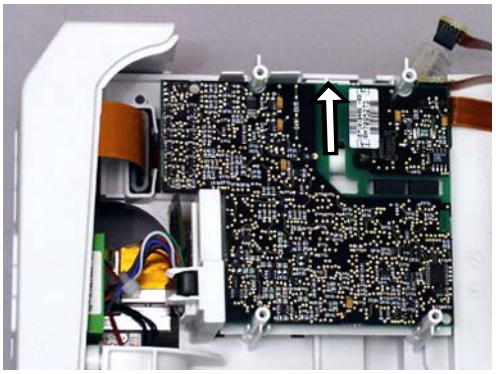
- Turn the ECG board 180 degrees around the input unit.



- Disconnect the ECG input flex connector from the ECG board. Be careful not to damage the flex.



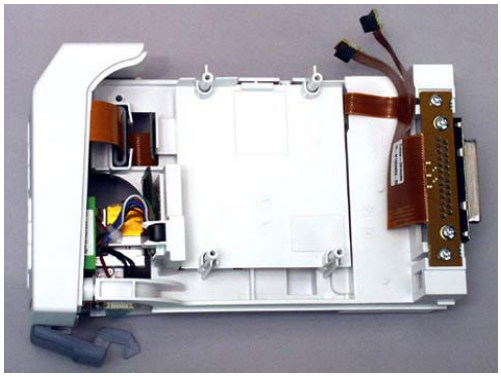
4. Removing the STP board.
- Lift the ECG-STP board insulator plate up.



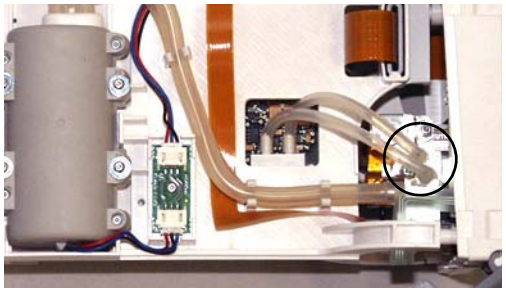
- Disconnect the module bus connector from the STP board.

- 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 care full not to damage the STP input flex. Make sure the STP input flex connector is properly connected.

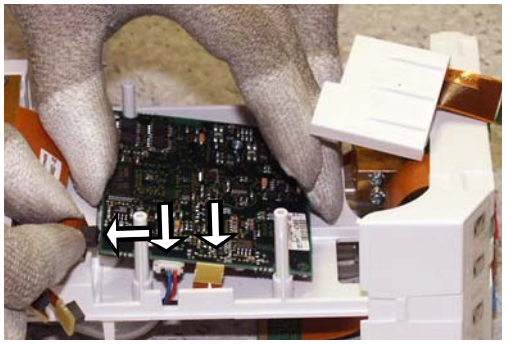


5. Removing the NIBP board:
- Lift the STP-NIBP board insulator plate up.

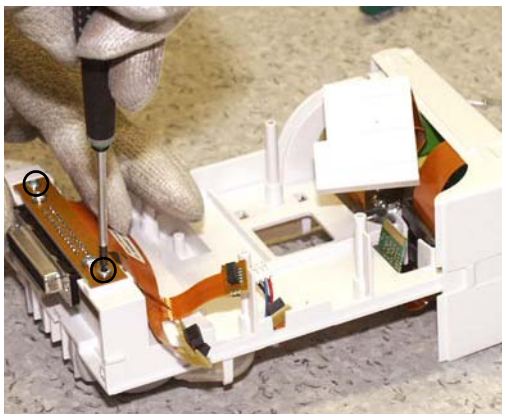


- Flip the module over and disconnect the hoses (2 pcs) coming from the manifold.

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. Removing the module bus connector:
- Remove the two screws (T8) holding the connector to the frame.

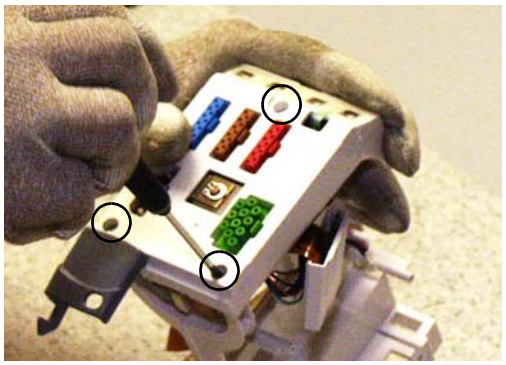
7. Removing the Front Chassis Unit:

- Carefully push/ pull the STP input flex connector through the ferrites to the other side of the frame. The ferrites should stay in place, if not, remember to reassemble them.

- Releasing 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.

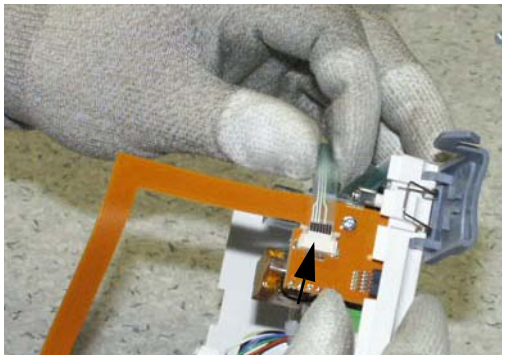
NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

- Pull the NIBP flex board through the frame.



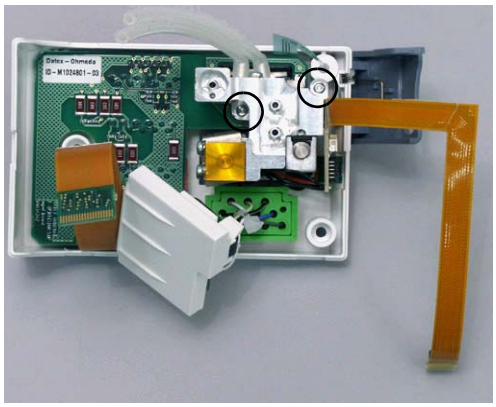
- Remove the three screws (T8) holding the front chassis to the module frame.

- Detach the front chassis unit from the module frame. Be careful not to damage the NIBP flex board.

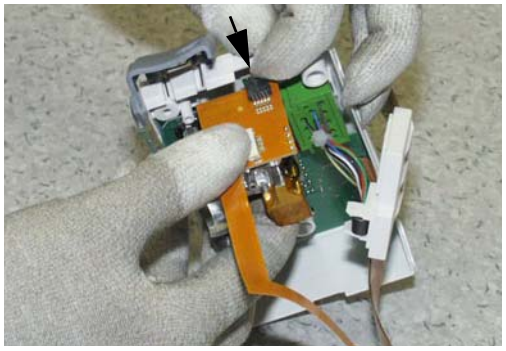


8. Removing the manifold:

- Open the connector lock from the NIBP flex board and disconnect the membrane keyboard flex.

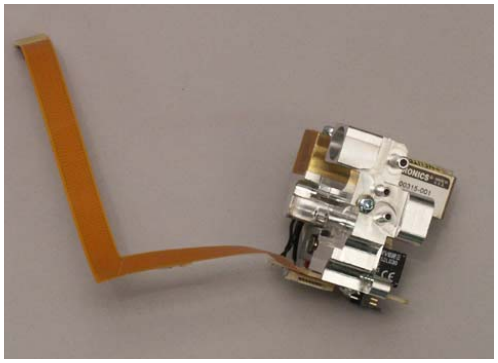


- Remove the two (T6) screws holding the manifold to the Front chassis.



- 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.

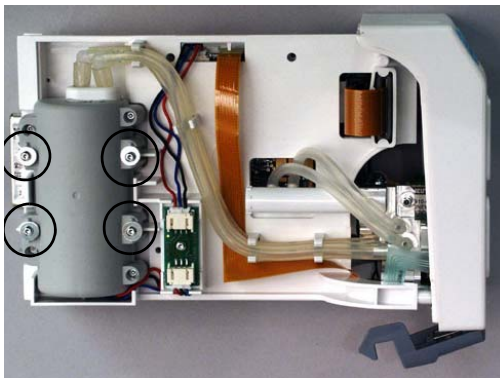


Reassemble the module in reverse order.

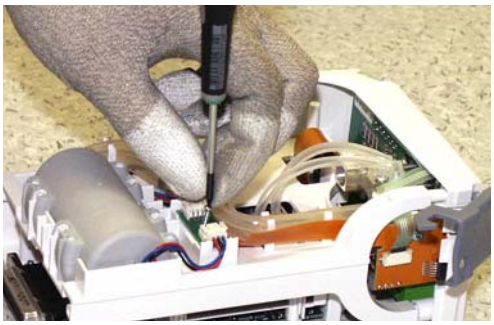
Check that:

- screws are tightened properly
- cables and hoses are connected properly
- there are no loose objects inside the module

6.2.1 Removing the pump unit



1. Follow the disassembly 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 pump unit.

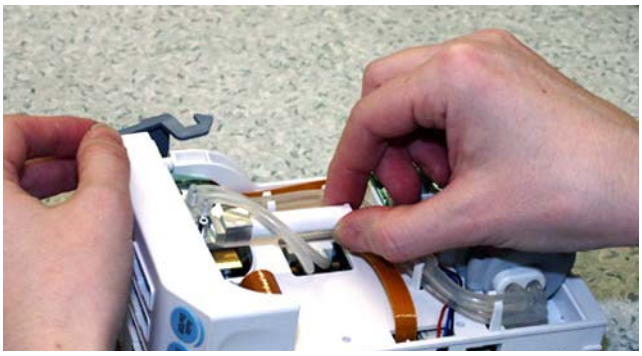
NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

Reassemble the pump unit in reverse order.

Check that:

- screws are tightened properly
- cables and hoses are connected properly
- there are no loose objects inside the module

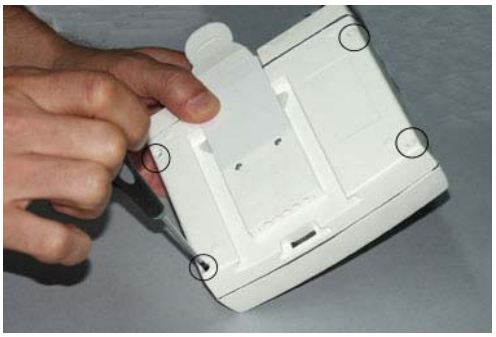
6.2.2 Replacing the NIBP air filter



1. Follow the disassemble instruction steps 1 and 2.
2. Remove the NIBP air filter cover and replace the filter.

Reassemble in reverse order.

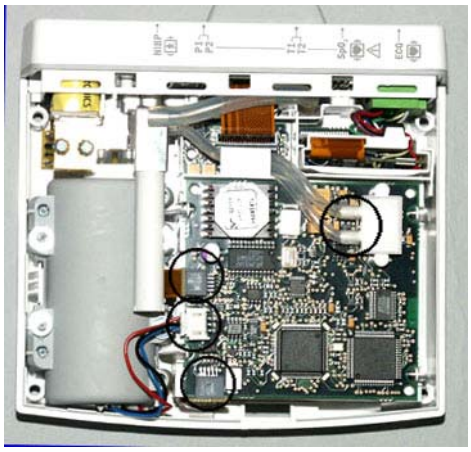
6.3 Disassembling and reassembling procedure, E-PSMP and E-PSM



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.

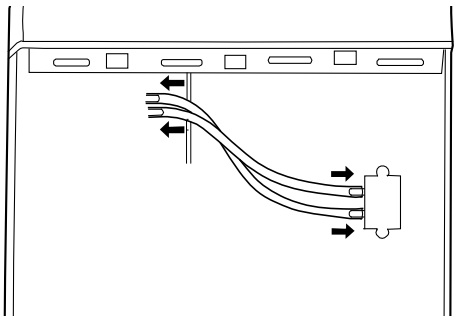
NOTE: Be careful not to damage the seal. When reassembling the seal may stick to the cover.



3. Removing the NIBP board

NOTE: You may remove the NIBP filter cover and the filter before disconnecting the flex cable.

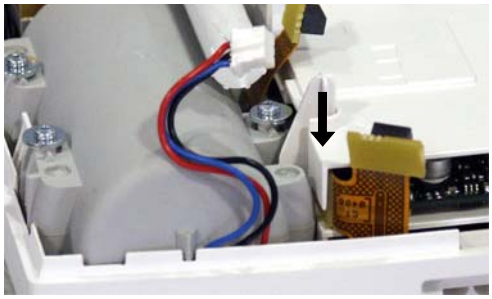
- Disconnect the module bus connector, pump connector and NIBP flex connector.
- Disconnect the hoses (2 pcs) coming from the manifold.



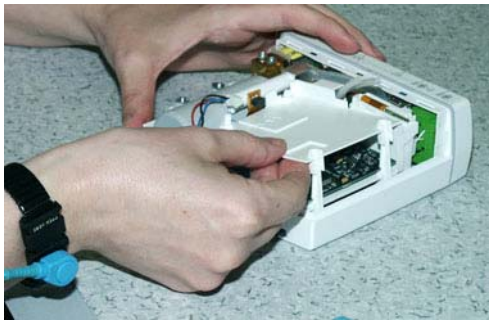
NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

- Remove the NIBP board.

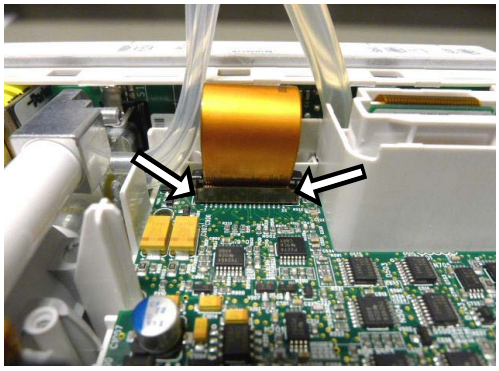
4. Disconnect the air intake hose from the NIBP manifold.



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.



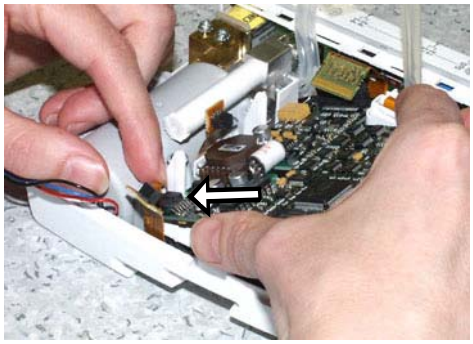
5. Lift the NIBP-STP insulator plate carefully up.



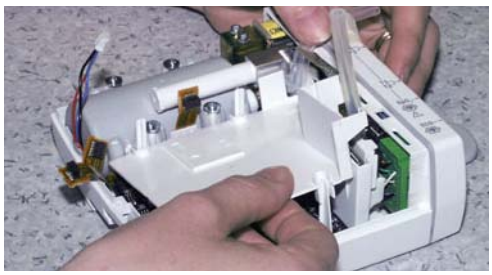
6. To remove the STP board

- Carefully open the connector lock and then disconnect the STP input flex cable from the STP board.

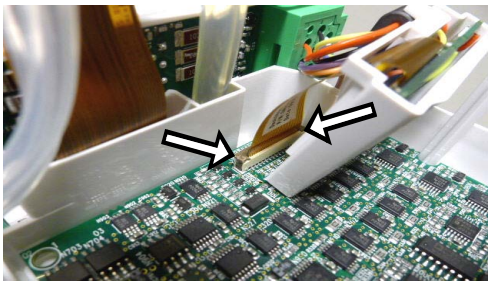
NOTE: When reassembling, ensure that the flex cable is aligned properly and the connector is locked.



- Lift the STP board a little to disconnect the module bus connector. Remove the STP board.

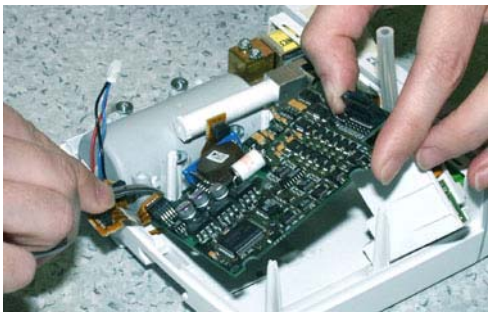


7. Remove the STP-ECG insulator plate. Be careful not to damage the NIBP hoses.



8. Hold down the ECG board. Carefully open the connector lock and then disconnect the ECG input flex cable from the ECG board.

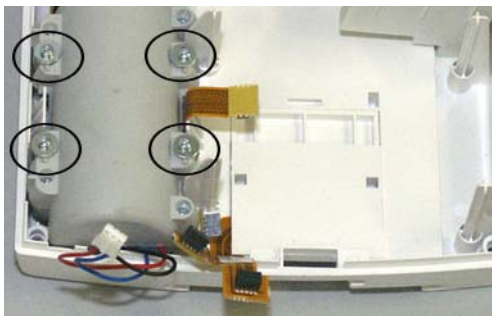
NOTE: When reassembling, ensure that the flex cable is aligned properly and the connector is locked.



9. Removing the ECG board

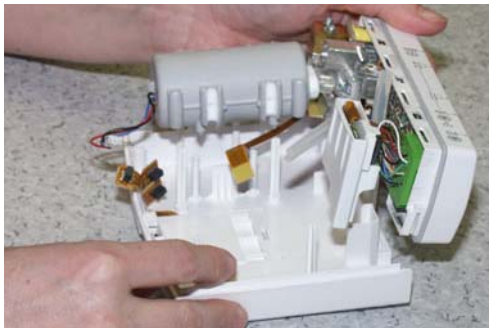
- While holding the ECG input unit out of the way, lift the ECG board a little and disconnect the module bus connector.
- Remove the ECG board.

10. Remove the NIBP air 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 carefully.

Reassemble the module in reverse order.

Check that:

- screws are tightened properly
- cables and hoses are connected properly
- there are no loose objects inside the module

6.3.1 Removing the pump unit

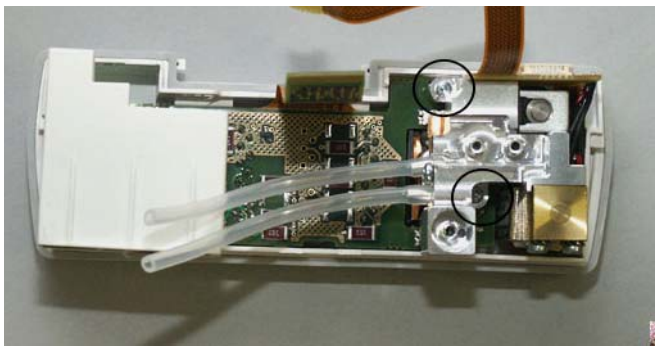
14. Disconnect the hoses from the manifold. The hoses follow the pump.

Reassemble the pump in reverse order.

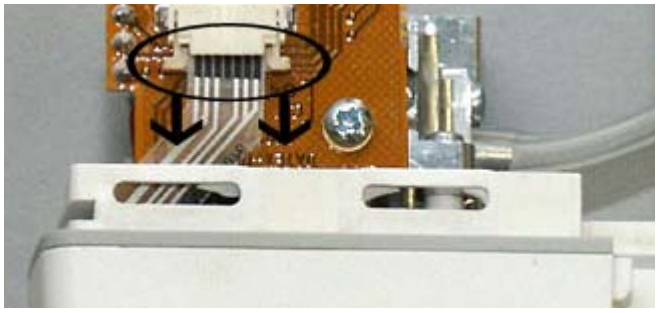
Check that:

- hoses are connected properly

6.3.2 Removing the manifold unit



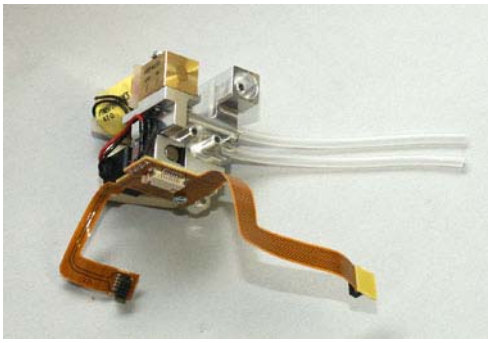
15. Disconnect the two (T6) screws holding the manifold to the front cover unit.



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 manifold unit in reverse order.

Check that:

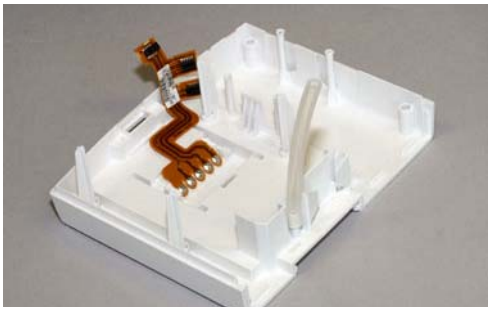
- screws are tightened properly
- cables and hoses are connected properly

- there are no loose objects

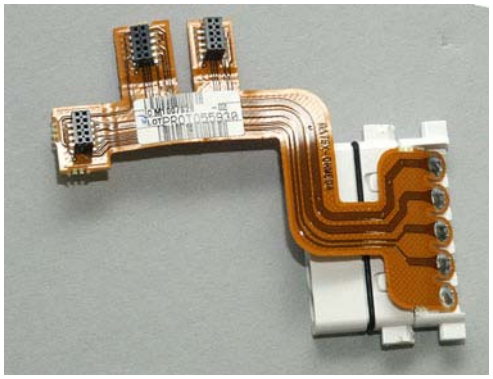
6.3.3 Removing the module bus connector

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.



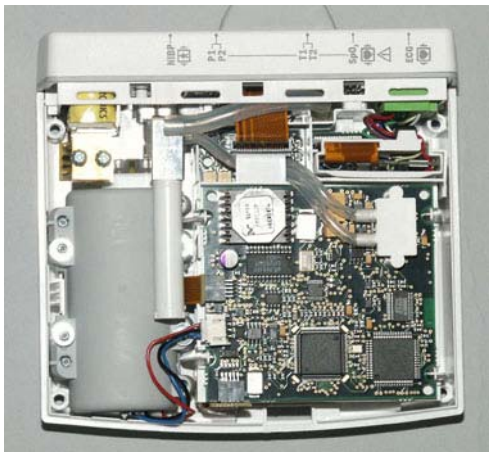
19. Pull the module bus connector carefully through the hole in the frame.



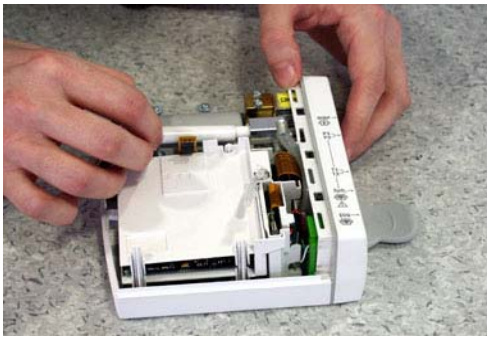
Reassemble the module bus connector in reverse order.
Check that:

- screws are tightened properly
- cables are connected properly
- there are no loose objects

6.3.4 Replacing the NIBP air filter



1. Follow the disassemble instruction steps 1 and 2.



2. Remove the NIBP air filter cover and replace the filter.

Reassemble in reverse order.

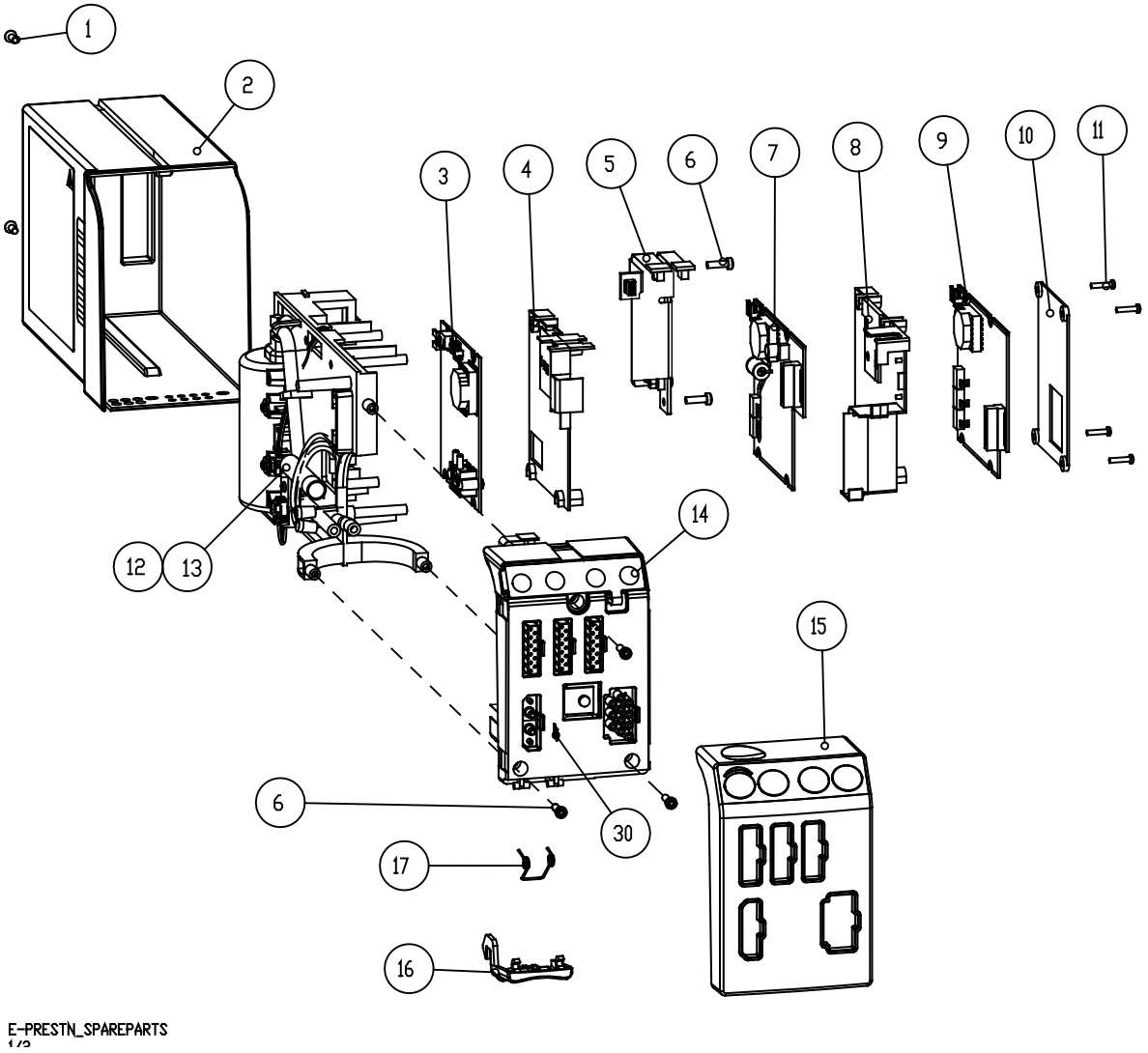
7 Service parts

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

7.1 Ordering parts

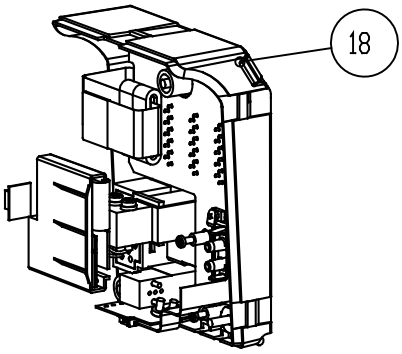
To order parts, contact GE Healthcare. Contact information is available at www.gehealthcare.com. Make sure you have all necessary information at hand.

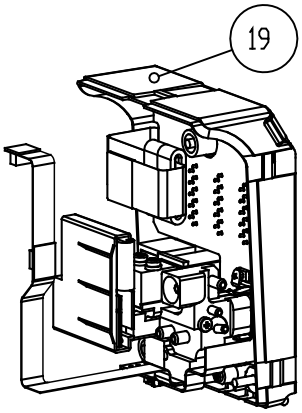
7.2 E-PRESTN, E-PRETN, E-RESTN

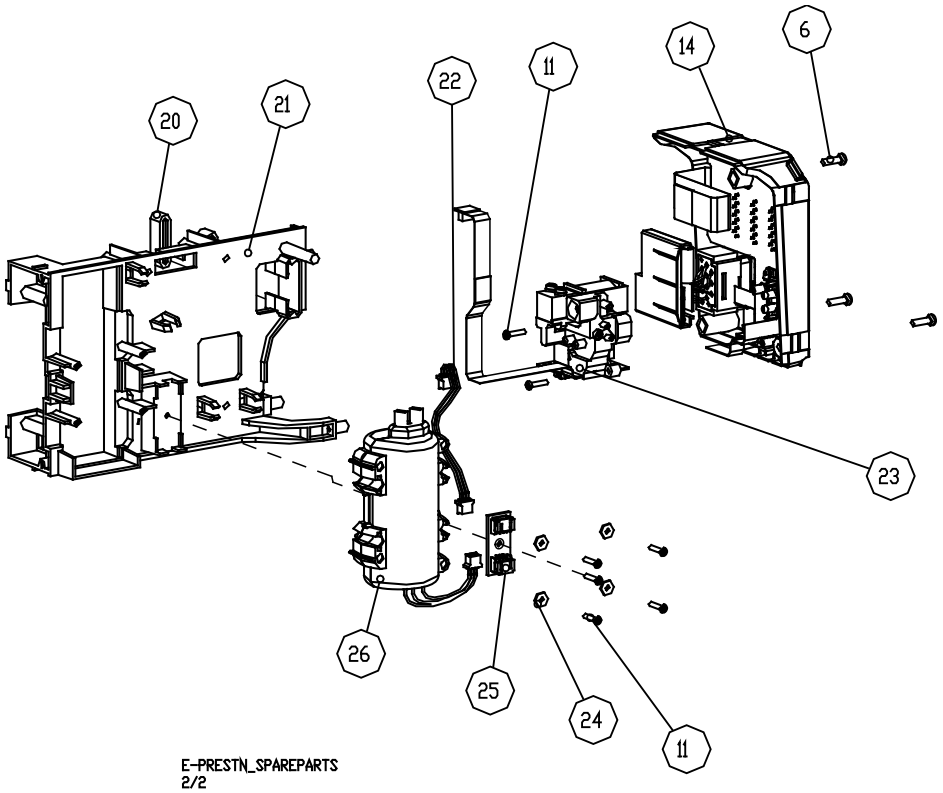


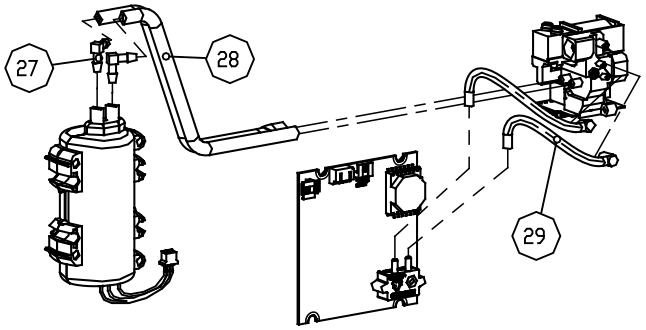
Item	Description	Order No.
1	SCREW, thread forming, M3x8mm, WN1423, torx T10, flat countersunk head, steel	*
2	Module Casing, Double	M1021037
3	NIBP Board PSM	M1007747
4	STP - NIBP insulator	M1008207
5	E-PRESTN Module bus connection board	M1024653
6	SCREW, for plastic PT, 3x10mm, WN1452, pan head, steel, zinc, head Torx 10, head max 5mm	*
7	STP-CO board, PSM	M1018406
8	ECG STP insulator	M1008205
9	ECG Board, PSM	M1007722

Item	Description	Order No.
10	Board Cover, E-(P)RE(S)TN	M1038754
11	SCREW, PT, 2.2mm×10mm, tor× head T6, pan head, steel	*
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	see the list of front covers	
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	*
25	E-PRESTN NIBP pump connection board	M1024369
26	NIBP Pump Unit, E-PSM(P)	M1011858
27	Tube connector, L-piece 3mm, white	73381

28	Tube silicon 3,18x6,35	73375-HEL
29	Angled hose, E-(P)RE(S)TN	M1023083
30	Snap spring	M1036967

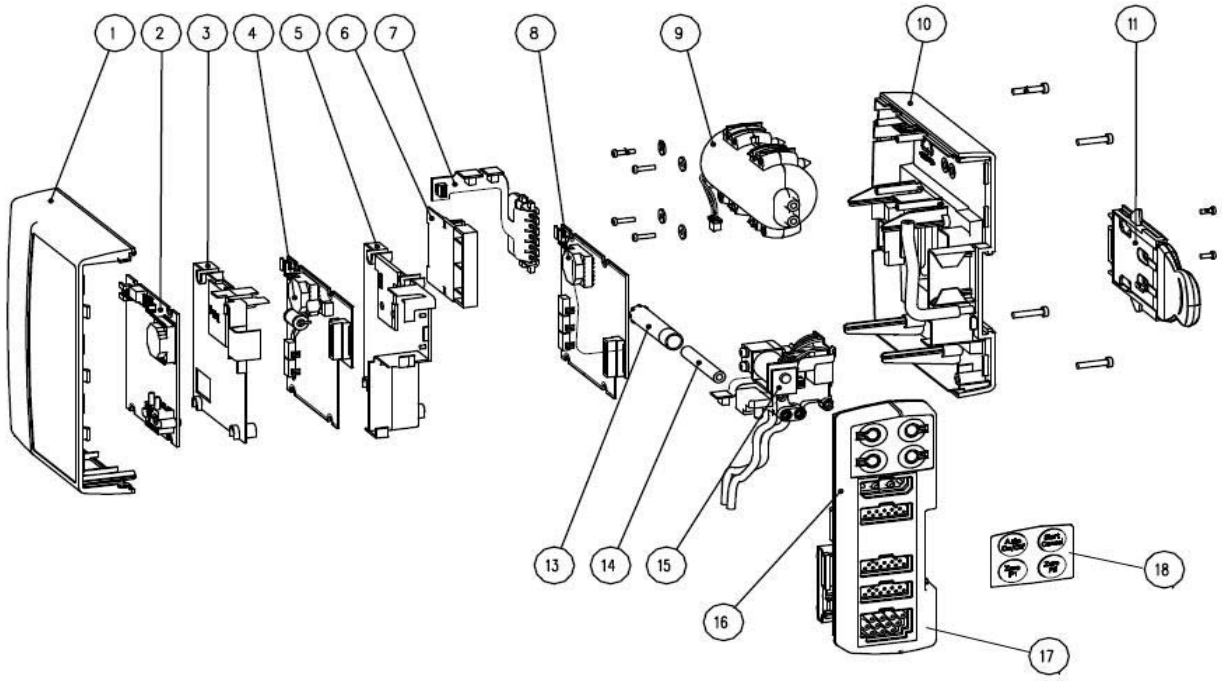
*) Part is not available from GE. Source locally.

7.2.1 Front cover for E-PRESTN, E-PRETN, E-RESTN

Item	Description	Order No.
15	Front Cover, CS, E-PRESTN	M1063515
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, CS, E-PRETN	M1063517
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, CS, E-RESTN	M1063519
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

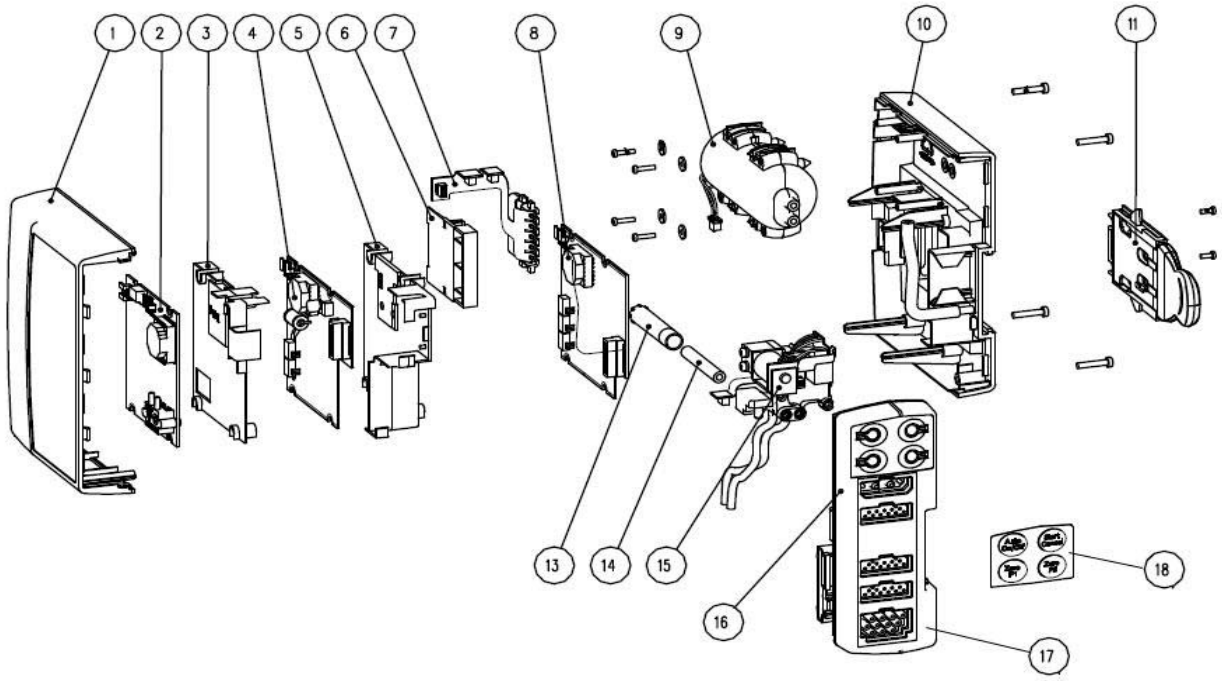
7.3 Patient Side Modules, E-PSM, E-PSMP (Rev. 01)



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	2086477-001
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	2086477-002
E-PSM-01, Front Panel Unit - ES, FRU	16) Front Panel Unit 17) Front Mask - ES 18) Front Panel Stickers: ES	2086477-003
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	2086477-004
E-PSM-01, Front Panel Unit - FR, PT, FRU	16) Front Panel Unit 17) Front Mask - FR, PT 18) Front Panel Stickers: FR, PT	2086477-005
E-PSM-01, Front Panel Unit - HU, FRU	16) Front Panel Unit 17) Front Mask - HU 18) Front Panel Stickers: HU	2086477-004
E-PSMP-01, Front Panel Unit - DE, FRU	16) Front Panel Unit 17) Front Mask - DE 18) Front Panel Stickers: DE	2086478-001
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	2086478-002
E-PSMP-01, Front Panel Unit - ES, FRU	16) Front Panel Unit 17) Front Mask - ES 18) Front Panel Stickers: ES	2086478-003
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	2086478-004
E-PSMP-01, Front Panel Unit - FR, PT, FRU	16) Front Panel Unit 17) Front Mask - FR, PT 18) Front Panel Stickers: FR, PT	2086478-005
E-PSMP-01, Front Panel Unit - HU, FRU	16) Front Panel Unit 17) Front Mask - HU 18) Front Panel Stickers: HU	2086478-004
E-PSMP-01, Front Panel Unit - SV, FRU	16) Front Panel Unit 17) Front Mask - SV 18) Front Panel Stickers: SV	2086478-004

7.4 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

7.4.1 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

Item	Description	Order No.
	Front Panel Sticker, E-PSM - NO	M1023748
	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

7.4.2 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

8 Earlier revisions

Patient Side Modules E-PSM, E-PSMP (Rev. 00)

For your notes:

Maintenance check form

Hemodynamic Modules E-PRESTN, E-RESTN, E-PRETN, E-PSMP, E-PSM

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	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
3.3. Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.4. Functional check				☐ ☐ ☐
3.4.2. ECG tests	☐ ☐ ☐	3.4.3. Impedance respiration tests		☐ ☐ ☐
3.4.4. Invasive pressure tests	☐ ☐ ☐	3.4.5. Temperature tests		☐ ☐ ☐
3.4.6. SpO2 tests	☐ ☐ ☐	3.4.7. NIBP tests		☐ ☐ ☐
3.4.8. Test completion				☐ ☐ ☐

Notes

Used service parts			

Signature	Date

For your notes:

3

Continuous Cardiac Output Module, E-PiCCO

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of single width plug-in Continuous Cardiac Output Module, E-PiCCO.

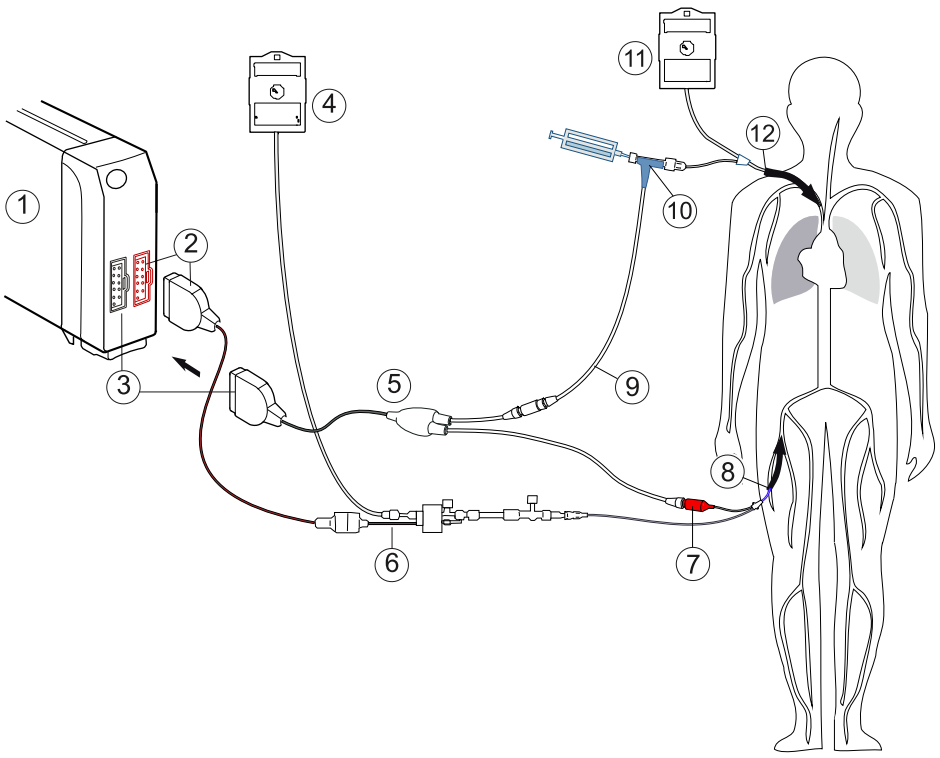


Figure 1 Cardiac output setup with closed injectate delivery system

(1) E-PiCCO module
(2) P8 pressure connector and cable (red)
(3) CCO connector and cable (gray)
(4) Flush (bag of fluids)
(5) PiCCO continuous cardiac output cable
(6) Disposable pressure transducer
(7) Catheter cable connector
(8) Thermodilution catheter (PULSIOcath)
(9) PiCCO injectate sensor cable
(10) Injectate temperature sensor housing
(11) Flush (bag of fluids)
(12) Central venous catheter

NOTE: For a comprehensive list of compatible supplies and accessories, refer to the E-PiCCO user documentation.

Equipment safety symbols

This symbol on the module refers to defibrillator precautions. To ensure protection against the effects of cardiac defibrillator discharge, always use the recommended cables and leadwires only (see the supplemental information manual). Using other cables or leadwires may result in damage to the equipment and compromise patient and/or user safety.

1.2 Measurement principle

1.2.1 Principle

The relationship between blood flow out of the aorta and pressure measured near the aorta (femoral artery or other large artery) is determined by the compliance function. The compliance function can therefore be characterized by measuring blood pressure and blood flow (cardiac output) simultaneously. Transpulmonary thermodilution cardiac output determined simultaneously with continuous arterial pressure measurement is utilized to calibrate the pulse contour analysis to each individual patient's aortic compliance function.

1.2.2 Calibration of the Pulse Contour Cardiac Output

To calibrate the measurement of continuous cardiac output, a reference thermodilution cardiac output is necessary. The E-PiCCO module uses the transpulmonary thermodilution as reference method.

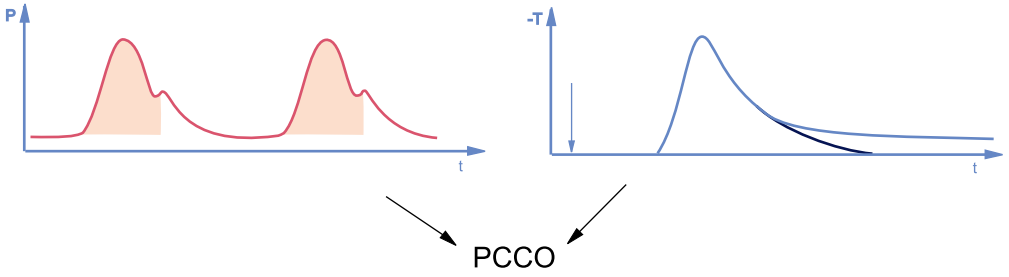


Figure 2 Calibration of pulse contour analysis by mean of thermodilution

1.3 Main components

1.3.1 Controls and connectors

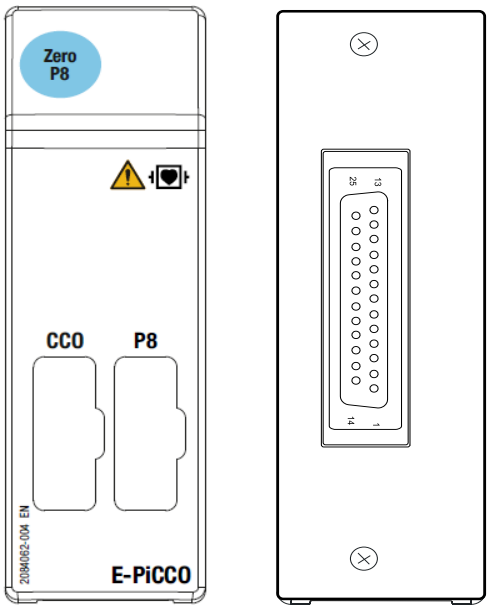


Figure 3 **Front panel of Continuous Cardiac Output Module, E-PiCCO, and the back of the module.**

Module key	Module	Description
Zero P8	E-PiCCO	Key for pressure zeroing

Connector	Module	Description
CCO	E-PiCCO	Connector for continuous cardiac output measurement
P8	E-PiCCO	Connector for invasive blood pressure measurement
D25 connector	E-PiCCO	Module bus connector

1.3.2 E-PiCCO module

The E-PiCCO module has a measurement board and a PI input board. The PI input board has been attached to the front chassis with the CCO and the invasive pressure connectors.

1.3.3 Measurement board

The measurement board consists of the following functional sections:

- Processor
- Cardiac output measurement
- Invasive blood pressure measurement

- Serial communication
- Isolation
- Power supply

Processor section

The CPU has a 32-bit high-speed H8SX single-chip microcontroller. It contains 768 Kbytes of flash memory and 24 Kbytes of RAM. The clock frequency is 16 MHz.

Cardiac output measurement section

The catheter and the probe contain a 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 coverted to 3.3V scale for sending to an AD Converter.

Because the temperature measurements are calibrated digitally and the non-linearity of catheter/probe is compensated for by software, ambient temperature change after calibration is the only factor that may influence the measurement.

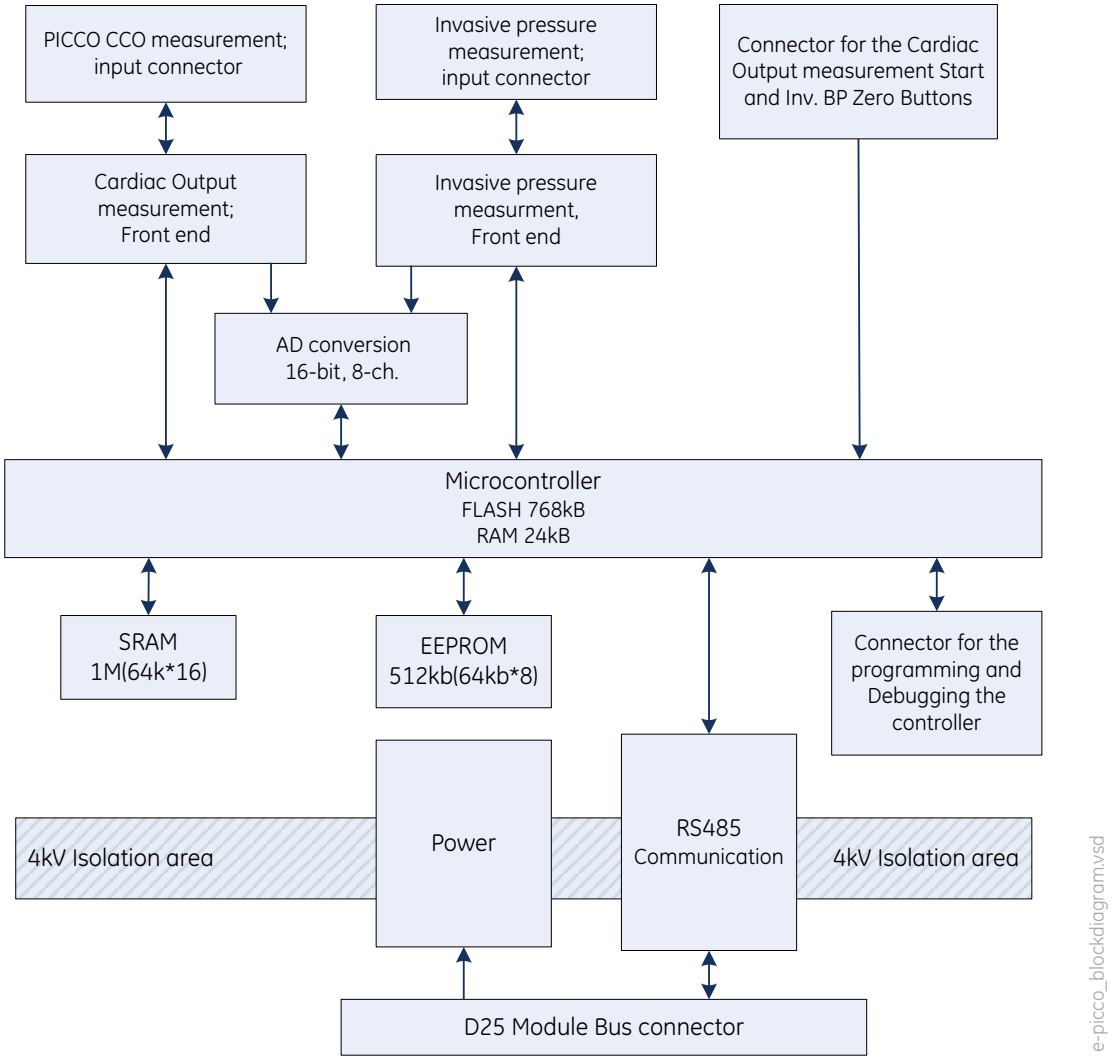


Figure 4 Measurement board block diagram

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.

The pressure transducer is detected by measuring the current of the sensor. The existence of the pressure transducer is also checked digitally by a jumper next to the connector.

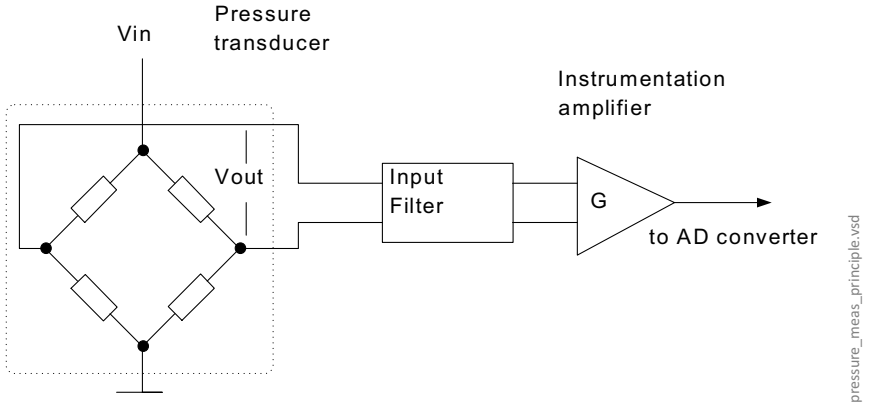


Figure 5 Pressure transducer's principle of operation

Serial communication

Serial communication between the module and the Ethernet to Module Bus Controller (EMBC) unit 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.

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.

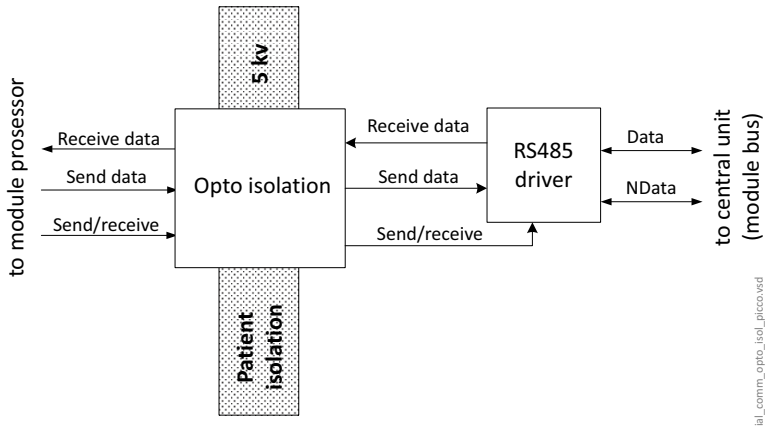


Figure 6 Serial communication and opto isolation

Isolation section

There are two opto isolators for data signal. Signals are processed on logical high-low levels even though the outputs of the opto isolators in the isolation section are analog signals.

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 Push-Pull type transformer driver is controlled by an oscillator circuit. The frequency of the oscillator is approximately 130 kHz with a pulse ratio of 50%. 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 switching regulator.

2 Configuration

There is no configuration for the E-PiCCO module.

2.1 Software update

The module software can be updated using a software CD and Webmin. The software update process involves transferring and activating the module software. First, you transfer the new software to the host monitor, either from the software CD using service laptop connected to the monitor, or by using InSite ExC. Then, you need to activate the software through Webmin.

For more detailed information about the software update, refer to the host monitor's Technical Manual.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual inspections
2. 3.2. Electrical safety tests
3. 3.3. Functional check

3.1 Visual inspections

Detach the module from the module slot and check that:

- the front cover is intact
- all connectors are intact and attached properly
- the module box and latch are 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

NOTE: Mark this task as complete on the checkout form.

3.2 Electrical safety tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual, Installation checkout chapter. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 25.

3.3 Functional check

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

3.3.1 Test setup

Required tools

– A multiparameter patient simulator with an adapter cable to the GE invasive pressure connector

– P/N: M1201957 PiCCO CCO Simulator (optional)

Connections

- Ensure that the module is connected to the monitor.

Invasive pressure:

1. Connect the multiparameter patient simulator with its invasive pressure adapter cable to the red invasive pressure connector in the module.

Cardiac output:

1. Connect the PiCCO CCO Simulator cable to the CCO connector in the module.

Monitor configuration

Invasive pressure:

1. Configure the ***P8*** waveform field to the monitor screen with adequate priority.
2. Select the ***P8*** tab in the ***Invasive Pressures*** menu and configure:
   Label: Art

Cardiac output:

1. Select ***Procedures > Cardiac Output > Setup*** and configure:
   Patient Type: Adult
   Catheter: PV2015L20
   Injectate Volume: 15 ml
   Measurement Type: Manual
2. Select ***Calibrate > Demographics*** and configure:
   Height: "any value"
   Weight: "any value"
   Gender: "Male" or "Female"

Simulator configuration

Invasive pressure:

Configure the simulator invasive pressure channels as follows:
Sensitivity: 5 µV/V/mmHg
InvBP output: "0 mmHg static pressure" or "atmosphere"

Cardiac output:

Configure the PiCCO CCO simulator as follows:
Bolus size: High
Catheter type: Standard
Injectate temperature: 21°C/ 0°C

NOTE: Refer to the simulators' documentation for details on how to use and configure the simulators.

3.3.2 Invasive pressure tests

1. Zeroing
   a. Ensure that the simulator InvBP output channel is configured to "0 mmHg static pressure" or "atmosphere".
   b. Zero the P8 invasive pressure channel by pressing **Zero P8** module key in the module.
   c. Check that a message ***Zeroing*** followed by a message ***Zeroed*** is shown in the P8 parameter window.

2. Static pressure
   a. Configure the simulator InvBP output channel to "200 mmHg static pressure".
   b. Check that a flat pressure line appears on the P8 waveform field. The reading in the parameter window shall be ***200 ±10 mmHg***.

NOTE: Recalibration is needed if the measured value is not within the specification limits. Calibrate the invasive pressure channels according to the instructions in 4.1. Invasive pressure calibration section.

3. Pressure waveforms
   a. Configure the simulator's InvBP output channel to "Arterial 120/80".
   b. Check that the pressure waveform for the P8 invasive pressure channel appears in the waveform window and the Sys/Dia (Mean) pressure values are shown in the related parameter window.
4. Mark this task as complete on the checkout form.

3.3.3 Cardiac output tests

Perform CCO calibration with the PiCCO CCO simulator.

NOTE: This test is optional.

NOTE: The invasive pressure measurement must be ***ON*** for CCO calibration.

5. Cardiac Output / CCO calibration
   a. Select the ***Procedures*** > ***Cardiac Output > Calibrate.***
   b. Select ***START C.O.*** to start the calibration.
   c. Wait until the ***Inject now!*** message appears on the Cardiac Output / CCO window. Turn the "Inject" toggle switch in the PiCCO CCO simulator to the "START" position and hold it there for 1 to 2 seconds before you release the switch.
   d. Check that a thermodilution curve is displayed on the screen and wait until the ***C.O. complete*** message is shown.
   e. Check that the measured C.O. value is updated to the screen and no error messages are shown.
   f. Select the ***Cancel/Reject Injectation*** to reject any noisy or erroneous measurement results.
   g. Repeat steps from b) to f) until you have at least 3 good measurement results.
   h. Check that the average of the measured C.O. values is updated to the C.O. field on the Cardiac Output / CCO window.

i. Select ***Confirm C.O. & Calibrate*** to complete the C.O. calibration.

NOTE: The PiCCO CCO simulator test is for functional check purpose only. Results can't be used for accuracy checking.

6. Mark this task as complete on the checkout form.

3.3.4 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

7. Complete on the "Maintenance check form" on page 25.

4 Calibration and adjustments

4.1 Invasive pressure calibration

Invasive pressure calibration shall be performed:

- whenever the pressure transducer in use is replaced with a new type of transducer
- if the invasive pressure calibration check in section "3.3.2" failed
- if the measured value is not within the specification limits

4.1.1 Required tools

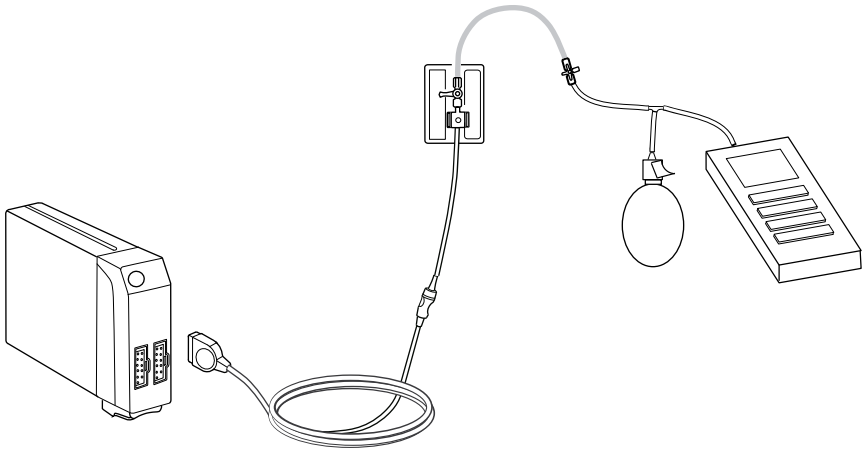
– A pressure manometer with a pressure pump
– Transducer adapter cable
– Invasive pressure transducer

NOTE: Refer to the E-PiCCO user documentation for compatible accessories.

NOTE: Pressure transducer is a key component in the measurement setup. If possible, perform the invasive pressure calibration with the same type of pressure transducer that is used in daily clinical use.

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

4.1.2 Connections

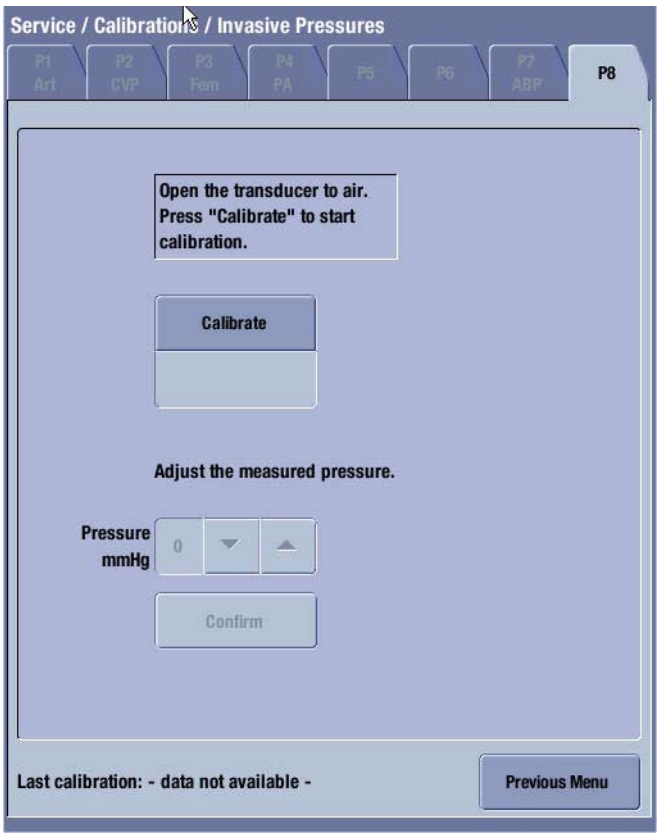


- Ensure that the module is connected to the monitor.
- Connect the transducer adapter cable to the red Inv BP connector in the module.
- Connect the invasive pressure transducer to the transducer adapter cable.
- Connect the pressure manometer with a pressure pump to the transducer's pressure line with a piece of tubing.

4.1.3 Procedure

1. Select ***Monitor Setup > Service Calibrations***.

2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Invasive Pressures***.
4. Select the ***P8 tab*** to calibrate the Invasive Pressure channel for E-PiCCO



5. Prepare the transducer for the zeroing by opening the dome stopcock to room air.
6. Select ***Calibrate***.
7. The monitor will start automatic zeroing of the invasive pressure channel. Wait until ***Zeroing*** message is replaced by ***Zero Ok*** message.
8. Pump a 200 mmHg ± 100 mmHg static pressure with the pressure pump when ***Create 200 mmHg pressure*** message is shown. The pressure measured by the module is updated in real-time to the invasive pressure calibration menu.
9. When the pressure is stabilized, check the pressure reading from the manometer.
10. Use the up-down spinner control in the calibration menu to adjust the reading measured by the module to match with the manometer reading. Select ***Confirm*** to complete the calibration when the two readings match each other.
11. Wait until ***Calibrated*** message is shown.

NOTE: ***Zero Failure*** message is shown in case the zeroing fails.

NOTE: ***'Calibration Error*** message is shown, if you do not start inflating the pressure within 45 seconds after the automatic zeroing is completed, or if the calibration fails.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues, and clinical configuration issues.

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

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

- the front cover is intact
- all connectors are intact, clean and attached properly
- the module box and latch are intact

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

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module

5.2 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.

  NOTE: Software version 2 with host build 2.0.8 or later: You can measure CCO and ScvO2 simultaneously when CCO is measured with the E-PiCCO and ScvO2 with the E-COPSv-01. Only the optical module should be connected to the E-COPSv-01 during this monitoring combination.
- Connect the accessories with a simulator to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active **(Monitor Setup > *Screen Setup* > *Upper Parameter Area***).

- Press a module key. Check that the related menu is opened or activity is started. Inoperatibility may refer to a loose keypad cable or other problem in the module.
- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.
- 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.

5.3 Service interface

Use the Webmin service interface to access device information and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information tab***.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the Continuous Cardiac Output Modules.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions, and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***Download Logs***
4. Select one of the log files for downloading.

NOTE: Depending on the CARESCAPE Monitor type, the log file downloading may be enabled only through remote Webmin access with a service laptop.

5.4 Messages

5.4.1 Invasive pressure

The messages below appear in the InvBP parameter window (PW), InvBP waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
No P8 transducer	MF	Pressure transducer and/or transducer adapter cable are/is disconnected from the module.	Connect the pressure transducer and/or transducer adapter cable to the module.
P8 not zeroed Not zeroed IPs not zeroed	PW WF MF	There is at least one invasive pressure channel, which is not zeroed.	Zero all invasive pressure channels.
P8 over range '>320mmHg' or '>43kPa'	MF PW	Measured pressure exceeds 320mmHg / 43 kPa measurement range. Transducer is not zeroed correctly.	The measurement range is between -40mmHg and 320mmHg. Zero the invasive pressure channel.
P8 under range '<-40 mmHg' or '<-5 kPa'	MF PW	Measured pressure exceed -40 mmHg /-5 kPa measurement range. Transducer is not zeroed correctly.	The measurement range is between -40 mmHg and 320 mmHg. Zero the invasive pressure channel.
Identical IP8 modules	MF	Identical IP modules. The monitor detects the same IP channel from two or more E-PiCCO, E-COPSv modules.	Host software version 2 with host build 2.0.8: Detach the IP cable from one of the modules providing identical IP channel. Host software version 2 with host build 2.0.7: Move one of the modules providing identical IP channel.
Calibrating	PW	Calibration of an invasive pressure channel is in progress.	Wait until calibration is completed successfully.

Message	Location	Possible causes	Possible solutions
Calibration failed	PW	Pressure calibration failure due to time-out. Pulsating waveform detected during the calibration. Gain is beyond the limits (±20% of the default gain).	Recalibrate. Start inflating the pressure within 45 seconds after the automatic zeroing is completed. Check the manometer reading to ensure that a static 100-300 mmHg pressure is present for calibration. Replace the transducer and recalibrate.
Calibrated	PW	Calibration of an invasive pressure channel is completed successfully.	No actions.
Zeroing	PW	Zeroing of an invasive pressure channel is in progress.	Wait until zeroing is completed successfully.
P8 zeroing failed	PW	Pulsating waveform is detected. Offset is > 150mmHg. Defective transducer.	Open the transducer to room air and zero the channel. Replace the transducer, open it to room air, and zero the channel.
Zero adj > 100mmHg	PW	Offset when zeroing is > 100mmHg (but <150mmHg) from the absolute zero of the module (with default gain).	Check transducer. Re-zero the pressure channel.
Zeroed	PW	Zeroing of an invasive pressure channel is completed successfully.	No actions.
Zero ICP separately	MF	ICP is an active IP channel, and ***Zero All*** is performed.	Zero the ICP channel separately.
Pressure measurement removed	MF	Measurement module has been removed.	Reconnect the module if you want to restart the measurement.
Pressure sensed		Pulsation detected during zeroing.	Re-zero
P8 standby		Channel set to standby state.	No measurements/alarms.
Disconnected		Possible arterial catheter disconnection detected.	Check catheter connection. Perform zeroing.

5.4.2 Cardiac output

The messages below appear in the parameter window (PW) or message field (MF).

Message	Location	Possible causes	Possible solutions
CO measurement removed	MF	The module is disconnected.	Reconnect the module or select ***Audio Pause*** to reset message.
Identical CO modules	MF	Two or more of the following modules are connected at the same time: E-COP, E-COPSv, M-COP, M-COPSv , E-PiCCO.	Connect only one of the listed modules at a time. Host software version 2 with host build 2.0.8 or later with E-PiCCO and E-COPSv-01 modules: Connect C.O. cable to only one of the listed modules at a time.
Re-calibrate CCO	MF, PW	CCO calibration is over 8 hours old.	Host software version 2 with host build 2.0.7 or earlier: Perform calibration. Host software version 2 with host build 2.0.8 or later: The message remains on screen until the next calibration is performed, but you can continue the measurement. If you choose to acknowledge the alarm, it will reappear every 4 hours until the next calibration is performed.
Calibrating	PW	Calibrating message is shown when CCO calibration is in process.	Wait until CCO calibration is completed
CCO meas. fail	PW	CCO calibration fail is shown when module informs unsuccessful CCO calibration.	Re-calibrate CCO. Contact technical support, if the problem is not resolved.
Not calibrated	PW	The module and CCO cable are connected but CCO measurement has not been calibrated.	Perform CCO calibration.
Confirm Calibration / Confirm CCO Calibration	PW/MF	Measurement data has not been confirmed before trying to exit the ***Cardiac Output /CCO Calibrate*** menu. In 15 minutes this message resets automatically.	Complete CCO calibration.
No CCO catheter	MF	The catheter is disconnected from the cable or the cable is disconnected from the module.	Reconnect catheter/cable or select ***Audio Pause*** to reset message.

5.5 Troubleshooting chart

5.5.1 Invasive pressure

Problem	Possible causes	Possible solutions
Abnormally low pressure	Transducer is wrongly positioned.	Check mid-heart level and reposition the transducer.
No pressure.	Defective transducer. Module is not connected. The transducer adapter cable is not connected to the module. Invasive pressure channel is not configured to the screen (with adequate priority).	Check or replace the transducer. Connect the module. Connect the transducer adapter cable with the transducer to the module. Configure the temperature channel to the screen (***Monitor Setup > Screen Setup***) with adequate priority and check that it is active.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module is limited to replacing faulty mechanical parts only (see chapter 7. Service parts for details).

WARNING **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. Maintenance and checkout each time after you have opened the module casing.

6.1.1 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.

6.1.2 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.

6.1.3 Required tools

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

6.2 Disassembling and reassembling procedure

Disassembling the Continuous Cardiac Output Modules, E-PiCCO (see the exploded view of the module in chapter 7. Service parts):

6.2.1 To replace the front cover

1. Detach the front cover of the module, use a small flat blade screwdriver to release the snaps that hold the front cover to the front chassis unit by. There are two snaps on both sides of the module and one snap on the top.

6.2.2 To disassemble the module

1. Remove the two screws (T10) from the back of the module.
2. Press the release latch and pull the module casing slowly backwards to remove it from the main body.
3. Detach the front cover (see 6.2.1).

NOTE: The PiCCO measurement board and input boards are not field replaceable separately. Therefore in case of faulty measurement board or input board the module must be repaired by using FRUs listed in chapter 7. Service parts.

6.2.3 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

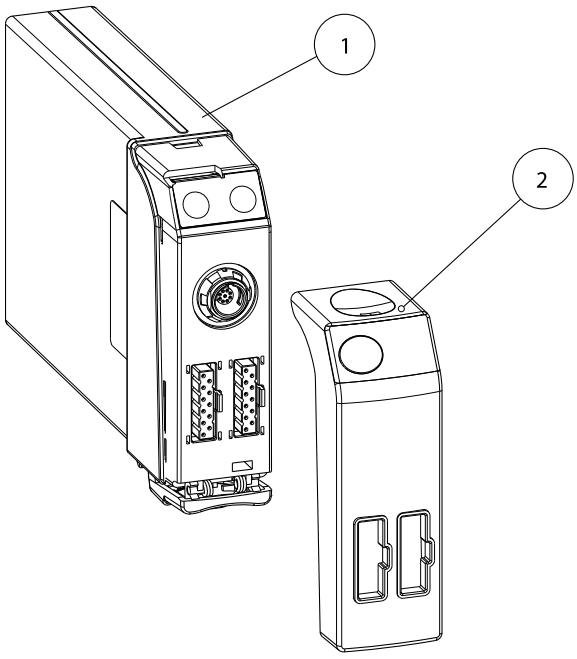
7 Service parts

7.1 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. Maintenance and checkout each time after you have opened the module casing.

7.2 Continuous Cardiac Output Module, E-PiCCO



Item	Description	Order No.
1	E-PiCCO module unit, FRU - Front chassis unit (inc. front chassis, membrane keypad, connector unit, latch, torsion spring) - Measurement board (inc. Measurement board, metal frame, mounting screws)	M1194087
2	Front Cover, CS, E-PiCCO, Spare part	2086149-001
2	Front Cover, DA, E-PiCCO, Spare part	2086154-001
2	Front Cover, DE, E-PiCCO, Spare part	2086155-001
2	Front Cover, EN, E-PiCCO, Spare part	2086156-001
2	Front Cover, ES, E-PiCCO, Spare part	2086157-001
2	Front Cover, FI, E-PiCCO, Spare part	2086159-001

Item	Description	Order No.
2	Front Cover, FR, E-PiCCO, Spare part	2086160-001
2	Front Cover, HU, E-PiCCO, Spare part	2086161-001
2	Front Cover, IT, E-PiCCO, Spare part	2086162-001
2	Front Cover, JA, E-PiCCO, Spare part	2086163-001
2	Front Cover, NL, E-PiCCO, Spare part	2086164-001
2	Front Cover, NO, E-PiCCO, Spare part	2086165-001
2	Front Cover, PL, E-PiCCO, Spare part	2086166-001
2	Front Cover, PT, E-PiCCO, Spare part	2086167-001
2	Front Cover, RU, E-PiCCO, Spare part	2086168-001
2	Front Cover, SV, E-PiCCO, Spare part	2086169-001
2	Front Cover, ZH, E-PiCCO, Spare part	2065164-001
3	Module Hardware kit, FRU - 2 mounting screws for metal frame - 2 mounting screws for front chassis unit - 2 mounting screws for module casing - Membrane keypad - Latch - Torsion spring	M1206392

Maintenance check form

Continuous Cardiac Output Module, E-PiCCO

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**
3.1. Visual inspections	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
3.2. Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. Invasive pressure tests				☐ ☐ ☐
3.3.3. Cardiac output tests				☐ ☐ ☐
3.3.4. Test completion				☐ ☐ ☐

Notes

Used service parts			

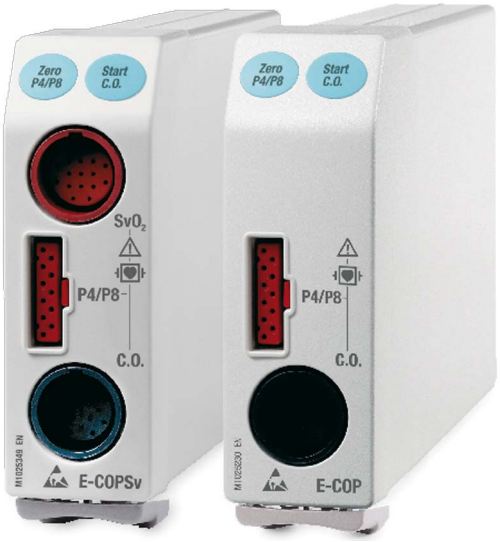
Signature	Date

For your notes:

4

Cardiac Output and SvO_2 Module, E-COPSv (Rev. 01)
Cardiac Output Module, E-COP (Rev. 01)

Technical Manual



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1 Product overview

1.1 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.

NOTE: Some information in this document may vary compared to older E-COP and E-COPSv module versions. If needed refer to earlier document version(s) for more information about older E-COP and E-COPSv modules versions.

Both modules E-COP and E-COPSv provide:

- Cardiac output (C.O.)
- Right ventricular ejection fraction (REF)
- Invasive blood pressure (InvBP) measurement
- Blood temperature (Tblood)

Additionally, the COPSv module provides venous oxygen saturation (SvO_2) measurement.

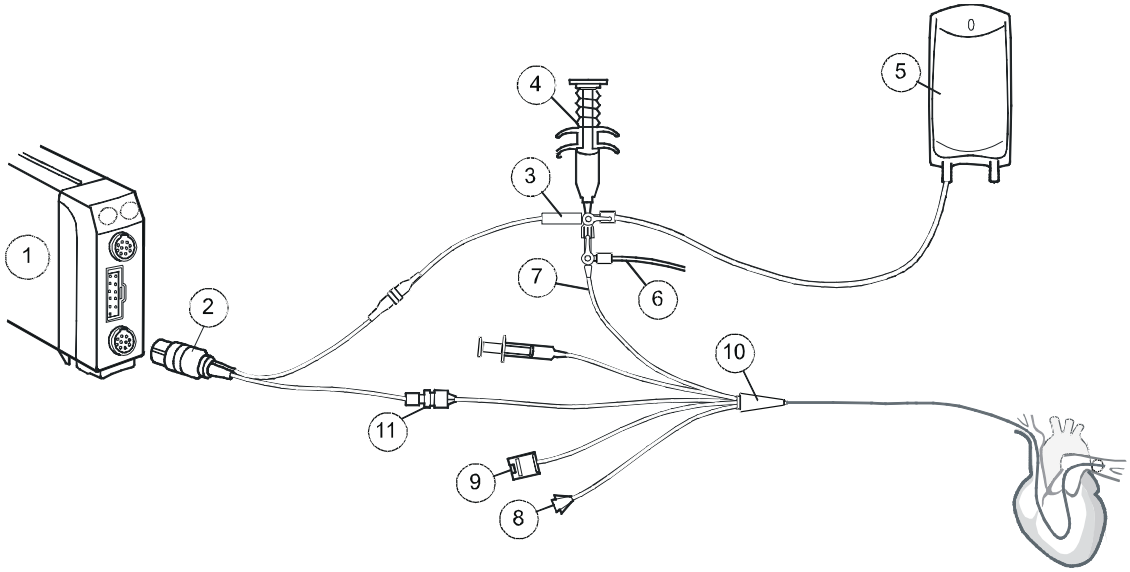


Figure 1 Cardiac output setup with closed injectate delivery system

(1) Module with C.O. measurement capability
(2) Catheter connecting cable
(3) Injectate temperature probe
(4) Injectate syringe
(5) Injectate solution
(6) CVP line to InvBP transducer or fluid infuser
(7) Proximal
(8) Distal lumen hub
(9) Optical connector (used for SvO2 measurement)
(10) Thermodilution catheter (Edwards Lifesciences corp. compatible)
(11) Catheter's thermistor

Equipment safety symbols

This symbol on the module refers to defibrillator precautions. To ensure protection against the effects of cardiac defibrillator discharge, always use the recommended cables and leadwires only (see the supplemental information manual). Using other cables or leadwires may result in damage to the equipment and compromise patient and/or user safety.

1.2 Measurement principle

1.2.1 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

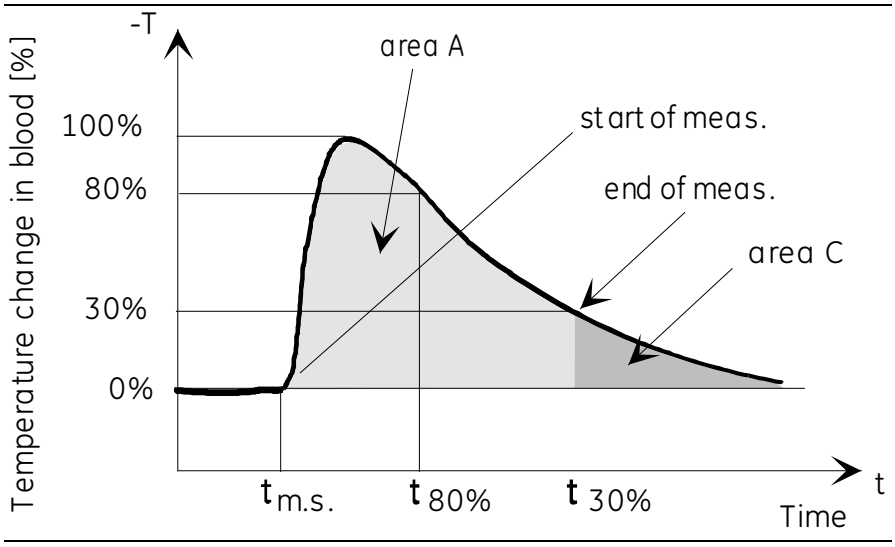


Figure 2 Cardiac output measurement curve

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.

1.2.2 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.

1.2.3 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, and 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.

1.3 Main components

1.3.1 Controls and connectors

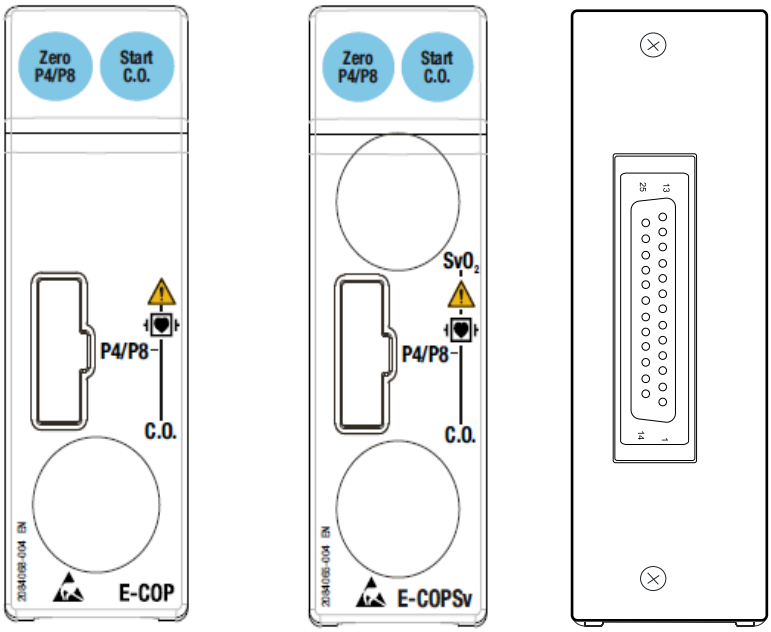


Figure 3 Front panels of Cardiac Output Modules, E-COP and E-COPSv, and the back of the module

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

1.3.2 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.

1.3.3 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 a 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 the non-linearity of catheter/probe is compensated for by software, ambient temperature change after calibration is the only factor that may influence the measurement.

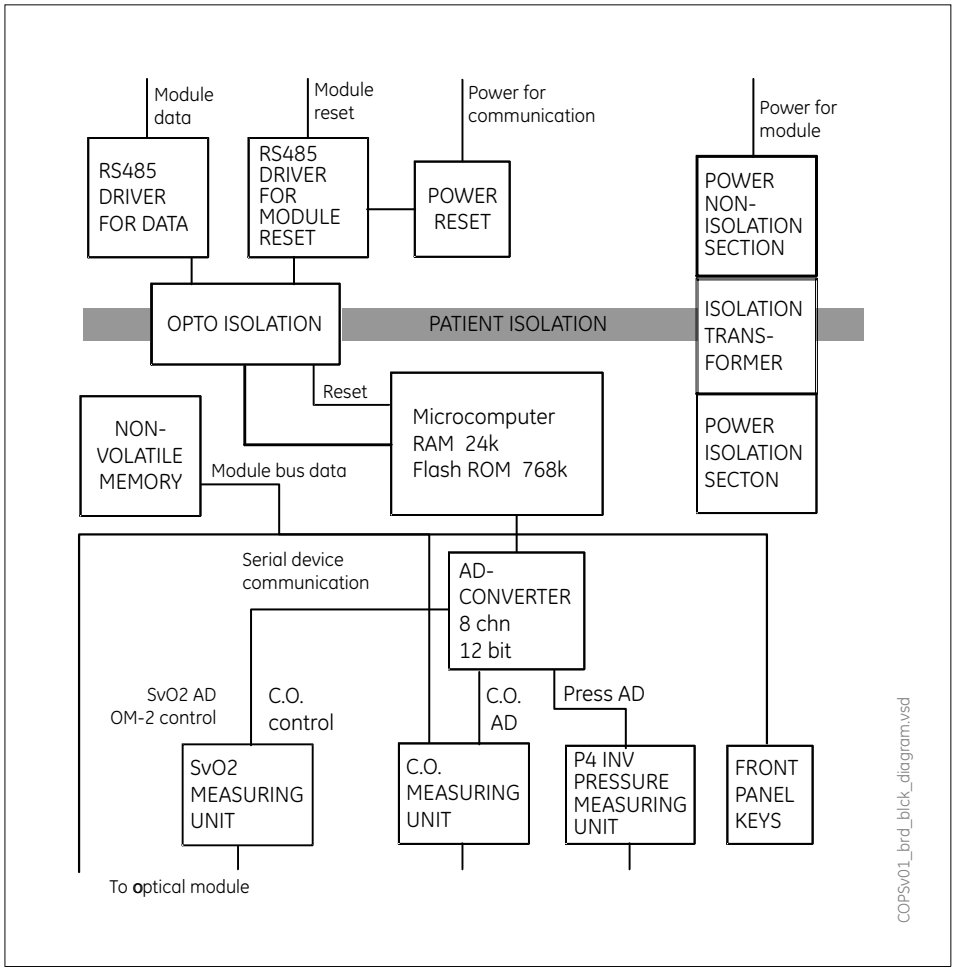


Figure 4 Measurement board block diagram. In E-COP module the SvO_2 section is excluded

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.

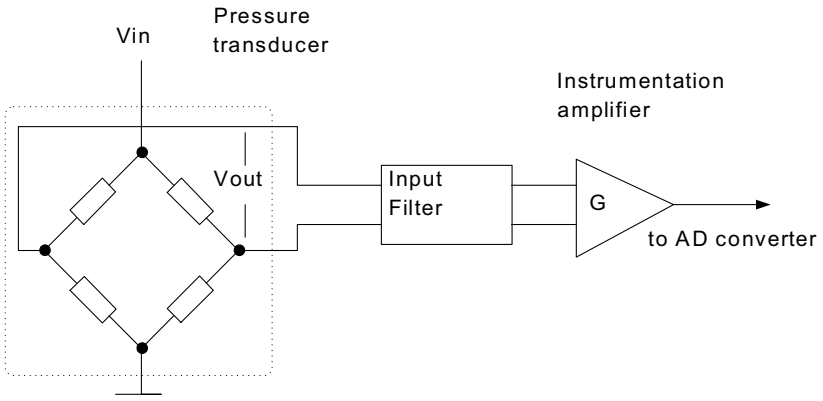


Figure 5 Pressure transducer's principle of operation

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 Ethernet to Module Bus Controller (EMBC) unit 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.

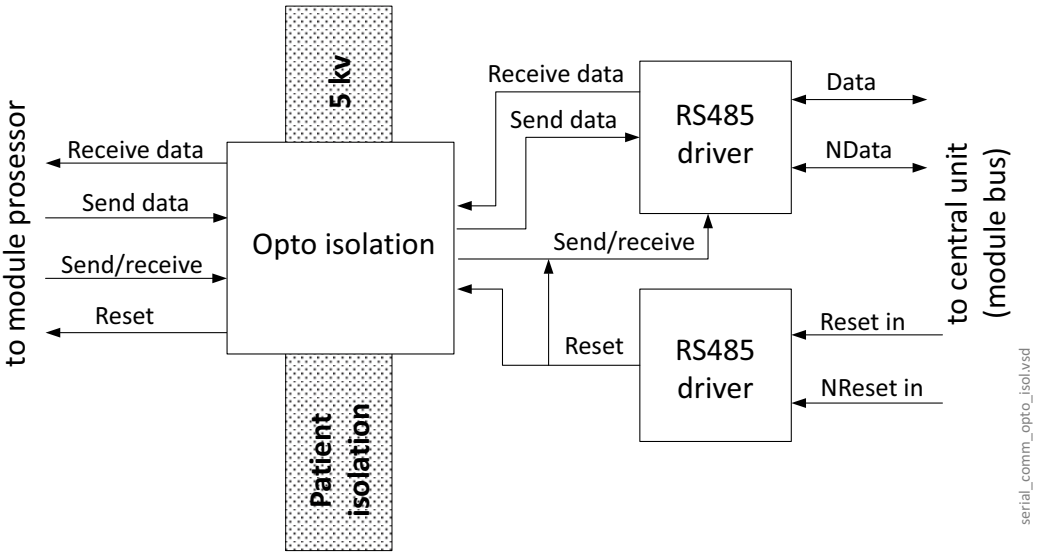


Figure 6 Serial communication and opto isolation

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.

2 Configuration

There is no configuration for the E-COP or E-COPSv modules.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual inspections
2. 3.2. Electrical safety tests
3. 3.3. Functional check

3.1 Visual inspections

Detach the module from the module slot and check that:

- the front cover is intact
- all connectors are intact and attached properly
- the module box and latch are 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

NOTE: Mark this task as complete on the checkout form.

3.2 Electrical safety tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual, Installation checkout chapter. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 33.

3.3 Functional check

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

NOTE: SvO_2 related checkout procedure steps below are valid for the E-COPSv module only.

3.3.1 Test setup

Required tools

– A multiparameter patient simulator with adapter cables to the GE invasive pressure connector and cardiac output connector
– Catheter Connecting Cable
– P/N: 890121, SvO_2 simulator. The old simulator works with E-COPSV-00 and E-COPSv-01 only if the S/N is smaller than SGQ14462015HA.
– P/N: 2089334-001, SvO_2 simulator.

NOTE: See the CARESCAPE monitor supplemental information manual for compatible accessories.

Connections

- Ensure that the module is connected to the monitor.

Invasive pressure:

1. Connect the multiparameter patient simulator with its invasive pressure adapter cable to the red invasive pressure connector in 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.

Cardiac output:

1. Connect the catheter connecting cable to the module's C.O. connector.
2. Connect the catheter connecting cable's injectate probe connector and blood catherer (blood temperature) connector to the simulator according to the instructions given in the patient simulator's manual.

SvO_2:

1. Connect the SvO_2 simulator cable to the red SvO_2 connector in the module.

Monitor configuration

Invasive pressure:

1. Configure the ***P8*** waveform field to the monitor screen with adequate priority.
2. Select the ***P8*** tab in the ***Invasive Pressures*** menu and configure:

   Label: P8

   Scale (mmHg): 0-200 mmHg

   Parameter Format: Sys/Dia (Mean)

Cardiac output:

1. Configure the CO + TBlood parameter windows to the monitor screen with adequate priority.
2. Select the ***Setup*** tab in the ***Cardiac Output*** menu and configure:

   Manufacturer: User Defined

Computation constant: 0.542

Measurement Type: Manual

Injectate Volume: 10 ml

Ref Measurement: Deselect

3. Select the ***TBlood Alarm*** tab ***> Setup*** tab in the ***C.O.*** menu and configure:

   TBlood Measurement: On

SvO_2

1. Configure the SvO_2 parameter window to the monitor screen with adequate priority.

Simulator configuration

Invasive pressure:

Configure the simulator invasive pressure channels as follows:

Sensitivity: 5 µV/V/mmHg

InvBP output: "0 mmHg static pressure" or "atmosphere"

Cardiac output:

Configure the simulator's cardiac output channel as follows:

Baseline Temperature/Blood Temperature: 37 °C

Injectate temperature: 0 °C or 2°C

SvO_2:

Turn the SvO_2 simulator's pulsation switch to 'Normal pulse' and the range switch to 'Medium'.

NOTE: Refer to the simulators' documentation for details on how to use and configure the simulators.

3.3.2 Invasive pressure tests

1. Zeroing
   a. Ensure that the simulator InvBP output channel is configured to "0 mmHg static pressure" or "atmosphere".
   b. Zero the P8 invasive pressure channel by pressing **Zero P4/P8** module key in the module.
   c. Check that a message ‘Zeroing’ followed by a message ‘Zeroed’ is shown in the P8 parameter window.

2. Static pressure
   a. Configure the simulator InvBP output channel to "200 mmHg static pressure".
   b. Check that a flat pressure line appears on the P8 waveform field. The reading in the parameter window shall be 200 ±10 mmHg.

NOTE: Recalibration is needed if the measured value is not within the specification limits. Calibrate the invasive pressure channels according to the instructions in 4.1. Invasive pressure calibration section.

3. Pressure waveforms
   a. Configure the simulator's InvBP output channel to "Arterial 120/80".

b. Check that the pressure waveform for the P8 invasive pressure channel appears in the waveform window and the Sys/Dia (Mean) pressure values are shown in the related parameter window.

4. Mark this task as complete on the checkout form.

3.3.3 Cardiac output tests

Check the C.O. measurement functionality with the C.O. simulator.

5. C.O. measurement
   a. Select the ***Procedure*** > ***Measurement*** tab in the ***Cardiac Output*** menu.
   b. Select ***START C.O.*** to start a manual C.O. measurement.
   c. Inject a 5 l/min C.O. wave from the simulator after the text 'Inject now!" message appears on the C.O. menu.
   d. Check that a thermodilution curve is displayed on the C.O. menu and the curve returns to the base level after the measurement is completed.
   e. Check that the measured C.O. value is updated to the C.O. menu and its close to the simulator's C.O. set value and no error messages are shown.
   f. Select the ***Cancel/Reject Injectation*** to reject any noisy or erroneous measurement results.
   g. Repeat steps from b) to f) until you have at least 3 good measurement results.
   h. Select ***Confirm C.O.*** to complete the C.O. measurement.
   i. Check that the average of the measured C.O. values and the Tblood reading is updated to the C.O. & Tblood parameter window.

NOTE: Check that the T injectate and Tblood values shown in the C.O menu during measurements are close to the simulator's set values to ensure successful measurement. Adjust simulator, if necessary.

NOTE: The C.O. simulator test is for functional check purpose only. Results can't be used for accuracy checking.

6. Mark this task as complete on the checkout form.

3.3.4 SvO_2 tests

Check the SvO_2 measurement functionality with the SvO_2 simulator.

7. In-Vitro Calibration
   a. Check that a 'Not calibrated' message is shown in the SvO_2 parameter window.
   b. Turn the SvO_2 simulator's pulsation switch to 'No pulse' position and range switch to 'Medium' position.
   c. Select the ***Calibration tab*** in the SvO_2 menu and then select ***Calibrate*** to start In-Vitro calibration.
   d. Wait until the 'In vitro calibrating' message disappears from SvO_2 parameter window and the Start SvO_2 button is enabled in the SvO_2 calibration menu.
   e. Complete the In-Vitro calibration by selecting ***Start SvO2***.
   f. Wait until the 'Calibrating' message disappears from SvO_2 parameter window.
   g. Check that the calibration date for In-Vitro calibration is updated correctly to the SvO_2 calibration menu.

8. In-Vivo Calibration

a. Turn the SvO2 simulator's pulsation switch to 'Normal pulse' position.
b. Select ***Calibrate*** to start In-Vivo calibration.
c. Wait until the 'In vivo calibrating' message disappears from SvO_2 parameter window and the Draw Blood Sample button is enabled in the SvO_2 calibration menu.
d. Complete In-Vivo Calibration by selecting ***Draw Blood Sample***.
e. Use the up-down spinner control in the calibration menu to adjust the ***Lab SvO_2%*** value to '81' and ***Lab Hb g/dl*** value to '11.5'.
f. Save the adjusted lab values by selecting ***Save Lab Values*** button.
g. Wait until the 'Calibrating' message disappears from SvO_2 parameter window.
h. Check that the calibration date for In-Vivo calibration is updated correctly to the SvO_2 calibration menu.
i. Select ***Close*** to close the SvO2 menu

9. SvO2 measurement
   a. Check that a SvO_2% reading appears to the SvO_2 parameter window.

NOTE: The SvO2 simulator test is for functional check purpose only. Results can't be used for accuracy checking.

10. Mark this task as complete on the checkout form.

3.3.5 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

11. Complete on the "Maintenance check form" on page 33.

4 Calibration and adjustments

4.1 Invasive pressure calibration

Invasive pressure calibration shall be performed:

- whenever the pressure transducer in use is replaced with a new type of transducer
- if the invasive pressure calibration check in section "3.3.2" failed
- if the measured value is not within the specification limits

4.1.1 Required tools

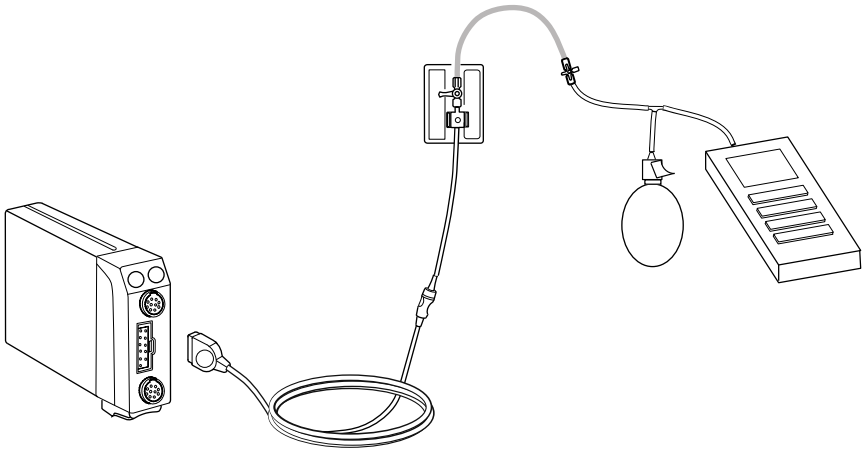
– A pressure manometer with a pressure pump
– Transducer adapter cable
– Invasive pressure transducer

NOTE: See the CARESCAPE monitor supplemental information manual for compatible accessories.

NOTE: Pressure transducer is a key component in the measurement setup. If possible, perform the invasive pressure calibration with the same type of pressure transducer that is used in daily clinical use.

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

4.1.2 Connections

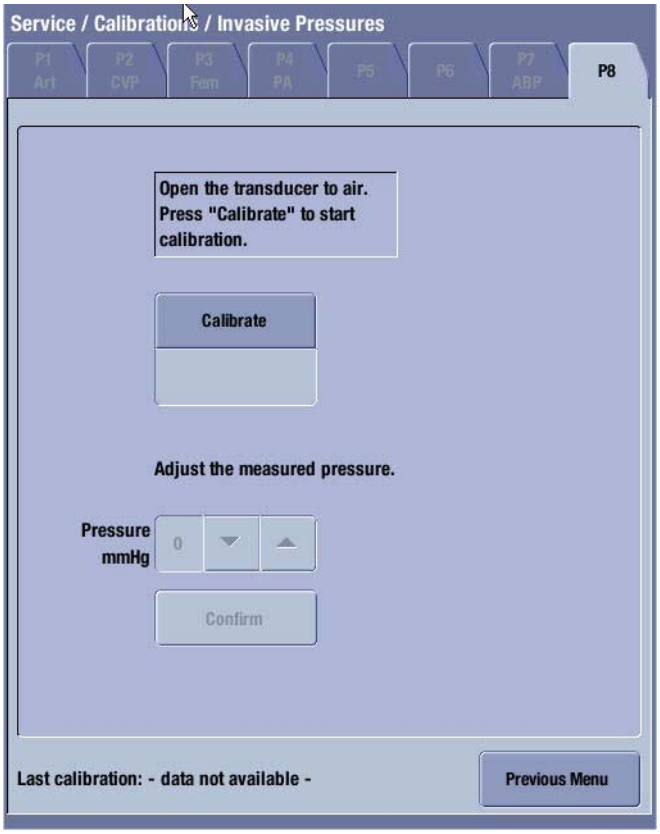


- Ensure that the module is connected to the monitor.
- Connect the transducer adapter cable to the red Inv BP connector in the module.
- Connect the invasive pressure transducer to the transducer adapter cable.
- Connect the pressure manometer with a pressure pump to the transducer's pressure line with a piece of tubing.

4.1.3 Procedure

1. Select ***Monitor Setup > Service Calibrations***.
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Invasive Pressures***.
4. Select the ***P8 tab*** to calibrate the Invasive Pressure channel for E-COP(Sv)

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.



5. Prepare the transducer for the zeroing by opening the dome stopcock to room air.
6. Select ***Calibrate***.
7. The monitor will start automatic zeroing of the invasive pressure channel. Wait until 'Zeroing' message is replaced by 'Zero Ok' message.
8. Pump a 200 mmHg ± 100 mmHg static pressure with the pressure pump when 'Create 200 mmHg pressure' message is shown. The pressure measured by the module is updated in real-time to the invasive pressure calibration menu.
9. When the pressure is stabilized, check the pressure reading from the manometer.
10. Use the up-down spinner control in the calibration menu to adjust the reading measured by the module to match with the manometer reading. Select ***Confirm*** to complete the calibration when the two readings match each other.
11. Wait until 'Calibrated' message is shown.

NOTE: 'Zero Failure' message is shown in case the zeroing fails.

NOTE: 'Calibration Error' message is shown, if you do not start inflating the pressure within 45 seconds after the automatic zeroing is completed, or if the calibration fails.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues, and clinical configuration issues.

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

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

- the front is intact
- all connectors are intact, clean and attached properly
- the module box and latch are intact

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

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module

5.2 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.

  NOTE: Host software version 2 with host build 2.0.8 or later: You can measure CCO and ScvO2 simultaneously when CCO is measured with the E-PiCCO and ScvO2 with the E-COPSv-01. Only the optical module should be connected to the E-COPSv-01 during this monitoring combination.
- Connect the accessories with a simulator to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active **(Monitor Setup > *Screen Setup* > *Upper Parameter Area***).

- Press a module key. Check that the related menu is opened or activity is started. Inoperatibility may refer to a loose keypad cable or other problem in the module.
- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.
- 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.

5.3 Service interface

Use the Webmin service interface to access device information and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information tab***.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the Cardiac Output Modules.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions, and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***Download Logs***
4. Select one of the log files for downloading.

NOTE: Depending on the CARESCAPE Monitor type, the log file downloading may be enabled only through remote Webmin access with a service laptop.

5.4 Messages

5.4.1 Invasive pressure

The messages below appear in the InvBP parameter window (PW), InvBP waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
No P8 transducer	MF	Pressure transducer and/or transducer adapter cable are/is disconnected from the module.	Connect the pressure transducer and/or transducer adapter cable to the module.
Not zeroed IPs not zeroed	PW, WF MF	There is at least one invasive pressure channel, which is not zeroed.	Zero all invasive pressure channels.
P8 over range '>320mmHg' or '>43kPa'	MF PW	Measured pressure exceeds 320mmHg / 43 kPa measurement range. Transducer is not zeroed correctly.	The measurement range is between -40mmHg and 320mmHg. Zero the invasive pressure channel.
P8 under range '<-40 mmHg' or '<-5 kPa'	MF PW	Measured pressure exceed -40 mmHg /-5 kPa measurement range. Transducer is not zeroed correctly.	The measurement range is between -40 mmHg and 320 mmHg. Zero the invasive pressure channel.
Identical IP8 modules	MF	Identical IP modules. The monitor detects the same IP channel from two or more E-PiCCO, E-COPSv modules.	Host software version 2 with host build 2.0.8: Detach the IP cable from one of the modules providing identical IP channel. Host software version 2 with host build 2.0.7: Move one of the modules providing identical IP channel.
Calibration	PW	Calibration of an invasive pressure channel is in progress.	Wait until calibration is completed successfully.
Calibration failed	PW	Pressure calibration failure due to time-out. Pulsating waveform detected during the calibration. Gain is beyond the limits (±20% of the default gain).	Recalibrate. Start inflating the pressure within 45 seconds after the automatic zeroing is completed. Check the manometer reading to ensure that a static 100-300 mmHg pressure is present for calibration. Replace the transducer and recalibrate.

Message	Location	Possible causes	Possible solutions
Calibrated	PW	Calibration of an invasive pressure channel is completed successfully.	No actions.
Zeroing	PW	Zeroing of an invasive pressure channel is in progress.	Wait until zeroing is completed successfully.
Zeroing failed	PW	Pulsating waveform is detected. Offset is > 150mmHg. Defective transducer.	Open the transducer to room air and zero the channel. Replace the transducer, open it to room air, and zero the channel.
Zero adj > 100mmHg	PW	Offset when zeroing is > 100mmHg (but <150mmHg) from the absolute zero of the module (with default gain).	Check transducer. Re-zero the pressure channel.
Zeroed	PW	Zeroing of an invasive pressure channel is completed successfully.	No actions.
Zero ICP separately	MF	ICP is an active IP channel, and ***Zero All*** is performed.	Zero the ICP channel separately.
Pressure measurement removed	MF	Measurement module has been removed.	Reconnect the module if you want to restart the measurement.

5.4.2 Cardiac output

The messages below appear in the message field (MF).

Message	Location	Possible causes	Possible solutions
CO measurement removed	MF	The module is disconnected.	Reconnect the module.
CO cable off	MF	The CO measurement cable is disconnected from the module.	Reconnect the CO measurement cable.
Identical CO modules	MF	Two or more of the following modules are connected at the same time: E-COP, E-COPSv, M-COP, M-COPSv , E-PiCCO.	Connect only one of the listed modules at a time. Host software version 2 with host build 2.0.8 or later with E-PiCCO and E-COPSv-01 modules: Connect C.O. cable to only one of the listed modules at a time.

5.4.3 SvO_2

The messages below appear in the message field (MF).

Message	Location	Possible causes	Possible solutions
SvO2 cable off	MF	The SvO2 cable is disconnected from the module.	Re-connect the cable to the module.
SvO2 signal poor	MF	Signal pulsation. Catheter is touching the wall, or an intensity shift in signal quality level.	Reposition and/or flush the catheter. Recalibrate.
SvO2 faulty cable	MF	Factory calibration of the optical module is corrupted. There is red/infrared transmitter error; the currents cannot be adjusted to the factory defaults.	Replace the optical module.
SvO2 not calibrated	MF	The optical module is connected to the monitor but the catheter has not been calibrated.	Perform InVivo calibration or accept the old calibration.
Recalibrate SvO2	MF	Calibration is older than 24 hours.	Perform InVivo calibration.
SvO2 measurement removed	MF	The module is disconnected.	Reconnect the module.

5.5 Troubleshooting chart

5.5.1 Invasive pressure

Problem	Possible causes	Possible solutions
Abnormally low pressure	Transducer is wrongly positioned.	Check mid-heart level and reposition the transducer.
No pressure.	Defective transducer. Module is not connected. The transducer adapter cable is not connected to the module. Invasive pressure channel is not configured to the screen (with adequate priority).	Check or replace the transducer. Connect the module. Connect the transducer adapter cable with the transducer to the module. Configure the temperature channel to the screen (***Monitor Setup > Screen Setup***) with adequate priority and check that it is active.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module is limited to replacing faulty mechanical parts only (see chapter 7. Service parts for details).

WARNING **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. Maintenance and checkout each time after you have opened the module casing.

6.1.1 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.

6.1.2 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.

6.1.3 Required tools

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

6.2 Disassembling and reassembling procedure

Disassembling the Cardiac Output Modules, E-COP and E-COPSv (see the exploded view of the module in chapter 7. Service parts):

6.2.1 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.

6.2.2 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 6.2.1).

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 "7. Service parts".

6.2.3 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

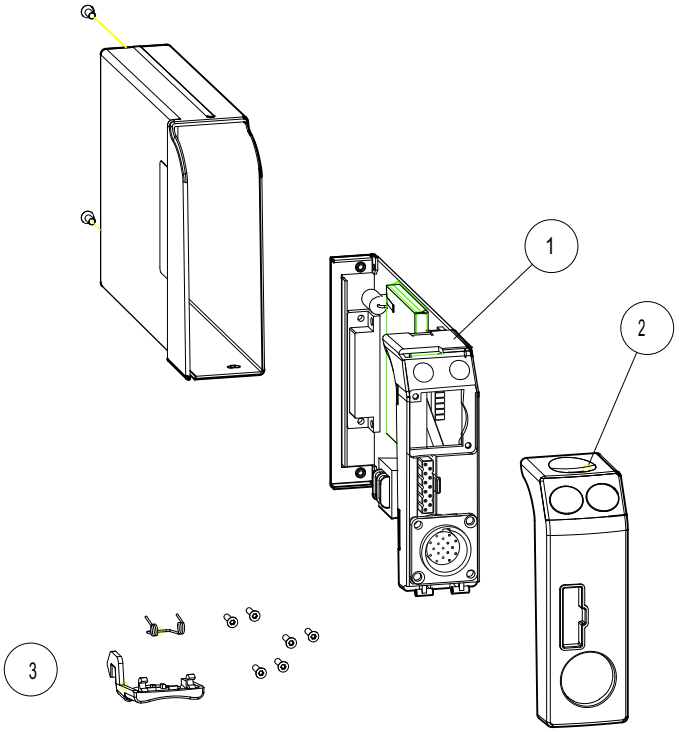
7 Service parts

7.1 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. Maintenance and checkout each time after you have opened the module casing.

7.2 Cardiac Output Module, E-COP

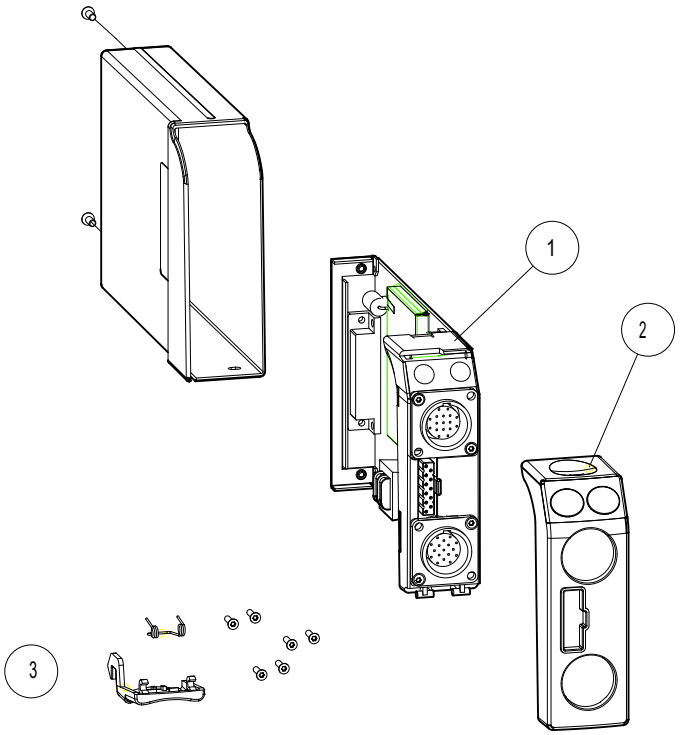


Item	Description	Order No.
1	E-COP module unit, FRU - Front chassis unit, FRU (inc. front chassis, membrane keyboard, connector unit, latch, torsion spring) - Measurement board, FRU (inc. Measurement board, metal frame, mounting screws)	2082034-001

Item	Description	Order No.
2	Front Cover, CS, E-COP	2086151-001
2	Front Cover, DA, E-COP	2086171-001
2	Front Cover, DE, E-COP	2086172-001
2	Front Cover, EN, E-COP	2086173-001
2	Front Cover, ES, E-COP	2086174-001
2	Front Cover, FI, E-COP	2086175-001
2	Front Cover, FR, E-COP	2086176-001
2	Front Cover, HU, E-COP	2086177-001
2	Front Cover, IT, E-COP	2086178-001
2	Front Cover, JA, E-COP	2086179-001
2	Front Cover, NL, E-COP	2086180-001
2	Front Cover, NO, E-COP	2086181-001
2	Front Cover, PL, E-COP	2086182-001
2	Front Cover, PT, E-COP	2086183-001
2	Front Cover, SV, E-COP	2086184-001
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.

7.3 Cardiac Output Module, E-COPSv



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))	2082033-001
2	Front Cover Unit, CS, E-COPSV	2086152-001
2	Front Cover Unit, DA, E-COPSV	2086185-001
2	Front Cover Unit, DE, E-COPSV	2086186-001
2	Front Cover Unit, EN, E-COPSV	2086187-001
2	Front Cover Unit, ES, E-COPSV	2086188-001
2	Front Cover Unit, FI, E-COPSV	2086189-001
2	Front Cover Unit, FR, E-COPSV	2086190-001

Item	Description	Order No.
2	Front Cover Unit, HU, E-COPSV	2086191-001
2	Front Cover Unit, IT, E-COPSV	2086192-001
2	Front Cover Unit, JA, E-COPSV	2086193-001
2	Front Cover Unit, NL, E-COPSV	2086194-001
2	Front Cover Unit, NO, E-COPSV	2086195-001
2	Front Cover Unit, PL, E-COPSV	2086196-001
2	Front Cover Unit, PT, E-COPSV	2086197-001
2	Front Cover Unit, SV, E-COPSV	2086198-001
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.

For your notes:

Maintenance check form

Cardiac Output Modules, E-COPSv, E-COP

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
3.1. Visual inspections	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. Invasive pressure tests				☐ ☐ ☐
3.3.3. Cardiac output tests				☐ ☐ ☐
3.3.4. SvO2 tests				☐ ☐ ☐
3.3.5. Test completion				☐ ☐ ☐

Notes

Used service parts			

Signature	Date

For your notes:

5

Dual Pressure Module, E-PP
Pressure Temp Module, E-PT
Pressure Module, E-P

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the Pressure Module, E-P, Pressure Temp Module, E-PT and Dual Pressure Module, E-PP.

The E-P, E-PT and E-PP modules are single width plug-in modules.

Module	Invasive BP	Temp
E-PP	2	-
E-PT	1	2
E-P	1	-

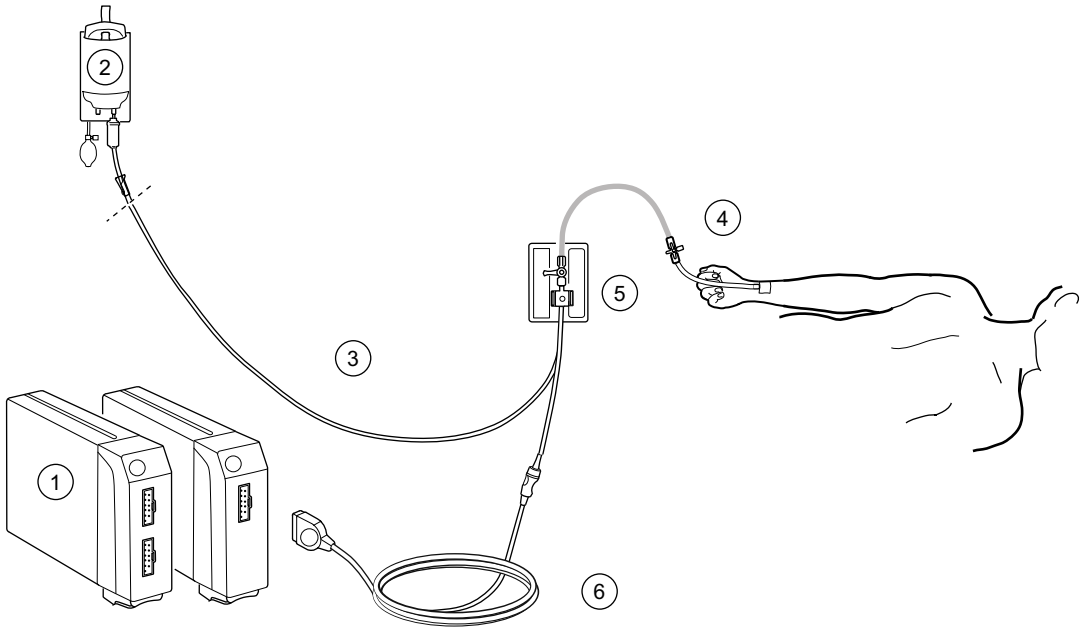


Figure 1 Invasive blood pressure setup

(1) Module with invasive blood pressure measurement capability
(2) Heparinized fluid bag with pressure infusor
(3) Flushing set
(4) Disposable catheter
(5) Transducer
(6) Adapter cable for InvBP transducer

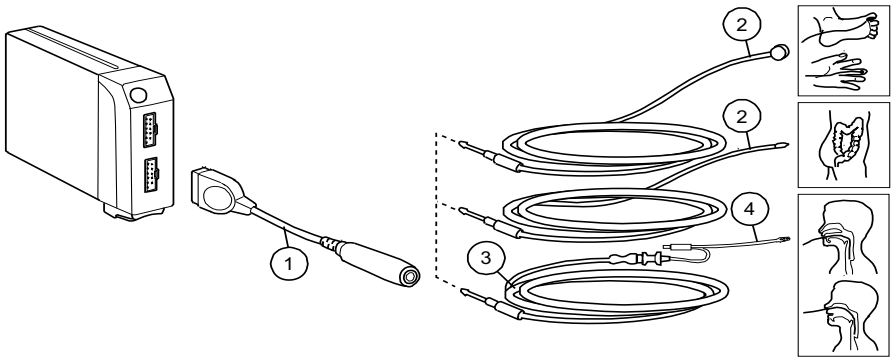


Figure 2 Temperature measurement

(1) Adapter cable for temperature probes
(2) Reusable temperature probe
(3) Adapter cable for disposable temperature probe
(4) Disposable temperature probe

Equipment safety symbols

This symbol on the module refers to defibrillator precautions. To ensure protection against the effects of cardiac defibrillator discharge, always use the recommended cables and leadwires only (see the supplemental information manual). Using other cables or leadwires may result in damage to the equipment and compromise patient and/or user safety.

1.2 Measurement principle

1.2.1 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.

1.2.2 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.

The E-PT module uses the constant current method. 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.

1.3 Main components

The E-PT module consists of the following main parts:

- STP Main Assembly
- Connector for temperature probes; temperature channels T3 and T4.
- Connector for an invasive blood pressure sensor; invasive blood pressure channel P3/P7.
- Key for pressure zeroing.

The E-P module consists of the following main parts:

- STP Main Assembly
- Connector for an invasive blood pressure sensor; invasive blood pressure channel P3/P7.
- Key for pressure zeroing.

The E-PP module consists of the following main parts:

- STP Main Assembly
- Connectors for an invasive blood pressure sensors; invasive blood pressure channels P5 and P6.
- Keys for pressure zeroing.

Communication between the module and the monitor 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 module bus are established via 25-pin D-type connector at the back of the module.

1.3.1 Controls and connectors

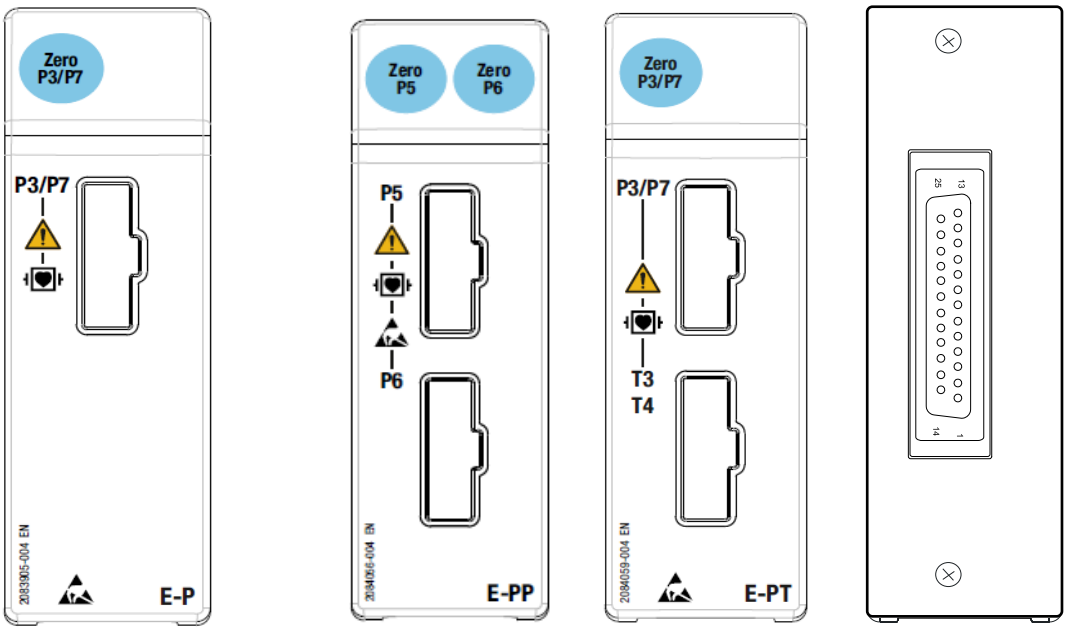


Figure 3 Front panel of E-P, E-PT and E-PP Modules and the back of the module

NOTE: The invasive pressure connector in the E-P and the E-PT module is labelled either as a P3 or as a P3/P7. However, the monitor software always identifies this invasive pressure port as P7 channel.

Module keys	**Module**	**Description**
Zero P3/P7	E-P, E-PT	Zero P7
Zero P5	E-PP	Zero P5
Zero P6	E-PP	Zero P6
Connector	**Module**	**Description**
P3/P7	E-P and E-PT	Invasive blood pressure
P5 and P6	E-PP	Invasive blood pressure
T3, T4	E-PT	Temp connector
D25 connector	E-P, E-PT, E-PP	Module bus connector

1.3.2 STP Main Assembly

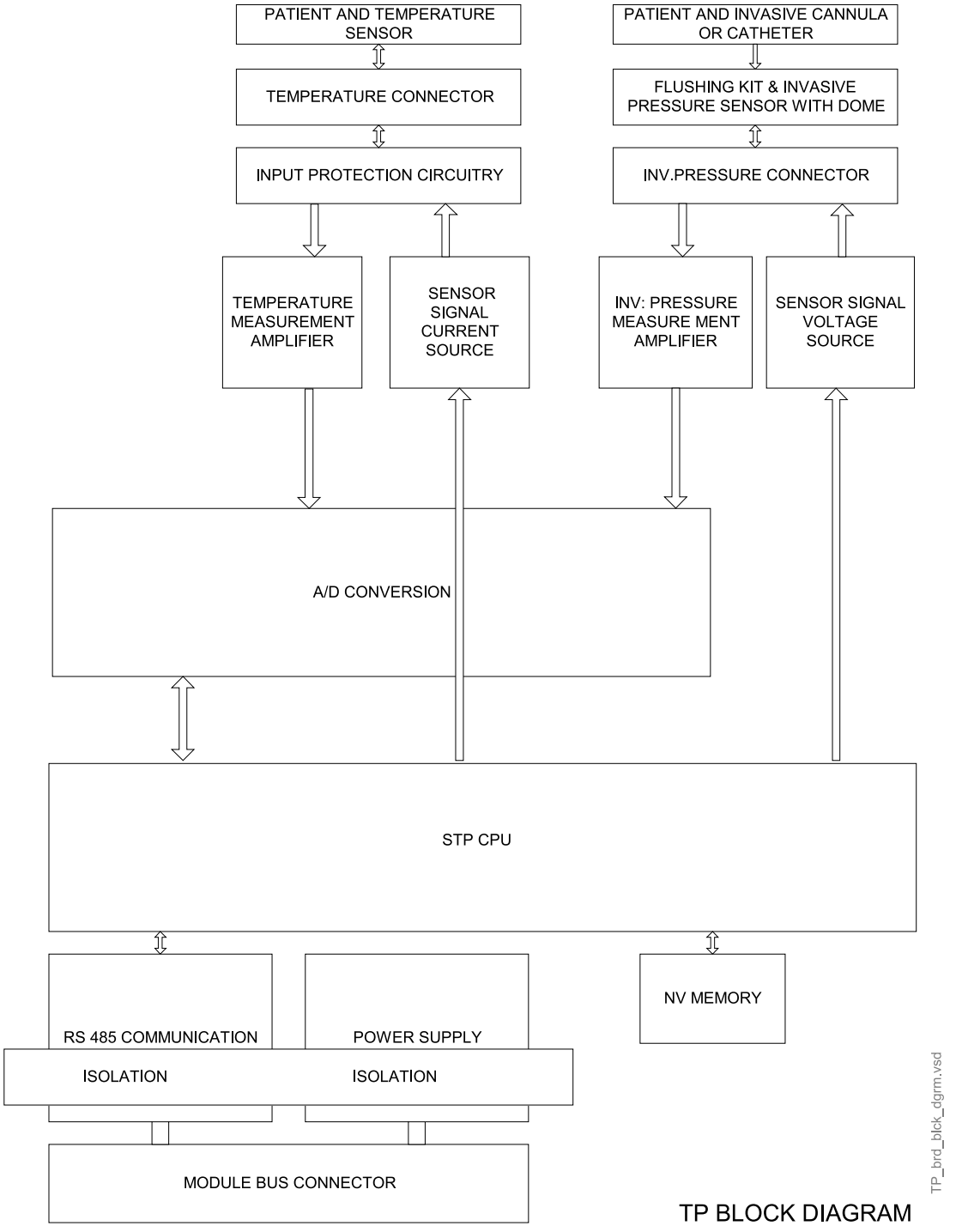


Figure 4 Block diagram - STP Main Assembly and input connectors

Microprocessor unit

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

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.

The constant current source supplies a 38 µA current through the temperature sensor (400 series NTC resistor). The constant current causes 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 main assembly through an A/D converter.

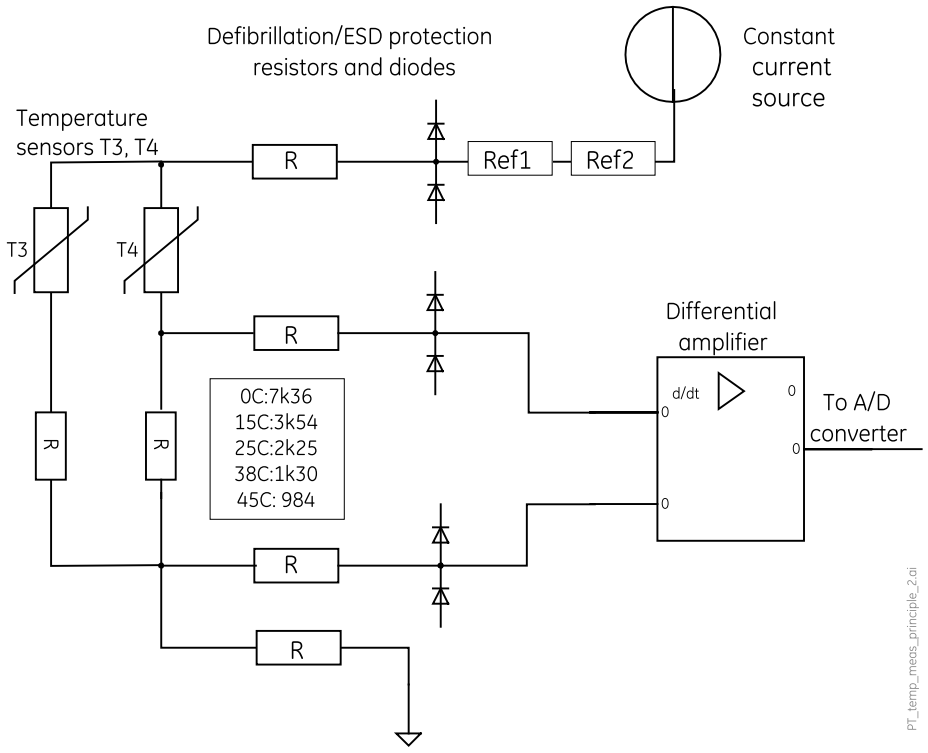


Figure 5 Temperature measurement principle

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.

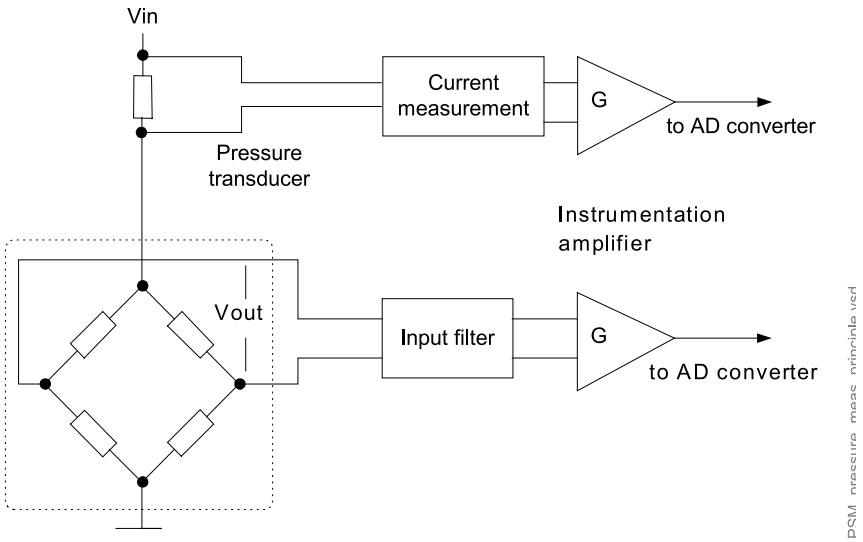


Figure 6 Pressure measurement principle

Serial communication

An RS485 type bus driver makes the serial communication between the module and monitor. Data transmission rate is 500kbps.

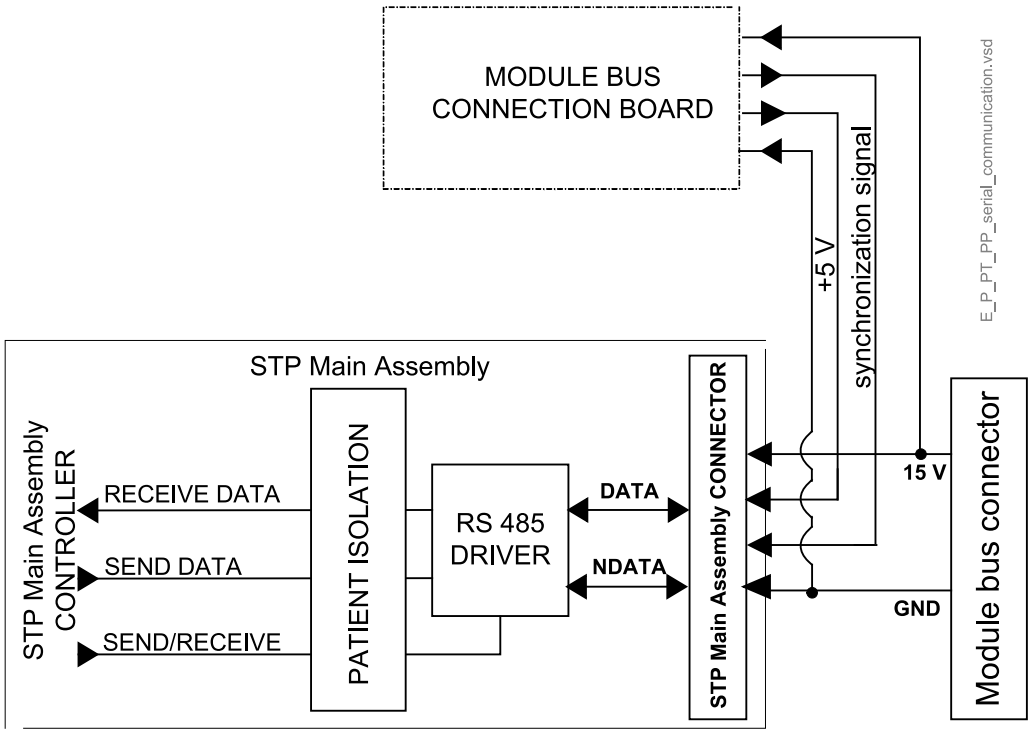


Figure 7 Serial communication of E-P, -PT and E-PP modules

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 Main Assembly is made with the switching power supply connected to a high voltage isolated transformer. The switching power supply on the STP Main Assembly 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 STP Main Assembly. The module receives only Vmod 13.8 - 16 V voltage from the module bus. 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 Configuration

2.1 P/PT/PP-setting

The E-P, E-PT and E-PP modules include the STP board and software. The P/PT/PP-setting defines the parameter set the module is capable to measure. This setting is stored into the permanent memory of the module.

The P/PT/PP-setting should be always checked and, if necessary, reconfigured after the STP main assembly has been replaced.

WARNING **Incorrect STP/TP/ST setting may cause erroneous operation of the module.**

2.1.1 Configuration

1. Disconnect all other parameter modules from the monitor, except the one you are configuring.

NOTE: The STP-setting can be configured only for one module at a time. Presence of several modules may cause the configuration to fail.

2. Log on to Webmin.
3. Select the ***Configuration*** –tab.
4. Select ***Modules > P/PT/PP-setting.***
5. Check the ***current configuration*** for the P/PT/PP modules. If the current configuration is incorrect, proceed to the next step and reconfigure it. Otherwise, leave the P/PT/PP-setting menu without changes.
6. Select the correct ***new configuration*** from the drop-down menu according to the following table.

NOTE: The picture may be slightly different compared to the monitor screen.

Module	New configuration
E-P	P
E-PT	PT
E-PP	PP

7. Select ***Submit***

Activation and verification

The new P/PT/PP-setting will come into effect only after the module is restarted. To restart the module:

1. Disconnect the configured module and wait for approximately 5 seconds.
2. Reconnect the module.
3. Update the Webmin-page. (Refresh the web or local browser).

4. Check that the ***current configuration*** is now correct for the module.
5. Reconnect all other modules.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual Inspections
2. 3.2. Electrical Safety Tests
3. 3.3. Functional check

3.1 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 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

3.2 Electrical Safety Tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual, chapter Installation checkout. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 5-31.

3.3 Functional check

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

3.3.1 Test setup

Required tools

– A multiparameter patient simulator with adapter cables to GE invasive pressure and temperature connectors

– Dual temperature adapter cable

NOTE: See the CARESCAPE monitor supplemental information manual for compatible accessories.

Connections

Ensure that the module is connected to the monitor.

Temperature:

- Connect the dual temperature adapter cable to the brown temperature connector in the module and check that it is configured for 400 series probes.
- Connect the multiparameter patient simulator with its temperature adapter cables to the dual temperature adapter cable.

Invasive pressure:

- Connect the dual invasive pressure adapter cable to the red invasive pressure connector in the module.
- Connect the multiparameter patient simulator with its invasive pressure adapter cables to the dual invasive pressure adapter cable.

Module	Invasive pressure channel	Temperature channel
E-P	P3 / P7	-
E-PT	P3 / P7	T3 and T4
E-PP	P5 and P6	-

NOTE: The invasive pressure connector in the E-P and the E-PT module is labelled either as a P3 or as a P3/P7. However, the monitor software always identifies this invasive pressure port as a P7 channel.

Monitor configuration

Invasive pressure:

1. Configure the Px waveform fields for the tested invasive pressure channels to the monitor screen with adequate priority.
2. Select the ***Px***-tab in the ***Invasive Pressure–***menu and configure:
   Label: Px
   Scale (mmHg): 0-200 mmHg
   Parameter Format: Sys/Dia (Mean)

NOTE: The 'x' in the Px refers to the invasive pressure channels being tested (see table above).

Temperature:

1. Configure the T3 and T4 parameter windows to the monitor screen with adequate priority.

2. Select the ***T3, T4***-tab in the ***Temperatures–***menu and configure:
   T3 Measurement: On
   T4 Measurement: On

Simulator configuration

1. Configure the simulator invasive pressure channels as follows:
   Sensitivity: 5 µV/V/mmHg
   InvBP output:"0 mmHg static pressure" or "atmosphere"
   Temperature: 37 °C

NOTE: Refer to the simulator documentation for details on how to use and configure the simulator.

3.3.2 Invasive pressure tests

Perform the following steps to all invasive pressure channels in the module.

NOTE: The 'x' in the Px refers to the invasive pressure channel being tested

1. Zeroing
   a. Ensure that the simulator InvBP output channel is configured to "0 mmHg static pressure" or "atmosphere".
   b. Zero the tested invasive pressure channels by pressing the related **Zero Px** module key.
   c. Check that a message "Zeroing" followed by a message "Zeroed" is shown in the Px parameter windows.

2. Static Pressure
   a. Configure the simulator InvBP output channel to "200 mmHg static pressure".
   b. Check that a flat pressure line appears on the related Px waveform field. The reading in the parameter window shall be 200 ± 10 mmHg.

NOTE: Recalibration is needed, if the measured value is not within the specification limits. Calibrate the invasive pressure channels according to the instructions in section 4.1. Invasive Pressure Calibration.

3. Pressure Waveforms
   a. Configure the simulator's InvBP output channel to "Arterial 120/80".
   b. Check that the pressure waveform for the tested invasive pressure channel appears in the Px waveform window and the Sys/Dia (Mean) pressure values are shown in the related parameter window.
4. Mark this task as complete on the checkout form.

3.3.3 Temperature tests

Perform the following steps to the both temperature channels in the E-PT module.

NOTE: The 'x' in the Tx refers to the temperature channel being tested

5. Temperature test
   a. Check that reading in the Tx temperature channel is 37 ± 0.1 °C and that no error messages are shown.

NOTE: Recalibration is needed, if the measured value is not within the specification limits. Calibrate the temperature channels according to the instructions in section 4.2. Temperature Calibration".

NOTE: NOTE: You can alternatively perform the above test using a "temperature test set", P/N 884515-HEL. Test each temperature channel with both test plugs. The reading in the Tx temperature channel shall be within ± 0.1°C of the nominal value.

6. Mark this task as complete on the checkout form.

3.3.4 Test completion

Select ***Discharge patient*** or ***Reset case*** from Data & Pages to discard any changes made to the monitor configuration during checkout.

7. Complete on the "Maintenance check form" on page 5-31.

4 Calibration and adjustments

4.1 Invasive Pressure Calibration

Invasive pressure calibration shall be performed:

- whenever the pressure transducer in use is replaced with a new type of transducer
- if the invasive pressure calibration check in section "3.3.2" failed.
- if the measured value is not within the specification limits.

4.1.1 Calibration setup

Required tools

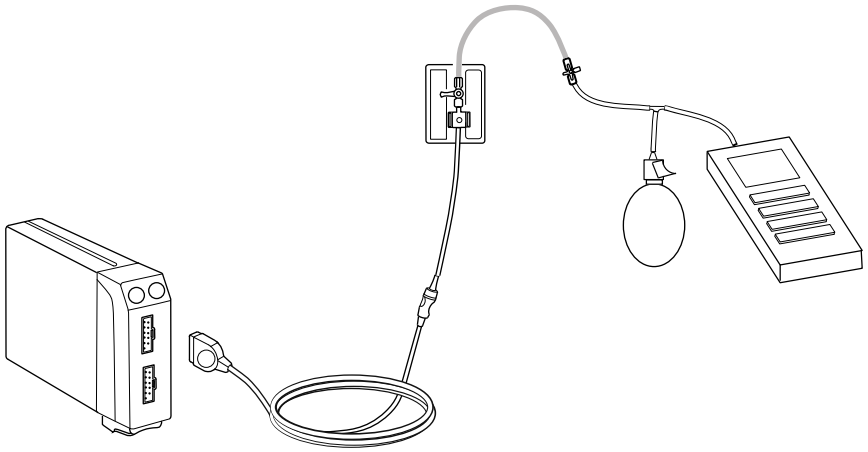
– A pressure manometer
– Transducer adapter cable
– Invasive pressure transducer

NOTE: See the CARESCAPE monitor supplemental information manual for compatible accessories.

NOTE: Pressure transducer is a key component in the measurement setup. If possible, perform the invasive pressure calibration with the same type of pressure transducer that is used in daily clinical use.

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

Connections



- Ensure that the module is connected to the monitor.
- Connect the transducer adapter cable to the red Inv BP connector in the module.
- Connect the invasive pressure transducer to the transducer adapter cable
- Connect the pressure manometer with a pressure pump to the transducer's pressure line with a piece of tubing

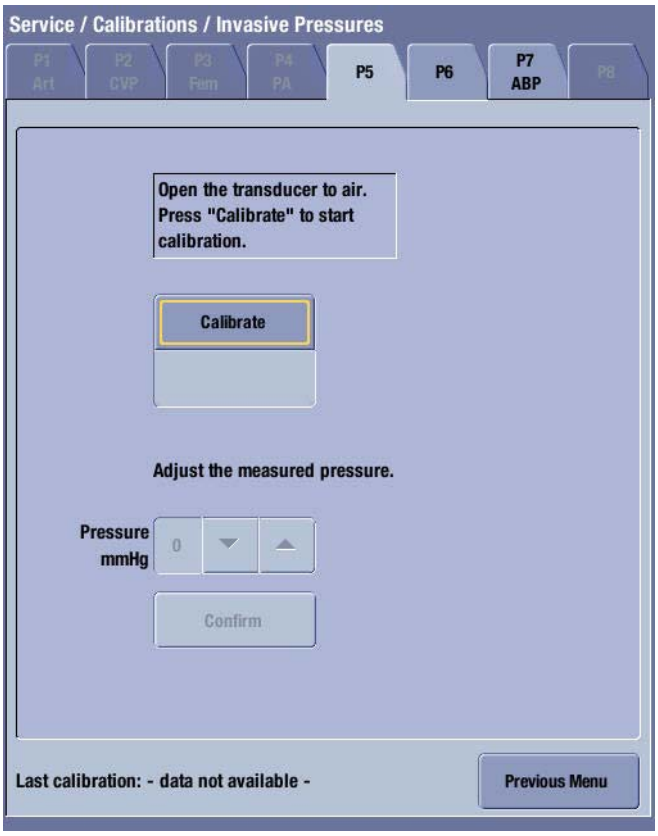
4.1.2 Procedure

1. Select ***Monitor Setup > Service Calibrations***

2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Invasive Pressures***
4. Select the tab for the Invasive Pressure channel you want to calibrate

Module	Inv BP channel
E-PP	P5 or P6
E-P or E-PT	P3 / P7

NOTE: The invasive pressure connector in the E-P and the E-PT module is labelled either as a P3 or as a P3/P7. However, the monitor software always identifies this invasive pressure port as P7 channel.



5. Prepare the transducer for the zeroing by opening the dome stopcock to room air
6. Select ***Calibrate***
7. The monitor will start automatic zeroing of the invasive pressure channel. Wait until the message 'Zeroing' is replaced by a message 'Zero Ok'
8. Pump a 200 mmHg ± 100 mmHg static pressure with the pressure pump when a message 'Create 200 mmHg pressure' is shown. The pressure measured by the module is updated in real-time to the calibration menu.
9. When the pressure is stabilized, check the pressure reading from the manometer.
10. Use the up-down spinner control in the calibration menu to adjust the reading measured by the module to match with the manometer reading. Select ***Confirm*** to complete the calibration when the 2 readings match each other.
11. Wait until a message 'calibrated' is shown.

Repeat the above procedure, steps 4 through 11, for the other invasive pressure channel in the E-PP module.

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

NOTE: A message 'Calibration Error' is shown, if you do not start inflating the pressure within 45 seconds after the automatic zeroing is completed, or if the calibration fails.

4.2 Temperature Calibration

Temperature calibration shall be performed:

- if the temperature calibration check in section "3.3.3" failed.
- if the measured value is not within the specification limits.

4.2.1 Setup

Required tools

– P/N 884515-HEL, Temperature calibration plugs

– Dual temperature adapter cable

NOTE: See the CARESCAPE monitor supplemental information manual for compatible accessories.

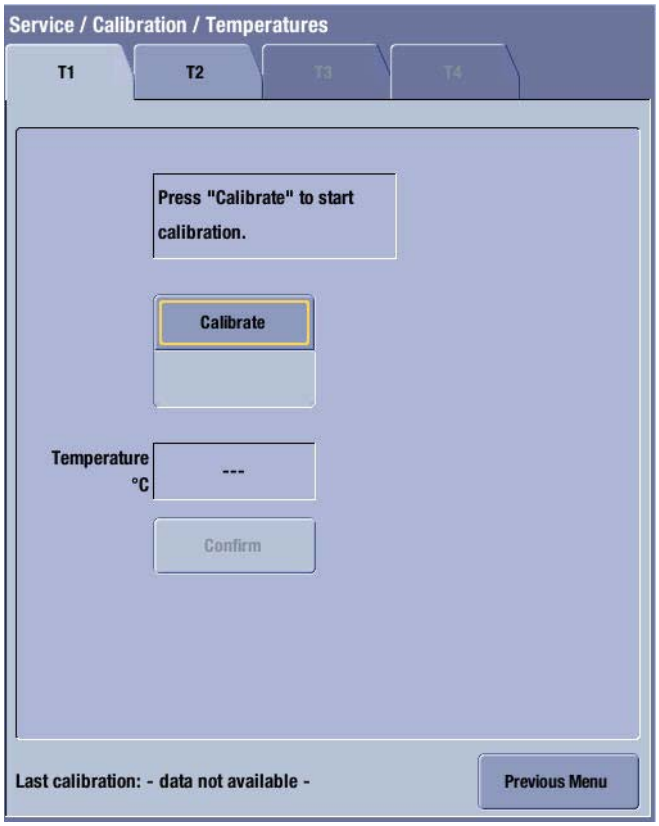
NOTE: Use only accurate, properly maintained, calibrated and traceable calibration tools for the calibration to ensure accuracy.

Connections

- Ensure that the module is connected to the monitor.
- Connect the dual temperature adapter cable to the brown temperature connector in the module.
- Check that the dual temperature adapter cable is configured for 400 series probes.

4.2.2 Procedure

1. Select ***Monitor Setup*** - ***Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Temperatures***
4. Select tab for the temperature channel ***T3*** or ***T4***, you want to calibrate.



5. Select ***Calibrate*** to start the calibration procedure.
6. Wait until a message '*Plug in 25 °C*' is shown. Plug in the temperature calibration plug labeled with TEMP 25°C/77°F to the dual temperature adapter cable connector T1 (=temperature channel T3) or T2 (=temperature channel T4).
7. Wait until the value is shown in the Temperature °C -field and select ***Confirm***.
8. Wait until a message 'Plug in 45 °C' is shown. Plug in the temperature calibration plug labeled with TEMP 45°C/113°F to the dual temperature adapter cable connector T1 (=temperature channel T3) or T2 (=temperature channel T4).
9. Wait until the value is shown in the Temperature °C -field and select ***Confirm***.
10. Wait until a message 'calibrated' is shown.

Repeat the above procedure, steps 3 through 10, for other temperature channel in the E-PT module.

NOTE: If calibration is not preceded within 30 seconds, the calibration is stopped automatically.

5 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 to the patient monitor's user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

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

5.1 Visual inspection

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

- the front cover is intact
- all connectors are intact, clean and are attached properly
- the module box and latch are intact

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

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module

5.2 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:

- If only part of the parameters are working, ensure the STP-setting is correct.
- 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.

5.3 Service Interface

Use the Webmin service interface to access device information, configuration information and service logs.

5.3.1 Configuration information

The Configuration Information module shows the current service configuration of the system and the modules. Disconnect all other modules from the monitor, except the E-P, E-PT or E-PP module.

To view Configuration information:

1. Logon to the Webmin -application.

2. Select the ***Information*** -tab.
3. Select ***Configuration Information***
4. Check that the P/PT/PP setting for the module is correct.

5.3.2 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information*** -tab.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.3 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the E-PP, E-PT, E-P module.

- ***Clinical Log*** is used for recording different system events, messages, clinical alarms, user interactions and internal communication events. The messages are explained in detail later in this chapter.
- ***Embc Frame Logs*** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs.

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin:

1. Log on to the Webmin -application.
2. Select the ***Diagnostics*** -tab.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media:

1. Log on to the Webmin -application.
2. Select the ***Diagnostics*** -tab.
3. Select ***Download Logs***.
4. Select one of the log files for downloading.

NOTE: Depending on the CARESCAPE Monitor type, the log file downloading may be enabled only through remote Webmin access with a service laptop.

5.4 Messages

5.4.1 Invasive Pressure

The messages below appear in the InvBP parameter window (PW), InvBP waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible Solutions
No P5 transducer No P6 transducer No P7 transducer	MF	Pressure transducer and/or transducer adapter cable disconnected from the module.	Connect pressure transducer and/or transducer adapter cable to the module.
Not zeroed IPs not zeroed	PW, WF MF	There is at least one invasive pressure channel, which is not zeroed.	Zero all invasive pressure channels
P5 Over range P6 Over range P7 Over range '>320mmHg' or '>43 kPa'	MF MF MF PW	Measured pressure exceeds 320 mmHg / 43 kPa measurement limit. Transducer not zeroed correctly.	The measurement range is between –40 mmHg and 320 mmHg. Zero the invasive pressure channel.
P5 under range P6 under range P7 under range '<-40 mmHg' or '<-5 kPa'	MF PW	Measured pressure exceed -40 mmHg /-5 kPa measurement range. Transducer is not zeroed correctly.	The measurement range is between -40 mmHg and 320 mmHg. Zero the invasive pressure channel.
Pressure measurement removed	MF	The module is disconnected.	Reconnect the module.
Identical IP5 modules Identical IP6 modules Identical IP7 modules	MF	Identical IP modules. The monitor detects the same IP channel from two or more modules..	Remove one of the modules providing identical IP channel.
Calibrating	PW	Calibration of an invasive pressure channel is in progress.	Wait until calibration is completed successfully.
Calibration failed	PW	Pressure calibration failure due to time-out. Pulsating waveform detected during calibration. Gain is beyond the limits (± 20% of the default gain)	Re-calibrate. Start inflating the pressure within 45 seconds after the automatic zeroing is completed. Check the manometer reading to ensure that a static 100-300 mmHg pressure is present for calibration Replace the transducer and re-calibrate.

Message	Location	Possible causes	Possible Solutions
Calibrated	PW	Calibration of an invasive pressure channel is completed successfully.	No actions.
Zeroing	PW	Zeroing of an invasive pressure channel is in progress.	Wait until zeroing is completed successfully.
Zeroing failed	PW	Pulsating waveform detected. Offset is > 150 mmHg. Defective transducer.	Open the transducer to room air and zero the channel. Replace the transducer, open it to room air and zero the channel.
Zero adj > 100 mmHg	PW	Offset when zeroing is > 100 mmHg (but <150 mmHg) from the absolute zero of the module (with default gain)	Check transducer. Re-zero the pressure channel.
Zeroed	PW	Zeroing of an invasive pressure channel is completed successfully	No actions.
Zero ICP separately	MF	ICP is an active IP channel and ***Zero All*** is performed	Zero the ICP channel separately.

5.4.2 Temperature

The messages below appear in the Temperature parameter window (PW) or the message field (MF).

Message	Location	Possible causes	Possible Solutions
Tx temperature error [x] refers to the temperature channel number	MF, PW	Calibration failure Hardware failure	Perform calibration. Check that front panel connectors are properly connected to the STP board. Replace STP board.
Performing temp test	PW	Automatic self-check is in progress	Wait until temperature self-check is completed. Check that no error messages appear to the screen.
Temperature measurement removed	MF	The module is disconnected.	Reconnect the module.

5.5 Troubleshooting chart

5.5.1 Invasive Pressure

Problem	Possible causes	Possible Solutions
Abnormally low pressure	Transducer wrongly positioned	Check mid-heart level and reposition transducer.
No Pressure	Defective transducer	Check or replace transducer
	Module not connected	Connect module.
	Transducer adapter cable not connected to the module	Connect the transducer adapter cable with the transducer to the module.
	Invasive pressure channel not configured to the screen (with adequate priority)	Configure the temperature channel to the screen ***(*Monitor Setup - *Screen Setup)*** with adequate priority and check that it is active.

5.5.2 Temperature

Problem	Possible causes	Possible Solutions
No temperature displayed	Temperature channel not configured to the screen (with adequate priority)	Configure the temperature channel to the screen ***(*Monitor Setup - *Screen Setup)*** with adequate priority and check that it is active.
	Incompatible temperature probe	Use correct probe (400 series)
	STP-setting incorrect.	Check the STP setting and configure, if needed.
	Faulty temperature probe	Replace temperature probe.
	Temperature out of measurable range.	The measurement range is between 10 and 45 °C

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module is limited to replacing faulty circuit boards and mechanical parts only (see chapter 7. Service parts" for details).

WARNING **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. Maintenance and checkout" after you have disassembled and reassembled the module.

6.1.1 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.
- Wear a grounded, antistatic wristband or heel strap 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.
- Store the semiconductors and electronic assemblies only in antistatic bags or boxes.
- Handle all PCB assemblies by their edges.
- Do not flex or twist a circuit board.

6.1.2 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.

6.1.3 Required tools

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

6.2 Disassembling and reassembling procedure

Disassembling the E-P, E-PT or E-PP (see the exploded view of the module in the chapter 7. Service parts"):

6.2.1 Replacing 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.

6.2.2 Detaching the STP main assembly

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 4 screws (T10) with nylon washers that secure the STP main assembly to the body plate.
4. Disconnect the front panel connector cable and the module bus connector from the STP main assembly.
5. Detach the STP main assembly.

6.2.3 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

7 Service parts

7.1 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. Maintenance and checkout" each time after you have opened the module casing.

7.2 Pressure and Pressure Temp Modules E-P, E-PT, E-PP

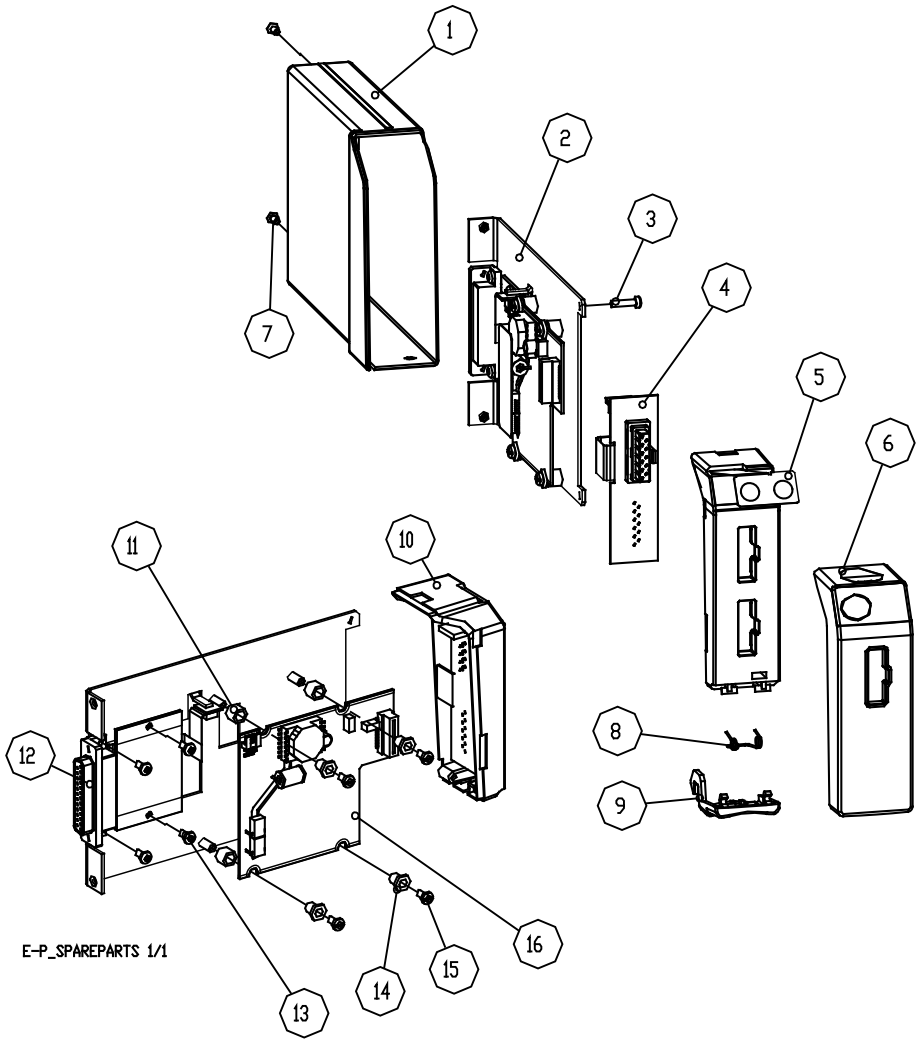


Figure 8 Exploded view, E-P

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	*
4	E-P Input board	M1025766
4	E-PP Input board	M1022749
4	E-PT Input board	M1021461
5	Membrane Keyboard	M1012126
7	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	*
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, machine, M3x6mm, DIN84 (ISO1207), slot head, cheese head, polyamide (nylon)	*
16	STP Main Assembly for E-P Module.	M1024765

*) Part is not available from GE. Source locally.

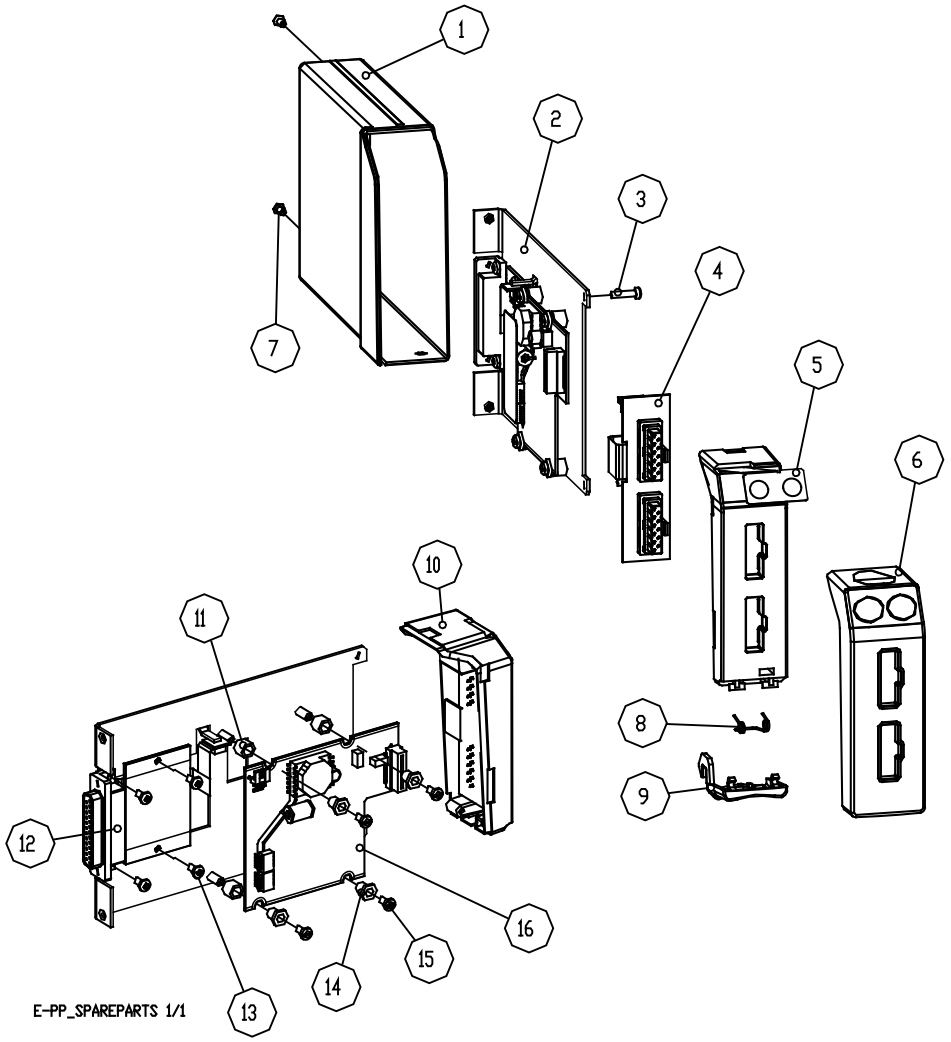


Figure 9 Exploded view, E-PP, E-PT

7.2.1 The front covers for E-P, E-PT, E-PP

Item	Description	Order No.
6	Front Cover, CS, E-P	2086265-015
6	Front Cover, DA, E-P	2086265-001
6	Front Cover, DE, E-P	2086265-002
6	Front Cover, ES, E-P	2086265-004
6	Front Cover, EN, E-P	2086265-003
6	Front Cover, FI, E-P	2086265-005
6	Front Cover, HU, E-P	2086265-014
6	Front Cover, IT, E-P	2086265-007
6	Front Cover, FR, E-P	2086265-006

Item	Description	Order No.
6	Front Cover, JA, E-P	2086265-008
6	Front Cover, NL, E-P	2086265-009
6	Front Cover, NO, E-P	2086265-010
6	Front Cover, PL, E-P	2086265-011
6	Front Cover, PT, E-P	2086265-012
6	Front Cover, SV, E-P	2086265-013
6	Front Cover, ZH, E-P	2086265-016
6	Front Cover, CS, E-PP	2085617-015
6	Front Cover, DA, E-PP	2085617-001
6	Front Cover, DE, E-PP	2085617-002
6	Front Cover, EN, E-PP	2085617-003
6	Front Cover, ES, E-PP	2085617-004
6	Front Cover, FI, E-PP	2085617-005
6	Front Cover, FR, E-PP	2085617-006
6	Front Cover, HU, E-PP	2085617-014
6	Front Cover, IT, E-PP	2085617-007
6	Front Cover, JA, E-PP	2085617-008
6	Front Cover, NL, E-PP	2085617-009
6	Front Cover, NO, E-PP	2085617-010
6	Front Cover, PL, E-PP	2085617-011
6	Front Cover, PT, E-PP	2085617-012
6	Front Cover, SV, E-PP	2085617-013
6	Front Cover, ZH, E-PP	2085617-016
6	Front Cover, CS, E-PT	2086271-015
6	Front Cover, DA, E-PT	2086271-001
6	Front Cover, DE, E-PT	2086271-002
6	Front Cover, EN, E-PT	2086271-003
6	Front Cover, ES, E-PT	2086271-004
6	Front Cover, FI, E-PT	2086271-005
6	Front Cover, FR, E-PT	2086271-006
6	Front Cover, HU, E-PT	2086271-014
6	Front Cover, IT, E-PT	2086271-007
6	Front Cover, JA, E-PT	2086271-008
6	Front Cover, NL, E-PT	2086271-009

Item	Description	Order No.
6	Front Cover, NO, E-PT	2086271-010
6	Front Cover, PL, E-PT	2086271-011
6	Front Cover, PT, E-PT	2086271-012
6	Front Cover, SV, E-PT	2086271-013
6	Front Cover, ZH, E-PT	2086271-016

Maintenance check form

Pressure Modules, E-P, E-PP, E-PT

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**
3.1. Visual Inspections	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. Invasive pressure tests				☐ ☐ ☐
3.3.3. Temperature tests				☐ ☐ ☐
3.3.4. Test completion				☐ ☐ ☐

Notes		

Used service parts			

Signature	Date

For your notes:

6

Masimo Module, E-MASIMO

Technical Manual

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1 Product overview

1.1 Introduction

This document 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. The device is intended to provide continuous monitoring of arterial oxygen saturation and pulse rate of hospitalized patients.

The E-MASIMO module uses the Masimo SET pulse oximetry technology.

Use only MASIMO SET sensors with the E-MASIMO module.

Masimo SET is a registered 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.**

CAUTION Incorrect sensor placement - prolonged monitoring or incorrect sensor application can cause skin irritation or impaired circulation. It is recommended that you check the probe site every four hours (more frequently for poor perfusion or for neonates). Refer to the intructions supplied with the sensor.

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).**

1.2 Main components

The E-MASIMO module consists of the following parts:

- SpO_2 board, MS-2011
- Sensor connector interface cable
- E-MASIMO interface board

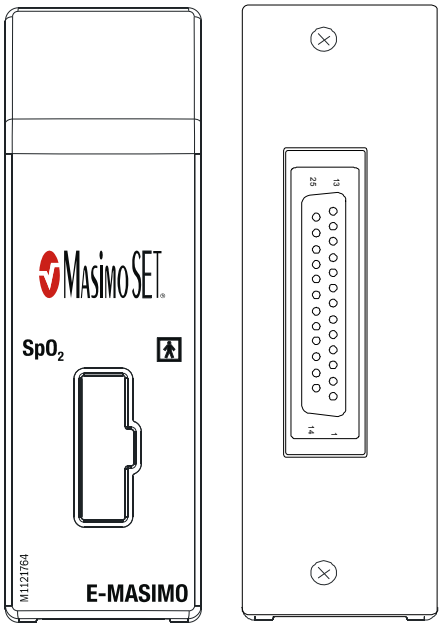


Figure 1 Front of Masimo Compatible Saturation Module, E-MASIMO, and the back of the module

Connector	Module	Description
SpO2	E-MASIMO	SpO2 connector
D25 connector	E-MASIMO	Module bus connector

Sensors can be plugged into the E-MASIMO module by using the MasimoSAT(R) interconnect cable. MasimoSAT(R) has two types of sensors: LNOP and LNCS. Refer to the supplemental information manual for E-Masimo specific interconnect cables and sensors.

The interconnect cable is plugged into a 11-pin connector on the front panel of the module.

1.2.1 Masimo SpO_2 board (MS-2011)

The Masimo MS-2011 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 SpO_2 and pulse rate values as well as status information are transferred from the MS-2011 to the E-MASIMO interface board. Communication between the MS-2011 and the 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 an RS485 serial interface.

1.2.2 E-MASIMO Interface board

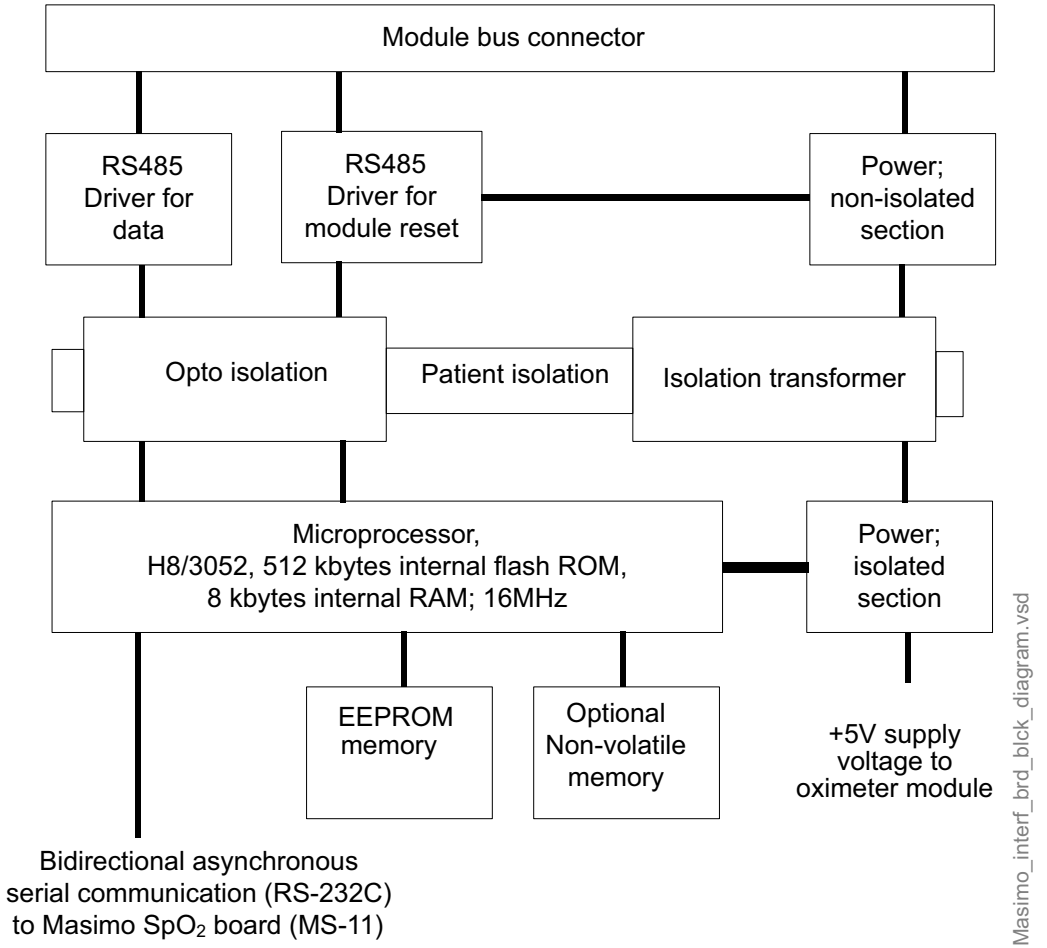


Figure 2 E-MASIMO Interface board block diagram

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 monitor. 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 V received from the module bus, 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 monitor are transferred through the patient isolation by high speed opto couplers.

Microprocessor, optional non-volatile memory

The microprocessor with an on-chip memory is used for converting and transferring data from the Masimo pulse oximeter MS-2011 to the monitor. The communication between MS-2011 and the CPU of E-MASIMO interface board is realized with bi-directional asynchronous serial communication.

The non-volatile memory is used for storing identification information such as a serial number, control number, date, etc.

2 Configuration

There is no configuration for the E-MASIMO module.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual inspections
2. 3.2. Electrical safety tests
3. 3.3. Functional check

3.1 Visual inspections

Detach the module from the module slot and check that:

- the front cover is intact
- all connectors are intact and attached properly
- the module box and latch are 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

NOTE: Mark this task as complete on the checkout form.

3.2 Electrical safety tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual, chapter Installation checkout. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 6-17

3.3 Functional check

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

3.3.1 Test setup

Required tools

– Masimo SpO_2 finger sensor, adult

– Masimo SpO_2 interconnect cable

NOTE: See the CARESCAPE monitor supplemental information manual for compatible accessories.

Connections

1. Ensure that the module is connected to the monitor.
2. Connect the SpO_2 interconnect cable to the SpO_2 connector in the module.
3. Connect the SpO_2 finger sensor to the SpO2 interconnect cable.

Monitor configuration

1. Configure the SpO_2 waveform field to the monitor screen with adequate priority.

3.3.2 SpO_2 test procedure

1. Connect the SpO_2 finger sensor to your finger. Wait until a pulse is found.
2. Check that the SpO_2 reading in the parameter window is between 90-100 and the plethysmographic waveform appears on the screen.

NOTE: You can verify the functionality of a pulse oximeter probe and monitor with a functional SpO_2 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.

3. Mark this task as complete on the checkout form.

3.3.3 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

4. Complete on the “Maintenance check form” on page 6-17.

4 Calibration and adjustments

There are no calibration or adjustments for the E-MASIMO module.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

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

- the front cover is intact
- all connectors are intact, clean and are attached properly
- the module box and latch are intact

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

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module
- Ferrite of the flex cable is attached properly

5.2 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the supplemental information manual.
- Check whether the module is identified as a primary or as a secondary SpO_2 channel and ensure that the screen configuration is done accordingly.
- Connect the accessories with a simulator to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (**Monitor Setup** - ***Screen Setup - Upper Parameter Area***).

- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.
- 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.

5.3 Service interface

Use the Webmin service interface to access device information and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the E-MASIMO module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information tab***.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and, alarms to help troubleshoot equipment problems. The following service logs may contain information related to the E-MASIMO module.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions, and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs.

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab.***
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***Download Logs***
4. Select one of the log files or snapshot files for downloading.

NOTE: Depending on the CARESCAPE Monitor type, the log file downloading may be enabled only through remote Webmin access with a service laptop.

5.4 Messages

The messages in the table below appear in the SpO_2 parameter window (PW), SpO_2 waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Probe off SpO2 probe off	PW MF	The SpO2 probe is not connected to the patient.	Connect the SpO2 probe to the patient.
No probe No SpO2 probe	PW MF	The SpO2 probe is not connected to the module.	Connect the SpO2 probe to the module.
Check probe Check SpO2 probe	PW MF	Red and infrared signals are not in balance.	Check the SpO2 probe and replace it, if needed.
Faulty probe Faulty SpO2 probe	PW MF	The probe is identified, but red and infrared leds take no current.	Replace the SpO2 probe.
Incompatible probe	PW	An incompatible SpO2 probe is detected by the monitor.	Replace the SpO2 probe with a compatible one.
Pulse search	PW	Searching pulse.	Wait until pulse is found.
Artifact	PW	Movement artifacts or shivering.	Try another measurement site.
Low signal quality	PW	Poor signal quality.	Try another measurement site or sensor.
Low perfusion	PW	Low perfusion at the measurement point.	Try another measurement site.
Interference	PW	Interference detected by the module.	Remove any sources of interferences.
Check device	PW	Module malfunction.	Check module operation and repair, if needed.
Identical SpO2 modules	MF	Two or more of the following modules are connected at the same time: E-NSAT, M-NSAT, E-NSATX, E-Masimo.	Connect only one of the listed modules at a time.
SpO2 measurement removed	MF	SpO2 module is disconnected form the module slot.	Reconnect the SpO2 module to the module bus.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module is limited to replacing faulty circuit boards or mechanical parts only (see chapter 7. Service parts for details).

WARNING **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. Maintenance and checkout after you have disassembled and reassembled the module.

6.1.1 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.

6.1.2 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.

6.1.3 Required tools

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

6.2 Disassembly and reassembly procedure

Disassembling the E-MASIMO Module (see the exploded view of the module in chapter 7. Service parts):

6.2.1 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.

6.2.2 To replace the Masimo SpO2 board or Masimo interface board

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 screw and the three nylon posts that secure the Masimo SpO_2 board to the Masimo interface board. Detach the Masimo SpO_2 board.
4. Detach the front cover (see 6.2.1).
5. Detach the Masimo interface board by removing the two screws located near the front chassis unit. Disconnect the SpO_2 connector cable from the SpO_2 interface board and pull out the front chassis unit.

6.2.3 Reassembling the module

Reverse the order of the disassembly steps.

NOTE: When reassembling the module, make sure that the pin connector on the Masimo SpO_2 board connects properly to the connector on the Masimo interface board underneath.

Check that:

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module
- ferrite of the flex cable is attached properly

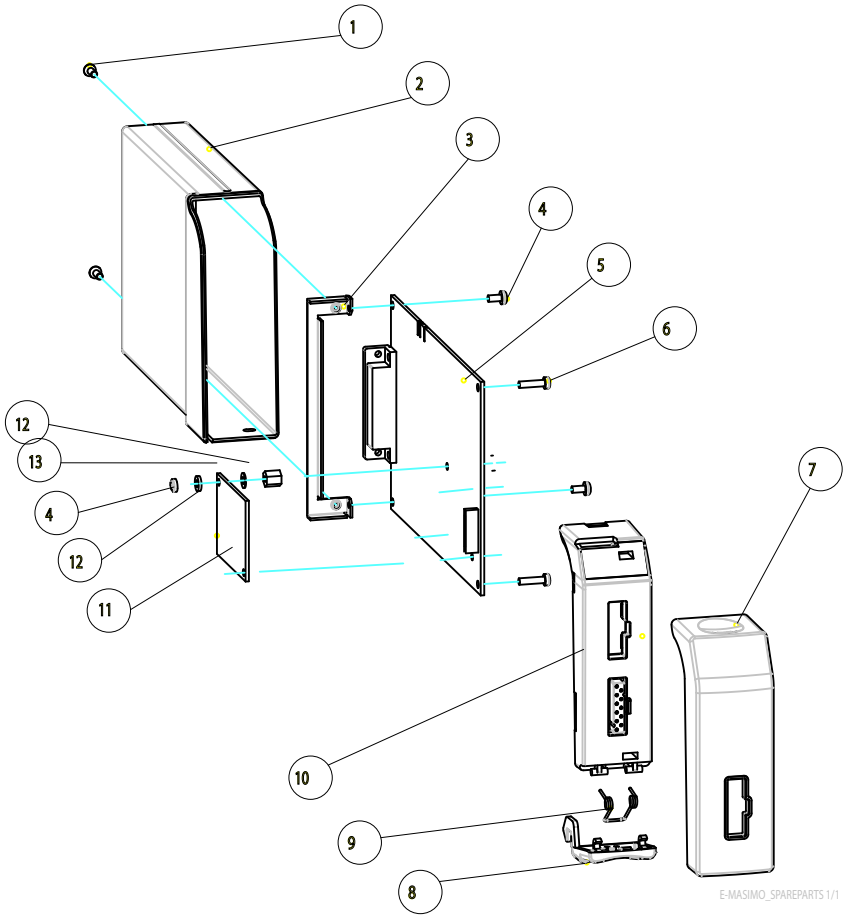
7 Service parts

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout after you have replaced any of the service parts listed below.

7.1 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.

7.2 Masimo compatible Saturation Module, E-MASIMO



Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel, zinc coated	*
2	Module Casing, Single, Injection molded	M1021035
3	Metal frame	879184
4	SCREW, machine screw, 3x6, DIN7985, ISO7045, TORX	*
5	Masimo Interface board, E-MASIMO	2081822-001
6	SCREW, screw for plastic,3.0 x12mm, torx head,	*
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)	2081821-001
11	OEM-ITEM, Masimo MS-2011 SpO2 board	2081823-001
12	MOUNTING, M3 threaded hexagonal spacer, L 7mm, D max 5.5mm, brass	640409-HEL

*) Part is not available from GE. Source locally.

For your notes:

Maintenance check form

Masimo Module, E-MASIMO

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**
3.1. Visual inspections	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. SpO2 test procedure				☐ ☐ ☐
3.3.3. Test completion				☐ ☐ ☐

Notes		

Used service parts			

Signature	Date

For your notes:

7

Nellcor Compatible Module, E-NSAT, E-NSATX Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the Nellcor Compatible Saturation Module, E-NSAT/E-NSATX. The E-NSAT/E-NSATX is a single width plug-in module.

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.

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 **Environmental conditions may cause inaccurate readings and alarms, decreased perfusion, and /or low signal strength. These conditions include: excessive ambient light, electrical interference, defibrillation, and excessive patient /sensor motion.**

1.2 Main components

The E-NSAT module consists of the following parts:

- Sensor connector cable
- Nellcor Pulse Oximeter board MP-100
- NSAT interface board (NIO)

The E-NSATX module consists of the following parts:

- Sensor connector cable
- Nellcor Pulse Oximeter board NELL1GE
- NSAT interface board (NIO)

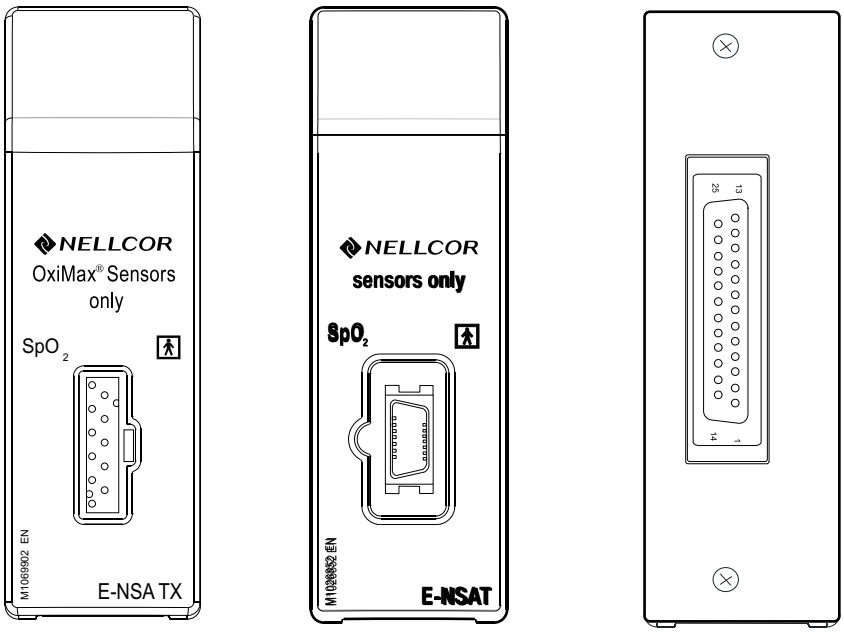


Figure 1 Front of Nellcor Compatible Saturation Module, E-NSAT and E-NSATX, and the back of the module

Connector	Module	Description
SpO2	E-NSAT, E-NSATX	SpO2 connector
D25 connector	E-NSAT, E-NSATX	Module bus connector

1.2.1 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.

1.2.2 E-NSATX

Sensors can be plugged into the E-NSATX module using the Nellcor OxiMax Spo2 interconnect cable. 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 SpO2 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.

1.2.3 NIO Interface board

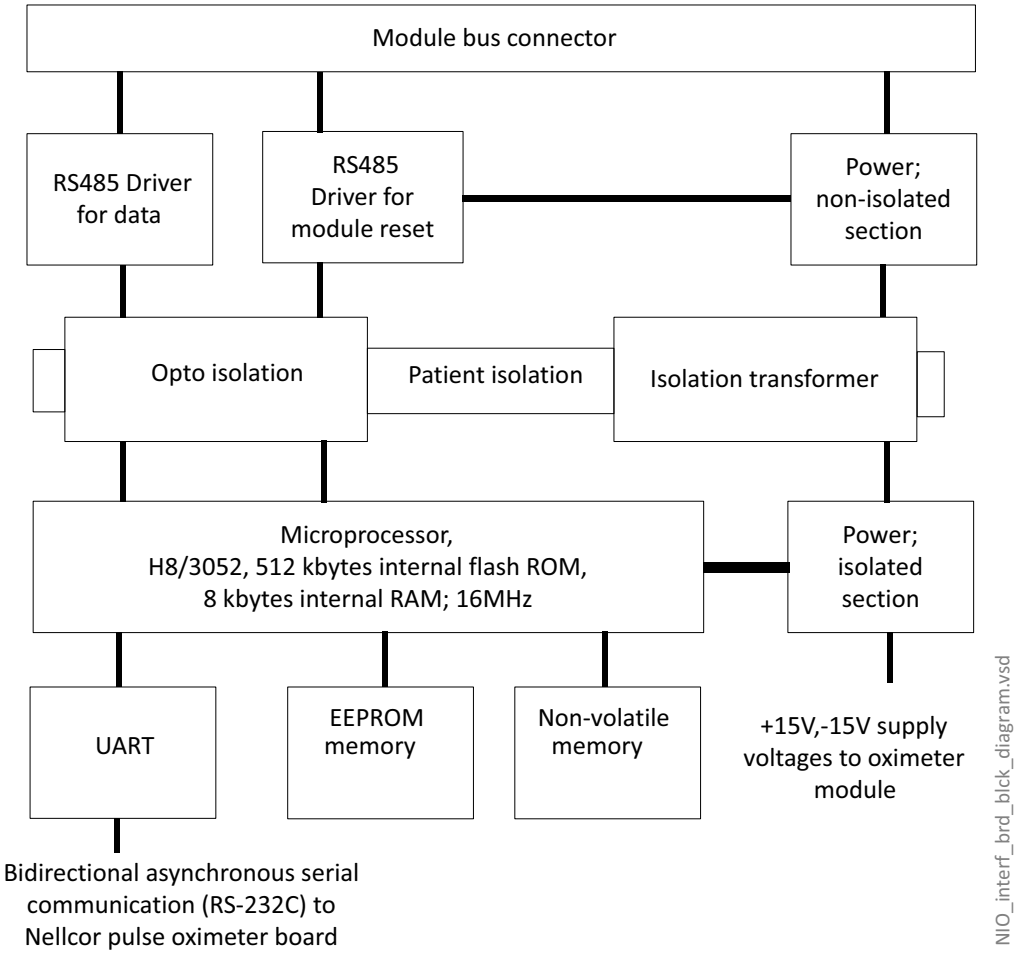


Figure 2 NIO Interface board block diagram

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 monitor. 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 V received from the central bus, 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.

Opto isolation

The signals of the serial communication bus between the NIO Interface board and the monitor are transferred through the patient isolation by high speed opto couplers.

Microprocessor, UART, non-volatile memory

The microprocessor with an on-chip memory is used for converting and transferring data from the Nellcor pulse oximeter board to the monitor.

The communication between the Nellcor pulse oximeter board 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 Configuration

There is no configuration for the E-NSAT and E-NSATX modules.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual inspections
2. 3.2. Electrical safety tests
3. 3.3. Functional check

3.1 Visual inspections

Detach the module from the module slot and check that:

- the front cover is intact
- all connectors are intact and attached properly
- the module box and latch are 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

3.2 Electrical safety tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual, chapter Installation checkout. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 7-21

3.3 Functional check

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

3.3.1 Test setup

Required tools

– Nellcor SpO_2 Interconnect cable

– Nellcor SpO_2 Finger sensor, adult

NOTE: See the supplemental information manual for compatible accessories.

Connections

1. Ensure that the module is connected to the monitor.
2. Connect the SpO_2 Interconnect cable to the SpO_2 connector in the module.
3. Connect the SpO_2 finger sensor to the SpO2 interconnect cable.

Monitor configuration

1. Configure the SpO_2 waveform field to the monitor screen with adequate priority.

3.3.2 SpO_2 test procedure

1. Connect the SpO_2 finger sensor to your finger. Wait until a pulse is found.
2. Check that the SpO_2 reading in the parameter window is between 90-100 and the plethysmographic waveform appears on the screen.

NOTE: You can verify the functionality of a pulse oximeter probe and monitor with a functional SpO_2 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.

3. Mark this task as complete on the checkout form.

3.3.3 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

4. Complete on the “Maintenance check form” on page 7-21.

4 Calibration and adjustments

There are no calibration or adjustments for the E-NSAT and E-NSATX modules.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

NOTE: Perform the checkout procedure described in section 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

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

- the front cover is intact
- all connectors are intact, clean and are attached properly
- the module box and latch are intact

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

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

5.2 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.
- Check whether the module is identified as a primary or as a secondary SpO_2 channel and ensure that screen configuration is done accordingly.
- Connect the accessories with a simulator to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (***Monitor Setup*** > ***Screen Setup > Upper Parameter Area***).

- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.
- 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.

5.3 Service interface

Use the Webmin service interface to access device information and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the E-NSAT/E-NSATX module is connected to the monitor.

1. Log on to the Webmin application.
2. Select the ***Information tab***.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the E-NSAT/E-NSATX module.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions, and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs.

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***Download Logs***
4. Select one of the log files or snapshot files for downloading.

NOTE: Depending on the CARESCAPE Monitor type, the log file downloading may be enabled only through remote Webmin access with a service laptop.

5.4 Messages

The messages in the table below appear in the SpO2 parameter window (PW), SpO2 waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Probe off' SpO2 probe off'	PW MF	SpO2 probe is not connected to the patient. NOTE: E-NSATX only	Connect the SpO2 probe to the patient.
No probe' No SpO2 probe'	PW MF	SpO2 probe is not connected to the module.	Connect the SpO2 probe to the module.
Check probe' Check SpO2 probe'	PW MF	Red and infrared signals are not in balance.	Check the SpO2 probe and replace it if needed.
Faulty probe' Faulty SpO2 probe'	PW MF	Probe is identified, but red and infrared leds take no current. NOTE: E-NSATX only	Replace the SpO2 probe.
Pulse search'	PW	Searching pulse.	Wait until pulse is found.
Artifact'	PW	Poor perfusion, movement artifacts, or shivering.	Try another measurement site.
Interference'	PW	Interference detected by the module.	Remove any sources of interferences.
Check device'	PW	Module malfunction.	Check module operation and repair, if needed.
Identical SpO2 modules'	MF	Two or more of the following modules are connected at the same time: E-NSAT, M-NSAT, E-NSATX, E-Masimo.	Connect only one of the listed modules at a time.
SpO2 measurement removed'	MF	SpO2 module is disconnected from the module slot.	Reconnect the SpO2 module to the module slot.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module is limited to replacing faulty circuit boards or mechanical parts only (see chapter 7. Service parts for details).

WARNING **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. Maintenance and checkout each time after you have opened the module casing.

6.1.1 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.

6.1.2 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.

6.1.3 Required tools

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

6.2 Disassembly and reassembly procedure

Disassembling the E-NSAT/E-NSATX module (see the exploded view of the module in chapter 7. Service parts):

6.2.1 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.

6.2.2 To replace the Nellcor pulse oximetry board or the NIO interface board

1. 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. Remove the 2 screws that secure the Nellcor pulse oximetry board to the NIO interface board. Detach the pulse oximetry board.
4. Detach the front cover (see 6.2.1).
5. Detach the NIO interface board by removing the two screws located near the front chassis unit. Disconnect the SpO2 connector cable from the Nellcor pulse oximetry board and pull out the front chassis unit.

6.2.3 Reassembling the module

Reverse the order of the disassembly steps.

NOTE: When reassembling the module, make sure that the pin connector on the Nellcor pulse oximetry board connects properly to the connector on the NIO interface board underneath.

Check that:

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module

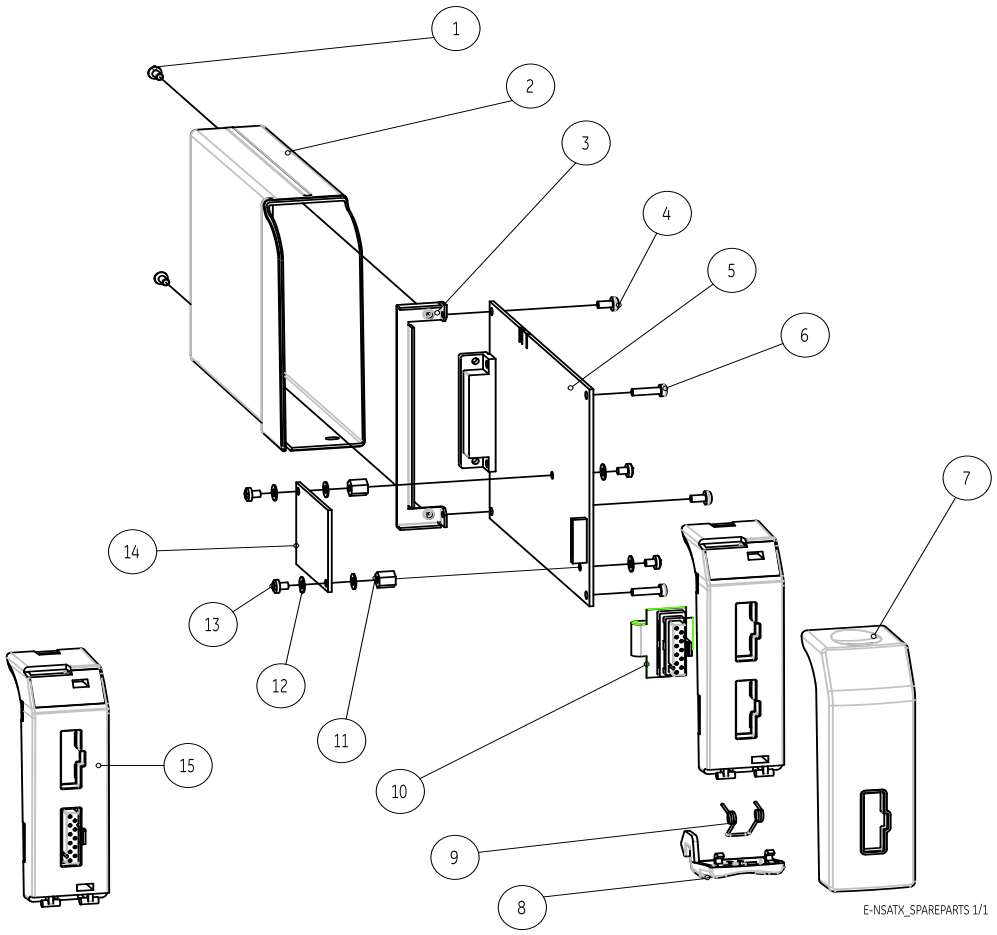
7 Service parts

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. Maintenance and checkout each time after you have opened the module casing.

7.1 Service parts for Nellcor compatible Saturation Module, E-NSATX

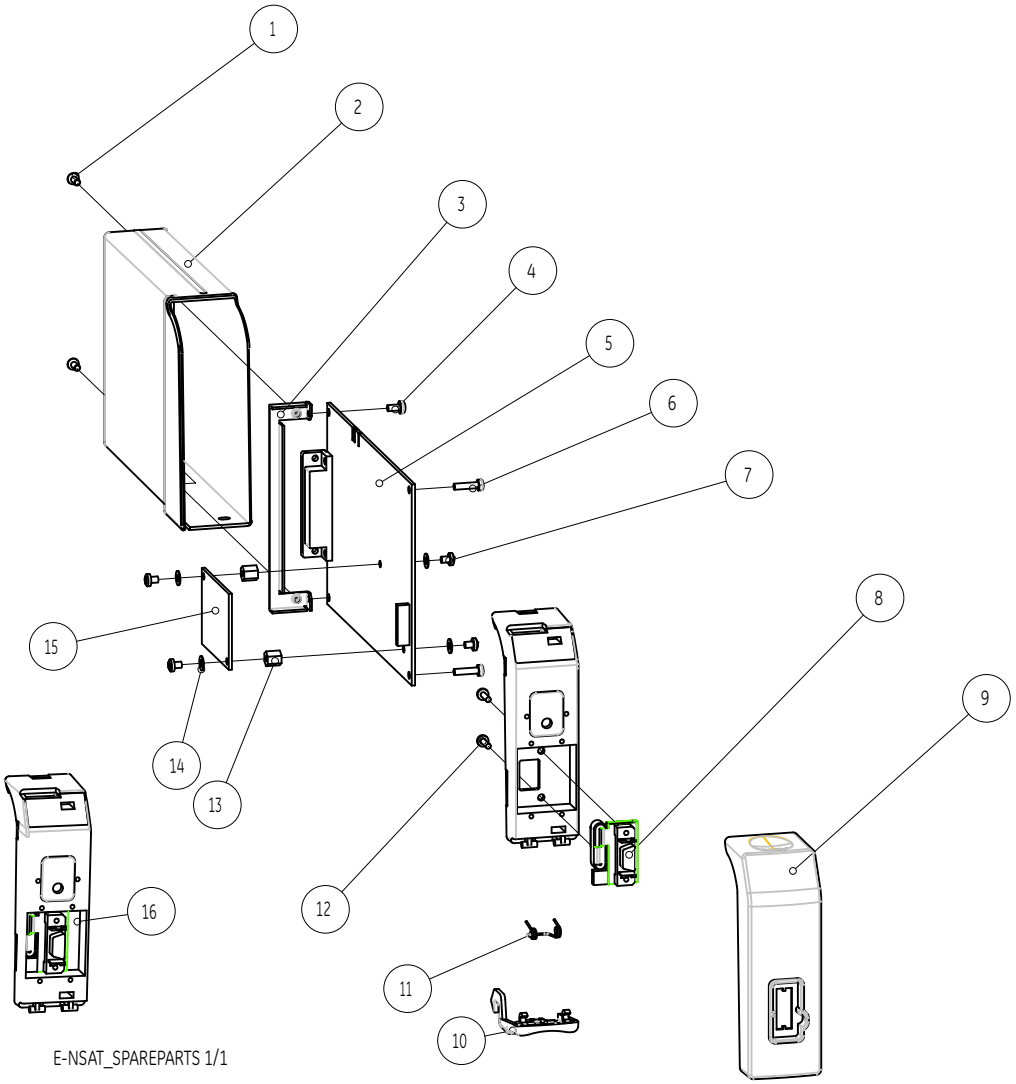


Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat	*
2	Module Casing, Single	M1021035
3	Metal Frame	879184
4	SCREW, machine screw, 3x6mm, DIN7985, ISO7045, torx	*
5	NELL1GE Interface board, E-NSATX	2081717-001
6	SCREW, screw for plastic, 3x12mm, WN1452, torx head, pan	*
7	Front Cover, CS, E-NSATX	M1063523
7	Front Cover, DA, E-NSATX	M1071156
7	Front Cover, DE, E-NSATX	M1071159

Item	Description	Order No.
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	2081716-001
11	MOUNTING, M3 threaded hexagonal spacer, L 7mm, brass	M1035473
12	WASHER, 3.2x7.0x0.5mm, nylon-6 (PA-6), DIN125	*
13	SCREW, machine, M3x4mm, DIN7985, torx head, pan	*
14	OEM-ITEM, Nellcor NELL-1GE Pulse Oximetry board	2081718-001
15	Front Chassis Unit, E-NSATX	2081716-001

*) Part is not available from GE. Source locally.

7.2 Oxygen Saturation Module, E-NSAT



Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel, zinc coated	*
2	Module Casing, Single, Injection molded	M1021035
3	Metal frame	879184
4	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	*
5	Interface board E-NSAT for MP100, Printed Circuit Assembly	M1026771
6	SCREW, screw for plastic,3.0 x12mm, torx head,	*
7	SCREW, machine, M3x4mm, DIN7985, torx head, pan head, steel, zinc coated	*
8	E-NSAT flex board, Printed Circuit Assembly	M1035951

Item	Description	Order No.
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	*
13	M3 threaded hexagonal spacer, L 7mm, D max 5.5mm, brass	M1035473
14	WASHER, 3.2x7.0x0.5mm, nylon-6 (PA-6), DIN125	*
15	Nellcor MP100 oximetry board	M1037711
16	Front Chassis Unit, E-NSAT	M1025088

*) Part is not available from GE. Source locally.

For your notes:

Maintenance check form

Nellcor Compatible Module, E-NSAT, E-NSATX

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**
3.1. Visual inspections	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. SpO2 test procedure				☐ ☐ ☐
3.3.3. Test completion				☐ ☐ ☐

Notes		

Used service parts			

Signature	Date

For your notes:

8

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

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the CARESCAPE Respiratory modules, E-sCO, E-sCOV, E-sCOVX, E-sCAiO, E-sCAiOV, and E-sCAiOVX. 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, X = gas exchange, 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	Gas exchange
E-sCOVX	X	X	X			X	X
E-sCOV	X	X	X			X	
E-sCO	X	X	X				
E-sCAiOVX	X	X	X	X	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.

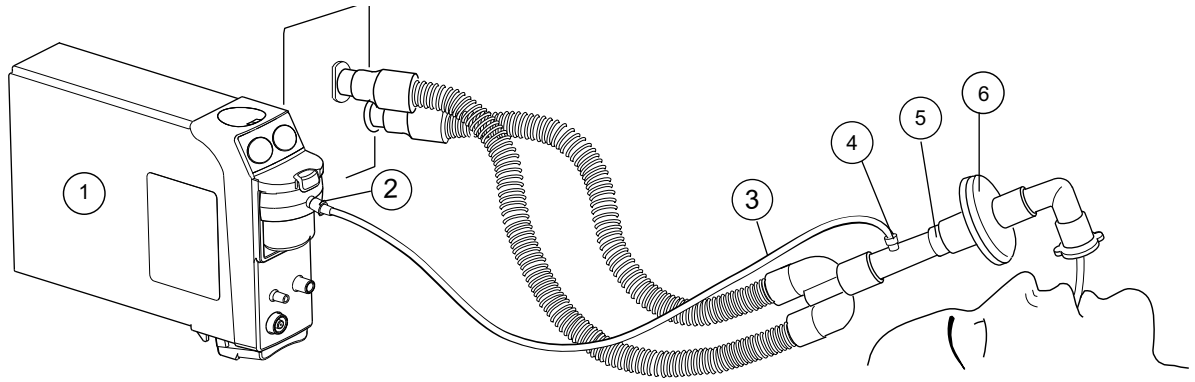


Figure 1 Airway gases measurement setup

(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 host systems:

- CARESCAPE Monitor B850
- CARESCAPE Monitor B650
- CARESCAPE Monitor B450 (gas exchange measurement not supported).

NOTE: The Neonatal Intensive Care Unit (NICU) software package of the CARESCAPE modular patient monitors may not support the use of CARESCAPE Respiratory Modules. For more information refer to the user documentation delivered with the monitor.

NOTE: Displayed data (including but not limited to TV, MV, RR, Raw and N_2O), trends and alarms may vary depending on the host device. Specifications listed in the User's Manual represent the capabilities of the modules. Always check the host device's User Manual for additional information.

1.2 Measurement principle

1.2.1 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).

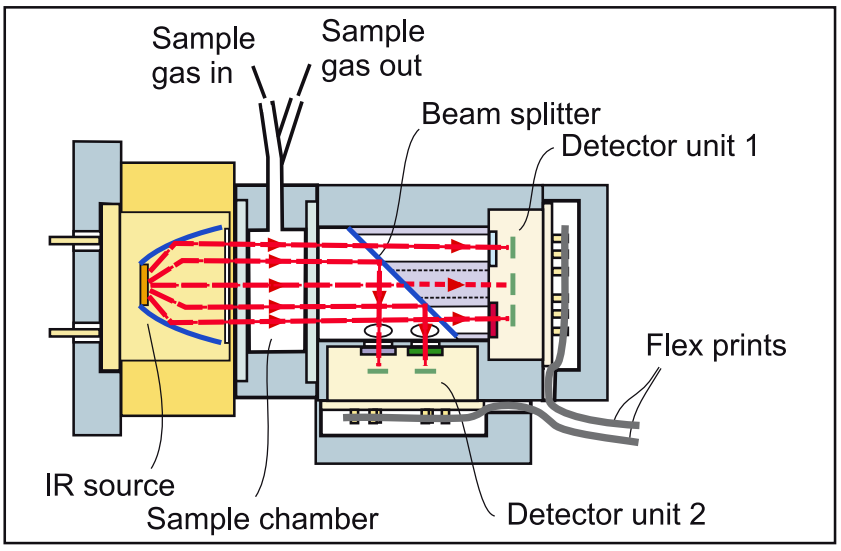


Figure 2 MiniTPX sensor principle

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.

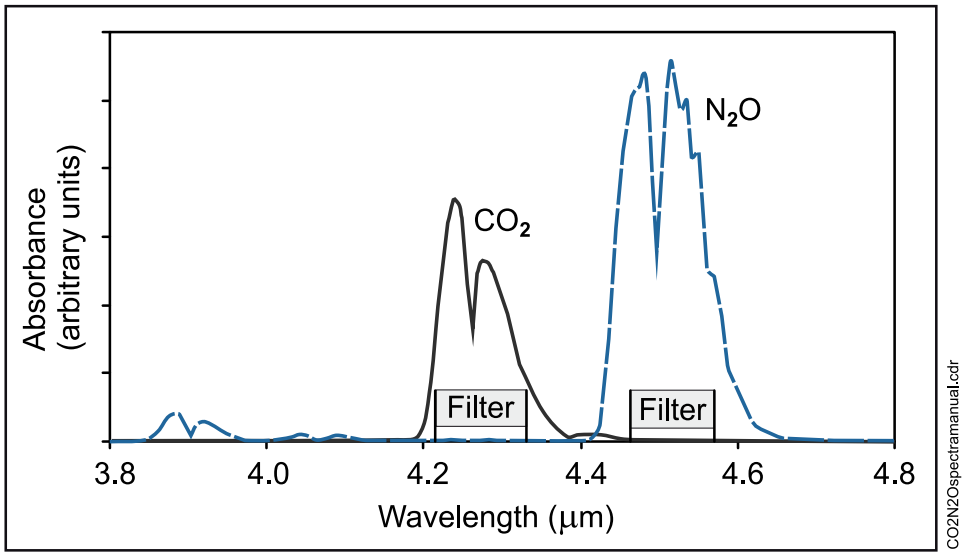


Figure 3 Absorbance of N_2O and CO_2

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.

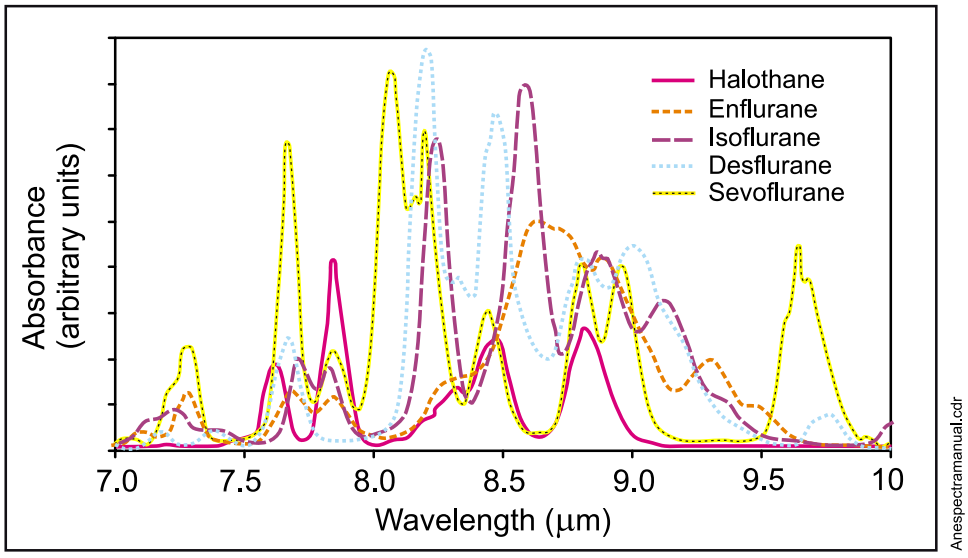


Figure 4 Infrared absorbance of AAs

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

1.2.2 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.

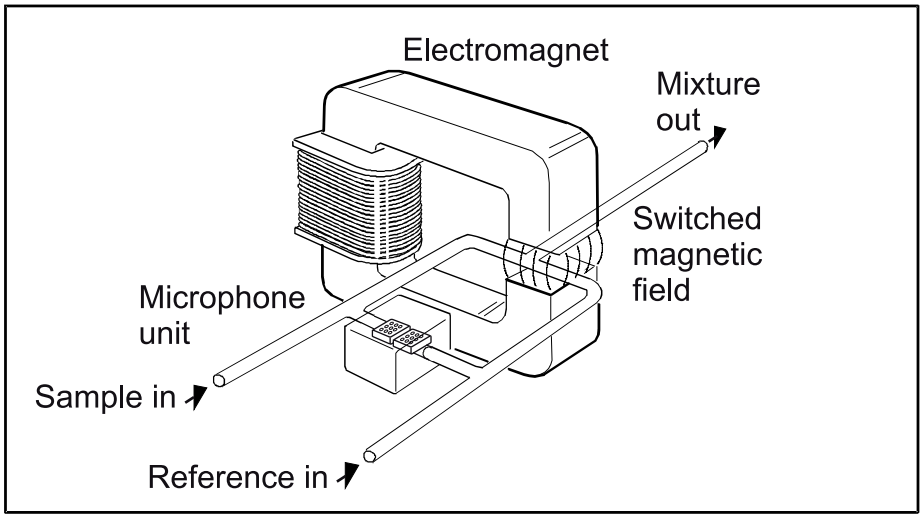


Figure 5 O_2 measurement principle

1.2.3 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 with ICU and ED software packages
- End inspiratory plateu pressure (P_{plat})
- PEEPi, PEEPe; available only in with ICU and ED software packages
- Total positive end expiratory pressure ($PEEP_{tot}$); available with OR and PACU software packages
- Real time airway pressure waveform (P_{aw})
- Static Positive End Expiratory Pressures (Static $PEEP_i$ and Static $PEEP_e$); available with ICU and ED software packages
- Static Plateau pressure (Static Pplat); available with ICU and ED software packages
- Static Compliance (Static Compl); available with ICU and ED software packages

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 ($PEEP_{tot}$).

1.2.4 Gas exchange measurement

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

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 4

and

$$VCO_2 = \int_{exp} f_{CO_2} dv - \int_{insp} f_{CO_2} dv$$ Formula 5

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 6

$$VCO_2 = fe_{CO_2} \times MV_e - fi_{CO_2} \times MV_i \quad [ml/min]$$ Formula 7

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 8

$$VCO_2 = (f_{Hald} \times fe_{CO_2} - fi_{CO_2}) MV_i \quad [ml/min]$$ Formula 9

with

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

1.3 Main components

The respiratory modules consist of:

- Gas sampling system

- MiniTPX measuring unit
- MiniOM measuring unit
- MiniPVX measuring unit
- CPU board

1.3.1 Controls and connectors

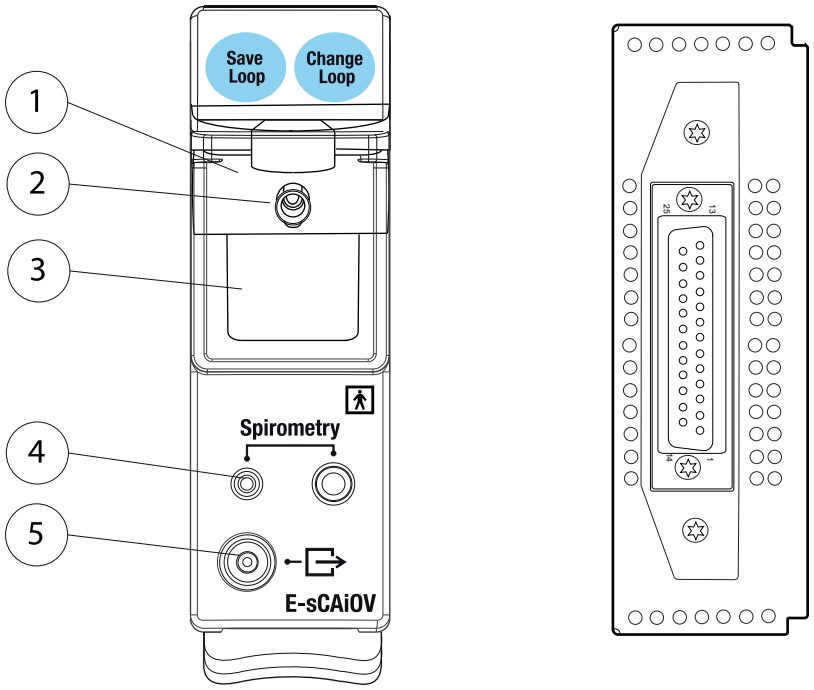


Figure 6 Front of CARESCAPE Respiratory Module, E-sCAiOV, and the back of the module

(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-sCOVX, E-sCAiOV, E-sCAiOVX	**Save Loop** saves a reference loop.
Change Loop	E-sCOV, E-sCOVX, E-sCAiOV, E-sCAiOVX	**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

1.3.2 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:

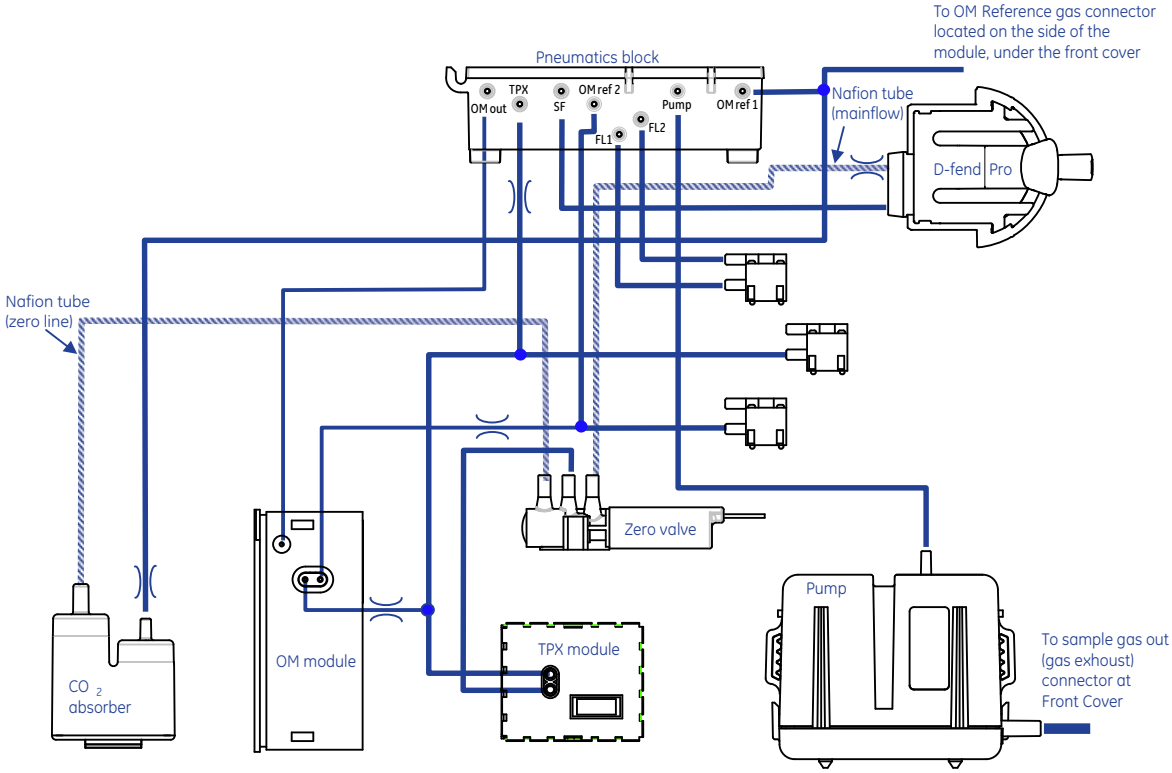


Figure 7 Gas sampling system

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.

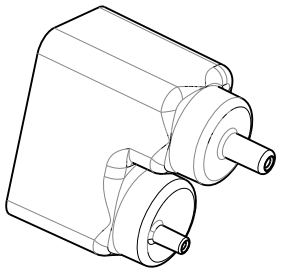


Figure 8 Absorber

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.

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.

1 Nafion is a registered trademark of Perma Pure Inc.

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'.

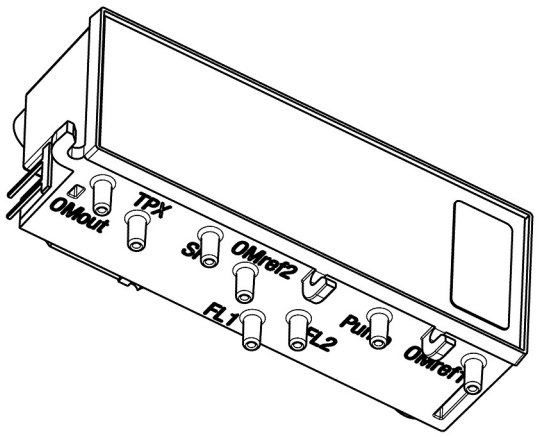
Pneumatics unit

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.

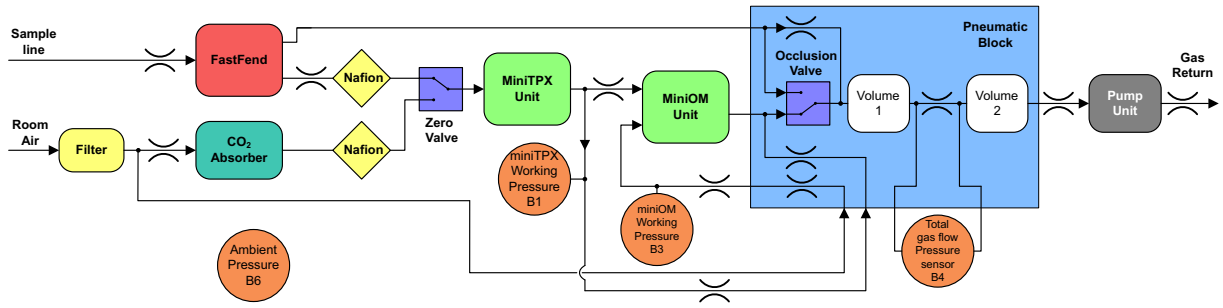


Figure 9 Gas tubing layout

1.3.3 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 "1.2.1. 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.

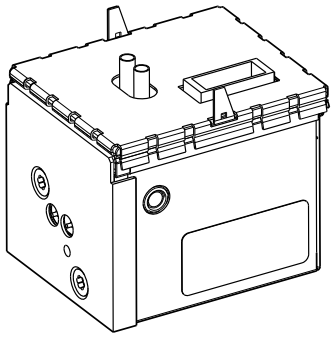


Figure 10 MiniTPX measuring unit

1.3.4 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 "1.2.2. 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.

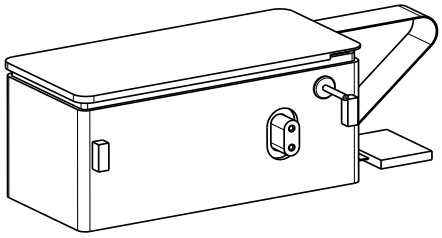


Figure 11 MiniOM oxygen sensor

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.

1.3.5 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.

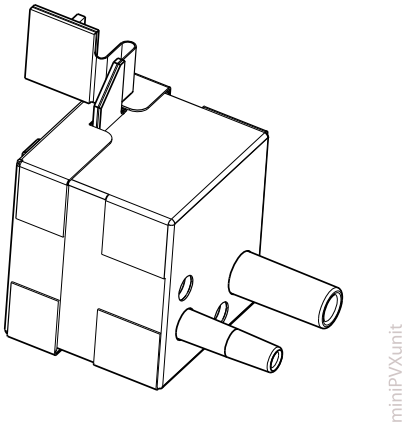


Figure 12 MiniPVX measuring unit

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.

1.3.6 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.

NOTE: The gas exchange measurement in the E-sCAiOVX and E-sCOVX modules works accurately only with 2-meter (7 ft) gas sampling lines.

1.3.7 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.

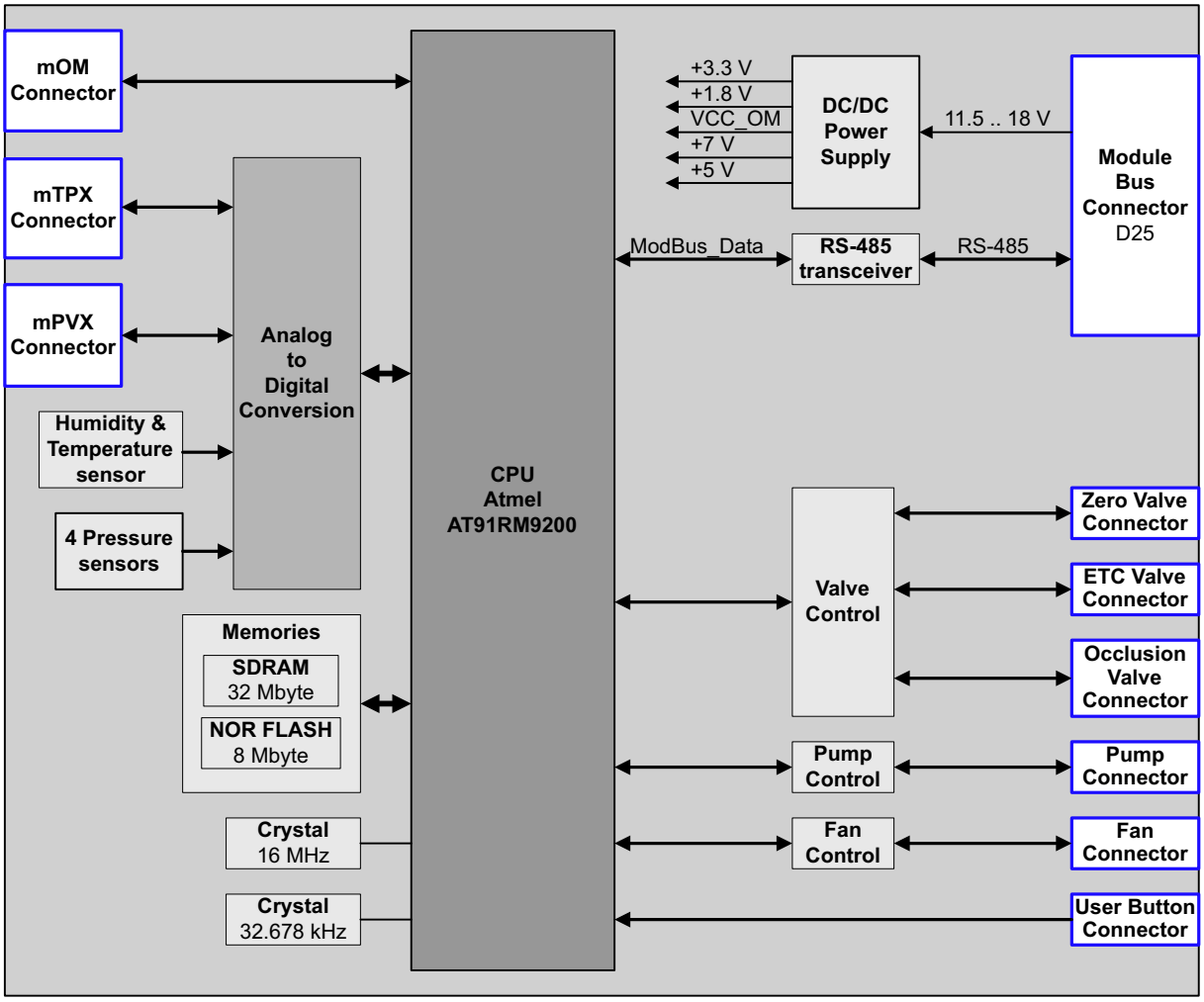


Figure 13 Signal processing on CPU board

1.3.8 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.

1.3.9 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.

1.3.10 Main Component Interactions

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

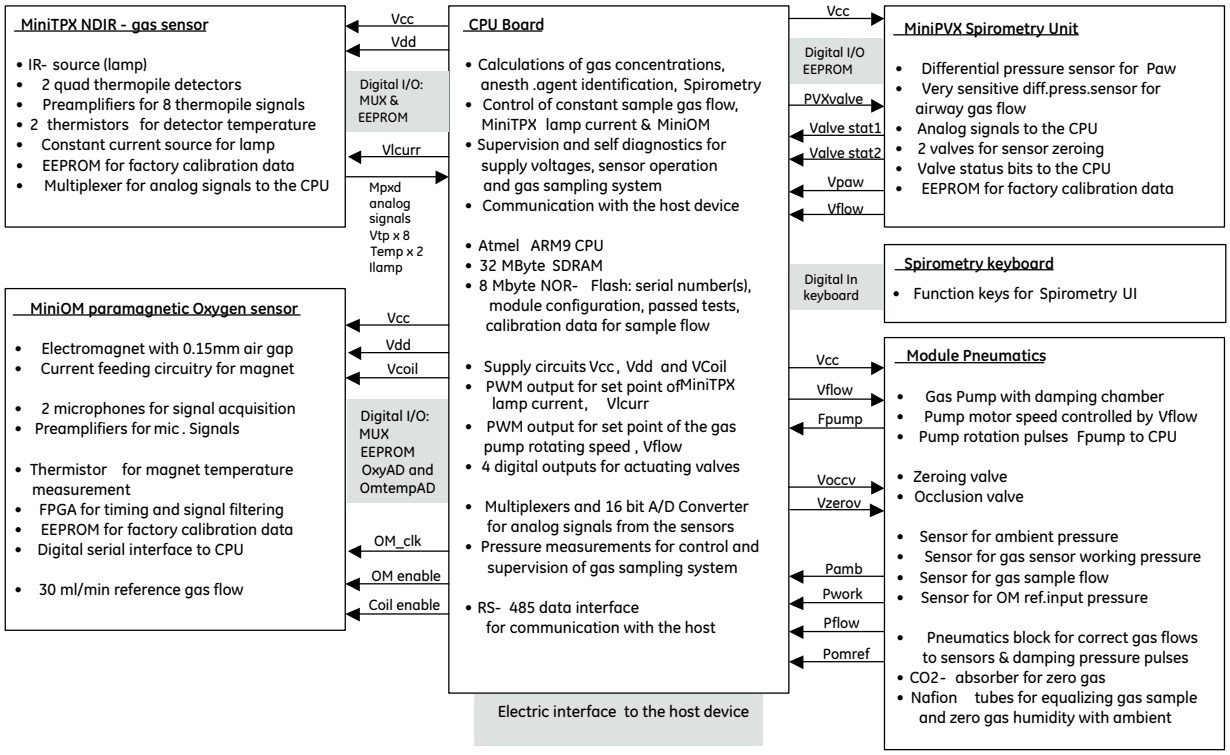


Figure 14 Block diagram

2 Configuration

There is no configuration for the CARESCAPE Respiratory Modules.

2.1 Software update

The module software can be updated using a software CD and Webmin. The software update process involves transferring and activating the module software. First, you transfer the new software to the host monitor, either from the software CD using service laptop connected to the monitor, or by using InSite ExC. Then, you need to activate the software through Webmin.

For more detailed information about the software update, refer to the host monitor's Technical Manual.

3 Maintenance and checkout

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

General warnings

This symbol is identified by a yellow background, black triangular band, and a black symbol.

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.**

General cautions

This symbol is identified by a white background, black triangular band, and a black symbol.

CAUTION Do not apply pressurized air to any outlet or tubing connected to the module. Pressure may destroy sensitive elements.

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 user documentation delivered with the monitor for compatible accessories.

3.1.2 Planned Maintenance Kits

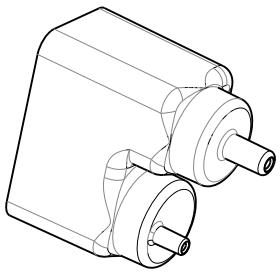
The required planned maintenance parts are included in a PM kit.

Part number	Description
2093610-001	One year Planned Maintenance Kit for CARESCAPE Respiratory modules. The PM kit includes the required Nafion tube, 230 mm (mainflow), the OM reference gas filter assembly with an O-ring and a PM sticker. NOTE: The one year PM kit does not include the CO_2 absorber and Nafion tube, 85 mm (zero line).
2093594-001	Four year Planned Maintenance Kit for CARESCAPE Respiratory modules. NOTE: The four year PM kit contains all required PM parts.

3.1.3 Replacement procedures

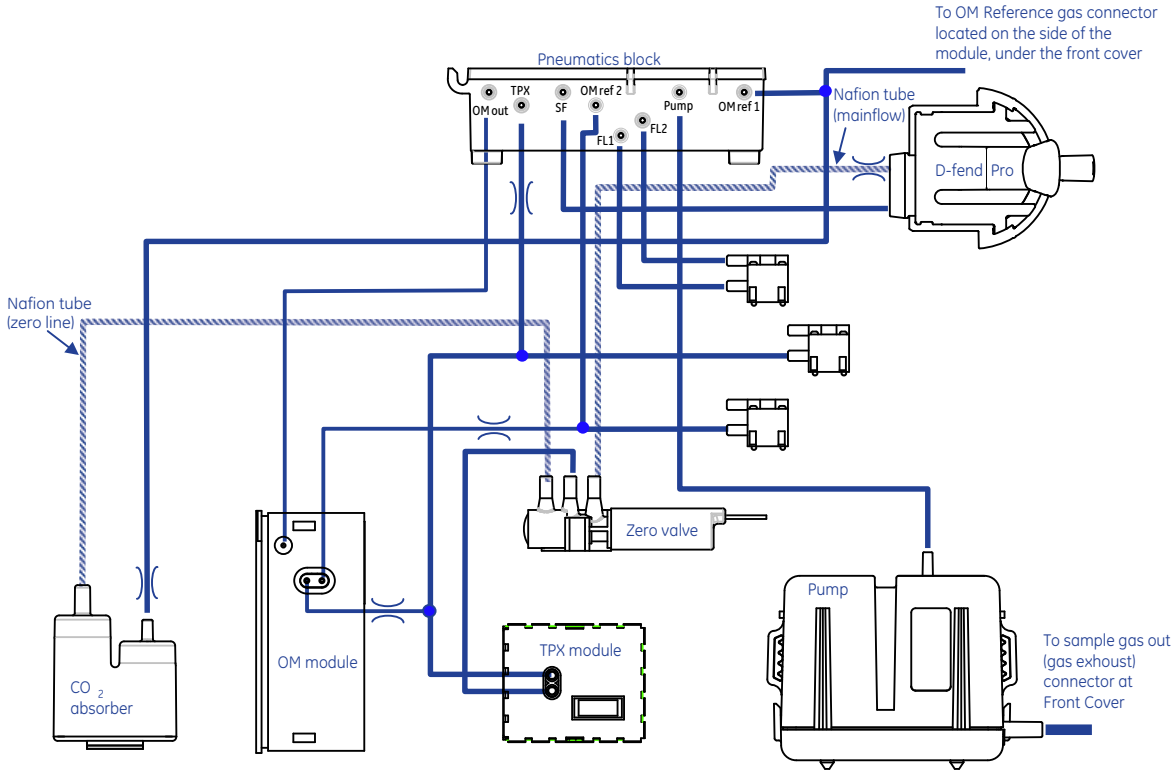
Replace the specified planned maintenance parts according to the chapter "6. Disassembly and reassembly".

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 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 CARESCAPE 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, and E-sCAiOVX modules)
- P/N: 755581-HEL QUICK CAL calibration gas, CO2, O2, N2O, package of 4 cans (with E-sCO, E-sCOV, and E-sCOVX 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, and E-sCAiOVX modules) US only
- P/N: 755587, Calibration Gas, CO2, O2, Balance, 4 cans/pkg (with E-sCO, E-sCOV, and E-sCOVX 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, E-sCOVX, E-sCAiOV, and E-sCAiOVX 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 user documentation delivered with the monitor for compatible accessories.

Connections

- Disconnect the module from the monitor, if connected.

Monitor configuration

1. Configure the CO2, O2, AA, and Flow waveform fields to the monitor screen with adequate priority.
2. Configure the Spiro 1 split screen to the monitor screen.
3. Select the ***Setup*** tab in the ***Spirometry and Gas Exchange*** menu and configure:

   Scaling: Auto

   Sensor Type: Adult

   Show Volume: TV

3.3.2 Procedure

Mark each task as complete on the checkout form.

1. Gas Sampling System Leak Test

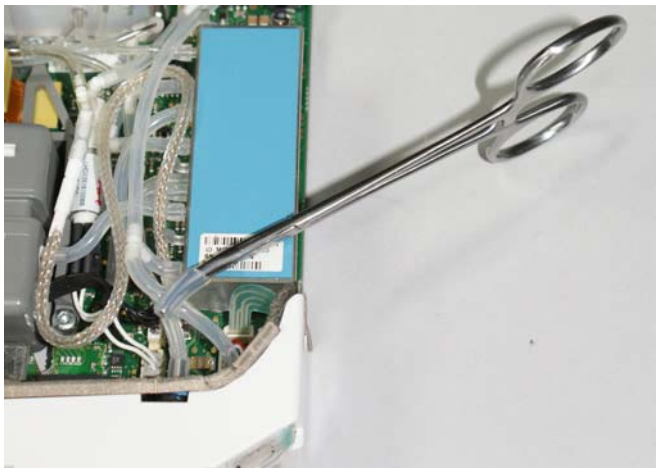
NOTE: The gas module shall be disconnected from the monitor during the leak test.

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 "6.2.1. Detaching the Front Cover" and "6.2.2. Detaching the Module Casing".

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 attach 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, E-sCOVX, E-sCAiOV, and E-sCAiOVX modules.

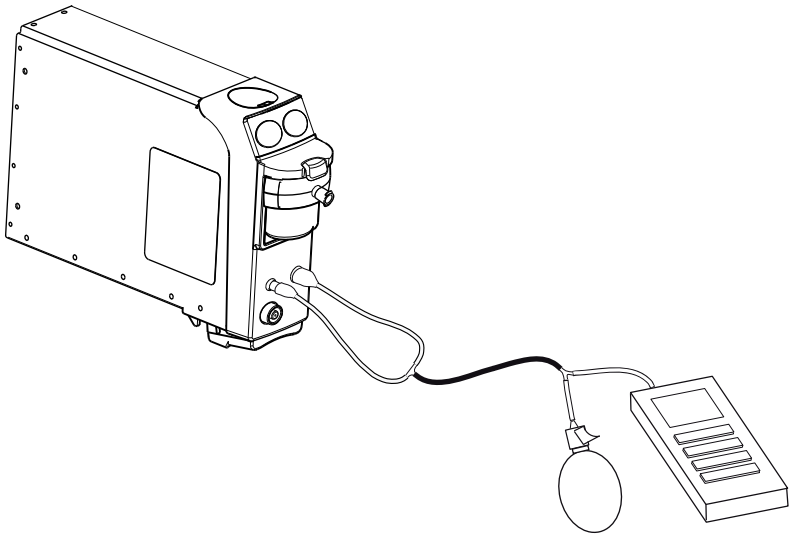
NOTE: The gas module shall be disconnected from the monitor during the leak test.

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 (1013 mbar), 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 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 "4.1.2. Sample Flow Rate Adjustment".

4. Reference Gas Flow Rate Check

Check the flow rate in reference gas inlet:

a. Connect the gas sampling line to the sampling line connector.
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.
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, E-sCOVX, E-sCAiOV, and E-sCAiOVX 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 gas sampling line to the sampling line connector.
c. Connect the end of the gas sampling line to the regulator on the gas container. Leave the regulator overflow port open to room air.
d. Select **Monitor Setup > *Service Calibrations***.
e. Enter the User Name and the Password and press ***Enter*** to get into the ***Calibrations*** menu.
f. Select ***Gases***.
g. 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 (%).

h. Open the zero valve to room air by selecting ***Zero valve Off*** (zero position).
i. Check that the ***CO2***, ***N2O*** and ***anesthesia agent*** values drop back near 0% and the ***O2*** reading near 21% (room air).
j. Stop feeding the calibration gas.
k. Turn the zero valve back to the normal measurement position by selecting ***Zero valve On*** (measurement position).

8. Gas Calibration

Perform gas calibration according to the instructions in section "4.2. Gas Calibration".

9. Agent Identification

NOTE: Perform this test only for E-sCAiO, E-sCAiOV, and E-sCAiOVX 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 ***IDu*** value (=agent ID unreliability) shown in the ***Monitor Setup / Service calibrations / 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 to the parameter window within 30 seconds.

12. Air Leak detection
    a. Detach the D-fend Pro water trap.
    b. Check that the message '***Check Water Trap***' appears to the parameter window 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 out' appears to the parameter window 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 to the waveform field and the ***EtCO2*** and ***FiCO2*** values are updated to the parameter window.

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

16. Flow waveform

NOTE: Perform this test only for E-sCOV, E-sCOVX, E-sCAiOV, and E-sCAiOVX 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 “Maintenance check form” on page 67.

4 Calibration and adjustments

4.1 Sample Flow Rate Adjustment

Sample flow rate shall be adjusted:

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

4.1.1 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 user documentation delivered with the monitor 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: Refer to the flowmeter documentation for user instructions.

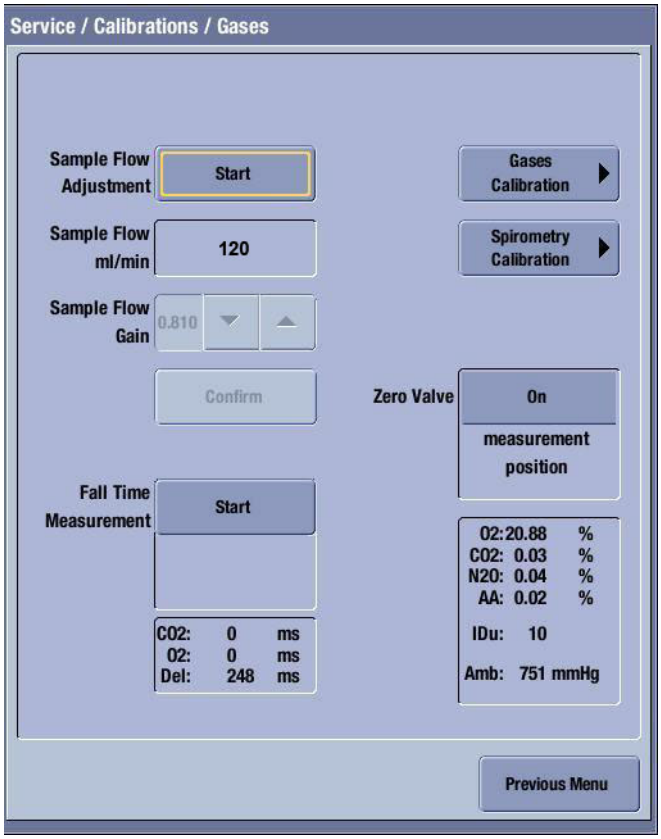
Connections

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.

4.1.2 Sample Flow Rate Adjustment

1. Select **Monitor Setup > *Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the ***Calibrations*** menu.
3. Select ***Gases***
4. Select ***Start Sample Flow Adjustment***



5. Adjust the sample flow to the nominal value 120 ml/min by using the ***Sample Flow Gain*** up-down spinner controls:
   - 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.
6. 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.
7. Repeat steps 5 and 6 until the flow meter shows a 120 ± 20 ml /min flow rate.
8. Select ***Stop Sample Flow Adjustment*** to save the new gain value to the permanent memory of the module.

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.

4.2 Gas Calibration

General warnings

This symbol is identified by a yellow background, black triangular band, and a black symbol.

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.

4.2.1 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, and E-sCAiOVX modules)

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

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

– 3 m / 10 ft anesthesia gas sampling line

NOTE: Use only the specified GE 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.

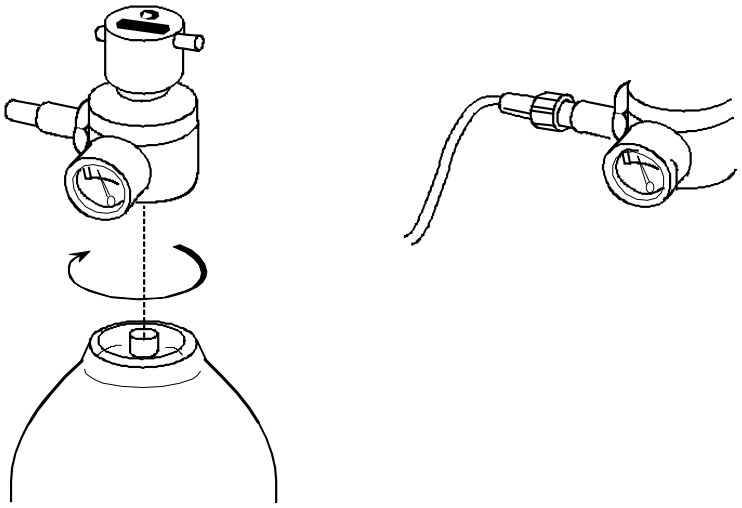


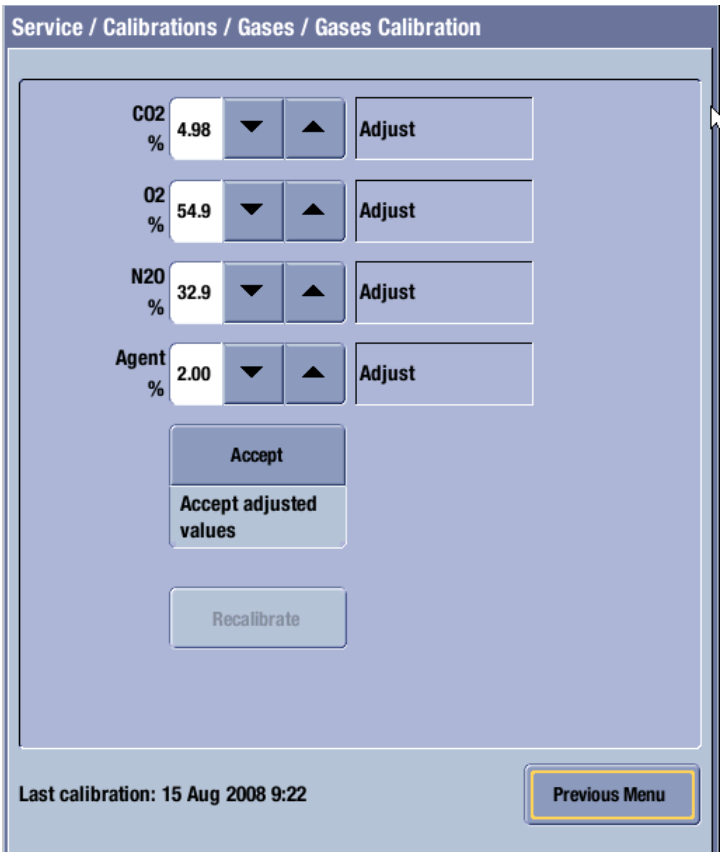
Figure 15 Connecting a gas regulator to the calibration gas container and connecting a sampling line to the gas regulator.

4.2.2 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 ***Monitor Setup > Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the ***Calibrations*** menu.
3. Select ***Gases***
4. Select ***Gases Calibration***



5. 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.
6. 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.
7. Use the up-down spinner controls in the calibration menu to 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.
8. 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.

4.3 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.

4.3.1 Calibration setup

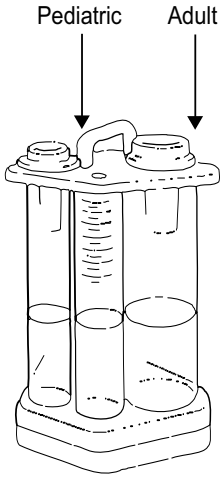
Required tools

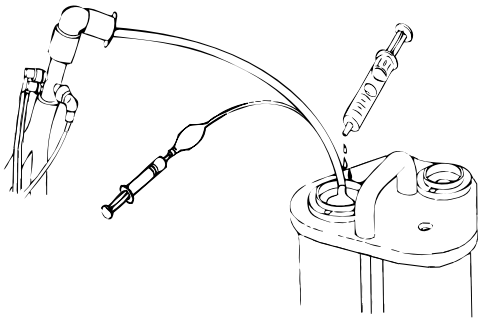
– P/N 884202-HEL Spirometry tester
– D-Lite and Pedi-lite sensors
– Spirometry tube
– Ventilator

NOTE: See the user documentation delivered with the monitor 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 ***Setup*** tab in the ***Spirometry and Gas Exchange*** menu and configure:
  Scaling: Auto
  Sensor Type: Adult
  Show Volume: 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.

4.3.2 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.

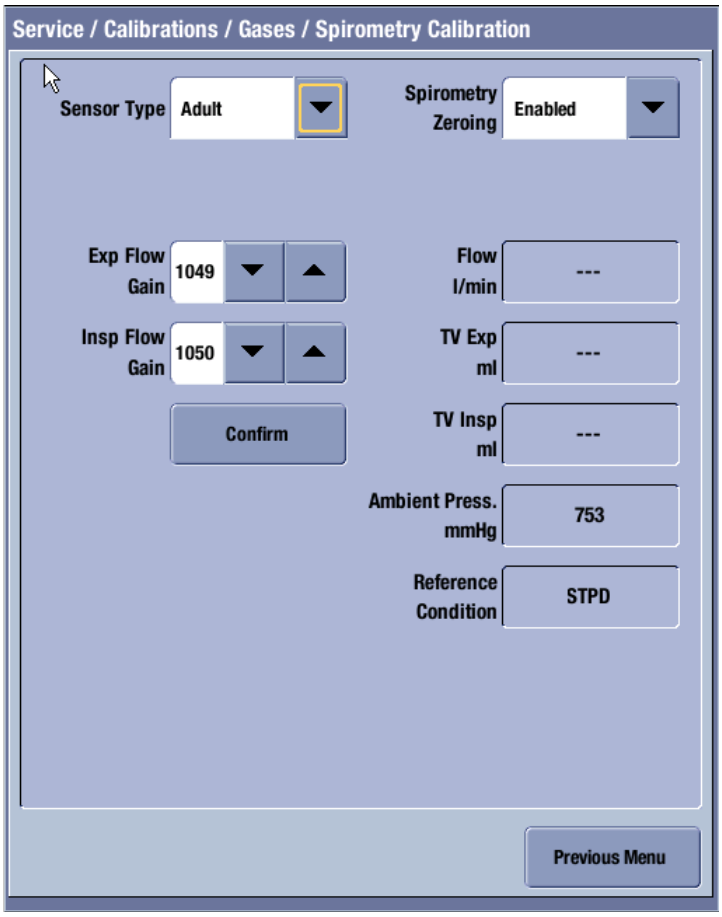
2. The measured flow values are shown in real-time in the ***TV Insp*** and ***TV Exp*** fields in the Flow parameter window. Compare these measured values to the TV value reading (highest water level) in the spirometry tester.

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 “4.3.3 Flow calibration”.

4.3.3 Flow calibration

1. Select ***Monitor Setup > Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the ***Calibrations*** menu.
3. Select ***Gases***
4. Select ***Spirometry Calibration***
5. Ensure that the ***Sensor Type*** is correct and that ***Spirometry Zeroing*** is Enabled.
6. Wait until the MiniPVX sensor performs an automatic zeroing. It will show a message ***'zeroing'*** in the Flow parameter window when zeroing takes place.
7. Adjust the ***Exp Flow Gain*** and/or ***Insp Flow Gain*** separately by using the related up-down spinner controls 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***.
8. Press ***Confirm*** to check the effect of the gain adjustment to the flow readings.
9. Repeat steps 6 and 7 until the flow values are within the specification.


Service / Calibrations / Gases / Spirometry Calibration
Sensor Type
Adult
Spirometry Zeroing
Enabled
Exp Flow Gain
1049
Insp Flow Gain
1050
Confirm
Flow l/min

TV Exp ml

TV Insp ml

Ambient Press. mmHg
753
Reference Condition
STPD
Previous Menu

5 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 CARESCAPE monitor user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

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

5.1 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

5.2 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 monitor compatible devices supplement or CARESCAPE supplemental information manual
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor compatible devices supplement or CARESCAPE supplemental information manual
- Connect the accessories to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (***Monitor Setup > Screen Setup > Upper Parameter Area***).

- 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.

5.2.1 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 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 for factory service.

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

5.2.2 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 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.

5.2.3 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 for repair.

5.2.4 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.

5.2.5 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 for repair.

5.3 Service Interface

Use the Webmin service interface to access device information and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the CARESCAPE Respiratory Module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information tab***.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the CARESCAPE Respiratory Module.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.

3. Select ***Download Logs***
4. Select one of the log files for downloading.

5.4 Messages

5.4.1 Gas measurements

The messages below appear in the gas parameter windows (PW), gas waveform fields (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Check water trap Check water trap and sample gas out. Wait for 30 sec. and press ***Home*** to continue.	PW, MF WF	Water trap is not connected. Air leak inside the internal tubing.	Connect the water trap and sampling line to the module. Check the tubing for leakages.
Sample line blocked Continuous blockage. Check sampling line and water trap.	PW, MF WF	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 tubing for leakages.
Check sampling gas out Check water trap and sample gas out. Wait for 30 seconds and press ***Home*** to continue.	PW, MF WF	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	PW, MF	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.

Message	Location	Possible causes	Possible solutions
Calibrating	PW & calibration menu	Gas calibration is in progress.	Wait until the calibration is completed successfully.
Failure in Agent ID	PW	Agent ID has failed.	Perform gas calibration. Check agent ID unreliability (see functional check). If it does not help, send the module to GE for factory repair.
Zeroing	PW & calibration menu	Zeroing is in progress.	Wait until zeroing is completed successfully.
Zero error	PW & calibration menu	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 for factory repair.
Calibrating error	PW & calibration menu	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	PW	Measured ***FiO2***>103%	Perform gas calibration.
Apnea deactivated	PW	Apnea alarm start-up conditions are not reached.	Apnea alarm detection is activated after the 3 breaths are detected.
Sensor INOP	WF	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 for service.

Message	Location	Possible causes	Possible solutions
Sensor INOP	WF	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	WF	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	WF	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 CARESCAPE monitor user's manual.
Low gas sample flow	MF	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.

Message	Location	Possible causes	Possible solutions
Incompatible gas module	MF	Incompatible gas module detected by the monitor.	Check the compatibility of the gas module.
Gas measurements removed	MF	The module is disconnected.	Reconnect the module.
Identical gas modules	MF	The monitor detects gas measurement from two or more modules.	Remove excess modules providing gas measurement.

5.4.2 Spirometry

The messages below appear in the spirometry parameter windows (PW), spirometry waveform fields (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
MVexp<<MVinsp	PW	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	PW	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	PW	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	PW	Zeroing is in progress.	Wait until zeroing is completed successfully.
Sensor INOP	WF	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 for service.
Over scale	WF	***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 CARESCAPE monitor user's manual.

Message	Location	Possible causes	Possible solutions
Scale changed	WF	Displayed for 10 seconds after autoscaling mode has changed Flow, Paw, or Vol scale.	N/A
Saving loop	MF	Spirometry loop is being saved.	N/A
Printing loop	MF	Spirometry loop is being printed.	N/A
Spirometry measurements removed	MF	The module is disconnected.	Reconnect the module.

5.4.3 Gas Exchange

The messages below appear in the gas exchange parameter windows (PW).

Message	Location	Possible causes	Possible solutions
No VO2, FiO2>85%	PW	Unable to measure gas VO_2 because the measured FiO_2 is out of gas exchange specification (>85%).	Use lower O_2 concentrations.
No VO2, FiN2O too high	PW	Unable to measure gas VO_2 because the measured FiO_2 + FiN_2O is out of gas exchange specification (>85%).	Use lower O_2 concentrations.
Artifact	PW	Module is unable to synchronize flow and CO_2.	Use a 2 meter gas sampling tube and spirometry tube with gas exchange.
Bypass flow high	PW	Module is unable to synchronize flow and CO_2 due to bypass flow.	Reduce fresh gas flow.
Out of range	PW	VO_2 or VCO_2 is <0 or >999 ml/min and thus out of measurement range. After changing the FiO2 setting on the ventilator, VO2 may be out of the specified range for several minutes.	Check that the gas sampling line and spirometry lines are correctly connected to the airway and to the gas module. Check that the correct sensor type (D-lite/ Pedi Lite) has been selected from the monitor menu.

5.4.4 Service gas module messages

Message	Location	Possible cause	Possible solutions
Service Gas Module - Error Code 0xGAS0001	MF	MiniTPX measuring unit failure	Return the module to GE Healthcare for service
Service gas module, CO2, N2O and AA sensor failed	WF		
Service gas module	PW		
Service Gas Module - Error Code 0xGAS0010	MF	MiniOM oxygen sensor failure	Return the module to GE Healthcare for service
Service gas module, O2 sensor failed	WF		
Service gas module	PW		
Service Gas Module - Error Code 0xGAS0011	MF	Simultaneous MiniTPX measuring unit and MiniOM oxygen sensor failures	Return the module to GE Healthcare for service
Service gas module, CO2, N2O and AA sensor failed	WF		
Service gas module, O2 sensor failed	WF		
Service gas module	PW		
Service Gas Module - Error Code 0xGAS0100	MF	Spirometry sensor failure	Replace the Spirometry sensor
Service gas module, spirometry sensor failed	WF		
Service gas module	PW		
Service Gas Module - Error Code 0xGAS0101	MF	Simultaneous MiniTPX measuring unit and Spirometry sensor failures	Return the module to GE Healthcare for service
Service gas module, CO2, N2O and AA sensor failed	MF		
Service gas module, spirometry sensor failed	WF		
Service gas module	PW		
Service Gas Module - Error Code 0xGAS0110	MF	Simultaneous MiniOM oxygen sensor and Spirometry sensor failures	Return the module to GE Healthcare for service
Service gas module, O2 sensor failed	WF		
Service gas module, spirometry sensor failed	WF		
Service gas module	PW		
Service Gas Module - Error Code 0xGAS0111	MF	Simultaneous MiniTPX measuring unit, MiniOM oxygen sensor, and Spirometry sensor failures	Return the module to GE Healthcare for service
Service gas module, CO2, N2O and AA sensor failed	WF		
Service gas module, O2 sensor failed	WF		
Service gas module, spirometry sensor failed	WF		
Service gas module	PW		

Message	Location	Possible cause	Possible solutions
Service Gas Module - Error Code 0xGAS1000 Service gas module, gas measurement failed Service gas module	MF WF PW	General gas measurement failure	Return the module to GE Healthcare for service
Service Gas Module - Error Code 0xGAS1001 Service gas module, gas measurement failed Service gas module	MF WF PW	Simultaneous MiniTPX measurement unit and general gas measurement failures	Return the module to GE Healthcare for service
Service Gas Module - Error Code 0xGAS1010 Service gas module, gas measurement failed Service gas module	MF WF PW	Simultaneous MiniOM oxygen sensor and general gas measurement failures	Return the module to GE Healthcare for service
Service Gas Module - Error Code 0xGAS1011 Service gas module, gas measurement failed Service gas module	MF WF PW	Simultaneous MiniTPX mearuement unit, MiniOM oxygen sensor, and general gas measurement failures	Return the module to GE Healthcare for service
Service Gas Module - Error Code 0xGAS1100 Service gas module, gas measurement failed Service gas module	MF WF PW	Simultaneous Spirometry sensor and general gas measurement failures	Return the module to GE Healthcare for service
Service Gas Module - Error Code 0xGAS1101 Service gas module, gas measurement failed Service gas module	MF WF PW	Simultaneous MiniTPX measurement unit, Spirometry sensor, and general gas measurement sensor failures	Return the module to GE Healthcare for service
Service Gas Module - Error Code 0xGAS1110 Service gas module, gas measurement failed Service gas module	MF WF PW	Simultaneous MiniOM oxygen sensor, Spirometry sensor, and general gas measurement failures	Return the module to GE Healthcare for service
Service Gas Module - Error Code 0xGAS1111 Service gas module, gas measurement failed Service gas module	MF WF PW	Simultaneous MiniTPX measurement unit, MiniOM oxygen sensor, Spirometry sensor, and general gas measurement failures	Return the module to GE Healthcare for service

5.5 Troubleshooting charts

5.5.1 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 CARESCAPE 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

5.5.2 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

5.5.3 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-sCAiOVX module
Nonphysiological VO_2 readings	- unstable O_2 delivery - gas mixer - RR over 35/min	- reference gas inlet port blocked - gas sampling line longer than 2 m - dead space of Y-piece > 8 ml - gas sampling line connected to HME - D-lite incorrectly placed	- select oxygram and verify the stableness of the curve - check reference port - change 2 m sampling line - check the dead space of Y-piece - gas sampling line should always be connected to D-lite - ALWAYS connect the D-lite between 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 > VO_2 > 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

6 Disassembly and reassembly

6.1 Disassembly guidelines

General warnings

This symbol is identified by a yellow background, black triangular band, and a black symbol.

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.**

WARNING **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.**

Field service of the module is limited to replacing the serviceable parts listed below (see also chapter "7. Service parts").

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

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

6.1.1 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 "7. Service parts"

6.1.2 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 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 for repair.

6.1.3 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.

6.1.4 Protection from dust

WARNING **Module must be handled with care 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.

6.1.5 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.

6.1.6 Required tools

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

6.2 Disassembly and reassembly procedure

Disassembling the module (see the exploded view of the module in chapter "7. Service 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

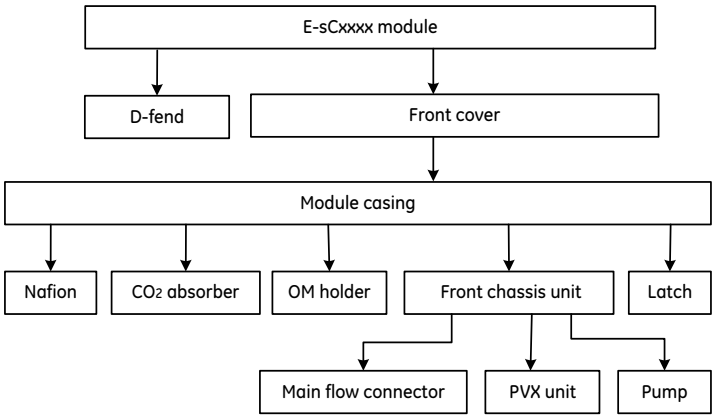
NOTE: Make sure that the Nafion tubes are routed in such a way that they don't come near the fan, and there is no risk of the fan being obstructed by the tubes. An obstructed fan will result in degraded ventilation inside the module, and a ***'Sensor inop'*** message being displayed.

- 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

.



6.2.1 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.

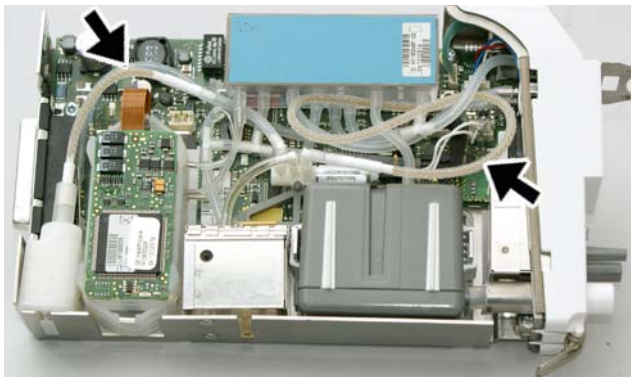
6.2.2 Detaching the Module Casing

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.

6.2.3 Replacement of Planned Maintenance Parts

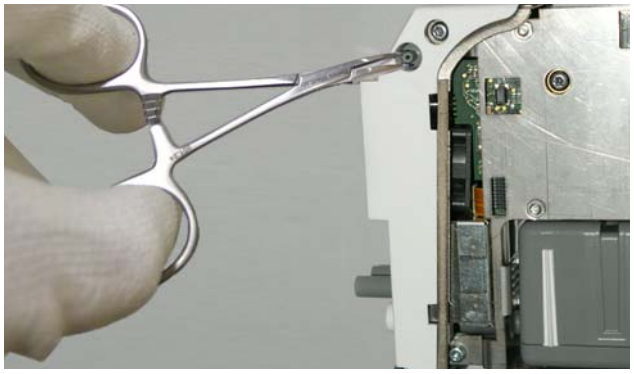


1. Carefully remove the main flow nafion tube and every 4th year the shorter zero line nafion tube.

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.

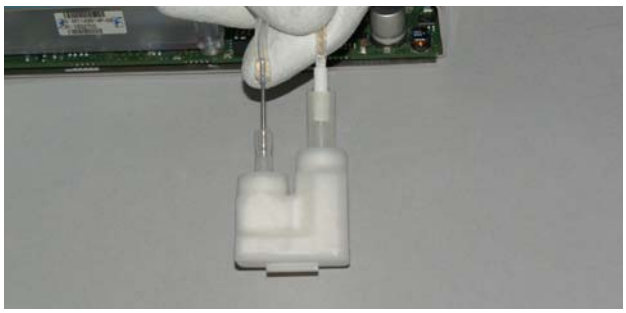
NOTE: The nafion tubes do not include the silicon fittings they are connected to. Use the original silicon fittings unless they are not damaged or leaking.



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.

6.2.4 Replacement of CO_2 Absorber

1. Lift the CO_2 absorber from the slot.

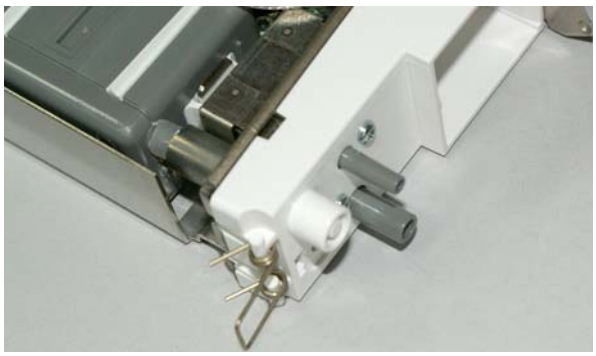


2. Detach the tubes from the absorber.
3. Connect the tubes to a new CO_2 absorber and place it to the slot.

6.2.5 Detaching the Latch

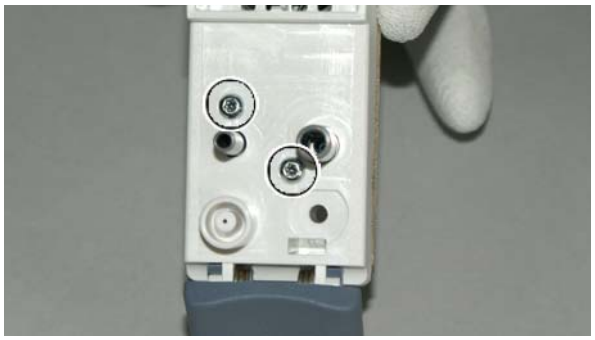
1. Pull the latch from the front chassis.

NOTE: Remember to detach the front cover first.

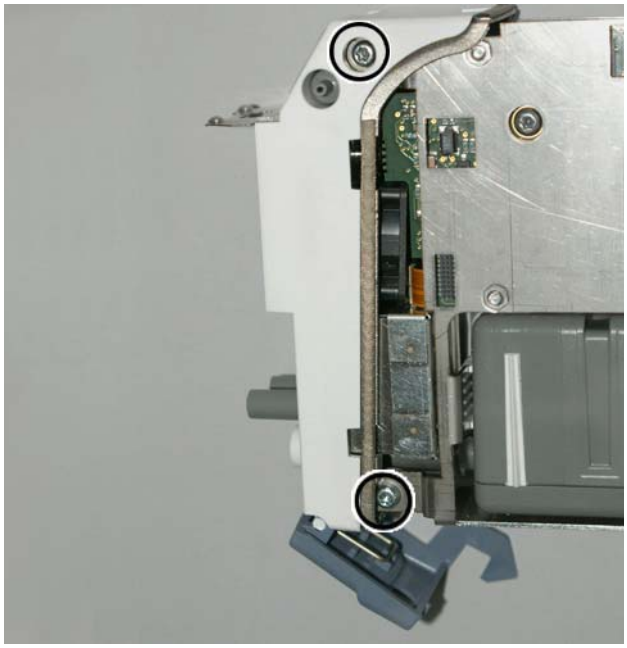


2. Remove the spring by squeezing it.

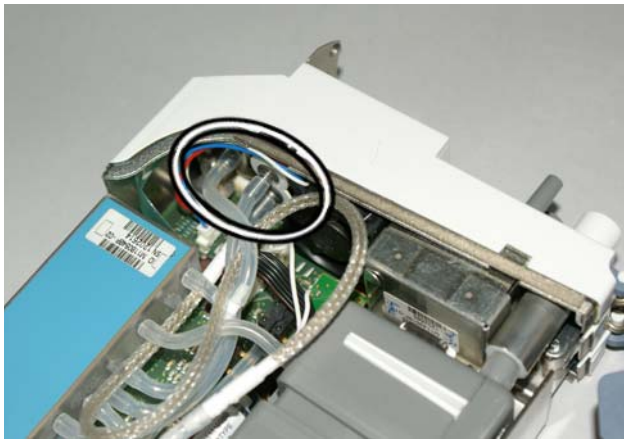
6.2.6 Detaching the Front Chassis Unit



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

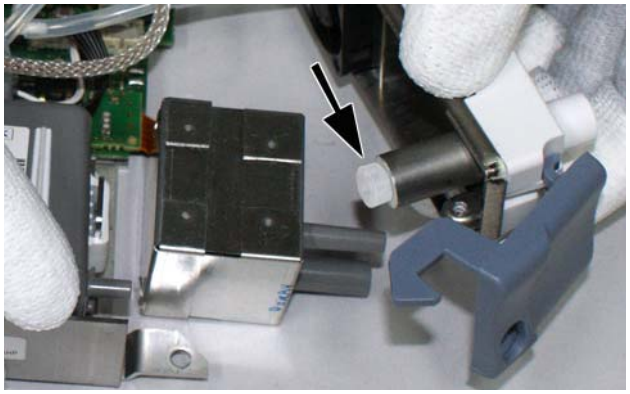


2. Remove the two screws (T10).



3. Carefully detach the three tubes.

4. Disconnect the fan and keypad cables.

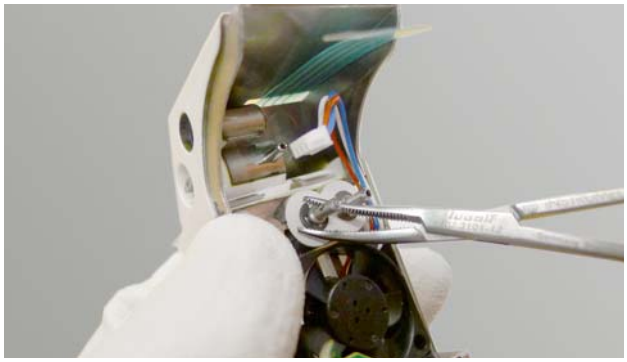


5. Detach the front chassis unit.

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

6.2.7 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.

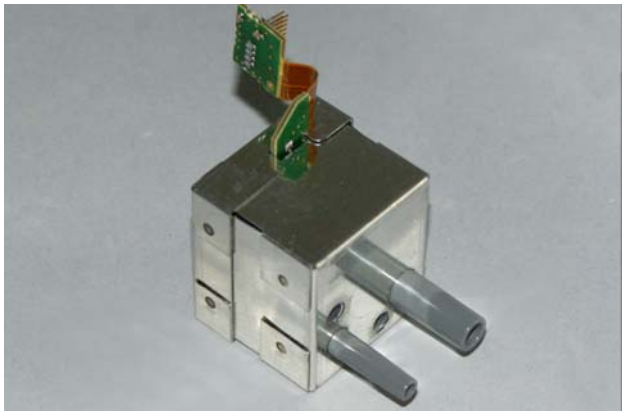
2. Carefully attach the main flow connector to the new front chassis unit.

6.2.8 Detaching the PVX Unit

The PVX unit is available as a FRU for E-sCAiOV and E-sCOV module models only.

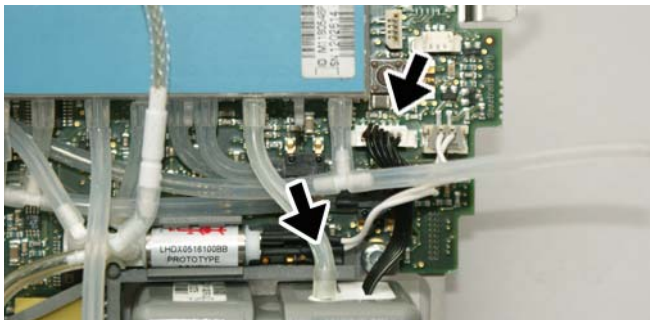
WARNING **The PVX unit of E-sCAiOVX and E-sCOVX modules must not be replaced in the field. Attempting to do so may result in inaccurate gas exchange measurement.**

1. Carefully disconnect the PVX connector.



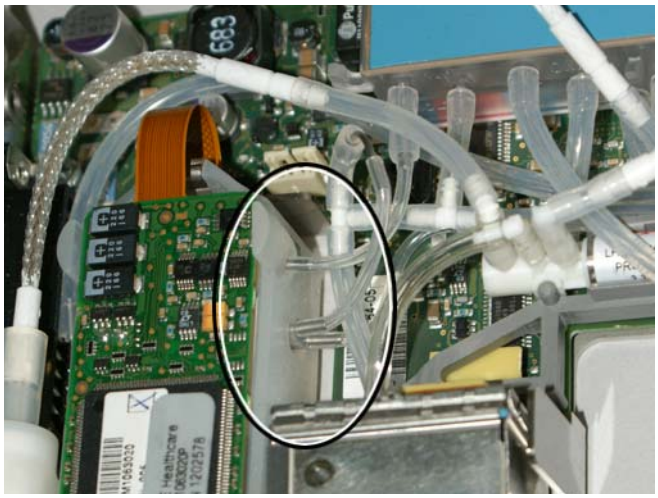
2. Detach the PVX Unit.

6.2.9 Detaching the Pump

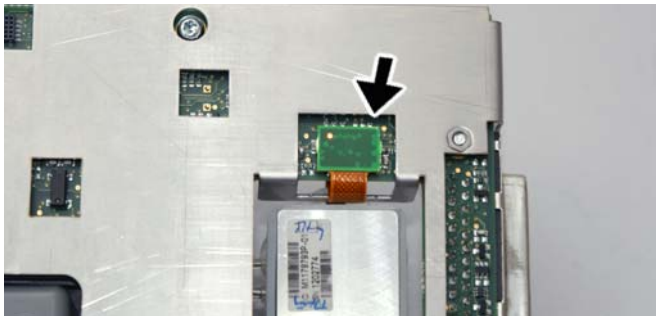


1. Carefully detach the tube from the pump.
2. Disconnect the pump cable from the CPU board.
3. Lift the pump from the metal brackets.

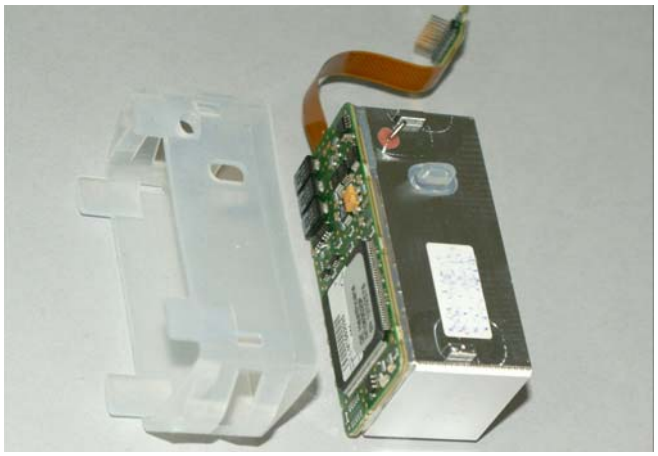
6.2.10 Detaching the OM holder



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.

7 Service parts

7.1 Ordering parts

To order parts, Contact GE. 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. Maintenance and checkout" after you have disassembled and reassembled the module.

7.1.1 Planned Maintenance Kits

The required planned maintenance parts are included in PM kits.

Part number	Description
2093610-001	One year Planned Maintenance Kit for CARESCAPE Respiratory modules. The PM kit includes the required Nafion tube, 230 mm (mainflow), the OM reference gas filter assembly with an O-ring and a PM sticker. NOTE: The one year PM kit does not include the CO_2 absorber and Nafion tube, 85 mm (zero line).
2093594-001	Four year Planned Maintenance Kit for CARESCAPE Respiratory modules. NOTE: The four year PM kit contains all required PM parts.

7.2 Spare parts

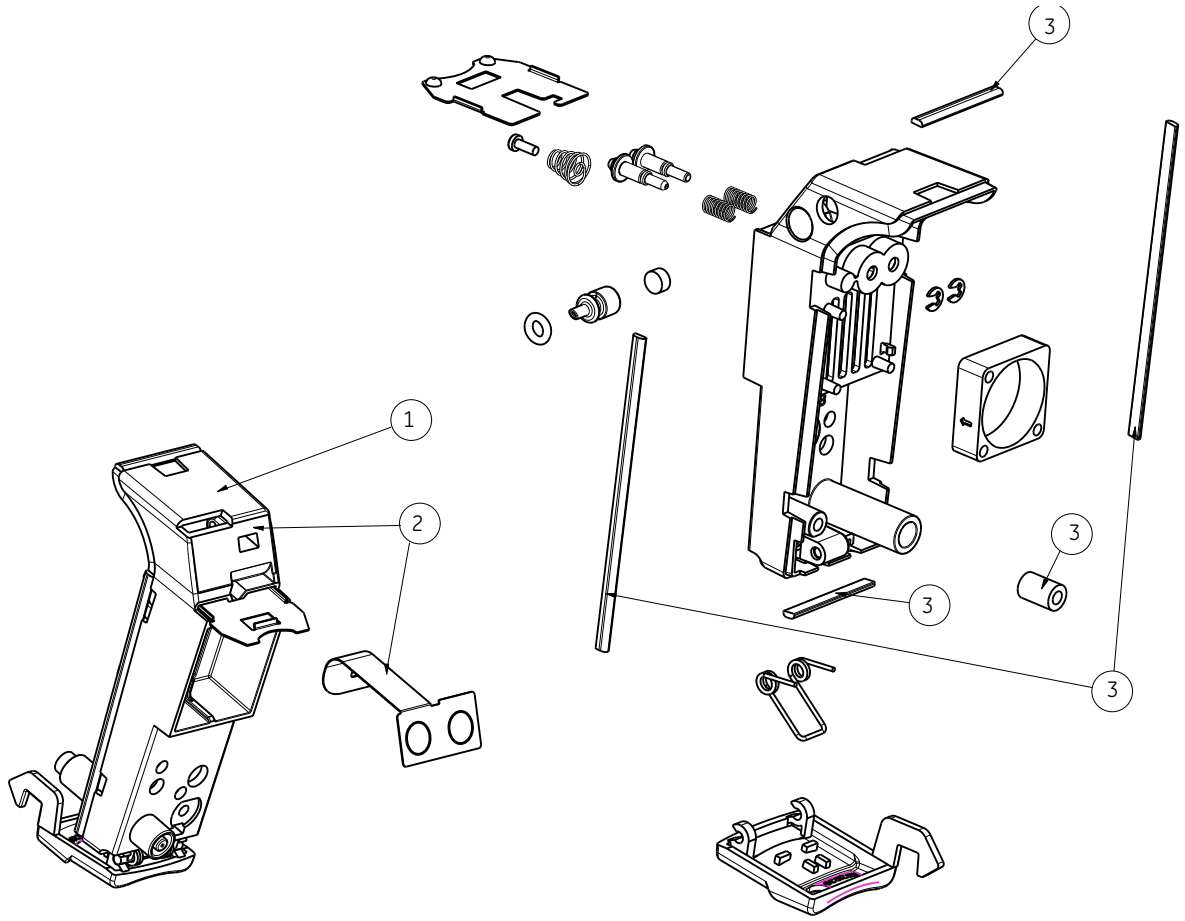


Table 6:

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-sCAiOVX, E-sCOV, E-sCOVX - Front Chassis Assembly including Membrane Keyboard	M1206529
3	FRU, HW Kit - All Mounting Screws - All Conductive Sealings - Pump Connector Silicone Tube - D25 Connector Shield - Latch - Torsion Spring	M1206533

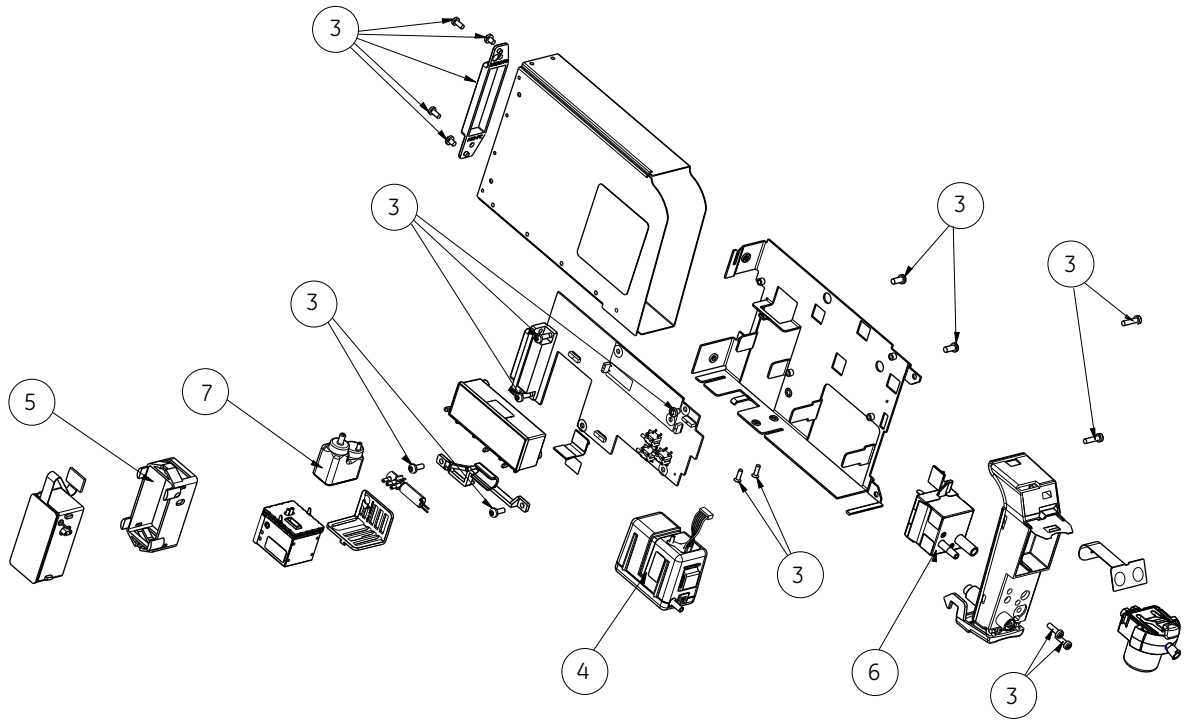


Table 7:

FRU#	FRU/ Item description	FRU / Item part number
4	FRU, Pump Unit	M1206290
5	FRU, OM Holder	M1206531
6	FRU, PVX Unit[1], E-sCAiOV, E-sCOV	M1206528
7	CO2 Absorber	M1206555

1 The PVX unit is available as a FRU for E-sCAiOV and E-sCOV module models only.

WARNING **The PVX unit of E-sCAiOVX and E-sCOVX modules must not be replaced in the field. Attempting to do so may result in inaccurate gas exchange measurement.**

7.2.1 Front covers

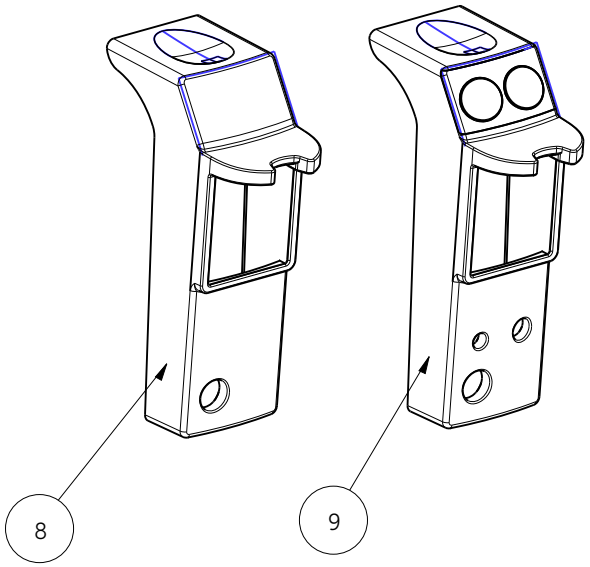


Table 8:

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-sCAiOVX	2080272-001
9	FRU, Front Cover, DA, E-sCAIOVX	2080301-001
9	FRU, Front Cover, DE, E-sCAIOVX	2080302-001
9	FRU, Front Cover, FI, E-sCAIOVX	2080303-001
9	FRU, Front Cover, FR, E-sCAIOVX	2080304-001
9	FRU, Front Cover, HU, E-sCAIOVX	2080305-001
9	FRU, Front Cover, IT, E-sCAIOVX	2080307-001
9	FRU, Front Cover, JA, E-sCAIOVX	2080310-001
9	FRU, Front Cover, NL, E-sCAIOVX	2080313-001
9	FRU, Front Cover, NO, E-sCAIOVX	2080314-001
9	FRU, Front Cover, PL, E-sCAIOVX	2080316-001
9	FRU, Front Cover, PT, E-sCAIOVX	2080317-001
9	FRU, Front Cover, RU, E-sCAIOVX	2080318-001

Table 8:

FRU#	FRU/ Item description	FRU / Item part number
9	FRU, Front Cover, SV, E-sCAIOVX	2080319-001
9	FRU, Front Cover, ZH, E-sCAIOVX	2080320-001
9	FRU, Front Cover, US, E-sCAIOVX	2080321-001
9	FRU, Front Cover, CS, E-sCAIOVX	2080322-001
9	FRU, Front Cover, ES, E-sCAIOVX	2080323-001
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
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-sCOVX	2080374-001
9	FRU, Front Cover, DA, E-sCOVX	2080378-001
9	FRU, Front Cover, DE, E-sCOVX	2080380-001
9	FRU, Front Cover, FI, E-sCOVX	2080381-001
9	FRU, Front Cover, FR, E-sCOVX	2080382-001
9	FRU, Front Cover, HU, E-sCOVX	2080383-001
9	FRU, Front Cover, IT, E-sCOVX	2080384-001
9	FRU, Front Cover, JA, E-sCOVX	2080385-001

Table 8:

FRU#	FRU/ Item description	FRU / Item part number
9	FRU, Front Cover, NL, E-sCOVX	2080386-001
9	FRU, Front Cover, NO, E-sCOVX	2080387-001
9	FRU, Front Cover, PL, E-sCOVX	2080388-001
9	FRU, Front Cover, PT, E-sCOVX	2080389-001
9	FRU, Front Cover, RU, E-sCOVX	2080390-001
9	FRU, Front Cover, SV, E-sCOVX	2080391-001
9	FRU, Front Cover, ZH, E-sCOVX	2080392-001
9	FRU, Front Cover, US, E-sCOVX	2080393-001
9	FRU, Front Cover, CS, E-sCOVX	2080394-001
9	FRU, Front Cover, ES, E-sCOVX	2080396-001
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

For your notes:

Maintenance check form

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

Customer	Monitor type	S/N
Service record #	Module type	S/N
Service engineer	Software version	
Planned maintenance ☐ Corrective maintenance ☐	Start 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 No:	Serial Number/ID:	Cal Due Date:

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

3.1. Replacement of planned maintenance parts	**Replaced**	**N.A.**
CO2 absorber (every 4th year)		
Nafion Tube, main flow		
Nafion Tube, zero line (every 4th year)		
OM Reference gas filter assembly		
Check that the fan and the ventilation holes are not covered in dust.		
PM Sticker		

3.2. Visual inspections	**Pass**	**Fail**
Module front cover is intact.		
All connectors are intact and attached properly.		
Module box and latch are intact.		
D-fend Pro and its connectors are clean and intact.		
Module and the applied parts are clean.		

3.3. Functional check	**Observed result**	**Acceptance criteria**	**PASS N.A. FAIL**
1. Gas Sampling System Leak Test	mmHg	Pressure drop ≤ 2 mmHg during 25 seconds.	☐ ☐
2. Spirometry System Leak Test	mmHg	Pressure drop ≤ 3 mmHg during one minute.	☐ ☐ ☐
3. Sample Flow Rate Check	ml/min	Within 120 ± 20 ml/min.	☐ ☐
4. Reference Gas Flow Rate Check	ml/mn	Within 10 - 50 ml/min.	☐ ☐

3.3. Functional check	**Observed result**	**Acceptance criteria**	**PASS**	**N.A.**	**FAIL**
5. Fan		Fan is running.	☐		☐
6. Module Keys		Keys are working correctly.	☐	☐	☐
7. Zero Valve Operation					
CO2:	%	***CO2*** value drops back near 0%.	☐		☐
O2:	%	***O2*** value is near 21% (room air).	☐		☐
N20:	%	***N2O*** value drops back near 0%.	☐	☐	☐
AA:	%	***Anesthesia agent*** value drops back near 0%.	☐	☐	☐
8. Gas Calibration		***Calibration Ok*** message appears.	☐		☐
9. Agent Identification					
Identified agent:		Agent is identified as Desflurane.	☐	☐	☐
IDu:		***IDu*** value < 75.	☐	☐	☐
10. Ambient Pressure					
Monitor	mmHg	The measured values do not differ more than ± 10 mmHg.	☐		☐
Barometer	mmHg				
11. Occlusion detection ***Sample line blocked*** and ***Low sample flow*** appear in:	s	Within 30 seconds.	☐		☐
12. Air Leak detection ***Check Water Trap*** appears in:	s	Within 30 seconds.	☐		☐
13. Gas exhaust blockage ***Sample Gas Out*** appears in:	s	Within 30 seconds.	☐		☐
14. Airway Gases ***CO2*** waveform appears:		Normal ***CO2*** waveform appears.	☐		☐
EtCO2 and ***FiO2*** values:		***EtCO2*** and ***FiO2*** values are updated.			
15. Apnea detection ***Apnea*** alarm appears in:	s	Within 30 seconds.	☐		☐
16. Flow waveform		Flow waveform responds when you breathe in and out.	☐	☐	☐
3.3.3. Test completion			☐	☐	☐

Notes

Used service parts			

Signature	Date

9

Compact Airway Modules E-CAiOVX, E-CAiOV, E-CAiO, E-COVX, E-COV, E-CO

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the Compact Airway modules, E-CO, E-COV, E-COVX, E-CAiO, E-CAiOV and E-CAiOVX. The Compact Airway modules are double width plug-in modules.

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

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				

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.

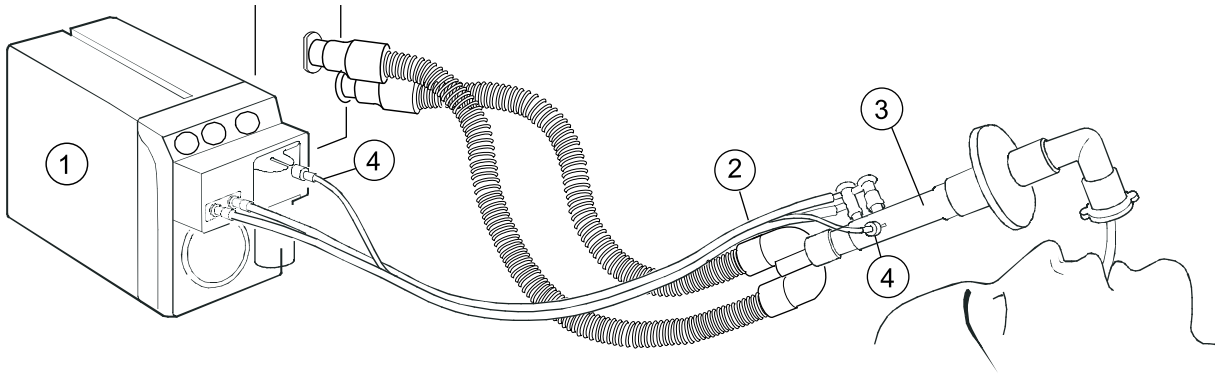


Figure 1 Airway gases measurement setup

(1) Module with spirometry measurement capability

(2) Patient spirometry tube

(3) D-lite(+) /Pedilite(+) sensor

(4) Gas sampling line

1.2 Measurement principle

1.2.1 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).

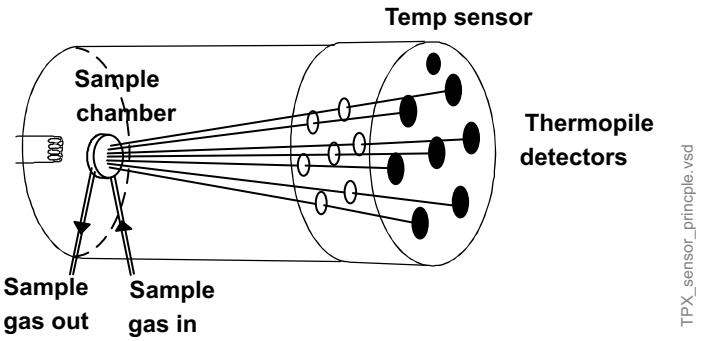


Figure 2 TPX sensor principle

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.

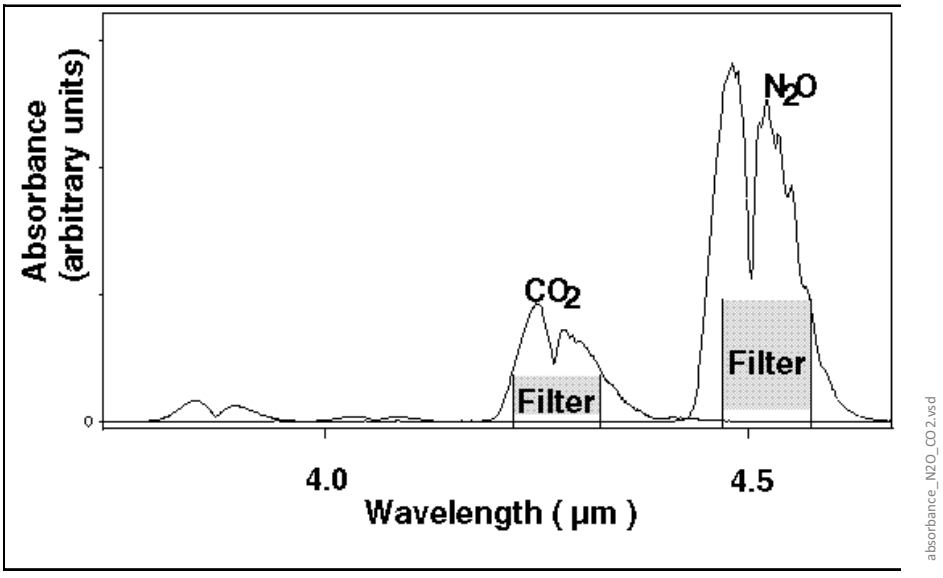


Figure 3 Absorbance of N_2O and CO_2

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 five equations.

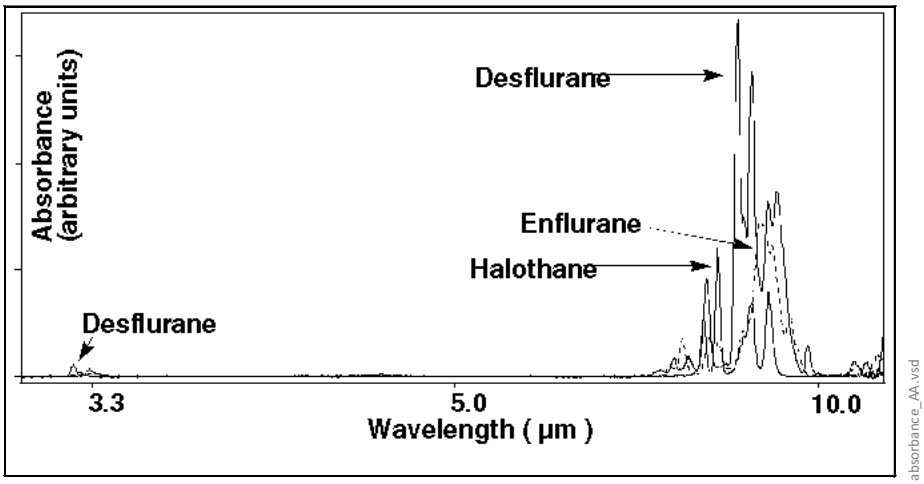


Figure 4 Infrared absorbance of AAs

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

1.2.2 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.

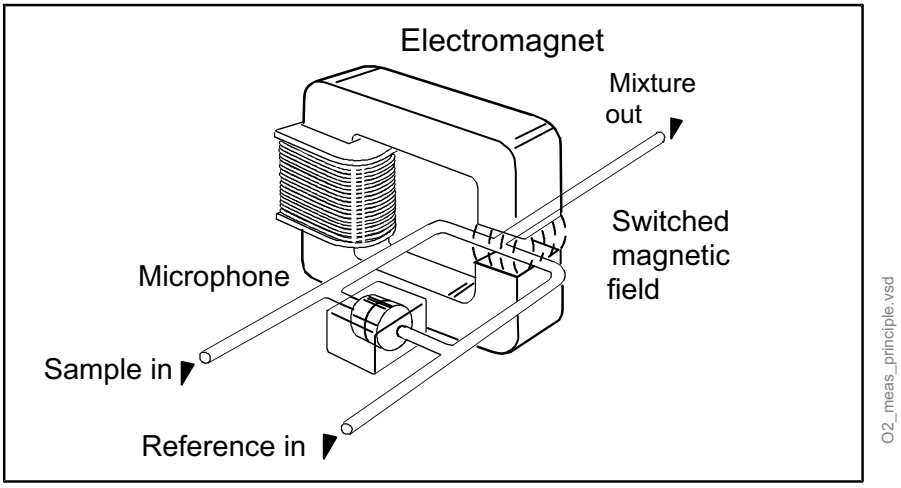


Figure 5 O_2 measurement principle

1.2.3 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 with ICU and ED software packages
- End inspiratory pressure (P_{plat})
- PEEPi, PEEPe; available only in with ICU and ED software packages
- Total positive end expiratory pressure ($PEEP_{tot}$); available with OR and PACU software packages
- Real time airway pressure waveform (P_{aw})
- Static Positive end expiratory pressures (Static $PEEP_i$ and Static $PEEP_e$); available with ICU and ED software packages
- Static Plateau pressure (Static Pplat); available with ICU and ED software packages
- Static Compliance (Static Compl); available with ICU and ED software packages

PEEP, P_{peak}, P_{mean}, and P_{plat} are measured by a pressure transducer on the PVX 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.

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.

1.2.4 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).

$$EE_{pedi} = 5.50 \times VO_2 + 1.76 \times VCO_2$$ Formula 12

1.3 Main components

The compact airway modules consist of:

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

1.3.1 Controls and connectors

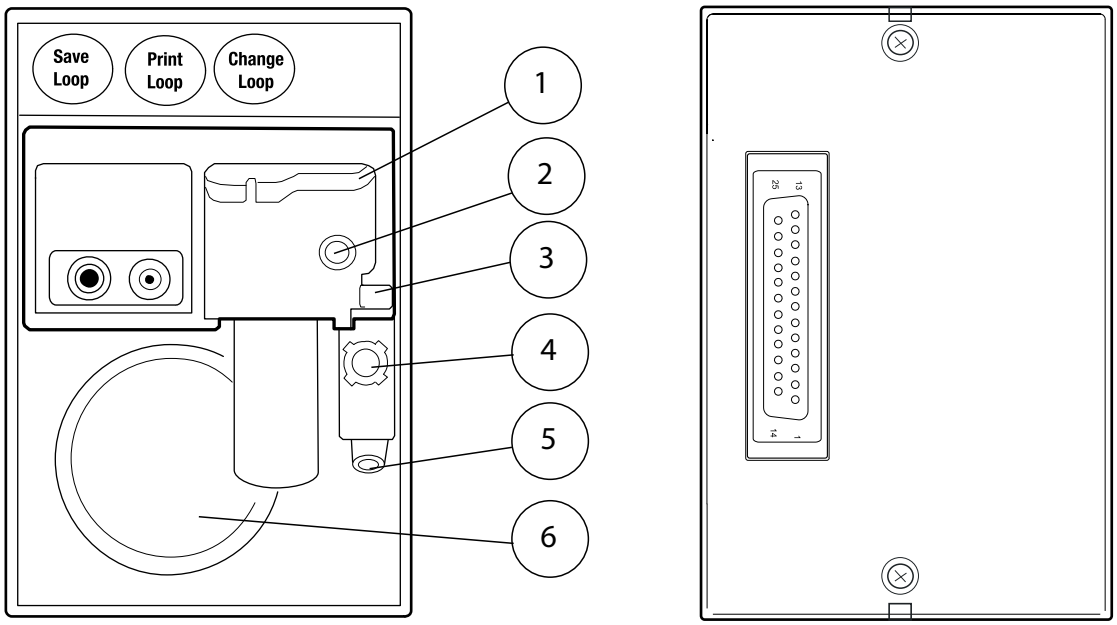


Figure 6 Front of Compact Airway Module, E-CAiOVX, and the back of the module

(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

1.3.2 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.

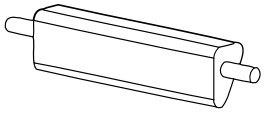


Figure 7 Absorber

Nafion[1)] tubes

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.

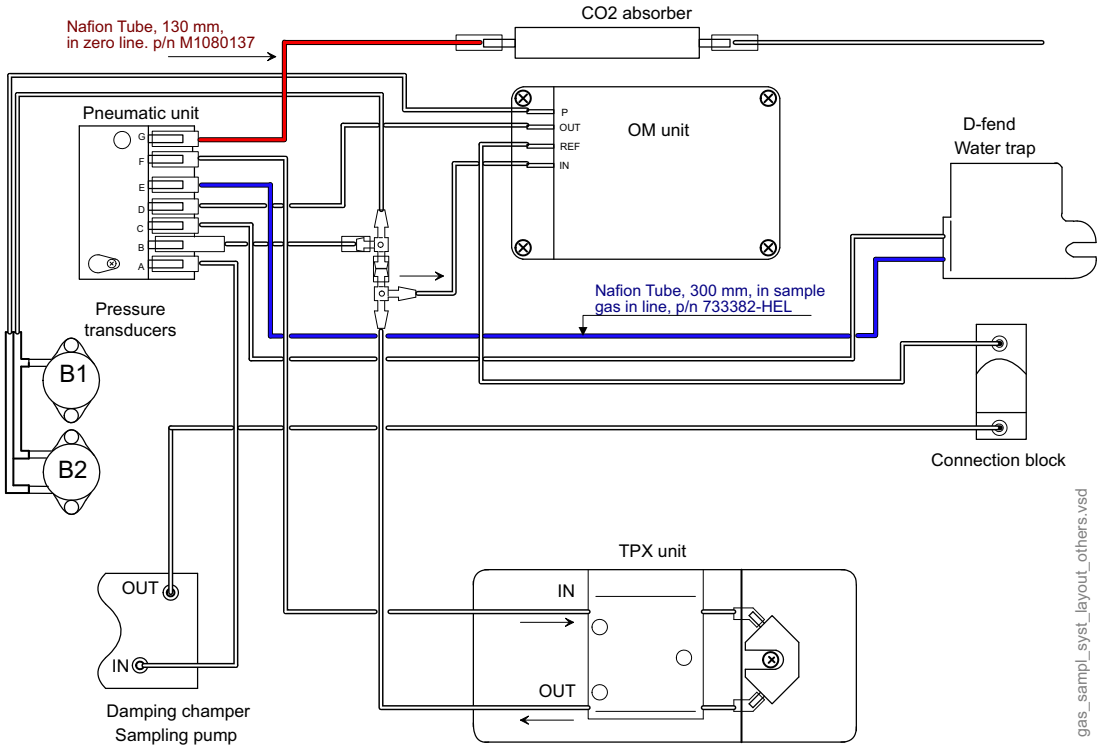
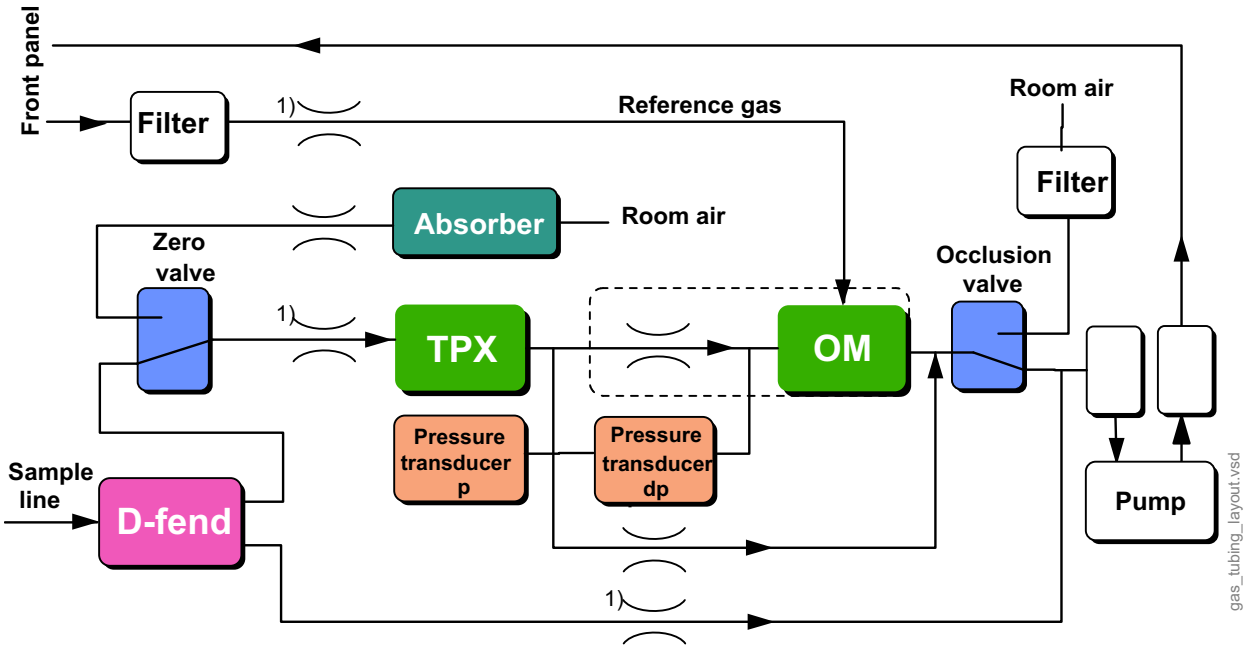


Figure 8 Gas sampling system layout



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

Figure 9 Gas tubing layout

1.3.3 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 unit's 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 seven thermopile signals and the temperature sensor signal to the CPU board.

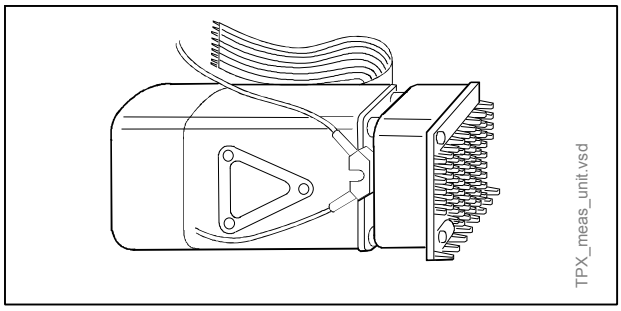


Figure 10 TPX measuring unit

OM measuring unit

The oxygen measurement is based on paramagnetic susceptibility. The gas and the reference gas, which 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.

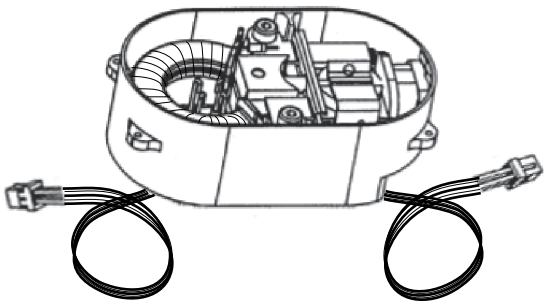


Figure 11 OM measuring unit

1.3.4 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 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.

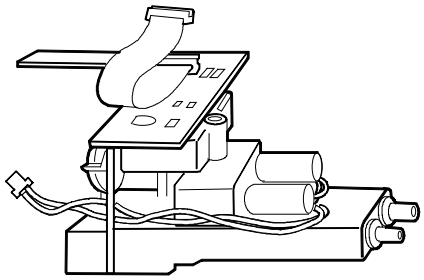


Figure 12 PVX measuring unit

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 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.

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.

NOTE: The gas exchange measurement in the E-CAiOVX and E-COVX modules works accurately only with 2-meter (7 ft) gas sampling lines.

1.3.5 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.

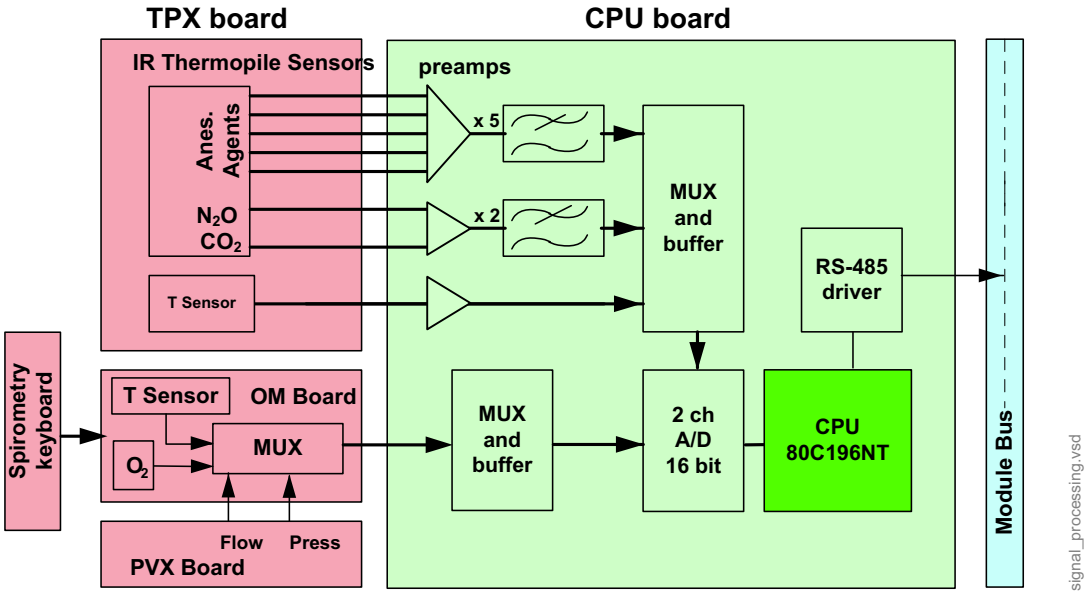


Figure 13 Signal processing

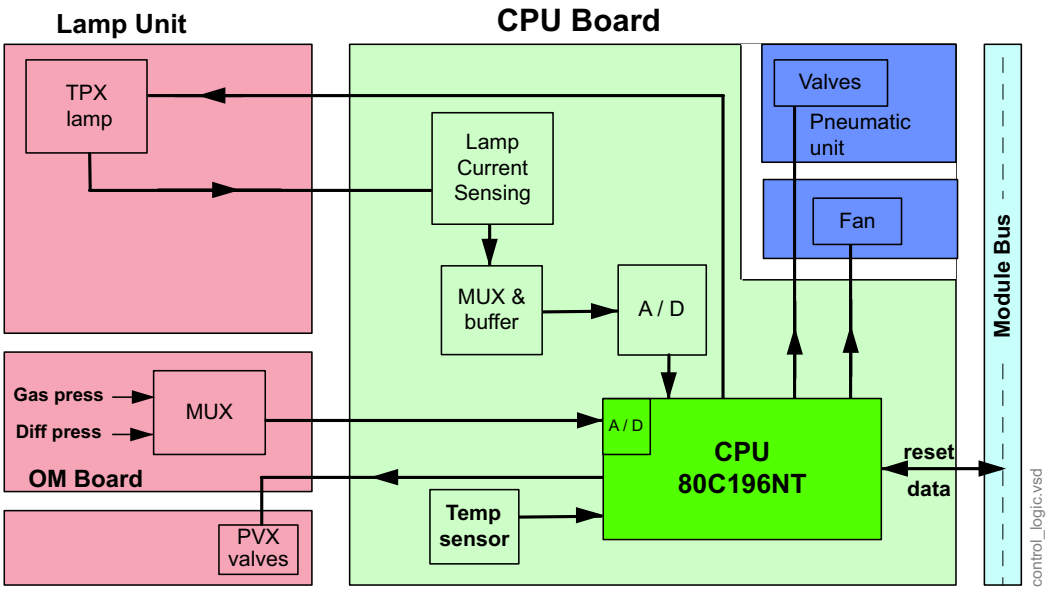


Figure 14 Control logic

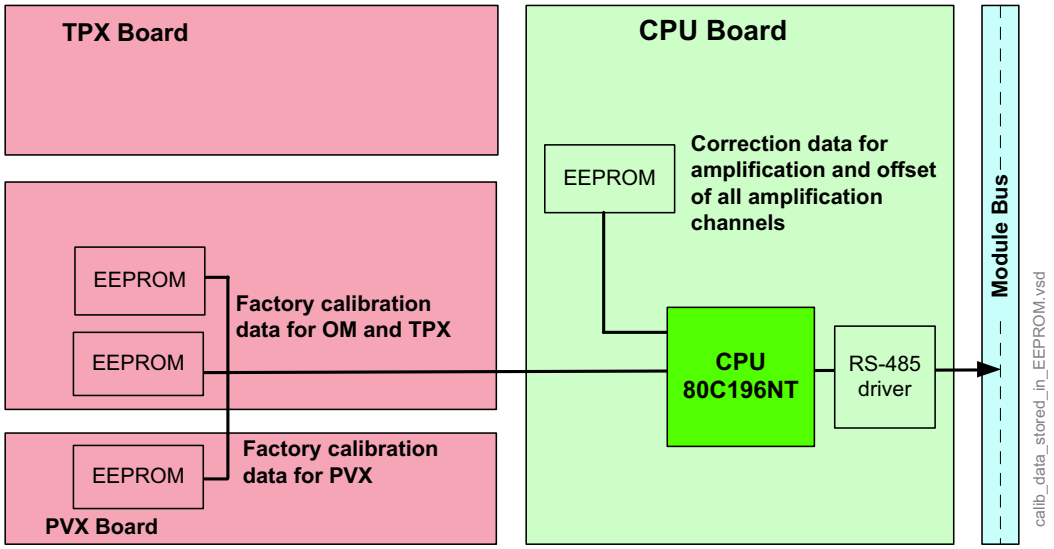


Figure 15 Calibration data stored in EEPROM

1.3.6 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.

For your notes:

2 Configuration

There is no configuration for the Compact Airway Modules.

3 Maintenance and checkout

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

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)**
Any of the front panel stickers	All steps	Check “Module Keys” only
D-fend O-rings or Reference gas filter assembly	All steps	Check “Gas Sampling System Leak Test” and “Sample Flow Rate Check”
Fan filter	All steps	Check “Fan” only
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, 300 mm	1	Once a year
Nafion tube, 130 mm	1	Once a year
Occlusion filter for pneumatic unit	1	Once a year
Reference gas filter assembly	1	Once a year
O-ring for reference gas filter assembly	1	Once a year
PM kit sticker	1	Once a year
D-Fend O-ring	2	Once a year
Fan filter	1	Once a year

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.

NOTE: See the supplemental information manual for compatible accessories.

3.1.2 Planned Maintenance Kits

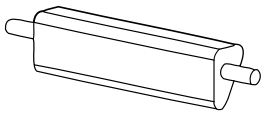
The required planned maintenance parts are included in a PM kit.

Part number	Description
2093592-001	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.

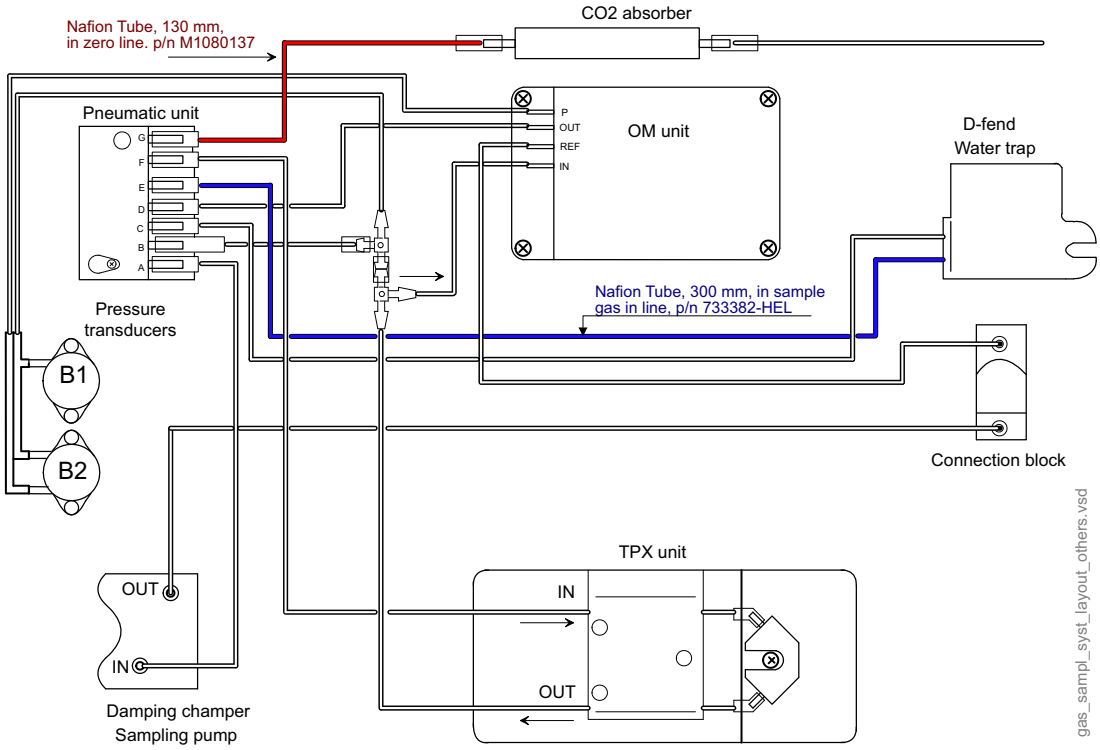
3.1.3 Replacement procedures

Replace the specified planned maintenance parts according to the following procedure. Refer to chapter 6. Disassembly and reassembly and chapter 7. Service parts for additional information.

1. Replace the CO2 absorber every 4 years.



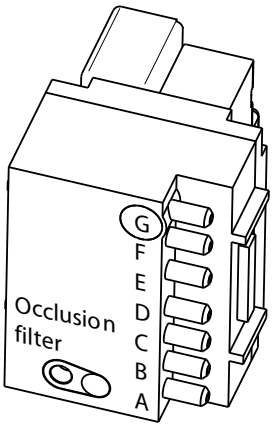
2. Replace the special tubes (Nafion) and check the condition of the internal tubing.
   - Replace the 130 mm Nafion tube in the zero line between the CO2 absorber and the pneumatic unit.
   - Replace the 300 mm Nafion tube in the sample gas line between the D-fend water trap and the pneumatic unit.
   - 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, contact GE Healthcare for factory repair.



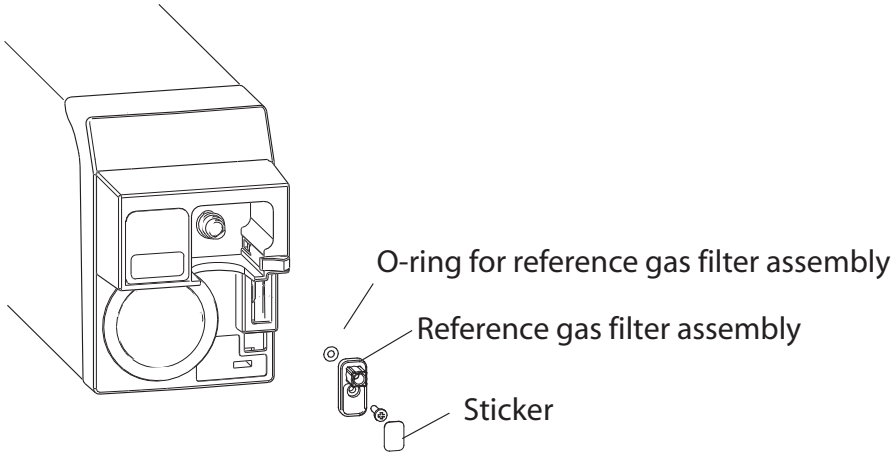
NOTE: The nafion tubes do not include the silicon fittings they connect to. Use the original silicon fittings unless they are not damaged or leaking.

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.

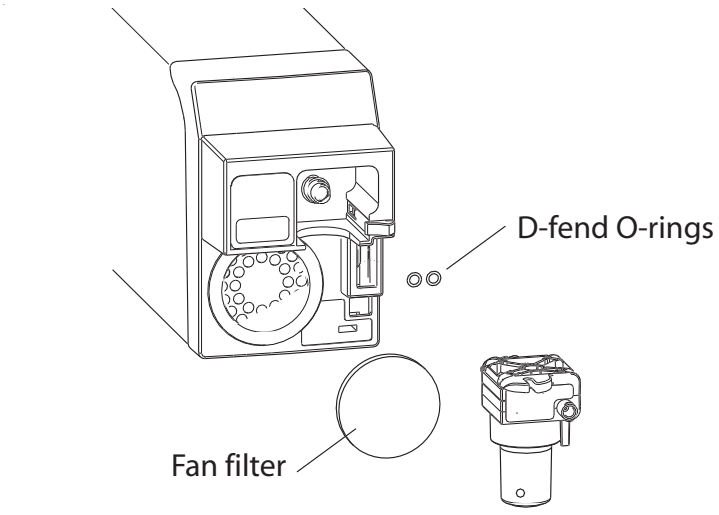
3. Replace the occlusion filter in the pneumatic unit:
   a. Open the screw that holds the black filter cover to the pneumatic unit.
   b. Detach the filter cover e.g. using a small flat blade screwdriver.
   c. Detach the white occlusion filter e.g. by turning the module upside-down so that the filter 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 labeling 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 Visual inspections

Detach the module from the module slot and check that:

- the front cover and the front panel sticker are intact
- all connectors are intact and are attached properly
- the D-fend latch is moving properly
- the module box and latch are intact
- the metal D-fend connectors and the D-fend O-rings 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 patient monitor's 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 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: See the supplemental information manual for compatible accessories.

Connections

- Disconnect the module from the monitor, if connected.

Monitor configuration

1. Configure the CO2, O2, AA, and Flow waveform fields to the monitor screen with adequate priority.
2. Configure the Spiro 1 split screen to the monitor screen.
3. Select the ***Setup*** tab in the ***Spirometry and Gas Exchange*** menu and configure:

   Scaling: Auto

   Sensor Type: Adult

   Show Volume: TV

3.3.2 Procedure

Mark each task as complete on the checkout form.

1. Gas Sampling System 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.

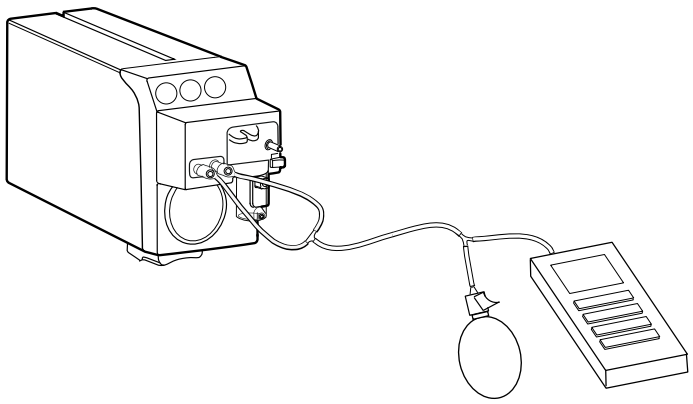
NOTE: The gas module shall be disconnected from the monitor during the leak test.

2. 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.

3. Fan
   a. Connect the module to the monitor.
   b. Check that the gas module's fan is running.

4. Module Keys

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

5. Sample Flow Rate Check

Check the sample flow rate.

NOTE: Gas measurement is not available during the first 2 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 21.1 °C (70 °F) and 760 mmHg (1013 mbar), 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 (2 m / 7 ft with E-COVX and E-CAiOVX, 3 m / 10 ft with E-CO, E-COV, E-CAiO and E-CAiOV) 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 200 ± 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 4.1. Sample Flow Rate Adjustment.

6. Reference Gas Flow Rate Check

Check the flow rate in reference gas inlet:

a. Keep the gas sampling line connected to the Sampling line connector.
b. Leave the other end of the gas sampling line open to room air.
c. Connect the flowmeter to the Oxygen reference gas inlet with a piece of tubing.
d. Check that the Reference Flow is within the following range:

31 - 45 ml/min with E-CO, E-COV, E-CAiO and E-CAiOV modules

27 - 40 ml/min with E-COVX and E-CAiOVX modules

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 > *Service Calibrations***.
d. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
e. Select ***Gases***.
f. 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 labeling of the calibration gas container.

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

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

8. Gas Calibration

Perform gas calibration according to the instructions in section 4.2. Gas Calibration.

9. Agent Identification

NOTE: Perform this test only for E-CAiO, E-CAiOV and E-CAiOVX 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 ***IDu*** value (=agent ID unreliability) shown in the ***Monitor Setup / Service calibrations / Gases*** menu is lower than 75.

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

If the value does not drop below 75, contact GE Healthcare for factory repair.

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. Fall Time Measurement
    a. Select ***Start Fall Time Measurement***.
    b. Feed calibration gas until the message 'Feed gas' near the fall time values changes to 'Ready'.
    c. Check that the measured fall times are within the following ranges:
    CO2: < 400 ms
    O2: < 400 ms
    DEL: < 800 ms

If necessary, repeat the same procedure to get all the values on the screen.

12. Occlusion detection
    a. Block the tip of the sampling line by your finger.
    b. Check that a 'Sample line blocked' message appears to the parameter window within 30 seconds.

13. Air Leak detection
    a. Detach the D-fend water trap.
    b. Check that the message 'Check Water Trap' appears to the parameter window 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 CO_2 waveform appears to the waveform field and the $EtCO_2$ and FiCO2 values are updated to the parameter window.

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

16. Flow waveform

NOTE: Perform this test only for E-COV, E-COVX, E-CAiOV and E-CAiOVX 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 goes downwards when you breathe in and upwards when you breathe out.

3.3.3 Test completion

- Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.
- Complete on the “Maintenance check form” on page 9-56.

4 Calibration and adjustments

4.1 Sample Flow Rate Adjustment

Sample flow rate shall be adjusted:

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

4.1.1 Calibration setup

Required tools

– A mass flowmeter for measuring air flow, minimum measurement range 100-300ml/min, accuracy 5% or better in the 100-300ml/min range.

– 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)

NOTE: See the supplemental information manual for compatible accessories.

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

NOTE: Refer to the flowmeter documentation for user instructions.

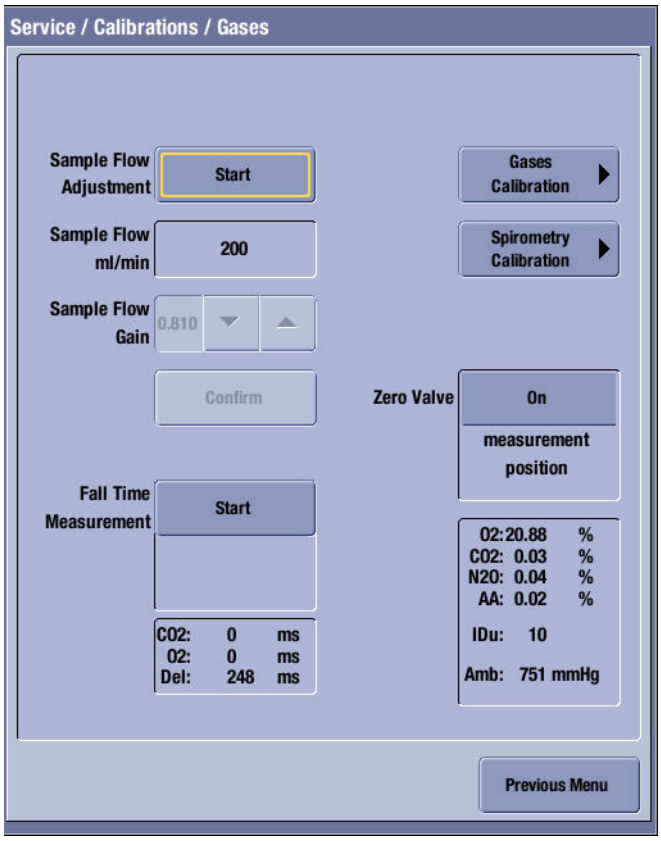
Connections

1. Ensure that the module is connected to the monitor.
2. Ensure that you have a new D-Fend 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.

4.1.2 Sample Flow Rate Adjustment

1. Select **Monitor Setup >** ***Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Gases***
4. Select ***Start Sample Flow Adjustment***



5. Adjust the sample flow to the nominal value 200 ml/min by using the Sample Flow Gain up-down spinner controls:
   - 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.
6. 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 200 ml/min and then check the actual measured flow rate from the flow meter.
7. Repeat steps 5 and 6 until the flow meter shows a 200 ± 20 ml /min flow rate.
8. Select ***Stop Sample Flow Adjustment*** to save the new gain value to the permanent memory of the module.

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 200 ml /min independent on the real flow rate.

4.2 Gas 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 patient monitor's user's manual for the recommendation for gas calibration interval in clinical use.

4.2.1 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-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
- 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)

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 labeling 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 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.

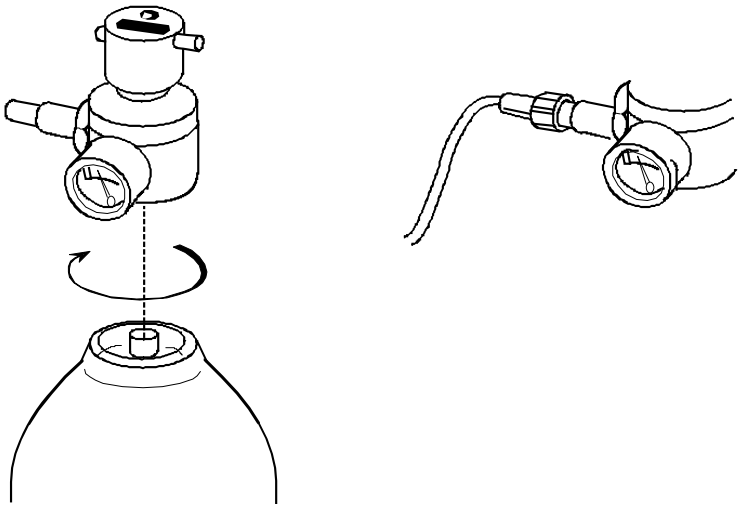


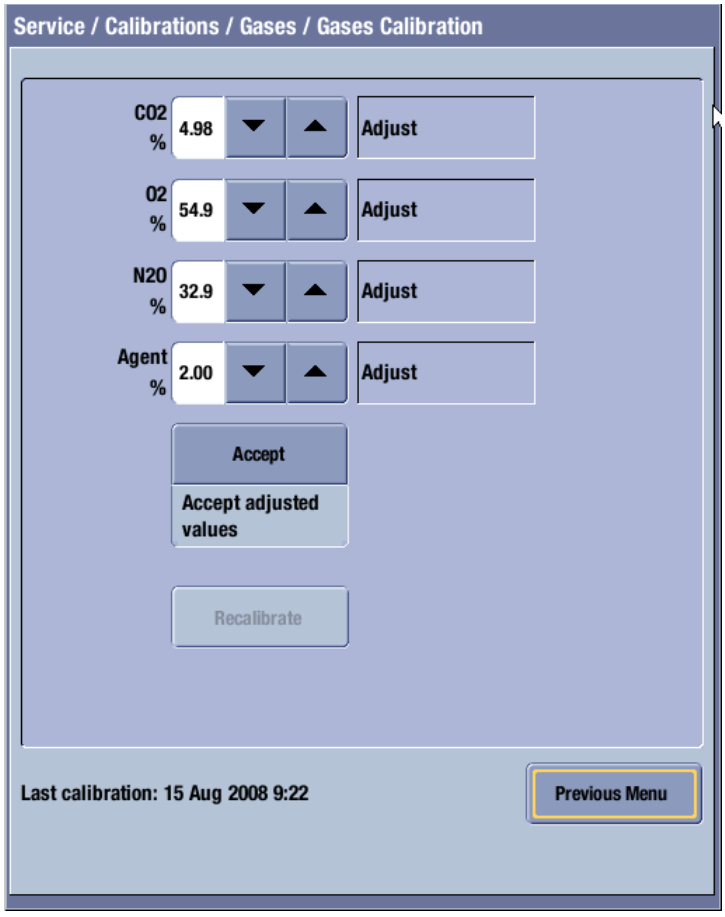
Figure 16 Connecting a gas regulator to the calibration gas container and connecting a sampling line to the gas regulator.

4.2.2 Procedure

1. Select ***Monitor Setup > Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Gases***
4. Select ***Gases Calibration***

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.



5. 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.
6. 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.
7. Use the up-down spinner controls in the calibration menu to adjust the gas readings shown in the calibration menu to match with the gas readings in the labeling of the

calibration gas container. Select Accept to accept the adjusted values when the gas readings match each other.

8. 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.

4.3 Spirometry Calibration

Patient spirometry does not require regular service calibration during planned maintenance, or after the PVX unit has been replaced.

The PVX 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.

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.

4.3.1 Calibration setup

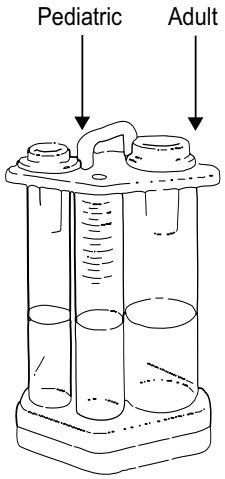
Required tools

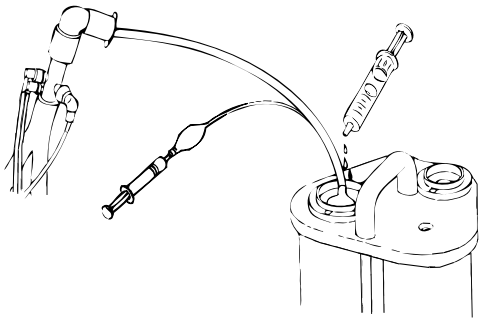
– P/N 884202-HEL Spirometry tester
– D-Lite and Pedi-lite sensors
– Spirometry tube
– Ventilator

NOTE: See the supplemental information 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 ***Setup*** tab in the ***Spirometry and Gas Exchange*** menu and configure:

  Scaling: Auto

  Sensor Type: Adult

  Show Volume: 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.

4.3.2 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.

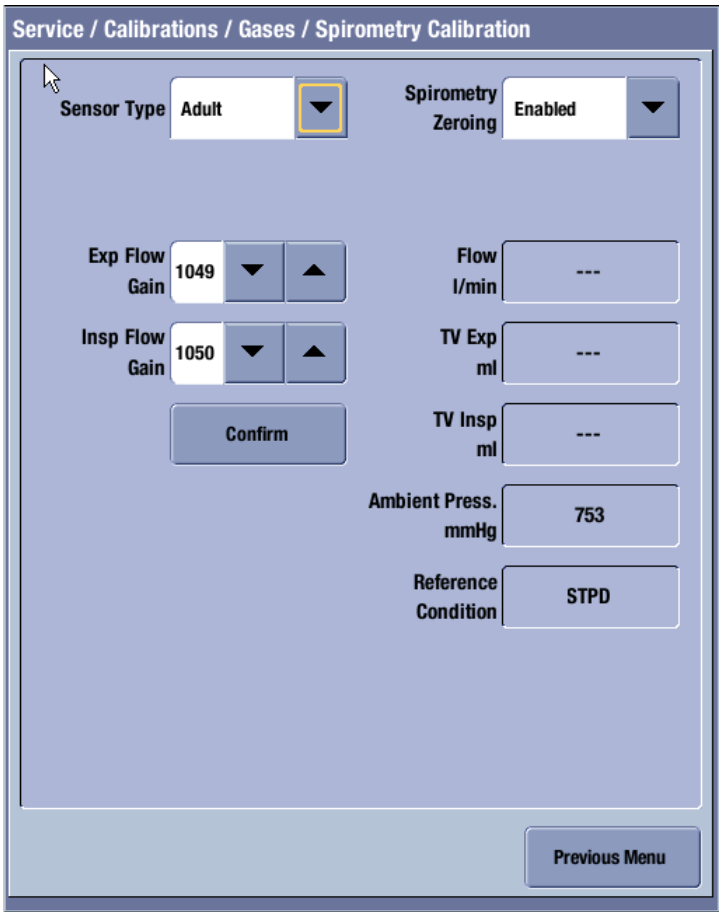
2. The measured flow values are shown in real-time in the ***TV Insp*** and ***TV Exp*** fields in the Flow parameter window. Compare these measured values to the TV value reading (highest water level) in the spirometry tester.

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 4.3.3 Flow calibration.

4.3.3 Flow calibration

1. Select ***Monitor Setup > Service Calibrations***
2. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
3. Select ***Gases***
4. Select ***Spirometry Calibration***
5. Ensure that the ***Sensor Type*** is correct and that ***Spirometry Zeroing*** is Enabled.
6. Wait until the PVX sensor performs an automatic zeroing. It will show a message "zeroing" in the Flow parameter window when zeroing takes place.
7. Adjust the ***Exp Flow Gain*** and/or ***Insp Flow Gain*** separately by using the related up-down spinner controls 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***.
8. Press ***Confirm*** to check the effect of the gain adjustment to the flow readings.
9. Repeat steps 6 and 7 until the flow values are within the specification.


Service / Calibrations / Gases / Spirometry Calibration
Sensor Type
Adult
Spirometry Zeroing
Enabled
Exp Flow Gain
1049
Insp Flow Gain
1050
Confirm
Flow l/min

TV Exp ml

TV Insp ml

Ambient Press. mmHg
753
Reference Condition
STPD
Previous Menu

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

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

- the front cover and the front panel sticker are intact
- the D-fend latch is moving properly
- all connectors are intact, clean and are attached properly
- the module box and latch are intact
- the metal D-fend connectors and D-fend O-rings 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 two 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
- the tubes that are connected to the Oxygen board pressure transducer are not pressed too deep
- there are no tubes or wires in contact with the sampling pump, the oxygen sensor, or its springs
- there are no loose objects inside the module

5.2 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.

- Connect the accessories to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (***Monitor Setup > Screen Setup > Upper Parameter Area***).
- 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 GE Healthcare 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.

5.2.1 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.
- 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 water trap should be replaced, when the 'REPLACE D-FEND' message appears.
- If any liquid has entered the internal tubing or the TPX 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 will 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, contact GE Healthcare service for factory repair.

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

5.2.2 OM 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 in filter assembly, and replace if needed.
- If the O_2 signal is noisy, check the measurement unit suspension.

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

5.2.3 TPX Measuring unit troubleshooting

- The TPX 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.
- Perform anesthetic agent measurement range check, if the agent identification check fails.

Anesthetic agent measurement range check

With this test you can check anesthetic agent measurement range one anesthetic agent at a time.

Required tools

- an anesthesia machine with patient circuit, vaporizer and anesthesia gas scavenging system
- 3 m / 10 ft anesthesia gas sampling line (with E-CAiO and E-CAiOV modules)
- 2 m / 7 ft anesthesia gas sampling line (with E-CAiOVX module)
- D-fend water trap

Connections

1. Connect the module to the monitor.
2. Connect the D-Fend water trap to the module.
3. Connect the gas sampling line to the sampling line connector in the water trap.
4. Connect the other end of the gas sampling line to the anesthetic gas output. Do not pressurize the sampling point. Use by-pass flow.
5. Connect the sample gas outlet (gas exhaust) of the module to the scavenging system.

Monitor configuration

1. Configure the AA numeric value to the monitor screen with adequate priority.

Checking the anesthetic agent measurement range

1. Turn on the monitor, and let it warm up for 2 hours.
2. Use the anesthesia machine to generate anesthetic agent, for example Desflurane. For detailed instructions of use, refer to the user documentation provided with the anesthesia machine.
   NOTE: Remember to take good care of the scavenging.
3. Enter the gas calibration menu and start the calibration.
4. The monitor will start automatic zeroing of the gas sensors. Wait until the message 'Zeroing' is replaced by a message 'Zero Ok' for the measured gases and press Normal screen / home key.
5. Divide the specified anesthetic agent measurement range into 4 test values. For example for Desflurane: 4, 6, 12 and 18%.
6. Feed the selected amount of anesthetic agent until the measured value stabilizes, then continue feeding it for 20 seconds.

   Check that the measured AA value corresponds to the set value on the anesthesia machine.

   NOTE: For the gas module measurement accuracy, see the supplementary information manual. Differences in anesthetic feeding systems may generate additional measurement inaccuracy.
7. Repeat step 6 for each test value.
8. Set the vaporizer setting back to zero and let the system flush the remaining anesthetic agent.
9. Change anesthetic agent and repeat steps 5 - 8.

   If the monitor shows abnormal readings or 0.00 when you feed the anesthetic agent, and/ or “Failure in Agent ID” error message on the monitor screen, the entire module must be replaced. In this case, contact GE Healthcare service for factory repair.

5.2.4 PVX Measuring unit troubleshooting

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

5.2.5 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 the software chip is properly installed.
- Check that the D25 connector is clean and intact.

5.3 Service Interface

Use the Webmin service interface to access device information and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the Compact Airway Module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information tab***.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the Compact Airway Module.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***Download Logs***
4. Select one of the log files for downloading.

5.4 Messages

5.4.1 Gas measurements

The messages below appear in the gas parameter windows (PW), gas waveform fields (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Check water trap Check water trap and sample gas out. Wait for 30 sec. and press Normal screen to continue.	PW, MF WF	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. Replace, if needed.
Sample line blocked Continuous blockage. Check sampling line and water trap.	PW, MF WF	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. Replace, if needed.
Check sampling gas out Check water trap and sample gas out. Wait for 30 seconds and press Normal screen to continue.	PW, MF WF	The sample gas outflow is blocked.	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.
		Internal tubing is blocked.	Check the internal tubing for blockages.

Message	Location	Possible causes	Possible solutions
		Pump failure.	1.Check the sample pump operation by measuring the sample gas flow rate. 2. Check that the screw inside the sampling pump is not loose (see 6.2.4. Tightening the screw inside the sampling pump). 3. Replace pump, if needed.
Replace water trap	PW, MF	Defective or contaminated D-fend. Occlusion in internal tubing.	Replace the D-fend water trap. Check sample and reference flows. Perform a visual check for the internal tubing. Remove the cause for occlusion.
Calibrating	PW & calibration menu	Gas calibration is in progress.	Wait until the calibration is completed successfully.
Failure in Agent ID	PW	Agent ID has failed. TPX unit or electronics failure.	1. Perform gas calibration. 2. Perform the Agent Identification check (see functional check). 3. Perform "Anesthetic agent measurement range check" (see TPX Measuring unit troubleshooting). If the calibration and either of the checks fail, send the module to GE Healthcare for factory repair.
Zeroing	PW & calibration menu	Zeroing is in progress.	Wait until zeroing is completed successfully.
Zero error	PW & calibration menu	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	PW & calibration menu	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	PW	Measured FiO_2>103%	Perform gas calibration.

Message	Location	Possible causes	Possible solutions
Apnea deactivated	PW	Apnea alarm start-up conditions are not reached.	Apnea alarm detection is activated after the 3 breaths are detected.
Sensor INOP	WF	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 lamp wire connection. Check the ambient pressure from the Gas Calibrations menu. Replace CPU. Return the module to GE Healthcare for service.
Calibrating gas sensor	WF	O_2, CO_2 and N_2O measurements are not available during the first 2 minutes after the module is connected due to warm-up. Anesthetic 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	WF	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.
Low gas sample flow	MF	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. Error in pneumatic initialization.	Check sample flow rate. Adjust, if needed. Check or replace the gas sampling line, water trap, or internal tubing. 1.Check that the screw inside the sampling pump is not loose (see 6.2.4. Tightening the screw inside the sampling pump). 2.Replace pump, if needed. Connect sample line and water trap to module and restart monitor
Incompatible gas module	MF	Incompatible gas module detected by the monitor.	Check the compatibility of the gas module.
Gas measurements removed	MF	The module is disconnected.	1. Reconnect the module. 2. Check that the D25 connector is clean and intact.
Identical gas modules	MF	The monitor detects gas measurement from two or more modules.	Remove excess modules providing gas measurement.

5.4.2 Spirometry

The messages below appear in the spirometry parameter windows (PW), spirometry waveform fields (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
MVexp<<MVinsp	PW	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 PVX, if needed. Clean the tubing.
Low volumes	PW	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	PW	Zero valve leaking or internal damage in the flow sensor. PVX ribbon cable or PVX valves cable loose.	Perform spirometry leakage test. Replace PVX sensor, if needed. Check PVX ribbon cable or PVX valves cable.
Zeroing	PW	Zeroing is in progress.	Wait until zeroing is completed successfully.
Sensor INOP	WF	There is no response from the PVX measurement board or there is an EEPROM checksum failure. PVX ribbon cable loose.	Replace PVX unit. Check PVX ribbon cable.
Over scale	WF	Flow or Paw waveform signal exceeds the upper limit of the current scale.	Change Flow/Paw waveform scale or use autoscaling.
Scale changed	WF	Displayed for 10 seconds after autoscaling mode has changed Flow, Paw, or Vol scale.	N/A
Saving loop	MF	Spirometry loop is being saved.	N/A
Printing loop	MF	Spirometry loop is being printed.	N/A
Spirometry measurements removed	MF	The module is disconnected.	Reconnect the module.

5.4.3 Gas Exchange

The messages below appear in the gas exchange parameter windows (PW).

Message	Location	Possible causes	Possible solutions
No VO2, FiO2>85%	PW	Unable to measure gas VO_2 because the measured FiO_2 is out of gas exchange specification (>85%).	Use lower O_2 concentrations.
No VO2, FiO2 too high	PW	Unable to measure gas VO_2 because the measured FiO_2 + FiN_2O is out of gas exchange specification (>85%).	Use lower O_2 concentrations.
Artifact	PW	Module is unable to synchronize flow and CO_2 due to wrong sample line length (>2 meter)	Use a 2 meter gas sampling tube and spirometry tube with gas exchange.
Bypass flow high	PW	Module is unable to synchronize flow and CO_2 due to bypass flow.	Reduce fresh gas flow.
Out of range	PW	VO_2 or VCO_2 is <0 or >999 ml/min and thus out of measurement.	Check that the gas sampling line and spirometry lines are correctly connected to the airway and to the gas module. Check that the correct sensor type (D-lite/ Pedi Lite) has been selected from the monitor menu.

5.5 Troubleshooting charts

5.5.1 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	- perform the gas sampling system leak test (see Functional check). - 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	- contact GE Healthcare for factory repair - 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 *Default Setup/ Care unit Settings / Parameters* menu

5.5.2 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 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 - 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 - 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

5.5.3 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
Nonphysiological VO_2 readings	- unstable O_2 delivery - gas mixer - RR over 35/min	- reference gas inlet port blocked - gas sampling line longer than 2 m - dead space of Y-piece > 8 ml - gas sampling line connected to HME - D-lite incorrectly placed	- select oxygram and verify the stableness of the curve - check reference port - change 2 m sampling line - check the dead space of Y-piece - gas sampling line should always be connected to D-lite - ALWAYS connect the D-lite between 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 > VO_2 > 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

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module frame is limited to replacing faulty circuit boards or mechanical parts only.

WARNING **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. Maintenance and checkout after you have disassembled and reassembled the module.

6.1.1 Serviceable parts

- CO Absorber
- D-fend
- Nafion tubes
- Fan filter
- Fan
- CPU board
- CPU software
- PVX Unit
- Pump
- Mechanical parts listed in chapter 7. Service parts

6.1.2 Service limitations

The following parts are not serviceable:

- OM Measuring unit
- OM board
- TPX measuring unit

NOTE: The OM board contains factory calibration data for the OM and TPX measuring units and for the pressure and flow sensors. The OM board can be repaired and calibrated only at the factory. In case of failure, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.

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 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.

6.1.3 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.

6.1.4 Protection from dust

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 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 just before assembling it to the module
- Remove the protective caps on CO_2-absorber just before assembling it to the module.
- The clothing of the service person must be such that the dust risk is taken into account.

6.1.5 Before disassembly

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

6.1.6 Required tools

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

6.2 Disassembly and reassembly procedure

6.2.1 Removing the module casing

To disassemble the compact airway module (see the exploded view of the module in chapter 7. Service parts):

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

To reassemble 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
- there are no loose objects inside the module

NOTE: The tubes that are connected to the Oxygen board pressure transducers should not be pressed too deep.

NOTE: Make sure that tubes are not in contact with the sampling pump or the O2 sensor, or its springs.

6.2.2 PVX unit

1. Remove the module casing.
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).

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

6.2.3 Pump unit

1. Remove the module casing.
2. Cut off the pump's clamp (panduit).

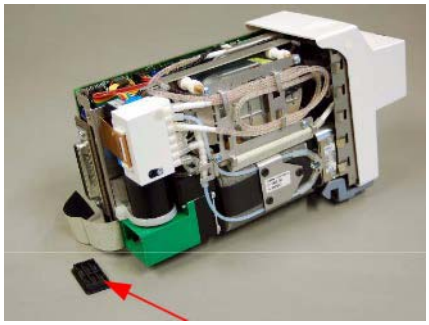
3. Unplug the hoses of the pump.
4. Disconnect the pump's cable from the CPU board. Pass the cable under the pneumatic unit by lifting it.

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

6.2.4 Tightening the screw inside the sampling pump

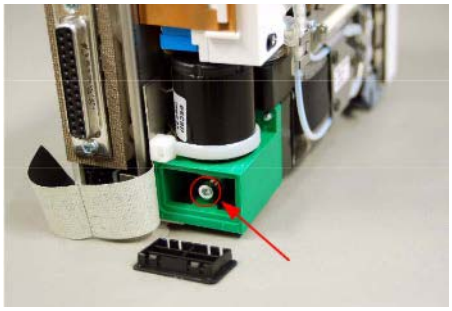
1. Remove the module casing.
2. Locate and detach the masking tape on the sampling pump.

Detach the cover plate of the pump with a flat plate screwdriver.



3. Locate the screw (H2.5) inside that sampling pump frame.

   Notice that depending on the position of the pump axis motor, you may have to rotate the axis to be able to tighten the screw.



4. Tighten the screw carefully with hexagon screwdriver. Torque (0,8 Nm)

   NOTE: You don't have to use torque wrench or torque screwdriver instead you can use the recommended standard hand tools. However, if you use a battery-operated tool, ensure that it is equipped with torque limiter and the torque is properly adjusted.
5. Reassemble the pump unit and the module in reverse order.

   NOTE: Make sure to route the tubes correctly and check that the tubes are not squeezed between the module casing and the internal parts.

6.2.5 CPU board

1. Remove the module casing.
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.

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

6.2.6 Software of CPU board

1. Remove the module casing.
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 chip from the CPU board.

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

7 Service parts

7.1 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.

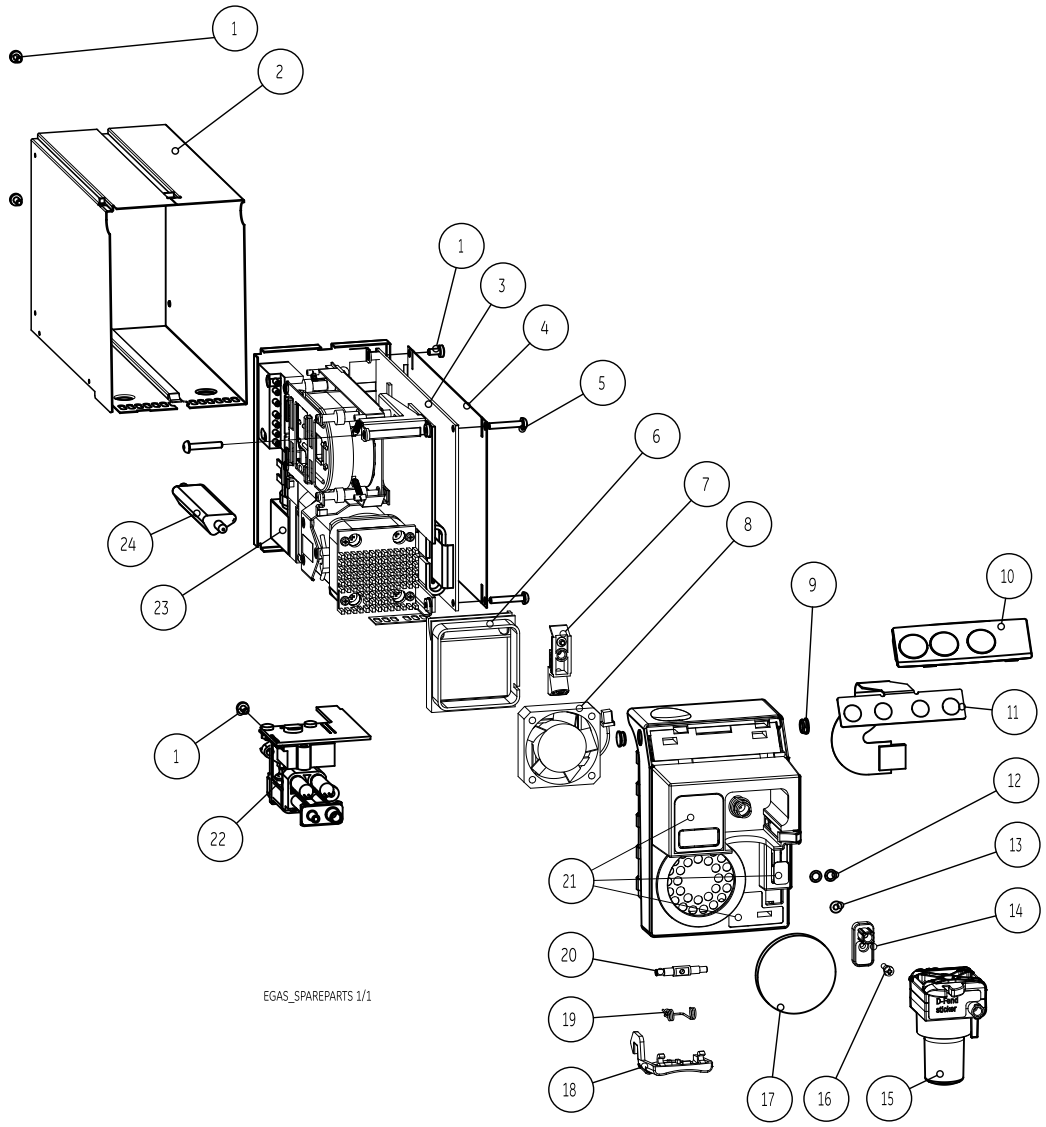
NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout after you have disassembled and reassembled the module.

7.1.1 Planned Maintenance Kits

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

Part number	Description
2093592-001	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.

7.2 Spare parts for E-CAiOVX, E-CAiOV, E-CAiO, E-COVX, E-COV, E-CO



Item	Description	Order No.
	Nafion tubing 300mm	733382-HEL
	Nafion tubing 130mm	M1080137
	Reference gas in sticker (white, all languages)	M1130739
1	SCREW, machine screw, M3x6mm, DIN7985 ISO7045, Pozidrive, pan head, steel, zinc	*

Item	Description	Order No.
2	Casing, E-GAS	M1023095
3	CPU BOARD, M-CAiOVX	8001806
4	Cover Plate for Gas Units	M1029000
5	SCREW, machine screw, M3x18mm, DIN7985, ISO7045, Pozidrive, pan head, steel, zinc, STZn	*
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, CS, E-COV(X), E-CAiOV(X)	M1063539
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

Item	Description	Order No.
16	SCREW, machine screw, M2.5x10mm, DIN7985, ISO7045, Pozidrive, pan head, steel	*
17	Fan filter, E-CAiOV	M1028987
18	Latch	M1021039
19	Torsion Spring, E-REC, E-GAS	M1024356
20	Joint, E-GAS, Turned	M1023087
21	Front Panel Sticker, E-CAiO, CS (A, B, D)	M1062551
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, CS (A,B,C)	M1052563
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

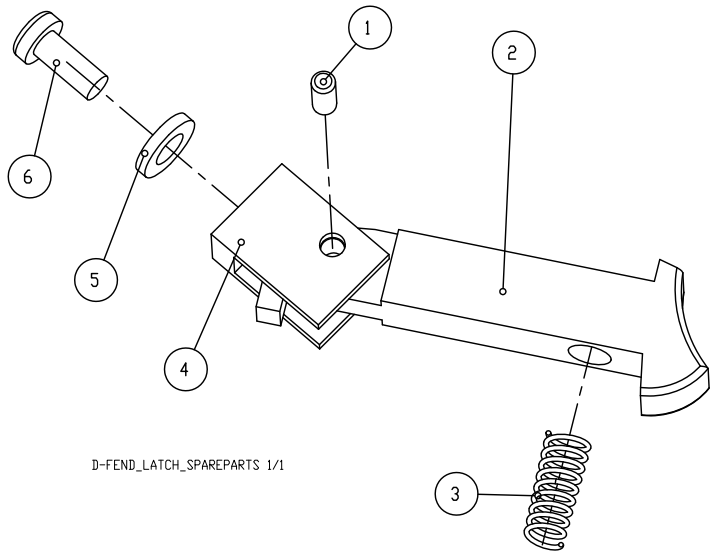
Item	Description	Order No.
21	Front Panel Sticker, E-CAiOV, NO (A,B,C)	M1035838
21	Front Panel Sticker, E-CAiOV, PL (A,B,C)	M1035844
21	Front Panel Sticker, E-CAiOV, PT (A,B,C)	M1035832
21	Front Panel Sticker, E-CAiOV, SV (A,B,C)	M1035836
21	Front Panel Sticker, E-CAiOVX, CS (A,B,C)	M1062554
21	Front Panel Sticker, E-CAiOVX, DA (A,B,C)	M1035943
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, CS (A,B,D)	M1062566
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

Item	Description	Order No.
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, CS (A,B,C)	M1062560
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
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, CS (A,B,C)	M1062557
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

Item	Description	Order No.
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

*) Part is not available from GE. Source locally.

7.2.1 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	*
6	Screw M2.5x6 mm, DIN7985 ISO7045, Pozidrive	*

*) Part is not available from GE. Source locally.

Maintenance check form

Compact Airway Modules, E-CAiOVX, E-CAiOV, E-CAiO, E-COVX, E-COV

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. Fan	☐	☐	☐	4. Module Keys		☐	☐	☐
5. Sample Flow Rate Check	☐	☐	☐	6. Reference Gas Flow Rate Check		☐	☐	☐
7. Zero Valve Operation	☐	☐	☐	8. Gas Calibration		☐	☐	☐
9. Agent Identification	☐	☐	☐	10. Ambient Pressure		☐	☐	☐
11. Fall Time Measurement	☐	☐	☐	12. Occlusion detection		☐	☐	☐
13. Air Leak detection	☐	☐	☐	14. Airway Gases		☐	☐	☐
15. Apnea detection	☐	☐	☐	16. Flow waveform		☐	☐	☐
3.3.3. Test completion						☐	☐	☐

Notes

Used service parts			

Signature	Date

For your notes:

10

Single-width Airway Module, E-miniC

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the Single-width Airway Module, E-miniC.

The Single-width Airway Module provides airway and respiratory measurements.

Letter C in the module name stands for CO_2.

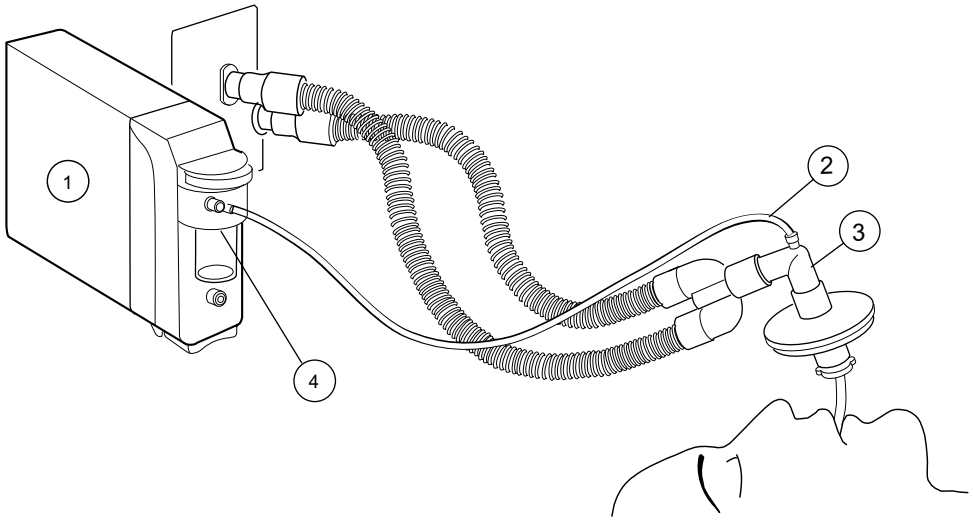


Figure 1 Airway gases setup with Single-width Airway Module, E-miniC

1. Module for measuring airway gases
2. CO_2 gas sampling line
3. Airway adapter with sampling line connector
4. Sampling line connector

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.

1.2 Measurement principle

1.2.1 CO_2 measurement

E-miniC is a side stream gas analyzer, measuring real time concentrations of CO_2. It is a non-dispersive infrared analyzer that measures absorption of the gas sample by 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.

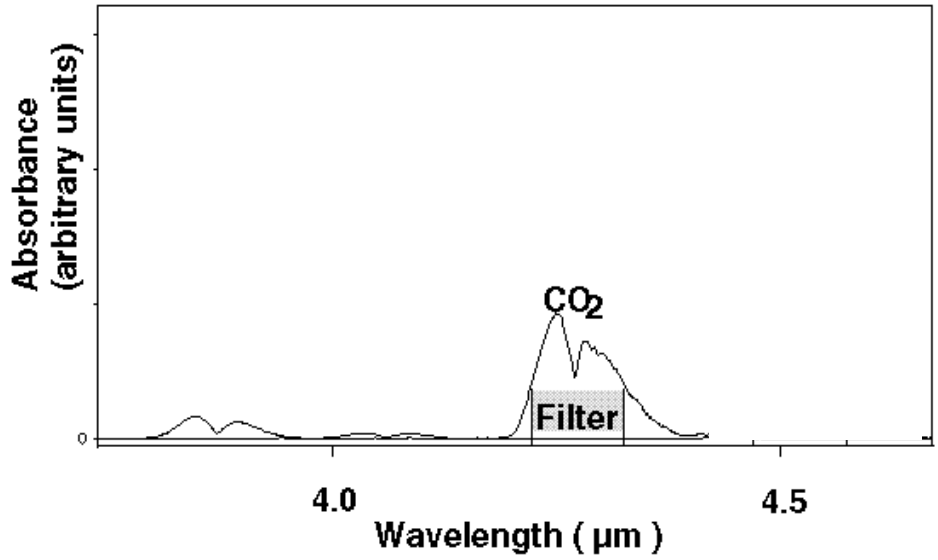


Figure 2 Absorbance of CO_2

1.3 Main components

1.3.1 Controls and connectors

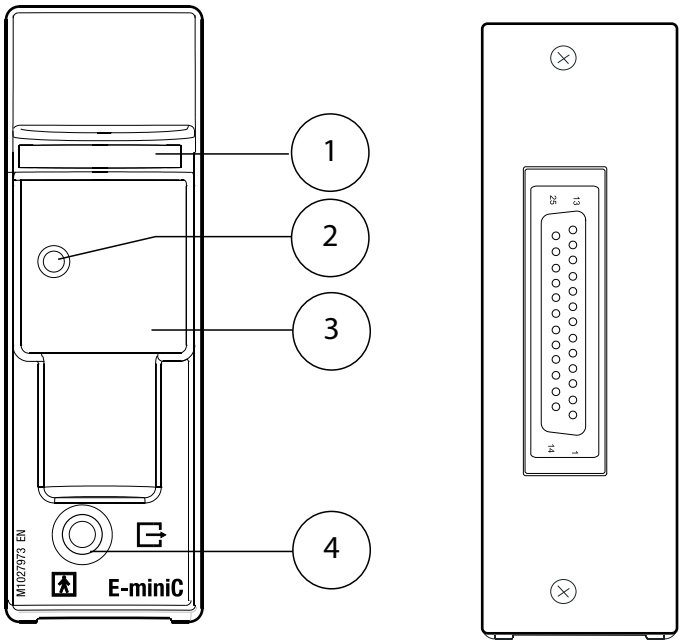


Figure 3 Front panel of the E-miniC module and the back of the module.

(1) Water trap latch
(2) Sampling line connector
(3) Mini D-fend water trap
(4) Sample gas outlet

Connector	Module	Description
D25 connector	E-miniC	Module bus connector

1.3.2 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 miniC sensor. After the measurement, the gas is exhausted from the sample gas out connector.

The sample flow is nominally 150 ml/min.

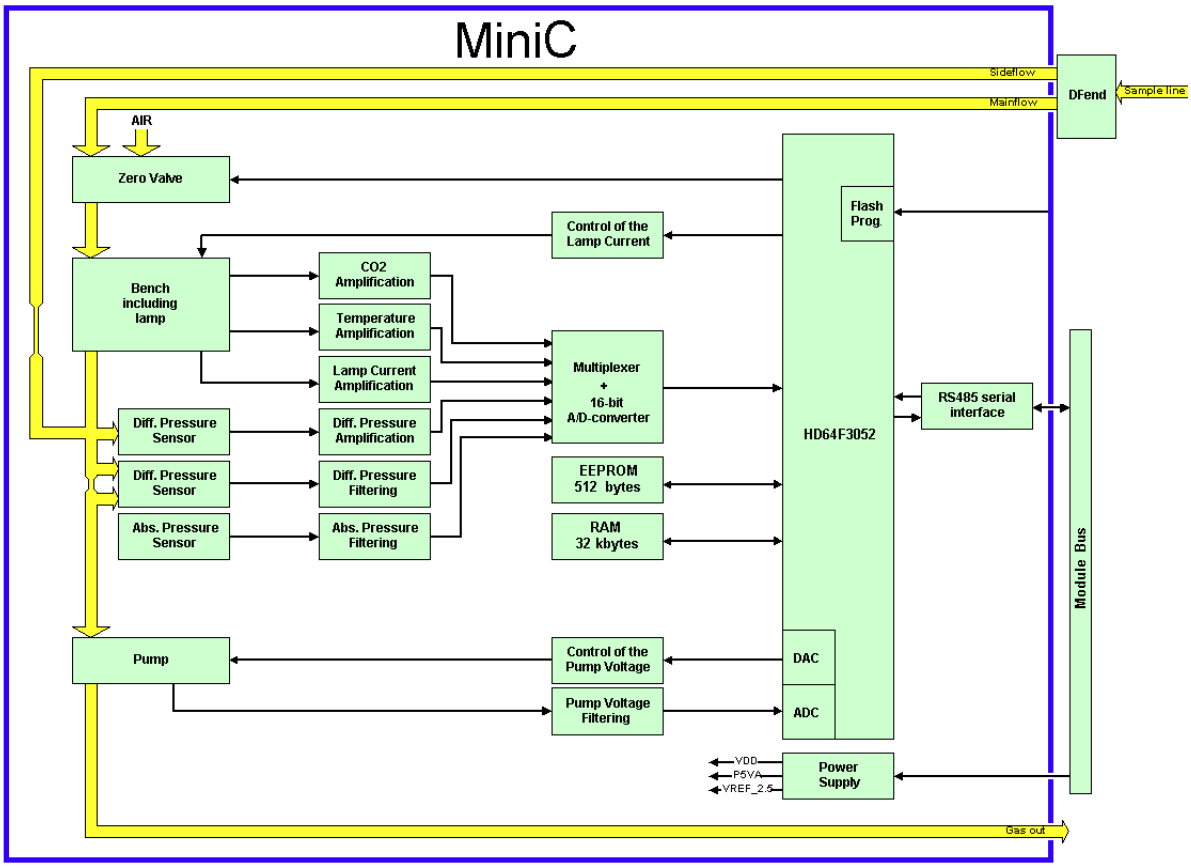


Figure 4 MiniC block diagram

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 sensor. When the valve is activated, room air is drawn through a filter into the internal system and the gas sensor.

Nafion[1)] tube

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 sensor.

1 Nafion is a registered trademark of Perma Pure Inc.

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 sensor. The following messages are based on the obtained pressure values: 'Sample line blocked', 'Check D-fend', 'Replace D-fend', and 'Check sample gas outlet'.

Absolute pressure transducer

The absolute pressure transducer measures real-time ambient pressure.

Sampling pump

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 Mini 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.

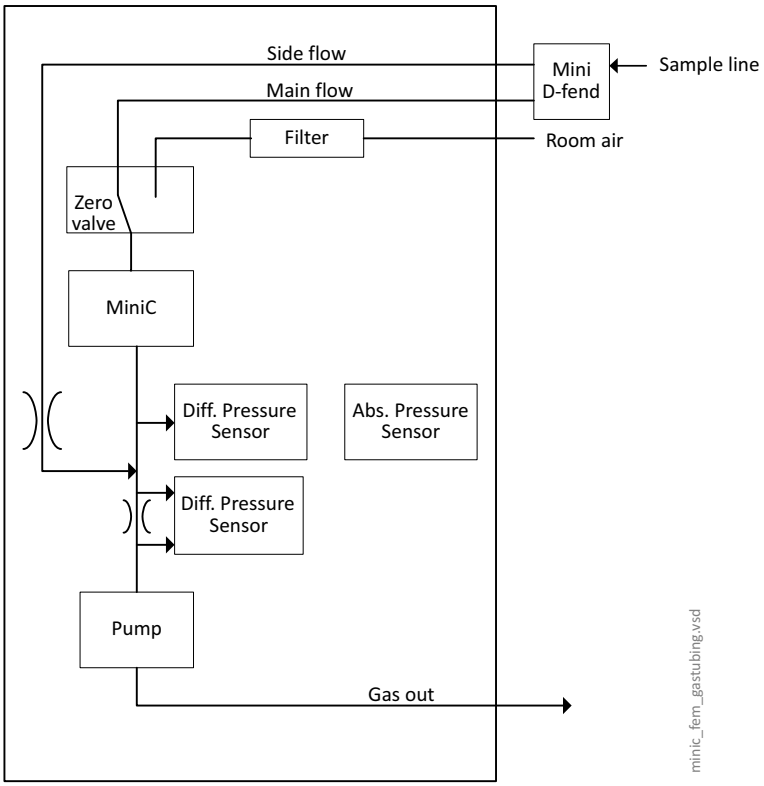


Figure 5 Gas tubing layout

1.3.3 MiniC sensor

The miniC sensor 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 sensor's temperature and it is used for temperature compensation.

The miniC sensor is connected to the CPU board and they can't be replaced separately.

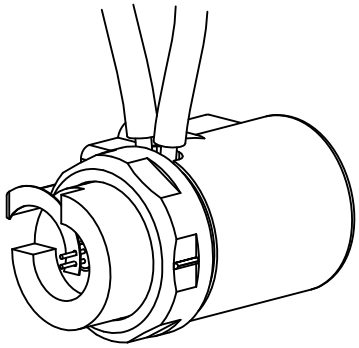


Figure 6 MiniC sensor

1.3.4 CPU board

The CPU board contains a processor, memories and all the analog signal processing needed. A miniC sensor 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 flex cable.

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.

2 Configuration

There is no configuration for the E-miniC module.

3 Maintenance and checkout

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

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 cover replaced	All steps	Not applicable
Mini D-fend O-rings	All steps	Check "Gas Sampling System Leak Test" and "Sample Flow Rate Check"
Module casing 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 checkout

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	1	Once a year
Mini D-fend™ O-ring	2	Once a year
Zero valve air filter	1	Once every 3 years

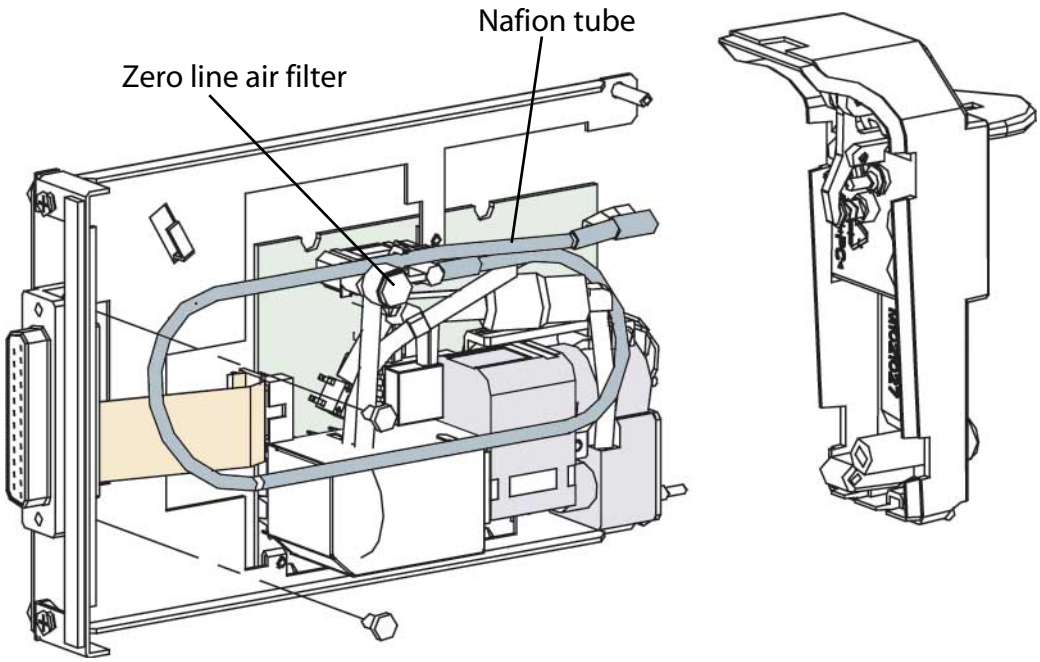
It is also recommended to replace the Mini D-fend water trap and the gas sampling line as part of the planned maintenance procedure.

NOTE: See the supplemental information manual for compatible accessories.

3.1.2 Replacement procedures

Replace the specified planned maintenance parts according to the following procedure. Refer to chapter 6. Disassembly and reassembly and to chapter 7. Service parts for additional information.

1. Replace the zero valve air filter once every 3 years.
   a. Use a small flat blade screwdriver to pull the old zero line air filter.
   b. Attach a new zero line air filter into place.

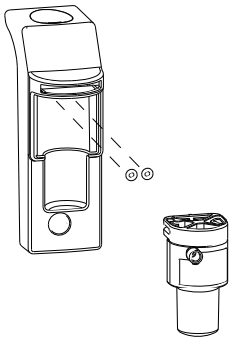


2. Replace the special tube (Nafion) and check the condition of the internal tubing.
   a. Replace the 300 mm nafion tube in the sample gas in line between the Mini D-fend water trap and the zero valve unit.
   b. Check that the tubing inside the module is not contaminated. Any contamination inside the tubing may indicate that the valve or sensor is contaminated, too. This can increase a risk of faulty operation in valve or sensor. The gas sensor is not possible to clean in the field. Therefore, replace the whole miniCO2 assembly with a new one.

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

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

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



3.2 Visual inspections

Detach the module from the module slot and check that:

- the front cover panel is intact
- all connectors are intact and attached properly
- the module box and latch are intact
- the metal D-fend connectors and the D-fend O-rings 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

NOTE: Mark this task as complete on the checkout form.

3.3 Functional checkout

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 100-300 ml/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
– 3 m / 10 ft gas sampling line
– A pressure manometer with either an integrated or a separate pressure pump

NOTE: See the supplemental information manual for compatible accessories.

Connections

Disconnect the module from the monitor, if connected.

Monitor configuration

1. Configure the CO2 waveform field to the monitor screen with adequate priority.
2. Select ***CO2 Setup*** tab in ***Gases*** menu and configure:
   FiO2 level: 21-40%

3.3.2 Procedure

1. 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.

2. Sample flow check

Check the sample flow rate.

NOTE: Gas measurement is not available during the first 1 minute after the module is connected due to warm-up. 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 21.1 °C (70 °F) and 760 mmHg (1013 mbar), 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 module with the gas sampling line to the monitor.
b. Connect the gas sampling line to the sampling line connector in the water trap.
c. Connect the other end of the gas sampling line to a flowmeter.
d. Check the sample flow rate reading from the flowmeter. The flow rate shall be within the specification limit 150 ± 25 ml/min.

NOTE: Readjustment is needed, if the measured value is not within the specification limits. Adjust the sample gas flow rate according to the instructions in section 4.1.2. Sample flow rate adjustment.

NOTE: If the sampling pump is noisy it indicates possible problems with motor bearing. In this case it is recommended to replace the noisy sampling pump with a new one.

3. 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.
a. Select **Monitor Setup > *Service Calibrations***.
b. Enter the User Name and the Password and press ***Enter*** to get into the Calibrations menu.
c. Select ***Gases***.
d. Start feeding calibration gas. Wait until the CO_2 value in the calibration menu rises to approximately 5%.

Open the zero valve to room air by selecting ***Zero valve Off*** (zero position).

e. Check that the CO_2 value in the calibration menu drops back near to 0%.
f. Stop feeding the calibration gas.
g. Turn the zero valve back to the normal measurement position by selecting ***Zero valve On***.

4. Gas calibration

Perform gas calibration according to the instructions in section 4.2. Gas calibration.

5. Ambient pressure

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

a. 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.

6. Occlusion detection
a. Block the tip of the sampling line by your finger.
b. Check that message 'Sample line blocked' appears to the parameter window within 30 seconds.

7. Air leak detection
a. Detach the Mini D-fend water trap.
b. Check that message 'Check Water Trap' appears to the parameter window within 30 seconds.

8. Airway gases
a. Breathe a minimum of 5 times to the tip of the sampling line.
b. Check that a normal CO_2 waveform appears to the waveform field and the $EtCO_2$ and $FiCO_2$ values are updated to the parameter window.

9. Apnea detection
a. Stop breathing to the gas sampling line.
b. Check that an 'Apnea' alarm appears to the message field within 30 seconds.

Mark each task as complete on the checkout form.

3.3.3 Test completion

- Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

- Complete on the "Maintenance check form" on page 10-36.

4 Calibration and adjustments

4.1 Sample flow rate adjustment

Sample flow rate shall be adjusted:

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

4.1.1 Calibration setup

Required tools

– A mass flowmeter for measuring air flow, minimum measurement range 100-300ml/min, accuracy 5% or better in the 100-300ml/min range.

– 3 m / 10 ft Gas sampling line

NOTE: See the supplemental information manual for compatible accessories

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

NOTE: Refer to the flowmeter documentation for user instructions.

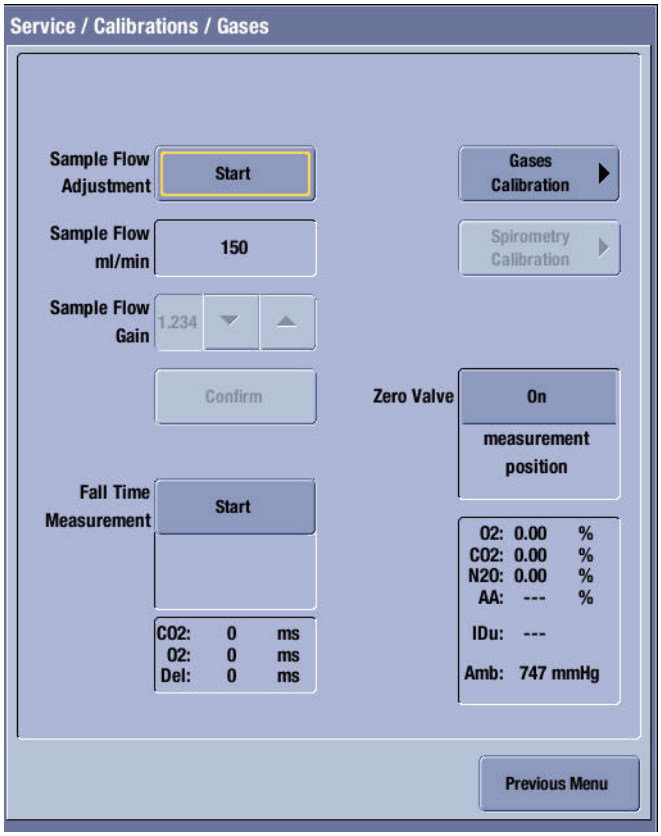
Connections

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

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

4.1.2 Sample flow rate adjustment

1. Select **Monitor Setup >** ***Service Calibrations***.
2. Enter the User Name and the Password and press ***Enter*** to get into the 'Calibrations' menu.
3. Select ***Gases***.
4. Select ***Start Sample Flow Adjustment***.



5. Adjust the sample flow close to the nominal value 150 ml/min by using the ***Sample Flow Gain*** up-down spinner controls:
   - 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.
6. 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 150 ml/min and then check the actual measured flow rate from the flow meter.
7. Repeat steps 5 and 6 until the flow meter shows a 150 ± 25 ml /min flow rate.
8. Select ***Stop Sample Flow Adjustment*** to save the new gain value to the permanent memory of the module.

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 150 ml /min independent on the real flow rate.

4.2 Gas calibration

Gas calibration shall be performed:

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

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

4.2.1 Calibration setup

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 supplemental information 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.

Connections

- Ensure that the module is connected to the monitor.
- Ensure that you have a new Mini D-fend water trap in use.
- Connect the gas regulator to the calibration gas container.
- Connect a new gas sampling line to the sampling line connector in the water trap.
- 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.

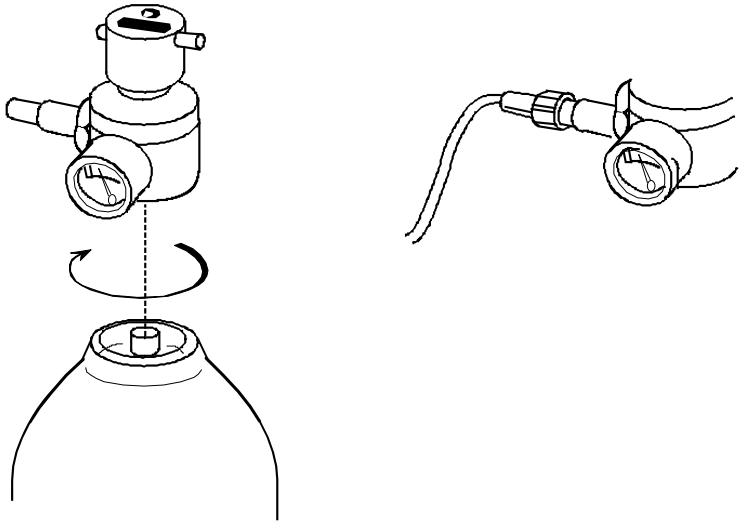


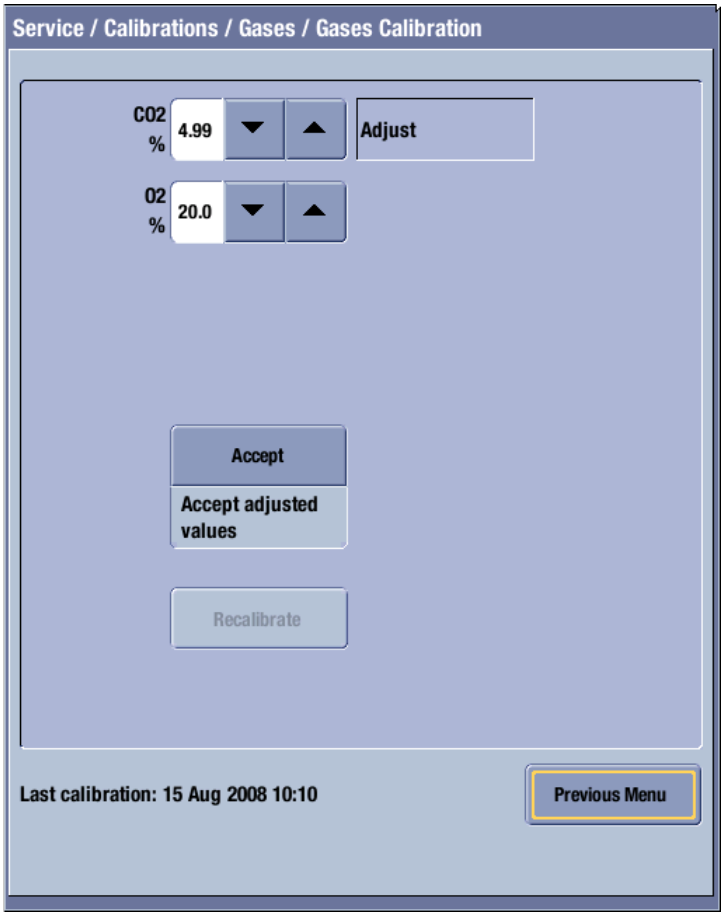
Figure 7 Connecting a gas regulator to the calibration gas container and connecting a sampling line to the gas regulator.

4.2.2 Procedure

1. Select the CO_2 Setup tab in the Gases menu and set the FiO_2 level to '21-40%'.
2. Select **Monitor Setup** > ***Service Calibrations***.
3. Enter the User Name and the Password and press ***Enter*** to get into the 'Calibrations' menu.
4. Select ***Gases***.
5. Select ***Gases Calibration***.

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. 'Gas calibration is not available during gas sampling warning' message is shown in the lower left corner of the calibration menu. Resolve the alarm condition before starting calibration.



6. The monitor will start automatic zeroing of the gas sensor. Wait until the message 'Zeroing' is replaced by 'Zero Ok' message.
7. Open the regulator after a message 'Feed gas' is shown. The measured gas concentration is shown in real-time in the gas calibration menu. Wait until the measured gas concentration is stabilized and 'Adjust' message is shown. Close the regulator.

8. Use the CO_2 up-down spinner controls in the calibration menu to adjust the CO_2 reading shown in the calibration menu to match with the CO_2 reading in the labelling of the calibration gas container. Select Accept to accept the adjusted value when the two CO_2 readings match each other.
9. Wait until message 'Ok' is shown.

NOTE: Message 'Zero Error' is shown in case the zeroing fails.

NOTE: 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 'Recalibrate' button to restart the calibration procedure from the beginning.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

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

- the front cover and the front panel sticker are intact
- the Mini D-fend latch is moving properly
- all connectors are intact, clean and are attached properly
- the module box and latch are intact
- the metal D-fend connectors and the D-fend O-rings 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 two 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

5.2 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.
- Connect the accessories to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (**Monitor Setup** > ***Screen Setup*** > ***Upper Parameter Area***).

- 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.

5.2.1 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.
- Whenever suspecting the sampling system and always after having done any work on it, check the sampling system for leakages and check the flow rate.
- The Mini D-fend water trap should be replaced, when the 'REPLACE D-FEND' message appears.
- If any liquid has entered the IR sensor due to water trap filter failure, contact GE Healthcare service.
- If the sampling pump is noisy it indicates possible problems with motor bearing. In this case it is recommended to replace the noisy sampling pump with a new one.
- Check that the tubing inside the module is not contaminated. Any contamination inside the tubing may indicate that the valve or sensor is contaminated, too. This can increase a risk of faulty operation in valve or sensor. The gas sensor is not possible to clean in the field. Therefore, replace the whole miniCO2 assembly with a new one.

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

5.2.2 MiniC sensor troubleshooting

- The CPU contains factory calibration data for the miniC sensor. Thus, they can't be replaced separately in the field. In case of failure, the complete miniCO2 assembly should be replaced.

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.

5.3 Service interface

Use the Webmin service interface to access device information and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the E-miniC module is connected to the monitor.

To view Device information

1. Log on to the Webmin application.
2. Select the ***Information*** tab.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the E-miniC module:

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin:

1. Log on to the ***Webmin*** application.
2. Select the ***Diagnostics*** tab.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media:

1. Log on to the ***Webmin*** application.
2. Select the ***Diagnostics*** tab.
3. Select ***Download Logs***
4. Select one of the log files for downloading.

5.4 Messages

The messages below appear in the CO2 parameter window (PW), CO2 waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Check water trap Check water trap and sample gas out. Wait 30 seconds and press Normal screen to continue	PW, MF WF	Water trap is not connected. Air leak inside the internal tubing.	Connect water trap to the module. Check internal tubing for leakages. Replace, if needed.
Sample line blocked Continuous blockage. Check sampling line and water trap	PW, MF WF	Gas sampling line is blocked. Water trap container is full. Water trap is occluded. Internal tubing is blocked.	Check external gas sampling line for blockages. Replace, if needed. Empty water trap container. Replace the water trap. Check internal tubing for blockages. Replace, if needed.
Check sampling gas out Check water trap and sample gas out. Wait for 30 seconds and press Normal screen to continue.	PW, MF WF	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. Replace, if needed. Check sample pump operation by measuring the sample gas flow rate. Replace pump, if needed.
Replace water trap	PW, MF	Defective or contaminated Mini D-fend. Occlusion in internal tubing.	Replace Mini D-fend water trap. Check sample and reference flows. Perform a visual check for the internal tubing. Remove the cause for occlusion.
Calibrating	PW & calibration menu	CO2 calibration is in progress.	Wait until calibration is completed successfully.
Zeroing	PW & calibration menu	CO2 zeroing is in progress.	Wait until zeroing is completed successfully.

Message	Location	Possible causes	Possible solutions
Zero error	PW & calibration menu	Autozeroing during measurement or in the beginning of gas calibration failed.	Check the zero valve operation. Replace zero valve and filter.
Calibrating error	PW & calibration menu	Feeding 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 used.	Recalibrate. Recalibrate. Use the specified calibration gas.
Apnea deactivated	PW	Apnea alarm start-up conditions are not reached.	Apnea alarm detection is activated after the 3 breaths are detected.
Sensor INOP	WF	Ambient pressure is too high or low. No response from the gas module, high temperature inside the module or EEPROM checksum failure.	Check ambient pressure from the Gas Calibration menu. Replace miniCO2 assembly. Return the module to GE Healthcare for service.
Calibrating gas sensor	WF	Gas measurement is not available during the first 1 minute after the module is connected due to warm-up.	Wait until warm-up is completed.
Over Scale	WF	Incorrect CO_2 scale. The CO_2 waveform clipped because $etCO_2$ value exceeds the upper limit of the current scale.	Change CO_2 waveform scale.
Low gas sample flow	MF	Sample flow deviates to less than 80% 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 gas sampling line, water trap, or internal tubing. Replace pump unit.
Incompatible gas module	MF	Incompatible gas module detected by the monitor.	Check the compatibility of the gas module.
Gas measurements removed	MF	The module is disconnected.	Reconnect the module.
Identical gas modules	MF	The monitor detects CO_2 measurements from two or more modules.	Remove excess modules providing CO_2 measurement.

5.5 Troubleshooting chart

Problem	Possible causes	Possible solutions
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 Mini 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
$ETCO_2$ over scale >20% Shown until 32%, specified range 0...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 Mini 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

Problem	Possible causes	Possible solutions
Abnormally high (or low) response to CO2, or sudden occlusion message.	Pressure transducer failure.	Replace miniCO2 assembly.
Unable to perform gas calibration.	Gas calibration is not available during the first 5 minute after the module is connected. Message 'Gas calibration is not available during the first 5 minutes' is shown in the calibration menu.	Wait until warm-up is completed.
	Gas calibration is not available during 'Sample line blocked', 'Check D-fend', and 'Check sample gas out' alarm condition. Message 'Gas calibration is not available during gas sampling warning' is shown in the calibration menu.	Resolve the alarm condition before starting calibration.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module frame is limited to replacing faulty circuit boards or mechanical parts only.

WARNING **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. Maintenance and checkout after you have disassembled and reassembled the module.

6.1.1 Serviceable parts

- The miniCO2 assembly, including the following components (CPU board, mini CO2 sensor, pump unit, tubing unit and zero valve and pressure transducers)
- tubing unit
- pump unit
- zero valve
- air filter
- Mini D-fend O-rings
- Nafion tube
- Mini D-fend
- mechanical parts listed in the service parts chapter

6.1.2 Service limitations

The following parts are not serviceable:

- miniC sensor and CPU board can't be replaced separately.

NOTE: The CPU contains factory calibration data for the miniC sensor. In case of failure, the complete miniCO2 assembly should be replaced. Attempts to repair or calibrate the unit elsewhere will adversely affect operation of the unit. The information provided in this document is for reference only.

6.1.3 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.

6.1.4 Protection from dust

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 mini D-fend 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 just before assembling it to the module
- The clothing of the service person must be such that the dust risk is taken into account.

6.1.5 Before disassembly

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

6.1.6 Required tools

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

6.2 Disassembling and reassembling procedure

6.2.1 Removing the module casing

To disassemble the airway module (see the exploded view of the module in chapter 7. Service parts):

1. Remove the two screws 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.

To reassemble 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 ends on them
- all tubes are connected properly
- there are no loose objects inside the module

6.2.2 Replacing the pump unit

1. Detach the front cover of the module by releasing the snaps that hold the front cover to he 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.
2. Remove the module casing, see page 10-31.
3. Unplug the two tubes from the back of the front chassis.
4. Detach the front chassis from the metal frame by removing the two screws.
5. Unplug the hose of the pump.
6. Disconnect the pump's cable from the CPU board.
7. Remove the two screws that connect the pump unit to the board.

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

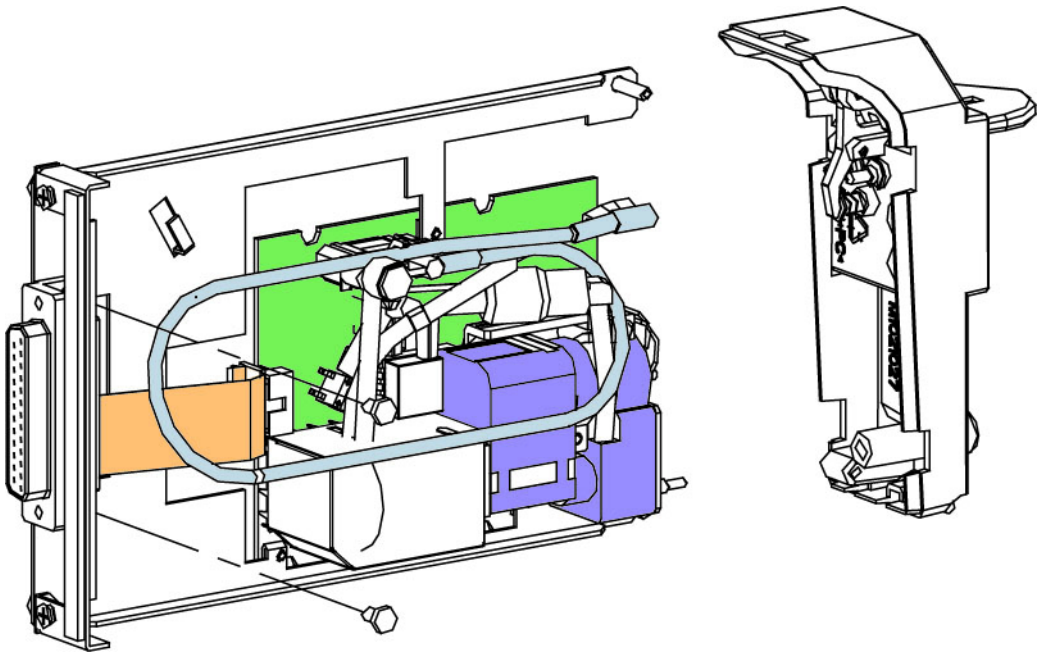


Figure 8 Uncovered E-miniC module

6.2.3 Replacing the miniCO2 assembly

1. Detach the front cover of the module by releasing the snaps that hold the front cover to he 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.
2. Remove the module casing, see page 10-31.
3. Unplug the two tubes from the back of the front chassis.
4. Detach the front chassis from the metal frame by removing the two screws.
5. Detach miniCO_2 assembly from the metal frame by removing the three screws.
6. Disconnect the flex board from miniCO_2 assembly.

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

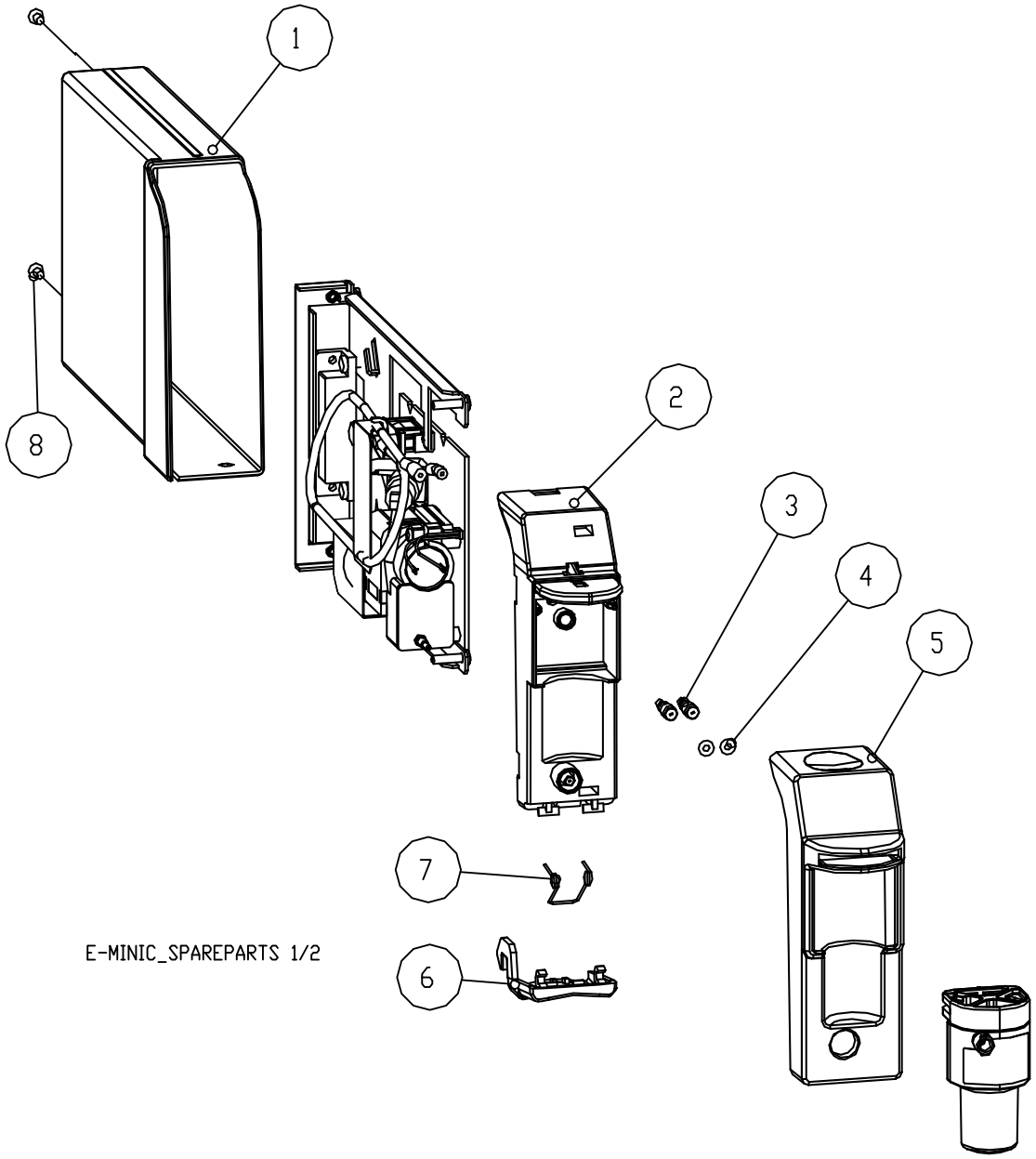
7 Service parts

7.1 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.

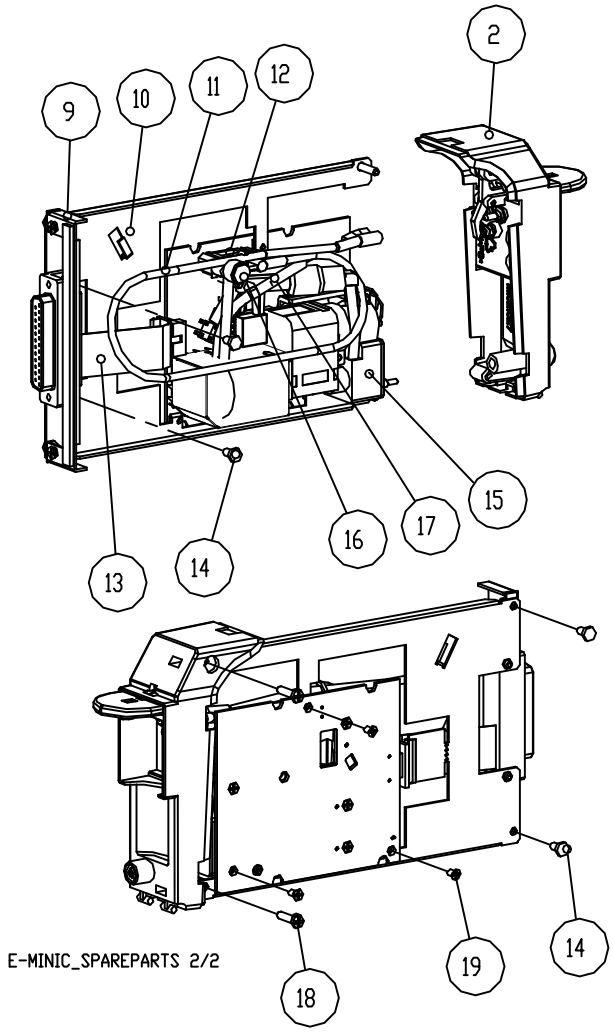
NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout after you have replaced any of the service parts listed below.

7.2 Single-width Airway Module, E-miniC



Item	Description	Order No.
	Mini D-fend, pkg of 10 pcs	8002174
-	MiniCO2 assembly, including the following components (CPU board, mini CO2 sensor, pump unit, tubing unit and zero valve and pressure transducers)	2083290-001
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
5	Front Cover, E-miniC	M1026943
6	Latch	M1021039
7	Torsion Spring	M1020935
8	Screw-cross rec. c/s h, stzn, m3x6	*

* Part is not available from GE. Source locally.



Item	Description	Order No.
9	Metal frame	879184
10	Frame, E-miniC	M1024360
11	Nafion tubing 300mm	733382-HEL
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	*
15	Pump Unit for miniC	2083166-001
16	Air filter, M-MiniC	M1011471
17	Tubing Unit for miniC	M1013717
18	Cross cylinder head screw M3x10	*
19	Screw-cross rec.c/s h,m3x8,acidproof	*

* Part is not available from GE. Source locally.

Maintenance check form

Single-width Airway Module, E-miniC

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 checkout						☐	☐	☐
3.3.2. Procedure						☐	☐	☐
1. Gas sampling system leak test	☐	☐	☐	2. Sample flow check		☐	☐	☐
3. Zero valve operation	☐	☐	☐	4. Gas calibration		☐	☐	☐
5. Ambient pressure	☐	☐	☐	6. Occlusion detection		☐	☐	☐
7. Air leak detection	☐	☐	☐	8. Airway gases		☐	☐	☐
9. Apnea detection	☐	☐	☐					
3.3.3. Test completion						☐	☐	☐

Notes

Used service parts			

Signature	Date

11

Entropy Module, E-ENTROPY (Rev. 01)

Technical Manual

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Maintenance check form **11-19**

1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the Entropy Module, E-ENTROPY-01. The E-ENTROPY-01 module is a single width plug-in module.

NOTE: Some information in this document may vary compared to older E-Entropy module version. If needed refer to earlier document version(s) for more information about older E-Entropy module version.

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.

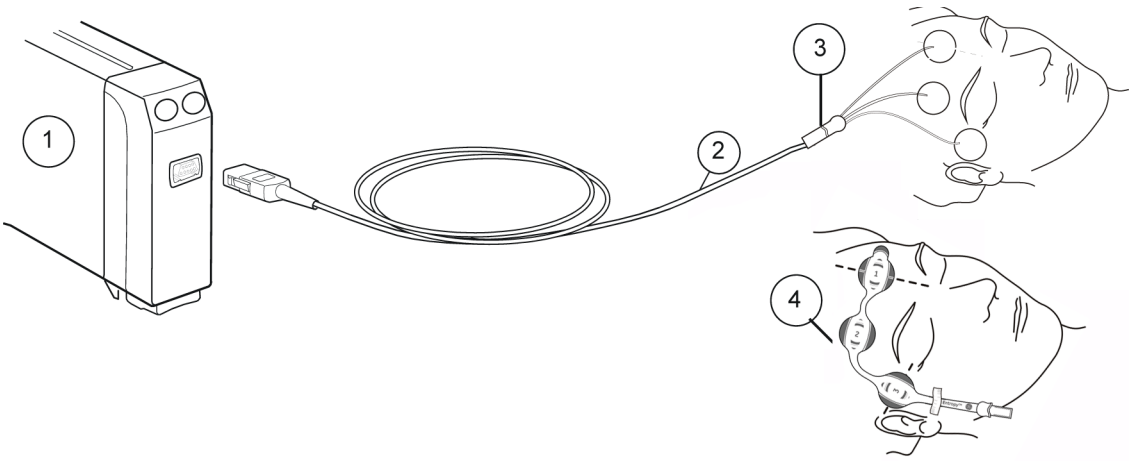


Figure 1 Measurement setup

(1) Entropy module
(2) Entropy sensor cable
(3) GE Entropy sensor
(4) Entropy sensor

1.2 Measurement principle

Entropy is a measure of irregularity in any signal. During general anesthesia, EEG changes from irregular to more regular patterns when anesthesia deepens. Similarly, FEMG quiets down as the deeper parts of the brain are increasingly saturated with anesthetics. The Entropy Module measures these changes by quantifying the irregularity of EEG and FEMG signals.

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.

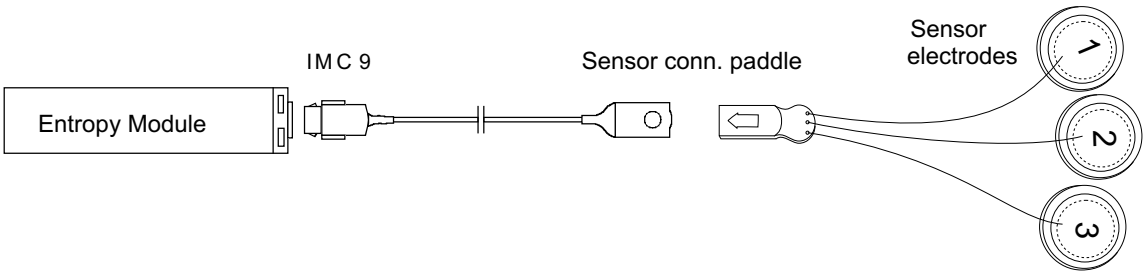


Figure 2 A general view of the cable connections

1.2.1 EntrEEG

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. 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.

1.2.2 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 "1.2.3. RE and SE"). Mains power frequency and its harmonics are digitally filtered away to reject interference noise from power lines.

1.2.3 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

1.2.4 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.

1.3 Main components

1.3.1 Controls and connectors

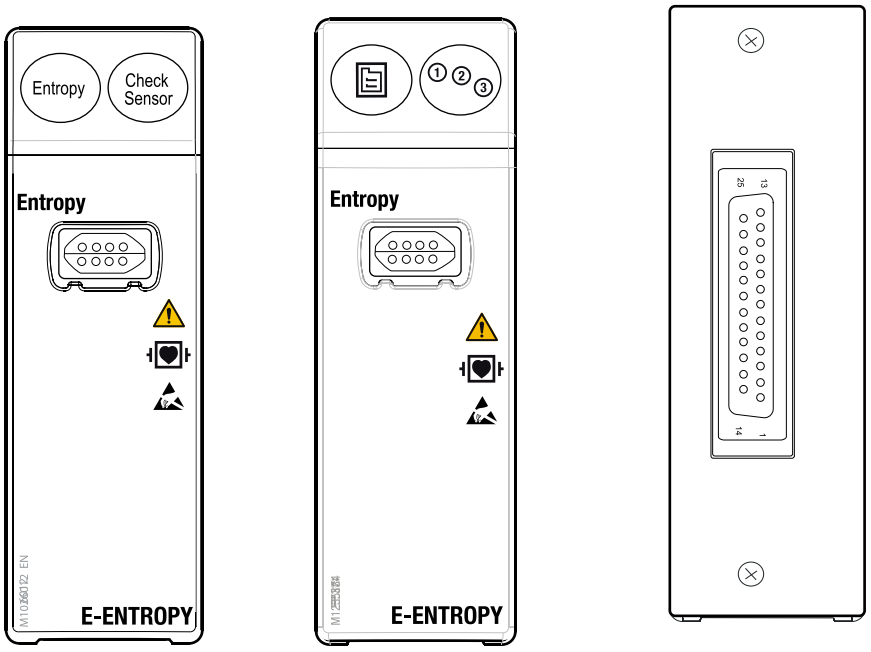


Figure 3 Front panel of Entropy Module, E-ENTROPY, and the back of the module

Module key	Module	Description
Entropy	E-Entropy	Opens the Entropy menu on the screen
Check Sensor	E-Entropy	Starts the manual sensor check
Connector	**Module**	**Description**
Entropy	E-Entropy	Entropy connector
D25 connector	E-Entropy	Module bus connector

1.3.2 Entropy board

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.

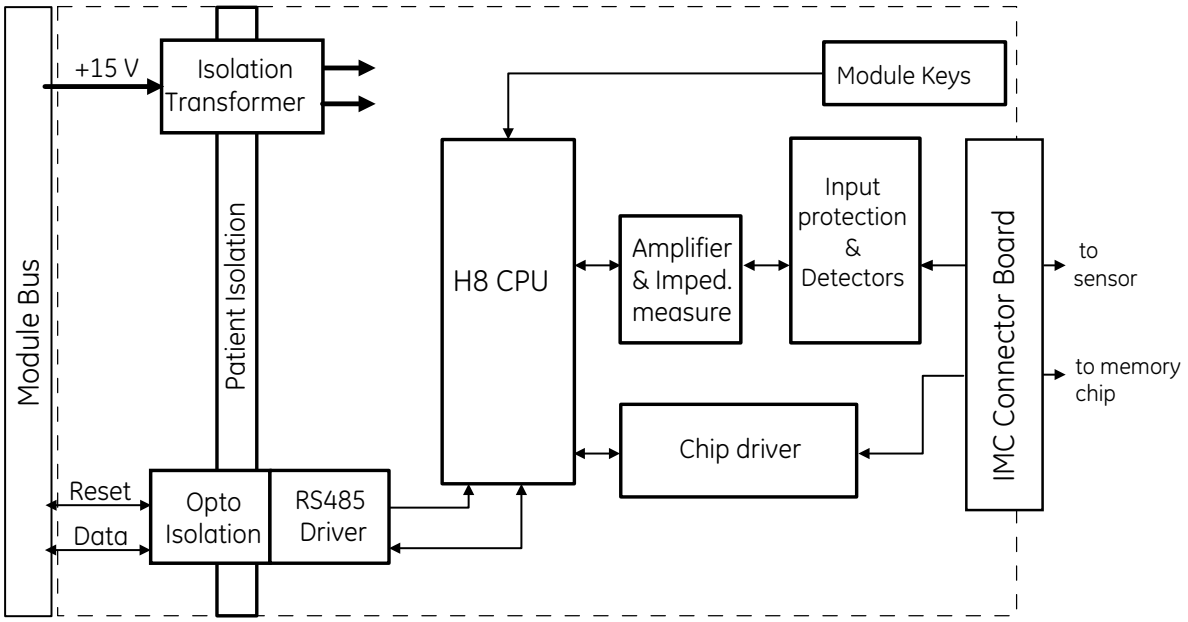


Figure 4 Entropy measurement system block diagram

2 Configuration

There is no configuration for the E-ENTROPY module.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual inspections
2. 3.2. Electrical safety tests
3. 3.3. Functional check

3.1 Visual inspections

Detach the module from the module slot and check that:

- the front cover is intact
- all connectors are intact and attached properly
- the module box and latch are 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

3.2 Electrical safety tests

Complete the Electrical safety tests found in the patient monitor technical manual, chapter Installation checkout. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 11-19

3.3 Functional check

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

3.3.1 Test setup

Required tools

– P/N: N-ES or Simulator for E-ENTROPY

– Entropy sensor cable

NOTE: See the supplemental information manual delivered with the manual for compatible accessories.

Connections

- Ensure that the module is connected to the monitor.

Monitor configuration

1. Configure the Entropy waveform field to the monitor screen with adequate priority.
2. Press the **Entropy** module key in the module to open the ***Entropy Setup*** menu and configure:
   Scale: 250uV
   Display format: RE+SE
   Automatic sensor check: ON

3.3.2 Entropy tests

1. Module and sensor recognition
   a. Connect the Entropy sensor cable to the module.
   b. Check that the Entropy EEG waveform field and related information appears to the screen.
   c. Check that a 'No sensor' message is shown in the Entropy parameter window.

2. Sensor checking
   a. Connect the Entropy simulator to the Entropy sensor cable.
   b. Check that a 'Checking sensor' message appears to the Entropy parameter window after a while and wait until all 3 electrodes are checked. The sensor check is passed, if a green circle with a check mark for each tested electrode is shown.

NOTE: The monitor may show messages ‘not an Entropy sensor’ and ‘Demo data’. These messages are normal for the Entropy simulator.

3. Functional check with a simulator
   a. Check that the EntrEEG waveform and RE & SE values appear on the monitor screen approximately 30 seconds after the sensor check is completed.

3.3.3 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

4. Complete on the “Maintenance check form” on page 11-19.

4 Calibration and adjustments

There are no calibration or adjustments for the E-ENTROPY module.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues, and clinical configuration issues.

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

5.1 Visual inspection

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

- the front cover is intact
- all connectors are intact, clean, and attached properly
- the module box and latch are intact

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

5.2 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.
- Connect the accessories with a simulator to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (**Monitor Setup** > ***Screen Setup*** > ***Upper Parameter Area***).
- Press a module key. Check that the related menu is opened or activity is started. Inoperatibility may refer to a loose keypad cable or other problem in the module.

- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.
- 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.

5.3 Service Interface

Use the Webmin Service Interface to access configuration information, device information, and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information*** tab.
3. Select ***Device Information***.
4. Check that the E-Entropy module is identified and the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the E-Entropy module.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions, and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs.

You can access one log file at a time for viewing or for downloading it to an external media

To view a log file in Webmin:

1. Log on to the Webmin application.
2. Select the ***Diagnostics*** tab.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file or a snapshot file to an external media:

1. Log on to the Webmin application.
2. Select the ***Diagnostics*** tab.
3. Select ***Download Logs***.
4. Select one of the log files or snapshot files for downloading.

5.4 Messages

The messages in the table below appear in the Entropy parameter window (PW), InvBP waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Cable off Entropy cable off	PW MF	Entropy sensor cable is disconnected from the module.	Connect the Entropy sensor cable to the module.
No sensor No Entropy sensor	PW MF	Entropy sensor is not connected to the Entropy sensor cable.	Connect the Entropy sensor to the Entropy sensor cable.
Not Entropy sensor Not an Entropy sensor	PW MF	The sensor used is not an Entropy sensor. An Entropy simulator is connected.	Connect correct type of Entropy sensor.
Sensor expired Replace Entropy sensor	PW MF	The Entropy sensor has expired. The Entropy sensor has been used for more than 24 h. The Entropy sensor is defective.	Replace with a new sensor (check the sensor expiry date from the sensor package).
Sensor off Entropy sensor off	PW MF	The Entropy sensor is connected to the Entropy sensor cable, but not attached to the patient.	Attach the Entropy sensor to the patient by following the sensor instructions.
Confirm sensor electrodes	PW	More than one Entropy sensor electrodes has poor contact. Automatic impedance check gets too high impedance values	Reattach the Entropy sensor electrode to the patient to ensure proper contact by following the sensor instructions. Ensure the sensor has good skin contact, it is positioned correctly, and the sensor is not dry. Press **Check Sensor** key on the module to verify good contact.
Confirm sensor electrode X NOTE: X is either 1, 2, or 3 and refers to one of the sensor electrodes in the Entropy sensor.	PW	One of the Entropy sensors electrodes has poor contact. Automatic impedance check gets too high impedance value for one electrode only.	Confirm Entropy sensor electrode 1, 2, or 3 (as indicated in the message) to ensure proper contact. Ensure the sensor has good skin contact, it is positioned correctly, and the sensor is not dry. Press **Check Sensor** key on the module to verify good contact.
Checking sensor	WF, PW	Sensor check is in progress. Can be either the initial sensor check, manual check, or periodic check.	Wait until the check has been performed.

Message	Location	Possible causes	Possible solutions
Sensor check failed Entropy sensor check failed	PW MF	Sensor check failed. One or more of the electrode impedances exceeds the impedance threshold.	Reattach the sensor to the patient by following the sensor instructions. Ensure the sensor has good skin contact, it is positioned correctly, and the sensor is not dry. Replace the sensor.
Artifacts	WF, PW	Signal contains exceed noise or artifact. Patient movements, eye blinks, shivering, deep breathing, arrhythmia or irregular beats may cause some measurements to fail.	Wait for good data. See Users manual.
Low signal	PW	The EEG amplitude is too low for reliable Entropy measurement.	See patient monitor's user's manual.
Starting up	PW	The sensor check has been passed and the Entropy measurement is starting.	Wait for about 30 seconds. Entropy values are displayed automatically on the screen.
Demo data	WF, PW	Entropy simulator is connected instead of Entropy sensor.	Disconnect the Entropy simulator.
Noise	WF	Unreliable Entropy calculation or distorted EEG waveform appear during electrosurgery, or other high frequency noise.	See patient monitor's user's manual.
Isoelectric EEG	WF, PW	Isoelectric (flatline) EEG detected in Entropy measurement.	See patient monitor's user's manual.
Identical Entropy modules	MF	Two or more Entropy modules are connected.	Connect only one Entropy module at a time.
Entropy measurement removed	MF	Entropy module is disconnected from the module slot.	Reconnect the Entropy module to the module bus.
Automatic check off	PW	Automatic sensor check is set off.	You can turn the automatic sensor check on from the Entropy menu.

5.5 Troubleshooting chart

Problem	Possible causes	Possible solutions
No EntEEG waveform or Entropy parameter window on the screen.	Entropy module is not connected.	Connect the Entropy module to the monitor and the Entropy sensor cable to the module.
	EntEEG waveform or Entropy parameter window is not configured to the screen, or the parameter priority is set too low.	Configure EntEEG waveform or Entropy parameter to the screen, or increase the priority of the parameter information.
	Entropy measurement is not supported by the active software package.	Entropy measurement is supported only by OR and PACU software packages.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module frame is limited to replacing faulty circuit boards or mechanical parts only.

WARNING **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. Maintenance and checkout" each time after you have opened the module casing.

6.1.1 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.

6.1.2 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.

6.1.3 Required tools

- antistatic wristband
- pincers
- torx screwdriver, T10
- flat blade screwdriver

6.2 Disassembling and reassembling procedure

Disassembling the E-ENTROPY module (see the exploded view of the module in chapter 7. Service parts):

6.2.1 Replacing 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.

6.2.2 Replacing the Entropy board

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. Disconnect the front panel connector cable and the membrane keyboard cable from the Entropy board.
4. Detach the front cover (see 6.2.1).
5. Detach the Entropy board by removing the two screws located near the front chassis unit. Pull out the front chassis unit.

6.2.3 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

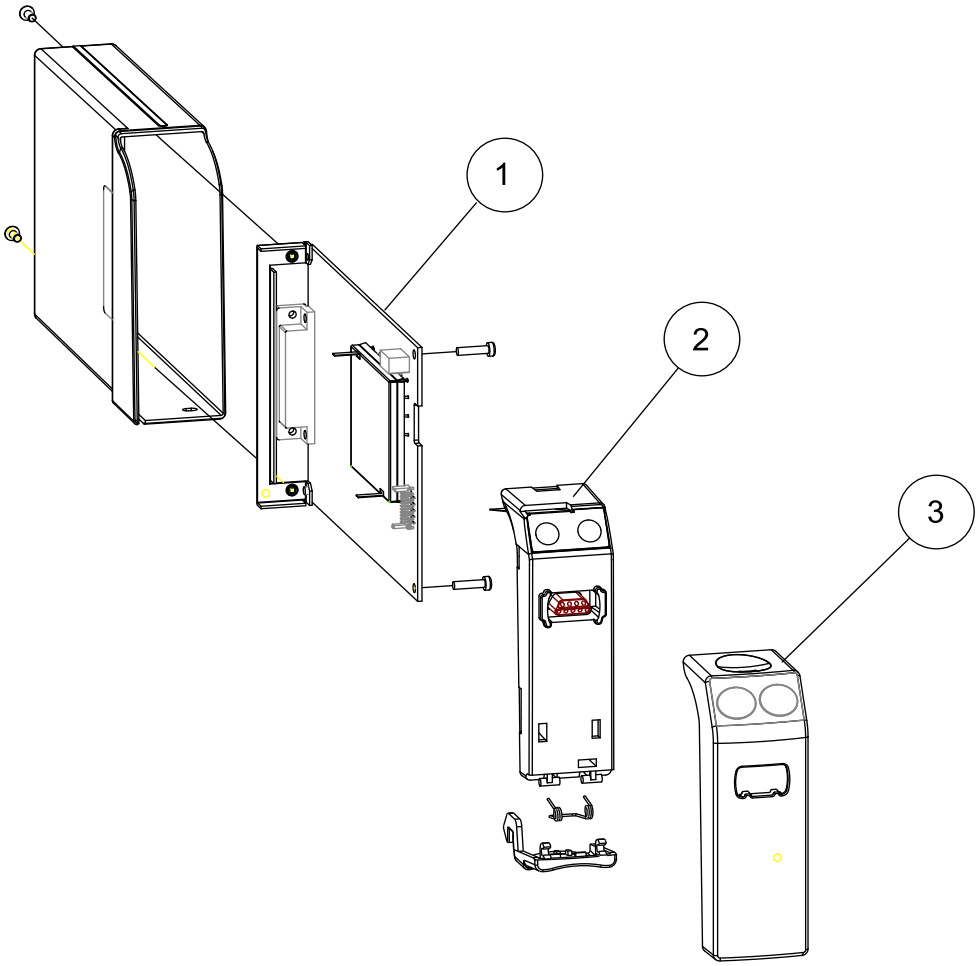
7 Service parts

7.1 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. Maintenance and checkout each time after you have opened the module casing.

7.2 Entropy Module, E-ENTROPY-01



Item	Description	Order No.
1	E-ENTROPY-01, Entropy Board, FRU - Measurement Board - Metal Frame - 2 mounting screws	M1235745
2	E-ENTROPY-01, Front Chassis Kit, FRU - Front Chassis - Membrane Keyboard - Connector Unit - Latch - Torsion Spring	M1235747

Item	Description	Order No.
3	E-ENTROPY-01, Front Cover, FRU - Front Cover, English	M1236171
3	E-ENTROPY-01, Front Cover, FRU - Front Cover, symbols	M1236170
	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

These parts are backward compatible with E-ENTROPY-00

Maintenance check form

Entropy Module, E-ENTROPY (Rev. 01)

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**
3.1. Visual inspections	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
3.2. Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. Entropy tests				☐ ☐ ☐
3.3.3. Test completion				☐ ☐ ☐

Notes

Used service parts			

Signature	Date

For your notes:

12

EEG Module, E-EEG, and EEG Headbox, N-EEG Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the EEG Module, E-EEG, and the EEG Headbox, N-EEG. The EEG module is a single width plug-in module.

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.

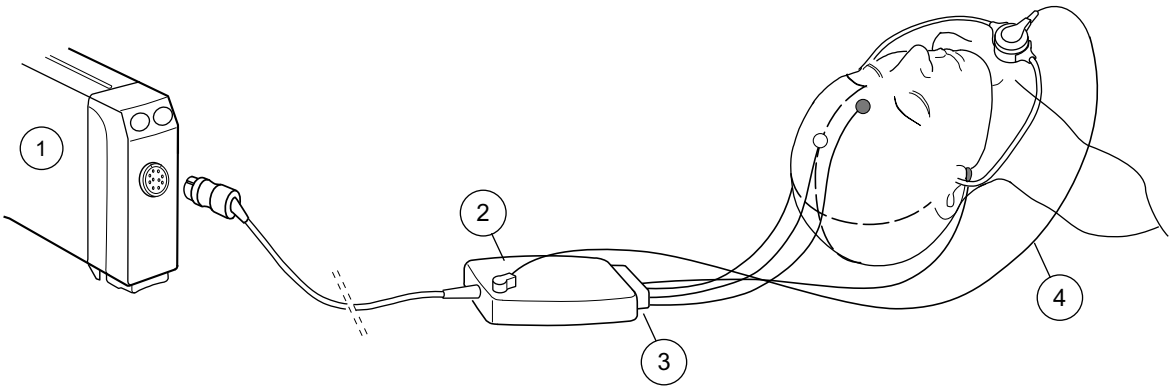


Figure 1 Measurement setup

(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 (required for AEP measurement)

1.2 Measurement principle

1.2.1 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 a referential electrode.

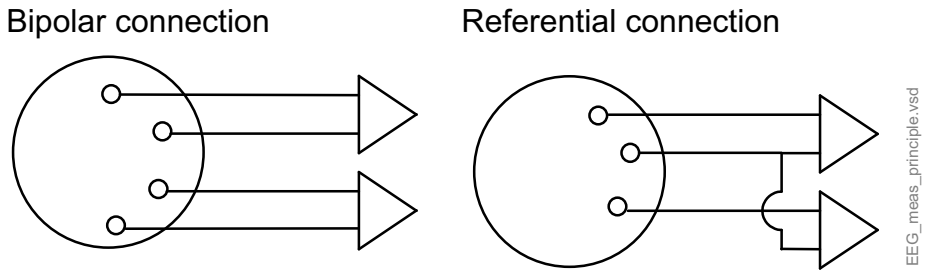


Figure 2 EEG measuring principle

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).

1.2.2 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 the power lines.

1.2.3 AEP

AEP is an electrical response of the nervous system to an 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.

1.2.4 Impedance measurement

The impedance measurement is performed for 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.

1.3 Main components

1.3.1 Controls and connectors

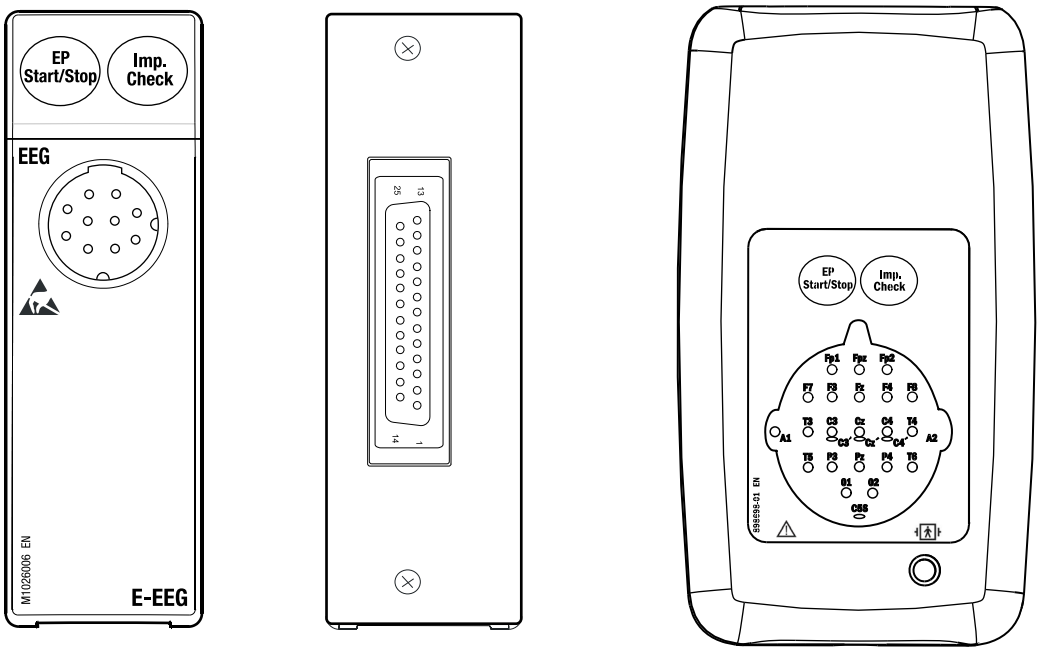


Figure 3 **Front panel and the back of EEG Module, E-EEG, and front panel of EEG Headbox, N-EEG**

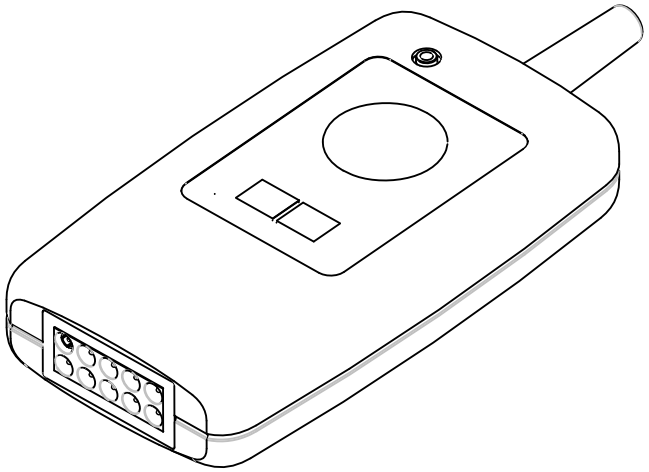


Figure 4 **N-EEG headbox**

Module key and Headbox key	Module	Description
EP Start/Stop	E-EEG, N-EEG	Starts/stops evoked potential measurement with the defined settings.
Imp.Check	E-EEG, N-EEG	Starts the manual measuring of the electrode impedance.
Connector	**Module**	**Description**
EEG	E-EEG	Connector for N-EEG
Headbox input connector	N-EEG	Connector for EEG leads
AEP	N-EEG	Connector for AEP earphone set
D25 connector	E-EEG	Module bus connector

1.3.2 Neuro board

The Neuro board is inside the E-EEG module and it 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.

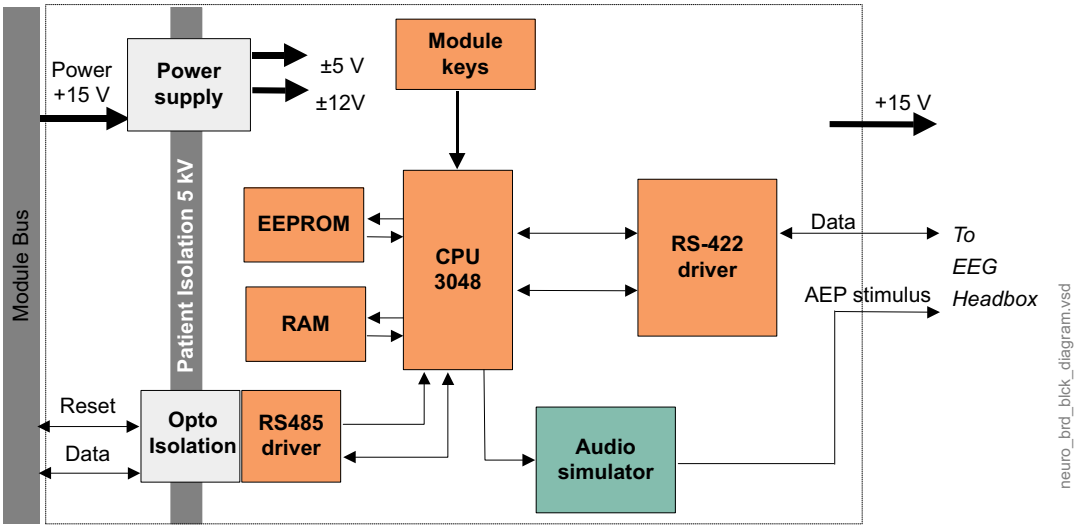


Figure 5 Neuro board block diagram

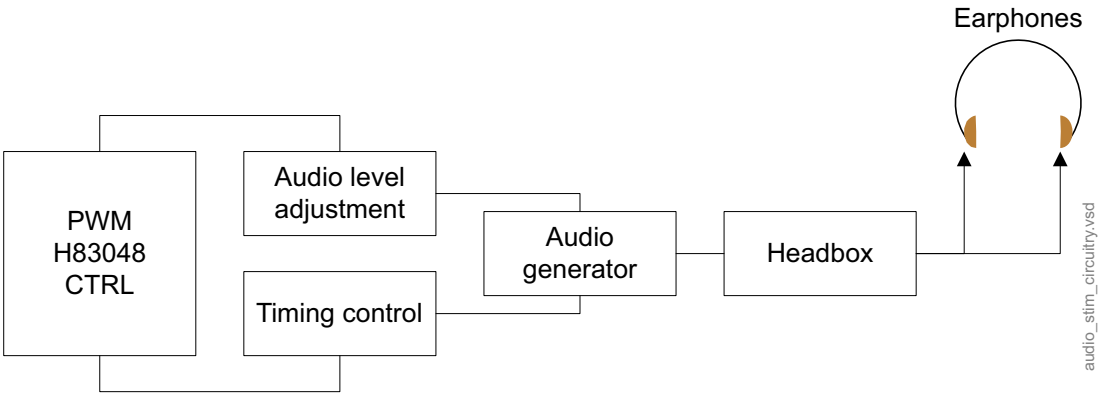


Figure 6 Audio stimulator circuitry

1.3.3 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

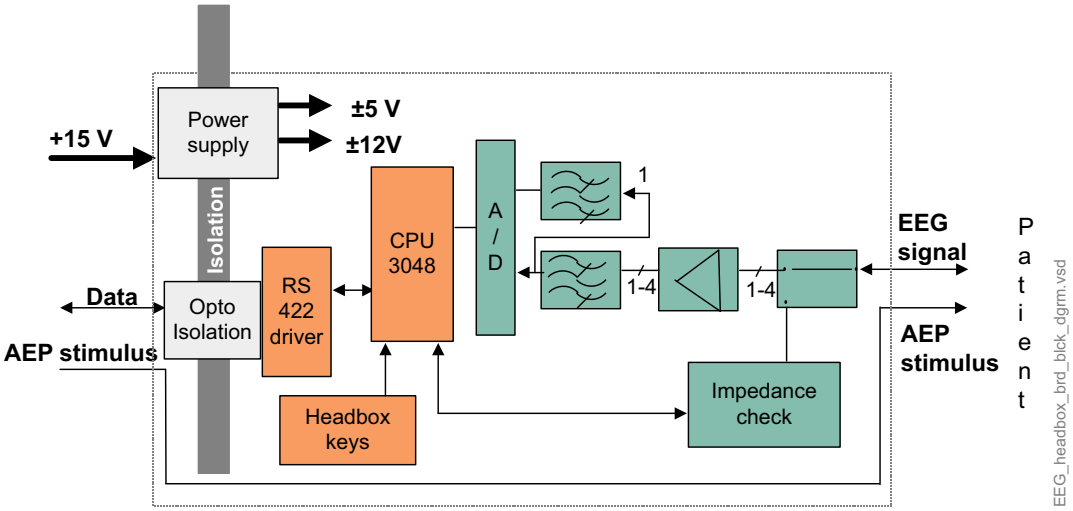


Figure 7 EEG headbox board block diagram

2 Configuration

There is no configuration for the E-EEG module.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual inspections
2. 3.2. Electrical safety tests
3. 3.3. Functional check

3.1 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

Check the external parts of the headbox:

- cover and the base of the headbox are intact
- the headbox sticker is intact
- connectors are intact and attached properly
- 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

NOTE: Mark this task as complete on the checkout form.

3.2 Electrical safety tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual, chapter Installation checkout. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 12-23

3.3 Functional check

3.3.1 Test setup

Required tools

- EEG simulator or signal generator (capable to output a 2 Hz sine waveform with 100µV peak-to-peak amplitude)
- P/N 898050 Preconfigured EEG Lead Set 1, Basic
- Standard earphones with a 3.5 mm phone plug

NOTE: See the supplemental information manual for compatible accessories.

Connections

1. Ensure that the E-EEG module is connected to the monitor.
2. Connect the EEG headbox to the E-EEG module.
3. Connect the EEG leadset to the EEG headbox.
4. Connect the leads (ch1+, ch1-, ch2+, ch2- and ground) of the EEG lead set to the simulator.
5. Plug in the earphones to the EEG headbox.

Monitor configuration

NOTE: Some menu selections differ according to according to software packages and/or license in use.

1. Configure the EEGNum parameter window to the monitor screen with adequate priority.
2. Select ***EEG Setup*** tab in ***EEG menu*** and configure:
   Scale: 100 µV
3. Select ***EEG Montage*** tab in ***EEG menu*** and configure:
   Montage: Basic
4. Select ***EEG View*** menu and select ***Numerical***
5. Select ***AEP Setup*** tab in ***EEG menu*** and configure:
   Stimulus Intensity: 80 dB

Simulator configuration

NOTE: Refer to the simulator documentation for details on how to use and configure the simulator.

1. Turn the simulator on.
2. Configure the simulator to output a 2 Hz sine waveform with 100 µV peak-to-peak amplitude to the EEG1 and EEG2 channels.

3.3.2 EEG tests

1. Impedance check

a. Start a manual electrode impedance check by pressing the **Imp. Check** key on the module.
b. Check that message "Checking electrodes" appears to the EEG1 and EEG2 parameter windows. Wait until the electrodes are checked and 'Electrodes Ok' message is shown.
c. Check also that electrode impedance values shown in the ***Numeric View*** in ***EEG View*** menu are less than 10 kΩ for the ch1 and ch 2 Imped+ and Imped- electrodes and no error messages are shown in the parameter windows.

2. EEG measurement
   a. Check that a sine waveform appears to the EEG1 and EEG2 waveform fields.
   b. Select ***Numeric View*** in the ***EEG View menu*** and check that the MF value is 2.0 ± 0.5 Hz, Delta% > 99 and Amplitude is 35 ± 3 µV.

3. AEP stimulation
   a. Start a manual AEP stimulation sequence by pressing the **EP Start/Stop** key on the EEG headbox.
   b. Check that a clicking sound comes from the earphones.
   c. Press the **EP Start/Stop** key on the module or on the headbox to stop the AEP stimulation.
4. Mark this task as complete on the checkout form.

3.3.3 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

5. Complete on the "Maintenance check form" on page 12-23.

4 Calibration and adjustments

There are no calibration or adjustments for the E-EEG module.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

Before beginning any detailed troubleshooting, complete thorough visual inspection for the EEG module and the EEG Headbox.

EEG Module:

- the front cover is intact
- all connectors are intact, clean, and attached properly
- the module box and latch are intact

EEG headbox:

- cover and the base of the headbox are intact
- the headbox sticker is intact
- connectors are intact and attached properly

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

- all screws are tightened properly
- all cables are connected properly
- the EMC cover is attached properly in the module
- there are no loose objects inside the module

If in doubt of having any loose parts or cable connections inside the EEG headbox, detach the cover of the EEG headbox by removing the four screws from the bottom of the headbox. Be careful with the two wired connectors in the circuit board attached to the cover. Check that:

- all screws are tightened properly
- all cables are connected properly
- there are no loose objects inside the headbox

5.2 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 5.4. 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.
- Connect the accessories to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (**Monitor Setup** > ***Screen Setup*** > ***Upper Parameter Area***).
- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.
- 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 Device Information and Service logs, if requested.

5.3 Service Interface

Use the Webmin Service Interface to access device information and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information tab***.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the E-EEG module:

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions, and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs.

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media:

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***Download Logs.***
4. Select one of the log files for downloading.

5.4 Messages

The messages below appear in the parameter window (PW), waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
EEG leads off Leads off	MF PW	EEG leads are not connected.	Connect the EEG leads.
EEG measurement removed.	MF	EEG module is disconnected from the module slot.	Reconnect the EEG module to the module slot.
Identical EEG modules	MF	Two or more EEG modules are connected.	Connect only one EEG module at a time.
Headbox off	PW	EEG headbox cable is not connected to the module.	Connected the EEG headbox cable to the module.
EEG measurement off	PW	EEG leads have been disconnected for 15 minutes for impedance check or have just been connected (<15 seconds ago).	Reconnect the leads to continue measurement, or wait for a few seconds.
Checking electrodes	PW	Automatic or manual check of electrode impedances is in progress, and the EEG measurement is being stopped for a few seconds.	Wait until checking the electrodes is completed.
Artifacts	PW	Unsuccessful EEG/EP measurement caused by muscle activity.	Calm down the patient and try a new measurement.

Message	Location	Possible causes	Possible solutions
High EMG	PW	High frontal muscle activity may disturb the EEG measurement. Noise from some equipment is coupling to the electrode cables.	Calm down the patient and try a new measurement. Remove noise sources, if possible.
Check GND Electrode	PW	The ground electrode impedance is over 5 kΩ.	Press the ground electrode to improve connection. Replace the electrode, if necessary. Perform ***Check electrodes.***
Poor electr. contact	PW	Electrode impedance is over 5 kΩ.	Check the individual impedances of the EEG electrodes from the ***EEG View Menu > Numeric View***. Press the electrode with high impedance to improve the connection. Replace the electrode, if necessary.
Big contact difference	PW	Big difference (>2.5 kΩ) in the electrode impedance may disturb the EEG measurement.	Check the individual impedances of the EEG electrodes from the ***EEG View Menu > Numeric View***, and try to make the electrode impedances closer to each other. Perform ***Check electrodes***.
Electrodes OK	PW	Electrode impedance is less than 5 kΩ.	No action.
AEP stimulation ON	PW	AEP stimulation is in progress, and clicks are being delivered to the headphones.	Wait until the AEP stimulation has been completed.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module frame is limited to replacing faulty circuit boards or mechanical parts only.

WARNING **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. Maintenance and checkout each time after you have opened the module casing.

6.1.1 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.

6.1.2 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.

6.1.3 Required tools

- antistatic wristband
- pincers
- flat blade screwdriver
- pozidrive screwdriver
- torx screwdriver, T10

6.2 Disassembly and reassembly procedure

6.2.1 E-EEG

Disassembling the E-EEG module (see the exploded view of the module in chapter 7. Service parts):

Replacing 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.

Replacing the Neuro board

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 6.2.1).
4. Disconnect the membrane keyboard cable from the Neuro board.
5. Detach the Neuro board by removing the two screws located near the front panel frame. Pull out the front chassis unit.

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

6.2.2 N-EEG

To disassemble the N-EEG headbox (see the exploded view of the module in chapter 7. Service parts):

1. Remove the four screws from the bottom of the headbox. Detach the electrode sticker located around a headbox input unit.
2. Carefully lift the cover off and disconnect the membrane keypad and the module headbox cable that is connected to the EEG headbox board.

3. Remove the four screws attached to the EEG headbox board - headbox input unit assembly and lift the assembly off the back cover.
4. Disconnect the headbox input unit connectors from the EEG headbox board.

Reassembling the N-EEG

Reverse the order of the disassembly steps.

Check that:

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the headbox

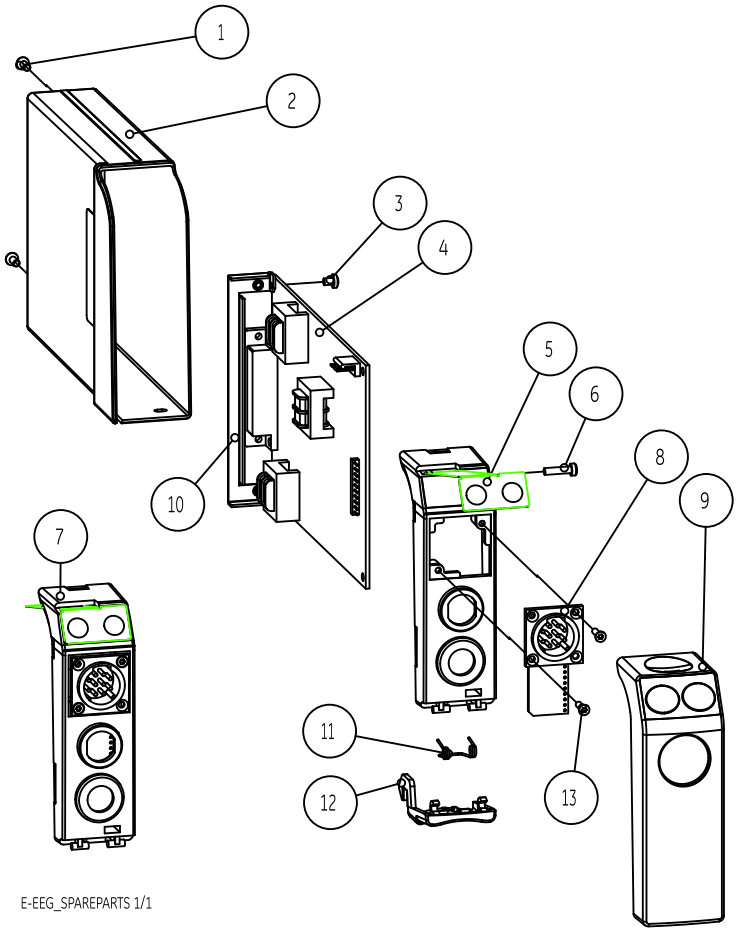
7 Service parts

7.1 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. Maintenance and checkout each time after you have opened the module casing.

7.2 EEG Module, E-EEG



Item	Description	Order No.	Replaced by
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel, zinc coated	*	
2	Module Casing, Single, Injection molded	M1021035	
3	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	*	
4	NEURO BOARD, M-EEG, Printed Circuit Assembly	898806	2080280-001
5	Membrane Keyboard, Sheet metal	M1012126	

Item	Description	Order No.	Replaced by
6	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	*	
7	Front Chassis Unit, E-EEG, Manufacturing assembly	M1025223	2080281-001
8	EEG Input board, E-EEG, Printed Circuit Assembly	M1021394	2080281-001
9	Front Cover, CS, E-EEG	M1063545	
9	Front Cover, DA, E-EEG	M1025170	
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, IT, E-EEG	M1025176	
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	*	

*) Part is not available from GE. Source locally.

7.3 EEG Headbox, N-EEG

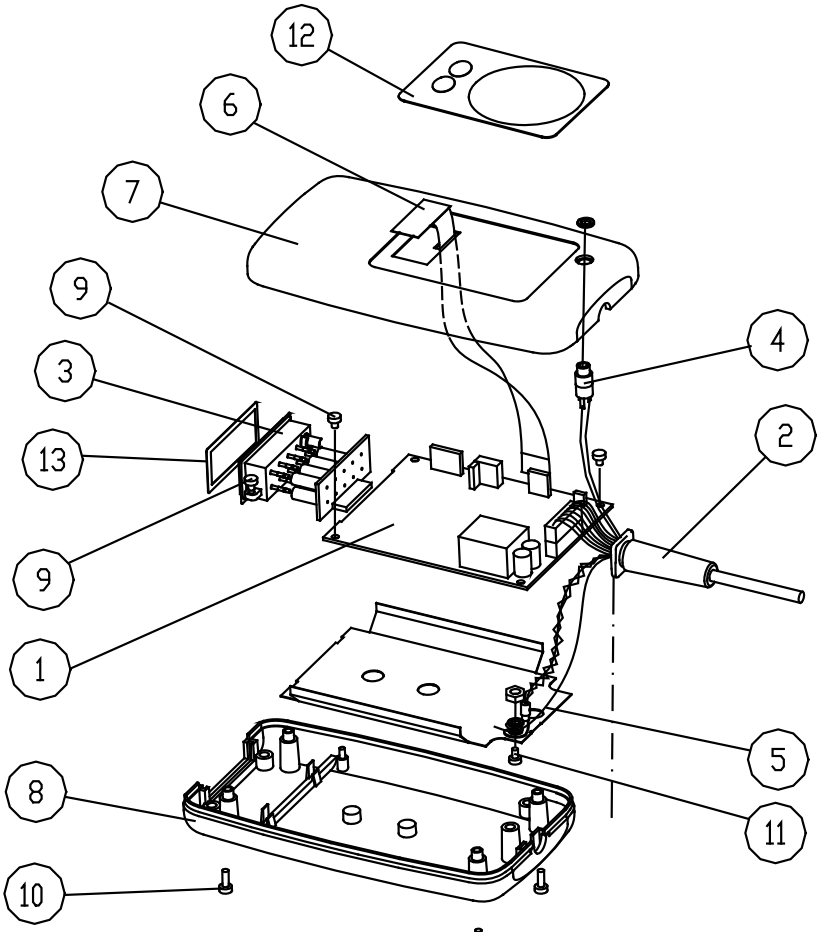


Figure 8 Exploded view of headbox

Item	Description	Order No.	Replaced by
1	EEG headbox board, N-EEG	898805	
2	Module-headbox cable, N-EEG	895610	2080309-001
3	Headbox input unit	896558	2080308-001
4	AEP-connector, N-EEG	896461	895610
5	EMC cover	898276	2080312-001
6	Membrane keypad	880101	2080312-001
7	Cover	896457	2080311-001
8	Bottom side of N-EEG	896557	2080311-001
9	Cross cyl. head screw M3x6	*	
10	Cross cylinder head screw M3x12	*	
11	Cross cylinder head screw M3x12 zinc-coated	*	
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	
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	
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	

*) Part is not available from GE. Source locally.

For your notes:

Maintenance check form

EEG Module, E-EEG, and EEG Headbox, N-EEG

Customer	Monitor	S/N
Service	Software	
Service engineer	Module type	S/N
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**
3.1. Visual inspections	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. EEG tests				☐ ☐ ☐
3.3.3. Test completion				☐ ☐ ☐

Notes		

Used service parts			

Signature	Date

For your notes:

13

BIS Module, E-BIS (Rev. 01)

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the BIS Module, E-BIS. BIS and the BIS logo are trademarks of Covidien AG, and are registered in the USA, EU and other countries. Later in this document Covidien AG will be referred to as Covidien. The BIS measurement is based on electroencephalography (EEG) signals, which are processed as the BIS index.

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 **Check Sensor** for impedance check.

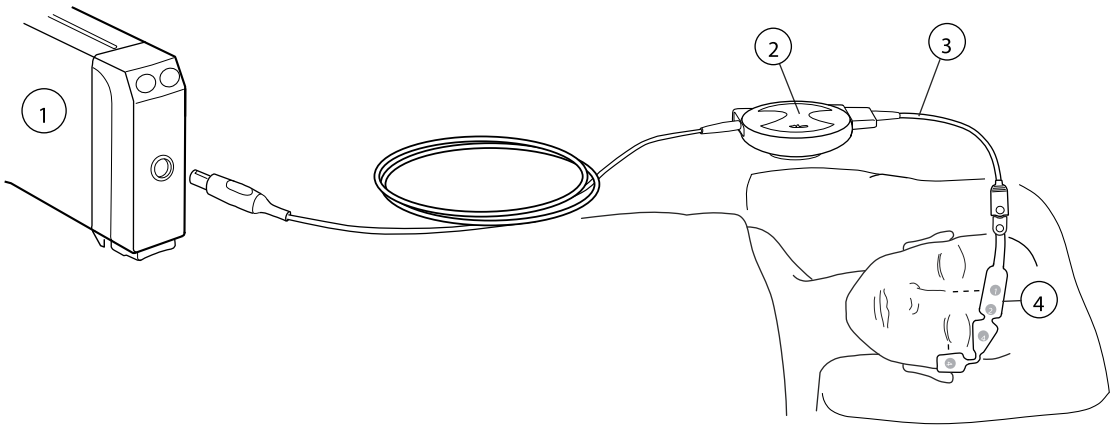


Figure 1 Measurement setup

(1) Module with BIS measurement capability, E-BIS
(2) Digital Signal Processing Unit, BISx
(3) Patient Interface Cable, PIC plus
(4) BIS Sensor

1.1.1 Accessories

The BIS measurement is based on Covidien AG technology, and all accessories are developed and manufactured by Covidien.

NOTE: Only Covidien accessories can be used with the E-BIS module.

1.2 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.

1.2.1 BIS measurement on the monitor screen

The waveform field shows the BIS EEG waveform. The following BIS related data appears in parameter window 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 it ranges from 30 to 55 dB. This frequency band contains power from muscle activity (electromyograph). High frequency artifacts may contribute to the measured signal.

Suppression ratio (SR) number indicates the percentage of suppressed (flat line) EEG detected over the last 63 seconds. It ranges from 0 to 100%.

1.2.2 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 parameter window with a picture of the sensor electrodes. The information on the passed or failed sensor check is shown in the parameter window for each electrode. The BIS measurement cannot continue if the first sensor check fails. In such a case a message 'Sensor check failed' is shown in the parameter window 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 a periodic ground electrode check, the signal disappears momentarily and the message 'Checking sensor' is displayed in the parameter and waveform windows. The BIS calculation stops during this check, and no measurement values are shown.

CAUTION Automatic sensor check may need to be disabled if the 1 nA 128 Hz impedance check signal interferes with other equipment, such as EEG module with evoked potentials measurement.

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

1.3 Main components

1.3.1 Controls and connectors

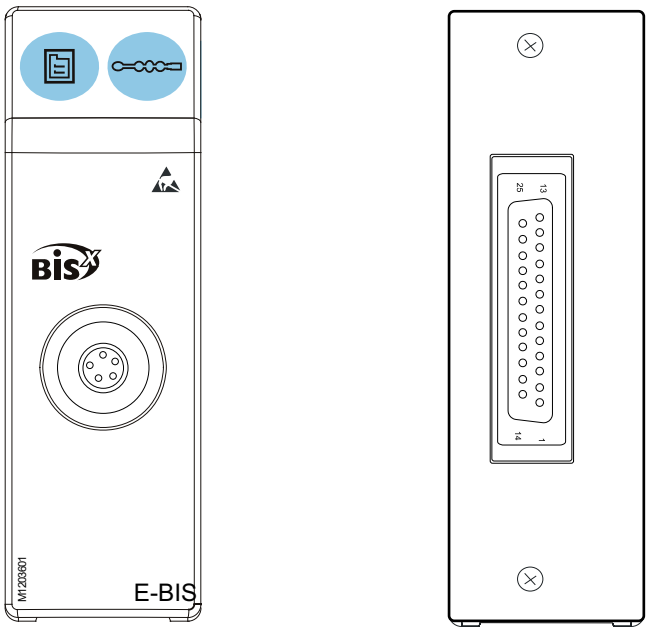


Figure 3 Front and back panels of BIS Module, E-BIS

Module key	Module	Description
	E-BIS	Opens the ***BIS*** menu on the screen.
	E-BIS	Starts the manual sensor check.
Connector	**Module**	**Description**
BIS	E-BIS	Connector for Digital Signal Processing Unit, BISx
D25 connector	E-BIS	Module bus connector

1.3.2 BIS measurement system block diagram

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.

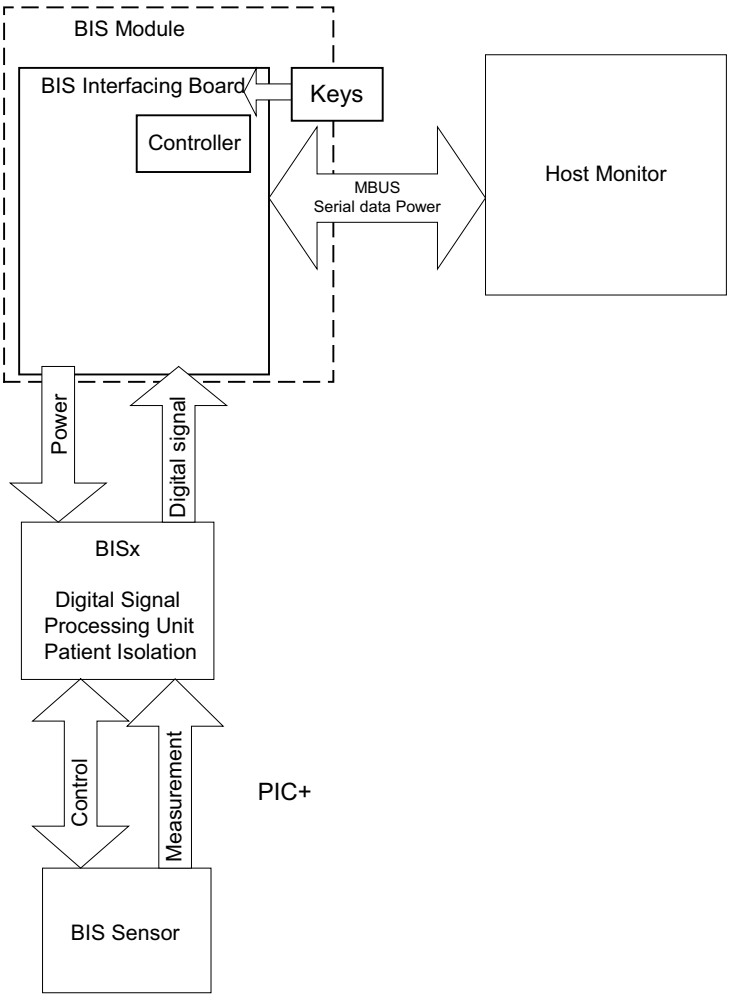


Figure 4 BIS measurement system block diagram

1.3.3 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 BISx Unit is connected to the module with a 2.7 m long shielded cable and to the BIS sensor with a 1.2m long patient interface cable, see Figure 1. 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, it needs to be noted that the measurement cables do not incorporate means to protect against burns in**

case of a defective ESU return electrode. To avoid burns at monitor measurement sites, ensure proper contact of the ESU return electrode to the patient. Also ensure that the ESU return electrode is near the operating area, and that measurement electrodes, leadwires and probes are far from the surgical site and the ESU return electrode.

CAUTION BIS measurement based on measuring the EEG signal is inherently very sensitive. Radiated electromagnetic field may cause erroneous measurements at various frequencies. Do not use electrical radiating equipment close to the BISx or DSC. Details regarding radiated field strengths are given in the technical specifications.

1.3.4 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.

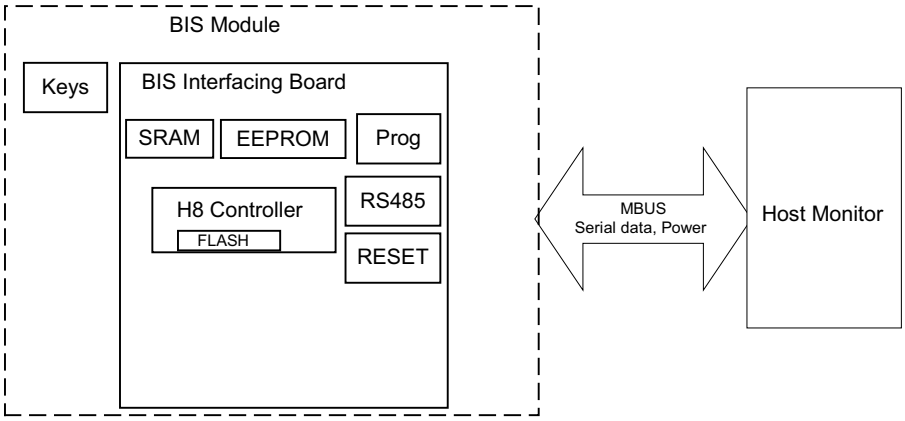


Figure 5 Block diagram of setup

2 Configuration

There is no configuration for E-BIS module.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual inspections
2. 3.2. Electrical safety tests
3. 3.3. Functional check

3.1 Visual inspections

Detach the module from the module slot and check that:

- the front cover is intact
- all connectors are intact and attached properly
- the module box and latch are intact

Check also the BISx Digital Signal Processing Unit to ensure that:

- the cover and the panel stickers are intact
- cables and their connections are 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

3.2 Electrical safety tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual, chapter Installation checkout. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 13-19

3.3 Functional check

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

3.3.1 Test setup

Required tools

– P/N 900508 BIS Sensor simulator

Connections

Ensure that the module is connected to the monitor.

Monitor configuration

Configure the ***BIS EEG*** waveform field to the monitor screen with adequate priority.

3.3.2 BIS tests

1. Module and BISx Digital Signal Processing Unit recognition
   a. Connect the BISx Unit with the Patient Interface Cable (PIC+) to the E-BIS module.
   b. Check that the BIS waveform field and related information appears to the screen and a 'No sensor' message is shown.

2. BISx Unit check
   a. Connect the BIS Sensor simulator to the PIC+ cable.
   b. Check that a 'Checking sensor' message appears to the BIS parameter window and wait for a while until all electrodes are checked. The sensor check is passed if a green circle with a check mark appears to the screen for each tested electrode.

   c. Select ***BIS Setup > Test DSC*** to activate the BISx Unit test. Wait for a while and check that the test shows 'PASS'.
3. Mark this task as complete on the checkout form.

3.3.3 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

4. Complete on the "Maintenance check form" on page 13-19.

4 Calibration and adjustments

There are no calibration or adjustments for the E-BIS module.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues, and clinical configuration issues.

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

Before beginning any detailed troubleshooting, complete a thorough visual inspection for the module and the BISx Digital Signal Processing Unit.

Module

- the front cover is intact
- all connectors are intact, clean and are attached properly
- the module box and latch are intact

BISx Unit

- the cover and the panel stickers are intact
- cables and their connections are intact

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

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module

5.2 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.
- Select ***BIS Setup > Test DSC*** menu to activate the BISx Digital Signal Processing Unit test. Wait until the test is completed. If the test result shows 'FAIL', it is an indication of a defective BISx Unit.

- Connect the accessories with a simulator to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (**Monitor Setup > *Screen Setup > Upper Parameter Area***).
- Press a module key. Check that the related menu is opened or activity is started. Inoperatibility may refer to a loose keypad cable or other problem in the module.
- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.
- 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.

5.3 Service interface

Use the Webmin service interface to access device information and service logs.

5.3.1 Device Information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the E-BIS module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information tab***.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the E-BIS module.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file or a snapshot file to an external media

1. Log on to the Webmin application.

2. Select the ***Diagnostics tab***.
3. Select ***Download Logs***
4. Select one of the log files for downloading.

5.4 Messages

The messages in the table below appear in the BIS parameter window (PW), InvBP waveform field (WF) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Module error BIS Module error	WF, PW MF	BISx Unit failure	Replace the BISx Unit.
Testing DSC	WF, PW	BISx Unit test is manually activated from BIS menu.	Wait until the BISx Unit test is completed. If the result is FAIL, repeat the test. Replace the BISx Unit, if the problem remains.
DSC Error BIS DSC Error	PW MF	The BISx Unit is not communicating or operating properly. (This may occur during the use of electrocautery device.)	Replace the BISx Unit.
Incompatible DSC	PW	Current module hw/sw is incompatible with this BISx Unit.	Connect correct type of BISx Unit.
No Sensor No BIS Sensor	WF, PW 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 the sensor and then the PIC+cable.
Sensor check failed BIS sensor check failed	WF, PW 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 the PIC+cable and then the BISx Unit.
Incompatible sensor	WF, PW	Sensor is not recognized. Sensor is not a BIS sensor.	Connect a correct type of sensor. Make sure that the PIC connector is clean and dry.
Replace Sensor BIS Sensor expired	PW MF	Sensor has been used for too many times or it's date has expired. The validity time for the sensor can't be determined. The sensor has been used for over 24 h.	Replace with a new sensor.

Message	Location	Possible causes	Possible solutions
Checking Sensor	WF, PW	Sensor check is in progress. Can be either the initial sensor check, the manual check, or the periodic check.	Wait until the check has been performed.
Apply Sensor	PW	Connection to the patient is loose.	Connect the sensor properly.
Demo data	WF, PW	BIS simulator is connected.	Disconnect the BIS simulator.
Poor signal	WF, PW	Artifacts or the amount of EMG activity prevents calculating BIS, data excluded. SQI < 50	Check the sensor, then the PIC cable. Reattach the senor to the patient by following the sensor instructions.
Artifact	WF, PW	Signal contains noise or artifact. Non-EEG data, such as EMG, eye blinks, or shivering is present.	Wait for good data.
Automatic check off	PW	Automatic sensor check is set off.	Turn the automatic sensor check on from the BIS menu.
High BIS impedance	MF	Electrode impedance is too high. Sensor is not properly attached to the patient.	Check the cable connections. Reattach the sensor to the patient by following the sensor instructions.
BIS Measurement removed	MF	The BIS module is disconnected from the module slot.	Reconnect the BIS module to the module slot.

5.5 Troubleshooting chart

Problem	Possible causes	Possible solutions
'Checking sensor' message stays more than 2 minutes.	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 ***Check Sensor*** button on the module front panel.
No BIS waveforms on the screen.	BIS waveform is not selected on the screen, or the priority is too low.	Press **Monitor Setup** key and select BIS waveforms on the screen with adequate priority.
Sensor impedance check is not available on menus.	Sensor is not connected to the BISx Unit, or the BISx Unit is not connected to the module.	Connect the sensor and the BISx Unit.
Sensor impedance check fails.	Sensor is poorly attached.	Attach the sensor by following the sensor instructions.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module frame is limited to replacing faulty circuit boards or mechanical parts only.

WARNING **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: The BISx Digital Signal Processing Unit is not field repairable. Do not disassemble the BISx Unit.

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

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

6.1.1 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.

6.1.2 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.

6.1.3 Required tools

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

6.2 Disassembly and reassembly procedure

Disassembling the E-BIS module (see the exploded view of the module in chapter 7. Service parts):

6.2.1 Replacing 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.

6.2.2 Replacing the interface board

1. Remove the front cover.
2. Remove the two screws (T10) from the back of the module.
3. While pressing the release latch, pull the module casing slowly backwards and remove it from the main body.
4. Detach the interface board by removing the two screws located near the front chassis unit. Disconnect the membrane keyboard cable and pull out the front chassis unit.

6.2.3 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

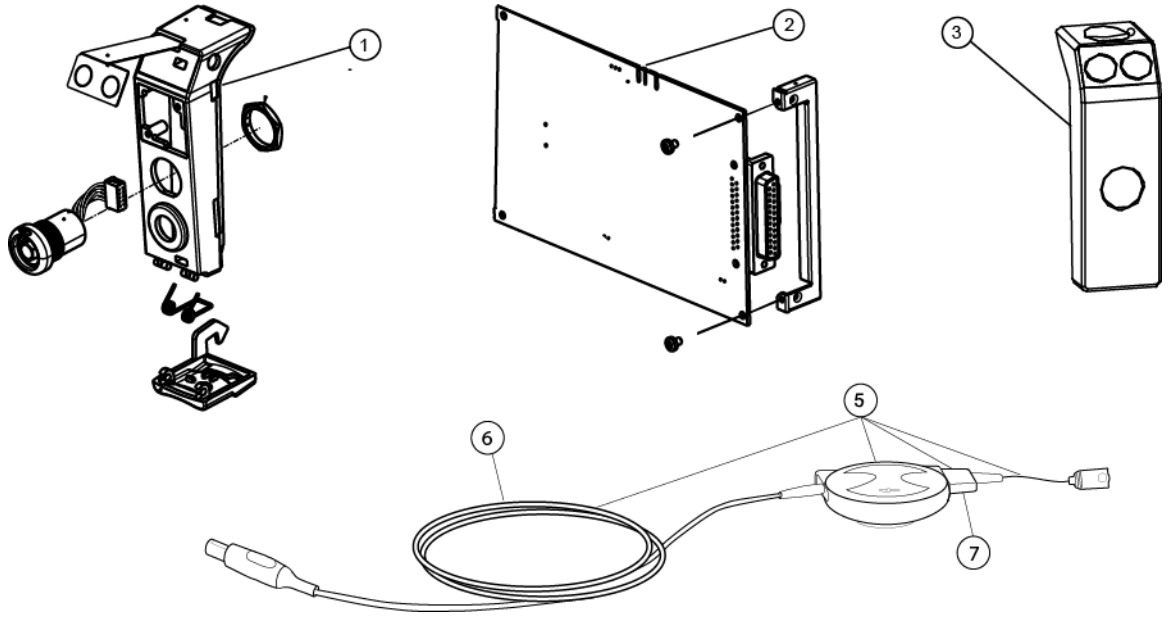
7 Service parts

7.1 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. Maintenance and checkout each time after you have opened the module casing.

7.2 BIS Module, E-BIS



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
2	E-BIS-01-JA, Interface Board, FRU - Interface Board (Japanese Version) - Metal Frame - 2 mounting screws	M1233348
3	E-BIS-01, Front Cover, FRU - Front Cover	M1203601-S

Item	Description	Order No.
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
5	BISx Digital Signal Processing Unit, including - Patient Interface Cable, PIC plus - GE BISx Host Cable Kit - BISx Bulkhead Connector	M1206545
6	GE BISx Host Cable Kit, FRU	2080644-001
7	BISx Bulkhead Connector, FRU	2080645-001

Maintenance check form

BIS Module, E-BIS

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**
3.1. Visual inspections	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
3.2. Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. BIS tests				☐ ☐ ☐
3.3.3. Test completion				☐ ☐ ☐

Notes		

Used service parts			

Signature	Date

For your notes:

14

NeuroMuscular Transmission Module, E-NMT Rev.01

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the NeuroMuscular Transmission Module, E-NMT-01. The E-NMT-01 module is a single width plug-in module.

NOTE: Some information in this document may vary compared to older E-NMT modules versions. If needed refer to earlier document version(s) for more information about older E-NMT modules versions.

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, response measurement is not available with regional nerve blocking.

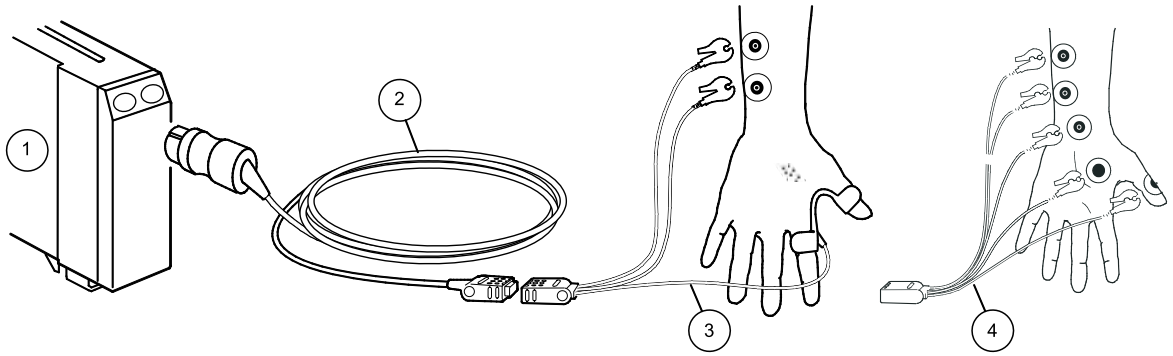


Figure 1 NMT Setup

(1) Module measuring NMT
(2) NMT sensor cable
(3) MechanoSensor
(4) ElectroSensor

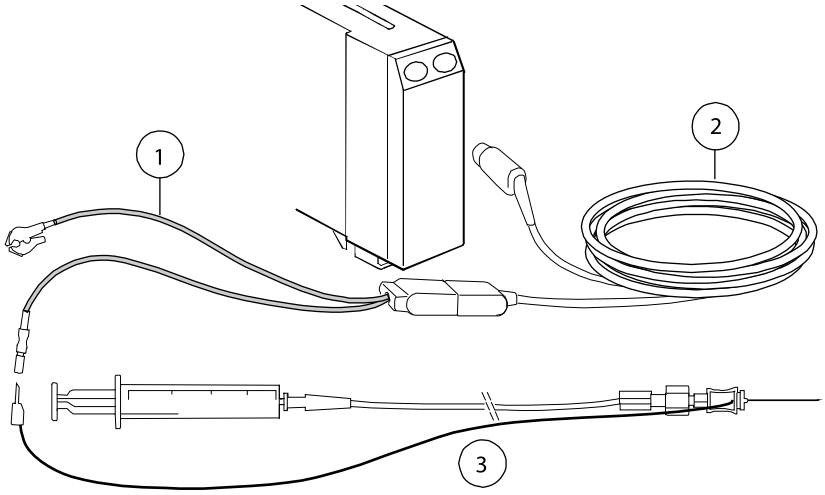


Figure 2 Regional block

(1) Regional block adapter
(2) Sensor cable
(3) Needle with syringe

WARNING **Do not place the NMT stimulating electrodes on the patient's chest. Application of the electrodes near the thorax may increase the risk of cardiac fibrillation.**

CAUTION Always stop the NMT measurement before handling the stimulating electrodes.

CAUTION Never subject a patient with an implanted electronic device to electrical stimulation without consulting a medical specialist first.

1.2 Measurement principle

1.2.1 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 if 1 second cycle time is used.

1.2.2 Tetanic/PTC

Tetanic/PTC (Post Tetanic Count) can measure deeper relaxation than TOF. The tetanic stimulation is produced when ***Start Tetanic/PTC*** is selected in the **NMT Setup** menu. The length of the stimulation is 5 seconds. The stimulation generates pulses with a frequency of 50 Hz and with a selected pulse width and current. After the tetanic stimulation and there is a 3 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 the responses do not fade away, a maximum of 20 responses are counted and the text '>20' is displayed.

After tetanic stimulation, NMT measurements are stopped for one minute. Then the monitor automatically continues with the previously selected TOF, DBS, or ST measurement cycle.

1.2.3 Response measurement

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, it is interpreted as no response.

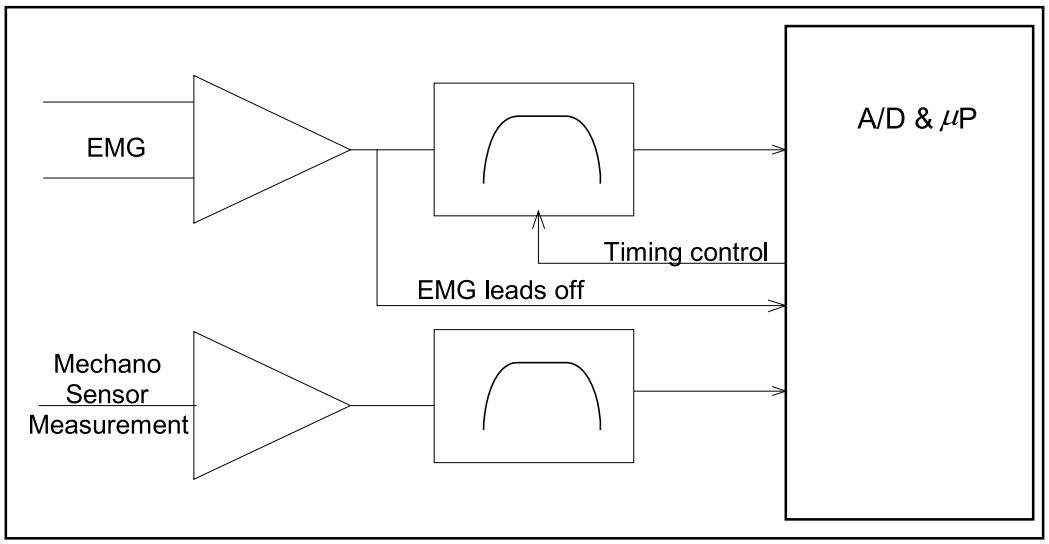


Figure 3 Principle of response measurement

1.2.4 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.

1.2.5 MechanoSensor measurement

MechanoSensor is attached between a thumb and an index finger. It measures the response as a movement of the thumb with a piezoelectric wafer.

1.2.6 Regional block

A regional block cable can be used as a nerve locator in local anesthesia. An adjustable stimulus current between 0 - 5.0 mA is given every 1, 2 or 3 seconds. The response measurement is ocular.

1.3 Main components

1.3.1 Controls and connectors

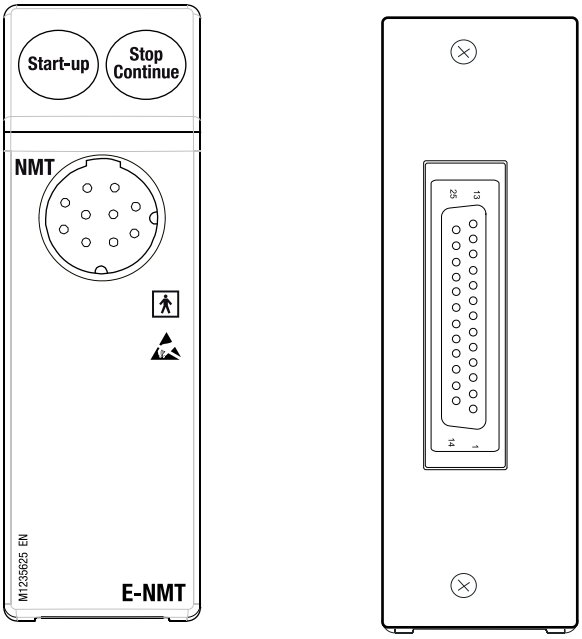


Figure 4 Front panel NeuroMuscular Transmission Module, E-NMT, and the back of the module

Module key	Module	Description
Start-up	E-NMT	Starts the search of supramaximal current and reference level, and proceeds with the selected measurement cycle.
Stop/Continue	E-NMT	Interrupts and restarts monitoring of the same patient.
Connector	**Module**	**Description**
NMT	E-NMT	NMT connector
D25 connector	E-NMT	Module bus connector

1.3.2 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

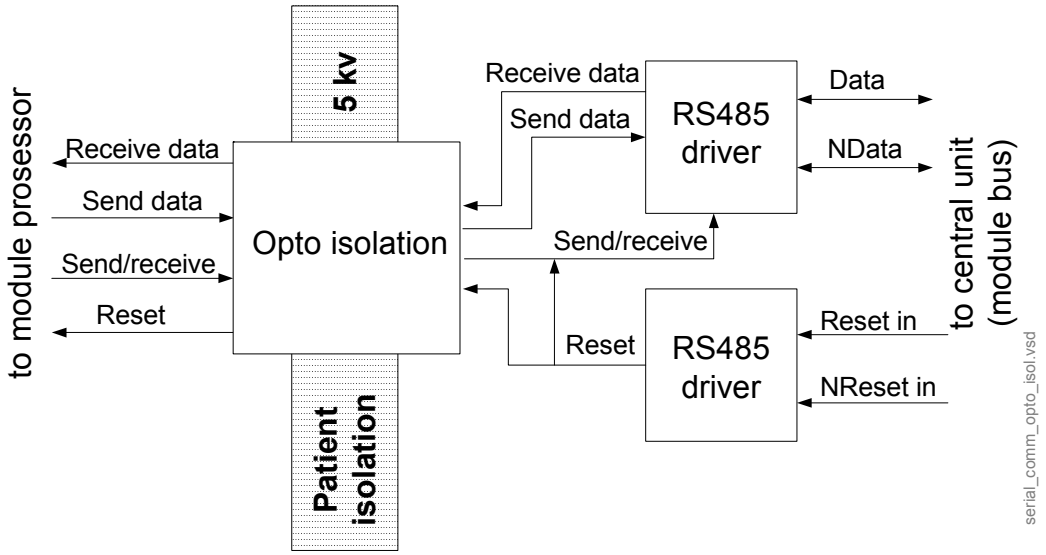


Figure 5 Serial communication and opto isolation

1.3.3 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.

2 Configuration

There is no configuration for the E-NMT module.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Module casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual inspections
2. 3.2. Electrical safety tests
3. 3.3. Functional check

3.1 Visual inspections

Detach the module from the module slot and check that:

- the front cover is intact
- all connectors are intact and attached properly
- the module box and latch are 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 patient monitor's user's manual. For details about cleaning, disinfecting and sterilizing the accessories, see the instructions for use in the accessory package.

NOTE: Mark this task as complete on the checkout form.

3.2 Electrical safety tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual, chapter Installation checkout. Perform Patient leakage current tests, Patient (source) leakage current test and Patient (sink) leakage current test.

Record the values of the tests on the "Maintenance check form" on page 14-21

3.3 Functional check

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

3.3.1 Test setup

Required tools

– P/N 871251-HEL, NMT Simulator
– NMT ElectroSensor
– NMT Sensor Cable, 1,5 m or NMT sensor cable 3,3 m

NOTE: See the supplemental information manual for compatible accessories.

Connections

Ensure that the module is connected to the monitor.

Monitor configuration

NOTE: Some menu selections differ according to according to software packages and/or license in use.

1. Configure the NMT waveform field to the monitor screen with adequate priority.
2. Select the ***NMT Setup*** menu and configure:
   Start with: New patient
   Current: Supra
   Stimulus Mode: TOF
   Stimulus Beep Volume: 2

Simulator configuration

Set the switch on the simulator to "Fade off" and turn the response knob to "max".

3.3.2 NMT tests

1. Module and sensor recognition
   a. Connect a NMT Sensor Cable with a NMT ElectroSensor to the module.
   b. Check that the NMT waveform field with related information is shown on the screen.
   c. Check that a 'Measurement OFF' message is shown on the parameter window.

2. Supramaximal current search and reference setting
   a. Connect the NMT ElectroSensor leads to the NMT simulator.
   b. Start NMT measurement (TOF) by pressing the **START-UP** module key. Check that the supramaximal current detected is less than 70 mA and that the message in the parameter window changes from 'Supramax search' to 'Setting reference'.

3. Functional check with a simulator
   a. Check that the module gives four successive stimulus pulses with approximately 0.5 second intervals. A sound signal should be heard from the loudspeaker during each of the stimulus pulses.
   b. Check that the responses for the four stimulus pulses are visible on the waveform field. Check also that in the TOF% value is within 95-105, Count is 4 and T1% is within 95-105.

c. Press the **STOP/CONTINUE** module key to stop the measurement.

4. Mark this task as complete on the checkout form.

3.3.3 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

5. Complete on the "Maintenance check form" on page 14-21.

4 Calibration and adjustments

There are no calibration or adjustments for the E-NMT module.

5 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 patient monitor's user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

NOTE: Perform the checkout procedure described in chapter 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

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

- the front cover is intact
- all connectors are intact, clean and are attached properly
- the module box and latch are intact

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

5.2 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 monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.
- Connect the accessories with a simulator to the module in doubt. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (**Monitor Setup** > ***Screen Setup*** > ***Upper Parameter Area)***.
- Press a module key. Check that the related menu is opened or activity is started. Inoperatibility may refer to a loose keypad cable or other problem in the module.
- Do a visual check to the accessories used with the module. If in doubt, replace the accessories with known good ones.

- 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.

5.3 Service interface

Use the Webmin service interface to access device information and service logs.

5.3.1 Device information

The Device Information shows the hardware and software information of the system and the modules. Ensure that the module is connected to the monitor.

To view Device information:

1. Log on to the Webmin application.
2. Select the ***Information tab***.
3. Select ***Device Information***.
4. Check that the software and hardware information is provided.

5.3.2 Log files

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems. The following service logs may contain information related to the E-NMT module.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions, and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the Carescape monitor technical manual to see the complete list of available service logs

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***View Logs***.
4. Select one of the log files for viewing.

To download a log file to an external media

1. Log on to the Webmin application.
2. Select the ***Diagnostics tab***.
3. Select ***Download Logs***
4. Select one of the log files or snapshot files for downloading.

5.4 Messages

The messages in the table below appear in the NMT parameter window (PW) or the message field (MF).

Message	Location	Possible causes	Possible solutions
Cable off NMT cable removed	PW MF	NMT sensor cable and sensor are not connected to the module.	Connect the NMT sensor and sensor to the module.
Measurement off	PW	Measurement is stopped.	Start the measurement.
EMG electrodes off	PW	One the recording electrodes (red or green) in NMT ElectroSensor is disconnected or broken.	Attach the electrodes to continue or start measurement. Replace the NMT Electrosensor, if broken.
Check electrodes	PW	One of the stimulating electrodes (white or brown) is disconnected or the cable is broken.	Check the white and brown stimulating electrodes. Replace the NMT ElectroSensor or MechanoSensor cable, if broken.
Supramax search	PW	The search of supramaximal stimulus pulse is in progress.	Wait until the search of supramaximal stimulus pulse is completed.
Setting reference	PW	Reference setting is in progress.	Wait until the setting of reference level is completed.
Regional block	PW	Nerve location with regional block stimulation is in progress.	Stop regional block stimulation.
TETANIC	PW	Tetanic stimulation is in progress.	Wait until the tetanic stimulation is completed.
Response too weak	PW	The maximum gain is insufficient to increase the response signal amplitude to a measurable level: • stimulus electrodes are loose • response electrodes are attached to a wrong place	Check that the stimulus current is not too weak. Check stimulus electrode placement and connections. Check that the response electrodes are not disconnected. If the electrodes are dry, replace them. Check that skin at the electrode site is properly prepared.
Reference not stable	PW	Reference setting fails because responses differ more than 10%: • patient is relaxated • movement artifacts	Start measurement with fixed current without reference measurement.

Message	Location	Possible causes	Possible solutions
Supramax not found	PW	Supramaximal stimulus current is not found. 70 mA is used as stimulus current.	Stop measurement, reposition the stimulus and the response electrodes, and restart the measurement.
NMT measurement removed	MF	NMT module is disconnected from the module slot.	Reconncet the NMT module to the module slot.
Identical NMT modules	MF	Two or more NMT modules are connected.	Connect only one NMT module at a time.

6 Disassembly and reassembly

6.1 Disassembly guidelines

Field service of the module frame is limited to replacing faulty circuit boards or mechanical parts only.

WARNING **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. Maintenance and checkout each time after you have opened the module casing.

6.1.1 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.

6.1.2 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.

6.1.3 Required tools

- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

6.2 Disassembly and reassembly procedure

Disassembling the E-NMT module (see the exploded view of the module in chapter 7. Service parts):

6.2.1 Replacing 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.

6.2.2 Replacing the NMT board

1. Remove the two screws (T10) from the back of the module.
2. Remove the release latch from the main body. While pressing the release latch, pull the module casing slowly backwards and remove it.
3. Detach the front cover (see 6.2.1).
4. Remove the two screws located near the front chassis unit.
5. Carefully pull out the front chassis unit to detach the connector that connects the NMT board to the NMT connector board.
6. Disconnect the membrane keyboard cable and the NMT connector cable from the NMT board.

6.2.3 Reassembling the module

Reverse the order of the disassembly steps.

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

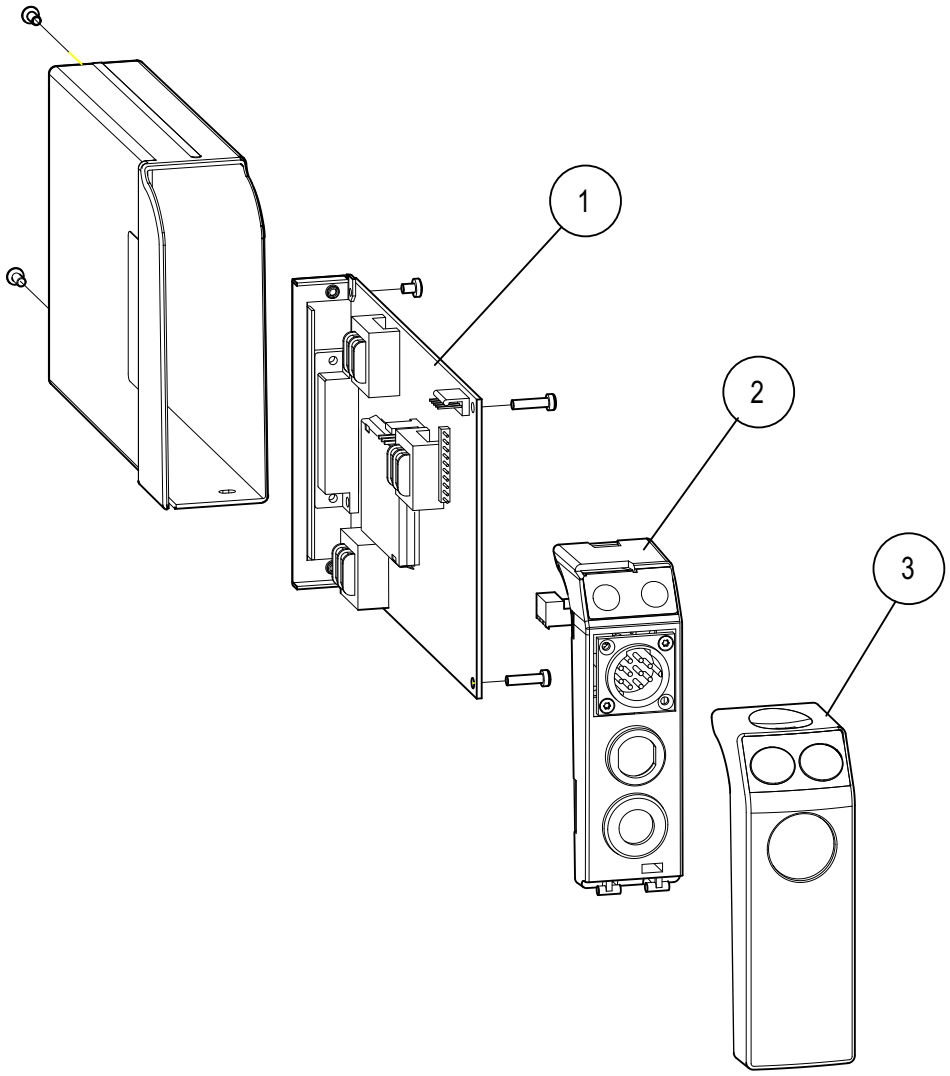
7 Service parts

7.1 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. Maintenance and checkout each time after you have opened the module casing.

7.2 Spare parts for E-NMT-01



Item	Description	Order No.
1	E-NMT-01, NMT board, FRU - NMT Measurement Board - Metal Frame - 2 mounting screws	2080924-001
2	E-NMT-01, Front Chassis Unit, FRU - Front Chassis - Membrane Keyboard - Connector Unit - Latch - Torsion Spring	2081701-001
3	E-NMT-01, Front Cover FRU, Danish	M1237377

Item	Description	Order No.
3	E-NMT-01, Front Cover FRU, Dutch	M1237378
3	E-NMT-01, Front Cover FRU, English	M1237379
3	E-NMT-01, Front Cover FRU, Finnish	M1237380
3	E-NMT-01, Front Cover FRU, French	M1237381
3	E-NMT-01, Front Cover FRU, German	M1237382
3	E-NMT-01, Front Cover FRU, Italian	M1237383
3	E-NMT-01, Front Cover FRU, Japanese	M1237384
3	E-NMT-01, Front Cover FRU, Norwegian	M1237386
3	E-NMT-01, Front Cover FRU, Polish	M1237387
3	E-NMT-01, Front Cover FRU, Portuguese	M1237388
3	E-NMT-01, Front Cover FRU, Spanish	M1237390
3	E-NMT-01, Front Cover FRU, Swedish	M1237391
3	E-NMT-01, Front Cover FRU, Czech	M1237394
3	E-NMT-01, Front Cover FRU, Hungary	M1237395
3	E-NMT-01, Front Cover FRU, Russian	M1237396
3	E-NMT-01, Front Cover FRU, Chinese	M1237397
3	E-NMT-01, Front Cover FRU, Italian	M1237383
3	E-NMT-01, Front Cover FRU, Japanese	M1237384
3	E-NMT-01, Front Cover FRU, Norwegian	M1237386
3	E-NMT-01, Front Cover FRU, Polish	M1237387
	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

NOTE: The parts listed in the table above are compatible with the E-NMT-00 modules with following limitations:

– NMT Board 2080924-001 can be used only together Front Chassis Unit 2081701-001.

– Front Chassis Unit 2081701-001 can be used only together NMT Board 2080924-001.

For your notes:

Maintenance check form

NeuroMuscular Transmission Module, E-NMT

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**
3.1. Visual inspections	☐ ☐ ☐	**Result µA** IEC, EN / UL	Limits µA IEC, EN / UL	
3.2. Electrical safety tests	☐ ☐ ☐			
Patient (source) leakage current test	S.F.C ground open		< 50 µA	☐ ☐ ☐
	S.F.C neutral open		≤ 50 µA	☐ ☐ ☐
	N.C		≤ 10 µA	☐ ☐ ☐
Patient (sink) leakage current test	using a test body		≤ 50 µA	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. NMT tests				☐ ☐ ☐
3.3.3. Test completion				☐ ☐ ☐

Notes		

Used service parts			

Signature	Date

For your notes:

15

F5, 5-Module Frame
F7, 7-Module Frame

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for the maintenance and service of the module frames F5 and F7 for 5 and 7 single-width modules.

The technical specifications are described in the supplemental information manual.

Figure 1 Module frames

1.2 Functional description

The F5 module frame is for stand-alone CARESCAPE Monitor B850 use. It provides places for five single-width E-modules or two double-width E-modules (plus one slot for one single-width E-Module). In the side of the F5 module frame there is a docking station for Patient Side Modules E-PSM or E-PSMP or PDM Module.

The F7 module frame is used with CARESCAPE Monitor B850 intergrated Carestations only. It provides places for seven single-width E-modules or three double-width E-modules (plus one slot for a single-width E-module). Patient side module E-PSM or E-PSMP can be connected to the F7 PSM connector by using the PSM pole mounts.

Free air convection is used for cooling the frames. Set up the monitor in a location that affords sufficient ventilation. The ventilation openings of the device must not be obstructed (by equipment, walls, or blankets, for example).

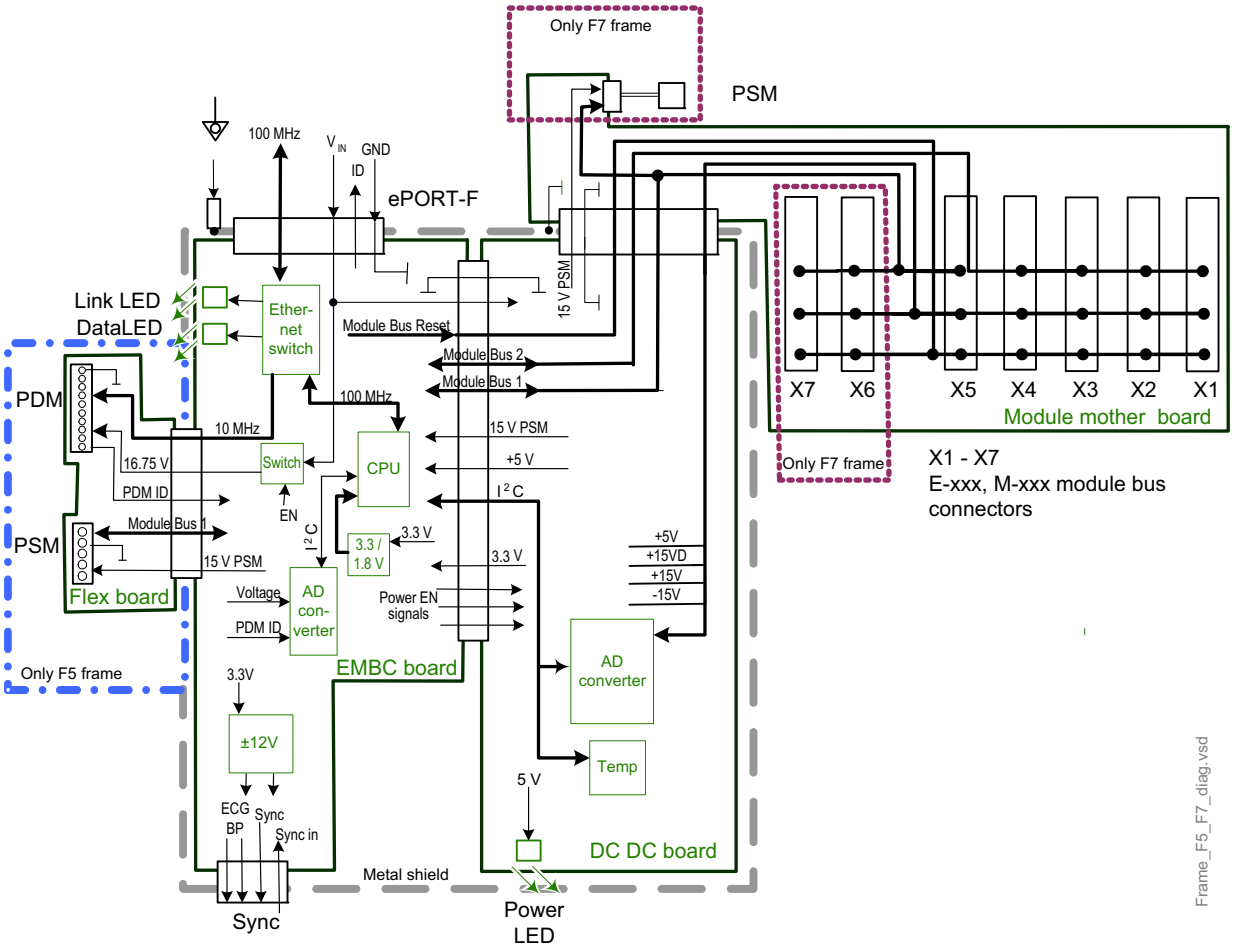


Figure 2 Module frame F5/F7, functional block diagram

1.3 Main components

The module frame, F5 or F7, has module slots for parameter modules. It includes a Mother board, and its own Power board (DC/DC) and EMBC board.

1.3.1 Connectors and signals

F5, 5-module frame

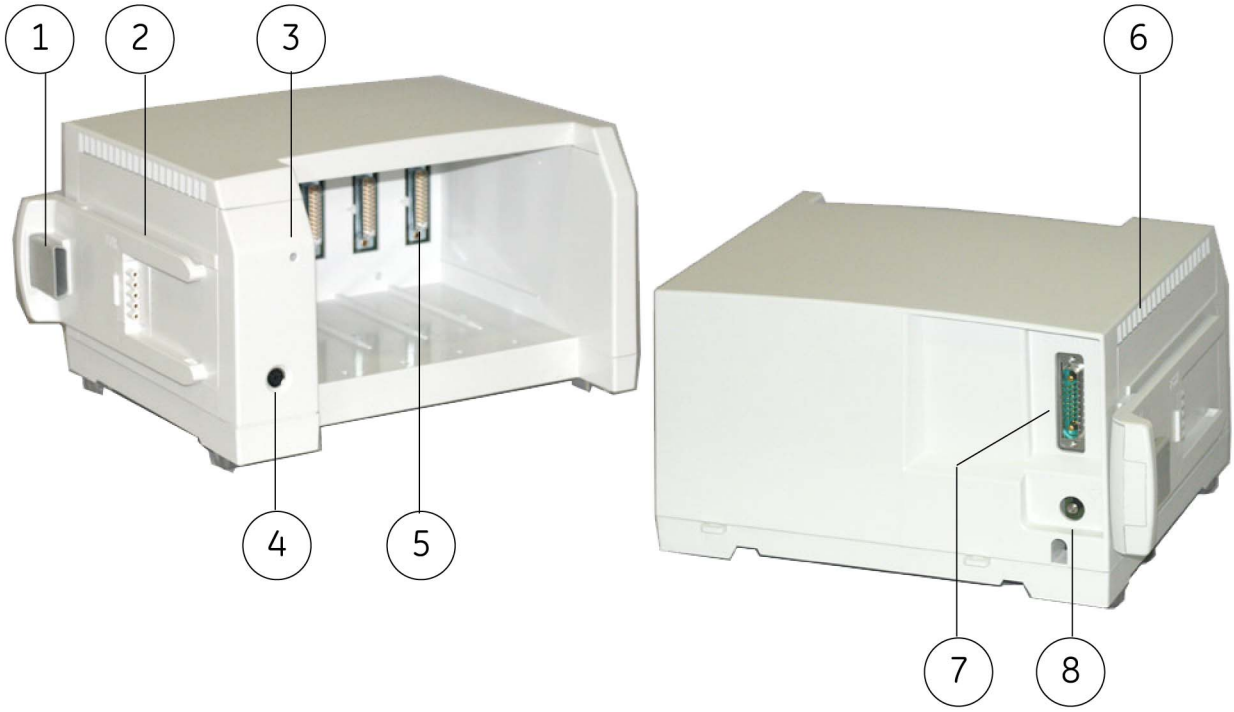


Figure 3 F5 External connections

(1) Connector for PDM module
(2) Connector for PSM module
(3) On/Standby LED
(4) Synchronization connector
(5) Module connector
(6) a) Communication LED, b) Link LED
(7) ePort Connector for the CARESCAPE monitor connection cable
(8) Equipotential connector

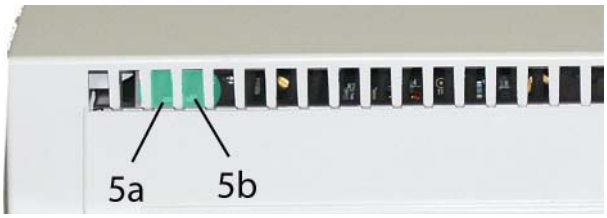
NOTE: The Defibrillation synchronization connector can be used only with E-(P)RE(S)TN and E-PSM(P)(W) modules. PDM module has its own defibrillation synchronization connector.

F7, 7-module frame

Figure 4 F7 modules frame, external connections

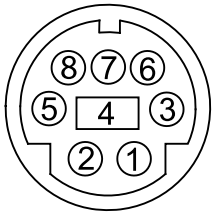
(1) On/Standby LED
(2) Synchronization connector
(3) Module connector
(4) Connector for the cable of Pole Mount for E-PSM
(5) a) Communication LED, b) Link LED
(6) ePort Connector for the CARESCAPE monitor connection cable
(7) Equipotential connector

Signals



Ref	Indicators	Normal function
1	On/Standby LED, green	lit
5a	Activity LED, green	lit
5b	Link LED, green	blinking

Synchronization connector

Connector	Pin	Signal
	1 2 3 4 5 6 7 8	Defib marker out Defib marker in Common signal GND N/A Analog out reference (GND) Analog out reference (GND) BP Analog out ECG Analog out

Defibrillation Sync out (pin1)

Digital defibrillator output synchronization signal. Defibrillation Sync indication is generated by ECG. When active, the signal is in state 1. After 10 ms the signal is reset to state 0. Defibrillation Sync is not generated before the indication is deactivated. The delay from the R wave peak to the start of the signal is maximally 35 ms.

Pressure out (pin 7):

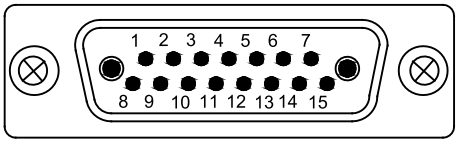
– P1 from hemodynamic module

The Invasive pressure output signal is 1 V/100 mmHg, originally ranging from 0 to 320 mmHg, and with a delay of approximately 25 ms. The signal requires an input impedance of 100 k.

Direct ECG (pin 8):

Delay (max.):	15 ms
Gain ECG (out)/ECG (in):	1 V/1 mV
Pacer:	5 V and 2 ms pulse

e-Port connector



1.3.2 EMBC Board

The EMBC board provides resources for module bus communication and Ethernet connection for PDM. It also provides analog output, defibrillator/IABP synchronization.

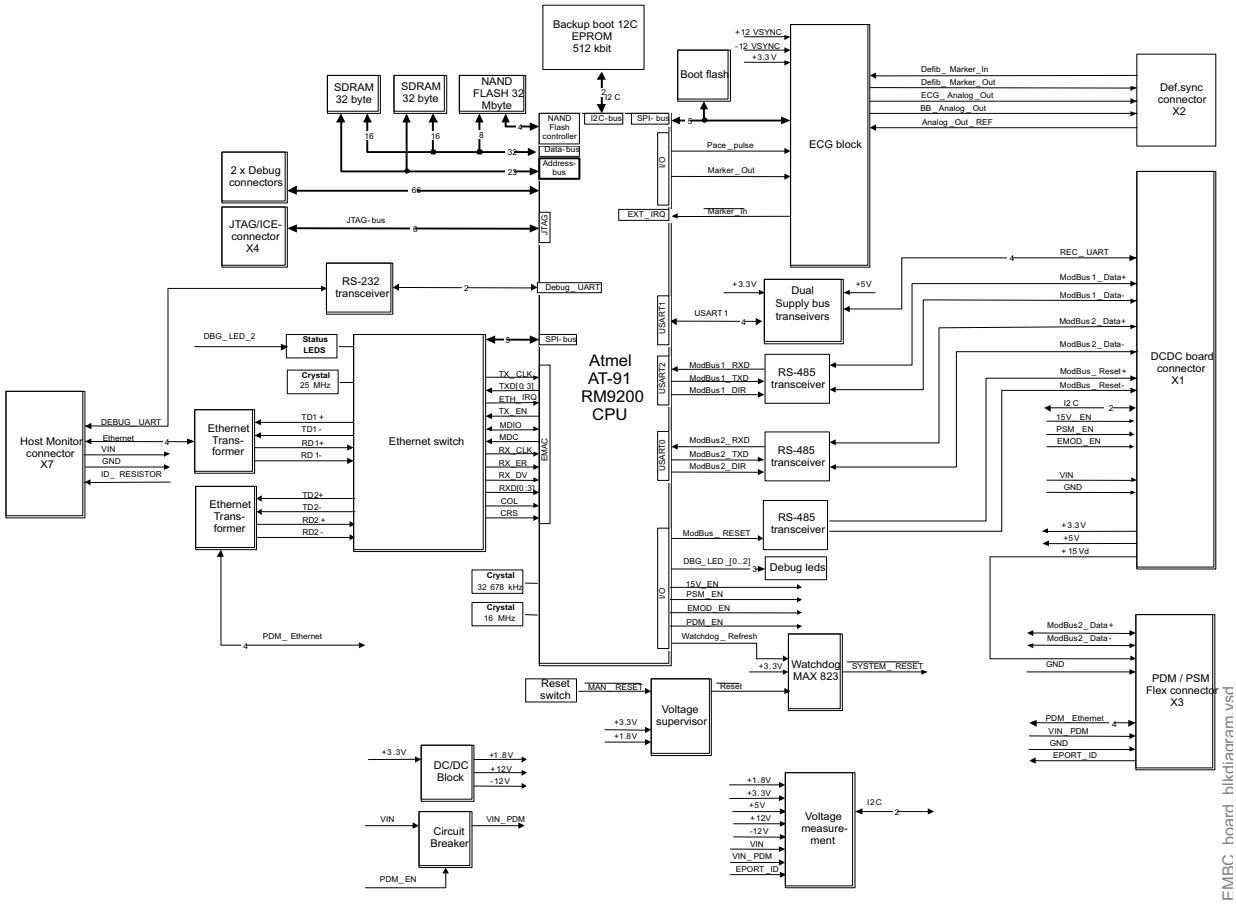


Figure 5 EMBC board block diagram

1.3.3 Power Board

The Power Board generates supply voltages for the EMBC Board, E-modules and PSM module and forms electrical interface between EMBC Board and Mother Board.

Modules, RS-485 communication and reset lines as well as Recorder serial communication lines are routed through Power Board from EMBC to Mother Board, where E-modules are connected. The supply voltages are generated on Power Board from input voltage coming from the host through EMBC Board. Because the host cable may be hot plugged to the EMBC Board, a hot swap control circuit is added to the input of the DCDC Board to limit the inrush current.

The Power Board shall work properly within the supply voltage range 14V - 18V. It provides +15V, +15Vd, -15V, +12V, -12V, +5V, +3.3V and +1.8V voltages to the module frame F5 or F7.

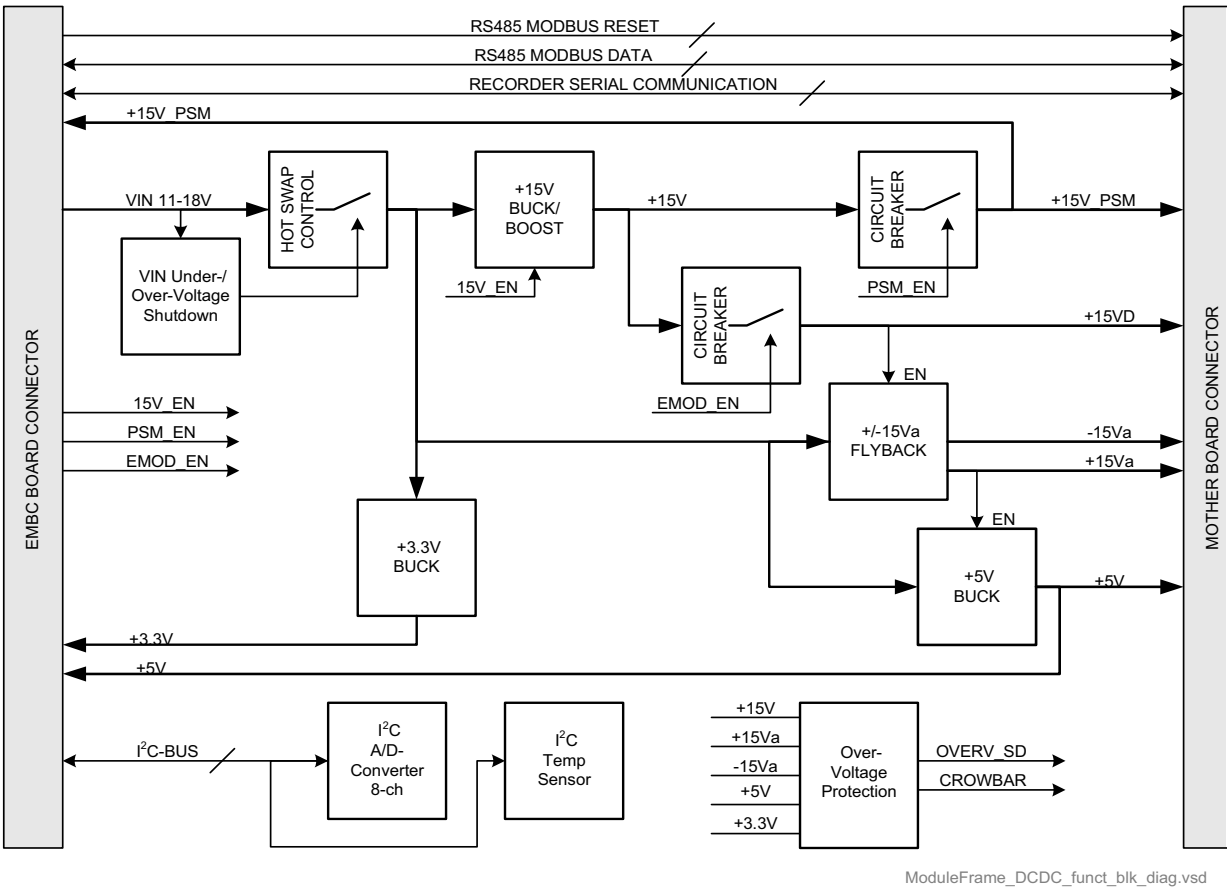


Figure 6 Power board block diagram

1.3.4 Mother board

The Mother board provides connection between modules and the EMBC board. It has protection circuits for signals.

1.3.5 PDM/PSM flex board

PDM/PSM flex board connects PDM and E-PSM to the EMBC board.

1.3.6 Front panel flex board

The Front panel flex board connects Analog output connector to the EMBC board.

2 Configuration

There is no configuration for the F5 and F7 module frames.

3 Maintenance and checkout

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

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 3.1)	**Electrical safety test (section 3.2)**	**Functional check (section 3.3)**
Frame casing opened either for troubleshooting purpose or for replacing any of the internal parts.	All steps	All steps	All steps
Front cover, or an other external part, replaced.	All steps	Not applicable	Not applicable

Planned maintenance

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

1. 3.1. Visual Inspections
2. 3.2. Electrical Safety Tests
3. 3.3. Functional check

3.1 Visual Inspections

Check that:

- F5 & F7 frame plastic is intact
- the PSM and PDM connectors are clean and intact (F5 only)
- the E-modules go in smoothly and lock up properly in all module slots
- the syncronization connector and e-port connector are clean and intact
- the cable between the module frame and the CPU unit is connected and the block screws are tightened properly
- all four rubber pads are in place and the screws on the bottom are tightened properly. Turn the frame onto one of its sides to check the pads.
- the module motherboard connectors are clean and intact.
- the frame and the applied parts are clean

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

3.2 Electrical Safety Tests

Complete the Electrical safety tests found in the CARESCAPE monitor technical manual, chapter Installation checkout. Perform Ground (Earth) integrity test.

Record the values of the tests on the "Maintenance check form" on page 15-35

3.3 Functional check

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

3.3.1 Test setup

Required tools:

- E-PSM(P)(W) or E-(P)RE(S)TN module for F5 Frame
- E-PSM(P)(W) and the pole mount cable for PSM or E-(P)RE(S)TN module for F7 Frame
- Any E-module with related accessories and simulator, except another multiparameter hemodynamic module (like E-PRESTN)
- A multiparameter patient simulator with invasive pressure adapter cable to GE invasive pressure connector
- 5 lead ECG trunk cable, IEC or AHA
- 5 leadwire set, IEC or AHA
- Oscilloscope
- Analog output cable (2000633-001)

NOTE: You can alternatively use the GE defib sync tester, 2040582-001, together with the Analog output cable, 2000633-001 and a multiparameter simulator to perform this test. Follow the instructions included with the tester. See analog output cable wire colors and related signals from the table below.

Connecting cables

1. Ensure that the frame is connected to the monitor host.
2. Ensure that the multiparameter hemomodule is connected to the frame.
3. Connect the 5-lead ECG trunk cable to the green ECG connector in the module.
4. Connect both 5-leadwire sets to the trunk cable and to the simulator.
5. Ensure the other selected module is connected to the frame and the related accessories connected to the module and simulator.
6. Connect the invasive pressure adapter cable to the simulator and the other end to the module.

3.3.2 Module communication test

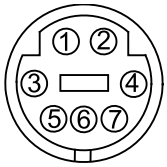
1. Switch on the monitor
2. Log in to Webmin.
3. Select ***Information*** > ***Device Information***.
4. Verify that software and hardware information for all connected parameter modules is provided.
5. Check that the related parameter data appears on the screen **Monitor Setup** - ***Screen Setup - Vertical Parameter Area***
6. Mark this task as complete on the checkout form.

3.3.3 Synchronization connector test

Perform this test only if an E-PSM(P)(W) or an E-(P)RE(S)TN module is in use with the patient monitor.

NOTE: This test can't be performed with a PDM module. If the patient monitor is only used with a PDM module, the synchronization connector test is not applicable.

1. Connect the analog output cable to the defibrillation synchronization connector in the patient monitor.
2. Connect the open wires of the other end of the analog output cable to the oscilloscope probe as described in each test. Use the figure and table below as a reference for making the connections.



Defibrillation synchronization connector		**Related wire color in the open end of the Analog output cable *)**
Pin number	**Signal**	
1	Digital defibrillator synchronization marker out signal	Black
2	Digital defibrillator synchronization marker in signal	Green
3	Common GND	Red
4	Analog GND	Blue
5	Analog GND	White
6	IP analog output	Yellow
7	ECG analog output	Grey

*) Brown wire is not connected.

Configuring the monitor

1. Configure ECG:

a. Select ***ECG1*** to the screen with waveform and adequate priority.

b. In the ***Parameter Setup > ECG > Setup***, select ***ECG1 Lead: II.***

2. Configure invasive pressure:

a. Select ***P1*** to the screen with waveform and adequate priority.

b. In the ***Parameter Setup > Invasive Pressures > P1***, select:

- ***Label: P1.***
- ***Scale (mmHg): 0-200 mmHg.***
- ***Parameter Format: Sys/Dia (Mean).***

Configuring the simulator

Refer to the simulator documentation for details on how to use and configure the simulator.

1. Configure ECG:

- ***ECG rhythm: a normal sinus rhythm***.
- ***Heart rate: 80 bpm***,
- ***Amplitude: 1 mV.***

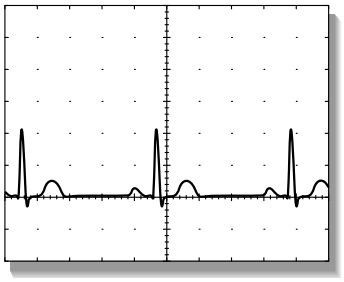
2. Only for modules with invasive pressure: configure invasive pressure:
   - ***Sensitivity: 5 µV/V/mmHg.***
   - ***InvBP output: "0 mmHg static pressure" or "atmosphere".***

Testing the synchronization connector

1. Test the ECG analog output signal:

a. Connect the oscilloscope probe to the ECG analog output signal (grey wire) and analog ground (blue or white wire).

b. Adjust the oscilloscope Time and Volts scales:



ECG analog output signal: Grey
Analog GND: Blue or White
Probe Type: x10
Time/Division: 200 mS
Volts/Division: 0.5V

c. Verify that the ECG analog output waveform shown on the oscilloscope screen corresponds to the ECG1 waveform on the monitor screen.

2. Test the Arterial BP output signal:

   NOTE: Perform this arterial BP test only if an E-PSMP, an E-PSMPW, an E-PRETN or an E-PRESTN module is in use with the patient monitor.

a. Ensure that the simulator's InvBP output channel is configured to 0 mmHg static pressure or atmosphere.

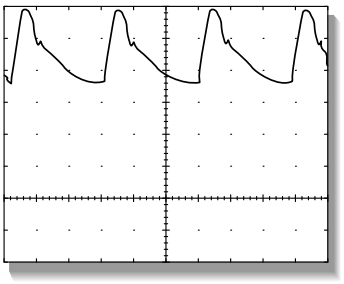
b. Press the ***Zero P1*** module key.

c. Check that a ***Zeroing*** message changes to a ***Zeroed*** message in the P1 parameter window.

d. Configure the simulator's InvBP output channel to Arterial 120/80.

e. Connect the oscilloscope probe to the InvBP output signal (yellow wire) and analog ground (blue or white wire).

f. Change the oscilloscope Volts scale:



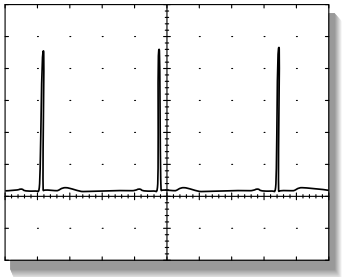
IP analog output signal: Yellow
Analog GND: Blue or White
Probe Type: x10
Time/Division: 200 mS
Volts/Division: 0.2V

g. Verify that the Arterial BP output waveform shown on the oscilloscope screen corresponds to the P1 waveform on the monitor screen.

3. Test the frequency of the Marker out signal

a. Connect the oscilloscope probe to the marker out signal (black wire) and common ground (red wire).

b. Change the oscilloscope Volts scale:



Digital defibrillator synchronization marker out signal: Black

Common GND: Red

Probe Type: x10

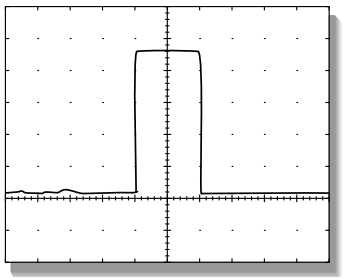
Time/Division: 200 mS

Volts/Division: 2V

c. Verify that the signal shown on the oscilloscope screen corresponds to the picture above.

4. Test the pulse width of the Marker out signal:

a. Change the Time scale in the oscilloscope:



Digital defibrillator synchronization marker out signal: Black

Common GND: Red

Probe Type: x10

Time/Division: 5 mS

Volts/Division: 2V

b. Verify that the signal shown on oscilloscope screen corresponds to the picture above

5. Mark this task as complete on the checkout form.

3.3.4 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

6. Complete on the "Maintenance check form" on page 15-35.

4 Calibration and adjustments

There are no calibration or adjustments for F5 and F7 module frames.

5 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 to the patient monitor's user's manual for troubleshooting monitoring problems, performance issues and clinical configuration issues.

NOTE: Perform the checkout procedure described in section 3. Maintenance and checkout each time after you have opened the module casing.

5.1 Visual inspection

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

- the cover and the module rails are intact
- all connectors are intact, clean and are attached properly
- used cables are intact
- the module box and latch of the connected modules are intact

In doubt of having any loose parts or cable connections inside the module frame, detach the frame cover by removing 2 screws (T20) from the bottom and 1 screw from the back of the module frame and check that:

- Screws are tightened properly
- Cables are connected properly
- There are no loose objects inside the module

NOTE: Perform the electrical safety check and the checkout procedure every time after you have opened the module frame.

5.2 LED indicators

Inside the module frame are Activity LED with two states dim and blinking and Link LED with three states dim, lit and blinking.

On the front panel green On/Standby (Power) LED lit whenever supplied with 15V and 5 V.

LED	Function	Cause
On/Standby LED	On	DC/DC Board functioning (+15V and +5V exist)
	Off	Monitor switched off Faulty DC/DC board (if monitor on) Disconnect cable

LED	Function	Cause
Communication LED (Ethernet Activity LED) green	Blinking	EMBC (Frame) and host or PDM Module and host are communicating.
	Off	EMBC (Frame) faulty and not communicating with host. PDM Module faulty and not communicating with host
Ethernet Link LED, green	On	Connection between EMBC (Frame) and host is OK
	Blinking	EMBC Software update in progress
	Off	Connection between EMBC (Frame) and host fails because of: - faulty cable, - broken connector in frame or in host, - faulty EMBC board

5.3 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 display message field. Find the possible cause and solution from the 'Messages' section later in the chapter.
- Check that the module frames connected are compatible with the monitor system. Compatibility information can be found from the CARESCAPE monitor supplemental information manual.
- Check that there are no duplicate modules connected to the monitor. List of identical modules can be found from the CARESCAPE monitor supplemental information manual.
- Connect a parameter module to the frame. Check that the parameters measured by the module are configured to the display with adequate priority and the parameters are shown to be active (**Monitor Setup** - ***Screen Setup - Upper Parameter Area***).
- Press a module key. Check that the related menu is opened or activity is started. Inoperatibility may refer to a loose keypad cable or other problem in the module.
- 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.

Refer to the patient monitor's user's manual for troubleshooting monitoring problems and clinical configuration issues.

5.4 Service Interface

Use the Webmin service interface to access device information, configuration information and service logs.

5.4.1 Configuration information

There is no configuration for the F5 and F7 module frames.

5.4.2 Device Information

The Device Information shows the hardware and software information of the system and the modules.

To view Device information:

1. Log on to the Webmin -application.
2. Select the ***Information*** -tab.
3. Select ***Device Information***.

The following sections are displayed if the corresponding devices are connected:

Acquisition Information - E-Module Frame - serial number, EMBC serial number, EMBC software number, EMBC software version, EMBC IP address.

5.5 Log files and snapshots

Service logs are used for recording different system events, errors and alarms to help troubleshoot equipment problems.

- **Clinical Log** is used for recording different system events, messages, clinical alarms, user interactions, and internal communication events. The messages are explained in detail later in this chapter.
- **Embc Frame Logs** is used for recording module communication events and errors for E-series parameter modules.

NOTE: Refer to the CARESCAPE monitor technical manual to see the complete list of available service logs

You can access one log file at a time for viewing or for downloading it to an external media.

To view a log file in Webmin:

1. Log on to the Webmin -application.
2. Select the ***Diagnostics*** -tab.
3. Select ***View Log Files***.
4. Select one of the log files for viewing.

To download a log file or a snapshot file to an external media:

1. Log on to the Webmin -application.
2. Select the ***Diagnostics*** -tab.
3. Select ***Download Logs***.
4. Select one of the log files or snapshot files for downloading.

NOTE: Depending on the CARESCAPE Monitor type, the log file downloading may be enabled only through remote Webmin access with a service laptop.

5.6 Messages

Message	Location	Possible causes	Possible Solutions
"XXXX" measurement(s) removed	Message field	The module is not connected properly.	Go to section 5.7. Troubleshooting chart
		The module connector of the frame is defective.	
		The frame is not properly connected to the host.	
		The EMBC board connectors (inside the frame) are loosen.	
		The EMBC board is defective. THe DC/DC board is defective.	

5.7 Troubleshooting chart

5.7.1 F5 and F7 module frames

Problem	Possible causes	Possible Solutions
The parameter module data is not shown on the monitor display	The parameter module is defective.	Go to corresponding module troubleshooting.
	The module is not connected properly.	Insert the module properly to it's rails.
	The module connector is defective.	Repair the frame with corresponding FRU.
	PSM/PDM modules work, but other E-modules data is not seen.	The Module Mother board (connector) is defective.
	Some of the frame or EMBC internal connectors are defective or connections loosen.	Replace the EMBC Module (FRU), or check the connections.
	The EMBC board is defective.	Replace the EMBC Module (FRU).
	The cable connecting frame to host is not properly connected, or is defective.	Check the cable connections, or replace the cable.
	The DC/DC board is defective.	Replace the EMBC Module (FRU).
	The monitor's display screen is not configured to display the parameter.	Go to **Monitor Setup** - ***Screen Setup - Vertical Parameter Area*** to verify that the parameter is selected to show on the screen.

Problem	Possible causes	Possible Solutions
The module can not be placed properly to frame	The PDM/PSM rail or connector is defective.	Replace the PSM/PDM dock (FRU).
	The E-Module rail or module connector (inside the frame) is defective.	Send the frame or the module to repair.
ECG sync signal is not available	Appropriate ECG module is not connected to the frame.	Check that E-(P)RE(S)TN Module or E-PSM(P) module is properly connected, or replace the module.
	The Sync connector is defective.	Replace the EMBC Module / send the EMBC Module or frame to service.

6 Disassembling and reassembling

6.1 Disassembly guidelines

Field service of the module frame is limited to replacing faulty circuit boards or mechanical parts only (see chapter 7. Service Parts for details).

WARNING **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 section 3. Maintenance and checkout each time after you have opened the module casing.

6.1.1 ESD precautions

All external connectors of the module are designed with protection from ESD damage. However, if the frame 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.

6.1.2 Before disassembly

WARNING **Perform a ground integrity measurement whenever service or repair has been done on the device.**

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

- Save and set aside all hardware for reassembly.

6.2 Disassembly and reassembly procedure

6.2.1 7-module frame, F7

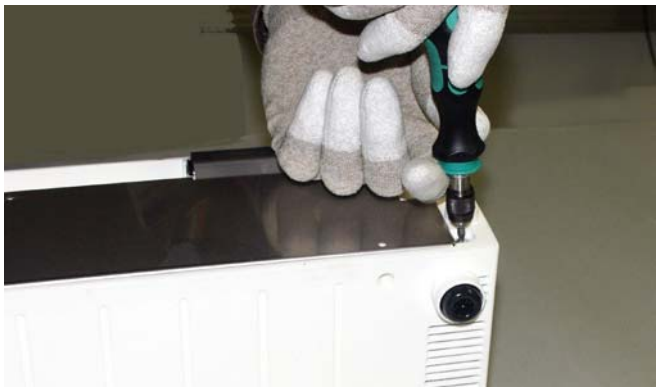
Required tools

- pincers
- screwdriver, TORX; T10, T20
- antistatic wristband

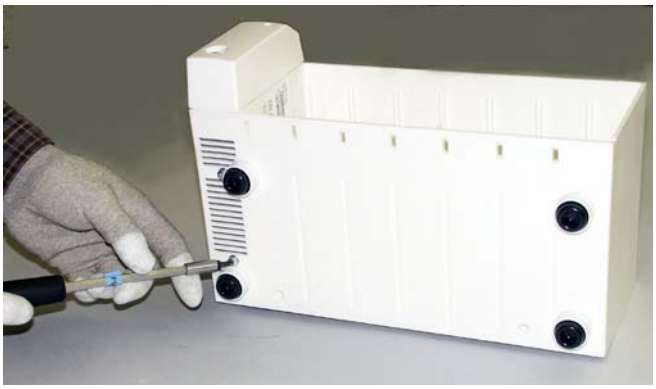
Disassembling the F7 module frame

1. Remove all modules and cables from the F7 module frame.

Changing the Ethernet Module Bus Converter Unit



1. Remove one screw (T10) from the back panel.



2. Remove the two screws (T20) at the bottom of the F7 module frame.

3. Draw carefully the EMBC Unit from the frame.

NOTE: When reassembling ensure that the connector is properly attached.

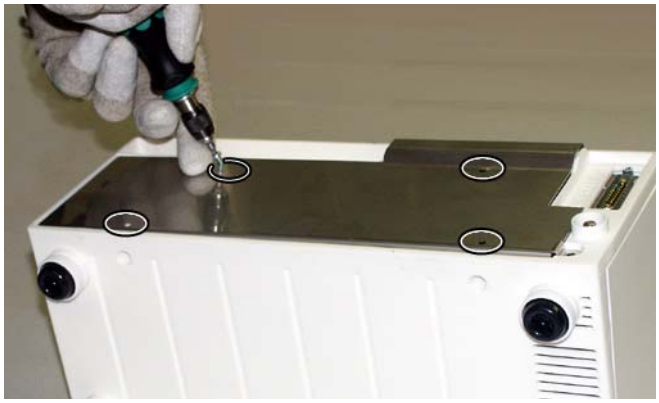
Changing the EMBC Unit cover

1. Detach the EMBC unit from the frame.
2. Release the front cover by pressing the top and bottom latches. Pull out the cover.

NOTE: When reassembling ensure that the latches lock properly.

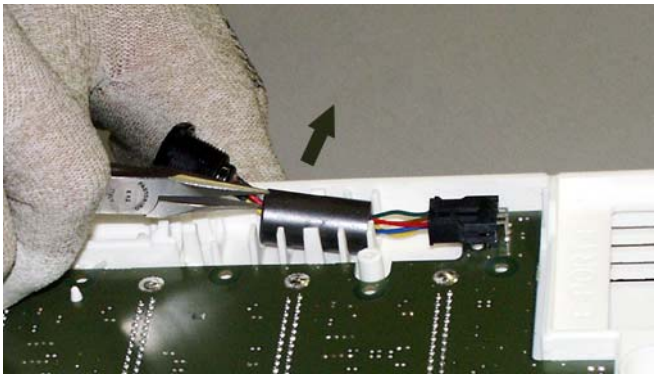
NOTE: The light guide is loose and comes off easily. Be careful not to drop it.

Changing the Module Board

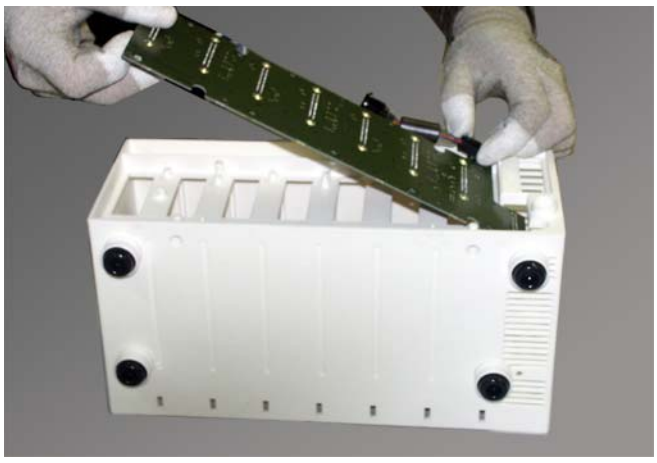


1. Remove the EMBC unit.
2. Remove four screws (T10) to detach the back plate.

3. Remove the 12 screws (T10) from the Module Board.

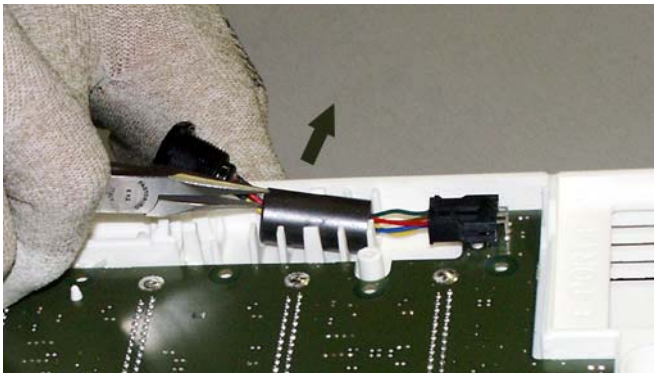


4. Carefully detach the cable connector and the ferrite from the brackets.



5. Carefully lift the Module Board from the frame cover.

Changing the PSM cable



1. Remove five screws (T10) from the back plate.
2. Detach the back plate.
3. Carefully detach the cable connector and the ferrite from the brackets.
4. Detach the connector from the Mother Board.

Reassemble the device in reverse order.

When reinstalling make sure the cable connecting the frame to the host is properly connected and secured.

Check that:

- screws are tightened properly
- cables are connected properly
- EMBC Unit is attached properly
- there are no loose objects inside the frame
- Ferrite of the PSMcable is attached properly

NOTE: Perform the electrical safety check and checkout procedure every time after you have opened the module box.

6.2.2 5-module frame, F5

Required tools

- pincers
- screwdriver, TORX; T10, T20
- thin, long screwdriver, TORX; T10
- antistatic wristband
- adjustable wrench

Disassembling the 5 module frame

1. Remove all modules and cables from the F5 module frame.

Changing the EMBC Unit

1. Unscrew 2 screws (T20) from the bottom and 1 screw from the back.

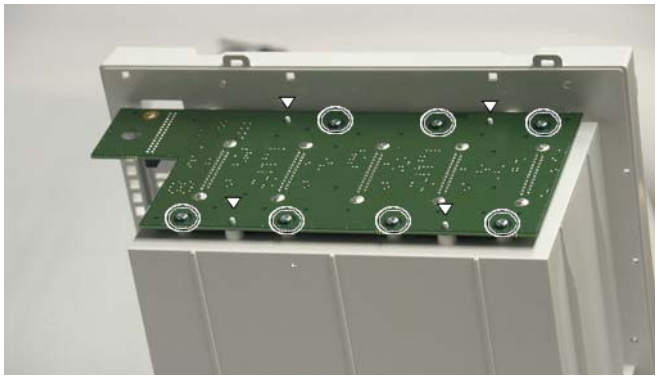
2. Pull out the EMBC unit.

Changing the cover and the Module board

1. Detach the EMBC unit.
2. Unscrew 3 screws from the bottom.

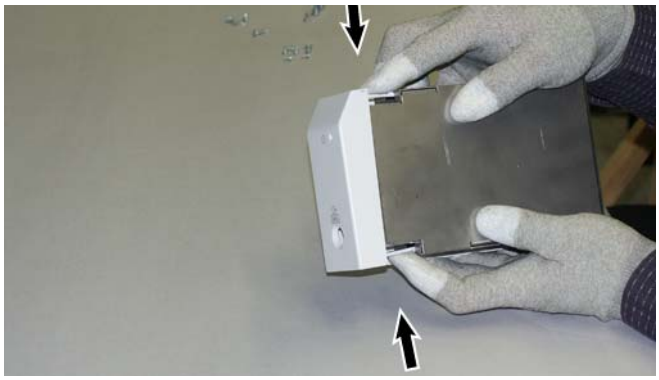
3. Unscrew 1 screw from the EMBC slot (under the cover).

4. Lift off the cover.



5. Unscrew 7 screws from the module mother board.
   NOTE: There are 4 guides to help you in reassembly.
6. Lift off the module mother board.

Changing the EMBC Module front cover



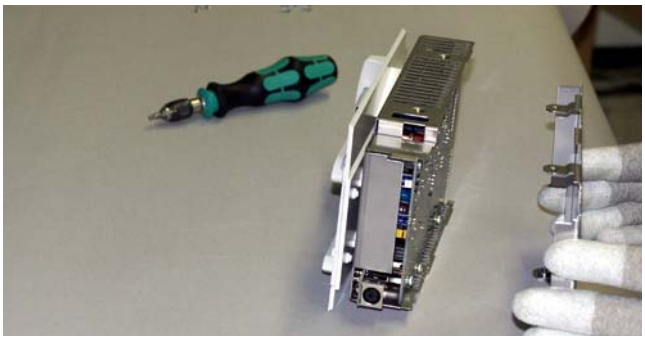
1. Detach the EMBC unit.
2. Release the front cover by pressing the top and bottom latches. Pull out the cover.

NOTE: The light guide is loose and comes off easily. Be careful not to drop it.

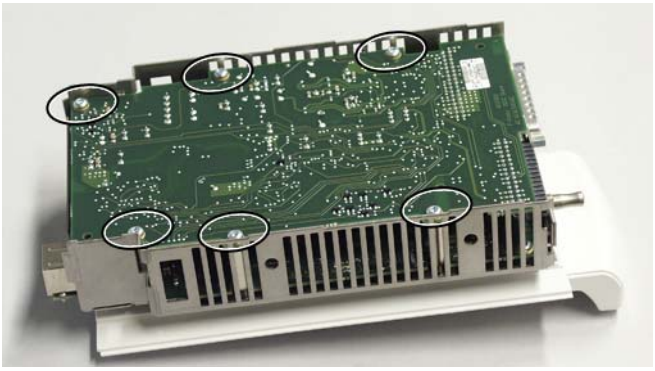
NOTE: When reassembling ensure that the latches lock properly.

Changing the PSM/PDM Dock

1. Detach the EMBC unit.
2. Detach the EMBC unit front cover.
3. Unscrew 2 screws from the top.

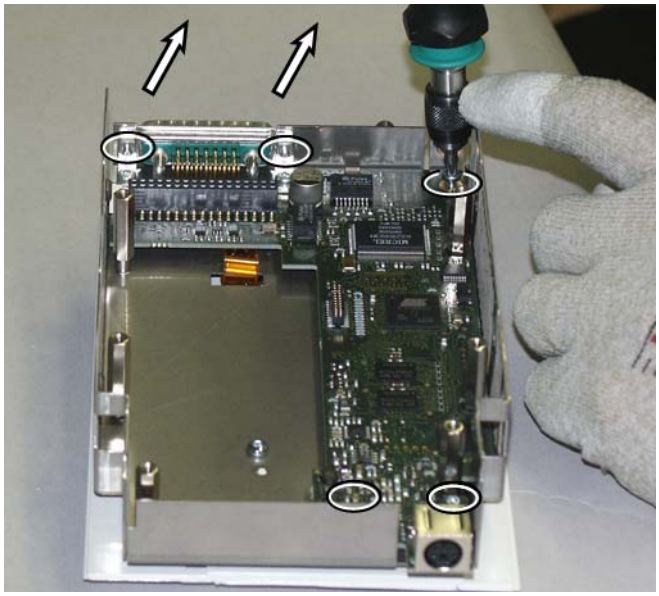


4. Remove the cover.

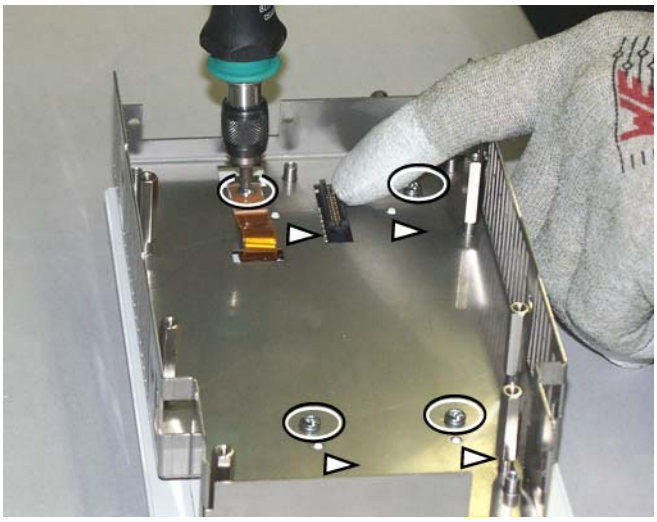


5. Unscrew 6 screws from the power board.

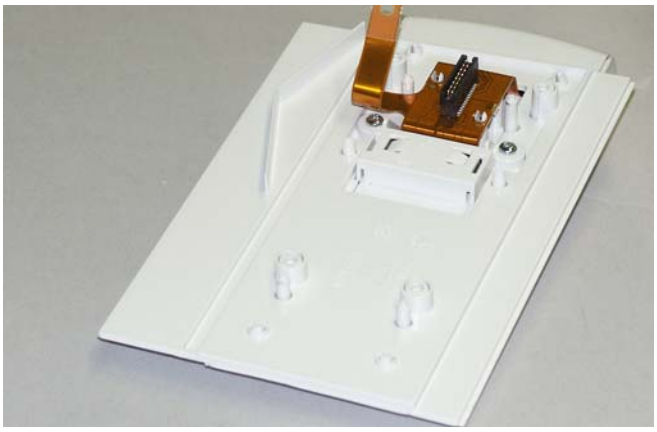
6. Lift off the board.
   NOTE: When reassembling, be careful with the EMBC power board. Make sure that the EMBC power board-EMBC board connector is properly aligned and not damaged.



7. Unscrew 3 screws from the EMBC board.
8. Unscrew 2 hexagon spacers from both sides of the connector at the end of the unit.
9. Unscrew 2 screws from the connector holders.
10. Lift off the board.



11. Remove the ground screw.
12. Unscrew 4 screws.
    NOTE: There are 4 guides to help you in reassembly.
13. Lift off the metal cover.



PSM/PDM Dock

Reassemble the device in reverse order.

When reinstalling make sure the cable connecting the frame to the host is properly connected and secured.

Check that:

- screws are tightened properly
- cables are connected properly
- EMBC Unit is attached properly
- there are no loose objects inside the frame

NOTE: Perform the electrical safety check and checkout procedure every time after you have opened the module box.

7 Service Parts

7.1 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 section 3. Maintenance and checkout each time after you have opened the module casing.

7.2 FRU kit

7.2.1 7 module frame, F7

Description	Order no.
Ethernet Module Bus Converter Unit, F7	2085009-001
PSM Cable and Module Board Kit, F7	M1151855

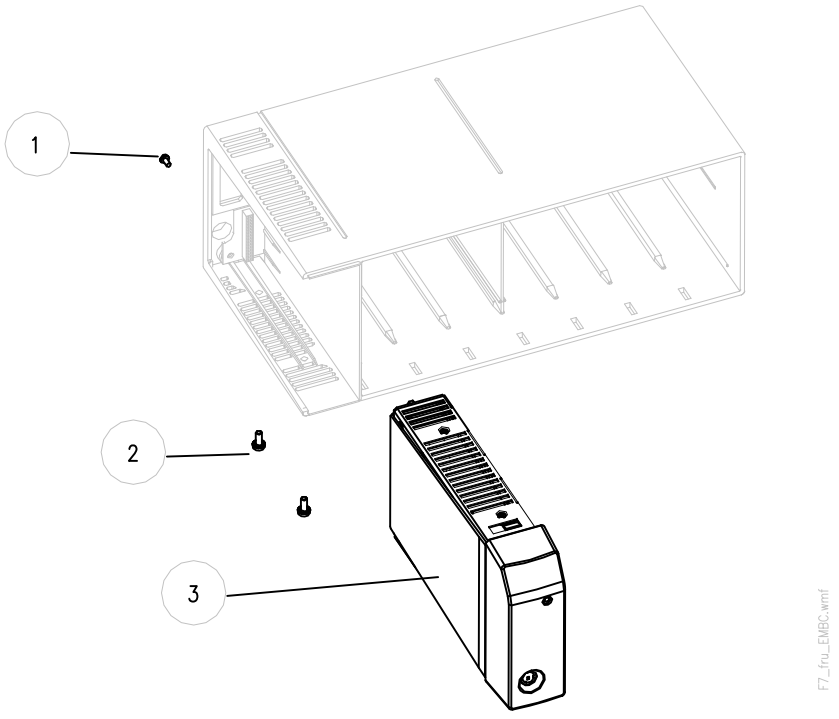


Figure 7 Ethernet Module Bus Converter Unit, F7

Ref #	Description
1	SCREW, M3x6mm, pan head, steel, STZN, TORX/T10
2	SCREW, M4x10mm, Pozidrive, pan head, steel, zinc coated, captive serrated lock washer
3	Ethernet Module Bus Converter Unit, F7

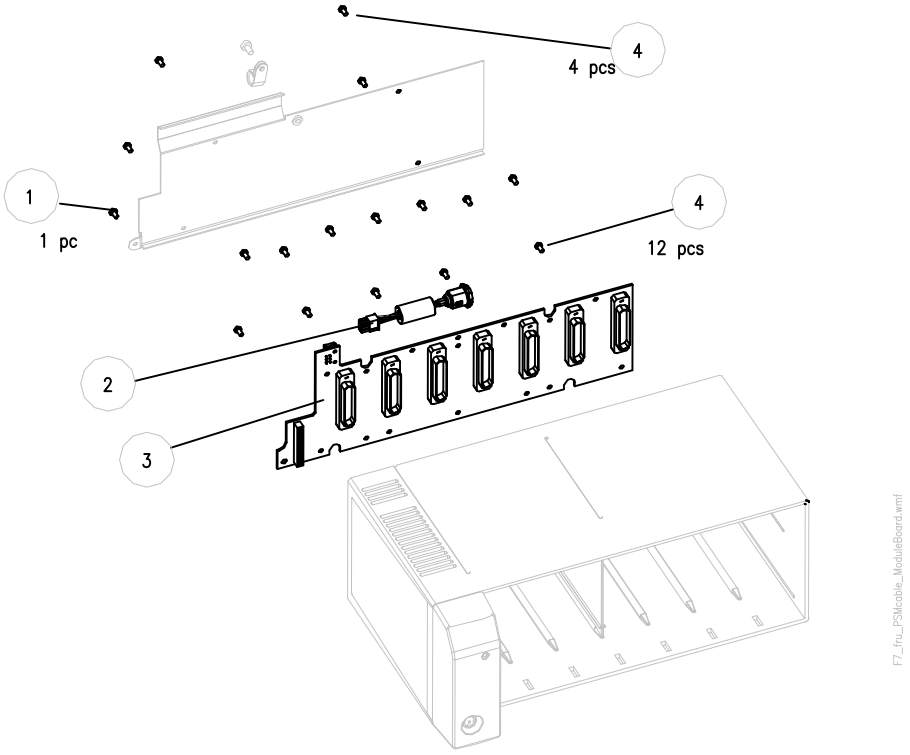


Figure 8 PSM Cable and Module Board Kit, F7

Ref #	Description
1	SCREW, M3x6mm, pan head, steel, STZN, TORX/T10
2	PSM Cable
3	Module Board
4	SCREW-PT, PAN-HEAD, TORX/T10, 3.0x6mm, ST-ZN

7.2.2 5 module frame, F5

Description	Order no.
Frame Cover and Module Board Kit, F5	M1151852
PSM/PDM Dock, F5	2085013-001
Ethernet Module Bus Converter Unit, F5	2085010-001

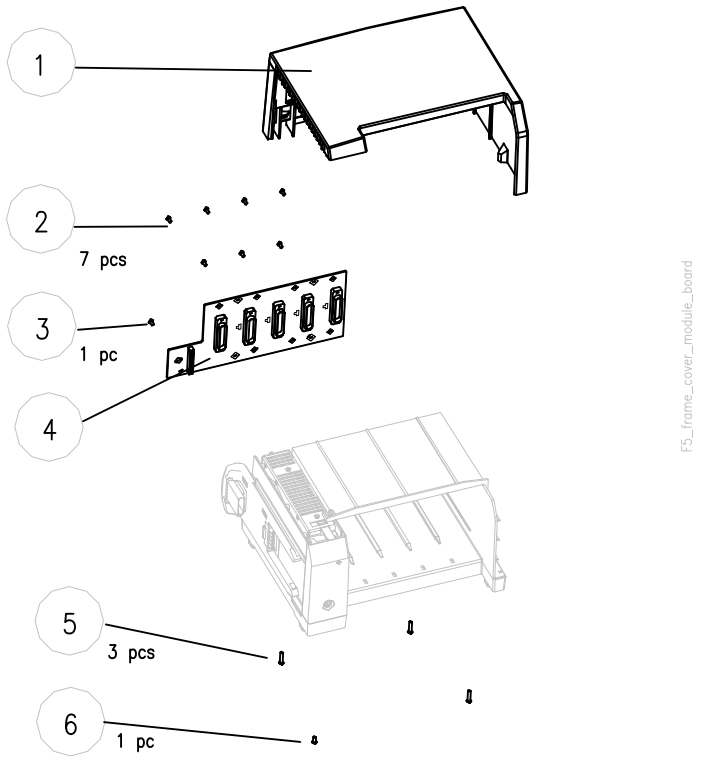


Figure 9 Frame Cover and Module Board Kit, F5

Ref #	Description
1	Frame Cover,F5
2	SCREW-PT, PAN-HEAD, TORX/T10, 3.0x6mm, ST-ZN
3	SCREW,M3x6mm, pan head, steel, STZN, TORX/T10,
4	F5-Frame motherboard
5	SCREW, PT3.5x16mm, pan head, steel, STZN, HEAD(ID=5.8mm), TORX/T10,
6	SCREW, PT3.5x7.5mm, pan head, steel, STZN, HEAD(ID=5.8mm, TORX/T10

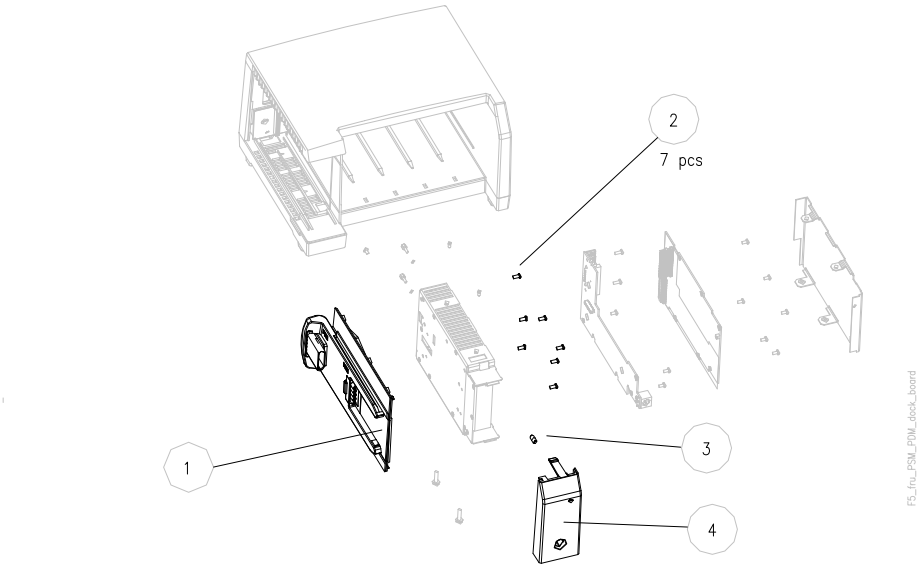


Figure 10 PSM/PDM Dock, F5

Ref #	Description
1	PSM/PDM Dock, F5
2	SCREW, PT3.5x7.5mm, pan head, steel, STZN, TORX/T10,
3	Light Guide, F5
4	Module Front Panel, F5

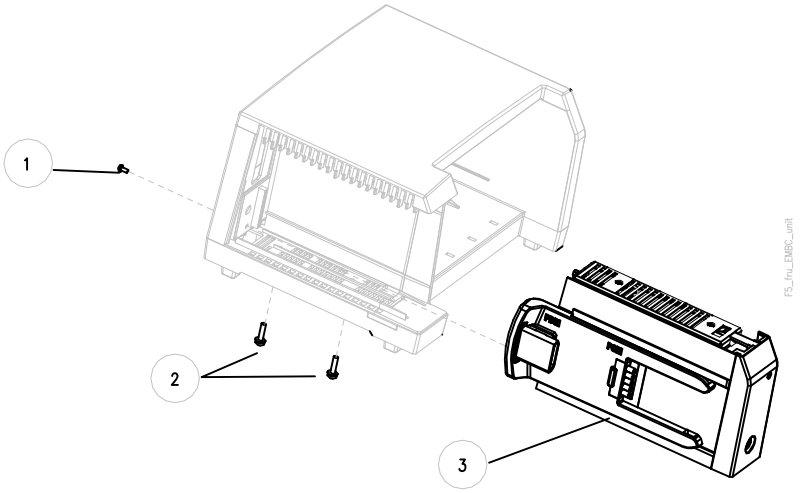


Figure 11 Ethernet Module Bus Converter Unit, F5

Ref #	Description
1	SCREW, M3x6mm, pan head, steel, STZN, TORX/T10
2	SCREW, M4x16mm, pan head, steel, zinc coated, TORX/T20
3	Ethernet Module Bus Converter Unit, F5

For your notes:

Maintenance check form

F5, F7 Module Frames

Customer	Monitor	S/N
Service	Software	
Service engineer	Frame	S/N
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**
3.1. Visual Inspections	☐ ☐ ☐	**Result** IEC, EN / UL	Limits IEC, EN / UL	
Electrical safety tests	☐ ☐ ☐			
Ground (earth) integrity				
Ground continuity test	without power cord		≤ 0.1 ohm	☐ ☐ ☐
	with power cord		≤ 0.2 ohm	☐ ☐ ☐
Impedance of protective earth connection	without power cord		≤ 0.1 ohm	☐ ☐ ☐
	with power cord		≤ 0.2 ohm	☐ ☐ ☐
3.3. Functional check				☐ ☐ ☐
3.3.2. Module communication test				☐ ☐ ☐
3.3.3. Synchronization connector test				☐ ☐ ☐
3.3.4. Test completion				☐ ☐ ☐

Notes		

Used service parts			

Signature	Date

For your notes:

16

Patient Data Module v2

Technical Manual

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1 Product overview

1.1 Introduction

This document provides information for maintenance and service of the Patient Data Module v2, hereafter referred to as PDM v2.

NOTE: Some information in this document may vary compared to older PDM v1 Module version. If needed refer to earlier document version(s) for more information about older PDM v1 Module version.

NOTE: If you are not using the PDM with the CARESCAPE Monitor B850, refer to the Patient Data Module (PDM) Service Manual.

The PDM is a data acquisition device for a GE modular system. It provides a connection from the patient monitor to the patient, processes the patient data signals and stores a limited amount of patient data (24 hours captured at 1 minute resolution) for seamless transport.

The PDM contains software and hardware to monitor the following parameters:

- ECG/respiration
- Noninvasive blood pressure
- Pulse oximetry
- Up to four channels of invasive blood pressure
- Cardiac output or two temperature channels
- Defibrillator sync/analog out interface

1.2 Measurement principle

The PDM is a portable acquisition device. It collects data from a patient, converts the data to a digital form for processing, and sends the data to a bedside, transport or surgical monitor for further processing and display.

The data that it collects, converts, and sends includes the patient's vital signs and physiological waveforms. It also stores patient history including trends and special events, and setup information such as blood pressure zero points and alarm limit settings. The patient history is stored so that the collected information is transferred with the PDM when a patient is transferred to a different monitor.

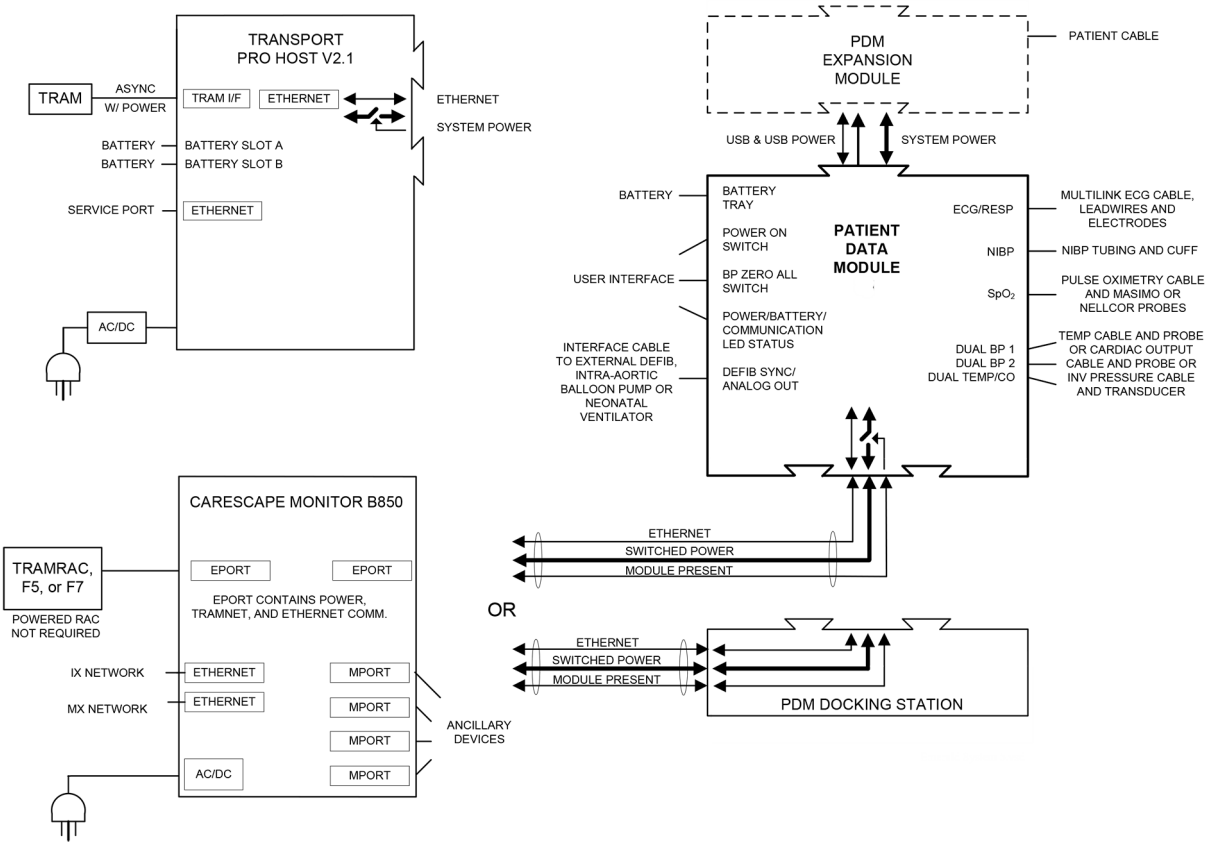
1.3 Main components

The Data Acquisition System board, referred to as DAS, consists of two independent patient parameter acquisition subsystems. The first subsystem, referred to as the Main DAS, provides interfaces to one pulse oximetry transducer, four invasive pressure transducers, one non-invasive blood pressure transducer, and either two temperature transducers or one thermal dilution cardiac output transducer.

The second subsystem, referred to as the ECG DAS, provides interfaces to ten ECG electrodes. It also supports the measurement of impedance-based respiration from up to two differential pairs of ECG electrodes and the detection of pacemaker activity from up to three differential pairs of ECG electrodes for the purpose of pacemaker identification. The ECG and respiration circuitry is electrically isolated from all the other parameters. Each isolated parameter section contains a processing unit and a serial communication unit. Communications are implemented through a custom serial communication link.

1.3.1 Internal main components

The PDM contains a main processor board, NIBP assembly with tubing, and Data Acquisition System.



The PDM shares power and communicates with host devices through the host interface connection called the ePort. The PDM connects to the bedside host patient monitor through the bedside docking station and an ePort cable. The PDM can connect to the bedside host patient monitor with just an ePort cable without the docking station, or the PDM can dock directly to the F5 Frame.

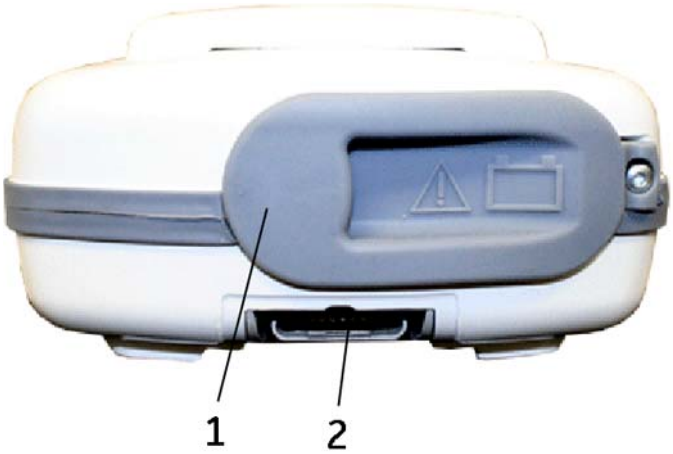


Figure 1 Rear view

(1) Battery door
(2) ePort host interface connection

Figure 2 Side view

(1) Docking station
(2) Pull tab

1.3.2 Battery

The PDM is designed to operate on battery power when used with a transport monitor or whenever AC power is interrupted. A complete battery management system allows you to obtain maximum battery performance. When connected to a bedside monitor, audible and visual alarms alert you when loss of power is imminent, and on-screen capacity gauges on the transport monitor indicate battery charge condition and capacity.

The Lithium-Ion battery is a rechargeable battery containing Lithium-Ion cells. Each battery contains an integrated electronic fuel gauge and a safety protection circuit. The processor within the equipment communicates with both the battery and the charger.

1.3.3 PDM ePort host interface cable

The PDM ePort host interface cable provides external power and communication between the PDM and a bedside or Transport monitor.

1.3.4 Controls

The power/zero all key has a dual role as a power on and zero all.

- Power on — Turns the data acquisition function ON. Power is derived from a battery or patient monitor. When turned on, the function changes to the zero all function.
- Zero all — Zeros all invasive pressure lines which are open to atmosphere. Each pressure can also be zeroed, if desired, with a menu option in the pressure menu.

1.3.5 Indicators

Communication and power indicators are identified in Figure 3.

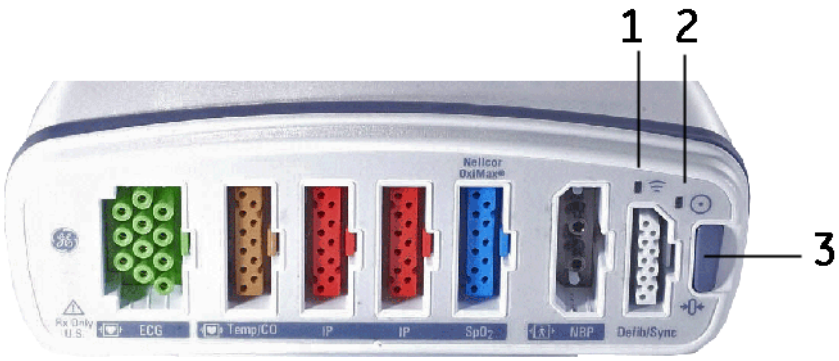


Figure 3 Communication and power indicators

(1) Communication icon and indicator

(2) Power icon and indicator

(3) Power ON/IBP Zero All button

Communication

The following LED condition identifies the communication status with a bedside or transport patient monitor.

- No light indicates no communication.
- Solid amber indicates an application reset.
- Solid green indicates communication.
- Flashing amber indicates communication failure.
- Alternately flashing with the power LED indicates software transfer.

Power

The following LED condition identifies the power status.

- No light indicates no power applied.
- Solid amber indicates software booting up.
- Solid green indicates powered by AC-derived mains or battery.
- Flashing amber indicates approximately five minutes battery power remaining.
- Alternately flashing with the communication LED indicates software transfer.

1.3.6 Connectors

PDMs connect to a bedside or transport patient monitor using the host interface connector. The host interface connector carries power and communication to the PDM. The defib sync connector carries analog and digital signals to auxiliary devices.

Patient connectors are shown in Figure 4.

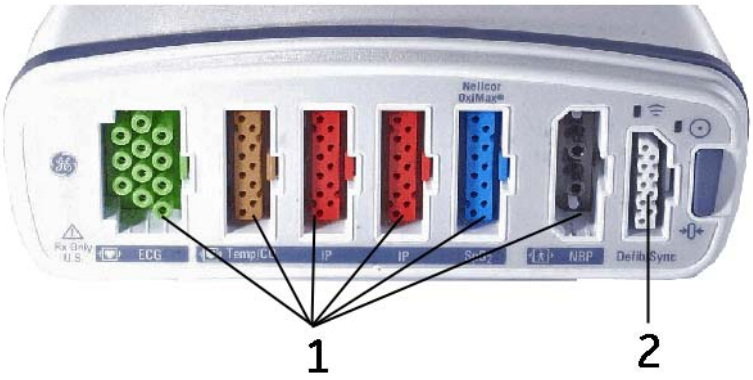


Figure 4 Patient connectors

(1) Patient cable connectors

(2) Defibrillator sync/analog out interface (for auxiliary equipment)

1.3.7 Hardware installation

For detailed instructions on installing the PDM with the patient monitor, see the CARESCAPE Monitor technical manual.

Mounting options

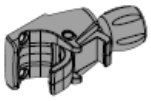
WARNING **For safety reasons, all connectors for patient cables and sensor leads are designed to prevent inadvertent disconnection, should someone pull on the leads. Do not route cables in a way that they may present a stumbling hazard.5**

WARNING **Do not hang articles on the IV pole that are not related to the PDM's use.**

WARNING **PHYSICAL INJURY- Take care when mounting devices to an IV pole. If a device is mounted too high the IV pole may become unbalanced and tip over.**

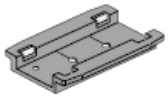
WARNING **To avoid accidental ingress of liquids, do not mount the PDM in a vertical position with the patient cables facing up or down.**

Mounting options include mounting to a bed headboard or footboard, an IV pole, or a roll stand using one of the docking stations. Mounting kits include all necessary hardware and installation instructions.

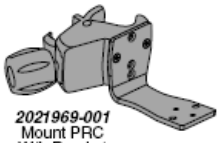


2021963-001
Pole/Rail Clamp

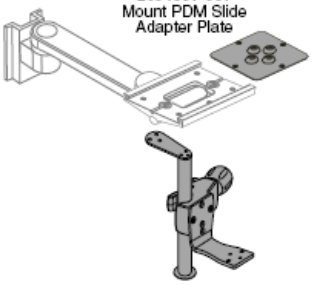
2021967-001
Mount PDM L-Bracket



2021968-001
Mount PDM Mini Dock

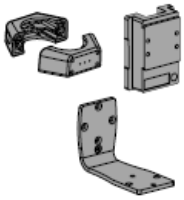


2021969-001
Mount PRC
W/L-Bracket



2034357-001
Mount PDM Slide
Adapter Plate

2022677-001
Mount PDM M-Arm
Down-Post



2022676-001
Mount PDM GCX
Rollstand/Wall Channel

Mounting points to note

- Before docking the PDM to the bedside dock, transport dock or mini dock, be sure that the PDM rails are aligned with the docking station rails. Shown below are the PDM rails engaged with the mini dock rails:

- Be sure that the PDM is mounted at a convenient height, allowing all users to align the PDM rails with the bedside dock rails, as shown:

- The PDM can be mounted using the Mini Dock (P/N 2021968-001), shown here with the L-bracket (P/N 2021967-001).

- An ePort host interface cable can be connected directly to the PDM as shown here:

Connect to bedside monitor

If using the PDM with a bedside monitor:

1. Connect one end of the ePort host interface cable to the PDM ePort connector.
   - 5 ft (P/N 2017098-001)
   - 15 ft (P/N 2017098-003)
   - 25 ft (P/N 2017098-005)
2. Connect the other end of the ePort host interface cable to the PDM adapter on the back of the host patient monitor.

The bedside dock (P/N 2030340-002) can be positioned using various mounts. Horizontal mounting of the bedside dock is recommended, as shown using the L-bracket (P/N 2021967-001). The ePort host interface cable is used to connect the bedside dock to the host patient monitor.

1.3.8 PDM admit/discharge cycle

Prior to patient use, perform an admit/discharge cycle on the PDM to clear all patient data. Refer to the patient monitor's user's manual for instructions.

CAUTION When admitting a new patient/starting a new case, you must clear all previous patient data from the system. To accomplish this, be sure the acquisition module is securely mounted, disconnect the patient cables, then discharge the previous patient/end the case.

2 Configuration

2.1 Webmin login

Refer to the CARESCAPE Monitor technical manual for Webmin user details.

From the patient monitor, navigate to Webmin in the local browser as follows:

1. Select ***Monitor Setup*** then ***Service***. The local browser opens and displays the Webmin login dialog box.
2. Type the username and password and click ***Login*** or press **Enter** on the keyboard.
   - Username: **biomed**
   - Password: **Change**<space>**Me**

NOTE: Username and password are case sensitive.

The Webmin session opens with the ***Information*** tab displayed.

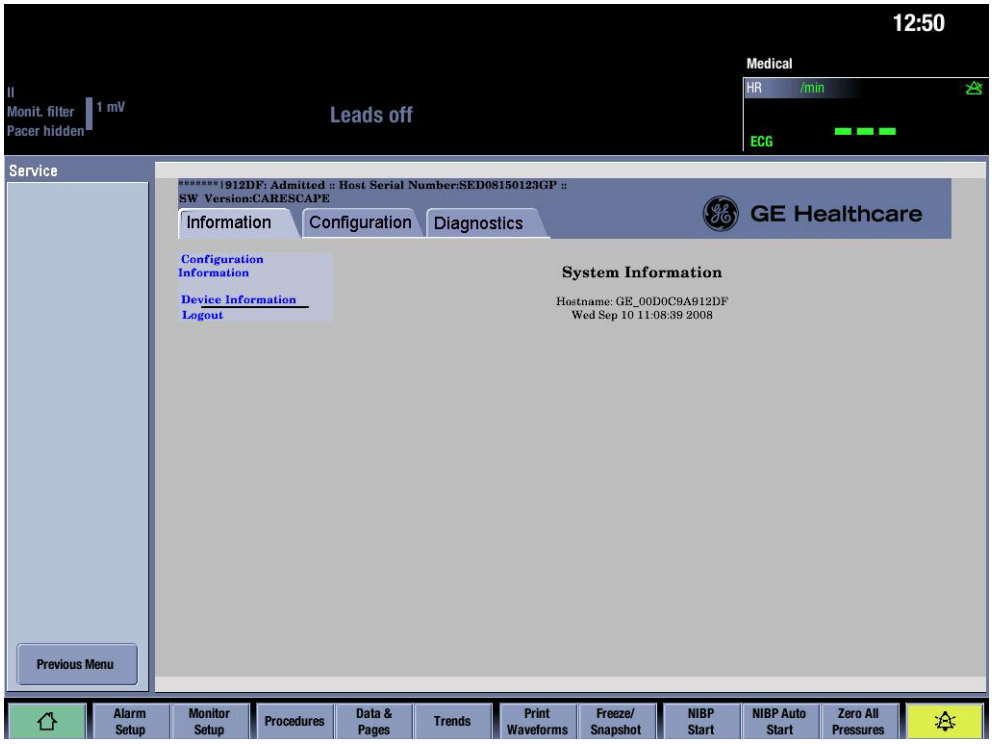


Figure 5 Webmin Information tab, accessed locally

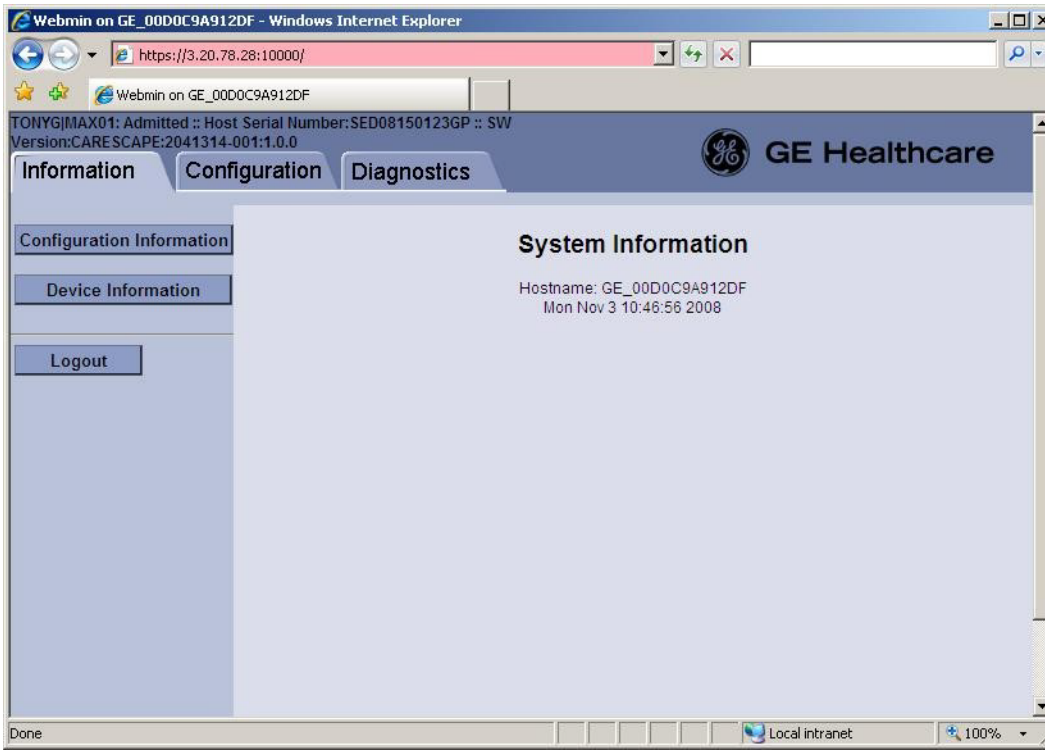
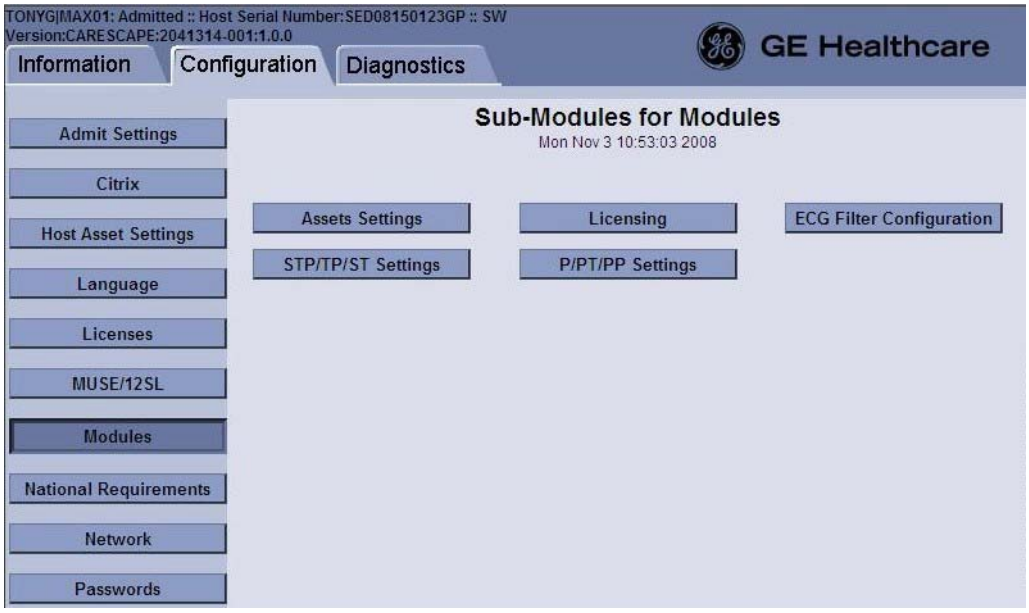


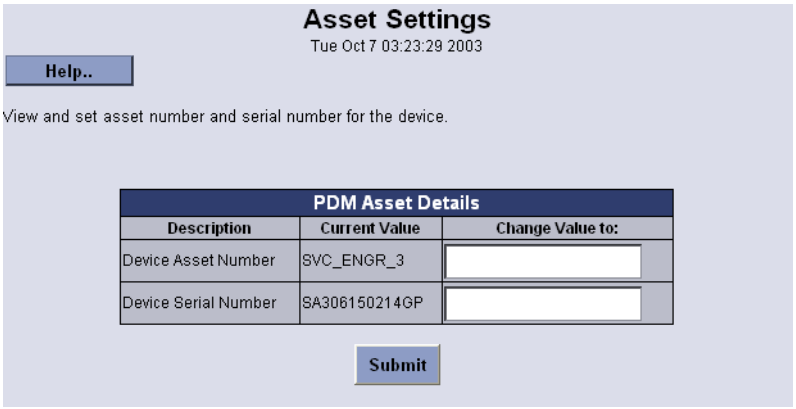
Figure 6 Webmin Information tab, accessed remotely

3. Select the ***Configuration*** tab, and then select ***Modules***.



2.2 Asset settings

1. Select ***Asset Settings*** to display the host serial number and asset number.



2. Enter the user assigned device asset number and click ***Submit***.

NOTE: The user assigned device asset number can be up to 13 alphanumeric characters.

NOTE: Only GE service personnel have privileges to change the device serial number.

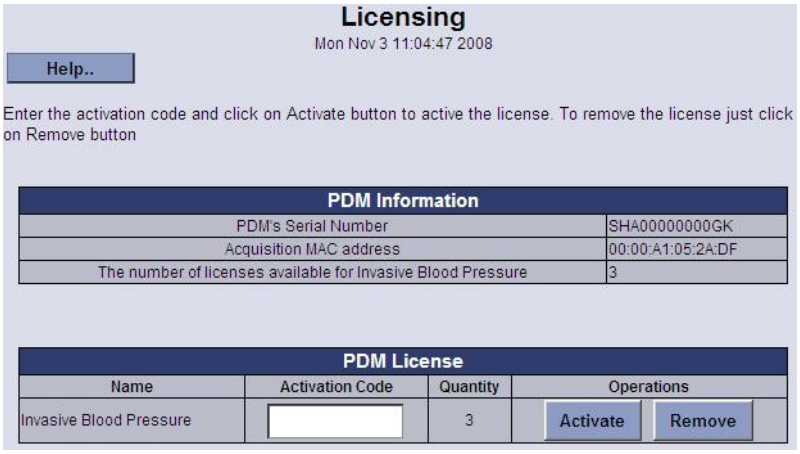
NOTE: The manufacturer's serial number must follow the specific format found on the serial number label on the PDM.

NOTE: The manufacturer's serial number must be edited if the PDM's main CPU board is replaced.

2.3 Licensing

Licensing is used for activating or removing license(s).

1. To obtain a license, contact GE technical support and provide the PDM serial number and MAC address. Contact information is available at www.gehealthcare.com.
2. Log into Webmin. See "Webmin login" on page 16-9.
3. Select ***Configuration > Modules > Licensing***.



4. On the ***Licensing*** window, enter the activation code and click ***Activate*** to complete the installation. Click ***Remove*** to remove a license.

NOTE: After installation, perform the checkout procedures provided in the CARESCAPE Monitor technical manual.

NOTE: A new activation code must be requested and entered if the PDM's main CPU board is replaced.

2.4 ECG Filter configuration

The ECG filter is always enabled. It can be disabled temporarily, but it will always default to ***Enabled*** after a power cycle or reboot.

CAUTION Do not disable ***ECG Filter*** during clinical use.

2.5 Software update

The module software can be updated using a software CD and Webmin.

The software update process involves transferring and activating the module software. First, you transfer the new software to the host monitor, either from the software CD using service laptop connected to the monitor, or by using InSite ExC.
Then, you need to activate the software through Webmin.

For more detailed information about the software update, refer to the host monitor's Technical Manual.

CAUTION Do not disconnect the power during software update. The PDM could be damaged.

NOTE: After installation, perform the checkout procedures provided in the CARESCAPE Monitor technical manual.

3 Maintenance and checkout

To help ensure the equipment remains in proper operational and functional order, adhere to a good maintenance schedule. The manufacturer recommends that the following be performed by service personnel each time the unit is serviced and every 12 months after installation:

- Visual inspection
- Electrical safety tests
- Checkout procedure

As you perform the maintenance checkout, record all results and activities on the checkout form.

CAUTION Make sure the patient is disconnected from the monitor before performing maintenance on the device.

3.1 Visual inspection

Remove power and all cables before inspecting or cleaning the equipment.

Inspect the equipment and its components carefully prior to installation, once every 12 months thereafter and each time the equipment is serviced. Do not use the equipment if damage is determined. Refer damaged equipment to qualified service personnel.

- Inspect the case for cracks or other physical damage.
- Check that front panel labels are intact.
- Inspect cables for fraying or other damage.
- Inspect all plugs and connectors for bent pins or other damage.
- Check for loose or missing screws on the mounting hardware.
- Check that the module is clean. Refer to the patient monitor's user's manual for cleaning precautions, requirements, procedures and recommended cleaning solutions.
- Mark this task as complete on the checkout form.

NOTE: Damaged cables or equipment should be replaced by service personnel.

3.2 Electrical safety tests

Complete the Electrical safety tests found in the Installation checkout section of the CARESCAPE Monitor technical manual.

3.3 Checkout procedure

1. Turn on the patient monitor. Wait until the normal monitoring screen displays.
2. Connect the module to the patient monitor.

3.3.1 Test setup

Required tools

ECG & Impedance respiration:

- A multiparameter patient simulator that supports the ECG parameter

- Multi-Link 12-lead ECG trunk cable, IEC or AHA
- Multi-Link 5-leadwire set, IEC or AHA
- Multi-Link 5-leadwire set, C2-C6, IEC or V2-V6, AHA

Invasive pressure:

- A multiparameter patient simulator with invasive pressure adapter cables to GE invasive pressure connectors
- Dual BP adapter cable (2005772-001)

Temperature:

- A multiparameter patient simulator with temperature adapter cables to GE temperature connectors
- Dual temperature adapter cable
- P/N 884515-HEL “Temperature test set” (optional)

SpO2:

- Masimo SpO2 Test Kit includes Masimo Tester and SpO2 Sensor Adapter Cable (2021087-001)
- Nellcor OxiMax pulse oximeter functional tester model SRC-MAX (2007650-002)

NIBP:

- Adult NIBP hose
- Adult NIBP cuff
- Infant NIBP cuff hose
- a rigid cylinder or pipe
- NIBP pressure manometer

NOTE: See the supplemental information manual for compatible accessories.

Defib/sync and analog output:

- Unterminated defib sync cable (2017842-001)
- Oscilloscope

Connections

ECG and impedance respiration:

1. Connect the 12-lead ECG trunk cable to the green ECG connector in the module.
2. Connect both 5-leadwire sets to the trunk cable and to the simulator.

Invasive pressure:

1. Connect the dual invasive pressure adapter cable to the red invasive pressure connector in the module
2. Connect the multiparameter patient simulator with its invasive pressure adapter cables to the dual invasive pressure adapter cable.

Temperature:

1. Connect the dual temperature adapter cable to the brown temperature connector in the module.
2. Connect the multiparameter patient simulator to the temperature adapter cable.

3. Check that the patient simulator is configured for the 400 Series probe.

SpO2 (Masimo):

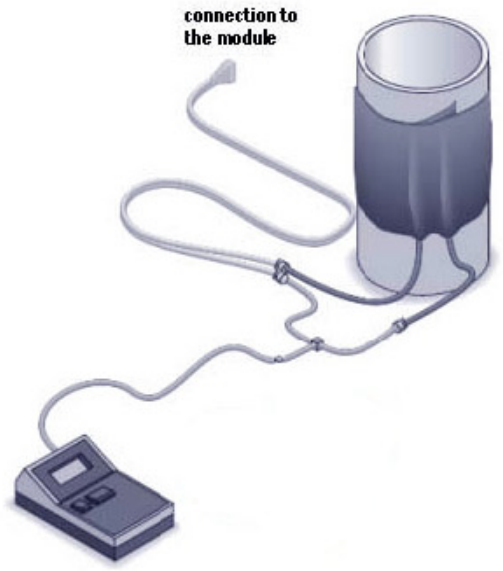
1. Connect the Masimo SpO2 tester to the SpO2 sensor adapter cable.
2. Connect the SpO2 adapter cable to the SpO2 connector on the module.

SpO2 (Nellcor OxiMax):

- Connect the SRC-MAX to the SpO2 connector on the module.

NIBP:

1. Ensure that the NIBP measurement module is connected to the monitor.
2. Connect an adult NIBP hose to the black NIBP module connector.
3. Connect an adult NIBP cuff to the adult NIBP hose.
4. Wrap the NIBP cuff around a rigid cylinder or pipe.
5. Connect the pressure manometer with either an integrated or separate pressure pump to the NIBP hose and NIBP cuff with a piece of tubing (see picture below)
6. Ensure that all the connections made are leak-proof.



Defib/sync and analog output:

- Connect the unterminated cable assembly to the **Defib/Sync** connector on the front of the PDM.

Monitor configuration

NOTE: If a parameter window is not visible after you have selected it to display on the screen, go to ***Monitor Setup > Screen Setup***. Use the arrow keys in the ***Order*** column to raise the priority of the parameter. For more information, refer to the patient monitor's user's manual.

ECG

1. Configure the ECG1, ECG2 and ECG3 waveform fields to display on the monitor screen with adequate priority.
2. Go to ***Monitor Setup > Parameter Setup > ECG***.
3. Select the ***Setup*** tab in the ***ECG*** menu and configure:

ECG1 Lead: II
ECG2 lead: V1
ECG3 lead: aVL
Beat volume: 1 or greater
Size: 1x

4. Select the ***Advanced*** tab in the ***ECG*** menu and configure:

   Primary HR source: IntelliRate

   Pacemaker Detection: Onor Sensitive.

Impedance respiration:

1. Configure the Resp waveform field to display on the monitor screen with adequate priority.
2. Go to ***Monitor Setup > Parameter Setup > Impedance Respiration***.
3. Select the ***Setup*** tab in the ***Impedance Respiration*** menu and configure:

   Respiration Measurement: On
   Resp Rate Source: Impedance

NOTE: To select these settings, the module must be connected, the Resp waveform must be displayed and the ECG leads must be connected to a simulator with an impedance respiration source.

Invasive pressure:

1. Configure the P1, P2, P3 and P4 waveform fields to display on the monitor screen with adequate priority.
2. Select the ***P1*** tab in the ***Invasive Pressure*** menu and set up the ***Label***, ***Scale*** and ***Parameter Format*** settings in the desired configuration for testing.
3. Repeat step 2 for the P2, P3 and P4 waveforms.

Temperature:

1. Configure the T1 and T2 parameter windows to display on the monitor screen with adequate priority.
2. Select the ***T1*** tab in the ***Temperature*** menu and configure:

   T1 Measurement: On

3. Select the ***T2*** tab in the ***Temperature*** menu and configure:

   T2 Measurement: On

SpO2:

- Configure the SpO2 waveform field to the monitor screen with adequate priority.

NIBP:

1. Configure the NIBP parameter window to display on the monitor screen with adequate priority.
2. Select the ***Setup*** tab in the ***Non-Invasive Blood Pressure*** menu and configure:

   Inflation Limits: Auto

Simulator configuration

ECG:

- Configure ECG settings as follows:

  ECG rhythm: a normal sinus rhythm

  Hearth rate: 80 bpm

  Amplitude: 1 mV

Impedance respiration:

- Configure impedance respiration settings as follows:

  Baseline impedance:1000 Ω

  Amplitude: 1Ω

  Respiration rate: 20 breaths per minute

  Lead selection: II (or LL)

Invasive pressure:

- Configure the simulator's P1, P2, P3 and P4 invasive pressure channels to 0 mmHg static and atmosphere pressure.

Temperature:

- Configure the simulator's temperature channels as follows:

  Temperature: 37°C/98.6°F

Defib/sync and analog output:

- Configure the settings as follows:

  Heart rate: 80 bpm

  Amplitude: 1.0 mV

3.3.2 ECG tests

1. Normal Sinus Rhythm
   a. Check that the monitor displays the ECG leads II, VI & aVL and the waveforms are noise-free. The monitor shall display a 80± 5 bpm heart rate and an audible QRS tone sounds with each QRS complex.

NOTE: If necessary, turn up QRS volume.

   b. Select the ***All ECG Waveforms*** view from the ***ECG Setup*** tab in the ***ECG*** menu. Check that all 12 ECG leads are available and they are noise free.
   c. Close the ***All ECG Waveforms*** view.

2. Pacemaker Detection
   a. Configure the simulator to show "Asynchronous Pacemaker Pulse"
   b. Check that pacemaker spikes are shown on the ECG waveform.
   c. Configure the simulator to show "80 beats per minute, Normal Sinus Rhythm".

3. Asystole Detection
   a. Configure the simulator to show "Asystole".
   b. Check that the 'Asystole' alarm appears on the monitor screen.
   c. Configure the simulator to show "80 beats per minute, Normal Sinus Rhythm".

4. Leads Off Detection
   a. Detach the RA/R leadwire from the simulator.
   b. Check that the Lead II waveform disappears from the ECG1 waveform field, followed by an "RA/R lead off" message.
   c. Check that Lead II is replaced by Lead III in the ECG1 waveform field after a while.
   d. Reconnect the RA/R leadwire to the simulator.
   e. Check that Lead III is replaced with Lead II in the ECG waveform field.

5. Mark this task as complete on the checkout form.

3.3.3 Impedance respiration tests

6. Respiration Rate
    a. Check that the RESP waveform is shown and the RR value is 20 (±5).
    b. Configure the simulator's Apnea Simulation to "32 sec".
7. Apnea Detection
    a. Check that the monitor activates the APNEA alarm.
    b. Configure the simulator's Apnea Simulation to "OFF"
8. Mark this task as complete on the checkout form.

3.3.4 Invasive pressure tests

9. Zeroing
    a. Ensure that the simulator InvBP output channels are configured to "0 mmHg static pressure" or "atmosphere".
    b. Zero the invasive pressure of the PDM by pressing the **IBP Zero All** button on the PDM
    or
    Zero the invasive pressure of the patient monitor by pressing the **Zero All Pressures** button on the patient monitor.
10. Static Pressure
    a. Configure the simulator's InvBP output channel to "240 mmHg static pressure".
    b. Check that the pressure waveform for the P1, P2, P3 and P4 waveform fields displays the flat pressure line in the related waveform field.
    c. Check that a reading of 240 ± 4 mmHg displays on the patient monitor.
11. Pressure Waveforms
    a. Configure the simulator's InvBP output channels to generate a waveform.
    b. Check that the pressure waveform for P1, P2, P3 and P4 waveform fields displays an appropriate waveform.
12. Mark this task as complete on the checkout form.

3.3.5 Temperature tests

Perform the following test step both to the T1 and T2 temperature channels.

NOTE: The 'x' in Tx refers to the temperature channel being tested.

13. Temperature check
    a. Check that the reading in the Tx temperature channel is 37°C/98.6°F ± 0.1°C/0.18°F.

NOTE: You can alternatively perform this test using a temperature test set (P/N 884515-HEL). Test each temperature channel with both test plugs. The reading in the Tx temperature channel shall be 37°C/98.6°F ± 0.1°C/0.18°F.

    b. Mark this task as complete on the checkout form.

3.3.6 SpO2 tests

14a. SpO_2 functions (Masimo)
    a. Make sure that the SpO_2 parameter is turned on.
    b. Verify the following are displayed at the patient monitor:

- A waveform with an SpO_2 label.
- An SpO_2% reading between 78-84%.

- A PRR reading between 60 and 62 beats per minute.

c. Disconnect the simulator cable from the acquisition device.

d. Mark this task as complete on the checkout form.

14b. SpO_2 functions (Nellcor OxiMax)

a. Verify that 2 AA alkaline batteries are installed in the NELLCOR SRC-MAX Pulse Oximetry functional tester.

b. On the SRC-MAX, verify that the **IR** and **RED** LED indicators are both lit.

c. Verify the SRC-MAX default indicators are as follows:

- Heart rate = 60 bpm
- Light = LOW
- MOD = LOW

d. Verify the following SpO_2 readings for saturation and pulse rate:

- Saturation (%): 75 ± 2
- Rate (bpm): 60 ± 2

e. Press and release the heart rate button on the SRC-MAX. Verify default indicators are lit as follows:

- Heart rate = 200 bpm
- Light = LOW
- %SpO_2 = 75
- MOD = LOW

f. Verify the following SpO_2 readings for saturation and pulse rate:

- Saturation (%): 75 ± 2
- Rate (bpm): 200 ± 3

g. Press and release the light button on the SRC-MAX. Verify default indicators are lit as follows:

- Heart rate = 200 bpm
- Light = HIGH
- %SpO_2 = 75
- MOD = LOW

h. Verify the following SpO_2 readings for saturation and pulse rate:

- Saturation (%): 75 ± 2
- Rate (bpm): 200 ± 3

i. Press and release the **%SpO_2** button on the SRC-MAX. Verify default indicators are lit as follows:

- Heart rate = 200 bpm
- Light = HIGH
- %SpO_2 = 90
- MOD = LOW

j. Verify the following SpO_2 readings for saturation and pulse rate:

- Saturation (%): 90 ± 2
- Rate (bpm): 200 ± 3

k. Press and release the **MOD** button on the SRC-MAX. Verify default indicators are lit as follows:

- Heart rate = 200 bpm
- Light = HIGH
- %SpO_2 = 90
- MOD = HIGH

l. Verify the following SpO_2 readings for saturation and pulse rate:

- Saturation (%): 90 ± 2
- Rate (bpm): 200 ± 3

m. Mark this task as complete on the checkout form.

3.3.7 NIBP tests

15. NIBP Leak Test

Check the NIBP tubing system for leakage:

a. Select **Monitor Setup > *Service Calibrations***.

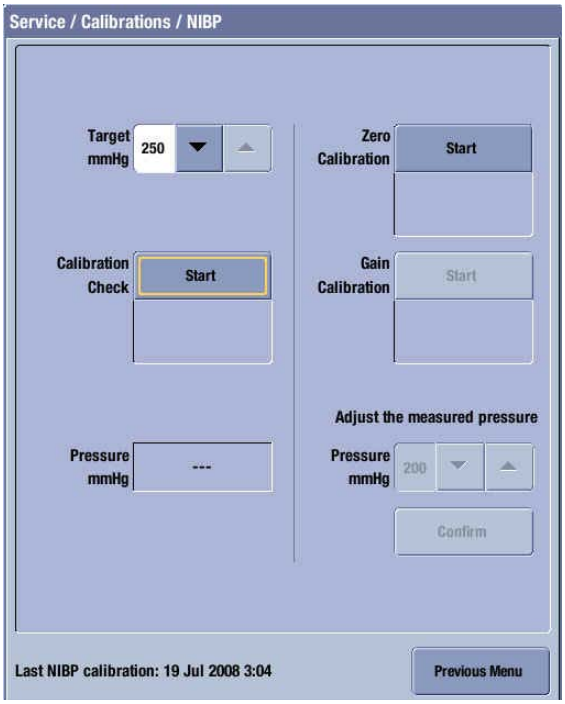
b. Enter username and password and press ***Enter***.

Username: **biomed**

Password: **Change**<space>**Me**

c. On the Calibrations menu, select ***NIBP***.

d. Select ***Start*** to start the "Calibration Check". This will close the safety and pulse valves.



A 250 mmHg static pressure is pumped into the cuff. The pressure measured by the module is updated in real-time to the calibration menu. Wait until the pressure stabilizes.

e. Verify that the pressure readings on the patient monitor (shown as ***CUFF*** in the ***NIBP*** parameter box) and the manometer are equal (± 1 mmHg) for at least one full minute. Take the appropriate action, depending on the results:

Results	Action
If the readings are equal, the device is properly calibrated.	Proceed to "16. NIBP over pressure" on page 16-21.
If the readings are not equal, the device requires calibration.	Perform the "Calibration procedure" on page 16-27.
If the pressure drops at a rate of 1 mmHg or more for every five seconds, there is a leak in the NIBP plumbing.	Correct the problem and perform the "Calibration procedure" on page 16-27.
If no problem is found, the device is properly calibrated.	Proceed to "16. NIBP over pressure" on page 16-21.

16. NIBP over pressure
    a. Squeeze the NIBP pump or NIBP pressure cuff until it registers a pressure of approximately 315 mmHg.
    b. Listen for the pressure to be released in a controlled manner.
    c. Mark this task as complete on the checkout form.

3.3.8 Defib/sync and analog output test

17. Defib/sync and analog output
    a. Refer to "Test cable plug and pinout" on page 16-29.
    b. Test the ECG, Arterial BP, and Marker Out signals from the **DEFIB SYNC** connector using an oscilloscope to connect to the appropriate wire on the test cable (see "Test cable plug and pinout" on page 16-29). They should resemble the waveforms in the following figures. Note that there are two Marker Out traces shown. The top trace shows the frequency of the pulses; the bottom trace shows the pulse width.

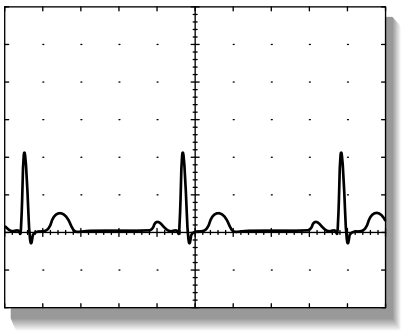
ECG

Signal pin: **1** Brown wire

Ground pin: **6** Green wire

Time/division: **0.2s**

Volts/division: **0.5v**



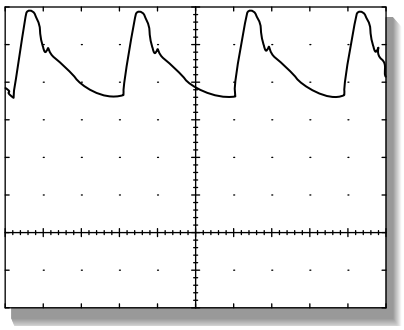
Arterial BP

Signal pin: **2** Red wire

Ground pin: **6** Green wire

Time/division: **0.2s**

Volts/division: **0.2v**



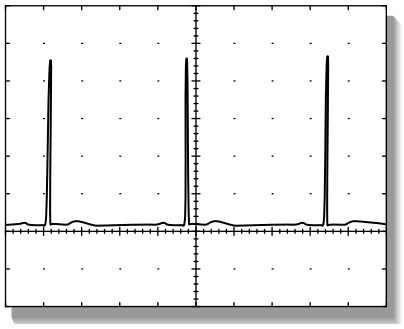
Marker Out (Frequency)

Signal pin: **9** Gray wire

Ground pin: **4** Yellow wire

Time/division: **10ms**

Volts/division: **0.5v**



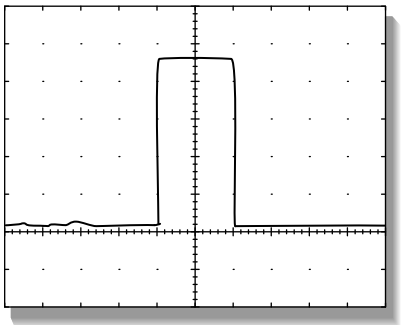
Marker Out (Pulse Width)

Signal pin: **9** Gray wire

Ground pin: **4** Yellow wire

Time/division: **5ms**

Volts/division: **1v**



NOTE: The Marker Out amplitude and pulse width are configured at 10v and 10ms, respectively, from the factory.

c. Short the gray wire (Marker Out) to the violet wire (Marker In) and observe small x-marks in the R-waves of the displayed ECG waveforms.

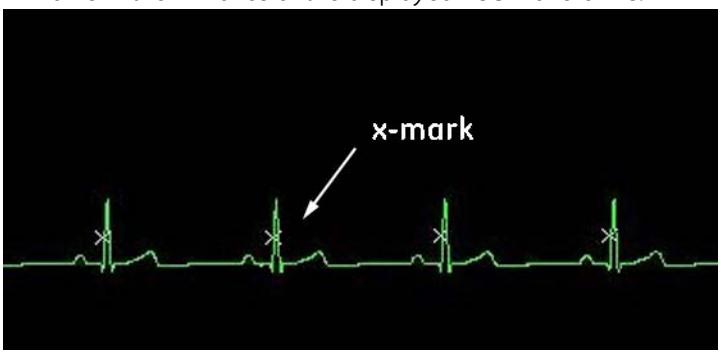


Figure 7 Sample x-marks in the R-waves of displayed ECG waveforms

d. If the above test fails, perform the calibration procedure for "Analog outputs" on page 16-28 and re-test.
e. Remove the test equipment.
f. Mark this task as complete on the checkout form.

3.3.9 Test completion

Select ***Discharge patient*** or ***Reset case*** to discard any changes made to the monitor configuration during checkout.

3.3.10 Complete checkout form

Complete the "Maintenance check form" on page 16-55.

3.4 Battery care

The Lithium-Ion battery is a rechargeable battery containing Lithium-Ion cells. Each battery contains an integrated electronic fuel gauge and a safety protection circuit. The processor within the equipment communicates with both the battery and the charger.

The following are facts about Lithium-Ion battery technology:

- The battery discharges on its own, even when it is not installed in the equipment. This discharge is the result of the Lithium-Ion cells and the bias current required for the integrated electronics.
- The self-discharge rate doubles for every 10ºC (18ºF) rise in temperature.
- The capacity loss of the battery degrades significantly at higher temperatures.
- As the battery ages, the full-charge capacity of the battery degrades and is permanently lost. As a result, the amount of charge that is stored and available for use is reduced.

The following terms are used to define the battery capacity:

- Design capacity — The theoretical capacity of the battery cells when the battery is new.
- Full charge capacity — The actual amount of charge the battery can store and deliver.
- Remaining charge capacity — The amount of full charge capacity currently remaining in the battery. This is a percent of full charge capacity.

3.4.1 Use recommendations

GE recommends the following methods to improve battery performance:

- Location — Position the equipment in a location that does not artificially increase the operating temperature of the batteries.
- Charging method — Whenever possible, use the Cadex Smart Two+ charger to charge the battery. The Cadex Smart Two+ charger maintains a lower battery cell temperature during the charge cycle. This reduction in temperature can extend the life of the battery.
- Conditioning guideline — Remove the batteries from the equipment every six months and condition it using the Cadex Smart Two+ charger. This condition cycle recalibrates the electronic fuel gauge.

NOTE: The Cadex Smart2 + charger is no longer available for purchase. However, if your site has a Cadex Smart2 + charger, you should continue to use it to charge and condition the battery.

3.4.2 Storage recommendations

Store the battery outside of the device at a temperature between 20ºC to 25ºC (68ºF to 77ºF). Storing the battery inside the PDM is not recommended for the following reasons:

- In a device that is powered by an AC power source, the battery cell temperature increases by 10ºC to 15ºC (18ºF to 27ºF) above the room's ambient temperature. This reduces the life of the battery.
- In a device that is powered by an AC power source ("floating"), the battery self-discharges to less than 90% of its full charge capacity after approximately two weeks. The battery is then recharged to 100% resulting in a 95% average state of charge. Storing the battery at a high state of charge also reduces the life of the battery. GE recommends that you remove the battery and store it near the PDM until it is needed.

3.4.3 Test the battery charge

Before installing a battery, verify the battery's state of charge. Press the green **TEST** button on the battery. The number of charge level indicator LEDs that illuminate measures the approximate charge remaining in the battery.

- Four LEDs illuminated: 75% – 100% of full charge capacity.
- Three LEDs illuminated: 50% – 74.9% of full charge capacity.
- Two LEDs illuminated: 25% – 49.9% of full charge capacity.
- One LED illuminated: 10% – 24.9% of full charge capacity.
- One LED flashing: < 10% of full charge capacity remaining.

Mark this task as complete on the checkout form.

3.4.4 Charge the battery

The battery can be charged by one of two methods:

- Inside a PDM that is connected to a powered host.
- Outside the PDM using a Cadex Smart Two+ battery charger.

Charge inside the PDM

The battery charges whenever the PDM is connected to an AC powered host.

Charge with a Cadex Smart Two+ battery charger

1. Insert the battery into the battery charger. The **RUN** LED lights.
2. Leave the battery in the charger until the **READY** LED lights

NOTE: If the **FAIL** LED lights, remove the battery from the battery charger and reinsert it. This corrects any battery charger time out errors. If the **FAIL** LED still lights, replace the battery.

NOTE: The Cadex Smart2 + charger is no longer available for purchase. However, if your site has a Cadex Smart2 + charger, you should continue to use it to charge and condition the battery.

3.4.5 Condition the battery

Remove or replace the battery

1. Open the battery door at the rear of the PDM.
2. Remove the battery.
3. Insert a new battery with the connection pins inserted first and facing down.
4. Close the battery door.
5. Connect the PDM to a host patient monitor and confirm that the battery LED lights green and the battery icon displays in the lower corner of the patient monitor.
6. Mark this task as complete on the checkout form.

Recycle the battery

Recycle the battery when it no longer holds a charge. Remove the battery from the PDM and follow your local recycling guidelines.

WARNING **EXPLOSION HAZARD - Do not incinerate the battery or store at high temperatures. Serious injury or death could result.**

4 Calibration and adjustments

CAUTION Make sure the patient is disconnected from the monitor before performing calibration and adjustments on the device.

If checkout fails, calibrate NIBP, ECG and IP Analog Out using the host interface.

4.1 NIBP

4.1.1 Required equipment

Use equipment with the following specifications for this calibration:

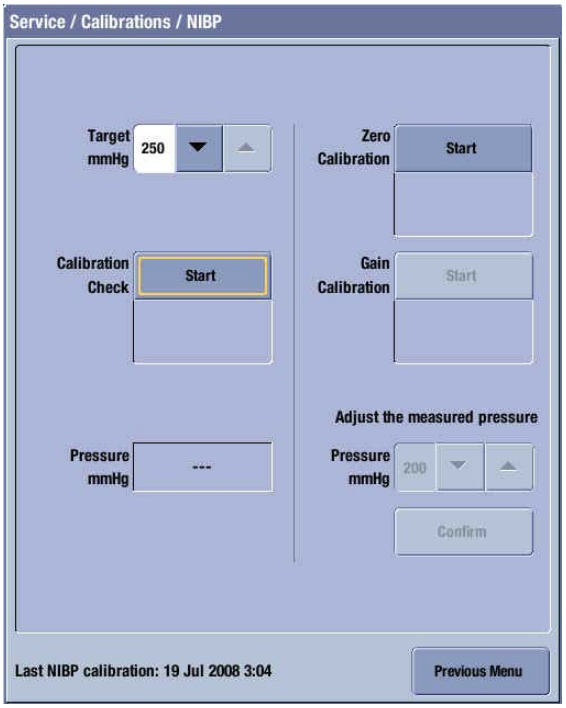
- NIBP cuff coupling (400787-005)
- NIBP hose coupling (400787-006)
- NIBP tee (4745-101)
- NIBP tubing 2 feet (401582-001)
- Digital manometer with a range of at least 0 to 1000 mmHg
  Accuracy 0.5% FS.
- NIBP tube (2017008-001)
- NIBP cuff (2203)
- Pipe: PVC

4.1.2 Calibration check procedure

1. Connect the PDM to the patient monitor.
2. Apply power to the patient monitor.
3. Make sure the power indicator on the PDM's front panel is ON (green).
4. Connect the digital manometer, noninvasive blood pressure (NIBP) cuff, tees and tubing, as shown in the illustration below, to the NIBP connector of the PDM.

5. Turn the digital manometer **ON** and set its range switch to the **1000 mmHg** setting.
6. At the patient monitor, select ***Monitor Setup > Service Calibrations***.

7. Enter username and password and press ***Enter***.
   - Username: **biomed**
   - Password: **Change**<space>**Me**
8. Select ***NIBP***. The following screen displays.



9. Next to ***Calibration Check***, select ***Start***.

The acquisition device starts pumping up the pressure cuff and pressures displayed on both the patient monitor and the manometer show an increase.

The pump shuts off at the set target pressure, and the pressure drops slowly before stabilizing.

NOTE: If the pressure continues to drop at a rate of 1 mmHg or more for every five seconds, there is a leak in the NIBP plumbing. If there is a leak in the NIBP plumbing, correct the problem and perform the "Calibration procedure" on page 16-27.

10. Verify that the pressure readings on the patient monitor (shown as ***CUFF*** in the ***NIBP*** parameter box) and the manometer are equal (± 1 mmHg) for at least one full minute.
    - If the readings are equal, the device is properly calibrated.
    - If the readings are not equal, the device requires calibration. Complete this section, then continue with "Calibration procedure" on page 16-27.
11. Select ***STOP***. The module then releases pressure in the cuff.
12. Disconnect the NIBP cuff and manometer from the acquisition device.
13. Mark this task as complete on the checkout form.

4.1.3 Calibration procedure

1. At the patient monitor, select ***Monitor Setup*** > ***Service / Calibrations*** > ***NIBP***.
2. Next to ***Zero Calibration***, select ***Start.***

3. Reconnect the deflated cuff and manometer to the PDM as shown in "Calibration check procedure" on page 16-26.
4. Next to ***Gain Calibration***, select ***Start***.

   The acquisition device starts pumping up the pressure cuff and pressures displayed on both the patient monitor and the manometer show an increase.

   The pump shuts off at about 250 mmHg, and the pressure drops slowly to about 240 mmHg before stabilizing.

NOTE: If the pressure continues to drop at a rate of 1 mmHg or more for every five seconds, there is a leak in the NIBP plumbing. If there is a leak in the NIBP plumbing, correct the problem and restart this calibration procedure.

NOTE: To abort the calibration process with no changes, press ***Stop Calibration***.

5. Under ***Adjust the measured pressure*** next to ***Pressure mmHg***, use the up or down arrow to select a pressure value that is 1 mmHg lower than the current manometer reading.
6. When the manometer falls to exactly the value that you selected in the popup window, select ***Confirm*** to enter the value. The module then releases pressure in the cuff.
7. Next to ***Calibration Check***, select ***Start***.
8. Make sure that the pressure readings (shown as ***CUFF*** in the NIBP parameter box) on the patient monitor and manometer are equal (± 1 mmHg) for at least one full minute.
9. Next to ***Calibration Check***, select ***Stop***.
10. Remove the cuff and manometer from the PDM.
11. Mark this task as complete on the checkout form.

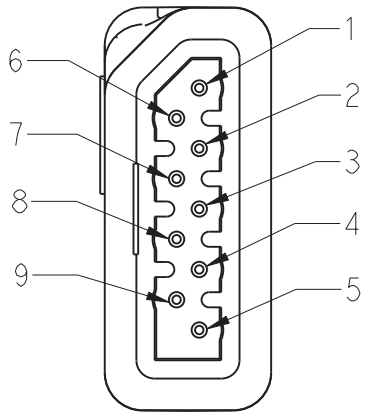
4.2 Analog outputs

4.2.1 Required equipment

Use the following equipment for this calibration:

- Unterminated defib sync cable (2017842-001)
- Digital voltmeter

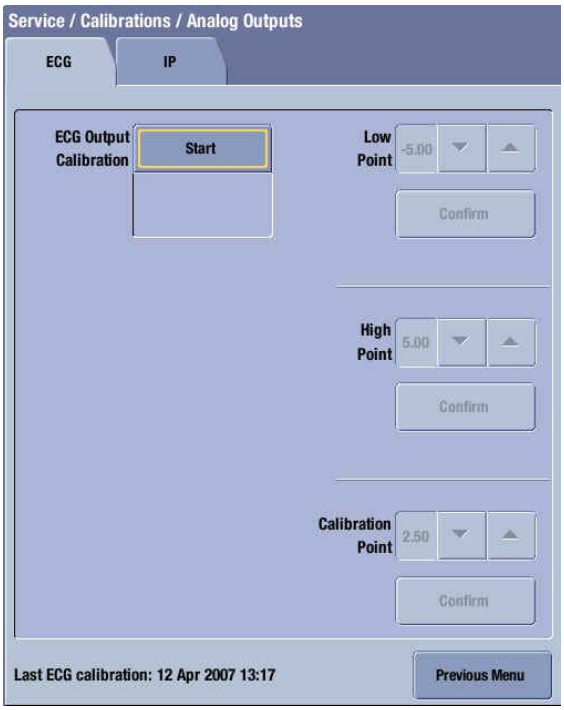
4.2.2 Test cable plug and pinout



Pin	Wire color	Signal name
1	Brown	ECG_ANALOG_OUT
2	Red	BP_ANALOG_OUT
3	Orange	NO_CONNECTION
4	Yellow	MARKER_RETURN
5	Shield	DRAIN WIRE
6	Green	ANALOG_RETURN
7	Blue	NO_CONNECTION
8	Violet	DEFIB_SYNC_MARKER_IN
9	Gray	DEFIB_SYNC_MARKER_OUT

4.2.3 Procedure

1. Connect the PDM to the patient monitor.
2. Disconnect all parameter cables.
3. Apply power to the patient monitor.
4. Make sure the power indicator on the PDM front panel is ON (green).
5. Connect the unterminated cable to the **Defib/ Sync** connector on the front of the PDM.
6. At the patient monitor, select ***Monitor Setup*** > ***Service / Calibrations***.
7. Select ***Analog Outputs***. The screen defaults to the ***ECG*** tab.



8. See "Test cable plug and pinout" on page 16-29 and connect the digital voltmeter to the appropriate unterminated cable:

Pin	Wire color	Signal name	Digital voltmeter
1	Brown	ECG_ANALOG_OUT	POSITIVE
6	Green	ANALOG_RETURN	GROUND

9. Next to ***ECG Output Calibration*** on the ***Service/Calibrations/Analog Outputs*** screen, select ***Start***.

NOTE: To abort the calibration process with no changes, press ***Stop Calibration***.

10. Measure DC voltages across the pins and type in or use the scroll buttons to enter the measured voltages for ***Low Point***, ***High Point*** and ***Calibration Point***.
11. To calibrate the IP output, select the ***IP*** tab.
12. See "Test cable plug and pinout" on page 16-29 and connect the digital voltmeter to the appropriate unterminated cable:

Pin	Wire color	Signal name	Digital voltmeter
2	Red	BP_ANALOG_OUT	POSITIVE
6	Green	ANALOG_RETURN	GROUND

13. Next to ***IP Output Calibration*** on the ***Service/Calibrations/Analog Outputs*** screen, select ***Start***.

NOTE: To abort the calibration process with no changes, press ***Stop Calibration***.

14. Measure DC voltages across the pins and type in or use the scroll buttons to enter the measured voltages for ***Low Point***, ***High Point*** and ***Calibration Point***.
15. Mark this task as complete on the checkout form.

NOTE: If the PDM's CPU board is replaced, perform calibration.

16. Proceed to the "Defib/sync and analog output test" on page 16-21.

5 Troubleshooting

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

5.1 Before you begin

CAUTION Make sure the patient is disconnected from the monitor before you begin troubleshooting the device.

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

- All I/O cable connections are secured
- All patient devices are properly powered

5.2 Device information and diagnostics

From the patient monitor, navigate to Webmin in the local browser as follows:

1. Select ***Monitor Setup*** then ***Service***. The local browser opens and displays the Webmin login dialog box.
2. Type the username and password and click ***login*** or press **Enter** on the keyboard.
   - Username: **biomed**
   - Password: **Change**<space>**Me**

NOTE: Username and password are case sensitive. Username and password cannot be created, edited or deleted.

The Webmin tool opens and defaults to the ***Information*** tab.

5.2.1 Device information

1. On the ***Information*** tab, select ***Device Information***.

   The following sections display when the PDM is connected:
   - ***Acquisition Information - PDM*** - software part number, active software version, main board revision, DAS board revision, serial number, asset number, MAC address, IP address, power frequency, ECG filter.
   - ***PDM License Information*** - license option, status number of license.

5.2.2 Diagnostics

Messages and errors in log files provide useful information to a trained technician.

1. Select the ***Diagnostics*** tab.
2. Select ***View Logfiles*** > ***PDM Log*** to view or ***Download Logs > PDM*** to download the log file.

NOTE: You can only download log files when you are logged onto Webmin remotely.

5.3 Problems and solutions

Problem	Possible causes	Possible solutions
Battery is not charging	• Battery tray is damaged • Battery connector is damaged • Battery is bad	Check the PDM battery interface as follows. 1. Check for damage to the battery tray. If damaged, replace the battery tray. See "Service parts" on page 16-54 for ordering parts and replacement procedures. 2. Check for damage to the battery connector inside the battery compartment. If damaged, contact GE technical support to service the PDM. 3. Check that the battery is charging by inserting a known good battery in the PDM. If not charging, contact GE technical support to service the PDM. Check the PDM battery as follows. 1. Check that the battery is fully charged by pressing the **TEST** button on the battery. If the LED is not at 100%, go to "Battery care" on page 16-23 for further charging and conditioning procedures. 2. Check for damage to the battery connector and external surfaces. If damaged, replace the battery. See "Battery" on page 16-39 for instructions. 3. Check that the battery is charging with the GE approved battery charger. If not charging, replace the battery. See "Battery" on page 16-39 for instructions.
External surface is damaged	• Top housing is damaged • Bottom housing is damaged	Check the PDM top and bottom housing as follows. 1. Check for cracks or other damage to the top housing. If damaged, replace the top housing. See "Service parts" on page 16-54 for ordering parts and replacement procedures. 2. Check for cracks or other damage to the bottom housing. If damaged, contact GE technical support to service the PDM.
NIBP is not functioning	• NIBP is not calibrated • NIBP pressure is leaking	Check the NIBP performance as follows. 1. Follow the "Calibration check procedure" on page 16-26. 2. If NIBP pressure is leaking (not maintaining ***CUFF*** pressure for at least one minute), check for leakage on the NIBP cuff. (Listen for hissing as air escapes.) 3. If NIBP is not calibrated, perform the NIBP "Calibration procedure" on page 16-27. 4. If NIBP is still not functioning, replace the NIBP assembly with manifold. See "Service parts" on page 16-54 for ordering parts and replacement procedures.

Problem	Possible causes	Possible solutions
No power	• ePort to host interface cable is damaged • Tram-net port on monitor is damaged • ePort interface on PDM is damaged • PDM battery is not charging	1. Check for damage to the ePort to host interface cable. If damaged, replace the cable. 2. Check for damage to the Tram-net port on the patient monitor. If damaged, go to the CARESCAPE Monitor technical manual, Field replaceable units section for ordering parts. 3. Connect a known good PDM to the patient monitor. If the PDM is not powering, go to the CARESCAPE Monitor technical manual Troubleshooting section for further information. 4. Check for damage to the ePort interface on the PDM. If damaged, contact GE technical support to service the PDM. 5. Check the PDM battery following steps in the 'Battery is not charging' section in this table.
No communication indicators (LEDs not illuminated)	Cable is bad	Replace cable
	ePort on the patient monitor is bad	1. Connect a known good PDM to the patient monitor. 2. If the PDM is not powering, replace the main CPU board.
	PDM is bad	Connect a known good PDM to the patient monitor.
No parameters	• Parameter cable is damaged • Parameter interface is damaged • PDM license is not activated • Patient monitor is not configured to display the parameter	1. Check for damage to the parameter cable(s). If damaged, replace cables. 2. Check for damage to the parameter interface. If damaged, contact GE technical support to service the PDM. 3. Check for licensing using Webmin. At the patient monitor, select ***Monitor Setup*** > ***Service***. Log on to Webmin with your username and password. On the ***Information*** tab, select ***Configuration Information*** to view PDM licenses. If license is not activated, install the license(s). 4. Check that the patient monitor is configured to display the parameter.
Noisy waveforms, missing markers or inaccurate patient data	• The ECG filter is not enabled • Parameter cable or interface is damaged	Check for ECG filter configuration using Webmin. 1. At the patient monitor, select ***Monitor Setup*** > ***Service***. Log on to Webmin with your username and password. 2. Select the ***Configuration*** tab, then ***Modules***. 3. Select ***ECG Filter configuration*** and check that is ***Enabled***. 4. If this does not correct the problem, follow steps in the 'No parameters' section in this table.
PDM will not dock	• Mounting rails are damaged • Docking station is damaged	1. Check for damage to mounting rails. If damaged, replace the mounting rails. 2. Check for damage to the docking station (bedside dock, transport dock, or mini-dock). If damaged replace the docking station.

5.4 Error messages

The following error messages display at the patient monitor if there is a serious problem with the PDM.

For further assistance, contact GE technical support with the error code and device serial number.

Error message	Possible causes	Possible solutions
COMMUNICATION FAILURE		Go to "No communication indicators (LEDs not illuminated)" on page 16-34.
BATTERY FAIL		Go to "Battery" on page 16-39.
Service the PDM - Error Code 0xPDM1000	The data in secure storage is corrupt.	Replace the main CPU board and re-install the software.
Service the PDM - Error Code 0xPDM1001	One or more of the PDM's flash file system partitions is full.	Replace the main CPU board and re-install the software.
Service the PDM - Error Code 0xPDM1002	An error occurred writing data to secure storage.	Replace the main CPU board and re-install the software.
Service the PDM - Error Code 0xPDM1003	An error occurred writing to the SPI bus.	Replace the main CPU board and re-install the software.
Service the PDM - Error Code 0xPDM1004	An error occurred reading the network interface information.	Replace the main CPU board and re-install the software.
Service the PDM - Error Code 0xPDM1005	An error occurred reading flash file system partition information.	Replace the main CPU board and re-install the software.
Service the PDM - Error Code 0xPDM1006	An error occurred using the TWI bus.	Replace the main CPU board and re-install the software.
Service the PDM - Configure Power Frequency	Power line frequency could not be read from secure storage using default.	Reapply the power frequency.
Service the PDM - Install License	Purchased option count could not be read from secure storage using default.	Re-install the license.
Service the PDM - Calibrate NIBP	NIBP calibration values could not be read from secure storage using defaults.	Perform NIBP calibration.
Service the PDM - Calibrate ECG Analog Out	ECG analog out calibration values could not be read from secure storage using defaults.	Perform analog-out ECG calibration.
Service the PDM - Calibrate IP Analog Out	IBP analog out calibration values could not be read from secure storage using defaults.	Perform analog-out IP calibration.
Service the PDM - Error 0xPDM100C	MAC address could not be read from hardware using default.	Replace the main CPU board.
Service the PDM - Error 0xPDM1100	Main CPU board 1.8V rail voltage out of spec.	Replace the main CPU board.

Error message	Possible causes	Possible solutions
Service the PDM - Error 0xPDM1101	Main CPU board 3.3V rail voltage out of spec.	Replace the main CPU board.
Service the PDM - Error 0xPDM1102	Main CPU board 5.4V rail voltage out of spec.	Replace the main CPU board.
Service the PDM - Error Code 0xPDM1103	Main CPU board 12V rail voltage out of spec.	Replace the main CPU board.
Service the PDM - Error Code 0xPDM1104	Main CPU board -12V rail voltage out of spec.	Replace the main CPU board.
Service the PDM - Error Code 0xPDM1105	Main CPU board power bus voltage out of spec.	Replace the main CPU board.
Service the PDM - Error Code 0xPDM1106	ECG DAS board 1.26V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM1107	ECG DAS board 3.3V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM1108	ECG DAS board 5V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM1109	ECG DAS board 7.5V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM110A	ECG DAS board -7.5V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM110B	Main DAS board 1.26V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM110C	Main DAS board 3.3V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM110D	Main DAS board 5V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM110E	Main DAS board 2.5V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM110F	Main DAS board Nellcor 5V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM1110	Main DAS board Nellcor -3V rail voltage out of spec.	Replace DAS assembly.
Service the PDM - Error Code 0xPDM1120	Temperature out of spec.	Replace the main CPU board.

6 Disassembly and reassembly

6.1 Disassembly guidelines

WARNING **Repair to the FRU level. Field repairs are recommended to the field replaceable unit (FRU) only. Attempting a field repair on a PCB or a factory sealed component or assembly could jeopardize the safe and effective operation of the PDM.**

NOTE: GE recommends using the new fasteners (screws, washers, etc.) provided in the FRU kits rather than re-using the old fasteners. Some fasteners are not intended to be re-used more than three times.

Take advantage of existing thread pattern cut by turning the screw counterclockwise until it drops into the existing thread pattern.

6.1.1 Tools required

A T10 and T6 TORX-style screwdriver and a standard set of hand tools are required for disassembly and assembly. Wearing safety glasses is recommended.

6.1.2 Before disassembly

Before disassembling the PDM, always do the following:

- Remove all cables.
- Remove the battery.
- Provide appropriate electrostatic discharge protection to prevent damaging the PDM. See “Electrostatic discharge (ESD) precautions” on page 16-37 below for details.

6.1.3 Hardware precautions

Observe the following guidelines when disassembling the PDM:

- Note the positions of wires, cables and different sized screws; marking them if necessary to ensure they are replaced correctly.
- Do not kink, pinch, stretch, twist, or tightly fold a flex cable.

6.1.4 Electrostatic discharge (ESD) precautions

All external connectors of the PDM 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 guaranty 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 soldering and test equipment.

- Use a static-free work surface (3M part number 8210 or equivalent) while handling or working on assemblies containing semiconductors.
- Do not remove semiconductors or assemblies containing semiconductors from antistatic containers (Velo-stat bags) until absolutely necessary.
- Make sure power to an assembly is turned off before removing or inserting a semiconductor.
- 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.

6.2 Exploded view

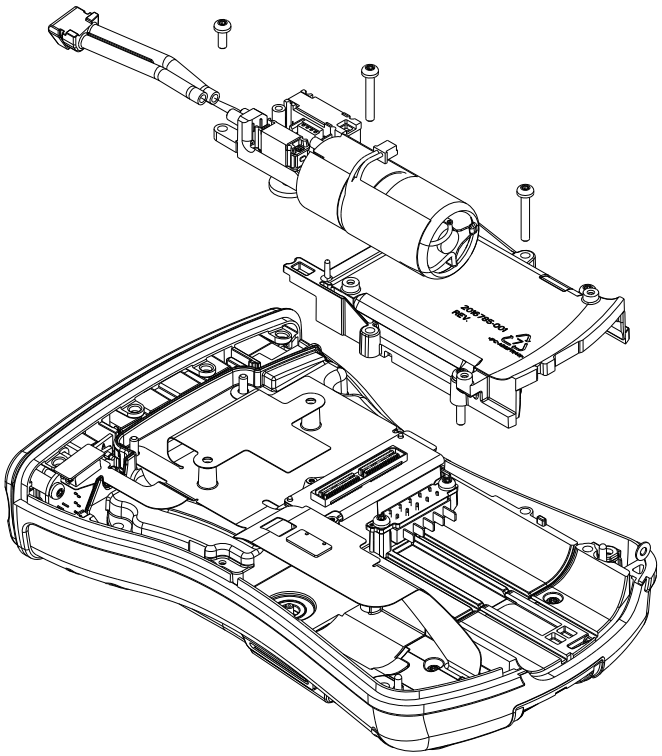


Figure 8 NIBP assembly detail

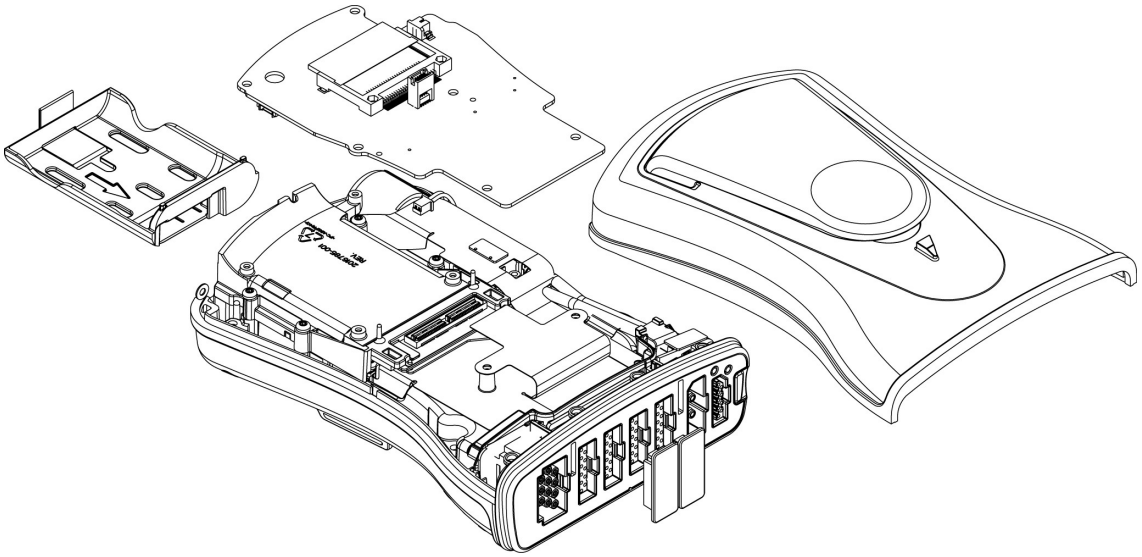


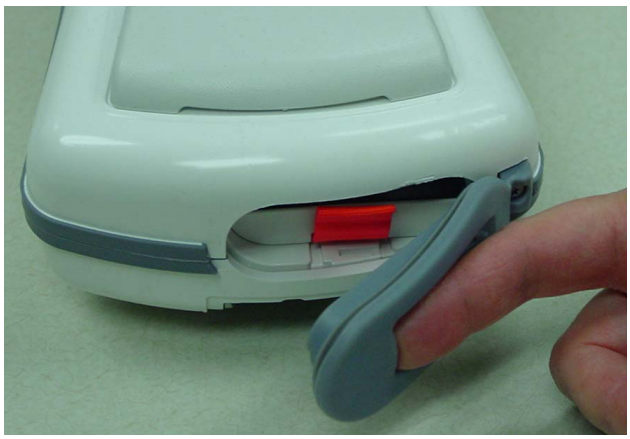
Figure 9 CPU assembly detail

6.3 Replacement procedures

Unless otherwise stated, reassemble the PDM in reverse order of disassembly.

6.3.1 Battery

1. Open the battery door by gently pulling on the battery door pull tab.

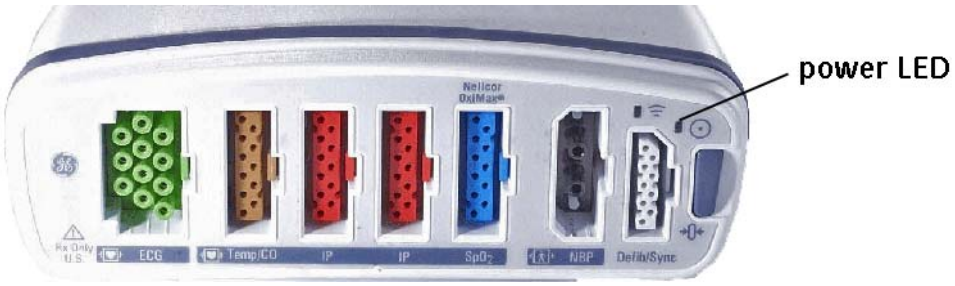


2. Pull the battery tray out of the PDM using the battery tray strap and remove the battery.
3. Insert the new battery with the test button facing up and the arrow pointing into the PDM.

4. Press the battery door closed until it seals the battery compartment.

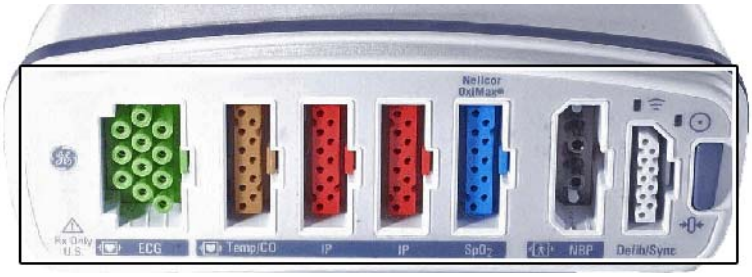
WARNING **PHYSICAL INJURY- Make sure the battery is completely inserted and the battery door is completely closed. Falling batteries could seriously or fatally injure neonatal or other vulnerable patients.**

5. Press the **Power** button on the PDM.
6. Verify that the **Power** LED illuminates amber while the PDM boots up, then illuminates green.



6.3.2 Labels

Apply labels as shown.



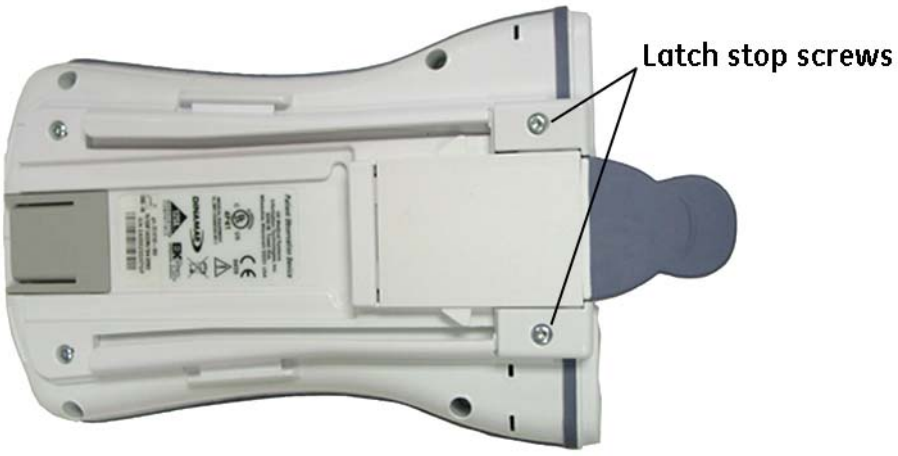
6.3.3 Battery door and tray

1. Remove 1 screw that holds the battery door to the housing and remove the door and washer.

2. Remove the battery if one is in the tray.
3. Use a flathead screw driver to lift the catch tab on the tray as you pull it out of the housing.

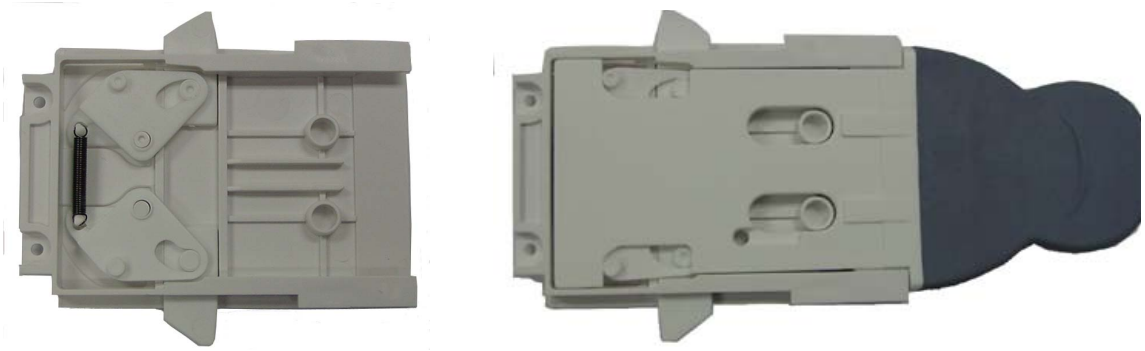
6.3.4 Pull tab and mount rail

1. Remove 2 screws on the latch stop. Remove the latch stop.



2. Grasp the pull tab between thumb and index finger as shown and gently pull it straight out about 1.27 cm/0.5 in. Lift the assembly out of the rail slot.

NOTE: In the event that the pull tab assembly comes apart when pulled from the rail slot, reassemble as shown below.



3. Remove 2 short screws at the rear of the mount rail and 2 long screws at the front of the mount rail.

4. Unseat the mount rail by twisting it slightly. Lift mount rail off the top housing.

NOTE: When reassembling, make sure there are not gaps between the mount rail and the housing when re-seating.

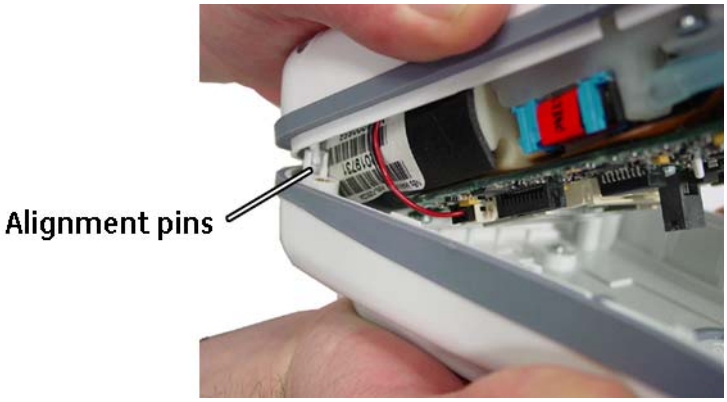
6.3.5 Top housing

1. Remove the pull tab and mount rail per above steps.
2. Remove 4 machine screws that hold the top and bottom housing together.

3. Turn the PDM right side up and lift off the top housing.
4. Install the top housing as follows:
   a. Inspect the gasket in the top housing to be sure it is securely placed in the groove.

b. Make sure the flex connector to the front panel board is connected securely.

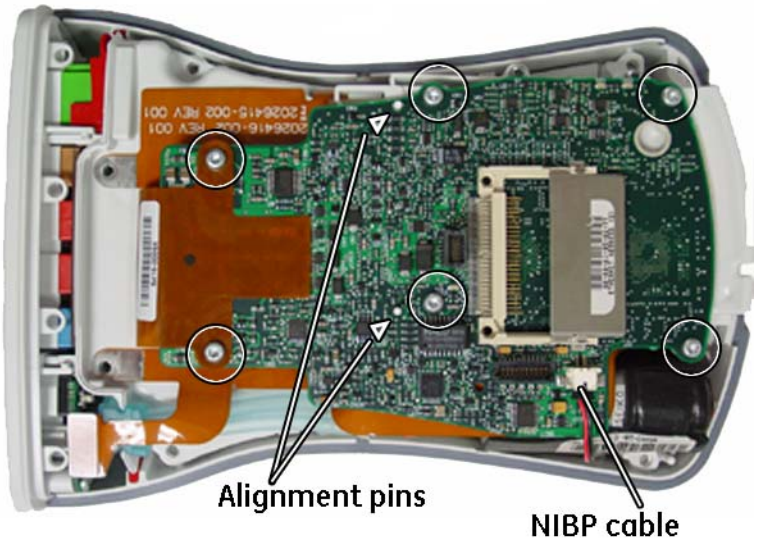
c. Starting at the rear of the module, position alignment pins of the top housing into the bottom housing holes, then close the housing straight down.



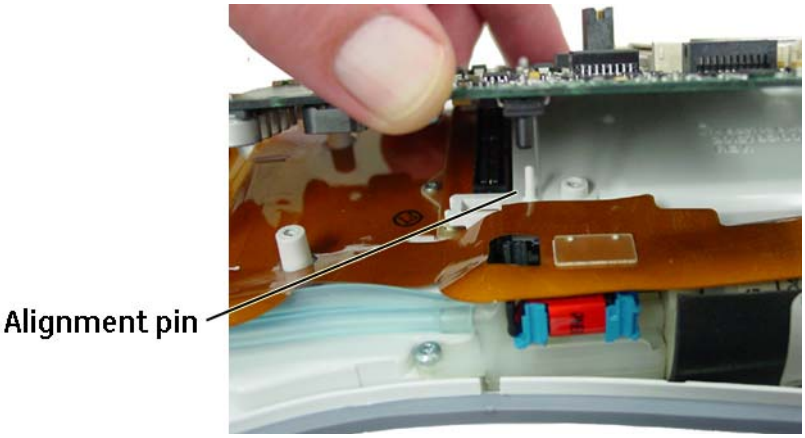
d. Squeeze the top and bottom housings together to eliminate gaps. Install the screw near the Power ON button first.

6.3.6 Main board

1. Remove the top housing per above steps.
2. Disconnect the NIBP cable from the connector without pulling on the wires.



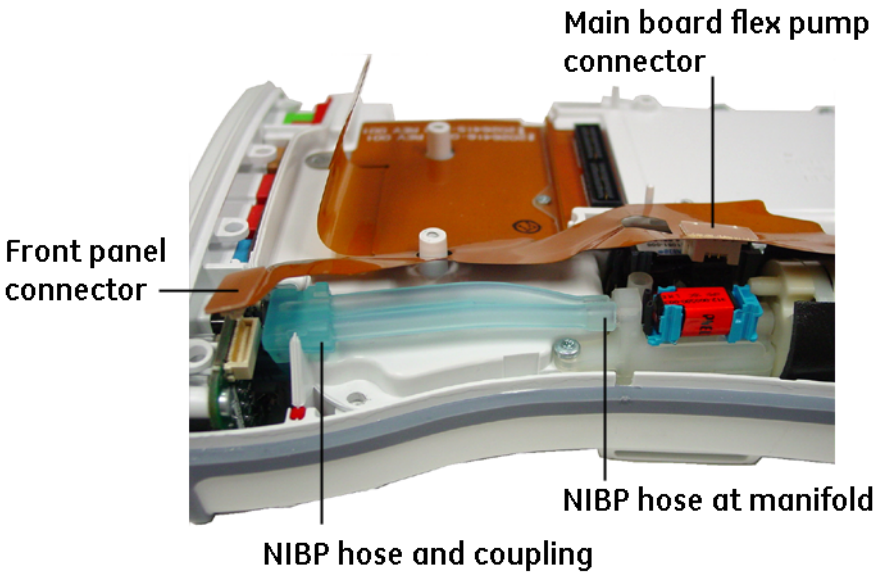
3. Remove 6 screws on the main board.
4. Remove the main board.
5. When installing the main board:
   a. Position the main board into the alignment pins. See figures above and below.
   b. Fold the flex material over the top of the board.
   c. Hold the main board in place while installing screws.



6. If needed, re-install the PDM software, using the CD included in the Main board FRU kit. See “Software update” on page 16-12.
7. Calibrate defib sync. Go to “Analog outputs” on page 16-28 for instructions.
8. Licensing information and manufacturer’s serial number must be re-entered as follows:
   a. Go to the host patient monitor and log on to Webmin. (See “Configuration” on page 16-9 for details.)
   b. Select the ***Configuration*** tab, select ***Modules*** > ***Assets settings***.
   c. Enter the manufacturer’s serial number and select ***Submit***.
   d. Select ***Licensing*** and enter the licensing information.
9. Complete the procedures in “Recommended checkout” on page 16-52.

6.3.7 NIBP hose and coupling

1. Remove the top housing and main board per above steps.
2. Disconnect the front panel connector.



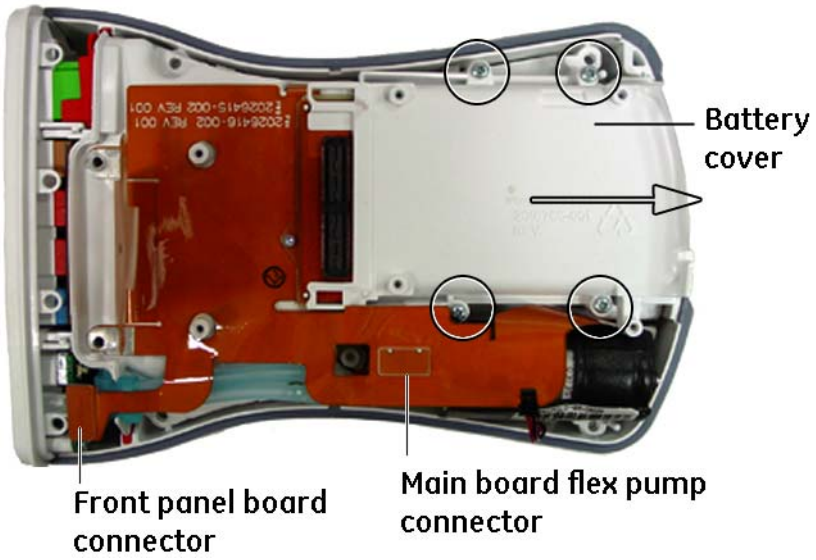
3. Disconnect the main board flex pump connector.
4. Hold flex out of the way and disconnect the NIBP hose from the coupling.
5. Remove hose from the manifold.

NOTE: When reassembling, slide hose all the way onto the manifold fitting so that the hose lays flat.

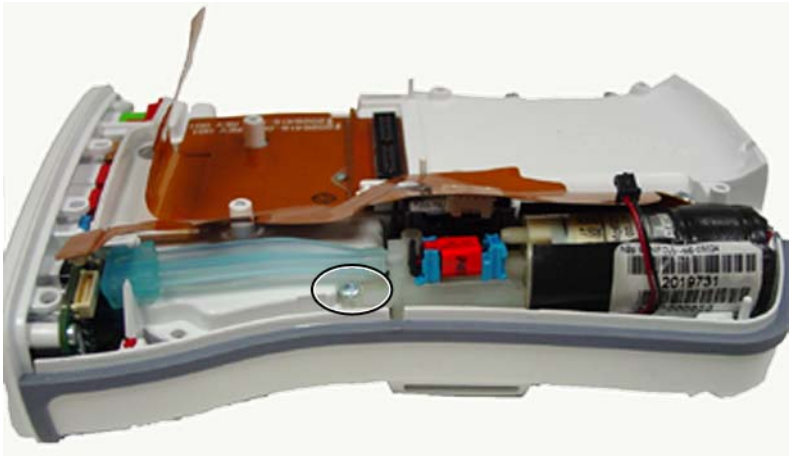
6. Complete the procedures in "Recommended checkout" on page 16-52.

6.3.8 NIBP assembly with manifold hose

1. Remove the top housing, main board, NIBP hose and coupling per above steps.
2. Remove 4 screws from the battery cover.

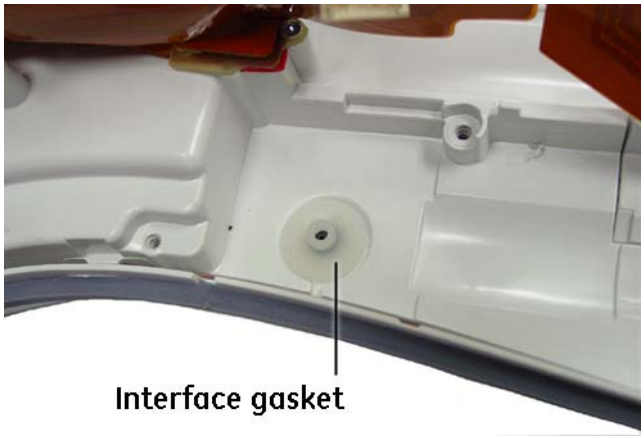


3. Grasp and slide the battery cover out to the rear.
4. Remove 1 screw under the pump tube connection.



5. Lift off the manifold with pump.

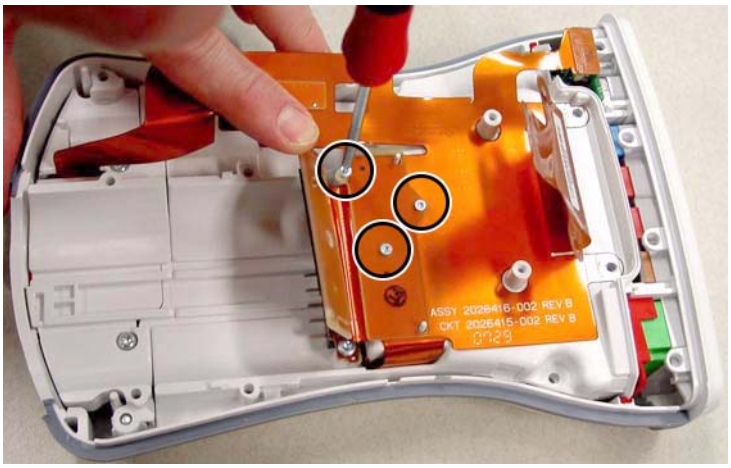
6. Remove the interface gasket.



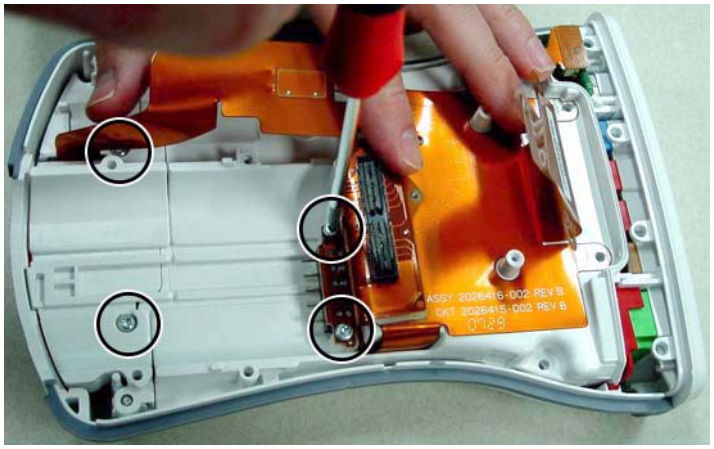
7. Before installing the NIBP assembly with manifold:
   a. Make sure the pump and manifold are fully seated together.
   b. Make sure the gasket is in place.
   c. Position the manifold and pump in the bottom housing and carefully press to seat connector.
   d. Install the screw, then connect the hose. Slide hose all the way onto the manifold fitting so that the hose lays flat.
   e. Make sure the pump is resting between the positioning protrusions.
   f. Complete the procedures in “Recommended checkout” on page 16-52.

6.3.9 Main flex circuit assembly

1. Using a T6 screwdriver, remove the 3 screws from the flex circuit assembly.



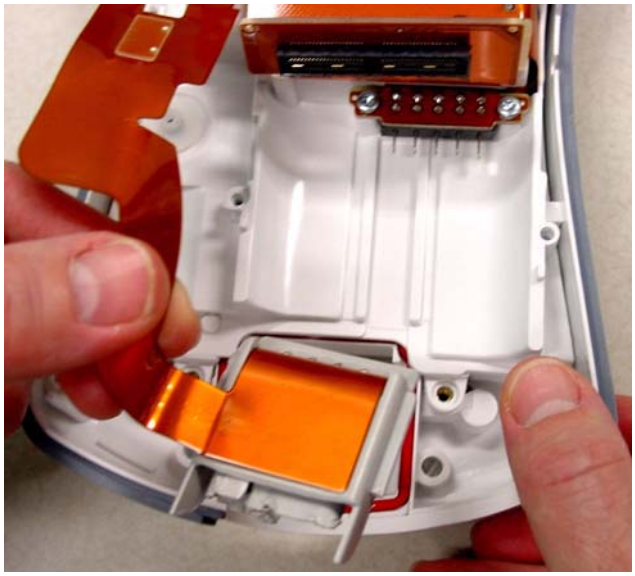
2. Remove the 2 screws holding the battery connector to the bottom housing and the 2 screws holding the DAS rear cover to the bottom housing.



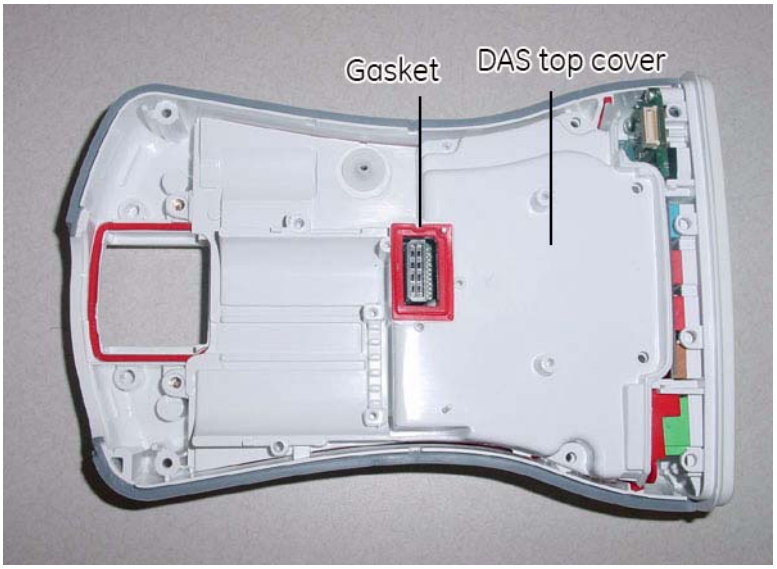
3. Insert a screwdriver under the DAS rear cover, pop up and remove the DAS rear cover.

NOTE: If the DAS rear cover is damaged, replace it with the new cover provided in the FRU kit when reassembling the PDM module. See steps 8 and 9.

4. Remove the ePort connector attached to the flex circuit assembly from the bottom housing.

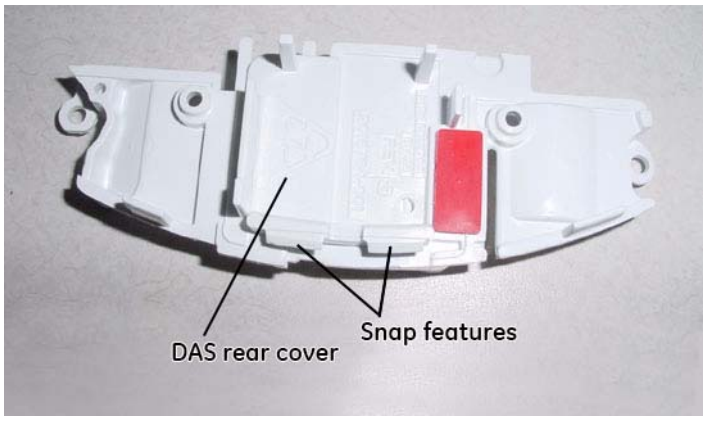


5. Remove the flex circuit assembly from the PDM module.
6. Before installing the replacement flex circuit assembly, ensure that the red gasket (1) is in place on the DAS top cover (2) as shown. (Gasket may remain attached to the removed flex circuit assembly.)

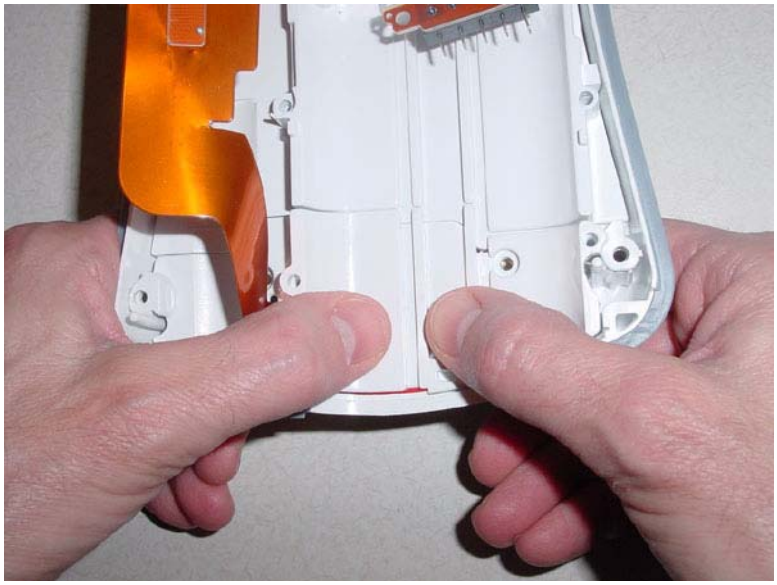


7. Replace the main flex circuit assembly in the reverse order of disassembly.

8. When replacing the DAS rear cover(1) , ensure that the red rectangular gasket is in place as shown below. Note the 2 snap features (2) on the DAS rear cover that secure the DAS rear cover to the bottom housing.



9. Press the DAS rear cover firmly into the bottom housing until the 2 snap features snap into place as shown:



10. After replacing the flex assembly, reassemble the PDM module in the reverse order listed.
11. Go to the Solar 8000M/i patient monitor service manual and complete checkout procedures.

6.4 Recommended checkout

After reassembling the PDM, always complete the electrical safety tests, checkout procedures, calibration tests, and regular maintenance procedures identified and described in this manual.

The following table indicates the recommended calibration and checkout tests to perform after corrective maintenance (FRU replacement).

Part Number	Description	Calibration Tests	Checkout Procedures	Electrical Safety Tests
2031069-002	Battery door and tray	None	None	None
2031069-003	Battery	None	None	None
2031069-004	Patient Data Module mount rail and pull tab	None	None	None
2031069-005	Label kit Nellcor	None	None	None
2031069-006	Label kit Masimo	None	None	None
2031069-007	NBP assembly with MFLD hose	"NIBP" on page 16-26	ECG, respiration, invasive blood pressure, temperature, Masimo or Nellcor OxiMax SpO2 (depending on the PDM SpO2 type), and defib sync/analog output tests in the "Checkout procedure" on page 16-13	Complete Electrical safety tests found in the CARESCAPE Monitor technical manual
2031069-008	NBP MFLD hose, coup only	"NIBP" on page 16-26	ECG, respiration, invasive blood pressure, temperature, Masimo or Nellcor OxiMax SpO2 (depending on the PDM SpO2 type), and defib sync/analog output tests in the "Checkout procedure" on page 16-13	Complete Electrical safety tests found in the CARESCAPE Monitor technical manual
2031069-009	Top housing	None	None	Complete Electrical safety tests found in the CARESCAPE Monitor technical manual

Part Number	Description	Calibration Tests	Checkout Procedures	Electrical Safety Tests
2031069-010	Main CPU (includes software CD)	"NIBP" on page 16-26	ECG, respiration, invasive blood pressure, temperature, Masimo or Nellcor OxiMax SpO2 (depending on the PDM SpO2 type), and defib sync/analog output tests in the "Checkout procedure" on page 16-13	Complete Electrical safety tests found in the CARESCAPE Monitor technical manual
2031069-013	Main Flex Assembly	"NIBP" on page 16-26	ECG, respiration, invasive blood pressure, temperature, Masimo or Nellcor OxiMax SpO2 (depending on the PDM SpO2 type), and defib sync/analog output tests in the "Checkout procedure" on page 16-13	Complete Electrical safety tests found in the CARESCAPE Monitor technical manual

7 Service parts

7.1 Ordering Parts

The parts lists in this section supply enough detail for you to order replaceable parts.

If you require additional information or troubleshooting assistance, contact GE Technical Support.

To order parts, contact GE Healthcare. Contact information is available at www.gehealthcare.com.

7.2 Parts

The table below lists replaceable assemblies that can be ordered.

Item Number	Description
2031069-002	Battery door and tray
2031069-003	Battery
2031069-004	PDM mount rail and pull tab
2031069-005	Label kit Nellcor
2031069-006	Label kit Masimo
2031069-007	NIBP assembly with MFLD hose
2031069-008	NIBP MFLD hose, coup only
2031069-009	Top housing
2031069-010	Main CPU board (includes software CD)
2017098-001 2017098-003 2017098-005	ePort to host interface cable, 5 ft. ePort to host interface cable, 15 ft. ePort to host interface cable, 25 ft.
2021968-001	Fixed mount adapter (Mini dock)
2030340-001	Bedside dock
2030341-001	Transport dock

Maintenance check form

Patient Data Module

1. Complete one sheet per unit.
2. Prior to testing, verify all equipment is calibrated via calibration labeling, and record calibration due date.

Test configuration, conditions and test equipment for unit under test			
Product/Model	**Customer asset tag**	**Serial number**	**Comments**
Maintenance type: Planned maintenance ☐ Corrective maintenance ☐			

Measuring equipment / test gases used					
ID number	**Manufacturer**	**Model number**	**Description**	**Serial number**	**Cal due date**

Test	**Results ✓**	
	Pass	**Fail**
Visual inspection		
Electrical safety tests Refer to the CARESCAPE Monitor technical manual		

Functional tests	**Results ✓**	
What to test?	**Pass**	**Fail**
ECG		
Impedance respiration		
Temperature 1 and 2		
Invasive BP (as required)		
SpO2		
NIBP		
Battery		
NIBP calibration check (if applicable)		
NIBP calibration (if applicable)		
Analog output calibration		
Defib/sync and analog output		

Parts replaced			

Test results ✓		**Signature of tester:**	**Date:**
Pass	**Fail**		

E-modules, PSM module, F5, F7 module frames

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Information Technologies, Inc.
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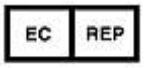

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