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## SECTION 1: INTRODUCTION

Manual Overview  
Warnings, Cautions, and Notes  
N-180 Pulse Oximeter Monitor Description  
Related Documents  
Conventions Used in this Manual  
Returning the Monitor

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### MANUAL OVERVIEW

This manual contains information for servicing the Nellcor N-180 pulse oximeter, and is only for individuals who have a technical background in analog and digital electronics. This product must be serviced by qualified personnel. Before servicing the N-180, read the operator's manual carefully for a thorough understanding of how this device operates.

### WARNINGS, CAUTIONS, AND NOTES

This manual uses three terms that are important for proper operation of the monitor: Warning, Caution, and Note.

#### Warning

A warning precedes an action that may result in injury or death to the patient or user. Warnings are boxed and highlighted in boldface type.

<b>Warning:</b> <b>This is an example of a warning. This is an example of a warning. This is an example of a warning.</b>
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#### Caution

A caution precedes an action that may result in damage to, or malfunction of, the monitor. Cautions are highlighted in boldface type.

**Caution:**    **This is an example of a caution. This is an example of a caution. This is an example of a caution**

#### Note

A note gives information that requires special attention. Here is an example:

Note:            This is an example of a note. This is an example of a note. This is an example of a note. This is an example of a note.

### N-180/N-180E PULSE OXIMETER MONITORS DESCRIBED

The N-180/N-180E Pulse Oximeter Monitors (to simplify writing and reading this manual, the term *monitor* is substituted from this point on) continuously and noninvasively measures functional oxygen saturation of arterial hemoglobin (SpO<sub>2</sub>), and pulse rate. Measurements are updated at each pulse beat.

These monitors are manufactured in a domestic and an international configuration. The domestic version uses standard English markings; the international version uses symbolic markings. Except where there is a clear

need to distinguish between monitor versions the single term *monitor* applies to either version.

The domestic version (N-180) operates on 110–120 VAC and the international version (N-180E) operates on 220–240 VAC. There are also differences in the way controls are marked. Because of the different operating voltages, the following electrical components differ.

- Transformer
- AC inlet
- Fuse

The parts listings in Section 9, Parts List, distinguish between the models where such distinctions are needed.

The physical and operational characteristics of these monitors are completely described in the respective operators manuals. These manuals and other publications that apply to operating and servicing the monitor are described in the following paragraph.

## **RELATED DOCUMENTS**

To perform test and troubleshooting procedures and to understand the principles of operation and circuit analysis sections of this manual, you must know how to operate the monitor. Refer to *Operators Manual Nellcor N-180 Pulse Oximeter* or to *Operators Manual Nellcor N-180E Pulse Oximeter*, as applicable.

To understand the various Nellcor sensors that work with the monitor, refer to the Nellcor poster *Pulse Oximetry* or to the information supplied with your individual sensors.

## **CONVENTIONS USED IN THIS MANUAL**

The following conventions are used in this manual:

- In text, active low logic signals are designated by an asterisk after the signal name (for example SIGNAL\*). On logic diagrams a virgule (/) before or after the signal name designates logic low active. In addition, an over score also designates logic low on some schematic device symbols.
- Signal names are printed in all capital letters.
- Fold out illustration numbers are preceded by the letters FO.
- The front panel switch that controls operating power to the monitor bears symbolic marks that are difficult to set in type. Therefore, the term ON/STDBY is substituted for the symbolic marking.

## **RETURNING THE MONITOR**

If you must return the monitor to Nellcor, call Nellcor's Technical Services department for shipping instructions. To facilitate repair or replacement processing Nellcor will give you a return goods authorization (RGA) number.

To repack the CO<sub>2</sub> indicator disconnect the sensor and the power cable. Carefully pack the monitor in the original shipping carton. If the original carton is unavailable, use a suitable carton with an appropriate amount of packing material. Mark the shipping carton and any shipping forms with the RGA number.

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## SECTION 2: PRINCIPLES OF PULSE OXIMETRY

Introduction  
Automatic Calibration  
Functional Versus Fractional Saturation  
Measured Versus Calculated Saturation

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### INTRODUCTION

Pulse oximetry is based on two principles: that oxyhemoglobin and deoxyhemoglobin differ in their absorption of red and infrared light, and that the volume of arterial blood in tissue (and hence, light absorption by that blood) changes during the pulsatile cycle. A pulse oximeter measures the oxygen saturation of arterial hemoglobin ( $\text{SpO}_2$ ) by passing red and infrared light into an arteriolar bed and determining light absorption. Two low-power light-emitting diodes (LEDs) in the oximetry sensor serve as light sources (red, nominally 660 nm; infrared, nominally 920 nm); a photodiode serves as the photo detector.

Because oxyhemoglobin and deoxyhemoglobin differ in spectral absorption, the relative absorption of red and infrared light by blood reflects hemoglobin oxygen saturation. To identify *arterial* hemoglobin oxygen saturation, the monitor relies on the pulsatile nature of arterial flow. At systole—as a new pulse of arterial blood enters the vascular bed—blood volume, and hence light absorption, increases. During diastole, blood volume and light absorption reach their lowest point. To measure  $\text{SpO}_2$ , the monitor uses the difference between minimum and maximum absorption of red and infrared light. Accordingly, the effects of nonpulsatile absorbers (that is, tissue, bone, venous blood) are eliminated. Red absorption and infrared absorption that are attributable to the pulsatile arterial blood are thus made distinct.

### AUTOMATIC CALIBRATION

Because light absorption by hemoglobin depends upon wavelength and the mean wavelength of LEDs vary, an oximeter must store the mean wavelength of the sensor red LED to accurately measure  $\text{SpO}_2$ . (The mean wavelength of the infrared LED is less crucial because the hemoglobin absorption curves are relatively flat in the portion of the infrared spectrum used.) Patented mechanisms automatically calibrate the monitor for the sensor red wavelength when the monitor is turned on. Calibration occurs periodically thereafter and each time a new sensor is connected. During manufacturing, the mean wavelength of the red LED is encoded in a resistor in the sensor. The monitor software reads this resistor and selects appropriate calibration coefficients for that sensor.

### FUNCTIONAL VERSUS FRACTIONAL SATURATION

This monitor measures functional  $\text{SpO}_2$ —oxygenated hemoglobin expressed as a percentage of the hemoglobin that is capable of transporting oxygen. Significant amounts of dysfunctional hemoglobin, such as carboxyhemoglobin or methemoglobin are not detected. In contrast, hemoximeters such as the IL 282 report fractional saturation—oxygenated hemoglobin expressed as a percentage of all measured hemoglobin, including measured dysfunctional hemoglobins. To compare functional  $\text{SpO}_2$  measurements to those from an instrument that measures fractional saturation, you must convert fractional measurements using the following equation:

$$\text{functional SpO}_2 = \frac{\text{fractional saturation}}{100 - (\% \text{ carboxyhemoglobin} + \% \text{ methemoglobin})} \times 100$$

## MEASURED VERSUS CALCULATED SATURATION

When saturation is calculated from a blood gas measurement of the partial pressure of arterial oxygen (PaO<sub>2</sub>), the calculated value may differ from measured SpO<sub>2</sub>. This is because the calculated saturation may not have been corrected for the effects of variables that shift the relationship between PaO<sub>2</sub> and saturation (figure 2-1). The variables are: pH, temperature, the partial pressure of arterial carbon dioxide (PaCO<sub>2</sub>), and the concentrations of 2,3-DPG and fetal hemoglobin.

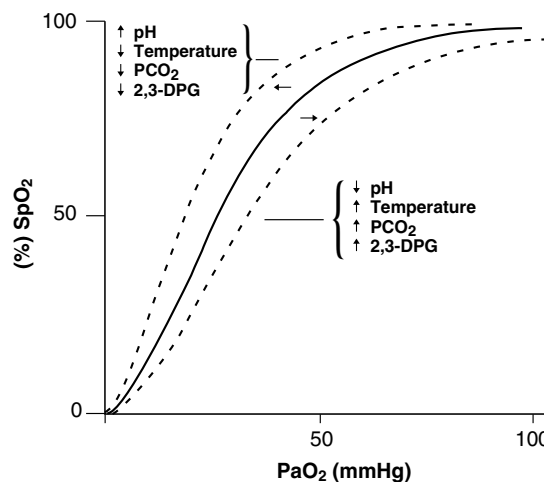


Figure 2-1: Oxyhemoglobin Dissociation Curve

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## **SECTION 3: FUNCTIONAL BLOCK AND CIRCUIT ANALYSIS**

Introduction  
Functional Block Analysis  
Circuit Analysis

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### **INTRODUCTION**

This section explains how monitor circuits operate and contains two parts.

- Functional block diagram analysis
- Circuit analysis

### **FUNCTIONAL BLOCK ANALYSIS**

Monitor functional elements (figure FOG-1) include:

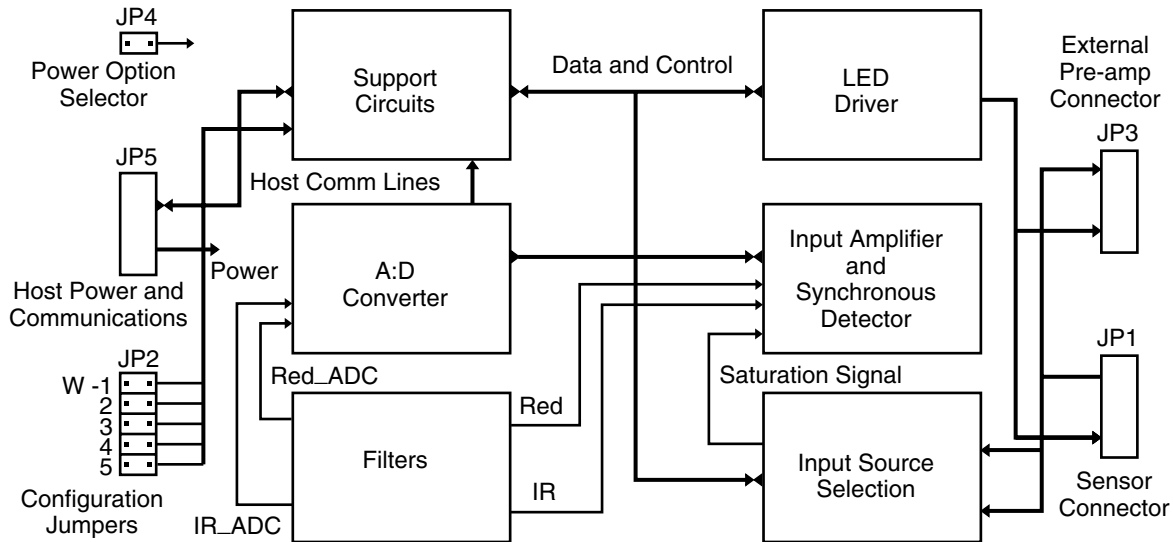
- Standard original equipment manufacturer (OEM) oximetry module (SOOM), model MP-203 oximetry module. For ease of reference this module is hereafter referred to as the oximetry module. In actual fact, the oximetry module is a printed circuit board (PCB).
- CPU PCB
- LED Drive PCB
- LED PCB
- Front panel controls
- AC power inlet
- Battery

### **Oximetry Module**

The oximetry module (figure 3-1) drives the oxygen transducer and conditions the signal derived from the patient (via the sensor connector).

The functional elements of the oximetry module are:

- LED driver
- Input amplifier and synchronous detector
- Input source selection
- Demodulator filters and amplifiers
- Analog to digital converter
- Support circuits



**Figure 3-1: Oximetry Module Block Diagram**

The patient signal (SAT for saturation), is conditioned and used to derive saturation percentage and pulse rate values. This same patient information is serial coupled to the CPU PCB and processed for display and for output through the serial communication port.

Section 2, Principles of Pulse Oximetry, explains how Nellcor sensors operate. An oxygen saturation signal is obtained from a Nellcor oxygen transducer at the selected patient measurement site such as a finger, nose or toe. Sensor LEDs generate alternate infrared and red light pulses at this site. A photodiode in the transducer responds to the modulated light energy transmitted through the measurement site. The photodiode SAT signal is coupled into the oximetry module via the monitor front-panel sensor connector.

### LED Driver

The LED drive circuits control the current to, and the timing of, the sensor LEDs. The current is controlled to maintain an optimal signal to noise ratio.

### Input Amplifier and Synchronous Detector

The SAT signal is conditioned by the input amplifier and the synchronous detector to provide signal gain and reduce or eliminate the effects of ambient interference (such things as ambient light and spurious electrical noise). The final analog conditioning of the SAT signal is accomplished by circuits in the filter block.

### Input Source Selection

There are two possible inputs to the oximetry module. These inputs are controlled via the LEMO signal. Only one input is used in the model N-180,

the differential input at JP1. If more than one input were used, the input source selection logic detects which input connector is active.

Connector JP1 goes to an internal preamplifier. The signal at connector JP3 requires an external preamplifier.

### **Demodulator Filters and Amplifiers**

The oximetry module includes two separate active filter channels, IR and red. These low-pass filter and amplifier circuits and associated gate circuits recover the patient's pulse waveform from the SAT signal. The next step is to digitize these pulse waveforms in the analog to digital converter circuit block.

### **Analog to Digital Conversion**

The analog to digital conversion block digitizes the demodulated IR and red signals. Sensor calibration information is also digitized for use in the saturation calculation algorithms.

### **Support Circuits**

Support circuits include the following:

- Processor Circuits
- Power

Oximetry module operations are controlled by an 80C552 micro controller supported by 512K electrically programmable read only memory (EPROM) and 256K random access memory (RAM). Module power is supplied by the CPU PCB via connector JP5.

## **CPU PCB**

Besides acting as a central controller and processing data from the oximetry module for display on the front panel LEDs, the multipurpose CPU PCB includes:

- a speaker driver
- an LED current check function
- a battery charger
- a battery condition monitor
- a power control
- a set of optical isolators for the RS-232 lines
- an RS-232 connector

## **Front Panel LED Displays**

Front panel displays consist of LEDs that show SpO<sub>2</sub> (saturation), pulse rate and relative pulse strength. The relative pulse strength indicator is a bar graph arrangement that does not have a legend. Status indicators are:

- Battery in use
- Low batt
- Pulse search
- Neo natal

Alarm status is conveyed by four red LEDs mounted behind the front panel membrane next to the five push-button switches. These respective LEDs light when the corresponding alarm condition occurs:

- High saturation
- Low saturation
- High rate
- Low rate

A fifth LED flashes once per second to show the audio alarm function is temporarily silenced or lights continuously if the alarm is disabled.

The front panel assembly includes the sensor input connector, LED Drive PCB, LED PCB, and the front panel controls (push buttons, control knob, and ON/STDBY switch). (This assembly is not available as a spare part but some elements, such as the PCBs are included on the spares list in section 9.)

## **AC Power Input and Control**

The AC power input and control includes the AC input receptacle, AC Power switch, two fuses, and a filter.

## **Battery**

The monitor takes DC power from an internal 12 volt sealed lead-acid battery. The battery is self-contained and connects directly to the CPU PCB at CN4. The battery charging circuit is on the CPU PCB.

## **CIRCUIT ANALYSIS**

This portion of section three describes major functional circuit blocks in detail. An understanding of monitor operation helps you locate and repair malfunctions. The descriptions are organized in top-down order. Each monitor PCB has an associated circuit analysis paragraph in this section.

## **Oximetry Module**

The oximetry module is a self-contained assembly that provides oxygen transducer power, conditions the resulting SAT signal, and calculates patient oxygen saturation and pulse rate. The saturation percentage, pulse rate, and other pertinent information are transmitted to the monitor CPU PCB for processing.

The functional elements of the oximeter module are as follows:

- LED Drive
- Input source selection
- Input amplifier and synchronous detector
- Demodulator filters and amplifiers
- Control signals
- Analog to digital converter
- Support circuits

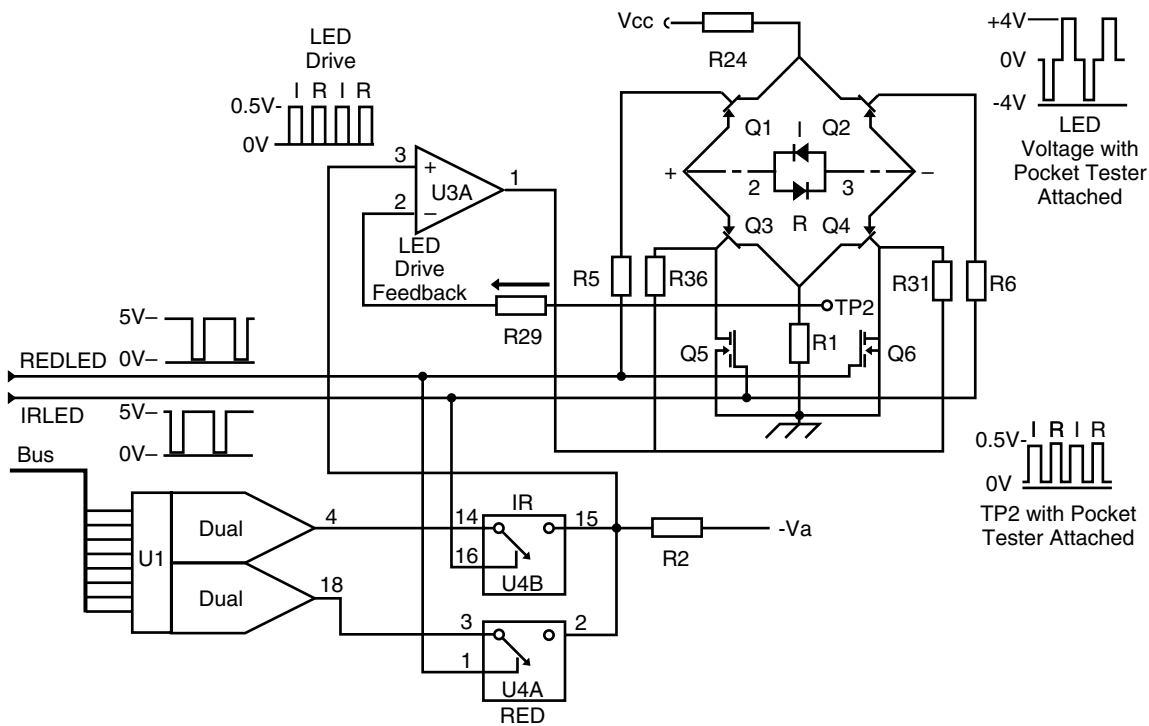
### **LED Drive Circuit**

The SAT signal development scheme requires lighting the measurement site using specific light wavelengths. Nellcor sensors have two LED sources, infrared (IR) and red. These LED sources are an integral part of each Nellcor oxygen transducer. The LEDs are alternately pulsed on and off by the oximetry module microprocessor.

The LED drive bias voltages are developed by dual DAC U1 (figure 3-2). Initially, both DACs in U1 are directed via the DACBUS to develop approximately 0.5 VDC on respective outputs (pins 4 and 18) coincident with the period each LED is selected. The microprocessor alternately closes FET



switches U4A and U4B via control lines IRLED\* (U4 pin 16) and REDLED\* (U4A, pin 1). The DAC outputs are gated by these signals and output on pin 2 and pin 15 of U4.



N-185/040

**Figure 3-2: Oximetry Module LED Driver Circuit**

The frequency of each control signal (IRLED\* and REDLED\*) is 1355.3 Hz, with a 25% duty cycle. When the DAC outputs are gated at U4 (pins 2 and 15) a four-phase LED drive signal with a frequency of 2710.6 Hz is created. A negative LED drive bias voltage applied to R2 ensures that the output of the LED driver U3A is zero during the times when an LED is not selected by either control line. This scheme counters any normal offsets that may be present in component U3A.

Typically, the LED drive signal has a peak-to-peak value of 0.5 volts. The lower boundary is 0 volts.

Initially, both LED drive levels are maximum (0.5 volts), but may be reduced as the processor adjusts each of the individual LED intensities to compensate for measurement site lighting variables. High background ambient light or highly translucent measurement sites (such as found in neonates) may cause a reduction in overall LED intensity.

As described, the LEDs operate in a four-phase sequence. Each phase lasts 184.5 microseconds, nominal.

Phase 1 IR LED on  
Phase 2 Both LEDs off

Phase 3    Red LED on  
Phase 4    Both LEDs off

The LED drive current switching is accomplished by Q1 through Q6 and the control lines, IRLED and REDLED. The figure illustrates the relationship of these components and their association with the red (R) and IR (I) LEDs in the sensor. The LEDs are shown as they appear electrically in the circuit without the interconnection diagram. The numerals 2 and 3 on either side of the back-to-back LEDs indicate pin numbers in the sensor connector.

The four-phase LED drive signal goes to U3A. The resulting drive potential is coupled equally to both sides of the bridge circuit via R31 to Q4 and via R36 to Q3. Control inputs IRLED and REDLED are pulsed low, to light respective LEDs. When both lines are a logic high, both LEDs are turned off because Q1 and Q2 are directly turned off by the control inputs via R5 and R6. Device Q3 and device Q4 are turned off by the conduction of Q5 and Q6, which are now conducting.

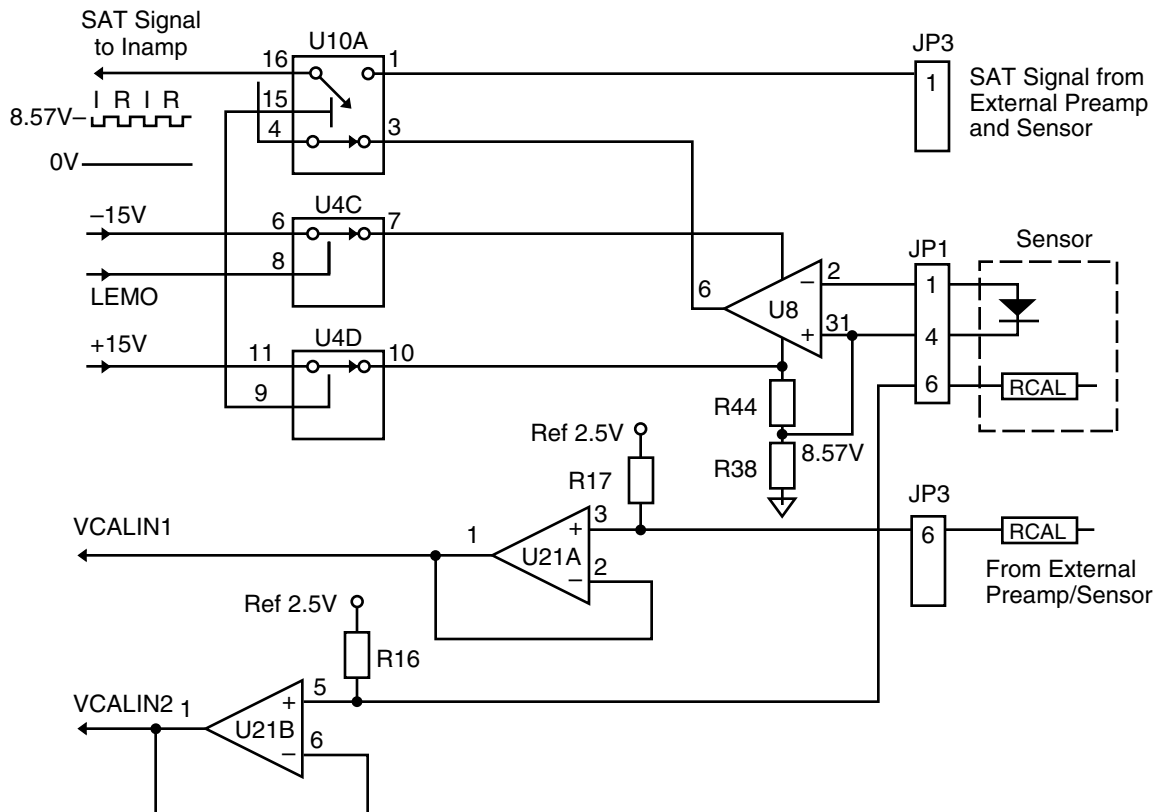
The IR LED (I) lights when control signal IRLED\* is pulsed low. Device Q5 turns off, allowing Q3 to respond to the drive level from U3A, and Q2 is turned on. The resulting current flow is from ground through R1, Q3, IR LED, Q2, and to Vcc. The red LED (R) lights when control signal REDLED\* is pulsed low. Device Q6 turns off, allowing Q4 to respond to the drive level from U3A, and Q6 is turned on. The resulting current flow is from Vcc through Q1, red LED, Q4 and R1 to ground. The LED back-to-back configuration ensures that the proper LED lights.

LED intensity is critical. Intensity variations during LED On-time, caused by any source other than blood oxygen levels, can distort the SAT signal. The LED driver is a current regulator. Its purpose is to keep the voltage at TP2 exactly the same as the input voltage to the circuit (U3A, pin 3). This is accomplished by using the voltage developed across R1 as a feedback to driver U3A. This circuit has a very high rejection of power supply changes that could cause intensity changes.

### **Input Source Selection Circuits**

The SAT signal is developed by the photodiode in the Nellcor sensor (figure 3-3), responding to the transmitted red and IR light at the measurement site. The transmitted light intensity depends on the LED drive level, the patient's oxygen saturation, and the amplitude of the pulse at the site.

The photodiode current is coupled into the oximetry module via JP1 (pin 1 and pin 4) to the signal input of U8, which performs current-to-voltage conversion for the photodiode signal. The non-inverting input of U8 is biased by R38 and R44 to 8.57 volts. Accordingly, U8 has an 8.57 volt maximum positive offset, in the absence of any light or energy on the photodiode. This bias prevents an absence of light from clamping U8 at +15 volts. The presence of light, or energy from any source, moves the output of U8 in a negative direction.



**Figure 3-3: Oximetry Module Input Source Selection Circuits**

An undisturbed saturation signal at the input amplifier is essentially a square wave (the actual amplitudes may vary between the IR and red phases) that has a frequency of 2710.6 Hz. The square wave peak-to-peak amplitude is proportional to LED transmitted light intensity, plus any artifact. The DC offset (negative from the +8.57 volt bias point) is dependent on steady-state background light or energy. Peak-to-peak amplitude changes in the signal depend on the modulation caused by pulsatile blood at the detector site.

The remainder of this description assumes that a Nellcor PT-2500 pulse oximeter module tester (pocket tester) is connected to the module input in place of a normal patient sensor. This establishes a reproducible set of values for discussion and comparison. The PT-2500 conditions the LED drive voltage and simulates a saturation of  $81\% \pm 1$  digit (80% to 82%) and a pulse rate of  $40 \pm 1$  bpm (39 to 41 bpm). Note that pocket tester pulse rate is dependent on LED switching rate and may differ on other Nellcor pulse oximeter models.

The SAT signal from the pocket tester is coupled to the SAT conditioning circuits via the sensor input to JP1 (pin 1 and pin 4) on the oximetry module PCB. After conditioning by current-to-voltage converter U8, the signal has the following characteristics:

DC offset:	approximately +8.5 volt
Frequency:	2710.6 Hz
Modulation:	maximum peak-to-peak amplitude, approximately 5 volt

The only additional oxygen saturation input requirement is the wavelength of the red LED. This number is derived from the RCAL resistor value located in the sensor or PT-2500. When a sensor is connected to the monitor, the RCAL resistor connects between JP1 pin 6 and ground to become part of a voltage divider with R16 on the PCB. Power for this divider is a 2.5 volt reference

developed in the module. This calibration voltage (VCALIN2) is sent to the analog to digital converter by buffer U21B.

### **Input Amplifier and Synchronous Detector**

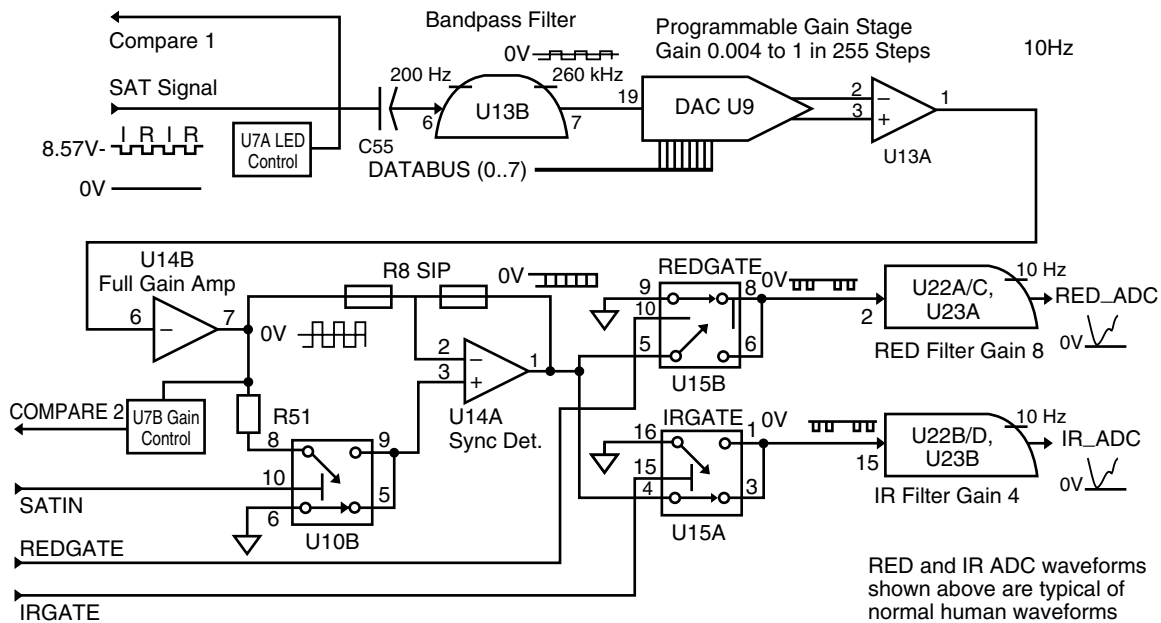
Refer to figure 3-4 and figure FO10-1 (sheet 3 of 7 and 4 of 7). The SAT signal is continuously monitored, and the LED drives controlled to prevent excessively high LED intensities, or the combination of LED intensity and background light or energy, from overloading the sensor photodiode. However, LED intensity must remain as high as possible to ensure optimal signal-to-noise figure readings. To compensate for excessive light, device U7 and associated components sample the SAT signal, while the signal is still DC coupled.

Initially LED intensity is set at maximum (56 milliamps) when power is applied to the monitor by setting the ON/STDBY switch to ON. If the total LED energy, or external light energy, or the combined LED energy and external light energy, is excessive, the DC offset at the output of U8 could be insufficient to prevent the SAT signal from going into the negative region of the U8 operating range. To prevent the output of U8 from going negative, U7 monitors the negative excursion of the SAT signal.

Device U7A is a negative peak detector that produces a DC output proportional to the maximum negative excursion of the SAT signal pulses. If negative excursions of the saturation signal exceed  $-10$  volts (indicating that the current-to-voltage converter stage output is approaching the negative supply voltage of  $-15$  volts), the microprocessor that is monitoring the output of U7A (COMPARE1) initiates action to reduce the output of the dual DAC that controls the LED intensity. The microprocessor may reduce current through only one of the LEDs, if necessary.

The SAT signal is next coupled through C55 removing the DC offset. The signal is then coupled to U13B, a band pass filter with a gain of 1, low-frequency roll-off at 200 Hz, and high-frequency roll-off at 260 kHz. The filter passes the SAT signal (2710.6 Hz) and effectively removes noise on either side of the SAT signal frequency.

The signal then goes to a programmable gain circuit, which consists of 8-bit DAC U9 and operational amplifier U13A. The DAC internal impedance ladder is in series with the operational amplifier feedback loop. Amplifier gain is controlled by microprocessor adjustment of the DAC impedance over 255 discrete steps. The maximum gain of the circuit is one. The minimum gain is 1 divided by 255 or 0.004.



**Figure 3-4: Oximetry Module Input Amplifier, Synchronous Detector, and Filter and Amplifiers**

The signal is then coupled to inverting amplifier U14B, which has a gain of  $-51$ . The output of U14B is used by the microprocessor as the sense point to determine input channel gain requirements. Device U7B monitors the amplified SAT signal at the output of the input amplifier.

Device U7B is a positive peak detector that produces a DC output proportional to the positive excursion of the amplified SAT signal pulses. If the positive excursions of the saturation signal exceed  $+10$  volt (indicating excessive amplifier gain), the microprocessor, which is monitoring the output of U7B (COMPARE2), acts to reduce the programmable stage gain.

The microprocessor controls U10B via the SATIN line, and closes the switch during phases 1 and 3 of the four-phase clock mentioned in the LED drive discussion. The result is that the voltage values represented by the IR and red LED On-times are inverted by the detector. The voltage values represented by the LED Off-times (phases 2 and 4) pass through the detector at their original voltage level and polarity. The output of U10B is conditioned by U14A.

The synchronous detector is an operational amplifier configured to operate as two different circuits, an inverting amplifier and a voltage follower. When the positive input of U14A is grounded by U10B, the device is an inverting amplifier that has a gain of one. When this input is not grounded, the device becomes a voltage follower that has a gain of one. The signal is still in the original multiplexed format and essentially a square wave at  $2710.6$  Hz.

Synchronous detection conditions the SAT signal so that subsequent filtering can reclaim the patient's pulse waveform component free of the  $2710.6$  Hz switching frequency. Synchronous demodulation is performed by analog switch U15, which is controlled by the REDGATE\* and IRGATE\* signals.

## Demodulator Filters and Amplifiers

There are three circuits in the demodulation and filtering block:

- Circuits that gate other logic
- IR Filter and amplifier
- Red Filter and amplifier

### ■ Gate logic:

Field effect (FET) switches U15A and U15B separate the IR information in the SAT signal from the red information (figure FO10-1 3 of 7). Phase one and phase three constitute the IR and red on-time segments, respectively. Phase two and phase four constitute the IR and the red off-time segments, respectively. The gate control inputs (IRGATE\* and REDGATE\*) to U15A and U15B are processor-controlled and operate in time-sequence with the four-phase LED drive control. The switch pairs in each gate operate exclusively so that the filter and amplifier input does not encounter an open circuit when switches to the signal input line are open.

During the time when phase one and phase two of the 2710.6 Hz saturation signal (IR ON and IR OFF) follow one another on the signal line, the processor strobes U15A twice. The first strobe pulse comes 114 microseconds after the beginning of phase 1 and continues for 70 microseconds, or to the end of phase 1. This strobe action gates the last 70 microseconds of IR ON signal level into the IR filter and amplifier. The next gate strobe pulse comes 114 microseconds after the beginning of phase 2 and continues for 70 microseconds, or to the end of phase 2. This strobe action gates the last 70 microseconds of IR OFF signal level into the IR filter and amplifier.

During the time that phases 3 and 4 of the 2710.6 Hz saturation signal follow one another on the signal line, the microprocessor strobes U15B twice. The first strobe pulse comes 114 microseconds after the beginning of phase 3 and continues for 70 microseconds, or to the end of phase 3. This strobe action gates the last 70 microseconds of RED ON signal level into the red filter and amplifier. The second gate control pulse comes 114 microseconds after the beginning of phase 4 and continues for 70 microseconds or to the end of phase four. This strobe action gates the last 70 microseconds of the RED OFF signal level into the red filter and amplifier.

To avoid errors due to sensor photodiode settling time, only the last 70 microseconds of each phase gets gated into the filter and amplifier. This scheme eliminates possible artifacts occurring during the first 114 microseconds of the phase. Photodiodes exhibit an exponential change when the energy from a sudden LED state-change occurs. Using only the last 70 microseconds of the photodiode output, after the diode has settled, excludes this potential error from the measurement.

### ■ IR filter and amplifier:

Refer to figure FO10-1 (sheet 4 of 7). The IR filter and amplifier circuit is an active low-pass type with a three-dB roll-off point at about ten Hertz and an approximate gain of four. The filter cannot track the high-frequency LED pulse input, but does respond to the low-frequency patient pulse modulation, reproducing the patient's pulse waveform at the filter and amplifier output. The IR filter and amplifier pulse waveform output is coupled to the analog to digital converter.

The input signal to the IR filter and amplifier, as explained above, is two 70-microsecond pulses separated by a 114 microsecond space (phases 1

and 2). Likewise, the next two phases (3 and 4) are gated into the RED filter and amplifier. This leaves a 483 microsecond period until the next pair of IR pulses is gated into the IR filter and amplifier. The overall pulse amplitudes are proportional to the transmitted light at the measurement site. The individual pulse pair amplitudes are a function of the low-frequency patient pulse modulation and artifacts at the measurement site.

These pulse pairs are coupled to the first of two identical filter and amplifier stages, each having a gain of approximately two. The signal is then coupled to the last stage, which has a gain of one for IR, and two for red. The DC offset of the resulting low-frequency patient pulse waveform is proportional to the average light intensity at the measurement site. The peak-to-peak amplitude of the patient pulse waveform is a result of the factors expressed in the Beers-Lambert Law, which is used to calculate oxygen saturation.

The patient pulse waveform at the IR filter and amplifier output labeled IR, must always be a positive voltage, because the next step is to digitize the waveform in the analog to digital circuits. To ensure that the waveform does not move to a negative level, the final amplifier stage input has a + 2.5 millivolts offset, which guarantees a minimum positive offset.

■ **Red Filter and amplifier:**

Refer to figure FO10-1 (sheet 4 of 7). The red filter and amplifier circuit is an active low-pass type with a -three dB roll-off point at about ten Hertz and a total gain of about four. The filter cannot track the high frequency LED pulse input, but does respond to the low frequency patient pulse modulation, reproducing the patient's pulse waveform at the filter and amplifier output. The red filter and amplifier pulse waveform output is coupled to the analog to digital converter.

The input signal to the red filter and amplifier is two 70-microsecond pulses separated by a 112 microsecond space (phase 3 and phase 4). The next two phases (1 and 2) are gated into the IR filter and amplifier the same way. This leaves a 483 microsecond period until the next pair of red pulses are gated into the red filter and amplifier. The overall pulse amplitudes are proportional to the transmitted light at the measurement site. The individual pulse-pair amplitudes are a function of the low frequency patient pulse modulation and artifact at the measurement site.

These pulse pairs are coupled to the first of two identical filter and amplifier stages, each having a gain of approximately two. The signal is then coupled to the last stage having a gain of two. The DC offset of the resulting low frequency patient pulse waveform is proportional to the ambient light intensity at the measurement site. The peak-to-peak amplitude of the patient's pulse waveform is a result of the factors expressed in the Beers-Lambert Law is used to calculate oxygen saturation.

The pulse waveform at the red filter and amplifier output labeled RED, must be a positive voltage, because the next step is to digitize the waveform in the measurement system. To ensure that the waveform does not move into a negative voltage region, the final amplifier stage input has a +2.5 millivolt input, which guarantees a minimum positive offset.

■ **Control signals:**

Refer to figure FO10-1 (sheet 4 of 7 and sheet 7 of 7). Measuring SpO<sub>2</sub> is controlled by logic signals from micro controller U5. The control signals are listed and defined below:

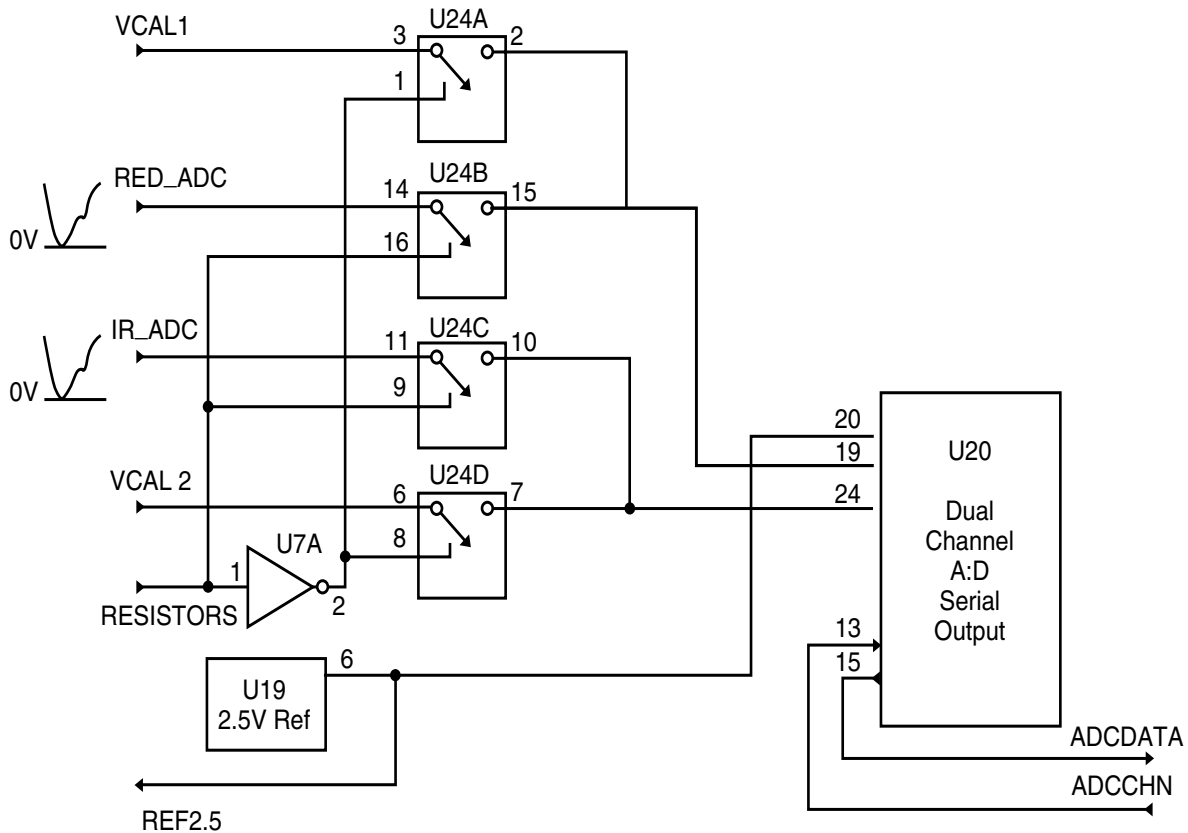
- IRGATE\* is a result of micro controller output PWM1\* ANDed with output CMT1. IRGATE\* controls the transmission of the IR on and off levels into the IR Filter and amplifier.
- IRLED\* from micro controller output CMSR4. IRLED\* controls the selection of the LED drive level at U4B and the direction of current applied to the sensor LEDs.
- REDGATE\* is a result of micro controller output PWM1\* ANDed with output CMT0. REDGATE\* controls the transmission of the red on and off levels into the red filter and amplifier.
- REDLED\* from micro controller output CMSR5. REDLED\* CONTROLS the selection of the LED drive level at U4A and the current direction applied to the sensor LEDs.
- SATIN from micro controller output CMSR3. SATIN controls the inverting amplifier through U10B and U14A.

**Analog to Digital Conversion**

Analog to digital conversion (figure 3-5) is accomplished by a dual-channel device (U20) that produces a multiplexed serial output. Channel 1 (AIN1) accommodates either VCAL1 voltage or the analog pulse waveform from the red filter and amplifier channel. Channel 2 (AIN2) accommodates either VCAL2 voltage or the analog pulse waveform from the IR Filter and amplifier channel. These selections are determined by the configuration of quad field effect transistor (FET) switch U24A, B, C, and D. Switching is controlled by logic signal RESISTORS.

Logic signal ADCCHN determines the output bit stream multiplexing from device U20. In turn, bit stream multiplexing determines the channel present on the ADCDATA line. The ADCDATA line is coupled directly to micro controller U5 for conditioning prior to transmission to the monitor display processing circuits.





**Figure 3-5: Oximetry Module Analog to Digital Conversion Circuits**

### Support Circuits

Support circuits include the following:

- Communications
- Processor circuits
- Power

#### ■ Communications:

The oximetry module CPU (figure 3-6) manages communications to other monitor electronics. There are two data signals (RXD, TXD) and three control signals at the module connection to the CPU PCB.

**CTS\*** clear to send is a logic signal (active low) transmitted to the oximetry module by the monitor to suspend data transmission from the module

**RESET\*** is an input (active low) from the main processor to effect a reset in the oximetry module

**RXD** is the receive data line from the CPU PCB

**TXD** is the transmitted data line to the CPU PCB

**C-LOCK** external synchronizing signal from ECG monitor (not used)

The communication data link is bi-directional-asynchronous and serial. Transmissions are checked for errors; the presence of an error is evidence of a hardware problem. No transmission retry capability is included.

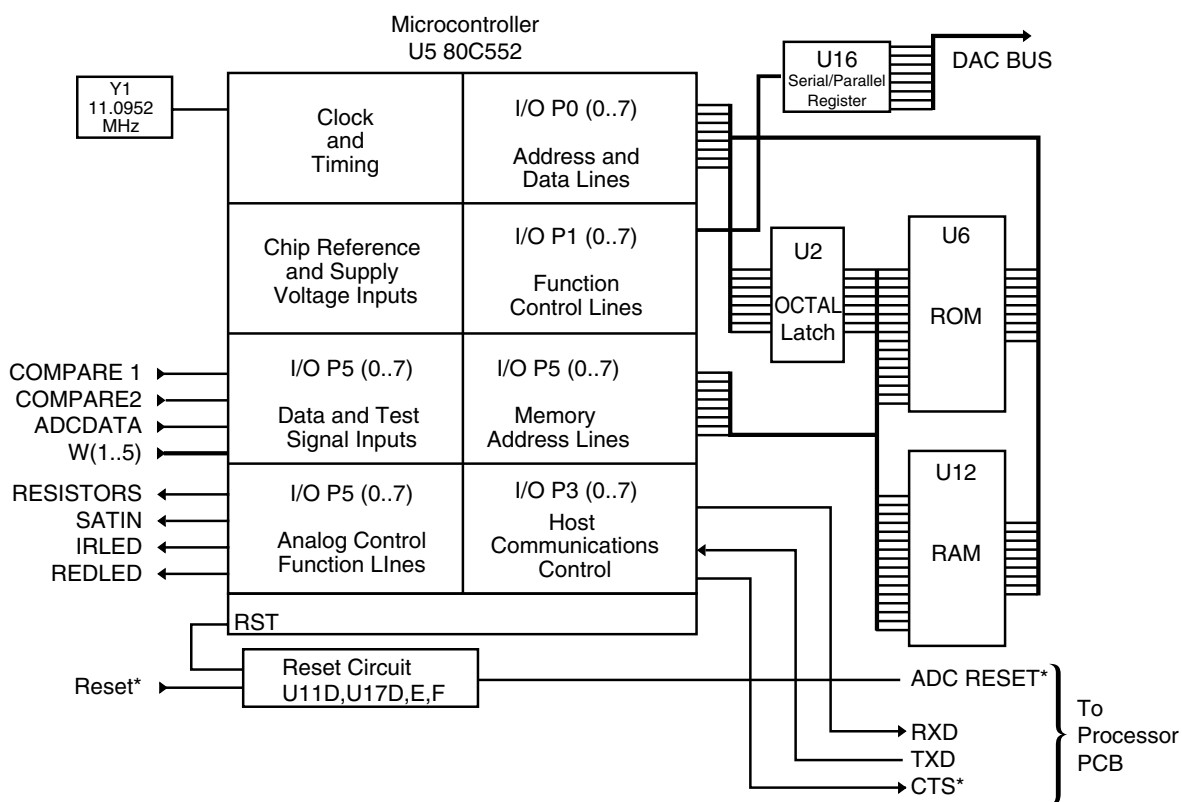
### ■ Oximetry Support Circuits:

Oximetry module support circuits consist of 80C552 micro controller U5 (figure FO10-1, sheet 7 of 7), ROM U6, and RAM U12, all served by octal latch U2. Serial-to-parallel shift register U16 outputs parallel data for the DACBUS. The oximetry module timing is set by an 11.0952 MHz crystal-controlled oscillator. Sections U11 and U17 perform reset and buffer functions for the communication link.

### ■ Power:

The following power is derived from the CPU PCB.

Volts	Tolerance	Current maximum (ma)
+5	±5 %	78.05
+15	±5 %	8.21
-15	±5 %	7.5
-6	±5 %	5.29



N-185/060

**Figure 3-6: Oximetry Module Support Circuits**

## CPU PCB

The CPU PCB:

- controls display functions
- manages the RS-232 link to external devices
- has multiple support circuits
  - speaker drive
  - LED current check
  - battery condition monitor
  - battery charging and power control

**CPU (Sheet 1 of 4)**

**Note:** Power and Ground connections for the ICs on the CPU board are shown as “power terminal” on the schematic

■ **Speaker drive circuit**

The speaker drive circuit is composed of transistor Q1 and FET Q2, in series with speaker and waveform conditioning components D1 and C3. The audio pulse tone (beep) is determined by the output frequency of processor U9 I/O, (lead A) CXS/PA5. This signal is buffered by U7B, which controls FET Q2. The beep frequency is proportional to the patient's oxygen saturation percentage, increasing in frequency with increasing saturation percentage.

Speaker volume is determined by the DC value of VOLUME, which controls the conduction of Q1. The DC value of VOLUME is determined by the output of DAC U3. Processor U9 sets the default value initially, but you can change the level by rotating the front-panel control knob.

■ **Back panel switch SW1**

Back panel switch SW1 is a dual-in-line package (DIP) switch. Switch settings control communications baud rate and the communications format (conversation or computer). In addition, a switch section in this DIP controls the default alarms for adult or neonate patients

**Battery Charging and Power Control (Sheet 2 of 4)**

Device U4B performs two functions: battery in use determination, and low battery notification. The circuit is a comparator with a logic input from processor U9 (BAT\_THRESH). The comparator normally monitors VPS, which reflects the value of the monitor DC operating voltage. When AC-powered, the value of VPS is typically 16 VDC. When battery-operated, VPS is typically less than 13.2 V (the actual value depends on the battery charge level).

■ **AC Operation**

The circuit performs as follows when the monitor is operating on AC power. VPS is equal to 16 V. Signal BAT\_THRESH is a logic high (+5 V) most of the time, and drops to a logic low for 200  $\mu$ s every 100 ms.

When the processor brings BAT\_THRESH to a logic low (0 V) the output of comparator U4B, LOWBAT, is examined at the same time. The sum of the logic low on BAT\_THRESH and 16 V on VPS is still a voltage greater (approximately 3.5 V) than the 2.5 reference input to U4B,

therefore LOWBAT remains a logic low. The processor responds by not turning on the BATT IN USE light.

■ **Battery Operation**

When the monitor operates on battery, VPS drops to approximately 13 V. When BAT\_THRESH is brought to logic low, the resulting voltage at U4B, pin 6, is below the 2.5 V reference (typically 2 V) and the comparator output (LOWBAT) rises to a logic high during the time that BAT\_THRESH is low. This change in LOWBAT only during the BAT\_THRESH low time period causes U9 to recognize battery operation and turns on the BATT IN USE light.

Resumption of AC power overrides the 2.5 V reference, notwithstanding the state of BAT\_THRESH, which is strobed to a logic low. The comparator output LOWBAT now rises to a logic high, the processor turns off the BATT IN USE light, and the circuit returns to AC power mode.

■ **Low Battery Warning**

During battery power, VPS is 13.2 V or less; this condition switches the output of U4B to a logic high during the BAT\_THRESH strobe. As the battery discharges signal VPS drops from the initial value. Eventually the value of VPS is low enough (typically, 11.2 V) to drive U4B, pin 6, permanently below the 2.5 V reference, regardless of the state of BAT\_THRESH. Now U4B output, LOWBAT, remains a logic high.

The processor logic detects LOWBAT high. Regardless of the level of BAT\_THRESH, the logic is conditioned by the low battery state to start flashing the LOW BATT light.

■ **Low Battery Shutdown**

To protect the battery from excessive discharge, the processor starts a 5-minute timer after turning on the LOW BATT light. At the end of five minutes, if AC operation has not resumed, the processor initiates a normal shut-down procedure through the WATCHDOG line

■ **ON/STDBY Switch**

Monitor operation is controlled by the ON/STDBY switch on the front panel. The switch is connected to the power control circuits on the CPU PCB via connectors CN5/CN1 on the LED Display PCB.

Power is applied to the monitor by connecting the source and drain of FET Q5, which connects the monitor ground (TP3) to the power ground (TP-2). Flip-flop U14B controls the gate of Q5. In turn, U14B is controlled by gates U13A, C, D, and associated components.

■ **Standby condition**

In standby, transistor Q5 is not conducting and U14B is RESET (logic low at Q). The ON/STDBY switch is in the STDBY position, which connects the STBY\_COM pole to the STDBY pole of the switch (VPS). Capacitor C13 charges to VPS (16 or 13 VDC depending on whether AC is connected to the monitor). Capacitor C14 is charged to +5 V from regulator U12. The inputs U13A (pin 1, +5 and pin 2, 0 V) set the output, pin 3, to a logic high. The WATCHDOG input to the circuit (U13C) equals VPS (measured with reference to PGND TP2). The ON input to the circuit (U13D) equals 0 V.

Because the monitor ground is floating most circuits are not functioning. The only functioning circuits are those operating on the PGND plane.

### ■ Standby to on

When the ON/STD BY switch is placed in the ON position, the STBY\_COM and ON poles of the switch are connected. Capacitor C13 discharges through R22, producing a positive spike into gate U13D. U13D inverts the spike that sets FF U14B and discharges C14 through D7. The ON input then remains at 0 V.

When U14B is SET the Q output (logic high) causes Q5 to conduct, connecting the PGND and system grounds. The processor starts operating and places a continuous stream of 0's and 1's on the WATCHDOG line. These transitions are differentiated by C16 and R20. The positive spikes are inverted by U13C and keep C14 discharged through D6.

The inputs to U13A (pin 1 0 V, pin 2 +5 V) set the output, pin 3, to a logic high. Line STANDBY, which reflects the charge on capacitor C13, will now be 0 V. The processor is now monitoring STANDBY.

### ■ On to standby

When you place the monitor in standby the STBY\_COM and STDBY poles of the switch connect. This action quickly charges C13 to VPS, so that the same value (logic high) is present on the STANDBY line.

Processor U9 logic detects the status change and removes the pulses from the WATCHDOG input to the control circuit. The cessation of negative pulses through D6 allows C14 to quickly charge to +5 V. This condition places two logic highs at the input of U13A. Accordingly, the output of U13A goes low, resetting U14B. The logic low on the Q output of U14B then stops conduction in Q5, removing power from the monitor. The circuit conditions are now as they were in the standby condition.

Processor U9 also uses this sequence to turn off the monitor in the event of low battery. In this case the trigger is not the STANDBY line, but information from the battery condition circuits.

### ■ Battery charger circuit

The battery charger circuit consisting of Q8, Q9, Q10, Q11, Q12, and associated components operates as a charging voltage source having a maximum current of 160 mA. The circuit keeps the battery charged to a maximum of 13.8 V.

When the battery voltage is below 13.8 V the circuit charges the battery until the voltage reaches 13.8 V. Then, the charger switches to constant voltage operation to maintain the battery charge at 13.8.

Resistors R52, R53, and VR1 drop the battery charge value (less the forward voltage drop of D4). The common point of R52 and R53 is the battery charge sense point. Regulator Q10 monitors the voltage at this point and controls transistor Q8 to maintain this point at a voltage that represents a battery voltage of 13.8 V. Variable resistor VR1 adjusts the voltage at this point.

The circuit composed of transistor Q11 and associated resistors constitutes a current-limiting circuit that has foldback characteristics. Battery charge current flows through R54. The voltage drop across R54 is proportional to charge current. Transistor Q11 is normally turned off by reverse bias generated by the R49/R50 divider. If the charge current increases so that the drop across R54 exceeds the drop across R49 Q11 turns on. This allows additional current to flow through VR1/R53 raising the voltage at the sense point. Transistor Q10 reacts by reducing

the drive to Q8, which in turn reduces the charging voltage, whereupon the cycle continues.

Should the battery or battery input circuit encounter a short, the voltage at the sense point (R53 and R54) drops; accordingly, Q10 attempts to increase the charge current. To prevent this increase and resultant overheating, a short circuit protection circuit is employed. Transistor Q12, normally held in conduction by the battery voltage value, shuts off. This results in Q9 turning Q8 off.

■ **DC power supplies and battery charger**

The DC power supplies consist of two unregulated DC sources derived from two individually isolated secondary windings of the power transformer. These supplies are used for the battery charger and various regulators.

Unregulated power for the main power supply comes from a 20 VAC isolated secondary. The AC is coupled onto the CPU PCB via connector CN5, filtered by inductor L1, and rectified by bridge D9. The resulting DC is from 15 to 25 V depending on the line voltage value. Three-terminal device Q4 regulates the DC at a maximum of 24 V. This voltage is passed through D2 and becomes VPS (TP4), which is used to power regulator Q3, providing a highly regulated +5 V for processor circuit power. The 24 VDC output from Q4 is also used by the battery charger circuits. Diode D3 isolates the battery from VPS when AC power is used.

In the absence of AC power, the 12-volt battery potential is coupled through D3 to supply regulator Q3. In this case D2 isolates the main power supply from the battery potential, reducing unnecessary current drain.

AC voltage for the RS-232 power supply comes from an 8 VAC isolated secondary. The AC is coupled onto the CPU PCB via connector CN7 and rectified by bridge D10. The resulting DC will be from 7 to 9 V depending on the line voltage value. Three-terminal device Q7 regulates the DC at 5 V. This voltage is isolated from all other grounds and powers only optical isolators PH1/PH2 and RS-232 device U10.

**RS-232 Port and Associated Isolators (Sheet 3 of 4)**

The CPU PCB processor U9 has two internal modems (modem 0 and 1), but only modem port 0 is used. This port accommodates four RS-232 signals as follows:

- RXA0    data received from the external device
- TXA0    data transmitted to the external device
- CTS0\*    clear-to-send level from the external device
- RTS0\*    ready-to-send level from the monitor

The RS-232 communication format and transmission speed (baud rate) are controlled by switch SW1 on the back panel. Switch settings are given in appendix A of this manual.

The RS-232 signals are isolated by optical isolators PH1A and PH1B on the output side and by PH2A and PH2B on the input side. The prefix ISO, meaning isolator, is given to all signals on the output side of the optical

isolators. Device U10 is a level adjuster. Device U-18 inductors A–H reduce electromagnetic interference.

### **LED Current Check Circuits (Sheet 4 of 4)**

When power is applied, the monitor housekeeping diagnostics check the current flowing to the LEDs to determine if any LED is malfunctioning in a way that could lead to the misinterpretation of the LED presentation. For example, if the top right segment in an LED display failed, you could interpret an eight as a six. The diagnostic check gives you confidence in the front panel readings. Here is how the diagnostics work.

Resistor R34 is placed in series with the current for LED driver QA1. The voltage drop across R34 is amplified by U17A, which compares this resulting value with the processor-controlled reference from VOLUME DAC U3/U4A. By driving selected segments while checking the current value at LED\_CHECK the processor logic can reveal if a segment is drawing too little or too much current.

If a current value is out of tolerance the processor displays Err 3 on the LED display. You can override an Err 3 condition by pressing any front-panel button, but for obvious reasons, you should only do this as an emergency measure. The operator manual has specific warning information regarding Err3 conditions.

### **LED Drive PCB**

Note: Power and Ground connections for the ICs on the CPU board are shown as “power terminal” on the schematic

Device U1A and device U2A on the LED Drive PCB (figure FO10-3) are decoders. Decoded output from U1A and U2A goes to 16 drivers. Eight outputs from decoder U1A feed drivers OA1A-H; eight outputs from U2A feed drivers OA2A-H. The 16 drivers output 16 signals named COM1-15. The state of signals COM 0-5 and signals COM 8-13 determine whether SATURATION and RATE LEDs light red (8-13) or green (0-5).

The binary input to the decoders U1A and U2A is fed to inputs A, B and C of the respective decoders. Depending upon the output of the CPU PCB microprocessor, these three signal lines represent encoded information to enable readings on SATURATION, RATE, BATTERY IN USE, LOW BATT, PULSE SEARCH, NEONATAL and the pulse amplitude LEDs. The actual segments that light on the respective LED elements depend upon the coding of DRV0-7 at the time that an LED is enabled. Signals DRV0-7 come from the CPU PCB I/O controller as signals LED 0-7 (which feed processor device U23, a driver).

### **LED PCB**

The LED PCB (figure FO10-4) consists of LEDs that provide status information,

- BATT IN USE (LD1)
- LOW BATT (LD2)
- PULSE SEARCH (LD3)
- NEONATAL (LD4)
- HIGH SAT (LD13)
- LOW SAT (LD14)
- HIGH RATE (LD15)
- LOW RATE (LD16)
- AUDIO ALARM OFF (LD17)

and operational information,

- pulse amplitude (LD5 AND LD6)
- oxygen saturation (LD7, 8 AND 9)
- pulse rate (LD10, 11, AND 12)

Pulse amplitude is represented by active segments of two light bar LEDs that are stacked vertically. Each light bar has ten segments but only eight of the respective segments are used.

Oxygen saturation and pulse rate readings come from two banks of seven-segment LEDs. These LEDs have green and red elements.

## **Front Panel Controls**

Controls are mounted on the front and rear panels of the monitor. Control signals are found on the CPU PCB, the LED Drive PCB, and the front panel membrane:

- Alarm push button assembly
- Control knob
- ON/STDBY switch

### **Alarm Push Button Assembly**

The alarm push button assembly has five membrane switches and a flat cable. The membrane switches and connecting cable are part of the monitor front panel assembly.

### **Control Knob**

The control knob connects to a sealed, two-phase rotary encoder mounted behind the front panel. Encoder outputs are ROTSWA and ROTSWB, which stands for phase A and phase B. The relationship of the phase A and phase B output signals from the encoder, relates whether the knob is rotating clockwise or counterclockwise. The amount of rotation encodes the corresponding amount of desired change.

### **ON/STDBY Switch**

The ON/STDBY switch is mounted on the front panel. The three switch contacts are connected to CN5 on the LED Drive PCB.

## **AC Power Input and Control**

Alternating current input and control elements consist of the AC power input and control unit (which includes the input receptacle) the Power switch, two fuses, and a built-in EMI filter. The fused AC routes to the primary of the power transformer. The filter reduces conducted line noise.



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## ***SECTION 4: ROUTINE MAINTENANCE***

Introduction  
Nellcor Recommendation

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### **INTRODUCTION**

The only routine service required is that which is mandated by your institution and local or national agencies.

### **NELLCOR RECOMMENDATION**

Nellcor recommends replacing the monitor 12 volt battery every 2 years.



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## **SECTION 5: TROUBLESHOOTING**

Introduction  
How to Use This Section  
Who Should Perform Repairs  
Replacement Level Supported  
Obtaining Replacement Parts  
Troubleshooting Guide

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### **INTRODUCTION**

This section explains how to find and correct equipment problems. The troubleshooting method incorporates decision trees and associated selection tables.

### **HOW TO USE THIS SECTION**

Use this section in conjunction with Section 7, Performance and Safety Tests, and Section 9, Spare Parts. To remove and replace a part you suspect is defective follow the instructions in Section 6, Disassembly Guide. The circuit analysis section, section three, offers information that can help you understand how the monitor functions. Observe monitor operation and note symptoms. Then scan the major paragraphs of this section for related troubleshooting procedures.

### **WHO SHOULD PERFORM REPAIRS**

Only qualified biomedical technicians should open the monitor housing, remove and replace components, or make adjustments. To simplify this chapter, these persons are identified as your “qualified service authority”. If your medical facility does not have qualified service personnel, contact Nellcor. Operators are only authorized to replace an entire monitor.

### **REPLACEMENT LEVEL SUPPORTED**

These procedures support a repair scheme that envisions swapping PCBs, but not individual discrete components such as resistors, ICs, and microprocessors. Once you isolate a suspected PCB, following the procedures in this section, replace that PCB with a known good PCB and check to see that the trouble symptom disappears and the monitor passes all performance tests. If the trouble symptom persists, swap the replacement PCB and the suspected malfunctioning PCB (the original PCB that was installed when you started troubleshooting) and continue troubleshooting as directed in this section.

### **OBTAINING REPLACEMENT PARTS**

Nellcor Technical Services provides technical assistance information and replacement parts. To obtain replacement parts, contact Nellcor. Refer to parts by the part names and part numbers listed in Section 9, Spare Parts.

### **TROUBLESHOOTING GUIDE**

Symptoms can occur in one or more of the following categories:

- Status messages on the front panel display
- Front panel display problems
- Interface problems

## Interpreting Symptoms

A monitor that malfunctions typically displays clear symptoms. These symptoms are listed in applicable table columns labeled *Symptom* in troubleshooting charts in this section. Alternately, when the symptoms are complicated and interrelated, a decision tree is used to simplify presenting the information. Follow the symptom descriptions in a given tree and then accomplish the applicable repair strategy as described in the accompanying table.

You may encounter a malfunction that has multiple causes. In such cases, work from left to right in the decision tree, as usual. Correct the first problem listed in the tree, then correct the next problem. Generally, the first problem listed is the most common or the easiest to verify. If you experience a symptom not listed in this section, please contact Nellcor Technical Service in Hayward, California.

## Status Messages

Status messages appear in the SATURATION display immediately after the ON/STDBY switch is set to ON. Status messages for seven error categories are given in table 5-1.

**Table 5-1: Status Messages by Category**

Symptom	Probable cause	Action
Err 1 (error 1)	Defective monitor Defective data memory	Contact qualified service personnel Replace the CPU PCB.
Err 2 (error 2)	Defective monitor Defective program memory	Contact qualified service personnel Replace the CPU PCB.
Err 3 (error 3)	Defective monitor Defective connection between the LED Drive PCB and the LED PCBs. Defective display components on the LED PCB. Defective display decoder and driver ICs on the LED Drive PCB. Defective CPU PCB.	Contact qualified service personnel Check the connectors labeled CN on both PCBs. (Refer to Section 6 for a wiring diagram.) Replace LED PCB Replace the LED Drive PCB Replace CPU PCB
Err5 over run	Slow data buffer	Set Power switch to off and then to on. If problem persists, replace CPU PCB.
Err6 over run	Receive buffer for MP-203 oximetry module	Set Power switch to off and then to on. If problem persists, replace CPU PCB.
Err 7 (error 7)	Communication error. Over run of transmission buffer for data to MP-203 oximetry module	Replace CPU PCB

## Front Panel Display

The front panel LEDs are automatically tested each time the monitor ON/STDBY switch is set to ON. This test takes place quickly and you probably cannot spot a missing segment of an LED display while this test is running (but if an LED is bad the test fails regardless). To manually check the LED display :

1. Press the HIGH SAT push-button and set the ON/STDBY switch to ON.

You see CHE LED displayed for a few seconds; then, 0 is displayed..

2. You can then sequentially light each LED segment by slowly rotating the control knob clockwise.
3. When the display reads 126 you have tested all the segments.
4. Turn control knob a bit more; the segments in the numeric displays (SpO<sub>2</sub> and heart rate) turn from green to red. Turn control knob a bit more and these segments turn red.

To check the front panel buttons:

1. Press the high saturation button and rotate the control dial counterclockwise.
2. You see CHE 1 in the display .
3. Press each control button; verify the respective LED to the left of each button lights.

The number of lighted bars corresponds to the number of DIP switches set to on.

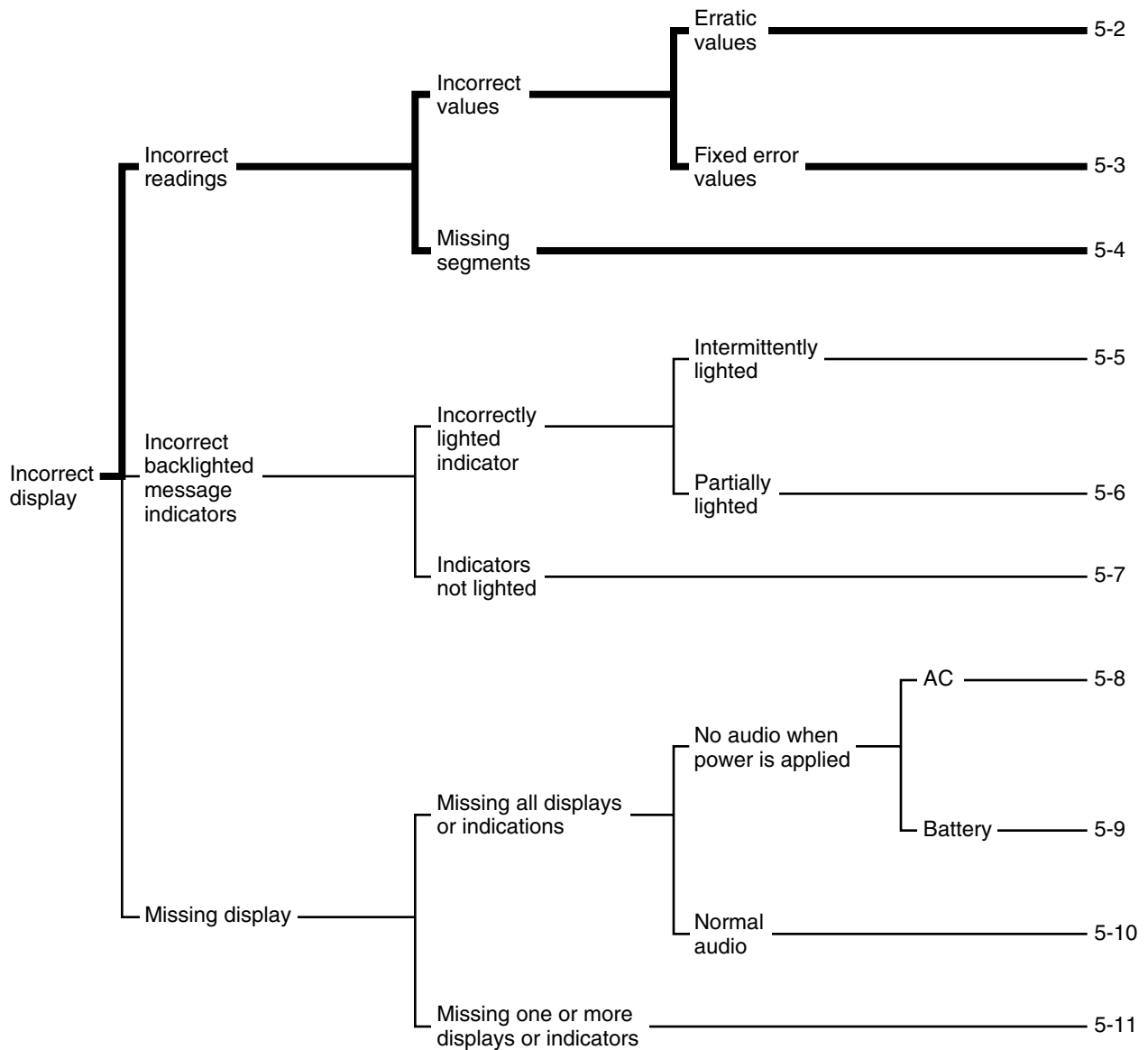
To check the speaker.

1. Rotate the control dial counterclockwise until CHE 2 is displayed.
2. Press high saturation button to sound the alarm at maximum volume.
3. Press low saturation button to sound the alarm at minimum volume.
4. Press audio alarm off button to silence the alarm.

Even though you can precisely determine which LED segment is bad, the replacement part is at the PCB level. Nonetheless, verifying a bad segment is a good way to confirm your diagnoses before replacing the LED driver PCB and LED PCB combination.

When you encounter a front panel display problem, use the decision tree in figure 5-1 (four parts) to find and replace the most likely component that could cause the symptoms you observe. The right side of the tree points to specific tables that describe exactly which components to remove and replace or other appropriate action you should take. Bold lines in the decision tree mark choices that lead to a table printed opposite the tree.

Symptoms ————— Use table listed below



28018A/15-1

Figure 5-1: Display Troubleshooting Decision Tree (1 of 4)

### Incorrect Readings

Pulse oximetry values are affected by incorrect sensor use, patient physiology, or ambient conditions. Use a Nellcor pulse oximeter tester to verify incorrect values before attempting corrective measures.

If the monitor indicates incorrect values when a pulse oximeter tester is connected, the problem is most likely in the monitor. Erratic and fixed error values fluctuate outside the expected range.

**Table 5-2: Erratic or Missing Values**

Probable cause	Action
Defective monitor	Contact qualified service authority
Defective sensor connector assembly.	Replace sensor connector assembly
Defective oximetry module	Replace oximetry module
Defective CPU PCB	Replace CPU PCB
Defective LED Drive PCB and LED PCB assembly	Replace assembly

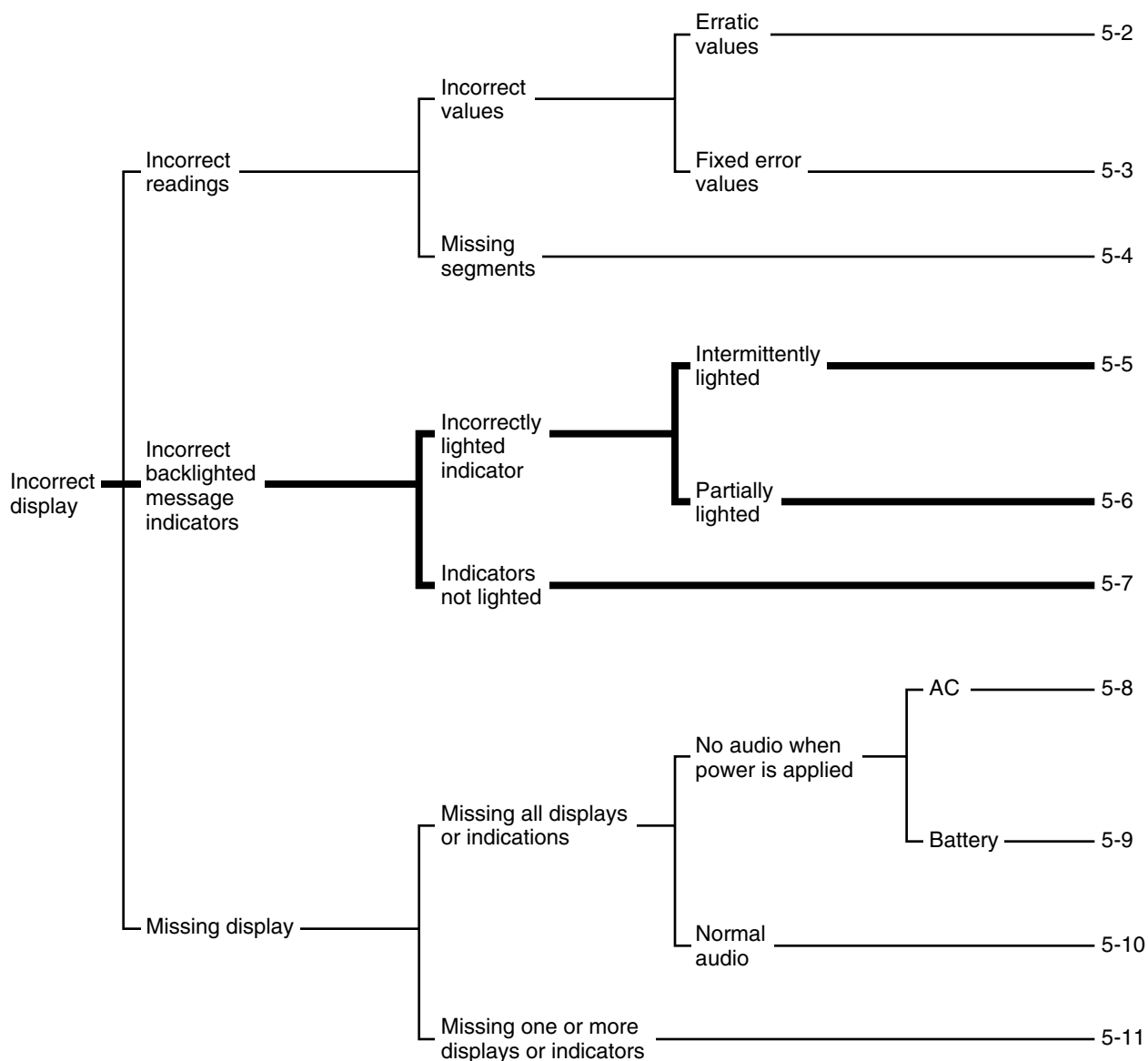
**Table 5-3: Fixed Error Values**

Probable cause	Action
Defective monitor	Contact qualified service authority
Defective oximetry module	Replace oximetry module
Defective CPU PCB	Replace CPU PCB
Defective LED Drive PCB and LED PCB assembly	Replace assembly

**Table 5-4: Missing Display Segments**

Probable cause	Action
Defective connection between the LED Drive and LED PCBs.	Check the connectors labeled CN on both PCBs.
Defective LEDs on the LED PCB.	Replace LED PCB.
Defective display decoder and driver ICs on the LED Drive PCB.	Replace the LED Drive PCB.
Defective CPU PCB	Replace the CPU PCB.

Symptoms ————— Use table listed below



28018A/15-2

**Figure 5-1: Display Troubleshooting Decision Tree (2 of 4)**

### **Incorrect Back-lighted Message Indicators**

All back-lighted message indicators use multiple LED arrays. Component defects, although rare, can occur in the following categories:

- Incorrectly lighted indicators
- Indicators do not light

Intermittently lighted indicators are evident by random flashing of the message text. Normal message flashing occurs at regular intervals.



**Table 5-5: Intermittently Lighted**

Probable cause	Action
Defective monitor	Contact qualified service authority
Defective connection between the LED Drive and LED PCBs.	Check the connectors labeled CN on both PCBs.
Defective leds on the LED PCB.	Replace LED PCB.
Defective display decoder and driver ICs on the LED Drive PCB.	Replace the LED Drive PCB.
Defective CPU PCB	Replace the CPU PCB

Partial indicator lighting shows up as a dim region behind the panel membrane.

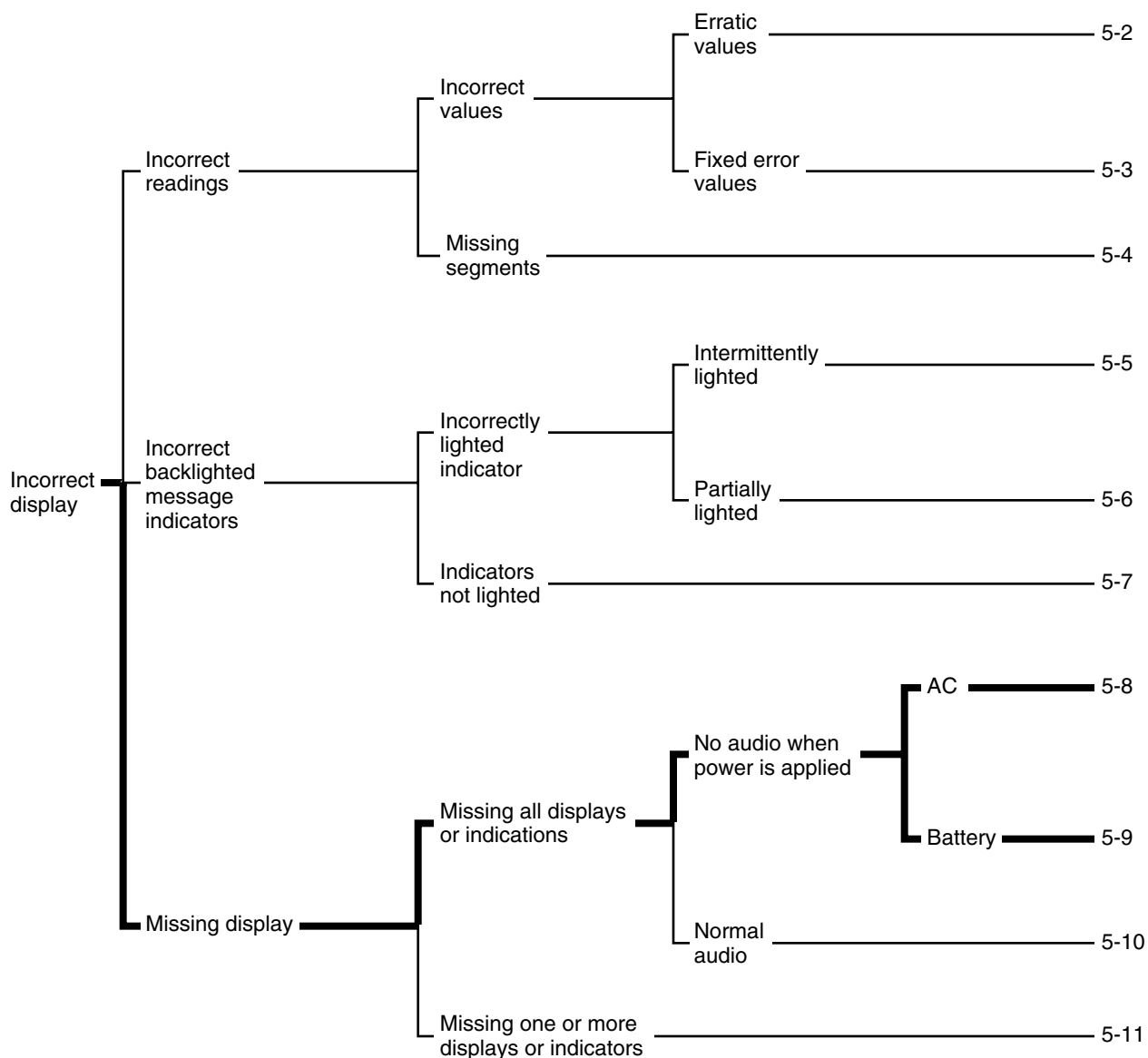
**Table 5-6: Partially Lighted**

Probable cause	Action
Defective monitor	Contact qualified service authority
Defective connection between the LED Drive and LED PCBs.	Check the connectors labeled CN on both PCBs.
Defective LEDs on the LED PCB.	Replace LED PCB.
Defective display decoder and driver ICs on the LED Drive PCB.	Replace the LED Drive PCB.
Defective CPU PCB	Replace the CPU PCB

**Table 5-7: Not Lighted**

Probable cause	Action
Defective monitor	Contact qualified service authority
Defective connection between the LED Drive and LED PCBs.	Check the connectors labeled CN on both PCBs.
Defective LEDs on the LED PCB.	Replace LED PCB.
Defective display decoder and driver ICs on the LED Drive PCB.	Replace the LED Drive PCB.
Defective CPU PCB	Replace the CPU PCB

Symptoms ————— Use table listed below



28018A/15-3

**Figure 5-1. Display Troubleshooting Decision Tree (3 of 4)**

### Missing Front Panel Display Segments

Missing display segment symptoms can mean missing all displays or indicators, or missing one or more displays or indicators.

No audio symptom. The monitor is connected to an AC power source, all displays and indicators are dark, and the dual-tone beep that occurs when you turn on the monitor does not sound.

**Table 5-8: AC Operation**

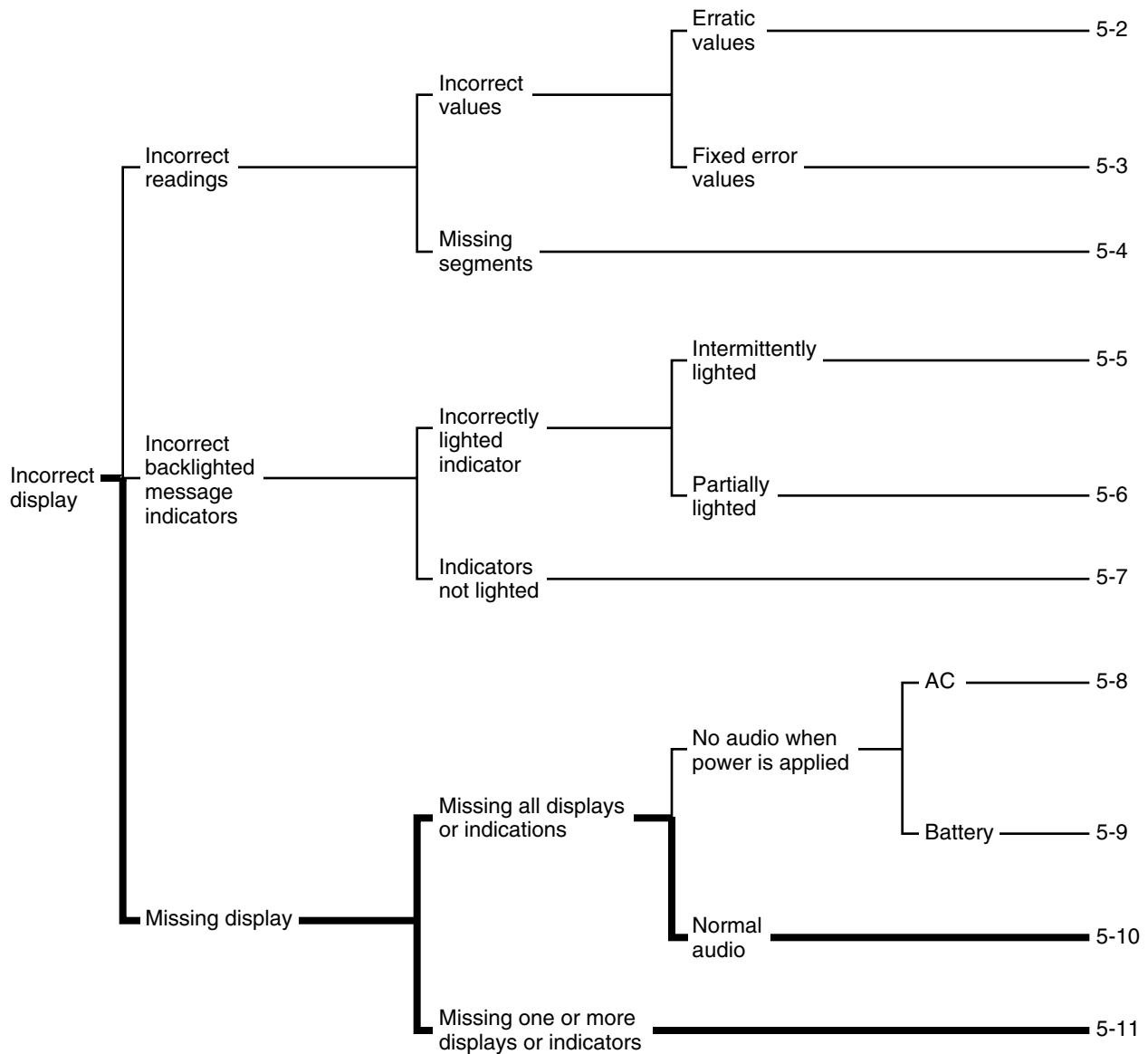
Probable cause	Action
The battery is discharged and the Power switch is set to OFF.	To restart the monitor set ON/STDBY switch to STDBY, set Power switch to ON, and set ON/STDBY SWITCH to ON .
The battery is discharged and the AC power source is defective.	To restart the monitor set ON/STDBY SWITCH to STDBY. Connect the AC power cord to a known good power source. Set Power switch to ON and set ON/STDBY to ON.
Defective monitor	Contact qualified service authority
Defective AC Input assembly	Replace the AC input assembly
Blown fuse	Replace AC fuse
Defective power transformer.	Replace the power transformer
Defective CPU PCB	Replace the CPU PCB

No Audio (second case)    The monitor is not connected to an AC power source, all displays and indicators are dark, and the power-up audio (dual-tone beep) is missing.

**Table 5-9: Battery Operation**

Probable cause	Action
The battery is discharged.	To restart the monitor set ON/STDBY switch to STDBY. Connect the AC power cord to a known good power source. Set Power switch to ON and set ON/STDBY to ON.
The battery is discharged and the AC power source is defective.	To restart monitor set ON/STDBY switch to STDBY, connect AC power cord to a known good AC outlet, set Power switch to ON, and set ON/STDBY switch to ON.
Defective monitor	Contact qualified service authority
Defective CPU PCB	Replace CPU PCB

Symptoms ————— Use table listed below



28018A/15-4

Figure 5-1: Display Troubleshooting Decision Tree (4 of 4)

Audio Present      Missing all message indicators, but power-up audio (dual-beep tone present) is normal.

**Table 5-10: Normal Audio When Power is Applied**

Probable cause	Action
Defective monitor	Contact qualified service authority
Defective connection between the LED Drive and LED PCBs.	Check the connectors labeled CN on both PCBs.
Defective display components on the LED PCB.	Replace LED PCB.
Defective display decoder and driver ICs on the LED Drive PCB.	Replace the LED Drive PCB.
Defective CPU PCB.	Replace CPU PCB.

**Table 5-11: Missing One or More Displays or Indicators**

Probable cause	Action
Defective monitor	Contact qualified service authority
Defective connection between the LED Drive and LED PCBs.	Check the connectors labeled CN on both PCBs.
Defective display components on the LED PCB.	Replace LED PCB.
Defective display decoder and driver ICs on the LED Drive PCB.	Replace the LED Drive PCB.

How To Find Problems In Your Controls

The monitor controls are on the front panel and the rear panel. Figure 5-2 is a decision tree to help you pinpoint problems that occur with front panel controls. This figure has two sheets.

Symptoms ————— Use table listed below

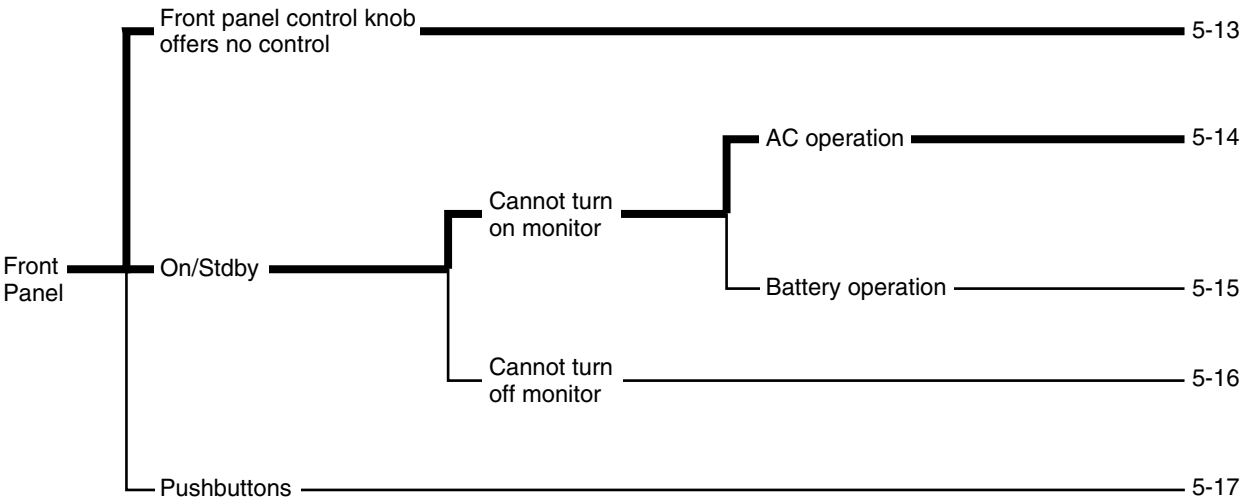


Figure 5-2: Front Panel Decision Tree (1 of 2)

## Front Panel Problems

Front panel action table 5-12 lists possible defective components and connections that could cause the symptoms noted in the related decision tree.

**Table 5-12: Front Panel Control Knob**

Probable cause	Action
Defective monitor	Contact qualified service authority
Defective control knob assembly	Replace control knob assembly
Incomplete connection at CN1 or CN7 on the LED Drive PCB.	Verify connections at CN1 and CN7 on the LED Drive PCB.
Incomplete connection at CN2 on the CPU PCB.	Verify connection CN2 on the CPU PCB.
Defective CPU PCB.	Replace CPU PCB.

## ON/STDBY Switch

In table 5-13 the monitor is connected to an AC power source. Operating the ON/STDBY switch has no effect.

**Table 5-13: Cannot Turn On Monitor (AC Operation)**

Probable cause	Action
The battery is discharged and the Power switch is set to OFF	To restart the monitor set the ON/STDBY switch to STDBY , set the Power switch to ON, and then set the ON/STDBY switch to ON.
The battery is discharged and the AC power source is defective.	To restart the monitor set the ON/STDBY switch to STDBY. Connect the AC power cord to a known good power source. Set the Power switch to ON and set the ON/STDBY switch to ON.
Defective monitor	Contact qualified service authority
Defective AC input assembly	Replace the AC input assembly
Defective power transformer	Replace the power transformer
Defective CPU PCB	Replace the CPU PCB
Defective switch	Replace switch

Symptoms \_\_\_\_\_ Use table listed below

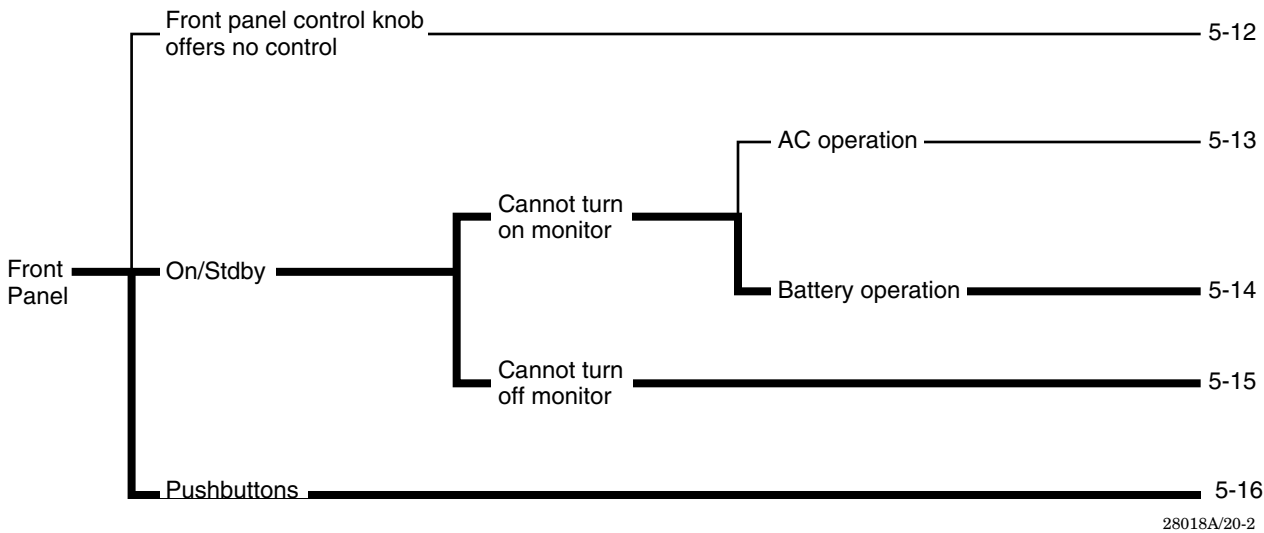


Figure 5-2: Front Panel Decision Tree (2 of 2)



In table 5-14, the monitor is disconnected from an AC power source and the ON/STDBY switch has no effect.

**Table 5-14: Cannot Turn On Monitor (Battery Operation)**

Probable cause	Action
The battery is discharged.	To restart the monitor, set the ON/STDBY switch to STDBY, connect the AC power cord to a known good AC outlet, set the Power switch to ON, and set the ON/STDBY switch to ON
The battery is discharged and the AC power source is defective.	To restart the monitor, set the ON/STDBY switch to STDBY, connect the AC power cord to a known good AC outlet, set the Power switch to ON, and set the ON/STDBY switch to ON
Defective monitor	Contact qualified service authority
Defective AC input assembly	Replace the AC input assembly
Defective power transformer	Replace the power transformer
Defective CPU PCB	Replace the CPU PCB

**Table 5-15: Cannot Turn Off Monitor**

Probable cause	Action
Defective monitor	Contact qualified service authority
Defective ON/STDBY switch assembly	Replace ON/STDBY switch assembly
Incomplete connection at CN1 or CN5 on the LED Drive PCB.	Verify connections at CN1 and CN5 on the LED Drive PCB.
Incomplete connection at CN2 on the CPU PCB.	Verify connection CN2 on the CPU PCB.
Defective CPU PCB.	Replace CPU PCB.

**Table 5-16: Push Buttons**

Probable cause	Action
Defective monitor	Contact qualified service authority
Incomplete connection at CN1 or CN6 on the LED Drive PCB.	Verify connections at CN1 and CN6 on the LED Drive PCB.
Incomplete connection at CN2 on the CPU PCB.	Verify connection CN2 on the CPU PCB.
Defective CPU PCB.	Replace CPU PCB.

## Rear Panel

Rear panel interface component symptoms occur in the following categories:

- DIP Selector Switch
- Power Switch
- RS-232 Communications Port

**Table 5-17: DIP Selector Switch Troubleshooting Chart**

Symptom	Probable cause	Action
No NEO LED	Incorrect DIP switch setting	Refer to monitor operator's manual for correct switch settings
Cannot change alarm limits from Adult to Neo or vice versa	Defective monitor	Contact qualified service authority
Cannot change baud rate	Defective CPU PCB.	Replace CPU PCB.

The Power switch must be set to ON to operate the monitor on AC power and to charge monitor batteries when the ON/STDBY switch is set to STDBY. The Power switch problems can be caused by the conditions listed in table 5-18.

**Table 5-18: Power Switch Troubleshooting Chart**

Symptom	Probable cause	Action
Monitor does not charge battery	Defective monitor or power cable	Contact qualified service authority
BATT IN USE indicator lighted when Power switch is set to on	Defective AC input assembly	Replace AC input assembly

Table 5-19 lists symptoms, probable causes and actions that apply to the RS-232 port.

**Table 5-19: RS-232 Communications Port Troubleshooting Chart**

Symptom	Probable cause	Action
Garbled output	Incorrect DIP switch baud rate settings	Refer to monitor operator's manual for correct switch settings.
	Defective peripheral device	Replace peripheral device
	Defective or incorrect interface cable.	Check interface cable, replace if required.
	Defective monitor	Contact qualified service authority
No signals on send and receive lines	Defective CPU PCB (optical isolators or drivers)	Replace CPU PCB.

---

## **SECTION 6: DISASSEMBLY AND ASSEMBLY GUIDE**

Introduction  
Tools Required  
Preliminary Procedures and Precautions  
Post Assembly Testing Requirements  
Top Level View of Monitor Assemblies  
Wiring Connections  
Procedures

---

### **INTRODUCTION**

This section describes how to disassemble the monitor when required for parts replacement, testing or troubleshooting. Assembly procedures are the reverse of disassembly.

### **TOOLS REQUIRED**

To disassemble the monitor you need

- Number one Phillips head screwdriver
- Number two Phillips head screwdriver
- Tweezers or small needle-nose pliers (not absolutely required but handy for retrieving dropped screws)
- Metric nut driver set or set of small metric wrenches

### **PRELIMINARY PROCEDURES AND PRECAUTIONS**

In some cases the PCBs have components on both sides. Handle PCBs with care. Before opening or disassembling the monitor, do the following:

1. Attach a grounding strap to your wrist.
2. On the monitor rear panel, set power switch to off.

<p><b>WARNING:</b> Failure to remove the AC power cord in the next step could expose you to lethal AC voltage.</p>
--

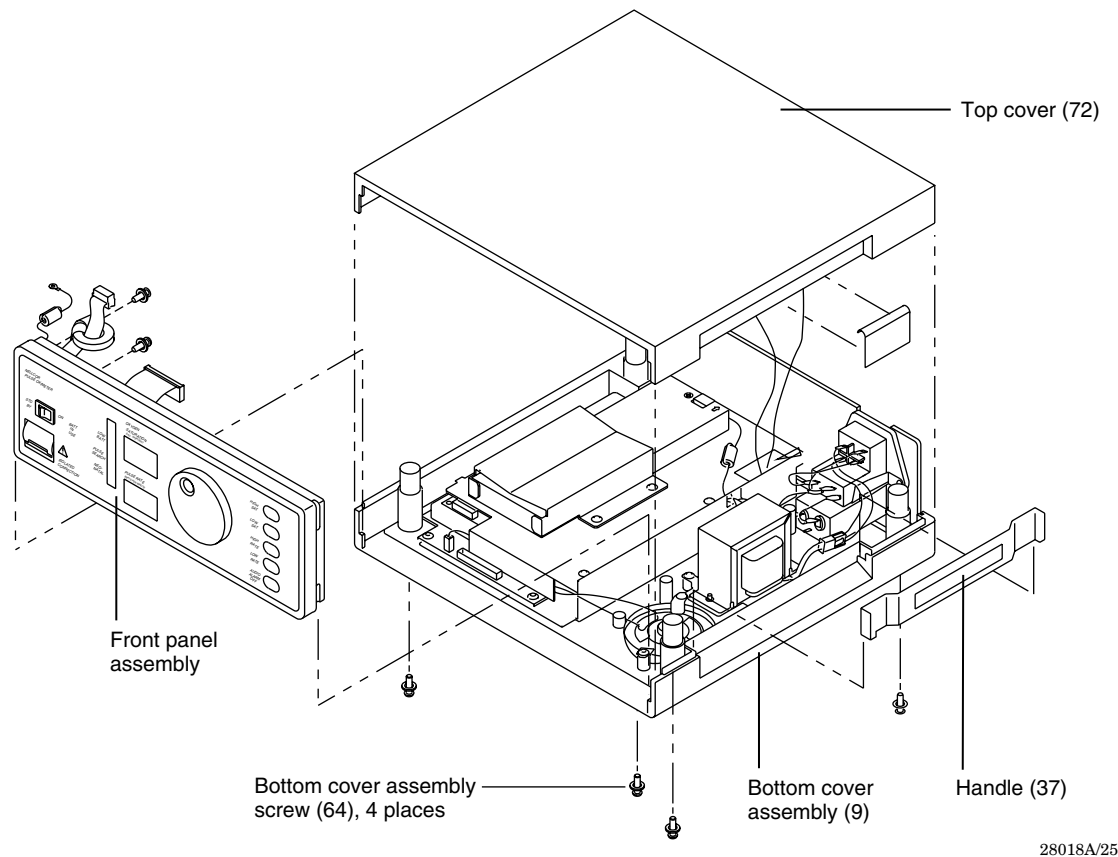
3. If attached, disconnect the AC power cord, oximetry sensor, and printer cable.

### **POST ASSEMBLY TESTING REQUIREMENTS**

If you remove and replace electrical components, perform the tests in Section 7, Performance and Safety Tests.

### **TOP LEVEL VIEW OF MONITOR ASSEMBLIES**

Figure 6-1 is an exploded view of the monitor that shows the relationship of three major assemblies: the top cover, the front panel assembly and the bottom cover assembly. Four screws hold the bottom cover assembly to the top cover. Each major assembly is in turn composed of minor assemblies.

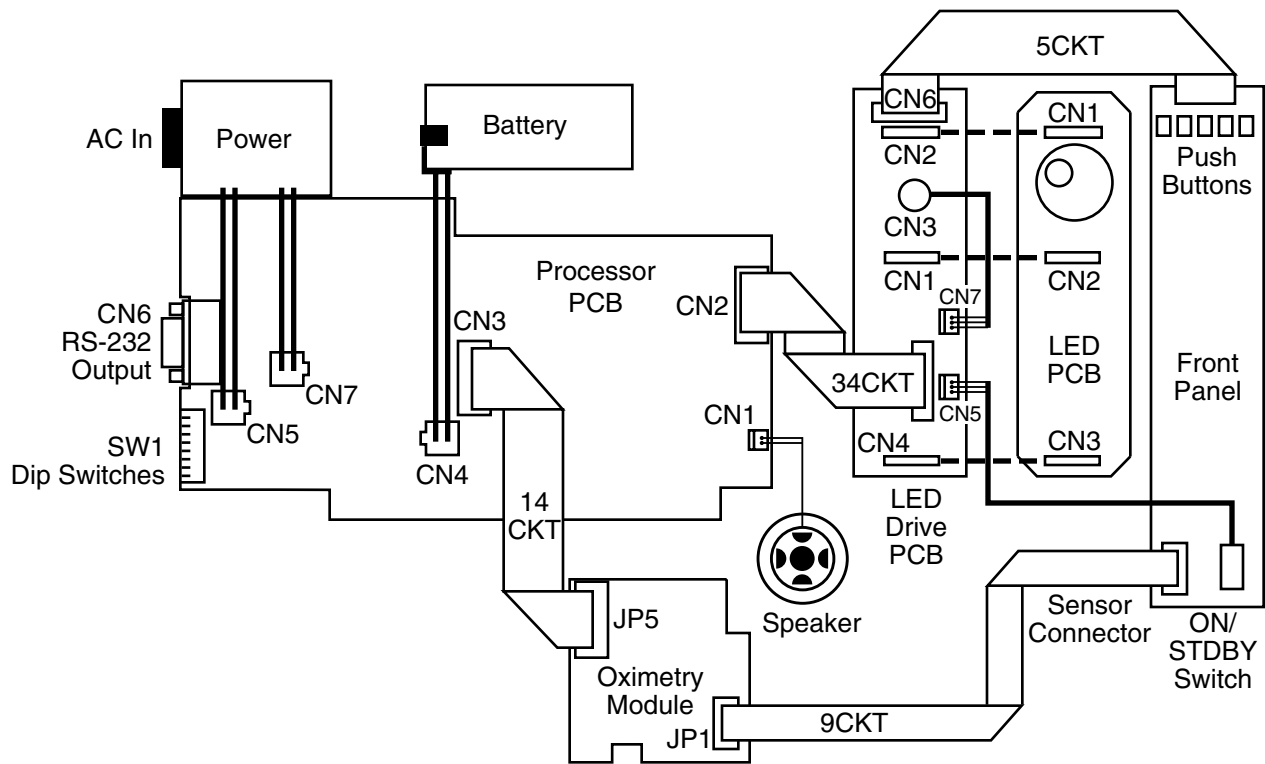


**Figure 6-1: Exploded View of Monitor**

## **WIRING CONNECTIONS**

Figure 6-2 is a wiring connection diagram that you can use for reference when disassembling and reassembling the monitor components. You can completely remove most cables by disconnecting the connectors at either end.

Some cable connectors have a retaining clip; ensure that you replace a retaining clip if you disconnect a cable connector that has one. Otherwise, you could experience erratic operation if a cable connector eventually comes loose.



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Figure 6-2: Monitor Cabling Diagram

## PROCEDURES

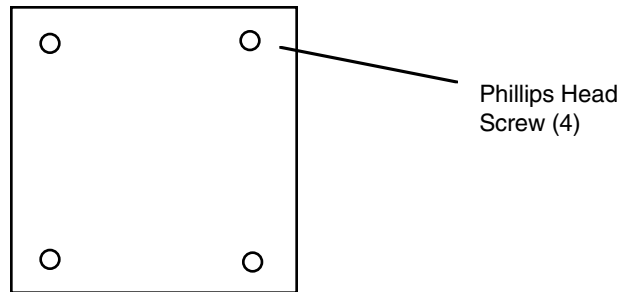
The following procedures are organized in a top down approach. Procedures for gaining access to and removing components in each major assembly are given, starting with the display housing components. In general, to reach components that are on the bottom of an assembly, you must perform all the steps leading to the assembly you wish to remove. For example, to replace the CPU PCB you must first remove the battery, top shield, and middle shield components.

Most screw fasteners have some arrangement of washers, either a combination flat washer and lock washer or a self locking type. To simplify writing this procedure, washer removal is omitted from the applicable steps. If a screw has a removable washer, and you remove the washer, ensure you replace the washer when you assemble the monitor.

## GAINING ACCESS TO COMPONENTS

Unfasten the top cover to gain access to components mounted on the bottom cover assembly and the front panel assembly. Here is how to unfasten the top cover assembly.

1. Place monitor upside down on the bench top.



Simplified bottom view of monitor.

2. Using a number two Phillips head screwdriver, remove the four bottom cover assembly screws.
3. Carefully return monitor to upright position with front panel facing you, and gather up the screws. Retain for replacement.

### **Removing Bottom Cover Components**

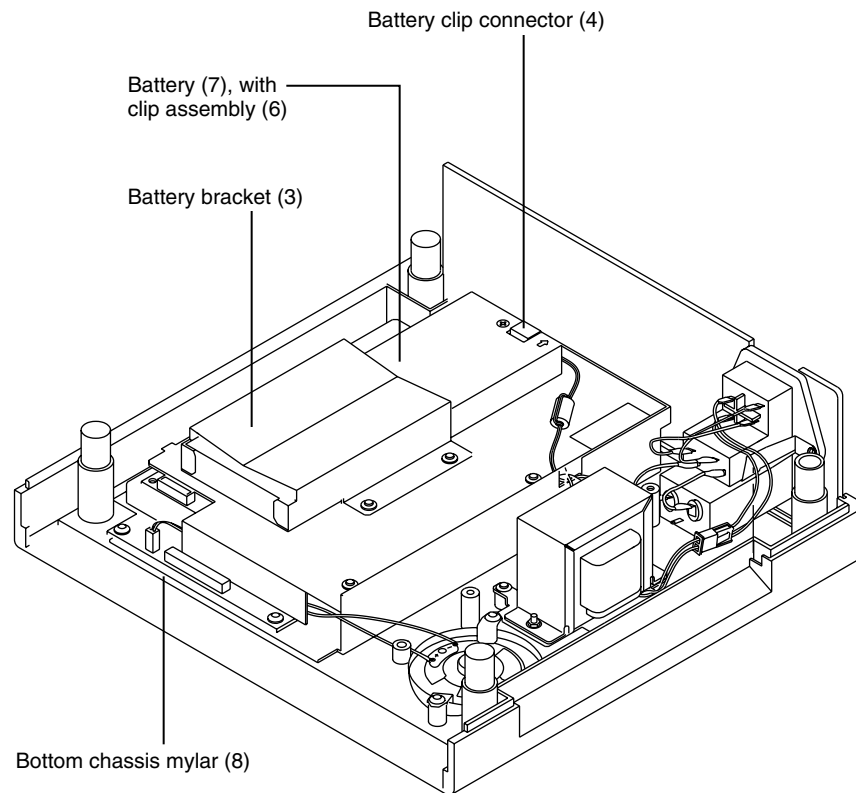
Replaceable components in the bottom cover include:

- Battery
- Speaker and speaker brackets
- Transformer
- AC inlet (AC power inlet and control)
- Top shield
- Oximetry module
- Middle shield
- Battery fuse
- CPU PCB
- Rear panel

### **Battery**

The following battery removal steps assume you are not troubleshooting the monitor, in which case, you must leave the battery connected. To remove the 12 VDC battery:

1. Gain access to the battery by following the instructions in this section for gaining access to components.
2. Remove four screws from battery bracket (figure 6-3) and lift off bracket.
3. Use a small flat blade screwdriver to carefully pry the battery clip assembly from the battery.
4. Remove battery.



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**Figure 6-3: Battery and Associated Components**

### Speaker and Speaker Brackets

To remove the speaker:

1. Gain access to the speaker by following the instructions in this section for gaining access to components.
2. The steps for removing the speaker and the associated speaker brackets are obvious by inspection.

### Top Shield

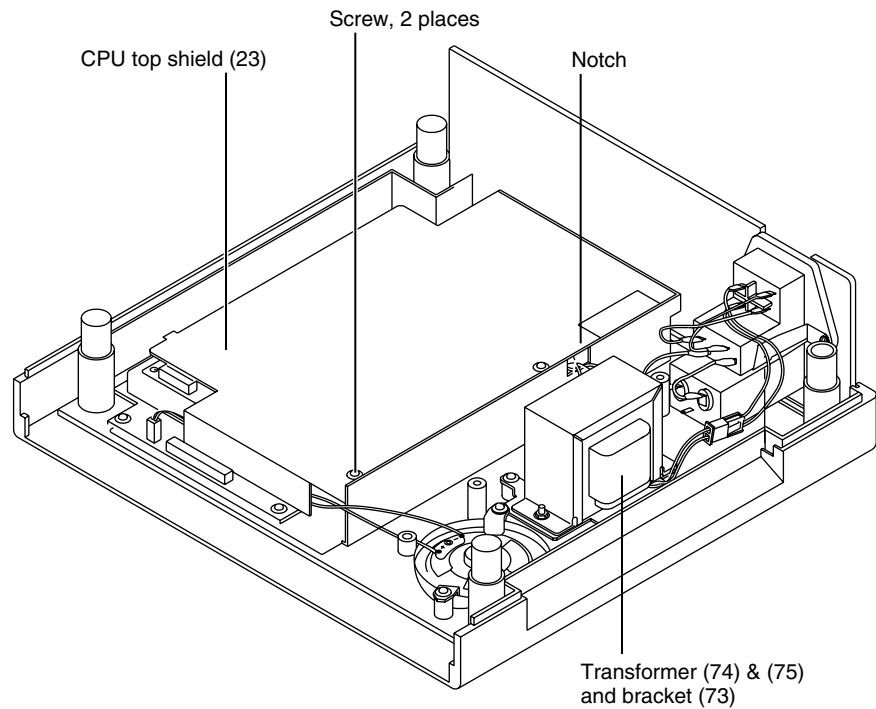
You must remove the top shield to gain access to the:

- Middle shield and oximetry module
- CPU PCB
- Battery fuse
- Transformer wiring connections to CPU PCB

To remove the top shield:

1. Gain access to the top shield by following the instructions in this section for gaining access to components.
2. Remove the battery (following instructions in this section) unless you are troubleshooting and need to have power applied.
3. Remove two screws that hold top shield to standoffs below (figure 6-4).

4. Rotate top shield being careful of transformer wires that enter notch near the back; slide tabs out and lift free.



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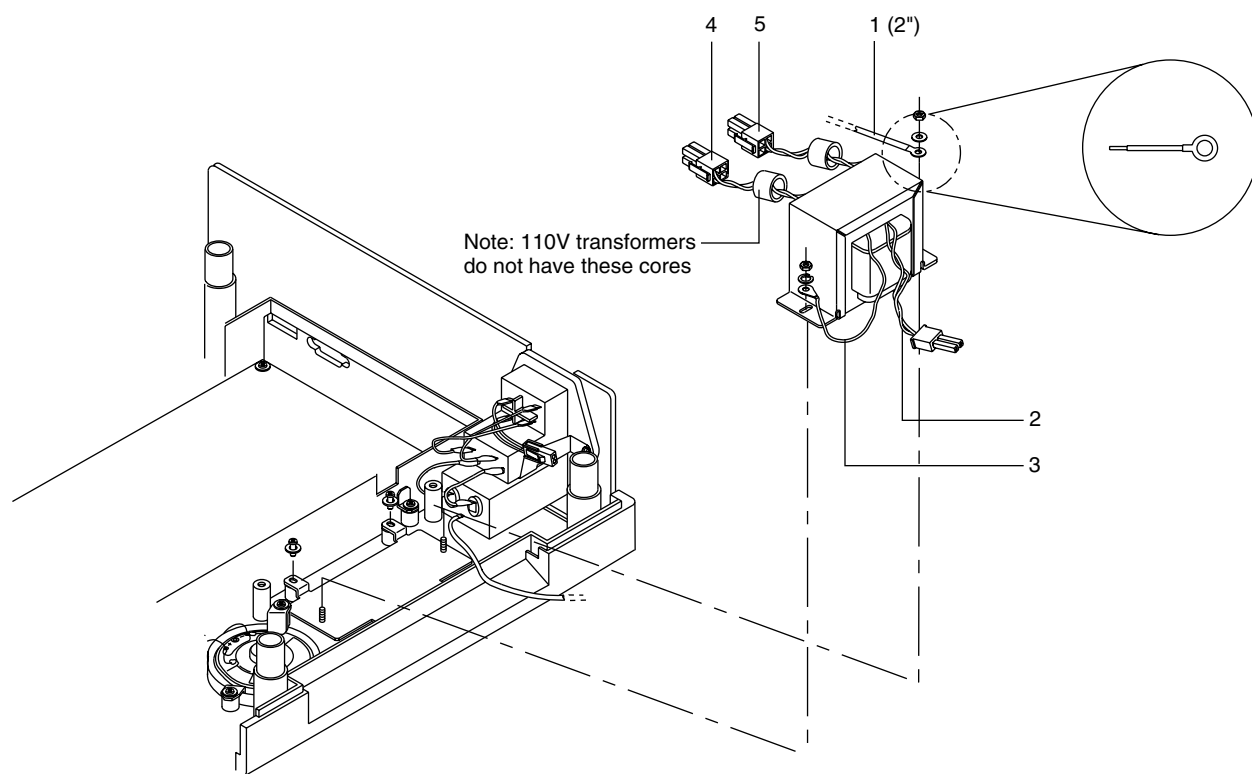
**Figure 6-4: Removing the Top Shield**

### **Transformer Removal and Replacement**

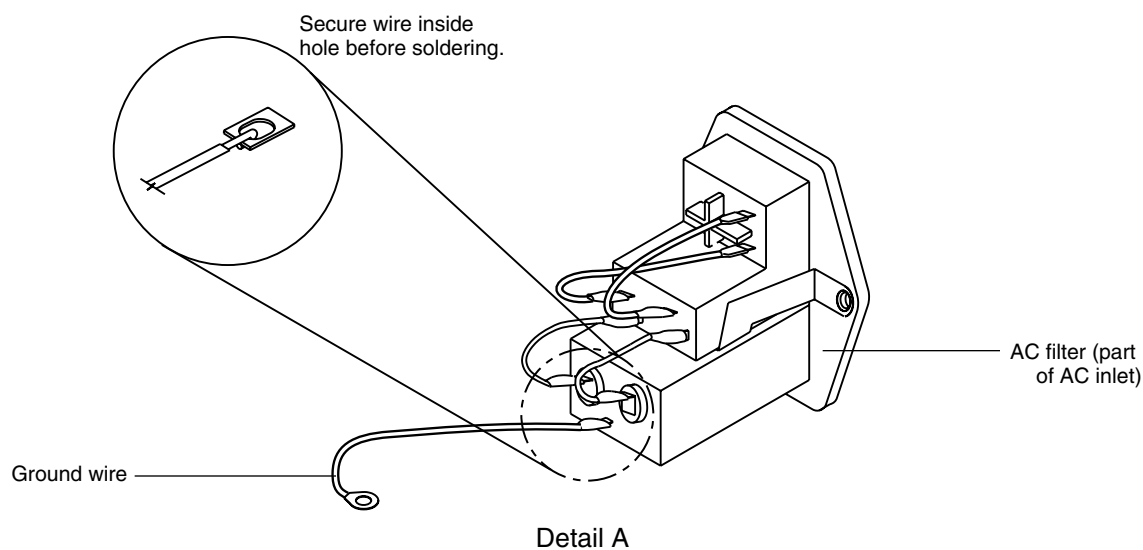
To remove and replace the transformer (figure 6-5, which also illustrates AC filter details) follow these steps:

1. Gain access to the transformer by following the instructions in this section for gaining access to components.
2. Remove top shield following instructions in this section.
3. Disconnect connector on CPU PCB connector CN5 (item 5 in illustration).
4. Disconnect connector on CPU PCB connector CN7 (item 4 in illustration).
5. Remove two 6 mm hex nuts holding transformer to transformer bracket.
6. Remove transformer.
7. Inspect AC filter and determine if a ground strap (item 1 in illustration) is soldered to the bottom ground lug of the filter.
8. If the AC filter lacks a ground wire, remove the filter and solder a ground wire on the filter lug (a 2-inch length of wire is included in the AC filter replacement kit). Follow the instructions for removing and replacing the AC filter as given in this section.





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**Figure 6-5: Transformer and AC Filter Details**

9. Position replacement transformer on studs.
10. Connect transformer wiring as follows:
  - a. Connect black and white wires (2-pin connector) to mating connector on AC switch portion of AC inlet assembly (item 2 in illustration).

- b. Connect blue wires to CPU PCB connector CN5 (item 5 in the illustration).
  - c. Connect yellow wires to CPU PCB connector CN7 (item 4 in the illustration).
11. Position AC filter ground-wire on the rear-most transformer bracket stud (item 1 in the illustration).
12. If there is a green and yellow wire (item 3 in the illustration) on the replacement transformer position the corresponding lug on the front transformer bracket stud.
13. Fasten wire leads 1 and 3 to transformer bracket studs using two 6 millimeter hex nuts.

### **AC Filter Removal and Replacement**

The AC filter is part of the AC inlet and control assembly. To remove and replace the AC filter:

1. Gain access to the AC filter by following the instructions in this section for gaining access to components.
2. To remove AC inlet assembly (that includes AC filter):
  - a. Remove screw holding AC inlet assembly to right side member of the rear panel assembly.
  - b. If required, remove 6 mm hex nut on the rear most transformer bracket stud (some monitors do not have a ground wire from the AC inlet assembly to the transformer stud).
  - c. Lift out left side of rear panel assembly and attached AC power inlet and control assembly (they are attached with a single screw).
3. Inspect replacement AC inlet filter for a ground wire on the bottom ground lug. If a ground wire is not soldered to the lug, solder a ground wire to the lug (a 2-inch length of wire is included in the replacement kit).
4. Position AC filter ground-wire on the rear-most transformer bracket stud (item 1 in the illustration) while simultaneously sliding AC inlet filter into position on the bottom assembly.
5. Fasten right side member of rear panel assembly to AC inlet and control assembly.

### **Battery Fuse**

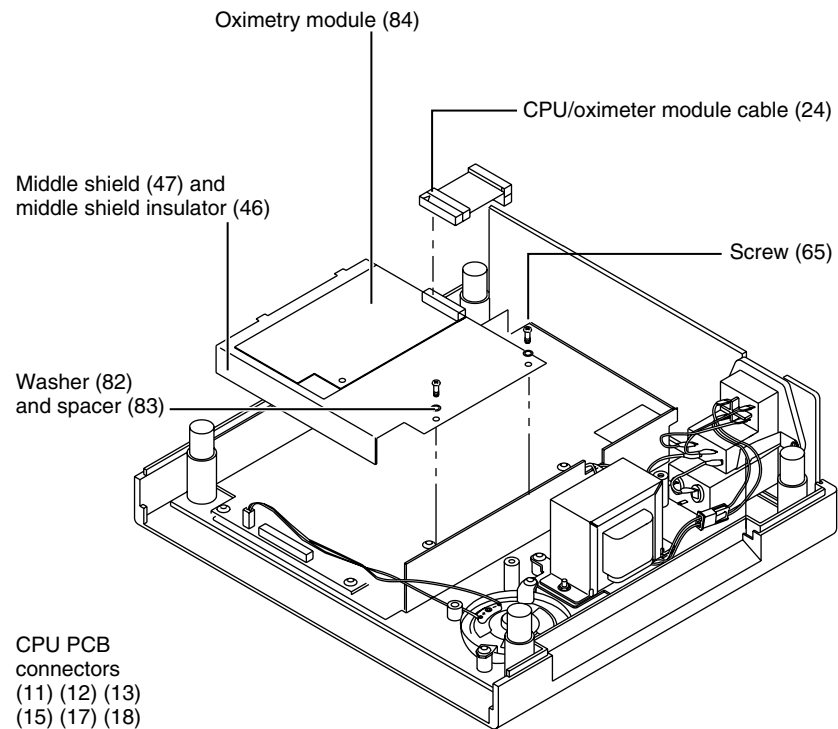
The battery fuse is in a fuse holder that is soldered to the CPU PCB. Once you remove the top shield you can see the fuse beneath the connector that routes between the CPU PCB and the oximetry module. To replace the fuse:

1. Disconnect the battery wire connector that connects to CN4 on the CPU PCB.
2. Disconnect the ribbon cable between the CPU PCB and the oximetry module.
3. Use a small flat blade screwdriver to gently pry the fuse from the holder.

## Middle Shield and Oximetry Module

You have to remove the middle shield to gain access to components in the bottom shield assembly. Here is how to remove the middle shield and oximetry module (figure 6-6).

1. Gain access to the middle shield by following the instructions in this section for gaining access to components; remove the battery and top shield.
2. Disconnect sensor connector cable from connector JP1 of oximetry module (not illustrated in figure).
3. Remove two screws and washers that hold middle shield assembly onto bottom shield standoffs.
4. Rotate middle shield assembly to gain some clearance and disconnect ribbon cable from oximetry module JP5.
5. Lift oximetry module and middle shield assembly free.
6. To completely remove oximetry module, remove three screws holding oximetry module to the middle shield.



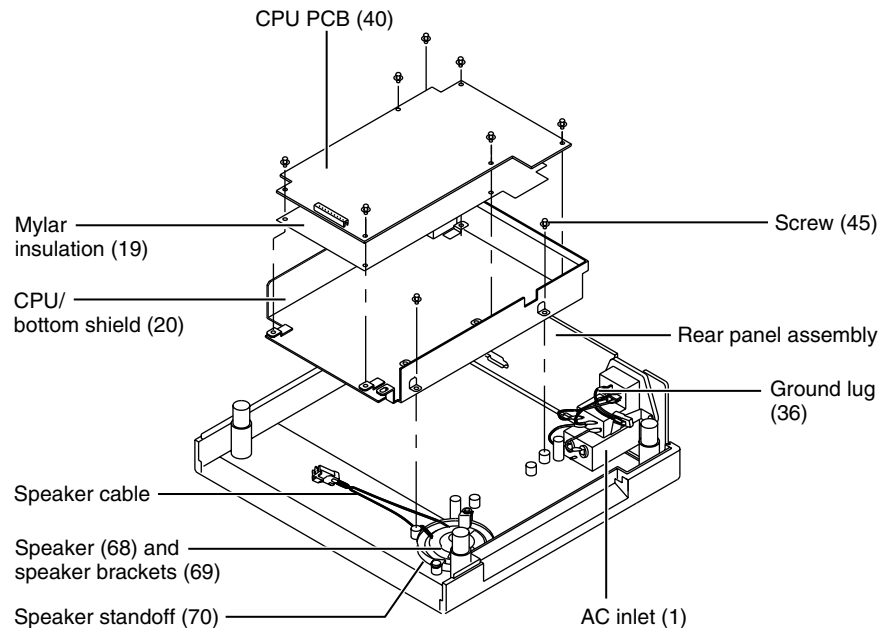
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**Figure 6-6: Middle Shield Components**

## CPU PCB and LCD PCB

The CPU PCB can be removed as a single unit. To remove the CPU PCB you have to first remove the oximetry module and the middle shield. To remove the CPU PCB (figure 6-7):

1. Remove middle shield following instructions in this section.
2. Remove three screws that hold the bottom shield to the bottom cover.
3. Remove 20-conductor ribbon cable from CN2.
4. Remove 2-conductor speaker cable on CN1.
5. Lift bottom shield free.
6. Remove four screws that fasten CPU PCB to bottom shield. (A fifth screw holds the mylar insulation in place; you can leave this screw fastened.)



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**Figure 6-7 Bottom Shield Components**

### **Rear Panel Assembly**

The rear panel assembly has a left and a right member; these members fasten to the AC power inlet and control assembly. Here is how to remove the rear panel assembly:

1. Remove bottom shield following instructions in this section.
2. Disconnect AC filter ground lead from transformer rear most transformer bracket stud.
3. Lift rear panel (including AC power inlet assembly) up and out.

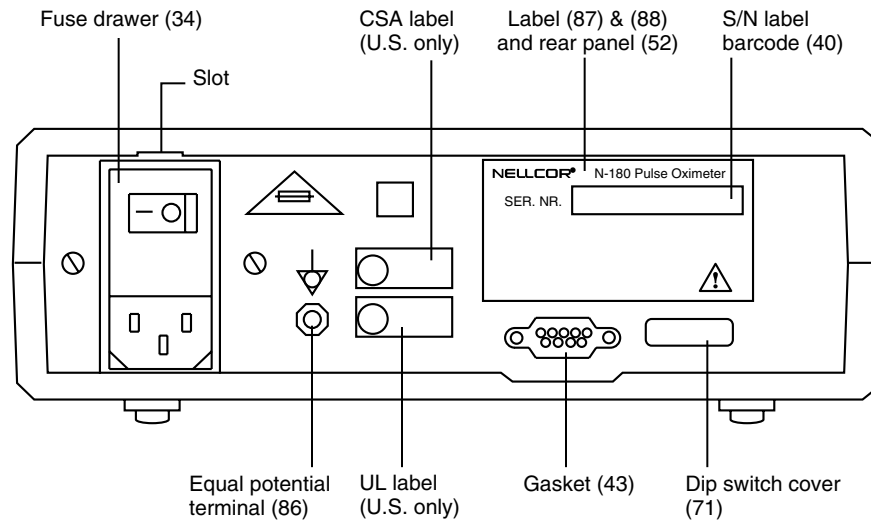
### **Fuse in the AC Power Inlet Assembly**

The two fuses for the monitor are installed in respective fuse holders that are part of the AC power inlet and control assembly. To replace a fuse:

1. Gain access to the fuses as follows:

- a. Remove AC power cord.
- b. Insert a screwdriver or other suitable tool into the rear panel slot on the rear panel (figure 6-8).
- c. Carefully pry the fuse holder door down and out (figure 6-9).

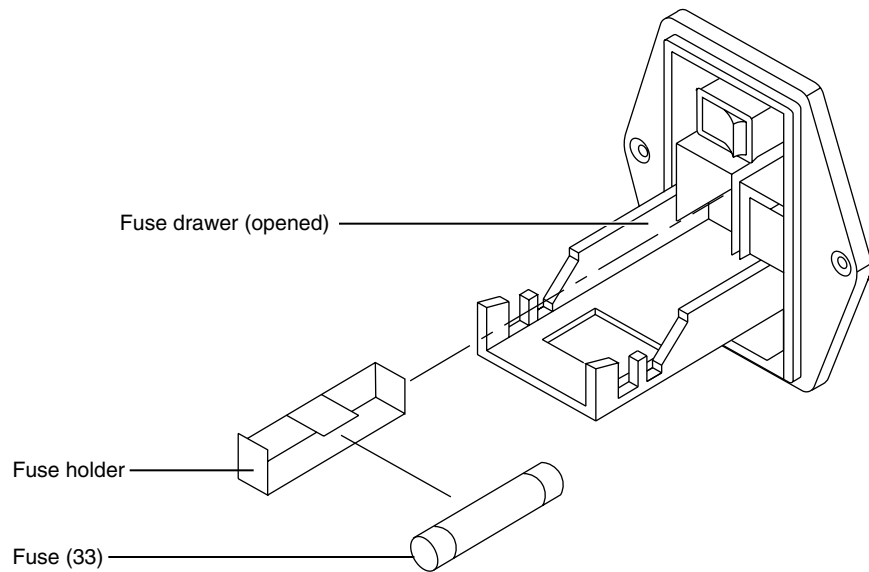
There are two fuse holders behind the fuse holder door.



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**Figure 6-8: AC Power Inlet and Control Assembly**

2. To remove a fuse holder insert the blade of a small screwdriver behind the white arrow embossed on the fuse holder (not illustrated) and pry out.  
Only one fuse holder is withdrawn in the illustration.
3. Remove remaining fuse; examine both fuses and determine condition of each fuse.
4. Slide a new fuse of the correct rating into the fuse holder that previously held the blown fuse (follow the legend on the rear panel when determining correct rating).
5. Replace remaining fuse.



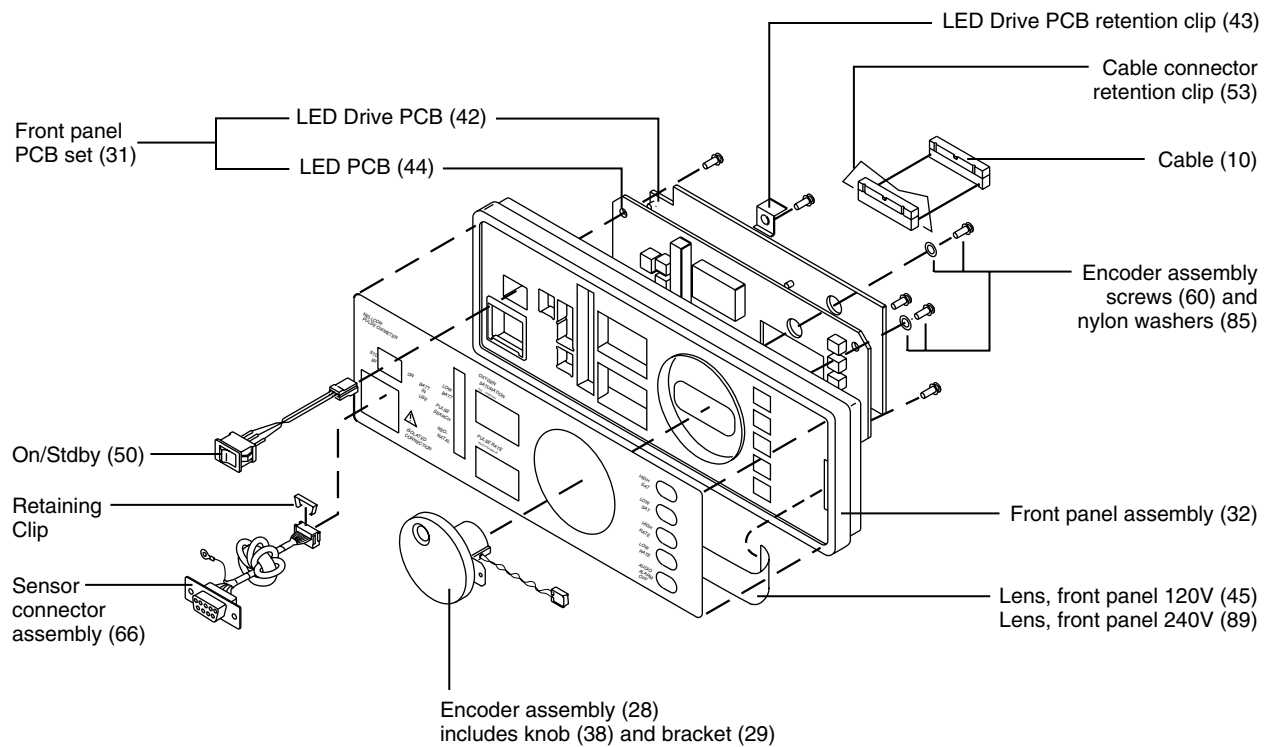
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**Figure 6-9: Fuse Holder**

### **Separating Front Panel Assembly From Bottom Cover**

The front panel assembly has a groove that fits into the bottom cover housing on either side. To remove the front panel assembly:

1. Gain access to the front panel following the instructions for gaining access to components in this section.
2. Release ribbon cable retainer clip and disconnect ribbon cable assembly (figure 6-10) from CN2 of CPU PCB.
3. Remove front panel ground wire from the chassis by removing the Phillips head screw located at the front-left battery hold-down bracket.
4. Release from 10-pin retainer clip holding the sensor cable assembly connector (to male connector of oximetry module) and disconnect sensor connector .
6. Grasp front panel at top edge and lift free of bottom cover.



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**Figure 6-10: Front Panel Assembly Components****Removing Front Panel Assembly Components**

Replaceable components in the front panel assembly include:

- LED Drive PCB
- PCB retention clip
- LED PCB
- Encoder assembly
- Sensor connector assembly
- ON/STDBY switch

**ON/STDBY Switch Assembly**

To remove the ON/STDBY switch assembly:

1. Gain access to ON/STDBY switch following instructions for gaining access to components and removing front panel assembly.
2. Disconnect ON/STDBY cable from CN5 on the LED Drive PCB.
3. From the interior side of the front panel, gently push switch assembly until free of front panel (two plastic tabs, one on either side of the switch, hold the switch in place).

**LED Drive PCB and LED PCB**

The LED Drive PCB and the LED PCB are connected together in a single physical assembly. The connection is achieved via six electrical connectors, three on each PCB.

1. Gain access to LED Drive PCB and LED PCB following instructions for gaining access to components and removing front panel assembly.
2. Disconnect encoder assembly cable from CN7 of LED Drive PCB
3. Remove screws holding encoder assembly and bracket.
4. Rotate encoder assembly bracket and remove two nylon spacers; withdraw bracket through the front panel cutout.
5. Disconnect membrane flex circuit from CN6 of LED PCB.
6. Remove screw and PCB retention clip.
7. At this stage, you can remove the LED PCB and LED Drive PCB together or simply remove the LED Drive PCB. To remove the combination:
  - a. Remove three screws holding LED PCB.
  - b. Remove the mated LED PCB and the LED Drive PCB.
  - c. To separate PCBs, simply pull the PCBs apart.

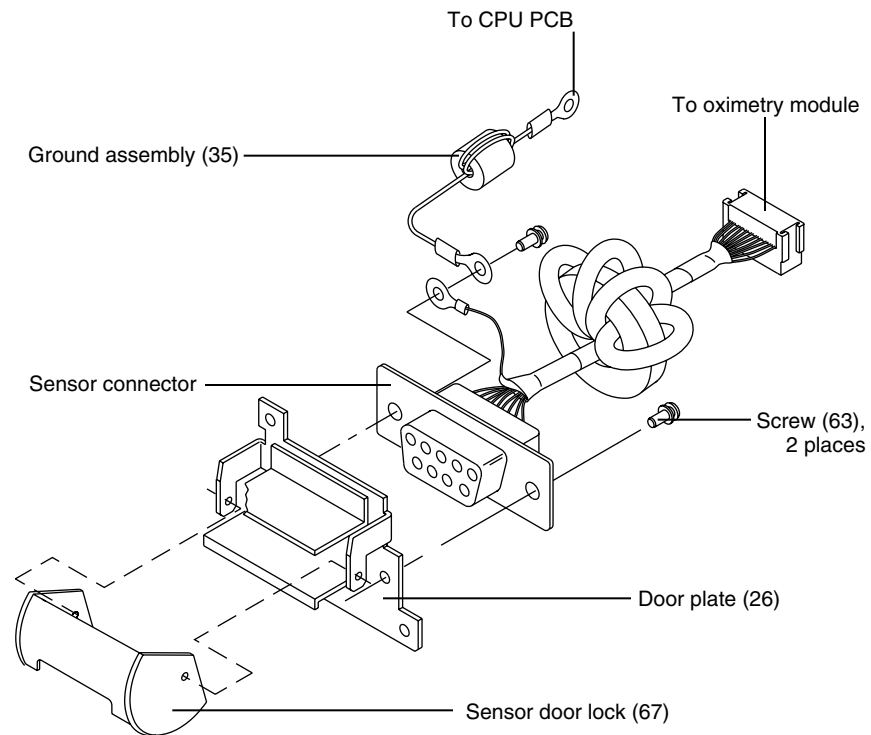
This action disconnects three 10-pin connectors (CN2, CN3, CN4) on the LED Drive PCB that respectively connect to CN1, CN2, and CN3 on the LED PCB.

### **Sensor Connector Assembly**

Remove the sensor connector to replace the sensor connector assembly door or the sensor connector. To remove the sensor connector assembly:

1. Gain access to sensor connector assembly following instructions for removing front panel assembly.
2. Remove screws fastening connector housing to sensor door (figure 6-11).
3. Remove sensor connector.





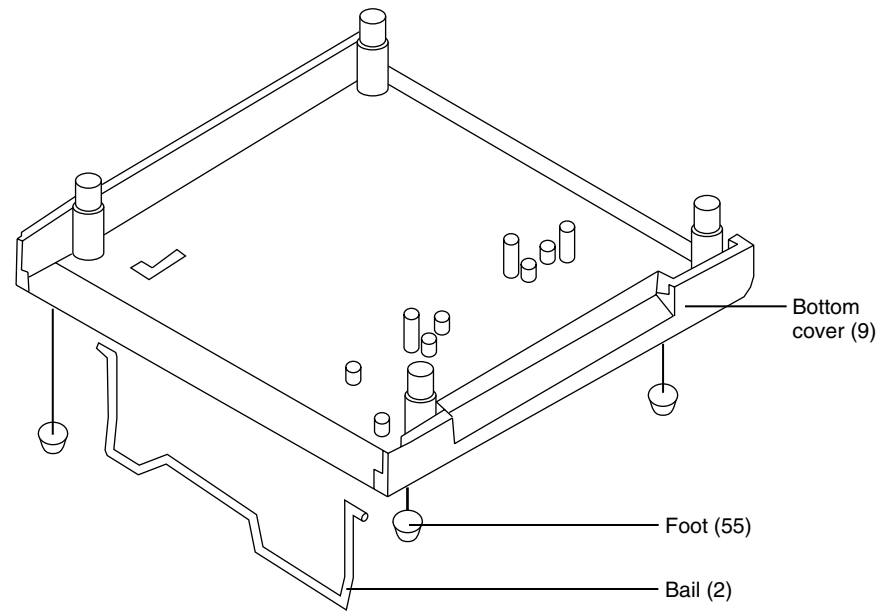
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**Figure 6-11: Sensor Connector Assembly Components**

### Bail and Feet

The bail is a formed piece of wire stock that folds down to elevate the front of the monitor for easier viewing (figure 6-12). The bail is held in place by tension. To remove the bail and feet:

1. Turn monitor upside down on a flat clean surface.
2. Extend bail as illustrated.
3. Push in on end pieces until you can lift bail free.
4. The feet are held in place with glue. To remove a foot, grasp with pliers and pull clear.



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**Figure 6-12: Bail and Feet**

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## SECTION 7: PERFORMANCE AND SAFETY TESTS

Introduction  
Required Test Equipment  
Building the Test Adapters and Fixtures  
Testing Performance  
Safety Tests

---

### INTRODUCTION

This section describes performance and safety test procedures. Perform the tests in this section upon completion of any repair work. If a monitor fails to perform as specified in any test, repair the monitor, and repeat the safety and performance test. Continue until the monitor passes all tests. You need not remove the monitor cover to perform these tests.

**Note:** Incorrect performance of the procedures described in this section may affect monitor safety or accuracy. To ensure continued accuracy, you must perform the procedures as described, using only the test equipment specified in this section.

### REQUIRED TEST EQUIPMENT

Table 7-1 lists required test equipment. The first item in the table is a special test adapter you must fabricate (figure 7-1). Likewise, there are two fixtures you must fabricate.

**Table 7-1: Required Test Equipment**

Item	Description
Test adapter one	Fabricated by customer
Bio-tek 370 or equivalent safety analyzer	Must meet current Association for the Advancement of Medical Instrumentation (AAMI) specifications
Digital multimeter	Fluke Type 87 or equivalent
Durasensor	Nellcor DS-100A
RCAL HI fixture	Fabricated by customer
RCAL LO fixture	Fabricated by customer
Oxisensor	Nellcor D-25
Pulse oximeter tester	Nellcor PT-2500 or equivalent

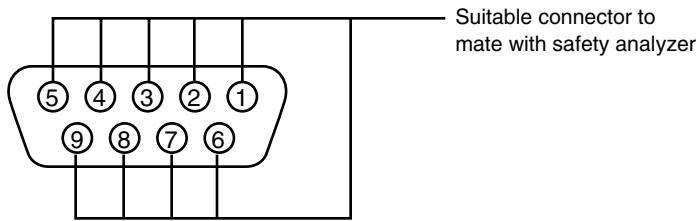
### BUILDING THE TEST ADAPTERS AND FIXTURES

You need the following parts to build test adapter one (figure 7-1):

- One 9-pin male D-type connector
- One connector hood
- Wire

Here are the directions for building test adapter one:

1. Connect a conductor to each pin of the connector.
2. Connect respective ends of each conductor together.
3. Solder ends.



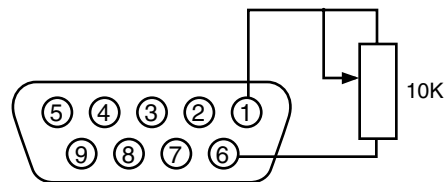
**Figure 7-1: Test Adapter One**

You need the following parts to build the RCAL HI and RCAL LO fixtures:

- Two 9-pin male D-type connectors
- Two connector hoods
- Two 10 kilohm, 10-turn trimpot, potentiometers
- Wire

Here are the directions for building test adapter one, the RCAL HI adapter (figure 7-2):

1. Solder 10 kilohm potentiometer leads across pin 1 and pin 6 respectively of a D-type connector.
2. Connect a 0.1 percent Ohmmeter between pin 1 and pin 6.
3. Adjust potentiometer for a 9,760 Ohm reading.



**Figure 7-2: RCAL Hi Test Fixture**

Test adapter two is constructed the same way as test adapter one, except you adjust the potentiometer to 6,040 Ohms.

## TESTING PERFORMANCE

Perform these tests to verify the monitor is operating correctly. To fully exercise monitor operation, perform these tests in the following order.

1. Battery operation
2. Battery charge
3. Pulse oximetry function
4. Data output

## How to Charge the Battery

Perform this procedure to fully charge the battery, or after performing the battery operation test. In addition, to insure the battery is fully charged, perform this procedure before attempting to repair the monitor.

1. Connect monitor to a an AC power source that matches requirements of your monitor as labeled on back panel near input connector.

2. Set back panel POWER switch to on.
3. Charge battery for at least 14 hours.

### **Testing Battery Operation**

The monitor is specified to operate on battery power a minimum of four hours with the display backlight on.

1. Charge battery for a minimum of 14 hours.
2. Connect a Nellcor pulse oximeter tester to monitor.
3. Disconnect monitor from AC power by pulling AC power cord out of AC power inlet on rear of monitor.
4. Set ON/STDBY switch to ON and verify that BATT IN USE lights.
5. The monitor must operate for at least two hours.
6. Verify LOW BATT light is displayed approximately five minutes before monitor ceases to operate on battery.
7. Allow monitor to continue operation until automatic shutdown occurs due to low battery.
8. If monitor passes this test, immediately recharge battery. Charge battery following instructions in this section.

### **Testing Pulse Oximetry Function**

These functional tests include:

- Power turn-on tests
- Operation with a pulse oximeter tester
- Normal operation

#### **Power turn-on Tests**

The power turn-on tests verify the following monitor functions:

- Self Test
- Adult defaults and alarm limit ranges
- Neonate defaults and alarm limit ranges

#### **Self Test**

1. Connect monitor to an AC power source.
2. Set A(dult) Neo Alarm DIP switch on monitor rear panel to A position.
3. While observing monitor front panel, set ON/STDBY switch to ON. The monitor must perform following sequence:
  - a. The monitor sounds a dual-tone beep tone for about two seconds.
  - b. All LEDs light for duration of beep tone.

Verify the OXYGEN SATURATION and PULSE RATE displays on the front panel each display 888 during the beep tone. The color of

the displayed 888 changes from green to red when the tone changes.

- c. All LEDs separately light in a scanning test pattern.
- d. The PULSE SEARCH display remains flashing.
- e. The bottom segment of pulse bar indicator remains lighted.

■ **Adult Defaults and Alarm Limit Ranges**

Perform the steps in the following table to check the adult defaults and alarm limit ranges.

1.	Press and hold HIGH SAT button.	Verify OXYGEN SATURATION displays an alarm limit of 100.
2.	Press and hold HIGH SAT button; rotate control knob counterclockwise.	Verify OXYGEN SATURATION display reduces to a minimum of 85.
3.	Press and hold LOW SAT button.	Verify OXYGEN SATURATION displays an alarm limit of 85.
4.	Press and hold LOW SAT button; rotate control knob counterclockwise.	Verify OXYGEN SATURATION display reduces to a minimum of 20.
5.	Press and hold HIGH RATE button.	Verify PULSE RATE displays an alarm limit of 140.
6.	Press and hold HIGH RATE button; rotate control knob counter-clockwise.	Verify PULSE RATE display reduces to a minimum of 55.
7.	Press and hold LOW RATE button.	Verify PULSE RATE display reduces to a minimum of 55.
8.	Press and hold LOW RATE button; rotate control knob counterclockwise.	Verify PULSE RATE display reduces to a minimum of 20.
9.	Press and hold audio alarm off button.	Verify OXYGEN SATURATION displays 60 and that PULSE RATE displays SEC.
10.	Press and hold audio alarm off button and rotate control knob counterclockwise.	Verify OXYGEN SATURATION display reduces to 30.
11.	Press and hold audio alarm off button and rotate control knob clockwise.	Verify OXYGEN SATURATION display increases to 120 and then reads off.
12.	Set ON/STDBY switch to STDBY.	
13.	Observe monitor front panel and set ON/STDBY switch to ON.	The monitor must perform the sequence as described in the self test procedures in this section.

- |     |  |   |
|-----|--|---|
| 14. | Press and hold HIGH SAT button.        | Verify OXYGEN SATURATION displays an alarm limit of 100.                          |
| 15. | Press and hold LOW SAT button.         | Verify OXYGEN SATURATION displays an alarm limit of 85.                           |
| 16. | Press and hold HIGH RATE button.       | Verify PULSE RATE displays an alarm limit of 140.                                 |
| 17. | Press and hold LOW RATE button.        | Verify PULSE RATE displays an alarm limit of 55.                                  |
| 18. | Press and hold audio alarm off button. | Verify OXYGEN SATURATION display reads 60 and that PULSE RATE display reads 'SEC. |

■ **Neonate defaults and alarm limit ranges**

Perform the steps in the following table to check the neonate defaults and alarm limit ranges.

- |     |  |   |
|-----|--|---|
| 1.  | Set A(dult) Neo Alarm DIP switch on rear panel to Neo                  | Verify NEO NATAL indicator lights.  |
| 2.  | Press and hold HIGH SAT button.  | Verify OXYGEN SATURATION displays an alarm limit of 95.   |
| 3.  | Press and hold HIGH SAT button; rotate control knob counterclockwise.  | Verify OXYGEN SATURATION display reduces to a minimum of 80.  |
| 4.  | Press and hold LOW SAT button.   | Verify OXYGEN SATURATION displays an alarm limit of 80.   |
| 5.  | Press and hold LOW SAT button; rotate control knob counterclockwise.   | Verify OXYGEN SATURATION display reduces to a minimum of 20.  |
| 6.  | Press and hold HIGH RATE button.                                       | Verify PULSE RATE displays an alarm limit of 200.   |
| 7.  | Press and hold HIGH RATE button; rotate control knob counterclockwise. | Verify PULSE RATE display reduces to a minimum of 100.  |
| 8.  | Press and hold LOW RATE button.  | Verify PULSE RATE displays an alarm limit of 100.   |
| 9.  | Press and hold LOW RATE button; rotate control knob counterclockwise.  | Verify PULSE RATE display reduces to a minimum of 20.   |
| 10. | Place ON/STDBY switch to STDBY.  | Observe monitor front panel;set ON/STDBY switch to ON. Monitor must perform sequence described in self test procedures in this section. |
| 11. | Press and hold HIGH SAT button.  | Verify OXYGEN SATURATION displays an alarm limit of 95.   |

- |     |  |   |
|-----|--|---|
| 12. | Press and hold LOW SAT button.   | Verify OXYGEN SATURATION displays an alarm limit of 80. |
| 13. | Press and hold HIGH RATE button.   | Verify PULSE RATE displays an alarm limit of 200.       |
| 14. | Press and hold LOW RATE button.  | Verify PULSE RATE displays an alarm limit of 100.       |
| 15. | This completes power turn-on test. At rear panel, set POWER switch to off. |   |

### **Operation with a Pulse Oximeter Tester**

Operation with a pulse oximeter tester includes the following tests:

- Alarms
- Alarm silence
- Volume control
- Oximetry circuit checks
- LED RCAL calibration factor

#### ■ **Alarms**

1. Connect monitor to a suitable AC power source.
2. Set A(dult) Neo Alarm DIP switch (switch 1) on rear panel A (switch is up).
3. Place ON/STDBY switch to ON and allow monitor to operate five minutes.
4. Connect a Nellcor pulse oximeter tester to oximetry sensor input of monitor and verify following:
  - a. The OXYGEN SATURATION and PULSE RATE displays both indicate 0 for a few seconds.
  - b. The pulse bar begins to track artificial pulse signal from tester.
  - c. After about ten seconds monitor displays a saturation and pulse rate within tolerances specified on tester.
  - d. The audio alarm may sound if oximeter tester is set to violate any of the default alarms.
  - e. The pulse beep sounds: and, if monitor is in an alarm condition, beep tone is indicated by a break in alarm tone.
  - f. If an alarm setting is violated, numeric display for that condition is red and the applicable alarm indicator flashes.

#### ■ **Alarm Silence**

1. Press audio alarm off button. Verify following:
  - a. The alarm is silenced.
  - b. The audio alarm off display lights.



- c. The pulse beep tone is audible.
- d. The audio alarm returns in approximately 60 seconds.
- 2. Press audio alarm off button; rotate control knob clockwise until OXYGEN SATURATION display reads OFF.
- 3. Release audio alarm off button.
- 4. Verify audio alarm off indicator and RED display flash and alarm does not return.

■ ***Volume Control***

- 1. Rotate control knob clockwise and verify sound level of beep tone increases.
- 2. Rotate control knob counterclockwise and verify beep tone can be turned off completely.

■ ***Oximetry Circuit Checks***

To perform the oximetry circuit checks you must examine RAM locations three through six. In all, there are seven RAM locations; but, the first three relate to ROM version numbers not to operational data. To examine the seven RAM locations:

- 1. Observe front panel oxygen saturation and pulse rate displays.
- 2. Simultaneously press and hold HIGH SAT and audio alarm off push buttons.
- 3. Turn control knob.

The number shown in the oxygen saturation display identifies one of seven (zero to six) visible RAM locations. Concurrently, the number shown in the pulse rate display is the real-time value of the RAM location shown in the oxygen saturation display.

The zero RAM location stores the first digit of the monitor software version. This number varies depending on monitor manufacture date. A typical number is one, meaning version one.

The first location of RAM stores the second digit of the monitor software version. This number can also vary depending on monitor manufacture date. A typical number is zero. When appended to the number in location zero the version is 1.0.

The second RAM location stores the software version of the oximeter module (MP-203) installed in the monitor. This number also depends on MP-203 manufacture date. A typical number is 101, meaning version 1.01.

You can examine all seven RAM locations by rotating the control knob while you continue to press the two buttons.

- 4. Examine following RAM locations to verify proper monitor operation.
  - a. Connect a PT-2500 pulse oximeter tester to monitor sensor input.

- b. Select RAM location three in OXYGEN SATURATION display. This is the location that represents the sensor RCAL value. The number in the PULSE RATE display must equal 63.

This step verifies proper operation of the rcsl determination system when a pulse oximeter tester is connected.

- c. Select RAM location four in OXYGEN SATURATION display.  
This is the location that controls the INAMP gain component.
- d. A nominal reading of 15 to 30 means SAT INAMP automatic gain circuit is operating correctly.

5. Remove oximeter tester from sensor input and connect *NELLCOR* D-25 sensor. Leave sensor open and face down on table.

Note: The sensor disconnect alarm sounds. Press the audio alarm off button if you want to remove the alarm.

6. Check red LED intensity as follows:

- a. Cover detector of the D-25 with opaque material.
- b. Select RAM location five in OXYGEN SATURATION display.  
This is the location that controls the red LED intensity. The number in the PULSE RATE display is over 200 (maximum equals 255).

- c. Uncover detector.

- d. Move sensor LEDs closer to sensor photodiode.

Notice that increasing the light near the photodiode makes the LED intensity decrease.

- e. Cover detector again.

- f. Read value of RAM location four and then read location five.

Note the value of location five has also decreased. The lowest values is less than 50.

- g. Open sensor (move LEDs away from photodiode).

After 10-30 seconds, the LEDs return to high intensity.

- h. Read RAM location four, and then read location five.

Note the value of location five has also increased.

7. Check IR LED intensity as follows:

- a. Cover detector of the D-25 with opaque material.
- b. Select RAM location six in OXYGEN SATURATION display.

This is the location that controls the IR LED intensity. The number in the PULSE RATE display is over 200 (maximum equals 255).

c. Uncover detector.

d. Move sensor LEDs nearer sensor photodiode.

Notice that increasing the light near the photodiode makes LED intensity decrease.

e. Read RAM location five and then read RAM location six.

Note the value of location six has also decreased. The lowest value is less than 50.

f. Open sensor (move LEDs away from photodiode).

After 10-30 seconds the LEDs return to high intensity.

g. Press buttons again, adjust control knob to RAM location five and then back to six.

Note the value of location six has also increased.

■ **LED RCAL Calibration Factor**

1. Remove the D-25 from monitor.

2. Simultaneously press and hold HIGH SAT and audio alarm off push buttons and observe front panel display.

3. Select RAM location three in OXYGEN SATURATION display.

The number in the PULSE RATE display must be 62. This step verifies proper operation of the RCAL determination circuit when nothing is connected.

4. Connect RCAL LO test resistor to sensor input.

The number in the PULSE RATE display must be 64. This step verifies proper operation of the RCAL determination circuit at the low end.

5. Remove RCAL LO test resistor from patient module and connect RCAL HI test resistor to sensor input.

6. Simultaneously press and hold HIGH SAT and audio alarm silence push buttons and observe front panel display.

7. Select RAM location three in OXYGEN SATURATION display.

The number in PULSE RATE display must be 84. This step verifies proper operation of RCAL determination circuit at high end.

**Normal Operation**

Normal operation tests the monitor using a live subject. The test is an overall performance check of the monitor. This procedure includes the LED excitation test and the patient monitoring test.

■ **Patient Monitoring**

1. Connect monitor to AC power source at your location. Observe operating voltage markings on monitor back panel.

2. Place ON/STDBY switch to ON and verify monitor is operating.

3. Connect DS-100A to sensor input of monitor and place sensor on your finger.
4. The monitor stabilizes on your physiological signal in about 10 to 15 seconds.

Verify saturation is normal (typically greater than 94 percent) and pulse rate is about 72 (standard resting heart rate, but this value varies widely between individuals) is correct.

## **Data Output**

The monitor can send data to a computer or to a printer using the RS-232 connection.

### **RS-232 Operation**

To test RS-232 operation, connect the monitor to a suitable computer that has a program that is compatible with the computer or conversation formats described in appendix A of this service manual. The following test is qualitative only and only verifies the RS-232 port is powered correctly.

1. Connect monitor to a suitable AC power source.
2. Set A(dult) Neo Alarm DIP switch on rear panel to A position (switch one up).
3. Place ON/STDBY switch to ON.
4. Connect a Nellcor pulse oximeter tester to oximetry sensor input of monitor and verify following.
  - a. The OXYGEN SATURATION and PULSE RATE displays each indicate zero for a few seconds.
  - b. The pulse bar begins to track artificial pulse signal from tester.
  - c. After about 10 seconds monitor displays a saturation and pulse rate within tolerances specified on tester.
  - d. The audio alarm may sound if tester is set to violate any of default alarms.
  - e. You hear pulse beep and if monitor is in an alarm condition, beep tone is indicated by a break in alarm tone.
5. Press audio alarm off button to silence alarm.
6. Connect monitor RS-232 serial port to corresponding communications port of your test computer, using a standard RS-232 cable.
7. At monitor, set back panel DIP switches to correspond to baud rate you intend to use.

Baud rate	Switch position	
	Switch 7	Switch 8
2400	Down	Up
4800	Down	Down
9600	Up	Down
19,200	Up	Up

8. Set monitor to conversation format by setting DIP switch two up.
9. At your test computer:
  - a. Start communication port control software.
  - b. Set communication software to agree with baud rate you set at monitor.
  - c. Once communication is established, type letter S .
  - d. Verify monitor echoes letter S and then sends current saturation value followed by a carriage return and linefeed.

## SAFETY TESTS

The following safety tests are required:

- Ground integrity
- Electrical leakage

### Ground Integrity

This test verifies the integrity of the power cord ground wire from the AC plug and connection with the monitor chassis ground.

1. Set electrical safety analyzer Function to Ground Resistance Test; set range to Milliohms.
2. Connect monitor AC plug to analyzer as recommended by analyzer operating instructions.
3. Connect analyzer resistance input lead to grounding stud on rear panel of monitor.
4. Verify analyzer indicates 0.150 (150 milliohms) or less.

### Electrical Leakage

These tests verify the electrical leakage of the monitor. There are three tests you must perform:

- Chassis source current
- Patient source current
- Patient sink current

#### Chassis Source Current

1. Set electrical safety analyzer Function to Leakage and Range to Microamps.

2. Connect AC plug to electrical safety analyzer as recommended by operating instructions.
3. Connect electrical safety analyzer leakage input lead to ground point on rear panel of monitor.
4. Verify analyzer indicates 100 microamps or less in on or standby operating modes for all of the following AC power configurations.

<u>AC polarity</u>	<u>Ground wire</u>
Normal	Normal
Reverse	Normal

### **Patient Source Current**

1. Set electrical safety analyzer Function to Leakage and Range to Microamps.
2. Connect monitor AC plug to electrical safety analyzer as recommended by analyzer operating instructions for patient source current.
3. Connect electrical safety analyzer leakage input lead to monitor sensor input connector, using adapter one.

The analyzer leakage indication must not exceed 10 microamps for 120 V monitors and 50 microamps for 220 V monitors. These readings apply for all of the following AC power configurations when the monitor ON/STDBY switch is set to ON or STDBY.

<u>AC polarity</u>	<u>Ground wire</u>
Normal	Normal
Reverse	Normal
Reverse	Open
Normal	Open

### **Patient Sink Current**

1. Set electrical safety analyzer Function to Leakage and Range to Microamps.
2. Connect monitor AC plug to electrical safety analyzer as recommended by analyzer operating instructions for patient sink current.
3. Connect electrical safety analyzer leakage input lead to monitor sensor input connector, using adapter one.

The analyzer leakage indication must not exceed 10 microamps for 120 V monitors and 50 microamps for 220 V monitors. These readings apply for all of the following AC power configurations when the monitor ON/STDBY switch is set to ON or STDBY.

<u>AC polarity</u>	<u>Ground wire</u>
Normal	Normal
Reverse	Normal
Reverse	Open
Normal	Open







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## SECTION 8: SPECIFICATIONS

Performance  
Environmental Requirements  
Electrical Characteristics  
Physical Characteristics

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### PERFORMANCE

#### Range

**Saturation**  
0–100%

**Pulse Rate**  
20–250 bpm (beats per minute)

#### Accuracy

**Saturation**  
(%SpO<sub>2</sub> ±1 standard deviation)

<b>SpO<sub>2</sub></b> Adults	70–100 %	±2 digits
	50–69 %	±3 digits
	0–49 %	unspecified

Neonates	70–95 %	±3 digits
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**Pulse Rate**  
20–250 bpm    ±3 bpm

Note: The monitor pulse oximeter is calibrated to read oxyhemoglobin saturation (%SpO<sub>2</sub>) of functional hemoglobin. Significant levels of dysfunctional hemoglobins (for example) carboxyhemoglobin, methemoglobin) may affect the accuracy of the monitor. Indocyanine green, methylene blue, and other intra-vascular dyes, depending upon their concentrations, may interfere with the accuracy of the monitor. Instrument performance may also be compromised by excessive patient movement, electrosurgical interference, or intense environmental illumination.

## **ENVIRONMENTAL REQUIREMENTS**

### **Temperature**

#### **Monitor**

50-104° F (10-40°C) operating  
32-122° F (0-50°C) storage

#### **Sensor**

Within physiologic range 82.4–107.6°F (28–42°C) for accurate measurement

### **Humidity**

Any humidity/temperature combination without condensation

### **Altitude**

0–10,000 ft (3,048 m)

## **ELECTRICAL CHARACTERISTICS**

### **Protective Class**

#### **Class I**

Mains-supplied unit using a protective ground

### **Degree of Protection**

#### **Type BF**

Patient electrically isolated

### **Voltage**

100–120 VAC  $\pm 10\%$ , 50–60 Hz  
or 220–240 VAC  $\pm 10\%$ , 50-60 Hz

### **Power Consumption**

Maximum rating: 25 VA

### **Battery**

#### **Type**

Lead-acid battery pack, 1.9 AH

#### **Battery Life**

Typically 6 hours for a new, fully charged battery. Capacity decreases with age.

#### **Recharge Period**

14 hours minimum

**Fuse (2 required)**

**0.16 amp for 120 V**  
2 required

**0.10 amp for 120 V**

**PHYSICAL CHARACTERISTICS**

**Dimensions**

2.875 in. high x 8.5 in. wide x 7 in. deep (73 x 216 x 178 mm)

**Weight**

6.6 lb (3 kg)



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## **SECTION 9: SPARE PARTS**

Introduction  
Spare Parts Listings

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### **INTRODUCTION**

This section lists monitor spare parts. Order spare parts by part number. Contact Nellcor Technical Services for assistance in filling your order.

### **SPARE PARTS LISTINGS**

Spare parts are listed in two tables. Both tables contain the same information, they are just organized differently for ease of reference. Table 9-1 lists spare parts by part number and item number order. Table 9-2 lists the parts alphabetically in description order.

If you have a part number or an item number and you want to know the description, refer to table 9-1. If you are looking for a part number and you know the part description, refer to table 9-2.

Table 9-1: Spare Parts Listed in Part Number Order

Description	Part #	Item #	Description	Part#	Item#
Battery Discharge Label Assy	021295	5	Equal Potential Terminal	057068	86
CPU PCB Assy, N180	022105	21	Mp-203 PCB	079590	84
Speaker Brackets, N180	022120	69	Conn, Hdr, R/A, 14 Pos, 2 Row	400114	14
CPU Ribbon Cable, N180	022151	22	Conn, Hdr, Str, 10 Pos, 2 Row	401110	16
Encoder Bracket	022153	29	Conn, Hdr, Str, 14 Pos, 2 Row	401114	17
Sensor Door Lock, N180	022156	67	Conn, Hsr, Srt, 34 Pos, 2 Row	401134	18
Knob, N180	022157	38	Conn, D-sub, 9	463102	13
Front Pnl Membrane Sw., N180	022158	45	Conn, 2 pos	491215	11
Front Panel, N180	022159	32	Conn, 4 pos	491216	12
Battery Bracket, N180	022161	3	Conn, Hdr, Str, 2 pos, 1Row	491234	15
Handle, N180	022168	37	Battery Clip, N180	491235	4
Rear Panel, Left, N180	022172	51	On/Off Switch, N180	631104	50
Top Cover, N180	022178	72	Switch, 01p, 8 pos	632101	71
Bottom Cover, N180	022182	9	Battery, 12v	640110	7
Rear Panel, Right, N180	022272	52	Fuse, N-180	691011	33
Transformer Bracket, N180	022273	73	Fuse Drawer, 1/4" X 1-1/4"	691191	34
Bail, N180	022342	2	Transistor	691212	76
Middle Shield Insulator	022346	46	Speaker Assy, N180	691222	68
Door Plate, H180	022661	26	Fuse, N-180E	691249	33
Grounding Lug, N180	022719	36	Transformer, N180E	691250	75
Bottom Chassis, Mylar, N180	022969	8	AC Inlet Assy, N180E	691251	1(A)
Speaker Standoff, N180	022976	70	Transformer, N180	691255	74
Lens, Front Panel	023004	89	Washer, Flat, Nylon	863903	85
Sensor Connector	023013	66	Scrw Plast, Pan, 4-20, 5/16	871031	60
Display PCB, N180	023014	25	Scrw Flat, N3, 14 mm, Ph, SS	880022	57
Front Panel PCB Set, N180	023026	31	Scrw Flat, M3, 14 mm, Ph, Znc	880023	56
Front Panel Assy, N180	023027	30	Washer, Flat, M6, SS	881012	79
Battery W/Clip, N180	023200	6	Washer, Flat, M3, Zinc	881013	78
Encoder Assy, N180	023210	28	Washer, Lock, Split, M6, Zinc	881014	81
Ground Cable Assy, H180	023214	35	Washer, Lock, Split, M3 Zinc	881015	80
Label, Serial Number, Bar Code	023655	40	Nut, Hex, M6, Zinc	882007	49
Middle Shield SOOM, N180	023666	47	Nut, Hex, M3, Zinc	882008	48
CPU Bottom Shield, N180	023668	20	Scrw Sems, Pan, M3x12, Split Loc	889001	65
LED Drive PCB	024105	42	Washer, Flat, M3, 55	889003	77
Cable, Mlidd, W/Conn LED/CPU	024567	10	Scrw Sems, Pan, M3 x 6, Split Loc	889007	62
Label, S/N, Rating 220/240 V	024570	87	Scrw Sems, Pan, M3 x 6, Split Loc	889008	63
CPU/SOOM Cable, N180	024668	24	Scrw Sems Pan, Ms3 x l4,	889010	61
CPU Bottom Shield, Mylar	024999	19	Rubber Feet, 15/16" Dia, Black	891319	55
LED PCB	026745	44	Edge Saddle, Nylon, Black	891320	27
LED Drive PCB Retention Clip	027094	43	Spacer, Collar Part	891321	82
CPU Top Shield, N180	027654	23	Spacer, Bush Part	891322	83
Label, S/N, N-180	027728	88	Scrw, Pan Hd, Ph, M3 x 6mm	891329	59
AC Inlet Assy, N180	027839	1	Scrw Pan Hd Ph, 6-32 x 1/4, Znc	891330	58
Label, U.L. Oximeter	051432	41	Scrw Sems, Pan, M3 x14	891331	64
Label, CSA (C.V)	051708	39	Retaining, Clip, 34 Pin Conn W/	891335	54
			Retaining, Clip, 14 Pin Conn W/	891336	53

Table 9-2: Spare Parts by Description and Item Order

Description	Part #	Item #	Description	Part#	Item#
AC Inlet Assy, N180	027839	1	Front Panel Membrane Sw., N180	022158	45
AC Inlet Assy, N180E	691251	1(A)	Middle Shield Insulator	022346	46
Bail, N180	022342	2	Middle Shield SOOM, N180	023666	47
Battery Bracket, N180	022161	3	Nut, Hex, M3, Zinc	882008	48
Battery Clip, N180	491235	4	Nut, Hex, M6, Zinc	882007	49
Battery Discharge Label Assy	021295	5	On/Off Switch, N180	631104	50
Battery W/Clip, N180	023200	6	Rear Panel, Left, N180	022172	51
Battery, 12v	640110	7	Rear Panel, Right, N180	022272	52
Bottom Chassis, Mylar, N180	022969	8	Retaining, Clip, 14 Pin Conn W/	891336	53
Bottom Cover, N180	022182	9	Retaining, Clip, 34 Pin Conn W/	891335	54
Cable, Mlidd, W/Conn LED/CPU	024567	10	Rubber Feet, 15/16" Dia, Black	891319	55
Conn, 2 pos	491215	11	Scrw Flat, M3, 14 mm, Ph, Znc	880023	56
Conn, 4 pos	491216	12	Scrw Flat, N3, 14 mm, Ph, SS	880022	57
Conn, D-sub, 9	463102	13	Scrw Pan Hd Ph, 6-32 x 1/4, Znc	891330	58
Conn, Hdr, R/A, 14 Pos, 2 Row	400114	14	Scrw, Pan Hd, Ph, M3 x 6mm	891329	59
Conn, Hdr, Str, 2 pos, 1Row	491234	15	Scrw Plast, Pan, 4-20, 5/16	871031	60
Conn, Hdr, Str, 10 Pos, 2 Row	401110	16	Scrw Sems Pan, Ms3 x 14,	889010	61
Conn, Hdr, Str, 14 Pos, 2 Row	401114	17	Scrw Sems, Pan, M3 x 6, Split Loc	889007	62
Conn, Hsr, Srt, 34 Pos, 2 Row	401134	18	Scrw Sems, Pan, M3 x 6, Split Loc	889008	63
CPU Bottom Shield, Mylar	024999	19	Scrw Sems, Pan, M3 x14	891331	64
CPU Bottom Shield, N180	023668	20	Scrw Sems, Pan, M3x12, Split Loc	889001	65
CPU PCB Assy, N180	022105	21	Sensor Connector	023013	66
CPU Ribbon Cable, N180	022151	22	Sensor Door Lock, N180	022156	67
CPU Top Shield, N180	027654	23	Speaker Assy, N180	691222	68
CPU/SOOM Cable, N180	024668	24	Speaker Brackets, N180	022120	69
Display PCB, N180	023014	25	Speaker Standoff, N180	022976	70
Door Plate, H180	022661	26	Switch, 01p, 8 pos	632101	71
Edge Saddle, Nylon, Black	891320	27	Top Cover, N180	022178	72
Encoder Assy, N180	023210	28	Transformer Bracket, N180	022273	73
Encoder Bracket	022153	29	Transformer, N180	691255	74
Front Panel Assy, N180	023027	30	Transformer, N180E	691250	75
Front Panel PCB Set, N180	023026	31	Transistor	691212	76
Front Panel, N180	022159	32	Washer, Flat, M3, 55	889003	77
Fuse, N-180	691011	33	Washer, Flat, M3, Zinc	881013	78
Fuse, N-180E	691249	33	Washer, Flat, M6, SS	881012	79
Fuse Drawer, 1/4" X 1-1/4"	691191	34	Washer, Lock, Split, M3 Zinc	881015	80
Ground Cable Assy, H180	023214	35	Washer, Lock, Split, M6, Zinc	881014	81
Grounding Lug, N180	022719	36	Spacer, Collar Part	891321	82
Handle, N180	022168	37	Spacer, Bush Part	891322	83
Knob, N180	022157	38	Mp-203 PCB	079590	84
Label, CSA (C.V)	051708	39	Washer, Flat, Nylon	863903	85
Label, Serial Number, Bar Code	023655	40	Equal Potential Terminal	057068	86
Label, U.L. Oximeter	051432	41	Label, S/N, Rating 220/240 V	024570	87
LED Drive PCB	024105	42	Label, S/N, N-180	027728	88
LED Drive PCB Retention Clip	027094	43	Lens, Front Panel	023004	89
LED PCB	026745	44			

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## **SECTION 10: SCHEMATIC DIAGRAMS**

Introduction  
Schematic List

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### **INTRODUCTION**

This section includes schematic diagrams for the monitor. These schematics are controlled engineering drawings created by Nellcor engineering support services. Accordingly, the number listed below is the engineering support services control number.

### **SCHEMATIC LIST**

Use these schematics for reference when reading the circuit analysis section or troubleshooting equipment. The order they appear in this chapter follows the order the applicable circuits are described (in section 3).

Title	Number
MINI SOOM MP-203 Schematic (7 sheets)	009590
CPU PCB Schematic (4 sheets)	022104
LED Drive PCB Schematic	024094
LED PCB Schematic	026744





## INTRODUCTION

Serial data is output from the monitor in digital RS-232 format. The connector is a 9-pin D-type, sub miniature, female. You use a switch to set the baud rate to 2400, 4800, 9600, or 19,200.

Serial data output (table A-1) from the monitor can be in two forms: conversation mode, where the monitor responds to inputs from an external ASCII device, or computer mode, where the monitor provides a periodic data string reporting saturation and pulse rate data, alarm conditions, and monitor status. The following paragraphs describe each output mode.

## CONVERSATION FORMAT

Select this format on the rear panel DIP switch by setting switch two up. At the serial communications connector on the rear panel, connect a computer or ASCII terminal that is ready to receive data.

When using conversation format the monitor responds by request only. At the computer or terminal, transmit a single request; the monitor responds by transmitting an alphanumeric string containing a data identifier and numeric data (nnn is a numeric value between 000 and 255). For example, if you request the current pulse rate by sending an R. The monitor responds by sending <STX>Rnnn<CR><LF> where(nnn) is the pulse rate.

## COMPUTER FORMAT

Select this format on the rear-panel DIP switch by setting switch two down. In this format, the monitor transmits a data string every 10 seconds; or if a parameter changes, the value is transmitted shortly thereafter the event occurs. Parameters are pulse rate, oxygen saturation and so forth. Note that in the following example string STX (start of transmission) and ETX (end of transmission) are shown in hexadecimal equivalents above their positions in the string. CHKSM stands for checksum. The string transmitted from the monitor has this format:

$$\begin{array}{cc} (02) & (03) \\ \langle \text{STX} \rangle \text{RnnnSnnnP000LnnnHnnnOnnnAnnnMnnnT000000Qnnn} & \langle \text{CR} \rangle \langle \text{LF} \rangle \langle \text{CHKSM} \rangle \langle \text{ETX} \rangle \end{array}$$

**Table A-1: Serial Data Output**

Character transmitted to monitor	String received from monitor			
R (pulse rate)	Rnnn			
S (oxygen saturation)	Snnn			
P (not used)	P000			
L (low rate alarm limit)	Lnnn			
H (high rate alarm limit)	Hnnn			
O (low sat. alarm limit)	Onnn			
A (alarm status in ASCII coded decimal)	(Logic 1 equals alarm condition)			
M (monitor status)	Bit 0		high rate	
	Bit 1		low rate	
	Bit 2		low sat	
	Bit 3		high sat	
	(In ASCII coded decimal)			
	Bit	Status	1	0
	0	Pulse search	Locked	Search
	1	Sensor	Attached	Off
	2	Audio alarm	Enabled	Disabled
	3	ECG	Not in use	In use
	4-7	Not used	—	—
T (time)	T000000			
Q (high saturation alarm limit)	Qnnn			