

Datex-Ohmeda
S/5™ M-Modules
Technical Reference Manual



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Master Table of Contents

Technical Reference Manual, S/5™ M-Modules

M1025359

For S/5™ Anesthesia Monitor and Critical Care Monitor and S/5™ Compact Anesthesia Monitor and Compact Critical Care Monitor

Document No.	Updated	Updated	Description	
8001008 -6			Hemodynamic Modules, M-NE12STPR, M-NE12STR, M-NE12TPR, M-NESTPR, M-NESTR, M-NETPR, M-ESTPR, M-ESTR, M-ETPR	1
8001009 -5			Compact Airway Modules, M-CAiOVX, M-CAiOV, M-CAiO, M-COVX, M-COV, M-CO, M-C	2
8001010 -4			Tonometry Module, M-TONO	3
8001011 -4			EEG Module, M-EEG and EEG Headbox, N-EEG	4
8001012 -4			Cardiac Output Modules, M-COP and M-COPSv	5
8001013 -4			Pressure Module, M-P, Pressure Temp Module, M-PT	6
8001014 -4			Dual Pressure Module, M-PP	7
8001015 -5			NIBP Module, M-NIBP	8
8001016 -3			Recorder Module, M-REC	9
8005426 -1			Oxygen Saturation Modules, M-NSAT, M-OSAT	10
8001018 -4			NeuroMuscular Transmission Module, M-NMT	11
8003840 -1			Anesthesia recordkeeping keyboard for, K-ARKB, Keyboard Interface Board, B-ARK and ARK Barcode Reader, N-SCAN	12
8001020 -5			Memory Module, M-MEM	13
8001021 -4			Interface Module, M-INT	14
8005676			Device Interfacing Solution, N-DISxxx	15
8003476-2			BIS Module, M-BIS	16
8003934-1			Remote Controllers, K-REMCO, K-CREMCO	17
8003487-3			Single-width Airway Module, M-miniC	18
8004390			Entropy Module, M-ENTROPY	19
8005571-1			PRETSN Module	20
8001005-5			Airway Modules, G-AiOV, G-AiO, G-AOV, G-AO, Gas Interface Board B-GAS	21

INTRODUCTION

This Technical Reference Manual provides information for the maintenance and service of the Datex-Ohmeda S/5™ M-Modules, record keeping keyboard, remote controllers and Device Interfacing System. These Datex-Ohmeda devices are designed for use with S/5™ Anesthesia Monitor, S/5™ Critical Care Monitor, S/5™ Compact Anesthesia Monitor, and S/5™ Compact Critical Care Monitor.

Please see also the *Technical Reference Manual* of the S/5 monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

For more detailed information about compatibility with different monitor software types and levels see the "Introduction" chapter of the slot of the module or other device.



S/5™ parameter modules, Device Interfacing Solution, Record keeping keyboard and Remote Controller

Notes to the reader

This Technical Reference Manual is intended for service personnel and engineers who will perform service and maintenance procedures on the Datex-Ohmeda S/5 Anesthesia Monitor, S/5 Critical Care Monitor, S/5 Compact Anesthesia Monitor or S/5 Compact Critical Care Monitor.

This Technical Reference Manual completes the Technical Reference Manual of the S/5 Anesthesia Monitor and S/5 Critical Care Monitor or S/5 Compact Anesthesia Monitor and S/5 Compact Critical Care Monitor.

- Document number M1025359 is the order number for the whole printed manual. This manual includes Technical Reference Manual Slots and every slot has own document number.
- The Technical Reference Manual, S/5 Modules gives detailed descriptions of parameter modules and other products that can be used with all S/5 modular monitors. Service check for each product is included in these slots.

For monitor or system specific information see:

The Technical Reference Manual of the S/5 Anesthesia Monitor and S/5 Critical Care Monitor or

The Technical Reference Manual of S/5 Compact Anesthesia Monitor and S/5 Compact Critical Care Monitor.

The manufacturer reserves the right to change product specifications without prior notice. Although the information in this manual is believed to be accurate and reliable, the manufacturer assumes no responsibility for its use.

GE Healthcare Finland Oy (GE) assumes no responsibility for the use or reliability of its software in equipment that is not furnished by GE.

Conventions used

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



Sign the check form after performing the procedure.

Hard Keys

Hard key names on the Command Board, the Remote Controller, and modules are written in bold D-O Sans (12 pt) typeface, e.g. **ECG**.

Menu Items

Menu items are written in bold italic, D-O Sans (11 pt) typeface, e.g. ***ECG Setup***.

'Messages'

Messages displayed on the screen are enclosed in single quotes, e.g. 'Please wait'.

Chapters

When referring to different chapters in the same manual, the chapter name is written in italic typeface and is enclosed in double quotes, e.g. chapter "*Cleaning and Care*."

Other documents

When referring to different documents, the document name is written in italic typeface, e.g. refer to *User's Reference Manual*.

Hypertext links

Hypertext links on PDF versions are written in blue color.

WARNING

Warnings are written in bold typeface (13 pt), for example:

WARNING

Use only hospital-grade electrical outlets and power cord.

CAUTION

Cautions are written in the following way (13 pt):

CAUTION

The circuit boards contain sensitive integrated circuits that can be damaged by an electrostatic discharge. Careful handling of the boards is therefore essential.

Datex-Ohmeda Hemodynamic modules
S/5™ NE12STPR Module, M-NE12STPR (rev. 02)
S/5™ NE12STR Module, M-NE12STR (rev. 02)
S/5™ NE12TPR Module, M-NE12TPR (rev. 02)
S/5™ NESTPR Module, M-NESTPR (rev. 01)
S/5™ NESTR Module, M-NESTR (rev. 01)
S/5™ NETPR Module, M-NETPR (rev. 01)
S/5™ ESTPR Module, M-ESTPR (rev. 04)
S/5™ ESTR Module, M-ESTR (rev. 04)
S/5™ ETPR Module, M-ETPR (rev. 04)

Technical Reference Manual Slot



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TABLE OF CONTENTS

HEMODYNAMIC MODULES

TABLE OF CONTENTS	i
Table of figures	iii
Introduction	1
1 Specifications	3
1.1 General specifications	3
1.2 Typical performance	3
1.2.1 NIBP	3
1.2.2 ECG	4
1.2.3 Pulse oximetry	4
1.2.4 Temperature	5
1.2.5 Invasive blood pressure	5
1.2.6 Respiration	5
1.3 Technical specifications	6
1.3.1 NIBP	6
1.3.2 ECG	6
1.3.3 Pulse oximetry	7
1.3.4 Temperature	7
1.3.5 Invasive blood pressure	7
1.3.6 Respiration	7
2 Functional Description	8
2.1 Measurement principle	8
2.1.1 NIBP	8
2.1.2 ECG	8
2.1.3 Pulse oximetry	8
2.1.4 Temperature	10
2.1.5 Invasive blood pressure	11
2.1.6 Respiration	11
2.2 Main components	11
M-ESTPR/-ETPR/-ESTR modules	11
M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR modules	12
2.2.3 NIBP board	13
2.2.4 ECG board in 3-and 5-lead measurement	15
2.2.5 ECG board in 12-lead measurement	17
2.2.6 ECG filtering	19
2.2.7 STP board	20
2.3 Connectors and signals	25
2.3.1 Module bus connector	25
2.3.2 Front panel connectors	26
2.3.3 Test points on boards	27
3 Service Procedures	29
3.1 General service information	29
3.2 Service check	29

3.2.1	Recommended tools	29
3.2.2	Recommended parts	29
3.3	Disassembly and reassembly	40
3.3.1	M-ESTPR, M-ESTR, and M-ETPR modules	40
3.3.2	M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR modules	40
3.4	Adjustments and calibrations	41
3.4.1	Pressure safety level detection "OFFSET"	41
3.4.2	NIBP calibrations	41
3.4.3	Temperature calibration	43
3.4.4	Invasive pressure calibration	43
4	Troubleshooting	45
4.1	Troubleshooting charts	45
4.1.1	NIBP	45
4.1.2	NIBP error code explanation	48
4.1.3	ECG	49
4.1.4	Pulse oximetry (SpO ₂)	49
4.1.5	Temperature	50
4.1.6	Invasive blood pressure	51
4.1.7	Impedance respiration	52
4.2	Troubleshooting flowcharts	53
4.2.1	M-NE12STPR and M-NESTPR module troubleshooting	53
4.2.2	M-ESTPR, M-ESTR, and M-ETPR module troubleshooting	54
5	Service Menu	55
5.1	NIBP service menu	56
5.1.1	NIBP demo menu	57
5.1.2	NIBP calibration menu	58
5.1.3	NIBP safety valve menu	59
5.1.4	NIBP pulse valve menu	60
5.1.5	NIBP buttons/leds menu	61
5.1.6	NIBP pneumatics menu	62
5.1.7	NIBP watchdog menu	63
5.2	ECG service menu	64
5.2.1	ECG setup menu	66
5.3	STP service menu	67
5.3.1	STP calibration menu	69
6	Spare Parts	70
6.1	Spare parts list	70
6.1.1	M-ESTP rev. 01, M-ETP rev. 00, M-EST rev. 00	70
6.1.2	M-NESTPR rev. 00, M-NETPR rev. 00, M-NESTR rev. 00	74
6.1.3	M-NE12STPR rev. 00, M-NE12STR rev. 00, M-NE12TPR rev. 00	78
7	Earlier Revisions	81
APPENDIX A		83
Service Check Form		1

TABLE OF FIGURES

Figure 1	S/5 NE12STPR Module, M-NE12STPR	1
Figure 2	Absorption of infrared light in the finger probe parts layout and schematic diagram	10
Figure 3	Front panel of M-ESTPR	11
Figure 4	Front panel of M-NESTPR	12
Figure 5	NIBP board functional block diagram	13
Figure 6	3- and 5- lead ECG board block diagram	15
Figure 7	12-lead ECG measurement block diagram	17
Figure 8	STP board block diagram	20
Figure 9	Temperature measurement principle	21
Figure 10	Pressure measurement principle	21
Figure 11	Pulse oximetry measurement block diagram	22
Figure 12	Serial communication and opto isolation of M-NESTPR/-NE12STPR	23
Figure 13	Serial communication and opto isolation of M-ESTPR	24
Figure 14	Module bus connector (X1) pin layout	25
Figure 15	M-NE12STPR and M-NESTPR module troubleshooting flowchart	53
Figure 16	M-ESTPR Module Troubleshooting Flowchart	54
Figure 17	Exploded view of M-ESTP Module	70
Figure 18	Exploded view of M-NESTPR Module	74
Figure 19	Exploded view of M-NE12STPR Module	78

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INTRODUCTION

This Technical Reference Manual Slot provides information for the maintenance and service of the hemodynamic modules. The S/5 M-ESTPR/-ESTR/-ETPR and S/5 M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR are double width modules designed for use with S/5 monitors. Later in this manual modules may be referred to w/o the system name S/5 for simplicity.

Please refer to the *Technical Reference Manual* of the S/5 monitor for information related to system e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The M-ESTPR/-ESTR/-ETPR and M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR modules provide general hemodynamic parameters



Figure 1 S/5 NE12STPR Module, M-NE12STPR

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

M-ESTP/-EST/-ETP,
M-ESTPR/-ESTR/-ETPR,
M-NESTPR/-NESTR/-NETPR,
M-NE12STPR/-NE12STR/-NE12TPR

Table 1 Options of S/5 hemodynamic modules

	Parameter	NE12STPR	NESTPR	NE(12) STR	NE(12) TPR	ESTPR	ESTR	ETPR
12	12-lead ECG	•		(•)	(•)			
N	NIBP	•	•	•	•			
E	ECG	•	•	•	•	•	•	•
S	Pulse oximetry	•	•	•		•	•	
T	Two temperatures	•	•	•	•	•	•	•
P	Two invasive blood pressures	•	•		•	•		•
R	Impedance respiration	•	•	•	•	•	•	•

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

NOTE: M-ESTP rev. 01, M-EST rev. 00 and M-ETP rev. 00 work only with S-STD93, S-STD94, S-ARK94, S-STD95, S-ARK95, S-STD96 and S-ARK96 software.

1 SPECIFICATIONS

1.1 General specifications

Module size	75 × 180 × 112 mm
W × D × H	3.0 × 7.1 × 4.4 in
Operation temperature	10 to 40 °C / 50 to 104 °F

@ M-ESTPR/-ETPR/-ESTR

Module weight	0.6 kg / 1.3 lbs
Power consumption	6 W

@ M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR

Module weight	1 kg
Power consumption	about 9 W

1.2 Typical performance

1.2.1 NIBP

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

Oscillometric measurement principle.

Measurement range	adult	25 to 260 mmHg
	child	25 to 195 mmHg
	infant	15 to 145 mmHg
Pulse rate range accepted	30 to 250 bpm	
Measurement interval	1, 2.5, 3, 5, 10, 15, 30, 60 min (=1h), 2h, 4h	
Typical measuring time	adult	23 s
	infant	20 s
Initial inflation pressure	adult	185 ± 10 mmHg
	child	150 ± 10 mmHg
	infant	120 ± 10 mmHg
Venous stasis	adult	80 ± 10 mmHg / 2 min.
	child	60 ± 10 mmHg / 2 min.
	infant	40 ± 10 mmHg / 1 min.
Cuff widths	please see <i>User's Guide</i>	

1.2.2 ECG

Lead selection, 12-lead ECG	I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6
Lead selection, other modules	I, II, III, aVR, aVL, aVF, V
Sweep speeds	12.5, 25, 50 mm/sec

DISPLAY FILTER

Diagnostic, 12-lead ECG	0.05 to 150 Hz
Diagnostic, other modules	0.05 to 100 Hz
Monitoring	0.5 to 30 Hz (-3 dB, with 50 Hz reject filter) 0.5 to 40 Hz (-3 dB, with 60 Hz reject filter)
ST filter	0.05 to 30 Hz (-3 dB, with 50 Hz reject filter) 0.05 to 40 Hz (-3 dB, with 60 Hz reject filter)

HEART RATE FROM ECG

Range	30 to 250 bpm
Accuracy	± 5 bpm or ± 5 %, whichever is greater
Resolution	1 bpm
Update interval	5 s
Averaging time	10 s

ST LEVELS (in main software)

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

SYNCHRONIZATION

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

1.2.3 Pulse oximetry

Measurement range	40 to 100 %
Accuracy	100 to 80 %, ± 2 digits
(% SpO ₂ ± 1 SD) ¹	80 to 50 %, ± 3 digits 50 to 40 %, unspecified
Display resolution	1 digit = 1 % of SpO ₂
Display averaging time	20, 10 sec, beat-to-beat
Pulse beep pitch	varies with SpO ₂ level

The monitor is calibrated over the measurement range against functional saturation SpO₂ func.

PULSE RATE FROM PLETH

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

¹ 1 SD (standard deviation) = 68 % of all readings in the specified range in stable conditions.

Adjustable pulse beep volume.

PLETH WAVEFORM

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

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

1.2.4 Temperature

Measurement range 10 to 45 °C (50 to 113 °F)
(In rev. ESTP 03/ EST 02/ETP 02 or earlier: 15 to 45 °C (59 to 113 °F))

Measurement accuracy ± 0.1 °C (25 to 45.0 °C)
 ± 0.2 °C (10 to 24.9 °C)

Display resolution 0.1 °C (0.1 °F)

Temperature test automatic (every 10 min)

Probe type compatible with YSI 400 series

1.2.5 Invasive blood pressure

Measurement range -40 to 320 mmHg

Measurement accuracy ± 2 mmHg or ± 5 %

Zero adjustment range ± 150 mmHg

Calibration range ± 20 %

Scales upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10 % of selected upper limit below zero.

Sweep speed 12.5, 25, 50 mm/s

DIGITAL DISPLAY

Range -40 to 320 mmHg

Resolution ± 1 mmHg

WAVEFORM DISPLAY

Range -30 to 300 mmHg

PULSE RATE FROM ARTERIAL PRESSURE

Measurement range 30 to 250 bpm

Resolution 1 bpm

Accuracy ± 5 bpm or ± 5 % whichever is greater

1.2.6 Respiration

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

Measurement range 4 to 120 bpm

Accuracy ± 5 bpm or ± 5 %

Resolution 1 bpm

Averaging time 30 s

Update interval 10 s

RESPIRATION WAVEFORM

Sweep Speeds 6.25 mm/s and 0.625 mm/s

1.3 Technical specifications

1.3.1 NIBP

Deflation rate, PR dep.	5 to 13 mmHg/s	
Inflation time	20 to 185 mmHg, 1 to 5 s	
Automatic software control, max. inflation pressure		
	adult	280 ±10 mmHg
	child	200 ±10 mmHg
	infant	150 ±10 mmHg
Over pressure limit, stops measurement after 2 seconds		
	adult	320 mmHg
	child	220 mmHg
	infant	165 mmHg

The safety valve limits the maximum cuff pressure to 320 mmHg in adult/child mode or 165 mmHg in infant mode. Independent timing circuit limits pressurizing (>15 mmHg) time to 2 minutes 10 seconds maximum in adult/child mode, and 1 minute 5 seconds in infant mode.

Zeroing to ambient pressure is done automatically.

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

Max. measurement time	adult	2 min
	child	2 min
	infant	1 min

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

Max. error ±4 mmHg.

Protection against electrical shock	Type BF defibrillation proof
-------------------------------------	------------------------------

1.3.2 ECG

Defibrillation protection	5000 V, 360 J
Recovery time	2 s
Input impedance	>2.5 MΩ (10 Hz)
CMRR	>100 dB (ST)
System noise	<40 μV (p-p, RTI)
Allowable offset	±300 mVDC
Gain range	0.2 to 5.0 cm/mV
Pacemaker pulse detection	2 to 500 mV, 0.5 to 2 ms pulses
Protection against electrical shock	Type CF defibrillator proof

1.3.3 Pulse oximetry

Protection against electrical shock	Type BF defibrillation proof
-------------------------------------	------------------------------

1.3.4 Temperature

Measurement accuracy	$\pm 0.1\text{ }^{\circ}\text{C}$ (25.0 to 45.0 $^{\circ}\text{C}$) $\pm 0.2\text{ }^{\circ}\text{C}$ (10.0 to 24.9 $^{\circ}\text{C}$)
----------------------	--

Protection against electrical shock	Type CF defibrillation proof
-------------------------------------	------------------------------

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

1.3.5 Invasive blood pressure

DIGITAL DISPLAY AVERAGING

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

Accuracy	$\pm 5\%$ or $\pm 2\text{ mmHg}$, whichever is greater
----------	---

Transducer and input sensitivity	5 $\mu\text{V/V/mmHg}$
----------------------------------	------------------------

Input voltage	5VDC max current 20 mA
---------------	---------------------------

Filter	0 to 4 - 22 Hz adjustable
--------	---------------------------

Zero set accuracy	$\pm 1\text{ mmHg}$
-------------------	---------------------

Calibration resolution	$\pm 1\text{ mmHg}$
------------------------	---------------------

Zero time	less than 15 s
-----------	----------------

Protection against electrical shock	Type CF defibrillation proof
-------------------------------------	------------------------------

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

1.3.6 Respiration

Excitation frequency, 12-lead ECG	62.5 kHz
Excitation frequency, other modules	31.25 kHz
Breath detection	automatic, range 0.3 to 6 Ω manually adjustable minimum detection: 0.2, 0.4, 0.6, 0.8, 1.0
Input dynamic range	0.2 to 6 Ω
Input impedance range	100 to 5000 Ω
Respiration Rate	min. 4 bpm max. 120 bpm
Lead off detection	>3 M Ω

2 FUNCTIONAL DESCRIPTION

2.1 Measurement principle

2.1.1 NIBP

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

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

The following parts are necessary for the NIBP measurement:

- M-NE12STPR/-NE12STR/-NE12TPR/-NESTPR/-NESTR/-NETPR (or M-NIBP) module
- twin hose (adult or infant model)
- blood pressure cuffs (various sizes)

2.1.2 ECG

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

ECG reflects:

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

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

2.1.3 Pulse oximetry

A pulse oximeter measures the light absorption of blood at two wavelengths, one in the near infrared (about 900 nm) and the other in the red region (about 660 nm) of the light spectrum. These wavelengths are emitted by LEDs in the SpO₂ 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 (SpO₂) using an empirically determined relationship between the relative absorption at the two wavelengths and the arterial oxygen saturation SaO₂.

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 $SaO_2\text{frac}$;

$$SaO_2\text{frac} = \frac{HbO_2}{HbO_2 + Hb + Dys\text{hemoglobin}} \quad \textbf{Formula 1}$$

or against functional saturation $SaO_2\text{func}$;

$$SaO_2\text{func} = \frac{HbO_2}{HbO_2 + Hb} \quad \textbf{Formula 2}$$

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

The oxygen saturation percentage SpO_2 measured by the Datex-Ohmeda module is calibrated against functional saturation $SaO_2\text{func}$. The advantage of this method is that the accuracy of SpO_2 measurement relative to $SaO_2\text{func}$ 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.

Probe

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 Datex-Ohmeda.

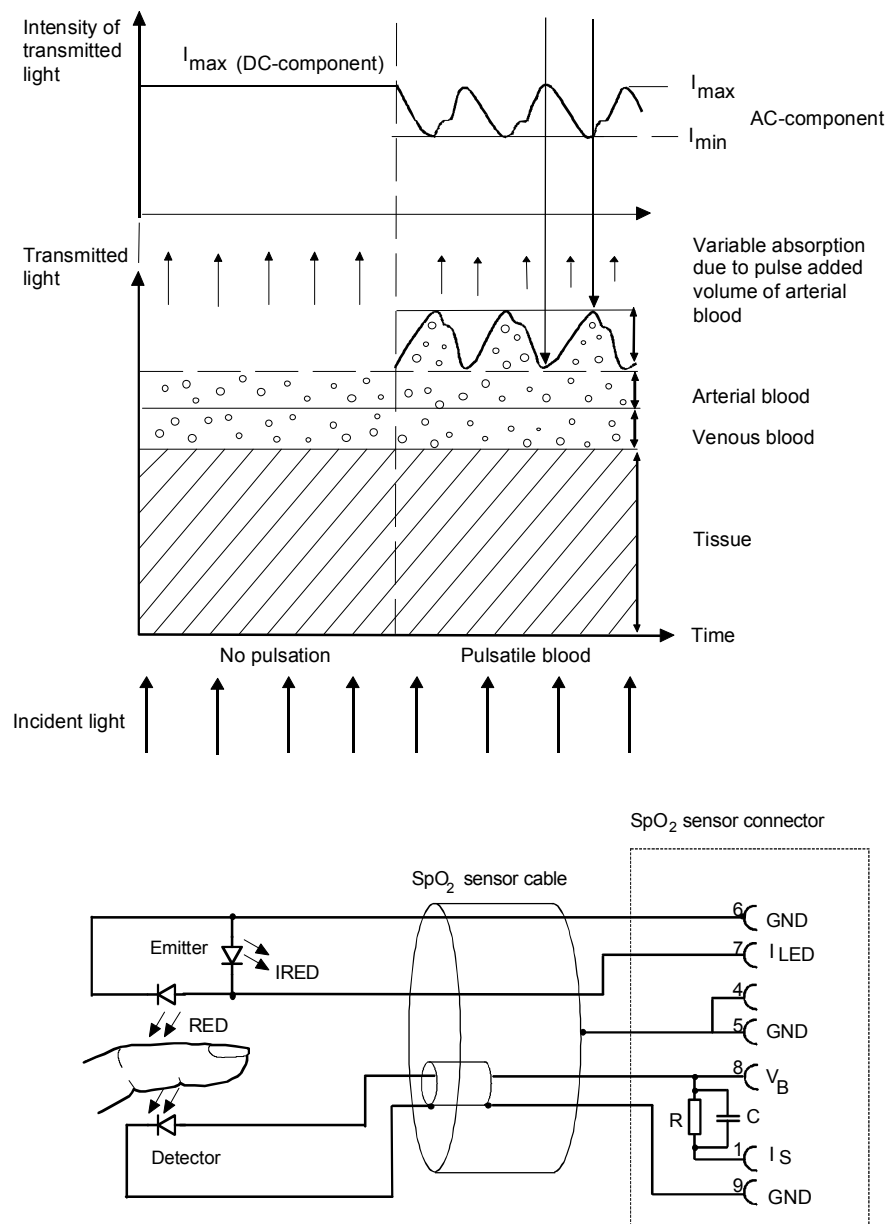


Figure 2 Absorption of infrared light in the finger probe parts layout and schematic diagram

2.1.4 Temperature

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

The resistance can be measured by two complementary methods:

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

generated across it.

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

2.1.5 Invasive blood pressure

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

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

2.1.6 Respiration

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

2.2 Main components

2.2.1 M-ESTPR/-ETPR/-ESTR modules

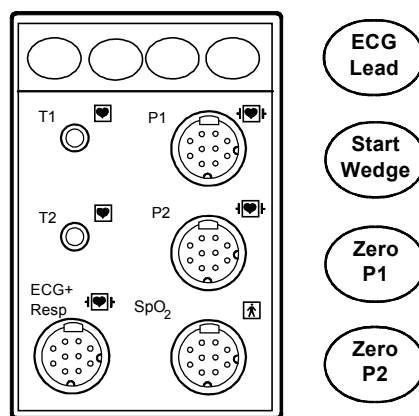


Figure 3 Front panel of M-ESTPR

The **M-ESTPR**, **M-ETPR**, and **M-ESTR** modules contain two main PC boards, the STP board and the ECG board. They work independently. Both of them have their own processor and software EPROM. Some components on the boards are not used in ETPR and ESTR modules.

In the **M-ESTPR** module, additionally, there are two small boards, the SP input and the ECG input boards, attached to the front panel of the module. The front panel has six connectors and four keys.