HP 783XX Series and HP 788XX Series

Service Manual - Volume 1

Patient Monitors and Neonatal Monitors

HEWLETT PACKARD

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Printing History

New editions are complete revisions of the manual. Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by the customer. The dates on the title page change only when a new edition or a new update is published.

Preface

This manual covers the following models:

- MODELS 78352A/78352C/78353A/78353B/78354A/78354C PATIENT MONITORS
- MODELS 78832A/78833A/78833B/78834A/78834C NEONATAL MONITORS
- MODEL 78356A GAS MONITOR

The contents of this manual (Volume One) apply to HP Models 78352A/C, 78353A, 78353B, 78354A and 78354C series, 78832A, 78833A, 78833B, 78834A/C series, and 78356A with the following serial numbers prefixed:

MODELS	PREFIX	MODEL	PREFIX
78352A	2640G	78832A	2412G
78352C	First Issue	78833A	2413G
78353A	2348G	78833B	2610G
78353B	2612G	78834A	2611G
78354A	2613G	78834C	First Issue
78354C	First Issue		
78356A	2717G		

Instruments with higher serial numbers may contain production changes. In such cases refer to the Manual Change sheets and Publication Change Notices enclosed with this manual.

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CONTENTS OVERVIEW

This manual contains service information for the Hewlett-Packard 78352/3/4, 78832/3/4 and 78356A monitors. The information is divided into two sections:

- Chapter 1 — Theory of Operation
- Chapter 2 — Maintenance Checks
  - Chapter 2a — Performance Assurance Checks
  - Chapter 2b — Specification Checks
  - Chapter 2c — Technical Specifications for all Monitors

Further sections covering disassembly and reassembly of the monitor, switch programming and adjustments, schematic diagrams and replaceable parts lists, are contained in Volume 2 of the manual (part number 78354-90010).

Documentation relating to these monitors:

Instrument	Document	Part Number
78352A	Operating Guide	78352-90001
78353B/4A	Operating Guide	78354-90001
78352C/4C	Operating Guide	78354-92001
78352A/2C/3B/4A/4C	Installation Guide	78354-90011
78833B/4A	Operating Guide	78834-91001
78834C	Operating Guide	78834-92001
78833B/4A/4C	Installation Guide	78834-90011
78356A	Operating Guide	78356-90001
78356A	Installation Guide	78356-90011

Note

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78352A }
78352C } monitors are      and  78832A } monitors are
78353A } referred to            78833A } referred to
78353B } in text as             78833B } in text as
78354A } 783XX Series           78834A } 788XX Series
78354C }                        78334C }
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Special Notation

Notes, cautions, and/or warnings may accompany the instructions in this manual. They are defined below:

Note

Notes provide emphasis to information or additional information "off line" from a procedure.

Caution

Cautions highlight procedures that must be followed to avoid damage to the recorder.

Warning

Warnings highlight procedures that must be followed to avoid hazards to human life or safety.

Contents

2. Maintenance Checks

2a. Performance Assurance Checks

2b. Specification Checks

2c. Technical Specifications for all Monitors

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1

Theory Of Operation

Introduction

This section contains an overall functional description of the following monitors:

- 78352A,78352C,78353A,78353B,78354A,78354C series of adult monitors
- 78832A,78833A,78833B,78834A,78354C series of neonatal monitors
- 78356A gas monitor

Also, more detailed descriptions of the individual sub-assemblies are contained in this section.

Functional description

The measured physiological signals are routed directly to the parameter board, where they are amplified and then A/D converted. The digital information is processed by the parameter board microprocessor. The digital section of the Parameter Board contains the microprocessor, the ROM storing the parameter program and a general purpose memory (RAM).

The results of the parameter processing are transferred to the shared memory. Here they are accessed by the display microprocessor for further processing. The shared memory, which is located on the Display uP Board, is used to store all parameter and waveform information. This information is used by the display microprocessor to update the wave RAM and the numerics RAM.

The wave information is routed from the display microprocessor through a D/A converter to the Interpolation Board. At the same time, alphanumeric information from the numerics RAM (character generator) is parallel-serial converted. The video driver on the Mother Board combines these two signals to drive the CRT. The CRT controller on the Display uP Board triggers the driver circuits on the Mother Board.

Data entered via the keyboard (e.g. alarm limits, lead configuration) is passed via the display microprocessor and stored in the shared memory, where it is accessed by the parameter board for appropriate action. When the parameter board reports back that the action has been carried out, the data is passed to the Display Board microprocessor, which initiates the appropriate display.

Shared Memory and Data Transfer

General

Data transfer in the 783XX series, the 788XX series and the 78356A is carried out via a common memory area, to which all function blocks have access. This common memory is the Shared Memory chip U40 on A2 Display uP board. The local bus systems are separated from the main shared memory bus by tri-state buffers.

Power Fail

In the event of power fail the configuration of the instrument at the time of power fail is held in the shared memory for 15 seconds.

Time Slices

In order to prevent collisions in the main bus, each function block is assigned a defined 2 ms time slice within the 20 ms CRT frame period. In this time slice it has sole right of access to the shared memory.

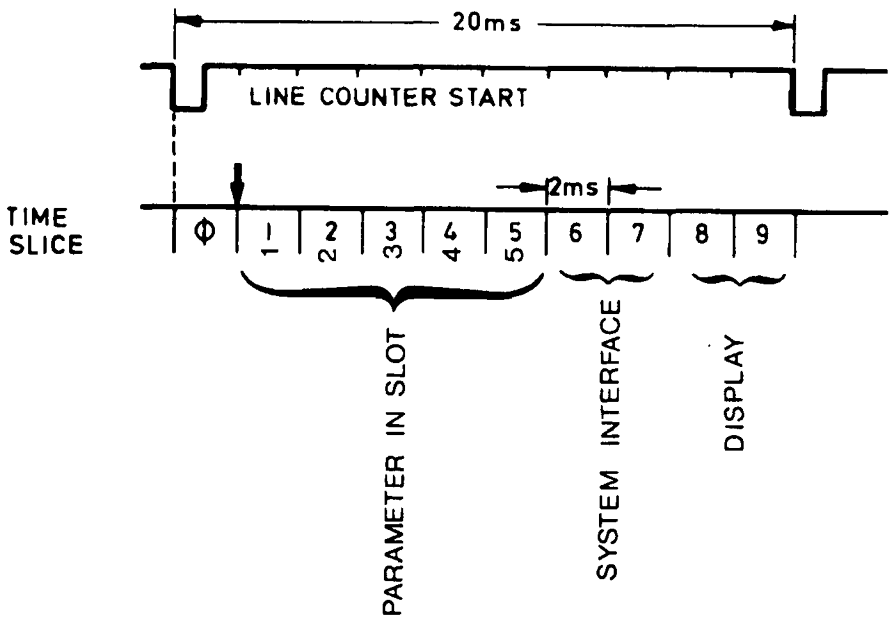

Figure 1-1. Allocation of Function Blocks to Time Slices

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Figure 1-2. Shared Memory System

Mother Board 78353-66501 and 78354-66501

The Mother Board contains the video circuits for the display and the interconnections between the boards which are slotted into the respective connectors on the board.

The main functions of the Mother Board are listed below:

1. Interconnection of boards slotted into the mother board
2. Video amplifier
3. Horizontal deflection circuits (slow sweep driver)
4. Vertical deflection circuits (fast sweep driver)
5. High-voltage circuits
6. Power-on reset
7. 5-V buffering

The monitor display is a raster scanned CRT. It utilizes magnetic deflection and is refreshed at a rate of 50 Hz. The CRT displays 720 vertical lines and operates at a vertical sweep frequency of 40 kHz. The Display uP Board supplies the horizontal sync signal (SLOW SYNC), the vertical sync signal (FAST SYNC) and the video drive signals to the Mother Board.

Video Amplifier

Four waveform video inputs (4/4, 3/4, 2/4, 1/4) and two numerics inputs (VIDEO NUM, VIDEO NUM INVERSE) are applied to the video amplifier circuits (U2, U3). The waveform and the numerics signals are applied to the CRT alternately. The positive 70 V supply for the video amplifier is taken from the high voltage circuits. It is fed directly to the cathode voltage regulator circuit, which also contains the black level adjust capability.

The basic trace intensity is dependent on the signal from the front-panel photo resistor and the setting of the brightness potentiometer (R24 on the Audio Board).

Horizontal Deflection Circuit

The slow horizontal sweep driver circuit generates a ramp (amplitude) which drives the horizontal deflection yoke. This circuit is contained in integrated circuit U5.

The oscillator in U5 is synchronized by a positive-going pulse at pin 2 (SLOW SYNC signal). Synchronization is inhibited during flyback time. The oscillator frequency is set with potentiometer R21. The linearity can be adjusted with potentiometer R22. A + 17 V supply is applied to Pin 8. Pin 9 provides the output to the deflection coil.

Vertical Deflection Circuit

The fast vertical sweep driver circuit utilizes the FAST SYNC signal from the Display uP Board (A2) to develop a ramp (amplitude) which drives the vertical deflection yoke and in turn deflects the cathode ray from the bottom of the screen to the top (18 us) and then quickly back to the bottom (7 us). L2 is used to adjust the picture height and L3 the linearity.

High Voltage Circuits

The flyback transformer T1 is used to generate the high voltages required by the CRT and the video amplifier.

The five supplies are:

1. A positive voltage of 10 kV for electron acceleration. This is the anode voltage.
2. A positive 100 V supply for grid G2 of the CRT.
3. A positive 300 V supply for grid G4 of the CRT (focus).
4. A supply of virtual 0 V for grid G1 of the CRT.
5. A positive 70 V supply for the video amplifier.

Control of the focus and black level is obtained by dividing the supply down with resistor chains. Both of these chains have potentiometers in them so that adjustments can be made. (R38 for focus and R55 for black level).

Power-On Reset

A power-on reset signal is generated from the + 5 V supply via U10A, B and associated components. It is used to reset all CPUs in the instrument.

5 V Buffering

The power-on reset signal and +5 V are applied to transistors Q11 and Q10, respectively, to generate the buffered + 5 V for use on the Display uP Board (A2) This is used in the event of power fail to save stored data for approximately 15 s.

Extender Board

The extender board (78354-66504) in the full modules 78354A/C and 78834A/C, the instrument is connected to the mother board with ribbon cables, and supports additional parameters.

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Figure 1-3. Mother Board Block Diagram

Display uP Boards 78353-66502 (16K byte), 78354-66502 (40K byte) 78354-66602 and 78354-66702 (48K byte)

The Display uP Board is the heart of the instrument. It contains the following functions:

1. Shared memory
2. Character generation (numerics)
3. Slow/fast sync. signal generation
4. Clock generation
5. 20 ms and 2 ms interrupt signal generation
6. Alarm trigger generation
7. Power fail circuit
8. Keyboard handling

The shared memory and data transfer are already described in "Shared Memory and Data Transfer".

Character Generation

The screen has a capacity of 30 small characters or 15 large characters in horizontal direction and 18 small characters or 9 large characters in vertical direction (4 small characters can be joined together to make 1 large character). The screen is thus divided up into a maximim of 540 small characters. Each character position is definedby a specific address. The hexadecimal addresses begin at the bottom left of the screen with address 000H, progress up to the top left (address 012H) and finish at the top right of the screen with address 21BH.

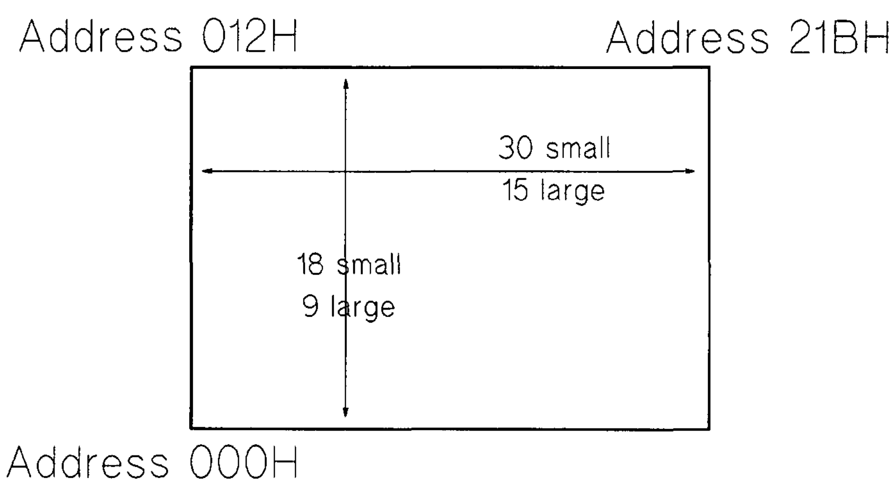


Figure 1-4. Address/Character Distribution on the screen

With each address from the CRT controller U20, the numerics RAM Ul6 passes information on the character to be displayed to latch U18 (6-bit ASCII data information code for character definition, plus one bit to define whether large or small character and one bit to define whether inverse or not).

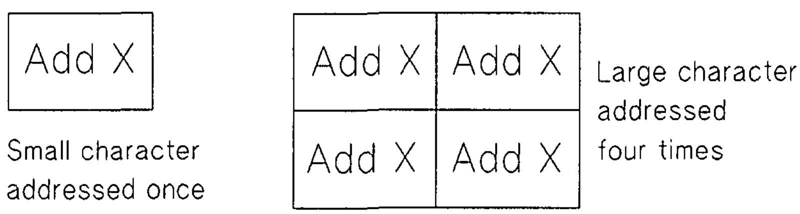
The 10-bit data is passed to the character generator U12: the 6-bit character information, the 3 bits from the column counter and the inverse bit. The data from the character generator is then latched into the parallel-serial shift register U11 for output to the video circuits on the Mother Board.

The sweep is delayed by two clock signals so that it does not start until the character information has reached the parallel-serial shift register U11; i.e. with one clock pulse, address 1 data is latched into the parallel-serial register, address 2 data is latched into U18 and address 3 data presented to the numerics RAM from the CRT controller.

The CRT controller U20 is programmed to provide 24 fast sweeps per row of addresses. The character size information is passed to column counter U14 to determine the number of fast sweeps per column. With an 8x8 dot matrix per small character, this gives 3 fast sweeps for every column for a small character, and 6 fast sweeps for every column for a large character.

The character size information is also passed to the load and clock multiplexer. The shift rate for small characters is twice as high as the shift rate for the large characters. In the wave area the characters are smaller than in the numeric area, 4x6 dot matrix instead of 5x7 dot matrix. All characters in the wave area and the inverse characters in the numeric area are displayed with half intensity.

Information from the CPU can only be written into the numerics RAM during the 2 ms horizontal retrace time. For large characters the ASCII information is written into the numerics RAM four times altogether.



Slow/fast Sync. Signal Generation

The CRT controller U20 also provides the slow sync. and the fast sync. signals for the video circuits on the Mother Board and the display enable (DE) signal for the interpolation circuits on A3.

Clock Generation

Clock chip U1 provides the clock signal for the clock divider U6. The clock signals generated here are used in the entire instrument.

2 ms Interrupt Signal Generation

The 2 ms interrupt circuit U2, U3, U8 is used to generate the shared memory access timing signals.

Alarm Trigger Generation

The CPU generates the QRS, alarm and INOP trigger signals and latches these from the data bus into U32 (alarm latch). U32 passes the trigger signals to the Audio Board for further processing.

Power Fail Circuit

In the event of power fail, the shared memory, U40, is buffered for at least 15 s. If power returns after these 15 s, the power fail signal is delayed (30 ms after the reset signal). This creates a power-on reset, i.e. instrument set-up is reconfigured. If power returns before the 15 s are up, the instrument set-up is maintained.

Display Software

The Display software contains the following modules:

- Initialisation of CRT controller
- Self tests (ROM/RAMS/sounds test) and error handling
- Service tests (CRT adjust, wave interpolation check)
- Keyboard handling
- Soft key labeling
- Display editing
- Processing and issuing of alarms
- Wave handling (wave addressing, wave RAM loading, erase
- bar control)
- Communication with the parameter software via the common shared memory

The display software is contained in one 32K x 8 EPROM (U26), and in one 8K x 8 EPROM (U50) on board 78354-66502, in one 16K EPROM (U50) on boards 78354-66602 and 78354-66702.

Note 78353-66502 Board U26 is 16K x 8,

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U47,U52,U54 and U55}
-              }
PON RESET           } not included
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Figure 1-5. Display Microprocessor Board Block Diagram

Single Channel Interpolation Board 78352-66503

The Interpolation Board contains most of the control circuit for generating the video pulses for the waveform display.

The Monitor display uses a vertical raster format of 720 vertical lines with a vertical raster frequently of 40 kHz and a frame frequency of 50 Hz. To eliminate the quantitization of sampled data, the Interpolation Board utilizes a smoothing algorithm. The smoothing algorithm interpolates four consecutive waveform samples. Depending on the relative values of the four samples, the intensity of the CRT beam is modulated to produce a continuous waveform with a constant line width.

The main functions of the Interpolation Board are listed below:

1. D-A converter
2. Sample and hold
3. Shuffle mux
4. Video pulse generator
5. Ramp generator
6. Raster line control
7. Erase bar latch
8. Wave length latch
9. Start-up delay
10. RAM for A2 display board (RAM 1)

D-A Convertor and Sample and Hold Circuits

The waveform is stored in digital form in the wave RAM 1 (U35). It is converted in U5 into an analog voltage in order to perform the smoothing algorithm. The smoothing algorithm uses four waveform samples. Analog multiplexer A (U8) acts as a 4 PST switch rotating one position in between every raster line. The sample and hold circuit (U10), therefore, holds the dc level of the present and previous 3 waveform samples.

Shuffle Mux

Analog multiplexer B (U11, U12) makes alternately available to the video pulse generator the four stored dc levels, in the correct time relationship.

Video Pulse Generator

The weighted comparators (U14, U15, U16, U17) generate a series of pulses in response to the waveform samples. The video pulse generator circuit translates the pulses from the weighted comparators into video pulses that are used by the video circuits on the Mother Board (A1).

Ramp Generator

The ramp generator (U28, Q1, Q2) generates a ramp for each raster line (fast sweep). The ramp signals are used by the weighted comparators for each sample that is displayed. The output combinational logic within the video pulse generator logically combines these pulses so as to produce four digital outputs corresponding to four levels of CRT beam intensity.

Raster Line Control

During data input to the DA converter U5, the raster line control (U1A, U1B) sends a WAIT signal back to the Display uP Board, in order to synchronize the CPU, which operates as a line counter. This status is reversed by the display enable signal.

Erase Bar Latch

The erase bar latch (U4A) provides waveform blanking (fading effect of erase bar) by using Data D0 information.

Wave Length Latch

The wave length latch (U3A) is used to blank the wave after a defined number of raster lines have been displayed.

Start-up Delay

The start-up delay (U7, U3B) drives MUX A decoder (U9A, U32) and MUX B decoder (U2) and ensures that the wave is blanked until all four samples are stored for the next frame.

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Figure 1-6. Single Channel Interpolation Board Block Diagram

Three-Channel Interpolation Board 78353-66503

The Interpolation Board (78353-66503) contains the control circuit for generating the video pulses for the waveform display.

The main functions of the Interpolation Board are listed below:

1. D-A conversion
2. Waveform smoothing
3. Load Control
4. Load Timing
5. Video Pulse generation
6. Ramp generation
7. Ramp timing
8. Erase bar latch

The 783XX and 788XX monitor series use a vertical raster format of 720 vertical lines with a vertical raster frequency of 40 kHz and a frame frequency of 50 Hz. To eliminate the quantization of sampled data, the Interpolation Board uses a smoothing algorithm. The smoothing algorithm interpolates four consecutive waveform samples, and is carried out separately for each of the three channels. Depending on the relative values of the four samples, the intensity of the CRT beam is modulated to produce a continuous waveform with a constant line width.

The waveform is stored in digital form in the wave RAM (U14). It is converted in DAC 1, 2 or 3 into an analog voltage, in order to perform the smoothing algorithm. The smoothing algorithm uses four waveform samples.

In the Hybrid circuits the dc levels of the four waveform samples are compared with the output signals of the ramp generators, resulting in a series of pulses. The output combinational logic within the video intensity logic circuits logically combines these pulses so as to produce four digital outputs corresponding to four levels of CRT beam intensity. These video pulses are transferred to the video circuits on the mother board (to the Z axis amplifier).

Data input and output from the DAC stage is controlled by the load-control circuit which also supplies a waveform-blanking signal for each channel, to the erase bar latch.

The load timing circuit controls the timing and sequence of signals into, and out of, the Hybrid circuits. The load timing circuit also provides a wave-blanking signal, to blank all waves, direct to the video intensity logic circuits.

The erase bar latch provides selective waveform blanking (fading effect of erase bar).

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Figure 1-7. Interpolation Board Block Diagram

Power Supply Board 78351-66506

+5 V DC Supply

In order to increase the efficiency of the analog dc power circuit (5 V), two unregulated dc voltages (8.2 V and 6 V) are provided. The 6 V dc supply is connected to the sensing circuit; if ever it falls below a threshold of 5.5 V, the 8.2 V dc is connected instead and remains connected until the 6 V dc returns to a value higher than 5.5 V.

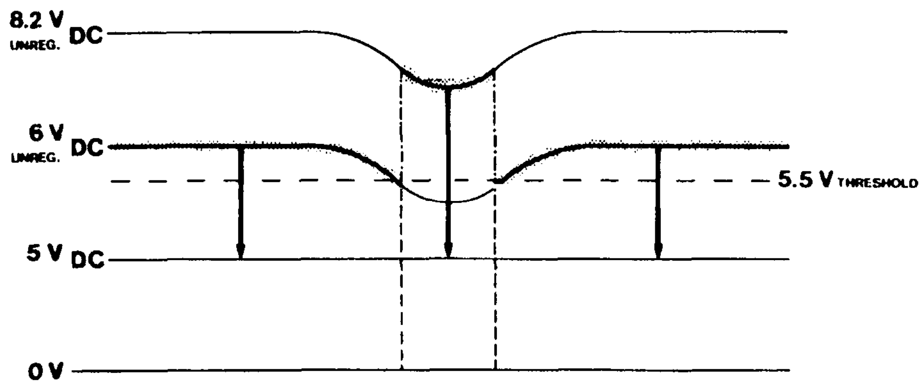

Figure 1-8. Voltage Sensing and Regulation

The unregulated 8.2 V dc is applied to transistor Q4 and the unregulated 6 V dc to transistor Q5. The unregulated 6 V is divided by R15/R16 and applied to sensing amplifier U6A. The -4 V ref is applied to 1:1 amplifier U6B, which alters the polarity of the signal to give a constant +4 V at the base of transistor Q7.

If the unregulated 6 V is higher than the 5.5 V threshold, CR12 conducts, setting the output of U6A to 3.4 V. Since the base potential of Q6 is now lower than that of Q7, Q7 is rendered conductive. This causes driver transistor Q5 to conduct, letting the +6 V pass to provide the +5 V. If the unregulated 6V is lower than the 5.5 V threshold, CR12 is reverse-biased and CR11 conducts. the output of U6A is now at 4.6V which means that the base potential of Q6 is higher than that of Q7. Q6 and Q4 are rendered conductive, letting the unregulated 8.2 V pass.

U6D is the current-sensing circuit and U6C the voltage sensing circuit for the +5 V supply. Q11 is the switch for the battery mode. The -4 V ref is generated by U3 and associated components. It is used as the reference power source for the +5 V and the +40 V power supplies.

±12 V DC Supplies

U1 and U2 are linear power regulators with internal current limiting. They provide the +12 V and -12 V dc supplies, respectively.

+17V DC Supply

U5 is an adjustable power regulator with internal current limiting and overload protection. It provides the +17 V dc supply.

Audio Board 78353-66512

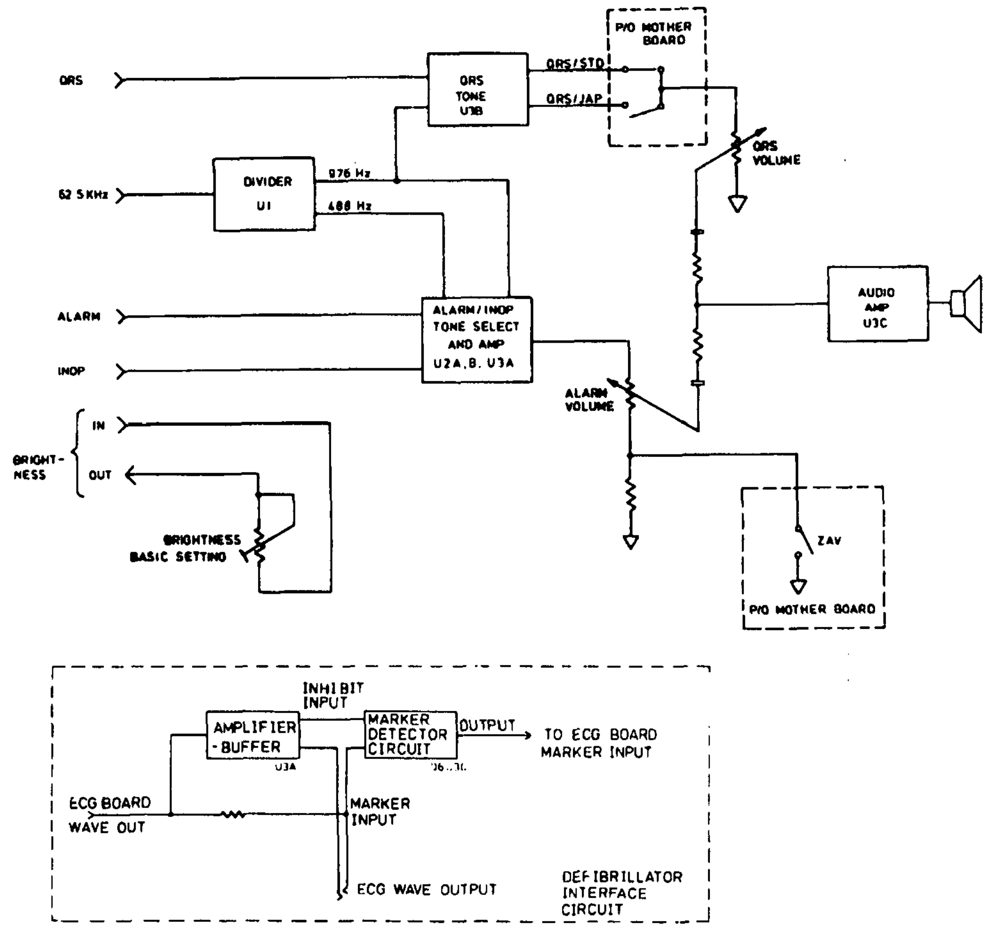

Figure 1-9. Audio Board Block Diagram

The Audio Board receives three signals (QRS, alarm, INOP) from the Display uP Board. Amplifier U3B creates the QRS tone, whereby appropriate jumpering (S1 on A1 Mother Board) can provide a differentiation between the standard and the Japanese QRS tones.

Divider U1 divides the 62.5 kHz signal to provide two signals (976 Hz and 488 Hz). These are used in conjunction with the alarm signal and the INOP signal, respectively. Gates U2A, U2B are used to select the signal to be amplified by U3A. Potentiometers are provided for QRS volume adjustment (R22) and alarm volume adjustment (R23).

All three signals are applied to audio amplifier U3C where they are amplified and applied directly to the loudspeaker. The Audio Board also contains the external brightness potentiometer R24 and houses the input jack (auxiliary inputs 2 and 21).

Defibrillator Interface circuit (78353-66511 only) - the defibrillator interface circuit is located on the Audio Board. When the defibrillator senses an ECG wave from either the tip or the ring of the phone jack, it sends back to the tip of the phone jack a marker pulse which is detected by the Marker Detector Circuit. The marker is indicated as a vertical line on the trace of the ECG wave.

Note The Audio board 78353-66509 does not include this circuit.

Battery Board 78832-66519

Battery Charge Circuit

When the unit is switched on, battery BT1 is charged via U3C and U3D. In this situation the +5 V supply to the parameter boards is supplied via Q2. The power-on signal at the base of Q1 causes Q1, and hence Q2, to conduct. U3B is switched on and acts as a diode bringing the base of U3A to +5 V. Hence U3A is reverse-biased and not conducting. So the +5 V supply is routed from the input connector via Q2 to the parameter boards.

When the power is switched off, Q2 is also switched off and the battery discharges power via U3A to the parameter boards.

Alarm Lamp Drive Circuit

The alarm lamp signal and 20 ms SYNC signal are combined at gate U1A. When the alarm lamp signal is low at the same time that the SYNC signal is low, the flip-flops (U2A, U2B) are cleared and the lamps are off.

When there is one rising edge on the alarm lamp signal between SYNC pulses, the output of U2B goes high and lamp L1 is switched on. When there are two rising edges the output of U2A goes high and lamp L2 is switched on.

ECG Board (Full Lead) 78354-66522(42)and 78354-66722(42)

The ECG Board contains the entire circuit required for ECG signal processing. It consists of an analog section containing:

1. Floating input circuit
2. Right leg drive
3. INOP detection circuit
4. Lead selector circuit
5. Grounded input circuity with bandpass and notch filters
6. A-D converter

and a digital section containing:

7. Microprocessor
8. ROM
9. RAM

Floating Input Circuit

The ECG input signals (C, LL, LA, RA) are applied, via the overvoltage protection circuits, to input amplifiers U1, U2 which provide a gain of 1. The signals are then routed to lead selector switch U4, U3. The amplified (U6) ECG signal is fed to modulator U6. The resulting AC voltage is transferred to the grounded section by transformer T2.

Right-Leg Drive

The common-mode error signal that serves as input to the right leg drive circuit is derived from the signals summed through R16 and R17. This common-mode error signal drives the right-leg drive amplifier U9A. The output of the right-leg drive amplifier returns to the patient through the patient cable, serving to prevent 50/60 Hz power line interference. Gates U10A, B, C switch this signal to the LL, LA or RA input (Q1, Q2, Q3, respectively) according to which lead is selected (I, II, III) for the other lead positions, connection via RL is used.

INOP Detection Circuit

If any of the leads are disconnected, right-leg drive amplifier U5A generates an INOP signal (logic high). This signal is passed to INOP comparator U9B, and then switched to modulator U6. It is transferred to the grounded circuit and once again detected (U15). From latch U21, it is transferred to the digital ECG circuits.

Lead Selector Circuit

U24 receives lead information from the microprocessor U27 via the data bus. The serial output from U24 drives the opto-coupler U39 via Q13, to transmit information to the floating circuit. U8 receives this incoming serial data and transmits parallel output to the lead switches U4, U3 and to the gates U7 and U10.

Grounded Input Circuit

Demodulator U11 provides the demodulated ECG signal. From here the signal is routed to the bandpass filter U12, U14, which functions in conjunction with the FILTER/DIAGnostic switching capability. When the FILTER (monitoring) mode is selected, the ECG signal is filtered, giving a bandwidth of 0.5 Hz to 30 Hz.

Pace Pulse Rejection: the demodulated signal is directed to the pace pulse hybrid circuit which detects pace pulses and transmits this information to uP via Latch U21. This signal is then transferred to the instrument's shared memory.

The notch filter removes AC line frequency artifacts and the results of AC line rectification from the waveform display during electrosurgery. The notch filter is bypassed in the DIAGnostic mode.

After these two filter stages, the ECG signal is A/D converted via DAC (10-bit) U16 and comparator U17 on the basis of successive approximation. In operation, the microprocessor first guesses a number, then U16 converts this to an analog signal and U17 compares it with the input voltage. The output of the comparator returns to the microprocessor for further processing.

Digital Circuits

The A/D converted ECG information is processed by the microprocessor U27 in the digital circuit and the results passed to the shared memory on the Display uP Board (A2). The digital circuit also processes data from the shared memory.

ECG Parameter Software

The ECG parameter software contains the following modules:

- ECG wave processing
  - A/D conversion
  - Pace pulse rejection
  - Digital filtering
  - Autofix/Autogain for the display
  - Beat detector
  - Trend*
  - Fibrillation and Noise detection
- Heart rate calculation
- Alarm derivation
  - Leads-off alarm
  - Asystole alarm
  - High rate alarm
  - Low rate alarm
- Keyboard handling
- Communication with shared memory
- Selftest and error handling

The ECG parameter software is contained in one 16K x 8 EPROM (U28) located on the ECG Board.

*Trend capability: The ECG trend times and display update times are listed below

Trend Time	Update Time
20 min	3.1 s
60 min	9.4 s
2 h	18.7 s
4 h	37.4 s
8 h	1.25 min
24 h	3.74 min

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Figure 1-10. ECG Board Block Diagram (Full Lead)

ECG Board (3 Lead) 78832-66522 (50 Hz) and 78832-66542 (60 Hz)

The ECG Board contains the entire circuitry required for ECG signal processing. It consists of an analog section containing:

1. Floating input circuit
2. Right leg drive
3. INOP detection circuit
4. Lead selector circuit
5. Grounded input circuit with bandpass and notch filters
6. A-D converter

   and a digital section containing:

7. Microprocessor
8. ROM
9. 2 RAMS

Floating Input Circuit

The ECG input signals (LL, LA, RA) are applied, via the overvoltage protection circuits, to input amplifiers U1, U2, U3, which provide a gain of approximately 15. The signals are then routed to lead selector switch U4. The amplified ECG signal is fed to modulator U6. The resulting AC voltage is transferred to the grounded section by transformer T2.

Right-Leg Drive

The common-mode error signal that serves as input to the right leg drive circuit is derived from the signals summed through R21 and R22. This common-mode error signal drives the right-leg drive amplifier U5A. The output of the right-leg drive amplifier returns to the patient through the patient cable, serving to prevent 50/60 Hz power line interference. Gates U10A, B, C switch this signal to the LL, LA or RA input (Q1, Q2, Q3, respectively) according to which lead is selected.

INOP Detection Circuit

If any of the leads are disconnected, right-leg drive amplifier U5A generates an INOP signal (logic high). This signal is passed to INOP comparator U5B, and then switched to modulator U6. It is transferred to the grounded circuit and once again detected (U15). From latch U21, it is transferred to the digital ECG circuits.

Lead Selector Circuit

Frequency selector U18, U19 is clocked by the 1 MHz signal from clock divider U30. It also receives lead select data (DO to D3) from latch U22. The frequency selector is used for lead select coding:

45.46 kHz	= Lead I
31.25 kHz	= Lead II
38.47 kHz	= Lead III
25 kHz	TEST Signal (low)
18.52 kHz	TEST Signal (high)

The signal is then sent to power driver Q6, Q7 and passed via transformer T1 to the floating circuit. The floating lead select logic consists of monostable multivibrators U7A, U7B, counter U8 and latch U9. The output signals are applied to lead selector U4 and right-leg drive gates U10A, B, C.

Grounded Input Circuit

Demodulator U11 provides the demodulated ECG signal. From here the signal is routed to the bandpass filter U12, U14, which functions in conjunction with the FILTER/DIAGnostic switching capability. When the FILTER (monitoring) mode is selected, the ECG signal is filtered, giving a bandwidth of 0.5 Hz to 30 Hz.

The notch filter removes AC line frequency artifacts and the results of AC line rectification from the waveform display during electrosurgery. The notch filter is bypassed in the DIAGnostic mode.

After these two filter stages, the ECG signal is A/D converted via DAC (10-bit) U16 and comparator U17 on the basis of successive approximation. In operation, the microprocessor first guesses a number, then U16 converts this to an analog signal and U17 compares it with the input voltage. The output of the comparator returns to the microprocessor for further processing.

Digital Circuits

The A/D converted ECG information is processed by the microprocessor U27 in the digital circuit and the results passed to the shared memory on the Display uP Board (A2). The digital circuit also processes data from the shared memory.

ECG Parameter Software

The ECG parameter software contains the following modules:

- ECG wave processing
  - A/D conversion
  - Digital filtering
  - Autofix gain for the display
  - Beat detector
- Heart rate calculation
- Alarm derivation
  - Leads-off alarm
  - Asystole alarm
  - High rate alarm
  - Low rate alarm
- Keyboard handling
- Communication with shared memory
- Selftest and error handling

The ECG parameter software is contained in one 8K x 8 EPROM (U28) located on the ECG Board.

Faltblatt von alte Seite 1-25 hier einfügen

Figure 1-11. ECG Board Block Diagram (3 Lead)

Pressure Board 78353-66532 (Single Channel) and 78353-66534 (Dual Channel)

Note Where block functions are repeated in both pressure channels, only channel 1 is described.

The pressure board contains all the circuits required for processing two pressure signals. The board supplies an excitation voltage to the transducers, and processes the resulting transducer output signals for display and system use.

Transducer Excitation Circuits

Frequency divider (U19, U10, U11) divides down a 1 MHz square-wave input to give a 2400 Hz square-wave output. This is filtered to give a sine wave which is input to the push-pull amplifier stage (Q1, Q2). This stage provides the excitation voltage and current to the transducer across transformer T3.

Transducer Signal Demodulation Circuits

The input signal from the transducer is transferred across transformer T1 to input-amplifier U1. This amplifier has a proportional gain of X1 or X8 for 40 uV or 5 uV transducers respectively. When a 5 uV transducer is used, pins 5 of the front panel connector are shorted together causing a light emitting diode to conduct, activating a light sensitive transistor (U17). This transistor conduct switching FET Q7 on. With Q7 conducting R1 is connected to ground thus increasing the gain of the amplifier (U1) by a factor of 8.

After amplification the signal is filtered (U2) before demodulation. The synchronous demodulator (U2, U3) rectifies the signal using an operational amplifier which has alternately an inverting gain and non-inverting gain. The excitation-voltage signal is used to switch the amplifier between inverting gain and non-inverting gain.

A 12 Hz low-pass filter (U7) then removes the excitation frequency to leave the dc pressure signal. This signal goes via amplifier U19A to the system output, and also via the selector switch (U12) to the analog to digital (A/D) conversion stage.

Analog to Digital Conversion

The analog to digital conversion uses a DAC (U14) and comparator (U13) in a method based on successive approximations. In this method the microprocessor supplies a number, then U14 converts this to an analog signal and U13 compares it with the input voltage. The output of the comparator returns to the microprocessor for further processing.

Transducer Disconnected Detection

If the transducer is not connected, a change in load current is sensed by resistor R22 in the push-pull amplifier stage (Q2, Q3). This resistor is connected to a differential amplifier (U19B), which amplifies the voltage across the resistor. Hence when the current in R22 changes, as the result of transducer disconnection, the output of the amplifier (U19B) will also change. This output voltage goes to the selector switch and then to the A/D conversion stage. Here it is converted into a digital signal for use in the digital circuits, to generate an INOP signal when necessary, and for storage in the shared memory to initiate pressure signal display.

Zero, Calibration and Test Functions

A DAC (U8) and amplifier (U5) are used to provide calibration and test functions to the input amplifier (U1). The same circuits also provide zero compensation for the transducer. When testing the board the input from the transducer to the input amplifier (U1) is grounded using a signal applied from latch U24, on the digital section of the board. The alternative test and calibration inputs are provided by the DAC (U8) as a result of the digital inputs to U8 from the microprocessor.

Digital Circuits

The A/D converted pressure information and transducer disconnected signal are processed by the microprocessor (U27) in the digital circuits and the results are passed to the shared memory on the display microprocessor board (A2). The digital circuits also process information from the shared memory for use in the pressure parameter circuit.

The additional EAROM in the digital circuits is used as a RAM and ROM facility for accurate storage and recall of the gain constant used by the internal software for the pressure signal display and output.

The watchdog timer (U29, U26, U15) is a counter (U15) which has a 2 ms input and is reset by a regular pulse via gate U29. If the microprocessor is not working correctly the pulse to U29 does not occur regularly and the counter is not reset. The output from the counter overflows via gate U26 to cause a reset in the microprocessor program, back to the initial power on sequence etc.

Pressure Parameter Software

The pressure parameter software contains the following modules:

- Pressure signal processing
  - Systolic/diastolic/mean detection and calculation
  - A/D conversion
  - gain fixing and storage, for output and display
- Alarm derivation
- Communication with the shared memory
- Self-test and error handling
- "Watchdog" timer
  - CPU reset
- Auto zero
- Trend [1]:
  - **78353B and 78354A/C:** trend times 20 min, 60 min, 2 h, 4 h, 8 h, 24 h
  - **78833A, 78833B and 78834A/C:** trend times 2 min, 20 min, 60 min, 2 h, 4 h, 8 h, 24 h

The pressure parameter software is contained in a 16K X8 EPROM (U28).

Note

[1] Trend capability: the pressure trend curve is the average values of mean, diastolic and systolic pressures. The trend information is updated at specified times dictated by the trend time selected - see table;

Trend Time	Update Time
2 min	—
20 min	12.5 s
60 min	37.4 s
2 h	1.25 min
4 h	2.5 min
8 h	5 min
24 h	15 min

The screen is divided into 384 points and each trend data sample requires 4 points, therefore the update time is calculated from: (trend time / 384) x 4

Faltblatt von alte Seite 1-29 hier einfügen

Figure 1-12. Pressure Board Block Diagram

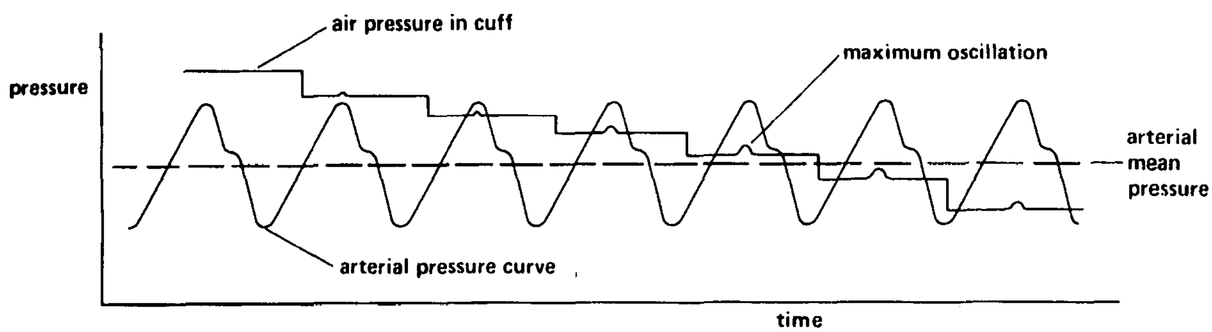
Non-Invasive Blood Pressure (NIBP) Board 78352-66535

For the new NIBP board 78352-66538 used on 78xxxC monitors see "Non-Invasive Blood Pressure (NIBP) Board 78352-66358".

General Principle of Operation

The measurement of blood pressure is based on the oscillometric method in which an inflated cuff around the patient's limb partially occludes the artery. The pulsatile arterial flow causes oscillations superimposed on the cuff pressure, the amplitude of which can be analysed to obtain the systolic, diastolic and mean pressure values. The procedure is microprocessor controlled and summarized as follows;

Cuff inflation	On instruction from the operator, via the keyboard, the microprocessor instructs the pump to inflate the cuff to about 180 mmHg pressure. The pressure in the cuff is measured by a piezo-resistive transducer. Signals from the transducer are sent to the microprocessor which switches off the pump when the required pressure is reached.
Arterial occlusion	At cuff pressures of about 180 mmHg the artery is occluded (no blood flow) and the pressure transducer detects only the cuff pressure.
Pressure decrements	The pressure in the cuff is released in steps of about 7 mmHg until the pressure partially occludes the artery. At this point the artery pressure oscillations are seen superimposed on the cuff pressure.(Below cuff pressure of 30 mmHg the steps reduce to 2 mmHg).
Cuff pressure and oscillations	As the pressure in the cuff is progressively released the magnitude of the oscillation as a function of the cuff pressure increases until the arterial mean pressure is reached. When the cuff pressure falls below the arterial mean pressure the oscillation magnitude decreases as illustrated in the following diagram:



Note This is a schematic representation only to demonstrate that the maximum oscillation is reached as the arterial mean pressure is approached. The microprocessor waits for two pressure cycles before decrementing to the next step, see Oscillations paragraph.

Oscillations

The pressure transducer detects both the cuff baseline pressure and pressure oscillation. These signals are amplified and filtered to separate the cuff baseline pressure and the pressure oscillations. The micro processor compares successive pressure oscillation magnitudes until it detects two oscillations of similar amplitude. By checking two subsequent oscillations it is possible to reject artefact due to patient movement. The baseline cuff pressure and oscillation magnitudes are stored in the memory and the cuff pressure is further decremented. Subsequent oscillation magnitudes will show decreases until no significant oscillations are seen.

Results

The microprocessor displays the arterial mean pressure together with the systolic and diastolic pressures. The cuff is completely deflated and depending on the selected cycle time is inflated to when the next measurement is to be made

---

Note

There are still some oscillations present above and below the systolic and diastolic values)

Safety circuit

If the cuff pressure exceeds 315mmHg ±10, the safety circuit cuts in to release the pressure via the release valve, and an error message is displayed. (The circuit is essentially a bellows which expands under pressure and trips a microswitch opening the release valve.)

The block diagram below illustrates the general principle of the non-invasive blood pressure.

Blatt von alte Seite 1-31 hier einfügen

NIBP Parameter Board 78352-66535

The NIBP parameter board is located on the extended mother board, of the full module 78354A. The board contains the pressure transducer, release valve, and all the circuitry necessary to operate the pressure pump and process the pressure signals. A safety circuit prevents the cuff from overpressurizing and is also mounted on the parameter board.

Pressure Transducer

The pressure transducer is of the piezo-resistive type and supplied with 10V dc from amplifier (U1). Pressure applied to the transducer causes a change in resistance and the output signal ranges between 0-70 mV.

Amplification and Filtering

The pressure transducer's output signal is amplified by (76-152) at U3. Cut-off frequency at U3 is 100 Hz. The amplified signal is sent to switch U8 directly and via the band pass filter network. The signal arriving directly at U8 contains information on cuff pressure (baseline cuff pressure and oscillation pressure) but the signal arriving from the band pass filter network contains only oscillation pressure information. The band pass filter network comprises of a 2nd order LP filter (fc = 10 Hz) and a 1st order filter (fc = 1 Hz). The switch in the filter network from U13 latch is included to obtain a fast decrease time for improved oscillation pressure detection. Switch U8 switches alternately at a rate determined by software, depending on the presence of oscillations.

Analog to Digital Conversion

The analog to digital conversion uses a 12 bit DAC and comparator (U5 & U6). The method used is successive approximation under the control of the uP.(In order to suppress noise the supply to the DAC includes the accurate -8 V from the reference supply (U7). The uP loads a value into the DAC which is compared to the voltage to be converted (i.e. pin 18). The output of the comparator (U6) indicates to the uP if the value on the data bus is the equivalent of the unknown input analog voltage.

Digital Circuit

The A/D converted pressure signals are sent to the Z80L microprocessor (U21) and after processing to the shared memory. ROM (U25) having 16K and RAM (U26) with 2K memory provide the necessary storage and recall of cuff/oscillation pressure information. The ROM contains the program for the control of the measurement process.

Clock divider U17A provides the microprocessor with a 2 MHz pulse. The watchdog timer circuit includes counter (U19) and receives the same 2 ms input as the microprocessor. If the microprocessor does not reset, the watchdog timer interrupts with a reset signal.

Safety and Valve/Pump Control

The purpose of this circuit is to release the pressure in the cuff if it exceeds 315 mmHg and also to provide the control signals for the valve and pump. The overpressure safety circuit has five connections on the pressure valve and the valve is held closed via a 5 V relay switch. If the pressure in the cuff exceeds 315 mmHg a metal bellows expands and cuts out the circuit holding the valve closed. If the power fails the safety valve opens automatically to release any cuff pressure.

NIBP Parameter Software

The software contains the following modules;

- A/D conversion in U5,
- systolic/diastolic/mean pressure detection & calculation,
- alarm determination,
- communication with shared memory,
- Watchdog timer - to reset CPU,
- overpressure circuit controlled by CPU,
- Trend*

NIBP parameter software contained in 16K ROM (U25)

*NIBP Trend Times are:

Trend Time	Update Time
20 min	12.5 s
60 min	37.4 s
2 h	1.25 min
4 h	2.5 min
8 h	5 min
24 h	15 min

Faltblatt von alte Seite 1-33 hier einfügen

Figure 1-13. Non-Invasive Blood Pressure Board Block Diagram (78352-66535)

Non-Invasive Blood Pressure (NIBP) Board 78352-66358

The new NIBP board 78352-96538 is used in the HP78352C, HP78354C Adult and HP78834C Neonatal Monitors. It is designed to be used with adult, pediatric and neonatal patients in either an OR or ICU environment.

This new NIBP board uses surface-mounted technology (SMT). This does not allow repairs to be carried out in the field.

Specifications

Safety	Complies with UL544, IEC 601-1, CSA C22.2 No. 125. Patient leakage current < 10uA at 100V/60Hz a.c. Protected against damage from defibrillation and electrosurgery.
Cuff Pressure Range	0 to 280 mmHg (0 to 37 kPa).
Cuff Inflation Rate	less than 10 s (typical for normal adult cuff).
Auto Mode Repitition	2, 5, 10, 15, 30 and 60 minutes. Time Defaults: 5 minutes (OR), 15 minutes (ICU).
STAT Mode Cycle Time	5 minutes.
Measurement Time	Auto/Manual: 35 s (adult), 20 s (neonatal) STAT: 17 s

Typical at HR greater than 60 bpm.

Cuff Pressure Accuracy	15°C to 25°C ±3 mmHg. 10°C to 35°C ±3 mmHg (±0.6% or reading). 0°C to 55°C ±3 mmHg (±1.7% or reading)
Display Update	Auto/Manual/STAT: < 2 s after end of measurement.
INOP Alarms	Trigger if a static pressure, an overpressure or an overlong measurement time is detected.

Patient Modes

The new NIBP board 78352-66538 is designed to be used with adult, pedatric and neonatal patients. The Measurement Ranges, Limit Alarms and Overpressure Safety Limits are listed for each patient mode in turn.

Adult Mode

Measurement Ranges and Limit Alarms	Systolic: 30 to 270 mmHg (4 to 36 kPa). Diastolic: 10 to 245 mmHg (1.5 to 32 kPa). Mean: 20 to 255 mmHg (2.5 to 34 kPa)

Limit Alarm Adjustment	5 mmHg (1 kPa) steps 2 mmHg (0.5 kPa) steps for 10 to 30 mmHg range.
Overpressure Safety Limits	maximum 330 mmHg (44 kPa).

Pediatric Mode

Measurement Ranges and Limit Alarms	Systolic: 30 to 180 mmHg (4 to 24 kPa). Diastolic: 10 to 150 mmHg (1.5 to 20 kPa) Mean: 20 to 160 mmHg (2.5 to 22 kPa)
Limit Alarm Adjustment:	5 mmHg (1 kPa) steps, 2 mmHg (0.5 kPa) steps for 10 to 30 mmHg range.
Overpressure Safety Limits	maximum 220 mmHg (30 kPa).

Neonatal Mode

Measurement Ranges and Limit Alarms	Systolic: 30 to 130 mmHg (4 to 17 kPa) Diastolic: 10 to 100 mmHg (1.5 to 13 kPa) Mean: 20 to 120 mmHg (2.5 to 16 kPa)
Limit Alarm Adjustment:	5 mmHg (1 kPa) steps, 2 mmHg (0.5 kPa) steps for 10 to 30 mmHg range.
Overpressure Safety Limits	maximum 165 mmHg (22 kPa).

Measurement Principle

Oscillometric Measurement

The measurement of the blood pressure is based on the ocillometric method in which an inflated cuff around the patients limb partially occludes the artery. The pulsitile arterial flow causes oscillations superimposed on the cuff pressure, the amplitude of which can be analyzed to obtain the systolic, diastolic and mean pressure values. The procedure is microprocessor controlled.

Measurement Method

The board offers an adult, pediatric or neonatal mode. The board also offers three methods of obtaining the non-invasive blood pressure.

- **Manual:** This method takes one measurement of systolic, diastolic and mean, on each request.
- **Auto:** This method takes repeated blood pressure measurements of systolic, diastolic and mean, at specific user-selected time intervals.
- **STAT:** This method imediately takes repeated blood pressure measurements of systolic, diastolic and mean, over a period of five minutes. This method uses a faster measurement procedure.

Related Literature

- Hewlett-Packard Application Note: Systolic Pressure Monitoring, A Comparison of the Oscillometric, Auscultatory and Invasive Techniques; 5954-2388.
- The Direct and Indirect Measuring Of The Blood Pressure - Geddas L.A. Chicago: Year Book Medical Publishers 1970; 104-5.

General Principle of Operation

Cuff Inflation

The cuff around the patients limb is connected to the board via a single tube. The cuff is inflated by the pressure pump once or repeatedly (depending on the measurement method used) to a cuff pressure above the patients systolic pressure.

For the first measurement, the cuff inflates to approximately 165 mmHg (Adult), 125 mmHg (Pedi) or 100 mmHg (Neo). For futher measurements the cuff inflates to approximately 20 mmHg above the previously measured systolic pressure.

Arterial Occlusion

When the cuff is greater than the systolic pressure then the artery is occluded and the pressure sensor only detects the cuff pressure.

Pressure Decrements

Cuff Deflation \ The pressure in the cuff is automatically released by the deflation system on the board. The deflation occurs in steps of approximately 7 mmHg until the cuff pressure is partially occluding the artery. At this point the arterial pressure oscillations are superimposed on the sensed pressure and are extracted by the bandpass filter for measurement purposes.

Oscillations

As the cuff is deflated, that is the pressure is progressively released, the magnitude of the oscillations as a function of the cuff pressure increases until the mean arterial pressure is reached. The minimum cuff baseline pressure which allows maximum amplitude of arterial pressure oscillations is identical to the mean arterial pressure. When the cuff pressure falls below the mean arterial pressure the oscillation magnitude decreases. The systolic and diastolic blood pressure values are deducted from the oscillometric signal by extrapolation, resulting in empirical values. For the extrapolation the attenuation rate of the signal on both sides of the maximum readings are used.

Safe Monitoring

The board has the following maximum limits which ensure the safety of the patient:

1. A maximum measurement time of: 120 seconds (Adult and Pediatrics Modes), 60 seconds (Neonatal Mode).
2. A maximum time of 120 seconds for a cuff pressure greater than 15 mmHg for adults and pediatric modes or 60 seconds for a cuff pressure greater than 5 mmHg for neonatal mode.
3. An overpressure system with the following limits:
   a. 330 mmHg maximum (for adult mode)
   b. 220 mmHg maximum (for pediatric mode)
   c. 165 mmHg maximum (for neonatal mode)

NIBP Parameter Board 78352-66538

The Analog Board—Hardware Description

Pressure Transducers and Input Amplifier

The static inflation pressure of the cuff is measured by two identical solid-state transducers (sensor 1 and 2). These transducers are mounted on either side of the input connector so that the same pressure is measured by both. The transducers are duplicated for safety reasons so that there is always a backup if one fails. If one channel produces a false value, the second channel provides a reference signal by means of which the error can be detected.

The transducers use a bridge circuit to measure the pressure of the cuff. Two amplifiers (U1,U2 or U4,U5) supply the bridge excitation voltage of +5 V (U1) and −5 V (U2). The excitation voltage is symmetrical so that a single-ended output is generated for A/D conversion.

The voltage on the voltage divider (R6, R7/8) is −1.875 V at zero pressure with no offset. The amplifier U2 adjusts the supply voltage for the transducer so that the voltage on the output pin 4 (sensor output) is equal to the offset voltage from R38,R39 (+5 mV). The other output of the transducer (pin 2) is amplified by U3 which has a gain of 111.

Oscillation Channel

An oscillation channel filters and amplifies the oscillations superimposed on the static cuff pressure. The signal first passes through a low pass filter (U7B with R25,R26,C23,C24) with a cutoff frequency of 3.5 Hz. The dc voltage is removed by two software-controlled high pass filters (C25,R27 and C27,R34) with a cutoff frequency of 0.4 Hz. The recovered oscillation signal is amplified by U7A, and output to the multiplexer U9.

Transistor Q1 increases the gain of U7A for neonatal blood pressure monitoring. Increased gain is needed when measuring neonatal blood pressure because of the smaller oscillations.

Switches U8A and U8C switch the time constant of the high pass filter to achieve rapid baseline recovery each time the cuff is deflated. This is required because each time the deflation valve opens, a strong signal is produced that creates an unwanted peak.

Multiplexer and A/D Conversion

The software-controlled multiplexer (U9) selects one of the following input signals for output to the A/D converter (U11):

- Static pressure channel 1 (Output from U3)
- Static pressure channel 2 (Output from U6)
- Oscillation channel
- Reference voltage (+3.8 V)
- Reference voltage (+1.5 V)
- Reference voltage (+5.0 mV)

The reference voltages are used for test purposes to ensure that the calibration is valid.

The output from the multiplexer (pin 8) is buffered by the amplifier (U10A) before it is input to the A/D converter (U11). A/D conversion is made by the type 7548 12-bit DAC (U11) and comparator (U12), by means of a successive approximation algorithm.

A reference voltage for the DAC of −6 V is produced by U10B. The reference element (U13) delivers a stable +5 V reference.

EEPROM and Latch

An EEPROM (U350) stores the factory calibration values for the sensors and other values required by the software. This non-volatile memory has a capacity of 128 8-bit words. Data is loaded and read serially by the 80C88A microprocessor (U26) on the digital board. The contents of the EEPROM are not lost when the module is unplugged.

The module is factory-calibrated by applying an accurate pressure of 220 mmHg to the sensors. The values produced are stored in the EEPROM and used for future reference.

A type '574 latch (U100) is connected to the data bus and stores the switch settings for MUX (U9), and switch (U8). It also transmits the signals to start the pump motor and close Valve 1.

Hardware Description

Note No opto-couplers are required on this board because the board is grounded.

Valve Drivers

Two valves are used to inflate and deflate the different types of cuff. Valve 1 is normally open (the valve for the adult cuff), and Valve 2 is normally closed (the valve for the neonatal cuff).

Valve 2 has two switches (Q3, Q4, Q9) and Valve 1 has only one switch (Q2, Q8). There are two switches to open and close Valve 2 to save power. A relatively high current is needed to change the state of the switch but a very low current is required to hold the selected state. Latch U310 on the Analog Board supplies the VALVE_2 signal. The valve is then held closed with a reduced current from transistor Q3 limited by resistors R53, R54 and R55.

It is not necessary to use the same power conservation technique for Valve 1 because it is activated very rarely in comparison with the adult valve. When it is activated, Valve 1 is opened only for a very short period.

Diodes CR8, CR3 and CR4, CR5 are protection diodes to limit the induction voltage if the valves are switched off.

Pump Motor

The pump motor is controlled by U12A, Q5, and the current limiting resistor R73, R74, R75, R76. The pump is activated when a +5 V signal (PUMP) is received from latch U100 at the non-inverting input of U12B. When the motor is switched on, the inrush current is limited to about 700 mA. When the motor is running, the current is reduced to between 300 and 400 mA depending on the load.

Diode CR9, CR2 protects the transistors from the back emf generated when the motor is switched off.

The Digital Board—Hardware Description

The Digital Board is based around one microprocessor; an 80C88 (U250). This processing power is needed to generate an NIBP reading

The 80C88 processes the signals from the analog board and runs the NIBP algorithm. Application software is stored on the 128 k x 8 EPROM (U320), and the 32 k x 8 RAM (U360).

The address decoder (U330) generates the chip select signals for the DAC (U210), and the latches U100, U310, U340, U400, U410.

A Watchdog ASIC (U240) supervises the processor. If either the time interval is too long, or the data bits are wrong, the ASIC sends a reset signal to restart the microprocessor.

Bitte Faltblatt von alter Seite 2-50a (VOLUME 2) hier einfügen

Figure 1-14. Non-Invasive Blood Pressure Board Block Diagram (78352-66538)

Partial CO_2 Pressure Board 78354-66540 and 78356-66540

General Principle of Operation

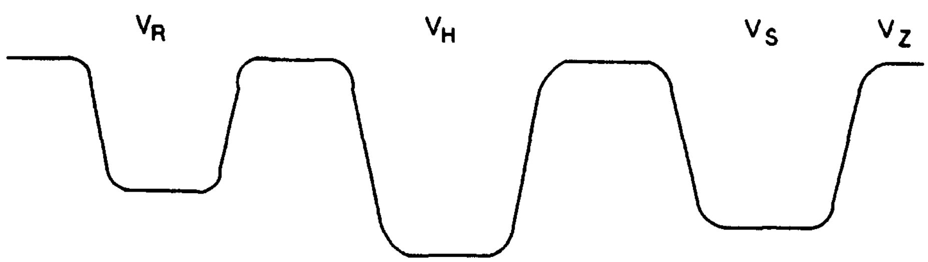
The concentration of carbon dioxide (CO_2) is measured directly and continuously from the patient's expired gases. Light arriving from an infra-red source passes successively through the expired (or inspired) gas, a filter wheel and an optical interference filter and is then detected by the photoresistor detector. The detector output is processed by the CO_2 parameter board.

The transducer is maintained at a constant temperature of 45°C to prevent condensation developing at the windows of the Airway Adapter (the transducer clips onto this). This also produces stable conditions for the optical filter inside the transducer to operate in. This is controlled by the temperature control circuit.

The CO_2 measurement technique is based on the absorbtion of infra-red energy by CO_2. A rotating filter wheel chops the in-coming light to produce a series of pulses. These pulses are used to calculate the value of CO_2 present in the expired gas using algorithms.

The chopping filter wheel forms the rotor of the dc motor. Four permanent magnets are placed symmetrically around the wheel to provide the magnetic attraction and repulsion from a drive-coil pair mounted on the surrounding stator. A properly-phased drive signal is obtained from the motor drive circuits by integrating and amplifying the voltage from a pair of sensing coils, also located on the stator. The relationship of the drive coils, sense coils and magnets are shown in the figure opposite. The motor is started by magnetically positioning a permanent magnet over one sense coil, then pulsing the drive coils.

The filter wheel contains 2 sealed chambers, one filled with CO_2 which is used as a reference absorbtion and other chamber filled with N2 which does not absorb infra-red light. An additional empty chamber in the filter wheel gives information on CO_2 enclosed in the transducer. The resulting analog signal at output of transducer's preamplifier is shown below;



CO_2 Parameter Board 78354-66540 and 78356-66540

The CO_2 parameter boards 78354-66540 and 78356-66540 contains the following main circuits:

- Motor and Temperature circuit,
- Preamplifier,
- Analog to Digital conversion,
- Digital circuits necessary to process data and transmit data to the instrument's shared memory.

Motor Circuit

When a transducer is connected to an instrument, pin C on J1 is connected to ground which in turn forces pin 11 on microcomputer U2 also to ground. The microcomputer recognizes the presence of a transducer and sends a pulse to the start up pulse generator (U3/Q1) via port 10 (pin 13) of U2. The start up pulse generator sends a pulse to power the sense coils of the transducer and start the filter wheel rotating. (If filter wheel start-up is not successful the start up pulse generator repeats with a second pulse 2 s later until motor runs). When the filter wheel rotates a sine wave voltage appears on the sense coils and the sine wave will be phase shifted by integrator U1B and amplified by variable gain stage U5/U1. The variable gain amplifier drives power amplifier Q2 and Q3 to power motor drive coils in the transducer.

To control the motor speed the zero crossing at TP1 (output U1B) is detected by Schmitt trigger U3D, which gives the microcomputer data about actual speed of the motor. An internal algorithm of the microcomputer controls the gain of U5 to the achieve correct motor speed of 40 Hz. When the start-up pulse is generated the gain of U5 is 0, but in normal operation when the motor is running the gain is between 0 and 1 to compensate for variations in motor speed. To achieve a symmetrical Motor Drive voltage (UMD) around zero the integrator U1D corrects the dc part of UMD by giving an offset to the flux integrator U1B (dc restoring).

Temperature Control Circuit

The sense thermistor of the transducer is part of a resistance bridge and its differential voltage is amplified by U1A and then Analog to Digital converted by U4. The microcomputer U2 uses an algorithm to filter the temperature data and provide a pulse width modulated signal at P21. Q4 and associated components make a flyback converter to provide a dc voltage to the heater thermistor in the transducer. The thermistor is only supplied with power when the motor runs. While the correct transducer operating temperature is being reached the message sensor warm up appears on the display.

Faltblatt von alte Seite 1-35 hier einfügen

Figure 1-15. 14360A Sensor, Mechanical Diagram

Preamplifier

The preamplifier U8A converts the incoming signal current from the biased photoresistor detector to obtain the CO_2 voltage signal. U8B and U15 build a variable gain stage to generate enough dynamic range for the A to D conversion. U15 is contolled by the microprocessor U13. Microcomputer U2 derives an auto zero (AZ) signal from the incoming motorphase. During this zero signal the output of U8 will be integrated by U9 and output U9 controls the current source made up by Q8, Q9 and Q10 which in turn loads capacitor C6 to a voltage that gives the correct current (93 uA) to the photoresistor detector. This current source is supplied by 80 V derived by the circuit around T1.

Analog to Digital Conversion

The values of the four samples, VR , VH, VS and VZ are measured by a dual slope integrating technique.

Comparator U11 detects the zero crossing of the (integrating) slopes. This information is used by the internal timer of the microprocessor U13 to determine the relative value of the four samples.

This A/D converter is also used to measure the analog O_2 voltage from the O_2 board by switching S2 and S3 of U16.

Digital Circuits

The digital part of the CO_2 parameter board builds a uP system which consists of microprocessor U13, 16K EPROM U28, 2K RAM U26, NOVRAM U27, address decoder U25, input latch U23 and shared memory buffers U20, U21 and U22. The clock U32, counter U29 and the shift registers U30 and U31 are used to provide the necessary clock and timing signals for the uP U13. The input latch U23 reads slotcode SC0, SC1 and SC2, the powerfail signal (PF), 20 ms clock, option switches (S1A for kPa or mmHg and S1B for respiration from CO_2) and by X1 Calstick position (out or in).

*Trend capability: The trend times and display update times are listed below

Trend Time	Update Time
20 min	3.1 s
60 min	9.4 s
2 h	18.7 s
4 h	37.4 s
8 h	1.25 min
24h	3.74 min

Oxygen Board 78354-66541 and 78356-66541

General Principle of Operation

The O_2 transducer measures oxygen concentrations in ambient or inspired air, operating on the polarographic principle.

Preamplifier Circuit

A battery on the O_2 parameter board supplies a reference voltage to the anode of the transducer which, after a warm-up time, causes the transducer to produce current when it is exposed to oxygen.

The current flows from the transducer to the O_2 parameter board (78354-66541 or 78356-66541), where it is amplified and converted to a voltage. This O_2 signal is transferred to the non-floating part of the O_2 board by modulator U5, transformer T1 and demodulator U4. After this signal has been filtered by R8 and C1 it passes to the the CO_2 board (78354-66540 or 78356-66540), where it is A/D converted and transmitted to the instrument shared memory. The Oxygen value is displayed on the screen as a percentage.

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Figure 1-16. CO_2/O_2 Board Block Diagram

Temp/Pleth/Aux Board 78353-66552 and 78354-66552

Pleth Floating Input Circuit

The Pleth input signal is applied, via diode clamp protection, to the Pleth pre-amplifier (U1A, U1C) which is an active-feedback amplifier giving a band-pass characteristic. The signal is then used in modulator (U1B, Q1), which provides a current directly proportional to the input Pleth signal. This current is detected on the grounded side of the transformer (T1) by means of a sensing resistor. The transformer also provides the power to drive a constant-current source (U36, U3, Q2) which supplies the lamp.

Test Function Generator

The frequency at the transformer is normally 250 kHz, but for test purposes a 125 kHz frequency is applied. This stimulates the test generator to output a square wave of 101.7 bpm, which is input as a test signal to the Pleth preamplifier.

INOP Detection Circuit

If the Pleth transducer is not connected the instrument can not operate. When the transducer is disconnected the current to the lamp does not flow. This is detected as a change in load by the INOP detector U18 with 78353-66552 board (U8 with 78354-66552), which generates an INOP signal. From latch U21 this signal is transferred to the digital Pleth circuits.

Pleth Sensor Circuit

The signal detected across the sensing resistor in the grounded section is demodulated by the Pleth Sensor and passed through a bandpass filter (U10). The signal is then routed via a selector switch (U15) to the A/D conversion stage. The signal is A/D converted by DAC U16 (12 bit) and comparator U17 on the basis of successive approximation. This same A/D conversion stage is also used for Temperature and Auxiliary signals.

Temperature Floating Input Circuit

The temperature measurement is based on the change in resistance of the transducer with changing temperature. This resistance is transformed across T2 to the grounded section. Two reference values (representing 40°C and 25°C) are also available at the input stage for calibration checks, which are carried out periodically by the microprocessor. The microprocessor checks for offset and drift errors, and removes the necessity for on-board adjustments.

Temperature Grounded Circuit

The resistance transformed across from the floating section provides damping for the resonant circuit (T1, C26, R63). As the amount of damping changes with temperature, the voltage across the resonant circuit also changes. This voltage signal is routed via a driver stage to a full wave rectifier and filter. The output is a dc level proportional to the input temperature signal. This dc signal is offset to make optimum use of the temperature range and then routed to the A/D conversion stage via selector switch U15.

Aux Input Circuit

The Aux parameter signal is routed, via selector switch U13, to the Aux buffer. This selector switch can also give a zero signal for calibration purposes and allows software recognition of the parameter cable which is connected, by identifying the particular series resistor in that cable. The output signal from the detection circuit is then fed, via selector switch U15, to the A/D conversion stage.

Digital Circuits

The A/D converted parameter information is processed by the microprocessor U27 in the digital circuit and the results passed to the shared memory on the Display microprocessor board. The digital circuits also processes information from the shared memory.

Temp/Pleth/Aux Parameter Software

The software contains the following modules:

- Pleth:
  - Autofix gain
  - Manual gain
  - Peak finding
  - Heart rate processing
  - INOP detection
  - Trend (78354-66552 BD)
- Temp:
  - Calibration checks
  - INOP detection
- Aux:
  - Auto zero
  - Parameter identification
  - Scaling

The PAT parameter software is contained in one 16K x 8EPROM (U28).

TREND: 8K x 8 RAM (U32) loaded. NO TREND: 2K x 8 RAM (U32) loaded. Trend times are as follows:

Trend Time	Update Time
20 min	3.1 s
60 min	9.4 s
2 h	18.7 s
4 h	37.4 s
8 h	1.25 min
24 h	3.74 min

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Figure 1-17. Temp/Pleth/Aux Board Block Diagram

Temperature Board 78832-66552 and 78834-66552

The temperature measurement is based on the change in resistance of the transducer with changing temperature. This signal, in the form of a voltage, is rectified and then A/D converted.

Input Circuits

Two reference resistors and two temperature inputs (in the form of resistances) are available at the input section of the board. The microprocessor, through relays (K1,2,3) and transistor switches (U7), controls which of the resistances is transformed across T1 to the next stage. The two reference values (representing 40°C and 25°C) are used for periodic calibration checks when the microprocessor checks for offset and drift errors.

Signal Rectification and A/D Conversion

The resistance transformed across T1 provides damping for the resonant circuit (T1, C1). The excitation frequency for the resonant circuit is supplied via frequently divider U3 and amplifier U4. The voltage across the resonant circuit changes, as the amount of damping changes, with temperature. This voltage signal is half-wave rectified (U1) giving an output dc level proportional to the input temperature signal. This signal is then dual slope A/D converted (U8) and goes to the respiration board digital circuits.

Digital Circuits

The A/D converted temperature information is processed by the microprocessor U13 in the digital circuits and the results passed to the shared memory on the display microprocessor board.

Temperature Parameter Software

The software controls hardware functions (relays, switches etc.) and A/D conversion. Software also checks calibration using the reference resistors and detects INOP conditions.

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Figure 1-18. Temperature Board Block Diagram

Dual Temperature Board 78353-66554 and 78354-66554

The temperature measurement is based on the change in resistance of the transducer with changing temperature. This signal, in the form of a voltage, is rectified and then A/D converted.

Input Circuits

Two reference resistors and two temperature inputs (in the form of resistances) are available at the input section of the board. The microprocessor, through relays (K1, 2, 3) and transistor switches (Q1, 2, 3), controls which of the resistances is transformed across T1 to the next stage. The two reference values (representing 40°C and 25°C) are used for periodic calibration checks when the microprocessor checks for offset and drift errors.

Signal Rectification and A/D Conversion

The resistance transformed across T1 provides damping for the resonant circuit (T1, C3). The excitation frequency for the resonant circuit is supplied via frequency divider U10 and amplifier U5. The voltage across the resonant circuit changes, as the amount of damping changes, with temperature. This voltage signal is full-wave rectified (U6) giving an output dc level proportional to the input temperature signal. This signal is then A/D converted and goes to the digital circuits.

Digital Circuits

The A/D converted temperature information is processed by the microprocessor U27 in the digital circuits and the results passed to the shared memory on the display microprocessor board.

Temperature Parameter Software

The software controls hardware functions (relays, switches etc.) and A/D conversion. Software also checks calibration using the reference resistors and detects INOP conditions.

- Board 78353-66554 contains 1K x 8 RAM and 8K x 8 EPROM
- Board 78354-66554 contains 2K x 8 RAM and 8K x 8 EPROM

Trend: Board 78354-66554 has trend capability. The trend times and display update times for single and dual temperature are shown in table.

Trend Time	**Update Time**	**Update Time**	
	T1	T2	Single Temp
20 min	3.6 s	24.9 s	3.1 s
60 min	10.7 s	1.25 min	9.4 s
2 h	21.4 s	2.5 min	18.7 s
4 h	42.7 s	5.0 min	37.4 s
8 h	1.42 min	10.0 min	1.25 min
24 h	4.27 min	30.0 min	3.74 min

Note

Single temperature - each data sample requires 1 point of screen, Dual temperature - T2 is updated every eighth point with respect to T1.

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Figure 1-19. Dual Temperature Board Block Diagram

Respiration Board 78832-66562

The changing impedance, during respiration, between two ECG electrodes (RL & LL) is measured and the signal processed to give a high resolution respiration signal output.

Input Circuits

The voltage across the two leads is transferred to the grounded section across transformer T1. In the grounded section the transformer forms part of a bridge network to which a 62.5 kHz sinusoidal signal is applied. This signal is derived from a 1 MHz square wave, which is first divided (U1) and then filtered to give an approximate sine shape at 62.5 kHz. The changing voltage across the bridge, which is proportional to the changing impedance across the electrodes, is input to the differential voltage amplifier (Q2, 3, 4, 5). The differential signal is then rectified using a synchronous demodulator (U4). The output signal from the demodulator is integrated (U5) and filtered to remove the excitation frequency and give a dc respiration signal.

INOP Detection

This respiration signal is applied to a clamping amplifier (U10) to limit the voltage to the 0 - 2 V range necessary for the analog to digital (A/D) converter. Together with a voltage derived from the input of the synchronous demodulator, this absolute value of the respiration signal is used to check whether an INOP condition exists (patient impedance > 2 kohms or patient cable disconnected).

Respiration Wave Signal Circuits

The dc respiration signal is also applied to the summing point (R30, R31). Amplifiers U9 and U6 form a feedback compensation loop and when the analog switch (Q7, 8, 9) is closed, the feedback loop works to bring the summing point to zero. When the analog switch is open, the voltage at the output of the integrator (U6) is fixed. The clamping amplifier (U11) has a gain of 33 and provides the input to the A/D converter. U11 also clamps the signal to the 0 to 2 V range.

Feedback Loop Operation

As an example, assume that the voltage at the output of U8 is +3 V (i.e. 1.5 kohm patient impedance). In this case the voltage at the output of integrator U6 is -3 V and at the summing point 0 V (see Figure 1-20). The resulting range for the A/D converter via U11 is from 1500-10 ohms to 1500+10 ohms. If the input impedance (i.e. patient impedance) exceeds 1500+10 ohms the microprocessor closes the analog switch (via FET driver) for approximately 3 ms. During this time the feedback loop via U9 and R40 is closed. This results in a fast change of the integrator output voltage until the voltage at the summing point is zero. This process takes approximately 1ms (see Figure 1-21).

The microprocessor now opens the analog switch and the voltage at the integrator output is again fixed. The new range in the example (Figure 1-22) is 1510-10 ohms to 1510+10 ohms.

Note All values are only used as examples and are not actual values.

A/D Conversion

The A/D converter has eight input channels, two of which are internally connected to the reference voltage and the input ground pin. The microprocessor controls the A/D converter via the ramp start pin (RS) and the address pins A0, A1, A2. If the RS pin is low the capacitor C15 is charged to the voltage at the selected input channel. If the RS pin goes high, C15 is discharged via a constant current source in the A/D converter. The output of the A/D converter is a pulse-width-modulated signal, where the pulse-width is proportional to the input voltage.

A. Initial conditions

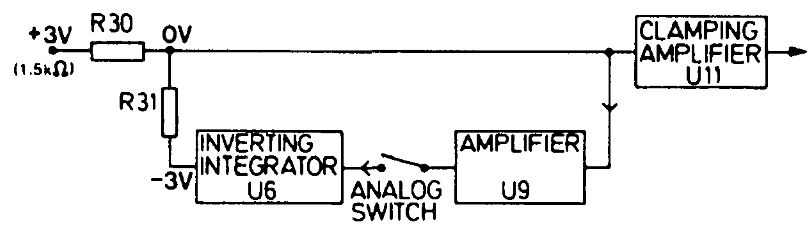

Figure 1-20. Feedback Loop Operation - Stage 1

B. Patient impedence increases to 1.5 kohm +10

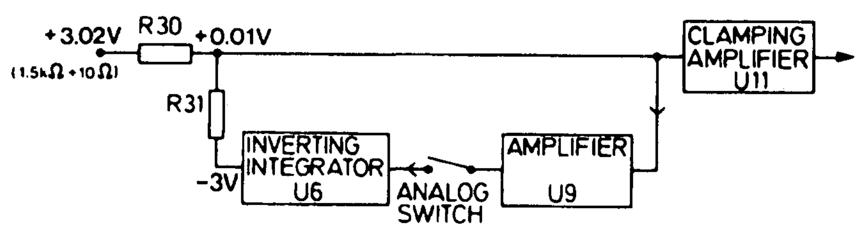

Figure 1-21. Feedback Loop Operation - Stage 2

C. Summing point again at zero volts

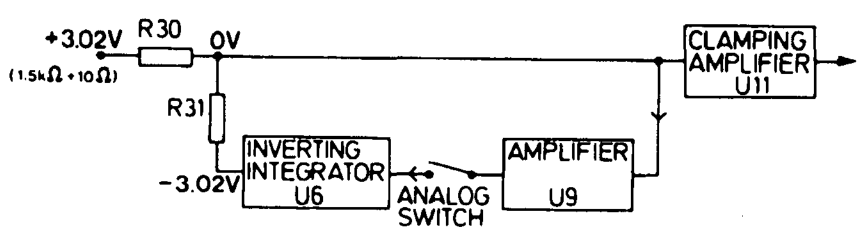

Figure 1-22. Feedback Loop Operation - Stage 3

Test Signals

Test signals T1 and T2 are applied to switch U2, bringing to ground one or both points across which the differential voltage is measured. The combinations of test signals and functions are shown in Table 1-1.

Table 1-1. Test Signals and Results

T1	T2	Function
0	0	1000
0	1	500
1	0	NO FUNCTION
1	1	MEASURING

Key: 0 = CMOS low level, 1 = CMOS high level

Digital Circuits

The A/D converted respiration and INOP signals are processed by the microprocessor (U13) in the digital circuits and the results are passed to the shared memory on the display microprocessor board (A2). The digital circuits also process information from the shared memory for use in the respiration parameter board.

Channel 1 of timer U16 is reset regularly during normal operation by a pulse from the microprocessor, forming a watchdog function. If the microprocessor is not working correctly it will not reset the timer. The timer then overflows and causes a hard reset of the microprocessor. The program makes an internal check and then begins a warm start to recover from the failure.

Respiration Parameter Software

The respiration parameter software has the following functions:

- Control Hardware functions and ADC
- Prepare ADC-reading for display
- Respiration Trigger
- Derive Alarm conditions
- Evaluate Trends
- Communicate with shared memory
- Internal Selftest
- Trend

Trend times are shown below:

* Trend Time	Update Time 78353B/4A
2 min	—
20 min	3.1 s
60 min	9.4 s
2 h	18.7 s
4 h	37.4 s
8 h	1.25 min
24 h	3.75 min

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Figure 1-23. Respiration Board Block Diagram

Transcutaneous Partial CO_2 and O_2 Board 78834-66572

The tcpCO_2/tcpO_2 (transcutaneous partial) pressure parameter board A72 is used in conjunction with transducers 15204A and 15205A on neonatal instruments 78833A and 78834A. It can process signals from either the 15204A tcpO_2 transducer or the 15205A tcpCO_2 transducer. With certain monitor configurations (78834A neonatal monitor) it is possible to have two of these parameter boards in the same instrument which enables the simultaneous measurement of tcpCO_2 and tcpO_2.

Barometer board 78834-66573 provides the transcutaneous parameter boards with atmospheric pressure information for calibration purposes and is secured to the parameter board with clips. Only one barometer board is necessary even if the Monitor is configured to monitor both tcpCO_2 and tcpO_2.

The floating and non-floating circuits of the board are separated by opto-couplers and a transformer.

Transducer Recognition

The 15204A and 15205A transducers each have a coding resistor which enables the Monitor to recognize whether a CO_2 or O_2 transducer is connected. The coding resistor forms part of a voltage divider and the resulting voltage produced when the transducer is connected to an instrument is fed to channel 8 of the analog mutiplexer U520.

tcpCO_2 Input

+12 V, -12 V are fed from the parameter board to the 15205A tcpCO_2 transducer for the internal amplifier supply. The tcpCO_2 input amplifier U501C amplifies the output voltage from the amplifier situated inside the 15205A tcpCO_2 transducer. The output of U501C is fed to channel 3 of multiplexer U520.

tcpO_2 Input

The tcpO_2 input amplifiers U502 and U501D converts the current produced by the 15204A tcpO_2 transducer into an analog voltage which is fed to channel 4 of analog multiplexer U520.
L

Polarization Voltage

The 15204A tcpO_2 transducer requires a polarization voltage for operation. This polarization voltage of -745 mV is fed to the cathode of the transducer, and is also required when the monitor is switched off and the transducer is still connected, allowing it to remain polarized and ready for use. This polarization voltage produced by the 2.5 V dc supply and associated circuitry is backed up by a rechargeable battery BT501. The output of the battery is fed to channel 7 of multiplexer U520 for monitoring the battery voltage.

Heater Circuit

Both the 15204A and 15205A transducers contain a heating coil. When in operation the heating coil heats up the patients skin to enhance the diffusion of gases through the skin. The temperature of the skin and therefore of the heating coils must be carefully kept within specified limits of the selected temperature (heating coil temperature can be selected using softkeys; choice of 37°C or in the range 42°C to 45°C in steps of 1/2°C).

The microprocessor U6 provides a pulse width modulated heat signal which is transferred from the non-floating to the floating circuits via opto-coupler U23. The heating coil circuit U510B produces a dc heating voltage which is fed to the heating coil. This signal is also used for the synchronisation of data transfer.

Temperature Control

Transducers 15204A and 15205A each have two internal thermistors which form part of a bridge circuit. T1 thermistor with U504 and associated components and T2 with U505 with associated components. The output of the thermistor bridges are fed to channel 5 and channel 6 of multiplexer U520. This information is used by the uP to feedback the required pulse width modulated signal to maintain the selected temperature. Two comparators U506A and U506B monitor the output of T1 bridge U504. If upper or lower specified temperature limits are outside the defined temperature limits the comparators switch off the heating coil (this is for patient safety).

Analog Multiplexer

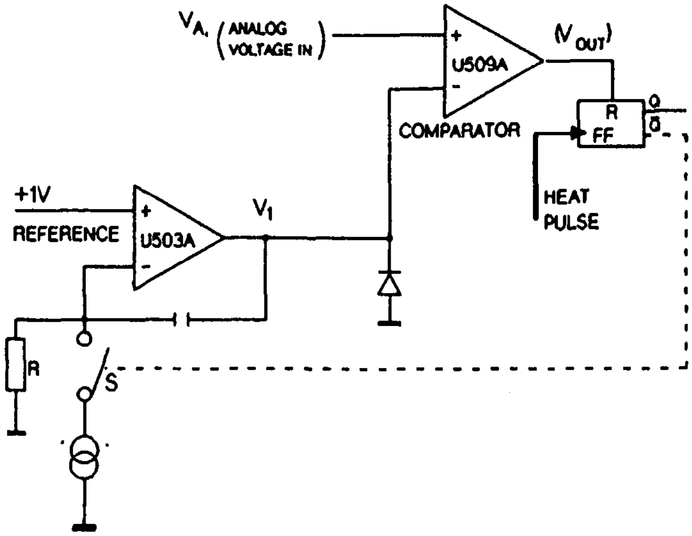
The analog multiplexer U510 has eight analog inputs;

- Channel 1 - floating ground
- Channel 2 - +2.5 V reference voltage
- Channel 3 - tcpCO_2 input
- Channel 4 - tcpO_2 input
- Channel 5 - Temp input T1
- Channel 6 - Temp input T2
- Channel 7 - Battery voltage
- Channel 8 - Transducer recognition

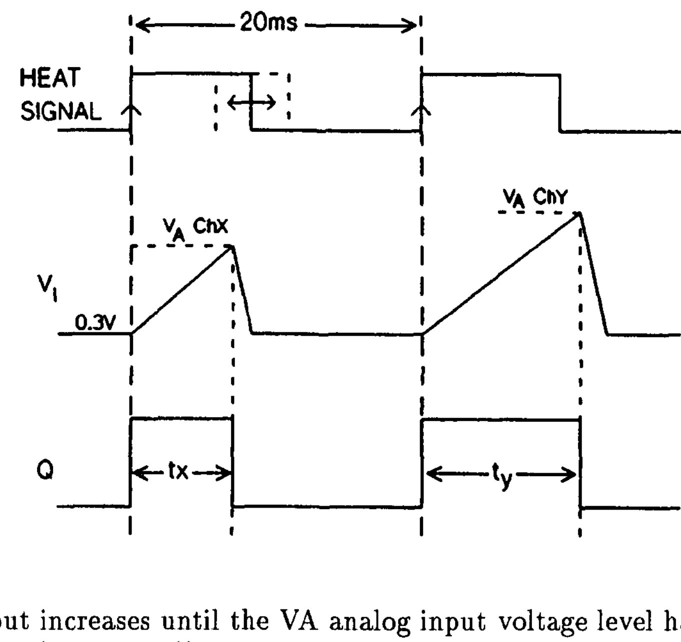
The multiplexer is controlled by counter U519. The output of the multiplexer is clamped between + and -3.2 V by diodes CR505 and CR506. This output is then given an offset by U508B to produce only positive voltages. These analog voltages are then fed, in sequence, to the analog pulse width conversion circuit U508A and U509.

Analog to Pulse Width Conversion

The analog to pulse width conversion operates as follows:

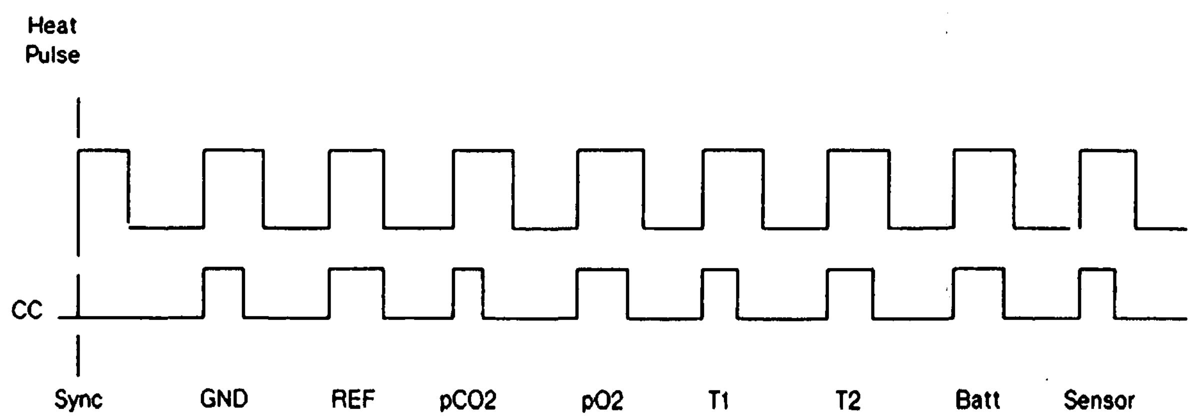


On the rising edge of the incoming heating pulse the output of flip-flop U523B is set high and switch S (CR 508) is opened. This starts the integration of +1V input of the integrator. The integrator output increases until the VA analog input voltage has been reached. At this time the comparator U509A resets the flip-flop U523B, so the output goes low and the switch S is closed to reset the integrator. The output Q of flip-flop U509A is therefore the pulse width modulated signal



The integrator output increases until the VA analog input voltage level has been reached, and the integrator is reset (S1 closed *) The output of comparator U509A is therefore the pulse width modulated signal having widths tx, ty ... and is proportional to the incoming analog voltages.

The 8 bit pulse width modulated signals, corresponding to the 8 analog voltages at multiplexer U520, and a 9th synchronization pulse is transmitted serially and represents a measurement cycle every 180 ms.



Each pulse width signal is proportional to the input signals to multiplexer U520. The pulse width modulated signals are then measured and the resulting information is processed by uP U6.

Repolarization

The 15204A tcpO_2 transducer can be electrically cleaned by repolarization. The uP U6 initiates, via softkey, a repolarization signal which is routed from the non-floating to floating circuit of the parameter board through relay K1. The repolarization signal reverses the polarization voltage applied to the 15204A tcpO_2 sensor's cathode and electrically removes deposits.

Floating Power Supply

The floating power supply consists of an alternator on the non-floating section of the parameter board (T1, T2, Q1, Q2), T2 transforms the dc voltage from the non-floating to the floating section of the board. On the floating side 7 different dc voltages are produced: +12 V, -12 V, LV+, LV-, +5 V, +2.5 Vref. and +1 Vref.

Digital Circuits

The pulse width modulated signals received by the uP U6 are processed by the firmware (EPROM U9) and the results are passed onto the monitors shared memory on the display uP board A2. U1,U2 and U3 are buffers for communication with the shared memory.

Clock

The 16 MHz clock U12 and divider circuit U10 produce a 4 MHz clock frequency for the 6303 uP system and a 250 kHz frequency for driving the floating power supply circuit.

Watchdog Circuit

Watchdog circuit provides reset information to the uP, if an error condition is present in the system for more than 400 ms.

EAROM

The additional EAROM in the digital circuits is used to store offset voltages of the floating hardware.

Barometer Board Information

The 8 bit data word from the Barometer board latch (U1 on A73) is fed directly onto the data bus. Bits B0 (feedback for successive approximately A/D conversion on the barometer board) and BI (barometer board recognition) are interfaced to the data bus via buffer U15.

*Trend capability: The trend times and display update times are listed below

Trend time	Update Time
2 min	—
20 min	3.1 s
60 min	9.4 s
2 h	18.7 s
4 h	37.4 s
8 h	1.25 min
24 h	3.74 min

Parameter Software

The $tcpO_2/CO_2$ software can be divided into 2 main blocks. These consist of the main program that takes care of processing $tcpO_2/tcpCO_2$ values and an interrupt program which looks after timing tasks such as A/D conversion, temperature control of the sensors and communication with the shared memory. Communication with the shared memory takes place every 20 ms.

Software Block Diagram

```
        Power On                                Interrupt (20ms)
           |                                       |
           |                                       |
     -------------     --------------           ---------
    |    Test     |   | Key          |         | Task    |--------
    |  Routines   |   | Processing   |         | Control |        |
    | Initialize  |    --------------           ---------         |
    |  Routines   |   | Error        |          ------------      |
    |-------------|---| Processing   |         | A/D        |     |
    |             |    --------------          | Conversion |-----|
    |             |   | Alarm        |          ------------      |
    | Background  |---| Processing   |         | Temperature|     |
    |             |    --------------          | Control    |-----|
    |    task     |   | Transducer   |          ------------      |
    |             |---| Recognition  |         | Shared     |     |
    |  Control    |    --------------          | Memory     |-----|
    |             |   | pO2          |         | Communicat.|
    |             |---| Processing   |          ------------
    |             |    --------------
    |             |   | pCO2         |
    |             |---| Processing   |
    |             |    --------------
    |             |   | Heating,     |
    |             |---| Power        |
    |             |   | Processing   |
    |             |    --------------
    |             |   | Barometer,   |
    |             |---| Pressure     |
    |             |   | Processing   |
    |             |    --------------
    |             |   | Trend        |
    |             |---| Processing   |
     -------------     --------------
```

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Figure 1-24. $TcpCO_2/O_2$ Board Block Diagram

Barometer Board 78834-66573

The Barometer Board (78834-66573) is secured and electrically connected to the tcpCO_2/O_2 board and supplies atmospheric pressure information, via connection X1, to this tcpCO_2/O_2 board. Atmospheric pressure (room air pressure) is measured for calibration purposes.

Circuit Operation

The barometer board consists of a pressure transducer U7 (bridge network) and appropriate circuit to provide the microprocessor U6 on the transcutaneous gas parameter board with an 8 bit digital word proportional to the barometric pressure. The temperature compensated pressure transducer elements are arranged in a bridge circuit and powered by a dc voltage supply of 10.0 V generated by U5A and U6. Leg 2 of the bridge circuit is held at zero by zero driver U6 and barometer adjustment is made via potentiometer R11. The pressure output signal is amplified at U4 and its voltage output, which is proportional to the atmospheric pressure, is fed to the feedback input of digital to analog converter U2.

The analog output of U2 is input to Schmitt trigger circuit U3 and this in turn is output (BO) to the microprocessor on the tcpCO_2/O_2 parameter board, A72.

U2 is an 8 bit DAC which is used as an analog to digital converter via successive approximation as follows:

The microprocessor U6 initiates an 8 bit digital signal equal to 1/2 of the full scale output of U2 and the analog signal produced by U2 is internally compared with the feedback voltage from U4. The comparator (U3) switches depending on whether the feedback voltage is higher or lower than the initial 1/2 fullscale first guess value. On the basis of this, output B0 is fed back to the microprocessor U6 and the most significant bit of the 8 bit word is set High or Low. The same then occurs for the next bit, bit 2, and this continues until 8 comparisons have been made. The digital signal then present at the input of U1 and therefore at the input of U2, is equal to the digitized voltage value from output of U4.

+5 V, +12 V and -12 V are also fed from the parameter board to the barometer via connector X1.

A -4 Vref. signal is fed from the mother board via the parameter board where it is required for A/D conversion, DAC U2 and generation of the transducer bridge voltage at U5A.

The barometric range is between 500 mmHg and 800 mmHg pressure which is equal to a signal output at U4 of between 0.04 mV and 38.71 mV.

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Figure 1-25. Barometer Board Block Diagram

Oxygen Saturation/Pleth (SPO_2) Board 78354-66510/520

The Oxygen saturation/pleth (SpO_2) parameter is based upon the principle of Pulseoximetry, whereby arterial bloodflow through tissue is detected optically. An adaptor holds two LEDs emitting red and infra-red light respectively, against one side of the patient's finger, nose or toe. Against the other side it holds a photodiode. The device is able to register small changes in the conductivity of light through the finger, in response to patient pulse. By isolating the pulsatile component of the signal, the SpO_2 board eliminates the effects of absorption from tissue, bone and venous blood.

The more heavily blood is oxygenated, the brighter red it becomes. Hence an algorithm comparing the conductivity of red and infra-red light, thereby measuring the colour of the blood, can also offer an indication of oxygen saturation.

The SpO_2 board is divided into two distinct areas - floating and grounded. These are connected by two high voltage optocouplers for data transfer, together with the power transformer for power transfer.

Floating Section

The sampling of signals from the photo-diode is in four discrete phases.

a. Dark Phase. Neither red nor infra-red LEDs are lit. Only ambient light is measured.

b. Red Phase. The red LED is lit, and the conductivity of the light through the finger measured.

c. Infra-Red Phase. The infra-red LED is lit, and conductivity measured.

d. Pleth Phase. Infra-red LED is lit and conductivity measured.

Consecutive frames composed of these four phases are repeated 375 times per second. Both the lighting of the LEDs and the sampling of the signal from the photo-diode is sequenced by a time multiplexor governed by the microprocessor. In perfect conditions, (i.e. no noise and constant ambient light), the signal from the photo-diode may be represented thus:

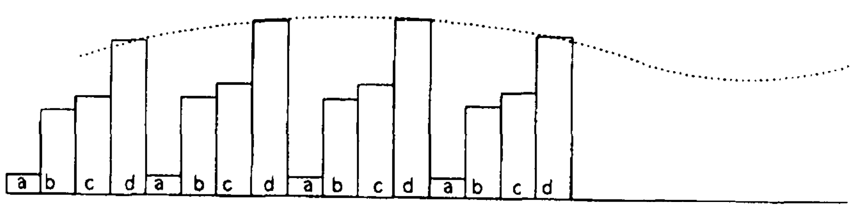

Diagram not to scale

Notice how the line joining (d) readings indicates the (amplitude modulated) plethysmograph wave.

The function of the floating section of the board is two fold:

a. To enable accurate reading of light conductivity by removing noise and compensating for ambient light in the pulse train.

b. To drive the two LEDs.

ESU Rejection

Two 4KHz low pass filters contained in U102 and U104A remove frequencies produced by Electro Surgery Units.

Ambient Light Rejection

High pass filter U104A rejects ambient light.

Amplification

The output stream from the photodiode is amplified at various points:

a. Amplifier in U104A, which converts current to voltage.

b. Variable amplifier in U104A. This is software controlled and monitored by comparator U111, which checks for wave clipping.

c. Amplifier contained in U104A. The pulse train is also shifted here such that the signal becomes symetrical to zero.

Compensation for Ambient Light

The series of switched low pass filters (LP RED, LP INFRA and LP PLETH) are used together with the capacitor labelled "DARK" to separate the four phases within each frame of the pulse train and compensate for the effects of ambient light. The sequence of operation is software controlled and takes place as follows:

a. **Dark Phase**
Switch governing capacitor "Dark" is closed. Switches governing LP RED, LP INFRA and PLETH are open. Capacitor "DARK" is charged by the pulse resulting from the ambient light reading.

b. **Red Phase**
Switch governing LP RED is closed. All others are open. Capacitor LP RED is charged by the pulse resulting from the red LED reading. The pulse received by amplifier A2 is equivalent to the value of (ambient light + red light) minus (ambient light).

c. **Infra-Red Phase**
As (b) above, but using capacitor LP INFRA.

d. **Pleth Phase**
As (b) above, but using capacitor LP PLETH.

The second series of low pass filters following amplifier A2 is used for further noise rejection.

The Transducer

As well as the connections to the transducer relating to the LEDs and photo-diode, two more wires are used to check the transducer itself. These are connected to resistor R2 (within the transducer), and enable monitoring to show:

a. That the transducer is properly connected.

b. What type the transducer is.

Multiplexer

Resistor R1, together with the four phase output train from the photo-diode, are time multiplexed by U107, which in turn is driven by the micro-processor uP.

LEDs

The LEDs are driven by controlled current source U121. Two demands must be met:

a. LEDs must be lit in their correct sequence, to produce the four phases of the pulse frame.

b. LEDs must be lit to an ideal intensity. This is dependent upon the light absorption of the patient's finger.

The pulse train from multiplexor U107 is converted into a digital signal by the software in microprocessor U212 U204. A process of successive approximation is used, in conjunction with DAC U153 and comparator U152.

DAC U120 controls the LED driver U121, using positive and negative analog pulses of 0-125 mA, thereby triggering it to light red and infra-red LEDs respectively. This produces the required pulse train. The intensity of illumination is determined by the current of this triggering pulse.

Notice that the link to the opto-couplers is taken from the microprocessor.

Selftest

Selftesting is achieved by closing the two switches marked "Selftest". This has the effect of disconnecting the transducer signal, and replacing it with an input taken directly from the controlled current source used to drive the LEDs. Software can then check almost all of the frontend circuit, by measuring ranges and gain of the signal received.

Grounded Section

The grounded section of the SpO_2 board is completely digital. It is essentially a dedicated microcomputer, and amongst other tasks, performs the following:

a. Calculation of the SpO_2 saturation percentage.

b. Control of the user-determined alarms.

c. Control of the "INOP" alarms.

d. Establishment of automatic magnitude (wave display).

e. Calculations concerned with trending.

Since the layout of this section will be familiar to most readers, only a few comments on unusual features will be made.

Input is via the two opto-couplers, U201 and U202, shared with the floating section of the board.

Switch S301 is the dip-switch used to configure the software (see Volume II)

EPROM U303 holds the software and RAM U304 provides a working area.

Clock U314, together with dividers U310 and U311 provide clock pulses to the microprocessor and the (switched mode) floating power supply.

The SpO_2 board has access to the motherboard during a 2 ms time slot within a 20 ms frame. This is controlled by the interrupt line from the motherboard. Buffers U305, U306 and U307 provide access to the main Address and Data buses, and hence to the shared memory. There is no Control bus as such, but a read/write line is included in the Address Bus.

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Figure 1-26. SpO_2 Board Block Diagram

780 System Interface (Non-Annotating) 78353-66590

The system board provides the system and alarm interface to 780 systems. The board provides the following functions:

1. **System control signals:**
   a. INOP
   b. Alarm reset
   c. Alarm on/off
   d. Patient alarm
   e. Recorder run
2. **Heart rate:**
   a. Beat-to-beat or average
3. **ECG or repiration wave**

Input Circuits

Buffers U1, U2 and U3 provide the TTL to CMOS interface to the system board. The control signals needed to the system board are decoded from the shared memory during the write cycle, using a 8K X 8 EPROM (U16). When the desired address appears on the bus a control signal is generated at the output of the EPROM, which causes the corresponding data to be latched in U4, U9, U12 and U15. Mutiplexer U14 selects either beat-to-beat heart rate for neonatal applications, or average heart rate for adult applications (programmed by switch setting).

Beat-to-beat Heart Rate

In the case of beat-to-beat heart rate the information is latched into U12. The information is then subsequently moved to U13 and then converted into an analog output by D/A converter U8 and opamp U7.

Average Heart Rate

Average heart rate information is presented in 9-bit-format, a lower and an upper byte. When the lower byte arrives it is latched into U12. When the upper byte arrives bit 9 is latched into U15 and the lower byte is shifted into U13 so that the D/A converter sees 9 bits at once. These are then converted as described above.

System Control Signals

The system control signals are present in shared memory as a status byte.

Status byte

Signal	Bit
	D7
recorder run = high	D6
alarm on = high	D5
alarm reset = high	D4
not used = high	D3
emergency alarm = high	D2
patient alarm = high	D1
INOP = high	D0

The status byte is latched in U9. INOP, alarm on/off and reset are open collector outputs with U_{max}= 30 V and I_{max}= 30 mA.

No INOP = open collector	INOP = 0 V
Alarm off = open collector	Alarm on = 0 V
No alarm reset = open collector	Alarm reset = 0 V

ECG Wave

The analog ECG wave comes to the system board from the mother board. U5 and associated components switch the gain of this wave in such a way that the analog wave appearing at the output of U6 is approximately the same size as the display wave. The gain factor is also present in shared memory and is latched by U4.

Respiration Wave

In units with respiration parameter, it is possible by changing the switch settings to have the respiration wave at the output instead of the ECG wave. This signal requires no further processing and passes via buffer amplifier U6B to the output.

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Figure 1-27. 780 System Board (Non-Annotating) Block Diagram

780 Interface Board (Annotating) 78353-66592

The system board takes parameter and alarm information from the shared memory and processes this information to provide output signals at the system output connector.

Digital Circuits

Parameter and alarm information in digital form from the shared memory is processed by the microprocessor (U1) in the digital circuits before D/A conversion (U25, U28). The watchdog timer (U17, U19) consists of a counter which has a 20 ms input and is reset regularly during normal operation by a pulse from the microprocessor. When the microprocessor is not working correctly the pulse does not occur and the counter is not reset. In this case the output of the counter overflows via gate U19 to cause a hard reset to the microprocessor. The program checks this condition and then begins a warmstart to recover from the failure.

Analog Circuits

In the analog circuits the parameter signals (except ECG (60 Hz) and temperature) are transferred via a multiplexer (U41) to a row of sample and hold filters. The temperature and ECG (60 Hz) go directly to two separate, high resolution, sample and hold filters are then routed to the system output connector. The alarm signal information (alarm on/off, INOP, patient alarm) is transferred to the analog circuits via latch U12. The signals are filtered in the alarm interface circuits and then routed to the system output connector. The system output configurations are shown in Table 1-2.

System Board Software

The system 780 board software contains the following modules:

- Self-test
- Offset-correction value storage
- Output configuration storage
- Signal processing

Table 1-2. System Output Configurations

J92 pin no.	Configurations 0-6							
	0	1	1*	2	3	4	5 #	6***
1	ECG wave analog							
2	pleth wave	encoded deselect		pleth wave	encoded deselect	pleth wave	$tcpO_2$	
3	signal gnd.							
4	recorder data	encoded alarm		recorder data	encoded alarm	recorder data		$tcpCO_2$
5	alarm gnd.							
6	heart rate average							
7	INOP							
8	reset							
9	patient alarm							
10	temp 1.							
11	resp. rate							
12	recorder return	encoded INOP		recorder return	encoded INOP	recorder return		Temp.2 ****
A	scaled pressure 2 wave		absolute pressure 2 (60)	scaled pressure 2 wave	absolute pressure 2 (60)	scaled pressure 2 wave	$tcpCO_2$	ECG wave
B	scaled pressure 1 wave				absolute pressure 1 (300)	scaled pressure 1 wave		absolute pressure 1 wave
C	systolic pressure 1							absolute pressure 2 wave
D	diastolic pressure 1							absolute pressure 3 wave
E	mean pressure 2						heart rate b-to-b	CO_2 wave
F	systolic pressure 2			absolute pressure 1 wave (300)	systolic pressure 2		cardio** respirogram mode	pleth wave
H	CO_2/resp. wave	resp. wave	CO_2 wave	resp. wave	scaled pressure 2 wave	resp. wave		

Table 1-2. System Output Configurations (continued)

J92 pin no.	Configurations 0-6							
	0	1	1*	2	3	4	5 #	6***
J	recorder channel 2		ET CO_2	recorder channel 2	scaled pressure 1 wave	delayed pressure 1 wave	delayed resp. wave	NIBP wave
K	ALARM ON/ OFF							
L	diastolic pressure 2		Fi O_2	absolute pressure 2 wave (60)	diastolic pressure 2		Fi O_2	
M	mean pressure 1							ET CO_2
N	recorder channel 1	control state 1	control state 5	recorder channel 1	control state 1	delayed ECG wave	delayed HR b-to-b	HR b-to-b

* output configuration for CO_2 /O_2 parameter

** for cardiorespirogram mode, switch S1 on system board should be open

*** no Aux Wave because it is available as analog signal

**** output configuration not available in German Language Option (PTB)

\# only available in 788XX series

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Figure 1-28. 780 System Board (Annotating) Block Diagram

SDN Board 78353-66595

The SDN (serial distribution network) board has two prime functions:

1. To receive data from the instrument's shared memory, process it and make the information ready for onward transmission to the SDN network.
2. To receive data from the SDN network, process it and transmit it to the shared memory, where it can be accessed by the instrument.

The SDN board permits interfacing with a Central Station (HP 78508/504/509) and an Arrhythmia System (HP 78720) via a system communication control (SCC), or via the SDN Interface in a Central Station. The SDN board also allows communication with other instruments in the branch. Connection to the SCC is by a single cable connected to the rear of the instrument.

Microprocessor Interface Circuit and I/O RAM

Incoming data from the instrument's shared memory is copied into the I/O RAM (U8, U9) through the buffers (U11, U12, U13) during the 4ms time interval of the instrument poll cycle. During the 4 ms dead time of the SDN poll cycle, transmit data already in the I/O RAM is copied into the SIC buffer RAM (U4, U5). During the rest of the remaining 32 ms SDN poll cycle time the board's uP (U10) can access data in the I/O RAM to decode, process (using ROMs U19, U31 and EPROM U16) and to load in new transmit data. RAM U21 serves as a interim store for data being processed by the uP.

System Interface Controller (SIC)

The SIC chip receives serial SDN data from the System Communication Control (SCC). The SIC uses a 12-bit shift register to convert incoming serial data into 12-bit parallel words to make it uP readable. This data is then stored sequentially in the SIC buffer RAMs U4, U5 ready for transmission to the uP interface circuit. Instrument data previously received by the SIC buffer RAM from the I/O RAM is put into serial form by the SIC chip and at the correct time transmits this data over the SCC into the SDN. The SIC reads, stores and translates only those messages specified by the board uP.

Data Synchronization Circuit

The data synchronization circuit (U24) synchronizes the clock input of the SIC with the incoming data so that it samples accurately the SDN data. The SCC has a 32 ms poll cycle time to completely sample each of the connected instruments in the branch. The SDN receives a sync. tap from the SCC and there follows a dead time of 4 ms whilst the SIC communicates with the uP (and the I/O RAM transmits data to SIC buffer RAM and the converse).

After this time has elapsed information can be transferred between the SDN and the SCC before the SCC switches to the next instrument. High priority information is sent first (all wave forms, HR alarms etc). The data synchronization and SDN transceiver circuit (U26, U28) ensures that all the board's timings are correct.

Control Logic

U22 contains the watchdog circuit which includes a counter to interrupt the uP with a reset signal if the uP fails to reset itself in the normal way. It also contains the decoder circuitry for the ROMs together with a buffer network between the SIC chip and shared memory transceiver.

Signature RAM

The signature RAM (U2) is accessed by both the SIC chip and uP. The uP interface circuit keeps a record of all possible signatures in this RAM to indicate which signatures the SIC chip should address.

Note Instrument internal board frame is 20 ms.

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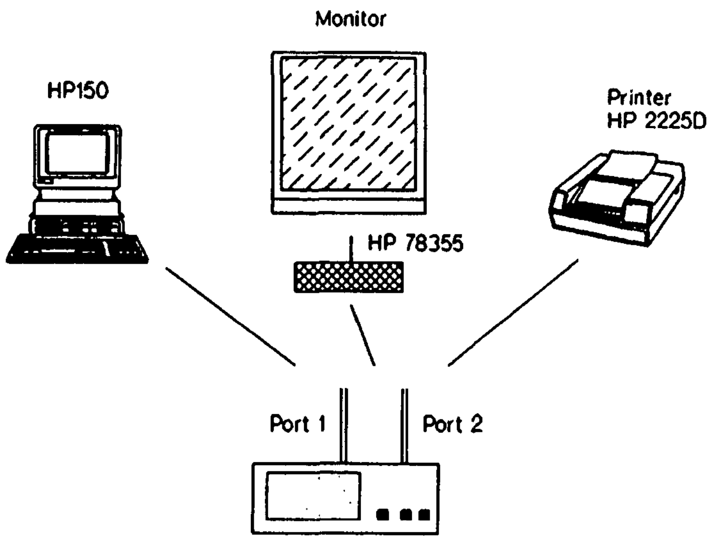
Figure 1-29. SDN Board Block Diagram

RS-232C Interface Board 78354-66598

Instruments with RS-232C interfaces allow connection to external devices such as HP 150 PC, ThinkJet Printer HP 2225D and Digital to Video Interface HP 78355A. Other non HP devices may be connected but must be compatible.



General Principle of Operation

The primary functions of the RS 232C interface are;

- access and sample relevant information in shared memory,
- to process and transmit information at the request of external devices such as HP 78355A and HP 150 PC (or other PC),
- on pressing the monitor's record softkey, the interface processes and transmits data to a ThinkJet printer.

The RS 232C interface can also drive two devices independently, and configuration can be changed while the monitor is in operation.

ROM/RAM

ROM (U7) capacity is 24K and RAMs (U9-11) capacity is 32K.

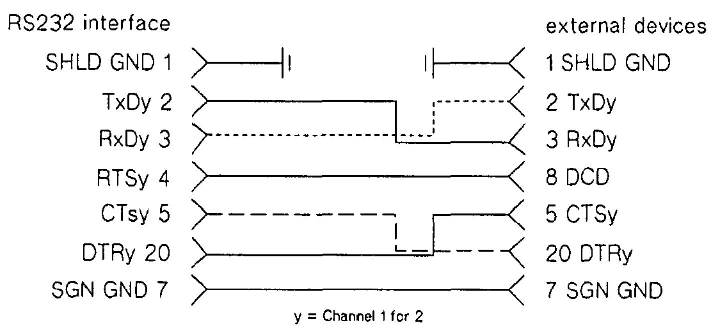
Counter-timer Circuit

Counter-timer U4 provides the correct timing for data to be read from the instument's shared memory (U40 on uP display board A3). U4 detects the 2 ms time slice within the 20 ms frame slot for the interface board to access shared memory data. Two other counters are used as clock dividers for generating the baud rates for the serial interface. Baud rate for channel 1 (Port 1) is fixed to 19200. Baud rate for channel 2 (Port 2) can be changed by altering the switch settings on switch block S1 (Channel 2 Baud rates; 19200, 9600, 2400 and 1200).

Serial Interface

The serial interface (U6) combines the following tasks;

- performs parrallel/serial conversion
- communicates asynchronous in accordance with ANSI-Standard RS232,
- data format is 8 bit without parity, 1 start,1 stop bit,
- two independent full duplex channels,
- communication control via hardware handshake,
- the following handshake signals are used:
  - DTR (Data Terminal Ready) output enables the transmitter of the connected device (interface board is ready to receive),
  - CTS (Clear To Send) enables the transmitter of the RS 232C interface (external device is ready to receive) - see cable wiring below:



Watchdog Circuit

The watchdog timer circuit receives the 20 ms signal as clock input and if the microprocessor does not reset the watchdog timer in time, the watchdog resets all the components of the RS 232C interface board.

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Figure 1-30. RS232C Block Diagram

2

Maintenance Checks

Introduction

Chapters 2a, 2b and 2c provide all the Mainenance Check information required for the 78XXX Series Patient and Neonatal Monitors. The Maintenance Check chapters cover the following:

Chapter 2a Performance Assurance Checks

Chapter 2b Specification Checks

Chapter 2c Technical Specifications for all Monitors

2a

Performance Assurance Checks

Introduction

This chapter contains performance assurance checks applicable to the 783XX and 788XX series of monitors. Any checks which are valid for only one of the monitors are clearly labelled with the appropriate monitor number.

General

Performance assurance checks, done from the front panel, verify that the unit is working, is in good operating condition, is safe for the staff and patient, and is accurate to clinically significant levels. Performance assurance, including safety tests, should be done after every repair. When the performance assurance procedures are used as a periodic check they should be scheduled to cover monitors that are not in use, i.e. at unoccupied beds.

For safety tests a safety tester should be used. For ease of use and efficiency the RIGEL Safety tester, Model 233 is recommended Figure 2a-1. For safety test procedure see operating instructions of Model used.

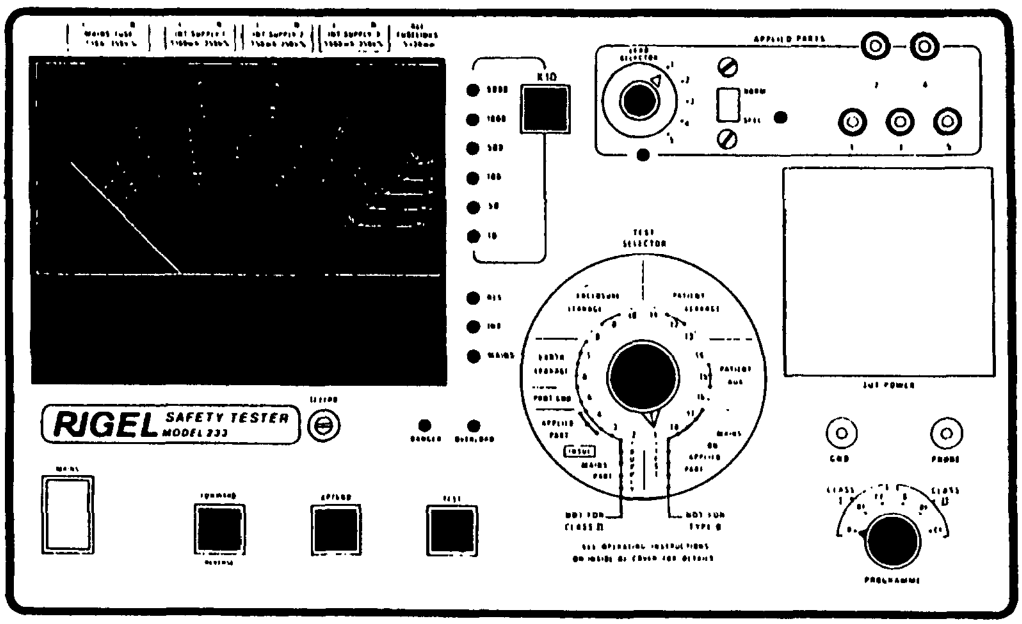


Figure 2a-1. Rigel Safety Tester

Note If a patient cable is used, additional leakage current will be introduced because of the cable's capacitance to ground. The maximum acceptable leakage current measured at the end of the patient cable is 20 uA while the specification at the instrument is 10 uA. However, the placement of the patient cable totally adjacent to a ground plane will increase the capacitance to ground during the test procedure and may increase the leakage current beyond the maximum test limit. Since this capacitance to ground is difficult to control, the test should be performed without a patient cable.

Test equipment

For the performance assurance checks the internal test function is used. The following test equipment is required:

- Patient simulator (recommended:

  Neurodyne Dempsey
  Model 211A US
  Model 212A Europe)

- Temperature probe (or resistor)
- Pressure simulation box (Figure 2a-9) or pressure gauge 14303A
- Respiration simulation boxes (Figure 2b-10 and Figure 2b-11)

General checks

1. Check power cord and power plug for good mechanical condition.
2. Clean CRT and key panel (see operating guide for cleaning).
3. Open top cover. Inspect all internal cables and connections, and circuit board insertion into mother board. Look for evidence of overheated or damaged components, or any other suspicious symptoms.
4. Disconnect all signal inputs to the monitor.
5. Apply power to the monitor, checking for smooth operation of the on/off switch.
6. Close top cover.

Monitor Service Test Mode

Most of the performance assurance checks are done using the internal test function. To enter service test mode, first leave monitor switched off for 20 s then press keys labelled 🔔 or [Silence/Reset] and ⎍ or [Cal Mark] simultaneously, and keeping them pressed, switch the monitor on. As soon as the monitor is switched on, the automatic self-test routine begins. (For a detailed explanation of the error messages which may appear at this point refer to *Volume 2* of the manual, Chapter I). When the test is successfully completed three tones sound, one after the other (QRS tone, alarm tone and leads off tone).

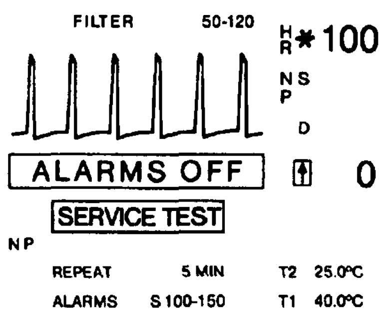
The screen display should be as shown below:

Note These displays are typical and will depend on the monitor Option.

If the self-test is successfully completed, and the display is as shown, the software is working correctly. The following tests check that the keys and controls are fully operational.

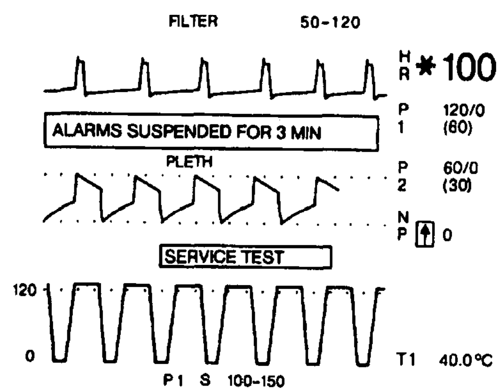
Typical Monitor Service Test Mode Displays

78352A/C Display



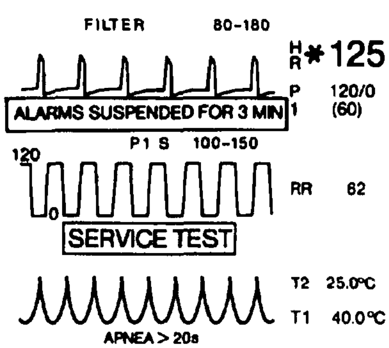
Opt. no1/4: Alarms Off
Opt. no2: Alarms suspended for 3 min

78353A/3B/4A/4C Display

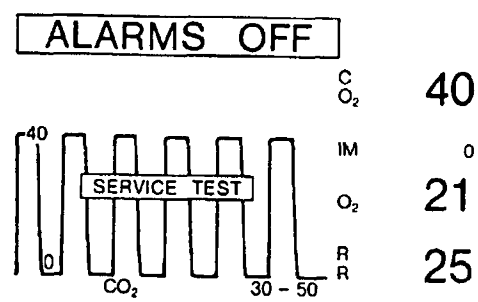


Opt. No1/4: Alarms off
Opt. No2: Alarms suspended for 3 min

78832A/3A/3B/4A/4C display



78356A display



Display Intensity

With the monitor in service test mode:

- Rotate the screwdriver intensity control (on the side of the rear panel) fully counter-clockwise. The display should be faintly visible.
- Rotate the intensity control fully clockwise. The display should now be bright and well focussed. The retrace should not be visible.

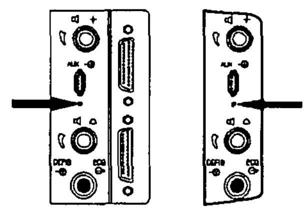


Figure 2a-2. Display Intensity

- Check the automatic intensity control by covering the photo resistor for a few seconds. The display should become less bright.

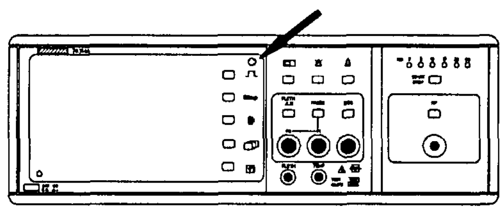


Figure 2a-3. Position of Photoresistor in A and B monitors

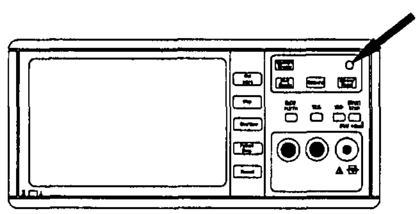


Figure 2a-4. Position of Photoresistor Monitor in "C" series monitors

Checks in ECG Setup Mode

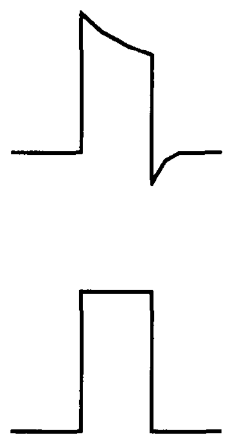
With the monitor in test mode, press the ECG setup key to display the "ECG Setup 1" softkey labels. Now check the following functions:

ECG Gain Press the ↑ and ↓ keys repeatedly to check the maximum and minimum gain respectively.

- Maximum gain of ECG trace: 30 mm/mV
- Minimum gain of ECG trace: 3 mm/mV

Filter/Diagnostic Mode Check

1. Check that the top of the pulse of the ECG test waveform slopes as shown on the right (FILTER mode).
2. Press the softkey labelled FILTER to select DIAG- nostic mode.
3. Check that the top of the pulse is approximately horizontal (squarewave) and that there is a definite difference from the FILTER mode pulse.



Filter Diagnostic pulse shapes

Alarms

a. Press or [Suspend] key to turn alarm capability on (only necessary if ALARMS OFF or ALARMS OFF FOR 3 MIN message is displayed)

b. Press the ALARMS key to access the ECG alarm setup.

c. Decrease the upper alarm limit, using HIGH key, to 95 bpm in 783XX series (to 120 bpm in 788XX series). After 10 s an audible alarm should sound and the numerics should flash alternately in normal and inverse display. The alarm lamps should also flash alternately (in 788XX series).

d. Press the or [Silence/Reset] key to silence the alarm. The numerics should now be displayed in inverse display and the alarm lamps stop flashing in the 78XXX series.

e. Turn the alarm capability off using the or [Suspend] The numerics should return to normal display and an ALARMS OFF or ALARMS OFF FOR 3 MIN message should be displayed.

f. Return upper alarm limit to previous display.

Parameter Set-up Keys

With the monitor in test mode, press each of the remaining parameter setup keys in turn to check that the correct display appears. The softkey label displays for pressure, plethysmograph and respiration are shown in Figure 2a-5

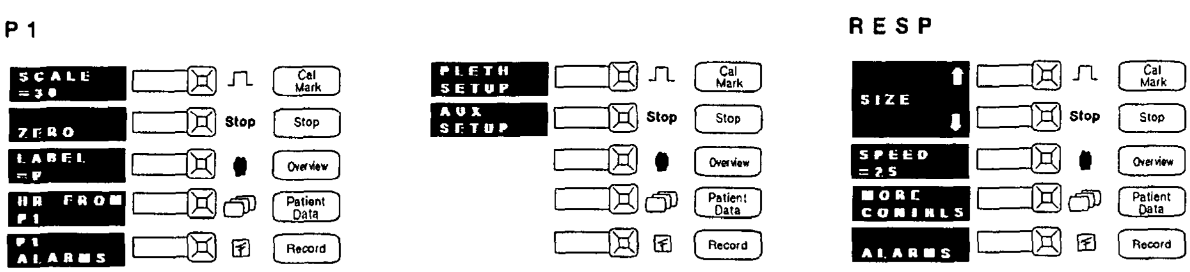


Figure 2a-5. Initial Set-up Displays for Pressure, Pleth and Respiration

This concludes the checks for the keys and controls. The remaining performance checks concern parameter signal input circuits and calibration procedures.

Pressure Channel Check and Calibration

The following procedure uses the calibration Gauge 14303A. For these checks it is assumed that the transducer and pressure gauge are functioning correctly.

a. Connect the gauge as shown in Figure 2-6. Set the stopcock so that the manometer bulb output is connected to both the gauge and the transducer.

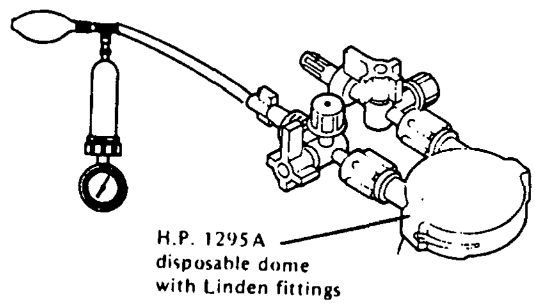


Figure 2a-6. Equipment for Pressure Calibration

b. Switch instrument on.
c. Connect the transducer to the instrument.
d. Press the pressure setup key then set the scale to 180 mmHg (24 kPa).
e. Vent the transducer to atmosphere by opening the stopcock, and push the Zero button. Close stopcock.
f. Open the release valve on the manometer bulb and rotate the gauge dial outer ring so that zero pressure is indicated.
g. Close the release valve and increase the manometer bulb pressure to 200 mmHg (30 kPa = 225 mmHg).
h. Press CAL MERCURY key. Mercury calibration setup is displayed.

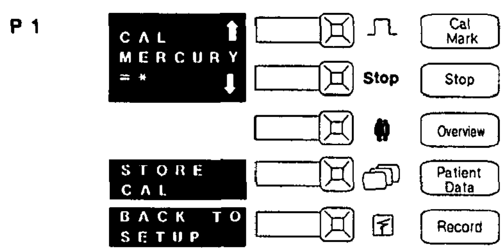


Figure 2a-7. Mercury Calibration Set-up Display

Adjust the pressure value shown in the softkey display (using the CAL MERCURY ↑ or CAL MERCURY ↓ key) until it equals the reading on the manometer.

Press the STORE CAL key.

Note

If the pressure value is already correct i.e. does not require adjustment, then the calibration factor is also correct and is not necessary to press the STORE CAL key.

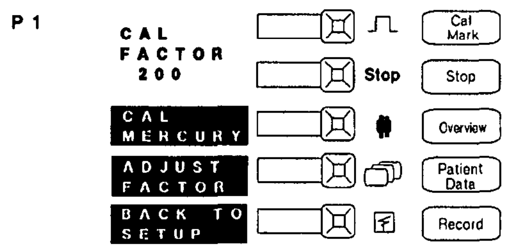


Figure 2a-8. Pressure Display after successful Calibration

Alternatively, a resistive simulator for 0 and 200 mmHg functioning on the 40 uV/V sensitivity range can be built according to Figure 2a-9 The simulation is connected to the pressure input and provides either a 0 mmHg or 200 mmHg input signal (switch closed and switch open respectively). This allows both the zeroing procedure and 200 mmHg calibration to be checked, as in the previous procedure.

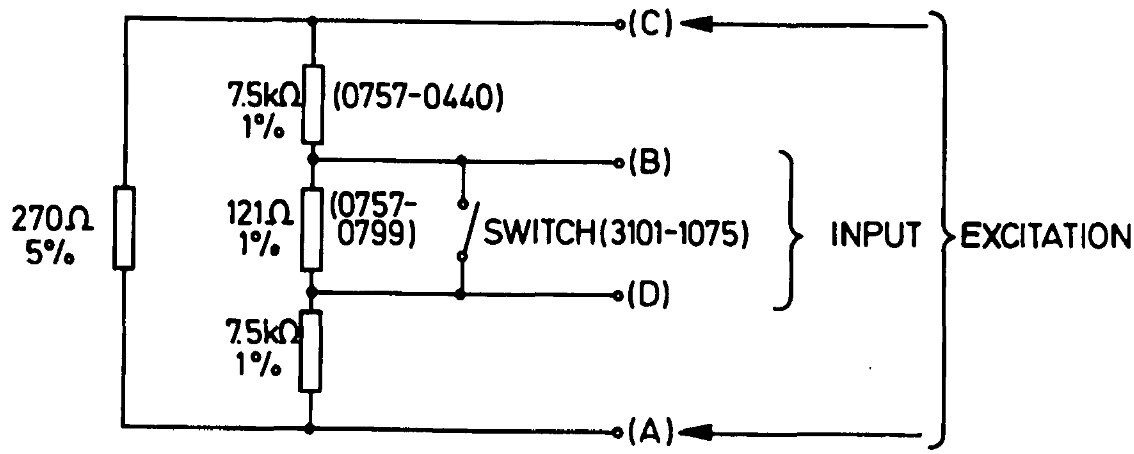
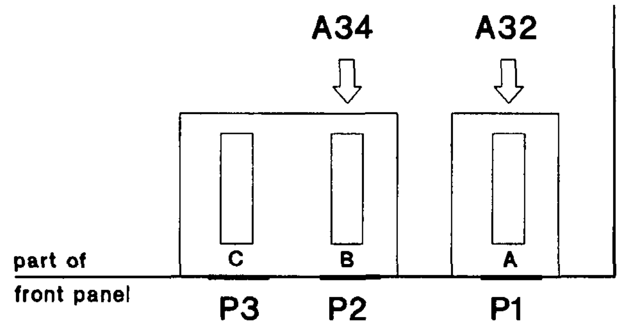


Figure 2a-9. Resistive Simulator for 0 and 200mmgh

Note

When two pressure boards (1 x PRESS and 2 x PRESS) are loaded (in 78354A) they should be in the positions shown below:



Slot C	Slot B	Slot A	78354A
	P1		
	P1/P2		#A21, #A24
	P2/P3	P1	#A22

CO_2 and O_2 Calibration and Adjustments

The following procedure describes how to calibrate and make adjustments to the CO_2 and O_2 parameter boards. Calibration/adjustments are necessary when the following conditions apply:

New installation:

- set correct altitude to allow for variations in atmospheric pressure (for CO_2 only),

Replacing CO_2 board:

- set correct altitude,
- set Calstik value,
- perform O_2 zero,

Replacing O_2 board:

- O_2 zero calibration.

O_2 Zero Calibration:

1. First enter service test mode by switching off instrument for at least 20s, then, pressing softkeys ⎍ or [Cal Mark] and 🔔 or [Silence/Reset] simultaneously,switch on the instrument but keeping the keys pressed until the three tones are heard.
2. Plug in short circuit plug (PN 78354AK #890, or 78354-47601).
3. Press O_2 setup key and display will change.
4. Press ALARMS key until `ALARMS OFF` is indicated on display.
5. Press and hold key (normally >5s) labelled 🗐 or [Patient Data] until display changes to `ZERO STORE`
6. Press `ZERO STORE` key for about 1s. This completes the O_2 zero calibration

Press O_2 setup key again to return to normal display.

CO_2 Service Setup

1. As in (1) above
2. Press CO_2 setup key to enter CO_2 setup.
3. Press ET ALARMS key until display indicates ALARMS = OFF
4. Press key labelled [key icon] or (Patient Data) until STORE appears on display. Altitude can now be adjusted.
5. Using appropriate keys, adjust altitude reading to the correct value of that instrument's particular installation location (i.e height above sea level, adjustment is made in 100 m steps).
6. Press *STORE* key for about 1s until display returns to ET ALARMS

Press CO_2 setup key once again to return to normal display.

CO_2/O_2 parameters are now calibrated/adjusted and ready for use.

Note

Note:O_2 zero calibration needs to be performed when either O_2 or CO_2 boards are replaced because the O_2 zero calibration information is stored in the NOVRAM U27 located on the CO_2 board (78354-66540).

Temperature Channel Checks

a. Switch the instrument on.

b. Connect precision resistor 2814.0 ohm ± 0.025% PN 0811-3444 to the temperature input. This represents an input of 20°C ± 0.2°C. Check that the temperature numerics displayed are correct.

c. Connect precision resistor 984.20 ohm ± 0.025% PN 0811-1681 (equivalent to 450 °C ±0.10 °C) to the temperature input. Check again that temperature numerics are correctly displayed.

Note: On 78834A #A22 the temperature display alternates between T1 and T2 when both temp. channels are loaded (at a rate of about 1s). This is because of limited display space.

Plethysmograph Channel Checks

a. Apply pleth transducer to ear or finger (depending on type used).

b. Plug pleth transducer into instrument. After a few seconds pleth curve will appear on display.

c. Autogain should adjust wave signal to lie between gridlines.

Barometer Board Checks

The Barometer Board is factory calibrated and normally needs no adjustment. The range of the built-in barometer is 500 mmHg to 800 mmHg (67 kPa to 106 kPa) with accuracy of 1% full scale. The accuracy of the barometric pressure reading may be checked against an absolute barometer. To do this connect a working $tcpCO_2/tcpO_2$ transducer to the monitor and proceed as follows:

- Press pCO_2/pO_2 setup key,
- Press the MORE CONTRLS key,
- Press BAROM PRESS and the display shows; (for example)

BAROM.	indicating a barometric
PRESS.	pressure of 722 mmHg for a monitor configured
722	to mmHg (or 96.3 for kPa version).

- read off the barometer pressure from an accurate (accuracy = ±0.5 mmHg) barometer. (Barometer Board adjustment is described in "Barometer Board Adjustment" in Chapter 2b.

$tcpCO_2/tcpO_2$ Channel Checks and Transducer

Troubleshooting

Performance assurance checks of the $tcpCO_2/tcpO_2$ channel may be checked either:

- by connecting working transducers to the transcutaneous inputs and performing measurements and calibration procedures as described in the instrument and sensor operating guides or

- using a comprehensive transducer simulation test box, which apart from verifying specifications (see "$TcpCO_2/tcpO_2$ Channel" in Chapter 2b) can also simulate normal operation of both the 15204A/15205A transducers. This is important in order to distinguish between transducer defects and parameter board defects. For information on this simulation test box contact the nearest HP Service Office regarding price and availability.

IMPORTANT: NOVRAM reprogramming

The circuitry on the $tcpCO_2/tcpO_2$ parameter board (78834-66572) includes a NOVRAM used primarily to:-

1. store reference values derived from specific components on the parameter board's input amplifier circuitry. These reference values are parameter board specific and are programmed as part of the factory parameter board final test procedure.
2. to store operator configuration settings.

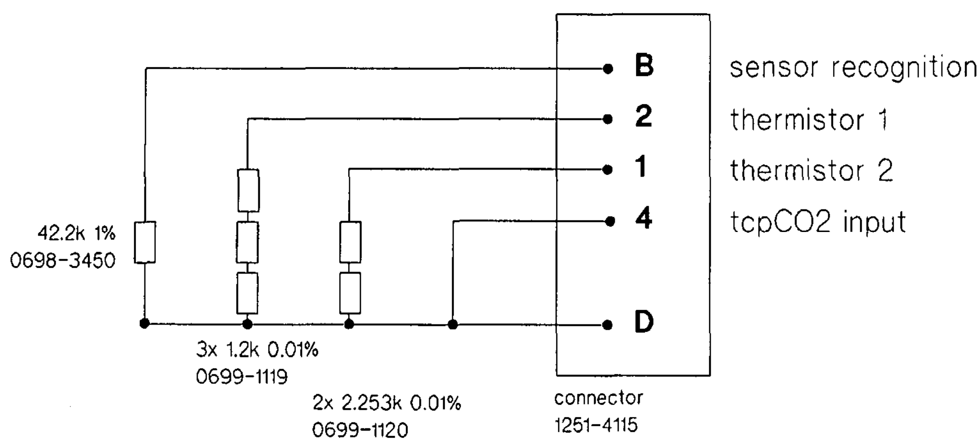
If component level repair is made on $tcpCO_2/tcpO_2$ input amplifier circuitry (U501,U502 etc. see schematic of parameter board) or if the NOVRAM itself has to be replaced then NOVRAM reprogramming **MUST** be performed by HP Service in order to ensure accurate transcutaneous gas measurements.

Note

Exchange boards are already programmed at the factory (as in 1 above) and do not require reprogramming by HP Service. Only configuration settings* (as in 2 above) must be reprogrammed and this is only necessary if the default settings have been altered (see following paragraphs NOVRAM reprogramming).

NOVRAM reprogramming - as in 1 above.

The NOVRAM reprogramming procedure is relatively easy and requires a special NOVRAM calibration jig. The individual parts, with part numbers and wiring connection are shown below;

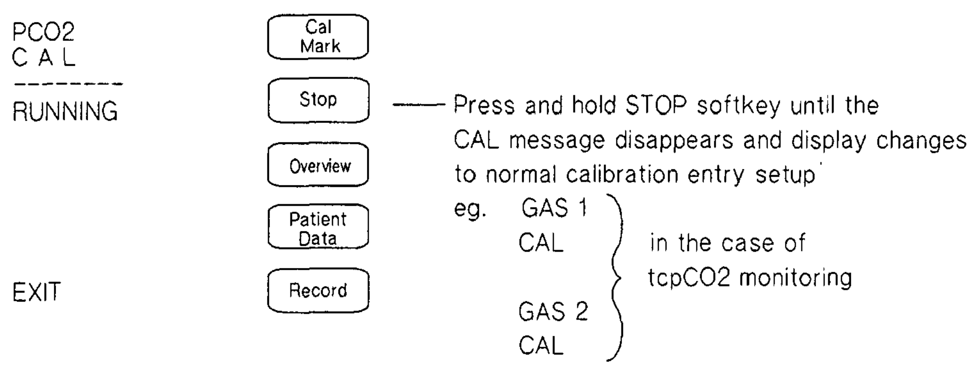


Note

The calibration jig is suitable for both $tcpCO_2$ and $tcpO_2$ circuits.

Proceed as follows;

- switch instrument on (normal operating mode),
- plug in the calibration jig,
- if the measured reference values are in the allowed range the pCO_2 and pO_2 numerics show the CAL message after 2 to 3 s, if not the calibration jig or the parameter board is not functioning correctly,
- press pCO_2 or pO_2 setup key and setup display should now show the CAL RUNNING message; (if a combined pCO_2 and pO_2 setup key exists the display gives you a choice of which to select eg. PO_2 SETUP or PCO_2 SETUP, press either one)



The NOVRAM reprogramming - 1 procedure is now complete.

NOVRAM reprogramming - as in 2 above

Configuration settings must also be reprogrammed since the NOVRAM also stores current operator configured settings which are necessary to ensure accurate $tcpCO_2/tcpO_2$ measurements. Proceed as follows:

- plug in working transducer (or calibration jig),
- press pCO_2/pO_2 setup key,
- (if cal. jig connected press STOP softkey until CAL RUNNING message disappears as described previously),
- (if cal. jig connected press BACK TO SETUP softkey),
- press MORE CONTRLS sofkey,
- press MORE CONTRLS softkey again to access configuration setup,
- press CHANGE CONFIG softkey,
- now enter the (previous*) operator configured settings (in the case of $tcpCO_2$ monitoring these are; correction facility, site timer facility, {gain and offset values in the Correction Setup mode}, and in the case of $tcpO_2$ monitoring are; room temperature, relative humidity, site timer facility),
- press STORE key to store data in NOVRAM.
- repeat for other pO_2 or pCO_2 if two separate inputs exist.

The NOVRAM reprogramming - 2 is now complete. Note: If this NOVRAM reprogramming - 2 is not performed the NOVRAM will automatically revert to the default values for the configuration settings listed as follows;

Note

If possible note the configuration settings before performing NOVRAM/component repair so that the same values and status can be re-entered (this of course will not be possible if the NOVRAM itself is defect).

- **tcp02 Configuration default settings:**

  Site timer: Off
  Room temperature: 25°C
  Relative Humidity: 50%

- **tcpCO_2 Configuration default settings:**

  Site timer: Off
  Correction : Off

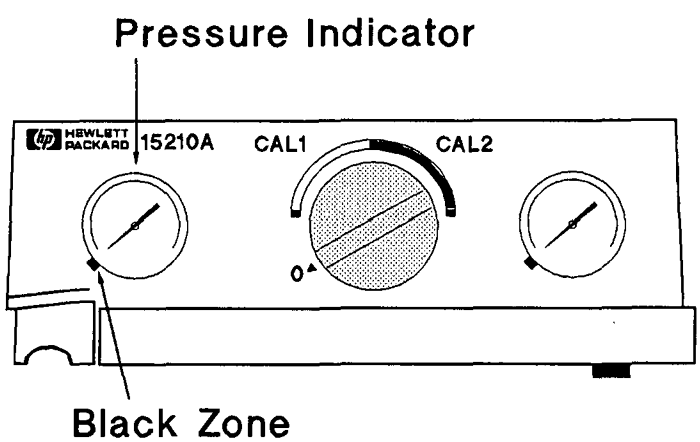
HP 15210A Calibration Unit

Installation

Description

The HP 15210A Calibration Unit contains two gas cylinders (CAL 1 mixture and CAL 2 mixture) connected to a calibration chamber via a time controlled valve. The valve is normally closed, ensuring that no gas is lost when the unit is not in use. When the timer is turned to "CAL 2" this gas is directed to the calibration chamber for a period of 15 minutes. After this time the valve automatically switches to "CAL 1" which in turn runs for 15 minutes.

This section provides the necessary information for you to install and service the HP 15210A.



HP 15210A Calibration Unit

Unpacking the Instrument

If external damage to the shipping carton is evident, ask the carrier's agent to be present when the unit is unpacked.

Initial Inspection

Check the instrument for any external damage such as dents and scratches on panel surfaces. If the shipping carton is not damaged, check the cushioning material and note any signs of severe stress as an indication of rough handling in transit. Retain the packaging material for possible repacking.

Claims For Damage

If physical damage is evident when the Calibration Unit is received or the unit does not meet the specified operational requirements, please notify the carrier and the nearest Hewlett-Packard Sales/Service office immediately. The Sales/Service office will arrange for repair or replacement without waiting for settlement of the claim against the carrier.

Repacking for Shipment or Storage

If the Calibration Unit is to be shipped to a Hewlett-Packard Sales/Service office, securely attach a tag showing the name and address of the owner, the model and serial number, and the repair required or symptoms of the fault. If available and reusable, the original shipping carton and packaging material should be used to provide adequate protection during shipping. The Hewlett-Packard Sales/Service office will provide information and recommendations on materials to be used if the original material is not available or reusable.

Instrument Identification

Hewlett-Packard uses a nine character sequence for instrument identification. This serial number is located on a plate attached to the rear panel of the instrument.

Specification

Gas supply:	2 low pressure cylinders.
Gas Cylinder Type	Disposable, lightweight, colour coded (CAL 1 - brown and CAL 2 - green)
Gas flow:	8 ml +4/-2 ml per minute for 15210-64010 and 15210-64020 12 ml +4/-2 ml per minute for 15210-60010 and 15210-60020.
Cylinder pressure:	indicated by an integral pressure manometer.
Timer period:	CAL 1 - 20 minutes CAL 2 - 20 minutes
Dimensions:	90mm (35.4in) high x 220mm (86.6in) wide x 235mm (92.5in) deep, (without cylinder)
Weight:	2.4kg (5.3lbs), (without cylinder)

Note

The 15210A is intended for use with Hewlett Packard **CAL 1** and **CAL 2** gas cylinders.

Part Number: CAL 1: 15210-60010 or
15210-64010 for EUROPE and JAPAN only

Part Number: CAL 2: 15210-60020 or
15210-64020 for EUROPE and JAPAN only

Operating Environment

The environment where the HP 15210A will be used should be reasonably free from vibration, dust, corrosive or explosive gases, extremes of temperature, humidity, etc. The HP 15210A operates within specifications at ambient temperatures between 0°C and 55°C. The maximum operating relative humidity is 95% at 40°C. Ambient temperatures or humidities which exceed these limits could affect the accuracy of the calibration unit and cause damage to components.

Operating Information

Each HP 15210A is delivered with a multilingual collection of stick-on operating labels. Each label summarizes day-to-day operating procedures using the Calibration Unit. It is intended to be stuck to the top surface of the Unit, however it may be attached to any flat, grease-free surface.

To attach label: clean the surface where the label is to be placed with soapy water to remove any dirt or grease. Dry the surface thoroughly. Peel off the paper backing and carefully place the label in the required position. Press down firmly with a clean dry cloth, paying particular attention to the edges.

Fitting the Gas Cylinders

When the Calibration Unit is delivered, no gas cylinders are fitted. Before putting the unit into service screw one cylinder of each type (CAL 1 and CAL 2) into the appropriate opening in the rear panel. The openings are marked CAL 1 and CAL 2 and accept the cylinders marked CAL 1 (brown labelling) and CAL 2 (green labelling) respectively. Screw the cylinders in until hand- tight (3 to 6 turns) and then ensure that the pressure indicators are showing approximately 16.5 bar (10.7 bar -Europe only).

When new, the calibration unit will contain a small amount of normal air. To expel this air before use and thus prevent inaccurate calibration, turn the timer control fully clockwise after fitting the gas cylinders and allow it to run for the full period. The calibration unit is now ready for use.

Storage of Gas Cylinders

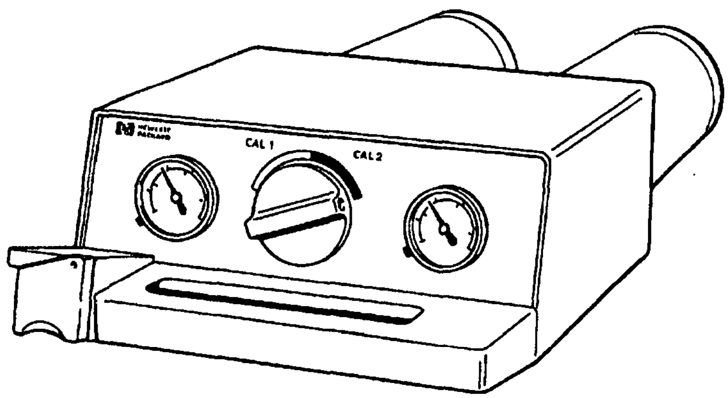
New gas cylinders should be stored in a cool place and not exposed to direct sunlight.

Disposal of Used Gas Cylinders

Do not crush or incinerate used gas cylinders. They may be disposed of as scrap metal.

Routine Maintenance

Changing the Gas Cylinders



HP 15210A Calibration Unit

Before each calibration the gas pressure indicator on the HP 15210A front panel should be read. If the indicator is in the "black" zone, change the gas cylinder as follows:

a. From the rear of the unit turn the empty gas cylinder anti-clockwise until the cylinder is free (3-6 turns).

b. Withdraw the empty cylinder.

c. Take a full gas cylinder of the appropriate type (CAL 1 or CAL 2) and insert it squarely into the rear of the unit. Turn clockwise until hand tight.

d. Check that the pressure indicator is no longer in the "black" zone.

Care and Cleaning

Keep the surfaces of the calibration unit clean and free of dust and dirt. Clean regularly with a lint-free cloth or sponge dampened in soapy water. Avoid using alcohol or ammonia based cleaners which may damage the Calibration Unit. Other strong cleaners such as Povidine RR, Lysol R and Mikroklene R are not recommended since they may stain the unit. Do not pour any liquid on the instrument while cleaning . Never use an abrasive material such as steel wool or metal polish. Cleaning agents and disinfectants should only be used in cases of stubborn dirt. If used, carefully remove any remaining traces of cleaning agent or disinfectant with clean water.

Note Do not allow water to enter the calibration chamber.

To clean the calibration chamber: use cotton wool soaked in soapy water to remove any deposits which may collect in the bottom of the chamber. Dry the chamber thoroughly after cleaning. In the case of severe blockages, a thin length of wire may be used to free the outlet pipe.

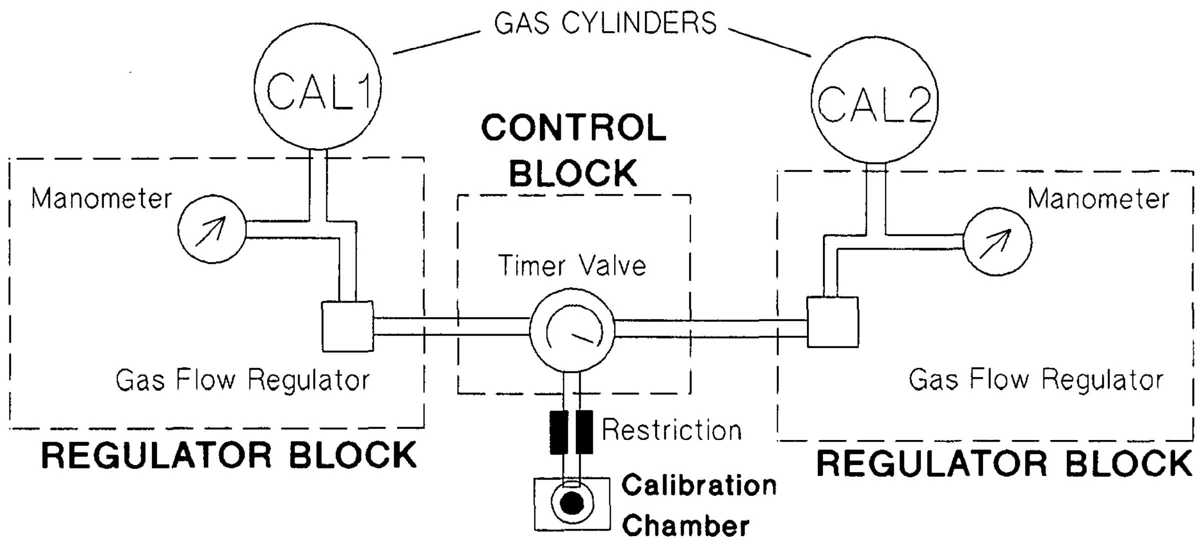


Figure 2a-10. Block diagram - Internal Components

Each gas cylinder is screwed directly into a pressure *regulator block*. These blocks ensure that, in combination with the *restriction*, the gas flow remains constant as the pressure in the cylinders falls with use. From the regulation blocks the gas is channelled to the *control block*. The gases pass into the control block via an opening in the side sealed with an "O"-ring and filter. The control block acts as a switch.

The operation of the switch is controlled by the timer section of the Control Block. On turning the timer control fully clockwise, CAL 2 gas is directed from the control block to the Calibration Chamber. At the 12 o'clock position of the timer control the Control Block automatically changes to CAL 1 gas. The two phases of the timer each last 15 minutes. At the end of the CAL 1 phases the gas supply to the Calibration Chamber is switched off.

A restriction piece is fitted in the tubing connecting the control block to the calibration chamber. The restriction helps to regulate the gas flow.

When a tranducer is placed in the calibration chamber it rests on the "O"- ring and thus prevents gas escaping. To maintain a steady gas flow over the transducer surface an outlet is provided in the rear of the calibration chamber. This outlet is connected to approximately 200mm of tubing for use in the "Performance Test" described on the next page.

Gas Flow Performance Checks

Hewlett-Packard recommends that the following gas flow check is conducted once a year.

Test Procedure

Test 1:

1. Check that the pressure indicators are not in the black zone (i.e. that there is an adequate supply of gas in the cylinders).
2. Remove the Calibration Unit cover (see disassembly).
3. At the rear of the calibration chamber are two plastic tubes. One tube goes to the control block and the other is not connected at one end. Take the free end of the latter piece of tubing and immerse it in a glass of water.
4. Place a transducer in the calibration chamber in the normal manner (the transducer prevents gas leaving the chamber other than via the outlet tubing at the rear).
5. Turn the timer control to "CAL 1" - a steady stream of bubbles should be observed in the water. This indicates a normal gas flow.
6. Turn the timer control to "CAL 2" - again a steady stream of bubbles should be observed to indicate a normal gas flow.

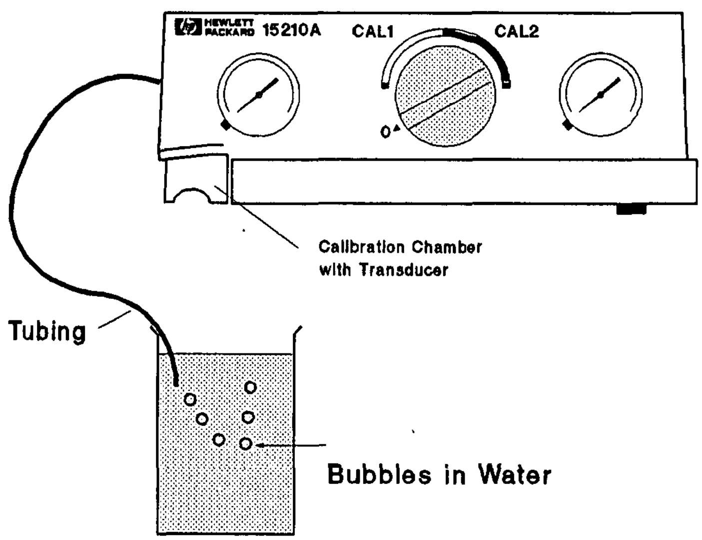


Figure 2a-11. Gas Flow Performance Check - Test 1

Action: If no air bubbles are observed or if bubbles are only released occasionally the supply of gas is not adequate. In this case proceed to tests 2/3.

For tests 2 and 3 the Regulator/Control Block must be removed from the unit. See "Disassembly" section 3. After disassembly refit the timer control knob to the timer and the gas cylinders.

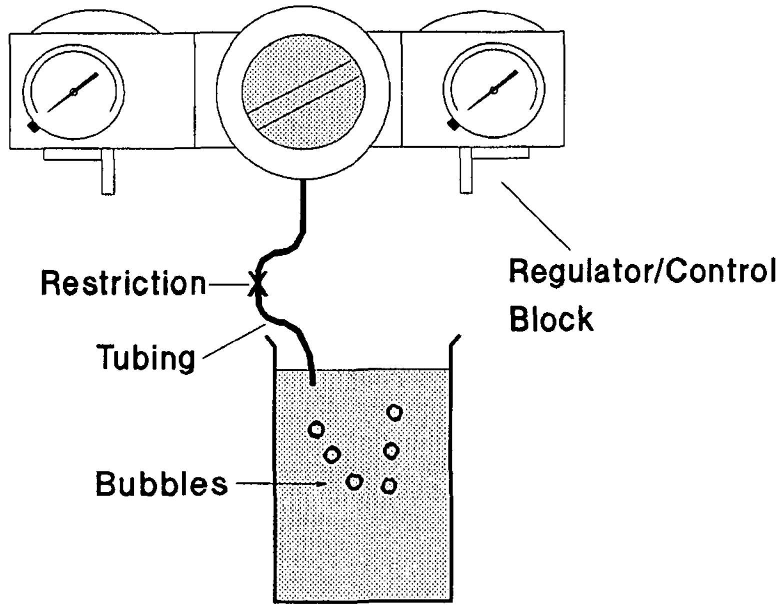


Figure 2a-12. Gas Flow Performance Check - Test 2/3

Test 2: Perform the test 1 again but this time place the tubing coming from the control block in the glass of water.

Action: If the gas flow is normal in this test, inspect the calibration chamber inlet and outlet pipes for blockage (see Care and Cleaning). If the gas flow is not adequate proceed to test 3.

Test 3: Remove the restriction (15210-23701) from the tubing. Place the free end of the tubing coming from the control block into the glass of water. Advance the timer first to CAL 1 and then to the CAL 2 positions. In both timer positions observe the gas flow.

Action: If the gas flow is normal in this test, replace the restriction (15210-23701).

If the gas flow is not adequate in either timer position, the complete calibration unit must be reassembled and returned to the nearest HP service office for repair.

The function of the "Timer" may be checked using a normal watch or clock. When turned fully clockwise the pointer should take approximately 15 minutes to reach the 12 o'clock position and then a further 15 minutes before the gas supply is switched off.

Disassembly

Tools Required:

- Pozidrive screwdriver, size GNl,
- Normal screwdriver, size 1/7,
- Hex-key (Allen-key), size SW 3mm.

1. Cover Removal, see Figure 2a-13.

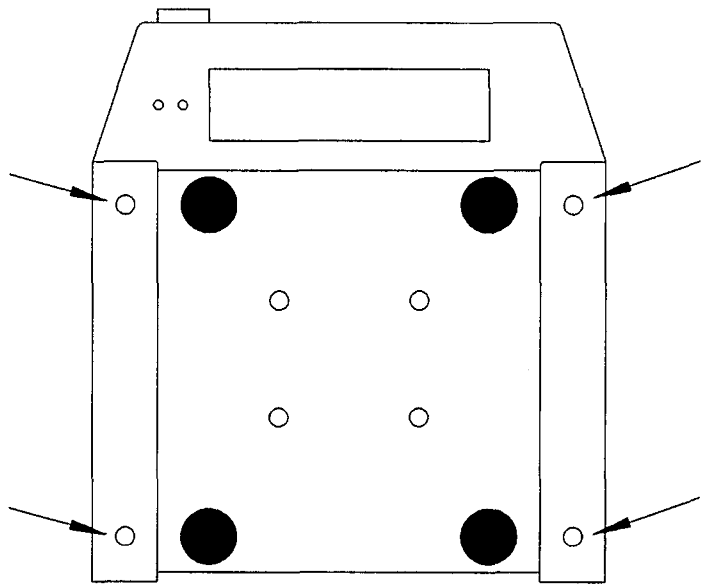


Figure 2a-13. Cover Securing Screws (veiwed from underneath)

   a. Remove both gas cylinders from calibration unit.

   b. Remove the four screws on the base of the unit (see diagram).

   c. Slide the cover off towards the rear of the unit.

2. Timer Control Knob

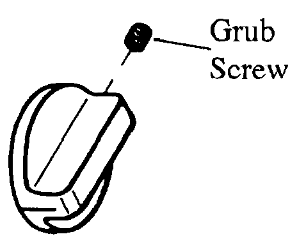


Figure 2a-14. Control Knob

   a. The timer control knob is secured with a "grub-screw" located in the side of the knob (see diagram). Loosen this screw approximately 2 turns. The knob can now be pulled off.

3. Regulator/Control Block Removal

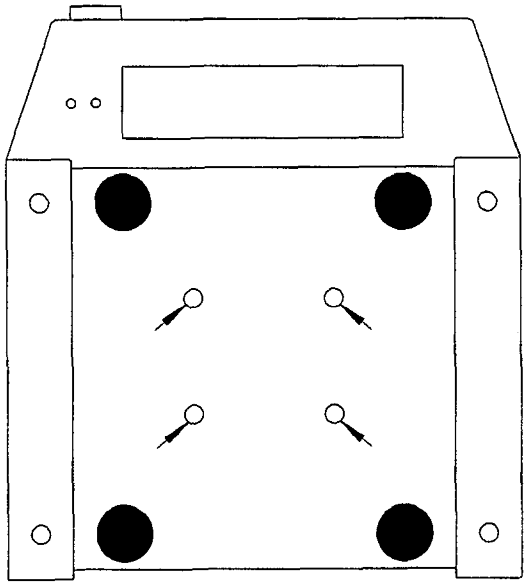


Figure 2a-15. Regulator Control Block Securing Screws

a. Complete operations 1 and 2 above.

b. Remove the connection pipe from the rear of the Calibration Chamber.

c. Unscrew the four remaining screws on the unit base to release the Regulator/Control Block.

d. The two screws on the regulator block side can now be removed to separate the regulator block from the control block. Be careful not to misplace the "O"-ring and filter which are fitted between the two blocks.

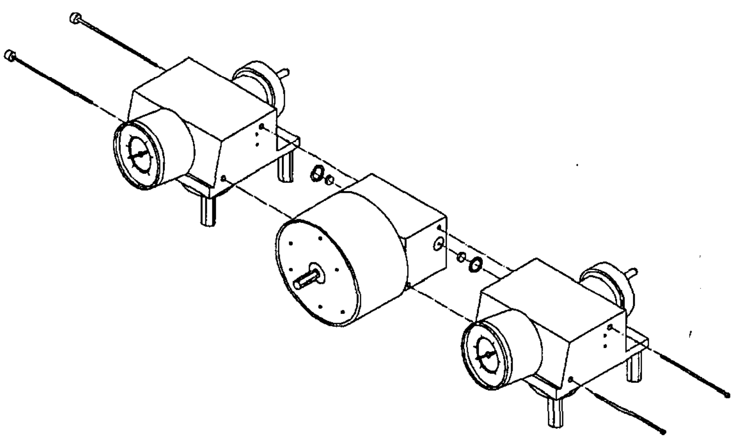


Figure 2a-16. Regulator and Valve Control Blocks

4. Flow Regulator (Restriction) Removal

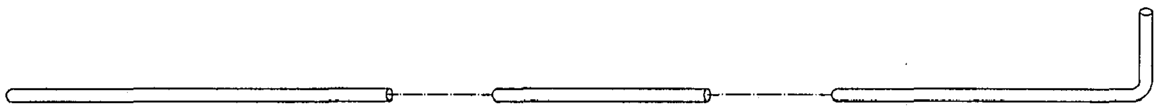


Figure 2a-17. Tubing and Flow Regulator

a. Complete operations 1,2, and 3.

b. The flow regulator can now be removed by pulling the tubing off.

Parts List

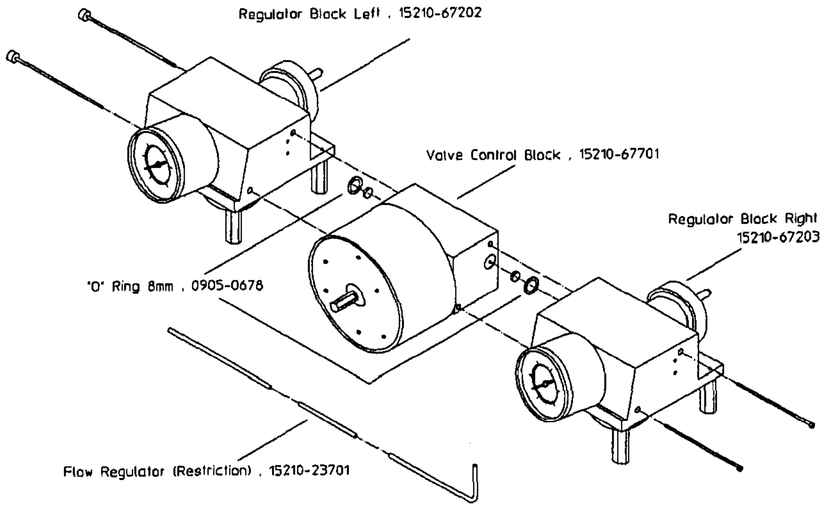


Figure 2a-18. Replaceable Parts for 15210A

Replaceable Parts for the 15210A

Part Number	Description
15210-47101	Flat sealing ring (to seal gas bottle)
15210-47107	Sealing ring
15210-47106	Membrane foil
15210-62401	Clock
15210-67701	Valve control block
15210-67202	Regulator block left
15210-67203	Regulator block right
15210-23701	Flow regulator restriction
0905-0678	8mm ring - between valve control block and regulator block
15210-27401	Timer control knob
0515-0777	Screw M6x8 (for timer control knob)
15210-04101	Cover - bottom
15210-04102	Cover - top
15210-24702	Spacer - hexagonal nut for mounting regulator block
15210-68703	Set of restrictions for adjusting gas flow

Transducer Troubleshooting

$tcpO_2$ (transcutaneous partial pressure of oxygen) and $tcpCO_2$ (transcutaneous partial pressure of oxygen) monitoring is a very application intensive procedure requiring the operator to maintain and correctly calibrate the transducers to avoid measurement problems. The physiological correlation between blood gas analysis derived partial O_2 and CO_2 values and transcutaneous partial O_2 and CO_2 measurements must also be considered before suspecting a transducer or instrument malfunction.

The general troubleshooting guide below covers mainly application and operator problems (this troubleshooting is also covered in the O_2 Operating Guide PN 15204-90001) and the CO_2 Operating Guide PN 15205-90001). $tcpO_2$ and $tcpCO_2$ monitoring error codes which appear on the monitor display are detailed in Chapter 1, Volume 2 of this service manual (PN 78354-90010).

$tcpO_2$ transducer:

1. **Problem:** Reading fluctuates.
   Cause: Switching of nearby electrical equipment; defibrillation; discharge of static electricity.
   Solution: There is no entirely satisfactory solution to this problem other than to remove the source of the interference.
2. **Problem:** After application of the transducer to the skin, it takes longer than specified to reach a stable value.
   Cause:
   a. Impaired vasodilation.
   b. Contact fluid layer too thick or air enclosed between transducer and skin.
   Solution:
   a. Evaluate patient status.
   b. Re-apply transducer.
3. **Problem:** Transcutaneous reading remains at a constant value without fluctuations. Little response to patient blood gas changes.
   Cause:
   a. Physiologic cause.
   b. Contact fluid layer too thick.
   c. Skin burn with blister formation underneath transducer.
   Solution:
   a. Evaluate patient status.
   b. Re-apply transducer.
   c. Change transducer site, reduce skin exposure time.
4. **Problem:** Reading fluctuates towards high values.
   Cause: Transducer loosely attached.
   Solution: Replace adhesive ring. Note, pO_2 in air is much higher than the paO_2 of the blood.

5. **Problem:** $tcpO_2$ reading drifts significantly during measurements.
   Cause:
   a. Damaged membrane.
   b. Transducer not polarized before calibration.
   Solution:
   a. Press lightly on the membrane surface with your finger. If the $tcpO_2$ reading first falls slightly and then rises again the membrane is intact. If the $tcpO_2$ reading first rises and then falls (or remains high), the membrane is defective.
   b. Re-calibrate.
6. **Problem:** The transcutaneous reading deviates significantly from the result obtained from blood gas analysis.
   Cause:
   a. Physiological cause.
   b. Inappropriate transducer temperature.
   c. Transducer incorrectly calibrated.
   d. Inaccurate blood gas analysis, improper handling of blood sample.
   Solution:
   a. Evaluate patient status.
   b. See Selection of Transducer Temperature below.
   c. Re-calibrate.
   d. Repeat analysis with blood gas analyzer.
7. **Problem:** Transducer can no longer be calibrated.
   Cause:
   a. Air bubble within electrolyte layer.
   b. Transducer was not polarized before calibration.
   c. The measuring surface of the transducer is contaminated.
   Solution:
   a. Repeat transducer preparation.
   b. The $tcpO_2$ transducer must be polarized for 15 minutes before calibration. This applies after each membrane change and after the transducer is plugged into the instrument.
   c. See "Cleaning the Measuring Surface".

$tcpCO_2$ transducer:

8. **Problem:** Reading fluctuates.
   Cause:
   a. Switching of nearby electrical equipment; defibrillation; discharge of static electricity.
   b. Transducer cable damaged.
   Solution:
   a. There is no entirely satisfactory solution to this problem other than to remove the source of the interference.
   b. Replace transducer.

9. **Problem:** After application of the transducer to the skin, it takes an unusually long time to reach a stable value.

   Cause:

   a. Impaired vasodilation.

   b. No 'Contact fluid' present or air enclosed between transducer and skin.

   Solution:

   a. Evaluate patient status.

   b. Re-apply transducer.

10. **Problem:** Transcutaneous reading remains at a constant value without fluctuations. Little response to patient blood gas changes.

    Cause:

    a. Physiologic cause.

    b. No 'Contact fluid' present of air enclosed between transducer and skin.

    c. Skin burn with blister formation underneath transducer.

    Solution:

    a. Evaluate patient status.

    b. Re-apply transducer.

    c. Change transducer site, reduce skin exposure time.

11. **Problem:** $tcpCO_2$ reading drifts significantly during measurements.

    Cause:

    a. Damaged membrane.

    b. Transducer not stabilized before calibration.

    Solution:

    a. Replace membrane.

    b. Wait for stabilization and recalibrate.

12. **Problem:** The transcutaneous reading deviates significantly from the result obtained from blood gas analysis.

    Cause:

    a. Physiological cause.

    b. Inappropriate transducer temperature.

    c. Transducer incorrectly calibrated.

    d. Inaccurate blood gas analysis, improper handling of blood sample.

    Solution:

    a. Evaluate patient status and refer to "Application", use of correction factors.

    b. See 'Application - Transducer Temperature'.

    c. Re-calibrate.

    d. Repeat analysis with blood gas analyzer.

13. **Problem:** Transducer can no longer be calibrated.

    Cause:

    a. Air bubble within electrolyte layer.

    b. Transducer was not stabilized before calibration.

    c. Membrane working life exceeded.

    Solution:

    a. Remembrane transducer.

    b. The $tcpCO_2$ transducer must be stabilized for 30 minutes before calibration. This applies after each membrane change and after the transducer is plugged into the instrument.

    c. Remembrane transducer.

Selection of Transducer Temperature

General: The correlation* between transcutaneous and arterial pO_2 improves as the transducer temperature is increased. However the skin becomes red as a result of the hyperemization at the measuring point caused by the heating up of the transducer. Three factors affect the degree of reddening:

a. Skin sensitivity at the point of contact.
b. Transducer temperature.
c. Application period.

In order to minimize the risk of blistering, the temperature should be as low as possible and the application period limited in accordance with the selected temperature and the patients skin sensitivity. Under certain circumstances it may take several days before the reddening of the skin disappears.

Note The $tcpCO_2$ transducer characteristics are dependent on the selected transducer temperature. Therefore, after this temperature is changed, a full calibration must be performed.

Under the following clinical situations there is, according to the present level of knowledge, limited or no correlation between transcutaneous and arterial blood gas tensions:

a. Profound peripheral vascoconstriction
b. Circulatory centralization (shock)
c. Arterial occlusive diseases
d. Arterio-venous shunts (e.g. Ductus arteriosus)
e. Edema of the skin (e.g. Oedema neonatorum) and other amomalies
f. Hypothermia during surgery.

tcp Transducer Auto Cleaning

The transducer*Auto Cleaning feature* is only available in conjunction with the 15204A transducer.

The measuring surface must be cleaned when air calibration is no longer possible (indicated by the message ERROR POLISH SENSOR) or after receiving persistant error messages during zero calibration.

The measuring surface can be cleaned electro-chemically or manually. Manual cleaning is only necessary when the electro-chemical process is not available on the monitor or not able to restore the correct operation of the transducer (e.g. in the case of severe deposits on the measuring surface).

For further information on this cleaning process consult transducer operating guide PN 15204-90001.

SpO_2 Channel Checks

Test Mode

1. Set the SpO_2 parameter so that the Pleth, and not the ECG, provides the Heart Rate reading shown on the top right of the monitor display. (See the SpO_2 section in the appropriate operating guide.)
2. Press the instrument setup key ⊡ or (Standard Display) .
3. Press and hold down the test key. The monitor indicates which key to press.
4. As an alternative to (2) and (3) above, go into Service Test Mode. This gives a continuous "hands off" display. To do this, first leave the monitor switched off for 20 s, then simultaneously press keys labelled ⎍ or (Cal Mark) and 🔕 or (Silence/Reset), and turn on the instrument.

The monitor display should show:

a. The SpO_2 numeric displays 100.
b. The Heart Rate is 100 bpm.
c. The SpO_2 wave is smooth and noise free.

Operating Mode

a. Attach the transducer to the finger of a normal, healthy person.

b. Plug the transducer into the 78XXX and switch on the instrument.

c. After a few seconds the pleth wave should appear on screen.

Check that:

a. The autogain adjusts the wave form displayed on screen, such that it lies between the gridlines. In this way it is about 50% of possible channel height.

b. The SpO_2 numeric displays 97% +/- 2%. Providing the person being monitored is healthy and unstressed, a reading far outside this range indicates a monitor or transducer error.

2b

Specification Checks

Introduction

The following specification checks should be used to ensure that the monitor is operating in accordance with the published specifications.

Note All specification checks assume that the internal controls of the monitor are adjusted as described under Adjustments (VOLUME 2).

In addition, these checks verify proper operation of various circuits in the monitor and can be used:

- As part of the incoming inspection check of the monitor (along with the performance assurance checks);
- Periodically, if maximum reliability is desired;
- Before or after repairs or adjustments (along with the performance assurance checks) prior to returning the monitor to regular service.

Specification Checks Test Equipment

See Table 2-1

ECG Channel

Note During all ECG channel checks the monitor must be programmed to output the ECG wave at the rear panel jack (see Volume 2).

ECG Amplifier

Input offset:

a. Connect DVM to jack on rear panel.

b. Set ECG-channel to DIAGnostic mode.

c. Connect patient cable to the ECG input and short all 3 inputs together.

Test Limit: V < 100 mV.

Input offset: (78352A/3B/4A only)

a. Adjust to Max. Gain.

b. Connect DVM to jack on rear panel.

c. Set ECG-channel to DIAGnostic mode.

d. Connect patient cable to the ECG input and short all inputs together.

Test Limit: V < 300 mV

Table 2b-1. Test Equipment Requirements for Specification Checks

Required Type	Recommended Model	Minimum Characteristics
Function Generator	HP 3310B HP 8011A	Output Level: 20V p-p Open Circuit Frequency Range: < 0.01 Hz to 500 kHz Frequency Response (Sine Wave): ± 1% 0.01 Hz to 50 kHz REF 1 kHz at full amplitude into 50 Ohm
Oscilloscope	HP 1740A	Bandwidth: dc to 100 MHz Sensitivity: 10mV/cm to 10 V/cm Time Base: 0.1 s/cm to 0.5 s/cm
DC Voltmeter	HP 3435A	DC Volts Range: 0.000 V to 1,000V Accuracy: ± 1mV
Test Cables and Components	HP 1250-0781	BNC TEE
	HP 11086A	BNC-BNC cable
	HP 10501	BNC-Clipleads Cable (Alligator Clips must be added 4 required)
	HP 1251-1190	P.C. Edge Connector
	HP 0757-0465	100 kohm ± 1% Resistor
	HP 0757-0442	10 kohm ± 1% Resistor
	HP 0757-0401	100 kohm ± 1% Resistor
	HP 0698-3159	26 kohm Resistor
	HP 0813-0029	1 Ohm Resistor
	HP 0160-3552	1 F Capacitor
	HP 0160-3718	47 nF Capacitor
	HP 0160-3726	1 uF Capacitor
	HP 0757-0449	20 kohm Resistor
	HP 2100-2066	2 kohm Potentiometer
	HP 0813-0029	1 Ohm Resistor
DC Power Supply	HP 6214A	1 V dc Output
Gertsch Transformer (Ratio Transformer)		

Gain Check

This check verifies that the gain of the ECG amplifier is 1000 for instruments without a system board, and is adjustable for instruments with system boards (gains 300 to 3000 with full system board, and 400, 800, 1600 and 3200 with simple system board).

System Board not Loaded

Connect the test equipment as shown in Figure 2b-1.

a. Set lead selector to Lead I.
b. Adjust the test equipment as follows:

Function Generator

- Frequency: 10 Hz
- Function: Sine Wave
- Output Level: 5 V p-p (measure with the oscilloscope at the output of the Function Generator while the Function Generator is connected to the 1000:1 divider circuit. Then reconnect the oscilloscope as shown in Figure 2b-1) *Test Limit:* The signal amplitude on oscilloscope should be between 4.2 V and 5.8 V p-p.

System Board Loaded (Option J10 or J11)

- using the same test setup adjust the output of the function generator to 1 V pp.
- adjust for maximum size of the displayed ECG wave on the monitor. *Test Limit:* The signal amplitude on the oscilloscope should be between 2.4 V and 3.9 V.

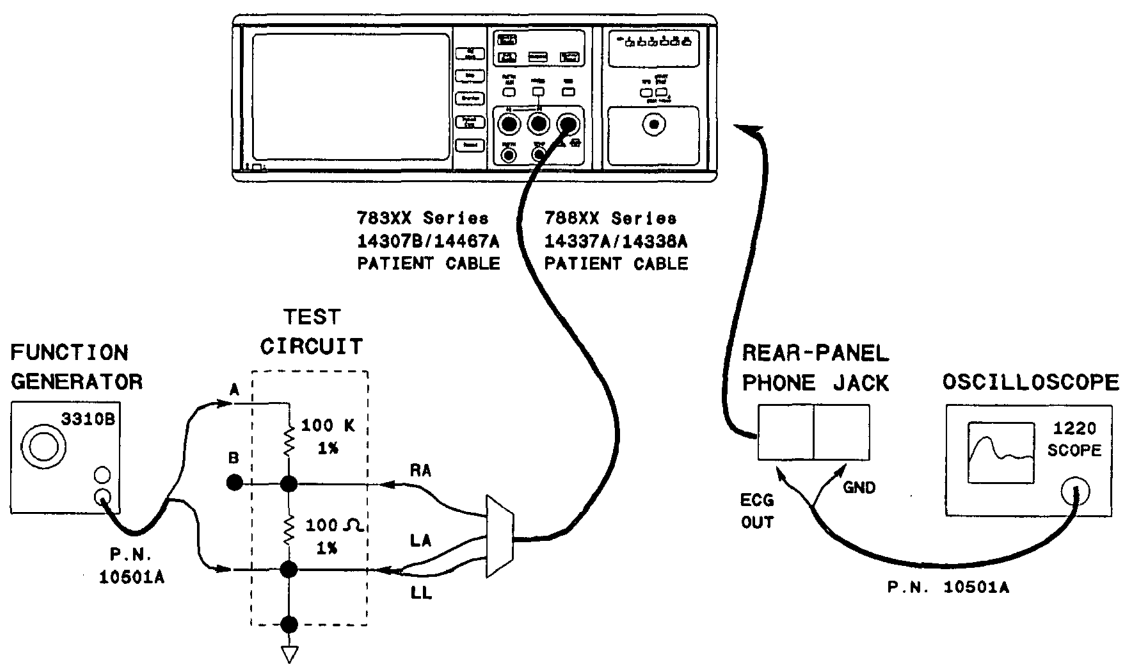


Figure 2b-1. ECG Amplifier Gain Frequency Response Test Set-up

Gain Check: (78352A/C/3B/4A/C only)

- Variable gain of 320 to 3200
- Select Max. Gain:
- Press: **ECG - SIZE** - ⇧ (several seconds) until signal is Max.

Trigger Sensitivity Check

- Connect the test equipment as shown in Figure 2b-2.
- Set output level of function generator to 0.25 V pp (heart rate should be displayed and flash light is visible).
- Test Limit: Trigger should occur at 0.250 V.

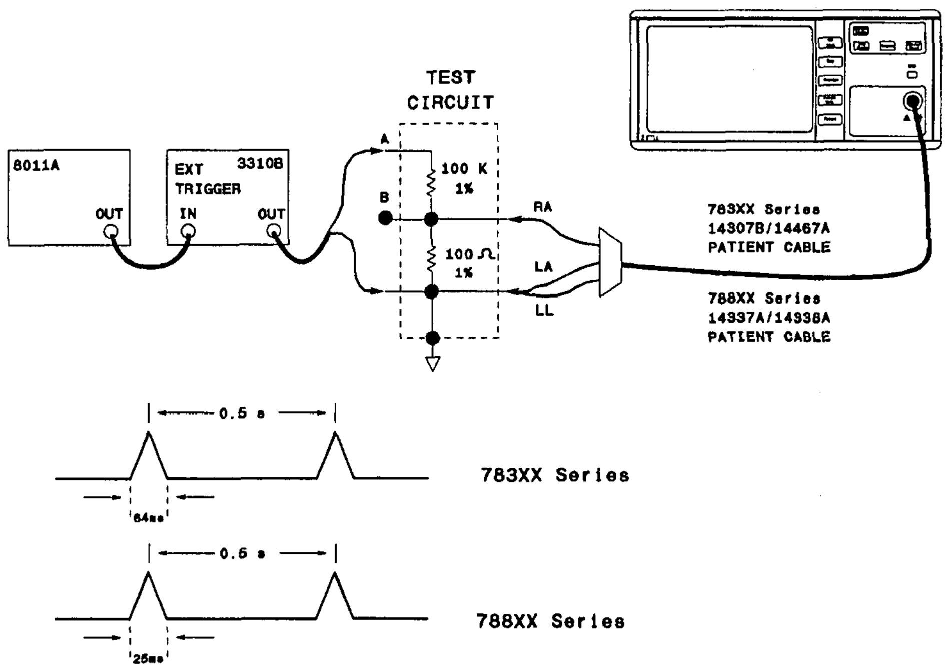


Figure 2b-2. Trigger Sensitivity Check Set-up

ECG Amplifier Noise Check

This procedure checks the maximum allowable ECG amplifier noise with reference the input.

a. Connect test equipment as shown in Figure 2b-3.

b. Switch to DIAGnostic mode.

c. Set lead selector to Lead I

Test Limit: Noise, excluding hum, should be < 35 mVpp on external scope.

78352A/C/3B/4A/C only:

d. Adjust to Max Gain.

Test Limit: Noise, excluding hum, should be <115 Vpp on external scope.

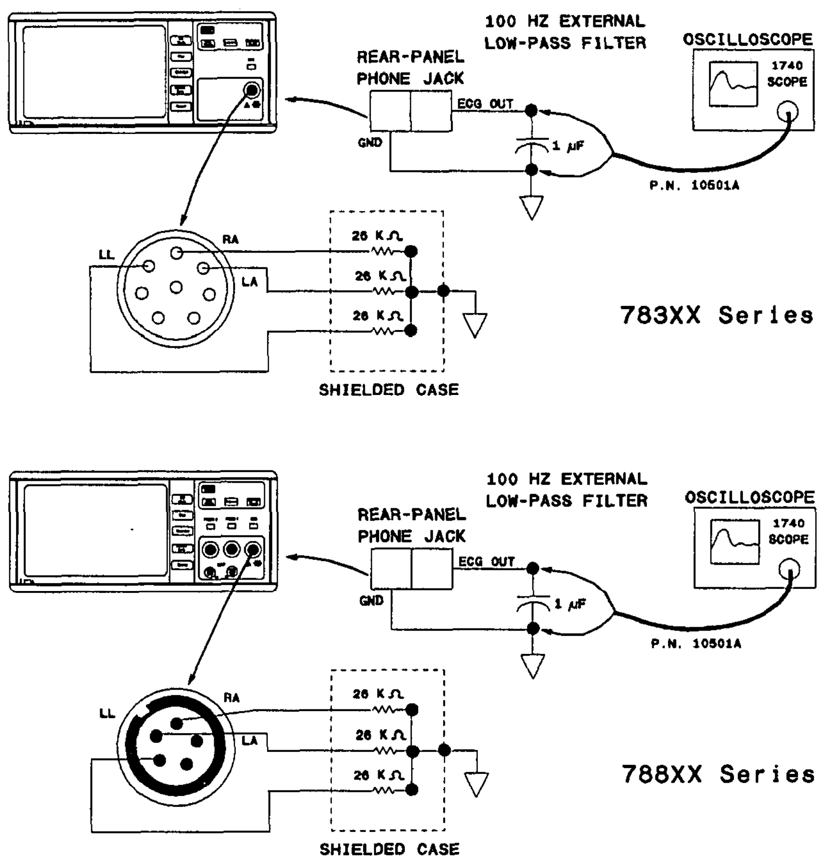


Figure 2b-3. ECG Amplifier Noise Test Set-up

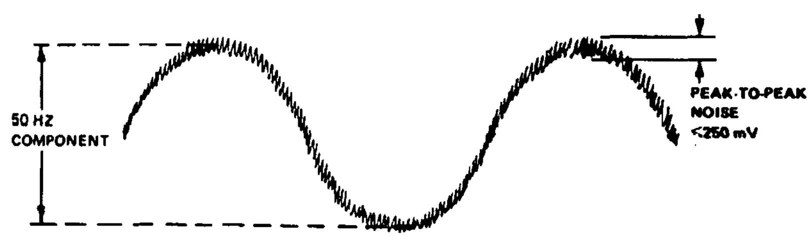


Figure 2b-4. ECG Noise with 50Hz Component

1mV Calibration Accuracy Check

This test checks the accuracy of the internal 1 mV calibration source.

a. Connect test equipment as indicated in Figure 2b-5.

b. Switch to DIAGnostic mode.

c. Set lead selector to Lead I.

d. Measure the +1 V source used in the test setup with an accurate dc Voltmeter, such as the HP 3435A. Adjust the source for a +1.000 V reading. (78352A/C/3B/4A/C: measure the +1.6 V source used.... ...)

e. Push ⎍ or [Cal Mark] key. On external scope the same amplitude as before should be observed (within ± 10%).

783XX series:

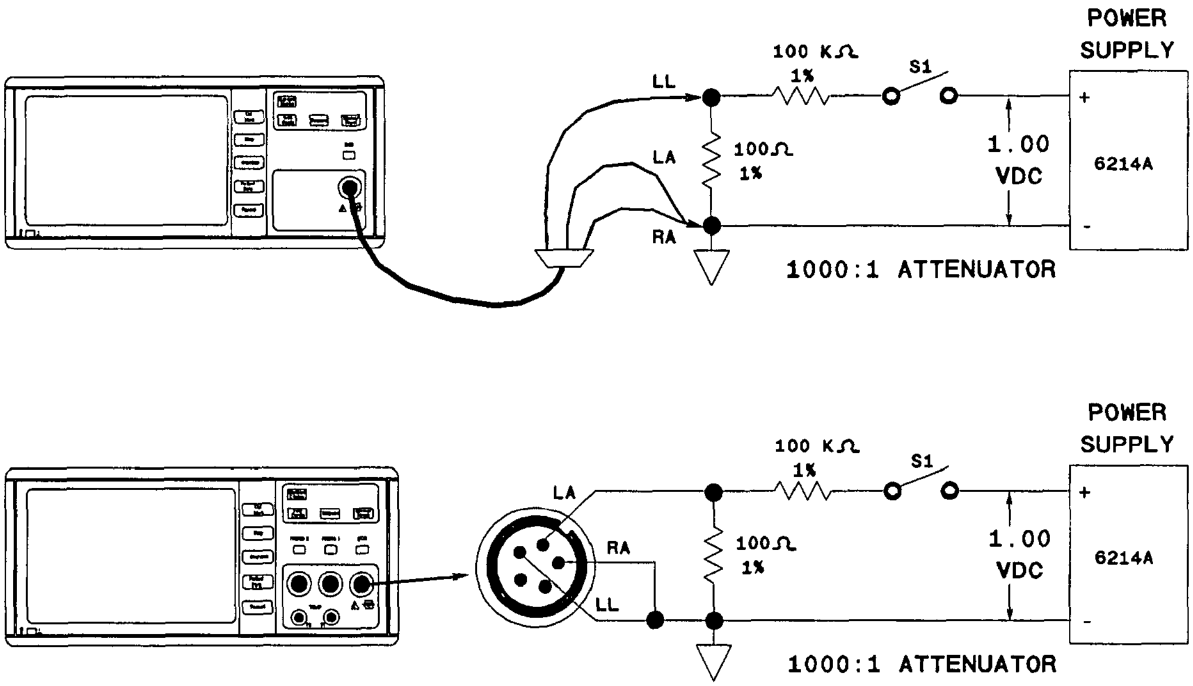


Figure 2b-5. 1 mV Calibration Test Set-up

Common Mode Rejection Ratio - CMRR

This procedure checks that the monitor will provide 90 dB (86 dB with Resp) common mode rejection of unwanted interference signals with up to 51 kOhm/47nF of electrode impedance imbalance.

1. Set function Generator to 20 V p-p (output 60 Hz)
2. Select DIAGnostic mode.
3. Connect test equipment as shown in Figure 2b-6
4. Measure AC voltage on external scope.
5. 78352A/C/3B/4A/C only - Set gain to Max Gain (SIZE)

Test Limit: V < 320 mV (500mV with Resp)

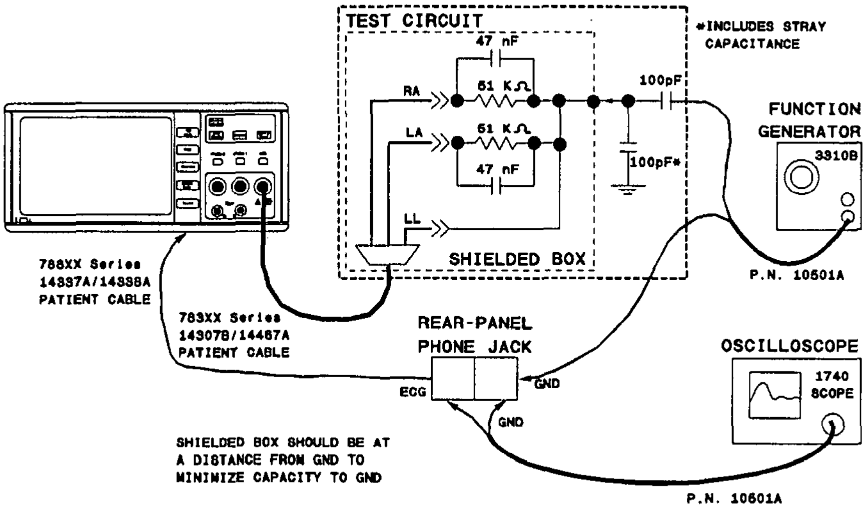


Figure 2b-6. Common Mode Rejection Set-up

Frequency Response

This check verifies the ECG Amplifier bandpass in diagnostic and monitoring modes and also the CRT display bandpass.

a. Connect test equipment as shown in Figure 2b-1.

b. Switch to DIAGnostic mode and set Lead Selector to I.

c. Set Function Generator to 10 Hz sinewave with an output level of approximately 0.8 V pp and connect to A on Test circuit.

d. Adjust Function Generator to give external scope amplitude of 8 cm at sensitivity of 0.2 V/cm.

e. Set Function Generator to 0.5 Hz and measure the amplitude on the external scope. Test Limit: Amplitude on Scope > 5.66 cm (3 dB down)

f. Set Function Generator to 100 Hz and measure amplitude on external scope. Test Limit: Same test limit as described in e.

g. Select FILTER mode.

h. Set Function Generator to 10 Hz and adjust manually for an amplitude of 8 cm on external scope (sensitivity 0.2 V/cm).

i. Set Function Generator to 0.5 Hz and measure amplitude on external scope.

j. Set Function Generator to 10 Hz, then measure the amplitude on monitor CRT.

k. Set Function Generator to 0.5 Hz and 30 Hz. The amplitude decrease should not be more than 3 dB.

78352A/C/3B/4A/C: two modes =

- ICU-Mode : 100 Hz = -3 dB
- OR-Mode : 30 Hz = -3 dB (Notch Filter)

Notch Filter Test

a. Connect equipment as shown in Figure 2b-1 and apply power to each instrument.

b. Set Function Generator output for a 10 V pp 10 Hz sine wave across test circuit points A and C and adjust ECG amplitude until Oscilloscope displays 10 V p-p at rear panel jack.

c. Sweep Function Generator frequency over a range of 0.5 Hz to 70 Hz. The Oscilloscope should show the response characteristic of Figure 2b-7 with instrument in FILTER mode.

d. Manually sweep the frequency of the Function Generator to the line frequency of exactly 50 Hz.

Test Limit: V notch < 760 mV, > 22.4 dB Notch Depth

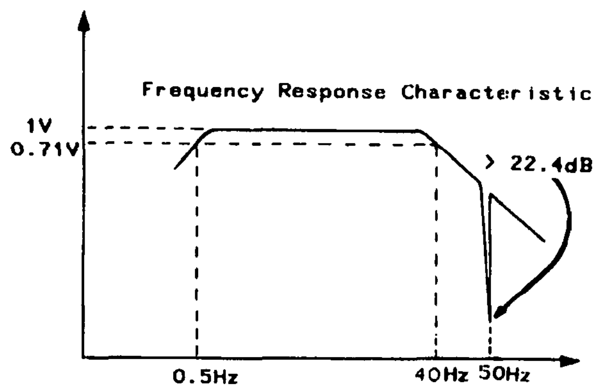


Figure 2b-7. Notch Filter Test Response Characteristic

Pressure Channel

These checks verify specification compliance of integral pressure circuitry.

Additional equipment required for these checks:

- Ratio Transfomer
- Impedance Simulator box
- Pressure Connector 1251-4953

Pressure Zero and Range Accuracy Check

Connect instrument as shown in Figure 2b-8.

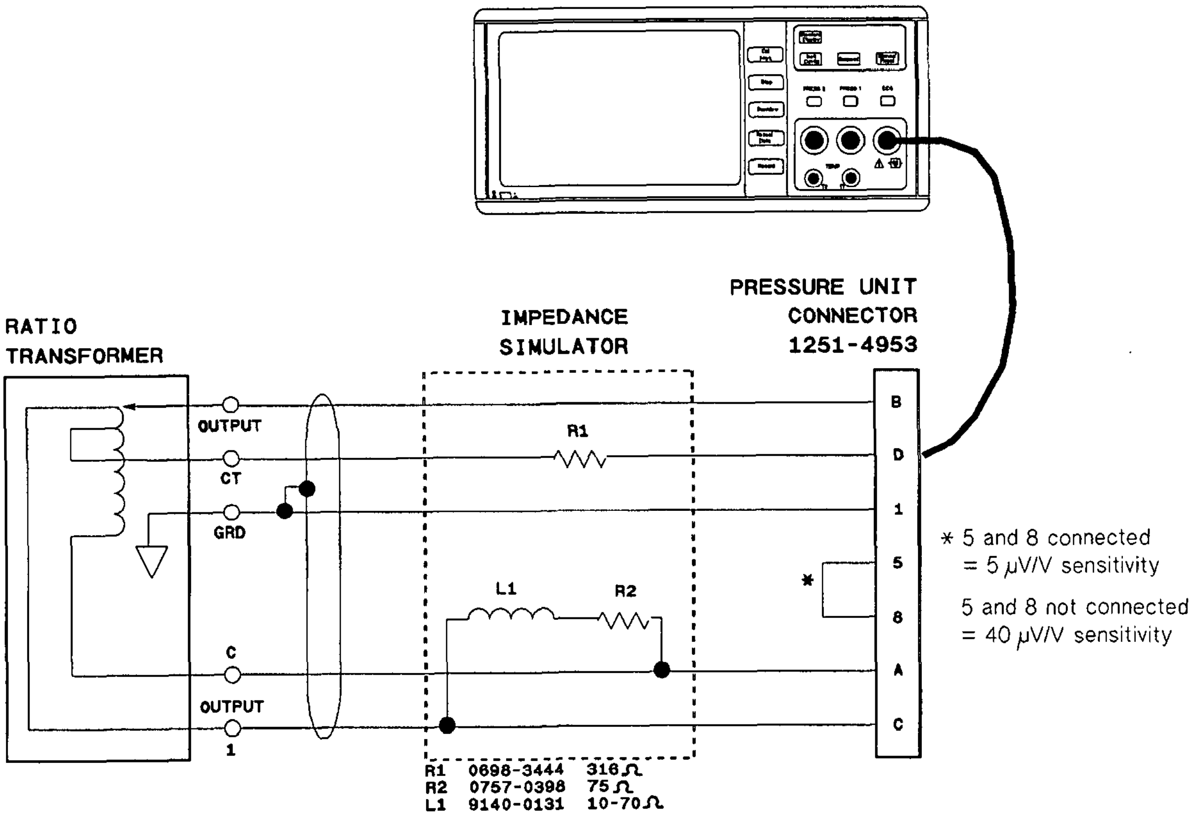


Figure 2b-8. Equipment for Zero and Range Accuracy Check

Specification : ZERO = ± 1 mmHg (± 0.1 kPa)

a. Set Ratio Transformer to 50000.

b. Press "PRESS" setup key.

c. Press "ZERO" softkey for at least 1 s. Prompt tone sounds when zeroing is completed. DISPLAY should show 0 mmHg ± 1 mmHg (0 kPa ± 0.1 kPa)

When Zeroing is completed

d. set Ratio Transformer to 50800

e. press "CAL" softkey

When calibration is completed the prompt tone sounds. Display should show 200 mmHg ± 1 mmHg.

f. Press "STORE CAL" softkey to store the calibrated value.

Pressure linearity check

Set Ratio Transformer to values shown in Table 2b-2 and verify linearity by observing readings on display. Readings should be within ± mmHg (± 0.2 kPa).

Transformer Test Settings for Pressure Output Linearity

Table 2b-2. mmHg Test

SETTINGS 40 uV	5 uV	READING mmHg
49920	49990	20
50000	50000	0
50080	50010	20
50160	50020	40
50240	50030	60
50320	50040	80
50400	50050	100
50480	50060	120
50560	50070	140
50640	50080	160
50720	50090	180
50800	50100	200
50880	50110	220
50960	50120	240

kPa Test

SETTINGS 40 uV	READING kPa
49910	-3
50000	0
50090	3
50180	6
50270	9
50360	12
50450	15
50540	18
50630	21
50720	24
50810	27
50900	30
50990	33

SETTINGS 5 uV	READING kPa
49989	-2.9
50000	0
50011	2.9
50023	6.1
50034	9.1
50045	12.1
50056	14.9
50068	18.1
50079	21.1
50090	24.0
50101	26.9
50113	30.1
50124	33.1

Plethysmograph channel

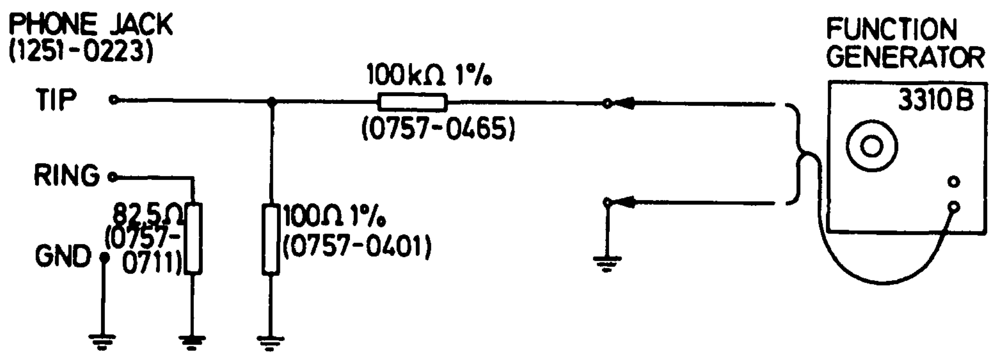


Figure 2b-9. Plethysmograph Channel Test Circuit

a. Set function generator to sine wave. Frequency 3.5 Hz.
b. Set amplitude to 10 Vpp.
c. Switch instrument on.
d. Connect test circuit to pleth input.
e. Pleth display with gridlines should appear.
f. Gain should be set automatically, so that waveform is positioned between gridlines.
g. Set function generator to 0.8 Hz. Verify that amplitude decrease is not more than approximately 25%.
h. Set function generator to 11 Hz. Verify that amplitude decrease is not more than approximately 25%.

Respiration Channel

INOP check

a. Connect instrument to test circuit shown in Figure 2b-10.

b. Rotate the potentiometer until - is displayed in the respiration numerics field. This should occur at 2.1 kOhm ± 15%.

Adult Respiration = between LL and RA

Neonate Respiration = between LL and LA

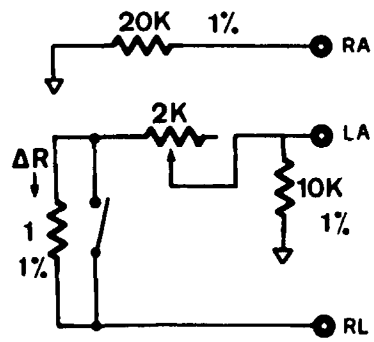


Figure 2b-10. Test Circuit for INOP check

Respirotach range check

Specification: 0 to 170 rpm

a. Connect instrument to test equipment as shown in Figure 2b-11
b. Set function generator to: negative pulse, dc offset, negative
c. Adjust level and offset level for negative 1 V pp signal.
d. Set frequency to 0.06 Hz - respiration rate displayed should be 4 rpm.
e. Set frequency to 2.8 Hz - respiration rate displayed should be 168 rpm.

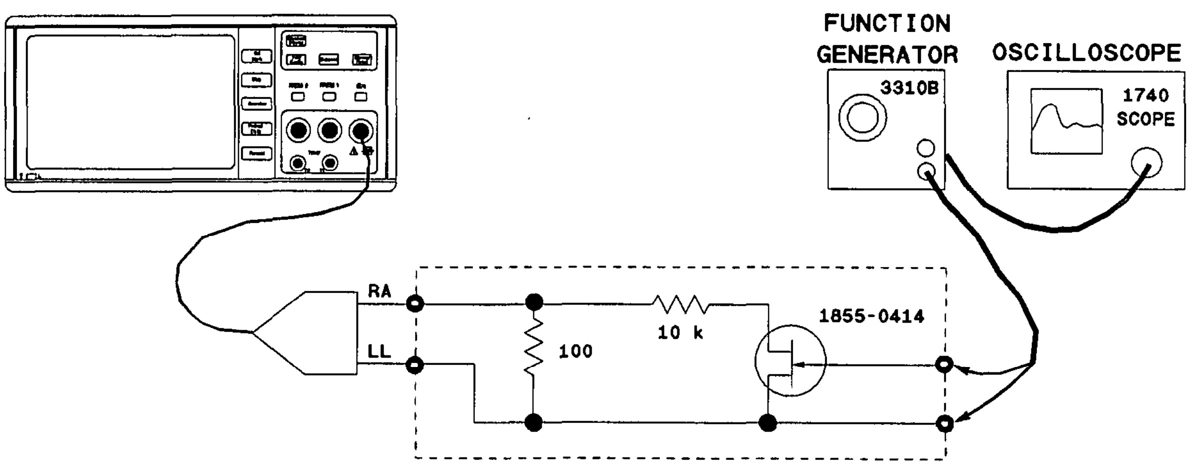


Figure 2b-11. Test Equipment for Respirotach Range Check

NIBP Calibration and Adjustments

The following procedure describes how to calibrate and make adjustments to the NIBP parameter board. The procedure is the same for the 78352A/C and 78354A/C instruments but the displays are different (78352A/C has more display space available). The 78352A/C displays are shown in italics to the left of the 78354A/C displays.

First remove top cover of instrument to access switch block S1 on NIBP board.

On switch block S1, switch 2 should be in the **open** position (in normal operation switch 2 should be in the **closed** position).

NIBP Diagram von alte Seite 2-31 hier einfügen

Connect a pressure gauge (0-320 mmHg), to the parameter input socket of the monitor via tubing used to connect a cuff to the monitor. Recommended pressure gauge kit can be ordered under 78354AK #888. If any other mercury manometer is used an expansion container, volume 250 ml ±10%, must be connected to the pressure circuit to simulate the cuff air volume (connecting material can be ordered under part number 78354-67001). It should be noted that a mercury manometer is not as accurate as the recommended pressure gauge and if the manometer tolerance is >1 mmHg calibration cannot be done within HP specifications.

Switch on instrument and the following information will appear on the screen where the blood pressure values normally appear:

```
78352A/C       78354A/C

S  0           N
D  0           P[↑] 0
[↑] 0
```

The bottom numbers indicate the current Mode of calibration and can be 0.... 5. If 0 is displayed, the monitor is in Mode 0 - which has no function.

Press Start/Stop (S/S) key for <1 s to advance to Mode 1

Mode 1 - Offset adj.

```
78352A/C        78354A/C

S  0            N   0/6
D  6          P[↑]  1
[↑] 1
```

Adjust the Offset pot. R3 until the displayed value equals zero, i.e. 0 on 78352A/C or 0/0 on 78354A/C

The / symbol represents a decimal point on the 78354A/C, and the numbers opposite S & D on the 78352A/C mean 0.6 (in this example, both displays are reading 0.6 mmHg).

Press S/S key for <1 s to advance to Mode 2

Note: It is not possible to go on to Mode 2 unless zeroing has been done.

Mode 2 - Gain adj.

The pump pressurizes the system to approximately 280 mmHg. Note: The system will first pressurize, release to approximately 0 and then repressurize to approximately 280 mmHg.

```
78352A/C        78354A/C

S  XYZ          N XYZ/X
D    X          P[↑] 2
[↑] 2
```

Adjust Gain pot. R12 until display equals gauge pressure which is approx. 280/0.

Press S/S key for <1 s to advance to Mode 3

Mode 3 - Range check

This Mode provides a linearity check of the pressure-sensor and input circuit. The pump pressurizes the pneumatic system to approximately 50 mmHg and the pressure displayed on the instrument should be checked against the gauge pressure reading. Each time the S/S key is pressed the pump steps up the pressure and the values on the display are again checked against the gauge pressure reading. This operation is to be repeated in steps of approximately 50 mmHg upto approximately 250 mmHg.

Press S/S key for <1 s to advance to Mode 4

Mode 4 - Leakage mode

System pressurizes to approximately 280 mmHg (continues upwards from last step in Mode 3). Wait 60 s. This is shown counting down on the display in the mode number field. When the 60 s is up the field above the mode number field indicates the leakage rate e.g.

```
78352A/C        78354A/C

S     3         N     3/9
D     9         P[↑] 4
[↑] 4
```

Which indicates a leakage rate of 3.9 mmHg/60 s. Maximum leakage rate should not be >6 mmHg/60 s. (If you wait longer, the display shows a further pressure drop).

Press S/S key for <1 s to advance to Mode 5

Mode 5 - Overpressure mode

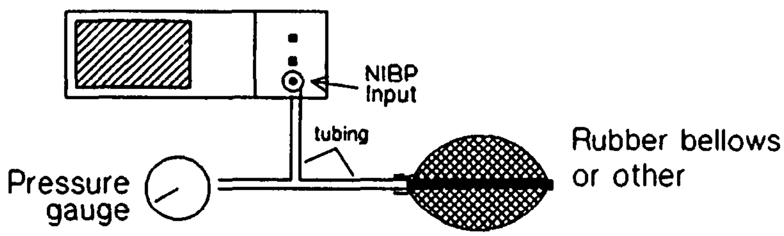
The system pressurizes to approximately 300 mmHg at which point the overpressure valve should open and release the pressure.

The calibration cycle is now complete and display returns to Mode 0. Remember to close switch S2 for normal operation.

Reseting Modes

At any time during the test modes the Monitor can be reset and return to Mode 0 by pressing the S/S key for longer than during mode checks (about 1 s).

Manometer Test Mode - The overall operation of the NIBP parameter board and accuracy of the pressure transducer may be checked without the need to remove the top cover of the instrument or to change switch settings. (No adjustments are possible in this mode). This test can be used to check the entire pressure range tolerances with an external manometer. To do this test connect the instrument, manometer and external pumping device as shown below:



Enter service test mode by switching off instrument for at least 20 s, then, pressing keys ⎍ or (Cal Mark) and 🔕 or (Silence/Reset) simultaneously, switch on the instrument but keeping the keys pressed until the three tones are heard.

The system can now be pressurized using the external pressurizing device. If the NIBP parameter board is functioning correctly the display should read the same as the pressure gauge (manometer). e.g. if gauge reads 60 mmHg the display should show:

N
P(↑) 60

within tolerances.

Press S/S key to release pressure in system.

Note This test mode does not use the internal pump of the monitor.

NIBP Calibration and Adjustments (HP78xxxC Only)

The following procedures detail how to calibrate and test the NIBP board (78352-96538) fitted in the 78352C, 78354C and 78834C monitors.

There are three procedures described in the following paragraphs. They are;

1. Calibration Procedure
2. Leakage Test Procedure
3. Linearity Test Procedure

Note

For use in Germany the calibration of NIBP boards must be accompanied by confimation by the PTB. The calibration switch is then sealed with a sacrificial PTB sticker so the board cannot be susequently calibrated without destroying this sticker.

For the calibration procedure you will need first to remove the top cover of the monitor to gain access to the calibartion switch.

For all the procedures you will need to place the monitor in Service Test mode. This is done by switching off the monitor for at least 20 s, holding down the [Cal Mark] and [Silence/Reset] keys simultaneously and switching on the monitor.

A pressure gauge (0-320 mmHg), needs to be connected to the parameter input socket of the monitor via tubing used to connect a cuff to the monitor. Recommended pressure gauge kit can be ordered under 78354AK #888. If any other mercury manometer is used an expansion container, volume 250 ml ±10%, must be connected to the pressure circuit to simulate the cuff air volume (connecting material can be ordered under part number 78354-67001). See figure in Manometer Test Mode. It should be noted that a mercury manometer is not as accurate as the recommended pressure gauge and if the manometer tolerance is >1 mmHg calibration cannot be done within HP specifications.

Calibration Procedure

The calibration of the NIBP board is described in the following steps. If the NIBP board is not for use in Germany, ignore references to PTB and PTB sticker.

1. Remove the PTB sticker to gain access to the calibration switch.
2. Press the calibration switch (S2) with a screwdriver.
3. Press the [START/STOP] key to close the valves.
4. Apply pressure to the circuit until the pressure guage reads 280 mmHg. The display shows values derived from the NIBP sensors.
5. Press-and-hold the [START/STOP] key for more than one second to calibrate the board.

   The display will replace the mmHg reading with a 0 and then 280 mmHg. The calibration is now completed.
6. Press the [START/STOP] key to open the valves and release the pressure. For Germany only:
7. The board must be checked by PTB and access to the calibration switch is sealed with a PTB sticker.

Leakage Test

This test checks both the NIBP board and the Test pressure circuit used to calibrate the board for leaks. The procedure is detailed in the following steps:.

1. Press the (START/STOP) key to close the valves.
2. Apply pressure to the cicuit until the pressure reads 280 mmHg. The display shows values derived from the NIBP sensors.
3. Observe the pressure reading after 60 seconds. The pressure must not have decreased more than 6 mmHg.
4. Press the (START/STOP) key to open the valves and release the pressure.

Linearity Test

This test checks the accuracy on the NIPB Parameter board across the measurable range. The procedure is detailed in the following steps:

1. Press the (START/STOP) key to close the valves.
2. Apply pressure to the circuit until the pressure guage reads 300 mmHg.
3. Observe the pressure displayed is 300 mmHg ± 5 mmHg.
4. Decrease the manometer pressure in 50 mmHg steps and check the pressure at 250, 200, 150, 100 and 50 mmHg are accurate to within ± 4 mmHg.
5. Decrease the manometer pressure to 0 mmHg, the display must show a value between 0 and 3 mmHg.
6. Press the (START/STOP) key to open the valves and release the pressure.

RS 232C Interface Checks

This check is to test if the RS 232C board is functioning correctly.

a. Remove top cover and OPEN switch S7 on switch block S1. The baud rate should be switched to 19200.

b. Now enter monitor test mode by switching off instrument for at least 20 s, then, pressing softkeys ⎍ or (Cal Mark) and 🔕 or ([Suspend) simultaneously, switch on the instrument but keeping the keys pressed until the three tones are heard. The CRT grid should now appear on the display.

c. Press softkey labelled ⍰ or (Record) and part numbers to ROMs loaded are displayed.

   The display now appears:

   ```
   RS232
   5180-XX?0
   ```

   to indicate service/test mode.

   Now short Port 1 to Port 2 with appropriate cable (cable is optional and can be ordered under number: 78599AI #H16. This cable is approx. 1.5 m long). During this self test Port 1 receives data from Port 2 and Port 2 receives data from port 1.

The display now appears:

```
RS232
5180-XX:0
```

which indicates board is functioning correctly.

If the symbol ? remains the RS 232C board is not functioning correctly.

Note XX are the 5th and 6th digits of an 8 digit EPROM part number.

Barometer Board Adjustment

The Barometer Board is factory calibrated. Should it be necessary however, to adjust the Barometer Board (component level replacement etc.) it is necessary to remove the top cover of the instrument to access the adjustment potentiometer R11. Switch instrument on and plug in either the test box described in 2.2.8 or a 15204A/15205A transducer and proceed as follows;

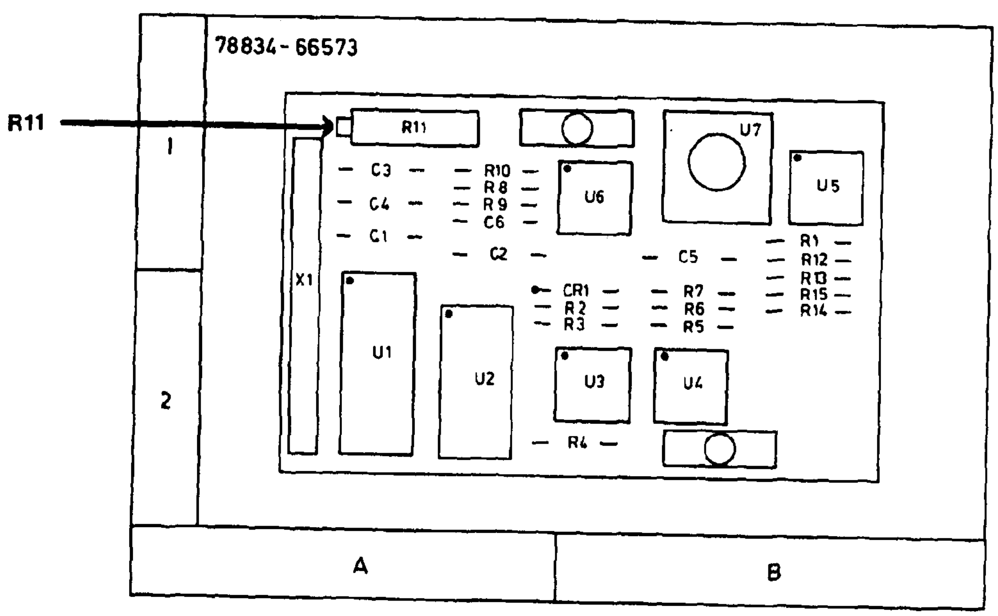
- Press PCO_2 or PO_2 setup key,
- Press the MORE CONTRLS key,
- Press the BAROM PRESS key and display shows; (for example):

```
BAROM...
PRESS...
722.....
```

Indicating a barometric pressure of 722 mmHg for a monitor configured to mmHg (or 96.3 for kPa version).

- Read off the barometer pressure from an accurate (accuracy = ±0.5 mmHg) barometer and adjust the potentiometer R11 until the display reads the barometer reading.

The Barometer Board is now adjusted.



Location of R11

$TcpCO_2/tcpO_2$ Channel

Complete specification checks can only be performed using a special comprehensive test box. Linearity, temperature control, cable defect simulation etc. can be verified with this special test box.

Note

This test box is different from the NOVRAM calibration jig described in "$tcpCO_2/tcpO_2$ Channel Checks and Transducer" in Chapter 2a. Contact the nearest HP Service Office for details and availability.

SpO_2 Board

Due to the sophisticated nature of the output / input signal of the SpO_2 board, it is not possible to test the device with a simple test circuit.

2c

Technical Specifications for all Monitors

Introduction

This chapter contains technical specifications in instrument numerical order.

Technical Specifications 78352A/C

This section contains the final specifications for the 78352A/C. The general instrument specifications are followed by those for the individual parameters.

General

Patient safety

- All inputs are CF-type.
- Otion N01 meets safety requirements CSA(C22.2 No.125).
- Option NO2 meets safety requirements of IEC 601-1.
- Option NO4 meets safety requirements of UL 544.
- Defibrillator protection up to 5 kV.

Power requirements:

Operating voltage:	115 V/230 V +10% -15% (IEC/USA) 115 V/230 V +10% -22% (Japan) (78352C): 100 V/200 V +10% -22% (Japan)
Frequency:	50/60 Hz
Power consumption:	75 W (max) (78352C): 55 W (max)

Environment:

Operating temperature:	0° to 55°C (78352C): 0° to 40°C
Storage temperature & relative humidity:	-40° to +75°C & 5% to 95%
Size:	160 mm high, 320 mm wide, 405 mm deep
Weight:	11 kg (24 lbs)

Trends stored at power off condition for a minimum of 1 hour.

Display

Superaster video display:

Screen size:	140 mm x 105 mm; 178 mm diagonal
Sweep speed:	12.5 mm/s, 25 mm/s or 50 mm/s gives 8 s, 4 s or 2 s of display respectively. (For respiration a speed of 6.25 mm/s is also available.)
Display mode:	fixed trace (moving bar).
Waveform display height:	Channel 1 64mm ± 10% (78352C): 55mm ± 10%
Numeric update time:	2 s
Resolution:	256 dots vertical, 500 dots horizontal. 500 dots horizontal.

ECG Channel (Full lead)

ECG Amplifier

Patient Safety:

Protected against defibrillator and electrosurgery potentials. Standard full lead selector.

Differential input impedance:
5 Mohm (at 10 Hz and including patient cable). (at 10 Hz and including patient cable).

Common Mode Rejection Ratio:

- FILTering 110 dB (with Resp. >106 dB)
- DIAGnostic 90 dB (with Resp. > 84 dB) at line frequency with patient cable and 51 kohm/47 nF imbalance.

Electrode offset potential:	±0.5 V max.
Baseline recovery:	1 s after defibrillation.
Noise:	35 uVpp, measured in the DIAGnostic mode and referred to the input, with each lead connected to ground through shielded 51 kohm/47 nF.

Cardiotach

Digital cardiotach

AUTO MODE

Heart rate depends on upper alarm limit setting;

Upper alarm limit setting:	≤ 150
Range:	15 to 2 x upper alarm limit
Upper alarm limit setting:	> 150
Range:	15 to 300 bpm

Accuracy:	± 1%.
Resolution:	1 bpm.
Sensitivity:	200 uV peak.
Pace pulse rejection:	meets requirements of AAMI EC13-1983 standard for Cardiac monitors (Automode).

MANUAL MODE

Heart rate range:	15 to 300 bpm.
Accuracy:	± 1%
Resolution:	1 bpm.
Sensitivity:	-5 mV to +5 mV.
Display gain:	3 mm/mV to 30 mm/mV (channel 1). (78352C only): 6 mm/mV to 55 mm/mV.

Analog output

ECG wave on phone-jack.

Gain:	320 to 3200 (dependent on display gain).
Bandwidth:	FILTering 0.5 to 25 Hz (OR), 0.5 to 100 Hz (ICU). DIAGnostic 0.05 to 100 Hz (OR and ICU).
Baseline offset:	≤100 mV at gain 1000.

Alarms

Technical alarm:	Leads Off.
Medical alarms:	Asystole Ventricular Fibrillation Heart rate
Alarm delay:	High rate < 10 s Low rate < 6 s

Test/Calibration

ECG simulated test waveform and numerics:

- 100 bpm ±2, waveform 1.5 cm pp.
- (78352C Only): waveform 2.7 cm pp.

Calibration signal: 1 mV ±10%

ST Segment Monitoring (78354-66722)

Leads: One selectable from I, II, III, a VR, a VL, MCL1, V, depending on the patient cable used.

ST measurement:	Median value updated every 15 seconds.
Resolution:	Fixed: ± 0.3 mm

Measurement Range:	-20 mm to +20 mm
Measurement Points Range:	Isolectric points range: -280 ms to +280 ms ST point range: 0 to +280 ms Measurment point resolution: 4ms
ST measurement points	
Reference:	Referred to R wave of QRS complex
Trends:	20 min, 1/2, 4, 8 and 24 h at (10 sec/1 min) resolution.
Trend Types:	Graphical: 78354C, Tabular: 78352C
Event marker: (available in Graphical trends only)	Automatic annotation: measurement points change, ECG lead change. Manual annotation available to the user at any time.
Parameter Display:	Permanent display of ST value below HR numeric.
Physiological Alarms:	Range: -10 mm to +10mm Adjust steps: 0.2 mm Alarm Delay: 30 sec.
Inop Alarms	
Technical alarms:	"Erratic ST" occurs when the variation between measured ST values over the sampling period exceeds limits for valid data. "Can't analyse ST" occurs when insufficient good beats are collected over the sampling period to produce an ST value. "ST paced beats" occurs when insufficient good beats are collected and more than 50% of the beats are paced over the sampling period.

Noninvasive Blood Pressure (NIBP)

General

Oscillometric method (with inflatable cuff) determines Mean arterial pressure (MAP), systolic and diastolic pressure.

Cuff pressure range:	0 to 280 mmHg (37 kPa), automatically released if pressure exceeds 315 ± 10 mmHg (42 ± 1.5 kPa).
Inflation time:	6 to 10 s (to 280 mmHg) typical using standard adult cuff.
Deflation time:	30 to 35 s typical.
Cuff pressure accuracy:	Better than ±3 mmHg (±0.4% kPa) for ambient temperature 15°C to 25°C, Better than ±3 mmHg (+0.6% of reading) for ambient temperature 10° to 35°C

	Better than ±3 mmHg (+1.7% of reading) for ambient temperature 0° to 55°C.

Add *rounding error* of ±1/2 digit (= ±0.5 mmHg of ±0.05 kPa) to above accuracies.

Measurement Range:

Systolic:	30 to 270 mmHg (4 to 36 kPa).
Diastolic:	10 to 245 mmHg (1.3 to 32 kPa).
MAP:	20 to 255 mmHg (2.6 to 34 kPa).

Note Measurements are only possible in the heart range 40 to 220 bpm.

Modes

Auto:

- Measurements are automatically repeated with a time interval set by the user (2, 5, 10, 15, 30 and 60 min).

Manual:

- A single measurement is taken.

Statim:

- (If fitted). A series of ten measurement cycles are taken over a five minute period. Only one QRS complex causing a pressure oscillation in the cuff is sensed at each inflation level.

Alarms

High and low pressure.

Alarm Limit Adjustment 78352C:

- 5mmHg (1kPa) steps,
- 2mmHg (0.5kPa) steps, range 10 – 30 mmHg (1.5 – 4 kPa)

Temperature Channel

Range:	15°C to 45°C.
Resolution:	0.1°C.
Accuracy (at 0°C to 40°C ambient temperature):	±0.1°C (25.0°C to 45.0°C) ±0.2°C (15.0°C to 24.9°C)
Average time constant:	10 s (Δt = 15°C)
Numeric display update time:	2 s. If out of range, no display. No alarm given.
Test temperature:	T1 = 40°C, T2 = 25°C + 0.1°C, ΔT = 15°C ± 0.1°C.

Trend

General

One long trend (24, 8, 4, or 2 h) and one short trend (60 or 20 mins) available on each parameter. Points on trend curve are averaged values. Alarms are shown as actual values. Power off, INOP and Alarms off are indicated.

ECG Channel

Heart rate trend;

Range:	20 to 180 bpm.
Resolution:	1 bpm.
Display points per trend curve:	384

Pressure Channel

The systolic, diastolic and mean values are combined in one display.

Range:	dependent on selected pressure scale.
Resolution:	1.2 mmHg (0.16 kPa).
Display points per trend curve:	96

Each point contains one systolic, one diastolic and two mean readings.

Dual Temperature Channel

T1 and T2 are displayed. T trend is directly readable from the display.

Range:	25°C to 42°C.
Resolution:	0.1°C.
Display points per trend table:	337 (T1) and 48 (T2).

System Interface

System outputs

Wave

Bandwidth:	FILting 0.5 – 25 Hz (OR), 0.5 – 100Hz (ICU). DIAGnostic 0.05 – 100 Hz (OR and ICU).
Gain:	Variable between 320 and 3200, dependent on display gain.

DC Output (HR):

Range:	15bpm to 300 bpm = 0.15 V to 3 V; 0 V for < 15 bpm
Accuracy:	± 5 bpm

Resolution: 1 bpm.

SpO_2/Pleth

SpO_2 is measured using a dual wavelength optical transducer. It measures pulse and SpO_2.

Range:	0% to 100% saturation
Numeric display:	Averaging period selectable 1/2/4/8/16 beats, with default 4.
Settling time:	Typ. < 5 s
Accuracy:	1SD 80% to 100% ± 1.5% 65% to 80% ± 2.5% 0% to 65% unspecified
Accuracy NELLCOR SpO_2 Transducers (78352C):	1SD 80% to 100% ± 3.0%

Alarms

Lower Alarm range:	50-95%, step 1%, default=90%
Upper Alarm range:	70-99%, OFF, step 1%, default=OFF
Alarm delay:	6 s
(78352C):	10 s
HR derived from Pleth	
Alarm delay:	High rate 10 s Low rate 6 s

Pleth Amplifier

Bandwidth:	0.8-11.0 Hz ± 25%
Settling time:	< 3 s

Cardiotach

Range:	30-300 bpm
Accuracy:	±1%
Resolution:	1 bpm

Graticule lines

Lower line:	25% of wave channel
Upper line:	75% of wave channel
Autofix:	50% of wave channel, peak values on Pleth graticule lines. Gain frozen after approximately 60 s.

Test

SpO_2 test signal:	100%
Pleth test signal:	50% of wave channel, 100 bpm.

Technical Specifications 78353A

This section contains the technical specifications for the 78353A. The general instrument specifications are followed by those for the individual parameters:

General

Patient safety:

- option N04 meets safety requirement UL544
- option N02 meets safety requirement IEC 601-1

Power requirements:

Operating voltage:	115 V/230 V +10% -15% (IEC/USA) 115 V/230 V +10% -22% (Japan)
Frequency:	50/60 Hz,
Power consumption:	55 W

Environmental:

Operating temperature:	0°C – 55°C
Storage temperature:	-40°C – +75°C
Size:	78353A 160 mm high, 320 mm wide, 405 mm deep
Weight:	78353A 11 kg (24 lbs)

Display

Superaster video display:

Screen size:	140 mm x 105 mm; 178 mm diagonal
Sweep speed:	12.5 mm/s, 25 mm/s or 50 mm/s gives 8 s, 4 s or 2 s of display respectively
Display mode:	fixed trace (moving bar)

Waveform display height:

```
Channel 1                 30 mm +/- 10%
-----------------------------------
Channel 2    normal       32 mm +/- 10%
Channel 3    mode
-----------------------------------
Channel 2    overlapping 64 mm +/- 10%
Channel 3    mode
```

Numeric update time:	2 s
Resolution:	256 dots vertical, 500 dots horizontal.

ECG Channel (3 lead)

ECG Amplifier

Patient safety:	Protected against defibrillator and electrosurgery potentials. Standard full lead selector.
Patient isolation:	12 MOhm below 60 Hz
Differential input impedance:	5 MOhm (at 10 Hz and including patient cable)
Common Mode Rejection Ratio:	FILTering 110 dB DIAGnostic 90 dB at line frequency with patient cable and 51 kohm /47 nF imbalance
Auxiliary current:	100 nA
Electrode offset potential:	± 0.5 V max.
Baseline recovery:	2 s after defibrillation
Noise:	35 uVpp, measured in the DIAGnostic mode and referred to the input, with each lead connected to ground through shielded 51 kOhm/47 nF.
Maximum input signal:	± 5 mV

Cardiotach

Digital cardiotach:

Heart rate depends on upper alarm limit setting.

Upper alarm limit setting:	< 150
Range:	15 – 300 bpm, (15 - 2 x upper heart rate limit)
Accuracy:	±1%
Resolution:	1 bpm
Sensitivity:	200 uV peak
Pace pulse rejection:	pace pulse width 0.2 – 2 ms any amplitude, relaxation time constant 15 ms to 200 ms

Analog Output

ECG wave on phone-jack:

Constant gain:	1000
Bandwidth:	FILTering 0.5 – 30 Hz DIAGnostic 0.05 – 100 Hz
Baseline offset:	< 100 mV at gain of 1000

Alarms

Technical alarm:	Leads Off, occurs if electrode is detached, dry, or if electrode offset potential out of spec.
Indication:	Three dashes flash in place of heart rate numerics and audible alarm is given.
Medical alarms:	Asystole occurs when interval between two QRS complexes exceeds 4 seconds.
Indication:	< 15 numerics flash and audible alarm is given.
Alarm range :	15-150 bpm, in steps of 5 bpm. Heart rate alarm occurs when heart rate is outside of selected alarm limits.
Indication:	Flashing heart rate numerics and audible alarm given.
Alarm delay:	High rate 10 s Low rate 6 s.

Test

- ECG simulated test waveform and numerics: 100 bpm ± 2, waveform 1.5 cm pp
- Calibration signal: 1 mV ± 10%

Trend Mode

In trend mode, an averaged heart rate is displayed instead of the ECG waveform.

- Range: 50 to 210 bpm
- Resolution: 1 bpm

In all trend modes, actual high or low HR alarms are shown as peaks of the appropriate height.

Plethysmograph Channel

Pleth. amplifier

Bandwidth:	0.8 – 11.0 Hz ±25%.
Settling time:	< 3 s.

Cardiotach

Range:	15-300 bpm.
Accuracy:	± 1%.
Resolution:	1 bpm.
Trigger sensitivity:	5 mm pp (32 mm display), 10 mm pp (64 mm display).

Graticule lines

Lower line:	25% of wave channel.
Upper line:	75% of wave channel.
Autofix:	50% of wave channel, peak values on Pleth graticule lines. Gain frozen after approx. 60 s.

Test

Pleth test signal:	50% of wave channel, 100 bpm.

Alarms

Medical Alarm:	Heart Rate derived from PLETH.
Alarm delay:	High rate 10 s Low rate 6 s.

Pressure Channel

Pressure amplifier

Range:	-30 mmHg to +300 mmHg -4 kPa to +40 kPa
Sensitivity:	Automatic: 5 uV/V/mmHg (37.5 uV/V/kPa) Manual: 40 uV/V/mmHg (300 uV/V/kPa)
Storage cycles of sensitivity values:	1000 cycles
Gain accuracy:	± 1%
Gain stability:	± 0.1 mmHg/°C ± 0.013 kPa/°C
Non-linearity:	0.5%
Bandwidth:	12 Hz
Minimum transducer load:	120 Ohm

Auto zero

Range:	± 200 mmHg (± 26 kPa)
Zero accuracy:	± 1.0 mmHg (± 0.13 kPa)
Zero drift:	0.1 mmHg/°C (0.013 kPa/°C)
Response time:	1 s

Pressure wave display

Graticule lines: normal 3 channel wave range 32 mm overlapping wave 64 mm

Graticule line labelling and resolution:

Range (mmHg)	Graticule line labelling lower	upper	Resolution (mmHg/cm) 64 mm	32 mm
-5 - +45	0	30	8	16
-10 - +90	0	60	16	32
-20 - +180	0	120	32	64
-30 - +270	0	180	48	96

Range (kPa)	Graticule line labelling lower	upper	Resolution (kPa/cm) 64 mm	32 mm
-0.5 - +4.5	0	3	0.78	1.56
-1.0 - +9.0	0	6	1.56	3.12
-2.5 - +22.5	0	15	4.16	8.33
-4.0 - -36.0	0	24	6.25	12.5

Alarms

1. High and low pressure alarms occur when selected pressure is outside alarm limits.

   Indication: flashing pressure numerics and audible alarm.

   Alarm delay: 8 s

2. Transducer disconnect alarm occurs when transducer not connected to instrument.

   Indication: P1 (or P2) NO TRANSDUCER message, three dashes flash in place of pressure numerics and audible alarm.

3. Pressure disconnect alarm occurs when mean pressure falls below 10 mmHg

   Indication: P1 (or P2) DISCONNECT message, flashing numerics and audible alarm.

   Alarm delay: 8 s

Calibration/test signal

Calibration signal (steps): 30/60/120/180 mmHg (3/6/15/24 kPa)

Simulated Test waveform and numerics (rate 100 bpm): P1: 180 mmHg (24 kPa) P2: 60 mmHg (6 kPa)

Duty cycle: 50% and frequency corresponds to 100 bpm.

Rear panel output

Output voltage range: -0.3 V to +3.0 V

Resolution: 10 mV/mmHg (75 mV/kPa)

Temperature Channel

Patient safety:	Leakage current: 10 uA Dielectric strength: 5 kV
Range:	15°C to 45°C
Resolution:	0.1°C
Accuracy:	± 0.1°C (25.0°C to 45.0°C) ± 0.2°C (15.0°C to 24.9°C)
Average time constant:	10 s (Δt = 15°C)
Numeric display update time:	2 s

No temperature display if measured temperature is beyond limits.

Test temperature:	40°C

No temperature alarm

Test temperature:	T1 = 40°C, T2 = 25°C ± 0.1°C, ΔT = 15°C ± 0.1°C.

Auxiliary Input Channel

General

Input impedance:	> 50 kOhm
Input voltage :	35 V
Bandwidth:	> 20 Hz
Input voltage range (waveform):	± 1.6 V
Input sensitivity:	1 cm/V (32 mm waveform channel) 2 cm/V (64 mm waveform channel).
Baseline for external devices:	50% of waveform

No graticule lines.

Auxiliary input - 78205D Pressure module

(mmHg only. Not possible with Option E20).

Graticule line labelling and resolution

As for Pressure Channel, see table.

Wave Input

Sensitivity:	45 mmHg range; 62.5 mm/V 90 mmHg range; 31.3 mm/V 180 mmHg range; 15.6 mm/V 270 mmHg range; 10.4 mm/V

DC-Input

Range:	0-300 mmHg (35 kPa).
Sensitivity:	100 mmHg/V (10 kPa).
Accuracy:	±3 mmHg (0.3 kPa).

Auxiliary input - 47210 Capnometer

Wave Input

Sensitivity:	0-60 mmHg (0.9 kPa) range; 9.5 mm/V (6.3 mm/V), graticule line at 40 mmHg (6 kPa). 0 – 90 mmHg (0 – 13.5 kPa) range; 6.3 mm/V (4.2 mm/V) graticule line at 60 mmHg (9 kPa).

DC-Input

Range:	0-150 mmHg (0-17.5 kPa).
Sensitivity:	50 mmHg/V (5 kPa/V).
Accuracy:	±3 mmHg (+0.3 kPa).
Speed selection:	6.25 mm/s.

System 780 Annotating Interface

Note There is no annotation of NIBP and SpO_2 values.

General

Auxiliary signals and parameters.

Internal processing accuracy: ± 50 mV

Selectable channels for external recorder.

Internal processing accuracy:	± 50 mV
Delay mode:	12 s delay time
Bandwidth:	Channel 1: 0 Hz to 50 Hz Channel 2: 0 Hz to 15 Hz
Parameters off condition:	-1 V

ECG System Outputs

Wave.

Bandwidth:	FILtering 0.5 Hz to 25 Hz DIAGnostic 0.05 Hz to 100 Hz
Amplitude:	2.5 Vpp (at 50% display)(78354A).
Gain:	variable between 320 and 3200, dependent on display gain.

DC output (HR)

Range:	15 bpm to 300 bpm = 0.15 V to 3 V; < 15 bpm = 0V
Accuracy:	± 5 bpm
Resolution:	1 bpm

Pressure system outputs

The following accuracies are additional to those given in the Pressure Channel data.

Wave (All the following voltages are ± 50 mV.).

Range (absolute):	-0.25 V to 2.7 V = -25 to 270 mmHg
Range (scaled):	- 5 to 45 mmHg = -0.50 V to 4.5 V, - 10 to 90 mmHg = -0.50 V to 4.5 V, -20 to 180 mmHg = -0.40 V to 3.6 V, -25 to 270 mmHg = -0.25 V to 2.7 V.
Range (absolute):	-0.33 V to 3.6 V = -25 to 270 mmHg

Range (scaled):	-0.5 to 4.5 kPa = -0.50 V to 4.5 V, - 1.0 to 9.0 kPa = -0.50 V to 4.5 V, -2.5 to 22.5 kPa = -0.50 V to 4.5 V, -3.3 to 36.0 kPa = -0.33 V to 3.6 V.)
Bandwidth:	0 Hz to 12 Hz.

DC Output

Range (systolic, diastolic and mean):	-30 mmHg to 300 mmHg = -0.3 V to 3 V ± 50 mV (-4 kPa to 40 kPa = -0.4 V to 4 V ± 50 mV)

Scaled wave on selectable channels for external recorder with offset of -2 V.

Plethysmograph system outputs

Wave.

Amplitude:	2.5 Vpp (at 50% display)

DC output (HR).

Range:	15 bpm to 300 bpm = 0.15 V to 3 V; < 15 bpm = 0 V
Accuracy:	± 5 bpm
Resolution:	1 bpm

Temperature system output

DC output.

Range:	15°C to 45°C = -0.5V to 2.5 V
Accuracy:	± 0.1°C for 25°C < T < 45°C ± 0.2°C for 15°C < T < 24.9°C
Resolution:	0.1°C (at ambient temperature of 0°C to 40°C)

Note The only temperature available at the system output is T1.

System 780 Non-Annotating Interface

ECG Wave

Frequency response:	FILTering 0.5 Hz to 25 Hz DIAGnostics 0.05 Hz to 100 Hz
Output amplitude:	2.5 Vpp - at 50% display 5 Vpp - at 100% display

Heart Rate

Range:	15 to 300 bpm = 0.15 to 3 V < 15 bpm = 0 V
Accuracy:	± 3 bpm

Control Signals

Reset:	active < 0.3 V/30 mA
Alarm off:	active < 1.1 V/30 mA
INOP:	active < 1.1 V/30 mA
Patient alarm:	active < 1.1 V/30 mA

Alarm Relay (only loaded on request)

Voltage:	30 V dc
Current:	2 A
Resistance:	50 mohm

Technical Specifications - 78353B and 78354A/C

This section contains the technical specifications for the 78353B and 78354A/C. The technical specifications are the same for both instruments with the following exceptions:

a. the 78354A/C can be configured to include NIBP, CO_2/O_2 and SpO_2.

b. The 78353B is a 3/4 module instrument and the 78354A is a full module instrument instrument. The 78354C comes in both sizes. The general instrument specifications are followed by those for the individual parameters:

General

Patient safety

- All inputs are CF-type.
- Option N01 meets safety requirements CSA(C22.2 No.125)
- Option NO2 meets safety requirements of IEC 601-1.
- Option NO4 meets safety requirements of UL 544.
- Defibrillator protection up to 5 kV.

Power requirements

Operating voltage:	115 V/230 V +10% -15% (IEC/USA) 115 V/230 V +10% -22% (Japan) (78352C):100 V/200 V +15% - 5% (Japan)
Frequency:	50/60 Hz,
Power consumption,	78353B - 75 W (max) 78354A/C - 80 W (max)

Enviromental

Operating temperature	0°C to 55°C
Storage temperature	-40°C to +75°C
Relative humidity	5% to 95%
Size: 78353B/4C	160 mm high, 320 mm wide, 405 mm deep
Size: 78354A/C	160 mm high, 425 mm wide, 405 mm deep
Weight: 78353B/4C	11 kg (24 lbs)
Weight: 78354A/C	14 kg (31 lbs)

Trends stored at power off condition for a minimum of 1 hour.

Display

- Superaster video display

Screen size:	140 mm x 105 mm; 178 mm diagonal
Sweep speed:	12.5 mm/s, 25 mm/s or 50 mm/s gives 8 s, 4 s or 2 s of display respectively. (For respiration a speed of 6.25 mm/s is also available.)
Display mode:	fixed trace (moving bar).

Waveform display height:

```
Channel 1                30 mm + 10%
   ----------------------------------
   Channel 2    normal
   Channel 3    mode         32 mm + 10%
   ----------------------------------
   Channel 2    overlapping
   Channel 3    mode         64 mm + 10%
```

Numeric update time:	2 s
Resolution:	256 dots vertical, 500 dots horizontal.

ECG Channel (Full lead)

ECG Amplifier

- Patient safety: Protected against defibrillator and electrosurgery potentials. Standard full lead selector.

Differential input impedance:	5 Mohm (at 10 Hz and including patient cable).
Common Mode Rejection Ratio:	FILTering 110 dB (with Resp. $\geq$ 106 dB) DIAGnostic 90 dB (with Resp. $\geq$ 84 dB) at line frequency with patient cable and 51 kohm/47 nF imbalance.
Electrode offset potential:	±0.5 V max
Baseline recovery:	1 s after defibrillation.
Noise:	35 uVpp, measured in the DIAGnostic mode and referred to the input, with each lead connected to ground through shielded 51 kohm/47 nF.

Cardiotach

Digital cardiotach

AUTO MODE

	Heart rate depends on upper alarm limit setting.
Upper alarm limit setting:	$\leq$150
Upper alarm limit range:	15 to 2 x upper alarm limit

Upper alarm limit setting	≤150
Upper alarm limit range:	15 to 300 bpm
Accuracy:	± 1%
Resolution:	1 bpm
Sensitivity:	200 uV peak
Pace pulse rejection:	meets requirements of AAMI EC13-1983 standard for Cardiac monitors (Automode).

MANUAL MODE

Heart rate range:	15 to 300 bpm
Accuracy:	± 1%
Resolution:	1 bpm
Sensitivity:	-5 mV to +5 mV
Display gain:	3 mm/mV to 30 mm/mV (channel 1)

Analog output

- **ECG wave on phone-jack.**

Gain:	320 to 3200 (dependent on display gain).
Bandwidth:	FILTering 0.5 to 25 Hz (OR), 0.5 to 100 Hz (ICU). DIAGnostic 0.05 to 100 Hz (OR and ICU).
Baseline offset:	≤100 mV at gain 1000.

Alarms

Technical Alarm:	Leads Off
Medical Alarms:	Asystole. Ventricular Fibrillation. Heart rate
Alarm delay:	High rate < 10 s Low rate < 6 s

Test/Calibration

ECG simulated test waveform and numerics:	100bpm ±2, waveform 1.5 cm pp
Calibration signal:	1 mV ±10%

ST Segment Monitoring (78354-66722)

Leads:	One selectable from I, II, III, a VR, a VL, MCL1, V, depending on the patient cable used.
ST measurement:	Median value updated every 15 seconds.
Resolution:	Fixed: ± 0.3 mm

Measurement Range:	-20 mm to +20 mm
Measurement Points Range:	Isolectric points range: -280 ms to +280 ms ST point range: 0 to +280 ms Measurment point resolution: 4ms
ST measurement points reference:	Referred to R wave of QRS complex
Trends:	20 min, 1/2, 4, 8 and 24 h at (10 sec/1 min) resolution
Trend Types:	Graphical: 78354C, Tabular: 78352C
Event Marker: (available in graphical trends only)	Automatic annotation: measurement points change, ECG lead change Manual Annotation: available to the user at any time.
Parameter Display:	Permanent display of ST value below HR numeric
Physiological Alarms:	Range: -10 mm to +10mm Adjust steps: 0.2 mm Alarm Delay: 30 sec.
Inop Alarms / Technical Alarms:	'Erratic ST' occurs when the variation between measured ST values over the sampling period exceeds limits for valid data. 'Can't analyse ST' occurs when insufficient good beats are collected over the sampling period to produce an ST value. 'ST paced beats' occurs when insufficient good beats are collected and more than 50% of the beats are paced over the sampling period.

Plethysmograph Channel

Pleth. amplifier

Bandwidth:	0.8 - 11.0 Hz ±: 25%
Settling time:	$\leq$ 3 s

Cardiotach

Range:	15-300 bpm (78354C): 30-300 bpm
Accuracy:	± 1%
Resolution:	1 bpm
Trigger sensitivity:	5 mm pp (32 mm display) 10 mm pp (64 mm display)

Graticule lines

Lower line:	25% of wave channel
Upper line:	75% of wave channel

Autofix

50% of wave channel, peak values on Pleth graticule lines. Gain frozen after ˜ 60 s.

Test

Pleth test signal: 50% of wave channel, 100 bpm.

Alarms

Medical Alarm:	Heart Rate (derived from PLETH).
Range:	15 to 250 bpm.
Alarm delay:	High rate 10 s, Low rate 6 s.

Pressure Channel

Pressure amplifier

Range:	-25 mmHg to +300 mmHg (-3.3 kPa to +40 kPa)
Sensitivity:	5 uV/V/ mmHg (37.5 uV/V/kPa) or 40 uV/V/mmHg (300 uV/V/kPa) selected automatically
Transducer load impedance:	120-500 Ohm
Gain accuracy:	± 1%
Gain stability:	± 0.1 mmHg/°C (± 0.013 kPa/°C)
Gain adjustment range:	± 10% (78354C): ±7%
Non-linearity:	0.5%
Bandwidth:	0 to 12 Hz

Auto zero

Range:	± 200 mmHg (± 26 kPa)
Zero accuracy:	± 1.0 mmHg (± 0.13 kPa)
Zero drift:	0.1 mmHg/°C (0.013 kPa/°C)
Response time:	1 s

Pressure wave display

Graticule lines: Normal 3 channel wave range 32 mm, Overlapping wave 64 mm

Graticule line labelling and resolution:

Range (mmHg)	Graticule line labelling lower	upper	Resolution (mmHg/cm) overlapping	normal
-5 - +45	0	3	8	16
-10 - +90	0	60	16	32
-20 - +180	0	120	32	64
-25 - +270	0	180	48	96

Range (kPa)	Graticule line labelling lower	upper	Resolution (kPa/cm) overlapping	normal
-0.5 - +4.5	0	3	0.78	1.56
-1.0 - +9.0	0	6	1.56	3.12
-2.5 - +22.5	0	15	4.16	8.33
-3.3 - +36	0	24	6.25	12.5

Pulse Rate

Derived from P1 only (not available with Opt.E20).

Range: 25 to 300 bpm

Accuracy: ±1%

Resolation: 1 bpm

Alarms

Technical Alarms: Transducer disconnect. Pressure disconnect

Alarm delay: 8 s

Medical Alarms: High and low pressure

Alarm delay: 8 s

Pulse rate: Range 25 to 250 bpm

Test/calibration

Calibration signal (steps): 30/60/120/180 mmHg (3/6/15/24 kPa)

Simulated test waveform and numerics: P1: 120 mmHg 15 kPa
P2: 60 mmHg 6 kPa

Noninvasive Blood Pressure (NIBP)

General

Oscillometric method (with inflatable cuff) determines Mean arterial pressure (MAP), systolic and diastolic pressure.

Cuff pressure range:	0 to 280 mmHg (37 kPa), automatically released if pressure exceeds 315 ± 10 mmHg (42 ± 1.5 kPa).
Inflation time:	6 to 10 s (to 280 mmHg) typical using standard adult cuff.
Deflation time:	30 to 35 s typical
Cuff pressure accuracy:	better than ±3 mmHg (±0.4% kPa) for ambient temperature 15°C to 25°C better than ±3 mmHg (±0.6% of reading) for ambient temperature 10°C to 35°C, better than ±3 mmHg (+1.7% of reading) for ambient temperature 0°C to 55°C.

Add *rounding error* of ± 1/2 digit (= ±0.5 mmHg of ±0.05 kPa) to above accuracies.

Measurement Range:

Systolic:	30 to 270 mmHg (4 to 36 kPa)
Diastolic:	10 to 245 mmHg (1.3 to 32 kPa)
MAP:	20 to 255 mmHg (2.6 to 34 kPa)

Note Measurements are only possible in the heart range 40 to 220 bpm.

Modes

- *Auto:*..measurements are automatically repeated with a time interval set by the user (2, 5, 10, 15, 30 and 60 min).
- *Manual:*..a single measurement is taken.
- *Statim:*..(If fitted) A series of ten measurement cycles are taken over a five minute period. Only one QRS complex causing a pressure oscillation in the cuff is sensed at each inflation level.

Alarms

High and low pressure.

Alarm Limit Adjustments (78354C):

- 5 mmHg (1kPa) steps
- 2 mmHg (0.5kPa steps for 10 to 30 mmHg (1.5 to 4kPa)

Respiration Channel

Respiration amplifier

Patient Protection: Protected against defibrillator

Differential input impedance:	> 1 Mohm (at < 50 Hz with ECG in parallel)
Sensing current:	< 80 uA rms, measured at 62.5 kHz
Isolation voltage:	5 kV
Noise:	(display) < 3 mm measured at full size
Test signal:	amplitude equivalent to impedance change of 1 ohm ± 10% at a rate of 25 ± 5%

Respiration trigger

Monitor automatically sets to automatic triggering

AUTO MODE:	Auto trigger level is set automatically
Sensitivity:	< 180 mohm at a Resp. rate of 30 rpm
Respiration rate range:	4 to 100 rpm
Accuracy:	± 3 rpm
MANUAL MODE:	Trigger level dependent on display size
Nominal level:	M Triggermark. Signals must be greater than this mark to be triggered.

Alarms

Respiration rate:	High rate 10 s Alarm delay: \HR/RR coincidence (manual mode only)
Apnea: Alarm delay:	10 s - 40 s

Fractional Inspired Oxygen

Range:	10% to 110%
Resolution:	1%
Instrument Accuracy:	± 2.5% of full Scale (21% calibration) or ± 2.0% of full Scale (100% calibration).
Warm up time using 15203A transducer:	from standby, less than 1 min, unpolarized, less than 2 hours
Instrument back up time (internal battery):	greater than 4 days.

Alarms

Medical Alarms	
(audible and visual):	High O_2 alarm (limit selectable from 24 to 100%) Low O_2 alarm (limit selectable from 18 to 90%)
Alarm delay:	15 s
Technical Alarm (audible and visual):	Transducer disconnected Break in sensor cable.
Test Signal:	21% O_2

Carbon Dioxide

General

Warm up Time:	15 min. (accuracy within 0.3 mmHg CO_2). (78354C): 30 min. (accuracy within 0.3 mmHg of its final value).
Stability:	±1 mmHg (over 7 day period).
Response Time:	< 125 ms (for step from 10% to 90%)

The following errors are due to O_2/N2O compensation and are additional to instrument accuracies given in the sections below.

I. Continuous measurement of O_2 (O_2 between 10% and 100%)

a. O_2 compensation: error in CO_2 reading less than ±1%.
b. N2O compensation (N2O is assumed to be 100% minus O_2%): error in CO_2 reading less than ±1%.

II. Standard compensation (O_2 parameter off)

a. O_2 compensation (45% O_2 assumed): error in CO_2 reading lessthan ±3%, for actual O_2 concentrations of 20% to 70%.
b. N2O compensation (if selected, 55% N2O assumed): error inCO_2 reading less than ±6%, for actual O_2 concentrations of 20% to 70% and actual N2O concentrations of 30% to 80%.

Instantaneous CO_2 Wave Display

Waveform displayed, with graticule lines, in channel 2 (height 32 mm) or over channels 2 and 3 (height 64 mm).

End Tidal CO_2 Numerical Display

Range:	1 to 150 mmHg (0 to 20 kPa)
Instrument accuracy:	±2 mmHg (0.29 kPa) ±1/2 LSD* (CO_2 = 0 to 40 mmHg (5.34 kPa), ±5.5% ±1/2 LSD (CO_2 = 40 mmHg (5.34 kPa)

to 100 mmHg (13.3 kPa)).
*LSD = Least Significant Digit.

Respiration Rate Numerical Display

Range: 0 to 150 rpm

Instrument Accuracy: ± 2 rpm

Alarms

Medical Alarms (audible and visual): CO_2 WAVE Inspired Minimum
Indicated when minimum value of CO_2 wave lies above 4 mmHg (0.53 kPa).

End Tidal CO_2: 1.High CO_2
Limit selectable from 20 to 100 mmHg (2 to 14 kPa)
2.Low CO_2
Limit selectable from 10 to 95 mmHg (1 to 13 kPa)

Alarm Delay: 15 s

Respiration Rate: High respiration rate

Alarm delay: 10 s

Apnea alarm (no change in instananeous CO_2 value):
Alarm delay: selectable from 10 to 40 s.

Technical Alarms (audible and visual): Transducer disconnected.
Test Signal: 0/40 mmHg (0/6 kPa) square wave at 25 rpm, 50% duty cycle.

Graticule Line Labelling and Resolution:

Range (mmHg)	Graticule Line Labeling		Resolution (mmHg/cm)	
	Lower	Upper	32 mm scale	64 mm scale
0 to 60	0	40	20.8	10.4
0 to 90	0	60	31.2	15.6

Range (kPa)			Resolution (kPa/cm)	
	Lower	Upper	32 mm scale	64 mm scale
0 to 9	0	6	3.12	1.56
0 to 13.5	0	9	4.69	2.34

Temperature Channel

Range:	15°C to 45°C
Resolution:	0.1°C
Accuracy (at 0°C to 40°C ambient temperature):	±0.1°C (25.0°C to 45.0°C) ±0.2°C (15.0°C to 24.9°C)
Average time constant:	10 s (Δt = 15°C)
Numeric display update time:	2 s If out of range, no display. No alarm given.
Test temperature:	T1 = 40°C, T2 = 25°C ± 0.1°C, ΔT = 15°C ± 0.1°C.

Auxiliary Input Channel

General

Input impedance:	> 50 kohm
Max. voltage:	35 V
Bandwidth:	≤ 20 Hz
Input voltage range (waveform):	± ;1.6 V
Input sensitivity:	1 cm/V (32 mm waveform channel). 2 cm/V (64 mm waveform channel).
Baseline for external devices:	50% of waveform. No graticule lines.

Auxiliary input - 78205D Pressure module

(mmHg only. Not possible with Opt.E20).

Graticule line labelling and resolution.

As for Pressure Channel, see table.

```
Wave Input
Sensitivity:              45 mmHg range; 62.5 mm/V
                          90 mmHg range; 31.3 mm/V
                          180 mmHg range; 15.6 mm/V
                          270 mmHg range; 10.4 mm/V

DC Input
Range:                   0-300 mmHg (35 kPa)
Sensitivity:             100 mmHg/V (10 kPa)
Accuracy:                +3 mmHg (0.3 kPa)
```

Auxiliary input - 47210 Capnometer

Wave Input Sensitivity:	0-60 mmHg (0-9 kPa) range; 9.5 mm/V (6.3 mm/V), graticule line at 40 mmHg (6 kPa) 0-90 mmHg (0-13.5 kPa) range; 9.5 mm/V (6.3 mm/V), graticule line at 60 mmHg (9 kPa).
DC Input Range:	0-150 mmHg (0-17.5 kPa).
Sensitivity:	50 mmHg/V (5 kPa/V).
Accuracy:	±3 mmHg (±0.3 kPa).
Speed selection:	6.25 mm/s.

SpO_2 / Pleth

SpO_2 is measured using a dual wavelength optical transducer. It measures pulse and SpO_2.

Range:	0% to 100% saturation
Numeric display:	Averaging period selectable 1/2/4/8/16 beats, with default 4.
Settling time:	< 5 s typical
Accuracy:	1SD 80% to 100% ± 1.5% 65% to 80% ± 2.5% 0% to 65% unspecified
Accuracy with HP M1190A transducer (78354C):	1SD 80% to 100% ± 1.5% 65% to 80% ± 2.5% 0% to 65% unspecified
Accuracy with NELLCOR transducers (78354C):	1SD 80% to 100% ± 3%

Alarms

Lower Alarm range:	50-95%, step 1%, default = 90%
Upper Alarm range:	70-99%, OFF, step 1%, default = OFF
Alarm delay:	10 s
HR derived from Pleth, Alarm Delay:	High Rate 10 s Low Rate 6 s (78354C): Low Rate 10 s

Pleth Amplifier

Bandwidth:	0.8 - 11.0 Hz ± 25%
Settling time:	< 5 s

Cardiotach

Range:	30 - 300 bpm
Accuracy:	± 1%
Resolution:	1 bpm

Graticule lines

Lower line: ... 25% of wave channel
Upper line: ... 75% of wave channel

Autofix: 50% of wave channel, peak values on Pleth graticule lines. Gain frozen after 60 s approximately

Test

- SpO_2 test signal: 100%
- Pleth test signal: 50% of wave channel, 100 bpm.

Alarms

HR derived from Pleth/ Alarm delay:	High Rate 10 s Low Rate 6 s (78354C): Low Rate 10 s

System Interface

General (Opt. J11 only)

Note There is no annotation of NIBP and SpO_2 values.

Auxiliary signals and parameters, Internal processing accuracy:	± 50 mV
Selectable channels for external recorder, Internal processing accuracy:	±50 mV
Delay mode:	12 s delay time
Bandwidth:	Channel 1 = 0 Hz to 50 Hz Channel 2 = 0 Hz to 15 Hz
Parameters off condition:	-1 V

ECG system outputs

Wave Bandwidth:	FILTering 0.5 to 25 Hz (OR), 0.5 to 100 Hz (ICU). DIAGnostic 0.05 to 100 Hz (OR and ICU).
Gain:	variable between 320 and 3200, dependent on display gain.

DC Output (HR) Range:	15 bpm to 300 bpm - 0.15 V to 3 V; < 15 bpm - 0 V
Accuracy:	± 5 bpm
Resolution:	1 bpm

Pressure system outputs

The following accuracies are additional to those given in the Pressure Channel data.

Wave (All the following voltages are ± 50 mV):

Range (absolute):	-25 to 270 mmHg = -0.25 V to 2.7 V (-3.3 to 36 kPa = -0.33 V to 3.6 V)
Range (scaled):	- 5 to 45 mmHg = -0.50 V to 4.5 V, (-0.5 to 4.5 kPa = -0.50 V to 4.5 V) -10 to 90 mmHg = -0.50 V to 4.5 V (-1.0 to 9.0 kPa = -0.50 V to 4.5 V) -20 to 180 mmHg = -0.40 V to 3.6 V (-2.5 to 22.5 kPa = -0.50 V to 4.5 V) -25 to 270 mmHg = -0.25 V to 2.7 V (-3.3 to 36.0 kPa = -0.33 V to 3.6 V)
Bandwidth:	0 Hz to 12 Hz
DC-Output Range (systolic, diastolic and mean):	-30 mmHg to 300 mmHg = -0.3 V to 3 V ± 50mV (-4 kPa to 40 kPa = -0.4 V to 4 V)

Scaled wave on selectable channels for external recorder with offset of -2 V.

Respiration system output

Wave Bandwidth:	2.5 Hz
Amplitude:	2.5 V (at 50% display height)
DC-Output (RR) Range:	5 resp/min to 100 resp/min = 0.1 V to 2 V
Accuracy:	± 3 resp/min

Plethysmograph system outputs

Wave Amplitude:	2.5 Vpp (at 50% display)
DC-Output (HR) Range:	15 bpm to 300 bpm = 0.15 V to 3 V; < 15 bpm = 0 V
Accuracy:	± 5 bpm
Resolution:	1 bpm

Temperature system output

DC Output (T1 only) - Range:	15°C to 45°C = -0.5V to 2.5V
Accuracy:	± 0.1°C for 25°C $\leq$ T $\leq$ 45°C (Opt.N12) ± 0.2°C for 15°C $\leq$ T $\leq$ 24.9°C

Resolution:	0.1°C (at ambient temperature of 0°C to 40°C)

Trend

General

One long trend (24, 8, 4, or 2 h) and one short trend (60 or 20 mins) available on each parameter. Points on trend curve are averaged values. Alarms are shown as actual values. Power off, INOP and Alarms off are indicated.

ECG Channel

Heart Rate Trend Range:	20 to 180 bpm
Resolution:	1 bpm
Display points per trend curve:	384

Respiration Channel

Respiration Rate Trend Range:	0 to 60 rpm
Resolution:	1 rpm
Display points per trend curve:	384

Pressure Channel

The systolic, diastolic and mean values are combined in one display.

Range:	dependent on selected pressure scale.
Resolution:	1.2 mmHg (0.16 kPa)
Display points per trend curve:	96

Each point contains one systolic, one diastolic and two mean readings.

Pleth Channel

The pleth trend curve shows peak-to-peak amplitude of the wave.

Range:	0 to 100% (78354C): 0 to 1; 1 represents amplitude after autogain freeze.
Resolution:	1% (78354C): 0.01
Display points per trend curve:	384

AUX Channel

CO_2 end tidal value trend.
Pressure, mean value trend.
Display points per trend curve: 384

Single Temperature Channel

Range:	25°C to 42°C
Resolution:	0.1°C
Display points per trend curve:	384

Dual Temperature Channel

T1 and T2 are displayed. ΔT trend is directly readable from the display.

Range:	25°C to 42°C
Resolution:	0.1°C
Display points per trend curve:	337 (T1) and 48 (T2)

Oxygen Channel

O_2 trend.

Range:	0 to 100%
Resolution:	1% volume of O_2
Display points per trend curve:	384

Carbon Dioxide Channel

CO_2 end tidal value trend.

Range:	0 to 60 mmHg/9 kPa (selected scale 40 mmHg/6 kPa), or 0 to 90 mmHg/13.5 kPa (selected scale 60 mmHg/9 kPa).
Resolution:	1 mmHg/0.13 kPa.
Display points per trend curve:	384

Respiration rate trend.

Range:	0 to 60 rpm
Resolution:	1 rpm
Display points per trend curve:	384

SpO_2 Channel (78354C)

Range:	60% to 100%
Resolution:	2%
Display points per trend curve:	384

Technical Specifications - 78832A

This section contains the technical specifications for the 78832A. The general instrument specifications are followed by those for the individual parameters.

General

Patient safety

- All inputs are CF-type.
- Option N01 meets safety requirements of CSA (C22.2 No. 125).
- Option N02 meets safety requirements of IEC 601-1.
- Option N04 meets safety requirements o UL 544.
- Defibrillator protection up to 5 kV.

Defibrillator protection: up to 5 kV

Power Requirements

Operating voltage:	115 V/230 V +10% -15% (USA/IEC) 115 V/230 V +10% -22% (Japan)
Frequency:	50/60 Hz
Power consumption:	40 W

Environmental

Operating temperature:	0°C to 55°C
Storage temperature:	-40°C to +75°C
Relative humidity:	5% to 95%

Size:	160 mm high, 320 mm wide, 405 mm deep
Weight:	11 kg (24 lbs)

Display

Superaster video display

Screen size:	140 x 105 mm; 178 mm diagonal
Sweep speed:	12.5 mm/s, 25 mm/s or 50 mm/s gives 8 s, 4 s or 2 s of display respectively. For respiration, a speed of 6.25 mm/s is also available
Display mode:	fixed trace (moving bar)
Waveform display height	Channel 1 30 mm ±10% Channel 2 32 mm ±10%
Numeric update time:	2 s
Resolution per waveform:	256 dots vertical, 500 dots horizontal

Trends are stored at power off for a minimum of 1 hour.

ECG Channel

ECG Amplifier

Patient Safety:

Protected against defibrillator and electrosurgery potentials. Standard full lead selector.

Differential input impedance: 1 Mohm (at 10 Hz and including patient cable).

Common Mode Rejection Ratio:

- FILTering 106 dB
- DIAGnostic > 86 dB at line frequency with patient cable and 51 kohm/47 nF imbalance and respiration in parallel.

Electrode offset potential: ±0.5 V max.

Baseline recovery: 2 s after defibrillation.

Noise: <35 uVpp, measured in the DIAGnostic mode and referred to the input, with each lead connected to ground through shielded 51 kohm/47 nF.

Cardiotach

Digital cardiotach, beat to beat rate:

Range: 15-350 bpm

Accuracy: ±1% of displayed value

Resolution: 1bpm

Sensitivity: 250 uV peak

No pace pulse rejection.

Analog Output

ECG wave on phone-jack:

Constant gain: 1000

Bandwidth: FILtering 0.5 to 25 Hz
DIAGnostic 0.5 to 100 Hz

Baseline offset: </= 100mV at gain of 1000

Alarms

Technical alarm: Leads off
occurs if electrode offset potential out of spec.

Indication: -?- three dashes flash in place of heart rate numerics and audible alarm is given.

Medical alarms:	Asystole occurs when interval between 2 QRS compexes exceeds four seconds.
Indication:	< 15 numerics flash, alarm lamps flash, and an audible alarm is given.
Heart rate alarm occurs when	heart rate is outside of selected alarm limits.
Indication:	flashing heart rate numerics and audible alarm given.
Alarm range:	15-30 bpm in steps of 5 bpm.
Alarm delay:	High rate 10 s, low rate 5 s.

Test/Calibration

- ECG simulated test waveform and numerics: 125bpm ± 2, waveform 2.5cm pp
- Calibration signal: 1 mV ±10%

Temperature Channel

Range:	15°C to 45°C
Resolution:	0.1°C
Accuracy:	± 0.1°C (25.0°C to 45.0°C) ± 0.2°C (15.0°C to 24.9°C)
Average time constant:	10 s (Δt = 15°C)
Numeric display update time:	2 s
If out of range, no display No alarm given. .	
Test temperature:	T1 = 40°C, T2 = 40°C ± 0.1°C, T = 0°C ± 0.1°C.
Isolation voltage:	5kV

Respiration Channel

Respiration amplifier

Patient Protection: Protected	against defibrillator potentials
Differential input impedance:	> 1 Mohm (at < 50 Hz with ECG in parallel)
Sensing current:	< 80 uA rms, measured at 62.5 kHz
Isolation voltage:	5 kV
Noise (display):	< 3 mm measured at full size
Test signal:	amplitude equivalent to impedance change of 1 ohm ± 10% at a rate of 60 ± 5% rpm

Respiration trigger

Monitor automatically sets to automatic triggering

Auto mode:	Auto trigger level is set automatically
Sensitivity:	< 180 mohm at a Resp. rate of 60 rpm
Respiration rate range:	< 170 rpm
Accuracy:	± 3 rpm
Manual mode:	Trigger level dependent on CRT display size
Nominal level:	M Triggermark. Signals must be greater than this mark to be triggered.

Respiration alarms

Apnea alarm: activated when no valid breath is detected within present apnea delay time.

Delay time:	10 to 40 s, adjustable in increments of 5 s
Indication:	APNEA message, 000 flashes, alarm lamps flash and audible alarm is given.
High rate alarm..Range:	50 to 170 rpm, in steps of 5rpm
Coincidence alarm:	(in manual mode only) activated if the interval between two detected QRS complexes equals the time between two breaths ± 12.5%
Indication:	HR=RR message

780 Annotating Interface

General

Annotating output for HP-annotating recorder. Delayed outputs for respiration wave and instantaneous heart rate (CRG).

Delay time:	2.5 mins
Parameters of condition:	-1 V

ECG System Outputs

- Wave

Bandwidth:	FILtering 0.5 Hz to 25 Hz DIAGnostic 0.05 Hz to 100 Hz
Amplitude:	2.5 Vpp (at 50% display height)

- DC output (HR)

Range average (HR):	15 bpm to 300 bpm = 0.15 V to 3 V;
Range instant (HR):	15 bpm to 240 bpm = 0.15 to 2.4V
Accuracy:	± 5 bpm

Resolution:	1 bpm

Respiration-system output

Wave:	
Bandwidth:	2.5 Hz
Amplitude:	2.5 V (50% display height)
DC-output:	
Range:	5 resp/min to 150 resp/min = 0.1 V to 3 V
accuracy:	±3 resp/min

Temperature - system output

DC-output (T1 only):	
Range:	ΔT 0°C to 30°C = 0 V to 3 V
Range:	T1: 15°C to 45°C = -0.5 V to 2.5 V
Accuracy:	±0.1°C for 25°C < T < 45°C ±0.2°C for 15°C < T < 24.9°C (at ambient temperature of 0°C to 40°C)
Resolution:	0.1°C

ΔT is standard, T1 is internally selectable

Trend

General

One long trend (24, 8, 4, or 2 h) and one short trend (60 or 20 or 2 mins) available on ECG (heart rate, 2 min is beat to beat), respiration (wave and apnea events). Points on trend curve are averaged values (except respiration). Alarms are shown as actual values. Power off, INOP and Alarms off are indicated.

ECG Channel

Heart Rate Trend Range:	50 to 210 bpm
Resolution:	1 bpm
Display points per trend curve:	384 (468 for 2 min trend)

Respiration Channel

Length of apnea event(s) (in seconds) displayed as a vertical bar.

Maximum height of bar:	60 s to 360 s (dependent on selected trend time)
Resolution of bar:	1 s
Number of bars per display:	192
Wave (2 min trend only) Display points per trend curve:	468

Technical Specifications - 78833A

This section contains the technical specifications for the 78833A. The general instrument specifications are followed by those for the individual parameters.

General

Patient safety

- All inputs are CF-type.
- Option N01 meets safety requirements of CSA (C22.2 No. 125).
- Option N02 meets safety requirements of IEC 601-1.
- Option N04 meets safety requirements o UL 544.
- Defibrillator protection up to 5 kV.

Defibrillator protection: up to 5 kV

Power Requirements

Operating voltage:	115 V/230 V +10% -15% (USA/IEC) 115 V/230 V +10% -22% (Japan)
Frequency:	50/60 Hz
Power consumption:	40 W

Environmental

Operating temperature:	0°C to 55°C
Storage temperature:	-40°C to +75°C
Relative humidity:	5% to 95%

Size:	160 mm high, 320 mm wide, 405 mm deep
Weight:	11 kg (24 lbs)

Trends are stored at power off for a minimum of 1 hour.

Display

Superaster video display

Screen size:	140 x 105 mm; 178 mm diagonal
Sweep speed:	12.5 mm/s, 25 mm/s or 50 mm/s gives 8 s, 4 s or 2 s of display respectively. For respiration, a speed of 6.25 mm/s is also available
Display mode:	fixed trace (moving bar)
Waveform display height:	Channel 1 30 mm ±10% Channel 2 normal 32 mm ±10% Channel 3 mode

	Channel 2 overlapping 64 mm ±10% Channel 3 mode
Numeric update time:	2 s
Resolution per waveform:	256 dots vertical, 500 dots horizontal

ECG Channel

ECG Amplifier

Patient Safety:

Protected against defibrillator and electrosurgery potentials. Standard three lead selector.

Differential input impedance: > 1 Mohm (at 10 Hz and including patient cable).

Common Mode Rejection Ratio:

- FILTering 106 dB
- DIAGnostic > 86 dB at line frequency with patient cable and 51 kohm/47 nF imbalance.

Electrode offset potential:	±0.5 V max.
Baseline recovery:	2 s after defibrillation.
Noise:	<35 uVpp, measured in the DIAGnostic mode and referred to the input, with each lead connected to ground through shielded 51 kohm/47 nF.

Cardiotach

Digital cardiotach, beat to beat heart rate

Range:	15 - 350 bpm
Accuracy:	± 1% of displayed value
Resolution:	1 bpm
Sensitivity:	250 uV peak

No pace pulse rejection

Analog Output

ECG wave on phone-jack:

Constant gain:	1000
Bandwidth:	FILtering 0.5 to 25 Hz DIAGnostic 0.5 to 100 Hz
Baseline offset:	< 100mV at gain of 1000

Alarms

Technical alarm: Leads off, ... occurs if electrode offset potential out of spec.

Indication: three dashes flash in place of heart rate numerics and audible alarm is given.

Medical alarms: Asystole, ... occurs when interval between 2 QRS compexes exceeds four seconds.

Indication: < 15 numerics flash, alarm lamps flash, and an audible alarm is given.

Heart rate alarm occurs when heart rate is outside of selected alarm limits.

Indication: flashing heart rate numerics and audible alarm given.

Alarm range: 15-30 bpm in steps of 5 bpm.

Alarm delay: High rate 10 s, low rate 5 s.

Test/Calibration

- ECG simulated test waveform and numerics: 125bpm ±2, waveform 2.5cm pp
- Calibration signal: 1 mV ±10%

Respiration Channel

Respiration amplifier

Patient Protection: Protected against defibrillator

Differential input impedance: > 1 Mohm (at < 50 Hz with ECG in parallel)

Sensing current: < 80 uA rms, measured at 62.5 kHz

Isolation voltage: 5 kV

Noise: (display) < 3 mm measured at full size

Test signal: amplitude equivalent to impedance change of 1 ohm ± 10% at a rate of 60 ± 5%

Respiration trigger

Monitor automatically sets to automatic triggering.

Auto trigger: Auto trigger level is set automatically

Sensitivity: < 180 mohm at a Resp. rate of 60 rpm

Respiration rate range: < 170 rpm

Accuracy: ± 3 rpm

Manual trigger: Trigger level dependent on CRT display size

Nominal level: M Triggermark. Signals must be greater than this mark to be triggered.

Respiration alarms

Apnea alarm activated when no valid breath is detected within present apnea delay ime.

Delay time:	10 to 40 s adjustable in ecrements of 5 s.
Indication:	APNEA message, 000 flashes, alarm lamp flashes and audible alarm is given.
High rate alarm range:	50 -170 rpm, in steps of 5rpm
Coincidence alarm:	(in manual mode only) activated if the interval between two detected QRS complexes equals the time between two breaths ± 12.5%.
Indication:	HR=RR message

Pressure Channel

Pressure amplifier

Range:	-35 mmHg to +300 mmHg (-4 kPa to +40 kPa)
Sensitivity:	5 uV/V/mmHg (37.5 uV/V/kPa) or (selected 40 uV/V/mmH (300 uV/V/kPa) (automatically
Gain accuracy:	± 1%
Gain stability:	± 0.1 mmHg/°C ± 0.013 kPa/°C
Gain adjustment range:	± 10%
Non-linearity:	0.5%
Bandwidth:	12 Hz

Auto zero

Range:	± 200 mmHg (± 26 kPa)
Zero accuracy:	± 1.0 mmHg (± 0.13 kPa)
Zero drift:	0.1 mmHg/°C (0.013 kPa/°C)
Response time:	1 s

Pressure wave display

Graticule lines:	normal 3 channel wave range 32 mm overlapping wave 64mm.

Pulse rate

Derived from P1 only (not available with Opt. E20)

Range:	25 to 300 bpm
Accuracy:	± 1%
Resolution:	1 bpm

Graticule line labelling and resolution:

++Range (mmHg)++	++Graticule++ ++line labelling++ ++lower	upper++	++Resolution (mmHg/cm)++ ++64 mm	32 mm++
-5 - +45	0	30	8	16
-10 - +90	0	60	16	32
-20 - +180	0	120	32	64
-25 - +270	0	180	48	96

++Range (kPa)++	++Graticule++ ++Line labelling++ ++lower	upper++	++Resolution (kPa/cm)++ ++64 mm	32 mm++
-0.5 - +4.5	0	3	0.78	1.56
-1.0 - +9.0	0	6	1.56	3.12
-2.5 - +22.5	0	15	4.16	8.33
-3.3 - -36.0	0	24	6.25	12.5

Alarms

Technical Alarms:	Transducer disconnect Pressure disconnect
Alarm delay:	8 s
Medical Alarms:	High and low pressure,
Alarm delay:	8 s Pulse rate
Range:	25 to 300 bpm

Test/calibration

Simulated test waveform and numerics:

- P1:.... 120 mmHg (15 kPa)
- P1:.... 60 mmHg (6 kPa)

Calibration signal (steps): 30/60/120/180 mmHg (3/6/15/24 kPa)

780 Annotating Interface

General

Annotating output for HP-annotating recorders.
Delayed outputs for respiration wave and instantaneous heart rate (CRG).

- Delay time: 2.5 mins
- Parameter off condition: -1 V

ECG System Outputs

- Wave

Bandwidth:	FILtering 0.5 Hz to 25 Hz DIAGnostic 0.05 Hz to 100 Hz
Amplitude:	2.5 Vpp (at 50% display).

- DC output (HR):

Range average HR:	15 bpm to 300 bpm = 0.15 V to 3 V;
Range beat-beat HR:	15 bpm to 240 bpm 0.15 V to 2.4 V
Accuracy:	± 5 bpm
Resolution:	1 bpm

Respiration-system output

Wave Bandwidth:	2.5 Hz
Amplitude:	2.5 V (50% display height)
DC-output (RR) Range:	5 resp/min to 150 resp/min = 0.1 V to 3V
Accuracy:	± 3 resp/min

Pressure system output (P1 only)

```
Wave scaled:               Range:
      -5 V to 45 mmHg  =   -0.3 V to 4.5 V
.....-10 V to 90 mmHg  =...-0.3 V to 4.5 V
.....-20 V to 180 mmHg =...-0.3 V to 3.6 V
.....-25 V to 270 mmHg =...-0.25 V to 2.7V
.....-0.5 to 4.5 Kpa   =...-0.5 V to 4.5 V
.....-1 to 9 Kpa       =...-0.5 V to 4.5 V
.....-2.5 to 22.5 Kpa  =...-0.5 V to 4.5 V
.....-3.3 to 36 Kpa    =...-0.33 V to 3.6 V
```

Accuracy: ± 50 mV
Bandwidth: 0 Hz to 12 Hz
DC-output -30 to 300 mmHg = -0.3 V to 3 V ± 50 mV
Range S/D/M: -4 to 40 Kpa = -0.4 V to 4 V ± 50 mV

Scaled wave on selectable channels for external recorder with offset of -2.V

Trend

General

One long trend (24, 8, 4, or 2 h) and one short trend (60 or 20 or 2 mins) available on ECG (heart rate , 2 min is beat to beat), respiration (wave and apnea events) and pressure (systolic diastolic and mean). Points on trend curve are averaged values (except respiration).Alarms are shown as actual values. Power off, INOP and Alarms off are indicated.

ECG Channel

Heart Rate Trend Range:	50 to 210 bpm
Resolution:	1 bpm
Display points per trend curve:	384 (468 for 2 min trend)

Respiration Channel

Length of apnea event(s) (in seconds) displayed as a vertical bar.

Maximum height of bar:	60 s to 360 s (dependent on selected trend time)
Resolution of bar:	1 s
Number of bars per display:	192
WAVE (2 min trend only)	
Display points per trend curve:	468

Pressure Channel

The systolic, diastolic and mean values are combined in one display.

Range:	dependent on selected pressure scale.
Resolution:	1.2 mmHg (0.16 kPa)
Display points per trend curve:	96 (117 for 2 min trend)

Each point contains one systolic, one diastolic and two mean values.

Technical Specifications - 78833B and 78834A/C

This section contains the technical specifications for the 78833B and 78834A/C. The technical specifications are the same for both instruments with the following exceptions:

a. The 78833B is a 3/4 module instrument and the 78834A is a full module instrument.

b. The 78834C comes in both sizes.

The general instrument specifications are followed by those for the individual parameters:

General

Patient safety

- All inputs are CF-type.
- Option N01 meets safety requirements CSA(C22.2 No.125).
- Option NO2 meets safety requirements of IEC 601-1.
- Option NO4 meets safety requirements of UL 544.
- Defibrillator protection up to 5 kV.

Power requirements

Operating voltage:	115 V/230 V +10% -15% (IEC/USA) 115 V/230 V +10% -22% (Japan)
Frequency:	50/60 Hz,
Power consumption:	78833B - 75 W (max) 78834A - 80 W (max)

Environmental

Operating temperature:	0°C to 55°C
Storage temperature:	-40°C to +75°C
Relative humidity:	5% to 95%
Size: 78833B/4C:	160 mm high, 320 mm wide, 405 mm deep
Size: 78834A/C:	160 mm high, 425 mm wide, 405 mm deep
Weight: 78833B/4C:	11 kg (24 lbs)
Weight: 78834A/C:	14 kg (31 lbs)

Trends stored at power off condition for a minimum of 1 hour.

Display

Superaster video display:

Screen size:	140 mm x 105 mm; 178 mm diagonal
Sweep speed:	12.5 mm/s, 25 mm/s or 50 mm/s gives 8 s, 4 s or 2 s of display respectively. (For respiration a speed of 6.25 mm/s is also available.)
Display mode:	fixed trace (moving bar).

Waveform display height: \

```
Channel 1                 30 mm ± 10%
   -----------------------------------
Channel 2    normal
Channel 3    mode         32 mm ± 10%
   -----------------------------------
Channel 2    overlapping
Channel 3    mode         64 mm ± 10%
```

Numeric update time:	2 s
Resolution:	256 dots vertical, 500 dots horizontal.

ECG Channel

ECG Amplifier

Patient Safety: Protected against defibrillator and electrosurgery potentials. Standard three lead selector.

	Protected against defibrillator and electrosurgery potentials. Standard three lead selector.
Differential input impedance:	5 Mohm (at 10 Hz and including patient cable)
.... (78834C):	1 Mohm(at 10 Hz and including patient cable).
Common Mode Rejection Ratio:	FILTering 110 dB (with Resp. $\geq$ 106 dB) DIAGnostic 90 dB (with Resp. $\geq$ 84 dB) at line> frequency with patient cable and 51 kohm/47 nF imbalance.
Electrode offset potential:	±0.5 V max
Baseline recovery:	2 s after defibrillation.
(78834C):........ :	1 s after defibrillation
Noise:	< 35 uVpp, measured in the DIAGnostic mode and referred to the input, with each lead connected to ground through shielded 51 kohm/47 nF.

Cardiotach

Digital cardiotach, beat to beat rate.

AUTO MODE

Upper alarm limit range:	15 to 300 bpm
Accuracy:	± 1%
Resolution:	1 bpm
Sensitivity:	250 uV peak

No Pace pulse rejection

MANUAL MODE

Heart rate range:	15 to 350 bpm
Accuracy:	± 1%
Resolution:	1 bpm
Sensitivity:	-5 mV to +5 mV
Display gain:	3 mm/mV to 30 mm/mV (channel 1)

Analog output

- ECG wave on phone-jack

Gain:	320 to 3200 (dependent on display gain).
Bandwidth:	FILTering 0.5 to 25 Hz DIAGnostic 0.5 to 100 Hz
Baseline offset:	</=; 100 mV at gain 1000.

Alarms

Technical Alarm:	Leads Off, occurs if electrode is detached, dry or if electrode offset potential out of spec.
Medical Alarms:	Asystole, occurs when interval between two QRS complexes exceeds four seconds.
Indication:	< 15 numerics flash, alarm lamps flash and an audible alarm is given.
Alarm delay:	High rate < 10 s Low rate < 6 s

Test/Calibration

ECG simulated test waveform and numerics:	100bpm ±2, waveform 1.5 cm pp (78834C): 125 bpm ± 2 waveform 1.5 cm pp
Calibration signal:	1 mV ±10%

Temperature Channel

Range:	15°C to 45°C
Resolution:	0.1°C
Accuracy:	± 0.1°C (25.0°C to 45.0°C) ± 0.2°C (15.0°C to 24.9°C)
Average time constant:	10 s (Δt = 15°C)
Numeric display update time:	2 s If out of range, no display No alarm given.
Test temperature:	T1 = 40°C, T2 = 40°C ± 0.1°C, T = 0°C ± 0.1°C.
Isolation voltage:	5kV

Respiration Channel

Respiration amplifier

Patient Protection: Protected	against defibrillator potentials
Differential input impedance:	> 1 Mohm (at < 50 Hz with ECG in parallel)
Sensing current:	< 80 uA rms, measured at 62.5 kHz
Isolation voltage:	5 kV
Noise (display):	< 3 mm measured at full size
Test signal:	amplitude equivalent to impedance change of 1 ohm ± 10% at a rate of 60 ± 5%

Respiration trigger

Monitor automatically sets to	automatic triggering
Auto mode:	Auto trigger level is set automatically
Sensitivity:	< 180 mohm at a Resp. rate of 60 rpm
Respiration rate range:	< 170 rpm
Accuracy:	± 3 rpm
Manual mode:	Trigger level dependent on CRT display size
Nominal level:	M Triggermark. Signals must be greater than this mark to be triggered.

Respiration alarms

Apnea alarm: activated when no valid breath is detected within present apnea delay time.

Delay time:	10 to 40 s, adjustable in increments of 5 s
Indication:	APNEA message, 000 flashes, alarm lamps flash and audible alarm is given.
High rate alarm..Range:	50 to 170 rpm, in steps of 5rpm
Coincidence alarm:	(in manual mode only) activated if the interval between two detected QRS complexes equals the time between two breaths ± 12.5%
Indication:	HR=RR message

Pressure Channel

Pressure amplifier

Range:	-25 mmHg to +300 mmHg (-3.3 kPa to +40 kPa)
Sensitivity:	5 uV/V/ mmHg (37.5 uV/V/kPa) or 40 uV/V/mmHg (300 uV/V/kPa) selected automatically
Gain accuracy:	± 1%
Gain stability:	± 0.1 mmHg/°C (± 0.013 kPa/°C)
Gain adjustment range:	± 10% (78834C): ±7%
Non-linearity:	0.5%
Bandwidth:	0 to 12 Hz

Auto zero

Range:	± 200 mmHg (± 26 kPa)
Zero accuracy:	± 1.0 mmHg (± 0.13 kPa)
Zero drift:	0.1 mmHg/°C (0.013 kPa/°C)
Response time:	1 s

Pressure wave display

Graticule lines:	Normal 3 channel wave range 32 mm, Overlapping wave 64 mm

Graticule line labelling and resolution:

Range (mmHg)	Graticule line labelling lower	Graticule line labelling upper	Resolution (mmHg/cm) 64mm	Resolution (mmHg/cm) 32mm
-5 - +45	0	3	8	16
-10 - +90	0	60	16	32

-20 - +180	0	120	32	64
-25 - +270	0	180	48	96

Range (kPa)	Graticule line labelling lower	upper	Resolution (kPa/cm) 64mm	32mm
-0.5 - +4.5	0	3	0.78	1.56
-1.0 - +9.0	0	6	1.56	3.12
-2.5 - +22.5	0	15	4.16	8.33
-3.3 - +36	0	24	6.25	12.5

Pulse Rate

Derived from P1 only (not available with Opt.E20).

Range: 25 to 300 bpm

Accuracy: 1%

Resolation: 1 bpm

Alarms

High and low pressure alarms: occur when selected pressure is outside alarm limits.

Indication: flashing pressure numerics and audible alarm.

Alarm delay: 8 s

Pulse rate: range 25 to 300 bpm

Transducer disconnect alarm: occurs when transducer not connected to instrument.

Indication: P1 (or P2) NO TRANSDUCER message, three dashes flash in place of pressure numerics and an audible alarm is given

Alarm delay: 8 s

Pressure disconnect alarm: occurs when mean pressure falls below 10 mmHg.

Indication: P1 (or P2) DISCONNECT message, flashing numerics and audible alarm is given.

Alarm delay: 8 s

Test/calibration

Simulated test waveform and numerics: P1: 120 mmHg (15 kPa)
P2: 60 mmHg (6 kPa)

Transcutaneous O_2 and CO_2 Channel ($tcpO_2$ and $tcpCO_2$)

General

$tcpO_2$ Numerical Display	
Range (3 Digits):	0 to 800 mmHg (0 to 99.9 kPa)
Non-linearity:	0.5% ± 1 digit
Temperature Drift:	< 0.1% per °C
$tcpCO_2$ Numerical Display	
Range (3 Digits):	0 to 150 mmHg (0 to 20 kPa)
Non-linearity:	1% ± 1 digit
Temperature Drift:	< 0.1% per °C

Transducer Heating

Selectable temperature settings:	37, 42, 42.5, 43, 43.5, 44, 44.5, 45°C
Accuracy:	± 0.1 °C
Maximum Heating Power:	833 mW (using transducers 15204A and 15205A), 640 mW (using transducers 15207A and 15208A).
Maximum Heating Power (78834C):	833 mW (using transducers 15204A and 15205A), 600 mW (using transducers 15207A and 15209A).
Temperature safeguards:	
Temperature Sensors (within transducer):	2 (78834C): 2 (15204A/15205A/15209A) 1, (15207A)

To prevent overheating, the heating power is switched off and an error message (delay 30 s) is generated under each of the following conditions:

a. temperature greater than 46 °C
b. temperature out of range
c. temperature sensor broken or shorted
d. microprocessor operation is interrupted.

Alarms

Medical Alarms (Audible and Visual):	High $tcpO_2$ (limit selectable from 20 to 300 mmHg - 2 to 40 kPa)
	Low $tcpO_2$ (limit selectable from 10 to 95 mmHg - 1 to 9.5 kPa)
	High $tcpCO_2$ (limit selectable from 20 to 150 mmHg - 2 to 20 kPa)
	Low $tcpCO_2$ (limit selectable from 10 to 95 mmHg- 1 to 9.5 kPa)

Alarm Delay:	8 s.
Technical Alarms (Audible and Visual):	Transducer disconnected. Site timer elapsed (limit selectable from 1h to 7 hs, in steps of 1 h.

Test Signal:

$tcpO_2$:	60 mmHg (8.0 kPa)
$tcpCO_2$:	40 mmHg (5.3 kPa)

780 Annotating Interface

General

Annotating output for HP-annotating recorders.
Delayed outputs for respiration wave and instantaneous heart rate (CRG).

Delay time:	2.5 mins
Parameter off condition:	-1 V

ECG system outputs

Wave Bandwidth:	FILTering 0.5 to 25 Hz DIAGnostic 0.5 to 100 Hz
Amplitude:	2.5 Vpp (@ 50% display height)
DC Output (HR):	
Range average HR:	15 bpm to 300 bpm = 0.15 V to 3 V
Range instant HR;	15 bpm to 240 bpm = 0.15 V to 2.4 v
Accuracy:	± 5 bpm
Resolution:	1 bpm

Respiration system output

Wave Bandwidth:	2.5 Hz
Amplitude:	2.5 V (at 50% display height)
DC-Output (RR) Range:	5 resp/min to 150 resp/min = 0.1 V to 3 V
Accuracy:	± 3 resp/min

Temperature system output

DC Output (T1 only) ... Range:	5°C to 45°C = -0.5V to 2.5V (78834C): T1: 15°C to 45°C = -0.5 V to 2.5 V
Accuracy:	± 0.1°C for 25°C $\leq$ T $\leq$ 45°C ± 0.2°C for 15 °C $\leq$ T $\leq$ 24.9°C (at ambient temperature of 0°C to 40°C)
Resolution:	0.1°C

Pressure system output

The following accuracies are additional to those given in the Pressure Channel data.

Wave

(All the following voltages are + 50 mV)

```
Range (scaled):   \ -5 to 45 mmHg   =   -0.50 V to 4.5 V
                   -10 to 90 mmHg   =  -0.50 V to 4.5 V
                   -20 to 180 mmHg  = -0.40 V to 3.6 V
                   -25 to 270 mmHg  = -0.25 V to 2.7 V
                   (-0.5 to 4.5 kPa = -0.50 V to 4.5 V
                    -1.0 to 9.0 kPa =  -0.50 V to 4.5 V
                   -2.5 to 22.5 kPa = -0.50 V to 4.5 V
                   (-3.3 to 36.0 kPa =-0.33 V to 3.6 V)
```

Bandwidth: 0 Hz to 12 Hz

DC Output:

Range (systolic, diastolic and mean):	-30 mmHg to 300 mmHg = -0.3 V to 3 V (-4 kPa to 40 kPa = -0.4 V to 4 V)

Scaled wave on selectable channels for external recorder with offset of -2 V.

$tcpO_2$ and $tcpCO_2$ system output

The following accuracies are traditional to those given in the $tcpO_2$ and $tcpCO_2$ channel data.

DC-Output ($tcpO_2$)

Range: 0 to 450 mmHg (0 to 60 kPa) = 0 to 4.5 V ± 50 mV

DC-Output ($tcpCO_2$)

Range: 0 to 150 mmHg (0 to 20 kPa) = 0 to 3 V ± 50 mV

Plethysmograph system outputs (78834C)

Wave Amplitude:	2.5 Vpp (at 50% display)
DC Output (HR) ... Range:	15 bpm to 300 bpm = 0.15 V to 3 V; OV for <15bpm
Accuracy:	± 5 bpm
Resolution:	1 bpm

Oxygen system output (78834C)

DC Output

Range: 0 to 100% = 0 to 3 V

Carbon Dioxide system output (78834C)

Wave Range: 0 to 60 mmHg (0 to 6 kPa) = 0 to 3.0 V
0 to 90 mmHg (0 to 9 kPa) = 0 to 4.5 V

Trend

General

One long trend (24, 8, 4, or 2 h) and one short trend (60 or 20 or 2 mins) available on ECG (heart rate, 2 min is beat to beat), respiration (wave and apnea events) and pressure (systolic, diastolic and mean). Points on trend curve are averaged (except respiration). Alarms are shown as actual values. Power off, INOP and Alarms off are indicated.

ECG Channel

Heart Rate Trend Range:	50 to 210 bpm
Resolution:	1 bpm
Display points per trend curve:	384 (468 for 2 min trend)

Pressure Channel

The systolic, diastolic and mean values are combined in one display.

Range:	dependent on selected pressure scale.
Resolution:	1.2 mmHg (0.16 kPa)
Display points per trend curve:	96 (117 for 2 min trend)

Each point contains one systolic, one diastolic and two mean values.

Respiration Channel

Length of apnea event(s) (in seconds) displayed as a vertical bar.

Maximum height of bar:	60 s to 360 s (dependent on selected trend time)
Resolution of bar:	1 s
Number of bars per display:	192

Wave (2 min trend only)

- Display points per trend curve: 468.

Dual Temperature Channel

T1 and T2 are displayed

ΔT trend is directly readable from the display

Range:	25°C to 42°C
Resolution:	0.1°C
Display points per trend curve:	337(T1) and 48(T2)

$tcpO_2$ and $tcpCO_2$ Channel

$tcpO_2$ trend

Range:	0 to 600 mmHg (0 to90kPa) dependent on selected scale
Maximum Resolution:	0.27 mmHg (0.04 kPa)
Display points per trend curve:	384

$tcpCO_2$ trend

Range:	0 to 240 mmHg (0 to 36 kPa) dependent on selected scale
Maximum Resolution:	0.27 mmHg (0.04 kPa)
Display points per trend curve:	384

Pleth Channel (78834C)

The pleth trend curve shows peak-to-peak amplitude of the wave.

Range:	0 to 1; 1 represents amplitude after autogain freeze.
Resolution:	2%
Display points per trend curve:	384

Oxygen Channel (78834C)

O_2 trend.

Range:	0 to 100%
Resolution:	1% volume of O_2
Display points per trend curve:	384

Carbon Dioxide Channel (78834C)

CO_2 end tidal value trend.

Range:	0 to 60 mmHg/9 kPa (selected scale 40 mmHg/6 kPa), or 0 to 90 mmHg/13.5 kPa (selected scale 60 mmHg/9 kPa).
Resolution:	1 mmHg/0.13 kPa.

SpO_2 Channel (78834C)

Range:	60% to 100%
Resolution:	2%
Display points per trend curve:	384

SpO_2 / Pleth (78834C)

SpO_2 is measured using a dual wavelength optical transducer. It measures pulse and SpO_2.

Range:	0% to 100% saturation
Numeric display:	Averaging period selectable 1/2/4/8/16 beats, with default 4.
Settling time:	< 5 s typical
Accuracy HP M1190A	
Transducer:	1SD 80% to 100% +/- 1.5% 65% to 80% +/- 2.5% 0% to 65% unspecified
Accuracy NELLCOR	
Transducers:	1SD 80% to 100% +/- 3.0%

Alarms

Lower Alarm range:	50-95%, step 1%, default = 90%
Upper Alarm range:	70-99%, OFF, step 1%, default = OFF
Alarm delay:	10 s
HR derived from Pleth	
Alarm Delay:	High Rate 10 s Low Rate 10 s

Pleth Amplifier

Bandwidth:	0.8 - 11.0 Hz +/- 25%
Settling time:	< 5 s

Cardiotach

Range:	30 - 300 bpm
Accuracy:	± 1%
Resolution:	1 bpm

Graticule lines

Lower line:	25% of wave channel
Upper line:	75% of wave channel

Autofix

50% of wave channel, peak values on Pleth graticule lines.
Gain frozen after 60 s approximately.

Test

SpO_2 test signal:	100%
Pleth test signal:	50% of wave channel, 100 bpm.

Pulse rate alarm limits

High and Low Ranges:	30 to 250 bpm.

Noninvasive Blood Pressure (NIBP)

General

Oscillometric method (with inflatable cuff) determines Mean arterial pressure (MAP), systolic and diastolic pressure.

Cuff pressure range:	0 to 280 mmHg (37 kPa), automatically released if pressure exceeds 315 ± 10 mmHg (42 ± 1.5 kPa).
Inflation time:	6 to 10 s (to 280 mmHg) typical using standard adult cuff.
Deflation time:	30 to 35 s typical
Cuff pressure accuracy:	better than ±3 mmHg (±0.4% kPa) for ambient temperature 15°C to 25°C
	better than ±3 mmHg (±0.6% of reading) for ambient temperature 10°C to 35°C,
	better than ±3 mmHg (+1.7% of reading) for ambient temperature 0°C to 55°C.

Add *rounding error* of ± 1/2 digit (= ±0.5 mmHg of ±0.05 kPa) to above accuracies.

Measurement Range:

Systolic:	30 to 130 mmHg (4 to 17 kPa)
Diastolic:	10 to 200 mmHg (1.3 to 13 kPa)
MAP:	20 to 120 mmHg (2.5 to 16 kPa)

Note Measurements are only possible in the heart range 40 to 300 bpm.

Modes

- Auto: measurements are automatically repeated with a time interval set by the user (2, 5, 10, 15, 30 and 60 min).
- Manual: a single measurement is taken.

- Statim: (If fitted) A series of ten measurement cycles are taken over a five minute period. Only one QRS complex causing a pressure oscillation in the cuff is sensed at each inflation level.

Alarms

High and low pressure.

Alarm Limit Adjustments:

- 5 mmHg (1kPa) steps
- 2 mmHg (0.5kPa steps for 10 to 30 mmHg (1.5 to 4kPa)

Fractional Inspired Oxygen (78834C)

Range:	10% to 110%
Resolution:	1%
Instrument Accuracy:	± 2.5% of full Scale (21% calibration) or ± 2.0% of full Scale (100% calibration).
Warm up time using 15203A transducer:	from standby, less than 1 min, unpolarized, less than 2 hours
Instrument back up time (internal battery):	greater than 4 days.

Alarms

Medical Alarms	
(audible and visual):	High O_2 alarm (limit selectable from 24 to 100%) Low O_2 alarm (limit selectable from 18 to 90%)
Alarm delay:	15 s
Technical Alarm (audible and visual):	Transducer disconnected Break in sensor cable.
Test Signal:	21% O_2

Carbon Dioxide (78834C)

General

Warm up Time:	30 min. (accuracy within 0.3 mmHg of its final value).
Stability:	±1 mmHg (over 7 day period).
Response Time:	< 125 ms (for step from 10% to 90%)

The following errors are due to O_2/N2O compensation and are additional to instrument accuracies given in the sections below.

I. Continuous measurement of O_2 (O_2 between 10% and 100%)

a. O_2 compensation: error in CO_2 reading less than ±1%.
b. N2O compensation (N2O is assumed to be 100% minus O_2%): error in CO_2 reading less than ±1%.

II. Standard compensation (O_2 parameter off)

a. O_2 compensation (45% O_2 assumed): error in CO_2 reading lessthan ±3%, for actual O_2 concentrations of 20% to 70%.
b. N2O compensation (if selected, 55% N2O assumed): error in CO_2 reading less than ±6%, for actual O_2 concentrations of 20% to 70% and actual N2O concentrations of 30% to 80%.

Instantaneous CO_2 Wave Display

Waveform displayed, with graticule lines, in channel 2 (height 32 mm) or over channels 2 and 3 (height 64 mm).

End Tidal CO_2 Numerical Display

Range:	1 to 150 mmHg (0 to 20 kPa)
Instrument accuracy:	±2 mmHg (0.29 kPa) ±1/2 LSD* (CO_2 = 0 to 40 mmHg (5.34 kPa), ±5.5% ±1/2 LSD (CO_2 = 40 mmHg (5.34 kPa) to 100 mmHg (13.3 kPa)). *LSD = Least Significant Digit.

Respiration Rate Numerical Display

Range:	0 to 150 rpm
Instrument Accuracy:	± 2 rpm

Alarms

Medical Alarms (audible and visual):	CO_2 WAVE Inspired Minimum Indicated when minimum value of CO_2 wave lies above 4 mmHg (0.53 kPa).
End Tidal CO_2:	1.High CO_2 Limit selectable from 20 to 100 mmHg (2 to 14 kPa) 2.Low CO_2 Limit selectable from 10 to 95 mmHg (1 to 13 kPa)
Alarm Delay:	15 s
Respiration Rate:	High respiration rate
Alarm delay:	10 s
Apnea alarm (no change in instananeous CO_2 value): Alarm delay:	selectable from 10 to 40 s.
Technical Alarms (audible and visual):	Transducer disconnected.
Test Signal:	0/40 mmHg (0/6 kPa) square wave at 25 rpm, 50% duty cycle.

Graticule Line Labelling and Resolution:.

Range (mmHg)	Graticule Line Labeling		Resolution (mmHg/cm)	
	Lower	Upper	32 mm scale	64 mm scale
0 to 60	0	40	20.8	10.4
0 to 90	0	60	31.2	15.6

Range (kPa)			Resolution (kPa/cm)	
	Lower	Upper	32 mm scale	64 mm scale
0 to 9	0	6	3.12	1.56
0 to 13.5	0	9	4.69	2.34

Technical Specifications - 78356A

This section contains the technical specifications for the 78356A gas monitor. The general instrument specifications are followed by those for the individual parameters.

General

Patient safety

- All inputs are CF-type.
- Option N01 meets safety requirements CSA(C22.2 No.125).
- Option NO2 meets safety requirements of IEC 601-1.
- Option NO4 meets safety requirements of UL 544.
- Defibrillator protection up to 5 kV.

Power requirements

Operating voltage:	115 V/230 V +10% -15% (IEC/USA) 115 V/230 V +10% -22% (Japan)
Frequency:	50/60 Hz,
Power consumption:	78356A - 95 W (max)

Environment

Operating temperature:	0°C to 55°C
Storage temperature:	-40°C to +75°C
Relative humidity:	5% to 95%
Size:	160 mm high, 320 mm wide, 405 mm deep
Weight:	11 kg (24 lbs)

Trends stored at power off condition for a minimum of 1 hour.

Display

Superaster video display:

Screen size:	140 mm x 105 mm; 178 mm diagonal
Sweep speed:	12.5 mm/s, 25 mm/s or 50 mm/s gives 8 s, 4 s or 2 s of display respectively. (For CO_2 capnogram, a speed of 6.25 mm/s is also available.)
Display mode:	fixed trace (moving bar).

Waveform display height:

```
Channel 1                30 mm ± 10%
    -----------------------------------
    Channel 2    normal
    Channel 3    mode         32 mm ± 10%
    -----------------------------------
    Channel 2    overlapping
    Channel 3    mode         64 mm ± 10%
```

Numeric update time:	2 s
Resolution:	256 dots vertical, 500 dots horizontal.

Inspired Oxygen

Range:	18% to 110%
Resolution:	1%
Instrument Accuracy:	+2.5% of full Scale (21% calibration) or +2.0% of full Scale (100% calibration).
Warm up time using 15203A transducer:	from standby, less than 1 min, unpolarized, less than 2 hours
Instrument back up time (internal battery):	greater than 4 days.
Medical Alarms (audible and visual):	High O_2 alarm (limit selectable from 24 to 100%) Low O_2 alarm (limit selectable from 18 to 90%)
Alarm delay:	15 s
Technical Alarm (audible and visual):	Transducer disconnected Break in sensor cable.
Test Signal:	21% O_2

Carbon Dioxide

General

Warm up Time:	15 min. (accuracy within 0.3 mmHg CO_2). +1 mmHg (over 7 day period). < 25 ms (for step from 10 to 90%)
Stability:	±1 mmHg (over 7 day period).
Response Time:	< 25 ms (for step from 10% to 90%)

The following errors are due to O_2/N2O compensation and are additional to instrument accuracies given in the sections below.

I. Continuous measurement of O_2 (O_2 between 10% and 100%)

a. O_2 compensation: error in CO_2 reading less than +1%.

b. N2O compensation (N2O is assumed to be 100% minus O_2%): error in CO_2 reading less than +1%.

II. Standard compensation (O_2 parameter off)

a. O_2 compensation (45% O_2 assumed): error in CO_2 reading less than +3%, for actual O_2 concentrations of 20% to 70%.
b. N2O compensation (if selected, 55% N2O assumed): error in CO_2 reading less than +6%, for actual O_2 concentrations of 20% to 70% and actual N2O concentrations of 30% to 80%.

Instantaneous CO_2 Wave Display

Waveform displayed, with graticule lines, in channel 2 (height 32 mm) or over channels 2 and 3 (height 64 mm).

End Tidal and Inspired Minimum CO_2 Numerical Display

Range:	1 to 150 mmHg (0 to 20 kPa)
Instrument accuracy:	+2 mmHg (0.27 kPa) for CO_2 values (CO_2 = 0 to 40 mmHg (5.34 kPa), < 40 mmHg (5.34 kPa), +5% for CO_2 values between 40 mmHg (5.34 kPa) and 100 mmHg (13.3 kPa).

Respiration Rate Numerical Display

Range:	0 to 150 rpm
Instrument Accuracy:	+2 rpm

Alarms

Medical Alarms (audible and visual):	CO_2 Inspired Minimum Indicated when minimum value of CO_2 wave lies above 4 mmHg (0.53 kPa).
End Tidal CO_2:	High CO_2 Limit selectable from 20 to 100 mmHg - (2 to 14 kPa) Low CO_2 Limit selectable from 10 to 95 mmHg (1 to 13 kPa)
Alarm Delay:	15 s
Respiration Rate:	High respiration rate
Alarm delay:	10 s
Apnea alarm:	(no change in instananeous CO_2 value)
Alarm delay:	selectable from 10 to 40 s.
Technical Alarms (audible and visual):	Transducer disconnected.
Test Signal:	0/40 mmHg (0/6 kPa) square wave at 25 rpm, 50% duty cycle.

Graticule Line Labeling and Resolution:

Range (mmHg)	Graticule Line Labeling	Resolution (mmHg/cm)

			Lower	Upper	32 mm scale	64 mm scale
0	to	60	0	40	20.8	10.4
0	to	90	0	60	31.2	15.6

Range (kPa)					Resolution (kPa/cm)	
			Lower	Upper	32 mm scale	64 mm scale
0	to	9	0	6	3.12	1.56
0	to	13.5	0	9	4.69	2.34

Trend

General

Long trend: 24, 8, 4, or 2h

Short trend: 60 or 20 mins

One long trend and one short trend are available on each parameter. Points on trend curve are averaged values.... Alarms are shown as actual values.... Power off, INOP and Alarms off are indicated.

Oxygen Channel

O_2 trend:

Range: 0 to 100%

Resolution: 1% volume of 02

Display points per trend curve: 384

Carbon Dioxide Channel

CO_2 end tidal value trend:

Range: 0 to 60 mmHg/9kPa (selected scale 40 mmHg/6kPa), or
0 to 90 mmHg/13.5kPa (selected scale 60 mmHg/9kPa)

Resolution: 1 mmHg/0.13 kPa

Display points per trend curve: 384

System Interface

General (Opt. J11 only)

Auxiliary signals and parameters:

Internal processing accuracy: ± 50 mV

Selectable channels for external recorder:

Internal processing accuracy: ±50 mV

Delay mode: 12 s delay time

Parameters off condition: -1 V

Instantaneous CO_2

Range:	0-90 mmHg (0-9 kPa) 0-4 V
Test:	square wave with 0 and 40 mmHg, 30 bpm

End Tidal CO_2

Range:	0-150 mmHg (0-15 kPa) 0-3 V
Test:	40mmHg

Respiration Rate

Range:	0-150 rpm, 0-3 V
Test:	30 rpm

O_2

Range:	0-100%, 0-3 V
Test:	100% O_2

A

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