NELLCOR

SERVICE MANUAL

NPB-295 Pulse Oximeter

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

To contact Mallinckrodt, Inc. representative: In the United States, call 1-800-635-5267; outside the United States, call your local Mallinckrodt representative.

CE 0123

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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 *Nellcor* model NPB-295 pulse oximeter. Only qualified service personnel should service this product. Before servicing the NPB-295, read the operator's manual carefully for a thorough understanding of operation.

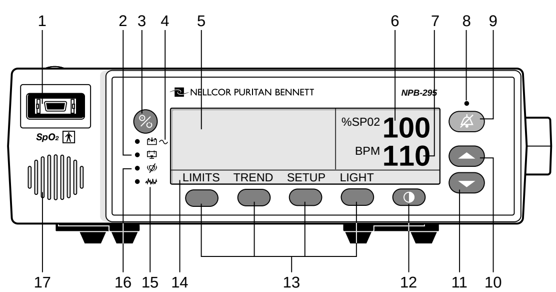
Warning: Explosion hazard. Do not use the NPB-295 pulse oximeter in the presence of flammable anesthetics.

1.2 NPB-295 PULSE OXIMETER DESCRIPTION

The NPB-295 is a portable pulse oximeter intended for use as a continuous noninvasive monitor of arterial oxygen saturation (SpO_2) and pulse rate.

It can be used on adult, pediatric and neonatal patients. Oxygen saturation and pulse rate are displayed digitally along with a plethysmographic waveform or a 10-segment blip bar that indicates pulse intensity. This monitor is intended for use in hospital and hospital-type facilities, during intra-hospital transport, and in home environments.

Through the use of the four softkeys, the operator can access trend information, select an alarm limit to be changed, choose the language to be used, adjust the internal time clock, and change communications protocol. The NPB-295 can operate on AC power or on an internal battery. The controls and indicators for the NPB-295 are illustrated in Figures 1-1 through 1-3.



1. SpO2 Sensor Port
2. Low Battery Indicator
3. Power On/Off Button
4. AC/Battery Charging Indicator
5. Waveform Display
6. %SpO2 Indicator
7. Pulse Beats Per Minute display
8. Alarm Silence Indicator
9. Alarm Silence Button
10. Adjust Up Button
11. Adjust Down Button
12. Contrast Button
13. Softkeys
14. Menu Bar
15. Motion Indicator
16. Pulse Search Indicator
17. Speaker

Figure 1-1: NPB-295 Front Panel

Figure 1-2 illustrates the various functions that are available through the use of the softkeys, and how to access them. A complete explanation of the keys is provided in the NPB-295 operator's manual.

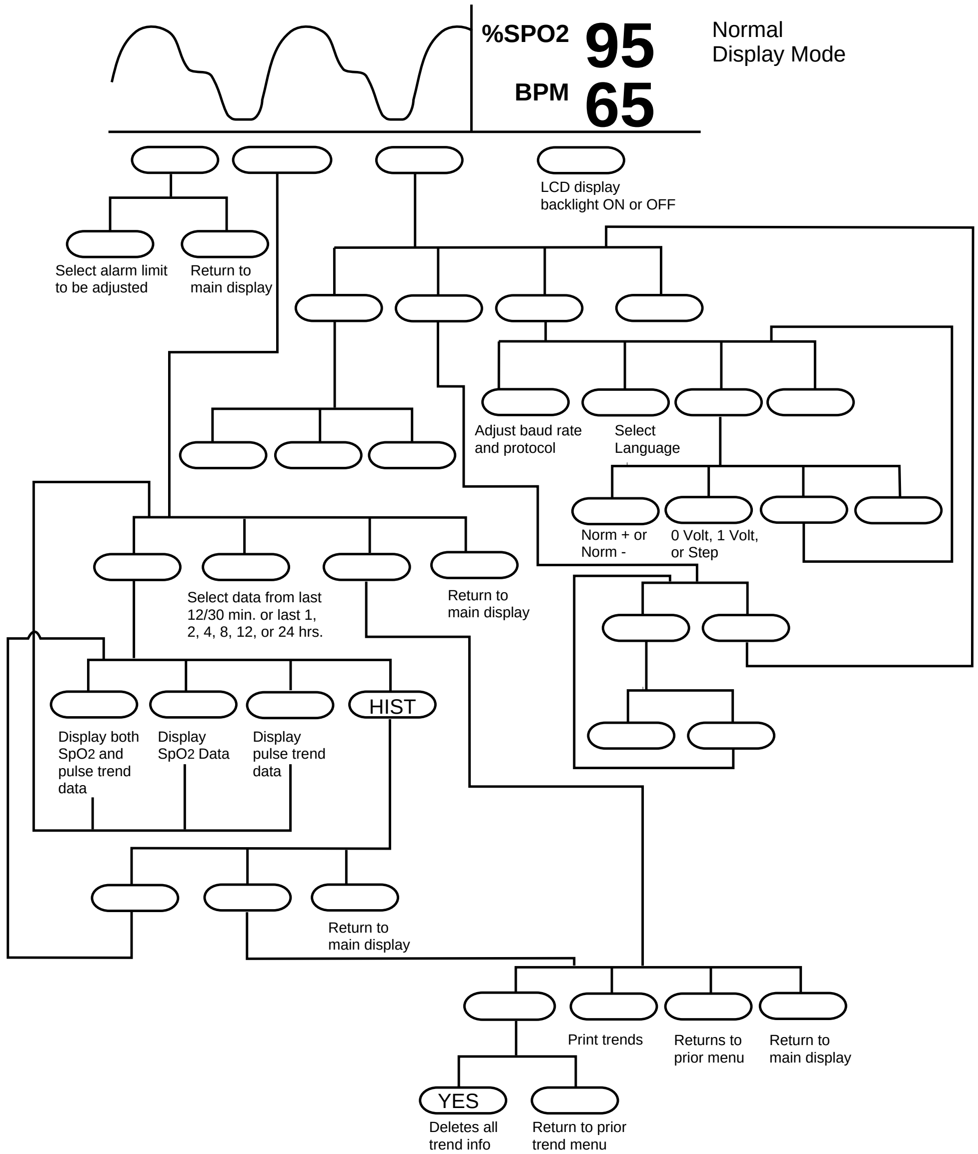
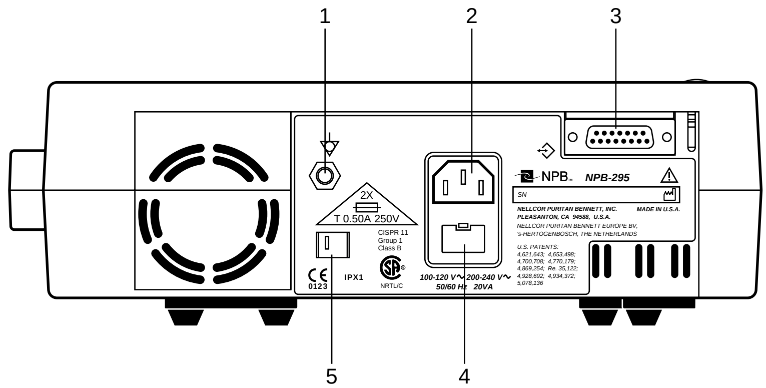


Figure 1-2: User Softkey Map



1. Equipotential (ground) Terminal
2. AC Inlet
3. DB-15 Interface Connector (Data Port)
4. Fuse Receptacle
5. Voltage Selection Switch

Figure 1-3: NPB-295 Rear Panel

1.3 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-295 operator’s manual. To understand the various *Nellcor* sensors that work with the monitor, refer to the individual sensor’s directions for use.

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SECTION 2: ROUTINE MAINTENANCE

2.1 CLEANING

Caution: Do not immerse the NPB-295 or its accessories in liquid or clean with caustic or abrasive cleaners. Do not spray or pour any liquid on the monitor or its accessories.

To clean the NPB-295, 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, fuse holder, or switches. Do not allow any liquids to penetrate connectors or openings in the instrument cover. Wipe sensor cables with a damp cloth. For sensors, follow each sensor's directions for use.

2.2 PERIODIC SAFETY AND FUNCTIONAL CHECKS

The NPB-295 requires no calibration.

The battery should be replaced every 2 years. See *Battery Replacement* on 6-5.

The following checks should be performed at least every 2 years by a qualified service technician.

1. Inspect the exterior of the NPB-295 for damage.
2. Inspect safety labels for legibility. If the labels are not legible, contact Mallinckrodt Technical Services Department or your local Mallinckrodt representative.
3. Verify 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 the NPB-295. Contact Mallinckrodt Technical Services Department or your local Mallinckrodt representative.
5. Inspect the fuses for proper value and rating (F1 & F2 = 0.5 amp slow blow).

2.3 BATTERY

Mallinckrodt recommends replacing the instrument's battery every 2 years. When the NPB-295 is going to be stored for 3 months or more, remove the battery prior to storage. To replace or remove the battery, refer to Section 6, Disassembly Guide.

If the NPB-295 has been stored for more than 30 days, charge the battery as described in paragraph 3.3.1. A fully discharged battery requires 14 hours with the monitor in standby, or 18 hours if it is in use, to receive a full charge. The battery is being charged whenever the instrument is plugged into AC.

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-295 cover. All tests except the battery charge and battery performance tests must be performed as the last operation before the monitor is returned to the user.

If the NPB-295 fails to perform as specified in any test, repairs must be made to correct the problem before the monitor is returned to the user.

3.2 EQUIPMENT NEEDED

Equipment	Description
Digital multimeter (DMM)	Fluke Model 87 or equivalent
Durasensor ® oxygen transducer	DS-100A
Oxisensor ® *II* oxygen transducer	D-25
Pulse oximeter tester	SRC-2
Safety analyzer	Must meet current AAMI ES1/1993 & IEC 601-1/1998 specifications
Sensor extension cable	SCP-10 or MC-10
Serial interface cable	EIA-232 cable (optional)
Stopwatch	Manual or electronic

3.3 PERFORMANCE TESTS

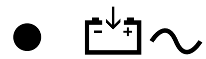
The battery charge procedure should be performed before monitor repairs whenever possible.

Note: This section is written using Mallinckrodt factory-set defaults. If your institution has preconfigured custom defaults, those values will be displayed. Factory defaults can be restored using the configuration mode procedure described in paragraph 4.3.3.

3.3.1 Battery Charge

Perform the following procedure to fully charge the battery.

1. Connect the monitor to an AC power source.
2. Verify the monitor is off and that the AC Power/Battery Charging indicator is lit.



3. Charge the battery for at least 14 hours in standby.

3.3.2 Power-up Performance

The power-up performance tests (3.3.2.1 through 3.3.2.2) verify the following monitor functions:

- Power-On Self-Test
- Power-On Defaults and Alarm Limit Ranges

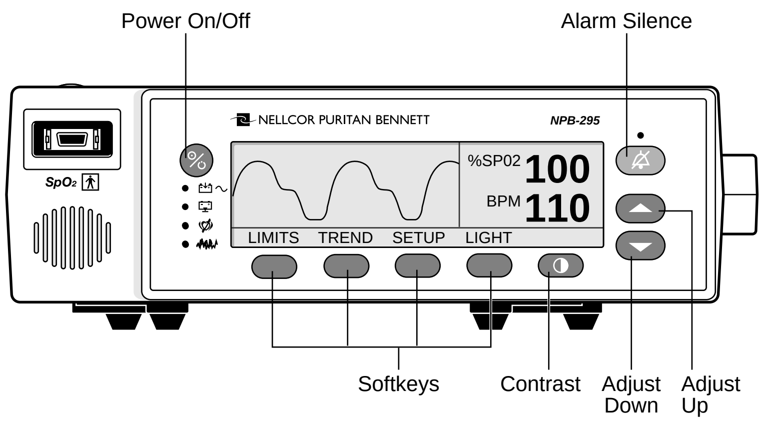


Figure 3-1: NPB-295 Controls

3.3.2.1 Power-On Self-Test

1. Connect the monitor to an AC power source and verify the AC Power/Battery Charging 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 Power On/Off button. The monitor must perform the following sequence.
   a. Within 2 seconds all LEDs are illuminated, then all pixels on the LCD display are illuminated, after which the backlight comes on.
   b. The indicators remain lighted.
   c. The LCD display shows the Nellcor Puritan Bennett logo and the software version of the NPB-295 (Figure 3-2).

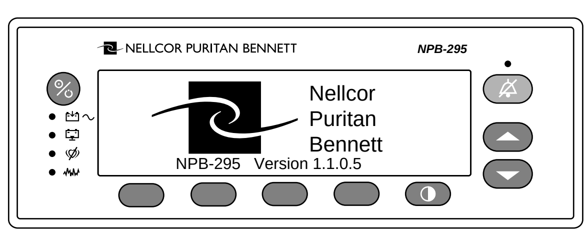


Figure 3-2: Self-Test Display

d. A 1-second beep sound indicating proper operation of the speaker, and all indicators turn off except the AC Power/Battery Charging indicators.

e. The NPB-295 begins normal operation.

3.3.2.2 Power-On Defaults and Alarm Limit Ranges

Note: When observing or changing default limits, a 10-second time-out is in effect. If no action is taken within 10 seconds, the monitor automatically returns to the monitoring display.

Note: The descriptions that follow are based on the assumption that Pleth is the view that has been selected. The steps to change an alarm limit are the same if the view being used is Blip.

1. Ensure that the monitor is on. Press and release the Limits softkey. Verify the monitor emits a single beep and the plethysmograph waveform is replaced with a display of the alarm limits. The high alarm limit for %SpO2 will indicate an alarm limit of "100" inside a box (Figure 3.3).

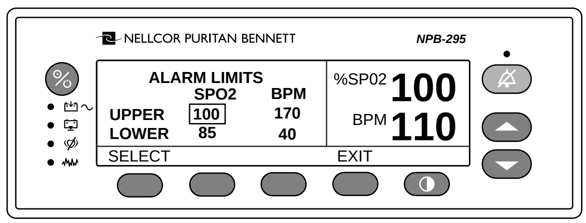


Figure 3-3: Adjusting %SpO2 Upper Alarm Limit

2. Press the Limits softkey. Press and hold the Down Arrow button. Verify the boxed number for %SpO2 upper alarm limit reduces to a minimum of "85."

Note: A decimal point in the display indicates that the alarm limits have been changed from factory default values.

3. Press the SELECT softkey. Verify the monitor emits a single beep and the box moves to the %SpO2 lower alarm limit of "85".

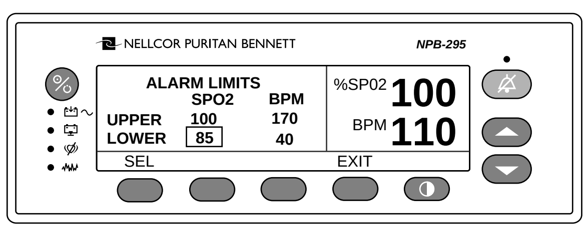


Figure 3-4: Adjusting % SpO2 Lower Alarm Limit

4. Press and hold the Down Arrow button and verify the %SpO2 lower alarm limit display reduces to a minimum of "20".

5. Press and hold the Up Arrow button and verify the %SpO2 lower alarm limit display cannot be raised past the upper alarm limit setting of "85".

6. Press the Exit button.

7. Press the Limits softkey then press the SELECT softkey two times Verify the monitor emits a beep after each keystroke. The Pulse upper alarm limit should be “170” and should be boxed.

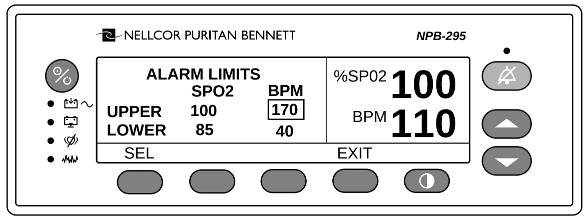


Figure 3-5: Adjusting High Pulse Rate Alarm

8. Press and hold the Down Arrow button. Verify the minimum displayed value is “40” for the Pulse upper alarm limit.

9. Press the exit button.

10. Press the Limits softkey then press the SELECT softkey three times. Verify the Pulse lower alarm limit display indicates an alarm limit of “40” and is boxed.

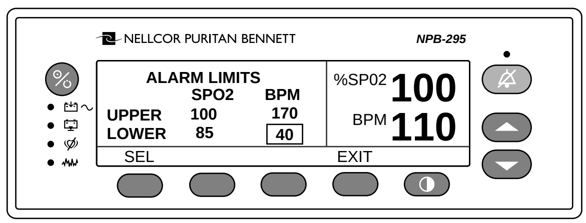


Figure 3-6: Adjusting Low Pulse Rate Alarm

11. Press and hold the Down Arrow button. Verify the boxed Pulse lower alarm limit display reduces to a minimum of “30”.

12. Press and hold the Up Arrow button and verify the boxed Pulse lower alarm limit display cannot be adjusted above the Pulse high limit of “40”.

13. Press the Power On/Off button to turn the monitor off.

14. Press the Power On/Off button to turn the NPB-295 back on.

15. Press and release the Limits softkey. Verify the %SpO2 upper alarm limit display is boxed and indicates an alarm limit of “100”.

16. Press the SELECT softkey. Verify the %SpO2 lower alarm limit display is boxed and indicates an alarm limit of “85”.

17. Press the SELECT softkey a second time. Verify the Pulse upper alarm limit display is boxed and indicates an alarm limit of “170”.

18. Press the SELECT softkey a third time. Verify the Pulse lower alarm limit display is boxed and indicates an alarm limit of “40”.

19. Press the Power On/Off button to turn the monitor off.

3.3.3 Hardware and Software Tests

Hardware and software testing includes the following tests:

- Operation with a Pulse Oximeter Tester
- General Operation

3.3.3.1 Operation with a Pulse Oximeter Tester

Operation with an SRC-2 pulse oximeter tester includes the following tests:

- Alarms and Alarm Silence
- Alarm Volume Control
- Pulse Tone Volume Control
- Dynamic Operating Range
- Nurse Call
- Analog Output
- Operation on Battery

3.3.3.1.1 Alarms and Alarm Silence

1. Connect the SRC-2 pulse oximeter tester to the sensor-input 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 Power On/Off button to turn the monitor on. After the normal power-up sequence, press the following softkeys; Setup, View, and Pleth. Verify the %SpO2 and Pulse initially indicates zeroes.

3. Move the modulation switch on the SRC-2 to LOW.

4. Verify the following monitor reactions:

   a. The plethysmograph waveform begins to track the artificial pulse signal from the SRC-2.

   b. The pulse tone is heard.

   c. Zeroes are displayed in the %SpO2 and Pulse displays.

   d. After about 10 to 20 seconds, the monitor displays saturation and pulse rate as specified by the tester. Verify the values are within the following tolerances:

      Oxygen Saturation Range = 79% to 83%

      Pulse Rate Range = 37 to 39 bpm

   e. The audible alarm sounds and both the %SpO2 and Pulse displays flash, indicating that both parameters have violated the default alarm limits.

5. Press and hold the Alarm Silence button on the front of the monitor for less than 3 seconds.

6. Verify the $\%SpO_2$ display indicates “60” and the Pulse display indicates “SEC” while the Alarm Silence button is pressed.

7. When the button is released the alarm is silenced.

8. With the alarm silenced, verify the following:

   a. The alarm remains silenced.

   b. The Audible Silence indicator lights.

   c. The $\%SpO_2$ and Pulse displays continue to flash.

   d. The pulse tone is still audible.

   e. The audible alarm returns in approximately 60 seconds.

9. While pressing the Alarm Silence button, press the Down Arrow button until the Pulse display indicates “30”.

10. Press the Up Arrow button and verify the displays indicate 60 SEC, 90 SEC, 120 SEC, and OFF. Release the button when the display indicates “OFF”.

11. Press and release the Alarm Silence button. Verify the Alarm Silence Indicator flashes.

12. Wait approximately 3 minutes. Verify the alarm does not return.

13. After 3 minutes, the alarm silence reminder beeps three times, and will continue to do so at approximately 3-minute intervals.

3.3.3.1.2 Alarm Volume Control

After completing the procedure in paragraph 3.3.3.1.1:

1. Press and hold the Alarm Silence button and verify the following:

   a. “OFF” is displayed for approximately 3 seconds.

   b. After 3 seconds:

      - a steady tone is heard at the default alarm volume setting
      - the $\%SpO_2$ display indicates “VOL”
      - the Pulse display indicates the default setting of 5.

2. While still pressing the Alarm Silence button, press the Down Arrow button until an alarm volume setting of 1 is displayed.

3. Verify the volume of the alarm has decreased but is still audible.

4. Continue pressing the Alarm Silence button and press the Up Arrow button to increase the alarm volume setting to a maximum value of 10.

5. Verify the volume increases. Press the Down Arrow button until a comfortable audio level is attained.

6. Release the Alarm Silence button. The tone stops.

3.3.3.1.3 Pulse Tone Volume Control

1. Press the Up Arrow button and verify the beeping pulse tone sound level increases.
2. Press the Down Arrow button and verify the beeping pulse tone decreases until it is no longer audible.
3. Press the Up Arrow button to return the beep volume to a comfortable level.

3.3.3.1.4 Dynamic Operating Range

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

1. Connect the SRC-2 to the SCP-10 or MC-10, which is connected to the NPB-295, and turn the NPB-295 on.
2. Place the SRC-2 in the RCAL 63/LOCAL mode.
3. Set the SRC-2 as indicated in Table 3-1.

Note: An "*" indicates values that produce an alarm. Press the Alarm Silence button to silence the alarm.

Table 3-1: Dynamic Operating Range

SRC-2 Settings			NPB-295 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*	198 - 204*
201	LOW	HIGH	79 - 83*	198 - 204*

Note: Allow the monitor several seconds to stabilize the readings.

4. Verify the NPB-295 readings are within the indicated tolerances.

3.3.3.1.5 Nurse Call

Note: The Nurse Call tests must be performed with the instrument operating on AC power.

1. Connect the negative lead of a voltmeter to pin 5 and positive to pin 11 of the data port on the back of the instrument (Figure A-2 in Appendix). Ensure that the audible alarm is not silenced or turned off.
2. Set the SRC-2 to create an alarm condition.
3. Verify an output voltage at pins 5 and 11 between +5 and +12 volts DC.
4. Press the Alarm Silence button. With no active audible alarm, the output voltage at pins 5 and 11 must be between -5 and -12 volts DC.
5. With the instrument in an alarm condition, use a DVM to verify there is no continuity between pins 8 and 15 and that there is continuity between pins 7 and 15.

6. Adjust the alarm limits so that there is no alarm condition. Use a DVM to verify there is continuity between pins 8 and 15 and that there is no continuity between pins 7 and 15.

3.3.3.1.6 Analog Output

Note: The Analog Output tests must be performed with the instrument operating on AC power.

1. Connect the negative lead of a voltmeter to pin 10 and positive to pin 6 of the data port on the back of the instrument (Figure A-1 in Appendix).
2. Press the following softkeys: Setup, Next, Next, and Analog. Press the 1-volt softkey.
3. Verify the output voltage is 1.0 ± 0.025 volts DC.
4. Leave the negative lead connected to pin 10 and verify 1.0 ± 0.025 volts DC on pins 13 and 14.

Note: If step 4 takes more than 2 minutes to complete, the analog output will time out. Repeat step 2 to initiate the analog output.

5. Move the positive lead back to pin 6.
6. Press the following softkeys; Setup, Next, Next, and Analog. Press the 0-volt softkey.
7. Verify the output voltage is 0.0 ± 0.025 volts DC.
8. Leave the negative lead connected to pin 10 and verify 0.0 ± 0.025 volts DC on pins 13 and 14.

Note: If step 8 takes more than 2 minutes to complete, the analog output will time out. Repeat step 2 to initiate the analog output.

9. Disconnect the voltmeter from the instrument.

3.3.3.1.7 Operation on Battery Power

1. With the instrument operating on AC, turn on the backlight.
2. Disconnect the instrument from AC and verify the AC/Battery Charging indicator and the backlight turn off.
3. Verify the instrument continues monitoring normally and that the low battery indicator is not lit.

Note: If the low battery indicator is illuminated, perform the procedure outlined in step 3.3.1.

4. Connect the instrument to AC and verify the backlight and AC/Battery Charging indicator turn on and that the instrument is monitoring normally.

3.3.3.2 General Operation

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

- 3.3.3.2.1 LED Excitation Test
- 3.3.3.2.2 Operation with a Live Subject

3.3.3.2.1 LED Excitation Test

This procedure uses normal system components to test circuit operation. A Nellcor™ *Oxisensor ® II* oxygen transducer, 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 the monitor to an AC power source.
2. Connect an SCP-10 or MC-10 sensor input cable to the monitor.
3. Connect a D-25 sensor to the sensor-input cable.
4. Press the Power On/Off button to turn the monitor on.
5. Leave the sensor open with the LEDs and photodetector visible.
6. After the monitor completes its normal power-up sequence, verify the sensor LED is brightly lit.
7. 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.
8. Open the sensor and notice that the LED intensity increases.
9. Repeat step 7 and the intensity will again decrease. This variation is an indication that the microprocessor is in proper control of LED intensity.
10. Turn the NPB-295 off.

3.3.3.2.2 Operation with a Live Subject

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

1. Ensure that the monitor is connected to an AC power source.
2. Connect an SCP-10 or MC-10 sensor input cable to the monitor.
3. Connect a Nellcor *Durasensor* ® oxygen transducer, model DS-100A, to the sensor input cable.
4. Clip the DS-100A to the subject as recommended in the sensor's directions for use.
5. Press the Power On/Off button to turn the monitor on and verify the monitor is operating.
6. The monitor should stabilize on the subject's physiological signal in about 15 to 30 seconds.
7. Verify the oxygen saturation and pulse rate values are reasonable for the subject.

3.4 SAFETY TESTS

NPB-295 safety tests meet the standards of, and are performed in accordance with, IEC 601-1 (EN 60601-1, Second Edition, 1988; Amendment 1, 1991-11, Amendment

2, 1995-03) and UL 2601-1 (August 18, 1994), for instruments classified as Class 1 and TYPE BF and AAMI Standard ES1 (ANSI/AAMI ES1 1993).

- Ground Integrity
- Electrical Leakage

3.4.1 Ground Integrity

This test checks the integrity of the power cord ground wire from the AC plug to the instrument chassis ground. The current used for this test is ≤6 volts RMS, 50 or 60 Hz, and 25 A.

1. Connect the monitor AC mains plug to the analyzer as recommended by the analyzer operating instructions.
2. Connect the analyzer resistance input lead to the equipotential terminal (grounding lug) on the rear panel of the instrument.
3. Verify the analyzer indicates 100 milliohms or less.

3.4.2 Electrical Leakage

The following tests verify the electrical leakage of the monitor:

- Earth Leakage Current
- Enclosure Leakage Current
- Patient Leakage Current
- Patient Source Current (Mains on Applied Part)

Note: For the following tests, ensure that the AC switch on the rear of the instrument is configured for the AC voltage being supplied.

3.4.2.1 Earth Leakage Current

This test is in compliance with IEC 601-1 (earth leakage current) and AAMI Standard ES1 (earth risk current). The applied voltage for AAMI ES1 is 120 volts AC 60 Hz, for IEC 601-1 the voltage is 264 volts AC, 50 to 60 Hz. All measurements shall be made with the power switch in both the “On” and “Off” positions.

1. Connect the monitor AC plug to the electrical safety analyzer as recommended by the analyzer operating instructions.
2. The equipotential terminal is not connected to ground.

Table 3-2: Earth Leakage Current Limits

AC POLARITY	LINE CORD	NEUTRAL CORD	LEAKAGE CURRENT
Normal	Closed	Closed	500 µA
Reversed	Closed	Closed	500 µA
Normal	Open	Closed	1000 µA
Normal	Closed	Open	1000 µA

3.4.2.2 Enclosure Leakage Current

This test is in compliance with IEC 601-1 (enclosure leakage current) and AAMI Standard ES1 (enclosure risk current). This test is for ungrounded enclosure current, measured between enclosure parts and earth. The applied voltage for AAMI/ANSI is 120 volts AC, 60 Hz, and for IEC 601-1 the applied voltage is 264 volts AC, 50 to 60 Hz.

1. Connect the monitor AC plug to the electrical safety analyzer as recommended by the analyzer operating instructions.
2. Place a piece of 200 cm^2 foil in contact with the instrument case making sure the foil is not in contact with any metal parts of the enclosure that may be grounded.
3. Measure the leakage current between the foil and earth.

Note: The analyzer leakage indication must not exceed values listed in Table 3-3.

Table 3-3: Enclosure Leakage Current Limits

AC LINE CORD	NEUTRAL LINE CORD	POWER LINE GROUND CABLE	IEC 601-1	AAMI/ANSI ES1 STANDARD
Closed	Closed	Closed	100 µA	100 µA
Closed	Closed	Open	500 µA	300 µA
Closed	Open	Closed	500 µA	300 µA
Open	Closed	Closed	500 µA	100 µA
Open	Open	Closed	500 µA	300 µA
Open	Closed	Open	500 µA	300 µA

3.4.2.3 Patient Applied Risk Current

This test is in compliance with AAMI Standard ES1 (patient applied risk current), and IEC 601-1 (patient auxiliary current). The leakage current is measured between any individual patient connection and power (earth) ground. The applied voltage for AAMI/ANSI is 120 volts AC, 60 Hz, and for IEC 601-1 the applied voltage is 264 volts AC, 50 to 60 Hz.

1. Configure the electrical safety analyzer as follows:

   Function: Patient Leakage
   Range: µA

2. Connect the monitor AC plug to the electrical safety analyzer as recommended by the analyzer operating instructions for Patient Leakage Current.
3. Connect the electrical safety analyzer patient leakage input lead to all pins of the monitor's patient cable at the end of the cable.
4. The equipotential terminal is not connected to ground.
5. All functional earth terminals are not connected to ground.
6. Measure the leakage current between the patient connector and earth.

Table 3-4: Patient Leakage Current Limits

AC LINE POLARITY	NEUTRAL LINE	POWER LINE GROUND CABLE	IEC 601-1	AAMI/ANSI ES1 STANDARD
Normal	Closed	Closed	100 µA	10 µA
Normal	Open	Closed	500 µA	50 µA
Normal	Closed	Open	500 µA	50 µA
Reverse	Closed	Closed	100 µA	10 µA
Reverse	Open	Closed	500 µA	50 µA
Reverse	Closed	Open	500 µA	50 µA

3.4.2.4 Patient Isolation Risk Current - (Mains Voltage on the Applied Part)

This test is in compliance with AAMI Standard ES1 (patient isolation risk current [sink current]), and IEC 601-1 (patient leakage current). Patient Leakage Current is the measured value in a patient connection if mains voltage is connected to that patient connection. The applied voltage for AAMI/ANSI is 120 volts AC, 60 Hz, and for IEC 601-1 the applied voltage is 264 volts AC, 50 to 60 Hz.

Warning: AC mains voltage will be present on the patient cable terminals during this test. Exercise caution to avoid electrical shock hazard.

1. Configure the electrical safety analyzer as follows:

   Function: Patient Leakage (Mains on Applied Part)
   Range: µA
2. Connect the monitor AC plug to the electrical safety analyzer as recommended by the operating instructions for patient sink (leakage) current.
3. Connect the electrical safety analyzer patient leakage input lead to all connectors in the patient cable at the patient end of the cable.
4. The equipotential terminal is not connected to ground.
5. All functional earth terminals are not connected to ground.
6. The analyzer leakage current must not exceed the values shown in Table 3-5.

Table 3-5: Patient Leakage Current Test Configurations - Mains Voltage on the Applied Part

AC LINE POLARITY	NEUTRAL LINE	POWER LINE GROUND CABLE	IEC 601-1	AAMI/ANSI ES1 STANDARD
Normal	Closed	Closed	5 mA	50 µA
Reverse	Closed	Closed	5 mA	50 µA

SECTION 4: POWER-ON SETTINGS AND SERVICE FUNCTIONS

4.1 INTRODUCTION

This section discusses how to reconfigure power-on default values, and access the service functions.

4.2 POWER-ON SETTINGS

The following paragraphs describe how to change power-on default settings.

Through the use of softkeys shown in Figure 1-2, the user can change:

- alarm limits
- type of display
- baud rate
- time and date
- trends to view

A decimal point is added to the right of a display when the alarm limit for that display has been changed to a value that is not a power-on default value. If the new value is saved as a power on default value, the decimal point will be removed. By using the service functions, changes can be saved as power-on default values.

Some values cannot be saved as power-on default values. A SpO2 Low limit less than 80 will not be saved as a power-on default. Audible Alarm Off will not be accepted as a power-on default. An attempt to save either of these values as default will result in an invalid tone. Both values can be selected for the current patient, but they will be lost when the instrument is turned off.

4.2.1 Factory Default Settings

Factory power-on default settings for the NPB-295 are listed in Table 4-1. Following the procedures listed in the paragraphs that follow can change these settings.

Table 4-1: Factory Default Settings

Parameter	Default Value
SpO_2 High	100%
SpO_2 Low	85%
Pulse Rate High	170 bpm
Pulse Rate Low	40 bpm
Alarm Volume	Level 5
Alarm Silence Duration	60 seconds
Alarm Silence Restriction	Sound Reminder
Pulse Beep Volume	Level 4
Data Port Mode	ASCII
Baud Rate	9600
Display	Pleth
Trend	Saturation
Contrast	Mid-range
Language	English
Nurse Call Polarity	Positive (NCALL+)

4.3 SERVICE FUNCTIONS

4.3.1 Introduction

These functions can be used to select institutional defaults, and to access information about the patient or instrument. A Mallinckrodt Customer Service Engineer should only access some of the items available through the service functions. These functions will be noted in the text.

4.3.2 Accessing the Service Functions

The sensor cable must be disconnected from the instrument to access service functions. Simultaneously press the 4th softkey from the left and the contrast button for more than 3 seconds. The menu bar will change to the headings listed in Figure 4-1.

Note: If a “Sensor Disconnected” prompt appears on the screen, press the Alarm Silence button and repeat the above procedure.

Note: If the above steps are performed with a sensor cable connected, only the Param and Exit softkeys appear on the screen.

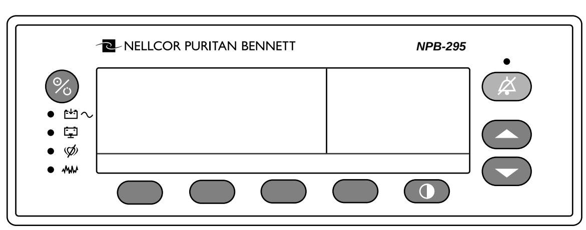


Figure 4-1: Service Function Softkeys

Figure 4-2 can be used as a quick reference showing how to reach different softkey functions. Items reached through the Param softkey can be accessed during normal operation. Functions provided by the Print and Next softkeys cannot be accessed when a sensor cable is connected to the instrument. Each of the various functions is described in the text to follow.

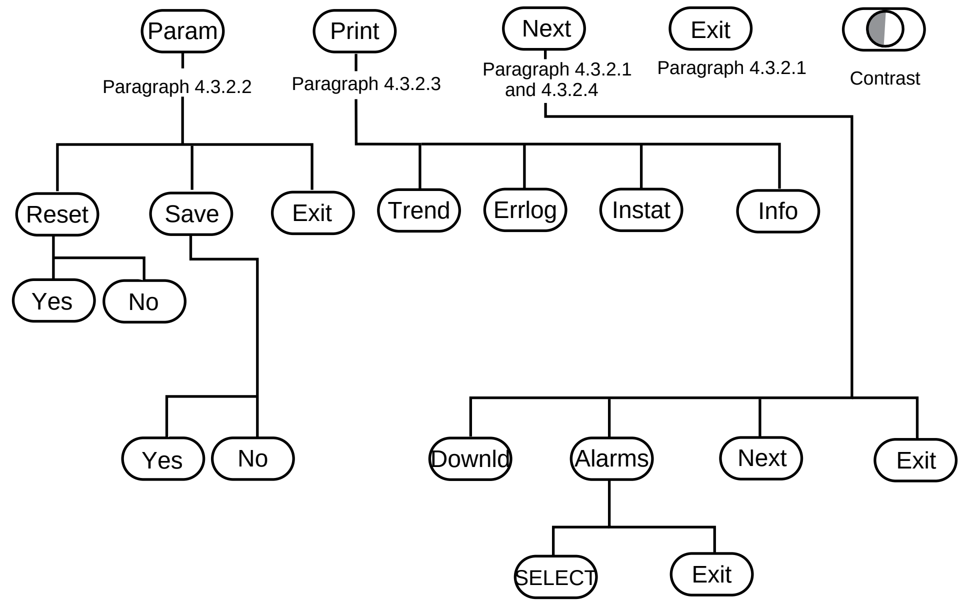


Figure 4-2: Service Function Softkey Map

4.3.2.1 Exit & Next Softkeys

NEXT

There are not enough buttons to display all of the options that are available at some levels of the menu. Pressing the Next button allows you to view additional options available at a given menu level.

EXIT

To back up one menu level, press the Exit button. The service functions can be exited by repeatedly pressing the Exit button.

4.3.2.2 Param

When the Param softkey is pressed, the function of the softkeys changes as shown in figure 4-3. These options can be accessed without disconnecting the sensor cable from the instrument.

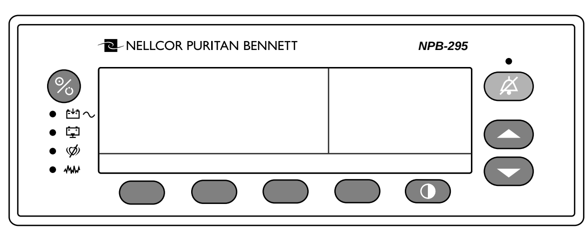


Figure 4-3: Param Softkeys

RESET

The Reset button is used to return to the factory default settings. If Yes is pressed, the instrument sounds three tones and the settings return to factory default values. When No is pressed, there are no changes made to the settings stored in memory.

SAVE

When adjustable values are changed from factory default, the Save button can be used to preserve the settings as institutional power-on default values. Pressing Yes stores the current settings in memory. The instrument sounds three tones indicating that the changes have been saved as power-on default values. The new saved values will continue to be used through power-on and off cycles until they are changed and saved again, or until they are reset. If No is pressed, the changed values will not be saved.

Note: An invalid tone indicates a parameter value cannot be saved as a power on default (refer to paragraph 4.2). Along with the invalid tone, a message will be displayed indicating which parameter could not be saved as a power-on default.

4.3.2.3 Print

PRINT

Accessing the Print softkey makes four printouts available. Refer to the Appendix for information about how to make connections to the data port and how data is presented in a printout. The appropriate printout can be selected by pressing the corresponding softkey. Figure 4-4 represents the softkey configuration after the Print softkey has been selected.

Up to 24 hours of trend data can be viewed on the printouts described below. When the instrument is turned on, trend data is recorded every 2 seconds. As an example, an instrument that is used 6 hours a week would take approximately 4 weeks to fill its memory. . The 24 hours of stored trend data is available for downloading to Score™ software for 45 days. There are no limitations for displaying or printing data.

Note: The two-letter codes and the symbols that occur in the printout are described in Table 10-3.

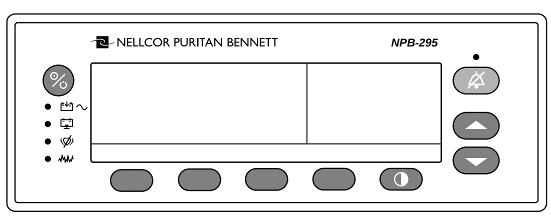


Figure 4-4: Print Softkeys

TREND

A Trend printout will include all data recorded for up to 24 hours of monitoring since the last Delete Trends was performed. A new trend point is recorded every 2 seconds. Figure 4-5 is an example of a Trend printout.

NPB-295 Version 1.0.0.000		TREND	SpO2 Limit: 30-100%		PR Limit: 100-180 bpm
TIME	%SpO2	PR (bpm)		PA	
01-Jul-97 14:00:00	100	120		220	
01-Jul-97 14:00:05	100	124		220	
01-Jul-97 14:00:10	100	190		220	
01-Jul-97 14:00:15	100	190		220	
01-Jul-97 18:00:43	- - -	- - -		- - -	
01-Jul-97 18:00:48	- - -	- - -		- - -	
NPB-295 Version 1.0.0.000		Trend	SpO2 Limit: 80-100%		PR Limit: 60-180 bpm
Time	%SpO2	PR (bpm)		PA	
01-Jul-97 18:00:53	- - -	- - -		- - -	
01-Jul-97 18:00:58	- - -	- - -		- - -	
01-Jul-97 18:01:03	98	100		140	
01-Jul-97 18:01:08	98	181*		190	
01-Jul-97 18:01:13	99	122		232	
Output Complete					

Figure 4-5: Trend Printout

The first two lines are the column heading lines. The first line includes information about the:

- type of instrument delivering the information
- software level, type of printout
- alarm parameters

The second line is the headings for the columns. The first and second lines are printed out every 25 lines, or when a change to an alarm limit is made. Patient data is represented with a date and time stamp for the data. In the example above, the "- - -" means that a sensor was connected but no data was being received (patient disconnect). Patient data that is outside of an alarm limit is marked with an *.

At the end of the printout "Output Complete" will be printed. This indicates that there was no corruption of data. If the Output Complete statement is not printed at the end of the printout, the data must be considered invalid.

ERRLOG (Mallinckrodt Customer Service Engineer Only)

A list of all the errors recorded in memory can be obtained by pressing the Errlog softkey. The first two lines are the column heading lines. The type of instrument producing the printout, software level, type of printout, and the time of the printout are listed in the first line. The second line of the printout is column headings. If nothing prints out, there have been no errors. An example of an Errlog printout is shown in Figure 4-6.

NPB-295 Version 1.0.0.000			Error Log	Time:	14600:00:07
Op Time	Error	Task		Addr	Count
10713:21:03	52	12		48F9	100
00634:26:01	37	4		31A2	3
Output Complete					

Figure 4-6: Errlog Printout

INSTAT (Mallinckrodt Customer Service Engineer Only)

The Delete softkey, described in operator's manual, allows the user to delete the most recent trend data. The current trend data, along with the deleted trends, can be retrieved from the instrument through an Instat printout.

The oldest deleted trend is Trend 1 on the Instat printout. If a Trend 1 already exists in memory from an earlier Delete, the next deleted trend will become Trend 2. Every time a Delete is performed from the User Softkeys the number of existing trends will increase by 1. The current trend will have the largest trend number.

Figure 4-7 illustrates an Instat printout. The first two lines are the column heading lines. Line one is for instrument type, software revision level, type of printout, and alarm parameter settings. The second line contains the column headings. A trend point is recorded for every 2 seconds of instrument operation. Up to 24 hours of instrument operation data can be recorded.

The final line on the printout shows Output Complete. This indicates that data has been successfully transmitted with no corruption. If there is no Output Complete line printed, the data should be considered invalid.

NPB-295	Version 1.0.0.000	Instrument		SpO2 Limit:	30-100%	PR Limit: 100-180 bpm	
TIME	Trend 01	%SpO2	PR (bpm)	PA	SpO2 Status	UIF Status	Aud
01-Jul-97	14:00:00	- - -	- - -	- - -	SD	BU LB AO	L
01-Jul-97	14:00:05	- - -	- - -	- - -	PS	BU LB AO	
01-Jul-97	14:00:10	100	120	220		BU LB	
01-Jul-97	14:00:15	100	120	220		BU LB	
NPB-295	Version 1.0.0.000	Instrument		SpO2 Limit:	80-100%	PR Limit: 60-180 bpm	
TIME	Trend 01	%SpO2	PR (bpm)	PA	SpO2 Status	UIF Status	Aud
01-Jul-97	14:24:24	79*	58*	220	PS SL PL	BU LB	M
01-Jul-97	14:24:29	79*	57*	220	PS SL PL	BU LB AS	M
01-Jul-97	14:24:29	0*	0*	- - -	PS LP SL PL	BU LB AS	H
NPB-295	Version 1.0.0.000	Instrument		SpO2 Limit:	80-100%	PR Limit: 60-180 bpm	
TIME	Trend 01	%SpO2	PR (bpm)	PA	SpO2 Status	UIF Status	Aud
11-Jul-97	7:13:02	99	132*	220	PH	BU	M
11-Jul-97	7:13:07	99	132*	220	PH	BU	M
11-Jul-97	7:13:12	99	132*	220	PH	BU	M
11-Jul-97	7:13:17	99	132*	220	PH	BU	M
11-Jul-97	7:13:22	99	132*	220	PH	BU	M
11-Jul-97	7:13:27	99	132*	220	PH	BU	M
11-Jul-97	7:13:32	99	132*	220	PH	BU	M
Output Complete							

Figure 4-7: Instat Printout

INFO (Mallinckrodt Customer Service Engineer Only)

Pressing the INFO softkey produces a printout of instrument information (Figure 4-8). A single line will be printed. The data presented in the printout going from left to right is:

- instrument type (NPB-295)
- Version is the software version level
- type of printout (INFO)
- CRC number (Cyclic Redundancy Check)
- time in seconds (current operating time/total operating time).

NPB-295 Version XXXXXX INFO CRC:XXXX SEC: 123456789/987654321

Figure 4-8: INFO Printout

Next

Additional options can be accessed from the main Service Functions menu by pressing the Next softkey. When Next is pressed, the softkeys change to the functions shown in Figure 4-9.

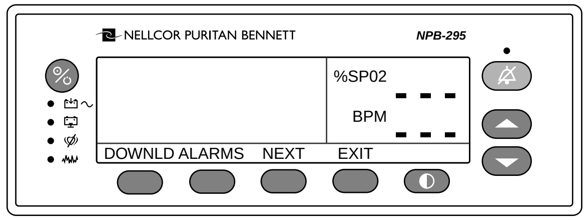


Figure 4-9: Next Softkeys

DOWNLD

When Downld is selected, the instrument will display the revision of the Boot Code. To exit Downld, cycle power to the instrument by pressing the Power On/Off button. Consult the DFU provided with any downloads or upgrades to the FLASH firmware.

ALARMS

Pressing the Alarms softkey can change characteristics of the audible alarm. When the Alarms softkey is pressed, the softkey's functions change as shown in Figure 4-10.

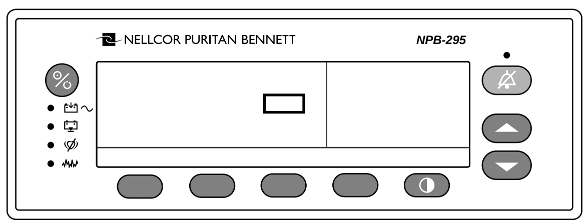


Figure 4-10: Alarms Softkeys

SELECT

The Sel softkey is used to select what function of the audible alarm is going to be changed. A box can be cycled between two choices: Allow Off and Off Reminder.

When Allow Off is selected, a choice is given between allowing an audible alarm Off or disabling the audible alarm Off. Pressing the Up or Down arrow key cycles between Yes and No. If Yes is selected, the operator has the option of selecting Audible Alarm Off. If No is selected, the operator is not given the option of selecting Audible Alarm Off as an alarm silence duration choice.

If the audible alarm is set to Off, a reminder tone can be sounded every 3 minutes to notify the user of this condition. The Up and Down arrow keys can be used to change the choice from Yes to No. Selecting Yes enables the Reminder. Selecting No disables the Reminder when the audible alarm is set to Off.

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SECTION 5: TROUBLESHOOTING

5.1 INTRODUCTION

This section explains how to troubleshoot the NPB-295. 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 Mallinckrodt Technical Services or your local Mallinckrodt representative.

5.4 REPLACEMENT LEVEL SUPPORTED

The replacement level supported for this product is to the printed circuit board (PCB) and major subassembly 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 when you started troubleshooting) and continue troubleshooting as directed in this section.

5.5 OBTAINING REPLACEMENT PARTS

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

Troubleshooting guide

Problems with the NPB-295 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 Mallinckrodt Technical Services or your local Mallinckrodt representative.

Table 5-1: Problem Categories

Problem Area	Refer to Paragraph
1. Power • No power-up on AC and/or DC • Fails power-on self-test • Powers down without apparent cause	5.6.1
2. Buttons • Monitor does not respond properly to buttons	5.6.2
3. Display/Alarms • Displays do not respond properly • Alarms or other tones do not sound properly or are generated without apparent cause	5.6.3
4. Operational Performance • Displays appear to be operational, but monitor shows no readings • Suspect readings	5.6.4
5. Data Port • NPB-295 serial port not functioning properly	5.6.5

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

5.5.1 Power

Power problems are related to AC and/or DC. Table 5-2 lists recommended actions to power problems.

Table 5-2: Power Problems

Condition	Recommended Action
1. Battery Low indicator lights steadily while NPB-295 is connected to AC and battery is fully charged.	1. Ensure that the NPB-295 is plugged into an operational AC outlet and the AC indicator is on. 2. Check the fuses. The fuses are located in the Power Entry Module as indicated in paragraph 6.3 and Figure 6-3 of the *Disassembly Guide* section. Replace if necessary. 3. Open the monitor as described in section 6. Verify the power supply's output to the battery while on AC. Disconnect the battery leads from the battery and connect a DVM to them. The voltage measured should be 6.80 ± 0.15 volts DC and the current should be 400 ± 80 mA. Replace power supply if above values are not met. 4. Check the ribbon connection from the bottom enclosure to the UIF PCB, as instructed in paragraph 6.5 of the *Disassembly Guide* section. If the connection is good, replace the UIF PCB.
2. The NPB-295 does not operate when disconnected from AC power.	1. The battery may be discharged. To recharge the battery, refer to paragraph 3.3.1, Battery Charge. The monitor may be used with a less than fully charged battery but with a corresponding decrease in operating time from that charge. 2. If the battery fails to hold a charge, replace the battery as indicated in Section 6, *Disassembly Guide*.
3. Battery Low indicator on during DC operation and an alarm is sounding.	There are 15 minutes or less of usable charge left on the NPB-295 battery before the instrument shuts off. At this point, if possible, cease use of the NPB-295 on battery power, connect it to an AC source and allow it to recharge (approximately 14 hours). The NPB-295 may continue to be used while it is recharging. (A full recharge of the battery while the monitor is being used takes 18 hours.)
4. Battery does not charge.	1. Replace battery if more than 2 years old. 2. Open the monitor as described in Section 6. Verify the power supply's output to the battery while on AC. Disconnect the battery leads from the power supply and connect a DVM to them. The voltage measured should be 6.8 ± 0.15 volts DC and the current should be 400 ± 80 mA. Replace power supply if above values are not met.

5.5.2 Buttons

Table 5-3 lists symptoms of problems relating to nonresponsive buttons and recommended actions. If the action requires replacement of a PCB, refer to Section 6, *Disassembly Guide*.

Table 5-3: Button Problems

Condition	Recommended Action
1. The NPB-295 responds to some, but not all buttons.	1. Replace Top Housing assembly. 2. If the buttons still do not work, replace the UIF PCB.
2. The NPB-295 turns on but does not respond to any of the buttons.	1. Replace Top Housing assembly. 2. If the buttons still do not work, replace the UIF PCB.

5.5.3 Display/Alarms

Table 5-4 lists symptoms of problems relating to nonfunctioning displays, audible tones or alarms, and recommended actions. If the action requires replacement of a PCB or module, refer to Section 6, *Disassembly Guide*.

Table 5-4: Display/Alarms Problems

Condition	Recommended Action
1. Display values are missing or erratic.	1. If the sensor is connected, replace the sensor connector assembly. 2. If the condition persists, replace the sensor extension cable. 3. If the condition still persists, replace the UIF PCB.
2. Display pixels do not light.	1. Check the connection between the UIF PCB and the Display PCB. 2. If the condition does not change, replace the Display PCB. 3. If the condition still persists, replace the UIF PCB.
3. Alarm sounds for no apparent reason.	1. Moisture or spilled liquids can cause an alarm to sound. Allow the monitor to dry thoroughly before using. 2. If the condition persists, replace the UIF PCB.
4. Alarm does not sound.	1. Replace the speaker as described in Section 6, *Disassembly Guide*. 2. If the condition persists, replace the UIF PCB.

5.5.4 Operational Performance

Table 5-5 lists symptoms of problems relating to operational performance (no error codes displayed) and recommended actions. If the action requires replacement of a PCB or module, refer to Section 6, *Disassembly Guide*.

Table 5-5: Operational Performance Problems

Condition	Recommended Action
1. The Pulse AMPLITUDE indicator seems to indicate a pulse, but the digital displays show zeroes.	1. The sensor may be damaged; replace it. 2. If the condition still persists, replace the UIF PCB.
2. SpO2 or Pulse values change rapidly; Pulse AMPLITUDE indicator is erratic.	1. The sensor may be damp or may have been reused too many times. Replace it. 2. An electrosurgical unit (ESU) may be interfering with performance: • Move the NPB-295 and its cables and sensors as far from the ESU as possible. • Plug the NPB-295 power supply and the ESU into different AC circuits. • Move the ESU ground pad as close to the surgical site as possible and as far away from the sensor as possible. 3. Verify the performance with the procedures detailed in Section 3. 4. If the condition still persists, replace the UIF PCB.

5.5.5 Data Port

Table 5-6 lists symptoms of problems relating to the data port and recommended actions. If the action requires replacement of the PCB, refer to Section 6, *Disassembly Guide*.

Table 5-6: Serial Port Problems

Condition	Recommended Action
1. No printout is being received.	1. The unit is running on battery power. Connect to an AC source. 2. The monitor's baud rate does not match the printer's. Change the baud rate of the monitor following instructions in paragraph 4.2.4. 3. The monitor's data port protocol setting is incorrect. Change the monitor's data port protocol setting following instructions in Appendix A. 4. If the condition persists, replace the UIF PCB.
2. The RS-232 nurse call is not working.	1. The unit is running on battery power. Connect to an AC source. 2. Verify connections are made between pins 5 (GND) and 11 (nurse call) of the data port. 3. Verify output voltage between ground pin 5 and pin 11 is –5 to –12 volts DC (no alarm) and +5 to +12 volts DC (during alarm). 4. If the condition persists, replace the UIF PCB.

5.6 ERROR CODES

An error code is displayed when the NPB-295 detects a non-correctable failure. When this occurs, the unit stops monitoring, sounds a low priority alarm that cannot be silenced, clears patient data from the display, and displays an error code. Table 5-7 provides a complete list of error codes and possible solutions.

Table 5-7: Error Codes

Code	Meaning	Possible Solutions
1	POST failure	Replace UIF PCB
4	Battery dead	1. Check the voltage selector switch. 2. Charge battery for 14 hours 3. Leads of battery reversed; refer to paragraph 6.5 4. Replace battery
5	Too many microprocessor resets within a period of time	1. Cycle power 2. Replace UIF PCB if code 5 repeatedly occurs 3. Replace Power Supply
6	Boot CRC error	Replace UIF PCB
7	Error on UIF PCB	1. Cycle power to clear error. 2. Check voltage selector switch for proper setting. 3. Replace UIF PCB
8 **11** **12**	Boot CRC Error Flash ROM corruption Excessive resets	1. Cycle power 2. Replace UIF PCB if code repeatedly occurs
52	Loss of settings	1. Cycle power 2. Check and reset settings if necessary 3. Check battery 4. Replace UIF PCB if code repeatedly occurs
76	Error accessing EEPROM	Replace UIF PCB
80	Institutional default values lost and reset to factory default values	1. Cycle power 2. Replace UIF PCB if code 80 repeatedly occurs
81	Settings lost (settings that were different from power on default values have been lost)	1. Cycle power 2. Check and reset settings if necessary 3. Check battery 4. Replace UIF PCB if code repeatedly occurs
82	Time clock lost	1. Reset time clock 2. Battery power was lost; check the battery 3. Replace the Power Supply
84	Internal communications error	1. Cycle power 2. Replace UIF PCB if code repeatedly occurs

SECTION 6: DISASSEMBLY GUIDE

6.1 INTRODUCTION

The NPB-295 can be disassembled down to all major component parts, including:

- PCBs
- battery
- cables
- chassis enclosures

The following tools are required:

- small, Phillips-head screwdriver
- medium, Phillips-head screwdriver
- small blade screwdriver
- needle-nose pliers or 1/4-inch socket
- torque wrench, 10 inch-pounds (1.13 Newton-meters)

WARNING: Before attempting to open or disassemble the NPB-295, disconnect the power cord from the NPB-295.

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

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 PRIOR TO DISASSEMBLY

1. Turn the NPB-295 Off by pressing the Power On/Standby button.
2. Disconnect the monitor from the AC power source.

6.3 FUSE REPLACEMENT

1. Complete procedure in paragraph 6.2
2. Disconnect the power cord from the back of the monitor.
3. Use a flat blade screwdriver to remove the fuse drawer from the Power Entry Module. Press down on the tab in the center of the fuse drawer with the screwdriver until a click is heard. Pull the drawer out as shown in Figure 6-1.

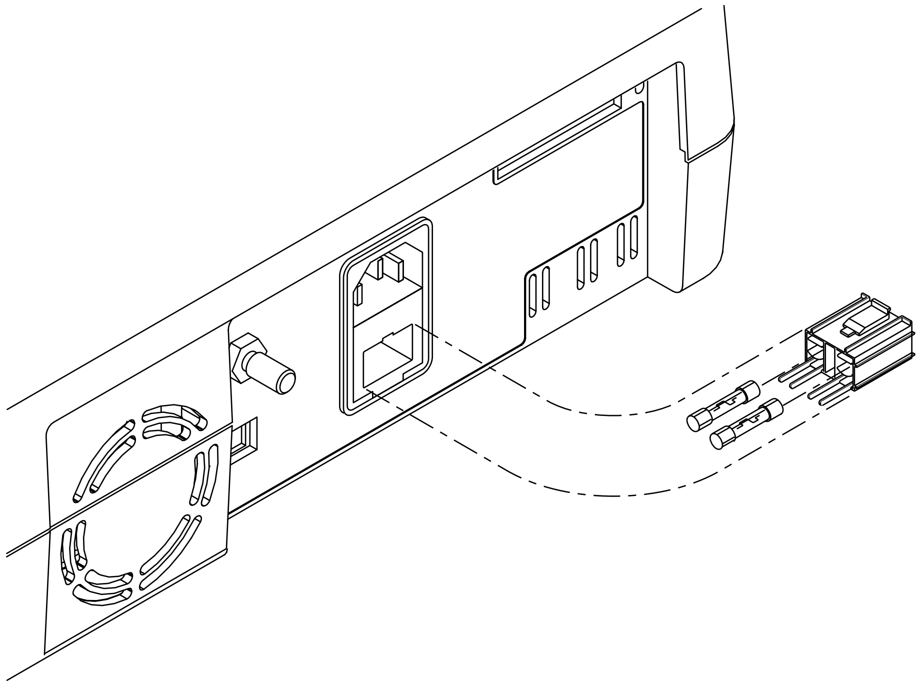

Figure 6-1: Fuse Removal

4. Put new, 5 x 20 mm, slow blow 0.5 amp, 250 volt fuses in the drawer and reinsert the drawer in the power entry module.

6.4 MONITOR DISASSEMBLY

Caution: Observe ESD (electrostatic discharge) precautions when disassembling and reassembling the NPB-295 and when handling any of the components of the NPB-295.

1. Set the NPB-295 upside down, as shown in Figure 6-2.

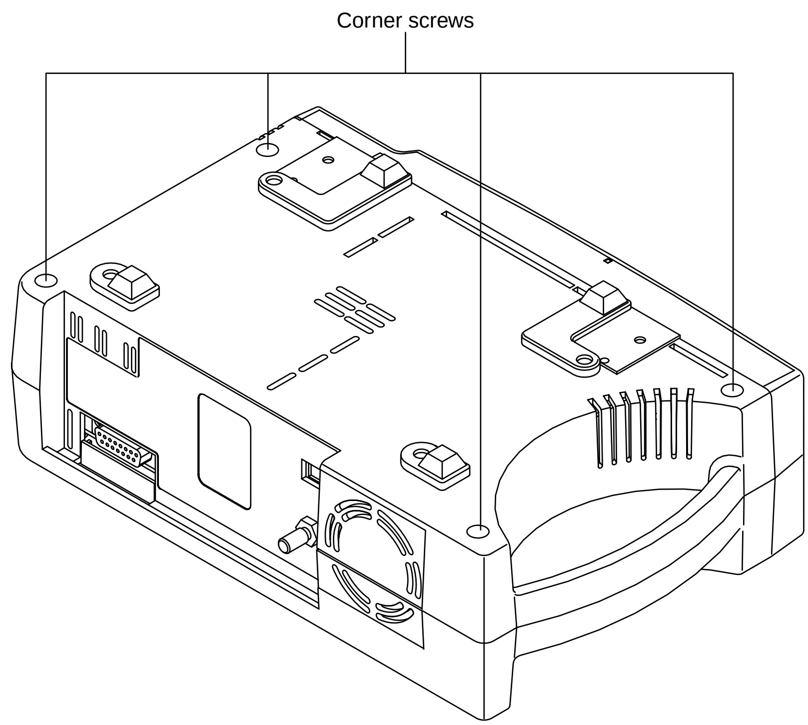

Figure 6-2: NPB-295 Corner Screws

2. Remove the four corner screws.
3. Turn the unit upright.
4. Separate the top case from the bottom case of the monitor being careful not to stress the wire harnesses between the cases.
5. Place the two halves of the monitor on the table as shown in Figure 6-3.
6. Disconnect the Power Supply from J6 on the UIF PCB.

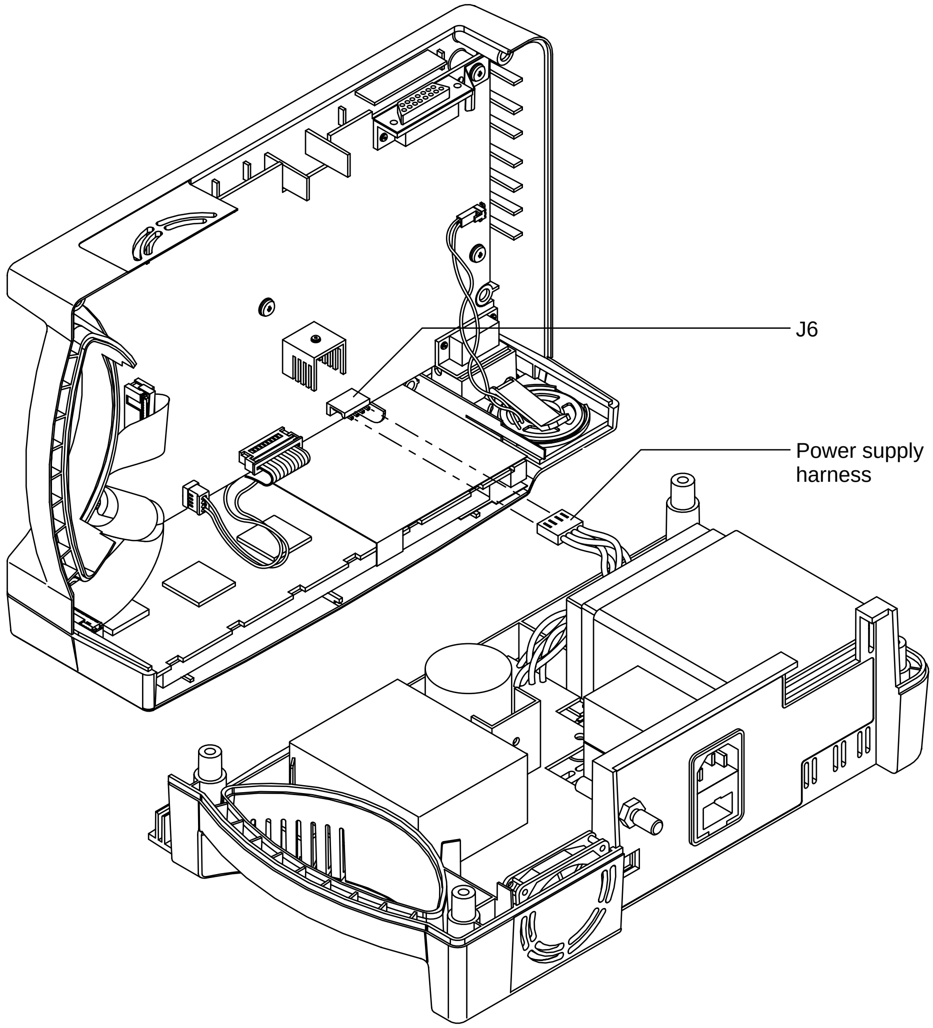

Figure 6-3: Separating Case Halves

6.5 MONITOR REASSEMBLY

1. Place the two halves of the monitor on the table as shown in Figure 6-3.
2. Connect the Power Supply to J6 on the UIF PCB.
3. Place the top case over the bottom case being careful to align the lens, Power Entry Module, and the fan with the slots in the top case.

Caution: When reassembling the NPB-295, tighten the screws that hold the cases together to a maximum of 10 inch pounds. Over-tightening could strip out the screw holes in the top case, rendering it unusable.

4. Install the four corner screws.

6.6 BATTERY REPLACEMENT

Removal

1. Follow the procedure in paragraphs 6.2 and 6.4.
2. Remove the two screws from the battery bracket and lift the battery out of the bottom case as shown in Figure 6-4.
3. Be sure to note the polarity of the leads. Use needle-nose pliers to disconnect the leads from the battery.

Note: The lead-acid battery is recyclable. Do not dispose of the battery by placing it in the regular trash. Dispose of properly or return to Mallinckrodt Technical Services for disposal.

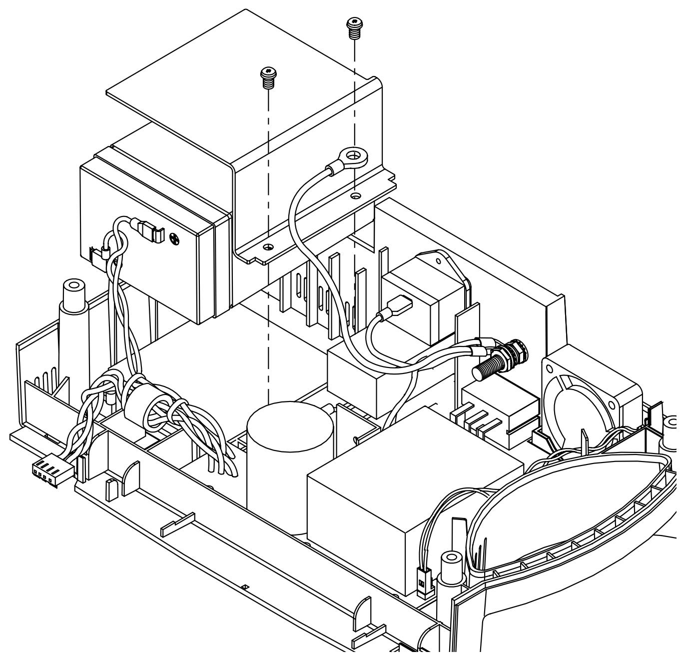

Figure 6-4: NPB-295 Battery

Installation

4. Connect the leads to the battery.
   - Red wire connects to the positive terminal
   - Black wire connects to the negative terminal.
5. Insert the new battery into the bottom case with the negative terminal towards the outside of the monitor.
6. Install the bracket and grounding lead with the two screws.
7. Complete the procedure in paragraph 6.5.
8. Turn the monitor on and verify proper operation.

6.7 POWER ENTRY MODULE (PEM) REMOVAL/INSTALLATION

Removal

1. Complete the procedures in paragraphs 6.2 and 6.4.
2. Push the top of the Power Entry Module (PEM) in from the outside of the case, and lift up.
3. Use needle-nose pliers to disconnect the leads from the PEM (see Figure 6-5).

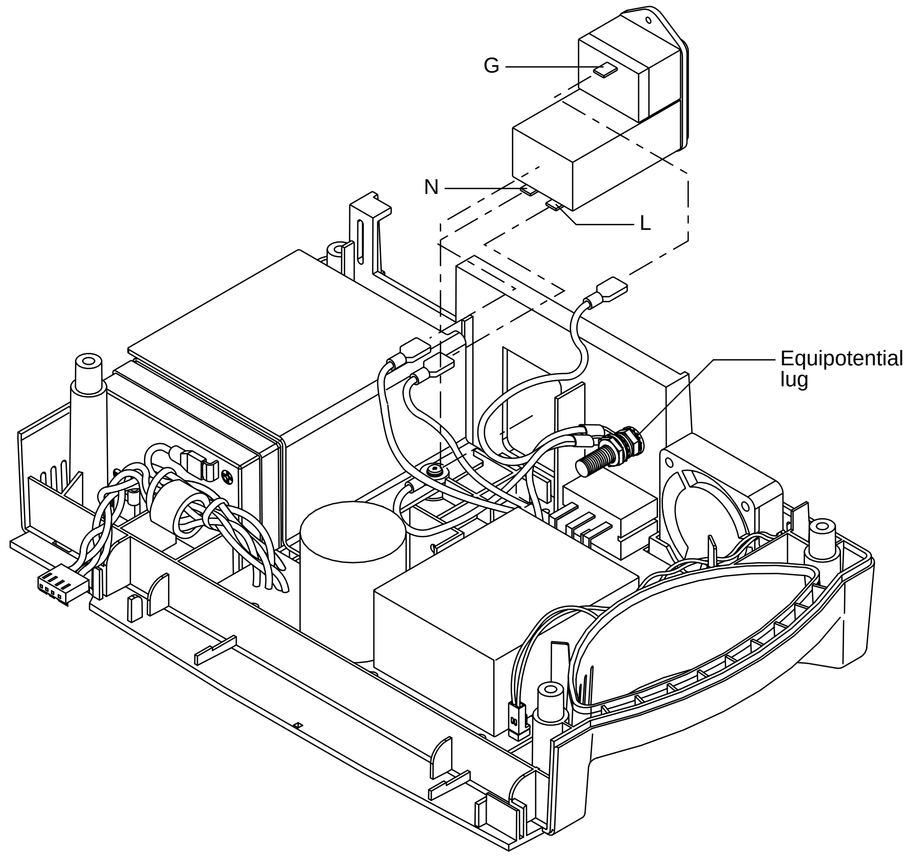

Figure 6-5: Power Entry Module

Installation

4. Refer to Table 6-1 and connect the leads to the PEM.
5. Install the PEM in the bottom case with the fuse drawer facing down. A tab in the bottom case holds the PEM in place. Insert the bottom wing of the PEM between the tab and the internal edge of the side wall of the bottom case. Push the PEM down and towards the outside of the monitor until it clicks into place.
6. Position the ground line from the PEM so that it does not come into contact with components of the Power Supply PCB.
7. Complete the procedure in paragraph 6.5.

6.8 POWER SUPPLY REMOVAL/INSTALLATION

Removal

1. Complete the procedures in paragraphs 6.2 and 6.4.
2. Disconnect the leads from the battery.
3. Complete the procedure in paragraph 6.7 steps 2 through 3.
4. Use a 10-mm wrench to disconnect the Power Supply ground lead from the equipotential lug (Figure 6-5).
5. Disconnect the fan wire harness from J1 on the Power Supply PCB (see Figure 6-7).
6. Remove the seven screws shown in Figure 6-6.
7. Lift the Power Supply out of the bottom case.

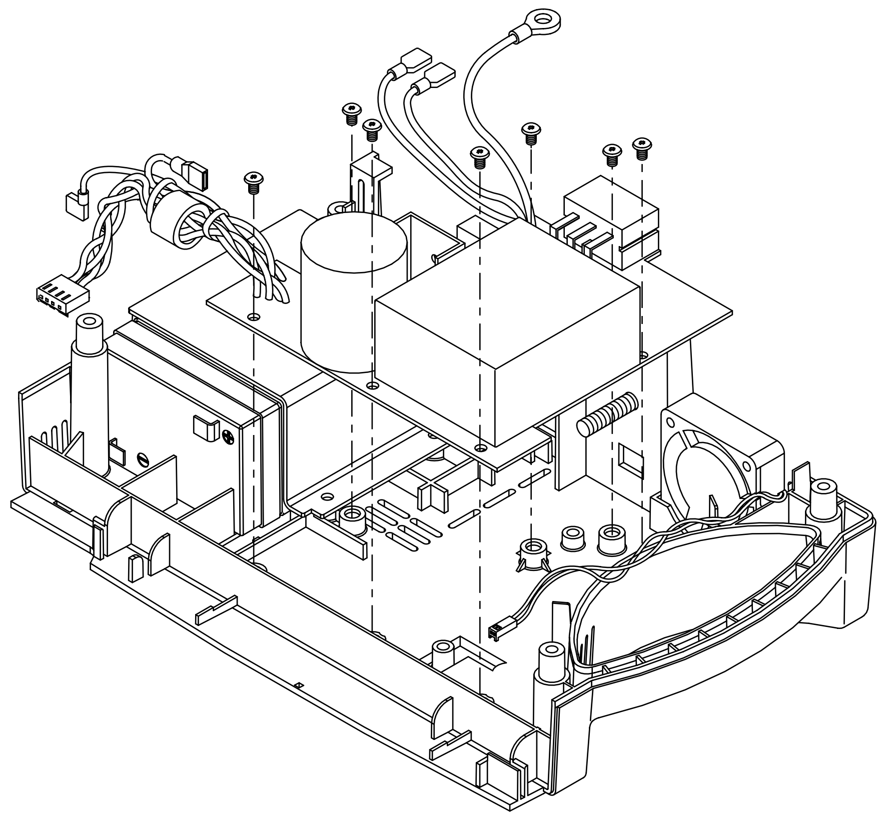

Figure 6-6: Power Supply

Installation

8. Reconnect the AC leads W1, W2, and W3 to the PEM following the instructions in Table 6-1 below and Figure 6-5.

Table 6-1: Power Supply Leads Connections

Power Supply Lead	Wire Color or Label	Connects To
W1	Green & Yellow	Equipotential Lug
W2	Brown/Labeled "L"	"L" on the Power Entry Module
W3	Blue/Labeled "N"	"N" on the Power Entry Module
W4	Red	Positive Battery Terminal
W5	Black	Negative Battery Terminal

9. Place the Power Supply in the bottom case.

Caution: When installing the Power Supply, tighten the seven screws to a maximum of 10 inch-pounds. Over tightening could strip out the screw holes in the bottom case, rendering it unusable.

10. Install the seven screws in the power supply and tighten.

11. Connect the cooling fan harness to J1 of the power supply.

12. Use a 10-mm wrench to connect the power supply ground lead to the equipotential lug. Tighten to 12 inch pounds.

13. Follow the procedure in paragraph 6.7, step 5 and 6.

14. Verify the ground wire to the PEM is positioned so that it does not come into contact with components on the Power Supply PCB.

15. Reconnect W4 and W5 to the battery by following the instructions in Table 6-1.

16. Complete the procedure in paragraph 6-5.

6.9 COOLING FAN REMOVAL/INSTALLATION

Removal

1. Complete the procedures in paragraphs 6.2 and 6.4.
2. Disconnect the fan wire harness from J1 on the Power Supply PCB (see Figure 6-7).
3. Lift the cooling fan from the slots in the bottom case (see Figure 6-7).

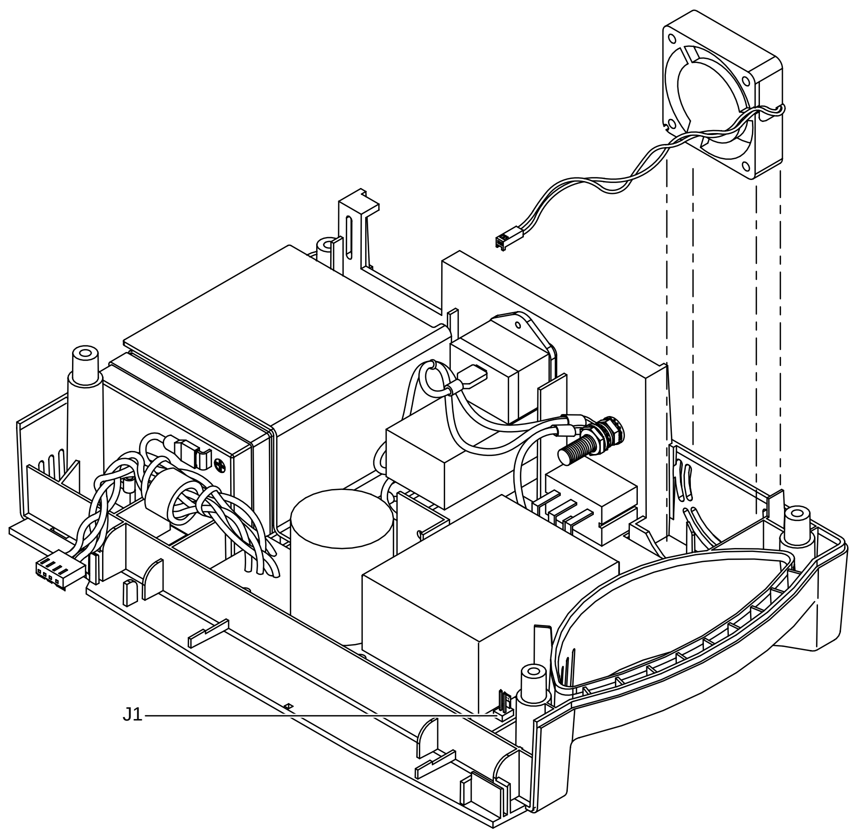

Figure 6-7: Cooling Fan

Installation

4. Connect the cooling fan wire harness to J1 on the Power Supply PCB.
5. Insert the cooling fan into the slots in the bottom case with the padded sides on the top and bottom and the fan's harness to the handle side of the case.
6. Complete procedure 6-5.

6.10 DISPLAY PCB REMOVAL/INSTALLATION

Removal

Caution: The LCD panel contains toxic chemicals. Do not ingest chemicals from a broken LCD panel.

1. Complete the procedures in paragraphs 6.2 and 6.4.
2. Disconnect the CCFL harness (two white wires) from J5 of the UIF PCB.
3. Use a small blade screwdriver to pry the clip from either edge of J9, then disconnect the Display PCB ribbon cable from the connector.
4. Remove the screw holding the clamp to the ferrite on the ribbon cable of the Display PCB.
5. Separate the adhesive connection of the double-sided tape and lift the Display PCB up to remove it from the top case.
6. Remove the used double-sided tape.

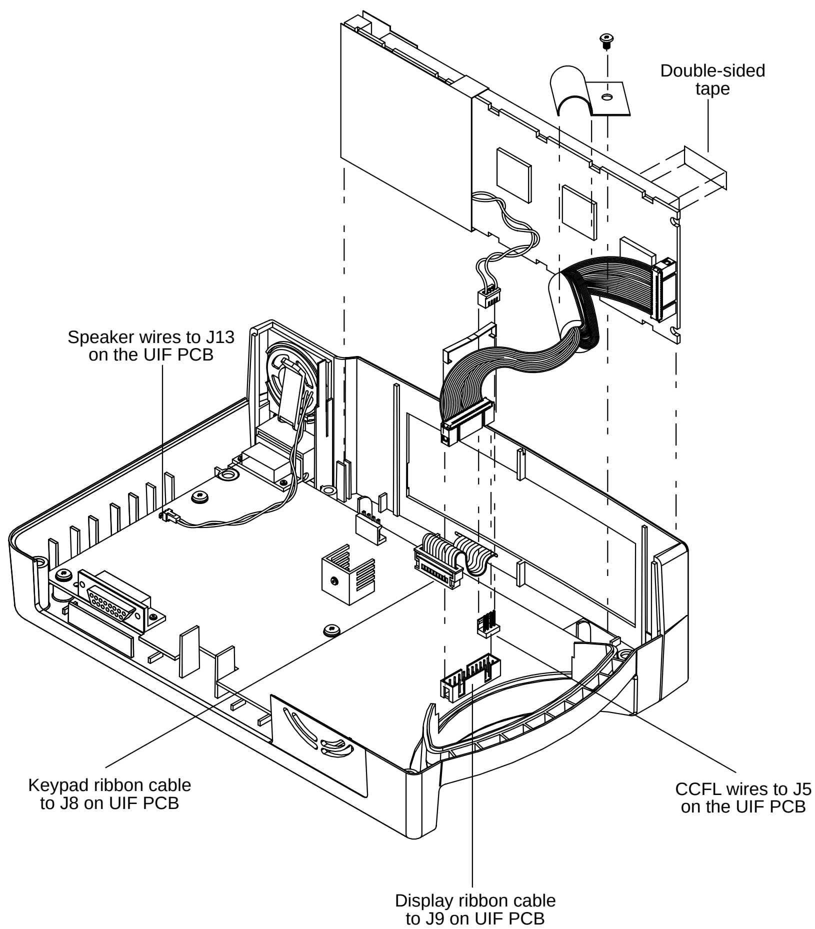

Figure 6-8: Display PCB

Installation

7. Install new double-sided tape as shown in Figure 6-8.
8. Slide the Display PCB into the grooves in the top case.
9. Check to make sure the Display PCB is firmly seated in the top case.
10. Apply pressure between the top case and the display PCB to make good contact with the double-sided tape.
11. Connect the wire harness with two white wires to J5 of the UIF PCB.
12. Connect the Display PCB ribbon cable to J9 of the UIF PCB.
13. Install the clip over the J9 connector.
14. Secure the ferrite on the ribbon cable from the Display PCB.
15. Place the clamp over the ferrite, assure that no wires are pinched, and screw the clamp to the UIF PCB.
16. Complete the procedure in paragraph 6.5.

6.11 UIF PCB REMOVAL/INSTALLATION

Removal

1. Complete the procedures in paragraphs 6.2 and 6.4.
2. Complete steps 2 through 4 of the procedure in paragraph 6.10.
3. Disconnect the keypad ribbon cable from J8 of the UIF PCB (Figure 6-8). J8 is a ZIF connector; lift up on the outer shell until it clicks, then remove the ribbon cable from the connector.
4. Disconnect the speaker cable from J13 on the UIF PCB.
5. Remove the four screws in the UIF PCB (Figure 6-9).
6. Remove the UIF PCB from the top case.

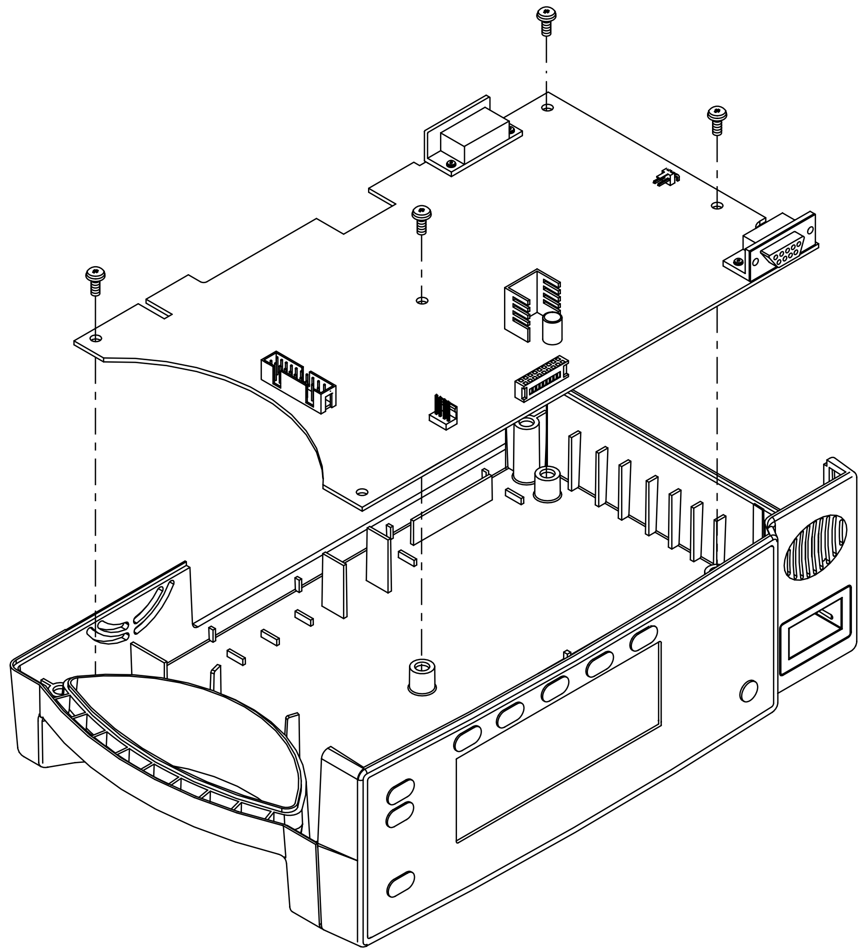

Figure 6-9: UIF PCB

Installation

Caution: When installing the UIF PCB, hand tighten the five screws to a maximum of 4 inch pounds. Over-tightening could strip out the screw holes in the top case, rendering it unusable.

7. Place the UIF PCB in the top case.
8. Install the four screws in the UIF PCB.
9. Lift up on the outer shell of J8 on the UIF PCB until it clicks.
10. Insert the keypad ribbon cable into J8 of the UIF PCB.
11. Slide the outer shell of J8 down until it locks in place.
12. Connect the speaker cable to J13 of the UIF PCB.
13. Complete steps 9 through 11 of the procedure in paragraph 6.10.
14. Complete the procedure in paragraph 6.5.

6.12 ALARM SPEAKER REMOVAL/INSTALLATION

Removal

1. Complete the procedures in paragraphs 6.2 and 6.4.
2. Disconnect the speaker wire harness from J13 on the UIF PCB (see Figure 6-10).
3. Pull the speaker holding clip towards the center of the monitor and lift the speaker from the top housing.

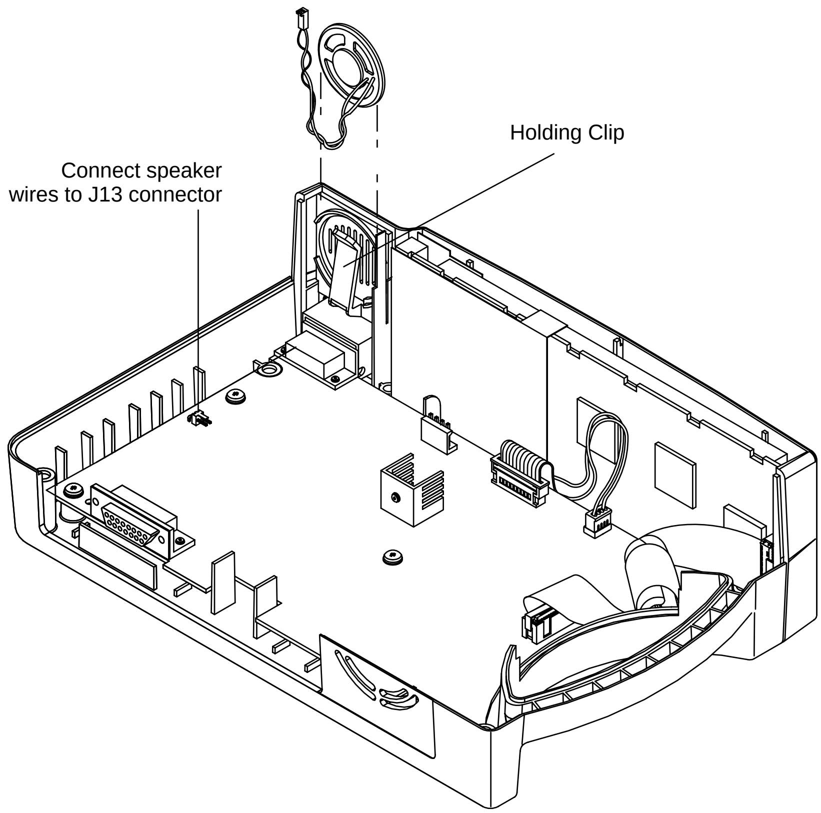

Figure 6-10: Alarm Speaker

Installation

4. Slide the speaker into the plastic holding clip provided in the top housing.
5. Connect speaker wire harness to J13 on the UIF PCB.
6. Complete the procedure in paragraph 6.5.

7.1 INTRODUCTION

Spare parts, along with part numbers, are shown below. Item numbers correspond to the callout numbers in Figure 7-1.

Table 7-1: Parts List

Item	Description	Part No.
1	Top Case Assembly (Membrane Panel Included)	048499
2	Fuse Drawer	691500
3	Fuses	691032
4	Power Entry Module	691499
5	Cooling Fan	035469
6	Power Supply	035800
7	LCD PCB	035416
8	Battery	640119
9	Battery Bracket	035307
10	UIF PCB	035355
	Alarm Speaker (not shown)	033494
	Rubber Feet (not shown)	4-003818-00
	Power Cord (not shown)	U.S. 071505 International 901862 U.K. 901863
	Tilt Stand (not shown)	891340
	GCX Mounting Kit (not shown)	035434

Figure 7-1 shows the NPB-295 expanded view with numbers relating to the spare parts list.

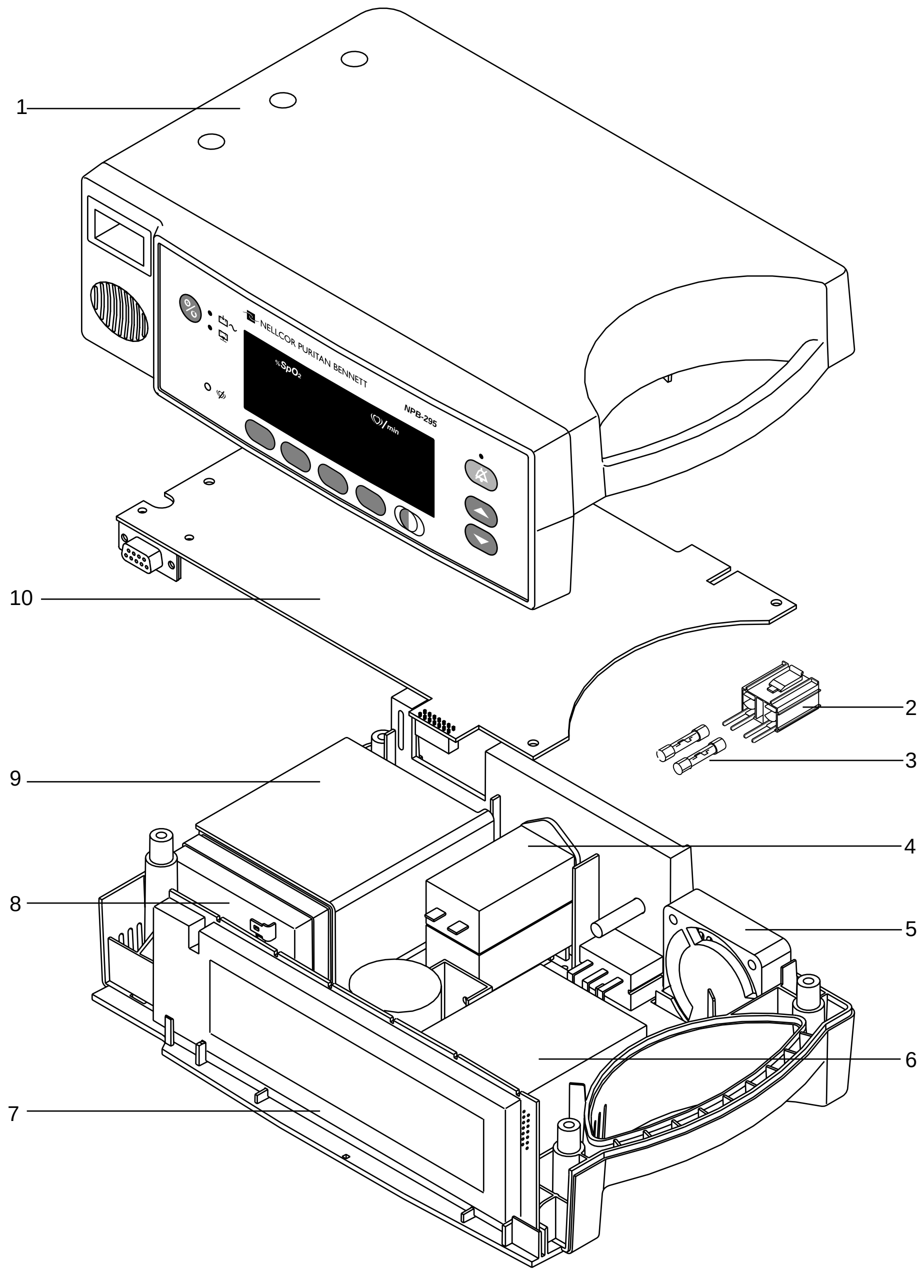

Figure 7-1: NPB-295 Expanded View

SECTION 8: PACKING FOR SHIPMENT

To ship the monitor for any reason, follow the instructions in this section.

8.1 GENERAL INSTRUCTIONS

Pack the monitor carefully. Failure to follow the instructions in this section may result in loss or damage not covered by any applicable Mallinckrodt warranty. If the original shipping carton is not available, use another suitable carton; North American customers may call Mallinckrodt Technical Services Department to obtain a shipping carton.

Before shipping the NPB-295, contact Mallinckrodt Technical Services Department 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 NPB-295 by any shipping method that provides proof of delivery.

8.2 REPACKING IN ORIGINAL CARTON

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

1. Place the monitor and, if necessary, accessory items in original packaging.

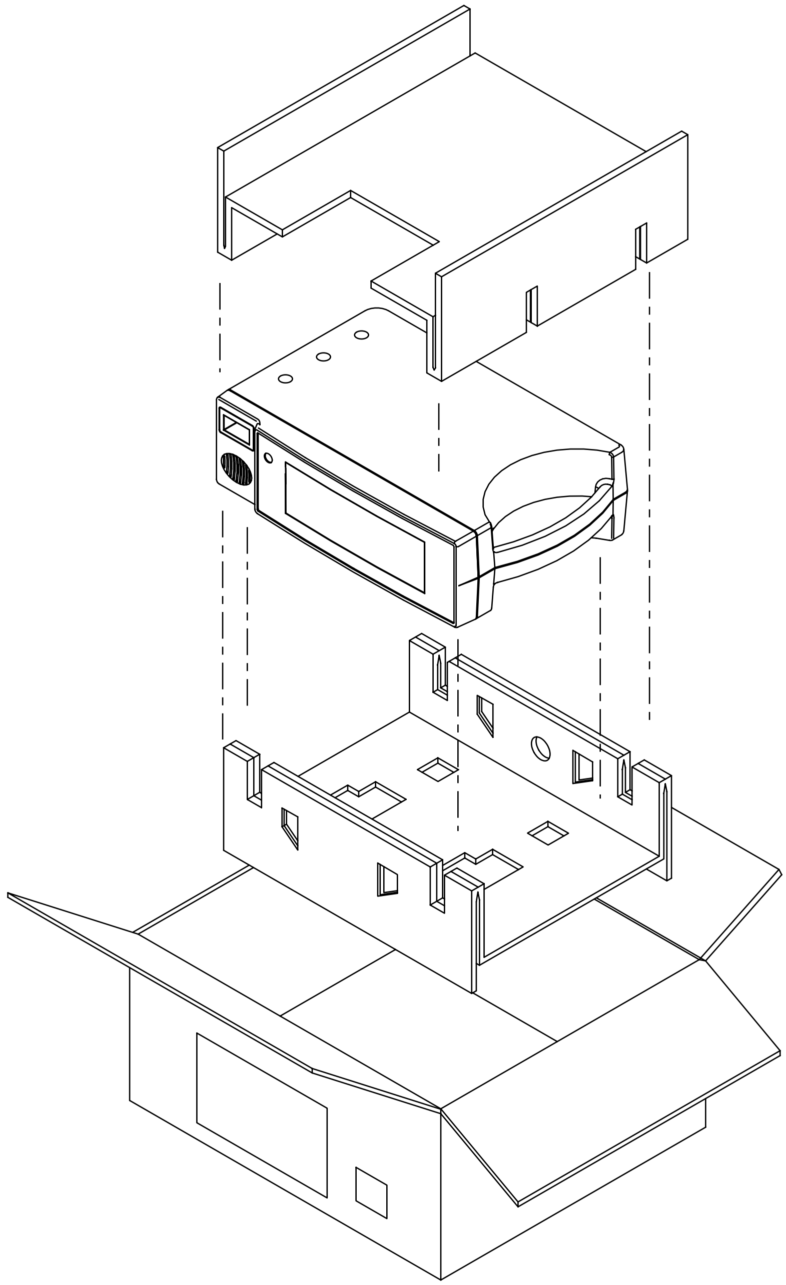

Figure 8-1: Repacking the NPB-295

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 N-295:

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

Designed to meet safety requirements of:

UL 2601-1 CSA-C22.2 No. 601-1-M90, IEC 601-1 (Class I, type BF), ISO 9919, EMC per EN 60601-1-2.

9.2 ELECTRICAL

Protection Class	Class I: per I.E.C. 601-1, clause 2.2.4
Degree of Protection	Type BF: per I.E.C. 601-1, clause 2.2.26
Mode of Operation	Continuous
Battery	
Type:	Rechargeable, sealed lead-acid, internal
Operating time:	8 hours minimum on new, fully charged battery under the following conditions: no alarms, no analog or serial output devices attached and no backlight
Recharge period:	14 hours for full charge (in standby) 18 hours for full charge (in use)
Fuses	2 each 5 X 20 mm Slow Blow 0.5 Amp, 250 volts
AC Power	
Selectable by switch	100-120 volts AC, 50/60 Hz or 200-240 volts AC, 50/60 Hz 20 VA

9.3 PHYSICAL CHARACTERISTICS

Dimensions	3.3 in H x 10.4 in W x 6.8 in D 8.4 cm H x 26.4 cm W x 17.3 cm D
Weight	5.7 lbs., 2.6 kg

9.4 ENVIRONMENTAL

Operating Temperature	5° C to 40° C (+41° F to +104° F)
Storage Temperature	
Boxed	-20° C to +70° C (-4° F to +158° F)
Unboxed	-20° C to +60° C (-4° F to +140° F)

Operating Altitude	-390 m to +3,658 m (-1,280 ft. to +12,000 ft.)
Relative Humidity	15% RH to 95% RH, noncondensing

9.5 ALARMS

Alarm Limit Range

% Saturation:	20-100%
Pulse:	30-250 bpm

9.6 FACTORY DEFAULT SETTINGS

Table 9-1: Default Settings

Parameter	Default Value
Alarm Silence Duration	60 seconds
Alarm Silence Restriction	Off with reminder
Alarm Volume	Level 5
Baud Rate	9600
Contrast	Mid-range
Data Port Mode	ASCII
Display	Pleth
Language	English
Nurse Call Polarity	Positive (NCALL+)
Pulse Beep Volume	Level 4
Pulse Rate High	170 bpm
Pulse Rate Low	40 bpm
SpO2 High	100%
SpO2 Low	85%
Trend	Saturation

9.7 PERFORMANCE

Measurement Range

SpO2:	0-100%
Pulse/Heart Rate:	20-250 bpm

Accuracy

SpO2

Adult:	70-100% ± 2 digits 0-69% unspecified
Neonatal:	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. Neonatal accuracy is determined with *Oxisensor II* N-25 sensors. In addition, the neonatal accuracy specification is 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.

SECTION 10: SERIAL PORT INTERFACE PROTOCOL

10.1 INTRODUCTION

When connected to the data port on the back of the NPB-295, printouts can be obtained, or communication of patient data can be sent to a Nellcor Oxinet II Monitoring System. Analog signals representing %SpO_2, Pulse Rate, and Pulse Amplitude are provided by the data port. A nurse call function is available from the data port. Each of these is discussed in more detail in the paragraphs that follow.

10.2 CONFIGURING THE DATA PORT

Items pertaining to the data port can be adjusted by following the softkey map in Figure 10-1. For a complete description of the softkeys, refer to the operator's manual.

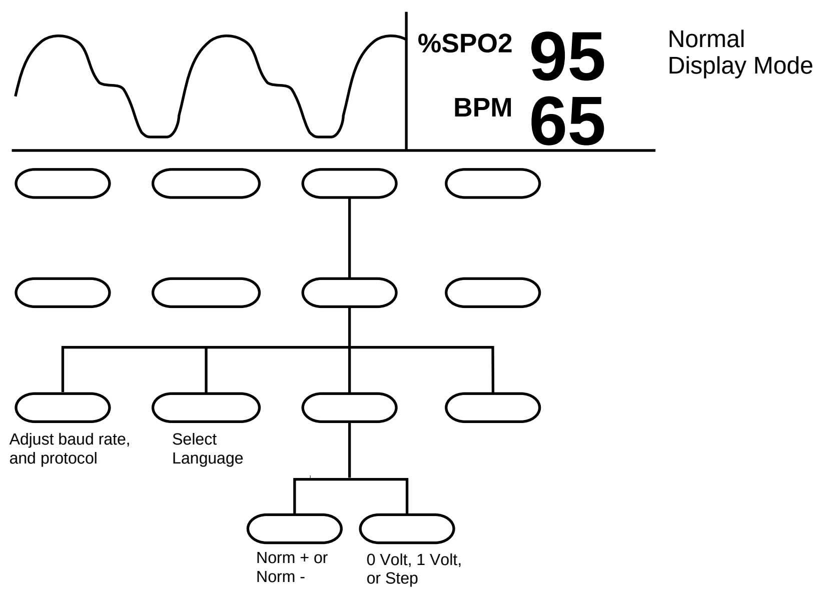

Figure 10-1: Data Port Softkeys

The COMM key is used to select communication protocols supported by the data port. The selections are:

- ASCII used for printouts
- OXINET II to enable communication with Oxinet
- Score ™ analysis software.

Note: When using Score™ software use the latest version. Contact Mallinckrodt's Technical Services Department or your local Mallinckrodt representative to determine the latest version of Score software.

- CLINICAL which is intended for Mallinckrodt use only
- GRAPH used for graphical printouts (will stop real-time print data)

To change the communication protocol, press Setup, Next, Select and Comm. Use the Adjust Up/Down buttons to select the desired communications protocol.

The baud rate may need to be changed to match the abilities of the attached equipment. To change the baud rate, press Setup, Next, and Comm. Use the Adjust Up/Down buttons to select a baud rate of 2400, 9600, or 19200.

Seven languages can be viewed on the screen and sent to the printer. The language being used can be changed by pressing Setup, Next, and Lang. Use the Adjust Up/Down buttons to select the desired language.

The voltage polarity for the Nurse Call, available at pins 11 and 5, can be selected through the softkeys. By pressing Setup, Next, Next, and NCALL, a choice of NORM + or NORM - is offered. NORM + sets the voltage to +5 volts DC to + 12 volts DC and NORM - sets the voltage to- 5 volts DC to - 12 volts DC when there is no audible alarm. When an audible alarm occurs, these voltages switch polarity. This signal is only available if the instrument is operating on AC power. For more information on Nurse Call, refer to paragraph A6 in this Appendix.

Analog calibration signals are provided to adjust a recorder to the output of the instrument. Selectable calibration signals are 1.0 volt DC, 0.0 volts DC, and Step. The signals are accessed by pressing Setup, Next, Next, and Analog. For more information on the analog signals, refer to paragraph A7 in this Appendix.

10.3 CONNECTING TO THE DATA PORT

Data is transmitted in the RS-232 format (pins 2,3, and 5) or RS-422 (pins 1,4,9, and 12). RS 232 data can be transmitted a maximum of 25 feet. The pin outs for the data port are listed in the chart below.

Table 10-1: Data Port Pin Outs

Pin	Signal
1	RXD+ (RS-422 positive input)
2	RXD_232 (RS-232 input)
3	TXD_232 (RS-232 output)
4	TXD+ (RS-422 positive output)
5	Signal Ground (isolated from earth ground)
6	AN_SpO2 (analog saturation output)
7	Normally Open, Dry Contacts, for Nurse Call (N.O. with no audible alarm)
8	Normally Closed, Dry Contacts, for Nurse Call (N.C. with no audible alarm)
9	RXD- (RS-422 negative input)
10	Signal Ground (isolated from earth ground)
11	Nurse Call (RS-232 level output {-5 to -12 volts DC with no audible alarm} {+5 to +12 volts DC with audible alarm})
12	TXD- (RS-422 negative output)
13	AN_PULSE (analog pulse rate output)
14	AN_PLETH (analog pleth wave output)
15	Nurse Call Common for Dry Contacts

Note: When the instrument is turned off, the contact at pin 7 becomes closed and the contact at pin 8 becomes open.

The pin layout is illustrated in Figure 10-1. The conductive shell is used as earth ground. An AMP connector is used to connect to the data port. Use AMP connector (AMP P/N 747538-1), ferrule (AMP P/N 1-747579-2) and compatible pins (AMP P/N 66570-2).

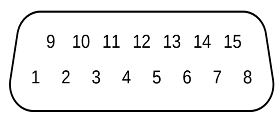

Figure 10-2: Data Port Pin Layout

When building an RS-422 cable, a resistor (120 ohm, 1/4 watt, 5%) must be added between pins 1 and 9 of the cable. The end of the cable with the resistor added must be plugged into the NPB-295. This resistor is not necessary for RS-232 cables.

The serial cable must be shielded (example: Beldon P/N 9616). Connectors at both ends of the serial cable must have the shield terminated to the full 360 degrees of the connector's metal shell. If rough handling or sharp bends in the cable is anticipated, use a braided shield.

10.4 REAL-TIME PRINTOUT

When a real-time display or printout is being transmitted to a printer or PC, a new line of data is printed every 2 seconds. Every 25^{th} line is a Column Heading line. A column heading line is also printed any time a value in the column heading line is changed. A real-time printout is shown below in Figure 10-2.

Note: If the data output stops transmitting, turn the power off and back on again, or, if connected to a PC, send an XON (Ctrl-q) to resume transmission.

NPB-295	VERSION 1.0.0.1		CRC: XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME		%SpO2	BPM	PA	Status	
01-Jul-97 14:00:00		100	120	220		
01-Jul-97 14:00:02		100	124	220		
01-Jul-97 14:00:04		100	190	220		
01-Jul-97 14:00:06		100	190*	220	PH	
01-Jul-97 14:00:08		100	190*	220	PH	
01-Jul-97 14:00:10		100	190*	220	PH	
01-Jul-97 14:00:12		100	190*	220	PH	
01-Jul-97 14:00:14		100	190*	220	PH	
01-Jul-97 14:00:16		100	190*	220	PH LB	
01-Jul-97 14:00:18		100	190*	220	PH LB	
01-Jul-97 14:00:20		100	190*	220	PH LB	
01-Jul-97 14:00:22		- - -	- - -	- - -	SD LB	
01-Jul-97 14:00:24		- - -	- - -	- - -	SD LB	
01-Jul-97 14:00:26		- - -	- - -	- - -	SD	
01-Jul-97 14:00:28		- - -	- - -	- - -	SD	
01-Jul-97 14:00:30		- - -	- - -	- - -	SD	
01-Jul-97 14:00:32		- - -	- - -	- - -	SD	
01-Jul-97 14:00:34		- - -	- - -	- - -	PS	
01-Jul-97 14:00:36		- - -	- - -	- - -	PS	
01-Jul-97 14:00:38		- - -	- - -	- - -	PS	
01-Jul-97 14:00:40		- - -	- - -	- - -	PS	
01-Jul-97 14:00:42		- - -	- - -	- - -	PS	
01-Jul-97 14:00:44		- - -	- - -	- - -	PS	
NPB-295	VERSION 1.0.0.1		CRC: XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME		%SpO2	BPM	PA	Status	
01-Jul-97 14:00:46		- - -	- - -	- - -	PS	
NPB-25	VERSION 1.0.0.1		CRC: XXXX	SpO2 Limit:	80-100%	PR Limit: 100-180 bpm
TIME		%SpO2	BPM	PA	Status	
01-Jul-97 14:00:48		79*	59*	220	SL PL LB	
01-Jul-97 14:00:50		79*	59*	- - -	PS SL PL LB	

Figure 10-3: Real-Time Printout

10.4.1 Column Heading

NPB-295	VERSION 1.0.0.1		CRC: XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME		%SpO2	BPM	PA	Status	

The first two lines of the chart are the Column Heading. Every 25th line is a Column Heading. A column heading is also printed whenever a value of the Column Heading is changed. There are three Column Heading lines shown in Figure 10-2. Using the top row as the starting point, there are 25 lines before the second Column Heading is printed. The third Column Heading was printed because the SpO_2 limits changed from 30-100% to 80-100%.

Data Source

NPB-295	VERSION 1.0.0.1		CRC XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME		%SpO2	BPM	PA	Status	

Data in the highlighted box above represents the source of the printout or display, in this case the NPB-295.

Software Revision Level

NPB-295	VERSION 1.0.0.1		CRC: XXXX	SpO2 Limit:	30-100%	PR Limit: 100-180 bpm
TIME		%SpO2	BPM	PA	Status	

The next data field tells the user the software level, (Version 2.0.0.0) and a software verification number (CRC XXXX). Neither of these numbers should change during normal operation. The numbers will change if the monitor is serviced and receives a software upgrade.

Alarm Limits

NPB-295	VERSION 1.0.0.1	CRC: XXXX	SpO2 Limit: 30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	BPM	PA	Status

The last data field in the top line indicates the high and the low alarm limits for %SpO_2 and for the pulse rate (PR). In the example above, the low alarm limit for SpO_2 is 30% and the high alarm limit is 100%. Pulse Rate alarm limits are, low 100 bpm, and high 180 bpm.

Column Headings

NPB-295	VERSION 1.0.0.1	CRC: XXXX	SpO2 Limit: 30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	BPM	PA	Status

Actual column headings are in the second row of the Column Heading line. Patient data that is presented in the chart, from left to right, is the time that the line was obtained, the current %SpO_2 value being measured, the current Pulse Rate in beats per minute (bpm), the current Pulse Amplitude (PA), and the operating status of the NPB-295.

10.4.2 Patient Data and Operating Status

Time

TIME	%SpO2	BPM	PA	Status
01-Jul-97 14:00:00	100	120		

The Time column represents the NPB-295 real-time clock.

Patient Data

NPB-295	VERSION 1.0.0.1	CRC: XXXX	SpO2 Limit: 30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	BPM	PA	Status
01-Jul-97 14:00:06	100	190*	220	PH

Patient data and the operating status of the unit are highlighted in the display above. Parameter values, at the time of the printout, are displayed directly beneath the heading for each parameter. In this example the %SpO_2 is 100, and the PR is 190 beats per minute. The "*" next to the 190 indicates that 190 beats per minute is outside of the alarm limits, indicated in the top row, for pulse rate. If no data for a parameter is available, three dashes (- - -) will be displayed in the printout.

PA is an indication of Pulse Amplitude. The number can range from 0 to 254. There are no alarm parameters for this value. It can be used for trending information. It is an indication of a change in pulse volume, pulse strength, or circulation.

Operating Status

NPB-295	VERSION 1.0.0.1	CRC: XXXX	SpO2 Limit: 30-100%	PR Limit: 100-180 bpm
TIME	%SpO2	BPM	PA	Status
01-Jul-97 14:00:06	100	190*	220	PH

The Status column indicates alarm conditions and operating status of the NPB-295. In this example the PH means Pulse High. A complete listing of the status codes is listed in Table 10-2. As many as 4 codes can be displayed at one time in the Status column.

Table 10-2: Status Codes

Code	Meaning
AO	**A**larm **O**ff
AS	**A**larm **S**ilence
BU	**B**attery in **U**se
LB	**L**ow **B**attery
LM	**L**oss of Pulse with **M**otion
LP	**L**oss of **P**ulse
MO	**Mo**tion
PH	**P**ulse Rate **H**igh Limit Alarm
PL	**P**ulse Rate **L**ow Limit Alarm
PS	**P**ulse **S**earch
SD	**S**ensor **D**isconnect
SH	**S**at **H**igh Limit Alarm
SL	**S**at **L**ow Limit Alarm
- - -	No Data Available
*	Alarm Parameter Being Violated

Note: A Sensor Disconnect will also cause three dashes (- - -) to be displayed in the patient data section of the printout.

10.5 TREND DATA PRINTOUT

In the ASCII mode, the format of data displayed when a trend printout is requested is similar to that of the real-time data. The only differences are that "TREND" is displayed in the top row instead of the "CRC:XXXX" software verification number, and there is no "Status" column.

In the GRAPH mode, the NPB-295 trend printout is a copy of the trend displayed on the NPB-295's screen.

Readings are displayed in 2-second intervals. The values on each row are an average for the 2-second period.

At the end of the printout, an "Output Complete" line indicates that the transmission was successful. If the "Output Complete" line is not present, the data should be considered invalid.

```
NPB-295    VERSION 1.0.0.1    CRC: XXXX    SpO2 Limit:   30-100%    PR Limit: 100-180 bpm
TIME                      %SpO2   PR (bpm)   PA
22-Nov-97  14:00:05         100   120        150
22-Nov-97  14:00:10         100   121        154
22-Nov-97  14:00:15         100   120        150
Output Complete
```

Figure 10-4: Trend Data Printout

10.6 NURSE CALL

An RS-232 Nurse Call signal (pins 5 and 11) can be obtained by connecting to the data port. It is in the form of a positive or negative voltage chosen by the user. This function is only available when the instrument is operating on AC power. The RS-232 Nurse Call will be disabled when the unit is operating on battery power.

The remote location will be signaled anytime there is an audible alarm. If the audible alarm has been set Off, or silenced, the Nurse Call function is also turned off.

Pin 11 on the data port is the RS-232 Nurse Call signal and pin 5 is ground (see Figure 10-1). When there is no audible alarm, the voltage between pins 10 and 11 will be a -5 volt DC to -12 volts DC, or +5 volts DC to +12 volts DC, depending on the option chosen via the softkeys (either NCALL+ or NCALL-). Whenever there is in an audible alarm, the output between pins 5 and 11 will reverse polarity.

An internal Nurse Call relay (pins 7, 8, and 15) provides dry contacts that can be used to signal a remote alarm. These contacts can be used whether the instrument is operating on AC or on its internal battery. Pin 15 is common, pin 7 is N.O., and pin 8 is N.C. Table 10-3 shows the state of the contacts for alarm and no alarm conditions, and for instrument off.

Table 10-3: Nurse Call Relay Pin States

Pin	No Alarm or Alarm Silenced	Audible Alarm	Instrument Off
7 N.O.	Open	Closed	Closed
8 N.C.	Closed	Open	Open

Table 10-4: Rating of Nurse Call Relay

Maximum Input Voltage	30 volts AC or DC (polarity is not important)
Load Current	120 mA continuous (peak 300 mA @ 100 ms)
Minimum Resistance	26 ohms to 50 ohms (40 ohms typical) during alarms
Ground Reference	Isolated Ground
Electrical Isolation	1,500 Volts

10.7 ANALOG OUTPUT

Analog outputs are provided for Saturation, Pulse Rate, and a Plethysmographic waveform. These outputs are available only if the monitor is operating on AC power.

The output voltage is 0.0 to + 1.0 volt DC for all three parameters. A 1.0 volt DC output for saturation equals 100%; for pulse rate it equals 250 bpm; and for plethysmographic waveform, it equals 255 pulse amplitude units (pau). The voltage will decrease as the values for these parameters decrease. If no data for a parameter is available, the output voltage for that parameter will be a 0.0 volts DC.

At power-on after the completion of POST, the instrument will initiate an automatic three-step calibration signal. The calibration signal will begin at 0.0 volts DC and hold that point for 60 seconds. It will then jump up to 1.0 volt DC and hold that value for 60 seconds. The third part of the calibration signal is a stair step signal. The stair step signal will start at 0.0 volts DC and increase up to 1.0 volt DC in 1/10 volt increments. Each increment will be held for 1 second. Through use of the softkeys, the 0.0 volts DC, 1.0 volt DC, or stair step signal can be selected individually (refer to Section 4).

SECTION 11: TECHNICAL SUPPLEMENT

11.1 INTRODUCTION

This Technical Supplement provides the reader with a discussion of oximetry principles and a more in-depth discussion of NPB-295 circuits. Block and schematic diagrams support a functional overview and detailed circuit analysis. The schematic diagrams are located at the end of this supplement.

11.2 OXIMETRY OVERVIEW

The NPB-295 is based on the principles of spectrophotometry and optical plethysmography. Optical plethysmography uses light absorption technology to reproduce waveforms produced by pulsatile blood. The changes that occur in the absorption of light due to vascular bed changes are reproduced by the pulse oximeter as plethysmographic waveforms.

Spectrophotometry uses various wavelengths of light to qualitatively measure light absorption through given substances. Many times each second, the NPB-295 passes red and infrared light into the sensor site and determines absorption. The measurements that are taken during the arterial pulse reflect absorption by arterial blood, nonpulsatile blood, and tissue. The measurements that are obtained between arterial pulses reflect absorption by nonpulsatile blood and tissue.

By correcting "during pulse" absorption for "between pulse" absorption, the NPB-295 determines red and infrared absorption by pulsatile arterial blood. Because oxyhemoglobin and deoxyhemoglobin differ in red and infrared absorption, this corrected measurement can be used to determine the percent of oxyhemoglobin in arterial blood: SpO2 is the ratio of corrected absorption at each wavelength.

11.2.1 Functional versus Fractional Saturation

The NPB-295 measures functional saturation, that is, oxygenated hemoglobin expressed as a percentage of the hemoglobin that is capable of transporting oxygen. It does not detect significant levels of dyshemoglobins. In contrast, some instruments such as the IL282 Co-oximeter measure fractional saturation, that is, oxygenated hemoglobin expressed as a percentage of all measured hemoglobin, including dyshemoglobins.

Consequently, before comparing NPB-295 measurements with those obtained by an instrument that measures fractional saturation, measurements must be converted as follows:

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

11.2.2 Measured Versus Calculated Saturation

When saturation is calculated from a blood gas measurement of the partial pressure of arterial oxygen (PaO2), the calculated value may differ from the NPB-295 SpO2 measurement. This is because the calculated saturation may not have been corrected for the effects of variables that can shift the relationship between PaO2 and saturation.

Figure 11-1 illustrates the effect that variations in pH, temperature, partial pressure of carbon dioxide (PCO2), and concentrations of 2,3-DPG and fetal hemoglobin may have on the oxyhemoglobin dissociation curve.

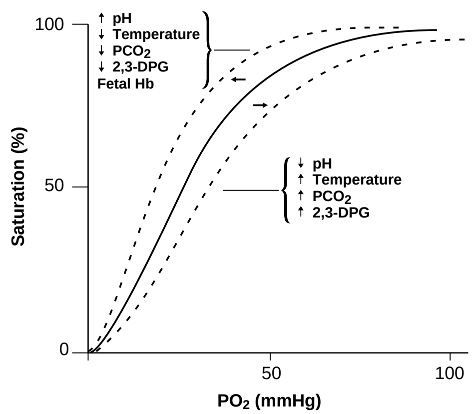

Figure 11-1: Oxyhemoglobin Dissociation Curve

11.3 CIRCUIT ANALYSIS

The following paragraphs discuss the operation of each of the printed circuit boards within the NPB-295 pulse oximeter. Refer to the appropriate schematic diagram at the end of this supplement.

11.4 FUNCTIONAL OVERVIEW

The monitor functional block diagram is shown in Figure 11-2. Most of the functions of the NPB-295 are performed on the UIF PCB functions on the UIF PCB include the 331 and PIC, and Memory. Other key components of the NPB-295 are the Power Entry Module (PEM), Power Supply, and the LCD Display.

The Display module includes the Membrane Panel and the LCD Display. The Membrane panel contains annunciators and push buttons, allowing the user to access information and to select various available parameters. The LCD Display PCB contains the LCD, which presents the patient data.

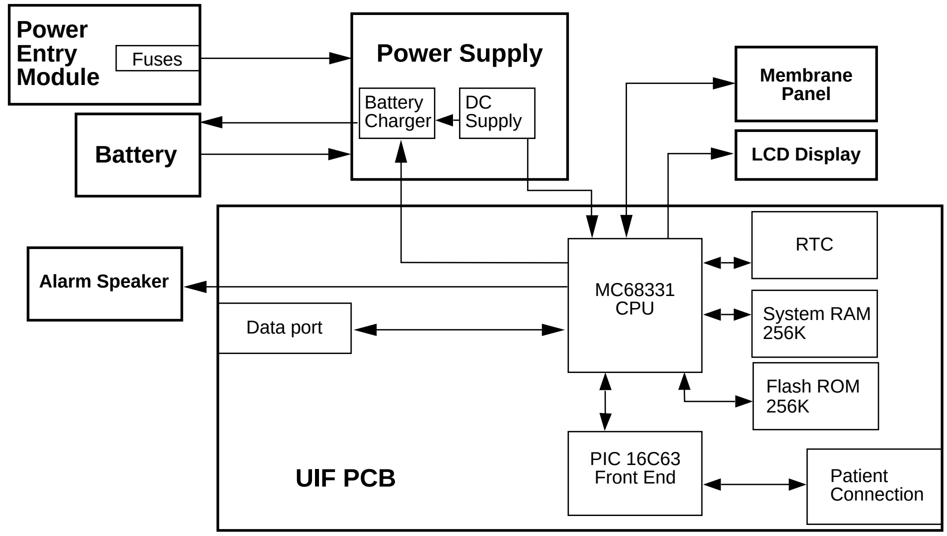

Figure 11-2: NPB-295 Functional Block Diagram

11.5 AC INPUT

A selector switch on the back of the NPB-295 allows the user to connect the monitor to AC power ranging from 100 volts AC to 240 volts AC. The switch has two positions, one for 100 volts AC through 120 volts AC and one for 210 volts AC through 240 volts AC. Verify the switch selection matches the AC power at your location before plugging the monitor into an AC outlet.

AC power enters the NPB-295 through the Power Entry Module (PEM). A 0.5 amp fuse is placed in both the “Hot” and “Neutral” lines. These user accessible fuses are located in a fuse drawer, which is part of the PEM on the back of the instrument.

11.6 POWER SUPPLY PCB THEORY OF OPERATION

The NPB-295 uses an unregulated linear power supply. This power supply provides the DC power needed to charge the battery, run the cooling fan and to power the User Interface PCB (UIF). Electro Static Discharge (ESD) protection and patient isolation from mains, is also provided by the power supply.

AC power from the PEM is passed through a step-down transformer, T2, which has two primary and two secondary windings. If switch SW1 on the back of the monitor is in the 120 volts AC position, the primary windings are in parallel. The primary windings are in series if SW1 is in the 240 volts AC position.

Each secondary winding is fused with a 2.0 amp fuse (F1 and F2). If a short circuit should occur in the DC circuitry, these fuses prevent the transformer from overheating. The output of the transformer varies, depending on load and input. Voltage measured between the outlet of a secondary winding and ground can be from 6 to 20 volts AC. High frequency noise from the AC line and from the UIF PCB is filtered by C6 and C8 before passing through the bridge rectifier.

Two outputs from the bridge rectifier are used in the NPB-295. The fan control circuit uses the negative output. The positive output is the Main DC ranging from 7 to 18 volts DC. This positive voltage is used for the battery circuit and to power the UIF PCB.

11.6.1 Fan Control

A fan control circuit on the Power Supply PCB is used to control the temperature inside the case of the NPB-295. The temperature sensor used in this circuit is U3. U3 turns on the cooling fan if the temperature inside the case gets above approximately 31° C. The cooling fan runs on approximately 15 volts DC.

Note: The fan is disabled if the unit is running on battery power.

11.6.2 Battery Circuits

Two circuits are included in this section of the Power Supply PCB. One circuit is used to charge the battery and the other circuit provides battery protection.

Charging Circuit

The Power Supply will charge the battery any time the NPB-295 is connected to AC power even if the monitor is not turned on. The voltage applied to the battery is 6.8 ± 0.15 volts DC and is current limited to 400 ± 80 mA.

Battery voltage is checked periodically by the processor. A signal from the processor turns the charging circuit off to allow this measurement to be taken. If the processor determines the battery voltage is below 5.85 ± 0.1 volts DC a low battery alarm is declared.

Battery Protection

Two types of battery protection are provided by the Power Supply: protection for the battery and protection from the battery.

Switch SW2 is a resettable component that protects the battery. SW2 opens and turns the charging circuit off if the temperature of the battery rises above 50° C. If the output of the battery exceeds 2.0 amps, F3 opens. F3 protects the battery from a short to ground of the battery output.

Protection from the battery is provided for the event the battery is connected backwards. Components on the UIF PCB and the Power Supply block and limit the voltage to provide protection to circuits in the instrument.

11.7 BATTERY

A lead-acid battery is used in the NPB-295. It is rated at 6 volts DC, 4 amphours. When new and fully charged, the battery will operate the monitor for 8 hours under the following conditions: no alarms, no analog or serial output devices attached and no backlight. The battery can withstand 400 charge/discharge cycles. Recharging the battery to full capacity will take 14 hours in standby or 18 hours if the instrument is being used.

Changeover from AC to battery power will not interrupt the normal monitoring operation of the NPB-295. However, when the unit is running on battery power, the cooling fan, data port, RS-232 Nurse Call, and LCD backlight will be turned off.

The 331 CPU on the UIF PCB monitors the charge level of the battery. If the voltage of the battery falls below 5.85 ± 0.1 volts DC, a low battery alarm is declared. The instrument will continue monitoring and alarming for 15 minutes then power down. This 15-minute alarm and power-down sequence can be repeated by turning the unit back on, provided the battery voltage remains above the critical level.

Battery voltage is considered critical when it decreases to 5.67 ± 0.1 volts DC. If the instrument is turned on and battery voltage is at the critical level, an error code is displayed and the instrument will not monitor the patient. The instrument will run for 15 minutes with the error code displayed and then power down.

Both conditions can be corrected by plugging the unit into an AC source for 14 hours to allow the battery to fully recharge.

11.8 USER INTERFACE PCB (UIF)

The UIF PCB is the heart of the NPB-295. All functions except the unregulated DC power supply, LCD display and membrane keypad reside on the UIF PCB.

11.8.1 Regulated DC Power Supply

The UIF PCB receives the Main_DC unregulated voltage of 7 to 18 volts DC from the Power Supply or 5.8 to 6.5 volts DC from the internal battery. From either of these signals, the regulated power supply on the UIF PCB generates +10.0, -10.0, -5.0 and +5.0 volts DC.

11.8.2 Controlling Hardware

Two microprocessors reside on the UIF PCB. The CPU is a Motorola MC68331CF (331). The second microprocessor PIC16C63 is referred to as the PIC and is controlled by the CPU.

CPU

The 331 is the main controller of the NPB-295. The 331 controls the front panel display, data storage, instrument status, sound generation, and monitoring and controlling the instrument's power. The 331 also control data port communication and the Nurse Call feature.

Battery voltage is checked periodically by the processor. A signal from the processor turns the charging circuit off to allow this measurement to be taken. If the processor determines that the battery voltage is below 5.85 ± 0.1 volts DC, a low battery alarm is declared by the PIC. If battery voltage on the UIF PCB is measured below 5.67 ± 0.1 volts DC, the monitor will display an error code and sound an audible alarm. Voltages measured at the battery will be slightly higher than the values listed above. The user will be unable to begin monitoring a patient if the battery voltage remains below this point. If either event occurs, plug the unit into an AC source for 14 hours to allow the battery to fully recharge.

When the NPB-295 is powered by AC, the RS-232 Nurse Call function is available. If no audible alarm conditions exist, the output will be -5 to -12 volts DC or +5 volts DC to +12 volts DC. These voltages are dependent upon the option selected by the use of the softkeys. Should an audible alarm occur, the output will change polarity.

The 331 also controls a set of dry contacts provided by a relay on the UIF PCB. The relay will function normally on AC power or on the internal battery power.

When the CPU sends a tone request, three items are used to determine the tone that is sent to the speaker. First, pulse tones change with the %SpO2 value being measured. The pulse beep tone will rise and fall with the measured %SpO2 value. Second, three levels of alarms, each with its own tone, can occur; High, Medium, and Low priority. Third, the volume of the pulse tone and alarm is user adjustable. Alarm volume can be adjusted from level 1 to level 10, with level 10 being the highest volume. Setting the volume to zero can turn off pulse tones.

A real-time clock is provided by the NPB-295. A dedicated real-time clock chip provides this.

User's interface includes the front panel display and the keypad. By pressing any of nine keys on the keypad the operator can access different functions of the NPB-295. The 331 will recognize the keystroke and make the appropriate change to the monitor display to be viewed by the operator. The monitor uses any changes made by the operator until it is turned off. Default values will be restored when the unit is powered-on again.

Patient data is stored by the NPB-295 and can be downloaded to a printer through the data port provided on the back of the monitor. An in-depth discussion of the data port is covered in the Appendix of this manual.

PIC

The PIC controls the SpO2 function and communicates the data to the 331.

A pulse width modulator (PWM) function built into the processor controls the SpO2 function. PWM signals are sent to control the intensity of the LEDs in the sensor and to control the gain of the amplifiers receiving the return signals from the photodetector in the sensor.

Analog signals are received from the SpO2 circuit on the UIF PCB. An A/D function in the PIC converts these signals to digital values for %SpO2 and heart rate. The values are sent to the 331 to be displayed and stored.

11.8.3 Sensor Output/LED Control

The SpO2 analog circuitry provides control of the red and IR LEDs such that the received signals are within the dynamic range of the input amplifier. Because excessive current to the LEDs will induce changes in their spectral output, it is sometimes necessary to increase the received signal channel gain. To that point, the CPU controls both the currents to the LEDs and the amplification in the signal channel.

At initialization of transmission, the LEDs' intensity level is based on previous running conditions, and the transmission intensity is adjusted until the received signals match the range of the A/D converter. If the LEDs reach maximum output without the necessary signal strength, the PWMs will increase the channel gain. The PWM lines will select either a change in the LED current or signal gain, but will not do both simultaneously.

The LED drive circuit switches between red and IR transmission and disables both for a time between transmissions in order to provide a no-transmission reference. To prevent excessive heat build-up and prolong battery life, each LED is on for only a small portion of the duty cycle. Also, the frequency of switching is well above that of motion artifact and not a harmonic of known AC transmissions. The IR transmission alone, and the red transmission alone, will each be on for about one-fifth of the duty cycle; this cycle is controlled by the PIC.

Input Conditioning

Input to the SpO2 analog circuit is the current output of the sensor photodiode. In order to condition the signal current, it is necessary to convert the current to voltage.

Because the IR and red signals are absorbed differently by body tissue, their received signal intensities are at different levels. Therefore, the IR and red signals must be demodulated and then amplified separately in order to compare them to each other. De-multiplexing is accomplished by means of two circuits that alternately select the IR and red signals. Two switches that are coordinated with the IR and red transmissions control selection of the circuits. A filter with large time-constant follows to smooth the signal and remove noise before amplification.

11.8.4 Signal Gain

The separated IR and red signals are amplified so that their DC values are within the range of the A/D converter. Because the received IR and red signals are typically at different current levels, the signal gain circuits provide independent amplification for each signal as needed. The gain in these circuits is adjusted by means of the PWM lines from the CPU.

After the IR and red signals are amplified, they are filtered to improve the signal-to-noise ratio and clamped to a reference voltage to prevent the combined AC and DC signal from exceeding an acceptable input voltage from the A/D converter.

11.8.5 Variable Gain Circuits

The two variable gain circuits are functionally equivalent. The gain of each circuit is contingent upon the signal's received level and is controlled to bring each signal to approximately 3.5 volts. Each circuit uses an amplifier and one switch in the triple SPDT analog-multiplexing unit.

11.8.6 AC Ranging

In order to achieve a specified level of oxygen saturation measurement and to still use a standard-type combined PIC and A/D converter, the DC offset is subtracted from each signal. The DC offsets are subtracted by using an analog switch to set the mean signal value to the mean of the range of the A/D converter whenever necessary. The AC modulation is then superimposed upon that DC level. This is also known as AC ranging.

Each AC signal is subsequently amplified such that its peak-to-peak values span one-fifth of the range of the A/D converter. The amplified AC signals are then filtered to remove the residual effects of the PWM modulations and, finally, are input to the PIC. The combined AC and DC signals for both IR and red signals are separately input to the A/D converter.

11.8.7 Real-Time Clock (RTC)

Real time is tracked by the NPB-295. As long as battery power or AC power is available, the instrument will keep time. If the battery is removed, the time clock will have to be reset.

The LCD will display the time and date for the data period highlighted by the cursor on a trend display. A time stamp is printed for each line of data on a printout. Real-time data is displayed and printed as Day, Month, Year, Hours, Minutes, and Seconds.

11.8.8 Patient Data Storage

Whenever the NPB-295 is turned on, it stores a "data point" in memory every 2 seconds (regardless of whether the NPB-295 is monitoring a patient or not). Up to 50 alarm limit changes will also be stored in trend data. The NPB-295 can store up to 24 hours of trend data. . The 24 hours of stored trend data is available for downloading to Score™ software for 45 days. There are no limitations for displaying or printing data.

Caution: Changing alarm limit settings uses up trend memory space. Change alarm limits only as needed.

Note: Trend memory always contains the MOST RECENT 24 hours of data, with newly collected data over-writing the oldest data on a rolling basis. The NPB-295 continues to record data points as long as the monitor is powered on, with "blank" data points collected if no sensor is connected to the monitor or patient. "Blank" data will over-write older patient data if the memory becomes full. Therefore, if you want to save old patient data, it is important that you turn your monitor off when you are not monitoring a patient, and that you download the trend memory, using Score software, before it fills up and over-writes the old data with new data (or "blank" data).

Note: When using Score™ software use the latest version. Contact Mallinckrodt's Technical Services Department or your local Mallinckrodt representative to determine the latest version of Score software.

If battery power is disconnected or depleted, trend data and user settings will be lost. All data is stored with error detection coding. If data stored in memory is found to be corrupted, it is discarded.

11.9 FRONT PANEL DISPLAY PCB AND CONTROLS

11.9.1 Display PCB

The Front Panel LCD PCB provides visual patient data and monitor status.

At power up, all indicators and pixels are illuminated to allow verification of their proper operation. Next, the Nellcor Puritan Bennett logo and the software revision level are displayed. After this cycle has been completed, the instrument is ready to begin monitoring.

The LCD allows the user to select among several different types of displays. Graphs, which are used for trend screens, can be displayed. Real-time patient data can include a plethysmographic waveform and digital values for SpO2 and BPM. If a plethysmograph is not desired, the operator can select to view only digital data for SpO2 and BPM along with a blip bar to show pulse intensity.

11.9.2 Membrane Keypad

A membrane keypad is mounted as part of the top case. A ribbon cable from the keypad passes through the top case and connects to the UIF PCB. Nine keys allow the operator to access different functions of the NPB-295.

These keys allow the user to select and adjust the alarm limits, cycle power to the unit, and to silence the alarm. Alarm volume and alarm silence duration can also be adjusted via the keypad. Pressing the softkeys can access a number of other functions. These functions are discussed in greater detail in Section 4.

Five LEDs are also part of the membrane keypad. These LEDs indicate AC power available, low battery, pulse search, alarm silence, and noise/motion.

11.10 SCHEMATIC DIAGRAMS

The following part locator diagrams and schematics are included in this section:

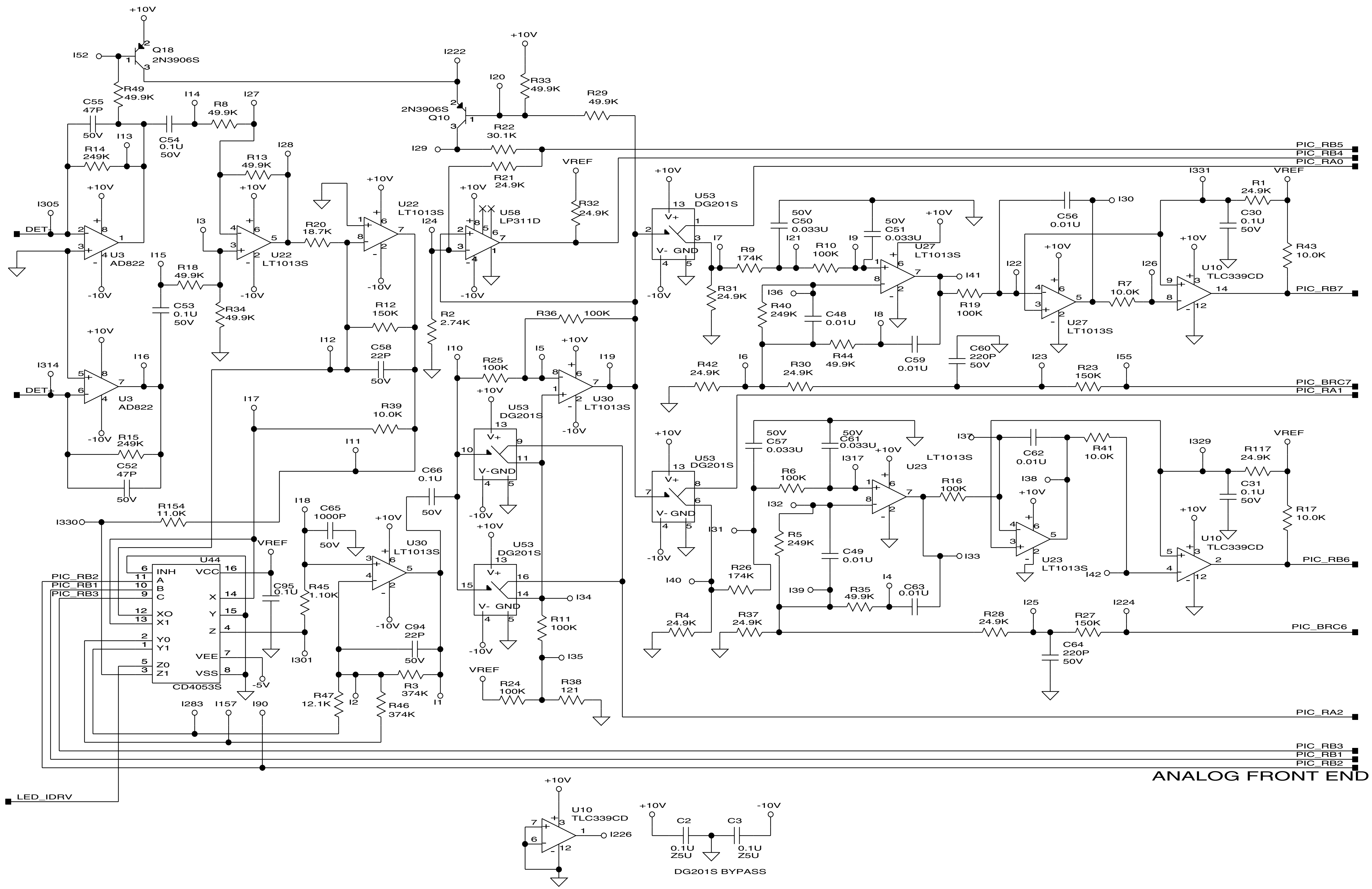

Figure 11-3
UIF PCB Front End Red/IR Schematic Diagram

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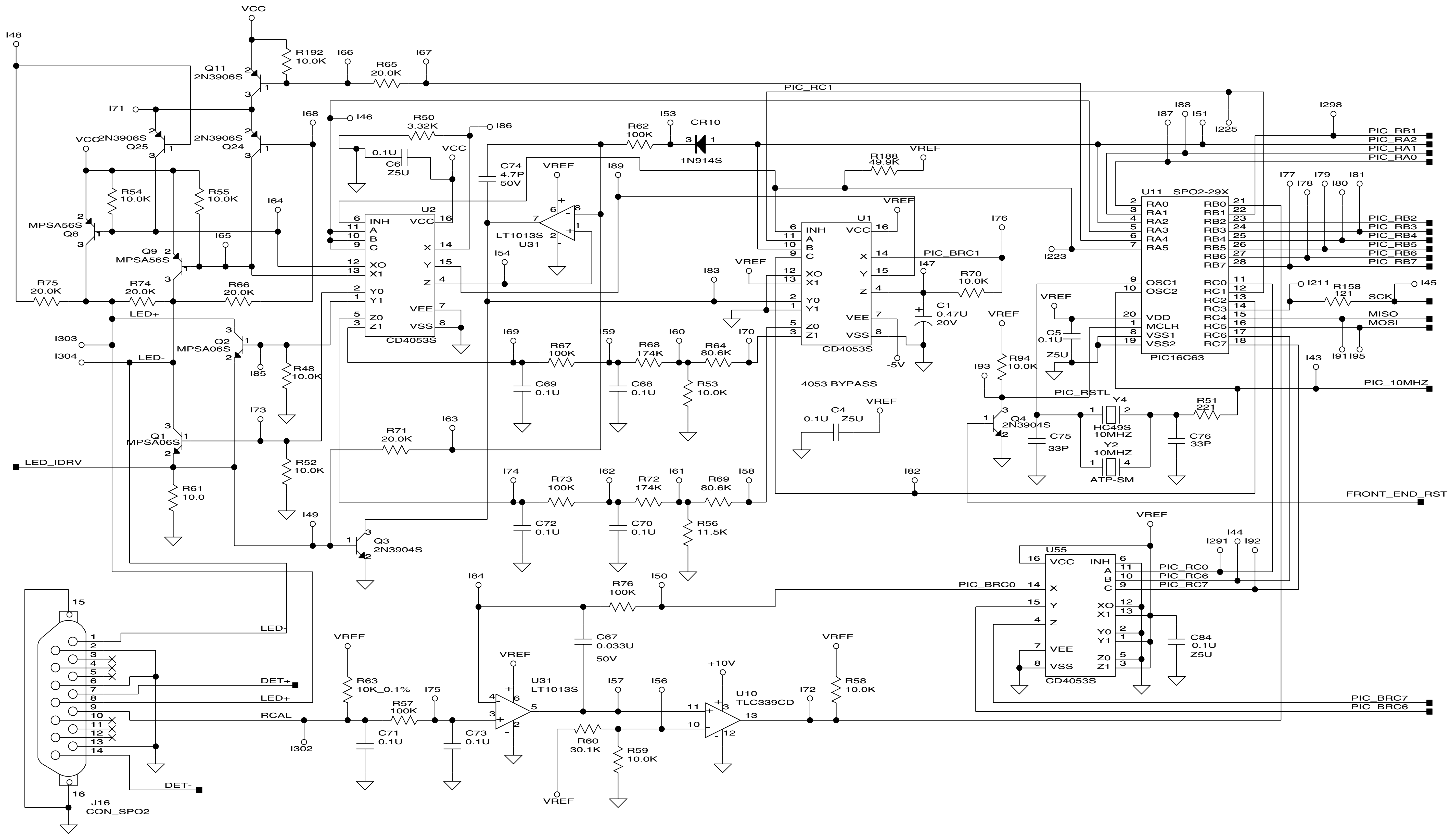

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Figure 11-4
Analog Front End Schematic Diagram

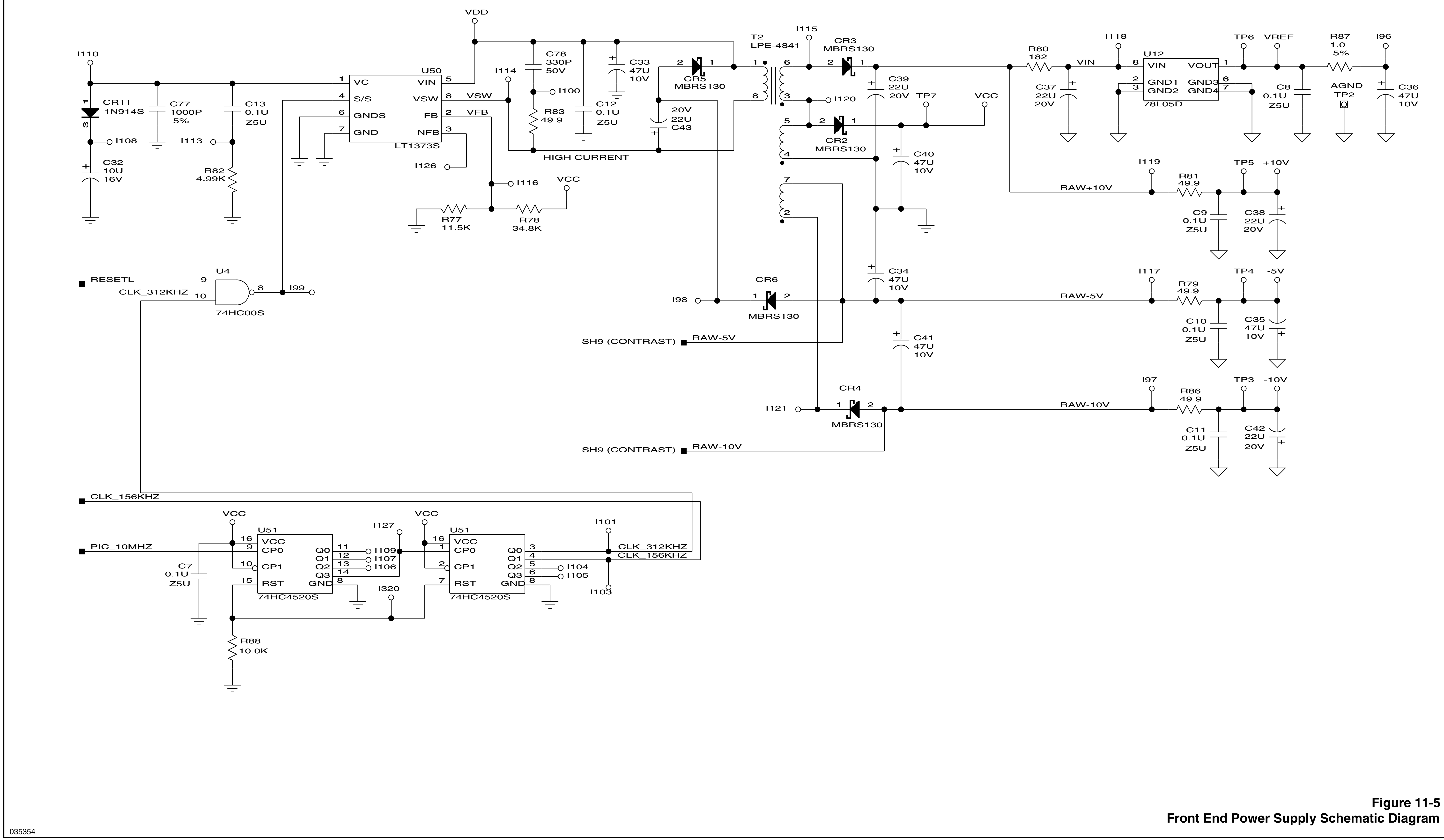

Figure 11-5
Front End Power Supply Schematic Diagram

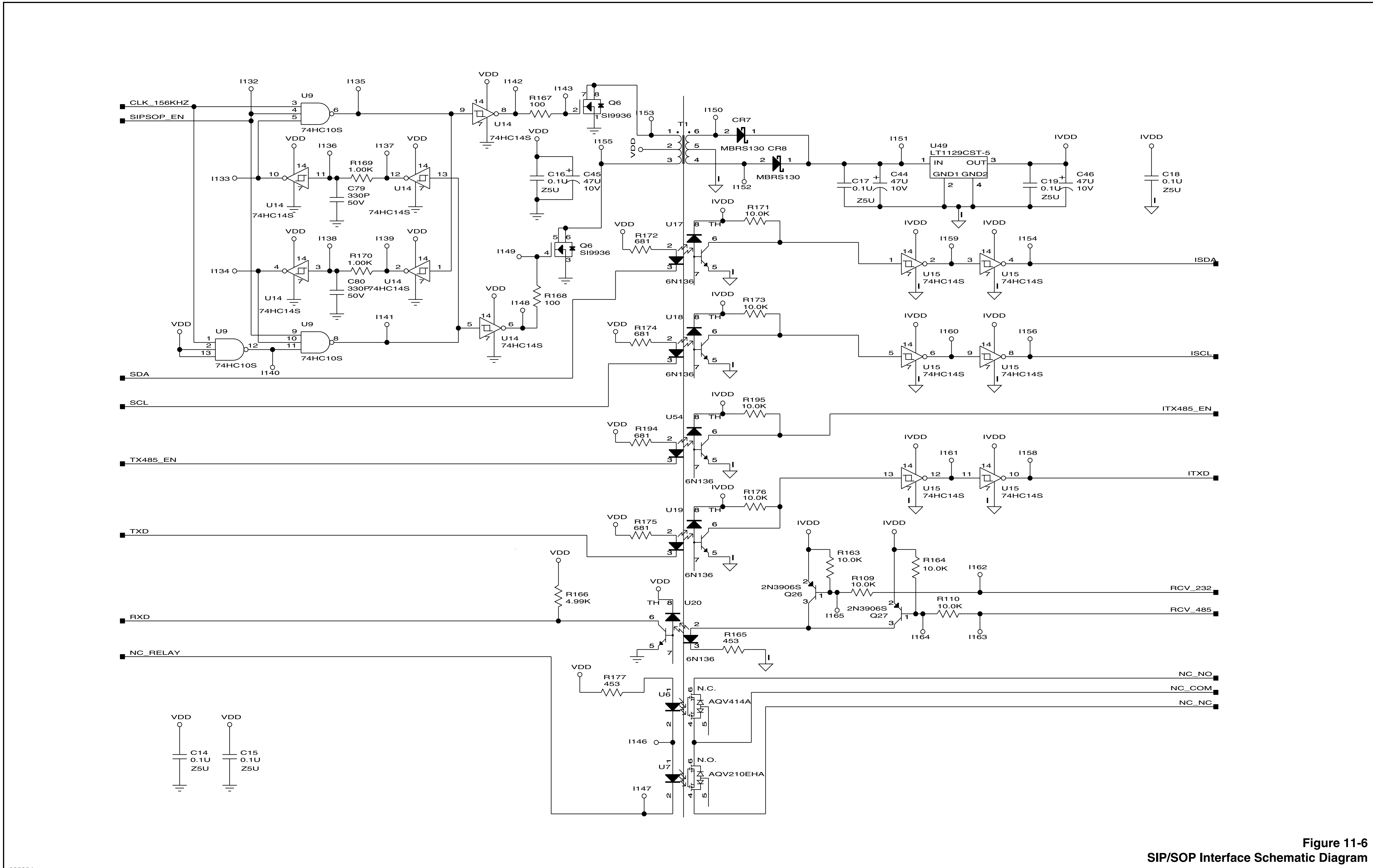

Figure 11-6
SIP/SOP Interface Schematic Diagram

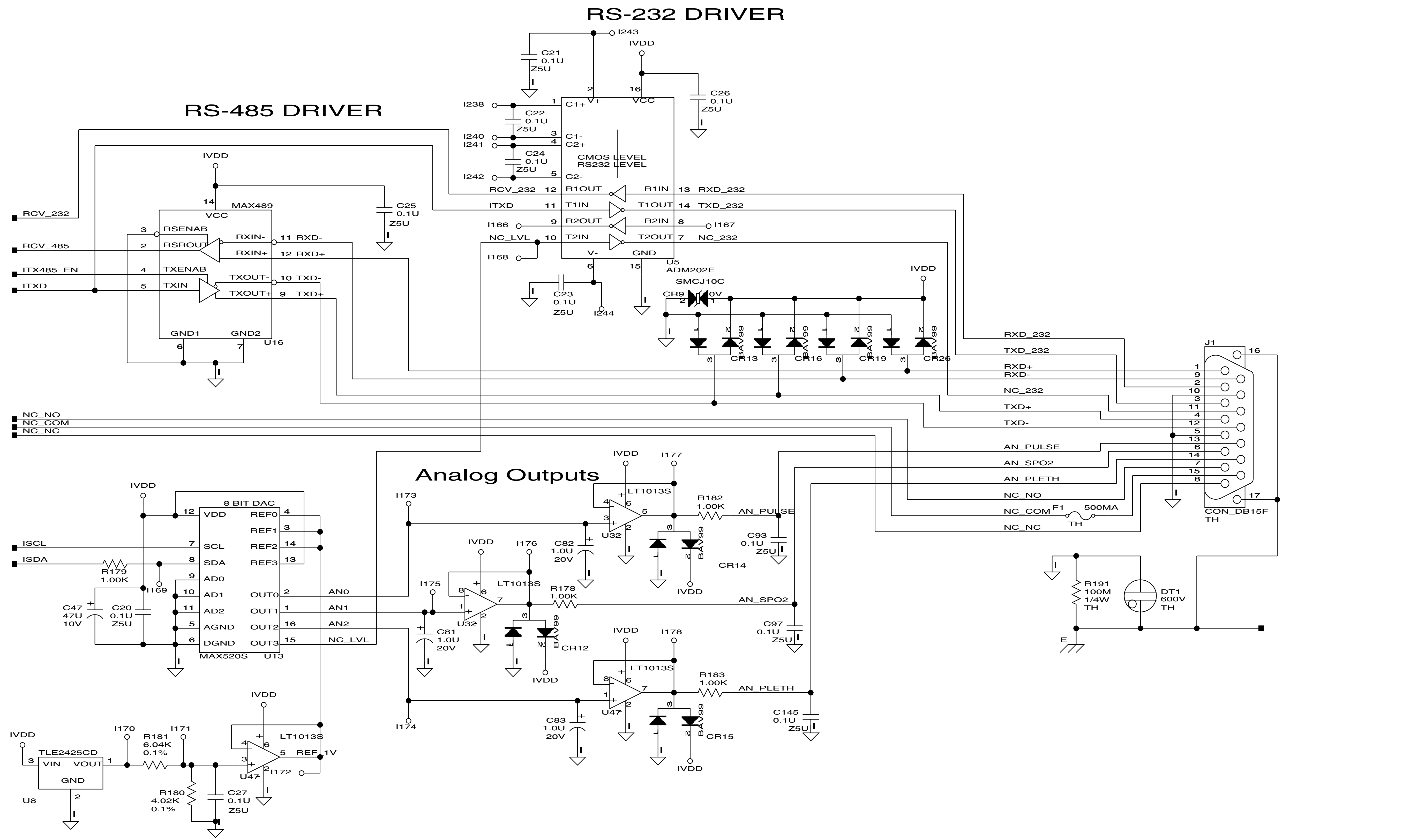

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Figure 11-7
Data Port Drivers Schematic Diagram

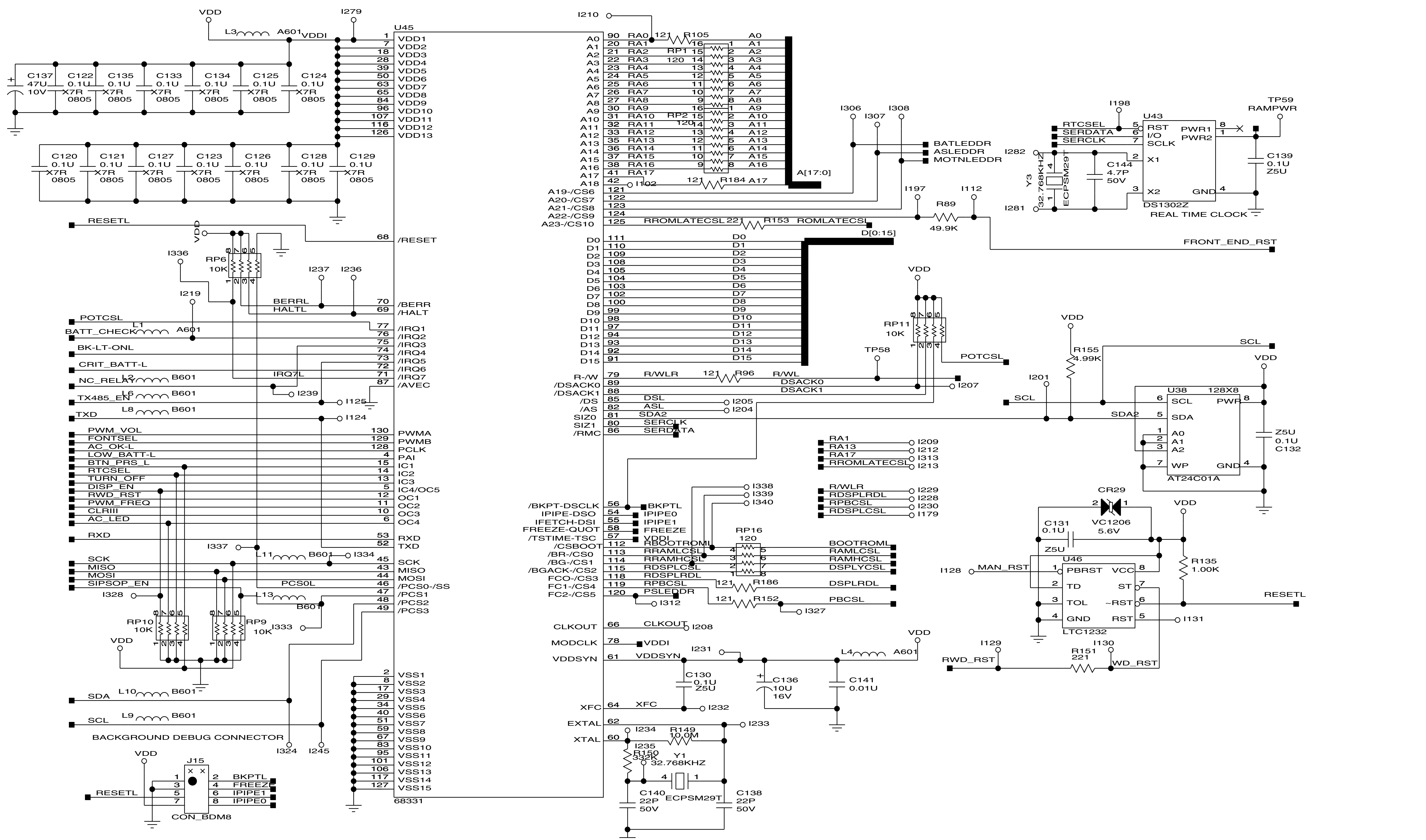

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Figure 11-8
CPU Core Schematic Diagram A

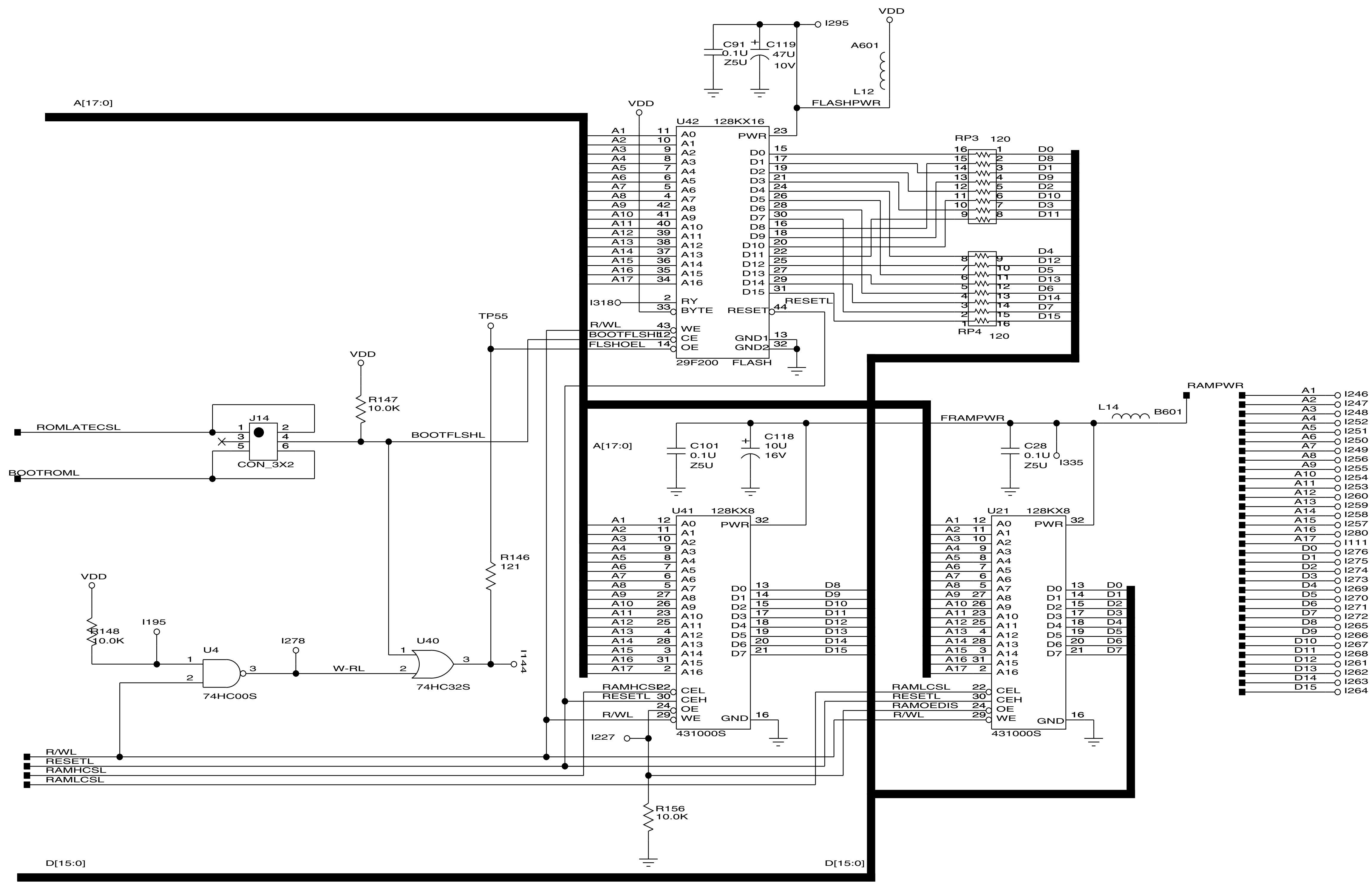

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Figure 11-9
CPU Memory Schematic Diagram B

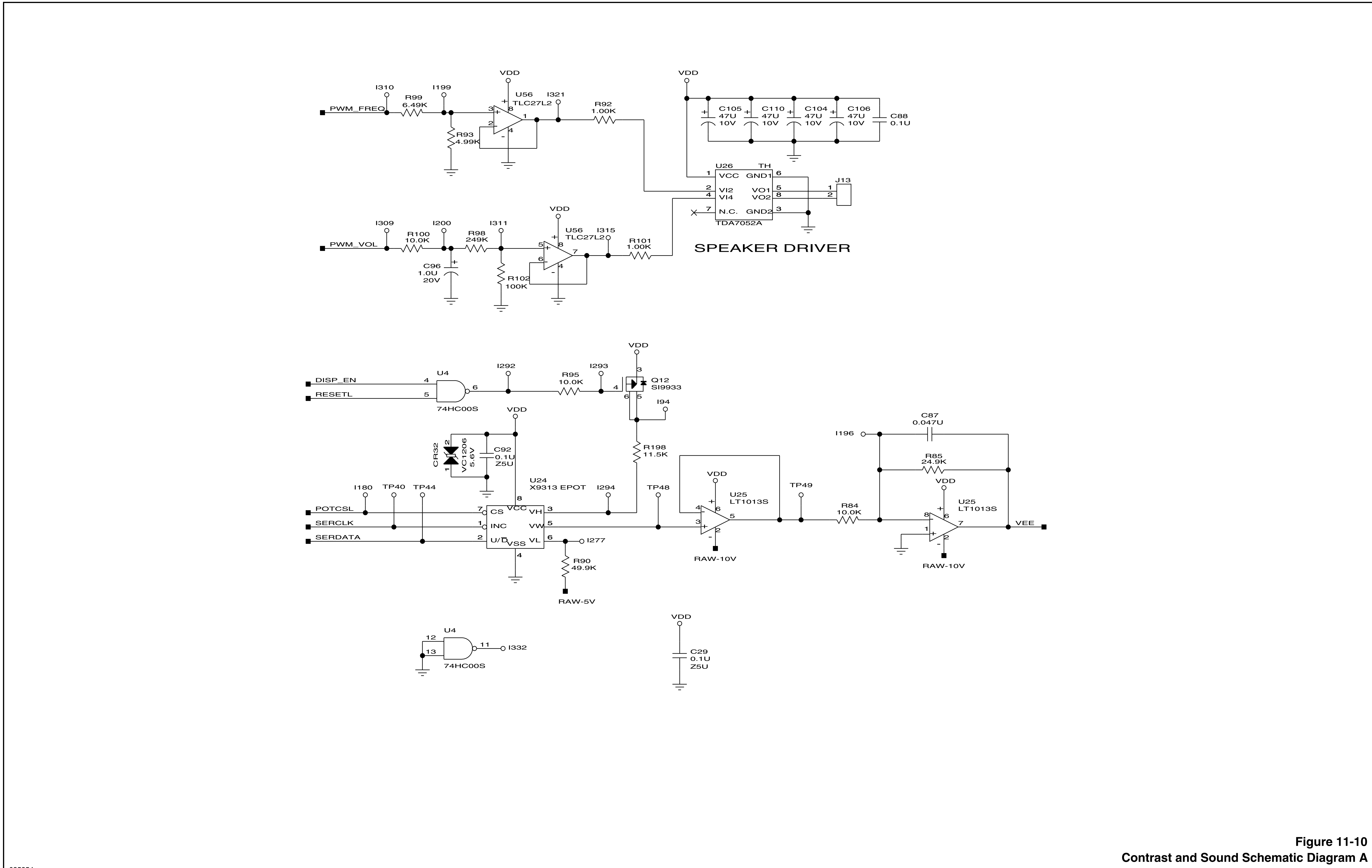

Figure 11-10
Contrast and Sound Schematic Diagram A

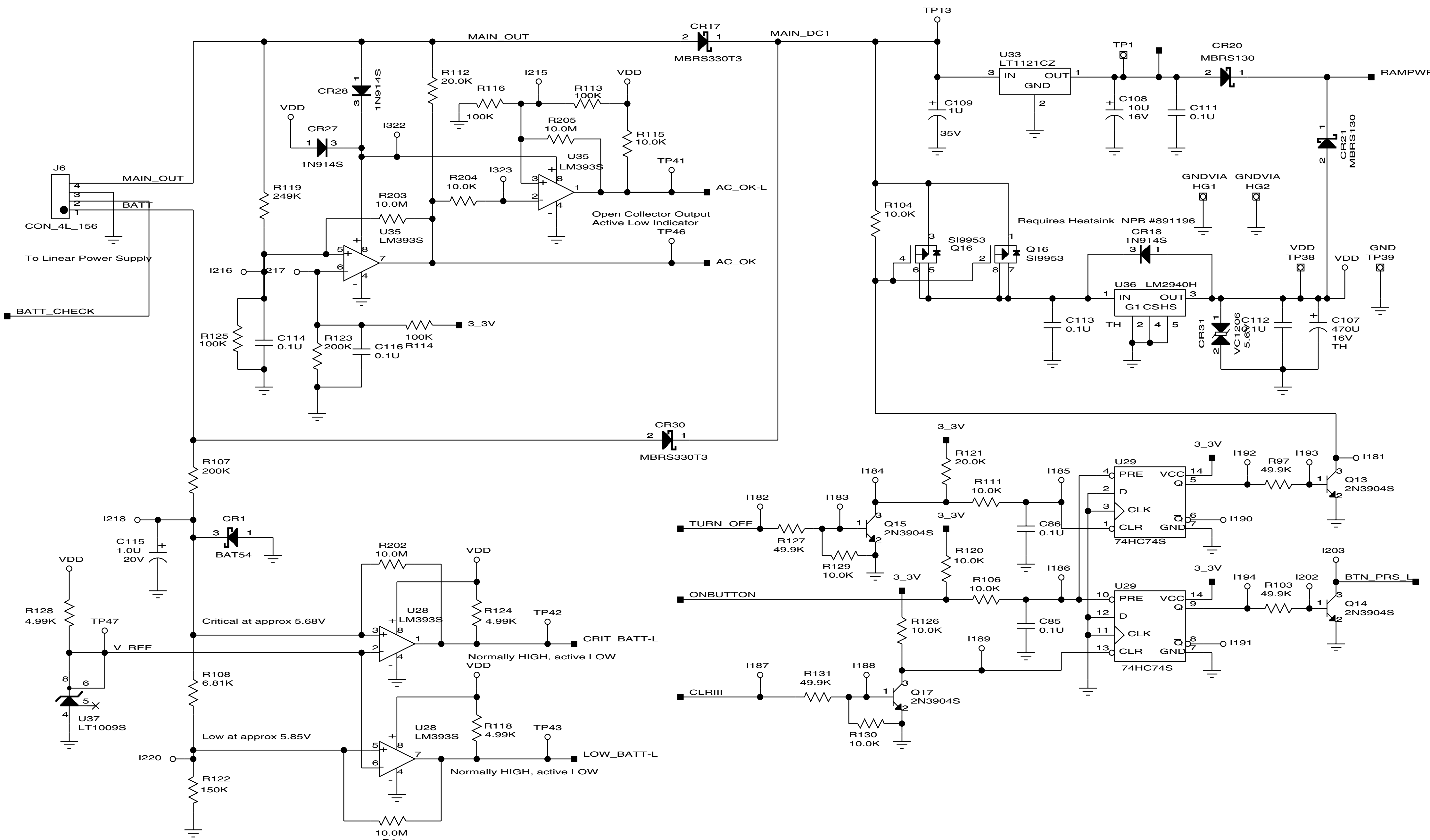

Figure 11-11
UIF PCB Power Supply Schematic Diagram B

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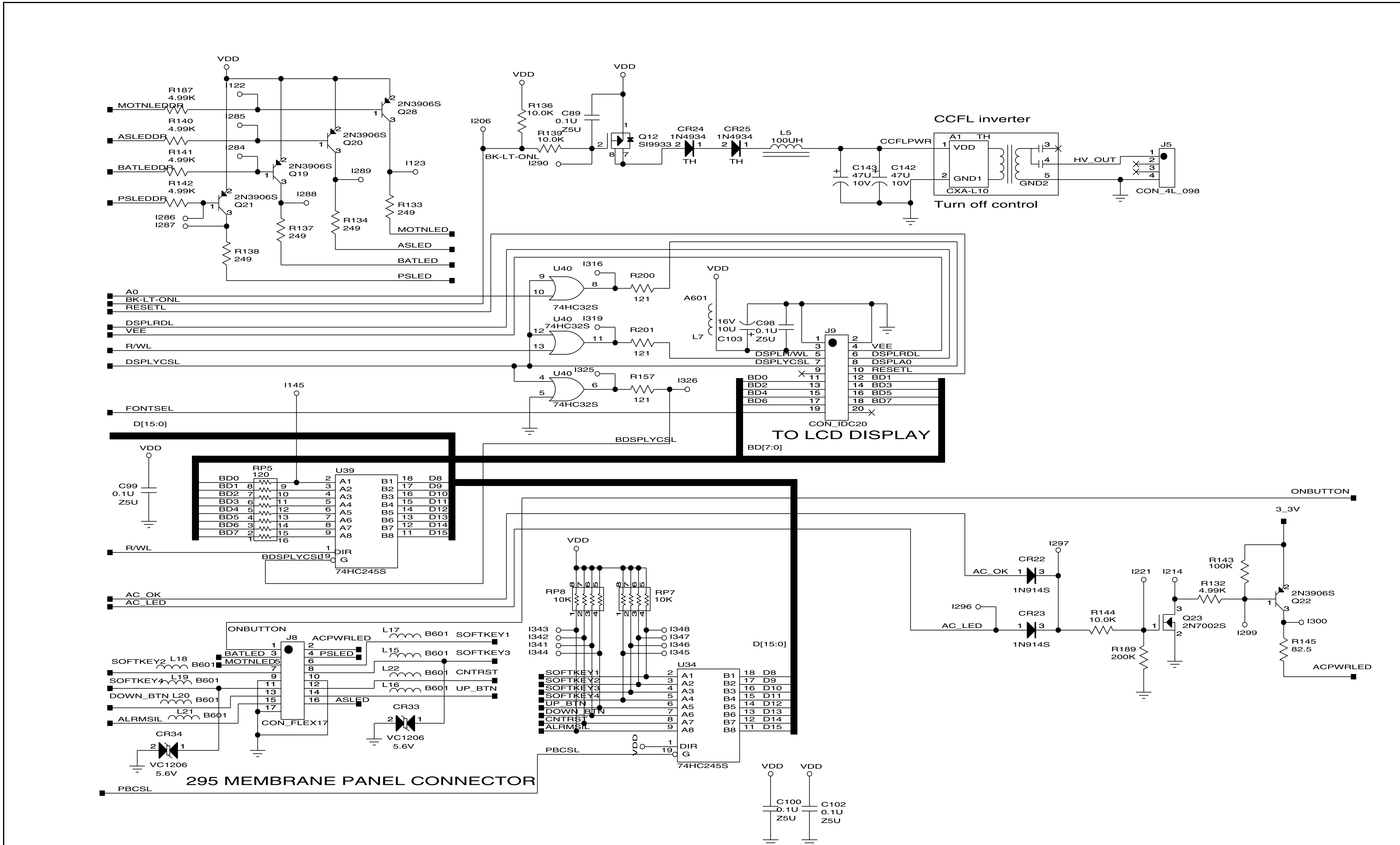

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Figure 11-12
Display Interface Schematic Diagram

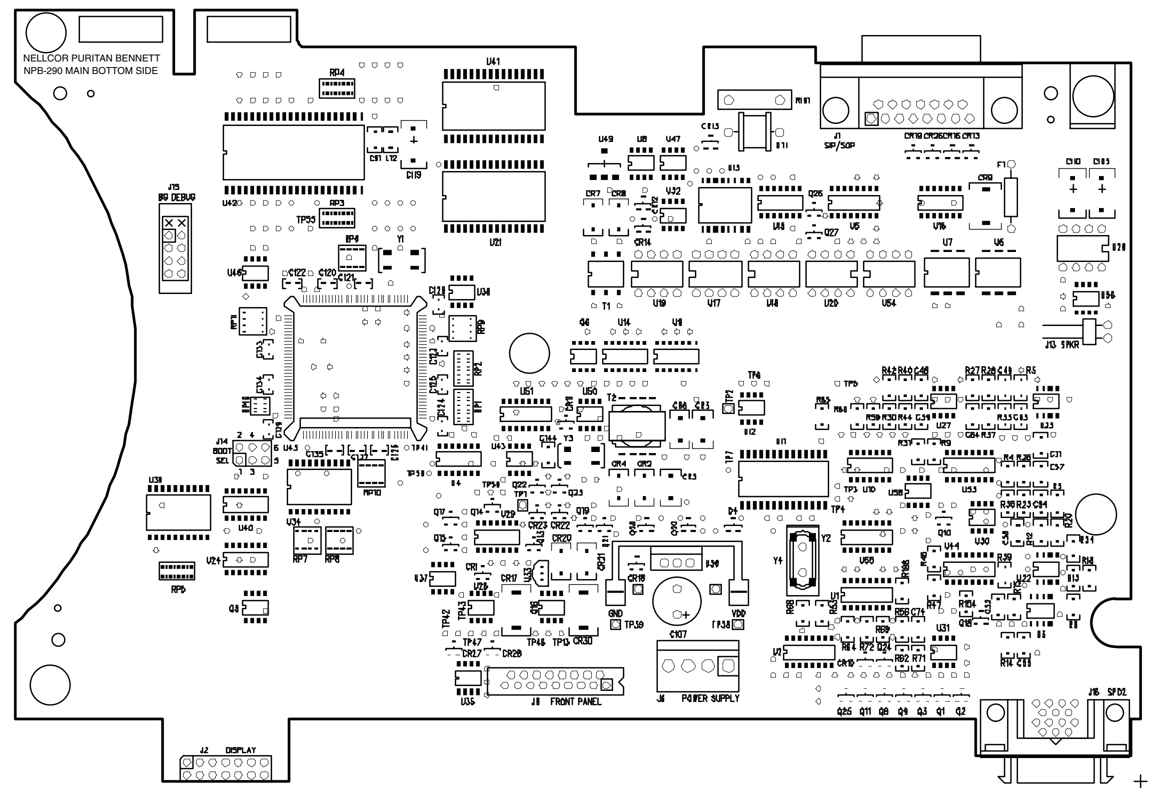

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Figure 11-13
UIF PCB Parts Locator Diagram

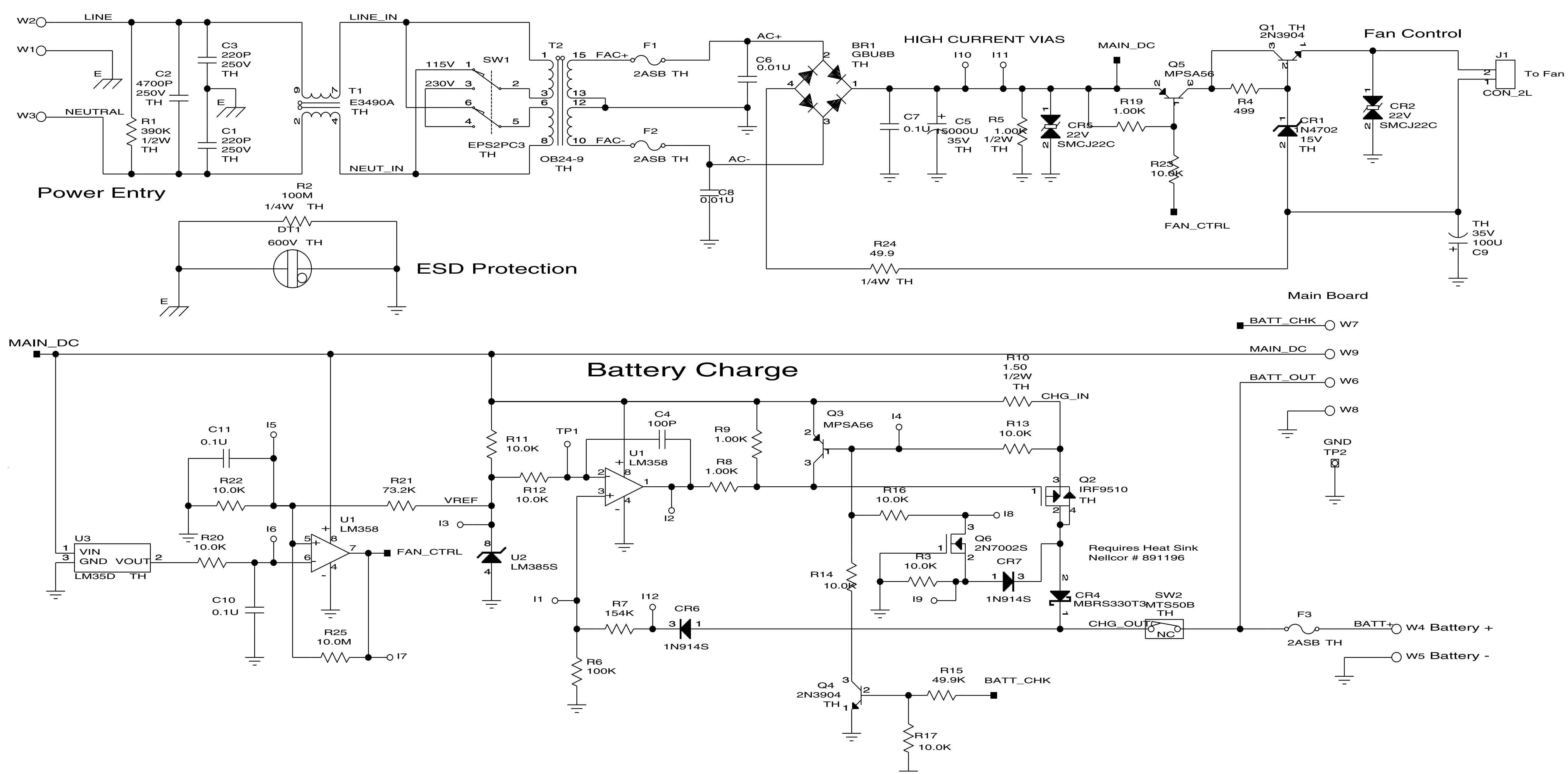

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Figure 11-14
Power Supply Schematic Diagram

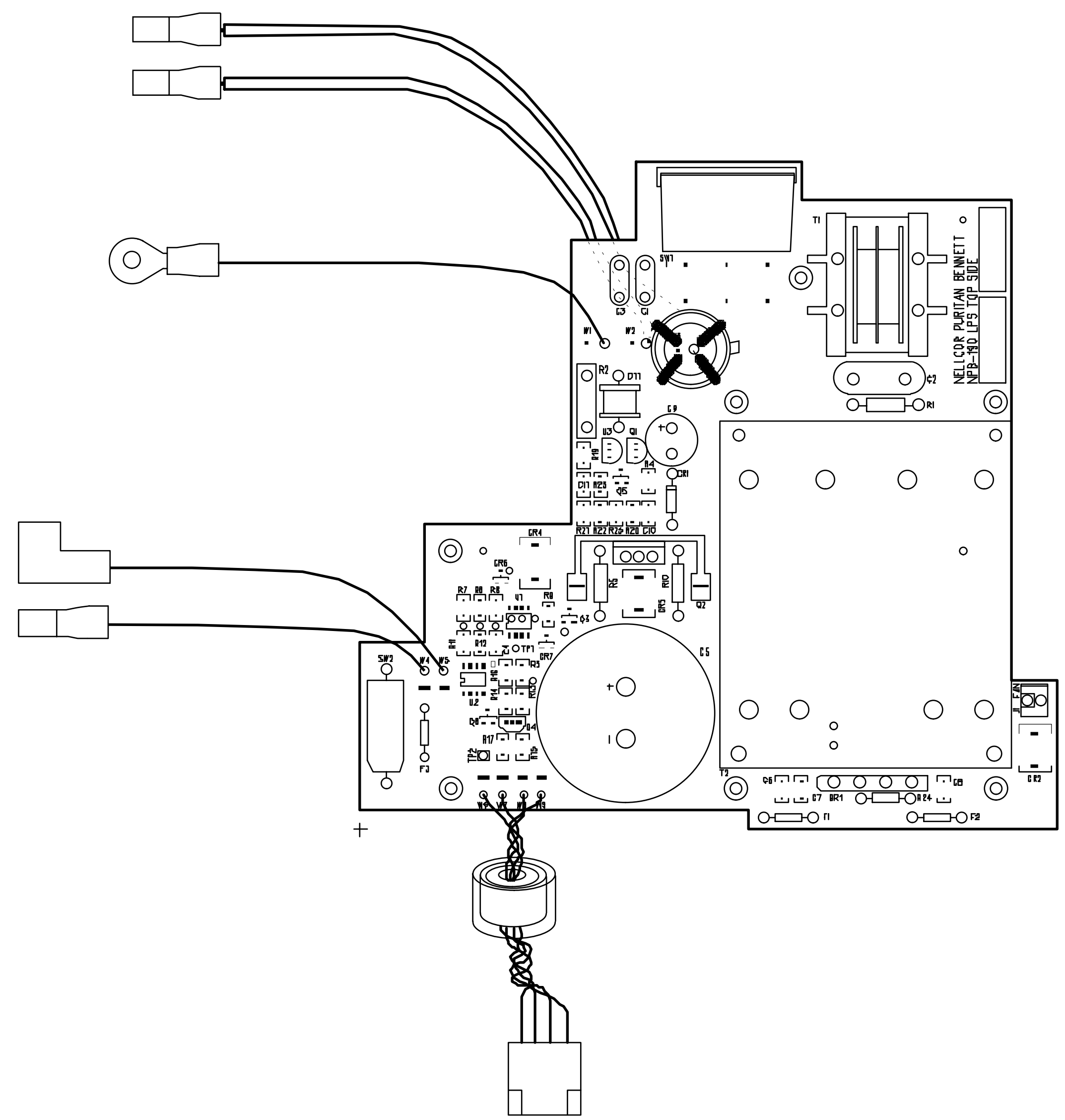

Figure 11-15
Power Supply Parts Locator Diagram

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