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On the first page of each chapter a table of contents for that chapter is provided.

This is a Service Manual for the Accutorr Plus monitor. **There are no Operating Instructions in this manual. Complete operating instructions and listing of available accessories are published in the Accutorr Plus Operating Instructions, P/N 0070-00-0428-02 (English) and P/N 070-00-0434 (5 Languages).**

Foreword.

This Service Manual (P/N 0070-00-0543) is intended as a guide, for technically qualified personnel, to use during repair and calibration procedures for the Accutorr Plus (part number 0998-00-0444-XX).

Notes and Precautions

NOTES are a general information statement concerning the Accutorr Plus.

A **CAUTION** is provided to alert the user to use special care necessary for the safe and effective use of the device. They may include actions to be taken to avoid effects on patients or users that may not be potentially life threatening or result in serious injury, but about which the user should be aware. Cautions are also provided to alert the user to adverse effects on this device of use or misuse and the care necessary to avoid such effects.

Please read and adhere to all notes and precautions listed here and in the appropriate areas throughout this manual.

Notes

- NOTE:** See the serial and product number label on the rear panel of the unit for part number identification. This manual also includes information on the optional Recorder and Predictive Temperature Modules and Infrared Temperature module.
- NOTE:** This manual does not provide operating instructions. Consult the Operating Instructions Manual for proper operation of this monitor.
- NOTE:** Unauthorized servicing may void the remainder of the warranty. Check with the factory or with a local authorized representative to determine the warranty status of a particular instrument.
- NOTE:** Do not change Room Number and /or Bed Letter on the Accutorr Plus during the transmission of temperature data.
- NOTE:** The AccuTemp thermometer should be at room temperature when it is used. If it has been in a very warm or very cold environment it may need time for the thermometer temperature to equalize to ambient temperature.
- NOTE:** Special care should be taken to insure that the front panel and glare screen are not scratched.
- NOTE:** New batteries are shipped in a discharged state for safety reasons. A new battery must be charged for 2 hours for Li-Ion or 8 hours for Sealed Lead Acid Battery before first use. The monitor may be used with AC mains power during the charge cycle but battery operation could be limited during this time.
- NOTE:** Never re-install an AC receptacle forcibly removed. The plastic locking tabs of the receptacle will be damaged, and if re-installed the receptacle may pull out in normal use.
- NOTE:** The connectors may be reversed or interchanged without affecting final function.
- NOTE:** Mindray DS USA, Inc. maintains a policy of continuous development for product improvement and reserves the right to change materials, specifications, and prices without notice.
- NOTE:** When replacing a Keyboard, you must replace the Graphic Panel.
- NOTE:** Monitors with Nellcor® and Masimo® SpO₂ do not report SpO₂ Runtime and Boot Software Versions.

NOTE: **The Accutorr Plus always displays time in a 24 hour format.**

Precautions

CAUTION: Li-Ion batteries are intended for replacement by qualified service personnel only.

CAUTION: Li-Ion batteries used in this device may present a risk of fire or chemical burn if mistreated. Do not disassemble, heat above 100°C (212°F), or incinerate. Replace battery with P/N: 0146-00-0069 only. Use of another battery may present a risk of fire or explosion.

CAUTION: Dispose of used battery promptly. Keep away from children. Do not disassemble and do not dispose of in fire.

CAUTION: This instrument utilizes multiple layer circuit boards and laser and ultra sonic welded surface mounted components. Do not attempt to unsolder welded components from the circuit board; the circuit board will be permanently damaged.

CAUTION: Soldering and solder removal equipment must be low voltage operated and grounded to avoid static charge and stray current induced component damage. Maximum wattage: 25 W.

CAUTION: The Inside Of This Instrument Contains Static Sensitive Components. Use correct static protection safeguards.

This publication may have been updated to reflect product design changes and/or manual improvements. Any such changes to this manual would be accomplished by supplying replacement pages and instructions for inserting or affixing them into the manual.

Theory of Operation

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This section of the manual explains the basic architecture of the Accutorr Plus. It is an overview, not a detailed circuit analysis. It is intended to be a tool, that if used properly, will lead to an understanding of the functions executed by a major functional block, and thus enabling a logical isolation and resolution of malfunctions.

The Accutorr Plus is offered in many functional configurations, including the options licensed and manufactured by third parties. The third party circuits will be treated solely as “black box” devices, with only the relevant input, output and power sources described.

The Theory of Operation section describes only the highest configuration level. Units built with fewer or different options may not use all of the capabilities of the Accutorr Plus, yet the over-all theories will remain constant.

1.1 Major Functional Blocks of the Accutorr Plus

- CPU/NIBP Module Assembly with LCD Display
- SpO₂ Processor Board
- Communication Board
- Main Power Supply and Battery Charger Assembly
- LED/Tone Module Assembly

1.2 CPU/NIBP Module Assembly with LCD Display

The Accutorr Plus CPU/NIBP module controls the functions of the NIBP, receives input data from the keypad, temperature probes and SpO₂ module, transmits output data to the recorder, interface connection for a serial I/O port for PC communication.

In addition, the CPU/NIBP module distributes the power from the power supply, which includes power and control signals to the LED/Tone module. Thru this board the power will be distributed to the rest of the system, for example, the Recorder and the SpO₂ modules. Also, the CPU/NIBP module supplies separate power to the LCD back light converter to be used on the Accutorr Plus.

The CPU/NIBP circuit board is comprised of both software and hardware. The following is a summary of the software control exercised and the major hardware affected. This is for informational purposes only, and both software and hardware controls maybe changed at any time without notice.

1.2.1 Software Overview

The software performs the following functions:

1. Initializes hardware and software modules
 - Micro controller ports and communications (serial) interfaces
 - Software entry points and variables
 - Read configuration from NVRAM
2. Performs power up diagnostic
 - Micro controller, FLASH, and STATIC RAM test
3. Perform NIBP functions
 - Start measurement
 - Repeat measurement
 - Over pressure limit
 - Enter or exit test mode
 - Abort measurement
 - Enter or exit calibration mode
 - Update alarm limits
 - Report alarm status
 - Report data
 - Determine inflation pressure
 - Perform controlled cuff deflation
 - Monitor DC and AC pressure and acquire pulsations
 - Reject artifacts
 - Decide on termination point and exhaust cuff pressure
 - Smooth pulsation data
 - Determine systolic, mean, diastolic pressure and heart rate
 - Check alarm conditions

4. Transmits/Receives data to/from Infrared/Predictive Temperature modules
5. Manages Recorder functions
6. Manages Keypad interface
7. Provides RS232 communications to PC for software download
8. Support Service Diagnostics
9. Error condition check
 - Maintain watchdog timer
 - Run-time diagnostic
10. Transmits/Receives data to/from SpO₂ module, if present
11. LCD backlight control

1.2.2 CPU Hardware Controls

1. Microcontroller executes the above functions including:
 - NIBP
 - Recorder
 - Temperature module, PTM or IR
 - SpO₂
 - LCD
2. Battery Back Up Circuitry for Power Savings
 - Static memory
 - Non-volatile RAM for configuration and future serial number
3. Flash ROM for Program Storage and Execution
4. Static RAM for Data Storage
5. RS232 level translation for PC Download and second interface for CIS/HIS
6. Real time clock with 16K of Lithium backed up NV RAM

1.2.3 NIBP Hardware functions

1.2.3.1 Main pressure transducer circuitry

A pressure transducer and amplifier combination is provided to acquire the cuff pressure signal.

1.2.3.2 Over pressure transducer circuitry

An over pressure transducer, independent of the main pressure transducer. Over pressure limits are set according to the patient size.

1.2.3.3 Five A/D channels

All channels are at 12 bit resolution and digitized at 101 Hz:

1. DC pressure
2. AC pressure (pulse)
3. Hardware over pressure transducer
4. Hardware over pressure cooperater reference
5. Battery voltage monitoring, when the Accutorr is in battery operation

1.2.3.4 Pulse Channel Filter

A high-pass filter is provided to isolate the pulsatile component from the DC cuff pressure. This pulsatile component is digitized as the pulse channel. The gain of this AC coupled channel is programmable in a manner consistent with the specified range of pulse amplitudes.

1.2.3.5 Inflation Pump

A pump capable of inflating the cuff within the specified time limit.

1.2.3.6 Bleed Valve

A valve and control system capable of bleeding down the cuff pressure.

1.2.3.7 Dump Valve

A valve to rapidly discharge the residual cuff pressure at the end of the measurement cycle.

1.2.3.8 Cuff Inflation Requirements

The cuff is initially inflated to a software-determined pressure dependent upon patient size. In timer mode, it should be a predetermined increment, traditionally 50 mmHg (40 mmHg for Neonates) (determined by the CPU), above the previous systolic reading, after the first measurement. The software detects error conditions in the pneumatic system such as disconnected cuffs or kinked hoses. To reduce the possibility of over inflating the cuff, the pump may be driven at a lower speed when pressurizing small neonatal cuffs. This is achieved by pulse width modulating the pump control signal. Further control of the neonatal inflation rate may be achieved by using the bleed valve to relieve some portion of the pump's delivery.

1.2.3.9 Pulse Acquisition Requirements

Pulse amplitudes from 0.06 mmHg to 12 mmHg are recognized. Pulse rates can range from 30 bpm to 250 bpm. The software discriminates pulses from the digitized pulse channel signal, and characterizes the pulses for amplitude, DC pressure, and pulse period. False triggering, due to the diacritic notch or noise is minimized.

1.2.3.10 Artifact Rejection Requirements

The software provides means of artifact rejection, both during acquisition and during subsequent processing of the pulse array. Means of rejecting artifacts include attention to the timing and amplitude of pulses relative to adjacent pulses. If motion artifact is detected during acquisition, the software may cause temporary suspension of the bleed down process until a quiescent patient condition returns.

1.2.3.11 Parameter determination Requirements

Pulses which are deemed acceptable after artifact processing are entered in the pulse array. Heart rate is taken to be the average rate of the pulse array data. Pulse periods differing excessively from the median are ignored. Pulses which do not appear to fit the amplitude envelope are removed. The systolic, diastolic, and mean pressures are then calculated in accordance with company standard algorithms. A fair amount of data manipulation and computation is required in the parameter determination. The results are reported no more than one second from the termination of the pulse acquisition phase.

1.2.4 Major Hardware Components

1.2.4.1 CPU

A microcontroller (min. 16Mhz) with three (3) serial communications controllers (SCC), a serial communication port (SCP), programmable chip select lines (to minimize glue logic), a IDMA controller, and parallel I/O ports for discrete signals.

1.2.4.2 Flash Memory

512K x 16 Flash Rom used for program storage and execution. A Flash Rom is used also for downloading new revisions of software via the CPU's serial I/O lines (SCC).

1.2.4.3 Battery Backed Up Static RAM

512K x 16 static ram is used for data storage, trend information, etc. This memory is used for data storage, therefore, a battery back up is provided.

1.2.4.4 Nonvolatile RAM

2K x 8 nonvolatile ram is used for configuration and serial number information. This memory requires a battery back up.

1.2.4.5 Micromanager

This device provides a number of features which are useful for management of this board. They are listed as follows:

- A. On/Off capability through keyboard control
- B. Watchdog timer
- C. Conversion of CMOS SRAM to pseudo nonvolatile memory

1.2.4.6 Battery Backup Voltage Regulator Circuitry

Implements regulation of the STANDBY VOLTAGE from the main power supply to 4V +/- 0.2V dc with a current draw of 821 uA max.

1.2.4.7 Real Time Clock

This device provide seconds, minutes, hours, date of the month, month, and year with leap year compensation. The device is memory mapped to be pointed to as software requires. Also, provisions for running this device include main power supply and battery operation, in order for the RTC to keep time when system is not powered up. A lithium battery is included, with a minimum of 10 years of operation, for configuration and clock data retention during battery changes and main battery failure. Accuracy is +/-2 minutes/month

1.2.4.8 Recorder Interface

IDMA capability for writing 8 bit buffered parallel data to the recorder. Handshaking signals to specify new line to be printed, request for next byte of data.

1.2.4.9 Communication Module

The module provides the following interfaces and functions:

- RS-232E or RS-485 drive from TTL levels. RS-232E driver for CIS/HIS that will provide minimum of 9V signal level.
- IC based DC/DC converter capable of converting VCC to 12VDC, with leakage current when off < 100uA. High frequency operation to limit emitted fields. Capable of providing an output current of 125 mA @ 12Vdc, with an efficiency of 80% or higher.
- Logic control the DC/DC converter that is used for the RS-485 interface drive voltage.
- Connection for the download three wire RS-485 interface.
- Signal driver for an external isolated relay that will be used for Nurse Call (future function), provided on pins of the 9 pin RS-232 connector.

1.2.4.10 LCD Display

DAC control provided from the LED/Tone Board controls the LCD View Angle.

1.2.4.11 EL Power Module

The power module generates the required AC power signal for the EL Panel LCD backlight using the system +12V DC (12.5V nominal). A means to allow the host the option of disabling the power source is also required to increase battery life.

1.2.4.12 Temperature Interface

The board provides a Serial Interface to either Temperature module.

1.2.4.13 SpO₂ Interface

The board provides a Serial Interface to SPO₂ and reset control of the module.

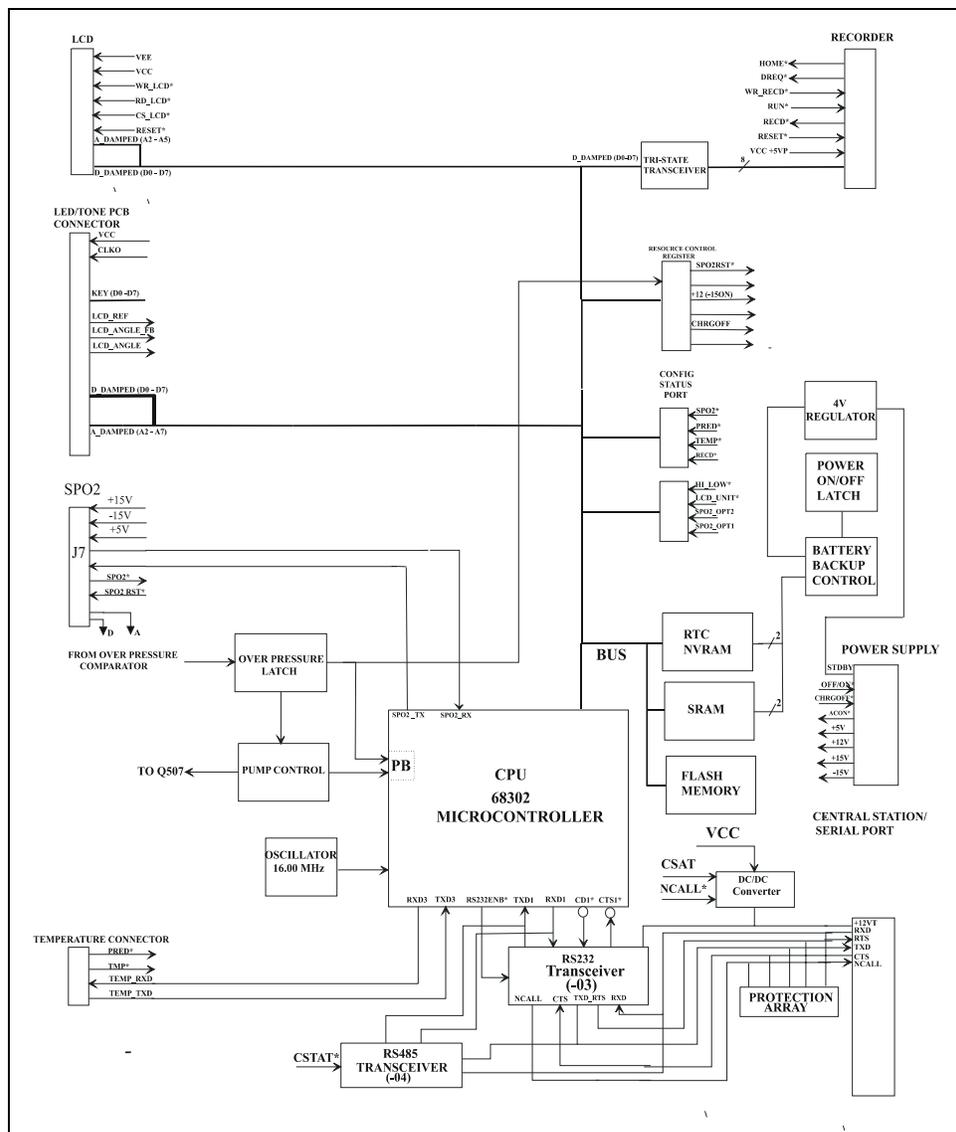


FIGURE 1-1 CPU/NIBP Board Functional Diagram

1.3 SpO₂ Processor Circuit Boards

There are three distinct technologies offered as options. *The option is selected at the time of manufacture and it is fixed for the life of the product.*

The selected technology uses proprietary sensors and interface cables. There are no “adapters” possible or available.

The available selections are:

- Nellcor SpO₂ system
- Masimo® SpO₂ system.

1.3.1 SpO₂ General Theory Of Operation

Regardless of manufacturer, SpO₂ determination is based on the relative attenuation of a red and an infra red light source. A sensor from the instrument contains two sets of LED's to illuminate a portion of the body (e.g. fingertip) and a single photo sensor detects the light returned. The LED's are alternately pulsed, red and infra red. Since hemoglobin is the carrier of oxygen in the blood and, the relative attenuation of the light sources is proportional to the amount of oxygen carried by the hemoglobin, a relative level of saturated hemoglobin can be determined. Since we are measuring the ratio of red and infra red return from the circulatory system, the detection method is substantially independent of skin color or total skin attenuation. Since the blood flow has a pulsatile characteristic, a pulse rate can also be computed from this information

NOTE: **There is no calibration possible for the determination of the SpO₂% or of the pulse rate derived. As mentioned above, we are measuring a ratio of intensity of two light sources to determine the % of saturated hemoglobin. The determination is based on proprietary software interpretation of the reflected light ratios, and it is validated against strict clinical trials where fresh arterial blood is examined with a clinical blood gas analyzer. Once the software is finalized, the SpO₂ monitor accuracy is fixed and there are no possible adjustments.**

NOTE: **The wavelengths of the light emitted are nominally 660nm and 890nm with the energy not exceeding 15mV.**

1.3.2 Nellcor MP 304 SpO₂ Circuit Board Theory of Operation

The MP 304 is a complete SpO₂ detection and determination circuit, proprietary of Nellcor® Puritan Bennett. The MP 304 is centralized around a Motorola MC68HC16 micro processor (U-4), driven by a 32.76 KHz. Oscillator. (Y-2) The processor is supported by a 32K x 8 static RAM (U-3) and a SpO₂ program boot EPROM (U-6).

Patient information is initially processed in a patented ASIC (U-1) (Application Specific Integrated Circuit). Clock pulses are provided by Y-1, a 10 MHZ oscillator. The resulting analog data is then routed into separate Red and Infra Red ADC's (Analog to Digital Converters) (U-5 and U-7) The resulting digital data is clocked into the microprocessor and is transmitted serially to the Nellcor® Interface Board (P/N 0670-00-0675) for further processing and display.

1.3.3 Nellcor Interface Board Theory of Operation

The Nellcor® interface circuit board establishes bi lateral communication and control of the Nellcor® Oximeter circuit board. The circuit board consists of a power supply section that converts +5 VDC into the logic and analog supplies required by the oximeter, and optically isolated logic control for the processing circuits of the oximeter. The optically isolated up converter U1 convert the +5 VDC from the main power supply, into an input voltage for U6, of about 5 VDC. The precision down converter, U6, steps down and regulates the +5 VDC voltage for the digital sections of the oximeter circuit. The optically isolated up converter U2 convert the +5 VDC to a bi polar +9 and -9 VDC input for U4 and U5, then regulated to +5 and -5 VDC. The logic control section, consisting of U1, U2 and U3, provide the buffer and isolation from the main CPU circuit to the Nellcor® oximeter section.

1.3.4 Nellcor MP506 SpO₂ Circuit Board Theory of Operation

The MP506 is a complete SpO₂ detection and determination circuit, proprietary of Nellcor® Puritan Bennett. The MP506 is comprised of an ATMEL AT91R40807 micro processor (U22), driven by a 32 Mhz oscillator (Y-2). The processor is supported by on-board RAM and external Flash Program Memory (U24). Patient information is initially processed under the control of a PIC micro controller (U17). The resulting data is then routed into separate red and infra red demodulation circuits. Patient data is then processed for serial transmission to the host system.

1.3.5 Nellcor MP506 Interface Board Theory of Operation

The Nellcor® MP506 interface circuit board (0670-00-0740) establishes bilateral communication and control of the Nellcor® MP506 Oximeter circuit board. The circuit board consists of a power supply section that converts the system +5 VDC into the logic and analog supplies required by the oximeter, and optically isolated logic control for the processing circuits of the oximeter. A 5V to 10V DC/DC converter (T1) and two voltage regulators (U4 and U5) generate the required digital (+5VD) and analog (+5VA) voltages. Regulator U4 also provides optocoupler U1 and protection array U6 with power. The logic control section, consisting of U1, U2 and U3, provide the buffer and isolation from the main CPU circuit to the Nellcor® MP506 oximeter section.

1.3.6 Masimo SET Technology®

Masimo SET® Technology, combines advances in fundamental sensor technology, digital signal processing, an easily portable platform and a low noise hardware platform incorporating multiple wavelengths applicable to many physiological parameters. Masimo SET® Technology is composed of three components; (1) new signal processing apparatus, (2) a new method for invivo measurement, and (3) new sensor technologies. The main benefit of Masimo® technology is the effective cancellation of unpredictable “in-band noise” (noise which is in the same frequency, phase and/or amplitude space as the desired signal). Conventional fixed filters, whether analog or digital form, have been designed to pass certain frequencies while rejecting others.

For example, a bandpass filter with a lower cut-off frequency of 1hz and an upper cut-off frequency of 10Hz will pass all frequencies between 1hz and 10Hz and reject frequencies below 1hz and above 10Hz. Therefore, any “noise” that has a frequency outside the pass band is rejected and not considered (i.e. 120Hz due to room light and 60Hz noise from electrical lines).

However, if noise exists between the pass band of 1hz and 10Hz it will enter the system with the desired signal and corrupt the measurement (i.e. patient motion at 2Hz). Fixed filters will always have this limitation. Masimo® has overcome these problems by developing a novel technique to accurately determine the noise reference (patents issued and pending); thus, making adaptive filters work in real-time even when applied to medical monitoring of widely variable and unpredictable patients. With this new technique, Masimo® is able to solve the perennial problem of motion artifact in pulse oximetry. Further technical information is available from Masimo® on the Internet at www.Masimo.com.

1.3.7 Masimo® Interface Board Theory of Operation

The Accutorr Plus Masimo® interface board (P/N: 0670-00-0716) provides an isolated data and power interface between the Accutorr Plus and the Masimo® MP-3 Pulse Oximetry Module. The patient isolation requirement for the Masimo® section is 1500VAC, less than or equal to 1mA leakage current, from input connectors J1 and J4-all terminals to J2-all terminals.

The isolated DC/DC converter, T1, supplies the regulated +5DIG as required by the Masimo® MS-3 Pulse Oximetry Module. The digital 5V is then utilized to generate the analog 15V used by the MS-3. The optocouplers (U1 and U2) isolate the signals used for bidirectional serial communication with the Masimo® MS-3 Pulse Oximetry Module. Control signal, SpO₂ COMM at J4 will allow the Accutorr Plus software to interrupt the serial transmission for future options. All data and control lines interfaced to the SpO₂ Module are opto isolated. Power to the SpO₂ Module is isolated by a DC/DC converter with the input coming directly from the CPU/LED Module.

1.4 Communications Board

The RS-232E interface required is implemented using a Maxim, MAX239 Multi-Channel Transceiver (U602). This chip was chosen because it has a minimum ± 9 volt output signal level. Communications is to support a 5 wire interface, 4 signals and a ground. The signals are described below:

SIGNAL	DESCRIPTION	INPUT/OUTPUT
RXD	Received Data from DCE to DTE device	Input
TXD	Transmitted Data from DTE to DCE device	Output
RTS	Request to send from DTE to DCE device	Output
CTS	Clear to Send from DCE device	Input
GND	Signal Ground	Input

All RS-232 signals are ESD protected by a U603, an SM14M24C Transient Voltage Suppressor array. The +12 Vt dc power required by the MAX239 is supplied from the onboard DC/DC converter. In addition the MAX239 requires 12 Vdc for the onboard DC/DC converter which makes -12 Vdc. This is supplied as an input to the communications module. The MAX 239 receivers are controlled by logic signal CSTAT*. Logic 0 enables the receivers, otherwise they are tristated.

The RS-232 signals appear on connector J603, a dual row 14 pin header which will have a mating 14 pin pendant ribbon cable attached. The other end of the ribbon cable assembly is a 9 pin panel mount 'D' connector.

1.4.1 LCD Inverter Power Supply

This describes the circuit that will provide the 90 VAC required for the LCD Module back lite excitation.

1.4.2 DC to AC Inverter

The inverter is powered by +12SW from the main power supply board. Once powered, the inverter is designed to provide the AC waveform required by the backlight. The output AC wave-form is 90 Vrms minimum voltage. The AC frequency is to be between 360Hz and 440Hz. C1 and C2 provide filtering of the inverter DC input.

1.4.3 Current Switch

The Q1 gate is connected to ELOFF*. This control signal is pulled low by R1 which maintains Q1 in the off state if it is floating. Since Q1 passes the inverter return current to the ground signal PGND on J651, Q1 must be on to enable the inverter. The host can turn on Q1 and enable the T1 inverter by driving ELOFF* high. D1 filters switching transients on +12SW when Q1 is turned on and off. Output connection of 90 VAC is at J-651 on the CPU / NIBP control board.

1.4.4 Power Supply Module

A $\pm 15\text{V}$ DC/DC Converter is used to supply power to the NIBP section. This module is powered by +5V. The Power Supply assembly is considered a “black box” item. There are no parts supplied except the AC and DC fuses.

1.4.5 Power Requirements

VOLTAGE	TOLERANCE	MAXIMUM CURRENT
+5 volts	$\pm 2\%$	1.5 amps
+12.5 volts	$\pm 5\%$	0.5 amps
Standby	8.1V to 17.5V	17mA

1.5 Main Power Supply

There are two distinct power supplies used in the Accutorr Plus. They are not interchangeable.

- Our part number 0014-00-0184 is configured for the use and charge of a sealed Lead Acid battery.

The battery charge profile is unique for this application.

- Our part number 0014-00-0225 is configured for the use and charge of a Lithium Ion battery.

The following theory of operation applies to both versions, with the obvious exception of the battery charging system.

1.5.1 Description

The power supply can operate off the AC power line or an on-board battery. The circuit selects automatically the best power source, with AC power being the default. The circuit will operate in the AC power mode and charge the battery at the same time. It is also able to operate the Accutorr Plus if there is no battery installed or the battery maybe fully discharged or shorted. The battery charging profiles are determined by a dedicated charge control integrated circuit.

This power supply is configured around three basic blocks. The first block is an AC to DC converter, consisting of an universal AC input switching regulator and a battery charger. The second block consist of a DC to DC converter, with a single + 5 VDC output. A second DC to DC converter supplies + 12.5, + 15 and - 15 VDC. Power to all the DC to DC converters is “OR”-ed from the battery or the AC to DC converter. When AC power is available, power to the DC to DC converters is always supplied from the AC to DC converter. In the absence of AC power, the on board battery is the primary power source.

The power supply also monitors the battery voltage. In the charge mode, a four stage charger detects battery condition and establishes the charge mode. Since the charging modes are substantially different for Sealed Lead Acid and Lithium Ion technologies, the following will list the charging stages:

1.5.2 Sealed Lead Acid battery

State 0:	trickle charge current under 50 ma. to bring the battery to chargeable level.
State 1:	bulk charge current of approx. 530 ma. Switches to State 2 at a battery voltage of 13.97 V.
State 2:	over charge voltage, 14.7 V. Switches to State 3 at a charge current of approx. 53 ma.
State 3:	float voltage state, maximum of 13.65 V
Typical charge time:	8 hours

NOTE: **No conclusions should be drawn from any no load voltage readings or from voltages of the battery during the charge cycles.**

1.5.3 Lithium Ion Battery

- Battery charge condition check: checks battery condition and temperature.
- Conditioning charge: charger pulses every second if voltage is under 5.8 V
- Fast charge: enabled if battery voltage is over 11.7 V, dual mode;
- Constant current: approx. 2 Amp. Up to 12.6 V
- Constant voltage: 12.6 V until termination of charge
- Charge termination: when charging current falls under 280 ma. or maximum time out of 2 hours.
- Typical charge time: 2 hours

1.6 LED and Tone Module

The Accutorr Plus LED/Tone Module performs three main tasks. 1) It drives all the 7-segments and discrete LED user displays on the keypad, 2) it generates an EN475 compliant alarm signal via the onboard Digital-to-Analog-Converter (DAC) and drives advisory tones to the speaker by the onboard power amplifier, and 3) it controls the interface between the main CPU and the keypad. The functionality on the module is accomplished by the use of a Field Programmable Gate Array (FPGA) device.

The LED / Tone Module is under direct control of the CPU / NIBP module for inputs, and converts the input data into LED segment drive as well as the audio tones for advisory and alarm conditions.

1.6.1 Keypad Control

Circuitry for scanning the keypad for key presses. The board scans a 3x8 matrix of keys. In the case of simultaneous key presses, a key is recognized by the software. The other key will not be recognized, until the initial key is released.

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2.1 Performance Specifications

Systolic Pressure Readout

Number of Digits:	3
Accuracy*:	Mean error less than ± 5 mmHg, Standard deviation less than ± 8 mmHg.
Range:	Adult Mode: 55 to 260 mmHg Pediatric Mode: 55 to 160 mmHg Neonatal Mode: 45 to 120 mmHg

* *Tested per ANSI/AAMI SP10-1992 methods.*

2.1.1 NIBP Measurement Cycle Time

Less than 30 seconds average at 80 BPM with 180 mmHg pump up pressure, without retries, motion artifact or arrhythmia with standard adult cuff on a healthy individual. Cycle time is affected by arm size and wrapping technique.

2.1.1.1 Pulse Rate

Range:	35-245 BPM for Adult and Pediatric 70-245 BPM for Neonate
Display Resolution:	1 BPM
Accuracy:	± 3 BPM or $\pm 3\%$, whichever is greater

2.1.2 Maximum Cuff Pressure

Two means of limiting cuff pressure are provided; a hardware over pressure monitor which limits the pressure to 330 mmHg for Adults, 220 mmHg for Pediatrics and 165mmHg for Neonates. A software overpressure monitor which vents if the pressure exceeds 300 mmHg for Adults and 200 mmHg for Pediatrics and 157 for Neonates. If the hardware over pressure circuit is tripped in normal operation then the unit must be turned off and back on to reset the system.

2.1.3 Inflation Source

This inflation source is capable of supplying sufficient air to bring a volume of 700 cc's to a pressure of 300 mmHg in no more than 35 seconds. If the cuff is not inflated to the desired pressure within 60 seconds then the cuff is vented and a retry cycle is initiated.

2.1.4 Leak Rate

With the bleed valve closed, the maximum pressure drop is 10 mmHg in 90 seconds measured with a 700 cc volume at a differential pressure of 250 mmHg.

2.1.5 Cuff Vent Rate

When the unit is vented, a volume of at least 700 cc's is reduced from a pressure of 250 mmHg to a pressure of 20 mmHg in a maximum of 14 seconds.

2.1.6 Temperature (Predictive)

Range:	90-110°F, 32-43°C
Display Resolution:	0.1°F, 0.1°C
Accuracy:	Meets ASTM E1112-86 for accuracy.

2.1.7 Nellcor® SpO₂

Range:	40-100% SpO ₂
Display Resolution:	1% SpO ₂
Display Update:	Less than 4 seconds
Calibration:	Automatic
Accuracy - Nellcor®:	± 2 digits from 70 - 100% SpO ₂ - Adult 3 digits from 70 - 100% SpO ₂ - Neonates unspecified from 40-69% SpO ₂
Pulse Rate Range:	21 to 249 BPM
Pulse Rate Accuracy:	±3 BPM.

Neonatal accuracy specifications are based upon testing the N-3000 and N-25 neonatal sensors on healthy adult volunteers in induced hypoxia studies, in the range of 70-100% SpO₂. The specified accuracy also takes into account published literature which predicts that there may be a small difference in% SpO₂ reported by the oximeter when measurements from adult and fetal blood with 100% fetal hemoglobin are compared. Fetal hemoglobin is present in concentrations varying from 10% to 90% in neonatal blood, and this percentage declines over time. As the percentage of fetal hemoglobin in neonatal blood declines, the theoretical effect on accuracy due to this source is reduced.

2.1.8 Masimo® SpO₂

Range:	40-100% SpO ₂
Display Resolution:	1% SpO ₂
Display Update:	Less than 4 seconds
Calibration:	Automatic
SpO ₂ Accuracy Saturation during No Motion Conditions ¹ :	
Adults:	70% to 100% ± 2 digits ³
Neonates:	70% to 100% ± 3 digits 40 to 69% SpO ₂ unspecified.
SpO ₂ Accuracy Saturation during Motion Conditions ² :	
Adults:	70% to 100% ±3 digits
Neonates:	70% to 100% ± 4 digits
Pulse Rate Range:	26 to 239 BPM
Pulse Rate Accuracy:	±3 BPM

¹The Masimo® MS-3 pulse oximeter with LNOP®•Adt sensors have been validated for no motion accuracy in human blood studies on healthy adult volunteers in induced hypoxia studies in the range of 70% to 100% SpO₂ against a laboratory co-oximeter and ECG monitor. This variation equals plus or minus one standard deviation. Plus or minus one standard deviation encompasses 68% of the population.

²The Masimo® MS-3 pulse oximeter with LNOP®•Adt sensors has been validated for motion accuracy in human blood studies on healthy adult volunteers in induced hypoxia studies while performing rubbing and tapping motions at 2 to 4 Hz. At an amplitude of 1 to 2 cm and non-repetitive motion between 1 to 5 Hz. At an amplitude of 2 to 3 cm in induced hypoxia studies in the range of 70% to 100% SpO₂ against a laboratory co-oximeter and ECG monitor. This variation equals plus or minus one standard deviation. Plus or minus one standard deviation encompasses 68% of the population.

³The SPO₂ accuracy during motion conditions is not specified for the LNOP Ear Sensors. The LNOP Ear Sensors have an SPO₂ accuracy of 70% to 100% ± 3.5% for adults during no motion conditions, however since the monitor cannot display 1/2 digits, the accuracy shall be rounded to ± 4 digits.

2.1.9 Battery

BATTERY TYPE	SEALED LEAD ACID	LITHIUM-ION
Number of Batteries:	1	1
Battery Voltage:	12 VDC nominal	11.1 VDC nominal
Battery Capacity:	2.3 Amp-Hour	3.6 Amp-Hour
Battery Run Times from full charge with a new battery at 25° C with 1 NIBP measurement every 5 minutes and recorder in use.	Accutorr Plus NIBP - 5 Hour Accutorr Plus NIBP with Trend Screen - 3 Hours Accutorr Plus NIBP with Trend Screen and SpO ₂ : Nellcor - 2 Hours Masimo® - 2 Hours	Accutorr Plus NIBP - 8 Hours Accutorr Plus NIBP with Trend Screen: - 8 Hours Accutorr Plus NIBP with Trend Screen and SpO ₂ : Nellcor - 4.5 Hours Masimo® - 4.5 Hours
Recharge Time:	8 hours max., in standby only	2 hours max., in standby only
Cyclic Service Life:	150 cycles, 100% to 20% of capacity 400 cycles, 100% to 40% of capacity	500 cycles, 100% to 30% of capacity 1000 cycles, 100% to 50% of capacity

2.1.10 Real Time Clock

RESOLUTION: 1 MINUTE

Accuracy: ± 1 minute/week

Display Format: 24 hours

Power: The real time clock maintains the time and date when the instrument is On or in the Standby mode, connected to AC mains or running from internal battery for at least ten years from original assembly. The real time clock will maintain time and date even if the instrument's main battery is disconnected.

2.2 Safety Characteristics

2.2.1 Risk (Leakage) Currents

Enclosure Risk Current (leakage): Less than or equal to 100 μ A in normal operating conditions.
Less than or equal to 300 μ A in any single fault condition.

Patient Source Current: Less than or equal to 10 μ A in normal operating conditions.
Less than or equal to 50 μ A in any single fault condition.

Patient Sink Current: Less than or equal to 50 μ A.

2.2.2 Dielectric Withstand

2500V RMS at 50 or 60 Hz for 1 minute from any patient lead or combination of patient leads to the chassis.

1500V RMS at 50 or 60 Hz for 1 minute AC mains hot or neutral to the chassis.

2.2.3 Ground Resistance

Ground resistance less than or equal to 0.1 ohm from the AC mains power inlet module's ground contact pin to any exposed metal part which may become energized when measured per UL-544 and IEC 601-1. A ground resistance of up to 0.2 ohm is allowed when measured from the U blade of the supplied AC line cord to any exposed metal part which may become energized.

2.2.4 Type of Protection Against Electric Shock

Class 1 with internal electric power source. Where the integrity of the external protective earth (ground) in the installation or its conductors is in doubt, the equipment is operated from its internal electric power source.

2.2.5 Degree of Protection Against Electric Shock

Monitor – Type B applied part.

NIBP – Type BF defibrillation protected applied part.

SpO₂ – Type BF defibrillation protected applied part.

Protection Against Hazards of Explosion

Not protected (ordinary).

Protection Against Ingress of Liquids

Not protected (ordinary).

2.3 Physical Characteristics

Size (maximum):

Main Unit:	19 cm(W) x 26.93 cm(H) x 20.83 cm (D) 7.5" (W) x 10.6" (H) x 8.2" (D)
Recorder Module:	5.33 cm(W) x 23 cm(H) x 11 cm (D) 2.1" (W) x 9" (H) x 4.25" (D)
Predictive Module:	5.7 cm(W) x 15.9 cm(H) x 11.8 cm (D) 2.25" (W) x 6.25" (H) x 4.63" (D)
Weight:	<4.95 kg (11 pounds), depending on configuration.

2.4 Environmental Characteristics

Operating Temperature:

Accutorr Plus with or without Recorder:	10°C to 40°C, (50°F to 104°F)
Infrared Thermometer Module:	18°C to 40°C, (65°F to 104°F)
Predictive Thermometer Module:	10°C to 32°C, (50°F to 90°F)
Operating Humidity:	15 to 90% max, non-condensing.
Shock and Vibration:	Meets IEC 68-2-27, IEC 68-2-37.
Shipping:	Meets ISTA Test Procedure 1A (less than 100 lbs.)
Storage Temperature:	-15°C to +40°C, +5°F to 104°F
Storage Humidity:	10 to 95%, non-condensing.
Operating Altitude:	1013 hPa to 782 hPa (0 to 7,000 ft.). for units with an LCD 1013 hPa to 697 hPa (0 to 10,000 ft.) for units without an LCD

2.5 Electrical Ratings

Voltage:	100 - 120 / 220 - 240 VAC
Current:	0.6 / 0.3 A
Frequency:	60 / 50 Hz
Power Consumption:	40 W, maximum

2.6 Agency Compliance

The Accutorr Plus is designed to comply with the following agency standards:

EN 60601-1:1990	Medical Electrical Equipment – General Requirements for Safety
UL 2601-1:1994	CSA C22.2, No. 601.1-M90
EN 475: 1995	Medical Devices Electrically Generated Alarm Signals
EN 865: 1997 (High End units only)	Pulse Oximeters for Medical Use – Requirements
EN 60601-2-30:1995	Particular requirements for the safety of automatic cycling indirect blood pressure monitoring equipment
IEC 601-1-2:2001	Particular requirements for safety (EMC)

EMC Requirements per FDA Reviewer Guidance for Premarket Notification Submissions (draft, November 1993), Section m.7.ii for:

- Steady-State Voltage
- Dropout
- Slow Sags and Surges
- Quasi-Static Field Susceptibility

2.7 Electromagnetic Compatibility

The Accutorr Plus has been tested and found to comply with the requirements of IEC 60601-1-2: 2001 “Collateral Standard Electromagnetic Compatibility Requirements and Tests.”

To ensure Electromagnetic Compatibility (EMC), operate the Accutorr Plus in accordance with the instructions for use.

To prevent the possibility of other equipment affecting the Accutorr Plus, insure adequate distances are maintained between devices.

3.0 *Repair Information*

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3.3 General Troubleshooting Guidelines	3-3
3.4 Test Equipment Required	3-4
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3.1 Introduction

This chapter of the Service Manual provides the technical information necessary to resolve most instrument malfunctions. Important prerequisites for effective troubleshooting are a thorough understanding of the instrument functions, and specifications, as well as an understanding of the theory of operation. (See "Theory of Operation" on page 1-1. See "Specifications" on page 2-1.)

Functional overviews of the major circuit blocks are provided in this manual, (See "Theory of Operation" on page 1-1). Technically qualified individuals may prefer to isolate problems to a sub-circuit or component level. Component level repair activity is not always possible. Isolation of defective components is frequently impossible without the functional emulation of operating software. The equipment and processes required are not cost effective on a single unit basis.

The procedures detailed in this chapter are for use by qualified technical personnel only. A comprehensive selection of Technical Training Seminars for this and other products is available. Contact the Registrar, Technical Support Department or your regional sales or service representative for course offerings and dates.

3.2 Safety Precautions

There are areas where improper repair techniques will cause further damage. When the instrument covers are removed, observe the following precautions and guidelines.

1. Power line voltages will be exposed; identify hazard points and avoid direct contact.
2. Battery terminals are accessible; do not short to each other or the positive terminal to ground circuits, as the capacity of the battery is sufficient to create an over heating safety hazard.
3. Fuses must not be by passed or replaced by different current, voltage or time delay ratings.
4. The circuit boards contain static sensitive components; use proper static safeguard techniques.

CAUTION: Li-Ion batteries are intended for replacement by qualified service personnel only.

CAUTION: Li-Ion batteries used in this device may present a risk of fire or chemical burn if mistreated. Do not disassemble, heat above 100°C (212°F), or incinerate. Replace battery with P/N: 0146-00-0069 only. Use of another battery may present a risk of fire or explosion.

CAUTION: Dispose of used battery promptly. Keep away from children. Do not disassemble and do not dispose of in fire.

3.3 General Troubleshooting Guidelines

This procedure does not cover all possible problems. The intent of troubleshooting is to provide quick isolation and remedy of malfunctions and to return the instrument promptly to safe patient care. A logical approach will quickly identify the problem and suggest cost effective solutions.

3.3.1 Troubleshooting Tips

1. Isolate the cause of the problem to be either clinical, instrument or external. If a clinical cause is suspected, take the physiological measurement by a manual method or use an alternate measuring device. Check the physiological value against the instrument specifications; if exceeds specification, continue with manual or alternate method.

If a problem with the instrument is suspected, first examine and / or replace patient connected accessories. Check instrument set-up / configuration. Ensure the correct battery charge profile is selected for the installed battery. If all set-ups are OK, replace instrument with similar device.

If the environment is suspected, observe if the malfunction coincides with other equipment cycling (especially high power motors, RF generators, etc.). Replace problem instrument with an identical substitute. Place the problem instrument in a low disturbance environment. If the problem persists in the low disturbance environment, the instrument performance may be suspect. If the substitute instrument exhibits similar poor performance in the original environment, the environmental causes must be eliminated.

2. Use the proper equipment. See "Test Equipment Required" in section 3-4 for problem isolation and resolution. Similar devices may be used if they equal or exceed performance standards of the equipment suggested.

CAUTION: This instrument utilizes multiple layer circuit boards and laser and ultra sonic welded surface mounted components. Do not attempt to unsolder welded components from the circuit board; the circuit board will be permanently damaged.

CAUTION: Soldering and solder removal equipment must be low voltage operated and grounded to avoid static charge and stray current induced component damage. Maximum wattage: 25 W.

3. Clean the repair area. After soldering operations, clean off the repaired area with ethyl or methyl alcohol and a stiff hair brush. This will remove residual solder flux, making the repaired area more visible for an inspection and returning the instrument to its original, neat appearance. Removal of the flux will also facilitate making electrical measurements in the affected area as the flux itself is not conductive.

3.3.2 Exchange Program

A comprehensive circuit board and electro-mechanical module exchange program is available. The exchange circuits and modules are warranted, factory pre-tested and calibrated. Final calibration of the exchange item is strongly suggested to match the new part to the host system. See section 4.4 for details concerning the exchange program.

3.4 Test Equipment Required

Equipment types other than these listed may be utilized if they equal or exceed the listed equipment performance.

- Dynatech Nevada Non-invasive Blood Pressure Simulator (Cuff Link)
- Power Supply, Power-Mate, 3A 20V
- Fluke D.V.M, Model 8050A
- Digital Storage Scope, Tektronix, 2230 100 MHZ
- Stop Watch, Wilson LW#119
- SpO₂ Simulator, Biotek Index, Smart SAT (All SpO₂ versions); N-1290 (Nellcor SpO₂ Only)
- RS232 Test Connector (Pins 2 and 3 Shorted)
- 700 cc Dummy Cuff, P/N 0138-00-0001-01
- Chart Paper, P/N 0683-00-0447-01
- Water Bath, Cole-Palmer model H-12-105-10
- Reference Quartz Thermometer, Hewlett-Packard model HP-2804A with Temp. Probe HP-1811A

3.5 Troubleshooting (Problem Isolation)

This section has been divided into two major areas; clinical and technical. Clinical problems can generally be resolved by the user. Technical problems may require resolution by a qualified technical service person. The error code table below indicates Technical problems with an asterisk (*). Error codes are displayed on the front panel LED's of the Accutorr Plus.

3.5.0.1 Error Codes

TYPE	CODE	DESCRIPTION	REASON
NIBP	8810	Retry - Unable to Measure	Motion artifact, cycle time-out, weak pulsations or no pulsations. A triple beep tone is generated.
	8811	Retry - Pump Higher	Insufficient cuff pressure. A triple beep tone is generated.
	8812	Stop - Cuff Overpressure	Excessive cuff pressure detected by the software. A triple beep tone is generated.
	8813	Stop - Unable to Measure	4 successive measurement attempts failed. A triple beep tone is generated.
TEMP (PTM)	8830	Check Probe	Tissue contact may have been lost.
	8831	Replace Probe	Defective probe or connection.
	8832	Battery Low	The 9V battery needs replacement.
SpO ₂	8850	No Sensor	No sensor connected.
	8851	Sensor Off	Sensor not on patient. (Masimo® SpO ₂ only)
	8852	Interference	Interference on signal. (Masimo® SpO ₂ only)
	8853	Pulse Search	Unit cannot find signal. (Nellcor SpO ₂ Module will report "Pulse Search" -8853- when the sensor is not on the patient.)
	8854	Weak Pulse	Weak pulse detected. (Masimo® SpO ₂ only)
	8856	Check Sensor	Sensor problem. (Masimo® SpO ₂ only)
	8857	PR<21	Pulse rate is less than 21 bpm. (Nellcor SpO ₂ only)
	8857	PR<26	Pulse rate is less than 26 bpm. (Masimo® SpO ₂ only)
	8858	PR>249	Pulse rate is greater than 249 bpm. (Nellcor SpO ₂ only)
8858	PR>239	Pulse rate is greater than 239 bpm. (Masimo® SpO ₂ only)	

TYPE	CODE	DESCRIPTION	REASON
SYSTEM	984*	NIBP Hardware Failure	NIBP A/D failure detected.
	985*	NIBP Overpressure Circuit not Programmed	The overpressure circuit is not set to the current patient size.
	986*	NIBP Overpressure Circuit not Tracking	The two pressure transducers are not tracking each other.
	987*	Stop - Hardware Overpressure	Excessive cuff pressure detected by hardware over-pressure sensor. A triple beep tone is generated.
	988*	TEMP Bad Calibration	Thermometer needs calibration.
	990*	TEMP Illegal Mode	Thermometer switch is set wrong.
	991*	TEMP Module Failed	Thermometer internal failure.
	995*	SpO ₂ Uncalibrated	SpO ₂ fails calibration check.
	996*	SpO ₂ Failure	SpO ₂ failed self-test.

3.5.1 Isolating the Problem, System Level

1. Determine if the problem is in the main NIBP unit or one of the add on accessories.
2. If the problem is in the accessory, replace the 9 Volt battery in the temperature module, if equipped, and check the recorder unit for correct paper, correct installation and paper jams.
3. If the problem is in the main NIBP and/or SpO₂ section, rule out these simple problems first:

If AC power is available, then the green LED adjacent to the front panel **ON/OFF** keys should be illuminated. If not, connect the power cord to live power outlet. If green LED fails to illuminate, there is a probable power supply malfunction.

Check the battery operation LED. Steady ON indicates battery operation. A flashing LED indicates a near depleted battery. If the green LED is NOT On, then the battery or power supply/charger may be suspect.

Confirm correct operating parameters selection, i.e., correct patient size selection, (Adult, Neonate, Ped.) and NIBP cuffs to match. In units with SpO₂, verify that a sensor is connected to the unit and it is of the proper type/size. Verify the proper battery charge profile is selected for the installed battery.

3.5.2 Isolating the Problem within the Main Unit

Problems within the main NIBP and/or SpO₂ unit are categorized broadly into power supply problems and NIBP and/or SpO₂ detection and display. For a monitor that will not even turn on, proceed to Power Supply and Battery Tests, otherwise skip to Diagnostics Test and beyond.

1. Power Supply and Battery test: The main power supply output voltages should be verified under normal instrument loads. Below are the tolerances for the voltages shown:

$$5V = 4.9 - 5.1$$

$$12.5V = 12 - 13$$

$$15V = 14.5 - 15.5$$

2. Perform Diagnostics Test 01 through 12. Repair or replace circuits or components that fail the Diagnostic Test.
3. Trend circuits test: Obtain a minimum of five NIBP measurements and simultaneous SpO₂ and Temperature readings if the Accutorr has those options. Confirm Trend storage function as explained in the operating instructions.

3.5.3 Isolating the Problems with Optional Accessory Modules

1. Predictive Temperature Module Test: Obtain one or more temperature readings from the optional temperature modules. They will be displayed in the temperature display window. If the readings are not displayed, replace the temperature probe first, then the complete module.
2. Infrared (Accutemp I.R.) temperature module test: The following paragraphs will assist you to separate those clinical issues that can result in inaccurate or inconsistent readings, as well as instrument malfunctions.

Since there are no user serviceable components (except 9V battery) inside the Accutemp I.R. all service requests should be directed to the factory.

3. Recorder Module Test: Obtain a print out of stored data, or perform diagnostics test (#4) to verify printer integrity. Substitute printer with a know good device to confirm diagnosis.

3.5.4 Clinical Issues

3.5.4.1 Multiple Temperature Measurements

The AccuTemp employs an easy and quick method to taking temperature measurements. Because of this it is tempting to take immediate, repetitive measurements. However, taking immediate repetitive measurements in the same ear, may result in a decrease in temperature. This is because the probe of an ear thermometer is cooler than the ear canal and will draw the heat from the ear canal, cooling the canal slightly. Waiting a few minutes before taking another temperature in the same ear will give the ear canal time to recover, and the readings should be consistent with the initial measurement.

3.5.4.2 How the AccuTemp Measures Arterial Temperature (Adults/Pediatrics)

The AccuTemp is a self-calibrating infrared ear thermometer that accurately measures the infrared heat energy radiating from the ear canal opening. The AccuTemp determines the highest temperature in the ear canal opening, measures the ambient temperature, and then calculates arterial (core) temperature through its patented heat balance system. This measurement will respond instantly to changes in arterial temperature without the delays and artifacts inherent in oral and rectal methods, providing the means to identify a fever faster and more reliably than other methods.

Temperature gradients in the ear canal vary with the amount of environmental exposure, perfusion patterns, ambient temperature, etc. The least variable and therefore most accurate is the small deep area of warmest, but still visible tissue. A conventional ear thermometer takes many readings of the same large area, which includes the high gradient distal ear tissue, resulting in low, non-reproducible, and inaccurate temperature readings. The AccuTemp utilizes a narrow field-of-view and scanning capability to search the ear for the small deep area of warmest tissue required for heat balance calculation to ensure highly accurate and reproducible arterial temperatures.

The temperature measurement will remain on the display for a minimum of 55 and a maximum of 65 seconds after the Start button is released. If using the AccuTemp with an Accutorr Plus, the temperature measurement can be transferred from the AccuTemp to the Accutorr Plus for display and entry into the trend database, by placing the AccuTemp in its holder within the 60 seconds after releasing the Start button. A beep tone is sounded from the Accutorr Plus once the temperature measurement information has been received by the Accutorr Plus.

NOTE: Do not change Room Number and/or Bed Letter on the Accutorr Plus during the transmission of temperature data.

The AccuTemp can be used to take temperature measurements for up to 128 power cycles without having to be put back into its holder. After 128 power cycles, the AccuTemp must be put back into the holder to be reset. When the 129th power cycle is reached and the Start button is pressed, 4 L's are displayed, indicating that the AccuTemp is locked and must be returned to its holder.

NOTE: The AccuTemp thermometer should be at room temperature when it is used. If it has been in a very warm or very cold environment it may need time for the thermometer temperature to equalize to ambient temperature.

3.5.4.3 Troubleshooting

The following table provides suggestions to resolve problems when taking temperature measurements:

SYMPTOM	SUGGESTION
Various readings when taking measurements in the same location, ear or axilla.	Quick repetitive measurements in the same location can result in a decrease in temperature. This can occur because the optical head of AccuTemp may slightly cool the area. Wait a few minutes for the temperature of the area to equilibrate. Replace cover and clean lens with an alcohol swab.
Various readings when taking measurements in opposite ears.	The patient may be lying down on one ear. The measurement of the ear that was down may be a higher temperature. Wait a few minutes for the temperature of the ear canal to equilibrate or use opposite ear. This is also a factor if the area has been covered for any reason, i.e., hat, blanket, bandage, telephone, etc.
No measurement or inaccurate measurements.	This can be caused by technique errors:-Not keeping the button pressed throughout the measurement.-Not scanning side-to-side (adults and pediatrics).-Twisting or rotating the probe instead of scanning side-to-side.-Not changing the protective optical film cover with each reading. (Even on the same patient.)-Debris on the lens.-Not covering the opening of the ear canal.-Presence of a visible wax plug, or dense hair blocking the view into the ear canal.-This can also be caused by low battery voltage.

ACCUTEMP ERROR	REASON
AccuTemp double beeps and displays "—" while holding the Start button. The AccuTemp then powers down.	Battery voltage < 5.7 VDC. Battery requires replacement.
AccuTemp double beeps while holding the Start button	Low battery condition. Battery voltage is between 6.2 and 5.7 VDC.
AccuTemp displays "E-00" or "E-01" while holding the Start button.	Return AccuTemp for service.

3.5.4.4 Maintenance

The AccuTemp can be wiped down with any hospital approved disinfectant, including bleach. With normal use, the only maintenance required is to keep the lens on the end of the probe clean. The lens is made of polycarbonate. Dirt, greasy films or moisture on the lens will interfere with the passage of infrared heat and affect the accuracy of the measurement. If necessary, clean the lens with a cotton swab dipped in alcohol. Periodic cleaning is recommended. To keep the lens clean when not in use, store the AccuTemp with an optical film cover in place.

3.6 Disassembly Instructions

CAUTION: The Inside Of This Instrument Contains Static Sensitive Components. Use correct static protection safeguards.

1. Power down the Accutorr Plus and remove the AC power cable.
2. Remove all cables and hoses from the front and rear of the instrument.
3. Remove temperature measuring module and recorder module, if equipped.

3.6.1 Removal of the Rear Housing

1. Place the Accutorr Plus with the display side down, onto a protective surface.

NOTE: Special care should be taken to insure that the front panel and glare screen are not scratched.

2. Remove the 4 screws from the corners of the back housing recess and the two screws in the center channel of the rear case.
3. Slowly lift the rear housing up and place in a safe location.
4. Disconnect battery connector (J4) from the Power Supply board.

3.6.2 Removal of the Front Bezel

1. Place the front housing with the display side down, onto a protective surface.
2. Disconnect the SpO₂ ribbon cable (J3) from the SpO₂ circuit board and the tubing from the NIBP front panel connector.
3. Slowly separate the assembly up and away from the front housing.

3.6.3 Removal of the Keyboard Assembly

1. Place the instrument with the display side down, onto a protective surface.
2. Remove the Front Bezel, as described above.
3. Remove the screws (4) securing the Keyboard Assembly and lift the keyboard, supporting and separating the connector to the LED/Tone board.

3.6.4 Removal of the LED/Tone board

1. Remove front bezel and keyboard.
2. Disconnect cable from J4, the speaker connection.
3. Remove the four screws holding the circuit board. Pull circuit board forward, disconnecting the rear J-1 connector.

3.6.5 Removal of the CPU / NIBP board

1. Disconnect J-505 NIBP pump connector, J-7 SpO₂ interface connector, and J-502 Power supply connector, all on the top edge of the board.
2. Disengage the captive cable connectors for the Recorder and Temperature options at the bottom left and right edges of the board.
3. Disconnect gray ribbon cable at J-603 to the external interface connectors.
4. Disconnect J-651 the LCD back lite connector.
5. Disconnect silicon hose from pump, at the right angle elbow.
6. Remove the four hexagonal spacers and one Phillips head screw on the board.
7. Lift board up gently and disconnect data ribbon cable from J-8 to the LCD display.

3.6.6 Removal of the Power Supply Assembly

1. Remove AC mains power cord and internal battery. Remove rear case.
2. Disconnect ribbon cable at J-3 on the power supply. Disconnect battery J-3 connector cable.

NOTE: **Do not remove the screws located at the end of the circuit board; the board will not come out and you may damage internal connections.**

3. Remove the two screws from the metal chassis / heat sink at the top end of the supply.
4. Remove the two screws from the metal chassis / heat sink at the bottom end of the supply. Slide the supply chassis out sufficiently to disconnect J-2, the AC Mains connection.

3.6.7 Removal of the LCD display

1. Remove the right side support bracket for the LCD. Disconnect data ribbon cable.
2. Disengage LCD circuit board from left side support bracket and disconnect back lite cable from the CPU / NIBP board.

3.6.8 Removal and replacement of the Internal Sealed Lead Acid or Li-Ion Battery

To remove the externally accessible battery, press the quick release tab on the battery access door and open door. The battery is retained internally in a sliding compartment, captured by a spring loaded release tab. Press the tab away from the battery; the battery will eject with a spring assist mechanism.

Reverse the process to install the replacement battery.

NOTE: New batteries are shipped in a discharged state for safety reasons. A new battery must be charged for 2 hours for Li-Ion or 8 hours for Sealed Lead Acid Battery before first use. The monitor may be used with AC mains power during the charge cycle but battery operation could be limited during this time.

3.6.9 Removal of the AC Input Receptacle Assembly (16)

1. Press the plastic locking tabs on the rear of the AC receptacle. A small screwdriver may be inserted at the cut out on the left of the AC connector, to release the locking tabs.
2. From the front side of the receptacle, starting at the edge closest to the Interface connector, press upwards, while pulling the connector out.
3. Disconnect the cable end from the Power Supply circuit board.
4. Remove the locking nuts from the safety ground terminal stud; remove ground conductor.

NOTE: Never re-install an AC receptacle forcibly removed. The plastic locking tabs of the receptacle will be damaged, and if re-installed the receptacle may pull out in normal use.

3.6.10 Thermal Printer (optional module)

1. Detach the complete module from the main NIBP section, by removing the two screws in the plastic housing. Grasp the plastic housing and pull to the rear to disengage the Interface connector.
2. Remove the two screws retaining the circuit board and the anti static shield assembly. Remove the shield.
3. Remove the remaining two screws and lift the circuit board out.

3.6.11 Thermometer, Predictive (optional module)

1. Detach the complete module from the main NIBP section by removing the two screws in the plastic housing. Grasp the plastic housing and pull to the rear to disengage the interface connector.
2. Disconnect the 9 V battery.

NOTE: Newer modules do not contain a battery. Skip this step.

3. Remove J2 and J3 connectors from the circuit board to front panel input receptacle.

NOTE: The connectors may be reversed or interchanged without affecting final function.

4. Remove the three screws securing the circuit board and anti static shield. Remove the assembly.

3.6.12 AccuTemp IR, Infrared Thermometer (optional module)

The AccuTemp has no user accessible adjustments or replaceable parts, except for the 9 Volt battery. If problems arise, contact Technical Service.

3.6.13 AccuTemp IR Mounting Cradle

The mounting cradle has no adjustments or replaceable parts. The mounting cradle houses a small circuit board and a photocell sensor.

3.7 Interconnect Cables Run List

3.7.1 Interface Specifications, Connectors and Functions.

3.7.1.1 Connector to LED / Tone PCB, J-2

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
1		Vcc return	D(digital ground)
2	Output	Reset	RST*
3	Input/Output	Damped Data Bus D(0)	D_Damp(0)
4	Input	Write Recorder	WR_REC'D*
5		Vcc return	D(digital ground)
6		FPGA Not Done	FPGA_NOT DONE*
7	Input/Output	Damped Data Bus D(1)	D_Damp(1)
8	Output	Read/ Write	R/W*
9		Vcc return	D(digital ground)
10	Output	LDS	LDS*
11	Input/Output	Damped Data Bus D(2)	D_Damp(2)
12	Output	Chip Select I/O	CS_IO*
13		Vcc return	D(digital ground)
14	Input	Write Delay	WR_DLY*
15	Input/Output	Damped Data Bus D(3)	D_Damp(3)
16	Input	ST Watchdog	ST_WDOG*
17		Vcc return	D(digital ground)
18	Input	LCD Angle	LCD_ANGLE
19	Input/Output	Damped Data Bus D(4)	D_Damp(4)
20	Input	LCD Angle Feed Back	LCD_ANGLE_FB
21		Vcc return	D(digital ground)
22	Input	LCD Angle Reference	LCD_REF
23	Input/Output	Damped Data Bus D(5)	D_Damp(5)
24	Output	TONE	TONE
25		Vcc return	D(digital ground)
26	N/C	N/C	N/C
27	Input/Output	Damped Data Bus D(6)	D_Damp(6)
28	Input	Read Configure	RE_CONFIG*
29		Vcc return	D(digital ground)
30	N/C	N/C	N/C
31	Input/Output	Damped Data Bus D(7)	D_Damp(7)
32		+5V Supply	VCC
33		Vcc return	D(digital ground)
34		+5V Supply	VCC

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
35	Input/Output	Damped Data Bus D(8)	D_Damp(8)
36	N/C	N/C	N/C
37		Vcc return	D(digital ground)
38		+5V Supply	VCC
39	Output	Clock O	CLOCK O
40		+5V Supply	VCC
41		Vcc return	D(digital ground)
42	Input	Keypad Data Bus (D0)	KEYD0
43	Output	Damped Address(2)	A_DAMPED(2)
44	N/C	N/C	N/C
45		Vcc return	D(digital ground)
46	N/C	N/C	N/C
47	Output	Damped Address(3)	A_DAMPED(3)
48	Input	Keypad Data Bus (D3)	KEYD3
49		Vcc return	D(digital ground)
50	N/C	N/C	N/C
51	Output	Damped Address(4)	A_DAMPED(4)
52	N/C	N/C	N/C
53		Vcc return	D(digital ground)
54	N/C	N/C	N/C
55	Output	Damped Address(5)	A_DAMPED(5)
56	N/C	N/C	N/C
57		Vcc return	D(digital ground)
58	Output	AC ON	ACON*
59	Output	Damped Address(6)	A_DAMPED(6)
60	Input	Switched ON/OFF	ON/OFFSW*
61		Vcc return	D(digital ground)
62	N/C	N/C	N/C
63	Output	Damped Address(7)	A_DAMPED(7)
64	N/C	N/C	N/C
65	Output	Vcc return	D(digital ground)
66	N/C	N/C	N/C
67	N/C	N/C	N/C
68	Output	AC LED ON	ACON_LED
69		+5V Supply	VCC
70	Input	High Low	HIGH/LOW*
71		+5V Supply	VCC
72	Input	LCD Unit	LCD_UNIT
73	N/C	N/C	N/C
74	N/C	N/C	N/C

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
75		SpO ₂ RESET	SpO ₂ RST*
76		+12V -15V ON	+12V -15V ON
77		CHARGE OFF	CHRGOFF*
78	N/C	N/C	N/C
79	Output	A/D Chip Select	ADC_CS*
80	N/C	N/C	N/C

3.7.1.2 Power Supply Header, J-502

PIN #	DESCRIPTION	NAME
14	+5V Supply	+5V
13	+5V Supply	+5V
12	+5V Return	D(Digital Ground)
11	+5V Return	D(Digital Ground)
10	+15V Supply	+15V
9	-15V Supply	-15V
8	+/- 15V Return	A(Analog Ground)
7	+12V Return	P(Power Ground)
6	+12V Supply	+12V
5	Standby	STDBY
4	AC ON	ACON*
3	+12V -15V ON	+12V -15V ON*
2	OFF/ON	OFF/ON*
1	Charge Off	CHRGOFF*

3.7.1.3 J-2 Keypad Connector

PIN #	FUNCTION	PIN #	FUNCTION
1	Battery LED	16	Key D7
2	Interval LED	17	Key D6
3	Neonatal LED	18	Key D5
4	Pediatric LED	19	Key D4
5	Adult LED	20	Key D3
6	Memory Full LED	21	Key D2
7	NIBP Ready LED	22	Key D1
8	Print LED	23	Key D0
9	Mute LED	24	On/Off Sw*
10	Data Scan LED	25	Ground
11	AC On LED	26	Stat_LED_ENO

PIN #	FUNCTION	PIN #	FUNCTION
12	AC On*	27	High_Low
13	Key 2	28	LCD_Unit
14	Key 1	29	Stat_LED_EN1
15	Key 0	30	Stat_LED_EN2

3.7.1.4 J-4 Speaker Connector

PIN #	FUNCTION
1	Speaker terminal
2	Speaker terminal
3	no connection

3.7.1.5 Recorder Connector, J-5

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
1	Output	TTL, recorder data	Buffered Data Bus,D(7)
2	Output	TTL, recorder data	Buffered Data Bus,D(6)
3	Output	TTL, recorder data	Buffered Data Bus,D(5)
4	Output	TTL, recorder data	Buffered Data Bus,D(4)
5	Output	TTL, recorder data	Buffered Data Bus,D(3)
6	Output	TTL, recorder data	Buffered Data Bus,D(2)
7	Output	TTL, recorder data	Buffered Data Bus,D(1)
8	Output	TTL, recorder data	Buffered Data Bus,D(0)
9	Output	ground	DGND
10	Output	TTL, recorder write	WR_REC'D*
11	Input	logic low: Recorder module attached	RECD*
12	Output	TTL, Reset recorder	RESET*
13	Output	TTL, Recorder home	HOME*
14	Output	TTL, Run print head	RUN*
15	Input	TTL, DMA request	DREQ*
16	Output	+5V supply (+/-2%)	VCC
17	Output	+5V printer supply (+/-1V)	+5VP
18	Output	+5V return	PGND
19	Output	+5V printer supply (+/-1V)	+5VP
20	Output	+5V return	PGND

3.7.1.6 Thermometer Connector, J-4

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
1	Input	TTL, serial in	TEMP_TXD
2	Input	TTL, serial in	TEMP_TXD
3	Output	ground	DGND
4	Output	ground	DGND
5	Output	TTL, serial out	TEMP_RXD
6	Output	TTL, serial out	TEMP_RXD
7	Input	TTL, serial in	SpO ₂ _TXD
8	Output	TTL, serial out	SpO ₂ _RXD
9	Input	TTL Level	SpO ₂ *
10	Output	TTL Level	SpO ₂ RST*
11	Output	9 - 17.3 VDC	STDBY
12	Output	ground	aground
13	Output	+5VDC +/- 2% supply	VCC
14	Output		VCC
15	Input	logic low: 0.8V max	PRED*
16	Input	Predictive Temp module attached	PRED*
17	Output	ground	DGND
18	Input	logic low: 0.8V max SpO ₂ option 2 installed	SpO ₂ _OPT2*
19	Input	logic low: 0.8V max IR Temp module attached	TYMP*
20	Input	logic low: 0.8V max SpO ₂ option installed	SpO ₂ _OPT1*

3.7.1.7 SpO₂ Connector, J-7

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
1	Output	+15V supply (+/-5%)	+15V
2	Output	Analog ground	AGND
3	Output	-15V supply (+/-5%)	-15V
4	Output	+5V supply (+/-5%)	+5V
5	Input	TTL, serial in	SpO ₂ _TXD
6	Input	SpO ₂ module installed: logic low @ 0.8V max	SpO ₂ *
7	Output	TTL, serial out	SpO ₂ _RXD
8	Output	ground	DGND
9	Output	TTL, module reset	SpO ₂ RST*
10	Output	ground	DGND

3.7.1.8 NIBP Pump Connector, J-505

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
1	Output	pump supply	filtered +12.5V supply
2	Input	pump return	+12.5V return
3	Input	power ground	P(power ground)

3.7.1.9 Backlight Connector, J-651

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
1	Output	100Vrms +/- 10% @ 300 to 500 Hz	ELPower
2	N/C		
3	Output	Return	PGND

3.7.1.10 Communication Connector, J-603

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
1	Output	12VDC +/- 5% @ 100mA	TR_PWR
2	N/C	--	---
3	Input	RS-232 or RS-485	RXD
4	Input	RS-232	RTS
5	Output	RS-232 or RS-485	TXD
6	Output	RS-232	CTS
7	Output	±9 Vdc min.	Nurse_Call
8	Output	Ground	DGND
9	Output	Ground	DGND
10	N/C	---	---
11	Output	Ground	DGND
12	Output	Ground	DGND
13	Output	RS-232, Receive	EXT_RXD
14	Input	RS-232, Transmit	EXT_TXD

3.7.1.11 LCD Connector, J-8

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
1	Out	Chassis Ground	CHASSIS
2	Out	ground	DGND
3	Out	+5V supply (+/-5%)	VCC
4	Out	View angle control -15V max	VEE

PIN #	INPUT/OUTPUT	DESCRIPTION	NAME
5	Out	TTL, control line	WR_LCD*
6	Out	TTL, control line	RD_LCD*
7	Out	TTL, control line	CS_LCD*
8	Out	TTL, address line	A<1>
9	Out	ground	DGND
10	Out	TTL, LCD reset	RESET*
11	Out	TTL, data line	Buffered Data Bus,D<0>
12	Out	TTL, data line	Buffered Data Bus,D<1>
13	Out	TTL, data line	Buffered Data Bus,D<2>
14	Out	TTL, data line	Buffered Data Bus,D<3>
15	Input	TTL, data line	Buffered Data Bus,D<4>
16	Out	TTL, data line	Buffered Data Bus,D<5>
17	Out	TTL, data line	Buffered Data Bus,D<6>
18	Out	TTL, data line	Buffered Data Bus,D<7>
19	Out	ground	DGND
20	Out	+5V supply (+/-5%)	VCC
21	Out	TTL Level	Buffered address Bus,A<3>
22	Out	TTL Level	Buffered address Bus,A<4>
23	Out	TTL Level	DSP_CONT*
24	Out	TTL Level	Buffered address Bus,A<5>
25	Out	+ 15VDC	+15VF
26	Out	-15 VDC	-15VF

3.7.2 Power Supply Connectors

3.7.2.1 AC input connector, J-2

PIN #	FUNCTION	PIN #	FUNCTION
1	AC Ground	4	N/C (pin removed)
2	N/C (pin removed)	5	AC Hot
3	AC Neutral		

3.7.2.2 DC output connector, J-3

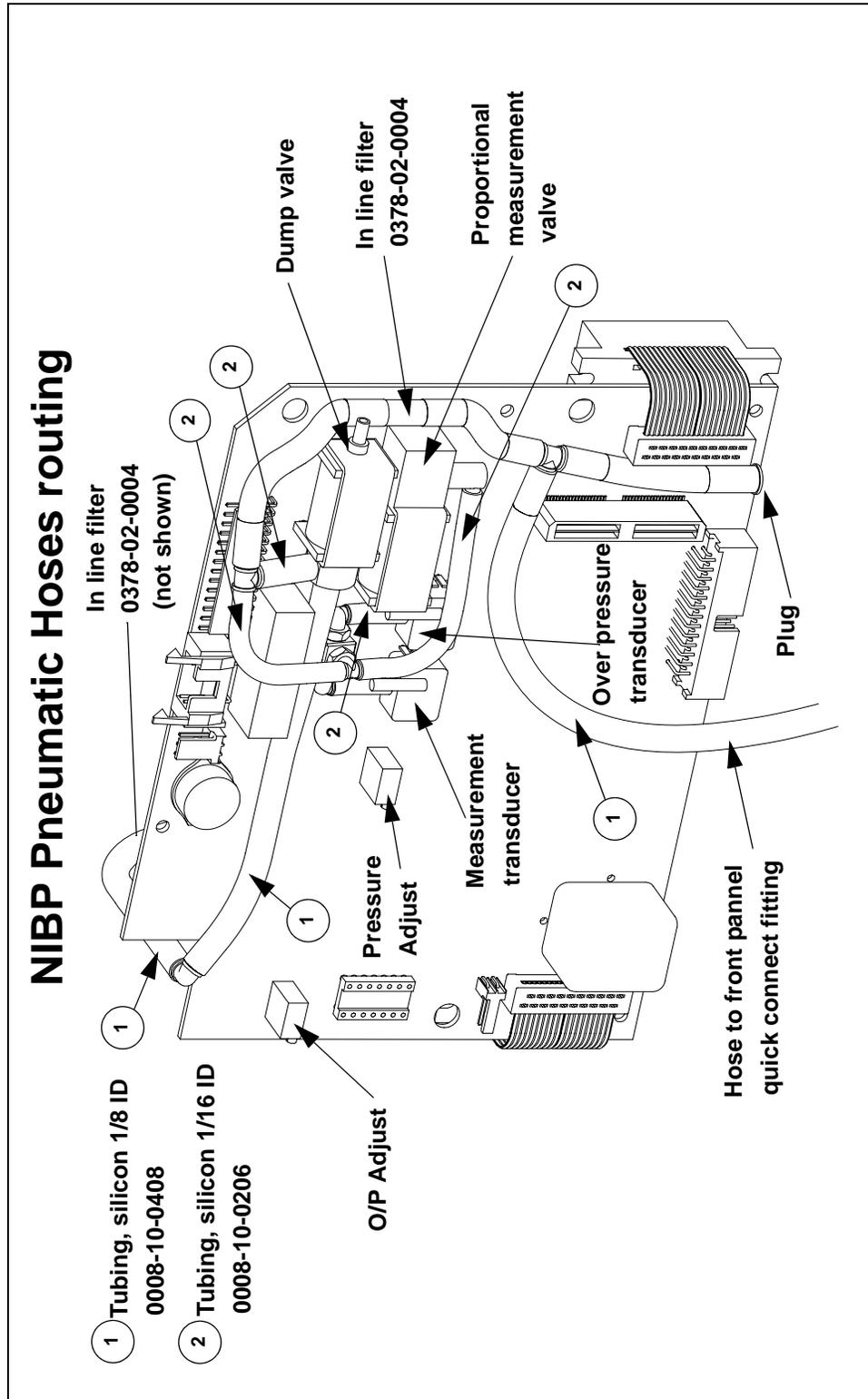
PIN #	FUNCTION	PIN #	FUNCTION
1	+5 V	8	Common
2	+5 V	9	+12.5 V
3	Common	10	STDBY
4	Common	11	ACON*
5	+15 V	12	+12-15ON*
6	-15 V	13	OFF/ON*
7	Common	14	CHRG OFF*

3.7.2.3 Battery connector, J-4

Connector Pin Out

PIN #	CONNECTION
1	Battery (-)
2	Thermistor
3	No Connection
4	No Connection
5	Battery (+)

3.8 Pneumatic Connections Diagram



4.0 *Replacement Parts Isometric Drawing*

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4.1 Introduction

This chapter of the Service Manual provides information necessary to identify the replacement parts and assemblies of the instrument.

4.2 Available Replacement Parts And Sub-Assemblies

The parts listings which follow are divided into two sections. The Isometric Drawings and the accompanying parts lists identify the available chassis mounted components.

4.3 Product Variations And Options

Product variations, due to differences for various line voltages, options and languages may require different components. These variations are reflected, where necessary, on the parts lists.

4.4 Exchange Program

An exchange policy for most of the printed circuit board assemblies is available. This program may provide the most expedient method of servicing the equipment. A standard charge for this service is made. Contact the Service Department for details concerning this exchange program.

Many circuit boards make extensive use of multi-layer technology and high density packaging. Individual component replacement is not recommended on these boards unless the technician is properly equipped to repair multi-layer circuit boards.

Circuit boards, returned as parts of the exchange program, that show evidence of improper repair techniques and are damaged in the process are not considered for exchange. Damaged boards will be invoiced at full value and no exchange credit will be applied.

4.5 Replacement Parts Pricing Information

Current parts prices and exchange charges can be determined by contacting the Order Entry Department.

4.6 Ordering Information

Replacement parts and assemblies are available from Mindray DS USA, Inc. Please follow these guidelines when ordering replacement items for the instrument.

1. Include the Model and Serial Number of the instrument.
2. Include the Part Number exactly as it appears in the Parts List under the column, "Part Number."
3. Include a description of the item.

Example Orders:

(1) ea. P/N 0014-00-0184
Main Power Supply Board
Serial No. XXXX-XX

(2) ea. P/N 0212-12-0404
Screw, #4-40 x .25 lg. Pan Head,
Serial No. XXXX-XX

NOTE: Mindray DS USA, Inc. maintains a policy of continuous development for product improvement and reserves the right to change materials, specifications, and prices without notice.

Many components are described with sufficient detail to permit procurement through local commercial channels. This applies to hardware, such as screws and fasteners, as well as to certain electronic components, such as resistors, capacitors, certain integrated circuits and transistors. In some cases, components are selected to meet special performance criteria above and beyond the component manufactures specifications. This may apply to solid state components, relays and batteries. The use of other than approved components in these applications may result in degradation of reliability or instrument performance.

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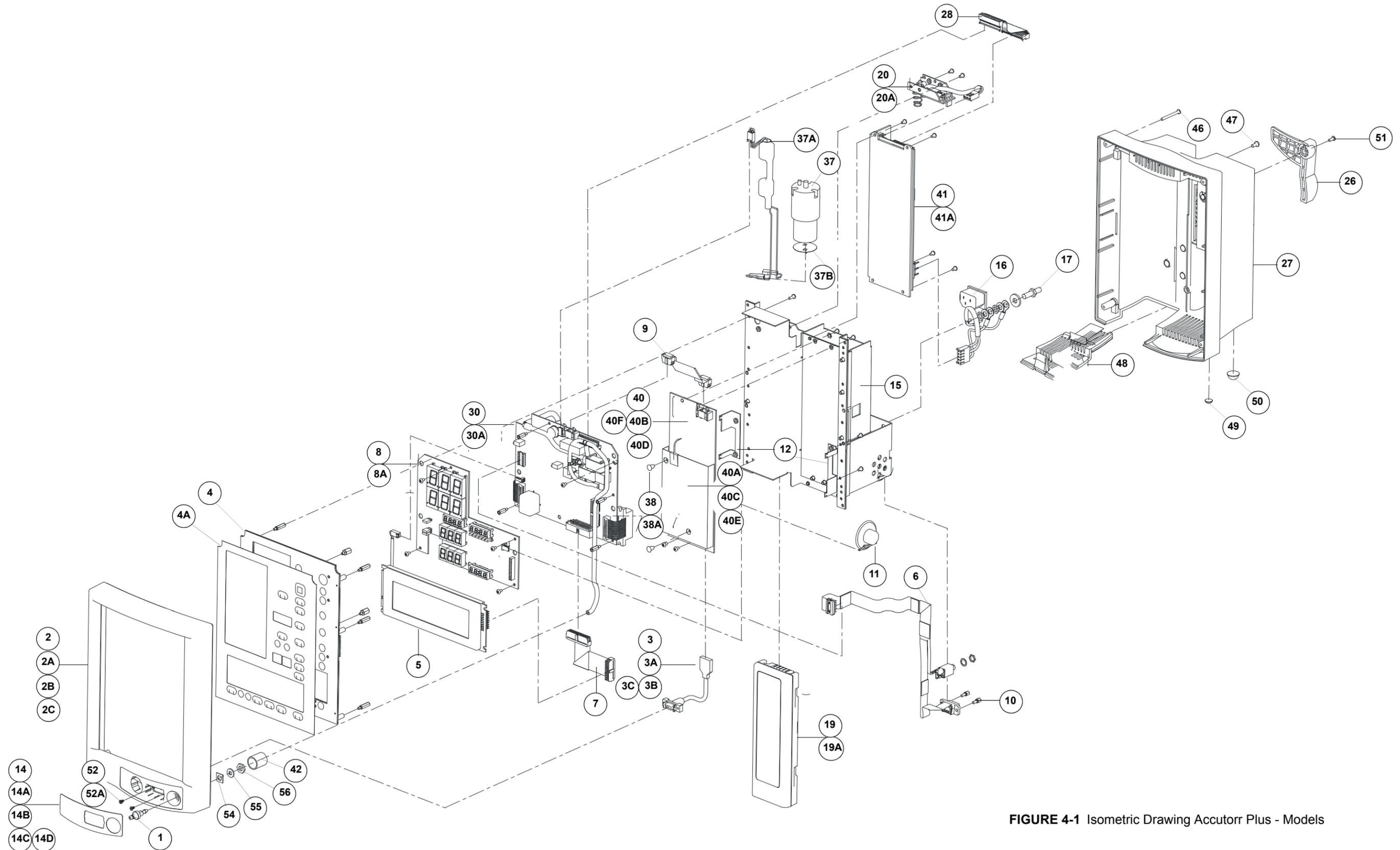


FIGURE 4-1 Isometric Drawing Accutorr Plus - Models

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4.7 Isometric Drawings And Parts List

The following item numbers are not used in this parts list: # 18, 21, 22, 23, 24, 25, 29, 31, 32, 33, 34, 35, 36, 39, 43, 44, 45, and 53.

FIGURE NO.	DESCRIPTION	PART NUMBER
1	Pressure connector	0103-00-0411
2	Bezel, front	0380-00-0359-04
2A	Bezel, front, Nellcor (MP304)	0380-00-0359-05
2B	Bezel, front, <i>with or without</i> Masimo® oximeter	0380-00-0359-06
2C	Bezel, front, Nellcor (MP506)	0380-00-0359-08
3	SpO ₂ connector assembly	0012-00-1223
3A	SpO ₂ connector assembly Nellcor (MP304)	0012-00-1222-01
3B	SpO ₂ connector assembly Masimo®	0012-00-1344
3C	SpO ₂ connector assembly Nellcor (MP506)	0012-00-1463
4	Keypad, without graphic panels	See Table.
4A	Graphic panels, must be replaced with keypad	See Table.
5	LCD display with backlight	0160-00-0062
6	Interface cable, download, phone jack	0012-00-1401
7	Interface cable for LCD	0012-00-1402
8	LED display circuit board for units with SpO ₂ option	0670-00-0727-01
8A	LED display circuit board for units without SpO ₂ option	0670-00-0727-02
9	Interface cable (SpO ₂ to CPU), all SpO ₂ options	0012-00-1403
10	Mounting screws for 9 pin Interface connector	0361-00-0164
11	Speaker with cable	0012-00-0257-05
12	LCD support brackets, left or right	0406-00-0755
14	Label, front bezel, no SpO ₂ option	0334-00-1509-01
14A	Label, front bezel, w/ Datascope SpO ₂	0334-00-1509-02
14B	Label, front bezel, w/ Nellcor (MP304) SpO ₂	0334-00-1509-03
14C	Label, front bezel, w/ Masimo® SpO ₂	0334-00-1509-04
14D	Label, front bezel, w/ Nellcor (MP506) SpO ₂	0334-00-1509-05
15	Chassis	0441-00-0173
16	AC (mains) power inlet w/cable	0012-00-0941
17	Ground lug	0124-00-0104-06
19	Battery, Lead Acid	0146-00-0043
19a	Battery, Lithium Ion	0146-00-0069
20	Battery retainer w/ connector cable, for Lead Acid Battery	0406-00-0808

* Replacement serial number labels are only provided upon return of the old label with unadulterated serial number clearly visible. An identical serial number label will be provided at a nominal cost.

FIGURE NO.	DESCRIPTION	PART NUMBER
20a	Battery retainer w/ connector cable, for Lithium Ion Battery	0997-00-0971
26	Release handle	0380-00-0268
27	Rear housing complete with pole cam and release handle	0380-00-0357-02
28	Interface cable, CPU / NIBP board to power supply	0012-00-1404
29	reserved, not used	
30	CPU/ NIBP circuit board for units <i>with</i> LCD displays	0670-00-1143-01
30a	CPU/ NIBP circuit board for units <i>without</i> LCD displays	0670-00-1143-02
37	Compressor for NIBP, 12 VDC	0104-00-0008
37a	Cable and filters for pump with quick connect term.	0012-00-1405
37b	Insulator, pump connector	0349-00-0314
38	Plastic push fasteners for Nellcor SpO ₂ shield	0344-00-0242
38a	Plastic push fasteners for Masimo® SpO ₂ shield	0344-00-0249
40	SpO ₂ circuit board, Mindray DS	0670-00-0593-03
40A	SpO ₂ circuit board, Nellcor MP304, (OEM)	0671-00-0162
40B	Interface board for Nellcor SpO ₂	0670-00-0675
40C	SpO ₂ circuit board, Masimo®, (OEM)	0671-00-0055
40D	Interface board for Masimo® SpO ₂	0670-00-0716
40E	SpO ₂ circuit board, Nellcor MP506, (OEM)	0671-00-0242
40F	Interface board for Nellcor MP506, SpO ₂	0670-00-0740
41	Power supply / batt. Charger for <i>Lead Acid batteries</i>	0014-00-0184
41a	Power supply / batt. charger for <i>Lithium Ion batteries</i>	0014-00-0225
42	Insulator tubing, PVC, .75"	0008-00-0324
46	Screw for rear housing (4-40 x 1.25")	0212-12-0420
47	Screw for rear housing (6-32 x .313")	0212-12-0605
48	Battery door, with plastic hinge	0380-00-0358-02
49	Rubber feet, small	0348-00-0191-02
50	Rubber feet, large	0348-00-0191-01
51	Screw, for release handle	0212-12-0405
52	Screw for Nellcor or Masimo® connector mounting	0211-00-0140
52a	Screw for Datascope connector mounting	0213-09-0405
54	Luer plate	0386-00-0162
55	Lock washer	0210-09-0025
56	Hex nut	0220-00-0004

* Replacement serial number labels are only provided upon return of the old label with unadulterated serial number clearly visible. An identical serial number label will be provided at a nominal cost.

FIGURE NO.	DESCRIPTION	PART NUMBER
N/S	Label, rear panel, (large label with finger caution symbol)	0334-00-1510
N/S	Label, Agency approvals and serial number	0334-00-1362- 03

* Replacement serial number labels are only provided upon return of the old label with unadulterated serial number clearly visible. An identical serial number label will be provided at a nominal cost.

4.7.1 Front Panel Keyboards And Graphic Panels Selection

NOTE: When replacing a Keyboard, you must replace the Graphic Panel.

Selection method:

1. Identify the type of monitor by referring to the product type the 0998- number found on the rear panel.
2. Select the correct keyboard type in the Keyboard column.
3. Select the correct graphic overlay from the Graphic Panel column.

MONITOR CONFIGURATION	MONITOR PART NUMBER 0998-00-0444	KEYBOARD PART NUMBER	GRAPHIC PANEL PART NUMBER
NIBP, Trend LCD, SpO ₂ (IEC, English)	C51; J51;	0331-00-0116-03	0330-00-0027-01
	C61; J61; C71; J71; C81; J81	0331-00-0116-04	
NIBP, Trend LCD (IEC, English)	C41; J41	0331-00-0116-02	0330-00-0026-01
NIBP only (IEC, English)	C31; J31	0331-00-0116-01	0330-00-0025-01
NIBP, Trend LCD, SpO ₂ (IEC, German)	C52; J52;	0331-00-0116-03	0330-00-0027-02
	C62; J62; C72; J72; C82; J82	0331-00-0116-04	
NIBP, Trend LCD (IEC, German)	C42; J42	0331-00-0116-02	0330-00-0026-02
NIBP only (IEC, German)	C32; J32	0331-00-0116-01	0330-00-0025-02
NIBP, Trend LCD, SpO ₂ (IEC, Spanish)	C53; J53;	0331-00-0116-03	0330-00-0027-03
	C63; J63; C73; J73; C83; J83	0331-00-0116-04	
NIBP, Trend LCD (IEC, Spanish)	C43; J43;	0331-00-0116-02	0330-00-0026-03
NIBP only (IEC, Spanish)	C33; J33	0331-00-0116-01	0330-00-0025-03
NIBP, Trend LCD, SpO ₂ (IEC, French)	C54; J54	0331-00-0116-03	0330-00-0027-04
	C64; J64; C74; J74; C84; J84	0331-00-0116-04	

MONITOR CONFIGURATION	MONITOR PART NUMBER 0998-00-0444	KEYBOARD PART NUMBER	GRAPHIC PANEL PART NUMBER
NIBP, Trend LCD (IEC, French)	C44; J44;	0331-00-0116-02	0330-00-0026-04
NIBP only (IEC, French)	C34; J34	0331-00-0116-01	0330-00-0025-04
NIBP, Trend LCD, SpO ₂ (IEC, Italian)	C56; J56; C66; J66; C76; J76; C86; J86	0331-00-0116-03 0331-00-0116-04	0330-00-0027-06
NIBP, Trend LCD (IEC, Italian)	C46; J46;	0331-00-0116-02	0330-00-0026-06
NIBP only (IEC, Italian)	C36; J36	0331-00-0116-01	0330-00-0025-06
NIBP, Trend LCD, SpO ₂ (IEC, Swedish)	C57; J57; C67; J67; C77; J77; C87; J87	0331-00-0116-03 0331-00-0116-04	0330-00-0027-07
NIBP, Trend LCD (IEC, Swedish)	C47; J47;	0331-00-0116-02	0330-00-0026-07
NIBP only (IEC, Swedish)	C37; J37	0331-00-0116-01	0330-00-0025-07

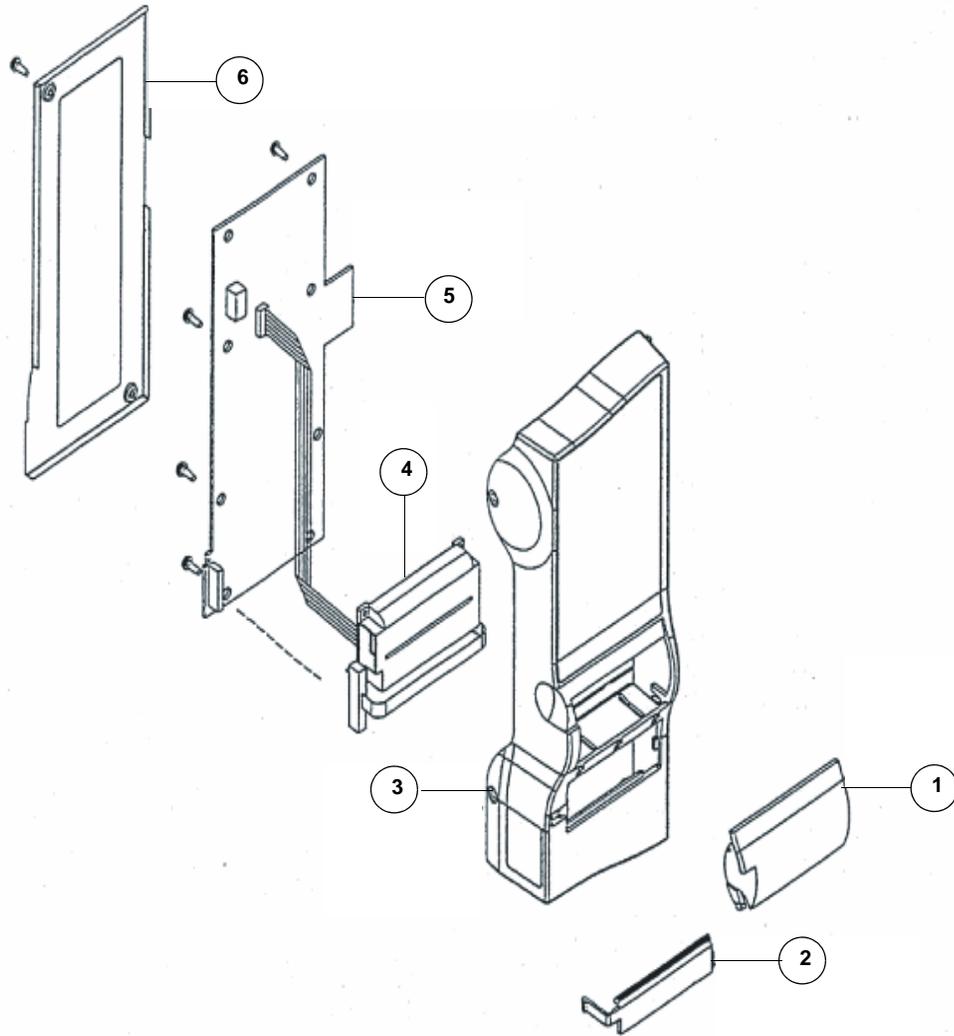


FIGURE 4-2 Isometric Drawing - Recorder Module

4.7.2 Recorder Module Isometric Parts List

FIGURE NO.	DESCRIPTION	PART NUMBER
1	Chart Paper Door	0380-00-0274
2	Chart Cutter	0380-00-0275
3	Recorder Main Housing	0380-00-0273-01
4	Printer Assembly w/printhead	0161-00-0015
5	Circuit Board, Includes Printer	0670-00-0583-02
6	Plastic Shield, Anti Static	0349-00-0251
N/S*	Label, Serial Number	0334-00-1304
N/S*	Label, Recorder Paper Replacement	0334-00-1435
N/S*	Captive Screw for Mounting	0217-02-0003
N/S*	Captive Washer for Above	0221-00-0121

* N/S are items not shown on drawing.

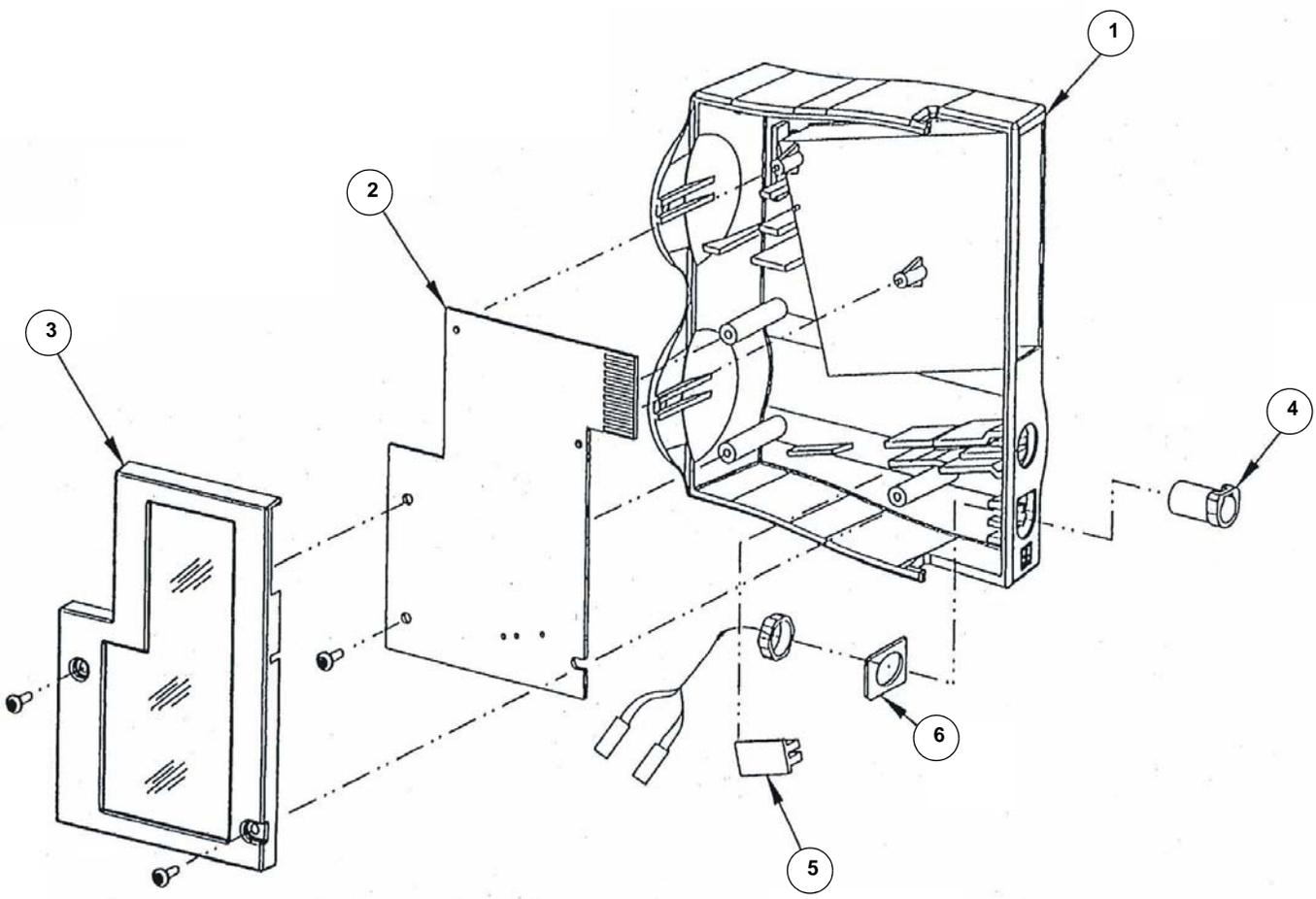


FIGURE 4-3 Isometric Drawing - Predictive Temperature Module

4.7.3 Predictive Temperature Module Isometric Parts List

FIGURE NO.	DESCRIPTION	PART NUMBER
1	Housing	0380-00-0271
2	Circuit Board	0670-00-0582
3	Anti Static Shield	0349-00-0252
4	Connector Assembly (without 9V battery)	0012-00-1335
5	Spacer, Probe	0432-00-0008
6	Washer, Flat	0221-00-0140
N/S*	Captive Screw for Mounting	0217-02-0003
N/S*	Captive Washer for Above	0221-00-0121

* *Not shown*

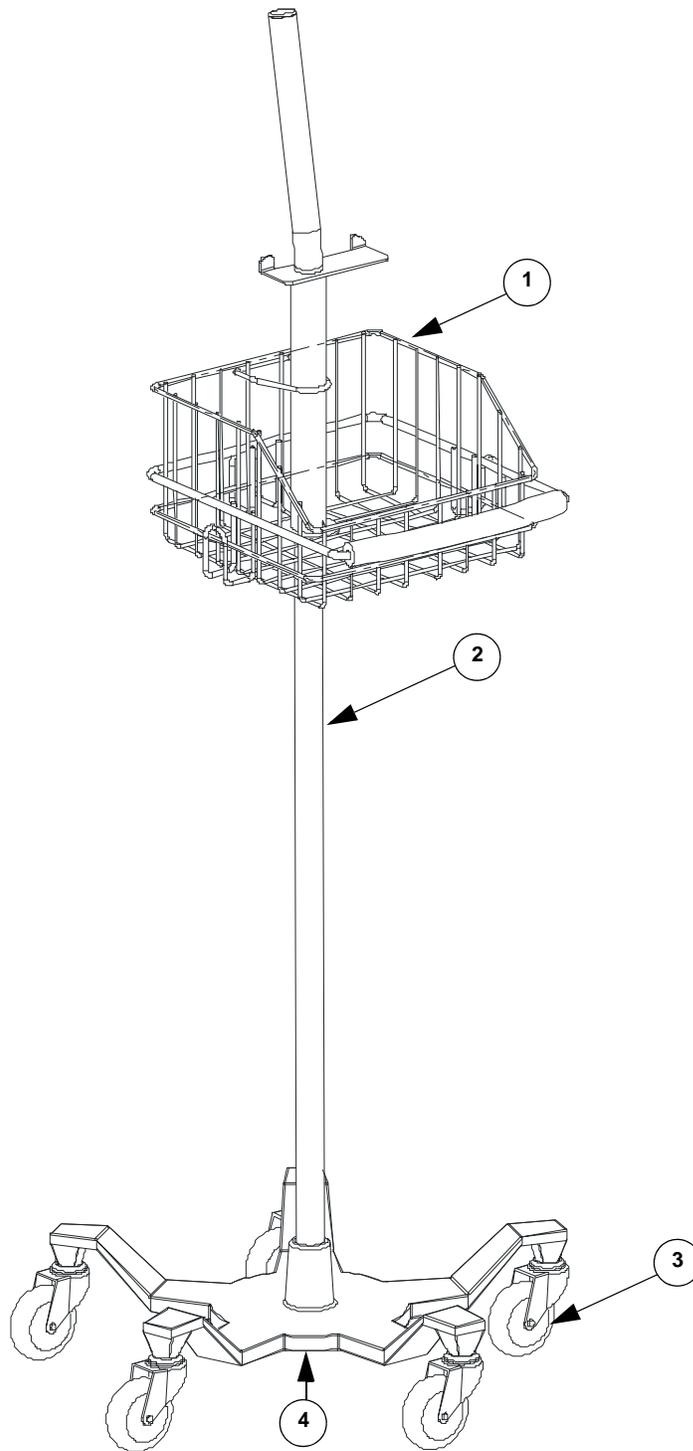


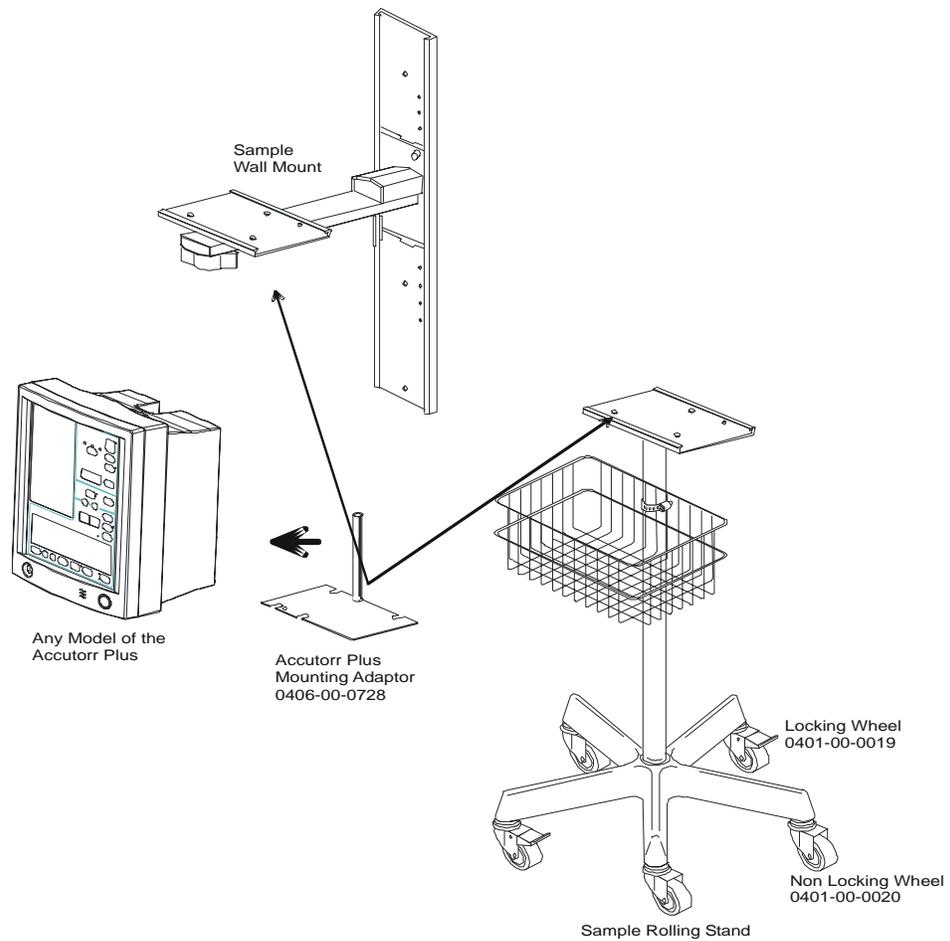
FIGURE 4-4 Isometric Drawing Mobile Stand - Type 2 (Black Base)

4.7.4 Mobile Stand Type 2 (Black Base) Assembly Parts List

FIGURE NO.	DESCRIPTION	PART NUMBER
1	Basket	0436-00-0117-03
2	Pole	0436-00-0118-02
3	Polyurethane Wheel	0401-00-0034
4	Base Casting	0436-00-0117-02
N/S*	Replacement Hardware Kit	0040-00-0305

* Not shown

4.7.5 Mounting Options



5.0 *Calibration*

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5.1 Introduction

The Accutorr Plus is a state of the art device employing digital determination and verification systems to obtain superior performance for the life of the product. Most function calibration constants are written into the operating software, therefore, for the most part, there are no means to calibrate or adjust system functions. The instrument contains extensive Service Diagnostics that will, in most cases, isolate a malfunction to the lowest serviceable module.

NOTE: **This procedure refers to this instrument as the UUT (Unit Under Test).**

All internal verifications and adjustments should be performed with the internal battery disconnected. Operate the UUT on the main power supply. This will insure a reliable power source for the test, as well as providing a measure of safety in case of accidental overload of the power source. To re-initialize the low battery detector circuits, reconnect the battery at the conclusion of all tests while the UUT is on A.C. power source. Reset the real time clock and date, if required.

5.1.1 Status and Error Code Table

The Accutorr Plus uses the various displays on the front panel to display the operational status. Error codes listed below can generally be resolved by the user however, error codes with an asterisk (*) may require resolution by a qualified technical service person.

5.1.1.1 Error Codes

Table 5-1

TYPE	CODE	DESCRIPTION	REASON
NIBP	8810	Retry - Unable to Measure	Motion artifact, cycle time-out, weak pulsations or no pulsations. A triple beep tone is generated.
	8811	Retry - Pump Higher	Insufficient cuff pressure. A triple beep tone is generated.
	8812	Stop - Cuff Overpressure	Excessive cuff pressure detected by the software. A triple beep tone is generated.
	8813	Stop - Unable to Measure	4 successive measurement attempts failed. A triple beep tone is generated.
TEMP (PTM)	8830	Check Probe	Tissue contact may have been lost.
	8831	Replace Probe	Defective probe or connection.
	8832	Battery Low	The 9V battery needs replacement.

Table 5-1

TYPE	CODE	DESCRIPTION	REASON
SpO ₂	8850	No Sensor	No sensor connected.
	8851	Sensor Off	Sensor not on patient. (Masimo® SpO ₂ only)
	8852	Interference	Interference on signal. (Masimo® SpO ₂ only)
	8853	Pulse Search	Unit cannot find signal. (Nellcor SpO ₂ Module will report “Pulse Search”-8853- when the sensor is not on the patient.)
	8854	Weak Pulse	Weak pulse detected. (Masimo® SpO ₂ only)
	8856	Check Sensor	Sensor problem. (Masimo® SpO ₂ only)
	8857	PR<21	Pulse rate is less than 21 bpm. (Nellcor SpO ₂ only)
	8857	PR<26	Pulse rate is less than 26 bpm. (Masimo® SpO ₂ only)
	8858	PR>249	Pulse rate is greater than 249 bpm. (Nellcor SpO ₂ only)
	8858	PR>239	Pulse rate is greater than 239 bpm. (Masimo® SpO ₂ only)
SYSTEM	984*	NIBP Hardware Failure	NIBP A/D failure detected.
	985*	NIBP Overpressure Circuit not Programmed	The overpressure circuit is not set to the current patient size.
	986*	NIBP Overpressure Circuit not Tracking	The two pressure transducers are not tracking each other.
	987*	Stop - Hardware Overpressure	Excessive cuff pressure detected by hardware over-pressure sensor. A triple beep tone is generated.
	988*	TEMP Bad Calibration	Thermometer needs calibration.
	990*	TEMP Illegal Mode	Thermometer switch is set wrong.
	991*	TEMP Module Failed	Thermometer internal failure.
	995*	SpO ₂ Uncalibrated	SpO ₂ fails calibration check.
	996*	SpO ₂ Failure	SpO ₂ failed self-test.

5.2 Precautions And Guidelines

In the event that the instrument covers are removed, observe these following precautions and general guidelines:

- Do not short component leads together.
- Perform all steps in the exact order given.
- Use extreme care when reaching inside the opened instrument. Do not contact exposed metal parts which may become live.

Read through each step in the procedure so it is understood prior to beginning the step.

5.3 Test Equipment And Special Tools Required

(Equipment types other than these listed may be utilized if they perform the required functions)

- Dynatech Nevada Non-Invasive Blood Pressure Simulator (Cuff Link)
- Power Supply - Power-Mate, 3A 20V
- Fluke DVM - Model 8050A
- Digital Storage Scope - Tektronix, 2230 100MHZ
- Stop Watch - Wilson LW #19
- SpO₂ Simulator - Biotek "Index"
- RS232 Test Connector (pins 2 and 3 shorted) - 9 pin male "D"
- 700 cc Dummy Cuff - 0138-00-0001-01
- Chart Paper - 0683-00-0447-01
- Water Bath - Cole-Palmer, model H-12-105-10
- Reference Quartz Thermometer - Hewlett-Packard model HP-2804A with Temp. Probe HP-1811A

NOTE: **Not approved for sale to customers in CE countries.**

5.4 Power-up Sequence, Internal Testing

1. Attach the AC power cord into the UUT rear panel AC Input Module.
2. Press the **ON/STANDBY** key to turn the UUT On. The UUT automatically performs internal self diagnostics. Verify that all the LED's (Light Emitting Diodes) display a series of scrolling LED tests or a countdown from 20 towards 0 (zero). After the initial power up sequence an "a" is displayed in the bed LED, a "0" is displayed in the Room LED's.
3. Press the **ON/STANDBY** key to turn the UUT off.

5.5 Service Diagnostics

The Service Diagnostics tests must be run in the sequence indicated. Not following the tests in the order shown may result in the test failing. The numbers and letters in parentheses after the title of each test, represent the room number and bed letter used to access the test.

5.5.1 Introduction (Hidden Key)

To enter the Service Diagnostics mode, while powering on the unit, press and hold the hidden key until two beeps are heard. The hidden key is the Adult symbol above the Patient **SETUP** key.

Verify that after the initial power up sequence a “0” is displayed in the Room LED, “a” is displayed in the Bed LED, and “ddd” is displayed in the Systolic LED’s.

5.5.2 Software Version Test (0a, 0b)

This test displays the installed software version (s) in the monitor. The results are displayed in the read outs illustrated in Figure 5-1 on page 5-5.

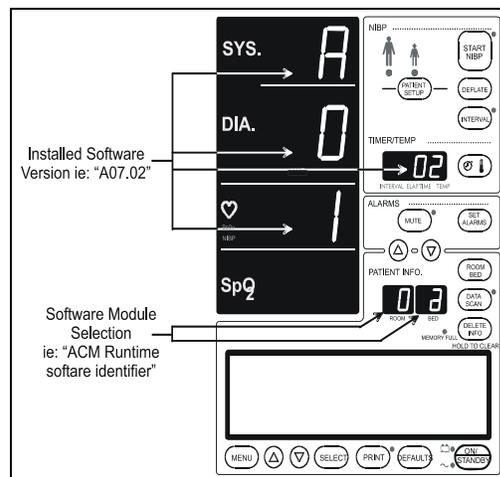


FIGURE 5-1 - Software Version Test

Confirm that the ROOM number is at “0”; otherwise use the “**ROOM/BED**” key to select the “ROOM”, and the **UP/DOWN** keys to set Room number to “0”.

Press **ROOM/BED** key to select BED. Use the **UP/DOWN ARROW** keys to select test “a” or “b”. Monitors without SpO₂ option may not display results for tests “0c” and “0d”. Press ROOM/BED again to lock in selection.

Press the **START NIBP** key.

Press the **DEFLATE** key until a beep is heard. This allows a selection of the next test.

Repeat process for test “b”.

Table 5-2

DESCRIPTION OF SOFTWARE MODULE	TEST ROOM NUMBER	SUB TEST PATIENT BED LETTER
ACM Runtime Software Version	0	a
ACM Boot Software Version	0	b
SpO ₂ ACM Runtime Software Version	0	c*
SpO ₂ ACM Boot Software Version	0	d*

NOTE: Monitors with Nellcor® and Masimo® SpO₂ do not report SpO₂ Runtime and Boot Software Versions.

5.5.3 Keypad Test

1. Press the Room Up arrow to change the Room Number to "1".
2. Press the Start NIBP key to run the keypad test.
3. Press any key on the keyboard. A number will appear in the Patient Bed Letter Display. This number is identified in Figure 5-1 on page 5-5. Verify that the correct number appears in the Patient Bed Letter Display when each key is pressed.

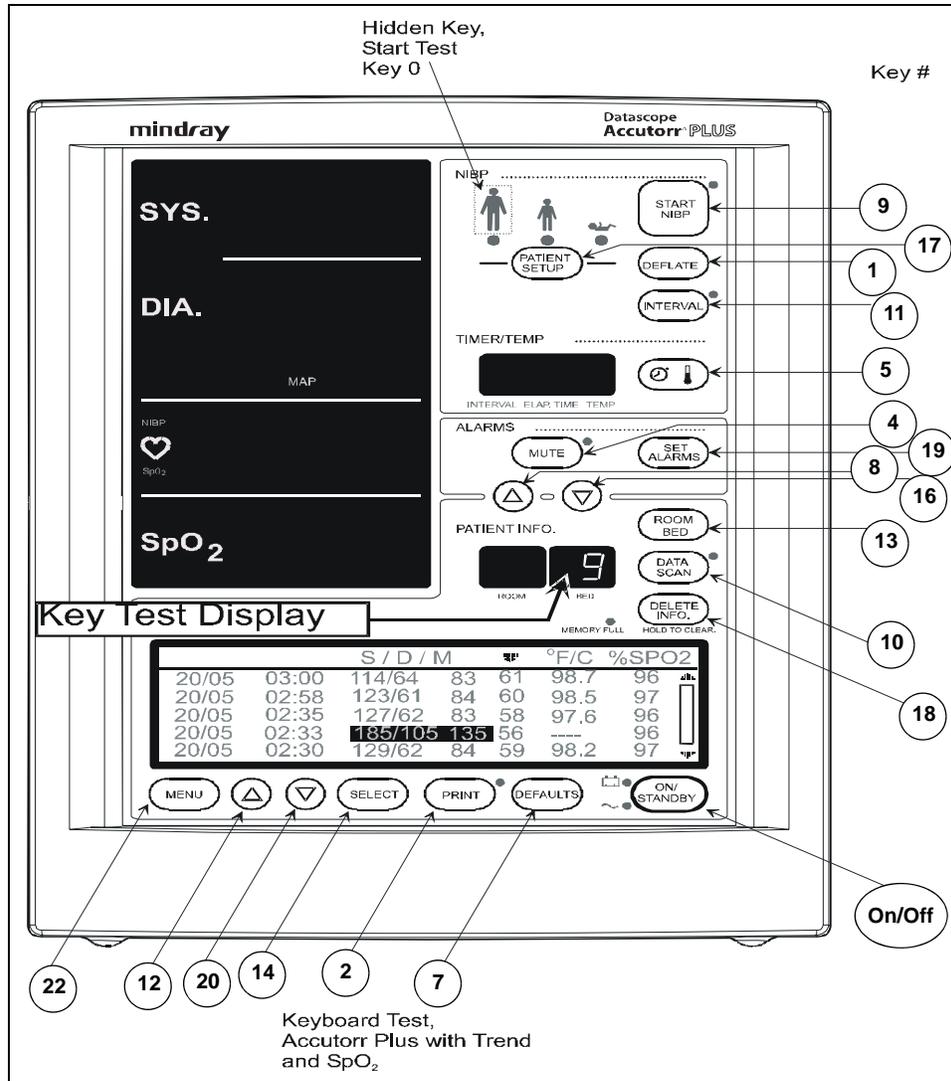


FIGURE 5-2

4. Press the **DEFLATE** key for 3 seconds to exit keypad test.

5.5.4 LED Test (2a, 2b)

This test allows the LED function to be verified by driving all seven LEDs with numbers from 0 to 9, in sequential order. For this test, all annunciator LEDs turn on for 1 second.

Table 5-3

TEST DESCRIPTION	TEST ROOM NUMBER	SUB TEST PATIENT BED LETTER
7 Segment LED Test	2	a
Annunciator LED Test	2	b

5.5.5 Communications Test (3a, 3b)

This test checks the integrity of the external communications systems. Test 3a checks the external RS232 interface and requires that the transmit and receive pins be connected together. Test 3b checks the Download port and requires that the tip (transmit) and ring (receive) pins be connected together. The CRC table is transmitted and received. If the CRC data received matches the CRC table transmitted, the test passes; otherwise a failure is reported.

Table 5-4

TEST DESCRIPTION	SHORT CONNECTOR PINS	TEST ROOM NUMBER	SUB TEST PATIENT BED LETTER
RS232 Port Test	Transmit (2) and Receive (3)	3	a
Download Port Test	Tip and Ring	3	b

5.5.6 Recorder Test (4)

1. Select Room Number 4 and press the NIBP **START** key to activate the test. This test prints out a pattern on the recorder if a recorder module is attached. A strip similar to Figure 5-3 will be printed.

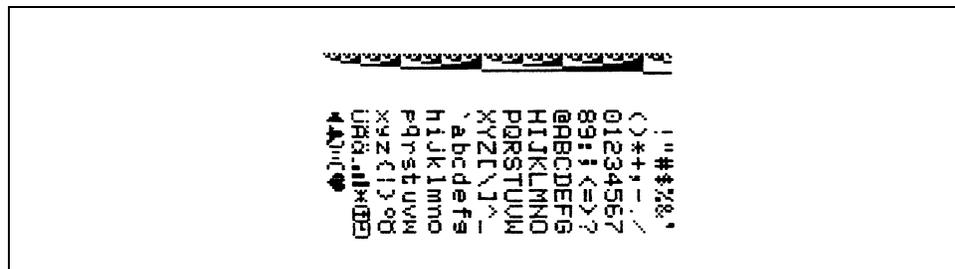


FIGURE 5-3

5.5.6.1 Recorder Print Head Adjustment

NOTE: This test and adjustment is performed only after a new printhead is installed.

1. Disconnect the printhead ribbon cable from the connector.
2. Check the oscillator frequency at TP-1 on the recorder control board. Proper frequency selection is determined by the printhead sensitivity. (The sensitivity rank is marked on the bottom side of the printhead flex cable, near the 90° bend in the cable.) Table 5-5 on page 5-9.

Table 5-5

PRINT HEAD RANK	OSCILLATOR OUTPUT (KHZ)	
	Minimum	Maximum
A	9.7	10.9
B	10.5	12.1
C	11.6	13.4

3. Adjust R-1 to the correct frequency.

CAUTION: Increasing printhead operating frequency beyond the specified limits will shorten the printhead life or result in immediate permanent damage.

4. Reconnect the printhead ribbon cable, and run a test strip to confirm proper print density. The print density is equally dependent on the printhead temperature, as well as on the sensitivity of the chart paper used. We recommend that the standard chart paper (P/N 0683-00-0447-01) for this printer be used for the print test.

5.5.7 Pump Test (5)

Select Room Number 5 and press NIBP **START** key to activate the test.

This test evaluates the ability of the pump to pressurize a fixed volume representative of an adult cuff to a typical adult pressure.

A fixed volume of 700 cc is pumped to a pressure of 300 mmHg. While the pump is operational, the elapsed time is displayed in the Timer/Temperature display. When the target pressure is reached, the elapsed time display holds its current reading and the pump deflates the chamber for another test. The test passes if the chamber is inflated in less than 35 seconds. Pressing the **DEFLATE** key at any time during the test causes the NIBP module to open all valves and ends the test. Pressing and holding the **DEFLATE** key for three (3) seconds clears the MAP display and exits the test.

5.5.7.1 Bleed Rate Test (6a, 6b)

Press the NIBP **START** key to activate the selected test. See Table 5-6 on page 5-10.

This test evaluates the ability of the instrument to maintain a constant bleed rate, for the purpose of accurate and repeatable NIBP measurements. This test also evaluates the ability of the system to reduce cuff pressure quickly.

A fixed volume of 700 cc is pumped to approximately 20 mmHg over the specified start pressure (see Table 5-6 on page 5-10), then vented to atmosphere through one of two different valves. During the test, the MAP display indicates the real-time system pressure and the Timer/Temperature display indicates the elapsed time in seconds. When the stop pressure is reached, the MAP display is blanked and the elapsed time displays the current reading. Pressing the **DEFLATE** key ends the test and deflates the chamber. Pressing and holding the **DEFLATE** key for three seconds clears the MAP display and exits the test. Each test is uniquely identified in the Patient Bed Letter Display as described in Table 5-6 on page 5-10. The table identifies each test, the corresponding start and stop pressures and required completion times.

Table 5-6

TEST DESCRIPTION	START PRESSURE (MMHG)	STOP PRESSURE (MMHG)	TIME (SEC.)	TEST ROOM NUMBER	SUB TEST PATIENT BED LETTER
Linear Bleed Valve Test	180	60	15-25 secs.	6	a
Dump Valve Test	250	20	14 sec. max.	6	b

5.5.8 Leak Test (7)

Select Room Number 7 and press the NIBP **START** key to activate the test.

This test evaluates the ability of the system to maintain a steady pressure.

A fixed volume is pumped up to an initial differential pressure of approximately 250 mmHg and monitored for a fixed period of time. While the pump is operational, peak pressure is displayed in the MAP display. When the target pump pressure is reached, the peak pressure is frozen in the MAP display during a five second dwell. During leakage measurement, the current pressure leakage is displayed in the MAP display and the elapsed test time (in seconds) is displayed in the Temperature/Time/Interval display. After the leakage measurement time has elapsed, the MAP and Temperature/Time/Interval displays are blanked and a "00" (Pass) or "FF" (Fail) will be displayed in the Bed window. Pressing the **DEFLATE** key at any time during the test causes the NIBP module to open all valves and ends the test. The maximum pressure drop is no more than 10 mmHg in any 90 second period when connected to a 700 cc volume.

Pressing the **DEFLATE** key ends the test and deflates the chamber.

Pressing and holding the **DEFLATE** key for three seconds clears the MAP display and exits the test.

5.5.9 Over Pressure Test (8a, 8b, 8c)

Select Room Number and Bed Letter per Table 5-7 on page 5-11. Press the NIBP **START** key to activate the test.

This test evaluates the ability of the system to prevent an over pressure condition, independent of software control, for each of 3 over pressure settings. A fixed volume of 700 cc's is pumped to a target pressure that is above the maximum over pressure specified for the respective over pressure limit (see Table 5-7 on page 5-11), while displaying the real-time system pressure in the MAP display. For this test, the software over pressure monitor is disabled. On completion, the MAP display indicates the maximum pressure reached and the Patient Bed Letter Display indicates if the over pressure sensor was activated (00) or not (FF). Pressing the **DEFLATE** key at any time during the test causes the NIBP module to open all valves and ends the test.

Following each over-pressure hardware test, the UUT must be turned off in order to re-enable the pump.

Table 5-7

TEST SIZE/MODE	TARGET PUMP PRESSURE (MMHG)	TEST ROOM NUMBER	SUB TEST PATIENT BED LETTER
Low	157, ± 5	8	a
Medium	210, ± 10	8	b
High	315, ± 15	8	c

5.5.10 Pulse Channel DC Offset Test (9a, 9b, 9c)

Select Room Number and Bed Letter per Table 5-8 on page 5-11, and press the NIBP **START** key to activate the test.

This test measures the DC offset for each of the three electronic gain settings available on the pulse channel. Results for each gain setting are displayed in the Timer/Temperature display (in Volts). Table 5-8 on page 5-11 describes the tests performed.

Table 5-8

TEST DESCRIPTION	ACCEPTABLE LIMIT (V)	TEST ROOM NUMBER	SUB TEST PATIENT BED LETTER
Gain 1 (Low) Test	1.50 to 1.83	9	a
Gain 2 (Med) Test	1.50 to 1.83	9	b
Gain 3 (High) Test	1.50 to 1.83	9	c

5.5.11 Pulse Channel Average Noise Test (10a, 10b, 10c)

Select Room Number and Bed Letter per Table 5-9 on page 5-12, and press the NIBP **START** key to activate the test.

This test measures the average noise for each of three electronic gain settings available on the pulse channel. Results for each gain setting are displayed in the Timer/Temperature display (in millivolts). Table 5-9 on page 5-12 describes the tests performed.

Table 5-9

TEST DESCRIPTION	ACCEPTABLE LIMIT (MV)	TEST ROOM NUMBER	SUB TEST PATIENT BED LETTER
Gain 1 (Low) Test	<25	10	a
Gain 2 (Med) Test	<50	10	b
Gain 3 (High) Test	<75	10	c

5.5.12 Main Pressure Transducer Verification Test (11a, 11b, 11c)

This tests the calibration of the main pressure transducer in LOW, MED, and HIGH modes. This is done by comparing the readings of the UUT to an external pressure gauge in LOW mode below 100 mmHg, in MED mode between 100 mmHg to 200 mmHg, and in HIGH mode between 200 mmHg to 300 mmHg. In the event of a disagreement between the device and an external gauge, the transducer must be calibrated by performing the calibration in section 5.5.15 "Main Pressure Transducer Calibration" on page 5-14.

1. Select diagnostic test "11" (Room) "a" (Bed).
2. Press the **START** NIBP key to start the LOW calibration test. Verify that the pump comes on, the pressure increases, and then the pump stops. After 10 seconds, verify that the pressure settles below 100 mmHg. Compare the final pressure displayed to an accurate external pressure gauge. The MAP LEDs reading should agree within $\pm 1\%$ with the external pressure gauge. If it does not agree, a failure has occurred and proceed to section 5.5.15 "Main Pressure Transducer Calibration" on page 5-14.
3. Press the **DEFLATE** key to release the pressure and exit the test.
4. Select diagnostic test "11" (Room) "b" (Bed).
5. Press the **START** NIBP key to start the MED calibration test. Verify that the pump comes on, the pressure increases, and then the pump stops. After 10 seconds, verify that the pressure settles between 100 mmHg and 200 mmHg. Compare the pressure displayed to an accurate external pressure gauge. The pressure MAP LEDs reading should agree within $\pm 1\%$ with the external pressure gauge. If it does not agree, a failure has occurred and proceed to section 5.5.15 "Main Pressure Transducer Calibration" on page 5-14.
6. Press the **DEFLATE** key to release the pressure and exit the test.
7. Select diagnostic test "11" (Room) "c" (Bed).

8. Press the **START** NIBP key to start the HIGH calibration test. Verify that the pump comes on, the pressure increases, and then the pump stops. After 10 seconds, verify that the pressure settles between 200 mmHg and 300 mmHg. Compare the final pressure displayed to an accurate external pressure gauge; the MAP LEDs reading should agree within $\pm 1\%$ with the external pressure gauge. If it does not agree, a failure has occurred and proceed to section 5.5.15 "Main Pressure Transducer Calibration" on page 5-14.
9. Press the **DEFLATE** key to release the pressure and exit the test.

5.5.13 Verification of Accutorr Plus Pneumatic Performance using the "Cufflink" NIBP Simulator (11d)

Select Room Number 11 and Bed Letter d, and press the NIBP **START** key to activate the test.

For these tests, program the Cufflink NIBP simulator to perform the desired test. Instead of pumping up the cuff, this test uses the Cufflink simulator to verify the Accutorr pressure reading for the NIBP Leak Test, Over Pressure test, and the Main Pressure Transducer Verification Test. The Accutorr displays the pressure in the MAP display. Pressing the **DEFLATE** key at any time during the test causes the NIBP module to open all valves and ends the test. Pressing and holding the **DEFLATE** key for three seconds clears the MAP display and exits test. The Cufflink simulator must be exited separately.

NOTE: **The reading and setting accuracy will be dependent on the accuracy of the Cufflink calibration and the Accutorr Plus condition.**

The Cufflink standard dynamic pressure simulation may produce Systolic / Mean / Diastolic read outs on the Accutorr Plus outside of the specified limits. The pressure simulation results may not be accepted as a measure of the Accutorr Plus clinical performance.

5.5.14 Over-pressure Transducer Verification <12c, 12a, 12b>

This test verifies that the over-pressure transducer is calibrated correctly. Calibration is checked in the Low level pressure mode so that the limit displayed in the MAP window should say 158 mmHg (± 1). If it does not, the transducer needs to be calibrated by proceeding to 5.5.16 "Over-pressure Transducer Calibration" on page 5-14. The over-pressure transducer should also be verified in the High and Mid level pressure modes.

1. Select diagnostic test "12" (Room) "a" (Bed). Low Limit
2. Press the **START** NIBP key to start the test.
3. Verify that the over-pressure value displayed in the MAP LEDs is 158 mmHg (± 1).
4. Repeat steps 1 through 3, but select test "12" "c" to check over-pressure limit, 315 mmHg (± 15); and test "12" "b" for Mid level over-pressure limit, 210 mmHg (± 10).
5. Press the **DEFLATE** key to exit this test.

5.5.15 Main Pressure Transducer Calibration

NOTE: This procedure should only be performed in the event that there was a failure in 5.5.12 "Main Pressure Transducer Verification Test (11a, 11b, 11c)" on page 5-12.

This is the procedure for calibrating the main pressure transducer in the event that there is a disagreement between the UUT and the external pressure gauge in the proceeding test. The device is calibrated by comparison with the Cufflink simulator at 158 mmHg (± 1) and then by adjusting R540 on the 0670-00-1143 PCB.

1. Connect the Cufflink simulator to the Accutorr Plus cuff connector, and connect a 700 cc test chamber to the open port of the simulator. Select the manometer function of the simulator.
2. Select diagnostic test "11" (Room) "d" (Bed).
3. Press the **START NIBP** Key to start HIGH calibration procedure.
4. Pump up the Cufflink simulator to 158 ± 1 mmHg.
5. Allow pressure to stabilize for 10 seconds. Read the pressure in the MAP display.
6. Adjust R540 on the 0670-00-1143 PCB until the MAP readout is the same as the simulator's manometer reading.
7. Press the **DEFLATE** key to exit this test.
8. Repeat 5.5.12 "Main Pressure Transducer Verification Test (11a, 11b, 11c)" on page 5-12.

5.5.16 Over-pressure Transducer Calibration

NOTE: This procedure should only be performed if a failure occurred in steps 1 through 3 of 5.5.14 "Over-pressure Transducer Verification <12c, 12a, 12b>" on page 5-13.

This is the procedure for calibrating the over-pressure transducer in the event that the display does not read 158 mmHg during the test for Low pressure mode in 5.5.14 "Over-pressure Transducer Verification <12c, 12a, 12b>" on page 5-13. The transducer is calibrated using R504 on the 0670-00-1143 PCB.

1. Adjust R4 on the 0670-00-0584-01 PCB, or R504 on the 0670-00-1143 PCB until the MAP readout is 158 mmHg.
2. Repeat 5.5.14 "Over-pressure Transducer Verification <12c, 12a, 12b>" on page 5-13.

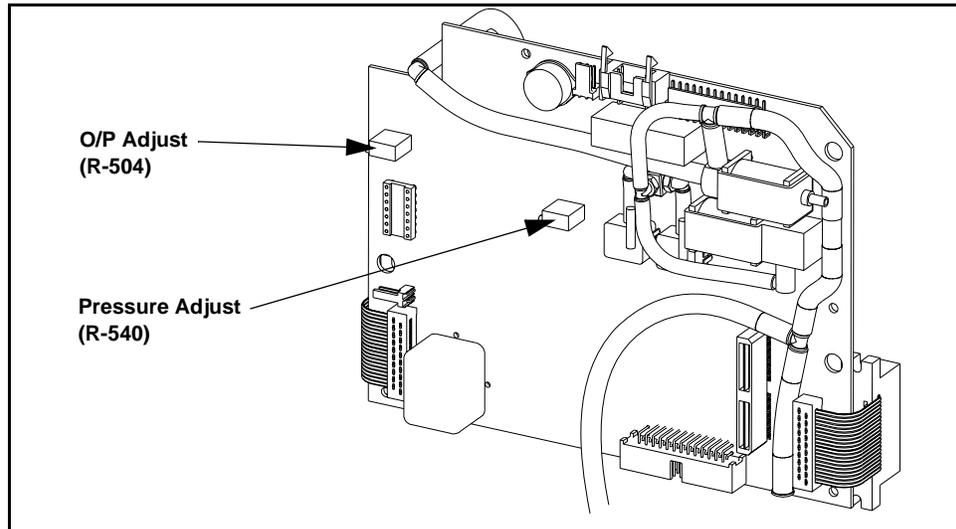


FIGURE 5-4

5.5.17 Battery Selection (13)

This section will allow the user to configure the unit for a Sealed Lead Acid or Lithium Ion battery.

1. Select diagnostic test (Room) "13".
2. Press the Start NIBP to enable the selection process. The pump will NOT start up.
3. The Diastolic display will show the currently configured battery type. Sealed Lead Acid will be represented by "La" and Lithium Ion will be represented by "Li".
4. Using the Patient Info **UP/DOWN ARROW** keys, select the appropriate battery type.
5. Press the **DEFLATE** key to confirm your choice. If the **DEFLATE** key is not pressed, the change will not take effect.

5.6 Predictive Thermometer Verification And Calibration

The Water Bath Method, utilizes laboratory grade stirred water bath to confirm that the PTM is operating within the specified limits.

In case of failure or inaccuracy of readings, the System Calibration Procedure may be followed to re-adjust the device to factory specifications.

This procedure requires high accuracy test equipment and therefore it is not recommended for field calibration. Mindray DS USA, Inc. offers a comprehensive factory service program to support this product.

5.6.1 Water Bath Method

1. Prepare a water bath set to 89.6 to 110.0°F as a temperature reference. Confirm temperature with a separate precision thermometer.
2. Snap a protective sheath onto the temperature probe, and immerse into the reference water bath for 30 seconds, or until the temperature display stops flashing. Record the temperature shown on the temperature display.
3. Apply the correction factor, shown in Table 5-10 on page 5-16, to obtain the calibrated measurement.

Table 5-10

CELSIUS READOUTS		FAHRENHEIT READOUTS	
Range	Subtract	Range	Subtract
32.0 to 41.0	0.6	89.6 to 102.0	1.1
41.0 to 43.0	0.5	102.1 to 106.0	1.0
		106.0 to 110.0	0.5

4. Compare readouts after correction factors are calculated. Proceed to System Calibration Procedure if readings are out of specification.

5.6.2 System Calibration Procedure

1. Connect a fresh 9 volt battery or an external power supply set to 9.1V to the predictive thermometer.

NOTE: **Newer modules do not contain a 9V battery. Skip this step.**

2. Set SW2-3 to closed position (the switch is towards the PCB). Connect resistor decade box to the temperature probe connector. Set the decade box to 8343 ohms, ± 2 ohms.

NOTE: **(All other settings of SW2 should be in the open position; away from the PCB.)**

3. Connect the DVM to J4-2 (-) and J4-7 (+) output jacks.
4. Jumper J4-2 and ground terminal (J2-1) jacks.
5. Switch power supply on or turn on the AccutorrPlus.
6. Adjust R1 until a reading of 100 mV, ± 5 mV is on the DVM.
7. Adjust the decade box to 4746 ohms, ± 2 ohms. Record the voltage displayed on the DVM.
8. Connect the DVM + lead to J4-4. Adjust R2 until the DVM reading is the same as the one recorded in step "7", ± 1 mV.
9. Remove all jumpers and test leads. The calibration is completed.
10. Set the decade box back to 8343 ohms. Power cycle the unit (switch off then on). The initial start-up temperature of 85.0oF should be displayed.

5.6.3 Temperature Verification Test, Infrared Thermometer (Applicable Only To Units Equipped With A Temperature Option)

1. Pre-heat water bath to 100°F. Place floating Black Body device into water bath and allow to stabilize until step 7, or a minimum of 30 seconds.
2. Prepare the thermometer for the verification process, by removing any disposable probe covers. Clean the probe lens with a swab dipped in alcohol.
3. Completely cover probe tip with a piece of aluminum foil, from the lens to the probe neck portion. Allow 5 minutes for the probe and foil to stabilize at ambient temperature.
4. Activate the thermometer, by pressing the button. Read the ambient temperature displayed and record the number as $T_A = \underline{\hspace{2cm}}$.
5. Remove the aluminum foil.
6. Check the water bath temperature against a laboratory grade mercury thermometer, with a verified accuracy of 0.4 °F (0.2 °C) or better. Record the water bath temperature as $TT = \underline{\hspace{2cm}}$.
7. Attach a disposable probe cover to the thermometer head. Insert the head into the floating Black Body cavity, such that the instrument is looking into the needle shaped end.

8. Press the button to measure the temperature. Record the temperature as $T_{DCALC} = \text{_____}$.
9. Select the appropriate correction factor from the following choices:
10. Core temperature correction: $K_{core} = 1.087$
11. Oral temperature correction: $K_{ora} = 1.058$
12. Rectal temperature correction: $K_{rectal} = 1.095$
13. The standard infrared thermometer is calibrated to indicate Core temperature, thus the correction factor to be used is $K = 1.087$.
14. Calculate the display temperature according to the following formula:

$K(T_T - T_A) + T_A = T_{dcalc}$ where:

T_{dcalc} is Calculated Display Temperature.

$K_{core} = 1.087$ Correction Factor for Core Temperature.

T_T is Target Temperature.

T_A is Ambient Temperature.

Sample Calculation:

Ambient temperature (T_A) measured: 72 °F

Water Bath temperature (T_T) measured: 98.6 °F

Correction Factor (K_{core}) = 1.087

$1.087(98.6 - 72) + 72 = 100.9$ °F thus,

Temperature displayed by thermometer is 100.9 °F, and calculated temperature is 100.9 °F, the accuracy has been verified.

Temperature value deviations: The calculated value is a function of the accuracy of the water bath temperature. As an example, a $\pm 1\%$ reading error of water temperature will result in a ± 1 °F reading input into the formula, resulting in a final calculated values of 99.9 to 101.9 °F.

With a display resolution of ± 1 digit and an over all resolution of ± 0.2 °F, the final, calculated reading may fall between 98.6 and 102.2.

5.6.4 Low Battery Sensing

The low battery threshold is not adjustable. When the battery has reached the low battery threshold, U4 and Q2, on the power supply, report this condition to the CPU on the Accutorr Plus.

5.7 Battery Test For Accutorr Plus

NOTE: During this test, the real time clock will reset.

1. Disconnect the cable from the battery and remove the AC power cord from the UUT. Connect the power supply positive output to the battery cable positive terminal and the negative power supply terminal to the negative terminal of the battery cable. Set the power supply voltage to 14.5, \pm .1 volts for SLA battery, 12.5 \pm .1 volts for Li-Ion battery.
2. Press the **ON/STANDBY** key to power up UUT. Verify that the normal power up sequence as described in this document occurs and that the indicator for the battery symbol on the keypad is lit.

5.7.1 Low Battery Indicator and Low Battery Cut-Off

CAUTION: During this test, the real time clock will be reset and any Trend information will be lost. Temporary user preference settings will also be erased.

Power Supply requirement: the power source used for testing needs to source 0 to 15 VDC and able to withstand current spikes of 3 to 4 Amperes without current or voltage sags.

1. Remove the battery pack and AC mains cord. Remove monitor rear cover. Disconnect the Battery Connector cable from the power supply.
2. Set the external power supply voltage to 14.5 VDC, current limit set to 4 Amps. Connect the positive of the external power supply to the input side of the F3 fuse. (4 A) Connect the negative side of the external power supply to the negative pin of the Accutorr Plus power supply or to the chassis near the battery connector.
3. Connect a DVM to the load side of F3 of the Accutorr Plus power supply and the chassis of the Accutorr Plus. This method will read the actual voltage applied to the internal power supply and will be the reading used to determine the Low Battery Indicator and Low Battery Cut-Off voltages.
4. Turn the monitor ON, and allow to complete the self check initialization.
5. Slowly decrease the external power supply voltage, in approximately 100 mv. steps, every 30 seconds. Note the voltage where the Battery LED begins to flash. Note this voltage and compare to the specification in the following table. Continue to decrease the voltage until the monitor turns off. This is the Low Battery cut-off voltage. Note this voltage and compare to the specification in the following table.

Table 5-11

TYPE OF BATTERY INSTALLED	LOW BATTERY INDICATOR LIMITS	LOW BATTERY CUT-OFF LIMITS
Sealed Lead Acid	10.95 to 11.63 VDC	9.8 to 10.7 VDC
Lithium Ion	9.95 to 10.61 VDC	8.7 to 9.5 VDC

6. Turn the monitor Off, re assemble and install the battery pack.

5.7.2 Set the Current Time

1. Press and hold the **TIMER/TEMP** key for 6 seconds. The hour digit only displays.
2. Press the **UP** or **DOWN ARROW** key to change the number.
3. Press the **TIMER/TEMP** key to activate the minute display.

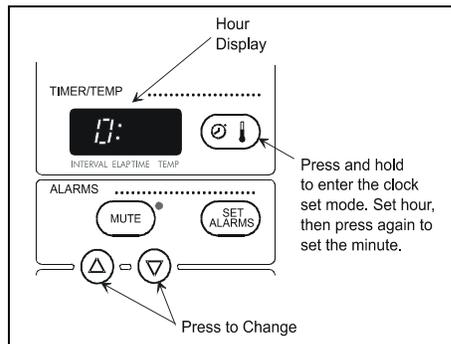


FIGURE 5-5 Hour Display

NOTE: The Accutorr Plus always displays time in a 24 hour format.

4. Press the **UP** or **DOWN ARROW** key (12 or 13) to change the number. Continue pressing the **TIMER/TEMP** key and the **ARROW** keys to set the month, day, and year (in that order).

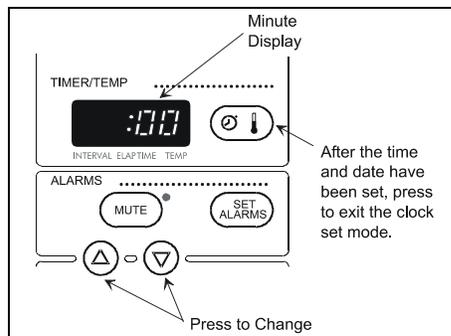


FIGURE 5-6 Minute Display

5.8 NIBP Normal Operation

1. Press the left **ARROW** key on the “Cufflink” Simulator to highlight **SELECT BP**, then press the **ENT** key. Set pressure test to 120/80 (90) and press the **ENT** key.
2. Attach the simulator “Cufflink” to the input pressure fitting of UUT.
3. Press the **INTERVAL** key of the keypad until a 1 is shown in the Timer/Temp./ Interval LED of the UUT. Press the **PATIENT SIZE** key to select Adult size indicator.
4. Press the Set **ALARMS** key to enter the alarm setting mode. Use the **UP** and **DOWN ARROW** keys to set the Systolic Low alarm to 115 mmHg.
5. Press the Set **ALARMS** key again and set the Diastolic Low Alarm to 95 mmHg.
6. Press the Start **NIBP** key. Verify the monitor takes a measurement and the Systolic and the Diastolic low alarms are violated. The LED’s for these parameters will blink on and off and an alarm tone will sound for the violation. Press the **MUTE** Key to silence the alarms.
7. After the fifth measurement is complete, allow the cuff to pump up. Press **DEFLATE** key. Verify cuff deflates.
8. Review the data that was stored in the database, by scrolling through the patient trend information. Use the **UP** and **DOWN ROOM** and **BED** keys or LCD display of the UUT and verify that the Systolic and Diastolic information is available in the LED’s for each stored settings
9. Remove the cuff from the UUT and press the **START** key. Confirm that the UUT pump runs and that it displays 8810 in the Room/Bed window within 60 seconds and attempts another inflation. Press the **DEFLATE** key to stop test.

5.9 Trend Memory Initialization

1. To clear the UUT Trend Memory for all patient settings, press and hold the **DEFLATE INFO.** key while powering up the unit.

5.10 SpO₂ Normal Operation (Accutorr Plus model with SpO₂)

NOTE: This procedure can be accomplished with the Biotek "Index" SpO₂ simulator or an equivalent SpO₂ simulator.

The purpose of this test is to verify that an SpO₂ signal is recognized, alarm limits are captured and the data is trended. A full operational test may be conducted, if so warranted, within the limits of the published specification. See chapter 3 of this manual for specifications.

1. Set the simulator to an SpO₂ saturation level of 98%, pulse rate of 60 bpm, and a pulse amplitude of 100%.
2. Set the Accutorr Plus SpO₂ HI alarm limit to 95% and the pulse rate HI alarm limit to 55 bpm.
3. Connect an NIBP cuff or a suitable simulator to the Accutorr Plus and start a measurement.
4. Confirm that the Accutorr Plus has determined an SpO₂ saturation level and has violated the SpO₂ HI alarm and the pulse rate HI alarm (flashing digits and alarm tone). Press the **MUTE** key to silence the alarms.
5. Check the trend screen to confirm that the measurement information has been saved.
6. Set the SpO₂ HI alarm to OFF and SpO₂ LOW alarm to 86.
7. Set the simulator to an SpO₂ saturation level of 90%, pulse rate of 95 bpm, and the pulse amplitude to approximately 10% (low perfusion Masimo® SpO₂ only).
8. The Accutorr Plus may intermittently determine SpO₂ values or indicate a status code of 8853 (Pulse Search) or 8854 (Weak Pulse / Low Perfusion will display). Adjust the simulator's pulse amplitude up and down until either status code of 8853 or 8854 displays.
9. Restore normal simulation parameters as described in step 1.
10. Remove the sensor from the simulator to induce a status code of 8851 (Sensor Off Masimo® SpO₂ only).
11. Disconnect the sensor from the Accutorr Plus to produce a status code of 8850 (No Sensor).

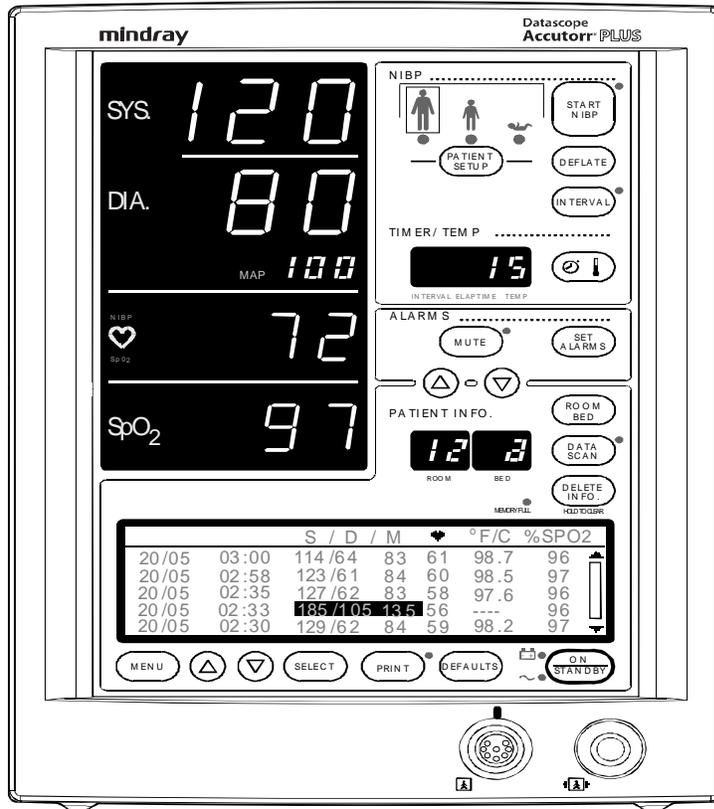


FIGURE 5-7 - Accutorr Plus NIBP with Trend Screen and Mindray DS SpO₂

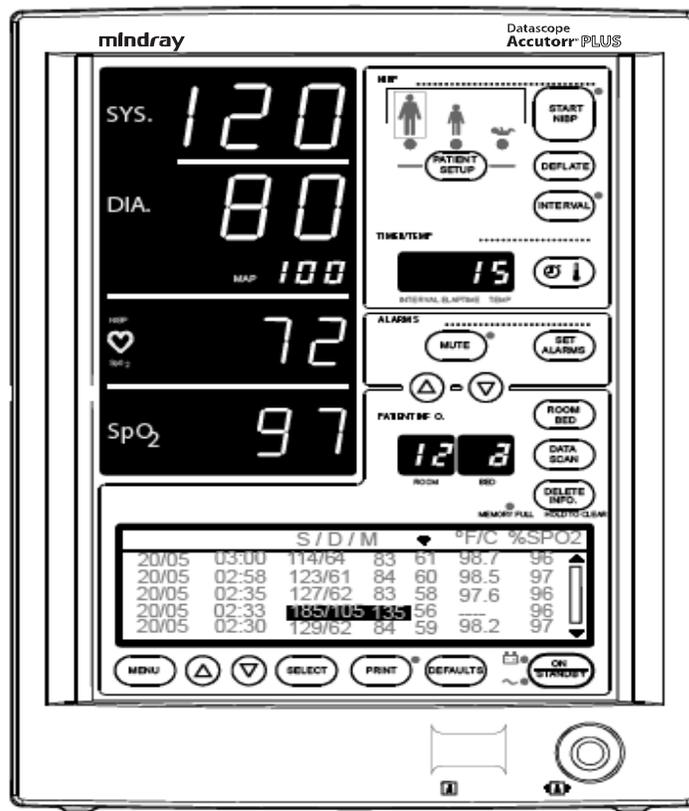


FIGURE 5-8 - Accutorr Plus NIBP With Trend Screen and Nellcor® or Masimo® SpO₂

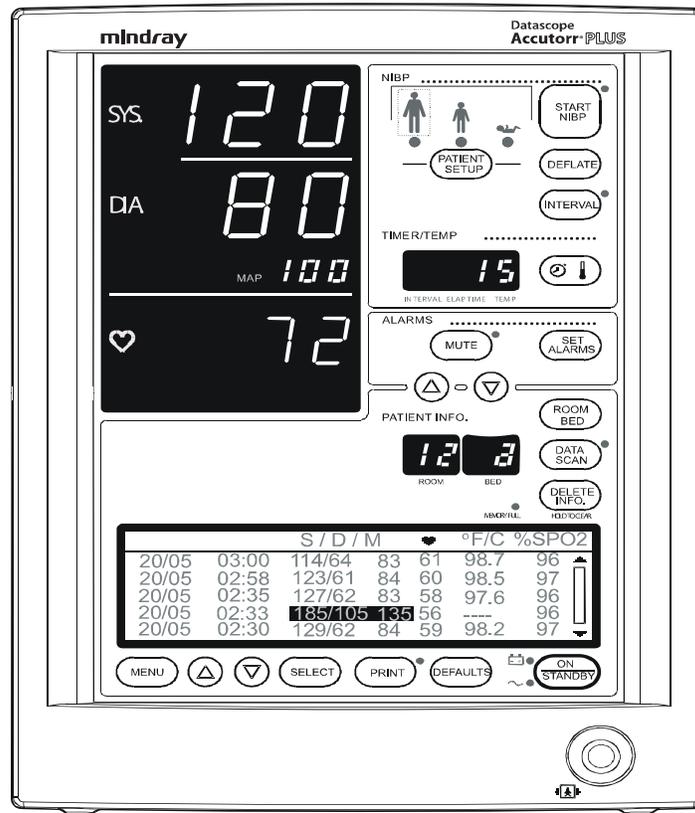


FIGURE 5-9 - Accutorr Plus NIBP with Trend Screen

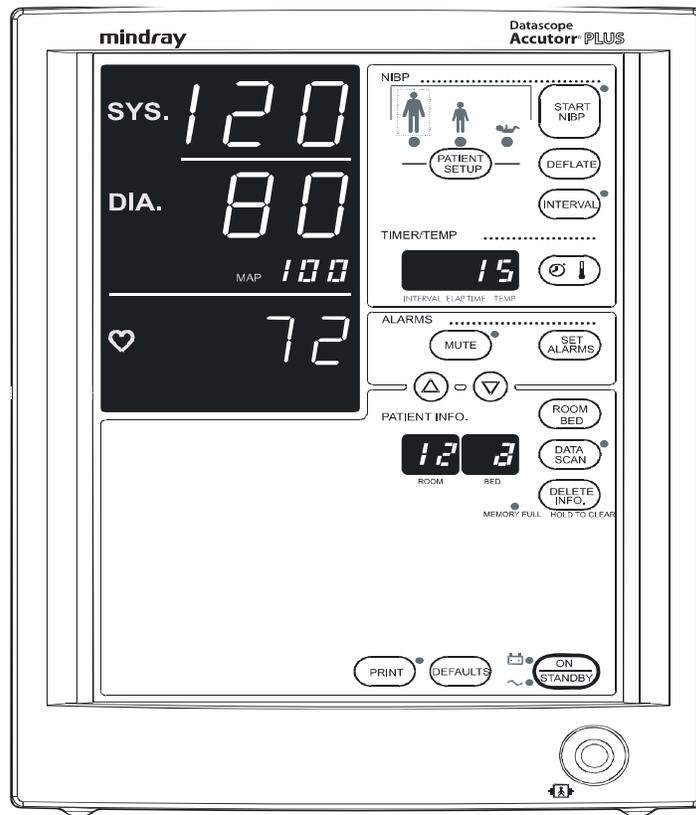


FIGURE 5-10 - Accutorr Plus NIBP

6.0 *Preventive Maintenance*

6.1 Introduction	6-1
6.2 Limitations Of Physiological Simulators	6-2
6.3 Preventive Maintenance Schedule	6-3

6.1 Introduction

The intent of this procedure is to ensure that the product continues to be safe and effective in its intended environment. Complete knowledge of the instrument characteristics and its relationship to the clinical environment are useful in determining changes in the performance of the monitor, and the clinical limitations of the device.

As a general rule, the instrument is not tested to the full limits of its capabilities at each service interval. Rather, representative points are tested and the results recorded. It is important to note that while not all functions are tested to the absolute limits, every function and option should be exercised. Declining performance over time is frequently the first indication of the need for more extensive service action.

6.2 Limitations Of Physiological Simulators

The physiological simulator is the principle aid for problem solving. Simulators have many of the same limitations as the devices that they will test. It is imperative that the simulator correlate well to a "Reference Standard*". The electronic simulators available attempt to replicate a broad spectrum of indices representative of normal and abnormal physiological events, within the interpretation of the manufacturer.

Most simulators (properly maintained) will provide reasonably accurate and consistent results, but may not produce the exact results when connected to similar monitors from different manufacturers. However, the consistent performance of a simulator is a good indicator of any change in the performance in the monitor.

* *For example, an accurate mercury column for pressure verification.*

6.3 Preventive Maintenance Schedule

The following preventive maintenance steps are required for continued satisfactory performance and safety of the Accutorr Plus and optional accessories. Inspections and replacement of consumable supplies and accessories that are subject to normal wear, must be accomplished at least as frequently as the inspection of the host unit. Read the Warranty statement in the Operating Instructions for description of warranty conditions.

The suggested minimum maintenance schedule is based on normally expected wear and tear of system and components. The intervals may be shortened at the user's discretion when conditions of use may warrant. In case of internal instrument failure, component replacement, and possible or actual instrument damage, it is strongly recommended that complete performance and safety verification be conducted.

6.3.1 Mechanical and Physical Visual Inspection (One Year Interval)

Check the following items for wear and physical damage: Repair or replace as needed.

- Outer case of Accutorr Plus, Recorder and Temperature module.
- Patient connected accessories such as blood pressure cuffs and hoses and related connectors. Check the SpO₂ sensor and cables. Check the temperature cables and probes. Verify and replenish the disposable items as needed. (i.e.,: probe covers, recorder chart supply).
- Power cords, external safety ground connections and communication cables.

6.3.2 Electrical Safety and Performance Checks (One Year Interval)

- Line power and battery power indicator lights functional in the proper modes.
- Line power and safety grounds are intact and within specifications.
- Non-invasive blood pressure section is functional within specifications.
- SpO₂ functions are operational and within specification.
- Temperature functions are operational and within specifications. Check the temperature module battery voltage under load: replace if under 8.8 V. Use only alkaline batteries.

NOTE: **Newer PTM modules do not contain a 9V battery.**

- Recorder is functional and documents available stored data.
- Check recorder paper path and clean as required.
- Error codes, failure messages, end user reported anomalies are collected and analyzed for reduced performance trends. Identify and correct causes as warranted.
- Perform ground resistance and chassis leakage tests.

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