# SERVICE MANUAL
# NELLCOR MODEL N-8000
# INTERFACE

## NOTICE

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WARNING -- THE NELLCOR MODEL N-8000 INTERFACE CONTAINS NO USER-SERVICABLE PARTS. FOR PROTECTION AGAINST ELECTRICAL HAZARD REFER ALL SERVICING TO QUALIFIED PERSONNEL.

WARNING -- FOR CONTINUED PROTECTION AGAINST FIRE HAZARD, REPLACE FUSES ONLY WITH THE SAME TYPE AND RATING.

CONTENTS

SECTION 1

INTRODUCTION

1.1 This Manual is provided to qualified service personnel for the purpose of maintaining and repairing the Nellcor Model N-8000 Interface. Dangerous voltages are exposed when the cover is removed. Certain components are critical to the protection of patients and operators and improper procedures can adversely effect the Instrument's calibration and/or safety. For protection of service personnel and patients, the procedures described in this manual are only to be performed by qualified service personnel.

1.2 Repairing and testing of the Instrument exposes service personnel to potentially hazardous voltages, and improper repair or adjusment may effect the accuracy or patient protection associated with the Instrument. Where appropriate, warnings or cautions have been included in the text of this Manual. The term WARNING is used to bring attention to a procedure or precaution that is important to insure the safety of service personnel or possibly the patient. The word CAUTION brings attention to a procedure that should be carefully followed in order to prevent damage to the Instrument or an error in calibration or performance. It is important that these warnings and cautions be read carefully and followed.

SECTION 2

DESCRIPTION OF THE INSTRUMENT

2.1 The Nellcor Model N-8000 Interface is designed to operate in conjuntion with a Nellcor Model N100 Pulse Oximeter to provide analog outputs for stripchart recorders, D/A converters, data loggers etc. and RS-232 communications with computers, printers etc. The input is a proprietary serial data stream on a fiber-optic link, providing rate, saturation, limits, alarm status, oximeter status and pulse waveform values. The analog outputs are provided on three BNC connectors, while the RS-232 connector is a standard 25 pin D-type connector. It is designed to be easily stacked with the Nellcor N-100 Pulse Oximeter during use. The Interface has no alarms nor audible indicators of its own, but can pass through the alarm status from the Oximeter on the serial channel.

2.2 The Nellcor Model N-8000 Interface is contained in one case. Inside are two modules. The power system consists of the AC inlet filter, fuse, switch and power supply. The only indicator light is on the front panel and simply shows that the power supply is running. All analog and digital processing takes place on a single processor board.

SECTION 3

## UNPACKING AND OPERATING INSTRUCTIONS

3.1 The Nellcor Model N-8000 Interface is packed in a single carton containing the instrument, User's Manual, power cord and fiber-optic cable. The box should be carefully unpacked and the contents verified.

3.2 The instrument is wrapped in a sealed plastic bag to protect it from condensation and moisture during shipping. If the Instrument is substantially colder than the surrounding ambient temperature, then condensation may occur when the unit is unsealed. For this reason, especially in areas of high humidity, the Instrument must be allowed to return to room temperature before being unsealed.

### 3.3 FUNCTIONALITY CHECK

3.3.1 To verify functionality of the Interface, connect the power cord to the back of the instrument and plug the cord in. Connect the fiber-optic link by pushing the blue end into the Interface input, labeled DATA INPUT, until it snaps in. Connect the grey end, in like fashion, to the N-100 Pulse Oximeter output, labeled DATA OUTPUT. Set Switches 10, 11 and 12 to the UP position. Turn on the Interface and leave the N-100 Pulse Oximeter off. With a digital voltmeter, measure the output voltage on each BNC connector to see that it is near zero volts. Push the F.S. (Full Scale) Button, above the SAT BNC connector, and verify that the output goes up to 10 volts. Do the same test on the RATE BNC connector, using the F.S. Button above the RATE connector. Next press the corresponding ZERO Buttons and verify that the outputs return to zero volts.

3.3.2 If a CRT terminal, with RS-232 interface is available, connect it according to the Interconnect Drawing in the User's Manual. If it is not available, or the RS-232 port is not to be used, proceed to Section 3.3.3. Refer to the Interface User's Manual and the terminal CRT manual to select the proper baud rate and then set Switch 5 UP and 6 and 7 DOWN to select Full Format. Turn the Interface off, and then on, to insure that the switches have been read. The CRT terminal should show the following:

NELLCOR INTERFACE V. X.X

(the X.X is the Software Version number, which will vary depending on the date of manufacture. Extra characters may appear in front of "NELLCOR" due to transients created during power-up)

Turn on the Pulse Oximeter. The Interface will send out the rate, saturation and pulse amplitude (% FS) once per minute. Refer to the User's Manual for exact descriptions of the displays. If the alarm or Pulse Oximeter status changes, a more lengthy message will be sent. This verifies functionality of the RS-232 port.

3.3.3 To verify functionality of the analog outputs, turn on the Pulse Oximeter and obtain front panel displays for rate and saturation by connecting it to a finger or the Nellcor Multi-Function Calibrator. Measure the output voltage from the SAT BNC connection and verify that it corresponds to the following formula:

Vsat = 10 * (SAT/100) (where SAT is the number on the Oximeter display)

Measure the output on the Rate BNC and verify that it corresponds to the following formula:

Vrate = 10 * (RATE/250) (where RATE is the number displayed on the Oximeter)

Check the pulse output with an oscilloscope to see that it creates a pulse waveform in time with the Oximeter bargraph.

3.4 If it is necessary to reship the instrument, the original shipping carton should be used. Remove the fiber-optic link and power cord and place them in the recess in the top of the carton for shipment. The carton should be carefully sealed with reinforced packaging tape.

SECTION 4

# TESTING AND CALIBRATION

4.1 This section details procedures for routine test and calibration checks for the Nellcor Model N-8000 Interface. Instructions for troubleshooting and repair of Interface defects are covered in Section 5. Refer also to Section 5 for instructions on cover removal and disassembly to access circuit components.

WARNING -- THE PROCEDURES IN THIS SECTION INVOLVE OPERATION OF THE INTERFACE WITH DANGEROUS VOLTAGES EXPOSED. ONLY QUALIFIED SERVICE PERSONNEL SHOULD PERFORM THESE CHECKS.

CAUTION -- THESE PROCEDURES CAN ADVERSELY AFFECT THE ACCURACY OF THE INTERFACE IF PERFORMED INCORRECTLY.

## 4.2 REQUIRED TEST EQUIPMENT

The following test equipment is required to perform the procedures described in this Section:

1. Digital voltmeter 3 1/2 digit.
2. Oscilloscope, 50 Mhz.
3. CRT terminal with RS-232 Interface (OPTIONAL)
4. Frequency Counter, 10 Mhz. with 5 digit accuracy

4.3 Simple power supply checks should be performed to verify that the components are receiving correct and clean sources of power. Connect the oscilloscope ground to the minus side of C25 and the probe to the plus side. Verify +5 volts with no more than 150 mv of noise. Move the probe to the plus side of C26 and verify +12 volts with no more than 100 mv noise. Lastly, check the minus side of C27 and verify -12 volts with less than 100 mv noise.

4.4 To verify the timing of the Interface, measure the crystal oscillator, at IC 4F, pin 37, with the frequency counter, and verify that it is 3.072 MHz. +/- 5 kHz.

4.5 CALIBRATION OF ANALOG OUTPUTS

4.5.1 There is a resident calibration routine in the Interface which is accessed by disconnecting the fiber-optic cable and placing all 12 Switches to the UP position. The button sequence is important so don't press buttons until instructed to do so. If the RS-232 port is connected, messages for the calibration routine steps will be displayed to further clarify which step is being performed. If unsure of what step is being done, turn the unit off and back on to restart the calibration steps. All measurements are to be made with the 3 1/2 digit voltmeter using ground at TP 2.

4.5.2 With the Interface off, place all Switches in the UP position and disconnect the fiber-optic link. Turn the unit on and verify that TP 1 reads approximately 5.3 volts. Check the voltages according to the table below and adjust using the corresponding potentiometer, if necessary, to obtain a reading of 0 volts +/- 10 mv.

D/A ZERO ADJUSTMENTS

| MEASURE AT | ADJUST USING | DESCRIPTION |
|---|---|---|
| J5-3 | R8 ("RZ") | Rate Output Zero |
| J5-5 | R10 ("SZ") | Saturation Output Zero |
| J5-7 | R13 ("PZ") | Pulse Output Zero |

4.5.3 Press the saturation ZERO Button on the back of the Interface. This sets the Full Scale DAC to zero for adjusting its zero level output. Measure the voltage at TP 1 and adjust R4 ("FZ") if necessary to obtain 0 +/- 5 mv.

4.5.4 Press the rate F.S. Button to set the Full Scale DAC to 10 volt range and set all others to their full scale values so they can be adjusted for full scale. Adjust the three outputs to 10 volts +/- 5 mv, according to the following table:

D/A FULL SCALE ADJUST

| MEASURE AT | ADJUST USING | DESCRIPTION |
|---|---|---|
| J5-3 | R23 ("RF") | Rate Output Full Scale |
| J5-5 | R20 ("SF") | Saturation Full Scale Output |
| J5-7 | R17 ("PF") | Pulse Full Scale Output |

4.5.5 Simultaneously press the Saturation ZERO and the Rate F.S. Buttons to set the Interface into a calibration waveform generation routine. Using the oscilloscope, check at each output (J5-3, 5 and 7) to see that the waveform is a sawtooth waveform running between 0 and 10 volts and has no discontinuities.

4.5.6 Push Switch 8 DOWN to exit the calibration routine and verify that the Rate and Sat Full Scale and Zero Buttons perform properly, within 10 mv.

NOTE: If it is necessary to go back into the calibration routine, turn off the unit, push Switch 8 back UP and turn the unit on again. The calibration routine can only be entered from power-up.

4.6 If the RS-232 port is being used, the following checks can be made to insure that the unit is sending and receiving at the right speed. Using the Frequency Counter, measure the baud rate, at IC 1C pin 9, according to the following table. The frequency should be within 2%.

NOTE: Each time a switch is changed, the unit must be turned off and then back on. There are no adjustments for the baud rates. If there is an error, the crystal or the timer chip IC 2D are likely faulty.

## BAUD RATE TABLE

| SWITCH SETTINGS | | | | BAUD RATE | FREQUENCY |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | | |
| D | D | D | D | 50 | 800 Hz |
| U | U | D | D | 75 | 1200 Hz |
| U | D | U | D | 110 | 1760 Hz |
| D | U | U | D | 134.5 | 2152 Hz |
| U | U | U | D | 150 | 2400 Hz |
| U | D | D | D | 300 | 4800 Hz |
| D | U | D | D | 600 | 9600 Hz |
| D | D | U | D | 1200 | 19200 Hz |
| U | D | D | U | 1800 | 28800 Hz |
| D | U | D | U | 2000 | 32000 Hz |
| D | D | D | U | 2400 | 38400 Hz |
| U | U | D | U | 3600 | 57600 Hz |
| D | D | U | U | 4800 | 76800 Hz |
| U | D | U | U | 7200 | 115200 Hz |
| D | U | U | U | 9600 | 153600 Hz |
| U | U | U | U | 19200 | 307200 Hz |

SECTION 5

TROUBLESHOOTING AND REPAIR

5.1 The following table is provided to suggest ways to isolate component failures. There are only two main systems in the unit; Power, which involves the inlet fuse, switch and power supply; and Processing, which is the Processor Board.

| SYMPTOM | PROBABLE DIAGNOSIS |
|---|---|
| 1. Unit not operative (no indicator light) | A. Blown fuse<br>B. Failed switch<br>C. Failed power supply See Section 5.2.1<br>D. Failed processor board See Section 5.3.1 |
| 2. Unit not operative (indicator light on) | A. Oximeter not connected<br>B. Processor board failure See Section 5.3.1 or 5.3.2 |
| 3. No analog outputs (RS-232 works) | A. Analog section failure See Section 5.3.3 or 5.3.4 |
| 4. No RS-232 function (analog outputs work) | A. Improper switch settings<br>B. Failed serial section See Section 5.3.5<br>C. Improper cabling |

## 5.2 POWER SYSTEM CHECKS

5.2.1 To check the power system on a stand alone basis, simply disconnect P2, where the power supply is connected to the processor board. Turn the unit on and measure the voltages at the power supply outputs to verify that +5, +12, and -12 are available. If the outputs are all zero, the problem is likely a blown fuse. Check the fuse and replace if necessary. If the fuse blows again, the power supply has failed and must be replaced. If not, then measure the voltages and verify them. If they are okay then the power system is correct.

## 5.3 PROCESSOR BOARD CHECKS

5.3.1 Verify that power is being received by the processor board correctly by measuring the voltages as follows:

| | |
|---|---|
| +5 | at C25 plus side |
| +12 | at C26 plus side |
| -12 | at C27 minus side |

5.3.2 If none of the outputs are functioning, and the Pulse Oximeter is connected and operating, then the problem is likely that the receiver in the Interface has failed, or it is in the processor section. This consists of the processor, IC 4F, decoding circuits 5E and 4H, program memory 6D (possibly 6E or 6F depending on software revision level), and memory IC's 5G, 6G, 5H, 6H, 5K, 6K, 5L and 6L. To isolate the problem further, try the Full Scale and Zero Buttons. If they function correctly, then the problem is most likely in the receiver UART IC 2E or clock generator 2D. If the Full Scale and Zero Buttons don't function correctly, then the problem is in the processor area.

5.3.3 If the serial outputs function correctly, this indicates that the receiver circuitry is okay and the processor is okay. The problem must be in the D/A conversion section. Place the Interface in the calibration mode by disconnecting the fiber-optic link and placing all Switches in the UP position. Turn the unit on and measure the voltage at TP 1. It should read zero volts. Press the SAT F.S. Button on the back panel and measure TP 1. It should now read approximately 5.3 volts. If it doesn't, the problem lies in the reference voltage IC 1K or the full scale reference circuitry IC 3K, 2K or 1G.

5.3.4 If only one of the analog outputs is malfunctioning, it can be isolated to the particular set of output IC's. Most likely would be the op-amp driving the output in question.

5.3.5 If the analog outputs work correctly, and the serial channel doesn't, the problem lies in the output UART IC 1C or the buffer IC's 1B and 1A. Check also that the frequency of the baud rate clock is correct. This can be verified according to the Baud Rate Table found in Section 4. To determine if the UART is functioning at all, connect the Pulse Oximeter to the Interface normally and with both running, use an oscilloscope to monitor the TxD (pin J1-3) for activity. This should vary between + and - 12 volts as characters are sent. To cause characters to be sent, select Full Format (Switch 5 UP, 6 and 7 DOWN) and with each press of the Audio Alarm Disable Button on the Pulse Oximeter, a string of characters should be sent. If characters are being sent and the frequency is correct, the problem is probably a mismatch of the baud rates of the Interface and the receiving device, or improper cabling.

## 5.4 INSTRUMENT DISASSEMBLY

5.4.1 To gain access to the power supply and processor board, simply remove the four flat-head screws on the top of the unit and remove the cover. If it is necessary to remove the processor board, remove the eight screws around the periphery (accessed through the screwdriver access holes in the chassis) and disconnect the three connectors from the board. Pull the board toward the front of the unit and lift at the front to clear the power supply. Be careful of the pushbutton caps and the RS-232 connector.

5.4.2 To remove the power supply, remove the four screws at the corners of the supply, unplug the supply from the processor board and disconnect the two leads, that connect to the power supply input, from their terminals.

5.4.3 Installation is simply the reverse of the above procedures.

SECTION 6

# THEORY OF OPERATION

## 6.1 INTRODUCTION

Refer to Section 8 for the instrument schematics. The major sections are the power supply and the processor board. The processor board can be further divided into digital processing and analog output circuitry.

## 6.2 POWER SYSTEM

AC power enters through a line filter to prevent noise from getting back onto the AC line or from entering the unit. Both sides of the line are switched through the power switch and then connect to the power supply. This supply provides +5 volts at approximately 1 Amp, and +12 and -12 at approximately 100 ma. The supply is current limited to prevent catastrophic failures in the event of a processor board failure which "shorts" the supply.

## 6.3 PROCESSOR BOARD

6.3.1 The Interface is based on an 8085 microprocessor with available 12K program memory and 4K RAM memory. Addressing of the memory and I/O circuitry is performed by address decoders 5D, 5E and 4H. Buffer gates 1D and 1E are used to read the 12 dip switches and the four push-buttons on the back panel. Gate 4G is simply a buffer to provide adequate drive to the remaining latches.

6.3.2 Serial communications are handled in two places by individual UART's. For data coming in from the Pulse Oximeter, IC 2E is connected to a fiber optic receiver. The serial transmission is a 2400 baud proprietary encoded data stream. Each time a character is received, it interrupts the processor which, in turn, reads the character and performs the required decoding. The other UART is IC 1C which is connected to line driver 1B and line receiver 1A. These form a standard RS-232

communications port. Each character received here also interrupts the processor which, in turn, determines what the request is and responds appropriately. The port has hardware handshaking available and, in addition, the software is configured to support XON/XOFF protocol.

6.3.3 Analog outputs for Rate, Saturation and Pulse waveforms are provided by three individual D/A converters, driven by another reference D/A converter. After reading the full scale selection from the dip switches, the processor will set the full scale DAC (latch 3K, D/A converter 2K and op-amp 1G) to the desired voltage. As messages from the Oximeter are received, the processor will calculate the desired rate, saturation and pulse values and they will be sent in like fashion, through their corresponding latch, D/A and op-amp.

6.3.4 A third output from timer chip, 2D, is the INT 7.5 line which interrupts the processor on a fixed interval basis and allows it to keep the running time.

SECTION 7

SPARE PARTS LIST

| P/N | DESCRIPTION |
|---|---|
| 071405 | Assy, Processor Board |
| 071307 | Assy, Power Supply |
| 631101 | Switch, On/Off |
| 803038 | Screw, Pan Head, 8-32 x 3/8" |
| 812038 | Screw, Flat Head, 6-32 x 3/8" |
| 802038 | Screw, Pan Head, 6-32 x 3/8" |
| 851101 | Kepnut, 4-40 |
| 691011 | Fuse, 1/2 Amp, Slo-Blow |

SECTION 8

# SCHEMATICS AND DIAGRAMS