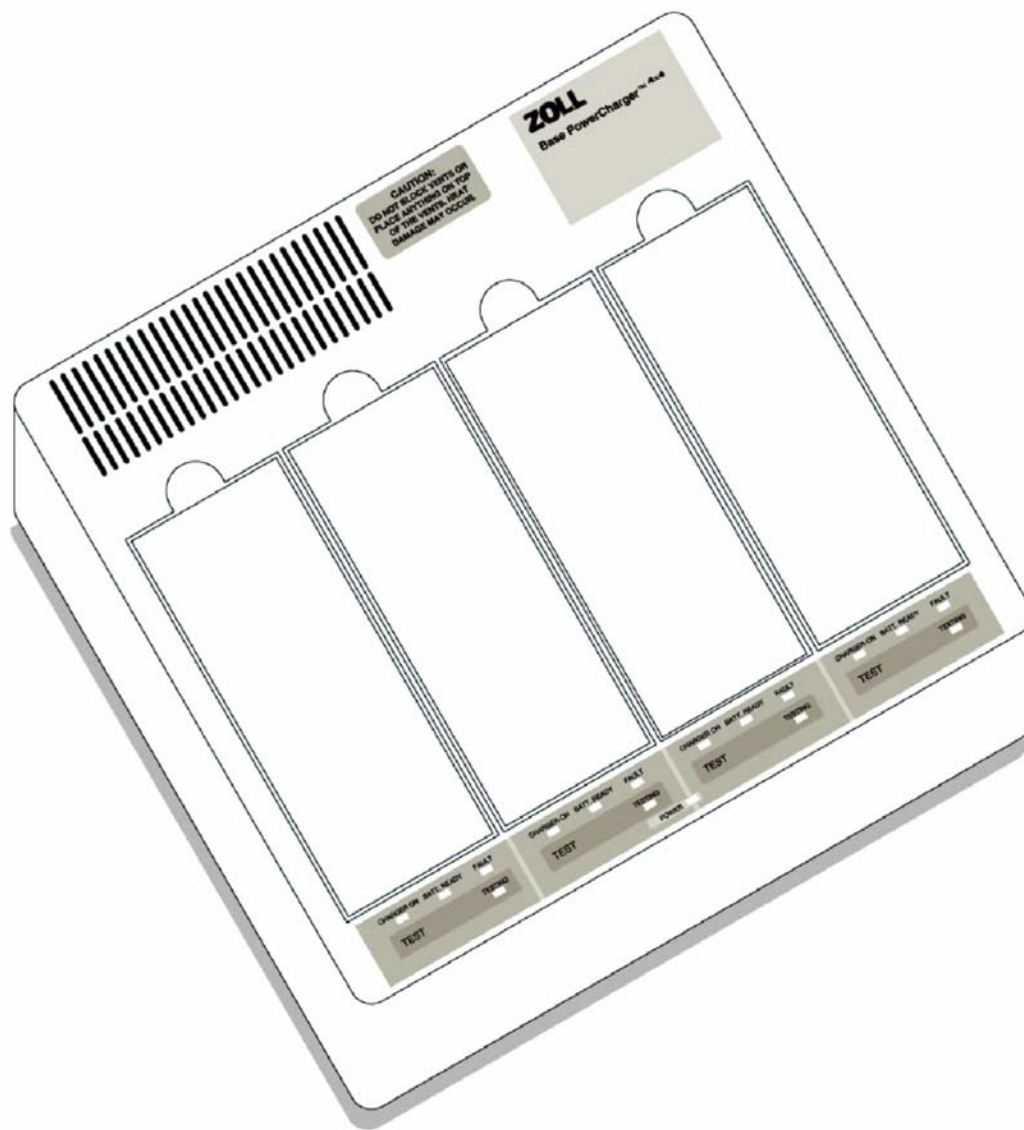


# ZOLL Base Powercharger 4x4 Service Manual





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## SAFETY CONSIDERATIONS

### WARNINGS

#### General

- The following is a list of service related safety considerations. For operation related safety considerations see the Base PowerCharger<sup>4x4</sup> Operator's Guide. Service Technicians should be aware of all safety considerations prior to servicing the equipment.
- **THE BASE POWERCHARGER<sup>4x4</sup> DEVICE SHOULD BE SERVICED BY QUALIFIED PERSONNEL ONLY!** Unauthorized persons should not attempt to service this device.
- The Base PowerCharger<sup>4x4</sup> is protected against interference from radio frequency emissions typical of two-way radios used in emergency service/public safety activities. Users of the Base PowerCharger<sup>4x4</sup> should assess the devices' performance in their environment of use for the possibility of radio frequency interference from high-power sources.
- Use only the AC power line cord supplied with the device. Failure to use the proper line cord could result in excess leakage currents and reduced safety.
- Only Qualified Personnel should disassemble the PowerCharger<sup>4x4</sup>. A shock hazard exists. Refer all problems to ZOLL Technical Service.
- Follow all recommended maintenance instructions. If a problem occurs, obtain service immediately. Do not use the Base PowerCharger<sup>4x4</sup> until the unit has been inspected by the appropriate personnel.
- Do not place anything on top of the Base PowerCharger<sup>4x4</sup>. Doing so may block the vents on the unit, preventing proper dissipation of heat during operation.
- Do not sterilize the Base PowerCharger<sup>4x4</sup>.
- Do not use alcohol or ketones (MEK, acetone, etc.) on the Base PowerCharger<sup>4x4</sup>.
- Always wait until the Base PowerCharger<sup>4x4</sup> has completed its charge cycle before removing batteries.
- Repeated use of partially charged batteries will reduce their capacity and operating life.

**Operator Safety**

- Do not operate the Base PowerCharger<sup>4x4</sup> in the presence of flammable agents (such as gasoline), oxygen-rich atmospheres, or flammable anesthetics. Using the device near the site of a gasoline spill may cause an explosion.
- Do not immerse or set the Base PowerCharger<sup>4x4</sup> in fluid. Using the device near or within puddles of water is a shock hazard to the operator, patient, and nearby personnel.

**Patient Safety**

- Do not mount the device directly above the patient. Locate the Base PowerCharger<sup>4x4</sup> and ZOLL resuscitation devices where they cannot harm the patient if they fall.

**Caution**

- Do not discharge a PD™ 4410 battery pack except in a Base PowerCharger<sup>4x4</sup> or compatible ZOLL Battery Charging/Testing device.
- Safety and effectiveness data submitted to the Food and Drug Administration (FDA) under section 510(K) of the Medical Device Act by ZOLL Medical Corporation to obtain approval to market is based upon the use of ZOLL accessories such as disposable electrodes, patient cables and batteries. ZOLL cannot make representations as to safety and clinical effectiveness when a device is used with non-ZOLL accessories. Users assume all responsibility for the safety and effectiveness of ZOLL products if used with non-ZOLL accessories. Further, ZOLL disclaims all implied and expressed warranties, including warranties of fitness and merchantability, and all product liability to the extent possible in the event of the use of a non-ZOLL accessory.
- The equipment may only be used with disposables, accessories, and consumable items when an agency, accredited for the testing of the equipment, has established that those items, in their intended use, meet its safety requirements.

## HOW TO USE THIS MANUAL

### Who it is for

The Base PowerCharger<sup>4x4</sup> Service Manual is a basic technical reference document designed for biomedical engineering personnel whose responsibilities include maintenance and repair of medical equipment.

### Purpose

Its purpose is to provide the basic information needed to allow biomedical engineering personnel to identify and/or repair the Base PowerCharger<sup>4x4</sup> to the sub-assembly (printed circuit board) level.

### Recommended Use

The Service Manual should be readily available in the facility's equipment maintenance library. It will be used for preventive maintenance checks and for troubleshooting when problems are reported.

The Operator's Guide, included as Appendix A, will be used in training new operators and for operational reference. This copy should be kept with the Base PowerCharger<sup>4X4</sup> Service Manual. A separately bound copy should be kept with the Base PowerCharger<sup>4X4</sup> device.

The Service Manual consists of several key sections:

#### **Section I: General Information**

This section contains a number of important notices and reference material, including safety warnings and ZOLL's warranty statement. **Be sure to review this section thoroughly before attempting to use or service the Base PowerCharger<sup>4x4</sup> device.**

#### **Section II: Checkout Procedures**

This section contains information you need in order to verify that the Base PowerCharger<sup>4X4</sup> is functioning properly, and procedures for checking the Base PowerCharger<sup>4X4</sup>.

For daily inspection and operational checks, see the Operator's Manual.

#### **Section III: Troubleshooting Guides**

This section contains an operational troubleshooting section, for use by non-technical personnel to respond to common problems detected during Base PowerCharger<sup>4X4</sup> operational use.

#### **Section IV: Functional Descriptions**

This section provides a basic technical description of the Base PowerCharger<sup>4X4</sup> main subassembly modules. The information should be thoroughly reviewed before servicing.

#### **Section V: Schematic Drawings**

Major circuit board schematics are included for troubleshooting purposes.

**Section VI: Component Layout Drawings**

Major component layout drawings are included for troubleshooting purposes.

**Section VII: Disassembly Procedures**

Step-by-step instructions are provided for removing subassemblies in the event of failure. Refer to the Service Policy in Section I for return and repair information.

**Section VIII: Replacement Parts**

This section contains a detailed listing of ZOLL part numbers for field replaceable parts available for the Base PowerCharger <sup>4x4</sup> and will allow the service person to identify and order replacement parts. No attempt to replace parts at the component level should be attempted or the ZOLL warranty may be voided.

**Appendix A: Operation**

The *Operator's Manual* has been reproduced here for convenience and consistency. It should be read and understood before attempting any service procedure.



SEE FILE PG7\_C.PM5

FOR THIS PAGE AND ALL OF THE  
SYMBOLS

## **SERVICE POLICY**

### **WARRANTY**

In North America: Consult your purchasing agreement for terms and conditions associated with your warranty.

Outside of North America: Consult ZOLL authorized representative.

In order to maintain this warranty, the instructions and procedures contained in this manual must be strictly followed.

For additional information, please call the ZOLL Technical Service Department at

1-800-348-9011            in North America

1-781-229-0020        outside of North America

### **SERVICE**

The Base PowerCharger<sup>4x4</sup> will provide trouble free operation without periodic recalibration or adjustment. However, it is recommended that the biomedical engineering department perform routine tests of the device to verify proper operation. (See Section II.)

#### **U.S.A. customers**

Should the Base PowerCharger<sup>4x4</sup> require service, contact the ZOLL Technical Service Department to obtain a return claim number. The unit should be returned, in its original container, to:

ZOLL Medical Corporation  
32 Second Avenue,  
Burlington, Massachusetts 01803-4420,  
Attn: Technical Service Department

Loaner instruments are available for use while repairs are being completed. To request loan equipment, contact ZOLL at 1-800-348-9011 (in Massachusetts: 1-781-229-0020).

Please have the following information available to expedite service:

- Unit serial number
- A description of the problem
- Department where equipment is in use
- A Purchase Order to allow tracking of loan equipment
- A Purchase Order for systems out of warranty

**International Customers**

Should the Base PowerCharger<sup>4x4</sup> require service, it should be returned, in its original container, to the nearest authorized ZOLL Medical Corporation service center. To determine which authorized ZOLL Medical Corporation service center to use, write, call or fax:

ZOLL Medical Corporation  
32 Second Avenue,  
Burlington, Massachusetts 01803-4420, USA  
Attn: International Sales Department  
1-781-229-0020 (voice)  
or  
1-781-272-5443 (fax)  
Attn: International Sales Department



## SECTION II CHECKOUT PROCEDURES

ZOLL recommends that you check your Base PowerCharger<sup>4x4</sup> for proper operation at least once every six months.

This section contains information you need in order to verify that the Base PowerCharger<sup>4x4</sup> is functioning properly.

Daily operational checks are described in Section 3, **Maintenance and Troubleshooting** in the *Operator's Guide*.

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**LEAKAGE CURRENT**

- Perform Leakage Current Test per your manufacturer's recommended procedure found in the Operator's Manual of your Leakage Tester.

**Observe:**

- After the test is complete, fill in the date , operator, and Base PowerCharger<sup>4x4</sup> serial number on the Test Data Sheet (Page II-4). Review the results against the limits below for any test that failed. If any test fails, circle the failed test on the Test Data Sheet and take corrective action.
- Record results on Test Data Sheet (Page II-4).

<b>TEST</b>	<b>90 - 265 VAC LIMITS</b>
Gnd Wire Resistance	N/A
Line Voltage	
Hot to Neutral	N/A
Hot to Gnd	N/A
Neutral to Gnd	N/A
Current Consumption	N/A
Chassis Leakage	
Normal Pol. w/Ground	< 500 $\mu$ A
Normal Pol. No/Ground	< 500 $\mu$ A
Reverse Pol. No/Ground	< 500 $\mu$ A
Reverse Pol. w/Ground	< 500 $\mu$ A
Ground Wire Leakage	
Normal Pol. No/Ground	< 500 $\mu$ A
Reverse Pol. No/Ground	< 500 $\mu$ A

**FUNCTIONAL TESTS****Continuity and Isolation Test**

- Take a measurement of the Digital Volt Meter (in ohms) by shorting the two (2) leads of the DVM.
- Record Results on Test Data Sheet (Page II-4).
- Place the red lead of the DVM on any part of the unit where there is exposed metal, except for the battery terminals, and place the black lead of the DVM on the ground part of the powercord.
- Record Results on Test Data Sheet (Page II-4).
- Subtract the two values and the difference should be less than 1 ohm.

- Record Results on Test Data Sheet (Page II-4).

### MANUAL TEST

- Check to see that the unit is connected to live AC mains. The **POWER** light should be lit.
- Remove all batteries from the Base PowerCharger<sup>4x4</sup>.
- Press each of the four (4) **TEST** buttons corresponding to each of the four (4) battery compartments.
- The unit will light all of the LED's associated with the compartment for a few seconds. This will be followed by a beep and then the **TESTING** and **BATT. READY** LED's will light for a couple of seconds. Then all LED's extinguish.
- Ensure that all of the **FAULT** indicators are off.
- If any of the **FAULT** lights are lit, the compartment is defective in some way. To identify the defect press and hold the **TEST** button. Illumination of specific indicator lights together represent a specific defect. (Refer to **FAULT CODES TABLE** on page III-3 to identify the fault and take corrective action).

**NOTE:** The device under test should be at operating temperature before checking/adjusting voltages. (Device powered up for a minimum of 20 minutes).

- Set the DVM to VOLTS DC.
- Test each battery compartment separately by placing the Black lead of the DVM on the left battery contact pin of the battery compartment and place the RED lead of the DVM on the shrouded (middle) pin of the same battery compartment.
- The voltage measurement on the DVM should be  $11.86 \pm 0.10$  VDC.
- Record Results on Test Data Sheet (Page II-4).
- If the voltage measurement is NOT  $11.86 \pm 0.10$  VDC, adjust RV1 (on 9301-0147) until the correct value is displayed.

### AUTO TEST OPTION

- Install battery into any well and observe that the **CHARGER ON** and **TESTING** LED's are illuminated.

**NOTE:** The **CHARGER ON** and **TESTING** LED's may go off within minutes, depending on the charge state of the battery pack installed. (i.e., Fully Charged)

### QUICK CHARGE OPTION

- Install battery into any well and observe that the **CHARGER ON** LED remains illuminated until the battery is "READY".
- The **TESTING** LED will **not** turn on by installing a battery into the charger.



<b>BASE POWERCHARGER<sup>4X4</sup></b>		
<b>DEVICE CHECKOUT PROCEDURE</b>		
<b>DATA SHEET</b>		
<b>S/N</b> _____	<b>OPERATOR</b> _____	<b>DATE</b> _____

**COPY THIS FORM BEFORE USING**

<b>SECTION 1. LEAKAGE TEST</b>
--------------------------------

Perform this Action:	Limits:	Circle the Result:
<b>1.1 Chassis Leakage</b>		
Normal Pol. w/ Ground	< 500 $\mu$ A	<b>YES or NO</b>
Normal Pol. No/ Ground	< 500 $\mu$ A	<b>YES or NO</b>
Reverse Pol. No/ Ground	< 500 $\mu$ A	<b>YES or NO</b>
Reverse Pol. w/ Ground	< 500 $\mu$ A	<b>YES or NO</b>
<b>1.2 Ground Wire Leakage</b>		
Normal Pol. No/ Ground	< 500 $\mu$ A	<b>YES or NO</b>
Reverse Pol. No/ Ground	< 100 $\mu$ A	<b>YES or NO</b>

<b>SECTION 2. FUNCTIONAL TEST</b>
-----------------------------------

Perform this Action:	Look for :	Circle the Result:

<p><b>2.1 Continuity and Isolation</b></p> <p>Resistance measurement of two (2) leads shorted to one another.</p> <p>Resistance measurement with Red lead on metal and Black lead on powercord ground.</p> <p>Subtract the two values above.</p>	<p>Record value: _____ohms</p> <p>Record value: _____ohms</p> <p>Difference should be &lt; 1 ohm</p>	<p><b>YES or NO</b></p>
--	--	-------------------------

### SECTION 3. MANUAL TEST

Perform this Action:	Look for :	Circle the Result:
<p><b>3.1</b> Remove all batteries from the Base PowerCharger™</p> <p>Press each battery compartment <b>TEST</b> button (4).</p> <p>Set DVM to VOLTS DC.</p> <p>Test each battery compartment</p>	<p>All LED's illuminate momentarily, the <b>Batt. Ready</b> and <b>Testing</b> light illuminate alone and then, all LED's go off.</p> <p>Ensure <b>FAULT</b> indicators are all off.</p> <p>Voltage is 11.86 ± 0.10 VDC</p>	<p style="text-align: center;"><b>YES or NO</b></p> <p style="text-align: center;"><b>YES or NO</b></p> <p style="text-align: center;"><b>YES or NO</b></p> <p style="text-align: center;"><b>YES or NO</b></p> <p style="text-align: center;"><b>YES or NO</b></p>

### SECTION 4. AUTO TEST

<b>For 4 x4 base chargers that are configured as auto test units.</b>		
Perform this Action:	Look for :	Circle the Result:
<p><b>4.1</b> Install Battery into any well.</p>	<p>Charger on and testing LED'S illuminate.</p>	<p><b>YES or NO</b></p>

## **SECTION III TROUBLESHOOTING**

This section answers many of the common problems or questions that arise during operation.

If trouble persists after consulting this guide, contact the appropriate technical personnel or ZOLL Technical Service Department.

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## TROUBLESHOOTING TABLE

Symptoms	TroubleShooting Method and Possible Causes
<b>POWER</b> light does not illuminate.	<ul style="list-style-type: none"> <li>• Check that the unit is plugged into an appropriate power source.</li> <li>• Check for defective power cord.</li> <li>• Plug unit into another power source.</li> <li>• Check for blown fuse. Disconnect power cord and open fuse holder to check fuses.</li> </ul>
<b>CHARGER ON</b> indicator light does not illuminate when battery is inserted into compartment.	<ul style="list-style-type: none"> <li>• Check that the battery is properly seated in battery compartment.</li> <li>• Check that battery contacts are clean and not damaged.</li> <li>• Check that unit is plugged into an appropriate power source.</li> <li>• Test the battery compartment for functionality.</li> <li>• Place another battery in the compartment.</li> </ul>
<b>TESTING</b> light does not illuminate when <b>TEST</b> button is pressed.	<ul style="list-style-type: none"> <li>• Check that the battery is properly seated in compartment.</li> <li>• Check that unit is plugged into an appropriate power source.</li> <li>• Remove the battery and press the <b>TEST</b> button to perform a compartment self-test. If it does not self-test the button is defective.</li> </ul>
Battery fails test cycle. ( <b>FAULT</b> light illuminates with <b>TESTING</b> light).	<ul style="list-style-type: none"> <li>• Verify that the battery compartment is fully operational with no defects.</li> <li>• Press and hold the <b>TEST</b> button to determine the fault code. (See <b>Fault Codes Table</b> on Page III-3).</li> <li>• If all <b>FAULT</b> LED's are on most likely there is a failure in the common circuitry.</li> </ul>

When the unit does not follow the Power-Up sequence explained elsewhere in this manual or if a fault light comes on at any time follow the steps listed below to identify the fault.

**Note:** The unit can be run through it 's self-test at any time, as long as there is no battery installed, by pressing the **TEST** button. When the self-test is invoked on a single battery compartment the unit will respond by lighting all the LED's associated with the compartment for a few seconds. This will be followed by a beep and then the **TESTING** and **BATT. READY** LED's will light for a couple of seconds. Then all LED's extinguish.

Faults that may endanger the reliable charging of a battery or the ability to charge/test successfully are latching faults that can only be cleared by power cycling after the fault is fixed. All other faults are self-clearing as soon as the fault condition is removed.

### Fault Codes Table

When the FAULT indicator light illuminates, press and hold the **TEST** button. The illumination of the following indicator lights together represent a specific defect identified under the **Fault Code** column.

Charger On	Batt. Ready	Fault	Testing	Fault Code
ON	OFF	OFF	OFF	Constant Current Voltage
ON	ON	OFF	OFF	Discharge
ON	ON	ON	OFF	Discharge Time
ON	ON	ON	ON	OverCharge
ON	ON	OFF	ON	Temperature
ON	OFF	ON	ON	Low Battery Voltage
ON	OFF	ON	OFF	High Constant Current
ON	OFF	OFF	ON	Shutdown
OFF	ON	ON	ON	High Battery Voltage
OFF	OFF	ON	ON	Battery Capacity
OFF	OFF	OFF	ON	Charger
OFF	ON	OFF	OFF	Constant Voltage
OFF	ON	OFF	ON	Vcc Voltage
OFF	ON	ON	OFF	Low Power Supply Voltage
OFF	OFF	ON	OFF	Low Constant Current

**NOTE:** A battery that has failed a capacity test will display the **TESTING & FAULT** LED's simultaneously. When the **TEST** button is pressed and held the LED pattern will not change. This is a normal operating condition and does not reflect a fault with the unit.

**Definition of Fault Codes**

<b>Constant Current Voltage:</b>	The Constant Current compliance Voltage is below the specified range.
<b>Discharge:</b>	Test discharge has been ineffective.
<b>Discharge Time:</b>	The unit is unable to perform the discharge test.
<b>OverCharge:</b>	The total delivered charge exceeds the specified range.
<b>Temperature:</b>	Internal charger temperature deviated from specified range.
<b>Low Battery Voltage:</b>	The Battery Voltage measured was below specified range.
<b>VCC Voltage:</b>	The internal five (5) volt supply deviated from specified range.
<b>High Constant Current:</b>	The amount of current during a charge was above specified range.
<b>Shutdown:</b>	Safety shutdown (#2) is not operating properly (shutdown).
<b>High Battery Voltage:</b>	The Battery Voltage was measured to be above the specified range.
<b>Battery Capacity:</b>	The battery's capacity was measured to be below the specified range.
<b>Charger:</b>	Safety shutdown (#1) is not operating properly (charge enable).
<b>Constant Voltage:</b>	The Constant Voltage deviated from the specified range.
<b>Low Power Supply Voltage:</b>	The charging voltage was measured to be below the specified range.
<b>Low Constant Current:</b>	The amount of current during a charge was below specified range.

## SECTION IV FUNCTIONAL DESCRIPTIONS

This section describes the basic operation of the circuits and supplements the troubleshooting guides in Section III of this manual.

For additional information, refer to the associated schematics found in Section V.

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## 1. SYSTEM

**NOTE:** Any reference to PD 1400 includes PD 1400, D 1400, PD 2000, D 2000, and ZOLL 1600 unless otherwise specified

### Product Overview

The ZOLL Base PowerCharger<sup>4x4</sup> (with QuickCharge or AutoTest) is a battery charger and testing system designed for management of PD 4410 battery packs used in ZOLL Medical Corporation resuscitation devices.

The ZOLL Base PowerCharger<sup>4x4</sup> (with QuickCharge or AutoTest) provides four battery charging/testing compartments. Up to four battery packs may be charged or tested in any combination at one time.

The ZOLL Base PowerCharger<sup>4x4</sup> can be configured in either the **AutoTest** or **QuickCharge** mode. This configuration is performed by ZOLL Medical Corporation prior to device shipment. The Base PowerCharger<sup>4x4</sup> is clearly labeled **AutoTest** or **QuickCharge** on the charger label directly beneath the product name. If the device is not labeled, the QuickCharge instructions should be followed for proper device operation. For questions concerning the chargers configuration please consult a ZOLL technical service representative.

### AutoTest

The ZOLL Base PowerCharger<sup>4x4</sup> with AutoTest automatically tests battery capacity with each battery recharge. In addition, the ZOLL Base PowerCharger<sup>4x4</sup> with AutoTest illuminates the **Batt. Ready** indicator when the battery is fully charged and capable of powering a PD 1400/D 1400 or PD 2000/D 2000 for approximately 2.0 hours in Monitor mode\*. Fully charged batteries whose capacity is insufficient to power the devices for this period of time will cause the **FAULT** light to illuminate. With AutoTest, the full charging cycle is complete in eight (8) hours or less. The AutoTest feature virtually eliminates the need to periodically test battery capacity since this test is performed each time a battery is recharged.

### QuickCharge

The ZOLL Base PowerCharger<sup>4x4</sup> with QuickCharge illuminates the Batt. Ready indicator when the battery is fully charged. The full charging cycle is complete in four (4) hours or less. The QuickCharge version provides **no** information regarding battery capacity because it does **not** test the battery capacity with each recharge. The ZOLL Base PowerCharger<sup>4x4</sup> with QuickCharge relies on the user to manually initiate the battery test cycle at recommended intervals (see Manual Battery Testing Procedure) in order to confirm adequate battery capacity.

**Note:** Actual battery run time will vary from model to model depending upon the amount of current that is drawn by each device. Refer to the Operator's Manual of your model to determine the actual battery run time. For example, a battery contains at least 1.5 ampere hours, while a ZOLL Defibrillator may draw approximately .8 ampere of current. The run time of the battery is calculated by dividing the battery capacity by the current drawn. In this example, there is a minimum of 1.875 hours of battery run time for this device.



## Standard Terms and Abbreviations

<b>CV</b>	Constant Voltage. Term applies to the type of charging technique used to charge a battery where a Constant Voltage is applied to the battery.
<b>CC</b>	Constant Current. Term applies to the type of charging technique used to charge a battery where a Constant Current is applied to the battery.
<b>Main PCB</b>	Refers to the electronics assembly which controls the voltage and current being supplied to the Battery Pack (PD4410).
<b>Embedded Processor</b>	A software programmable device used to sense and process a series of input signals to produce control/status output signals.
<b>LED</b>	Light Emitting Diode.
<b>Micro-processor</b>	A software programmable device used to sense and process a series of input signals to produce control/status output signals.
<b>mS</b>	Milliseconds.
<b>PCB</b>	Printed circuit board.
<b>PD1400</b>	This term refers to the any of the PD1400/1600/2000 Pacemaker/Defibrillator family of products that are compatible with the Base PowerCharger <sup>4x4</sup> .
<b>μS</b>	Microseconds.

## 2. COMMON CIRCUITRY DESCRIPTION

As shown in the attached Block Diagram each charger compartment operates independently from the others except that all four compartments share a common DC power bus, VCC power supply, voltage references and temperature measurement circuitry. The occurrence of a fault condition in one of the common circuit areas may cause all four charging compartments to suspend operation.

In the following sections there will be periodic reference to a device's reference designation and pin number. For example, U3.5 will refer to pin number 5 of device U3. This information is to be associated with the attached system diagram and schematic set. In a similar fashion there will be reference to the microprocessor's port designation. For example, P3.1 will refer to the microprocessor's bit 1 of I/O port 3. Refer to the 8051 Data Handbook for a detailed description of the 87C752 I/O port capabilities and other features.

## DC Power Bus Circuitry

All four charging compartments share an unregulated 30V DC Power Bus which is used by each compartment as the power source for its switching power supply control circuit. This DC bus is created from a 24Vac input which originates from a chassis mounted transformer and enters the board via 2 pin connector J3. This AC input is rectified by bridge BR1 and filtered by capacitors C133, C233, C333 and C433. Any transients from the line which are not eliminated by the filter capacitors are absorbed by the metal oxide varistor TV1. JP8, R42, R43, R44, and D11 dissipate energy stored on the caps when AC is turned off. JP8 allows this dissipation circuit to be disabled.

## +12Vdc Supply

U3 with R7 and R8 provide a regulated 12 volts used to operate the alarm. C1 provides RF bypassing. C2 is a voltage filter capacitor. D1 is a reverse current protection diode. JP7 provides the user with the ability to select where the raw voltage comes from for the alarm.

## Logic Power Supply

A +5V +/- .25V power supply is produced from the +24Vac input (originating from connector J3) to power the analog and digital circuitry on the board. D4 and D5 along with C8, R9, and C3 rectify and filter this AC input voltage providing an unregulated 30Vdc input voltage for the fixed +5V output switching regulator U4. U4 along with D3, L1, C5, C6, C7 and R11 are implemented in a "buck" configuration. D2 provides a final over voltage protection for the logic supplies. For more details on "buck" converter operation see Switchmode Power Supply section.

## Reference Voltages

A two terminal, 1.235V band gap reference (U9) is used to create all of the reference voltages that are routed to the charging compartments. U9 is biased by R27 and buffered by amplifier U8B. C25 is an RF filter capacitor.

A second temperature compensated reference is created from device U9 to set the constant voltage mode output of each charger compartment. The positive input of amplifier U8A is referenced to the sum of U9 and the voltage across signal diode D10. Resistors R25, R26, R28 and potentiometer RV1 set the nominal gain of the amplifier to a range of 1.48 - 1.72. C24 and C27 provide RF filtering. C23 provides power supply filtering and bypassing. The voltage developed across the silicon diode varies inversely to ambient temperature. This diode characteristic causes the reference circuit to automatically adjust the CV charge voltage down as temperature rises which is in accordance with the recommendations of the lead-acid battery manufacturer.

Amplifier U6A, along with gain resistors R22 and R23, are used to create a third 3.3V reference voltage. C18 and C19 provide RF filtering. C20 provides power supply bypass and filtering. This reference voltage is bussed to an A/D input of each charger compartment's microprocessor and used to verify the accuracy of the VCC supply voltage (refer to VCC Test Circuitry Section for more details). This self-test feature insures that all A/D readings are accurate and not corrupted by a faulty VCC supply voltage.

## Temperature Measurement Circuitry

Temperature measurement circuitry is provided in order to compensate for battery charge and capacity test variations due to temperature. The signal generated by voltage divider RT1 and R24 is buffered by amplifier U6B and routed to an A/D input of each microprocessor through R135, R235, R335, and R435 for isolation. C22 and C21 provide RF filtering. Since thermistor RT1 has a nominal value of 10K at 25°C, the output voltage at room temperature will be 2.5V (midrange on the microprocessor A/D). With an 8 bit converter on each microprocessor, the system's internal ambient temperature can be determined within the range 0 - 70°C with 5% accuracy and 1°C resolution.

Temperature compensation is based on ambient, not battery temperature.

## Alarm Circuitry

U1A and R1, R2 and Q1 provide the control mechanism for turning the alarm (LS1) on from the alarm ports located on each compartment microprocessor.

## Battery Detection Circuitry

A set of battery detection circuits, comprised of differential amplifiers U5A U5B, U5C and U5D and associated components, signals each microprocessor if a battery is installed into its charging compartment. The input signal for each circuit is the battery sense lead which enters the board, along with the battery positive and negative terminals, via connector J1. A resistor divider (R13/R14, R15/R16, etc.,) is used for each battery detect op amp input to keep the working voltage range within the VCC supply voltage. Each op amp within U5 is configured as a comparator with a 1.2V threshold reference presented to the negative input pin.

Diodes D6 through D9 protect each amplifier from static discharge and C9, C11, C15, and C17 are used as filter capacitors. C10, C12, C14, and C16 are RF filtering capacitors. Each charging compartment's microprocessor observes its battery detection signal at port P1.7 (U104.22) with a positive voltage signifying the presence of a battery.

## 3. COMPARTMENT CIRCUITRY DESCRIPTION

The following section describes the electronics that are common to all four charger compartments. A block diagram overview of compartment circuitry is attached. For simplicity, all part designators will be referenced to the first compartment only. All of the reference designators for the other three compartments are exact increments of 100 in relation to charging compartment 1's values. The reference designators for the microprocessor, for example, is U104, U204, U304 and U404 for charging compartment 1, 2, 3 and 4 respectively. All reference designators below 100 are associated with common circuitry.

### Microprocessor

Each charging compartment contains a microprocessor that controls charging, discharging and capacity testing of the compartment's battery. The microprocessor also monitors battery voltage, battery current, system ambient temperature and the system power supply to determine if any fault condition has occurred. Four status LED's and a test switch are also controlled by the microprocessor.

The microprocessor (U104) is a 87C752 running at 6.144 MHz with 16K of internal ROM and 64 bytes of internal RAM. It also includes a five bit I/O port (port #0; pins 6 - 8, 23 and 24) and two 8 bit I/O ports (port #1 and #3; pins 13 - 22 and 1- 5, 25 - 27). The lower five bits of port 1 are configured as analog inputs (pins 13 - 19).

The operating frequency is derived from the external crystal circuit (Y101, C103, C102, R114) connected to the processor (at U104.10 and U104.11). R124 and C123 provide the reference voltage for the internal A/D.

C112, C101, C129, C130 are bypass capacitors associated with various IC's located within each compartment circuitry.

For a summary of the microprocessor I/O pin assignments and Battery Test, Charging Voltage and Current Settings see the following tables below.

Port & Pin	In / Out	Analog /Digital	Signal Name	Description
P0.0	--	D	--	- Not Used -
P0.1	--	D	--	- Not Used -
P0.2	--	D	--	- Not Used -
P0.3	O	D	WDO	Watchdog output.
P0.4	O	D	CAPOUT	PWM Capacity Level Indicator
P1.0	I	A	V_BATT	Battery Voltage
P1.1	I	A	V_TST	VCC Test.
P1.2	I	A	TEMP	Temperature
P1.3	I	A	I_SENSE	Current Sense
P1.4	I	A	FREQ	Clock Test
P1.5	--	D	--	- Not Used -
P1.6	I	D	TEST-	Enable support diagnostics (not available in all versions of code release).
P1.7	I	D	BAT_DET+	Battery Detection.
P3.0	O	D	CHRG_LED+	Charge LED
P3.1	O	D	RDY_LED+	Ready LED
P3.2	O	D	TST_LED+	Test LED
P3.3	O	D	FALT_LED+	Fault LED.
P3.4	O	D	SHUTDWN+	Charge Shutdown
P3.5	O	D	CHRG_ENB-	Charge control circuit enable.
P3.6	O	D	SSEL0-	Charge state select bit 0.
P3.7	O	D	SSEL1-	Charge state select bit 1.

Summary of the Battery Test and Charging Voltage and Current Settings;

SSEL0-	SSEL1-	Control State	I Limit	V Set
1	1	Discharge	--	Battery voltage
0	1	Discharge	--	Battery voltage
1	0	CC Charge	0.500 Amps	16.5 Volts
0	0	CV Charge	1.0 Amps	~ 11.75 Volts (actual value changes with temperature)

## Clock Test Circuitry

Clock testing is provided by the R123 and C122 R/C network. As part of its start-up verification sequence the microprocessor drives the port pin low and then releases it to charge up to VCC. After a delay of approximately 110  $\mu$ S it reads the voltage to determine if it has reached the 2/3 charge point or approximately 3.3 volts. If it perceives the value to be outside acceptable limits it may be because the crystal oscillator circuit (Y101, C103, C102) is out of specification. In this event the microprocessor will revert to a fault condition to prevent improper operation.

## VCC Test Circuitry

A VCC test is provided by the 3.3V voltage reference circuit which was presented in the "Common Circuitry" section. The microprocessor reads the reference value through its A/D port (U104.14). If it perceives the value to be outside acceptable limits it may be because either the VCC power is out of specification or the reference device has failed. In either event the microprocessor will revert to a fault condition to prevent improper operation.

A series resistor (R136) is provided in line with the 3.3V reference to insure that if a microprocessor fails within one of the charging compartments that it does not prevent the others from operating.

## Watchdog Circuit

The Watchdog device (U101) provides two functions. First, it acts as a power on reset circuit to insure that the microprocessor is held RESET until the +5 volt VCC power supply is stable. The watchdog timer continues to monitor the power supply and drives RESET high if the VCC supply falls below tolerance (4.62 volts nominal) anytime during normal operation. Secondly, the device will reset the microprocessor if it does not receive a "refresh strobe" at its input pin (U101.7) at least once every 250 milliseconds. If a reset condition occurs, the microprocessor will be held reset for a minimum of 250 mS.

Whenever the microprocessor is held reset by the watchdog, the switchmode power supply circuitry is also disabled via diode D103 and R117. As current is sourced through this device, the safety current limiting comparator (U103.13 and U103.14) turns on causing a "shut down" of the power supply output. Refer to Switchmode Power Supply Section for a detailed description of the switchmode power supply control circuitry.

## Shut Down Control

The Watchdog device (U101) as described above has the ability to both disable the microprocessor and shut down power supply operation. The microprocessor also has the ability to shut down power supply operation in the event that a fault condition is detected. This control function is provided via inverter U106 and diode D102 via R117. As described in the previous section, current sourced through the diode causes the safety current limiting comparator (U103.13 and U103.14) to turn on producing a shut down of the power supply output.

Power supply shut down also occurs when the battery test load is enabled.

## Charge Control Circuitry

The microprocessor establishes one of three different voltage and current control settings to support CV and CC battery charging and battery test. The following paragraphs describe the voltage and current control functions in detail.

A fail-safe charge enable circuit is provided which requires that the microprocessor is functioning properly before the current and voltage control limits are established. This is accomplished via the circuit built around the NOR gate U107C. During normal operation the microprocessor produces a pulse train (signal CHRG\_ENB-) with a frequency of approximately 500 HZ and a pulse width of approximately 10  $\mu$ S. This signal passes through the DC blocking capacitor C132 where it is buffered and inverted by U107. The output of U107 (U107.8) is rectified by the network comprised of D110, C131 and R140 which charges up to +5V at each pulse. After the voltage across C131 exceeds 2.4 volts both Schmitt triggered gates (U107B and U107D) are enabled. Since the R/C time constant of C131 and R140 is much slower than 500 Hz, the rectified voltage does not have time to drop below the logic high threshold limits of U107.4 and U107.12 before the next pulse occurs. If a failure causes the microprocessor to halt, leaving the CHRG\_ENB- signal at either a stable logic high or logic low, R141 will pull both U107C.9 and U107C.10 inputs high. This action causes the mode select gates (U107B and U107D) to be disabled.

Diode D111 is provided to prevent the voltage transition which comes through C132 from exceeding the high and low input signal requirements of the CMOS logic (at U107.9 and U107.10).

One of two possible voltage and current limiting values are selected via control gate U107A and U107B. The microprocessor asserts SSEL0- low (at U104.26) to select a one amp charge rate (FET Q104 turned off via control gate U107A) and a nominal CV voltage setting of 11.75 volts (FET Q102 turned off via control gate U107A). If the SSEL0- signal is driven high, FETs Q104 and Q102 are turned on to establish a current control setting of 500 mA and a voltage limit of 16.5V by placing shunt resistor R129 across R104 via Q104 and R120 across R119 via Q102. the gate of Q102 is protected by R121 and the gate of Q104 is protected by R130. For a summary of the current limits for each of the two charge select states see table on page IV-6.

Diodes D107 provides static discharge protection for the gates of the current and voltage selection FETs (Q104 and Q102).

## Display Drive Circuitry

The four status LEDs; **CHARGER ON**, **BATT. READY**, **TESTING** and **FAULT** on the LED PCB assembly are controlled by PORT 3 control lines of the microprocessor (U104 pins 2 -5). Each control signal is buffered by both a logic inverter (U106A, U106B, U106C and U106D) and a darlington driver (U7 or U2). A 270 ohm resistor network (RN1 & RN2) limits the LED on current to 15mA. J2 connects all of the LED and test switch control signals to the LED PCB assembly over a ribbon cable. Resistor R17 turns on the 'POWER' LED on the LED PCB when the +5V VCC logic supply powers up.

See the Operator's manual for further clarification of the LEDs and their use.

## Test Switch Interface Circuitry

A simple interface circuit and a single input port line is used to monitor the test switch located on the LED PCB. An internal pull-up resistor in the microprocessor holds the input pin high (port P1.6) until the test switch is pressed causing this signal to short to ground.

R134 limits the current into the microprocessor from a possible short circuit and D106 is used as a guard against static discharge.

## Battery Voltage Sense Circuitry

The microprocessor monitors the switchmode power supply output and the battery voltage over a range of 8.5 to 16.5 volts to determine the battery's charge status and if it or the internal control electronics or the power supply has failed. The microprocessor resolves the voltage reading to within 50 millivolts (33mV, 8 bit) in order to support the battery charging algorithm requirements.

Op amp U105A forms a basic amplifier circuit with a gain of approximately -0.574 and an offset of 8.01V (established by the resistor combination R111, R112 and R110). Resistors R133 and R132 form a voltage divider to drop the battery voltage by a factor of 6 to keep the signal range within the input requirements of the op amp device (U105A). The resulting output signal (at U105.1), ranging from 0 to 4.85 volts is read by the microprocessor at its analog input (U104.13).

Capacitors C111 and C108 provide noise filtering while and capacitors C109 and C110 provide RF interference and static discharge protection. C119 is a power supply bypass capacitor.

$$A/D \text{ (voltage)} = 5 - ((\text{Battery voltage} - 8.01) * 0.574)$$

## Current Sense Circuitry

The microprocessor monitors the supply current over a range of approximately 0 to 2 amps to determine the battery's charge status or if a control circuit has failed. The microprocessor resolves a current reading to within 8.3 milliamps in order to support the battery charging control requirements.

OP amp U102B forms a basic amplifier circuit with a gain of approximately 24 to amplify the current sense signal through the 100 milliohm resistor (R127). The gain of the circuit is established by resistor values R125 and R126. The resulting output signal (I\_SENSE at U102.7), ranging from 0 to 4.85 volts is read by the microprocessor at its analog input (U104.16).

Capacitor C120 provides noise filtering while and capacitors C114, C115, and C116 provide RF interference and static discharge protection. R 106 is a balancing resistor in the non-inverting input line to the amplifier.

$$A/D \text{ (Current)} = \text{Battery Current} * 2.37$$

## Switchmode Power Supply Operation

At the heart of each compartment is a switchmode power supply which establishes each of the charging configurations for the charging compartment. When a battery is inserted and charging is initiated, the switchmode power supply provides a constant voltage to charge the battery. As the battery charges up and the input current into the battery falls below a predetermined level, the battery charging mode is changed by the microprocessor to a constant current charge until the battery is fully charged. Upon completion of the constant current charge sequence, a timed overcharge is applied to insure that the battery has been fully recharged.

U103 is a fixed frequency pulse width modulation control IC that contains the building blocks for the power supply. As shown in Figure 1, U103 is configured in a "buck" orientation with power FET Q103 being the switch shown in the diagram.

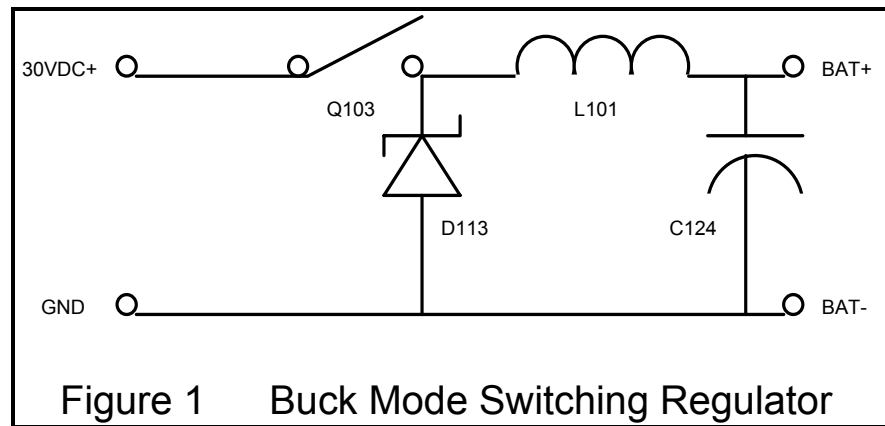


Figure 1 Buck Mode Switching Regulator

When the switch is closed, current builds through inductor L101 inducing a magnetic field. The amount of energy stored in the inductor depends upon how long the switch is closed. When the switch is opened, current starts to decrease through the inductor. The voltage at the cathode of D113 clamps to -0.4V as the current through the inductor decreases ( $V = L \cdot di/dt$ ). With catch diode D113 now forward biased, there is a path for the energy stored in the inductor to be transferred to the load. The cycle repeats itself with the "ON" and "OFF" time of the switch determined by a feedback control loop.

The PWM control device U103 operates at a 100KHz switching frequency which is determined by the C107 and R118 R/C network. An internal open collector transistor "switch" at U103.9 turns Q103 on through a series gate resistor R138 by pulling one end of R137 to ground. D109 clamps the gate-source voltage of Q103 to acceptable levels and the network consisting of Q105, D108 and R139 speeds up the turn-off time of Q103. There are three error feedback amplifiers that control the "ON" and "OFF" time of the internal switch; two of which are internal to the PWM control device and one control amplifier (U102A) that is external. All three amplifiers are OR'ed together at pin 3 of U103. The internal amplifiers are tied together and brought out to pin 3 of U103 and the external amplifier U102A is diode OR'ed through D101 such that the amplifier that demands minimum "ON" time, dominates control of the loop. Power to the regulator IC is filtered via R115 and C117.



When no battery is present in a charging compartment, the voltage feedback amplifier with inputs at U103.1 and U103.2 dominates control of the loop. The negative input of the amplifier is tied to the temperature compensated reference through R103 for isolation purposes. The positive input of the amplifier senses the power supply output voltage via voltage divider R128 and R119 through R108. The divider is filtered by C127 and C118. R/C network R102 and C106 compensate the amplifier ensuring stable operation. R120 is placed in parallel with R119 via Q102 to change the maximum charging voltage during CV or CC charging. R121 is the gate protection resistor in Q102.

During battery charging, the current feedback amplifier U102A dominates control of the loop. The output current of the power supply is measured through sense resistor R127. The sense voltage developed across this resistor is then compared to a fraction of the on board 1.2V reference determined by the voltage divider resistors R104 and R105. The result of this compare function is to limit the output current of the power supply to 1A during CV charging and by placing R129 across R104 to 500mA during CC charging. Capacitor C125 provides stabilization for this control loop. C105 and C113 provide RF filtering and C104 provides power supply bypassing. R 107 is a balance resistor for U102A.

A second current feedback amplifier with inputs at U103.13 and U103.14 limits supply current to 2A in the event of a failure of amplifier U102A. Operation of this amplifier is similar to that of U102A with resistor divider R118 and R101 providing a reference voltage to compare against the voltage generated across current sense resistor R127 through R116. C126 stabilizes the amplifier ensuring proper control loop operation. R130 is a series gate protection resistor for Q104.

A final level of component failure protection is provided by the 2A pico-fuse F101. Each Compartment output voltage is protected by a transorb from positive to negative terminal TV101. JP101 and a transformer, rather than an inductor, allows the switches to be converted from a Buck regulator to a flyback style.

## Battery Test Control Circuitry

The microprocessor initiates a battery test sequence when it has detected the presence of a battery in the charging compartment and the test switch has been pressed. A fail-safe charge enable circuit is provided which requires that the microprocessor is functioning properly before the test load can be applied to the battery. Refer to the **Charge Control Circuitry Section** (Page IV-8) for a description of the Charge Enable Control circuitry.

Once the Charge Enable control is established, the microprocessor may either charge or discharge the battery to prepare a battery for use or determine its ability to perform under load. To apply the test load, the microprocessor asserts SSEL1- high (at U104.25) which places the load resistor (R3) across the battery via the output of U106.12 through R122 to the transistor Q101. As the load is applied across the battery, the power supply is caused to shut down via the current flow through diode D104.

Diodes D105 provides static discharge protection for the gate of the load control FET (Q101).

## Battery Capacity Output (optional)

Output control line P0.4 (U104.24) is used to develop an analog output that is proportional to the capacity of a battery that has been tested. The microprocessor's port line P0.4 is configured as a pulse width modulated output which is filtered by the R131 and C128 R/C network. The resulting DC voltage is buffered by amplifier U105B and bussed to connector J101.2. R113 is a current limiting resistor inserted for protection against accidental shorts. C121 is an RF bypass capacitor.

## 4. LED PCB

The LED PCB assembly provides the user interface to each of the four charging compartments within the Base PowerCharger<sup>4x4</sup> system. A ribbon cable running from J2 of the main PCB to P4 on the LED PCB carries the signals that drive the status LED's and test switches for each charging compartment.

Located on this assembly are four test switches; SW1 - SW4 (one for each charging compartment), a power on indicator (LED171 or 172) and four sets of status indicators (LED1 - LED4 for charging compartment 1, LED5 - LED8 for charging compartment 2, LED9 - LED12 for charging compartment 3 and LED13 - LED16 for charging compartment 4). All of the drive and interface electronics for these devices are located on the main PCB and are described in the Display Drive Circuitry section and the Test Switch Interface Circuitry.

## Power Up Operation

At power on, the POWER indicator will turn on. The controller for each channel will perform a series of power-on diagnostics (including a test of the four LED's) and then advance to the appropriate mode based on whether a fault is detected, a battery is present, and the status of the test switch. See **Diagnostics** Section for a detailed description of the power-on diagnostics.

If a fault is detected, the controller will revert to the FAULT Mode. Any power brown-out (< 90VAC) or interruption will cause a charging sequence to be restarted when proper power is re-established.

If a test is in progress during a power brown-out or interruption the controller will revert to normal operation when proper power is re-established. Press the **TEST** button to start the testing cycle again.

## Turn on Delay

The system will delay no more that 10 seconds after power on to allow the battery/power electronics to stabilize and go through a self test. The **CHARGER ON** indicator will be turned on after the delay, if a battery is present.

## Charge Mode

In this mode of operation the controller will perform a charging sequence on the battery. The **CHARGER ON** indicator will be turned on at this time. When the CV/CC charge sequence is completed the **CHARGER ON** indicator will be turned off and the **BATT. READY** indicator will be activated. For more information, see the Battery Charging Algorithm section.

## Battery Test Mode

This mode will occur only if the test button is activated and a battery is detected by the controller. The **TESTING** indicator will be activated whenever the channel is in this test mode. The battery test sequence will be as follows;

- First the battery will be fully charged.
- Battery charging will then be disabled.
- A test load will be presented to the battery. The load is to simulate the load presented by the 1400 Series Devices. This load will be maintained until the battery is depleted.
- The capacity will then be calculated (see discussion below).
- Finally, the battery will be recharged.

If the capacity is determined to be adequate a **BATT. READY** indicator will be activated after the battery is recharged and the **TESTING** indicator will remain on. If the capacity is insufficient the **TESTING** and **FAULT** indicators will be activated at the end of the capacity test and the battery will be recharged, if possible. To abort this mode the user must either remove the battery or interrupt the AC power. Refer to the Battery Charging Algorithm section.

## Unit Test Mode

This mode occurs only if the test button is activated for two seconds with no battery installed. When a self test is performed all LED's illuminate for a brief period of time and if successful the **TESTING** and **BATT. READY** indicator's are turned on for a few seconds or if there is a failure the **FAULT** LED is turned on and left on. This test will be also run automatically at power up and after a battery is removed.

## Fault Mode

If a fault is identified by the controller the **FAULT** LED for that channel will light (all other LED's for that channel will be turned off ). If the test button is activated for 2 seconds in this state then one of 15 patterns of the four LED's will be activated to indicate the type of fault. This pattern will remain on only while the key is pressed. This mode will be reset every time a battery is installed or removed and at power up. See the Operator's manual for a description of the fault codes.

## Idle Mode

If the battery is not in place the channel will remain in a standby mode ( all LED's are off except for the AC Power LED).

## Battery Charging Algorithm

The algorithm used to charge the battery in both the charge and test modes is as follows;

- When a battery is installed the controller will begin charging operation in a CV charge mode. At this time a charge timer will be started.
- The CV mode will continue until the charge current drops to the constant current charge rate. The controller will then record the length of time "T" required to arrive at this CC charge point.
- The controller will then switch to a constant current charging mode and charge the battery at a CC charge rate until the battery's voltage peaks ( i.e. remains constant or begins to drop) during a three minute period.
- The controller will then maintain a top off CC charge for a period of time equal to the value T (obtained above) divided by 6. i.e.  
$$\text{Time}_{\text{TOP1}} = T / 6$$
- Upon completion of the top off phase the controller will return to an appropriate mode to maintain a float charge on the battery. The controller will remain in this state until the AC power or the battery is removed.

## I/O Signal Summary

Pin No.	I/O	Signal Name	Definition	Comments
5	I/O	B1 +	Battery Charge Pin	
1	I	B1 SENS +	Battery Sense	Battery #1 detection signal.
9	I/O	B1 -	Battery Return	
6	I/O	B2 +	Battery Charge Pin	
2	I	B2 SENS +	Battery Sense	Battery #2 detection signal.
10	I/O	B2 -	Battery Return	
7	I/O	B3 +	Battery Charge Pin	
3	I	B3 SENS +	Battery Sense	Battery #3 detection signal.
11	I/O	B3 -	Battery Return	
8	I/O	B4 +	Battery Charge Pin	
4	I	B4 SENS +	Battery Sense	Battery #4 detection signal.
12	I/O	B4 -	Battery Return	

## Diagnostics

The following sections describe several types of diagnostics that will be performed by the system to insure product safety and simplify assembly and test requirements.

## Power Up

As AC power is applied, the controller will perform a series of internal tests to determine if the electronics are functional. The following tests are performed ;

- Timer Accuracy. Verify that the internal clock/timing function has not shifted fundamental frequency.
- Memory Validity. Verify that all of the embedded processor's internal memory locations (RAM and ROM) are functional.
- Power Supply Accuracy. Verify that the logic power supply is within tolerance
- LED Test. Turn the four LED's on for a short period.

If any of the first three functional tests fail, the controller will revert to the Fault mode (see Fault Mode section). It will be left to the user to verify that the LED's are functional.

## User Tests

This mode occurs only if the test button is activated for two seconds with no battery installed. A self test will be performed which will include turning on all LED's for a brief period of time. If successful, the **TESTING** and **BATT. READY** indicator's will be turned on for a few seconds. If a failure is detected, the **FAULT** indicator will be turned on and left on. This test will also be run automatically after a battery is removed. The following tests will be performed:

- **Timer Accuracy.** Verify that the internal clock/timing function has not shifted fundamental frequency.
- **Memory Validity.** Verify that all of the imbedded processor's internal memory locations (RAM and ROM) are functional.
- **Power Supply Accuracy.** Verify that the logic power supply is within tolerance.
- **Charger voltage control test.** Verify CC and CV voltage levels

## Run Time Tests

The controller will perform a series of internal tests to insure safe operation. Some of these tests will be performed continuously. Other tests will be performed at the appropriate moment of run time operation. A summary follows;

- **Power Supply accuracy.** Verify that the power supply is within tolerance.
- **OverCharge Timer test.** Performed during the CV/CC charge sequence. Limit the amount of time battery is subjected to charge to less than 4 AH.
- **Battery Voltage validity.** Performed during the CC charge sequence. Verify that the battery is within acceptable voltage limits.
- **Charge Current validity.** Performed during the CC charge sequence. Verify that the charge current is within acceptable limits.
- **Temperature validity.** Performed continuously. Verify that the temperature is within acceptable limits. If temperature is too high or too low the controller will disable constant current charging and will turn the FAULT indicator on.
- **Embedded Processor Operation.** Performed continuously. Verify that the processor is properly executing its program.

If any of these tests fail, the controller will either be disabled or will revert to the Fault mode.

For those faults in which the microprocessor is still functional, CV charge operation will be maintained. Except for a battery voltage failure the microprocessor will continuously attempt fault recovery. In the event of a battery voltage failure the microprocessor will stay in the fault mode until the battery is removed.

If the microprocessor is disabled the charge circuitry will revert to CV charge operation and the FAULT indicator will flash to indicate this condition to the user.

## SECTION V SCHEMATIC DRAWINGS

ZOLL Base PowerCharger<sup>4x4</sup> schematic drawings are included here to supplement the information presented in:

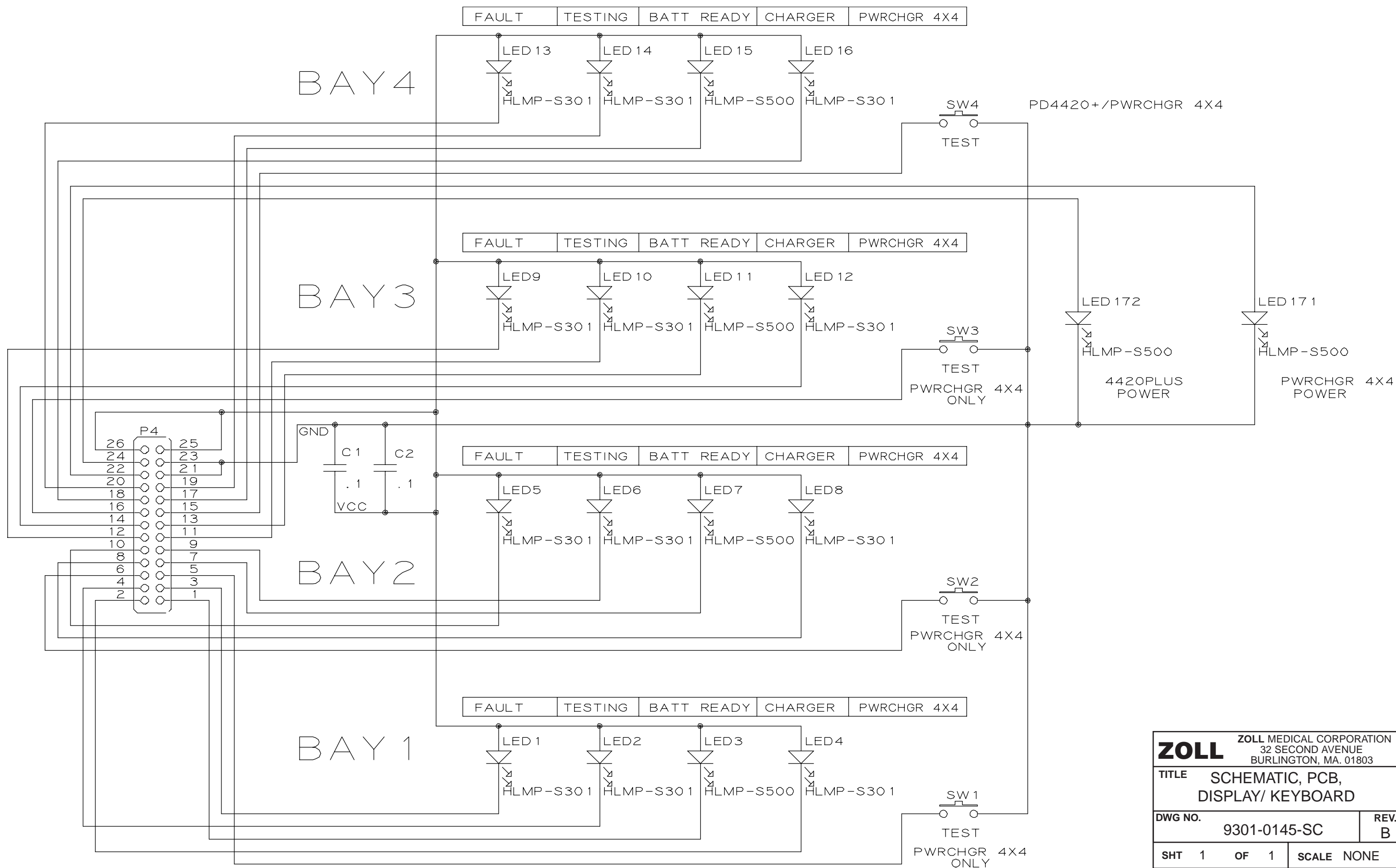
- Section III, Troubleshooting
- Section IV, Functional Descriptions
- Section VI, Component Layout Drawings

### LIST OF DRAWINGS

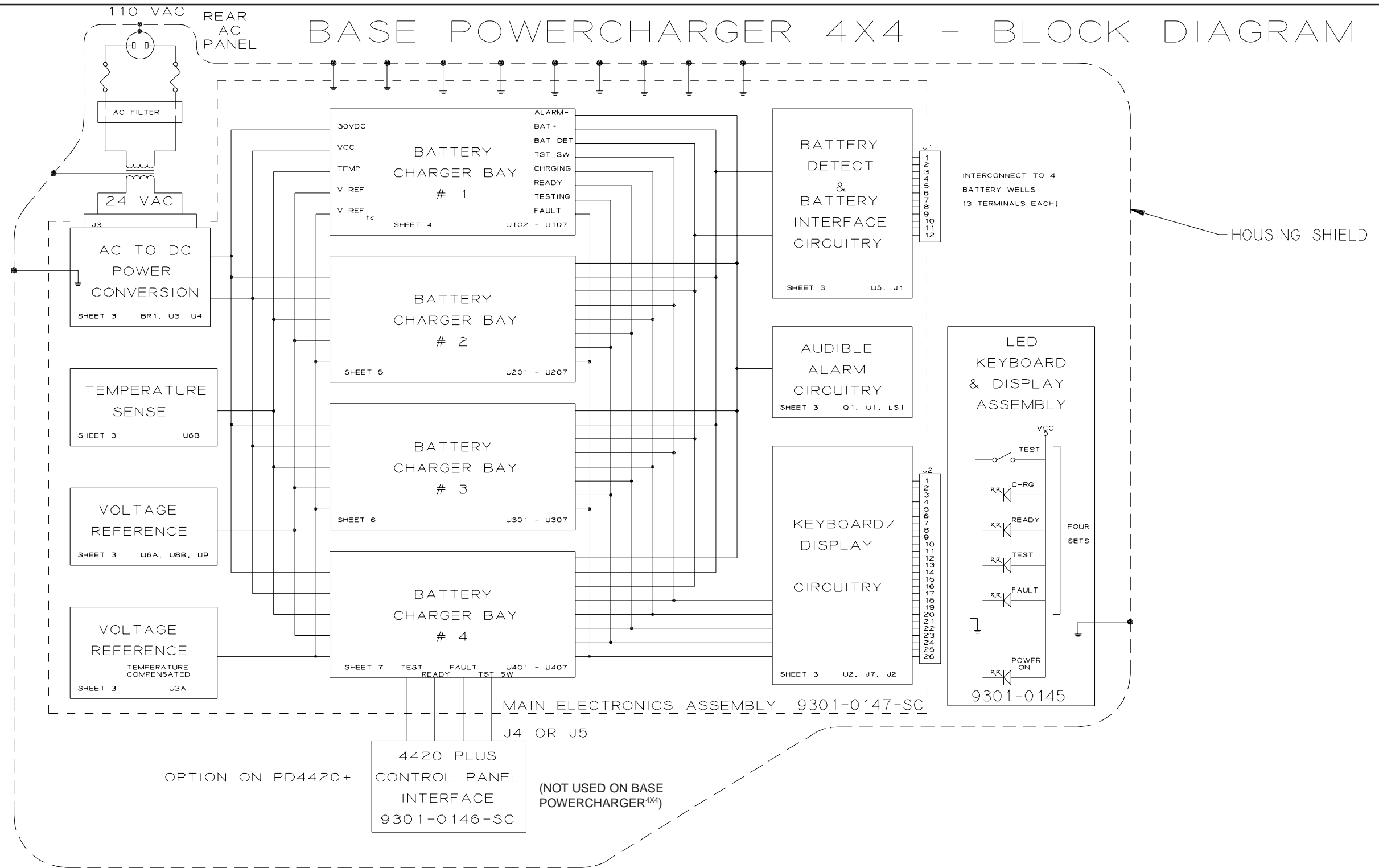
<b>Description</b>	<b>Page</b>
1. Display / Keyboard, PCB .....	V-3
2. System .....	V-4







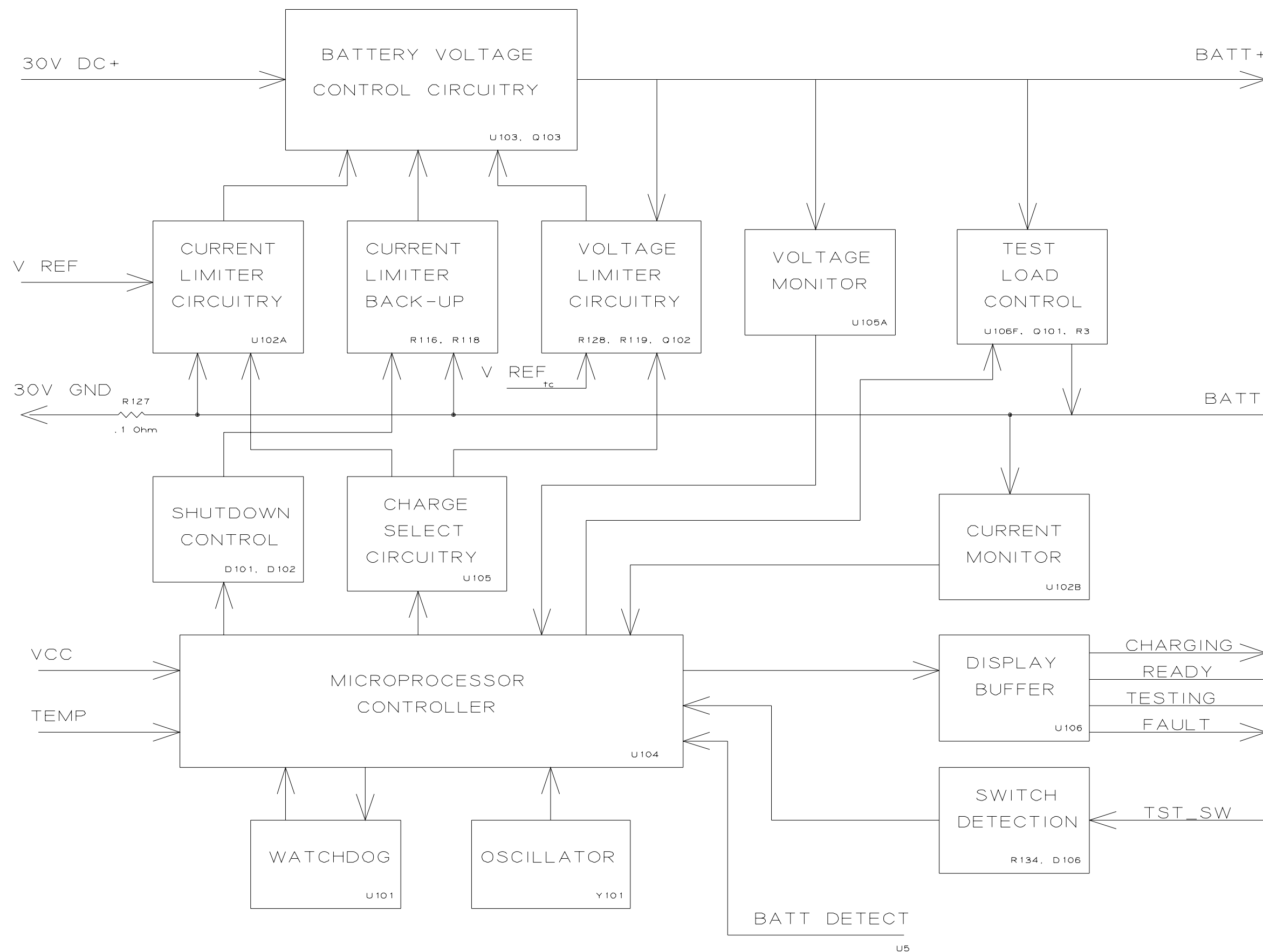
<b>ZOLL</b>		ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE SCHEMATIC, PCB, DISPLAY/ KEYBOARD			
DWG NO. 9301-0145-SC		REV. B	
SHT 1	OF 1	SCALE NONE	



LAST USED:

R44	Q1	JP8	YX01
RX43	QX05	JPX01	L1
D11	TP15	RN2	LX01
DX14	TPX04	RV1	LS1
C31	TV1	RT1	BR1
CX33	TVX01	J5	FX01
SP1		JX01	U10
			UX07

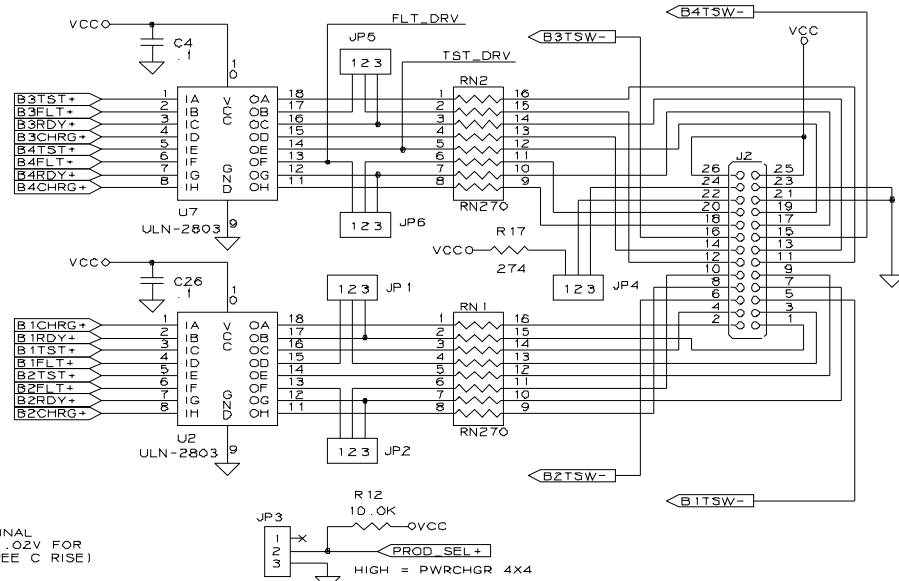
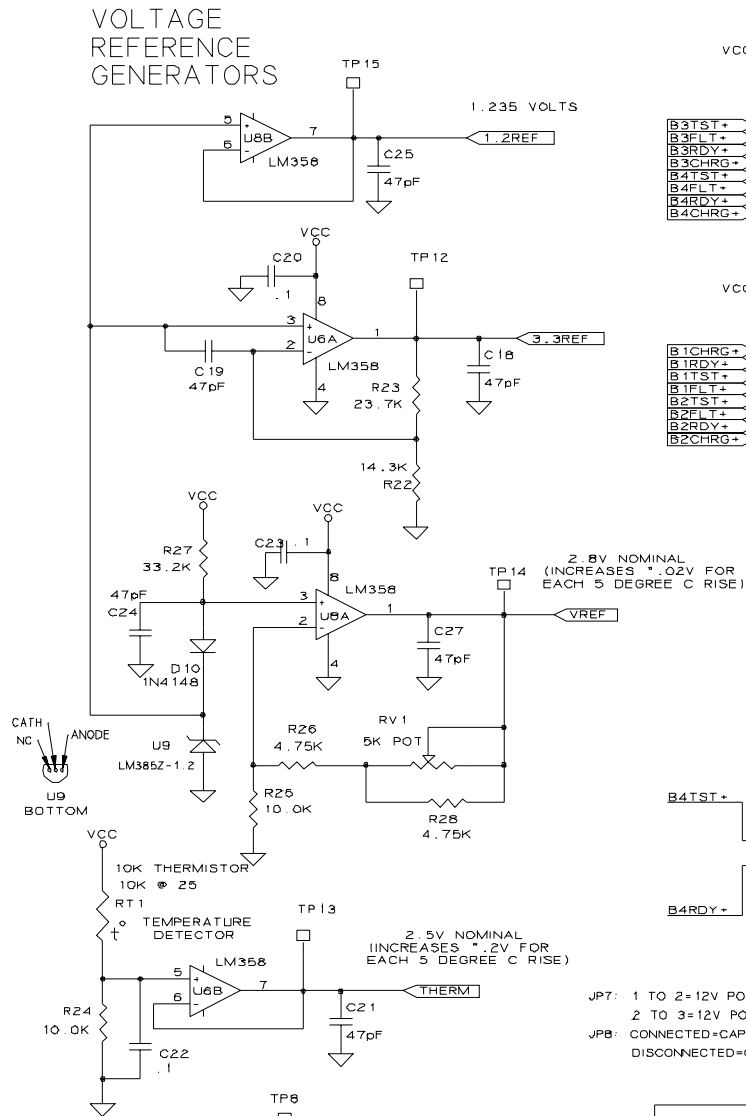
<b>ZOLL</b> ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE SCHEMATIC, PCB, SYSTEM, BASE POWERCHARGER <sup>4X4</sup>	
DWG NO. 9301-0147-SC	REV. B
SHT 1 OF 7	SCALE NONE



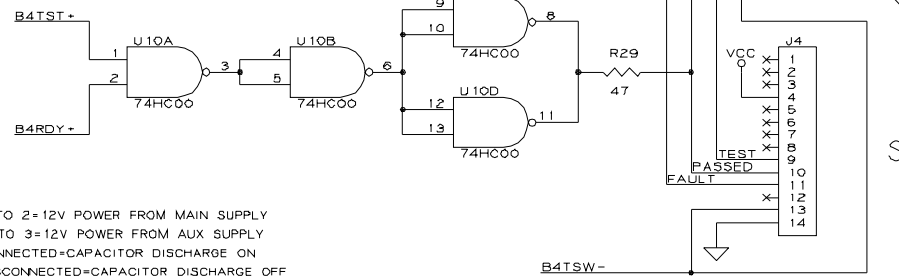
<b>ZOLL</b> ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803		
TITLE SCHEMATIC, PCB, SYSTEM, BASE POWERCHARGER <sup>4X4</sup>		
DWG NO.	9301-0147-SC	REV. B
SHT 2	OF 7	SCALE NONE

PWRCHGR 4X4 JP1, JP2, JP3, JP4, JP5, JP6 CONNECT 1-2

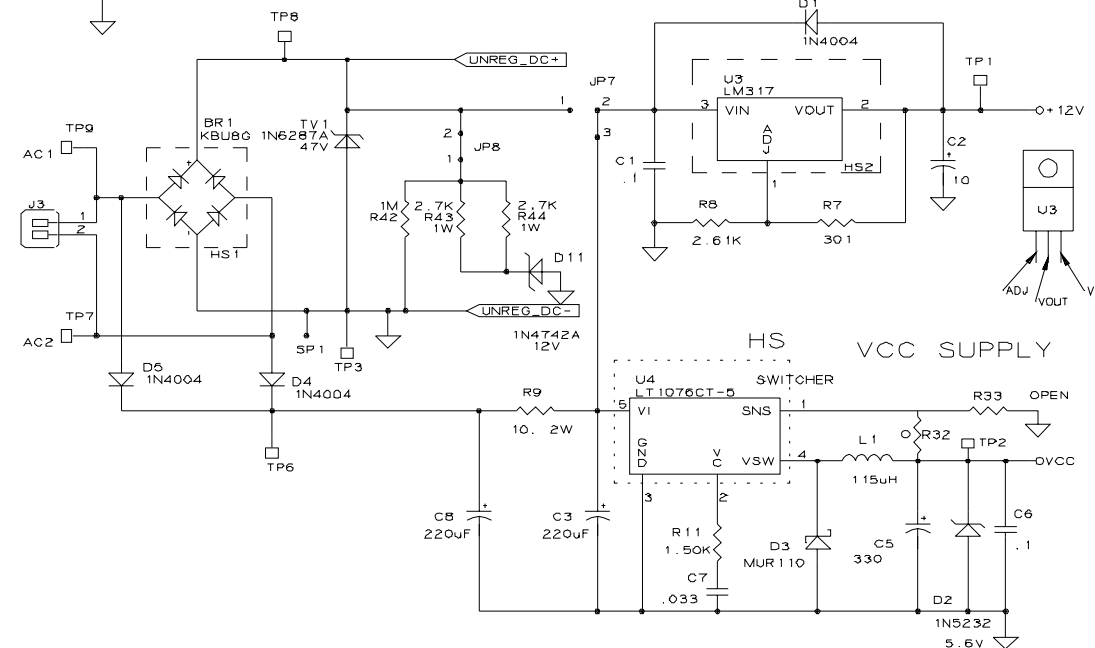
KEYBOARD/DISPLAY INTERFACE



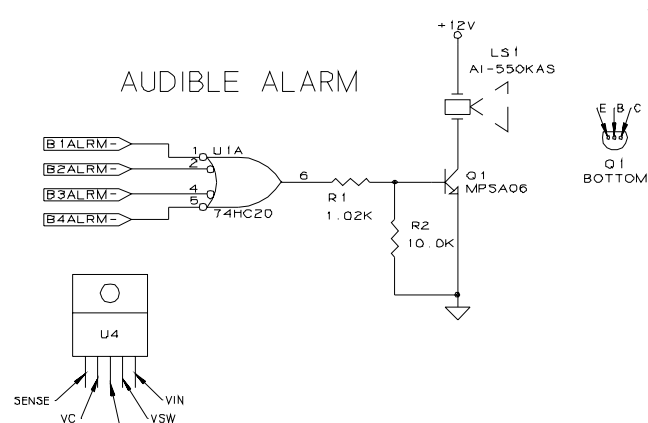
CONTROL PANEL INTERFACE



JP7: 1 TO 2=12V POWER FROM MAIN SUPPLY  
2 TO 3=12V POWER FROM AUX SUPPLY  
JP8: CONNECTED=CAPACITOR DISCHARGE ON  
DISCONNECTED=CAPACITOR DISCHARGE OFF

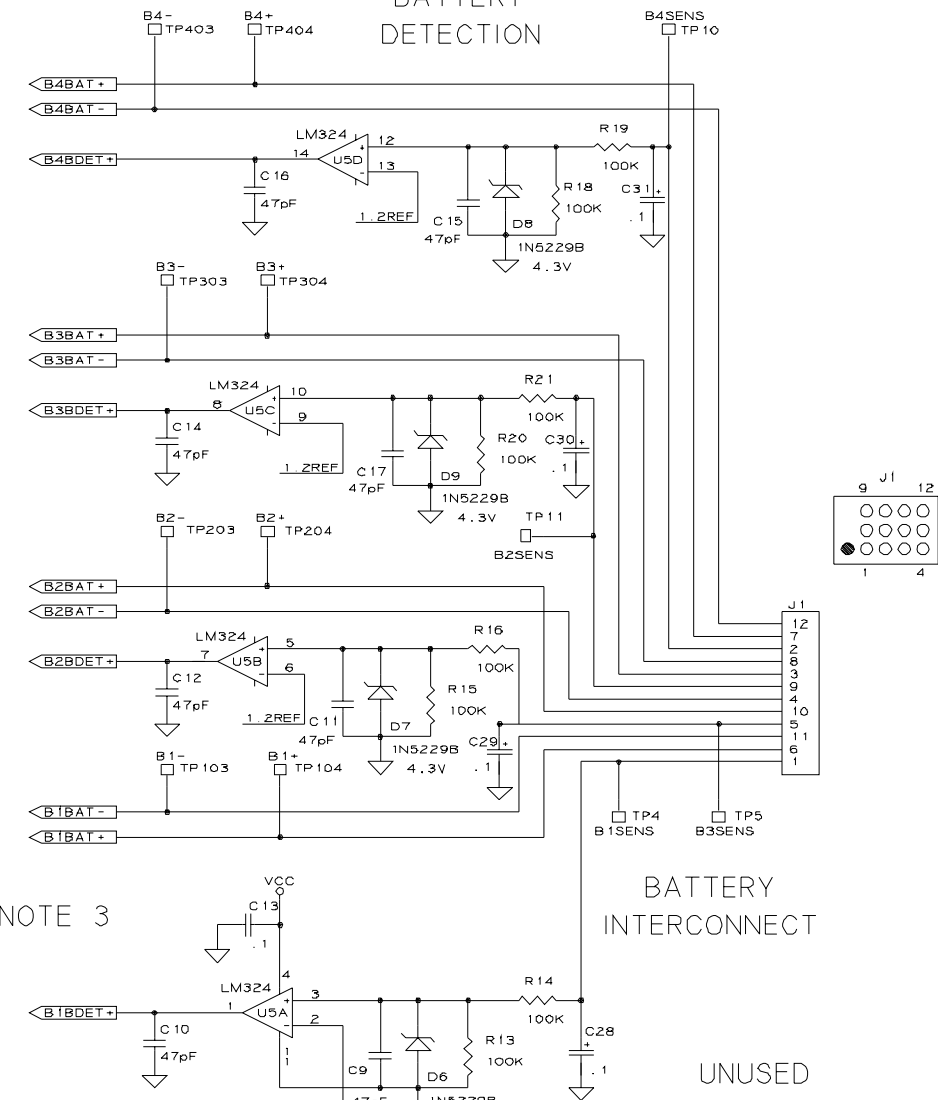


AUDIBLE ALARM



- NOTES:
1. ALL RESISTORS ARE 1% TOLERANCE UNLESS OTHERWISE SPECIFIED.
  2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE STATED.
  3. EITHER J4 OR J5 CAN BE UTILIZED TO CONNECT THE TEST PCB.

BATTERY DETECTION



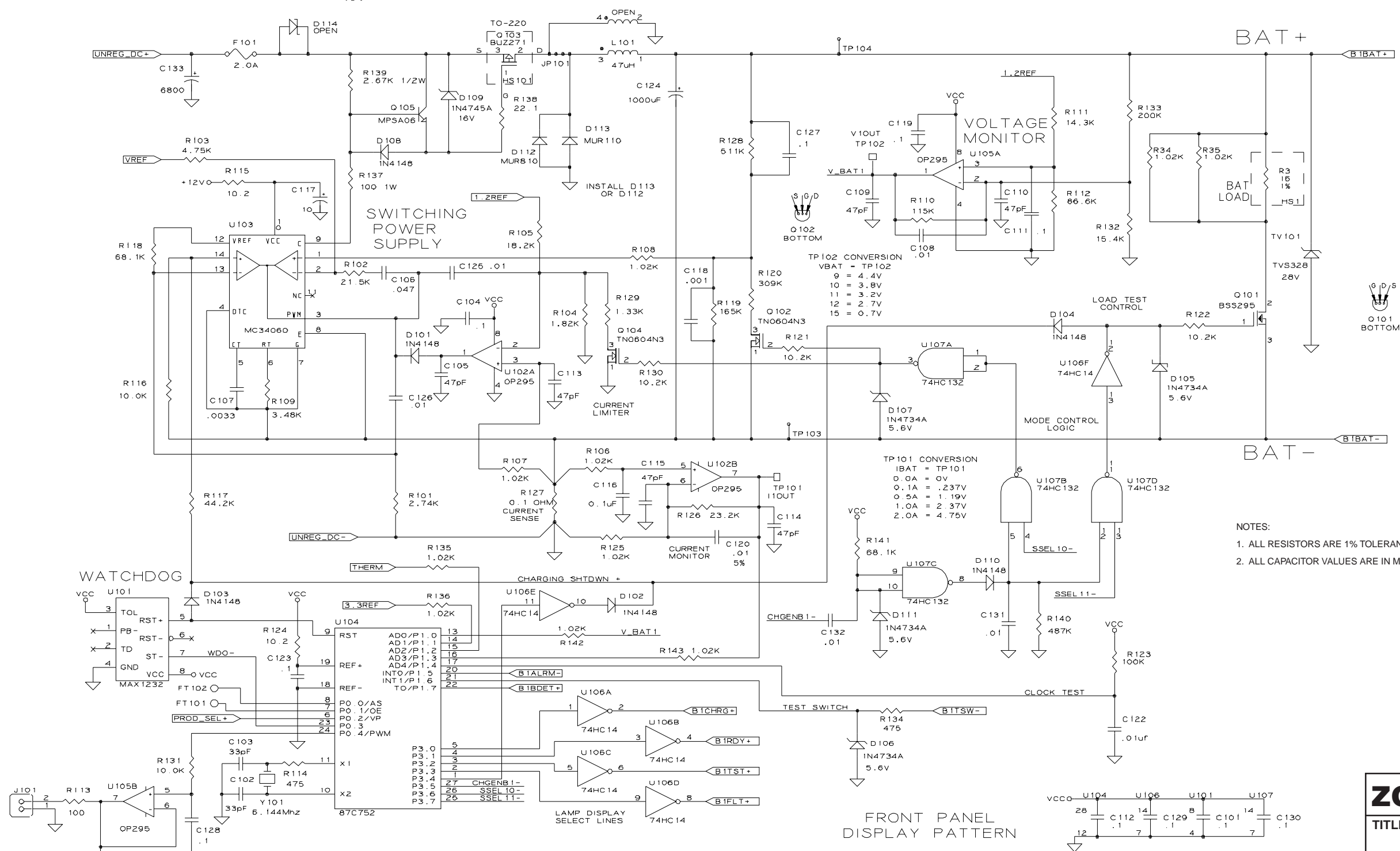
BATTERY INTERCONNECT

UNUSED

<p><b>ZOLL</b> ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803</p>			
		<p>TITLE SCHEMATIC, PCB, SYSTEM, BASE POWERCHARGER 4X4</p>	
DWG NO.	9301-0147-SC	REV.	B
SHT 3	OF 7	SCALE	NONE

# CHARGER BAY 1

OPTION 1. INDUCTOR BUCK CONVERTER WITH JP101 SHORTED AND INDUCTOR INSTALLED.  
 OPTION 2. FLYBACK CONVERTER WITH JP101 OPEN AND XFMR INSTALLED.



- NOTES:  
 1. ALL RESISTORS ARE 1% TOLERANCE UNLESS OTHERWISE SPECIFIED.  
 2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

CHARGE_SELECTION_TABLE			
SSEL10-	SSEL11-	CHARGE_MODE	
0	0	CV CHARGE	
0	1	ENABLE TEST LOAD	
1	0	CC CHARGE	
1	1	ENABLE TEST LOAD	

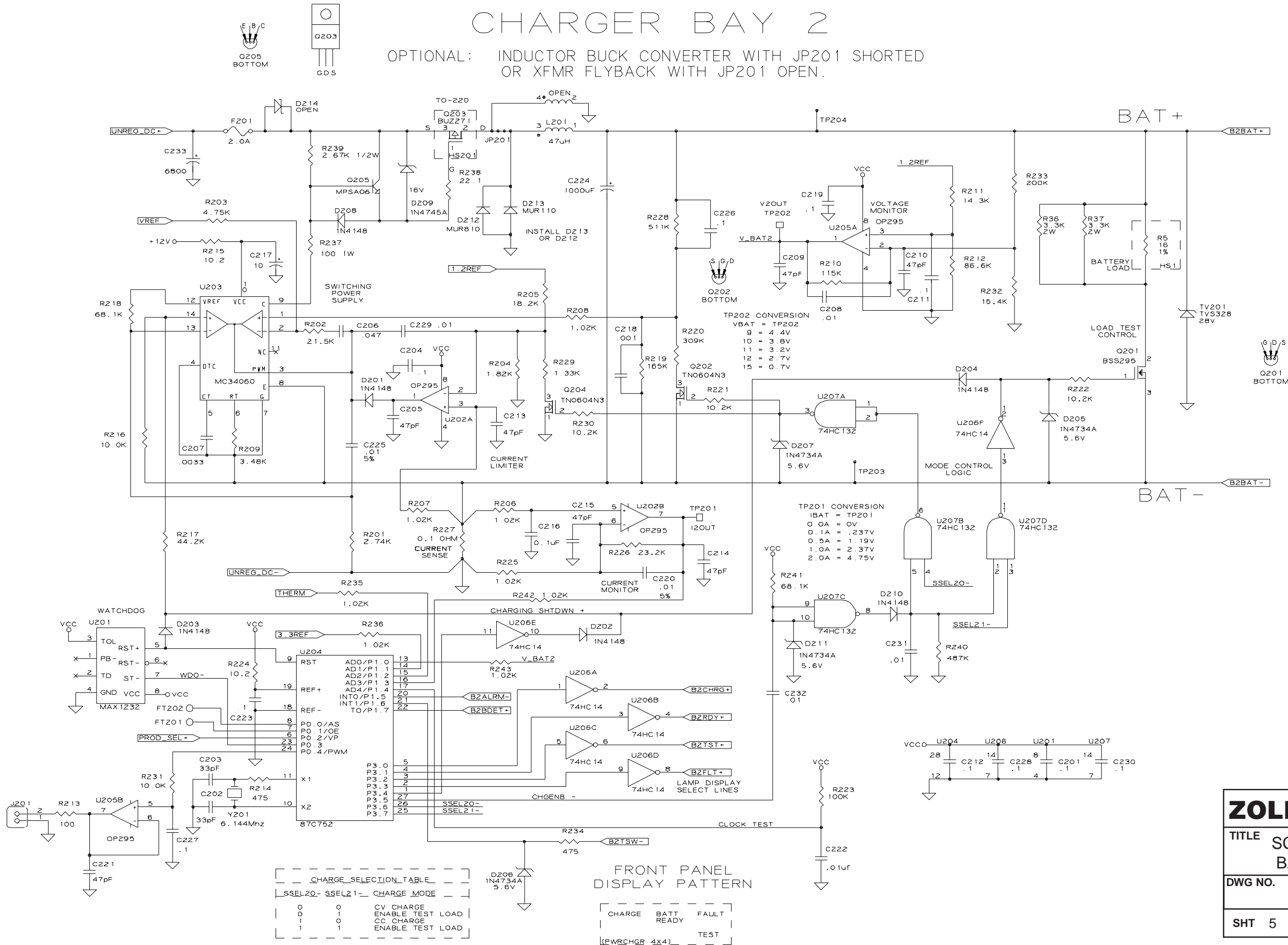
FRONT PANEL DISPLAY PATTERN

CHARGE	BATT READY	FAULT
[PWRCHGR 4X4]		TEST

<b>ZOLL</b> ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE SCHEMATIC, PCB, SYSTEM, BASE POWERCHARGER4X4	
DWG NO. 9301-0147-SC	REV. B
SHT 4 OF 7	SCALE NONE

# CHARGER BAY 2

OPTIONAL: INDUCTOR BUCK CONVERTER WITH JP201 SHORTED  
OR XFMR FLYBACK WITH JP201 OPEN.



**ZOLL** ZOLL MEDICAL CORPORATION  
 32 SECOND AVENUE  
 BURLINGTON, MA. 01803

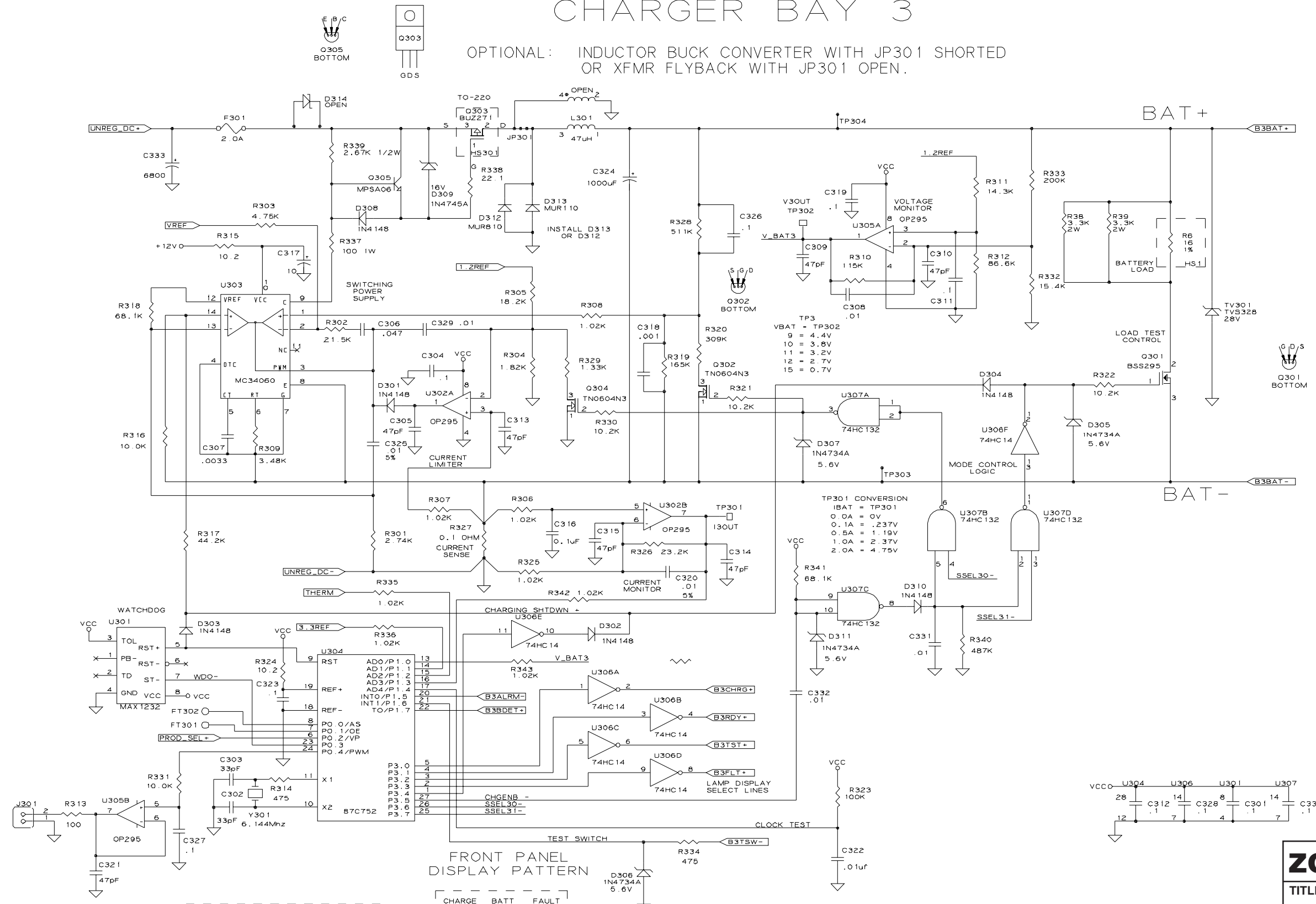
TITLE SCHEMATIC, PCB, SYSTEM,  
 BASE POWERCHARGER<sup>4X4</sup>

DWG NO. 9301-0147-SC REV. B

SHT 5 OF 7 SCALE NONE

# CHARGER BAY 3

OPTIONAL: INDUCTOR BUCK CONVERTER WITH JP301 SHORTED  
OR XFMR FLYBACK WITH JP301 OPEN.



CHARGE\_SELECTION\_TABLE

SSEL30-	SSEL31-	CHARGE MODE
0	0	CV CHARGE
0	1	ENABLE TEST LOAD
1	0	CC CHARGE
1	1	ENABLE TEST LOAD

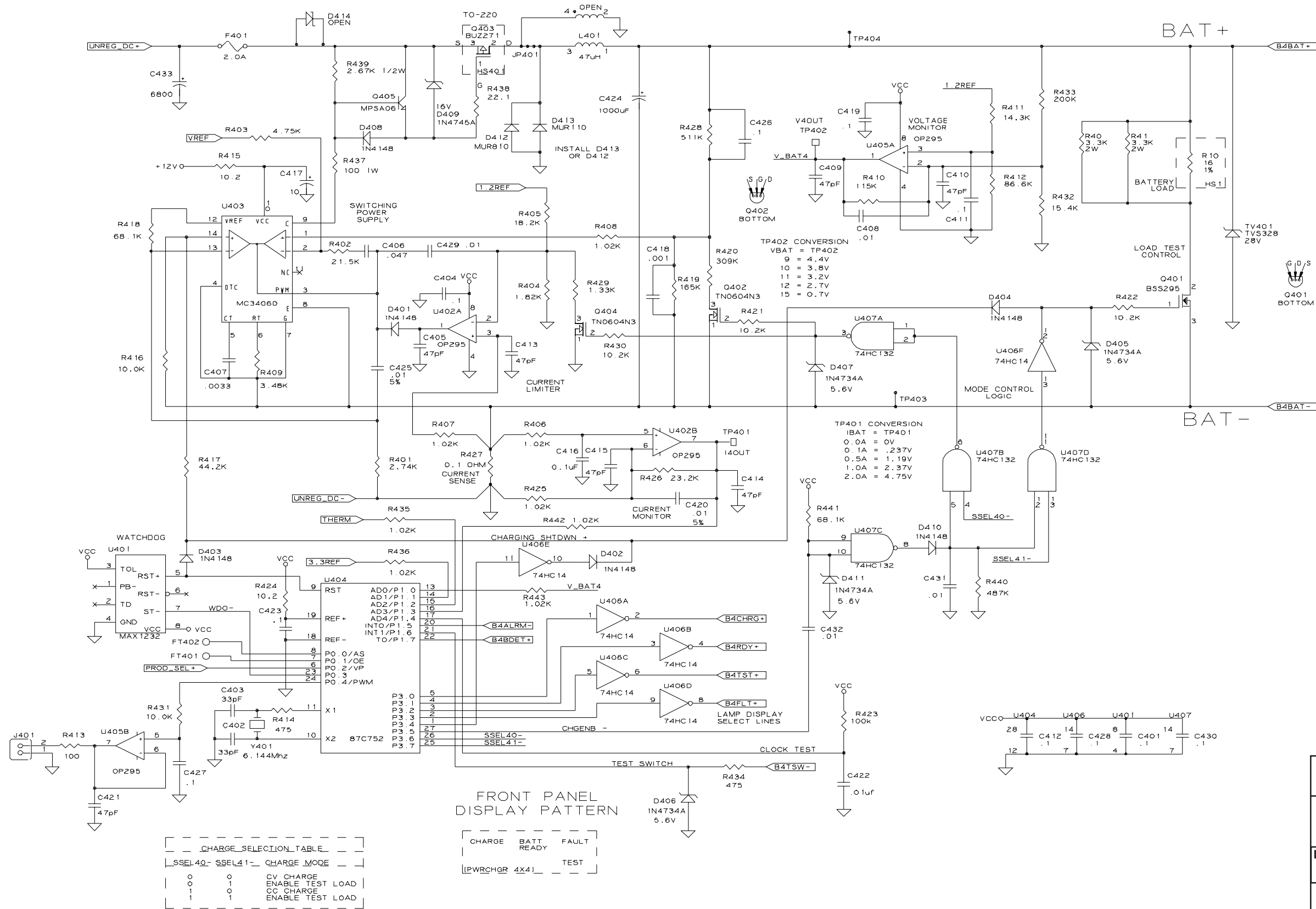
FRONT PANEL DISPLAY PATTERN

CHARGE	BATT READY	FAULT
[LWRCHGR 4X4]		TEST

<b>ZOLL</b> ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE SCHEMATIC, PCB, SYSTEM, BASE POWERCHARGER4X4	
DWG NO. 9301-0147-SC	REV. B
SHT 6 OF 7	SCALE NONE

# CHARGER BAY 4

OPTIONAL: INDUCTOR BUCK CONVERTER WITH JP401 SHORTED OR XFMR FLYBACK WITH JP401 OPEN.



**ZOLL** ZOLL MEDICAL CORPORATION  
32 SECOND AVENUE  
BURLINGTON, MA. 01803

TITLE SCHEMATIC, PCB, SYSTEM,  
BASE POWERCHARGER<sup>4X4</sup>

DWG NO. 9301-0147-SC	REV. B
SHT 7 OF 7	SCALE NONE



## SECTION VI COMPONENT LAYOUT DRAWINGS

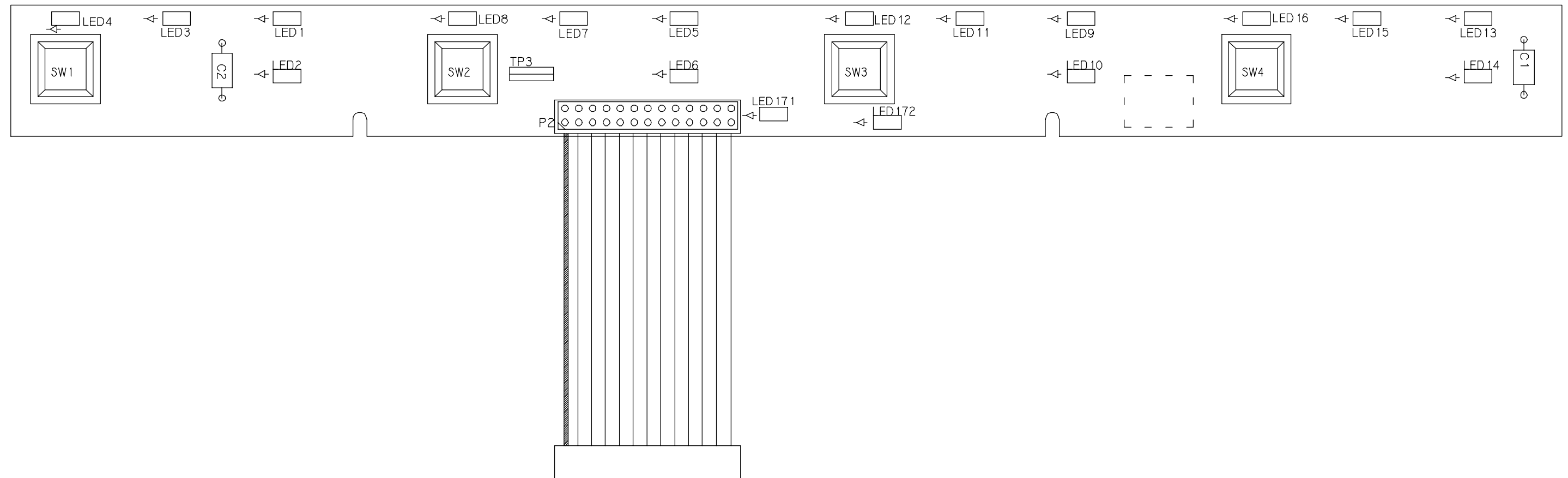
ZOLL Base PowerCharger<sup>4x4</sup> component layout drawings are included here to supplement the information presented in:

- Section III, Troubleshooting
- Section IV, Functional Descriptions
- Section V, Schematic Drawings

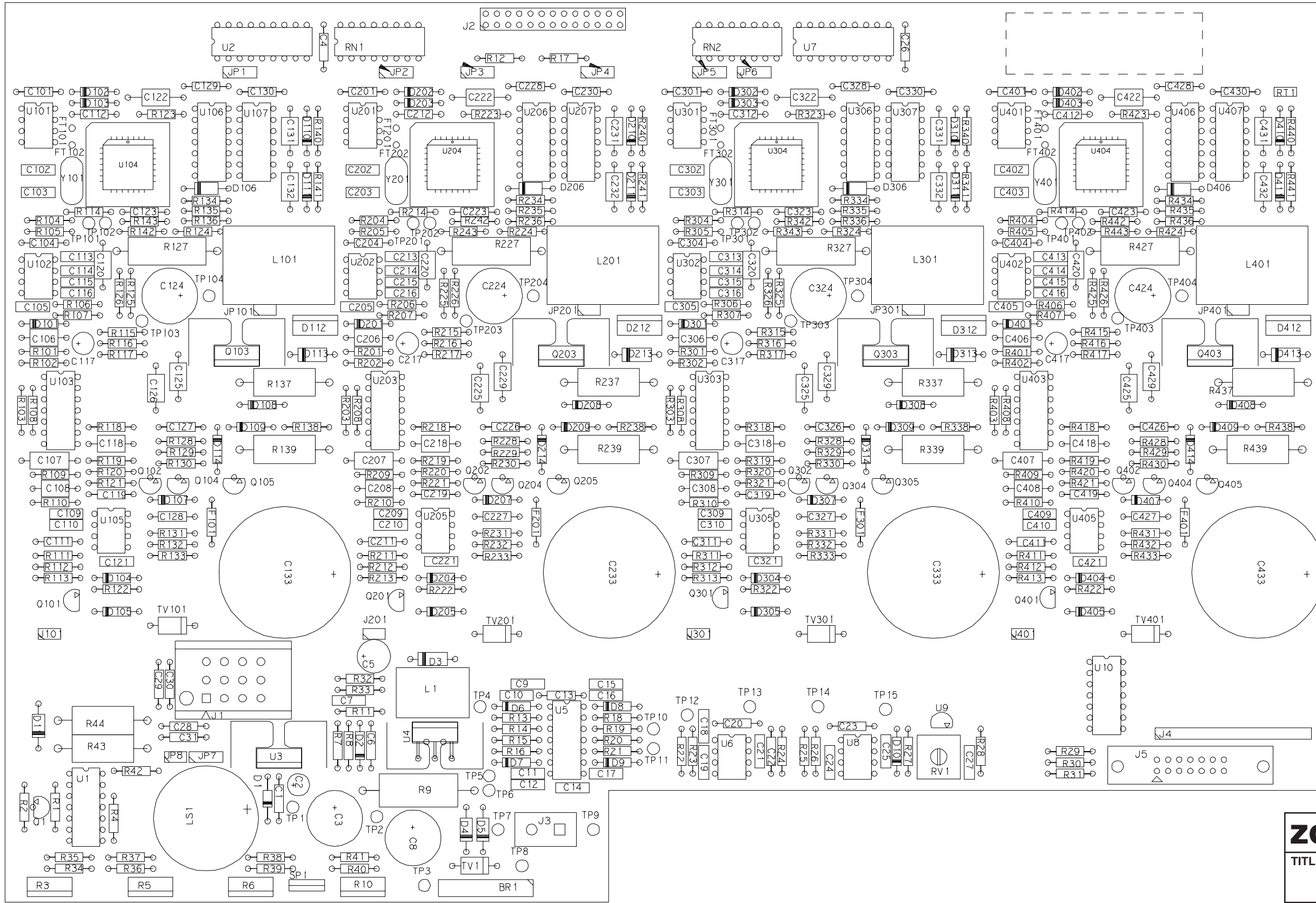
### LIST OF DRAWINGS

<b>Description</b>	<b>Page</b>
1. LED, PCB, Base PowerCharger <sup>4x4</sup> .....	VI-3
2. System .....	VI-4





<b>ZOLL</b>			ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803
TITLE ASSY DWG, PCB, LED, BASE POWERCHARGER <sup>4X4</sup>			
DWG NO. 9301-0145-AD		REV. B	
SHT 1	OF 1	SCALE NONE	



<b>ZOLL</b>		ZOLL MEDICAL CORPORATION 32 SECOND AVENUE BURLINGTON, MA. 01803	
TITLE ASSY DWG, PCB, SYSTEM, BASE POWERCHARGER <sup>4x4</sup>			
DWG NO.		REV.	
9301-0147-AD		A	
SHT 1	OF 1	SCALE NONE	

## SECTION VII DISASSEMBLY PROCEDURES

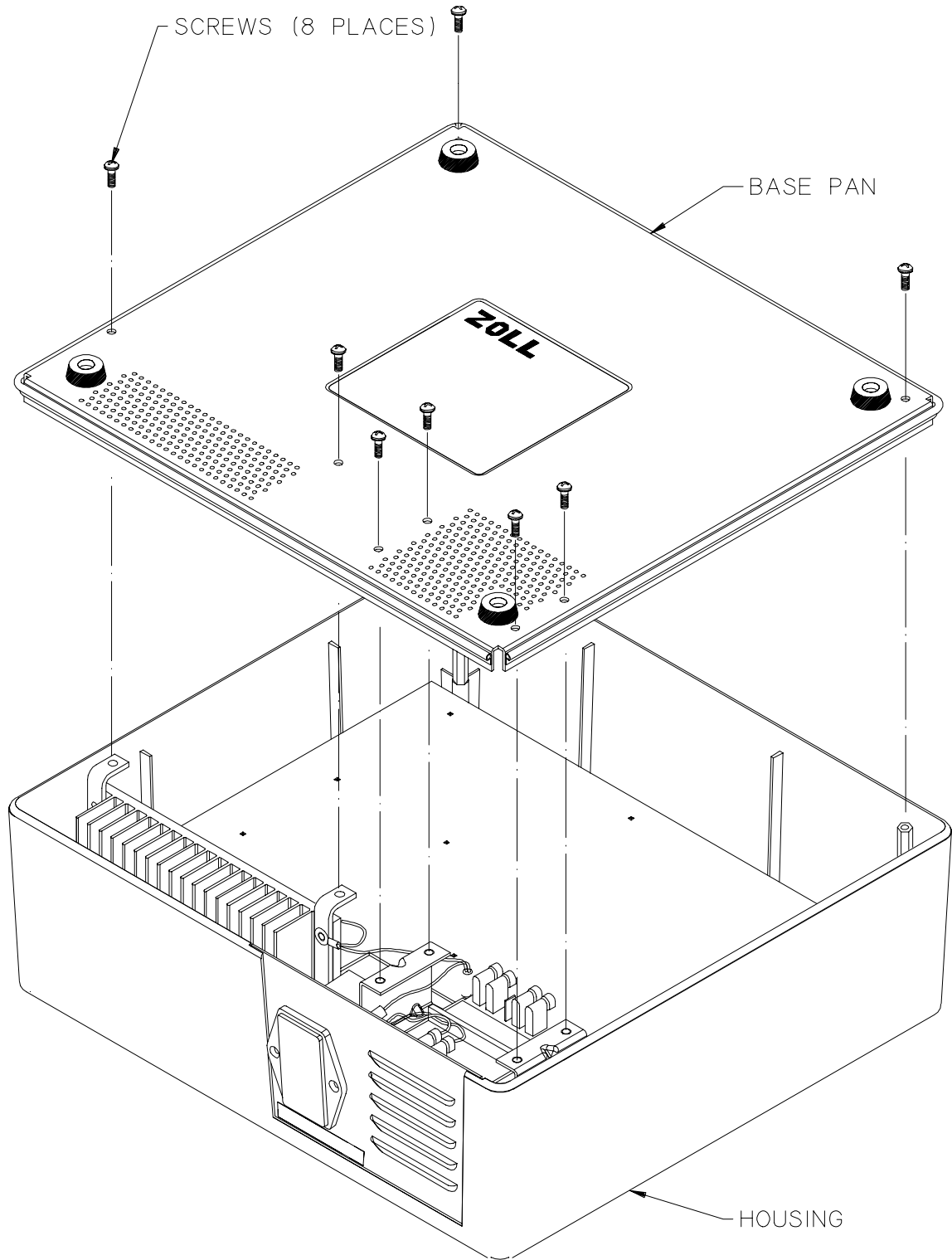
This section is designed to assist in the removal and replacement of Base PowerCharger<sup>4x4</sup> components. Assembly and disassembly should be performed on a soft, protected work surface to guard against scratches.

### WARNING

- Lethal voltages exist within the Base PowerCharger<sup>4x4</sup>. Units should be serviced by qualified personnel ONLY!
- **Before removing any components be sure the unit is unplugged and all batteries have been removed from the unit.**
- **Be sure to observe anti-static precautions whenever the unit is open.**

### NOTE

- Cable paths and connector locations should be noted prior to disassembly. If cables are run in locations other than those indicated by the manufacturer, the unit may exhibit HI-POT failure, fuse blowing, or may not close properly.
- Torque specifications for screws are provided under the installation instructions.



## 1. REMOVING THE BASE PAN

### TOOLS REQUIRED:

- No. 2 Phillips head screwdriver

1. Remove the eight (8) screws as shown in the illustration.
2. Lift Base Pan straight up and remove.

## INSTALLING THE BASE PAN

### TOOLS REQUIRED:

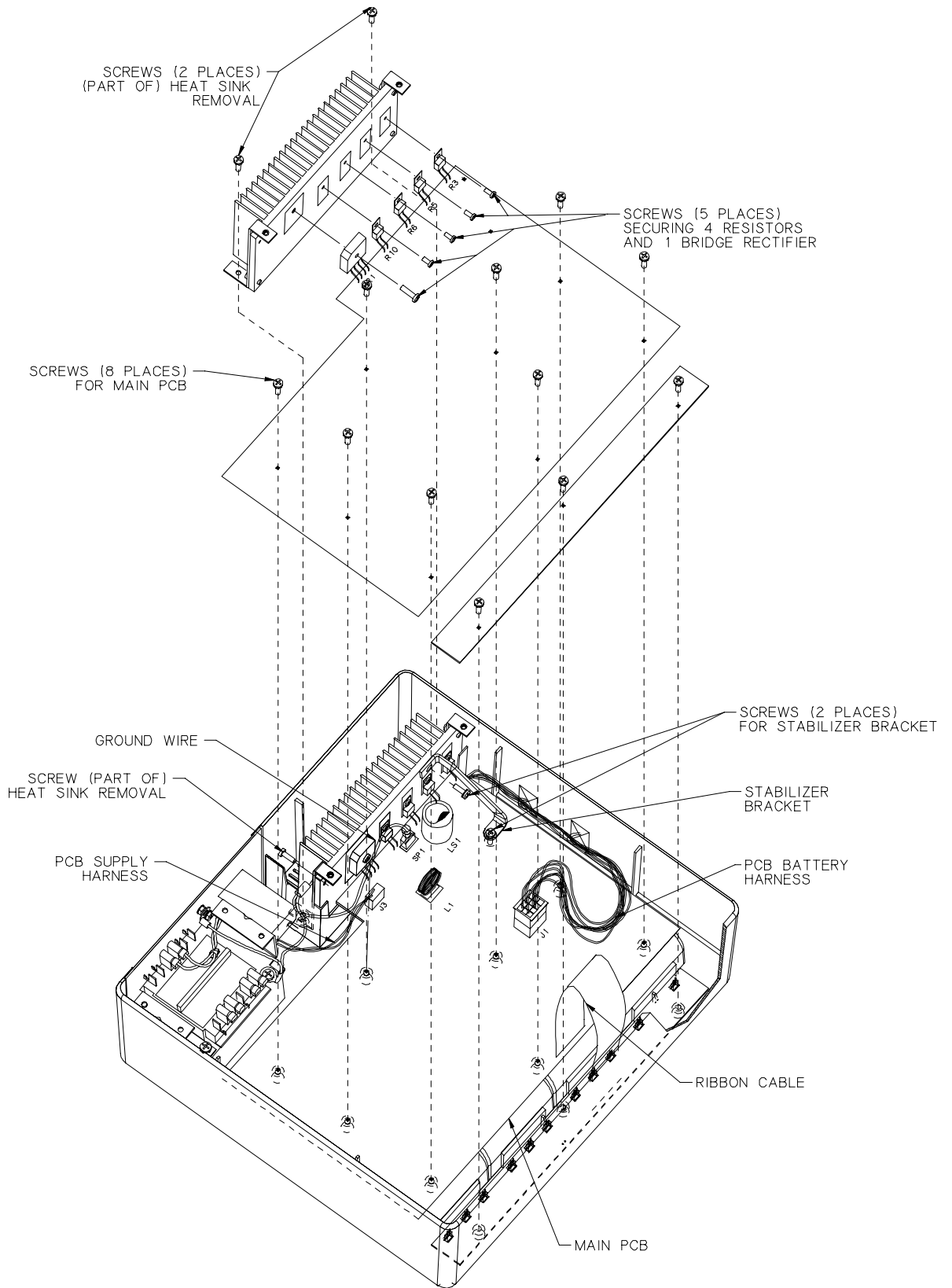
- No. 2 Phillips head screwdriver

1. Reverse steps 1 & 2 above.

#### NOTE:

- Eight (8) screws to be torqued 7-9 inch pounds.

# DISASSEMBLY PROCEDURES





## 2. REMOVING THE MAIN PCB ASSEMBLY

### TOOLS REQUIRED:

- Two (2) No. 1 Phillips head screwdrivers (Extended and Short shaft).
- Needle Nose Pliers

1. Remove the Base Pan as described on page VII-3.
2. Disconnect Ribbon Cable from Main PCB.
3. Disconnect the PCB Battery Harness (J1) from Main PCB.
4. Disconnect grounding wire at spade (SP1) on Main PCB.
5. Disconnect the PCB Supply Harness (J3) from the Main PCB.
6. Remove two (2) screws securing the Stabilizer Bracket .
7. Remove eight (8) screws securing the Main PCB to the Upper Housing.
8. Remove five (5) screws securing the four (4) resistors and one (1) bridge rectifier from Heatsink.
9. Before removing the Main PCB, loosen (by slightly twisting) the four (4) resistors and one (1) bridge rectifier mounted on the heat sink with needle nose pliers.
10. Remove the complete Main PCB assembly.

## INSTALLING THE MAIN PCB ASSEMBLY

### TOOLS REQUIRED:

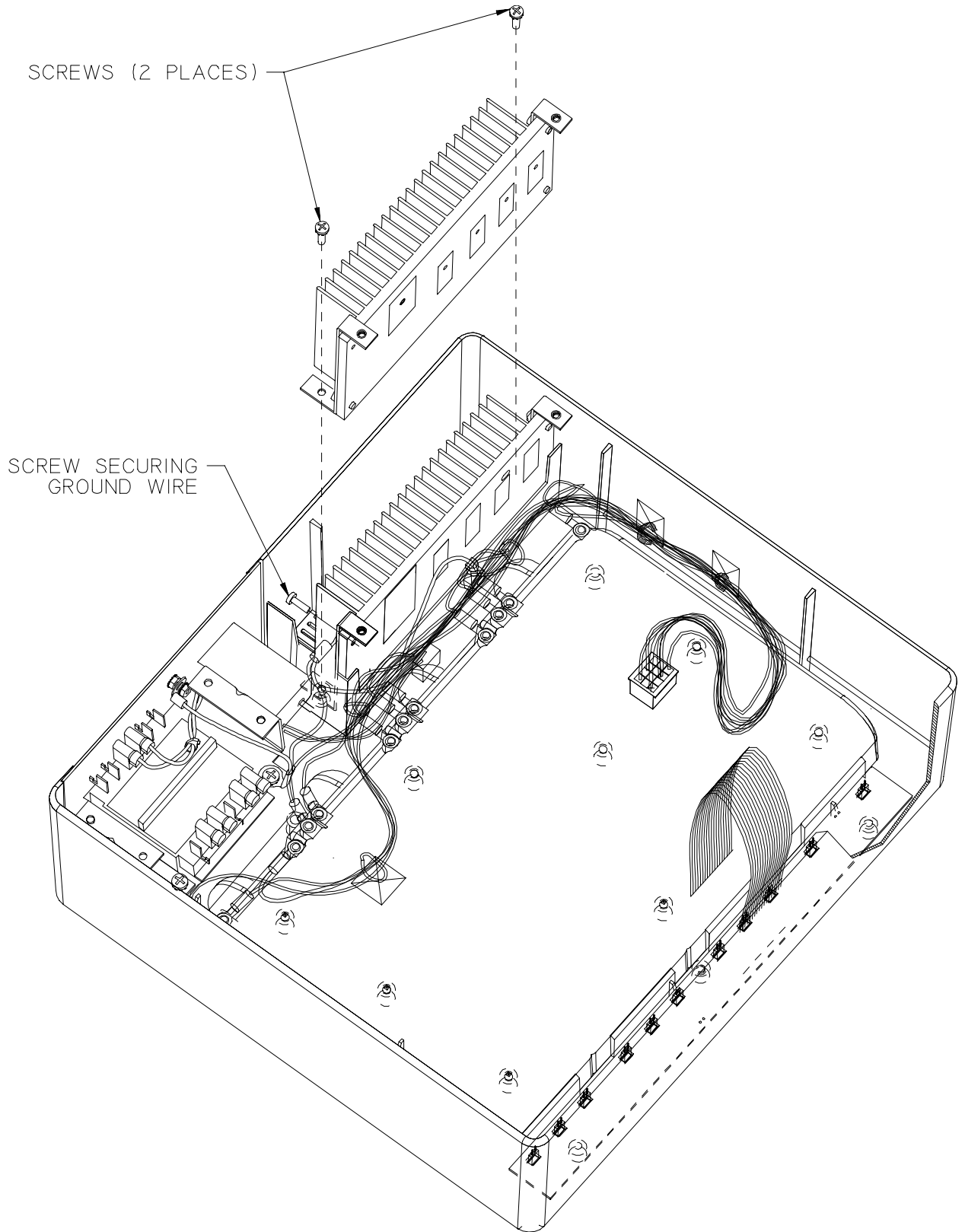
- No. 1 Phillips head screwdriver

1. Reverse steps 2 through 10 above.
2. Install the Base Pan as described on page VII-3.

### NOTE:

- Screws (above) to be torqued 7-9 inch pounds.





### 3. REMOVING THE HEAT SINK

#### TOOLS REQUIRED:

- No. 1 Phillips head screwdriver
- Adjustable Wrench

1. Remove the Base Pan as shown on page VII-3.
2. Remove the Main PCB as shown on page VII-5.
3. Remove two (2) screws securing the Heat Sink to the Upper Housing.
4. Lift Heat Sink straight out.
5. Remove one (1) screw securing the ground wire to the Heat Sink.
6. Remove the two (2) Heat Sink Mounting Brackets (if necessary).
7. Remove the Heat Sink.

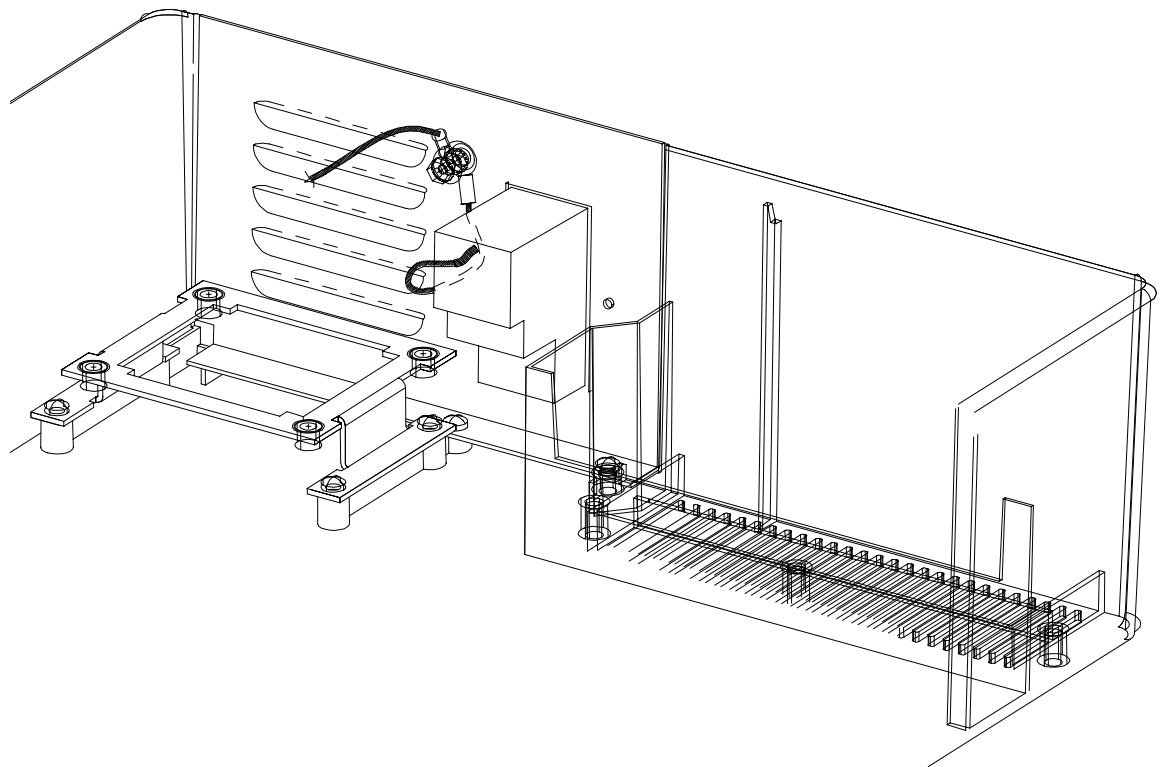
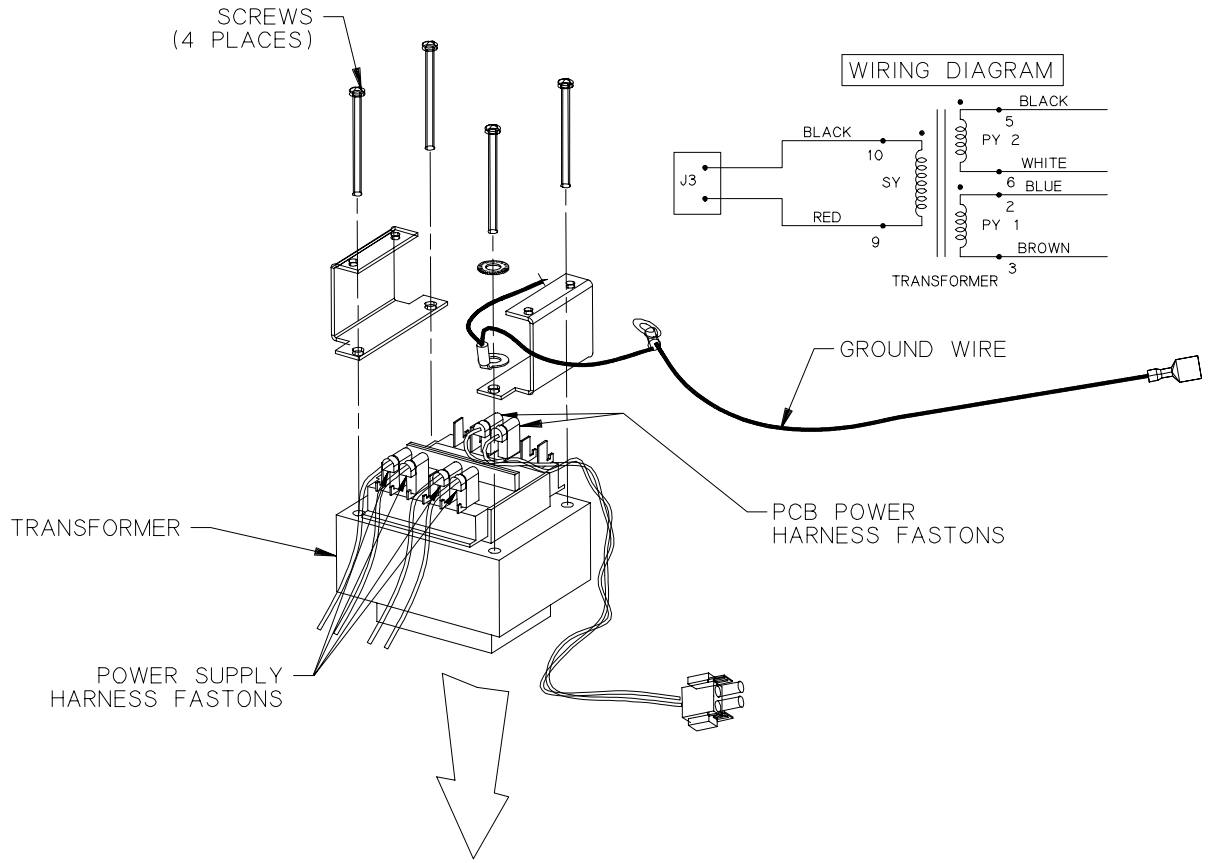
### INSTALLING THE HEAT SINK

#### TOOLS REQUIRED:

- No. 1 Phillips head screwdriver

1. Reverse steps 2 thru 7 above.  
**CAUTION:** When reconnecting the components to the Heat Sink, check the following:
  - That there are no burrs, nicks or scratches on the surface of the Heat Sink, especially where the components will mount.
  - That there are no metal flakes, chips or other debris that might have attached to the Heat Sink.
  - That the thermal pad is installed and is properly seated.
2. Install the Main PCB as described on Page VII-5.
3. Install the Base Pan as described on Page VII-3.  
**NOTE:**
  - Screws (above) to be torqued 7-9 inch pounds.
  - The two (2) screws securing the Heat Sink Mounting Brackets should be torqued to 9-10 inch pounds.

DISASSEMBLY PROCEDURES



## 4. REMOVING THE TRANSFORMER

### TOOLS REQUIRED:

- No. 1 Phillips head screwdriver
- Needle Nose Pliers

1. Remove the Base Pan as described in VII-3.
2. Disconnect the PCB Supply Harness fastons and the Power Supply Harness fastons from the top of the Transformer.
3. Loosen four (4) screws from the upper mounting bracket of the Transformer.
4. Remove the upper mounting bracket and screws.
5. Remove the Transformer.

## INSTALLING THE TRANSFORMER

### TOOLS REQUIRED:

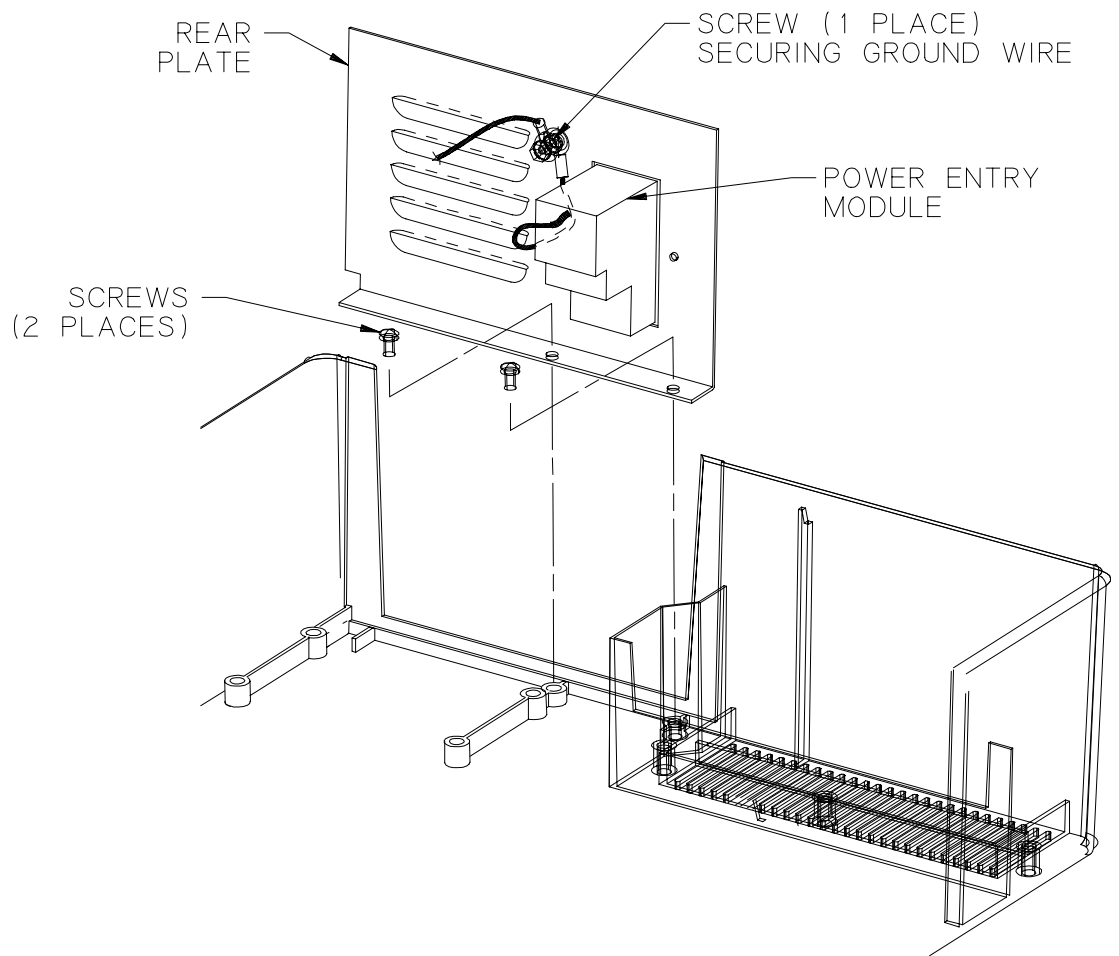
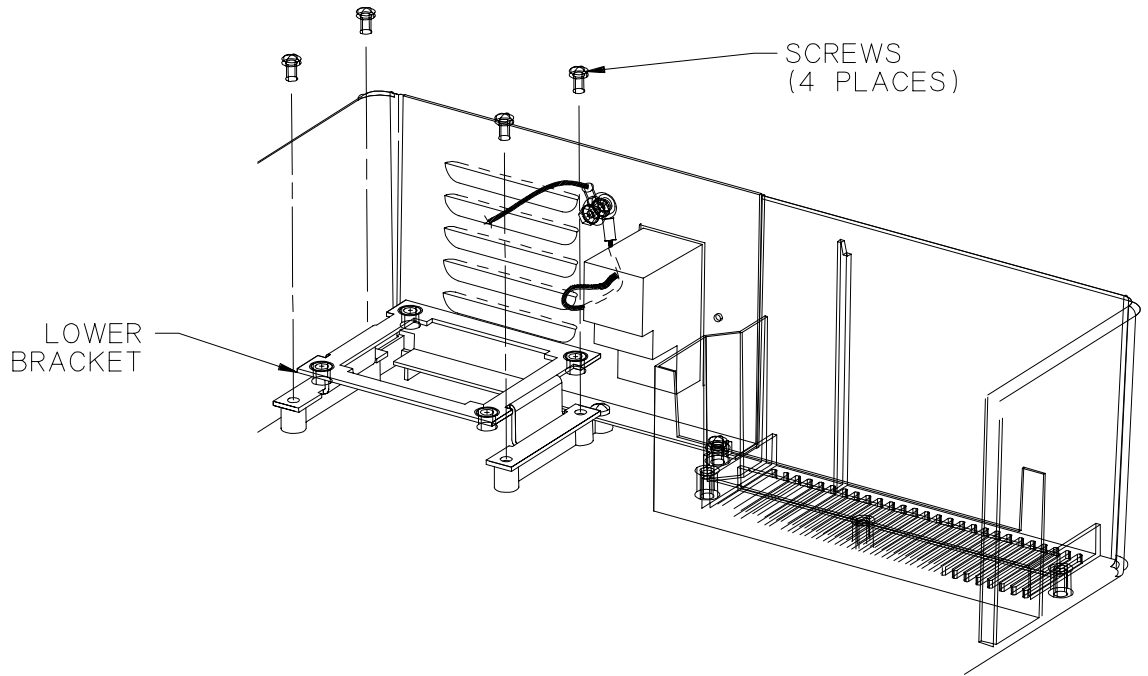
- No. 1 Phillips head screwdriver

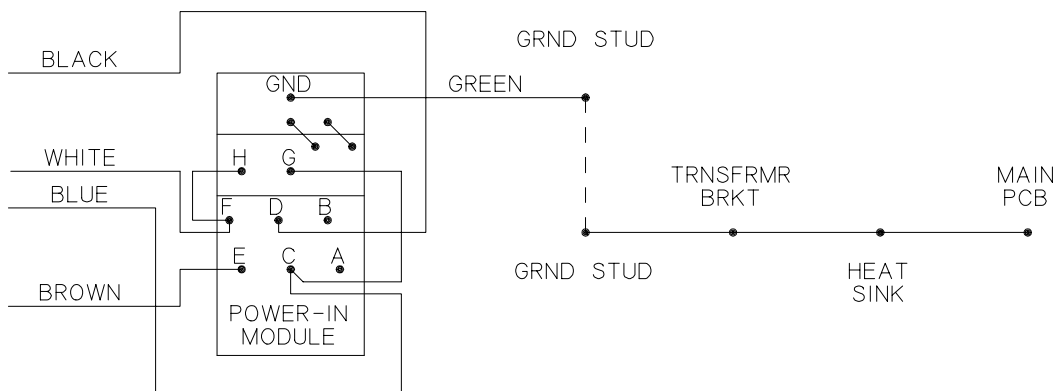
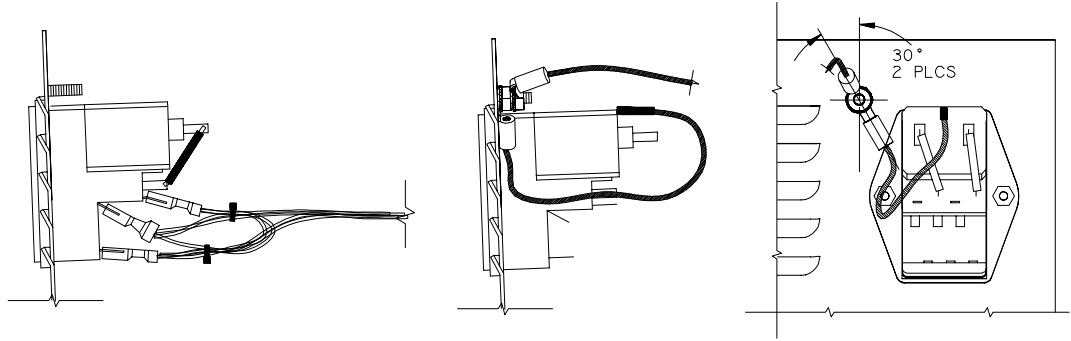
1. Reverse steps 2 thru 5 above.
2. Install the Base Pan as described on Page VII-3.

#### NOTE:

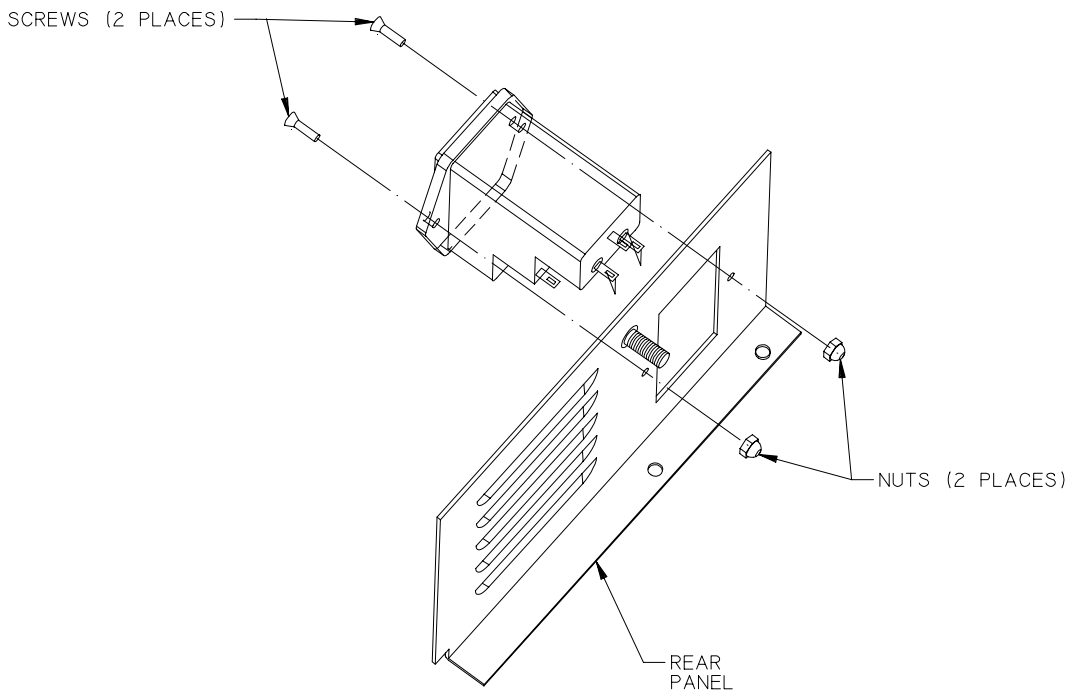
- Screws (above) to be torqued 7-9 inch pounds.
- The PCB Power Harness is routed under the ground wire (attached to the rear plate). If mis-routed, the Base PowerCharger<sup>4x4</sup> may exhibit HI-POT failures or fuses blowing.

DISASSEMBLY PROCEDURES





WIRING DIAGRAM





## 5. REMOVING THE POWER ENTRY MODULE

### TOOLS REQUIRED:

- No. 1 Phillips head screwdriver
- Adjustable Wrench

1. Remove the Base Pan as described on page VII-3.
2. Remove the Main PCB as described on page VII-5.
3. Remove the Heat Sink as described on page VII-7.
4. Remove the Transformer as described on VII-9.
5. Remove four (4) screws from the lower mounting bracket of the Transformer.
6. Remove the Lower Bracket of the Transformer.
7. Remove two (2) screws securing the Rear Plate to the Upper Housing.
8. Remove the Rear Plate and Power Entry Module together as a unit.
9. Remove grounding screw from the Rear Plate.
10. Remove two (2) screws securing the Power Entry Module to the Rear Plate.
11. Remove the Power Entry Module by sliding through the Rear Plate.

## INSTALLING THE POWER ENTRY MODULE

### TOOLS REQUIRED:

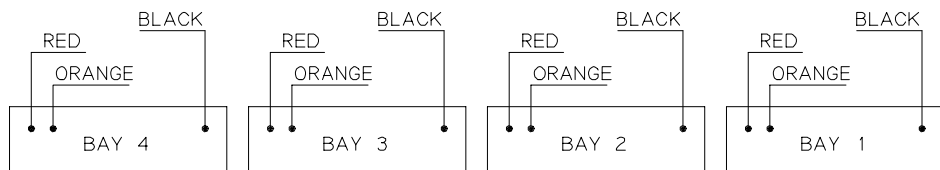
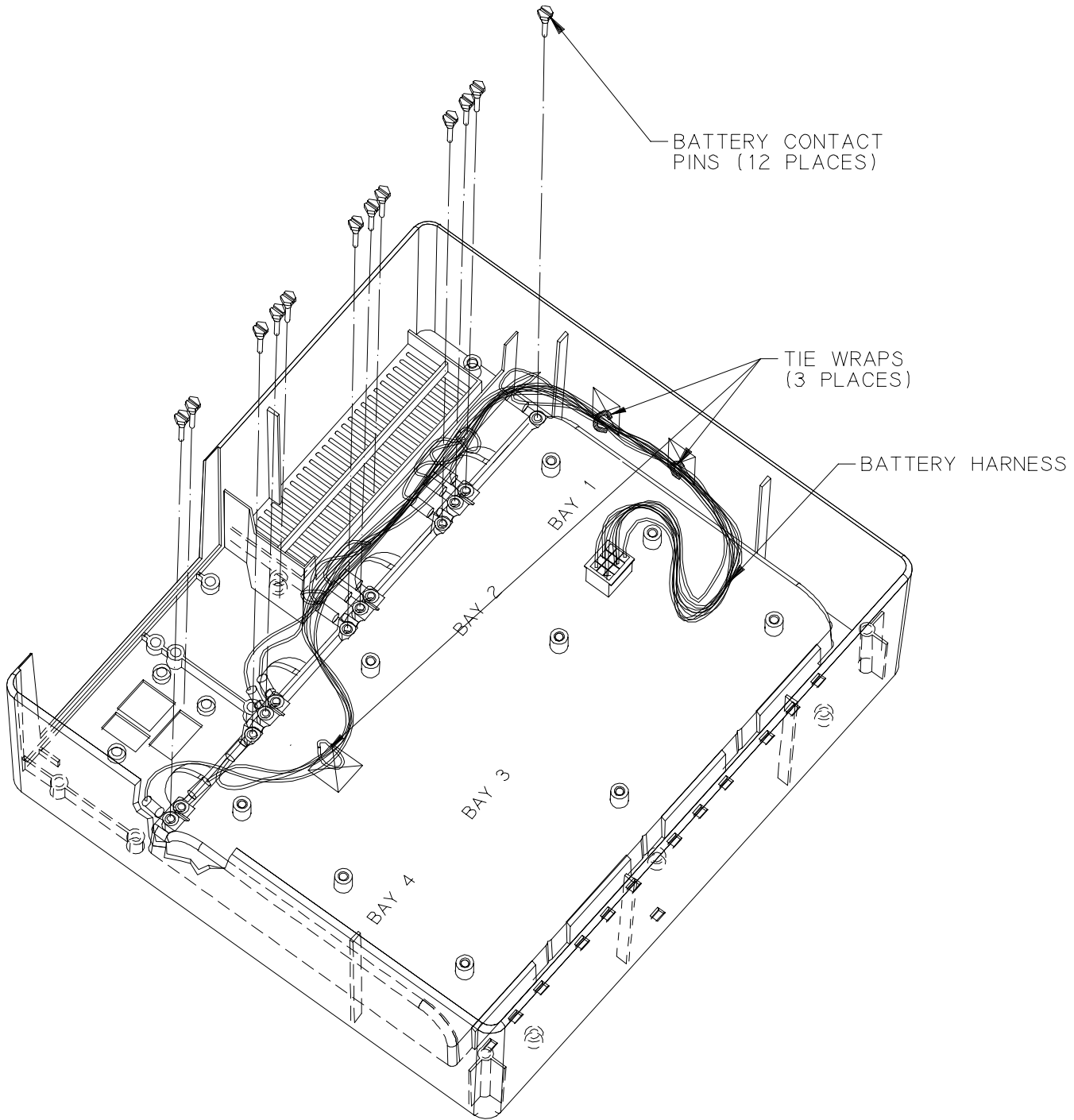
- No. 1 Phillips head screwdriver
- Adjustable Wrench

1. Reverse steps 2 thru 11 above.
2. Install the Base Pan as described on page VII-3.

#### NOTE:

- Screws (above) to be torqued 7-9 inch pounds. The two screws securing the Power Entry Module to the rear plate should be torqued 4-5 inch pounds.

DISASSEMBLY PROCEDURES



## 6. REMOVING THE BATTERY HARNESS AND CONTACT PINS

### TOOLS REQUIRED:

- No. 1 Phillips head screwdriver

1. Remove the Base Pan as described on page VII-3.
2. Remove the Main PCB as described on page VII-5.
3. Cut two (2) tie wraps.
4. Remove the twelve (12) Battery Contact Pins securing the Battery Harness to the Upper Housing.
5. Remove the Battery Harness.

## INSTALLING THE BATTERY HARNESS AND BATTERY CONTACT PINS

### TOOLS REQUIRED:

- No. 1 Phillips head screwdriver

1. Reverse steps 3 thru 5 above.
2. Install the Main PCB as described on page VII-5.
3. Install the Base Pan as described on page VII-3.  
**Note:** Screws (above) to be torqued 7-9 inch pounds.



## SECTION VIII REPLACEMENT PARTS

This section contains a listing of the replacement parts available for the Base PowerCharger<sup>4x4</sup> unit.

Replacement parts may be ordered through your sales representative, distributor, or directly from ZOLL Medical Corporation. When ordering parts, please provide the following information:

- the Base PowerCharger<sup>4x4</sup> model and serial number
- Field Replaceable Unit part number
- Description of the replacement part

**ZOLL reserves the right to substitute different parts to reflect modifications and improvements in ZOLL BasePowerCharger<sup>4x4</sup> circuitry and design.**

To order directly from ZOLL Medical Corporation, address your request to:

<b>ZOLL Medical Corporation</b>	Telephone	(800) 348-9011
32 Second Avenue		(781) 229-0020
Burlington, MA. 01803	FAX: Sales	(781) 272-5578
Attention: Technical Service Department	Service	(781) 229-0758

Current replacement part pricing is available from your sales representative or distributor. You may also contact ZOLL's Technical Service Department for price quotations.

## FIELD REPLACEABLE UNITS

Description	Part Number
1. Plastic Housing .....	9310-0123
2. Stabilizer Bracket .....	9320-0115
3. EMI Base Pan Gasket .....	9320-0117
4. Rubber Foot .....	0310-0057
5. Main PCB Assembly .....	9301-0147
6. PCB Power Supply Harness Assembly .....	9500-0075
7. PCB Battery Harness Assembly .....	9500-0115
8. PCB Supply Harness Assembly.....	9500-0074
9. LED PCB.....	9301-0145
10. Battery Contact Pin .....	9330-0100
11. Hex Standoff, M/F 6-32x2.5 .....	0160-0250
12. Sem Screw 6-32x3/8" .....	0163-0912
13. Sem Screw 4-40x1/4" .....	0163-0900
14. Sem Screw 6-32x1/4" .....	0163-0910
15. Sem Screw w/ Int. 6-32x1/2".....	0163-0940
16. Keycap Test Switch.....	9310-0279
17. Earth Ground Main Assembly .....	9500-0073
18. Earth Ground Bonding Assembly.....	9500-0018
19. Label Set, PowerCharger <sup>4x4</sup> .....	9305-0095-01
20. EMI Housing Gasket .....	0500-0460
21. T & B MiniBase 4-Way .....	0501-0016
22. Keps Nut .....	0163-0284
23. Cable Tie.....	0501-0001
24. Trans Sil Insulator Pad.....	0165-0024
25. Rubber Sil Insulator .....	0165-0027
26. Transformer.....	9141-0034
27. Top Transformer Bracket .....	9320-0057
28. Bottom Transformer Bracket.....	9320-0058
29. Screw, 10-32x2" .....	0163-0238
30. Rear Plate .....	9320-0022
31. Power Entry Module.....	0500-0022
32. Screw, 4-40x3/8" .....	0163-1316

33. Locknut/Hex, 4-40 with Nylon Insert .....	0163-0044
34. HeatSink.....	9165-0002
35. HeatSink Mounting Base .....	9320-0047
36. Label, Screw Cover.....	9305-0101
37. Slow Blow Fuse, 2A, 250V.....	0180-0003
38. Label, Fuse Warning.....	9305-0258-01
39. Shrink Tubing .....	0500-0204
40. Label, Specification.....	9305-0268-01





# Appendix A

## Converting PowerCharger<sup>4x4</sup> to AutoTest

### WARNING

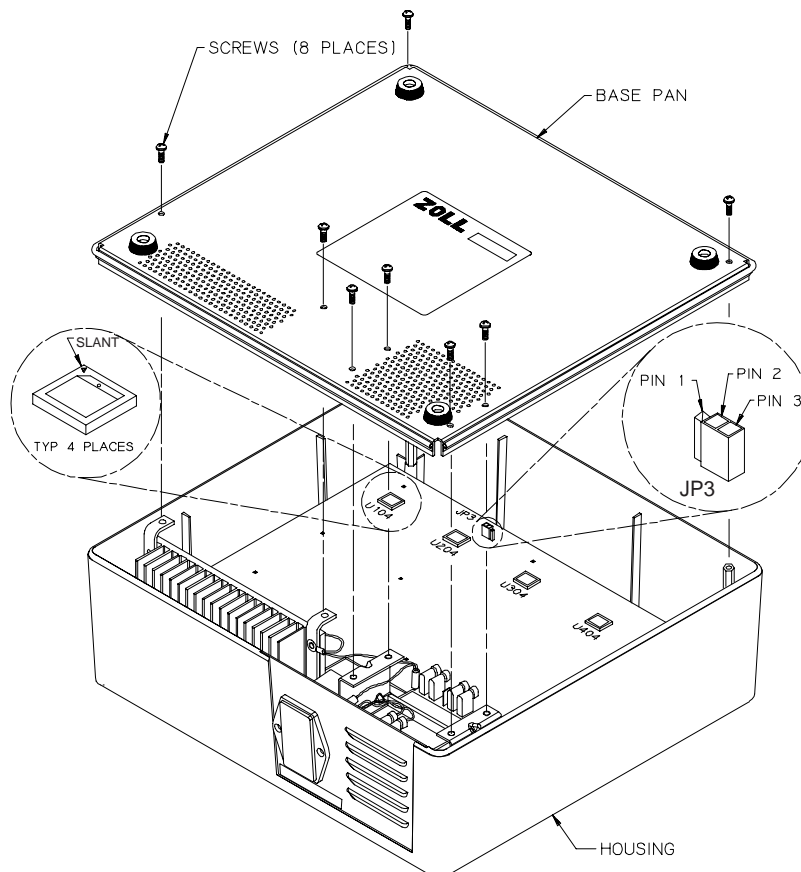
- Lethal voltages exist within the Base PowerCharger<sup>4x4</sup>. Units should be serviced by qualified personnel ONLY.
- Before removing any components be sure the unit is unplugged and all batteries have been removed from the unit.
- Be sure to observe anti-static precautions whenever the unit is open.

Assembly and disassembly should be performed on a soft, protected work surface to guard against scratches.

1. Remove the eight (8) screws located in the base pan of the Base PowerCharger<sup>4x4</sup> (Four (4) screws in the feet of the base pan do NOT need to be removed). Lift base pan straight up and remove.
2. Locate four (4) software proms @ U104, U204, U304, and U404. (Refer to diagram for correct orientation of the software proms). With a prom remover or appropriate pointed tool, carefully remove four (4) proms indicated.
3. Carefully place the four (4) new software proms supplied with Service upgrade Kit (Part Number 7777-0251) in the appropriate locations (U104, U204, U304, U404). The proms are marked with appropriate part number and revision level. The correct prom to be installed in the device is always the prom with the latest revision level. (Refer to diagram for correct orientation of the software proms).
4. Remove JP3 from Pins 1 and 2.
5. Carefully place JP3 on Pins 2 and 3. (Refer to diagram for correct location).
6. Place base pan on Base PowerCharger<sup>4x4</sup>. Install the eight (8) screws into the base pan.

**NOTE:** Screws to be torqued 7-9 inch pounds.

7. Carefully remove the label located on the front upper right corner of the device with an exacto knife and replace with AutoTest label (9305-0406-01).
8. Connect the Power Cord of the Base PowerCharger<sup>4x4</sup> to live AC mains.
9. Place battery in each well and confirm the **CHARGER ON** and **TESTING** LED's illuminate simultaneously.

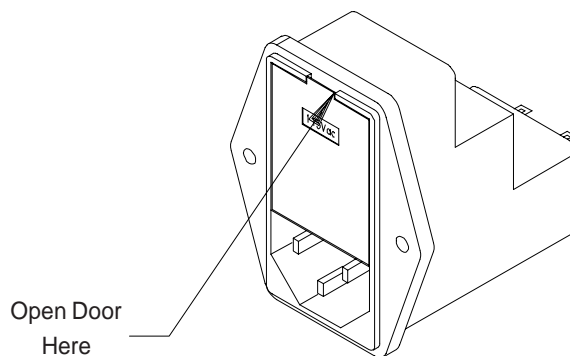




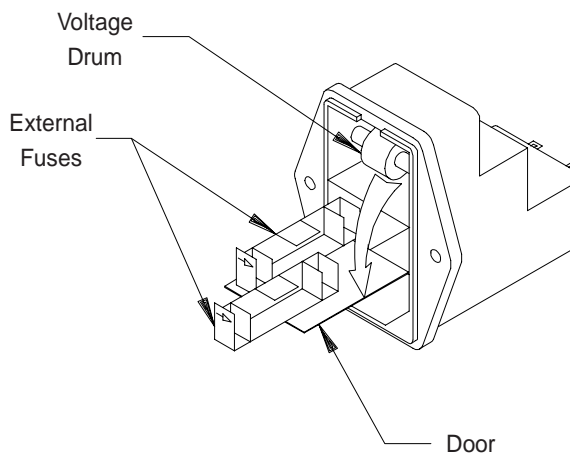
# Appendix B

## Changing the AC Line Setting of the Base PowerCharger<sup>4x4</sup>

The voltage wheel can be found within the Power Module located on the rear plate of the Base PowerCharger<sup>4x4</sup>. The Base PowerCharger<sup>4x4</sup> can be set for line voltages of 100V, 120V, 220V, and 240V. To set the unit to a different line voltage than the voltage shipped perform the following steps:



1. Insert screwdriver into slot on the PowerModule and twist to open the door.



2. Remove voltage drum from Power Module by pulling straight out. Set voltage drum to appropriate voltage setting by turning the voltage drum.
3. Place voltage drum back into Power Module. Close door. Make sure the voltage setting appears in the window of the door.

