NELLCOR PURITAN BENNETT™

SERVICE MANUAL

Nellcor Puritan Bennett™
NPB-3900 Patient Monitor

To contact Nellcor Puritan Bennett's representative: In the United States, call 1-800-NELLCOR or 510 463-4000; outside the United States, call your local Nellcor Puritan Bennett representative.

Caution: Federal law (U. S.) restricts this device to sale by or on the order of a physician.

CE 0123

047940A-0398

Corporate Headquarters

Nellcor Puritan Bennett Inc.
4280 Hacienda Drive
Pleasanton, California 94588
U.S.A.
Tel. 510 463-3900 or
1-800-NELLCOR

U. S. Service Repair Center

Nellcor Puritan Bennett Inc.
2200 Faraday Avenue
Carlsbad, California 92008
U.S.A.
Tel. 619 482-5000

European Office

Nellcor Puritan Bennett Europe BV
Hambakenwetering 1
5231 DD ’s-Hertogenbosch
The Netherlands
Tel. +31.73.6485200

Asia/Pacific Office

Nellcor Puritan Bennett HK Ltd.
Room 1602 Evergo House
38 Gloucester Road
Wanchai
Hong Kong
Tel. +852.2529.0363

Regional/Local Offices

Nellcor Puritan Bennett UK Ltd.
10, Talisman Business Centre
London Road
Bicester, Oxfordshire OX6 0JX
United Kingdom
Tel. +44.1869.322700

Nellcor Puritan Bennett Belgium NV/SA
Interleuvenlaan 62/8, Zone 2
B-3001 Heverlee
Belgium
Tel. +32.16.400467

Nellcor Puritan Bennett France
3 avenue du Canada, Bâtiment Sigma
LP851 Les Ulis
91975 Courtaboeuf Cedex
France
Tel. +33.1.69.82.14.66

Nellcor Puritan Bennett Germany GmbH
Black-&-Decker-Strasse 28
65510 Idstein
Germany
Tel. +49.6126.5930

Nellcor Puritan Bennett Italia S.r.L.
Via Edison 6
20090 Assago (MI)
Italy
Tel. +39.2.4577161

Nellcor Puritan Bennett Finland Oy
Kappelitie 8
02200 Espoo
Finland
Tel. +358.9.270.92.900

To obtain information about a warranty, if any, for this product, contact Nellcor Puritan Bennett Technical Services or your local Nellcor Puritan Bennett representative.

TABLE OF CONTENTS

List of Figures

List of Tables

LIST OF FIGURES

LIST OF TABLES

SECTION 1: INTRODUCTION

1.1 MANUAL OVERVIEW

This manual contains information for servicing the NPB-3900 series of patient monitors. Only qualified service personnel should service this product. Before servicing the NPB-3900, read the operator's manual carefully for a thorough understanding of operation.

1.2 WARNINGS, CAUTIONS, AND NOTES

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

1.2.1 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.

1.2.2 Caution

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

1.2.3 Note

A note gives information that requires special attention.

1.3 NPB-3900 PATIENT MONITOR DESCRIPTION

The purpose and function of the NPB-3900 series of patient monitors is to monitor: ECG; heart rate; noninvasive blood pressure (systolic, diastolic, and mean arterial pressures); functional arterial oxygen saturation; and temperature for adult and pediatric patients in all hospital areas and hospital-type facilities. They may be used during hospital transport and in mobile, land-based environments, such as ambulances.

Refer to the NPB-3900 operator's manual for a description of the NPB-3900 controls, indicators, and operation. The physical and operational characteristics of the monitors are described in the operator's manual and Section 9, *Specifications*, of this manual.

The parameter measurements for each model in the NPB-3900 series are indicated in Table 1-1.

Table 1-1: Model Configuration

Model	Parameter			
	NIBP	**SpO_2**	**TEMP**	**ECG**
NPB-3910	X	X		
NPB-3920	X	X	X	
NPB-3930	X	X		X
NBP-3940	X	X	X	X

1.4 P-3900 INTRODUCTION

The P-3900 is an optional, standalone printer designed for use with the NPB-3900 patient monitor. The P-3900 communicates with the monitor using a null-modem cable connected between each device’s RS-232 connector. The P-3900 contains an internal battery, which, when fully charged, will operate the printer for 3 hours (typical, at 25°C, producing fifteen 20-second printouts per hour). The P-3900 can be connected to AC power using an external power supply. The P-3900 uses the same type power supply as the NPB-3900 monitor, the PS-120V or PS-240V.

The P-3900 does not have an On/Off switch. The printer can sense when it has an established communications link with the monitor. At that time, the green LINKED indicator on the front panel lights, indicating that the printer is ready for operation. See the NPB-3900 operator’s manual for more information regarding use of the printer.

1.5 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 the NPB-3900 operator’s manual. To understand the various Nellcor Puritan Bennett sensors, ECG leads, blood pressure cuffs, and temperature probes that work with the monitor, refer to the operator’s manual and individual directions for use that accompany these accessories.

SECTION 2: ROUTINE MAINTENANCE

2.1 CLEANING

WARNING: Do not spray, pour, or spill liquid on the NBP-3900, its accessories, connectors, switches, or openings in the chassis. Do not immerse the NPB-3900 or its accessories in liquid or clean with caustic or abrasive cleaners.

To clean the NPB-3900, dampen a cloth with a commercial, nonabrasive cleaner and wipe the exterior surfaces lightly. Do not allow any liquids to come in contact with the power connector or switches. Do not allow any liquids to penetrate connectors or openings in the instrument. For cables, sensors, and cuffs, follow the cleaning instructions in the directions for use that accompany these accessories.

2.2 PERIODIC SAFETY AND FUNCTIONAL CHECKS

Nellcor Puritan Bennett recommends that the following checks be performed at least every 2 years by a qualified service technician.

1. Inspect the exterior of the NPB-3900 for damage.
2. Inspect labels for legibility. If the labels are not legible, contact Nellcor Puritan Bennett's Technical Services Department or your local Nellcor Puritan Bennett representative.
3. Verify that the unit performs properly as described in paragraph 3.3.
4. Perform the electrical safety tests detailed in paragraph 3.4. If the unit fails these electrical safety tests, do not attempt to repair. Contact Nellcor Puritan Bennett's Technical Services Department or your local Nellcor Puritan Bennett representative.

2.3 BATTERY

If the NPB-3900 has not been used for a long period of time, the battery will need charging. To charge the battery, connect the NPB-3900 to an AC source as described in the *Setup & Use* section of the operator's manual.

NOTE: Storing the NBP-3900 for a long period without charging the battery may degrade the battery capacity. A complete battery recharge when not using the monitor requires 8 hours. The battery may be recharged while the monitor is in use; in which case, the battery will require 14 hours to be recharged. The battery may require a full charge/discharge cycle to restore normal capacity.

Nellcor Puritan Bennett recommends that the NPB-3900's sealed, lead-acid battery be replaced at 2-year intervals. Refer to Section 6, *Disassembly Guide*.

2.4 ENVIRONMENTAL PROTECTION

Follow local governing ordinances and recycling plans regarding disposal or recycling batteries and other device components.

SECTION 3: PERFORMANCE VERIFICATION

3.1 INTRODUCTION

This section discusses the tests used to verify performance following repairs or during routine maintenance. All tests can be performed without removing the NPB-3900 covers.

If the NPB-3900 fails to perform as specified in any test, repairs must correct the problem before the monitor is returned to the user.

3.2 EQUIPMENT NEEDED

Table 3-1 lists the equipment required for performance verification.

Table 3-1: Required Test Equipment

Equipment	Description
Digital multimeter (DMM)	Fluke Model 87 or equivalent
Sensor extension cable	EC-8
Durasensor® finger clip sensor	DS-100A
Oxisensor® II adhesive sensor	D-25
ECG cable	CE-10
ECG electrodes	Standard
ECG leads	LE series
NIBP hose	SHBP-10
NIBP cuff	SCBP series
Temperature probe	Welch Allyn *SureTemp*® (blue capped probe)
Pulse oximeter tester	Nellcor Puritan Bennett SRC-2
ECG simulator	Dynatech Nevada medSim 300 or equivalent
NIBP simulator	Bio-Tek “BP Pump” or equivalent
Thermometer Calibrator Key	Welch Allyn Model 767
Safety analyzer	Bio-Tek 601 Pro or equivalent
Stopwatch	Manual or electronic

3.3 PERFORMANCE TESTS

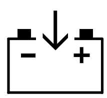
The battery charge and battery performance tests should be performed before monitor repairs whenever the battery is suspected as being a source of a problem. All other tests should be performed following monitor repairs. Before performing the battery performance test, ensure that the battery is fully charged (paragraph 3.3.1).

This section is written using Nellcor Puritan Bennett factory-set power-up defaults. If your institution has reconfigured custom defaults, those values will be displayed.

3.3.1 Battery Charge

Perform the following procedure to fully charge the battery.

1. Connect the monitor to an AC power source using the PS-120 or PS-240 external power supply and power cord, if needed.



2. Verify that the EXTERNAL POWER indicator is lit.
3. Charge the battery for at least 8 hours. The battery may require a complete charge/discharge cycle to restore its normal capacity.
4. To check for a full charge, perform the procedure in paragraph 3.3.2 "Battery Performance Test."

3.3.2 Battery Performance Test

The monitor is specified to operate typically on battery power for a minimum of 4 hours, at 25°C, with one NIBP measurement every 15 minutes. Before performing this test, ensure that the battery is fully charged (paragraph 3.3.1).

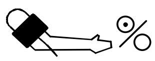
1. Connect the Nellcor Puritan Bennett SRC-2 pulse oximeter tester to the monitor via the EC-8 sensor cable. Connect the NIBP simulator to the monitor via the SHBP-10 hose.
2. Set the SRC-2 switches as follows:

SWITCH	POSITION
RATE	38
LIGHT	LOW
MODULATION	LOW
RCAL/MODE	RCAL 63/LOCAL

3. Set the NIBP simulator to simulate a pressure setting of 120/80 mmHg and heart rate of 80 bpm.
4. Ensure that the monitor is ***not*** connected to AC power.

5. With the NPB-3900 turned off, press the ON/STANDBY button and verify that the battery icon appears at the bottom of the display after the power-on self-test is completed. The boxes in the battery icon should all be filled, indicating the battery is charged.

6. Verify that the monitor is responding to the SpO_2 simulator signal and that the audible alarm is sounding. Use the knob to select the SpO_2 Menu and permanently silence the SpO_2 audible alarm.



7. Use the knob to select the NIBP Menu and set the Automatic Measurement Interval to 15 minutes. Exit the menu and press the front panel NIBP button to manually initiate the first NIBP measurement. Subsequent NIBP measurements will be taken automatically every 15 minutes.

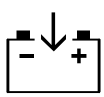
8. The monitor must operate for at least 4 hours before the monitor automatically powers down due to low battery condition.

9. Verify that the low battery alarm occurs 15-30 minutes before the battery fully discharges.

10. Allow the monitor to operate until it automatically powers down due to low battery condition. Verify that an audible alarm sounds when the monitor automatically shuts down. Press the alarm silence button to terminate this audible alarm.

11. If the monitor passes this test, immediately recharge the battery (paragraph 3.3.1, steps 1–3).

3.3.3 Power-On Self-Test



1. Connect the monitor to an AC power source using the PS-120 or PS-240 power supply and power cord, and verify that the EXTERNAL POWER indicator is lit.

2. Do not connect any input cables to the monitor.

3. Observe the monitor front panel. With the monitor off, press the ON/STANDBY button. The monitor must perform the following sequence.

   a. The monitor emits a beep.

   b. A few seconds later, the display backlight illuminates, but the display is blank.

   c. The Nellcor Puritan Bennett logo then appears for a few seconds, with the version numbers of the boot and operational software displayed in the lower left corner of the display. (The upper version number corresponds to the boot software, the lower version number corresponds to the operational software.)

   d. A beep signals the end of the power-on self-test. The power-on self-test takes approximately 10 seconds to complete.

   e. Upon successful completion of the power-on self-test, the display will be in the normal monitoring screen configuration. No vital-sign numeric values or trend values will be displayed.

3.3.4 Hardware and Software Tests

Hardware and software testing includes the following tests applicable to the indicated models in the series.

- 3.3.4.1 SpO_2 Testing — NPB-3900
- 3.3.4.2 Operation with an ECG Simulator — NPB-3930, NPB-3940
- 3.3.4.3 Verification of Pneumatic System — NPB-3900
- 3.3.4.4 Operation with a Temperature Simulator — NPB-3920, NPB-3940
- 3.3.4.5 General Operation — NPB-3900

3.3.4.1 SpO_2 Testing (NPB-3900)

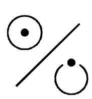
SpO_2 testing includes the following tests.

- 3.3.4.1.1 Alarms and Alarm Silence
- 3.3.4.1.2 Heart Rate Tone Volume Control
- 3.3.4.1.3 Dynamic Operating Range
- 3.3.4.1.4 LED Excitation Test

3.3.4.1.1 Alarms and Alarm Silence

1. Connect the SRC-2 pulse oximeter tester to the EC-8 sensor extension cable and connect the cable to the monitor. Set the SRC-2 as follows:

SWITCH	POSITION
RATE	38
LIGHT	LOW
MODULATION	OFF
RCAL/MODE	RCAL 63/LOCAL



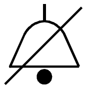
2. Press the ON/STANDBY button to turn the monitor on. After the normal power-up sequence, verify that the SpO_2% display initially indicates zero or is blank.

NOTE: The pulse bar may occasionally indicate a step change as the monitor is in the pulse search mode.

3. Move the modulation switch on the SRC-2 to LOW.
4. Verify the following monitor reaction:
   a. The pulse bar begins to track the artificial pulse signal from the SRC-2.
   b. Initially, zero is displayed in the SpO_2 frame, or it is blank.
   c. After about 10 to 20 seconds, the monitor displays saturation and heart rate as specified by the tester. Verify that the values are within the following tolerances:
      Oxygen Saturation Range 79% to 83%
      Heart Rate Range 35 to 41 bpm

d. The audible alarm sounds and both the SpO_2% and HEART RATE displays flash, indicating both parameters have violated the default alarm limits.

e. The heart rate tone is heard. (Heart rate tone source, found in the Heart Rate Menu, should be set to “SpO_2”.)



5. Press the ALARM SILENCE button on the front panel of the monitor. The audible alarm is temporarily silenced.

6. Verify the following:

   a. The audible alarm remains silenced.

   b. The “slashed bell” icon appears in each numeric frame on the display.

   c. The SpO_2% and HEART RATE displays continue flashing.

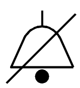
   d. The heart rate tone remains audible.

   e. The audible alarm returns in approximately 60 seconds.

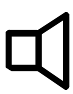
3.3.4.1.2 Heart Rate Tone Volume Control

Connect the SRC-2 pulse oximeter tester to the EC-8 sensor extension cable and connect the cable to the monitor. Set the SRC-2 as follows:

SWITCH	POSITION
RATE	38
LIGHT	LOW
MODULATION	LOW
RCAL/MODE	RCAL 63/LOCAL



1. Power on the monitor and verify that the SpO_2 and heart rate values are correctly displayed. Press the ALARM SILENCE button on the front panel of the monitor to temporarily silence the audible alarm.



2. Verify that the heart rate tone source, found in the Heart Rate Menu, is set to “SpO_2”. Press the VOLUME button on the front panel of the monitor. Within 3 seconds of having pressed the button, rotate the knob CW and verify that the beeping heart rate tone sound level increases.

3. Rotate the knob CCW and verify that the beeping heart rate tone decreases until it is no longer audible. Rotate the knob CW to return the beep volume to a comfortable level. (Note that 3 seconds after the last button-press or rotation of the knob, function of the knob reverts to moving the highlight on the display screen.)

3.3.4.1.3 Dynamic Operating Range

The following test sequence verifies proper monitor operation over a range of input signals.

1. Connect the SRC-2 to the NPB-3900 (using an EC-8) and turn the NPB-3900 on.
2. Place the SRC-2 in the RCAL 63/LOCAL mode.
3. Set the SRC-2 as indicated in Table 3-2. Verify that the NPB-3900 readings are within the indicated tolerances. Allow the monitor several seconds to stabilize the readings.

NOTE: A “*” indicates values that produce an alarm. Press the ALARM SILENCE button to temporarily silence the audible alarm.

Table 3-2: SRC Settings and NBP-3900 Indications

SRC-2 Settings			NPB-3900 Indications	
RATE	**LIGHT**	**MODULATION**	**SpO_2**	**Pulse Rate**
38	HIGH2	LOW	79 - 83*	35 - 41*
112	HIGH1	HIGH	79 - 83*	109 - 115
201	LOW	LOW	79 - 83*	195 - 207*
201	LOW	HIGH	79 - 83*	195 - 207*

NOTE: For the pulse rate setting of 201 bpm, the pulse rate tolerance of 195 to 207 bpm is greater than the ±3 bpm accuracy specification of the monitor, due to the performance characteristics of the SRC-2 tester.

4. Turn the monitor off.

3.3.4.1.4 LED Excitation Test

This procedure uses normal system components to test circuit operation. A Nellcor Puritan Bennett *Oxisensor II* adhesive sensor, model D-25, is used to examine LED intensity control. The red LED is used to verify intensity modulation caused by the LED intensity control circuit.

1. Connect an EC-8 sensor extension cable to the monitor.
2. Connect a D-25 sensor to the sensor extension cable.
3. Press the ON/STANDBY button to turn the monitor on.
4. Leave the sensor open with the LED and photodetector visible.
5. After the monitor completes its normal power-up sequence, verify that the sensor LED is brightly lit.

6. Slowly move the sensor LED in proximity to the photodetector element of the sensor. Verify, as the LED approaches the optical sensor, that the LED intensity decreases.

7. Open the sensor and notice that the LED intensity increases.

8. Repeat step 6 and the intensity again decreases. This variation is an indication that the microprocessor is in proper control of LED intensity.

9. Turn the NPB-3900 off.

3.3.4.2 Operation with an ECG Simulator (NPB-3930, NPB-3940)

1. With the monitor off, connect the ECG leads to the appropriate jacks on the ECG tester.
2. Connect the leads to the CE-10 ECG cable. Connect the CE-10 to the ECG input port on the NPB-3900. Set the ECG tester as follows:

Heart rate:	30 bpm
Amplitude:	1 millivolt
Lead select:	II

Normal sinus rhythm

Adult mode

NOTE: The accuracy of the monitor's ECG measurements is ±5 bpm. In the procedure below, add the tolerance of the simulator to the acceptable range of readings.

3. Press the ON/STANDBY button to turn the monitor on. After the normal power-up sequence, verify the following monitor reactions:

   a. After at least five heartbeats, the monitor displays a heart rate of 30 ±5 bpm.

   b. The audible alarm sounds and the HEART RATE display flashes, indicating the heart rate is below the default lower alarm limit.

4. Press the ALARM SILENCE button. Verify that the audible alarm is silenced.

5. Increase the heart rate setting on the ECG simulator to 240 bpm.

6. After at least five heartbeats, verify that the monitor displays a heart rate of 240 ±5 bpm.

7. Verify that the audible alarm sounds and the HEART RATE display flashes, indicating that the heart rate is above the default upper alarm limit.

8. Press the ALARM SILENCE button to silence the alarm.

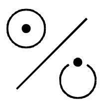
9. Decrease the heart rate setting on the ECG simulator to 120 bpm.

10. After at least five heartbeats, verify that the monitor displays a heart rate of 120 ±5 bpm.

11. Disconnect the LL lead from the ECG simulator. Verify that the “Leads Off” alarm message appears, three dashes are displayed in the HEART RATE display, and a low priority audible alarm sounds.

12. Reconnect the LL lead to the ECG simulator. Verify that the “Leads Off” alarm message no longer appears and that the audible alarm is silenced.

13. Repeat steps 11 and 12 for the LA and RA leads.



14. Turn the monitor off.

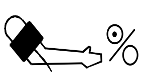
3.3.4.3 Verification of Pneumatic System (NPB-3900)

Tests in paragraphs 3.3.4.3.1 through 3.3.4.3.5 verify the functionality of the NPB-3900 pneumatic system. These tests were designed to use the Bio-Tek “BP Pump” noninvasive blood pressure simulator. The internal test volume of the Bio-Tek simulator is 250 cm^3, which is used to calculated the inflation/deflation rate periods. The Bio-Tek simulator, or any equivalent NIBP simulator, is required to perform these tests.

The NPB-3900 must be placed in Diagnostic Mode, with the NIBP Test screen active for each of the NIBP tests. For a detailed explanation of the Diagnostic Mode, refer to Section 4, *Power-up Defaults Menu and Diagnostic Mode.*

Each of the tests described in paragraphs 3.3.4.3.1 through 3.3.4.3.5 must be performed to verify pneumatic system functionality. These tests can be performed individually (in any order) or sequentially. Prior to performing any of these tests, perform the following setup procedure. If these tests are performed in sequence, this procedure needs to be performed once prior to the first test.

1. Turn on the Bio-Tek simulator and press the MODE button to place the simulator in test mode. The simulator screen will indicate “Internal Cuff” and “Pressure Gauge”.



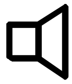
2. Connect the simulator hose to the NIBP connector on the NPB-3900.

3. Follow the procedure described in Section 4 to place the NPB-3900 in Diagnostic Mode with the NIBP Test screen active.

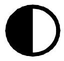
3.3.4.3.1 Pressure Transducer Accuracy

The pressure transducer accuracy test verifies the pressure accuracy of the NBP-3900 pressure transducer.

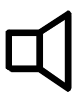
1. Confirm that the Bio-Tek simulator is in test mode. The simulator should display “Pressure Gauge”. Confirm that the simulator is set up for the internal cuff.



2. Confirm that the NIBP Test screen is active on the NPB-3900. Press, then release, the SPEAKER button on the NPB-3900 to verify that the valve is closed.



3. Press the CONTRAST button on the NPB-3900, then the ZERO button on the simulator, to perform an offset adjustment so that the simulator and NBP-3900 both display a pressure of 0 mmHg.
4. Press the SELECT button on the simulator until the simulator displays “Pressure Source Set Test Pressure”. Use the UP/DOWN buttons on the simulator to adjust for 250 mmHg.
5. Press the START PUMP button on the simulator. The simulator will begin to pressurize. The current pressure in mmHg is displayed on both the simulator and NPB-3900 displays.
6. Allow 15-20 seconds for the pressure to stabilize. The pressure displayed on the NPB-3900 and the simulator should be within 5 mmHg of one another to complete the test successfully.
7. Press the STOP PUMP button on the simulator to stop the test.

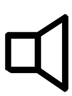


8. Press and hold the SPEAKER button until the NPB-3900 displays a pressure of 0 mmHg.
9. Additional NIBP tests may be performed at this time. If no further NIBP tests are to be conducted, turn the NPB-3900 off. Normal monitoring operation will return the next time the monitor is turned on.

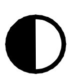
3.3.4.3.2 Pneumatic Leakage

The pneumatic leakage test verifies the integrity of the pneumatic system. A timer/stopwatch is required for this test.

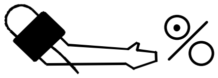
1. Ensure that the Bio-Tek simulator is in test mode. The simulator should display “Pressure Gauge”. Confirm that the simulator is set up for the internal cuff.



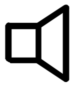
2. Ensure that the NIBP Test screen is active on the NPB-3900. Press, then release, the SPEAKER button on the NPB-3900 to verify that the valve is closed.



3. Press the CONTRAST button on the NPB-3900, then the ZERO button on the simulator, to perform an offset adjustment so that the simulator and NBP-3900 both display a pressure of 0 mmHg.



4. Press the NIBP button on the NPB-3900 to activate the pump. Hold the button until the NPB-3900 displays a pressure of approximately 250 mmHg. Allow 15-20 seconds for the pressure to stabilize. Record the pressure displayed on the monitor, and initiate a 1-minute timer. After 1 minute, again record the pressure displayed. The test is successfully completed if the pressure has dropped by 6 mmHg, or less, during the 1-minute period.



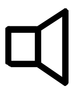
5. Press and hold the SPEAKER button until the NPB-3900 displays a pressure of 0 mmHg.

6. Additional NIBP tests may be performed at this time. If no further NIBP tests are to be conducted, turn the NPB-3900 off. Normal monitoring operation will return the next time the monitor is turned on.

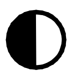
3.3.4.3.3 Inflation Rate

The inflation rate test verifies the inflation rate of the NPB-3900. A timer/stopwatch is required for this test.

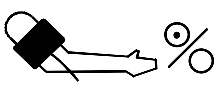
1. Ensure that the Bio-Tek simulator is in test mode. The simulator should display “Pressure Gauge”. Confirm that the simulator is set up for the internal cuff.



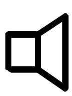
2. Ensure that the NIBP Test screen is active on the NPB-3900. Press, then release, the SPEAKER button on the NPB-3900 to verify that the valve is closed.



3. Press the CONTRAST button on the NPB-3900, then the ZERO button on the simulator, to perform an offset adjustment so that the simulator and NBP-3900 both display a pressure of 0 mmHg.



4. Press the NIBP button on the NPB-3900 to activate the pump, and simultaneously start the timer. Hold the NIBP button until the monitor displays a pressure of 280 mmHg. When a pressure of 280 mmHg is reached, stop the timer. The test is successfully completed if the inflation time is between 1 and 6 seconds.



5. Press and hold the SPEAKER button until the NPB-3900 displays a pressure of 0 mmHg.

6. Additional NIBP tests may be performed at this time. If no further NIBP tests are to be conducted, turn the NPB-3900 off. Normal monitoring operation will return the next time the monitor is turned on.

3.3.4.3.4 Deflation Rate

The deflation rate test verifies the deflation rate of the NPB-3900. A timer/stop watch is required for this test.

1. Ensure that the Bio-Tek simulator is in test mode. The simulator should display “Pressure Gauge”. Confirm that the simulator is set up for the internal cuff.

2. Ensure that the NIBP Test screen is active on the NPB-3900. Press, then release, the SPEAKER button to verify that the valve is closed.

3. Press the CONTRAST button on the NPB-3900, then the ZERO button on the simulator, to perform an offset adjustment so that the simulator and NBP-3900 both display a pressure of 0 mmHg.

4. Press the NIBP button on the NPB-3900 to activate the pump. Hold the button until the NPB-3900 displays a pressure of 280 mmHg. Initiate a 1-minute timer, and simultaneously press and hold the ALARM SILENCE button on the NPB-3900. This will cause the pneumatic system to deflate at a rate of 3 mmHg/sec ±1.5 mmHg/sec. After 1 minute, record the pressure displayed on the NPB-3900. The test is successfully completed if the monitor displays a pressure reading of 10 mmHg to 190 mmHg.

5. Press and hold the SPEAKER button until the NPB-3900 displays a pressure of 0 mmHg.

6. Additional NIBP tests may be performed at this time. If no further NIBP tests are to be conducted, turn the NPB-3900 off. Normal monitoring operation will return the next time the monitor is turned on.

3.3.4.3.5 Over-pressure

The over-pressure test verifies the functionality of the over-pressure relief system of the NPB-3900.

1. Ensure that the Bio-Tek simulator is in test mode. The simulator should display “Pressure Gauge”. Confirm that the simulator is set up for the internal cuff.

2. Ensure that the NIBP Test screen is active on the NPB-3900. Press, then release, the SPEAKER button on the NPB-3900 to verify that the valve is closed.

3. Press the CONTRAST button on the NPB-3900, then the ZERO button on the simulator, to perform an offset adjustment so that the simulator and NBP-3900 both display a pressure of 0 mmHg.

4. Press the SELECT button on the simulator until the simulator displays “Overpressure Test”. Press the START TEST button on the simulator. The simulator will pressurize the system until the monitor’s over-pressure relief system activates, including the warning display screen. The simulator will display the pressure value that caused the NPB-3900 over-pressure relief system to activate. The test is successfully completed if the simulator displays a pressure reading of 280 mmHg to 330 mmHg.

5. Press and hold the SPEAKER button to ensure that the NPB-3900 displays a pressure of 0 mmHg.

6. Additional NIBP tests may be performed at this time. If no further NIBP tests are to be conducted, turn the NPB-3900 off. Normal monitoring operation will return the next time the monitor is turned on.

3.3.4.4 Operation with a Thermometer Calibration Key (Models 3920 and 3940)

1. Remove the probe from its holder.
2. Insert the calibration key in the temperature input port ***T*** on the NPB-3900.
3. Press the ON/STANDBY button to turn the monitor on. After the normal power-up sequence, verify that the temperature reads 36.3 ±0.1 °C (or 97.3 ±0.2 °F).
4. Turn the monitor off.

3.3.4.5 General Operation

The following tests provide an overall performance check of the system:

- 3.3.4.4.1 Operation with a Human Subject
- 3.3.4.4.2 Serial Interface Test
- 3.3.4.4.3 Printer Verification

3.3.4.5.1 Operation with a Human Subject

Patient monitoring involves connecting the monitor to a human subject for a qualitative test.

1. Connect an EC-8 sensor extension cable to the monitor. Connect a Nellcor Puritan Bennett *Durasensor* finger clip sensor, model DS-100A, to the sensor extension cable. Clip the DS-100A to the subject as described in the sensor directions for use.
2. Connect a CE-10 ECG cable to the NPB-3930 or NPB-3940. Connect ECG leads to the cable. Connect ECG electrodes to the leads. Apply ECG electrodes to the subject according to the lead's and electrodes' directions for use.
3. Connect an SHBP-10 blood pressure hose to the monitor. Apply the appropriate SCBP series blood pressure cuff to the subject according to the cuff directions for use.
4. Connect a blue-capped *SureTemp* oral thermometer probe to the NPB-3920 or NPB-3940. Place the probe in its holder in the module on the rear of the monitor.
5. Press the ON/STANDBY button to turn the monitor on and verify that the monitor is operating.
6. The monitor should stabilize on the subject's physiological signals in about 15 to 30 seconds. Verify that the saturation and heart rate are reasonable for the subject.
7. Press the NIBP button on the front panel of the monitor. Verify that the blood pressure values are reasonable for the subject.

8. Remove the temperature probe from its holder. Following the directions in the NPB-32900 operator’s manual, apply a new probe cover and take the subject’s temperature. Verify that the temperature measurement is reasonable for the subject.

3.3.4.5.2 Serial Interface Test

RS-232

Perform the following procedure to test the serial port voltages. The test is qualitative and only verifies that the serial interface port is powered correctly, and that the “nurse call” signal is operational. The serial connector is a male DB-9 located on the monitor’s rear panel, identified with the RS-232 symbol.

1. Turn the monitor ON.
2. Set up the DMM with the function set to “VDC” at a range of 10 volts.
3. Connect the DMM negative lead to connector pin 5 (GND), or the shell of the RS-232 connector.
4. Connect the DMM positive lead to the following pins, in turn, and verify the voltage values listed in Table 3-3. (Voltage for pin 9 is that listed for the “no alarm” condition.)

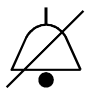
Table 3-3: Serial Interface Measurements

		Measurement (V)		
Pin	**Signal**	**Min**	**Typical**	**Max**
1	not used	-0.4	0.0	0.4
2	RXD <<<	-0.4	0.0	0.4
3	TXD >>>	-5.0	-9.0	-15.0
4	DTR >>>	-5.0	-9.0	-15.0
5	GND	-0.4	0.0	0.4
6	DSR <<<	-0.4	0.0	0.4
7	RTS >>>	-5.0	-9.0	-15.0
8	CTS <<<	-0.4	0.0	0.4
9	Alarm Out >>> (no alarm)	-5.0	-9.0	-15.0
9	Alarm Out >>> (alarm underway)	5.0	9.0	15.0

5. Connect the *Nellcor Puritan Bennett* SRC-2 pulse oximeter tester to the monitor via the EC-8 sensor extension cable.

6. Set the SRC-2 switches as follows:

SWITCH	**POSITION**
RATE	38
LIGHT	LOW
MODULATION	LOW
RCAL/MODE	RCAL 63/LOCAL

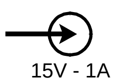


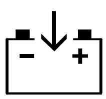
7. Verify that the monitor is responding to the SpO_2 simulator signal and the audible alarm is sounding. If desired, press the ALARM SILENCE button to temporarily silence the audible alarm.

8. Connect the DMM positive lead to pin 9 and verify the voltage value listed in Table 3-3. (Voltage for pin 9 is that listed for the "alarm underway" condition.)

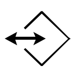
3.3.4.5.3 Printer Verification (For Optional Printer)

Printer verification consists of connecting the printer to the monitor and the monitor to a human subject for a qualitative test.



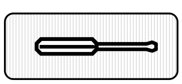


1. Connect the output of the appropriate power supply, PS-240V or PS-120V, to the labeled connector in the rear of the printer. When the printer's external power supply is connected, the printer front-panel charging LED is lighted.

RS-232 

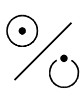
2. Connect the serial cable between the labeled connectors in the rear panels of the monitor and the printer.

3. The printer front-panel communication LED is lighted when the RS-232 communications link is completed.



4. Rotate the monitor knob to highlight the setup icon . Press the knob and ensure Communications Selection is (Printer).

5. Connect an EC-8 sensor extension cable to the monitor. Connect a *Nellcor Puritan Bennett Durasensor* oxygen transducer, model DS-100A, to the sensor extension cable. Attach the DS-100A to the subject as described in the sensor directions for use.



6. Press the ON/STANDBY button to turn the monitor on and verify that the monitor is operating.

7. The monitor should stabilize on the subject's physiological signal in about 15 to 30 seconds. Verify that the saturation and heart rate is reasonable for the subject.

8. Press the printer CONTINUOUS BUTTON. Verify that the printout contains vital signs across the top of the paper, and that aSpO_2 waveform, with grid marks, occupies the center portion of the paper. Press the CONTINUOUS BUTTON again to terminate printout.

9. Disconnect the sensor and shut off the monitor.

3.4 SAFETY TESTS

NPB-3900 safety tests consist of the following Leakage Currents elements, performed in accordance with IEC 601-1.

3.4.1 Protective Ground Continuity

NOTE: The NPB-3900 does not require an isolated Earth Ground terminal, neither is one installed. No Protective Ground Continuity check is required.

3.4.2 Electrical Leakage

NPB-3900 leakage current tests consist of the following elements, performed in accordance with IEC 601-1, clause 19:

- Patient Leakage Current
- Patient Leakage Current, with Mains Voltage on the Applied Part

3.4.2.1 Patient Leakage Current

This test measures patient leakage current in accordance with IEC 601-1, clause 19, for Class II, type CF equipment. Patient leakage current in this test is measured from any individual patient connection to earth (power ground).

NOTE: This test requires a test cable for each patient connector. For example, the ECG test cable consists of the ECG cable connector, with all the conductors shorted together, connected to a test lead from the electrical safety analyzer. Test cables for SpO_2 and temperature can be configured in a similar manner.

1. Configure the electrical safety analyzer as recommended by the analyzer operating instructions.

2. Connect the appropriate external power supply input power cord to the analyzer as recommended by the analyzer operating instructions. Connect the external power supply output cord to the monitor.

3. Connect the ECG test cable to the ECG connector on the NPB-3930 /3940 and the appropriate input connector on the analyzer. Turn on the NPB-3930/3940.

4. Perform the test as recommended by the analyzer operating instructions. Patient leakage current is measured under various conditions of the AC mains. For each condition, the measured leakage current must not exceed that indicated in Table 3-4.

5. Repeat the test for the SpO_2 and temperature patient connections, using the appropriate test cables.

Table 3-4: Current Test

Test Condition	Allowable Leakage Current (milliamps)
Normal polarity	0.01
Normal polarity; Neutral (L2) open	0.05
Reverse polarity	0.01
Reverse polarity; Neutral (L2) open	0.05

3.4.1.3 Patient Leakage Current, with Mains Voltage on the Applied Part

This test measures patient leakage current in accordance with IEC 601-1, clause 19, for Class II, type CF equipment. In this test, 110% of mains voltage is applied between each patient connection and earth (power ground). Patient leakage current is then measured from any individual patient connection to earth.

NOTE: This test requires the same test cables for each patient connector as described in section 3.4.1.2.

WARNING: AC mains voltage will be present on the applied part terminals during this test. Exercise caution to avoid electrical shock hazard.

1. Configure the electrical safety analyzer as recommended by the analyzer operating instructions.
2. Connect the monitor's appropriate external power supply input power cord to the analyzer as recommended by the analyzer operating instructions. Connect the external power supply output cord to the monitor.

3. Connect the ECG test cable to the ECG connector on the NPB-3930/3940 and the appropriate input connector on the analyzer. Turn on the NPB-3930/3940.
4. Perform the test as recommended by the analyzer operating instructions. Patient leakage current is measured with normal and reverse mains polarity. For each condition, the measured leakage current must not exceed that indicated in Table 3-5.
5. Repeat the test for the SpO_2 and temperature patient connections, using the appropriate test cables.

Table 3-5: Leakage Current

Test Condition	Allowable Leakage Current (milliamps)
Normal polarity	0.05
Reverse polarity	0.05

SECTION 4: POWER-UP DEFAULTS MENU AND DIAGNOSTIC MODE

4.1 INTRODUCTION

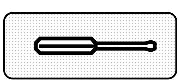
This section discusses use of the Power-up Defaults Menu to configure power-on default settings, and the Diagnostic Mode to obtain service-related information about the monitor.

4.2 POWER-UP DEFAULTS MENU

The purpose of the Power-up Defaults Menu (Table 4-1) is to allow the authorized user to create a “power-up default” for each setting in the NPB-3900. Power-up defaults are the settings in effect each time the NPB-3900 is powered on. Once the Power-up Defaults Menu is entered, physiological monitoring is terminated. The screen layouts do NOT display any information associated with normal monitoring operation.

Use the following procedure to configure the power-up default settings for the NPB-3900 monitor.

1. While in normal monitoring mode, adjust each accessible setting on the monitor as desired, using the techniques described in the operator’s manual. Such settings include alarm limits, choice of display type for the graphic frame, and ECG lead select.



2. Use the knob to invoke the Set-up Menu (choose the screwdriver icon found along the bottom of the display).
3. Select the menu item “Enter Power-Up Defaults Menu”. Once selected, a pop-up box appears with the text “Enter 3-Digit Passcode”. Use the knob to enter the passcode, 2 1 5. This passcode is set at the factory and may not be changed.
4. The Power-up Defaults Menu is now present. The available menu items are explained in the table that follows. Make changes to these menu items as desired.

Table 4-1: Power-Up Defaults Menu

MENU ITEM*	CHOICES**	EXPLANATION
Accept Current Settings?	“**Yes**” “No”	If “Yes” is chosen, the current NPB-3900 settings become the power-up defaults.

Table 4-1: Power-Up Defaults Menu - (Continued)

MENU ITEM*	CHOICES**	EXPLANATION
Permanent Audible Alarm Silence	"**Make Available**" "Deny Access"	If "Make Available" is chosen, the caregiver may permanently silence the audible alarm for a particular parameter via the Alarm/Limits Menu. Some institutions may wish to prevent audible alarms from being permanently silenced. If so, "Deny Access" should be selected.
Alarm Suspend	"Make Available" "**Deny Access**"	If "Make Available" is chosen, the caregiver may invoke the Alarm Suspend Mode by pressing and holding the Alarm Silence button for 2 seconds. Some institutions may wish to prevent Alarm Suspend from being invoked. If so, "Deny Access" should be selected.
Auto-Set Limits	"**Make Available**" "Deny Access"	If "Make Available" is chosen, the caregiver may invoke the Auto-Set Limits function via the Alarm/Limits Menu. Some institutions may wish to prevent Auto-Set Limits from being invoked. If so, "Deny Access" should be selected.

Table 4-1: Power-Up Defaults Menu - (Continued)

MENU ITEM*	CHOICES**	EXPLANATION
Language	"**English**" "Français" "Deutsch" "Español" "Italiano" "Portugués" "Japanese" "Chinese" "Russian"	The language selected will be used for all the text shown on the display; the selected language will be effective the next time the monitor is powered up.
Enter Diagnostic Mode	"Yes" "**No**"	If "Yes" is chosen, the Power-up Defaults Menu is exited and the Diagnostic Menu appears.
Done		When selected, the Power-up Defaults Menu is immediately exited and the user is instructed to power down the monitor.
* The choice in effect at the time the screen is accessed is shown in parentheses following the menu item.		
** Bold type indicates the choice when the factory-set default menu appears. The highlighting is displayed in reverse video.		

5. After making any desired changes to the menu items, choose the menu item "Accept current settings?", select "YES", then select "Done".
6. Upon selecting "Done", a Notice screen will appear, with the directions that the monitor must be powered off, and that any changes made to the power-up defaults will be in effect next time the unit is powered up.

NOTICE

Turn off the monitor at this time. Any changes made to the power-up defaults will be in effect the next time the monitor is turned on.

4.3 RESTORING FACTORY SETTINGS

CAUTION: In addition to restoring factory defaults, this procedure will also clear the contents of trend memory.

NOTE: Read this procedure completely before performing the first step.

The following technique can be used to restore the monitor's power-up default settings which were originally established at the factory:

1. With the monitor powered off, simultaneously press the Volume and Contrast buttons on the front keypad.
2. While continuing to press the Volume and Contrast buttons, power-up the monitor.
3. Continue to keep the Volume and Contrast buttons depressed until the power-up diagnostic sequence is complete. When the normal monitoring screen appears, release the two buttons.

4.4 DIAGNOSTIC MODE

The purpose of Diagnostic Mode is to allow factory, field-service, and hospital biomedical technicians access to a series of test and system-related information screens for the purpose of verifying NPB-3900 performance or troubleshooting problems.

To access the Diagnostic Mode, first invoke the Power-up Defaults Menu as described in section 4.2. Then, select the menu item, "Enter Diagnostic Mode". Choose "Yes". The Power-up Defaults Menu will be exited and the Diagnostic Menu will appear.

DIAGNOSTIC MENU

Error Codes
System Information
System A/D Values
NIBP Test

Return

The Diagnostic Menu lists the test and system-related information screens. Selection of an item in the menu will invoke that test or information screen. The test and information screens that appear in the Diagnostic Menu are as follows:

- Error Codes
- System Information
- System A/D Values
- NIBP Test
- Return

4.4.1 Error Codes

This screen displays the 10 most recent error code types, logged by the NPB-3900. After 10 error code types have been logged, the oldest error code type will be deleted as new error code types are added. Adjacent to each error code will be an entry which is the number of occurrences of that error. This means that if there are many occurrences of one type of error code, that one error code won't "overwrite" the other 9 error codes.

Next to the occurrence field is the time and date of the most recent occurrence of the error code. Error codes may not be changed or reset in this screen. When in the Error Code screen, the "Return" item is always highlighted; a press of the knob will return the user to the Diagnostic Menu. Rotating the knob while in the Error Code screen will have no effect.

NOTE: Refer to Section 5.6.2 for more detail on error codes.

4.4.2 System Information

SYSTEM INFORMATION	
Monitor On-Time	1563
Backlight On-Time	871
Battery Deep Discharges	152
System Software Version	V 2.01
SpO_2 Software Version	Nellcor MP204/205 V1.1.0.6 10/06/95

Return

This screen displays several system-related items:

- **Monitor On-time**: Displays the number of hours, rounded to the nearest hour, that the Main PCB has been operational. This value may not be reset. (See Note 1.)

  NOTE 1: Monitor on-time, backlight on-time, and battery deep discharge values are stored in nonvolatile memory. When a new Main PCB is installed, this value will be set at zero.

- **Backlight On-time**: Displays the number of hours, rounded to the nearest hour, that the LCD Backlight has been operational. This value may be reset to zero, for instance, when a technician changes the backlight or installs a new LCD. (See Note 1.)

- **Battery Deep Discharges**: Displays the number of deep-discharge cycles seen by the battery. The monitor records a deep discharge cycle when the battery voltage reaches 5.6 V, the voltage at which a “Low Battery” alarm is issued. This value may be reset to zero, for instance, when a technician installs a new battery. (See Note 1.)

- **System software version**: Displays the revision level of the system software. This revision level is also momentarily shown on the LCD as part of the Copyright screen. This value may not be changed by the user.

- **SpO_2 software version**: Displays the revision level of the software of the SpO_2 EEPROM module. This value may not be changed by the user.

When in the System Information screen, the knob may be rotated to select any of the “changeable” items. If one of those items is selected, a press of the knob will cause a pop-up menu to appear. The first item in the pop-up will read “Make no change”; the second item in the pop-up will read “Reset to zero”. Exiting the screen is accomplished in the normal manner, by selecting “Return”.

4.4.3 System A/D Values

SYSTEM A/D VALUES

1.	1.478	12.	1.478
2.	0.235	13.	0.235
3.	3.652	14.	3.652
4.	0.782	15.	0.782
5.	4.012	16.	4.012
6.	0.045	17.	0.045
7.	2.149	18.	2.149
8.	1.025	19.	1.025
9.	0.478	20.	0.478
10.	1.369	21.	
11.	0.702		
SpO_2 S1	S018	SpO_2 S2	S0010

Return

This screen displays the current value of each analog-to-digital (A/D) channel, in volts. Some of the channels are for AC-coupled signals (such as ECG input), so the numbers on the screen will be constantly changing when an input signal is present. These AC-coupled values indicate whether basic functionality of the channel is present, but no significance can be derived from the values of the numbers displayed. However, other A/D channels read DC voltages, (for example, power supply voltages and battery voltage) so those voltage values provide useful diagnostic information.

The Primary and Secondary Status messages from the SpO_2 module will be displayed and updated at the rate of about once per second. Presence of the correct SpO_2 message indicates that, at a basic level, communication between the SpO_2 module and the main monitor processor is working correctly. None of the displayed values may be changed or reset in this screen. When in the System A/D screen, the “Return” item is always highlighted; a press of the knob will return the user to the Diagnostic Menu. Rotating the knob while in the System A/D screen will have no effect. The A/D channel designators are shown in Table 4-2.

Table 4-2: A/D Channel Designators

A/D CHANNEL DESIGNATOR		A/D CHANNEL DESIGNATOR	
1.	ECG	12.	(BATTERY VOLTAGE) X 0.5
2.	RWAVE	13.	TEMP PROBE <=0=ORAL, 1=RECTAL,2=CAL KEY, >=3 NONE)
3.	PACEMAKER	14.	+3.3VDC POWER SUPPLY
4.	TEMP 1(93° TO 112°)	15.	(NIBP VOLTAGE REF) X 0.8

Table 4-2: A/D Channel Designators - (Continued)

5.	PRESSURE XDUCER 1	16.	GROUND REFERENCE
6.	PRESSURE XDUCER 2	17.	(+5 VDC POWER SUPPLY) X 0.8
7.	NIBP OSCILLATORY	18.	ADC MID-SCALE VALUE
8.	ECG LEADS OFF	19.	ADC FULL-SCALE VALUE
9.	TEMP 2(59° TO 93°)	20.	ADC ZERO-SCALE VALUE
10.	ISOLATED VOLTAGE REF	21.	(NOT USED)
11.	ISOLATED VOLTAGE ZERO		
	SpO_2 S1 S018		SpO_2 S2 S010

4.4.4 NIPB Test

WARNING: Never apply an attached blood pressure cuff to a patient while the monitor is in Diagnostic Mode. Injury could result.

NIBP TEST

Pressure (mmHg) 179
Valve: OPEN

Press “NIBP” to activate pump; release to stop pump.

Press “Volume” to open valve; release to close valve.

Press “Alarm Silence” to open proportional valve and deflate at 3 mmHg/s; release to close valve.

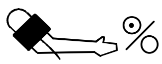
Press “Contrast” to perform offset adjust.

Return

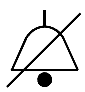
An NIBP Test screen is provided to facilitate troubleshooting problems and perform verification testing for the NIBP subsystem. Typically, when these tests are performed, the pneumatic system is connected to an external pressure-reading device and a closed reference volume. The NIBP Test screen provides a real-time numeric display of the pressure in the pneumatic system, means for controlling the pump and valve, and a display indicating whether the valve is open or closed.

The NIBP Test screen elements are described below.

- **Pressure Display**: The real-time value of the system pneumatic pressure is displayed in mmHg. The value is updated at the rate of approximately two times per second.
- **Valve Display**: A display indicates whether the valve is open or closed.

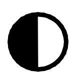


- **Activate pump**: While the ***NIBP button*** is pressed, the pump will run. If system pressure reaches the hardware over-pressure protection point (280 to 330 mmHg), the safety valve will open and the pump will be disabled, until the pressure falls below the safety threshold.



- **Deflate**: For as long as the ***Alarm Silence button*** is pressed, the valve will open and bleed off pressure at the rate of 3 ±1.5 mmHg/sec. It is useful to control the bleed rate to 3 mmHg/sec to facilitate certain AAMI SP10 tests. Any time the bleed rate falls below 3 mmHg/sec, the valve will open and remain at maximum as long as the button is pressed.

- **Open Valve**: While the ***Volume button*** is pressed, the valve opens and remains at maximum as long as the button is pressed.



- **Offset Adjust**: A momentary press of the ***Contrast button*** will invoke the "zero calibration" routine that is performed immediately prior to each blood pressure measurement. This routine looks at the pressure in the system, and if the pressure is non-zero, an offset is applied which causes the system pressure to be displayed as "zero".

When in the NIBP Test screen, the "Return" item is always highlighted; a press of the knob will return the user to the Diagnostic Menu. Rotating the knob while in the NIBP Test screen will have no effect.

SECTION 5: TROUBLESHOOTING

5.1 INTRODUCTION

This section explains how to troubleshoot the NPB-3900 if problems arise. Tables are supplied that list possible monitor difficulties, along with probable causes, and recommended actions to correct the difficulty.

5.2 HOW TO USE THIS SECTION

Use this section in conjunction with Section 3, *Performance Verification*, and Section 7, *Spare Parts*. To remove and replace a part you suspect is defective, follow the instructions in Section 6, *Disassembly Guide*. The circuit analysis section in the Technical Supplement offers information on how the monitor functions.

5.3 WHO SHOULD PERFORM REPAIRS

Only qualified service personnel should open the monitor housing, remove and replace components, or make adjustments. If your medical facility does not have qualified service personnel, contact Nellcor Puritan Bennett Technical Services or your local Nellcor Puritan Bennett representative.

5.4 REPLACEMENT LEVEL SUPPORTED

The replacement level supported for this product is to the printed circuit board (PCB) and major subassembly or component level. Once you isolate a suspected PCB, follow the procedures in Section 6, *Disassembly Guide,* to replace the PCB with a known good PCB. Check to see if the trouble symptom disappears and that the monitor passes all performance tests. If the trouble symptom persists, swap back the replacement PCB with the suspected malfunctioning PCB (the original PCB that was installed in the monitor before you started troubleshooting) and continue troubleshooting as directed in this section.

5.5 OBTAINING REPLACEMENT PARTS

Nellcor Puritan Bennett Technical Services provides technical assistance information and replacement parts. To obtain replacement parts, contact Nellcor Puritan Bennett or your local Nellcor Puritan Bennett representative. Refer to parts by the part names and part numbers listed in Section 7, *Spare Parts*.

5.6 TROUBLESHOOTING GUIDE

Problems with the NPB-3900 are separated into the categories indicated in Table 5-1. Refer to the paragraph indicated for further troubleshooting instructions.

NOTE: Taking the recommended actions discussed in this section will correct the majority of problems you may encounter. However, problems not covered here can be resolved by calling Nellcor Puritan Bennett Technical Services or your local representative.

Table 5-1: Problem Categories

Problem Area	**Refer to Paragraph**
1. Power • No power-up • Fails power-on self-test • Powers down without apparent cause	5.6.1
2. Error Messages	5.6.2
3. Buttons/Knob • Monitor does not respond properly to buttons	5.6.3
4. Display/Audible Tones • Display does not respond properly • Tones do not sound properly	5.6.4
5. Operational Performance • Displays appear to be operational, but monitor shows no readings • Suspect readings • Printer not responding	5.6.5

All of the categories in Table 5-1 are discussed in the following paragraphs.

5.6.1 Power

Table 5-2 lists recommended actions to address power problems.

Table 5-2: Power Problems

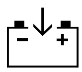
Condition	Recommended Action
1. With external power supply connected, the green EXTERNAL POWER indicator  on the front panel is not lit.	1. Ensure that the external power supply input (PS-120V or PS-240V) is plugged into an operational AC outlet of the appropriate voltage and frequency. 2. Disconnect the power supply output cable from the monitor. Measure the voltage across pins 1 and 4 of output connector. If the open circuit voltage does not measure approximately 17 ±3 V~ RMS, replace the power supply. 3. If the battery is severely discharged or shorted, the EXTERNAL POWER indicator will not light. Connect the external power supply to an AC outlet and to the monitor. Allow the battery to charge for 30 minutes. If the EXTERNAL POWER indicator still does not light, replace the battery. 4. Inside the monitor, check the ribbon cable and ensure that it is properly connected to the main PCB. 5. The EXTERNAL POWER indicator is embedded in the keypad. Ensure that the keypad is plugged into Main PCB. If the connection is good, replace the keypad. 6. If the problem persists, replace main PCB.
2.The NPB-3900 fails to power-up when the ON/STANDBY button is pressed ... with the monitor connected to external power supply	1. Connect the appropriate external power supply (PS-120V or PS-240V) to the monitor. Ensure that the external power supply input is plugged into an operational AC outlet of the appropriate voltage and frequency. Ensure that the green EXTERNAL POWER indicator is lit. If the indicator is not lit, follow the steps described in Condition 1, above. 2. Ensure that the keypad is plugged into Main PCB. If the connection is good, replace keypad. 3. If the problem persists, replace the main PCB.

Table 5-2: Power Problems - (Continued)

Condition	Recommended Action
3. The NPB-3900 fails to power-up when the ON/STANDBY button is pressed with the monitor *not* connected to external power supply.	1. First, follow the steps described in Condition 2, above, to ensure that the monitor will operate when connected to an external power supply. 2. Check fuse F301 located on the Main PCB, near the battery cable connector. Replace fuse if necessary. 3. Recharge the battery as directed in paragraph 3.3.1. If the battery fails to hold a charge, replace the battery. 4. If the problem persists, replace the main PCB.
4. The NPB-3900 turns on, then shuts off and sounds an alarm and no error code is displayed.	1. Press the alarm silence button to terminate the audible alarm. Ensure that the external power supply is connected and the green EXTERNAL POWER indicator is lit. If the monitor operates successfully, the battery may be discharged, or the battery fuse may be blown. 2. Recharge the battery as directed in paragraph 3.3.1. If the battery fails to hold a charge, replace the battery. 3. Check fuse F301 located on the Main PCB, near the battery cable connector. Replace the fuse if necessary. 4. If problem persists, replace the main PCB.

5.6.2 Error Codes

When the NPB-3900 detects an error condition, the monitor shows an error code on the display screen. If such an error occurs during monitoring operation, an audible alarm tone will sound, as well. Press the ALARM SILENCE button to terminate the audible alarm tone.

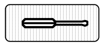
When an error code appears on the display, a number in hexadecimal representation indicates the nature of the error. Additionally, Diagnostic Mode may be used to gain access to an error code record, stored in nonvolatile memory, of the last 10 error codes encountered by the monitor. See Section 4 for further details on Diagnostic Mode.

Each error code corresponds to a particular problem in the monitor. Recommended actions to take when an error code is encountered are listed in the sections that follow.

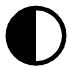
As an aid to troubleshooting, the NPB-3900 provides the capability for technicians to print out a copy of the error log.

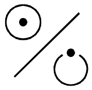
Generating an Error Log printout

1. Connect a P-3900 printer to the monitor, and its power supply to an appropriate source. Refer to the operator's manual.



2. Use the Setup button and displayed menu to verify that the Printer mode is the selected option for the Communications Selection item. (It is the factory-set default value.)
3. Turn monitor power OFF.





4. Simultaneously press the contrast button and the On/Standby button to power up the monitor. Keep the contrast button depressed until the monitoring screen appears (after 10 seconds). The error code printout is generated automatically.

If error codes listed on the Diagnostic Mode error code screen or on the error log printout are in the range from 1 to 65 (hex), a hardware problem has been detected. Refer to Table 5-3, **Serviceable Hardware Codes** for additional information on these codes.

5.6.2.1 Serviceable Hardware Error Codes

In Table 5-3 are error codes that correspond to hardware problems, and the recommended actions to take should such an error be encountered.

Table 5-3: Serviceable Hardware Error Codes

Hex Code	Explanation	Recommended Action
1	Improper shutdown.	1. Cycle power. 2. If this error persists, return monitor for service.
2	NIBP Sensor Error. The two pressure transducers do not agree.	1. Check for blocked hoses in the pneumatic system. 2. Replace Main PCB.
3	NIBP Pressure Violation Error. The pressure on the cuff could not be removed by normal means. A fault has been detected in the NIBP system that could not be handled by releasing pressure by normal means.	1. Cycle power. 2. Check for blocked hoses in the pneumatic system. 3. Replace Main PCB.

Table 5-3: Serviceable Hardware Error Codes - (Continued)

Hex Code	Explanation	Recommended Action
4	The measured value of the 3.3-volt power supply is low.	1. Check power supply. 2. Replace Main PCB.
5	The measured value of the 3.3-volt power supply is high.	1. Check power supply. 2. Replace Main PCB.
7	The measured value of the 12-volt power supply is high.	1. Check power supply. 2. Replace Main PCB.
8	The measured value of the 5-volt power supply is low.	1. Check power supply. 2. Replace Main PCB.
9	The measured value of the 5-volt power supply is high.	1. Check power supply. 2. Replace Main PCB.
A	The measured value of the isolated reference supply on the front end is low.	1. Check power supply. 2. Replace Main PCB.
B	The measured value of the isolated reference supply on the front end is high.	1. Check power supply. 2. Replace Main PCB.
D	A checksum error is detected on the NIBP region of Flash Memory.	Cycle power. If error persists, replace Main PCB.

Table 5-3: Serviceable Hardware Error Codes - (Continued)

Hex Code	Explanation	Recommended Action
E	A checksum error is detected on the power-up settings region of Flash memory.	1. Turn Power Off 2. Turn power back on while pressing both the Contrast and Volume buttons. See Section 4.3. 3. All user selections must be restored. 4. If error persists, replace Main PCB.
64	The SpO_2 module is sending an error messages to the host CPU.	Cycle power. If problem persists, replace Main PCB.
65	The SpO_2 module is not communicating with the host CPU.	Cycle power. See Section 5.7. If problem persists, replace main PCB.

5.6.2.2 Other Error Codes

If an error code occurs that is not listed in Section 5.6.2.1, take the following actions:

1. Turn the monitor off, then on again.
2. If the error code still appears, take the monitor out of service and contact Nellcor Puritan Bennett Technical Services or your local Nellcor Puritan Bennett representative for advice on remedial action.
3. If the monitor powers up and the error code does not recur, enter the Diagnostic Mode and invoke the Error Code screen. Examine the record of the last 10 error codes and determine if the same error code occurred previously.
4. If the Error Code screen indicates that the same error has occurred previously, take the monitor out of service and contact Nellcor Puritan Bennett Technical Services or your local Nellcor Puritan Bennett representative for advice on remedial action.
5. If the Error Code screen indicates no previous occurrences of this error, the monitor may be returned to service.

As a reference, Table 5-4 lists the general categories for other error codes. The error code categories are shown only in hexadecimal format.

Table 5-4: Error Code Categories

Code (hex)	Explanation
500xxxx	internal user interface error
501xxxx	remote serial port error
502xxxx	date and time error
503xxxx	NIBP error
504xxxx	front end error
505xxxx	alarm error
506xxxx	audio error
507xxxx	recorder error
508xxxx	trend error
509xxxx	flash memory data error
50axxxx	SpO_2 error
50bxxxx	ECG error
50cxxxx	power-down task error
50dxxxx	on-board diagnostic error
50exxxx	power monitor error
50fxxxx	temperature measurement error
510xxxx	internal user interface error
511xxxx	error handling error
513xxxx	serial driver error
514xxxx	system software errors

5.6.3 Buttons/Knobs

Table 5-5 lists recommended actions to address problems with the knob and front-panel buttons.

Table 5-5: Buttons/Knob Problems

Condition	Recommended Action
1. The NPB-3900 fails to power-up when the ON/STANDBY button is pressed.	Take steps as noted in section 5.6.1.
2. The NPB-3900 powers-up, but some/one of the other buttons does not respond.	1. Ensure that the keypad is plugged into the Main PCB. If the connection is good, change the keypad. 2. If the problem persists, change the Main PCB.
3. When the knob is rotated, no highlight appears on the display screen, and/or the monitor does not respond to knob presses.	1. Ensure that the encoder cable is plugged into the Main PCB. If the connection is good, change the encoder. 2. If the problem persists, replace the Main PCB.

5.6.4 Display/Audible Tones

Table 5-6 lists recommended actions to address problems with the display and audible tones.

Table 5-6: Display/Audible Tones Problems

Condition	Recommended Action
1. System powers-up and… • LCD screen is totally black or white. Or, • LCD screen is illuminated, but no data is visible. Or, • LCD screen has data, but is not illuminated.	1. Adjust the LCD screen contrast by pressing the contrast button momentarily, then turning the knob four revolutions in each direction. Turning the knob clockwise should brighten the screen; turning the knob counter-clockwise should darken the screen. 2. Ensure that the backlight cable is connected to the main PCB. 3. Ensure that the LCD connector is properly connected to the main PCB. 4. If problem persists, replace main PCB. 5. If problem persists, replace LCD assembly.

Table 5-6: Display/Audible Tones Problems - Continued

Condition	Recommended Action
2. NPB-3900 responds to button press, but key press tone fails to sound.	1. Ensure that the speaker cable is connected to the main PCB. 2. If the problem persists, replace the speaker assembly. 3. If the problem persists, replace the Main PCB.
3. Audible alarm does not sound.	1. Verify alarm volume setting in the Alarm/Limits menu, and test operation of the alarm tone by pressing the volume button while the alarm volume setting is displayed. 2. Ensure that the speaker cable is connected to the Main PCB. 3. If the problem persists, replace the speaker assembly. 4. If the problem persists, replace the Main PCB.

5.6.5 Operational Performance

Table 5-7 lists recommended actions to address problems related to operational performance.

Table 5-7: Operational Performance Problems

Condition	Recommended Action
1. The monitor appears to be operational, but the physiological values are suspect or nonexistent.	1. Replace each patient cable (or hose) with a known-good cable. 2. Ensure that the Patient Connector PCB is properly connected to the main PCB. Ensure that the hoses in the pneumatic system are properly connected, and that the NIBP pump motor is connected to the Rear Connector PCB. 3. If the problem persists, replace the Patient Connector PCB. 4. If the problem persists, replace Main PCB.

5.7 TROUBLESHOOTING THE OXIMETRY FUNCTION

5.7.1 Introduction

The oximetry functional hardware is embedded on the NBP-3900 main printed circuit board. (Note that “oximetry” and “SpO_2” are used interchangeably in this manual.) This section assumes that the NBP-3900 has been thoroughly checked and that all indications point to an oximetry malfunction.

5.7.2 Fault Evaluation

Table 5-8 provides fault indications and possible solutions.

Table 5-8: Fault Evaluation

Indication	Action
NPB-3900 gives error code 64 or 65, indicating communications problem w/ SpO2 module.	Check 5-volt digital power supply. Check processor clock Y1. Check TXD buffer U5.
NPB-3900 gives low-priority alarm, “SpO2 Cable/Sensor Disconnect”	Sensor may be disconnected or damaged. Patient Connector PCB may be defective.
NPB-3900 gives status message “SpO_2 Pulse Search”	The sensor may be improperly applied to the patient or may be damaged. Try another sensor. Try an SRC-2 pulse oximeter tester to check oximetry functionality. Cover the sensor to eliminate the possibility of ambient light interference. The patient’s perfusion may be too poor for the instrument to detect an acceptable pulse. Try using *C-Lock* ECG synchronization, if available. Check + and –5 volt analog power supplies. Check for proper LED drive function. Check the signal path from the photodetector input to the A:D converter.
Waveform output incorrect	Sensor or interconnecting cables may be damaged. Noise may be present.

5.7.3 Waveforms

Figures 5-1 through 5-5 are typical waveforms as measured at various test points (labeled TP) on the oximetry module. These waveforms are valuable in tracing signals and locating faults. The user must use a *Nellcor Puritan Bennett* SRC-2 pulse oximeter tester. Contact Nellcor Puritan Bennett's Technical Services Department or your local Nellcor Puritan Bennett representative if you have difficulty replicating these waveform examples.

5.7.3.1 Preamplifier and PGA Outputs Waveform

5.7.3.1.1 SRC-2 Settings

Rate:	112
Light:	High2
Modulation:	LOW
RCAL/MODE:	RCAL 63/LOCAL

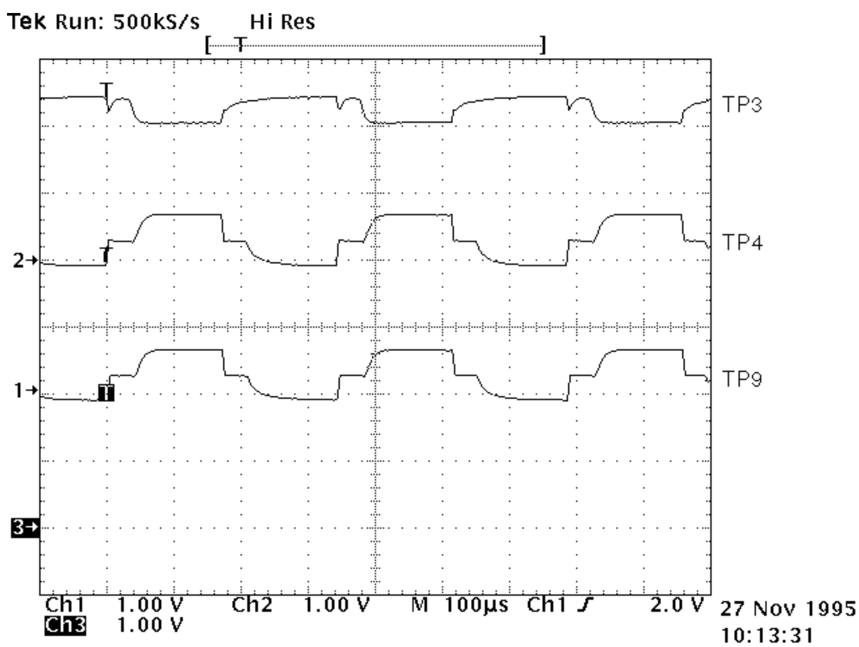


Figure 5-1: Preamplifier and PGA Outputs

5.7.3.1.2 Trace Descriptions

CHNL 2 :	TP3 Primary Input Preamplifier
CHNL 1 :	TP4 Secondary Input Preamplifier
CHNL 3 :	TP9 PGA output

5.7.3.2 Filter Outputs and ADC Input Waveform

5.7.3.2.1 SRC-2 Settings

Rate:	112
Light:	High2
Modulation:	HIGH
RCAL/MODE:	RCAL 63/LOCAL

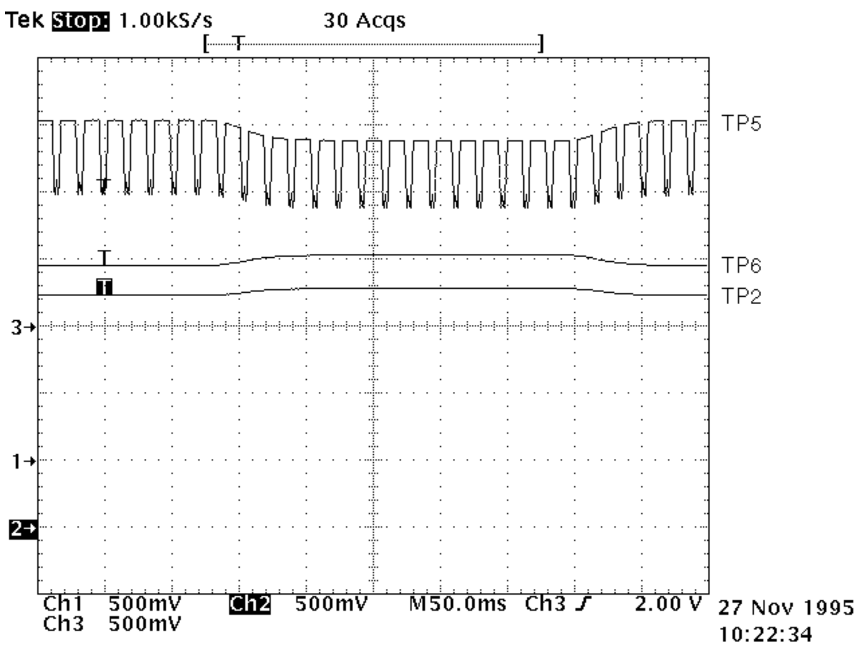


Figure 5-2: Filter Outputs and ADC Input

5.7.3.2.2 Trace Descriptions

CHNL 3 :	**TP5 ADC Input**
CHNL 1 :	**TP6 Red Filter Output**
CHNL 2 :	**TP2 IR Filter Output**

5.7.3.3 SpO2 Module with an SRC-2 Waveform

5.7.3.3.1 SRC-2 Settings

Rate:	112
Light:	High2
Modulation:	HIGH
RCAL/MODE:	RCAL 63/LOCAL

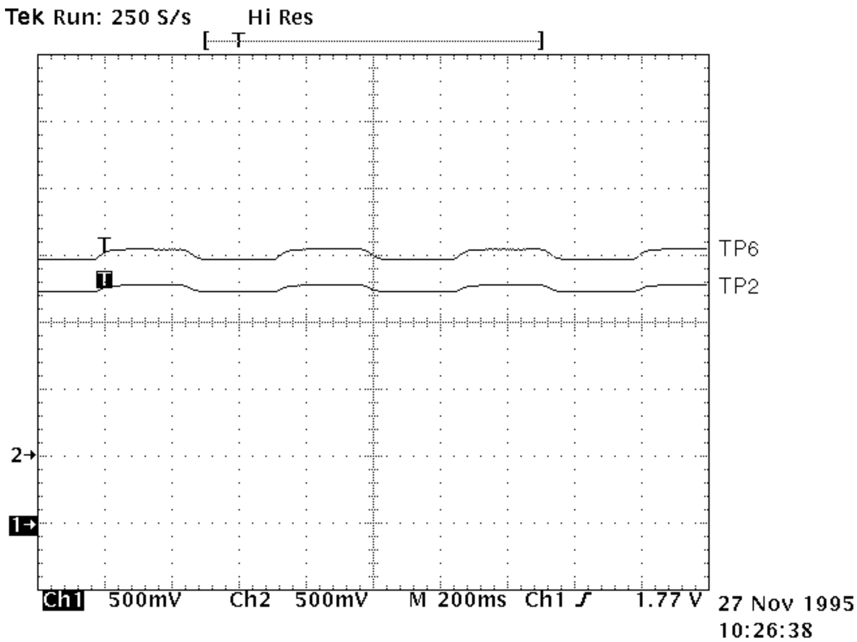


Figure 5-3: SpO2 Module with an SRC-2

5.7.3.3.2 Trace Descriptions

CHNL 2 :	TP6 Red Filter Output
CHNL 1 :	TP2 IR Filter Output

5.7.3.4 SpO2 Module with an SCR-2 LED Drive Current Test at TP7 Waveform

5.7.3.4.1 SRC-2 Settings

Rate:	112
Light:	High2
Modulation:	HIGH
RCAL/MODE:	RCAL 63/LOCAL

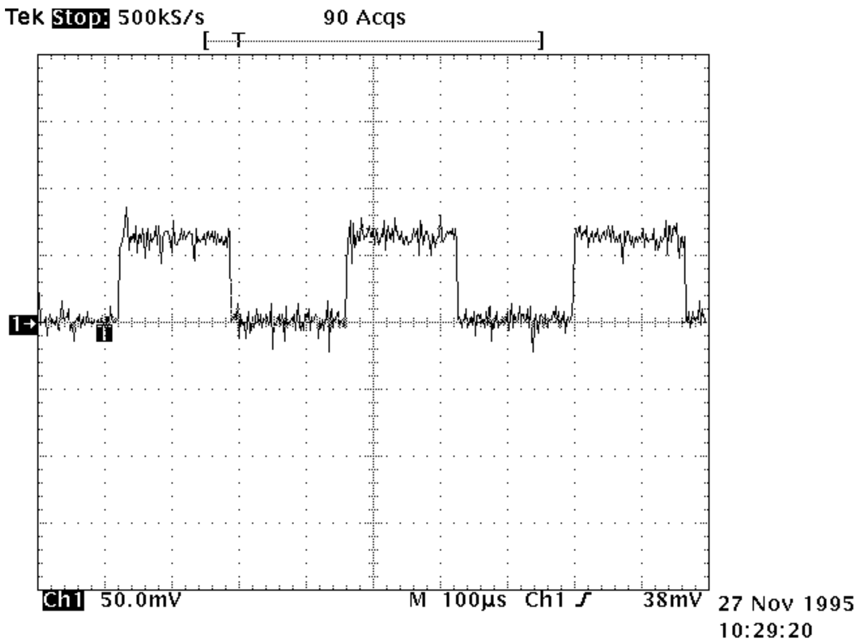


Figure 5-4: SpO2 Module with SRC-2 Drive Current Test at TP7

5.7.3.5 SpO2 Module with SCR-2 Waveform

5.7.3.5.1 SCR-2 Settings

Rate:	112
Light:	High2
Modulation:	HIGH
RCAL/MODE:	RCAL 63/LOCAL

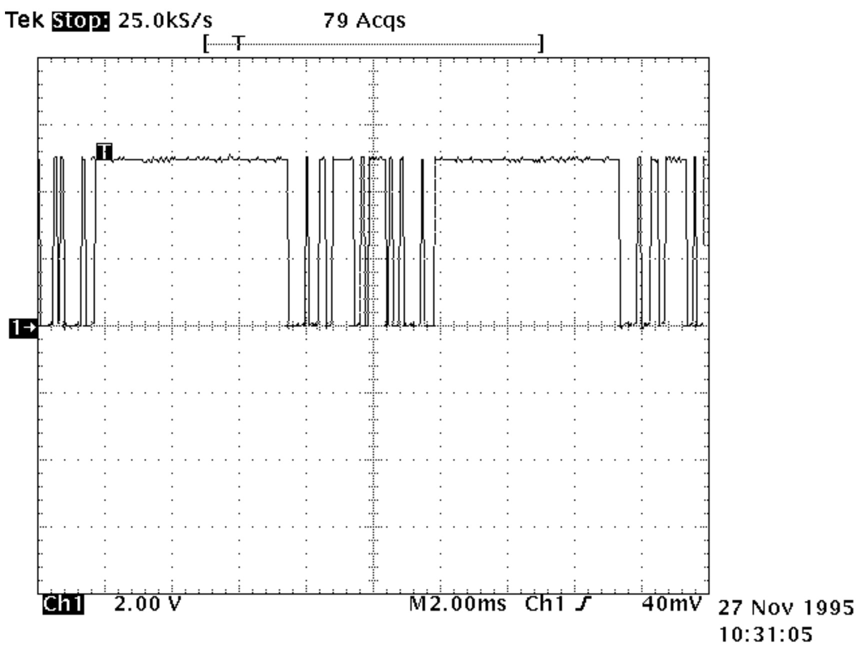


Figure 5-5: SpO2 Module with SRC-2

5.7.3.5.2 Trace Description

Serial Port TXD Signal, U4 Pin 25

5.8 P-3900 TROUBLESHOOTING GUIDE

Table 5-9 lists recommended actions to address printer problems.

Table 5-9: P-3900 Troubleshooting Guide

Condition	Recommended Action
1. With external power supply connected, the green EXTERNAL POWER indicator on the front panel is not lit.	1. Ensure that the external power supply input (PS-120V or PS-240V) is plugged into an operational AC outlet of the appropriate voltage and frequency. 2. Disconnect the power supply output cable from the printer. Measure the voltage across pins 1 and 4 of output connector. If the open circuit voltage does not measure approximately 17 ±3 V~ RMS, replace the power supply. 3. If the battery is severely discharged, the EXTERNAL POWER indicator may not light. Connect the external power supply to an AC outlet and to the printer. Allow the battery to charge for 30 minutes. 4. Open the printer enclosure and ensure that all connectors are properly seated. 5. If the problem persists, replace the battery. 6. If the problem persists, replace the Printer PCB. 7. The EXTERNAL POWER indicator is embedded in the Front Panel. If the problem persists, replace the Front Panel.

Table 5-9: P-3900 Troubleshooting Guide - (Continued)

Condition	Recommended Action
2. No printout occurs when control buttons are pressed on P-3900 front panel.	1. Open the printer paper door and verify that the printer is properly loaded with paper. 2. Ensure that the green LINKED indicator is lit. If not, first determine that the serial cable is properly connected between printer and NPB-3900 monitor. Next, on the NPB-3900 monitor, check the “Set-up Menu” and verify that “Communications Selection” is set to “Printer”. If the indicator is still not lit, replace the serial cable with a known-good cable. 3. Connect a known-good external power supply to an AC outlet and to the printer. If both the green front panel indicators are lit (EXTERNAL POWER and LINKED), then the printer should operate. If the EXTERNAL POWER indicator still fails to light, follow the steps outlined in Condition 1. 4. Open the printer enclosure and ensure that all connectors are properly seated. 5. If the problem persists, replace the Printer PCB. 6. If the problem persists, replace the printer mechanism.
3. Printer paper will advance, but paper remains blank when printing should be present.	1. Open the printer door and verify that paper is oriented correctly. The PAPER icon adjacent to the door release button illustrates proper orientation of the paper roll. (The paper is thermally sensitive on one side only; if the roll is installed backwards, printing will not occur.) 2. If the problem persists, replace the printer mechanism.

SECTION 6: DISASSEMBLY GUIDE

6.1 INTRODUCTION

WARNING: Performance Verification. Do not place the NPB-3900 into operation after repair or maintenance has been performed, until all Performance Tests and Safety Tests listed in Section 3 of this service manual have been performed. Failure to perform all tests could result in erroneous monitor readings.

The NPB-3900 can be disassembled down to all major component parts, including:

- PCBs
- battery
- cables
- function buttons
- chassis enclosures

The following tools are required:

- medium, Phillips-head screwdriver
- needle-nose pliers
- 9/16-inch socket (for knob encoder)

  3/16 inch socket (for rear-panel RS-232 connector).

WARNING: Before attempting to open or disassemble the NPB-3900, disconnect the power supply from the NPB-3900.

WARNING: High voltage is generated by the LCD backlight driver. Exercise caution when operating monitor with covers open.

Caution: Observe ESD (electrostatic discharge) precautions when working within the unit.

Caution: If internal battery cable has been disconnected, pay particular attention to polarity of the cable before reattaching. If battery cable polarity is reversed, it is likely that circuit damage will occur.

NOTE: Some spare parts have a business reply card attached. When you receive these spare parts, please fill out and return the card.

6.2 HOW TO USE THIS SECTION

The step-by-step procedures that are used to access replaceable parts of the NPB-3900 are illustrated in the Disassembly Flow Charts in paragraphs 6.3, Figures 6-1, 6-2, 6-3 and 6-4. As indicated in the flow charts, the monitor consists of two main assemblies, the Front Case Assembly, and Rear Case Assembly. The Main PCB assembly is separable from the front case assembly.

The circles on the flow charts contain reference designators that point to specific steps in the Disassembly Procedures. The Disassembly Procedures, paragraphs 6.4, 6.5, and 6.6 contain detailed disassembly instructions, accompanied by illustrations.

The rectangular boxes on the flow charts represent the various spare components or subassemblies. The digits appearing in these boxes are their respective part numbers. Section 7, *Spare Parts*, contains a complete listing of the available spare parts.

The Disassembly Flow Charts are organized so that minimum disassembly is required to remove and replace defective items.

Further important disassembly information may be found in the diagrams in the Appendix.

6.3 DISASSEMBLY FLOW CHARTS

The charts have been developed for use with all models of the NPB-3900 family. Therefore, some disassembly procedures will not be applicable to model configurations of less than the full complement of functions. In most cases, the relevant subassemblies will not have been installed, and it will be apparent that the pertinent procedures will not apply. However, when a temperature-measuring function is involved, a different hardware configuration of the rear-case assembly is shown in the flow chart.

The charts have been developed to provide service personnel with the most direct route to a replaceable item after a troubleshooting analysis has led to a probable cause, traced to hardware sources.

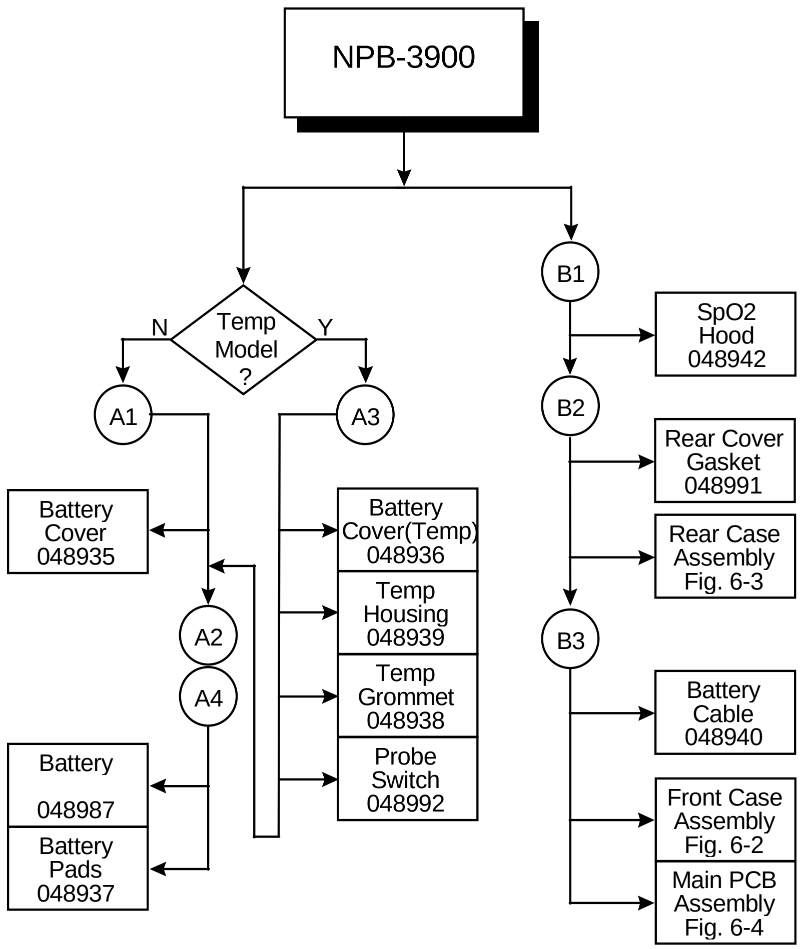


Figure 6-1: Top Level Disassembly Flow Chart

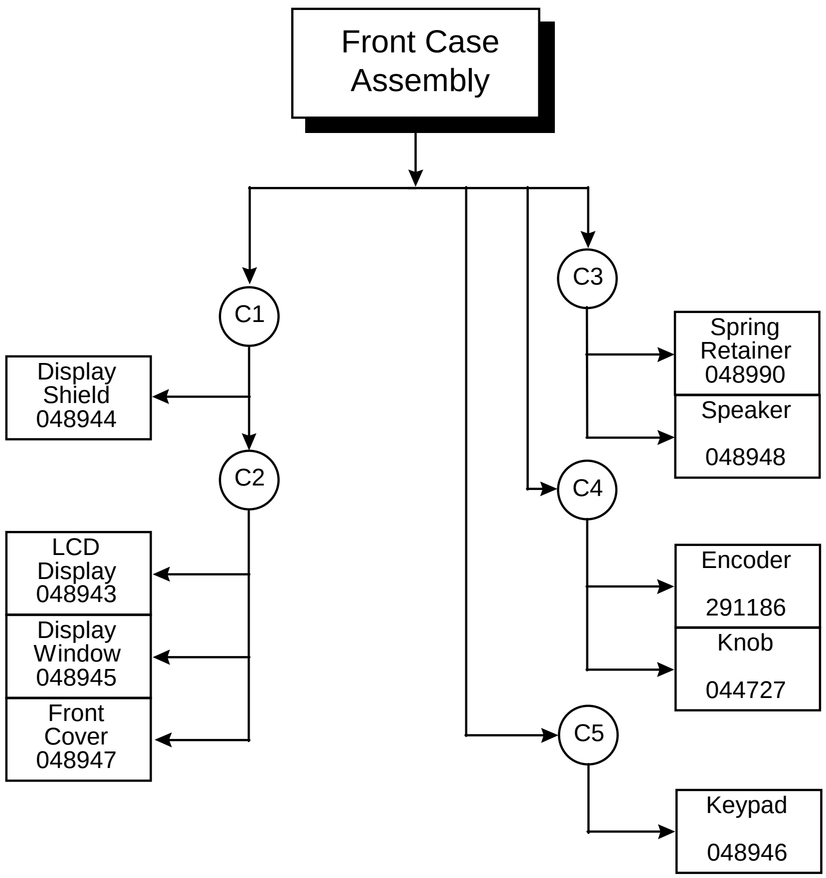


Figure 6-2: Front Case Disassembly Flow Chart

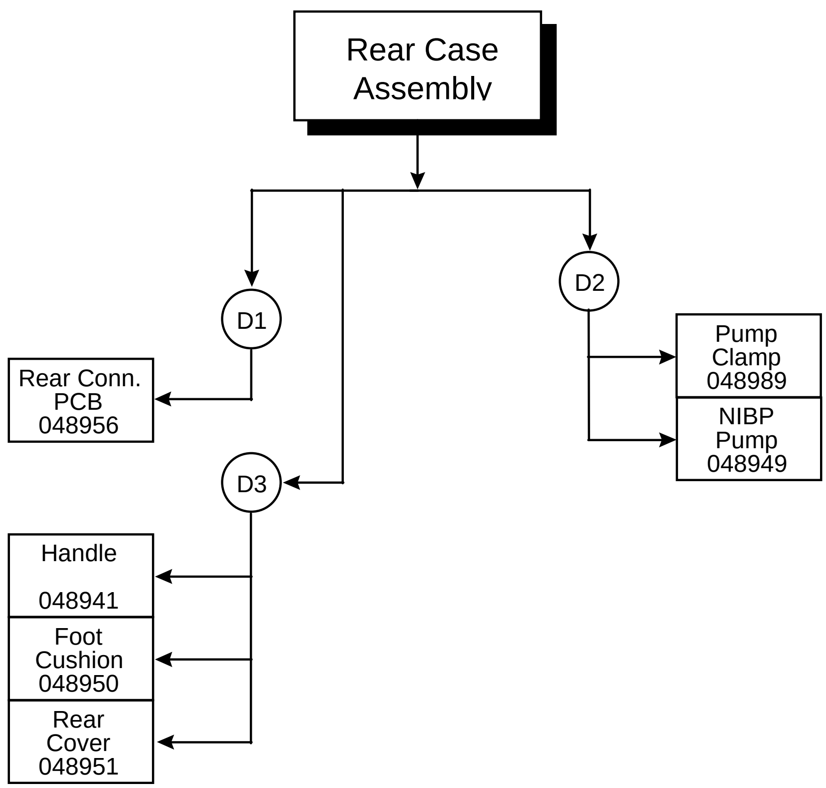


Figure 6-3: Rear Case Disassembly Flow Chart

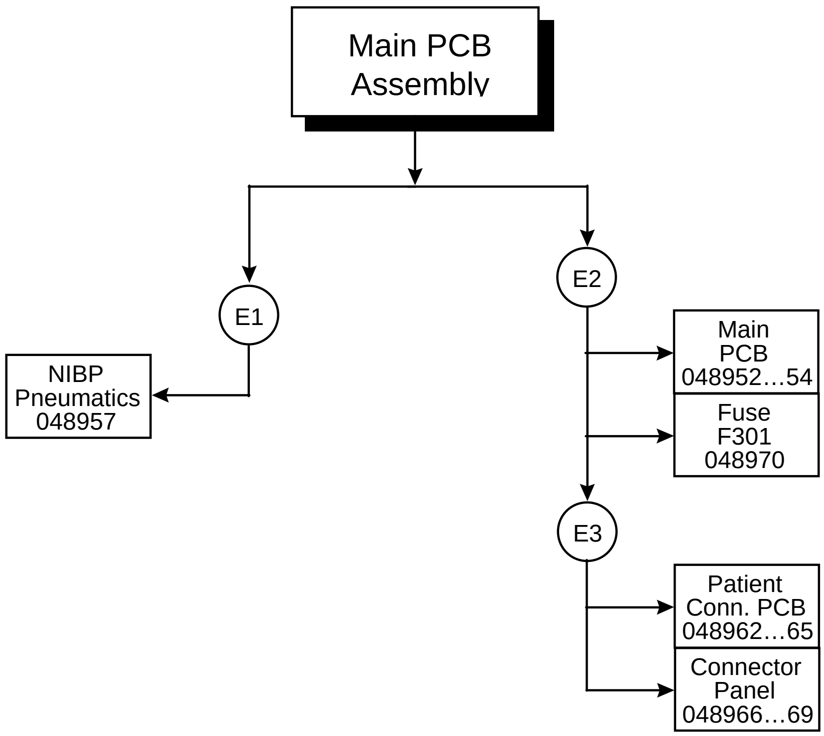


Figure 6-4: Main Board Disassembly Flow Chart

6.4 CLOSED CASE DISASSEMBLY

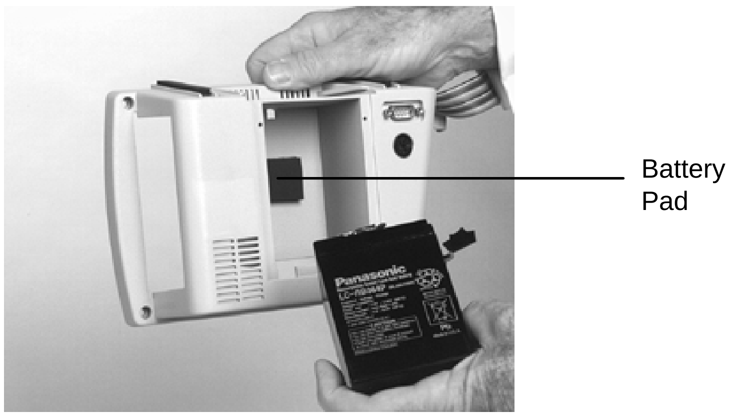
The paragraphs in this section describe and photographically illustrate procedures for disassembling the NPB-3900 to enable removal and replacement of suspected defective assemblies/components.

The sequence supports the guides in the previous paragraphs of this section.

The illustrations may also contain juxtaposed photographs of the relevant spares.

See Figure 6-1. If there is no apparent reason to replace the battery, begin with procedure **B1**. If the battery needs replacement, and there is no temperature module (Models 3910 and 3930), begin with procedure **A1**.

Step A1
Procedure
To remove the Battery from Models 3910 and 3930, when a Temperature module is not installed: Use a Phillips head screwdriver to remove the two screws fastening the battery cover to the rear case. Remove the battery cover.
Illustration



Step A2

Procedure

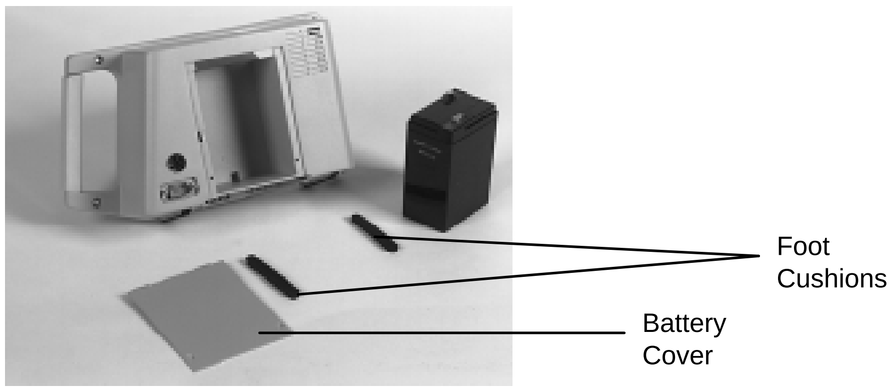
Disconnect the spade terminal connectors from the battery terminals.

Caution: Pay particular attention to polarity of the battery cable before reattaching. If battery cable polarity is reversed, it is likely that circuit damage will occur.

Remove battery.

As required, remove the battery cushions on the inside of the battery compartment and battery cover.

Illustration



Step A3

Procedure

To remove the battery from Models 3920 and 3940, when a temperature module is installed:

Illustration

Step A3
Procedure
Use a Phillips head screwdriver to remove the two screws fastening the temperature module housing to the rear case assembly.
Illustration

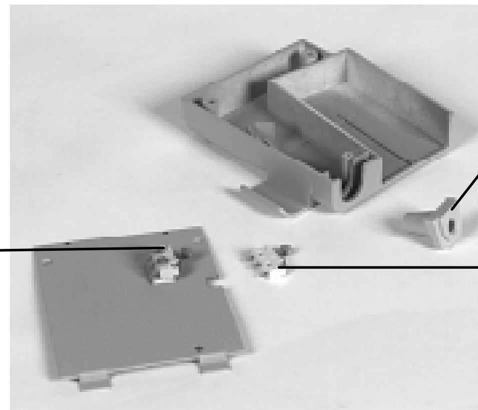

Step A3
Procedure
Remove the temperature module housing and the battery cover.
Illustration


Procedure

The probe sensor contact switch is mounted on the outer side of the battery cover.

As required, disconnect the leads from the probe switch to the rear panel connector. Remove the switch.

Illustration



Step A4

Procedure

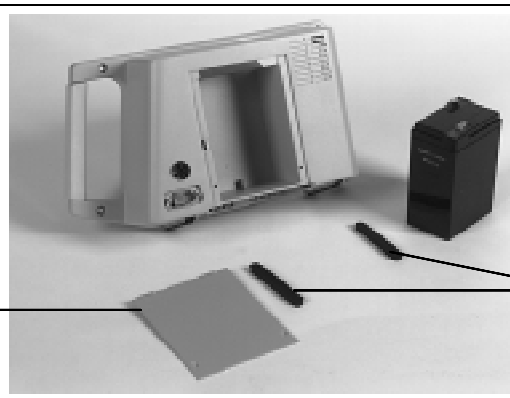
Disconnect the spade terminal connectors from the battery terminals.

Caution: Pay particular attention to polarity of the battery cable *before* reattaching. If battery cable polarity is reversed, it is likely that circuit damage will occur.

Remove battery.

As required, remove the battery cushions on the inside of the battery compartment and battery cover.

Illustration



Step B1

Procedure

To separate the Front and Rear Case Assemblies:

Remove the SpO2 connector hood by squeezing the sides to release the detents holding the hood in place.

Illustration

Step B2

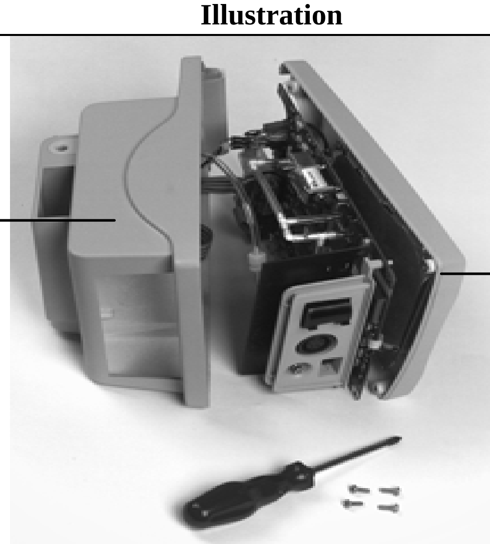
Procedure

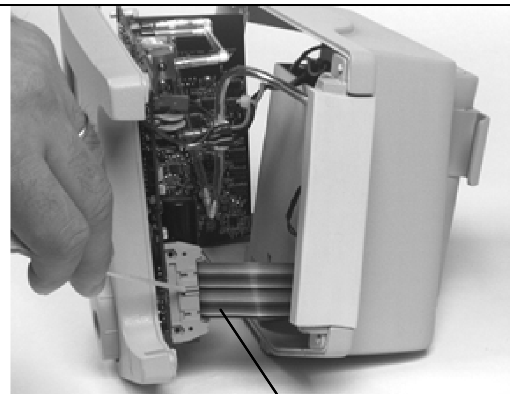
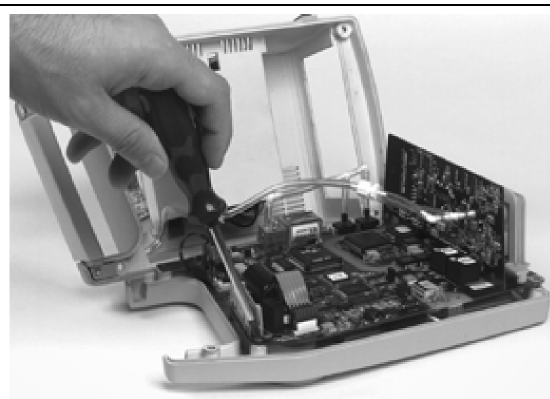
Use a Phillips head screwdriver to remove the four screws fastening the front to rear case assemblies.

Separate the main front and rear case assemblies.

If the rear cover gasket seal is to be replaced, remove it.

Illustration



Step B2
Procedure
Disconnect the ribbon cable and its connector from the PCB assembly.
Illustration
 Ribbon Cable and Connector
Procedure
To remove the Main PCB Assembly from the Front Case Assembly: Use a Phillips head screwdriver to remove screws holding the Main PCB Assembly in place in the Front Cover Assembly. *For reassembly, note the two guides in the cover and the corresponding two notches in the PCB.*
Illustration


Step B3

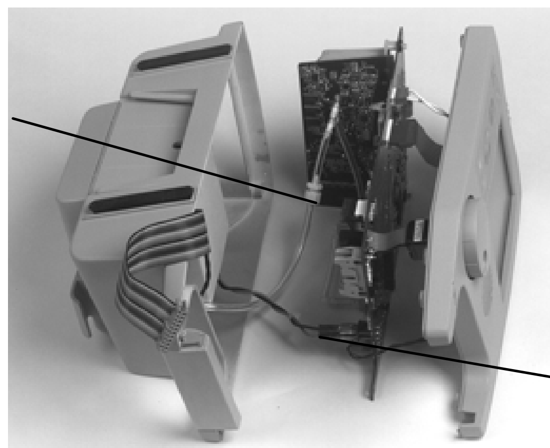
Procedure

Disconnect the remaining connectors at the Main PCB.

Disconnect the battery cable spade terminals from the main PCB assembly. If the battery cable is to be removed, the cable must also be disconnected from the battery, as described in Procedure A.

Caution: Pay particular attention to polarity of the battery cable *before* reattaching. If battery cable polarity is reversed, it is likely that circuit damage will occur.

Illustration



Step B3

Procedure

Unscrew the NIBP Luer connector. See Illustration in Step B2.

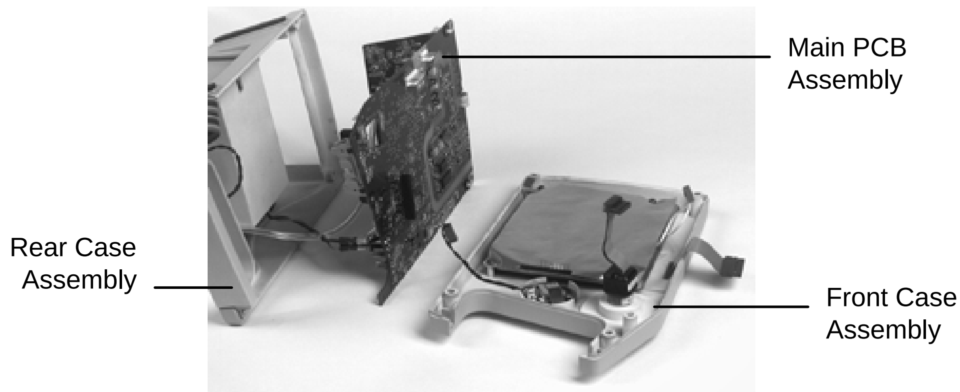
There are now three separate items:

Front Cover Assembly

Rear Case Assembly

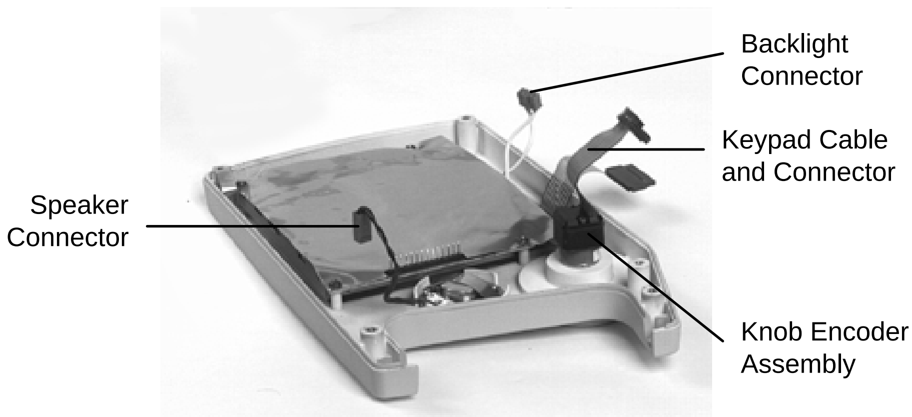
Main PCBPCB Assembly

Illustration

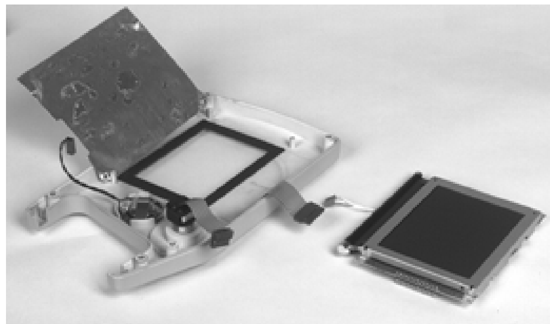


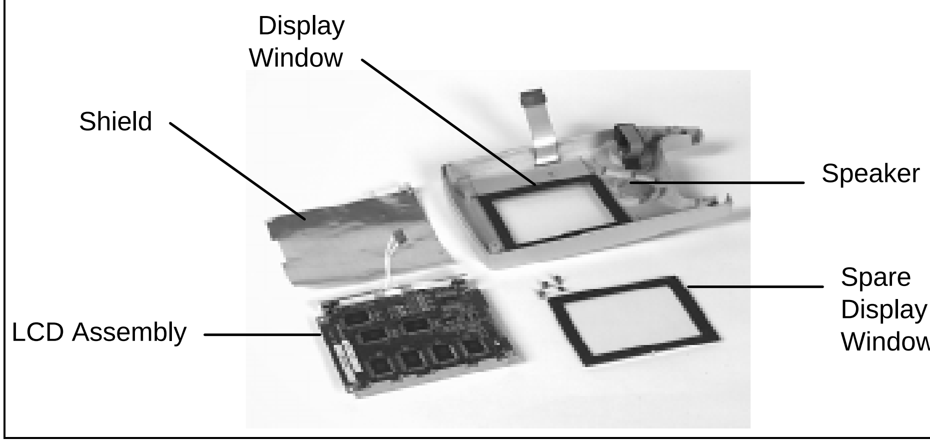
6.5 FRONT CASE DISASSEMBLY

See Figure 6-2.

Step C1
Procedure
To remove the Display: Use a Phillips head screwdriver to unfasten the four corner screws and remove the display shield.   The four screws also hold the LCD assembly in place.
Illustration


Step C2
Procedure
Remove the LCD Assembly, providing access to the Display Window. Remove Display Window by carefully prying up one corner, then peeling back.
Illustration





Step C3

Procedure

To remove the speaker:

Remove the retaining spring clip.

Remove the speaker.

Illustration

Step C4

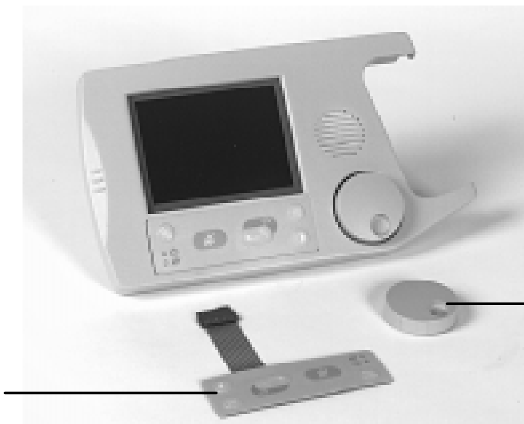
Procedure

To remove the NPB Knob and Encoder:

From the front, remove the knob by grasping the sides of the knob firmly and pulling straight back from the monitor. (The knob is friction fit on the stem of the encoder assembly.)

Use a 9/16” hex socket to unscrew the fastening nut on the outside of the front case. The encoder may now be pulled away from the front case.

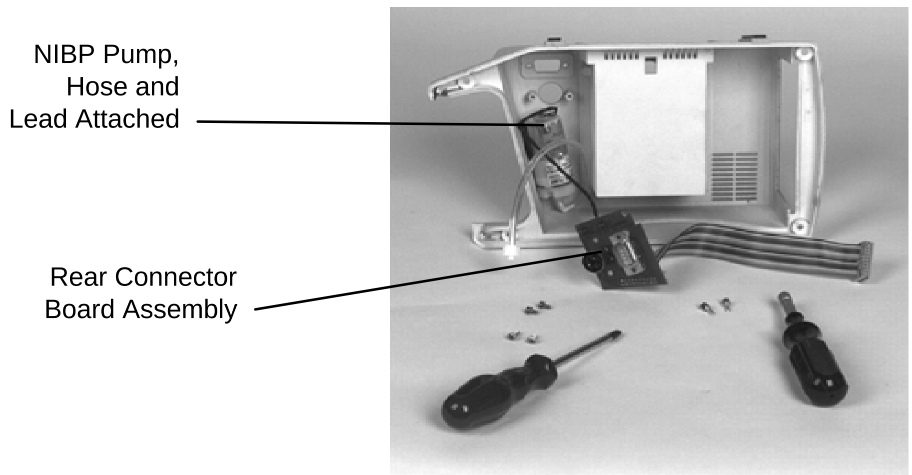
Illustration

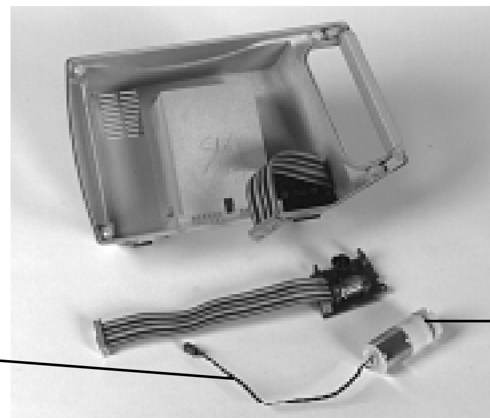
<table>
<tr><td>Step C5</td></tr>
<tr><td align="center">Procedure</td></tr>
<tr><td>To remove the Keypad
The keypad is attached with an adhesive to the front panel. From the front side of the panel, carefully pry up one corner of the keypad from the cover, and peel away from the cover.
Carefully, thread the cable out through the slot in the cover.</td></tr>
<tr><td align="center">Illustration</td></tr>
<tr><td>
</td></tr>
</table>

6.6 REAR CASE DISASSEMBLY

See Figure 6-3.

Step D1
Procedure
To remove a Rear Connector PCB: Use a Phillips head screwdriver to remove the two screws holding the Rear Connector PCB to the rear cover.   From outside the rear cover, use 3/16 socket driver to remove the two standoff fasteners of the RS-232 connector.   From inside the rear cover, remove the Rear Connector PCB Assembly.
Illustration



Step D2
Procedure
To remove NIBP Pump: Use Phillips head screwdriver to unfasten screw holding clamp to rear cover. Disconnect power lead from Rear Connector PCB. Remove Clamp and Pump.
Illustration

Step D3
Procedure
To remove Handle and Foot Cushions: Each end of the handle is friction-fit onto a cross-shaped boss. Use flat-bladed screwdriver to carefully pry one end of the handle. When the end of the handle has begun to loosen from the boss, use the same technique to begin to pry up the other end. Alternate prying action between each end of the handle until the handle is free of the rear case. Foot cushions are attached with an adhesive to the bottom surface of the rear cover, and can be removed by lifting one end of the foot and peeling off.

6.7 MAIN PCB DISASSEMBLY

See Figure 6-4.

Step E1

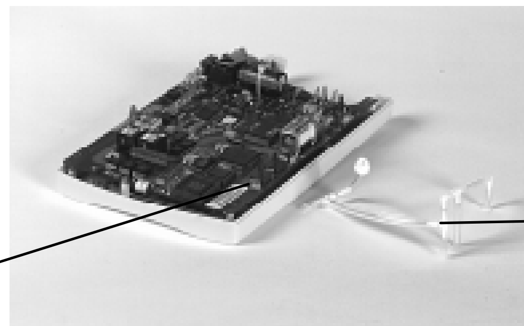
Procedure

To remove NIBP Pneumatic Assembly from the Main PCB Assembly:

Pull tubing from barbed fitting on rear of NIBP panel connector.

Pull tubing from fittings on the pressure sensors and valve.

Illustration



Step E2

Procedure

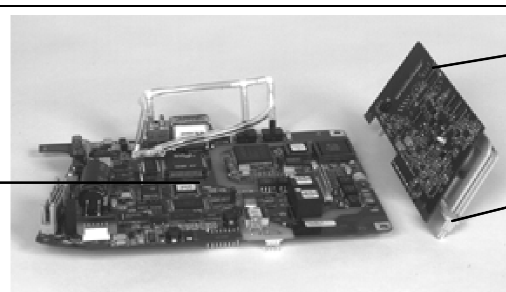
To separate the Patient Connector PCB Assembly from the Main PCB Assembly:

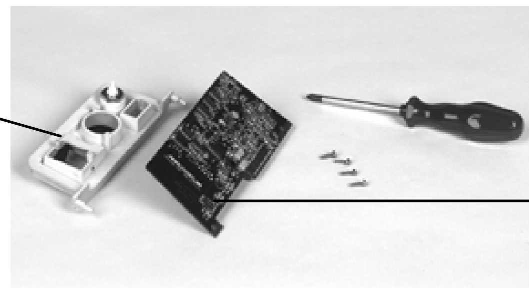
Use wire cutters to remove the two Tinnerman fasteners securing the Patient Connector PCB Assy to the underside of the Main PCB.

Disconnect the Patient Connector PCB Assy by pulling it straight up from the Main PCB.

The battery fuse F301, located near the battery cable connector on the Main PCB, may be replaced if necessary.

Illustration



Step E3
Procedure
To separate the Patient Connector PCB from the Connector Panel: Use Phillips head screwdriver to remove four screws fastening the two assemblies together. NOTE: Two of the screws are accessible on the face of the Connector PCB; two are accessible through access holes in the PCB.
Illustration


SECTION 7: SPARE PARTS

7.1 INTRODUCTION

Spare parts, along with part numbers, are listed in the tables that follow. “Item No.” corresponds to the callout numbers in Figures A 29 through A-31 that are found in the Appendix. The “Step Ref.” corresponds to the disassembly procedures described in Section 6.

7.2 TOP LEVEL ASSEMBLY

Table 7-1: Top Level Assembly

Item No.	Description	NPB Part No.	Step Ref.
1	Battery Cover (Models 3910, 3930)	048935	A1
2	Battery Cover (Models 3920, 3940)	048936	A3
3	Battery	048987	A2/A4
4	Battery Pads	048937	A2/A4
5	Temperature Module Housing	048939	A3
6	Temperature Probe Sensor Switch	048992	A3
7	Temperature Probe Grommet	048938	A3
8	SpO_2 Connector Hood	048942	B1
9	Rear Cover Gasket	048991	B2
10	Ribbon Cable and Connector	048934	B2
44	Battery Cable	048940	B3

7.3 FRONT CASE ASSEMBLY

Table 7-2: Front Case Assembly

Item No.	Description	NPB Part No.	Step Ref.
11	Front Cover Assembly (with Keypad and Display Window)	048947	C2
12	Display Shield	048944	C1
13	LCD Assembly	048943	C2
14	Display Window (with Gasket)	048945	C2
15	Speaker	048948	C3
16	Spring Retainer Clip and Pad	048990	C3
17	Knob	044727	C4
18	Encoder	291186	C4
19	Keypad	048946	C5

7.4 REAR CASE ASSEMBLY

Table 7-3: Rear Case Assembly

Item No.	Description	NPB Part No.	Step Ref.
20	Rear Connector PCB (with Ribbon Cable)	048956	D1
21	Pump Clamp	048989	D2
22	Pump Pad	048988	D2
23	NIBP Pump, Fitting, and Tubing	048949	D3
24	Rear Cover (Assembly) with Feet Cushions and Gasket	048951	D3
25	Foot Cushion	048950	D3
45	Handle	048941	D3

7.5 MAIN PCB ASSEMBLY

Table 7-4: Main Board Assembly

Item No.	Description	NPB Part No.	Step Ref.
26	Main PCB (Model 3910)	048952	E2
27	Main PCB (Model 3920/3940)	048953	E2
28	Main PCB (Model 3930)	048954	E2
30	NIBP Pneumatic (Assembly) with Tubing, and Fittings	048957	E1
31	Patient Connector PCB (Model 3910)	048962	E3
32	Patient Connector PCB (Model 3920	048963	E3
33	Patient Connector PCB (Model 3930)	048964	E3
34	Patient Connector PCB (Model 3940)	048965	E3
35	Fuse F301, 4A	048970	E2
40	Connector Panel (Model 3910)	048966	E3
41	Connector Panel (Model 3920)	048967	E3
42	Connector Panel (Model 3930)	048968	E3
43	Connector Panel (Model 3940)	048969	E3

Note: The Main PCB for all of the NPB-3900 models has jumpers which must be set correctly so that the User Interface software is configured to support the measuring parameters of each particular model . There are two jumpers, marked “JP101” and “JP102”, located immediately below the NIBP valve. Ensure that the jumpers are installed as noted in the table which follows:

Table 7-5: Main PCB Jumper Configuration

Model Number	JP101	JP102
NPB-3910	Installed	Installed
NPB-3920	Installed	Empty
NPB-3930	Empty	Installed
NPB-3940	Empty	Empty

7.6 P-3900 PRINTER

Spare parts, along with part numbers, are listed in the table that follows. "Item No." corresponds to the callout numbers in Figure A-32 found in the Appendix.

Table 7-5: P-3900 Printer

Item No.	Description	NPB Part No.	
1	Battery, 12 V Rechargeable	048972	
2	PCB Assembly	048971	
3	Chassis	048973	
4	Cover	048974	
5	Cable, Battery to PCB	048976	
6	Cable, Power Conn. to PCB	048977	
7	Panel, Front	048978	
8	AR-42 Printer Mechanism (complete)	048979	
9	Door Assembly	048980	
10	Switch, Membrane	048983	
11	Rubber Foot	891435	
12	Cable, RS-232	902202	

SECTION 8: PACKING FOR SHIPMENT

8.1 GENERAL INSTRUCTIONS

Pack the monitor carefully. Failure to follow the instructions in this section may result in loss or damage to the monitor. If the original shipping carton is not available, use another suitable carton. North American customers may call Nellcor Puritan Bennett Technical Services to obtain a shipping carton.

Prior to shipping the monitor, contact Nellcor Puritan Bennett's Technical Services Department or your local Nellcor Puritan Bennett representative for a returned goods authorization (RGA) number. Mark the shipping carton and any shipping documents with the RGA number. European customers not using RGA numbers, should return the product with a detailed, written description of the problem.

Return the monitor by any shipping method that provides proof of delivery.

To pack the monitor for return, disconnect all cables. It is not necessary to return sensors, patient cables, NIBP hose and cuff, temperature probe, or external power supply.

8.2 REPACKING IN ORIGINAL CARTON

If available, use the original carton and packing materials. Pack the monitor as follows:

1. Place the monitor in original packaging.
2. Place in shipping carton and seal carton with packaging tape.
3. Label carton with shipping address, return address and RGA number, if applicable.

8.3 REPACKING IN A DIFFERENT CARTON

If the original carton is not available, use the following procedure to pack the monitor:

1. Place the monitor in a plastic bag.
2. Locate a corrugated cardboard shipping carton with at least 200 pounds per square inch (psi) bursting strength.
3. Fill the bottom of the carton with at least 2 inches of packing material.
4. Place the bagged unit on the layer of packing material and fill the box completely with packing material.
5. Seal the carton with packing tape.

6. Label the carton with the shipping address, return address, and RGA number, if applicable.

SECTION 9: SPECIFICATIONS

9.1 GENERAL

Size:	
Width:	10.5” (26.7 cm)
Height:	6.2” (15.7 cm)
Depth:	3.7” (9.4 cm)
	4.6” (11.7 cm) with temperature module
Weight:	4.9 lb (2.2 kg) excluding accessories, options, cables
Display:	
Screen Type:	Liquid Crystal Display (LCD), Monochrome, Cold Cathode Fluorescent Backlit
Screen Size:	103 mm x 79 mm
Resolution:	320 x 240 pixels

9.2 SAFETY STANDARDS

IEC 601-1, UL 2601-1, CAN/CSA C22.2 601.1

Protection Class:	Class II, internally powered equipment, per IEC 601-1, clause 2.2.5
Degree of Protection:	Type CF: per IEC 601-1, clause 2.2.26
Mode of Operation:	Continuous

9.3 ELECTRICAL

Power Sources

Internal Battery:

Type:	6V, 4 Ampere Hours; Sealed, lead-acid
Battery Operating Time:	4 hours, typical, for a fully charged battery, at 25°C, one NIBP per 15 min.

External Power Supply:

PS-120V:	100 - 120VAC, 50 - 60 Hz, 0.15 A
PS-240V:	220 - 240VAC, 50 - 60 Hz, 0.8 A

9.4 ENVIRONMENTAL

Mechanical Shock:	IEC 68-2-27; 100 g; 6 msec; three axes; 18 total shocks; non-operating
Mechanical Vibration:	IEC 68-2-6; Sinusoidal; 10 - 58 Hz; 0.15 in. displacement 58 - 150 Hz; 2 g acceleration 4 min/sweep; 20 sweeps/axes, non-operating

Thermal:

Operating Temperature:	0 to 50°C
Storage Temperature:	-20 to 60°C

Humidity:

Operating:	5 to 95% RH, non-condensing
Storage:	5 to 95% RH, non-condensing
Water Resistance:	IEC 529 Classification IPX1 (Protected against vertically dripping water)
Altitude:	0 - 10,000 ft (0 - 3050 m)
Electromagnetic Compatibility	Radiated and conducted electromagnetic energy per CISPR 11, Class B

9.5 MEASURING PARAMETERS

9.5.1 ECG Measurement/Display

Heart Rate Range:	20 - 250 BPM
Heart Rate Accuracy:	±5 BPM

Bandwidth:

Normal Monitoring:	0.5 Hz to 40 Hz
Extended Low Frequency Response:	0.05 Hz to 40 Hz (user selectable)
Leads:	3 Lead (user selectable)
Display Sweep Speeds:	12.5, 25, and 50 mm/sec
Pacemaker Detection:	Indicator on waveform display (user selectable)
ECG Size (sensitivity):	0.5, 1, 2, 4 mV/cm
Lead Off Detection:	Detected and displayed
Input Impedance:	> 5 MΩ
CMMR (common mode rejection ratio):	> 90 dB at 50 Hz or 60 Hz
Input Dynamic Range:	±5 mV AC, ±300 mV DC
Defibrillator Discharge Recovery:	<5 sec per IEC 601-2-27 <8 sec per AAMI EC13-1992
Standards:	Meets the performance standards of ANSI/AAMI EC13-1992. Instead of a 1 mV standardizing voltage *(section 3.2.2.9)*, a fixed, 1 cm reference bar is always present in the ECG display, along with the ECG size setting expressed in mV/cm. The following information references particular sections of ANSI/AAMI EC13-1992.
Leads-off sensing waveform. *Section 3.1.2.1(b)*	Applied currents less than 0.25 microamps.
Tall T-wave rejection. *Section 3.1.2.1(c)*	T-wave of 0.6 mV amplitude will not affect heart rate determination.
Heart rate averaging *Section 3.1.2.1(d)*	Averages six of the most recent eight detected R-R intervals excluding the longest and shortest of the eight intervals.
Response to irregular rhythm. *Section 3.1.2.1(e)*	a) Ventricular bigeminy: the NPB-3900 counts both large and small QRS complexes to display a rate of 80 bpm.

	b) Slow alternating ventricular bigeminy: the NPB-3900 inconsistently counts the large T-wave following the first Q-wave and the smaller QRS complexes, Thus causing the rate to vary between 38 and 80. With slightly smaller T-wave, the rate was 30 bpm consistently. c) Rapid alternating ventricular bigeminy: the NPB-3900 generally counts only the first QRS complex of each pair to display a rate of 60 bpm, with infrequent counting of the second complex, resulting in a momentary increase to 70 bpm. d) Bi-directional systoles: the NPB-3900 counts both the positive and negative phases of the large complexes due to the long interval between them. It also counts the small complexes, for an averaged heart rate of 135 bpm, with variation between 127 and 157 bpm due to inconsistent counting.
Heart rate meter response time. *Section 3.1.2.1(f)*	a) Change from 80 to 120 BPM: 3 sec b) Change from 80 to 40 BPM: 7 sec
Time to alarm for tachycardia. *3.1.2.1(g)*	<u>Waveform 4(a)</u> <u>Amplitude</u> 0.5 mV 1mV 2mV <u>Waveform 4(b)</u> <u>Amplitude</u> 1 mV 2mV 4mV

Pacemaker pulse rejection without over/undershoot. *3.1.4.1*

a. For single (ventricular-only) pacemaker pulses alone, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 700 mV pulse-amplitudes, the NBP3900 correctly displays heart rate as zero bpm (Asystole).

b) For single (ventricular-only) pacemaker pulses with normally paced QRS-T, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 700 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of the QRS-T rhythm (60 bpm for the specified test waveform).

c) For single (ventricular-only) pacemaker pulses with ineffectively paced QRS pattern, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 700 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of the underlying QRS-T rhythm (30 bpm).

d) For atrial/ventricular pacemaker pulses alone, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 340 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of zero bpm (Asystole).

e) For atrial/ventricular pacemaker pulses with normally paced QRS-T, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 700 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of the QRS-T rhythm (60 bpm), except for the case of 2.0 ms width and -700 mV amplitude, which causes a displayed heart rate of 120 bpm.

f) For atrial/ventricular pacemaker pulses with ineffectively paced QRS pattern, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 340 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of the underlying QRS-T rhythm (30 bpm).

Pacemaker pulse rejection with over/undershoot. *3.1.4.2*

a) For single (ventricular-only) pacemaker pulses alone, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 120 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of zero bpm (Asystole), except for cases with 2.0ms width and ± 2mV amplitude and 25% over/undershoot (time constant t0 is 55 ms.) which cause a displayed heart rate of 60 bpm.

b) For single (ventricular-only) pacemaker pulses with normally paced QRS-T, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 700 mV pulse-amplitudes, the NBP-3900 correctly displays heart rate of the QRS-T rhythm (60 bpm), except for the case of 2.0 ms width and +700 mV amplitude, which causes a displayed heart rate of 120 bpm.

c) For single (ventricular-only) pacemaker pulses with ineffectively paced QRS pattern, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 120 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of the underlying QRS-T rhythm (30 bpm).

d) For atrial/ventricular pacemaker pulses alone, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 120 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of zero bpm (Asystole), except for cases with 2.0ms width and ± 2mV amplitude and 25% over/undershoot (time constant t0 is 55 ms.) which cause a displayed heart rate of 60 bpm.

e) For atrial/ventricular pacemaker pulses with normally paced QRS-T, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ± 700 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of the QRS-T rhythm (60 bpm for the specified test waveform).

f) For atrial/ventricular pacemaker pulses with ineffectively paced QRS pattern, with 0.1 and 2.0 ms. pulse-widths and ±2 mV and ±120 mV pulse-amplitudes, the NBP3900 correctly displays heart rate of the underlying QRS-T rhythm (30 bpm).

9.5.2 NIBP (Noninvasive Blood Pressure) Measurement/Display

Technique:	Oscillometric
Measurement Modes:	
Auto:	Automatic BP measurements at intervals of 1, 3, 5, 10, 15, 30, 60, and 90 minutes
Manual:	Single measurement initiated by Start/Stop button
STAT:	Series of consecutive measurements for 5 minutes
Cuff Pressure Display:	10 - 300 mmHg
Blood Pressure Measurement Range:	
Systolic:	60 to 250 mmHg
Mean Arterial Pressure:	30 to 235 mmHg
Diastolic:	20 to 220 mmHg
Pulse Rate Range:	40 to 200 BPM
Blood Pressure Accuracy:	Mean error and standard deviation per ANSI/AAMI SP10, 1992
Pulse Rate Accuracy:	Greater of ±2 BPM or ±2% of pulse rate value
Standards:	Meets performance standards of ANSI/AAMI SP10-1992

9.5.3 Temperature Measurement/Display

Technique:	Welch-Allyn *SureTemp*® Thermistor Probe
Range:	84°F to 108°F (28.9°C to 42.2°C)
Accuracy:	±0.2°F, (±0.1°C)
Measurement Time:	Oral - approximately 4 seconds Rectal - approximately 15 seconds

9.5.4 SpO_2 Measurement/Display

Range:

Pulse Rate:	20–250 BPM
% Saturation:	0–100%

Accuracy:

Pulse Rate:	±3 BPM
SpO_2:	70–100%: ±2 digits 0–69% Unspecified

Accuracies are expressed as plus or minus “X” digits (saturation percentage points) between saturations of 70-100%. This variation equals plus or minus one standard deviation (1SD), which encompasses 68% of the population. All accuracy specifications are based on testing the subject monitor on healthy adult volunteers in induced hypoxia studies across the specified range. Adult accuracy is determined with *Oxisensor II* D-25 sensors. Accuracy for neonatal readings is determined with *Oxisensor II* N-25 sensors. In addition, the neonatal accuracy specification is adjusted to take into account the theoretical effects of fetal hemoglobin in neonatal blood on oximetry measurements.

Pulse Rate (optically derived) 20–250 bpm ±3 bpm

Accuracies are expressed as plus or minus “X” bpm across the display range. This variation equals plus or minus 1 Standard Deviation, which encompasses 68% of the population.

9.6 TRENDS

Type:	Tabular
Memory Storage:	12 hours, nonvolatile
Data interval:	20 seconds: (Stored data point is the average over 20-second interval)
Tabular Format:	One table for all variables Six fields per row (time and 5 vital signs)
Display interval:	Per NIBP measurement, or 15 minutes for no NIBP, or 20 seconds during alarm condition.

9.7 P-3900 PRINTER (OPTIONAL)

Type:	Thermal
Size:	6.7” x 3.8” x 5.0” (17.0cm x 9.7cm x 12.7cm)
Weight:	3.8 lb (1.5 kg)
Paper Width	50 mm
Print Speed:	25 mm/s

POWER SOURCES

Internal Battery

Type:	Sealed, lead-acid, 12V, 1.2 amp/hr
Battery Operating Time:	3 hours, typical, at 25^{o}C (fifteen 20-second printouts per hour)

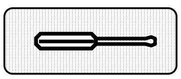
External Power Supply

PS-120V	100 - 120V, 50 - 60Hz, 0.15A
PS-240V	220 - 240V. 50 - 60 Hz, 0.8A

SECTION 10: RS-232 INTERFACE

10.1 SERIAL INTERFACE CONNECTION

The 9-pin connector mounted on the rear panel provides an access port for a serial (RS-232) interface to the P-3900 Printer, or to a suitably configured personal computer. Alternatively, qualified service personnel can use the connector to send a Nurse Call signal.



NOTE: The “Communications Selection” item in monitor’s “Set-up Menu” must be set to “Printer” if the P-3900 is to be used; or, must be set to “Trend Xfer” if trend data is to be exported to a personal computer. (Set-up Menu is opened by selecting the screwdriver icon found along the bottom of the display.)

Table 10-1: RS-232 Serial Interface Connections

Pin #	Signal	Direction
1	not used	
2	Rx data	<<<<
3	Tx data	>>>>
4	DTR	>>>>
5	Signal Ground	<<>>
6	DSR	<<<<
7	RTS	>>>>
8	CTS	<<<<
9	Alarm Out	>>>>

10.2 NURSE CALL

Pin 9 of the RS-232 serial interface connector provides an “Alarm Out” signal. Any time there is an alarm condition active in the NPB-3900, pin 9 will go to plus RS-232 level voltage (> +5 VDC), ***if*** “Nurse Call Signal” is set to ON in the Set-up Menu. Any time there is no active alarm condition, pin 9 will be at minus RS-232 level voltage (< -5 VDC). If in the Set-up Menu “Nurse Call Signal” is set to OFF, pin 9 will always be at the minus RS-232 level voltage. In order to make use of the Alarm Out signal, pin 9 should be connected to a high-impedance circuit (> 1000Ω) and protected against transient voltages.

10.3 EXPORTING TREND DATA

In order to download trend data from the NPB-3900, communication software, such as PROCOMM™, should be installed in the external computer. The transfer protocol should be set as follows:

Baud Rate:	19,200
Data Bits:	8
Start Bit:	1
Stop Bits:	1
Parity:	None

Connect the NPB-3900 to the serial port of the computer using a null modem cable. Start the communication program on the computer and enter terminal emulation mode. To initiate the transfer, type tr (lower case is necessary), followed by a carriage return <cr>.

If the command is not accepted, the response to an invalid command is ??, followed by a carriage return <cr>.

In response to a valid command, the NPB-3900 will send a comma-delimited ASCII text file comprising the entire contents of the NPB-3900's trend memory. Each line is divided into five main groups, separated by a space <sp> and ending with a carriage return <cr> and line feed <lf>. The format for each line is:

RECORD<sp>DATE<sp>TIME<sp>ALARMS<sp>VITALS<cr><lf>

The fields within each group are identified and defined as follows:

RECORD:

record number,

Format:

2 characters
no leading zero suppression
right justified

DATE:

day, month, year,

Format:

day and month: 2 characters
year: 4 characters
no leading zero suppression
right justified

TIME:

hours, minutes, seconds,

Format:

2 characters
no leading zero suppression
right justified

ALARMS:

heart rate alarm, SpO2 alarm, (respiration rate alarm), systolic pressure alarm, diastolic pressure alarm, mean arterial pressure alarm, (temperature alarm),

Each field in this group is either:

0: corresponding vital sign was not in alarm state

or,

1: corresponding vital sign was in alarm state

NOTE: In order to maintain a consistent trend data format between the NPB-3900 and NPB-4000 patient monitors, the NPB-3900 maintains a field for “respiration rate alarm” and “temperature alarm”, even though the NPB-3900 does not have an alarm for respiration rate or temperature. For the NPB-3900, the fields for “respiration rate alarm” and “temperature alarm” will always have a value of “0”.

VITALS:

heart rate, SpO2, (respiration rate), systolic pressure, diastolic pressure, mean arterial pressure, temperature,

Field Name	**Units**	**Format**
heart rate	1/min	4 characters; leading zeroes suppressed; right justified
SpO2	%	4 characters; leading zeroes suppressed; right justified
respiration rate	-	value will always be “0”; right justified
systolic pressure	mmHg	4 characters; leading zeroes suppressed; right justified
diastolic pressure	mmHg	4 characters; leading zeroes suppressed; right justified
mean arterial pressure	mmHg	4 characters; leading zeroes suppressed; right justified
temperature	degrees C (no degrees F)	4 characters, including decimal point; leading zero not suppressed; right justified

NOTE: In order to maintain a consistent trend data format between the NPB-3900 and NPB-4000 patient monitors, the NPB-3900 maintains a field for “respiration rate”, even though the NPB-3900 does not measure respiration rate. For the NPB-3900, the field for “respiration rate” will always have a value of “0”.

If no vital sign was measured during a 20-second trend interval, characters in the corresponding field will be blank (<sp><sp><sp><sp>,). If the vital sign displayed dashes during a 20-second trend interval, characters in the corresponding field will contain dashes (----,).

Example of several lines of a trend file:

```
01, 04,02,1998, 08,37,22, 0,0,0,0,0,0,0,  72,  96,   0, 140,  90, 106,37.8,

01, 04,02,1998, 08,37,02, 0,1,0,0,0,0,0,  69,  82,   0,    ,    ,    ,38.0,

02, 04,01,1998, 22,43,05, 0,0,0,0,0,0,0, 103,----,   0,    ,    ,    ,38.2,

02, 04,01,1998, 22,42,45, 0,0,0,0,0,0,0, 103,----,   0, 127,  73,  95,38.1,
```

APPENDIX - TECHNICAL SUPPLEMENT

A-1 GENERAL

This section contains descriptions of the principles of operation of the major functional modules of the monitor, including the overall block diagram, power supply, isolated front end, NIBP control, the SpO_2 processing module, and microcontroller.

A-2 BLOCK DIAGRAM

The Monitor (see Figure A-1) contains an isolated front-end section, powered by an isolated power supply, and in which the signals from SpO_2, temperature, and ECG sensors are processed. The plastic tubing provides sufficient isolation for signals from the cuff in NIBP monitoring.

A single A/D converter is used to digitize processed temperature, NIBP, and ECG inputs; the SpO_2 module produces digitized data.

A microcontroller, Intel 386, requests and receives instructions from a flash memory. The processor has a 16-bit data bus, and uses 19 of the 24-bit address bus. These, and eight control signals, are used to read and write to the DRAM, flash memory, UART, and FPGA (programmable gate array). Other interface connections are made through the I/O port signals, timer signals, and interrupt signals.

The FPGA provides signals for control and data to the LCD. Bias voltage and backlight power for the LCD are provided by the power supply section. The FPGA processes front-panel button and Nellcor Puritan Bennett knob operations.

Circuit details for these blocks are contained in this section, of the manual. This section provides a brief theory of operation of the circuits noted in the block diagram. Portions of the schematic diagrams are reproduced for some paragraphs.

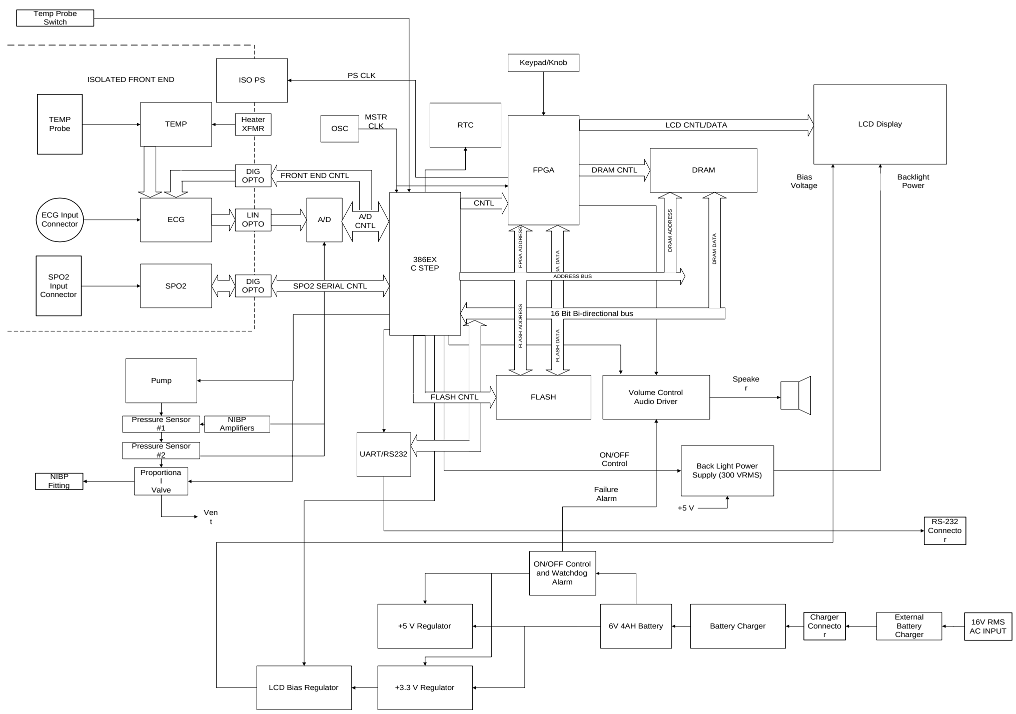


Figure A-1: NPB-3900 Block Diagram

A-3 ISOLATED PATIENT CONNECTION SECTION

A-3.1 General

The connections to the patient consist of:

ECG (three directly connected leads)
Temperature (probe)
SpO2 (DS-100A sensor, etc.)
NIBP (pneumatic cuff)

The NIBP section is isolated by virtue of the plastic tubing used to connect to the patient blood pressure cuff. The ECG, Temp, and SpO_2 sections are isolated by a floating power supply, digital optocouplers, and linear optocouplers.

A-3.2 Isolated Power Supply

The patient connection electronics are powered by an isolated power supply. A full bridge drives transformer T201 with a 100 kHz drive. EMI reducing components serve to limit the sharp rising and falling edges of the waveform. Rectifiers D10 and D11 with linear regulators U5 and U6 create ±5 VDC for the floating circuits. LC filters are used to reduce ripple. D3 and D4 provide ±5.5 VDC for U72 to improve the output swing.

A-3.3 Digital Transfers

Two digital optocouplers, U200 and U201, are used to transfer data and clock signals to the isolated front end. Serial shift register U66 receives the serial data, which is loaded into the register outputs when one shot U4 times out at the end of the clock burst. The eight bits thus loaded are:

MUX A,B,C	The analog MUX channel (1 of 8) selector
LSEL 1,2	The ECG lead selector (3 valid combinations)
0.5 HZ	Low freq. ECG cutoff selector
ECGRES	ECG quick baseline reset
Parity	As required to force ODD parity

Parity is forced by the host to ODD for each digital transfer. If EVEN parity is sensed, the analog channel will be forced to plus full scale. The digital signal PARCHK is high for EVEN parity and S3.5 thus forces PARSIG high, making the analog output high. The listing of channels in section 0 indicates those which may be used to judge a parity problem.

A-3.4 Linear Optical Coupler

The ECG and temperature measurements are transmitted from the floating section via a linear optical coupler (U202). The coupler has an LED and two matched photodiodes. One photodiode is used in a servo loop to control LED illumination. The second photodiode controls the output voltage on the other side of the isolation barrier. The two photodiodes are matched to produce a very linear result. The coupler has a raw gain of 1.000 with a tolerance of +17.5% to -23.1%. All analog signals measured from the isolated front end are corrected for gain and offset errors by reading the ground and precision reference located within the isolated section.

A-3.5 Analog Multiplexer

The analog signals from the floating section are selected by a multiplexer (U67). The multiplexer selection is chosen by the digital byte loaded via the digital optocouplers. The eight available channels and their use as a parity check are shown in the following table.

Signal Name	Description	Parity Error Indication
ECG	ECG signal	N/A
TPROBE	Temperature Probe Code	>4 volts
PACEM	Digital Pacemaker Pulse	>4 volts
TEMP1	1st half of temperature range	N/A
TEMP2	2nd half of temperature range	N/A
LEG	LEG drive signal	N/A
+V4.096	Precision Reference	N/A
AGND	Analog Ground	>4 volts

The table shows that three channels can be used for parity checking, the other channels may go to the positive limit during normal operation.

A-3.6 Voltage Reference and Ground

The system uses two measurements to establish the offset and gain of all signals measured via the linear optical coupler. The measurements of ground (to establish offset) and a precision (U82) +4.096 volt reference (to establish gain) determine correction coefficients used to correct all signals transferred across the isolation barrier.

A-4 TEMPERATURE MEASUREMENT CIRCUIT

A-4.1 General

Patient temperature is measured using a thermistor probe. To speed up oral temperature measurements, the system controls a warmer in the probe tip and applies a predictive algorithm to the measurement process. The warmer is controlled to raise the probe temperature to 93 °F (typically) before the probe is used by the patient. Typical oral temperature measurement time is 4 seconds.

The probe warmer (a 30-ohm resistor in the probe assembly) is driven by a 100 kHz waveform through an isolation transformer (T202). The RMS value of this waveform is about 3 volts, providing 100 ma RMS through the probe warmer. The waveform is duty-cycle modulated under system software control to regulate the probe temperature.

A-4.2 Temperature Probe

The temperature sensor is an accurate thermistor in the probe whose resistance varies with temperature. The temperature circuit applies a constant voltage (0.4551 volts) to the thermistor at all times. The current through the thermistor varies with temperature based on its resistance value.

The temperatures (including ambient and over temperature) to be measured by the NPB-3900 range from 16°C to 44.5°C (60.7 °F to 112.1 °F).

Resistance	Temperature C	Temperature F	Probe Current (μA)
20,000	25.00	77.00	22.76
8,900	44.53	112.16	51.13
13,742	33.78	92.80	33.12
30,100	15.93	60.67	15.12

The chart shows the probe resistance and corresponding current at room temperature, the high and low extremes, and the resistance (13,742 ohms) for the center current of the designated range.

A-4.3 Temperature Measurement Circuit

See Figure A-2. The first stage of the circuit is designed to produce an output signal (TEMP1, from U72A) that spans the voltage range of +4 to -4 volts as the thermistor covers the full temperature range. The output voltage is highest (+4) at 112 °F, reaches zero at 93 °F, and goes to -4V at 60 °F. The second stage signal (TEMP2, from U72B) is a simple analog inverter.

The A/D conversion system reads the result from the first stage (TEMP1) while its output is positive, otherwise the result is read from the second stage (TEMP2). The conversion circuit can read slightly negative voltages, so both stages are active near zero. This arrangement is made so that maximum resolution can be obtained over the required temperature range.

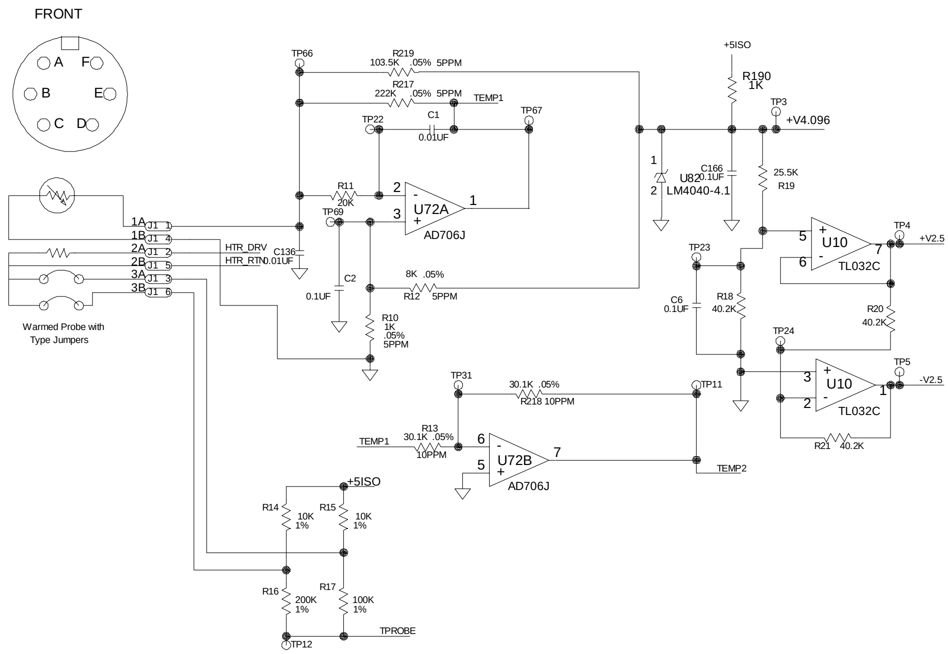


Figure A-2: Temperature Measurement Circuit

Data from the probe manufacturer indicates that the relationship between probe resistance and temperature is:

$$Temp(Kelvin) = \frac{1}{\left(Ra + Rb\ln(Rt) + Rc(\ln(Rt))^3\right)}$$

Where:

Rt = probe resistance in ohms

Ra = 9.69872E-4

Rb = 2.3283E-4

Rc= 8.062E-8

The probe resistance is measured by interpreting the TEMP1 and TEMP 2 voltages from the temperature circuit. The precise probe resistance is determined from the TEMP1 voltage by this formula:

$$R_{PROBE} = \frac{24666.6}{\frac{V_{TEMP1}}{V_{REF}} + 1.79549}$$

If the TEMP1 voltage is zero or negative, substitute -TEMP2 voltage for TEMP1 in the equation above.

The voltages from the temperature circuit should be corrected for gain and offset using the isolated ground and reference measurements. V_{REF} would be assigned a value of 4.096.

A-4.4 Temperature Probe Keying

The temperature probe has jumper keys that are used to code the various probes used with the system. Two pins of the probe's connector (J1) are open or shorted to ground to indicate the coding. A simple DAC is made using resistors to create a voltage indicative of the coding arrangement.

Pin 3A	Pin 3B	Code	Voltage (±0.5 volts)
Open	Open	No Probe	3 V
Open	Shorted	Cal Key	2 V
Shorted	Open	Rectal Probe	1 V
Shorted	Shorted	Oral-Axillary Probe	Zero

A-5 ECG INPUTS

A-5.1 General

The ECG section uses three-lead patient connection methodology. The input signal comes from two leads, while the third lead is driven to minimize common mode voltages. The three leads are called RA (right arm), LA (left arm) and LL (left leg). The user can choose from three input lead selections so the signal can come from RA-LA, RA-LL, or LA-LL.

A-5.2 Input ECG Lead Protection

The three input leads are protected from defibrillator pulses, static electricity, and other interference sources by 1K resistors built into the ECG cable assembly and on board MOV surge arrestors. RC filters serve protection and filtering functions.

A-5.3 Input ECG Signal First Gain Stage.

See Figure A-3. The three input leads pass through analog multiplexers to differential amplifier U80. Weak pull-ups on the two leads insure that an open lead will be pulled up to +5V. The differential amplifier is configured for a gain of 4 with resistors R284 and R285. The junction of the two resistors is the center of the two input leads, and serves as a monitor for input common mode voltage.

Buffer U75B drives (AC coupled) the shield of the input cable to effectively minimize input cable capacitance. Buffer U75B also drives integrator U75A with the common-mode monitor signal.

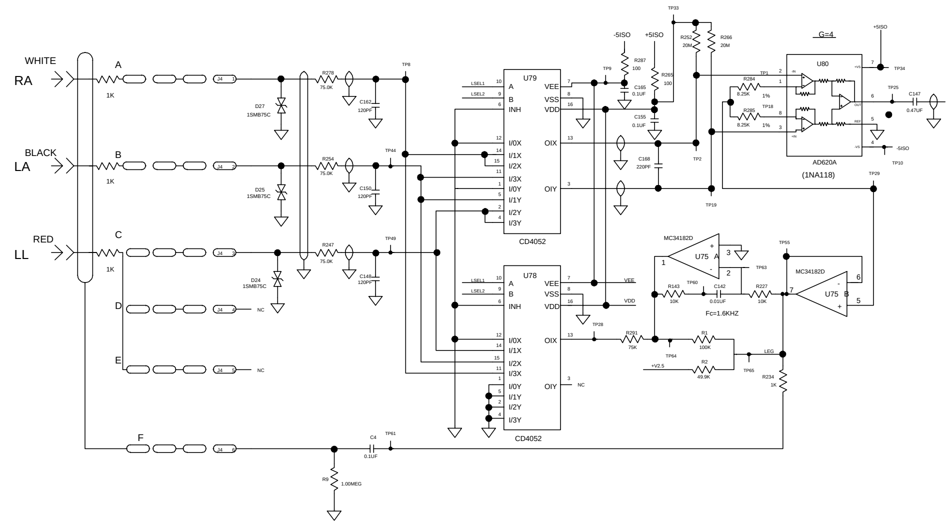


Figure A-3: ECG Processing Circuitry, First Stage

A-5.4 ECG Lead Off Detection

The output from the third lead drive amplifier is one of the signals monitored by the system. Since the third lead is usually the “leg” lead this integrator is called the leg drive amplifier, and its monitored output is called LEG. Two resistors are used to bias the output positive so that it can be monitored by the system A/D converter. The monitored signal represents the LEG drive signal according to the following table.

LEG Amplifier Output	LEG Monitor Signal
5	2.5
2	1.75
0	1.25
-2	0.75
-5	0

LEG drive signals (corrected for offset and gain errors) in excess of plus or minus 2 volts (>1.75 or <0.75 on the monitor signal) are an indicator of a lead off condition.

A-5.5 ECG Second Gain Stage

See Figure A-4. The ECG signal is AC coupled to gain amplifier U73B, configured for a gain of 35. The low frequency RC cutoff frequency can be selected to use a 6.8 Meg ohm resistor (0.05 Hz), 750 K resistor (0.5 Hz), or a 1K resistor (340 Hz). The 1K resistor is used to rapidly reset the ECG front end during transient initial connections or in the event of other major signal disturbances. The 6.8 Meg resistor is the default selection with digital bits 0.5 Hz and ECGRES selecting the 750 K or 1 K respectively.

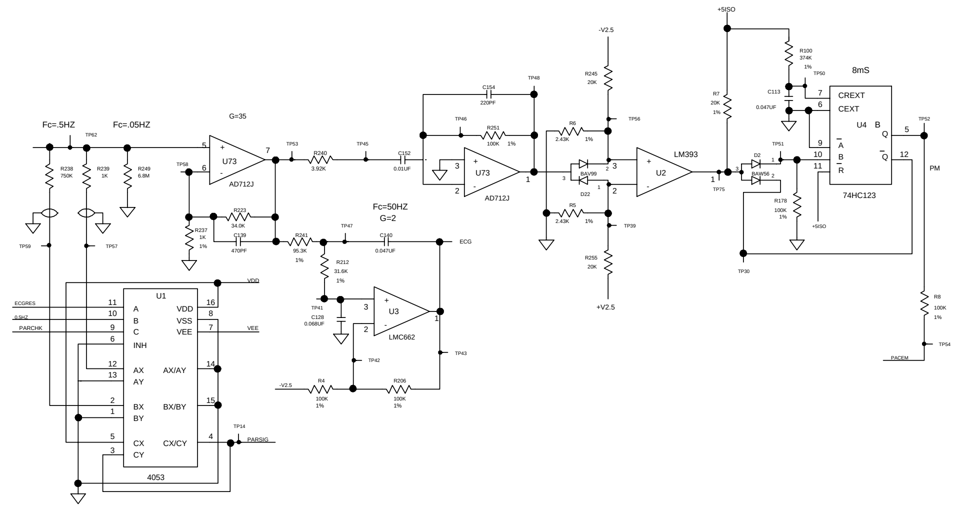


Figure A-4: ECG Processing Circuitry, Second Stage

A-5.6 Pacemaker Detection

The ECG signal through the first two gain stages has an upper bandwidth of 1.8 kHz. This bandwidth is high enough to pass the rapid rise time, short width, pacemaker signal. Differentiator U73A is tailored to recognize this fast rise/fall signal, and will trigger comparator U2, and one-shot U4B. The one-shot is set for a width of 8 msec and configured (with external blanking via D2) to be non-retriggerable. The width is enough to guarantee recognition by the system sampling rate while the non-retriggerable attribute prevents double pulse recognition. The output pulse is attenuated to become 0-2.5 volts. A voltage > 2.0 volt is considered a logical one.

A-5.7 Monitored ECG Signal

In addition to driving the pacemaker detection circuit, U73 also feeds the last ECG gain stage U3A. This stage applies a two-pole 50 Hz upper bandwidth and a gain of 2. The circuit includes an offset to center the output at 2.5 volts. The resulting ECG signal is monitored by the system A/D converter. Signals >4 volts or <0.5 volt are indicative of ECG signal overload.

A-6 ON/OFF POWER CONTROL

A-6.1 General

See Figure A-5. The NPB-3900 is turned ON and OFF by alternate button pushes of the front panel membrane switch. The button is sensed at U301 pin 3. U302 pin 3 produces a pulse for each button push which toggles U303 pin 1 between the ON and OFF state. A high level on U303 pin 4 resets the unit to the OFF state from U301 pin 4 when the battery is first connected to the unit, and from the ALARM signal if the unit operation stops because of watchdog time-out. The rising edge of the ON signal sets U303 pin 13 which starts the power supplies in the unit. Unit operation starts only via a push of the front panel button, but operation will stop based on signals from three possible sources:

- A second push of the ON/OFF button.
- A processor command PSOFF which will shut the unit OFF.
- The absence of the watchdog pulse train WDT_PULSE, which triggers an ALARM.

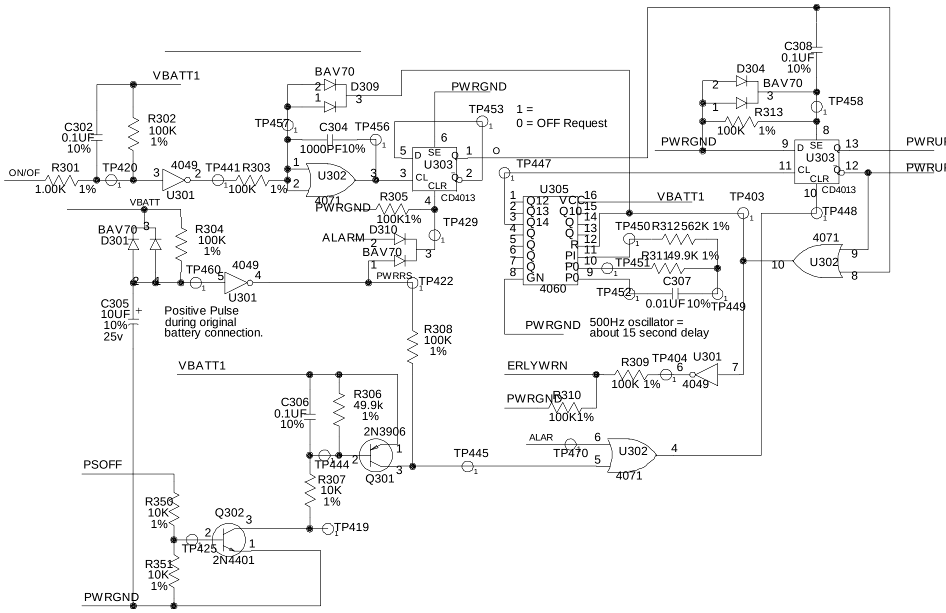


Figure A-5: Power ON/OFF Circuitry

A second push of the front panel button will drop the ON signal. While the unit is still running (PWRUP is high) U302 pin 10 will go low allowing timer U305 to run and masking further ON/OFF button pushes (via D309) until the OFF cycle is complete. The internal oscillator of timer U305 will create a rising edge on U303 pin 11 after about 10 seconds, turning the unit OFF. When the timer is started, the processor receives a signal from U301 pin 6 called ERLYWRN, which is an early warning signal to indicate that power will be turned OFF. The processor receives this signal as soon as the user requests the OFF state, and can clean up stored parameters and make an orderly shutdown.

When the processor wants to shut the unit down, it issues a high PSOFF signal which raises U302 pin 5. This resets the PWRUP flip-flop and shuts the unit down. In a normal shutdown procedure, the user issues an OFF command, the processor responds to the early warning signal, performs the shutdown procedure (showing a shutdown screen), and terminates the process before U305 times out by issuing the PSOFF signal.

A-6.2 Processor Watchdog

See Figure A-6. When the unit is powered up and running normally, it makes a pulse train gated by the watchdog timer called the WDT_PULSE signal. While this signal is present capacitor, C353 remains discharged. If something happens to the processor, the watchdog will time out. Regardless of which level the

WDT_PULSE goes to, capacitor C353 will charge up in about 500 msec. The rising edge will clock the ALARM flip-flop (U304) and set the ALARM signal.

The ALARM signal is reset when the battery is first connected to the unit, or by a push of the Alarm Silence push button on the front panel.

When the ALARM signal is set, it will raise U302 pin 4 and shut off the power supplies in the unit. It will also reset the ON flip-flop to the OFF state.

A-6.3 Watchdog Alarm

See Figure A-5. When the alarm signal is set, voltage regulator U315 will turn on, regulating the battery voltage to 5 VDC at pin 8. This 5 VDC will power the speaker amplifier U313 and oscillator U314. The oscillator will produce an alarm tone, which will drive the speaker until the alarm silence button is pressed.

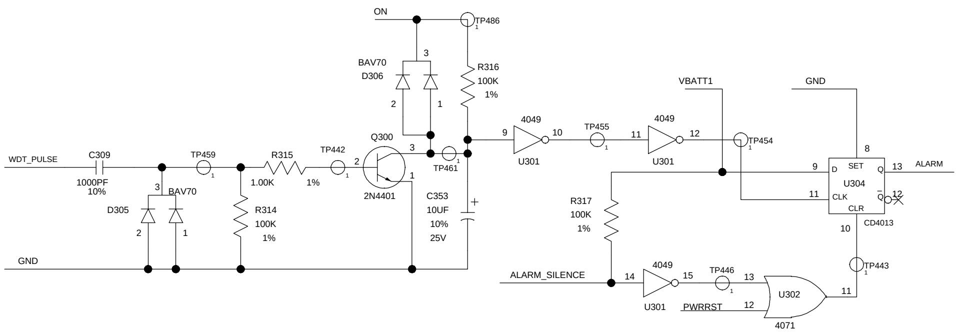


Figure A-6: Watchdog Circuitry

A-7 AUDIO VOLUME AND SPEAKER DRIVE

See Figure A-7. The operational tones produced by the monitor produce the SPKRFREQ signal. This signal is volume controlled by U310, a digital potentiometer. The SPKRU/D and SPKR_ADJ_PLS digital signals control the setting of the potentiometer. The attenuated waveform (from U310 pin 13) goes to the speaker drive amplifier U313, which connects to the speaker.

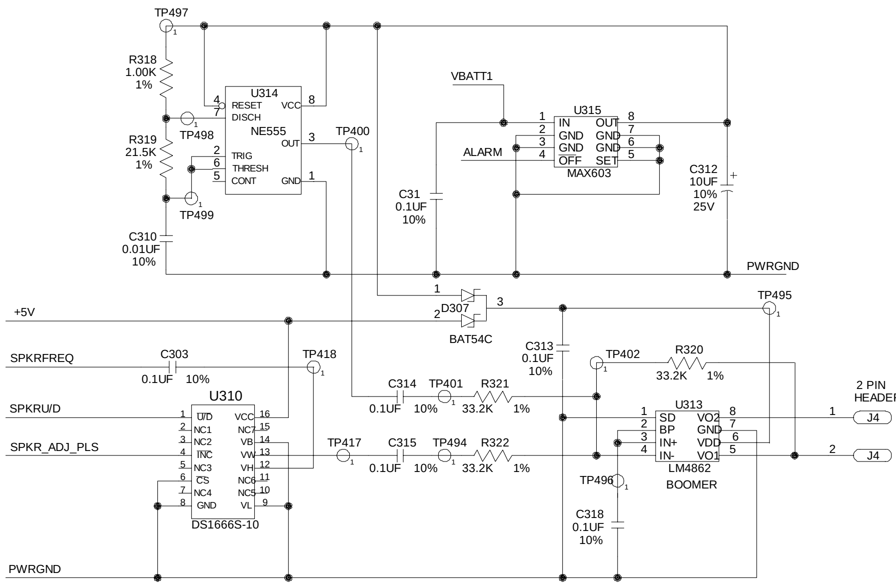


Figure A-7: Audio Volume Circuitry

A-8 POWER SUPPLIES

A-8.1 General

The NPB-3900 unit is operated from a 6-volt 4-AH sealed lead-acid battery. The battery charger provides enough power to charge the battery even when the unit is operating. Fuse F301 (4A) provides the main power source for the internal power supplies. Polyswitch F302 (a 1A resettable fuse) provides power to the ON/OFF and ALARM circuits. If F301 blows, the alarm will still be activated.

A-8.2 General Buck Regulator Design

Several regulators in the NIBP3900 are buck-switching converter designs, a simplified diagram of which is shown in Figure A-8. In a buck converter (which provides a reduced, or bucked, output voltage), a series switch applies the input voltage to the output through an inductor. When the inductor current has built to a level sufficient to satisfy the load, the switch is opened. The current flowing in the inductor causes its input lead to fly down until it is caught by the catch diode at a voltage slightly below ground. The inductor current then diminishes until the switching cycle is repeated.

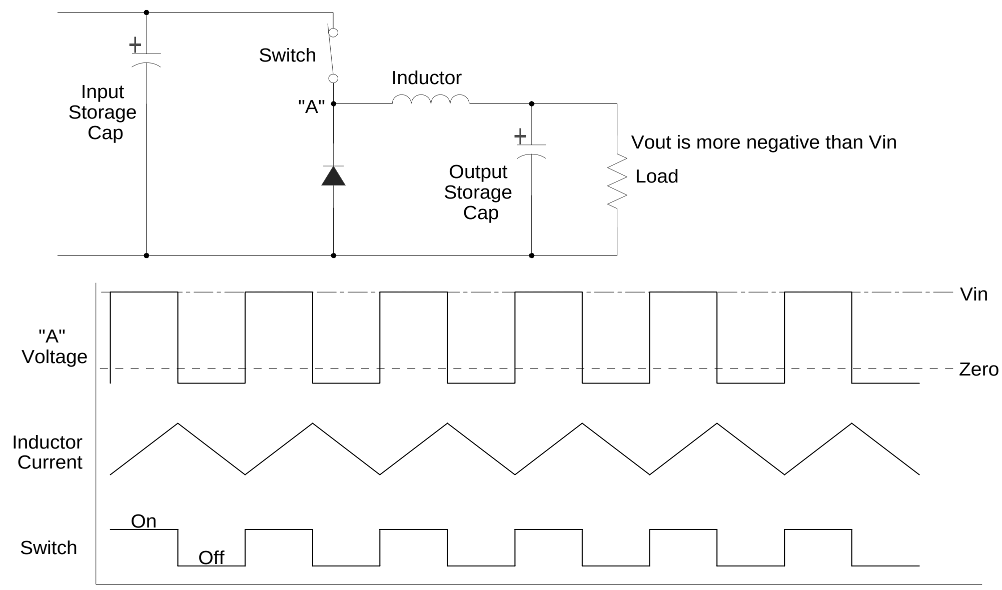


Figure A-8: Buck Power Regulator, Simplified Schematic & Waveforms

A-8.3 Battery Charger Power Supply

See Figure A-9. The transformer for mains isolation is external to the NPB-3900. The external unit provides an isolated 15 VRMS to the DIN connector on the back of the unit. This AC voltage is rectified by D318 and filtered to produce 16 to 25 VDC on C335. The battery charger is an integrated buck-switching regulator. The power switch is internal, the output inductor is L306, and the catch diode is D317.

The regulator contains an accurate output current sense resistor located between pins 6 and 11, which is used to limit output current during charging. The specific current limit value is adjusted by R331.

When not in current limit, the output voltage is set to 7.1 volts. In voltage-controlled operation, attenuator R326/R327 drives U309 pin 5 to 2.5 volts. To prevent battery drain when the unit is not operating, switches Q309 and Q310 disconnect the attenuator unless the charger receives power. These transistor switches also drive the front panel LED (via CHRGLED) and provide a processor input signal (CHRGST) to indicate that charger power is applied. Diode D308 and transistor Q303 provide a redundant voltage limiting mechanism at 8 volts in the event of a failure of the primary voltage regulation mechanism.

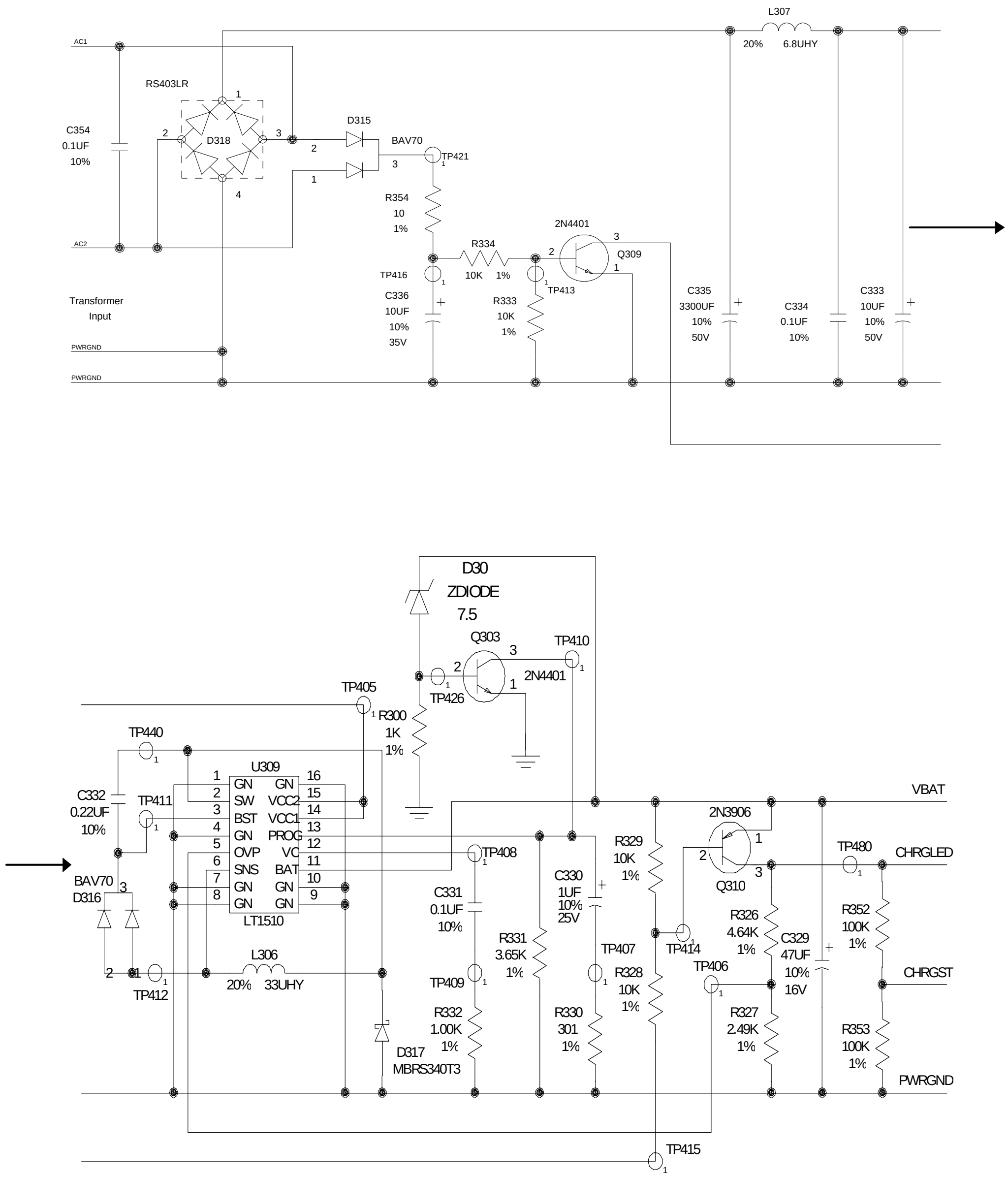


Figure A-9: Battery Charger Circuitry

A-8.4 Power Supply (3.3 volt)

See Figure A-10. The PWRUP signal enables/disables a buck-switching regulator (U306) that produces a regulated 3.3 volts at C345. The power switch is integrated within the IC, the catch diode is D312, and the output inductor is L301.

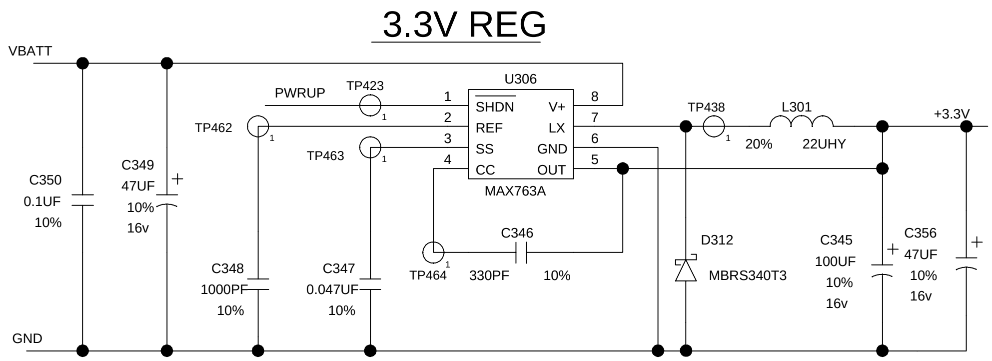


Figure A-10: 3.3V Regulated Supply

A-8.5 Power Supply (5.0 volt)

See Figure A-11. The PWRUP signal enables/disables a buck-switching regulator (U308) that produces a regulated 5.0 volts at C340. The power switch is Q308, the catch diode is D314, and the output inductor is L308.

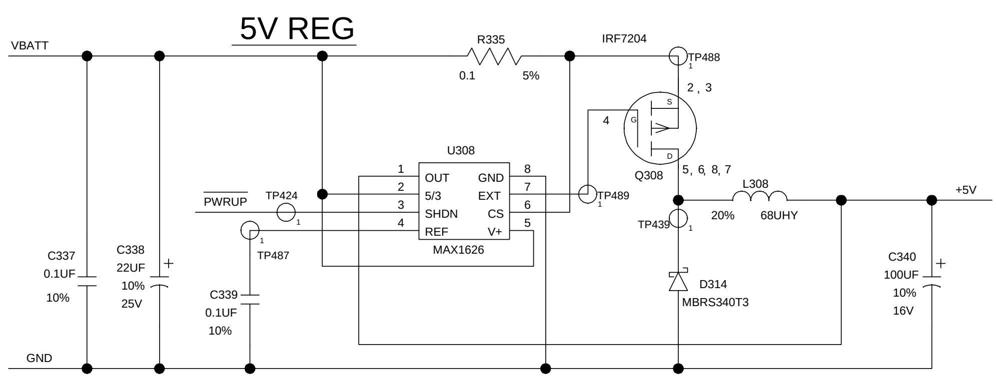


Figure A-11: 5V Regulated Supply Circuitry

A-8.6 LCD Bias Power Supply

See Figure A-12. The LCD display requires a negative bias voltage (LCDBIAS) that adjusts the contrast of the display. The bias supply is thus an adjustable regulator, controlled by digital signals from the processor. The design is a modified buck regulator whereby the switch is Q307, the output inductor is L309, and the catch diode is D313. In the modified design, the output is taken from the bottom of the catch diode in order to produce a negative voltage. The output voltage is monitored by the regulator via R336. Output current is limited by R337. The output voltage setpoint is established by a DAC inside U307 set by processor signals LCDADJ and LCDCTRL.

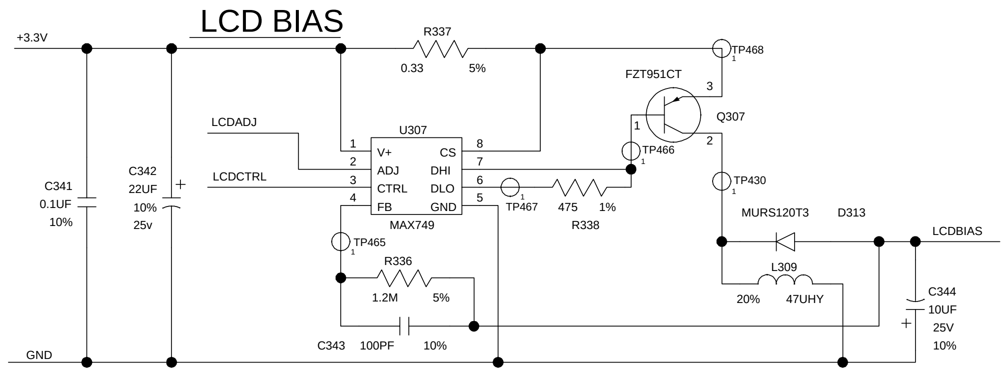


Figure A-12: LCD Bias Supply Circuitry

A-8.7 Backlight Power Supply

See Figure A-13. The LCD display backlight is a cold cathode fluorescent light (CCFL), which requires a high voltage during normal operation. The starting voltage may be as high as 1000 VRMS, the running voltage is about 300 VRMS at 3 ma. This voltage is produced by a resonant Royer oscillator which produces a sinusoidal output waveform at about 50 kHz. The transistors Q305 and Q306 receive their base drive from the transformer. The output waveform is the result of the transformer inductance resonating with C352 and the CCFL reflected capacitance.

The backlight power supply can be disabled by the processor with the BACKLITE_OFF signal, which cuts out the base drive signal.

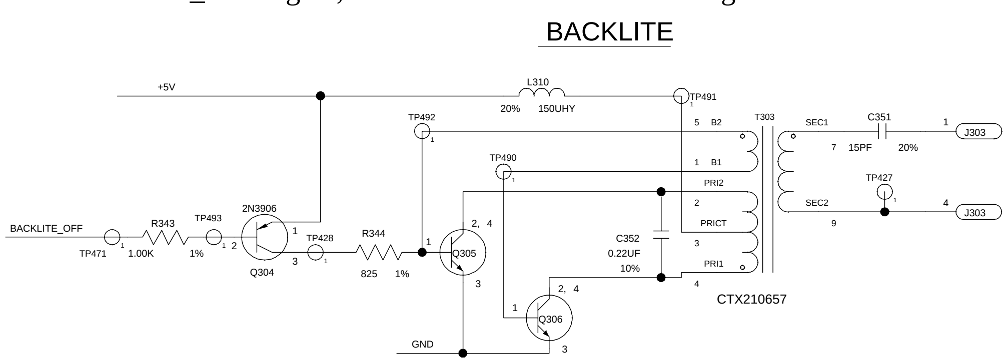


Figure A-13: LCD Backlight Supply Circuitry

A-8.8 Isolated ±5-Volt Power

See Figure A-14. The isolated patient connection front end receives power from full bridge driven transformer T1. The two drivers for T201 (U204 and U205) receive complementary signals called FE_100KHZ. If power is removed from the front end, both signals are brought to zero, stopping the transformer drive.

Inductors L200 and L201 along with capacitors C220 and C209 serve to reduce the speed of the waveform edges for high speed EMI reduction.

Figure A-14 also includes the circuitry to supply for the heater, beginning with the 100 kHz input to U206, and transformer coupled through T202 to the connector.

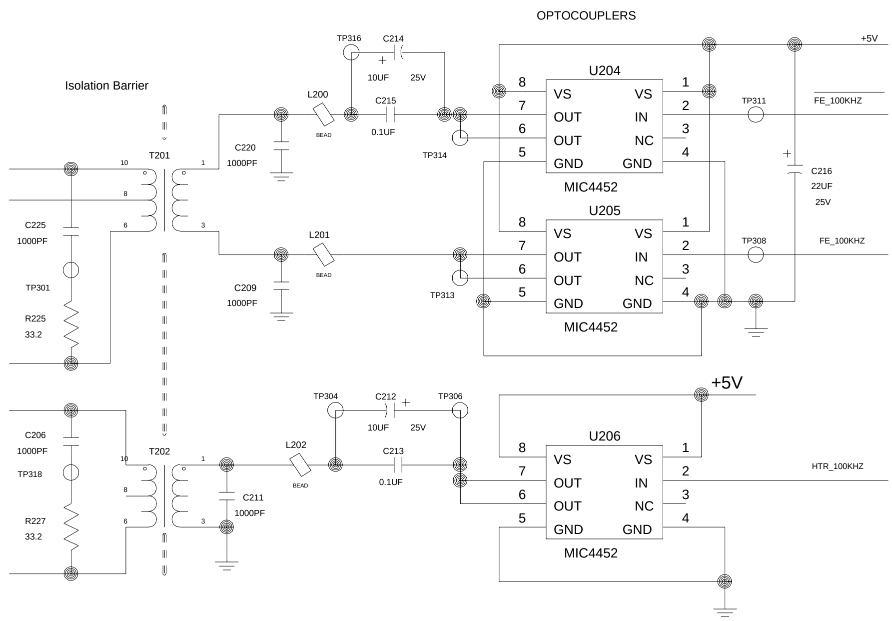


Figure A-14: Isolated ±5V Supply Circuitry

A-9 NIBP SECTION

A-9.1 General

The NPB-3900 contains a pneumatic noninvasive blood pressure system. Mechanically the system consists of a pump, a proportional valve, and two pressure sensors. During a blood pressure reading, the system pumps up the cuff to a specific pressure then bleeds air slowly out while "listening" to the pressure for the heartbeat. The relative loudness of the heartbeat during the test is used to determine the systolic and diastolic pressure readings.

A-9.2 Power

See Figure A-15. The control and amplification circuits of the NIBP section have their own power supply, regulated to +5 from the battery by linear regulator U2S. The power for the NIBP section is labeled +5VREG, and is enabled by the processor using NPANPWR.

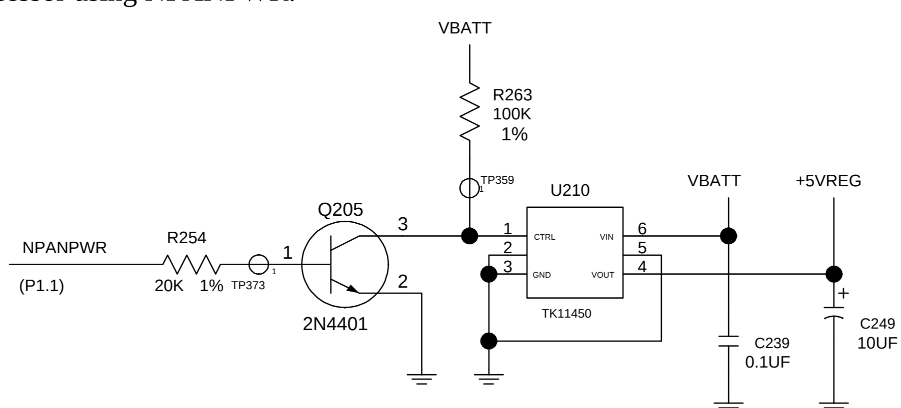


Figure A-15: NIBP Power Sourcing Circuitry

A-9.3 Pump Control

See Figure A-16. The air pump is powered from the battery voltage and (for redundancy) requires that two semiconductor switches be activated for operation. The NPPVEN signal must be high to turn on the Q210 P channel, and PUMPPWM must be high to turn on the Q210 N channel. The PUMPPWM signal can be pulse width modulated by the processor to control the speed of the pump.

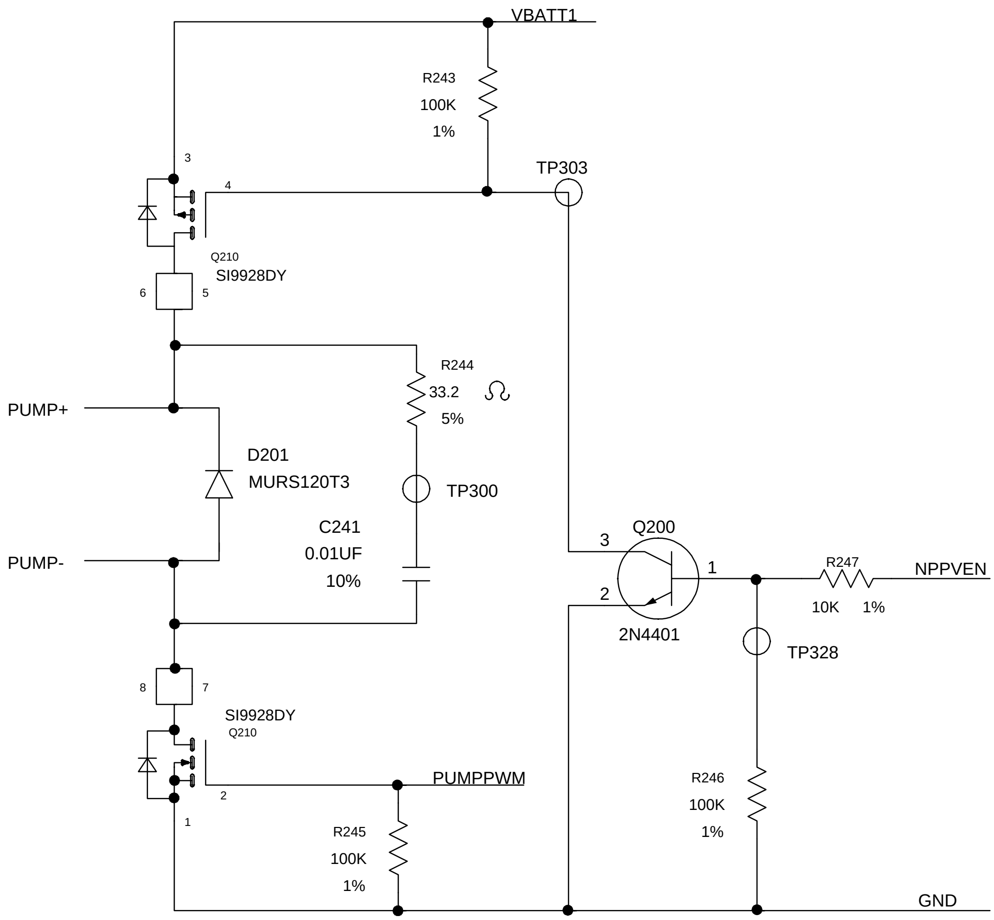


Figure A-16: NIBP Pump Control Circuitry

A-9.4 Pressure Sensors

See Figure A-17. Two redundant pressure sensors (PS201 and PS202) monitor the air pressure in the NIBP system. The sensors are powered from the NIBP +5VREG power and produce an output of 0-5 volts from pressures of 0-360 mm.

Pressure sensor PS210 is used during the NIBP test. It is monitored directly by the system A/D as an indicator of system pressure. The signal from PS1 is AC coupled and amplified by U216 to produce the OSC signal monitored by the system A/D. The OSC signal represents the oscillatory channel used to monitor the small pressure variations caused by the heartbeat. The first U216 stage provides AC coupling and buffering. The second stage provides low-pass filtering and gain (A_v=18) , the last stage provides additional AC coupling, gain (A_v=3.6), and adds a DC offset to center the output in the A/D range.

Pressure sensor PS202 is monitored by the system A/D and is used as a safety backup to limit the maximum pressure in the system regardless of software commands. When the output of PS202 reaches 4.2 volts, comparator U216 will trip, dropping the NPPVEN signal, which will stop the air pump (via Q210 P) and open the bleed valve (via Q211 P).

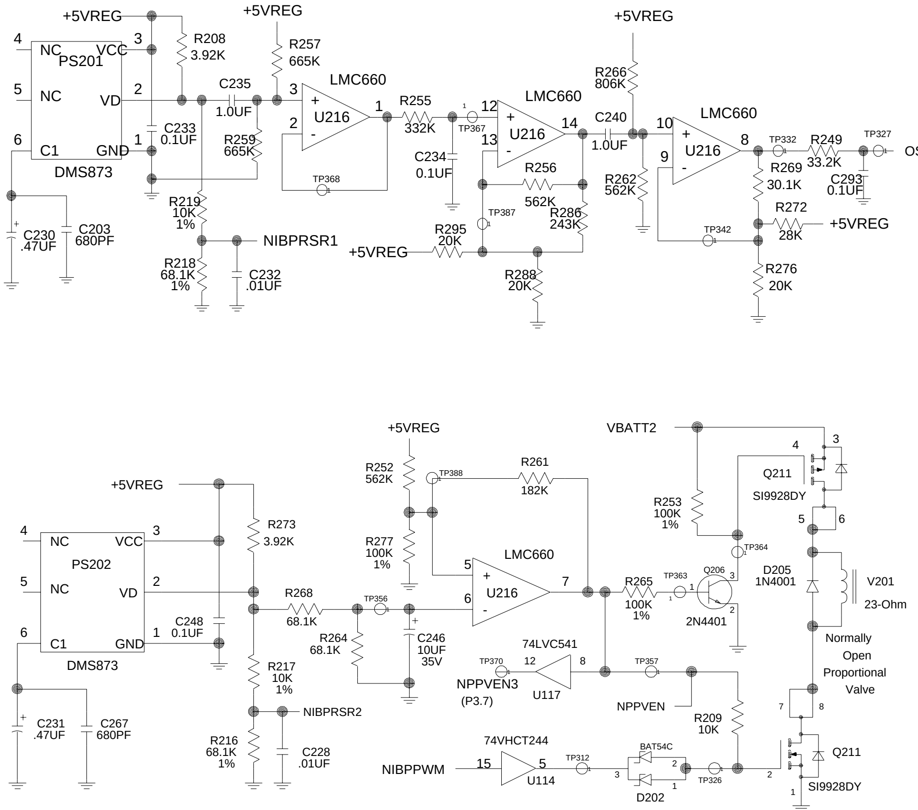


Figure A-17: NIBP Pressure Sensors Processing Circuitry

A-9.5 Proportional Valve Control

See Figure A-18. The single valve used in the NPB-3900 NIBP section vents the pneumatic system. The valve is normally open when no power is applied. Power comes from Polyswitch F303 (1A). The valve will close in proportion to the amount of current passing through it. The current is duty-cycle modulated by the NIBPPWM signal, which turns on the N channel section of Q11.

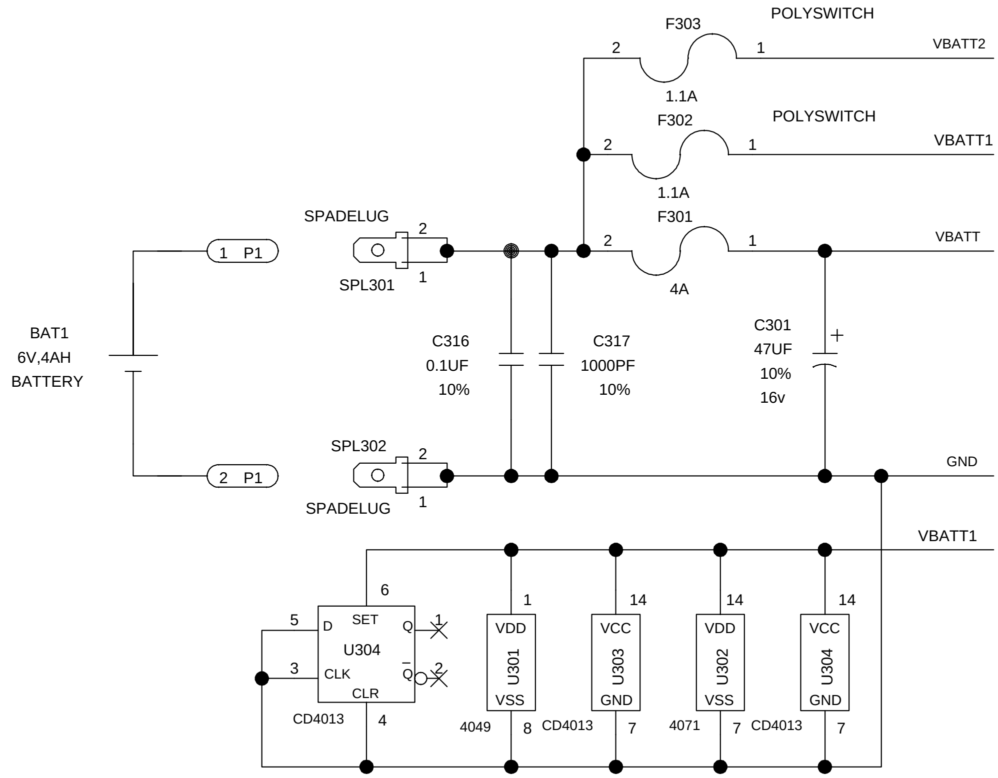


Figure A-18: Proportional Valve Powering Circuitry

A-10 SYSTEM A/D

See Figure A-19. All analog information monitored by the NPB-3900 passes through the 12-bit high speed sampling A/D, U207. The A/D full scale is set at 4.096 by reference diode D200.

(The schematic includes the circuitry that interfaces with the SpO_2 signal processing component.)

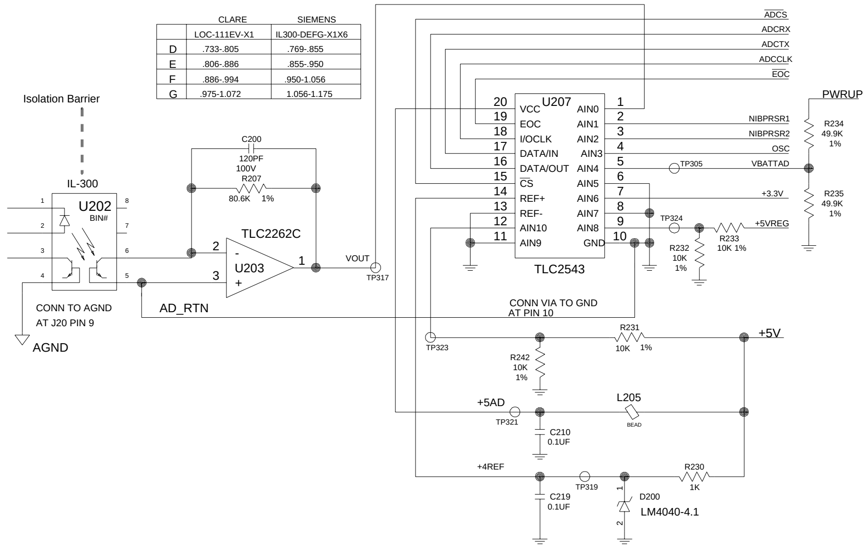


Figure A-19: A/D Circuitry

Signals processed through the A/D Converter are listed in the following table, and they correspond to channels identified in the schematic.

Channel	Signal
1	Isolated Front End Channels
2	NIBP Pressure Sensor 1
3	NIBP Pressure Sensor 2
4	NIBP Oscillatory channel
5	Battery Voltage (÷2)
6	Ground
7	+3.3 volt Power Supply
8	Ground
9	NIBP +5 volt power (÷2)
10	Ground
11	+5 volt power (÷2)

A-11 BUTTONS AND LIGHTS

The NPB-3900 front panel contains 5 membrane switches and two lights brought to the main board through J2. EMI-reducing R/C networks are applied to each line.

Signal	Function
CHRGLED	LED, on when charger connected
STNDBY	LED, blinks when unit in standby mode
ON/OFF	Button, turns unit ON and OFF
ALARM_SILENCE	Button, silences ongoing alarms
NIBPPB	Button, initiates NIBP measurement
AUDTONVOL	Button, allows volume adjustment
LCDCONTRST	Button, allows LCD contrast adjustment

A-12 SpO_2

A-12.1 General

See Figure A-20. The NPB-3900 contains a saturated blood oxygen measurement system using pulse oximetry techniques for noninvasive monitoring. The SpO_2 section is a separate minisystem with its own analog section, A/D converter, and microprocessor. The SpO_2 section resides in the isolated portion of the NPB-3900 and receives +5ISO and -5ISO DC power via transformer T201. This section communicates via RS-232 digital transfers through optical isolators U208 and U209.

The SpO_2 function is built around an 80C552 microcontroller, and the function consumes approximately 0.5 watts.

The SpO_2 function incorporates *C-Lock*® ECG synchronization to allow measurements on patients with low perfusion or in the presence of patient motion. An ECG synchronization signal is used to prevent erroneous indications in the SpO_2 measurements during ECG measurements.

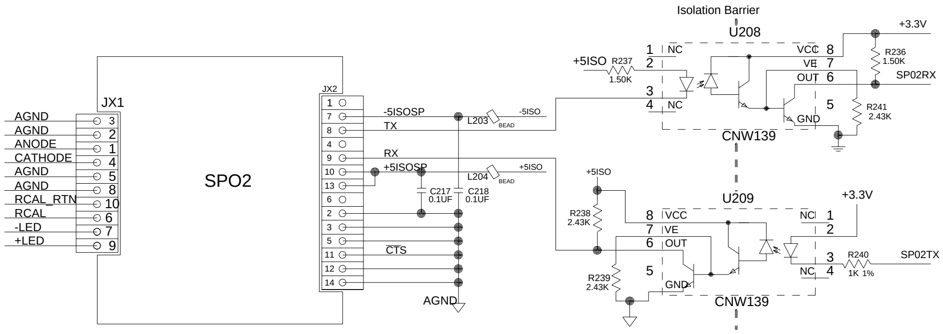


Figure A-20: Interfacing with SpO2 Processing

A-12.2 Functional Interconnections

Other than supply voltages provided to the SpO2 function, there are three data signals utilized in the SpO2 function:

CTS* clear to send a logic signal (active low, designated by "*") transmitted to the module by the monitor function to suspend data transmission from the SpO2 function

RX is the receive data line to the SpO2 function

TX is the transmitted data line from the SpO2 function

A-12.3 Oxichip Circuit

At the heart of the SpO2 function is the *Oxichip* ™ integrated circuit U1, which provides variable LED drive, photodetector amplification, variable gain, demodulation, filtering, and signal conditioning for the analog-to-digital converter (ADC) input. The *Oxichip* circuit generates its own LED modulation and photodetector demodulation timing. It requires a single clock at *x, the desired LED switching frequency. A block diagram of the *Oxichip* is shown on sheet 2 of the schematic. The *Oxichip* circuit pin descriptions are provided in Table A-1.

Table A-1: *Oxichip* Circuit Pin Descriptions

Pin Name	Pin #, type	Signal Description
CS*	1, DI	Chip Select, latches the data bus into the storage registers. Connected to WR* U4 P3.6.
LE	2, DI	Latch Enable, enables writing to the storage register. Connects to U4.P1.1.
CYCLE	3, DO	Indicates whether the *Oxichip* circuit is in Red or IR cycle. High is Red, Low is IR. Connects to U4.P3.3.
CLH	4, LP	High side current limit protection. Connect to LED supply voltage through 10-watt resistor in parallel with a 220 µF capacitor.

Table A-1: *Oxichip* Circuit Pin Description - (Continued)

Pin Name	Pin #, type	Signal Description
LEDPOS	5, LO	+LED connection to sensor.
LEDNEG	6, LO	-LED connection to sensor.
CLL	7, LP	Low side current control. Connects to LED supply return through 10 watt resistor.
GATE	8, DO	Combined gate signal, rising edge initiates a COMPARE A/D conversion. Connects to U4.STADC.
SATIN*	9. DO	LED on or off status indicator, high is off, low is on. Connects to U3.P4.3.
RESET*	10, DI	Input to Schmitt Trigger for generating a reset.
SRT	11, DO	Output of Schmitt Trigger, active high reset pulse.
VSS	12, DP	Digital power return.
VSSA	13, AP	Analog power return.
FR3OUT	14, AO	Red filter chain, op amp 3 output.
FR3NEG	15, AI	Red filter chain, op amp 3 inverting input.
FR2OUT	16, AO	Red filter chain, op amp 2 output.
FR2NEG	17, AI	Red filter chain, op amp 2 inverting input.
FR1OUT	18, AO	Red filter chain, op amp 1 output.
FR1NEG	19, AI	Red filter chain, op amp 1 inverting input.
RED	20, AO	Red demod/demux output.
PGAOUT	21, AO	Programmable gain amplifier output.
SOUT	22, AO	Ambient light auto-null amp output.
SINNEG	23, AI	Ambient light auto-null amp inverting input.
SWITCH	24, AO	Ambient light auto-null switch output.
A2OUT	25, AO	Photodetector amp 2 output.
A2INNEG	26, AI	Photodetector amp 2 inverting input.
A1NPOS	27, AI	Photodetector amps 1 and 2 non-inverting inputs.
A1NNEG	28, AI	Photodetector amp 1 inverting input.
A1OUT	29, AO	Photodetector amp 1 output.
VREF 3125	30, AO	3.125 volt reference output.

Table A-1: *Oxichip* Circuit Pin Description - (Continued)

Pin Name	Pin #, type	Signal Description
VREF25	31, AO	2.5 volt buffered reference output.
VREF22	32, AO	2.2 volt reference output.
IR	33, AO	IR demod/demux output.
FI1NEG	34, AI	IR filter chain, op amp 1 inverting input.
FI1OUT	35, AO	IR filter chain, op amp 1 output.
FI2NEG	36, AI	IR filter chain, op amp 2 inverting input.
FI2OUT	37, AO	IR filter chain, op amp 2 output.
FI3NEG	38, AI	IR filter chain, op amp 3 inverting input.
FI3OUT	39, AO	IR filter chain, op amp 3 output.
LS	40, AO	Level shifted and multiplexed output to ADC.
VDDA	41, AP	Analog power.
VDD	42, DP	Digital power.
RED-IR*	43, DI	Multiplexer select input, high is Red, low is IR. Connects to U4.P1.2.
CLK_16	44, DI	Clock speed select, high is 128xfMOD, low is 8xfMOD.
CLK	45, DI	Clock input.
D4	46, DI	Data bit 4. Connected to AD4.
D3	47, DI	Data bit 3. Connected to AD3.
D2	48, DI	Data bit 2. Connected to AD2.
D1	49, DI	Data bit 1, Connected to AD1.
D0	50, DI	Data bit 0. Connected to AD0.
LIM	51, DO	Overcurrent limit indicator, high indicates current limit has tripped. Connected to U4.P4.6.
EN*	52, DI	LED enable, high disables LED drive, low enables LED drive. Connected to U4.P1.0.

A-12.4 Preamplifier

NOTE: In the following discussion, parts that are internal to the *Oxichip* circuit are noted with a “U1.” Prefix.

The current-to-voltage (I-to-V) converter has a gain of -249K V/A and a low-pass corner frequency of 30 kHz. The voltage amplifier has a gain of -2 V/V and a low-pass corner frequency of 20 kHz. The voltage amplifier is disconnected from the I-to-V converter during LED switching transients to prevent transmission of the switching spikes into the Programmable Gain Amplifier (PGA).

The ambient light canceller (ALC), which consists of U1.A3, R6, and C6, generates a current opposing the DC current coming from the photodetector, which is caused by ambient light. The ALC switches on during the Red cycle and has a closed-loop frequency of 240 Hz. It can cancel up to 36 μa of DC photocurrent. The response time to a change in LED drive is less than 2 ms.

The RC filter that removes sensor cable noise is comprised of R1 and C49. Component CR4 serves as an ESD-protection diode.

A-12.5 Programmable Gain Amplifier (PGA), Demodulator and Demultiplexer

The PGA (U1.A4) provides a variable gain to accommodate a wide range of signal strengths. As the PGA amplifies the signal from the preamp by a programmable gain, the demodulator shifts the frequency down to baseband, while the demultiplexer separates the IR and Red components of the signal. The PGA has a programmable gain from 1 to 128 in powers of 2.

The PGA output goes to the peak detectors for status monitoring and to the demodulator/demultiplexer (U1.A5, which is internal to the *Oxichip* circuit) for signal processing.

There are two peak detectors: one detects positive peaks (above the 2.2-volt reference) and one detects negative peaks, or valleys (below the 2.2-volt reference). This measurement point is referred to as COMPARE2, or C2. The peak and valley detector circuitry consists of CR3, R26, R41, R42, C42, and C41.

The response of the peak detectors is nonlinear since the CR2 diode impedance changes as the voltage on the diode changes. The changing time constant is limited to no faster than 20.8 μs. The delay time constant is 19.8 ms.

A-12.6 Filters and Level Shifter

The filters and level shifters are shown on the schematic sheet 2.

The 10 Hz filters eliminate the high frequency components of the optical signal and get it ready for conversion to a digital signal, thereby smoothing out the Red and IR signal from the demutiplexer. The gain of the Red filter is eight, while the gain if the IR filter circuit is five.

The Red filter circuit components consist of U1.A6-8, R19-21, R31, R34-37, C22, C29-30, and C37-38. The IR filter circuit components consist of U1.A10-12, R22-24, R32-33, R38-40, C23-24, C31-32, and C39. The IR filter is identical to the Red filter except for the component values in the last stage.

The level shifter moves the reference for the signal back to ground. The level shifter (U1.A9) selects the desired signal and shifts the signal reference from 2.2 Vref to ground, or 0 volts. This circuit has a gain of two and an intentional offset of 80-120 mV at the output.

A-12.7 LED Driver

The LED driver circuit generates regulated and programmable currents for driving the sensor LEDs. The circuit switches the current in the proper phases of the LED strobe cycle. The IR and Red currents can be programmed independently. The LED currents are generated by forcing a programmable voltage across R9, then switching the resulting current through the LEDs.

The LED driver is almost entirely contained within the *Oxichip* circuit. This driver also has an over-current detection feature that shuts down all LED drive if the average current exceeds 44 ma. The over-current trip level is set by passing the LED current through R10 and C9 and comparing the voltage drop to V_{DD}-0.3 V. Components CR5 and CR6 serve as ESD-protection diodes. See schematic sheet 2.

A-12.8 References

There are three voltage references on the *Oxichip* circuit. The 3.125 V reference is used for Rcal stimulus and the high resolution A/D converter reference. It is a low-impedance output. The 2.2 V buffered reference is used as the signal ground for the photodetector cathode and is a low-impedance output. The 2.2 reference is used for signal ground in the rest of the circuit. It is a high-impedance output and is filtered by C3.

A-12.9 Reset Schmitt Trigger

The power-on reset function is accomplished with a Schmitt Trigger inside the *Oxichip* circuit and external components R45 and C44. The Schmitt Trigger supplies an active high reset to the processor on RTS. Diode CR2 protects the *Oxichip* circuit from the discharge of C44.

A-12.10 High Resolution A/D Converter

The oximetry function uses a Crystal Semiconductor CS510A 16-bit A/D converter for the conversion of the filtered optical signals and for Rcal measurements. This A/D converter is shown on schematic sheet 2 as U2.

A-12.11 Input Filter

The input filter of U2 is through the level shifter circuit, which consists of R18 and C13. The Rcal filter circuit consists of R17, C20-21.

A-12.12 Power Decoupling

The power supply decoupling circuit consists of R29, R30, C16-18, C28, and C26-27.

A-12.13 Status and Timing

The LED drive, ALC, demodulator, and demultiplexer require timing signals to operate properly. All the proper timing sequences are provided by the state machine—the OXICLK signal—within the *Oxichip* circuit. The state machine requires a clock from the CPU at 8x the desired LED strobe frequency.

A-12.14 Analog Power Regulation

The oximetry function analog functions are powered by ±5 VDC. Analog filtering is provided by R15-16 and C11-12.

A-12.15 Microcontroller

The oximetry module microprocessor is an 80C552 IC (U4) with 64K ROM (U3), 32K RAM (U7) and an address latch (U6). The connection to the *Oxichip* circuit gain is the data bus.

A-13 MICROCONTROLLER

A-13.1 General

See Figure A-21. The microcontroller is an Intel 386EX with a 16-bit data bus and a 24-bit address bus, of which we use 19 bits. There are eight control signals used, ADS#, W/R#, D/C#, M/IO#, WR#, RD#, BLE#, and BHE#. The processor requests and receives instructions from the flash memory. The DRAM memory is used for storage of variables, etc.

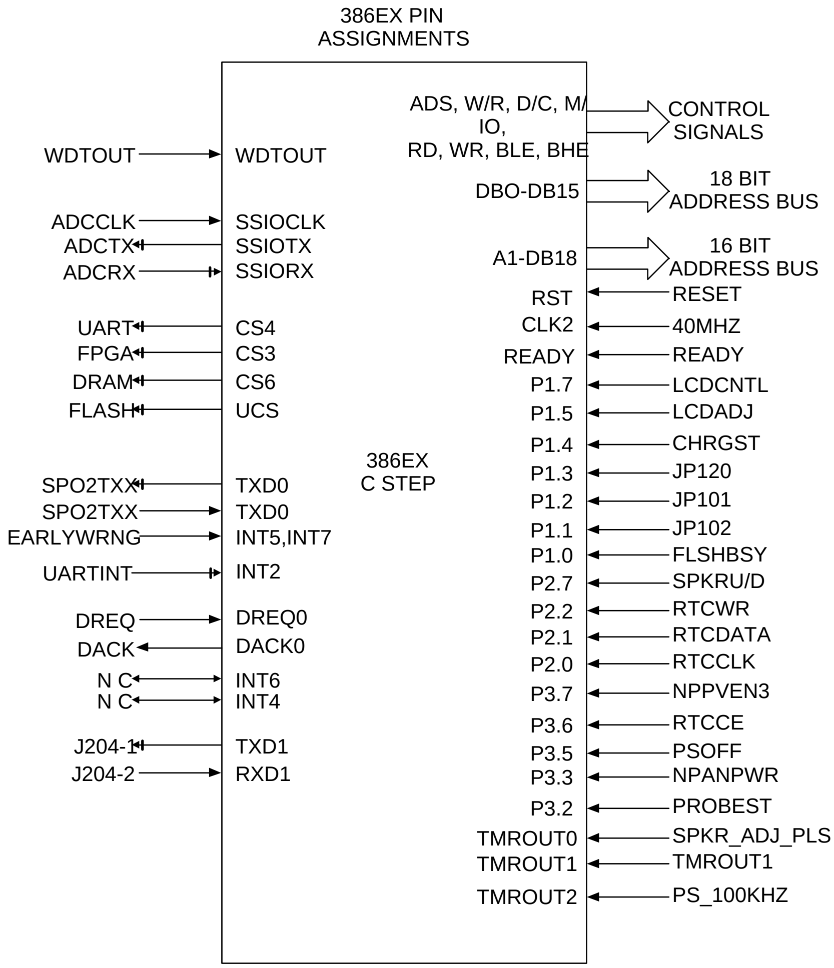


Figure A-21: Microcontroller Signal Assignments

A-13.2 Signal Connections

The 386EX uses its data and address bus along with eight control signals to read and write to the DRAM, flash, UART, and FPGA. Other interface connections are made through the I/O port signals, timer signals, interrupt signals, asynchronous port signals, and the synchronous port signals. These signals are shown in Figure A-21.

A-13.2.1 Reset

This signal is an input to the 386EX and is generated by the voltage detector, VR102, and FPGA circuits during power up. It resets all of the internal registers and synchronizes the internal clocks.

A-13.2.2 40MHz Clock

The main system clock is generated by oscillator X103, which generates a 40MHz clock signal which is routed to the processor and FPGA. The processor divides this clock by 2 and internally generates a PH1 clock and a PH2 clock. These internal clocks control all of the processor's signal generation.

A-13.2.3 Ready

The processor generates the READY signal whenever it has been programmed to generate READY signals. As an example, when a DRAM access occurs, which has one wait state, the Chip Select Unit in the processor will generate the READY signal to end the DRAM cycle.

A-13.2.4 Standby

This bit is port bit 1.5 and is programmed by the software to turn a LCD display on and off to indicate that the NPB-3900 is on but in power save mode, and touching any button or the knob will bring the LCD display back to life.

A-13.2.5 LCDCRTL and LCDADJ

These signals are used together to adjust the LCD contrast voltage up and down. Software generates these signals via port bits 1.7 and 1.6, respectively. The LCDCRTL signal selects the Dallas digital potentiometer and the LCDADJ signal adjusts the potentiometer up to generate the proper negative bias voltage to the LCD display. See paragraph 5.5.

A-13.2.6 NPANPWR

This signal is at port bit 3.3 and the software programs it high to turn the NIBP power on. When low, the NIBP power is off.

A-13.2.7 SPKRU/D and SPKR_ADJ_PLS

These two bits, port bits 2.7 and TMROUT0 respectively, work together to adjust the Dallas audio potentiometer to control the speaker volume.

A-13.2.8 RTCE, RTCWR, RTCDATA, RTCCLK

These signals are connected to port bits 3.6, 2.2, 2.1, and 2.0, respectively. They are programmed by the software to generate the necessary signal levels to read or write to the RTC.

A-13.2.9 PSOFF

Port bit 3.5 is used to turn the power supply of the NPB-3900 off. Software controls this and it is usually activated after an EARLYWRNG signal (INT5/INT7) has been received from the power supply to indicate that the off button has been pushed.

A-13.2.10 PS_100KHZ

This signal is generated from the internal timer 2 unit and is programmed by software to generate a 100 kHz signal which goes to the FPGA and in turn is anded with the WDT signal to generate the SYNC ALRM to the power supply circuits.

A-13.2.11 CHRGST

This input on port bit 1.4 is from the power supply circuit and is used to indicate that the battery eliminator is connected to the NPB-3900 and is charging the battery.

A-13.2.12 PROBEST

Input port bit 3.2 is the probe status bit and is generated by a microswitch to indicate whether the temperature probe is installed in its housing (low) or has been removed (high).

A-13.2.13 NPPVEN3

This input port bit 3.7 comes from the NIBP circuit and indicates that the NIBP circuit has been turned on and is enabled.

A-13.2.14 WDTOUT

This output is from the processor's Watchdog Timer Unit and is a clock signal that is combined with the PS_100KHZ signal. It is low and is kept low by the software retriggering the WDT unit. If the software fails to update the WDT unit, the signal will go high and the flip-flop is set high, inhibiting the signal thus causing the power supply to shut down.

A-13.2.15 ADCCLK, ADCTX, ADCRX

These signals are connected to the Synchronous Serial Unit within the processor and control the ADC in the NPB-3900. The processor's DMA1 channel initiates a DRAM memory transfer to the SSU and the 16-bit word is serially output to the ADC and the front-end. Each data bit on the ADCTX line is strobed into the ADC and the front end serial shift register on the leading edge of the ADCCLK signal. At the same time, the ADC puts out the previous conversion's data on the ADCRX line. This data is input to the SSU and the data is read by software. The first byte of the ADCTX line controls the ADC and the second byte is decoded by the front end to choose the analog mux channel routed to the linear opto and to select the ECG leads. The STXCLK signal is generated in the FPGA.

A-13.2.16 UART, FPGA, DRAM, FLASH CHIP SELECTS

These signals are generated by the processor's Chip Select Unit and are generated each time the address space which corresponds to the signal is enabled. Only one of these signals can be true at a time and the software programs the address space for each of these signals. These signals are all low true. The DRAM is connected to CS6# and requires 1 wait state, the Flash is connected to UCS# and requires one wait state, the FPGA is connected to CS3# and requires 0 wait states, and the UART is connected to CS4# and requires one wait state.

A-13.2.17 SpO_2TX and SpO_2RX

These signals are from the processor's Asynchronous Serial Unit and is used to interface to the SpO_2 section. All data and control information is passed back and forth between the processor and the SpO_2 section via these two signals.

A-13.2.18 EARLYWRNG and UARTINT

These two signals are interrupts, EARLYWRNG from the power supply circuit and UARTINT from the UART. The EARLYWRNG signal is connected to INT5 and INT7, and goes high to tell the processor that the unit's off button has been pushed. The UARTINT signal is generated by the UART to indicate that the transmit buffer is empty or the receive buffer is full.

A-14 PROGRAM STORAGE/EXECUTION

A-14.1 General

The program for the NPB-3900 is stored in a 256K X 16 flash, U111. The flash is address-mapped in the upper 512k byte address space and requires one wait state (100ns) for reading or writing to the flash. Upon powering up, the processor requests and receives an instruction at location FFFFF0 hex, utilizing the address bus, signal UCS# from the chip select unit within the processor, and the data bus.

The executable flash is a word oriented flash, that is, reading and writing is done on a word basis, and byte reads and writes are not allowed.

The chip select unit has UCS# assigned to the executable flash. The executable flash is assigned the upper 256k words, or 512k bytes in the system. The word address space is 40000-7FFFF hex, which is 80000-FFFFF hex in bytes.

The executable flash requires one wait state for reading and writing. It has a long delay from output data on to output data float. This requires that data buffers be installed between the 386EX and the flash. Since doing this only for the flash is awkward, the buffers were put in for all external devices.

The read cycle time for the executable flash is 100 nanoseconds (ns). The write pulse width must be at least 50 ns. Refer to the timing diagrams for the flash for minimum timing parameters. See Figure A22.

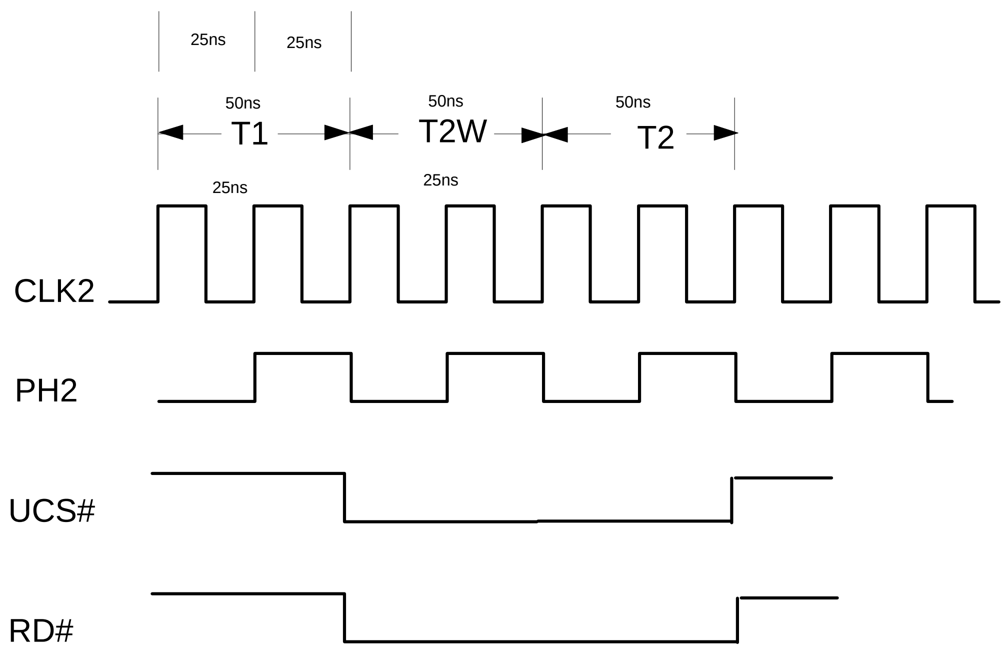


Figure A-22: Flash Timing Parameters

Writing to the flash has the same timing as above, except that the read signal is replaced with the write signal.

A-15 DRAM CONTROL

A-15.1 General

The DRAM control consists of one 256Kx16 DRAM chip (U113), three 74AC157 address mux chips, address resistors, and the FPGA control circuit.

CS6# has been assigned to the DRAM memory address space, 0-3FFFF hex words, or 0-7FFFF hex bytes. The CS6# control register in the chip select unit (CSU) must be programmed for 1 WAIT STATE. Since the data bus is 16 bits wide and the DRAM is a x16 part, most transfers will be of the 16-bit variety. However, 8-bit transfers are allowed, and we have made provisions for byte addressing. This is done by using the upper and lower cas signals, UCAS and LCAS.

A-15.2 DRAM Timing

See Figure A-23. For the DRAM design we must generate 6 signals: RAS#, UCAS#, LCAS#, DRAMOE#, DRAMWR#, and CASADREN. All of these signals are generated in the FPGA from the 386EX signals, ADS#, CS6#, M/IO#, D/C#, WR#, and RD#. Since the CSU is programmed for one wait state, the CSU generates the READY# signal, which terminates the transfer.

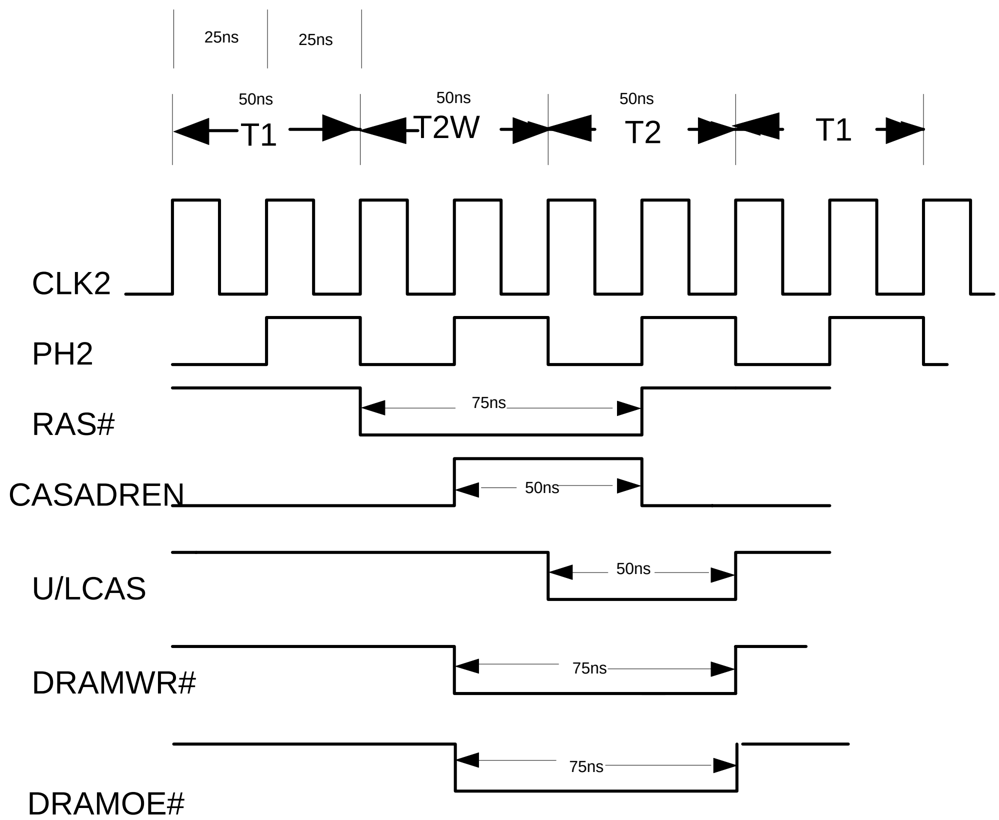


Figure A-23: DRAM Timing Parameters

The DRAM requires 130 ns total time, read/write and precharge for each cycle. There is one wait state for each DRAM access and a total of three T states which is 150 ns. Since the DRAM minimum access time is 130 ns, we have 20 ns of margin. We are using the Hitachi HM51W4260AL, which has a RAS# time of 70 ns, a precharge time of 50 ns, a CAS# time of 20 ns, and a WE# time of 15 ns. The BLE# and BLH# signals are used to select byte-oriented reads and writes. There are 2 CAS# lines, which are used to implement the byte writes.

The RAS# and CAS# requirements are shown in Figure A-24.

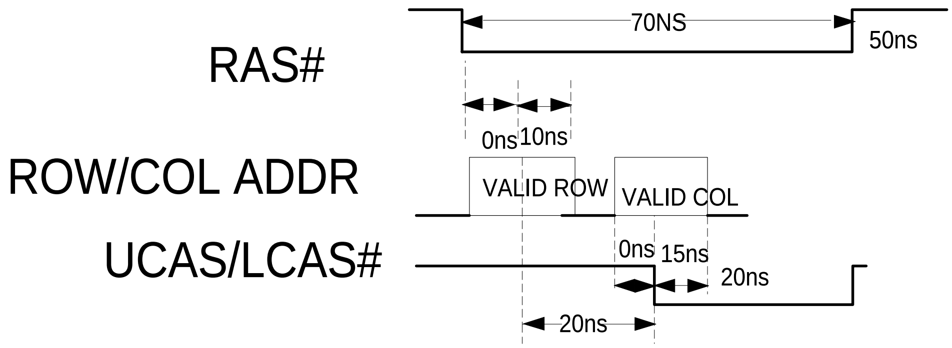


Figure A-24: RAS and CAS Timing

A-15.3 DRAM FPGA CIRCUITS

The DRAM control circuits in the FPGA must decode the various 386EX control signals and generate the DRAM signals. This is done by using CS6# to set a flip-flop when ADS# and PH2 are true. When this is true, a flip-flop is set, which is output as RAS# and is 75 ns long. This signal is generated for all DRAM accesses and refresh. The DRAM output is enabled when either BLE# or BHE# is true, which means a read is occurring. Since the DRAM outputs are bi-directional, we need to disable the DRAMOE# signal if a write is taking place. The WR# signal being false allows DRAMOE# to occur, and if it is true, then the DRAMWR# signal occurs. The BLE# and BHE# signals are also used to generate the UCAS# and LCAS# signals during a read or write operation. Since we are using RAS only for refresh, the CAS signals must be inhibited for refresh.

A-16 REAL TIME CLOCK (RTC)

A-16.1 General

The RTC is a 14-pin package (U120) with an internal crystal. Power connections go to 3.3V, which is separate from the main 3.3V and is generated from the battery via U103. When power shuts off, this 3.3V will still power the RTC and it will continue to keep time. The RTC is an Epson with part number RTC-4543SA. It interfaces to the processor via four port pins, P3.6, P2.1, P2.2, P2.3, which are software programmable. The software must generate the correct timing on these pins to read and write to the RTC.

A-16.2 RTC Timing

A-16.2.1 Read Operation

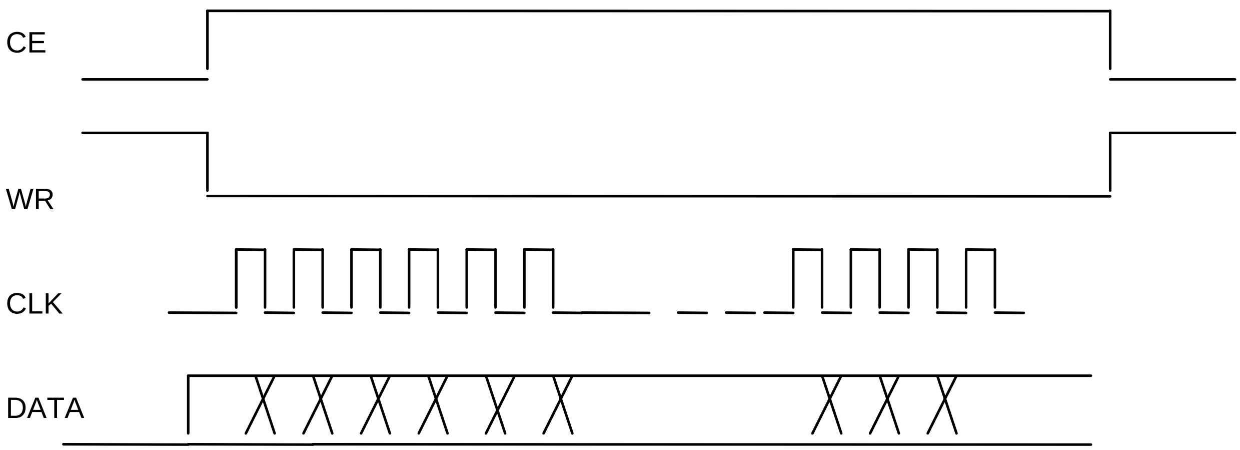


Figure A-25: Read Timing

When the WR signal is low and the CE signal is high, the RTC enters the data output mode.

At the first rising edge of the CLK signal, the clock and calendar data are loaded into the shift register and the LSB of the seconds digit is output from the DATA pin.

The remaining seconds, minutes, hour, day of the week, day, month, and year data is shifted out in sequence and in synchronization with the rising edge of the CLK signal so that the data is output from the DATA pin.

A-16.2.2 Write Operation

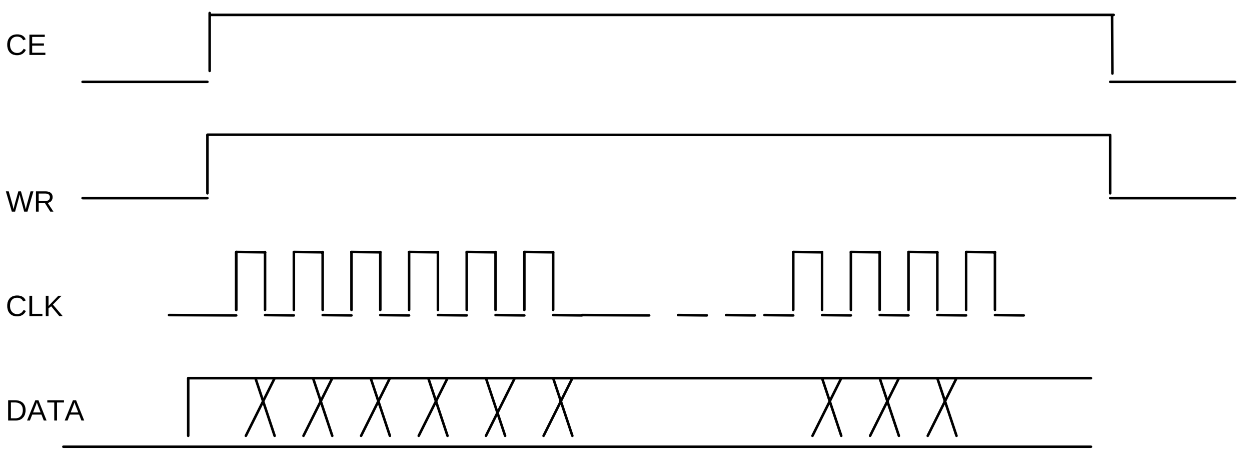


Figure A-26: Write Timing

When the WR signal is high and the CE signal is high, the RTC enters the data input mode.

In this mode, data is input in succession and in synchronization with the rising edge of the CLK signal, to the shift register from the DATA pin, starting from the LTS-B of the seconds digits.

After the last data is input to the shift register at the rising edge of the 52^{nd} clock pulse, the contents of the shift register are transferred to the timer counter.

A-17 UART OPERATION

A-17.1 General

The NPB-3900 has one UART. CS4# selects the UART and data is written and read via the data bus. A Maxim 211E (U119) translates the UART signals to RS-232 voltage levels.

The NPB-3900 and recorder have RS-232 male interface connectors. They are connected using a null modem cable with female connectors. The pin assignments are shown below.

A-17.2 NPB-3900 Connections to Printer

Connector NPB-3900 (Male)	Null Modem Cable Female --------------------------	Female	Connector Recorder Male
NC 1	**1**	**1**	**1 NC**
<<<< **RX 2**	**2**	**3**	**3 TX** <<<<
>>>> **TX 3**	**3**	**2**	**2 RX** ->>>>
>>>> **RESET 4**	**4**	**6**	**6 RESET** >>>>
<< >> **GND 5**	**5**	**5**	**5 GND** << >>
<<<< **DSR 6**	**6**	**4**	**4 NC**
>>>> **RTS 7**	**7**	**8**	**8 CTS** >>>>
<<<< **CTS 8**	**8**	**7**	**7 RTS** <<<<
>>>> **ALM 9**	**9**	**9**	**9 NC**

The RS-232 signal levels are defined in the following paragraphs.

Signals are considered to be in the MARK (“1”) state when the voltage is more negative than - 3 volts with respect to ground. Signals are considered to be in the SPACE (“0”) state when the voltage is more positive than + 3 volts with respect to ground.

For data signal lines, TX and Rex, the signal is considered to be in the binary “1” state when the voltage is more negative than - 3 volts. The signal is considered to be in the binary “0” state when the voltage is more positive than + 3 volts.

Figure A-27: Data Signal

Control signals, DSR, RTS, RST, and CTS are considered to be ON when the voltage is more positive than + 3 volts, and considered to be OFF when the voltage is more negative than - 3 volts.

Figure A-28: Control Signal

A-18 FPGA GLUE LOGIC

The Actel FPGA (U105) is a 3.3V, 4000 gate device which contains miscellaneous control and glue logic for the NPB-3900. It is packaged in a 100-pin TSOP. The register map for writing and reading follows.

HEX Address	Write	Read	# Bits	Data Bus Bits
300	Pump PWM	Same	8	D7-D0
302	Valve PWM	Same	10	D9-D0
304	Heater PWM	Same	10	D9-D0
306	Speaker Duty Cycle	Same	16	D15-D0
308	Control Reg	Same	16	D15-D0
30A	Reset Knob	Int Knob/Misc	9	D11,D10,D7-D2
30C	WDTEN	Push Button	5	D7-D3
30E	LCD Data	Same	16	D15-D0
…	…	Frequency Rate Variable	8	D8-D0

The FPGA contains the following control circuits.

1. DRAM control
2. PUSH BUTTON detect
3. RESET/CLOCK PHASE control
4. CONTROL REGISTER control
5. READ-BACK multiplexer
6. PUMP/VALVE PWM
7. TEMPERATURE PROBE HEATER PWM
8. SPEAKER FREQUENCY generator
9. KNOB detect
10. A/D CONVERTER SELECT control
11. Miscellaneous circuits

A-18.1 DRAM CONTROL

The DRAM control circuits consist of a small state machine to generate RAS#, LCAS#, UCAS#, DRAMOE#, WRITE#, CASADREN#, FDRRD, and ENDTABFR. The process of reading, writing, and refreshing the DRAM is controlled by these circuits.

A-18.2 PUSH BUTTON DETECT

When a membrane switch is pressed, a low true signal occurs. All of the membrane switches are ored together to generate the PBINTPD signal which is read via address 30A hex, bit 6, of the status register. The software polls the status register at a known rate and checks to see if this bit is set.

A-18.3 RESET/CLOCK PHASE CONTROL

When power is turned on, a reset signal is entered on pin 64. The RESETFF is set true on the next CLK_40MHz rising clock edge and RESET exits on pin 47. This is the master reset signal for the whole board and the 386EX. At the same time, it is required to make sure that the control circuits are in sync with the 386EX, and this is done by generating our own phase 1 (CLK_PH1) and phase 2 (CLK_PH2) signals. CLK_PH1 starts as soon as RESET goes low. CLK_PH2 always follows CLK_PH1 and is the inverse of CLK_PH1. These clocks are 50% duty cycle clocks running at 20MHz(50 ns period). Each T state of the processor is composed of 2 phases or clock states, first CLK_PH1, then CLK_PH2, and is 50 ns long.

A-18.4 CONTROL REGISTER DECODE CONTROL

The CONTROL REGISTER is a 16-bit register with miscellaneous programmable control bits. These 16 bits are programmable and can be read back via the READ BACK MULTIPLEXER.

A-18.5 READ-BACK MULTIPLEXERS

The read-back multiplexers allow the software to read back the registers programmed, the knob and push buttons, and other miscellaneous signals. The explanation of this circuit is in the register section on the page 3 schematic explanation.

A-18.6 PUMP PWM CONTROL

This circuit consists of an 8-bit holding registers and 8-bit up/down counter, being clocked at 313 kHz. This circuit is used to control the NIBP pump by generating a pulse width modulated signal that drives the pump. The pump PWM signal exists on pin 3. The enable for this signal is the PWM_GO signal in the CONTROL register.

The software loads a value into the 8-bit holding register. The counter is clocked by a 313 kHz clock. When the counter overflows, the value in the holding register is loaded into the counter synchronously with the 313 kHz clock. The counter operates as a count-up then count-down circuit, always generating the same frequency, but with different duty cycles.

Once a value is loaded into the counter, the counter counts up until it overflows. If PUMP_PWM_GO is true, then the PUMP_PWM_FF is output on pin 3. When the counter overflows, the PUMP_PWM_FF changes state, and the counter is reloaded with the holding register’s value. Now the counter counts down until it overflows, at which time, the flip-flop changes state, the holding register’s value is reloaded, and counting continues in the up direction. Since the same value is loaded each time, the total time for a count up and a count down is 313 kHz divided by 255, and, therefore, the signal frequency remains the same. The duty cycle changes as the software programs the holding register, thus allowing for a fully off to a fully on signal.

A-18.7 VALVE PWM CONTROL

This circuit consists of a 10-bit holding register and 10-bit up/down counter, being clocked at 5MHz. This circuit is used to control the NIBP VSO valve by generating a pulse width modulated signal which drives the valve. The valve PWM signal exits on pin 74. The enable for this signal is the VALVE_GO signal in the CONTROL register.

The software loads a value into the 10-bit holding register. The counter is clocked by a 5MHz clock. When the counter overflows, the value in the holding register is loaded into the counter synchronously with the 5MHz clock. The counter operates as a count up then count down circuit, always generating the same frequency, but with different duty cycles. Once a value is loaded into the counter, the counter counts up until it overflows. If VALVE_GO is true, then the VALVE_PWM_FF is output on pin 74. When the counter overflows, the VALVE_PWM_FF changes state, and the counter is reloaded with the holding register’s value. Now the counter counts down until it underflows, at which time, the flip-flop changes state, the holding register’s value is reloaded, and counting continues in the up direction. Since the same value is loaded each time, the total time for a count up and a count down is 5mHz divided by 1023, and, therefore, the signal frequency remains the same. The duty cycle changes as the software programs the holding register, thus allowing for a fully off to a fully on signal.

A-18.8 TEMPERATURE PROBE HEATER PWM CONTROL

The NPB-3900 has a predictive temperature probe which has a heater at the tip of the probe. This heater is controlled by software programming a PWM. It works exactly the same as the VALVE PWM, except it has a 100 kHz clock, and its output is gated with the 100 kHz clock. The PWM controls the number of 100 kHz pulses put out to the heater.

A-18.9 SPEAKER FREQUENCY GENERATOR

The speaker requires tones from about 300 Hz to 1 kHz with a 55% duty cycle. In order to give software full control over both the frequency and duty cycle, there are two software programmable 8-bit up counters, one for generating the low portion of the TONE_OUT and one for generating the high portion. The TONE_OUT flip flop is jammed reset when the FREQ_GO bit in the CONTROL REGISTER is low. This enables the SPEAKER LOW counter. The software programs the high and low values into the respective holding registers, then sets the FREQ_GO bit. The TONE_OUT on pin 55 is low, and remains low until the SPEAKER LOW counter overflows, which sets the TONE_OUT high and loads the SPEAKER HIGH counter. This counter now increments until it overflows, which now sets the TONE_OUT signal low and reloads the SPEAKER LOW counter. This process continues until the software turns off the TONE_OUT signal by resetting the FREQ_GO bit in the CONTROL REGISTER.

A-18.10 KNOB DETECT

The rotating knob on the front of the unit has an optical interface. It is supplied with 5 volts and it and generates two signal channels (A and B) that are input to the FPGA on pins 93 and 94. When the knob rotates clockwise the square wave on CHANNEL A leads the square wave on CHANNEL B by 90 degrees. When rotating counterclockwise, CHANNEL B leads CHANNEL A by 90 degrees. This circuit exclusively ors the channels and generates an edge each time a channel input changes state. One flip flop is set on the rising edge and another is set on the trailing edge. These 2 flops are ored together and exit on pin 62, which is for debugging purposes only. Thus, the software polls the status register and if the KNOB INTERRUPT is high in bit 7 of hex address 30A, software reads the status of the two input channels in bits 4 and 5 of the same register. Software keeps track of these bits and can determine which one changes first to determine the direction. It is up to the software to keep up with the knob rotation and in which direction it is turning.

A-18.11 A/D CONVERTER SELECT CONTROL

The ADCS signal is used to reset and enable the ADC (U207, A/D Converter). When powering up, the reset signal into the FPGA is ored into the ADCS signal or gate and goes high, then low when reset goes away. On the high to low transition the ADC resets itself and is ready for a new command. A programmable bit in the Control register, bit 7, can also be set by software to perform this function. When the ADC is commanded to take a conversion and EOC goes low, indicating the ADC is busy, the ADCS signal goes high as recommended by the vendor to keep noise out of the ADC.

A-18.12 MISCELLANEOUS CIRCUITS

The master clock from the 40MHz oscillator enters the FPGA on two pins, 39 and 75. CLK2_40MHZ is the 40MHz internal clock for the FPGA. A separate clock is required for the I/O flops, and this is generated as IOCLK from the same 40MHz internal clock coming in on a different pin.

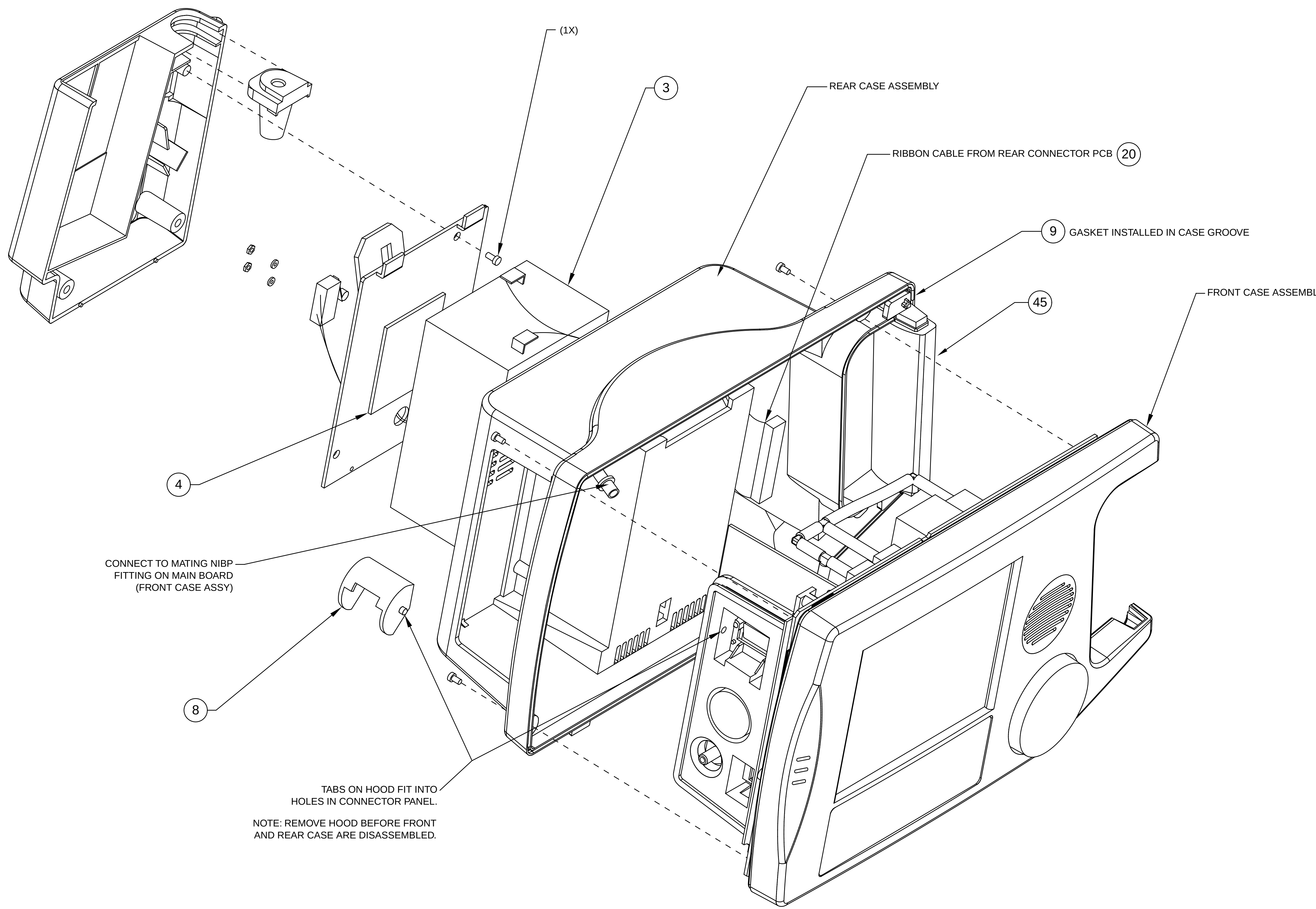


Figure A-29

NPB-3900 Top Assembly Drawing (Sheet 1 of 2)

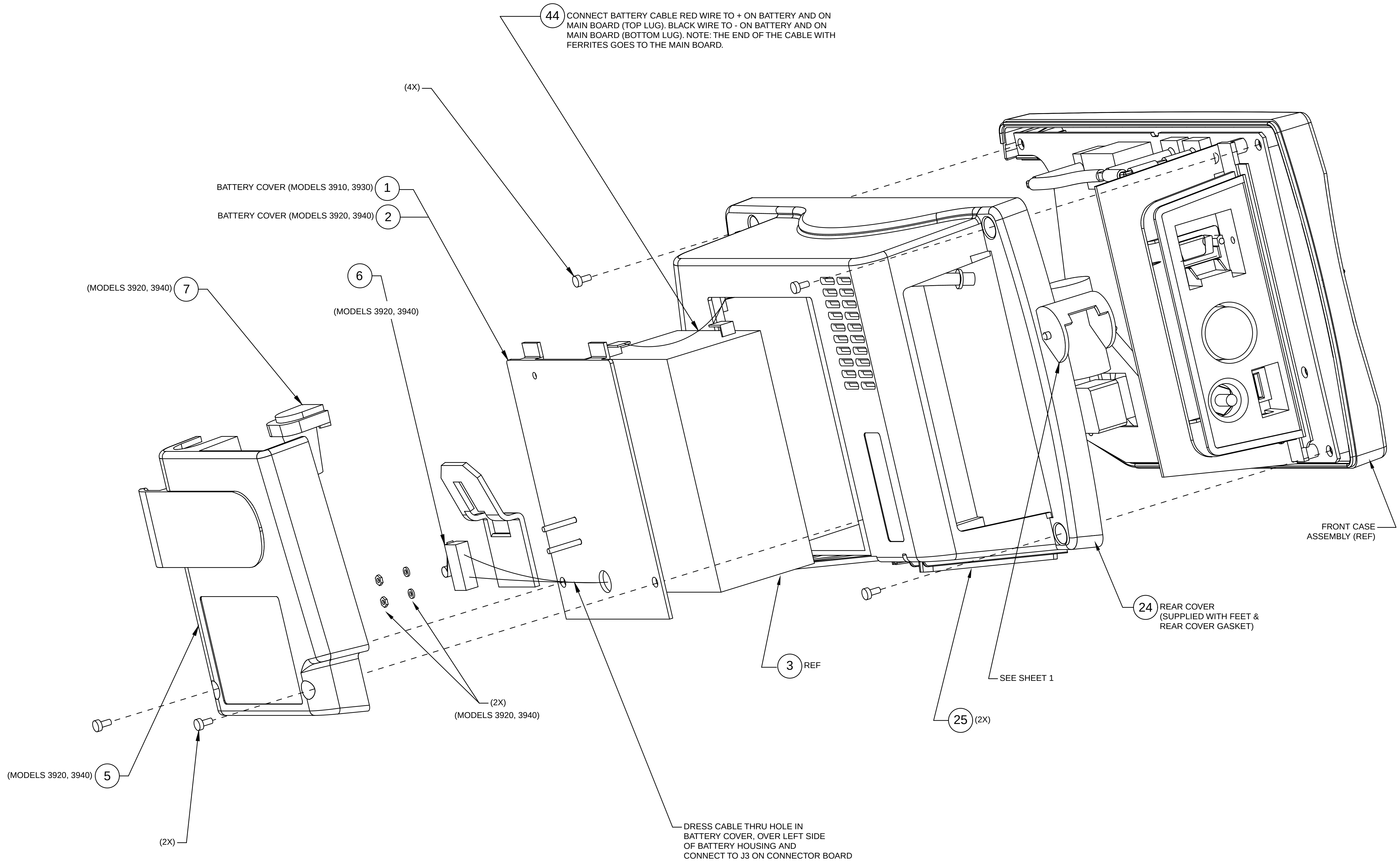


Figure A-29

NPB-3900 Top Assembly Drawing (Sheet 2 of 2)

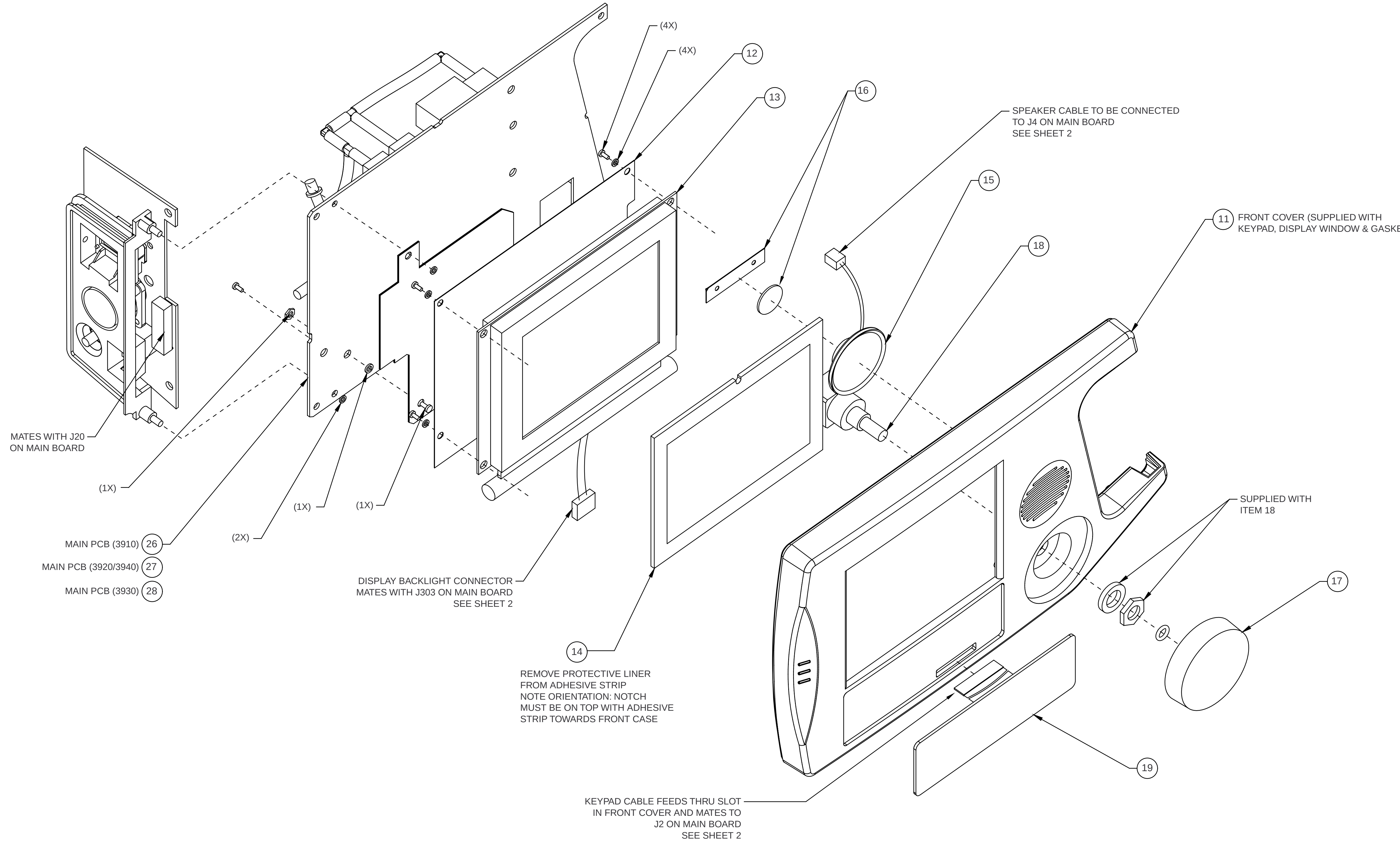


Figure A-30

NPB-3900 Front Case Assembly Drawing (Sheet 1 of 2)

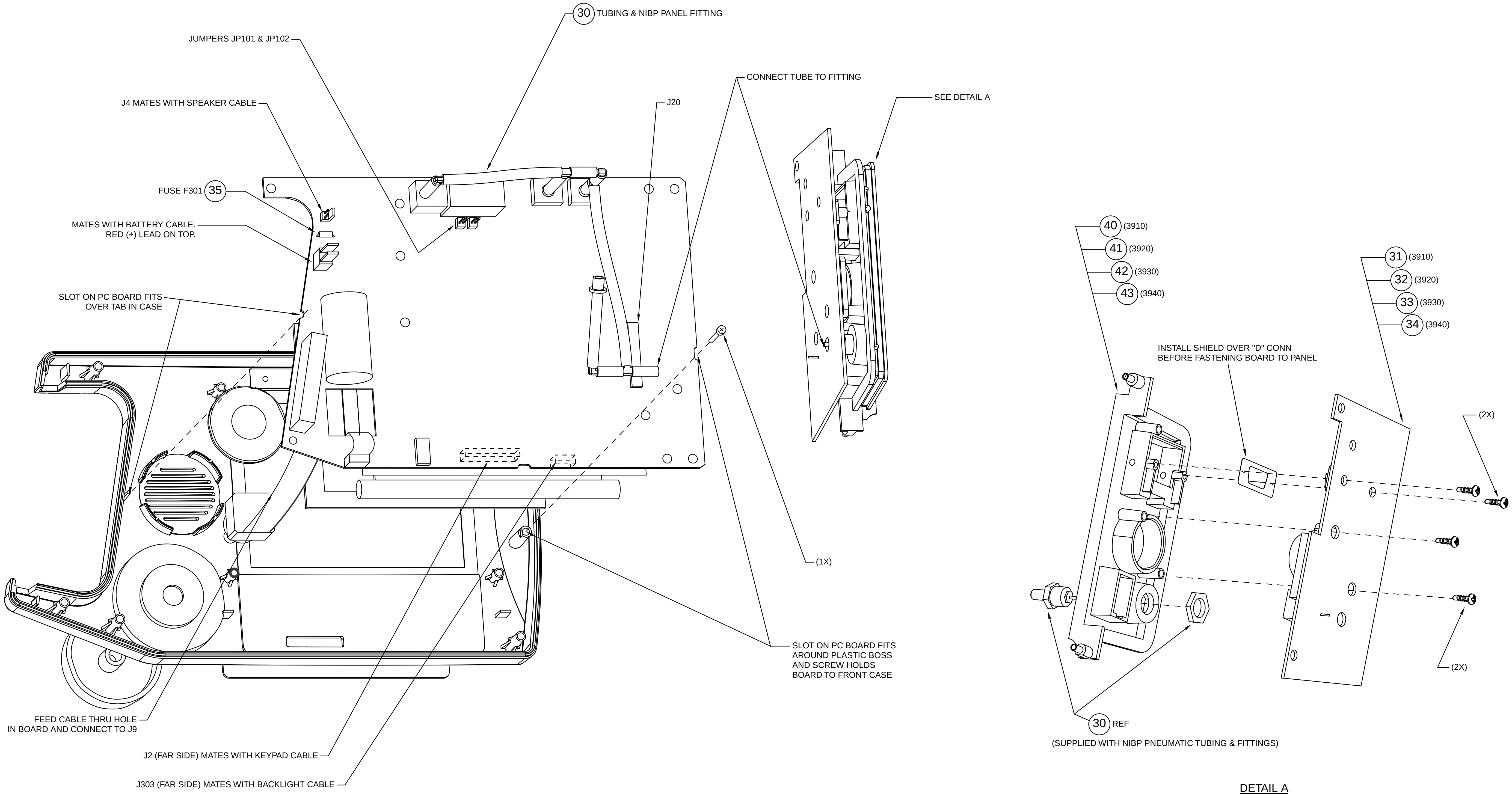


Figure A-30

NPB-3900 Front Case Assembly Drawing (Sheet 2 of 2)

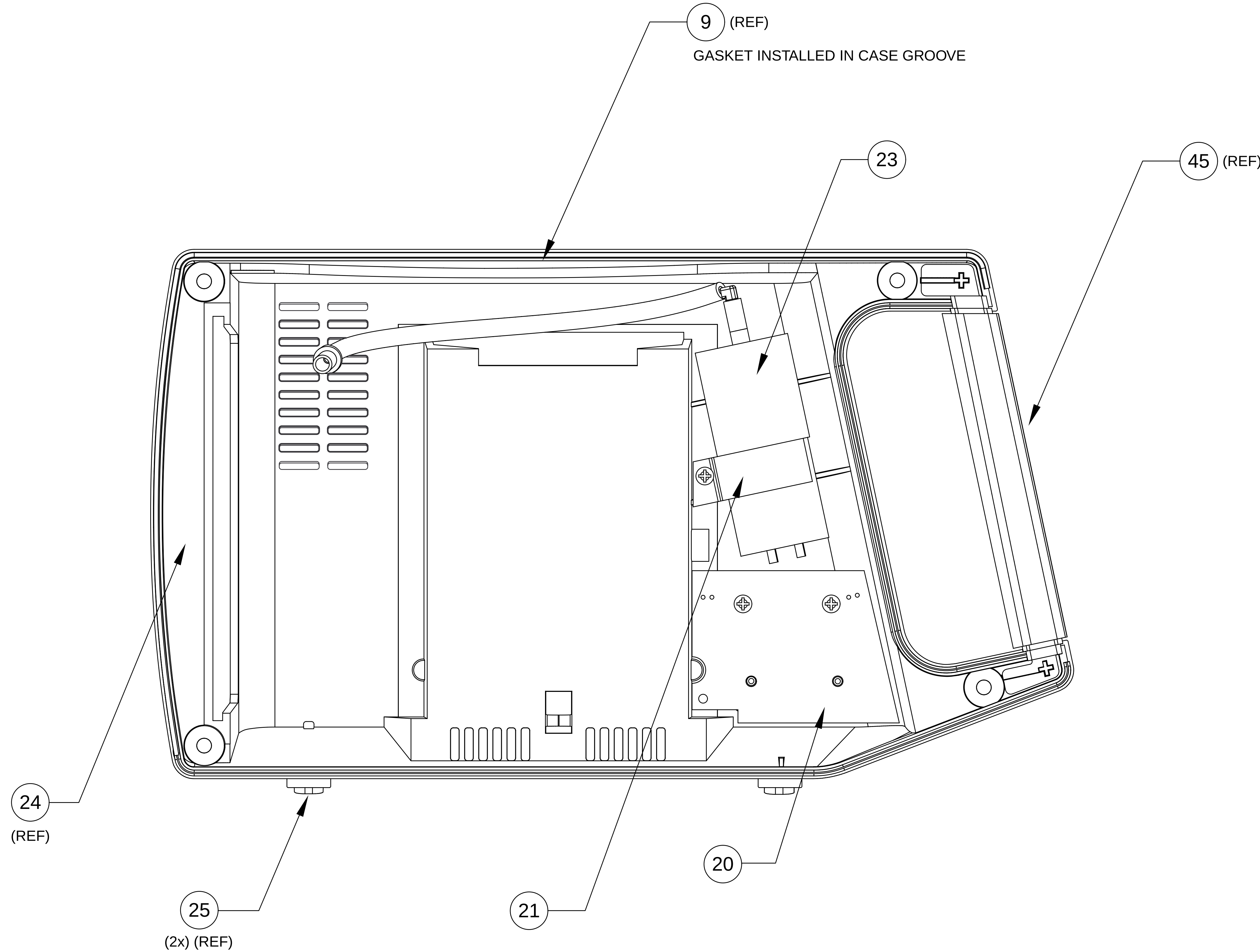


Figure A-31

NPB-3900 Rear Case Assembly Drawing

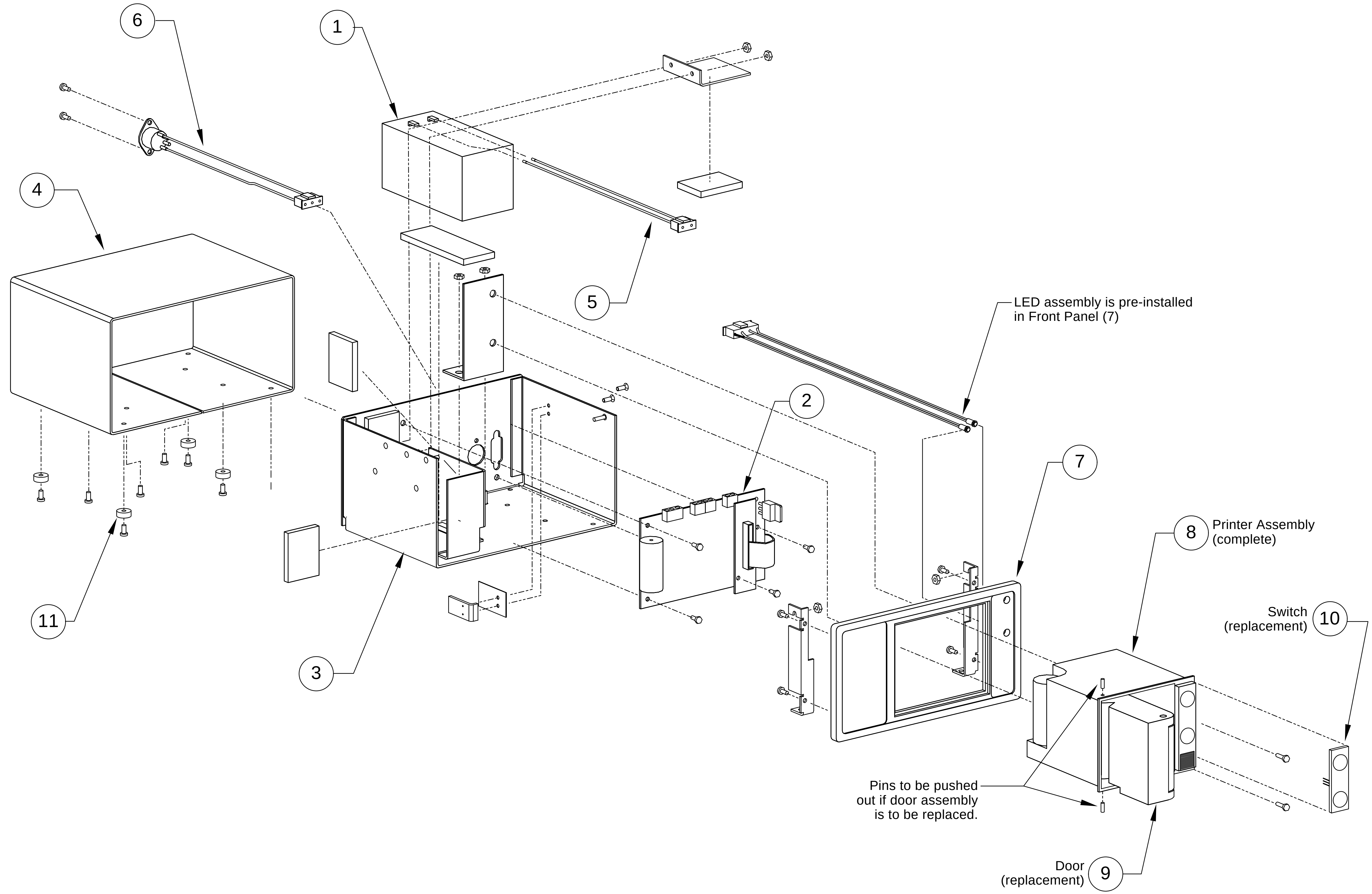


Figure A-32

P-3900 Assembly Drawing

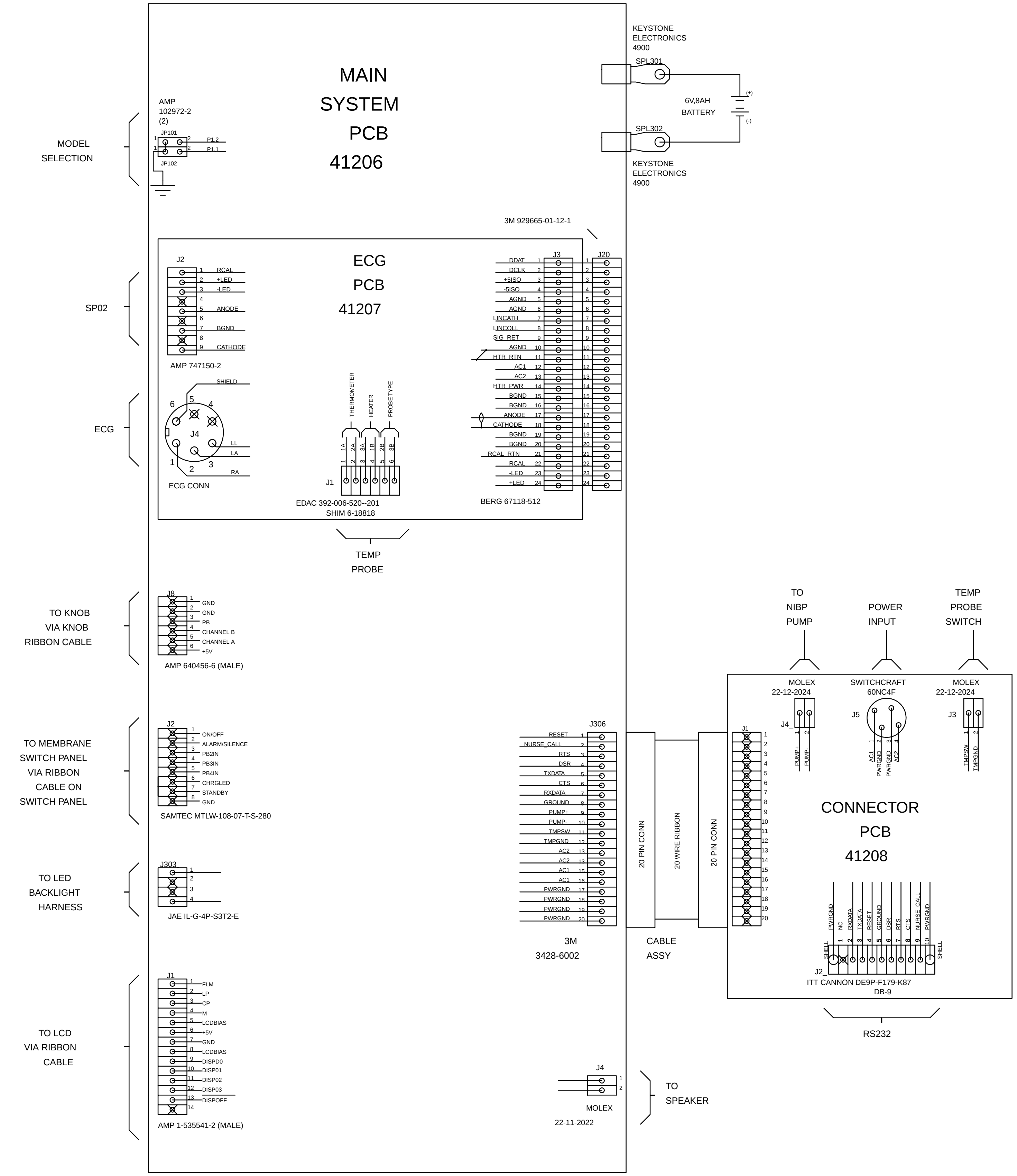


Figure A-33

NPB-3900 Interconnect Diagram

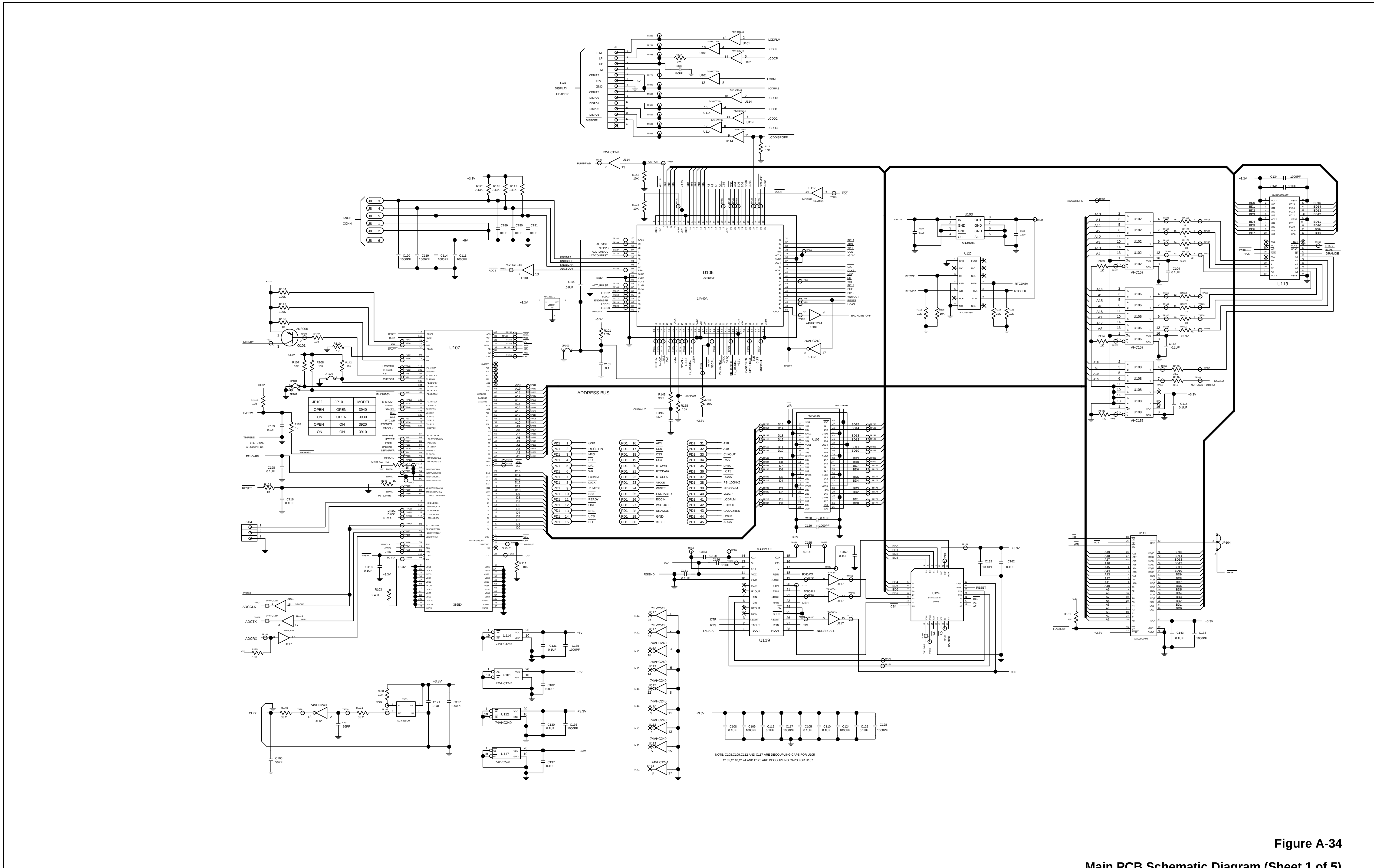


Figure A-34

Main PCB Schematic Diagram (Sheet 1 of 5)

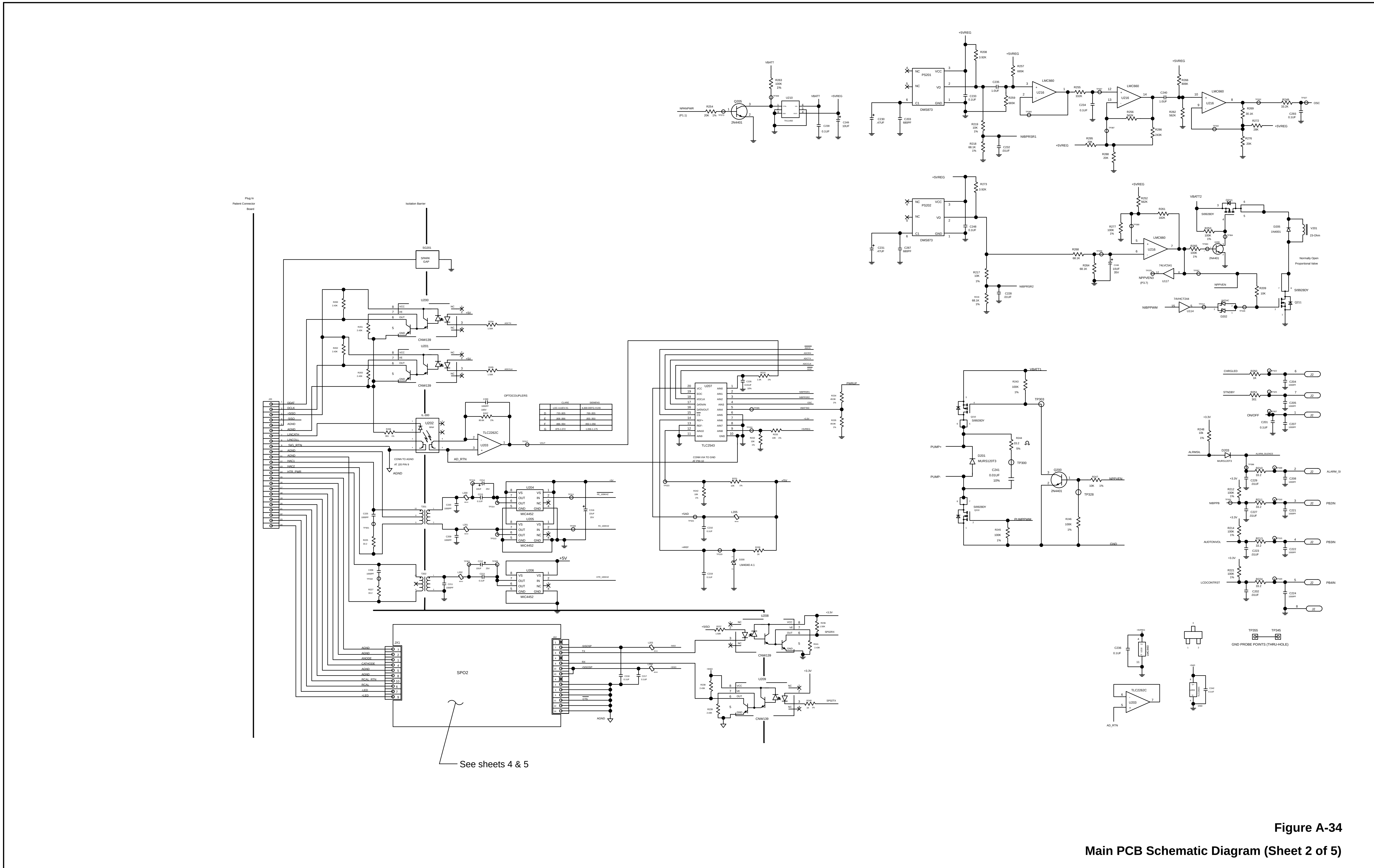


Figure A-34

Main PCB Schematic Diagram (Sheet 2 of 5)

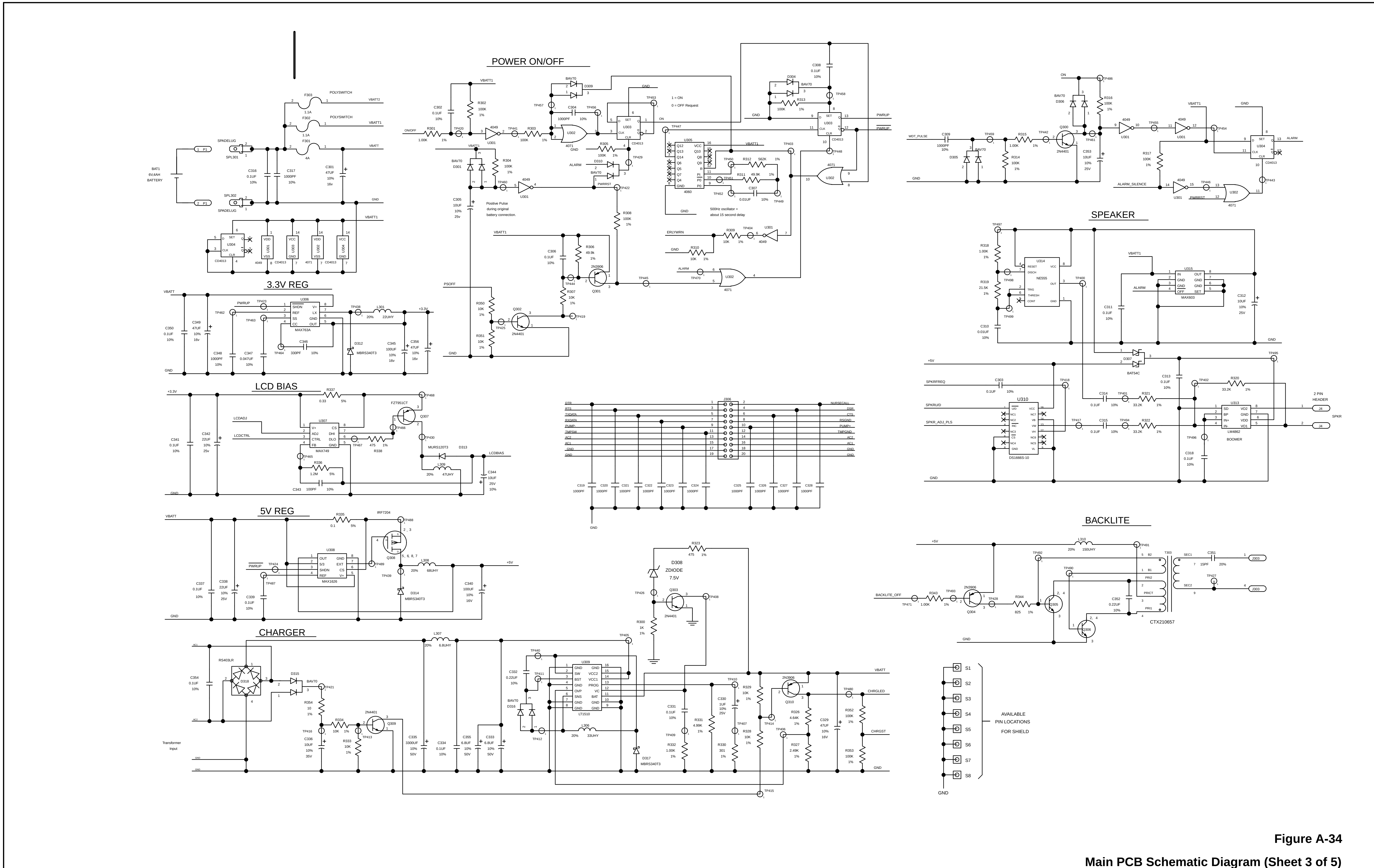
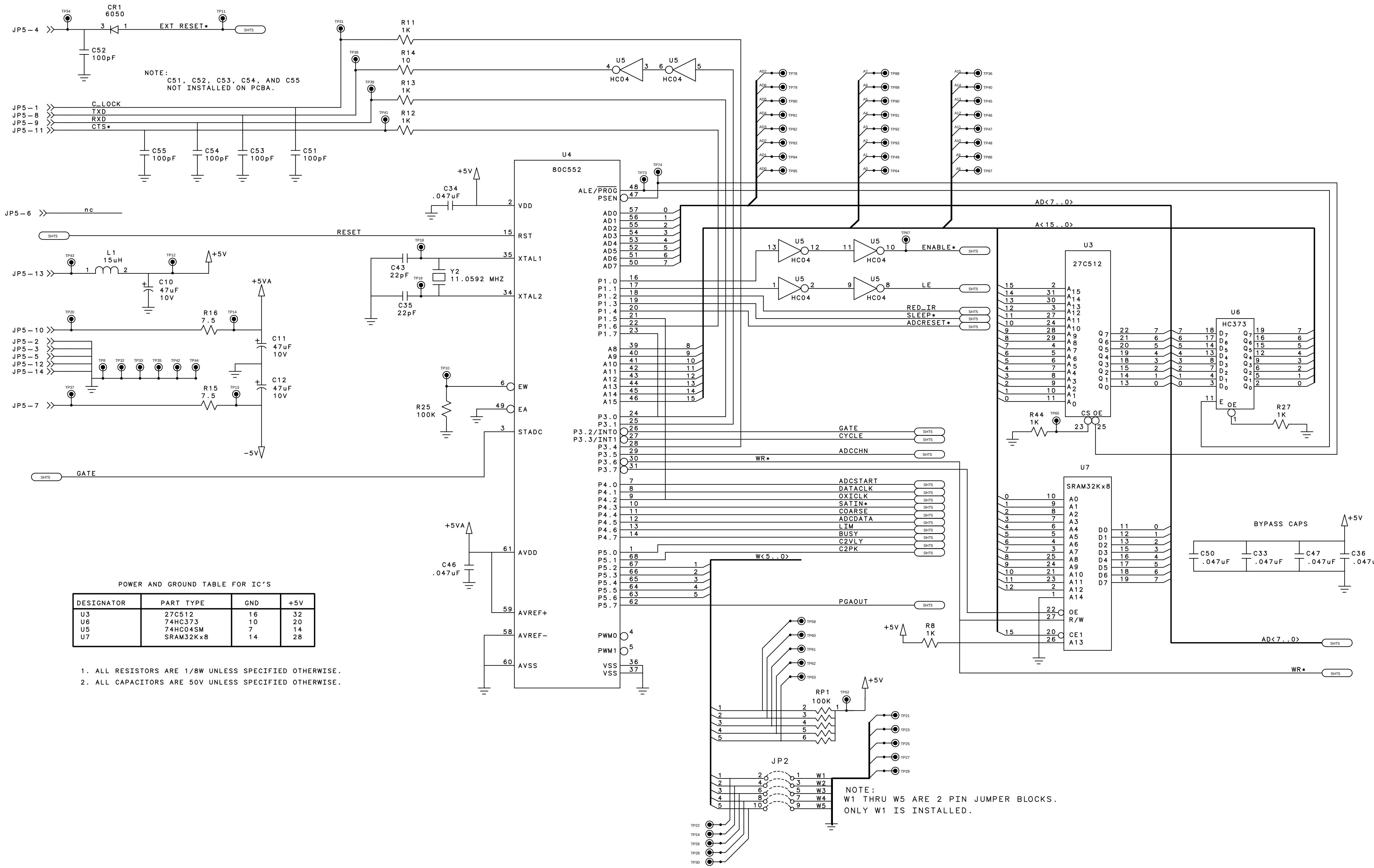


Figure A-34

Main PCB Schematic Diagram (Sheet 3 of 5)



DESIGNATOR	PART TYPE	GND	+5V
U3	27C512	16	32
U6	74HC373	10	20
U5	74HC04SM	7	14
U7	SRAM32Kx8	14	28

Figure A-34

Main PCB Schematic Diagram (Sheet 4 of 5)

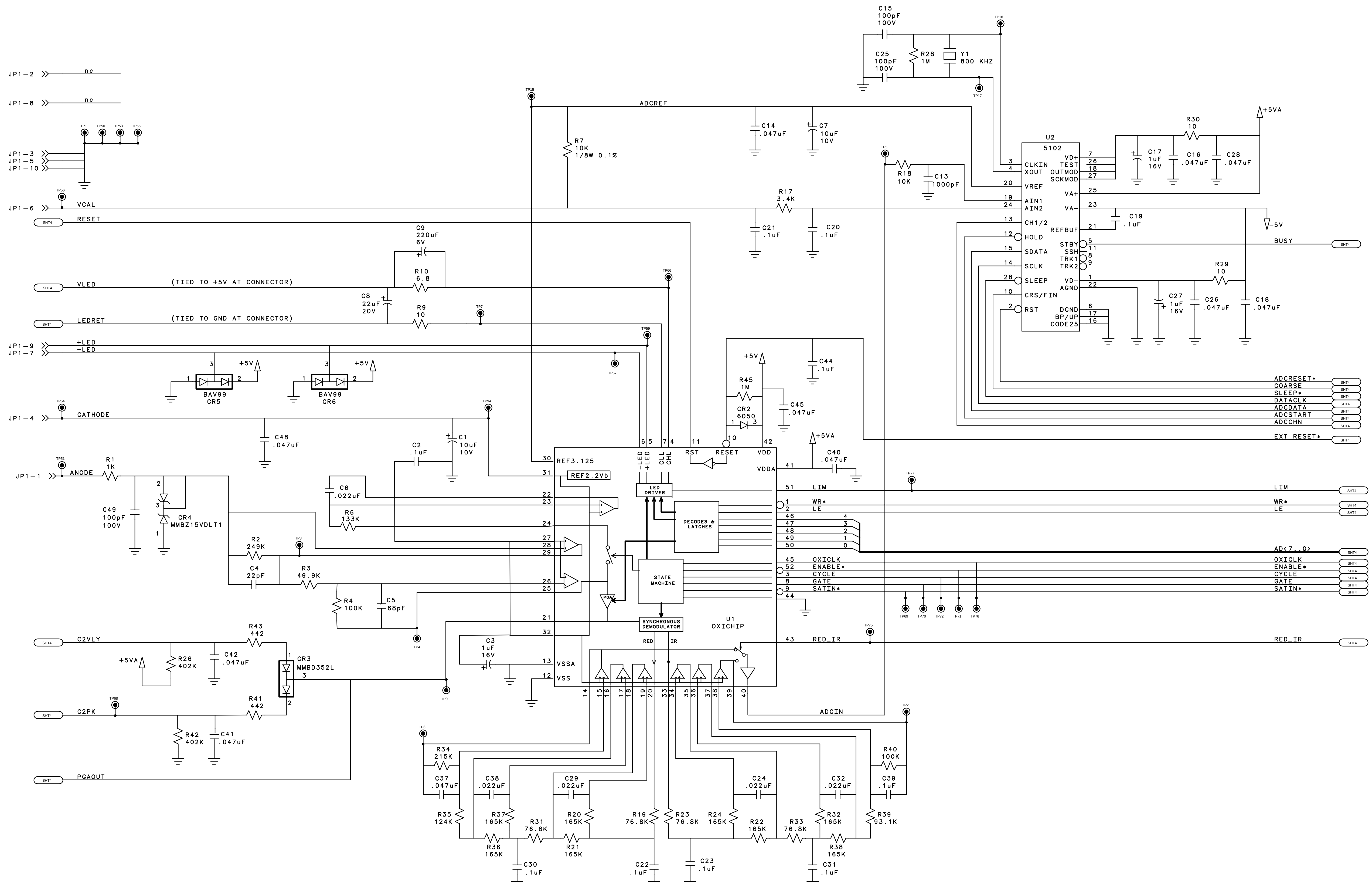


Figure A-34

Main PCB Schematic Diagram (Sheet 5 of 5)

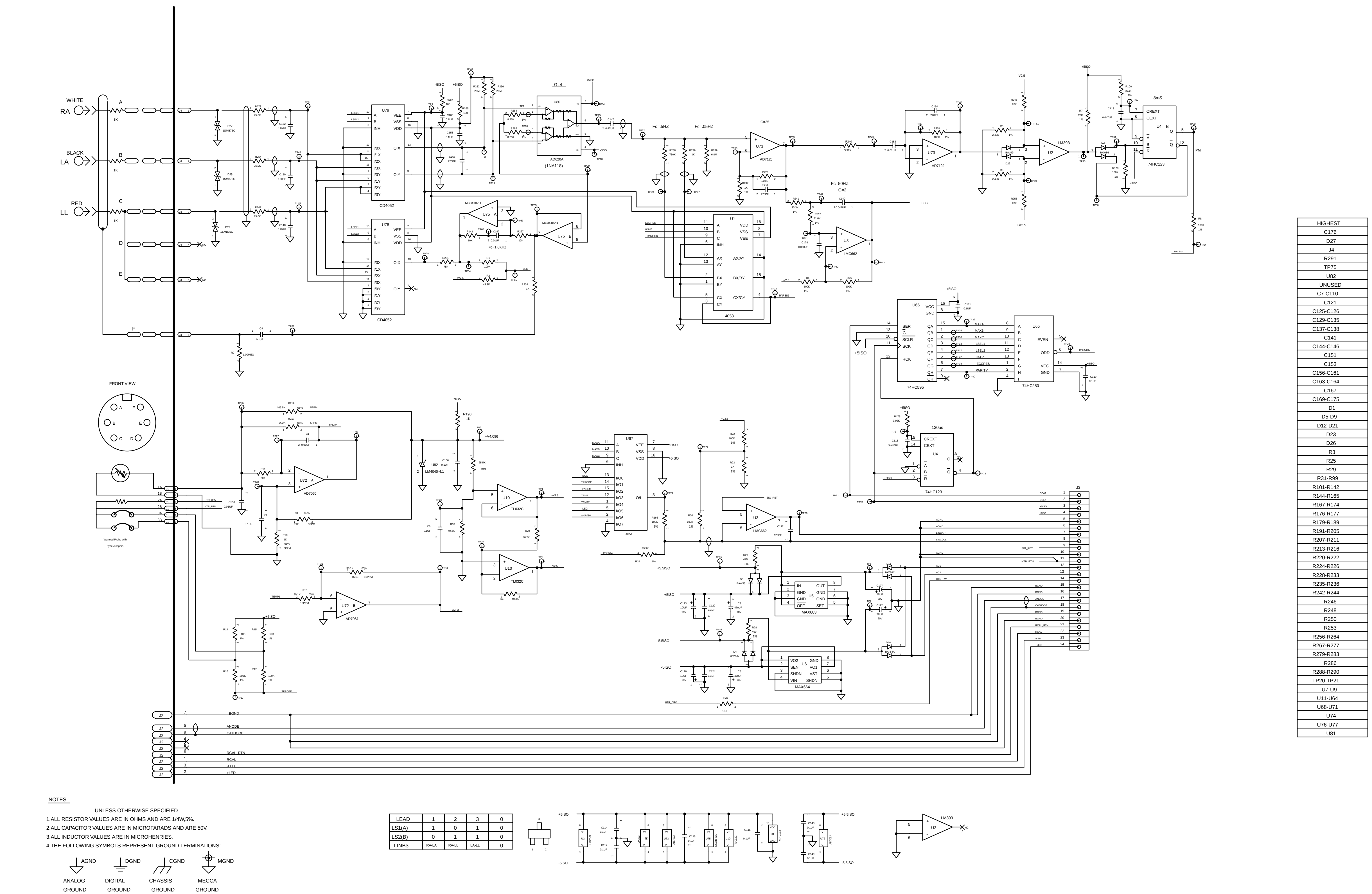


Figure A-35

NPB-3900Patient Connector PCB Schematic Diagram