User's Guide

SLUU335A–December 2008–Revised January 2010

bq78PL114 8S EVM

The PowerLAN™ 8S Evaluation Module (EVM) is a complete evaluation system for the bq78PL114 Battery Management Controller and bq76PL102 Dual-Cell Li-Ion Battery Monitor integrated circuits supporting 3-to-8 Li-ion cells. The EVM includes bq78PL114 and two bq76PL102 devices, FETs and temperature sensors on circuit modules. With a personal computer (PC) interface dongle, an interface cable, a PC USB cable, and Windows™-based PC software, the user can configure the bq78PL114, monitor the device operation, log system measurements and observe functionality under various charge and discharge conditions. The EVM comes with the base bq78PL114 installed and can be configured to work with the bq78PL114S12. This guide is designed to assist you with connecting and configuring the EVM to work with rechargeable lithium-ion batteries.

Contents

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1 Features

- Support for 3-to-8 cell series packs
- Support for one temperature sensor per series element, plus one FET and one board temperature, ten total
- One bq78PL114 and two bq76PL102 devices
- TI BMU devices and balancing circuits on a SO-DIMM module
- ~70-mA equivalent continuous balancing current (balancing circuits on this assembly)
- FETs – CHG, DSG, and PRE
- Contains secondary protector circuits, i.e., 2x bq29410
- 50-V, 30-A continuous rating with supplied heatsinks
- 0.005-Ω (5-mΩ) shunt resistor, 5-mV/A signal to bq78PL114
- Connections for cells, temperature sensors, SMBus
- Cell connections copied to second connector for ease of test
- High-current, stud-type connections for power pass-through
- SOC display using five green LEDs and pushbutton switch
- LED (red) for fuse-blow output indication
- VSS test point stud for scope or meter connection
- Component patterns to modify the circuit for the bq78PL114S12 firmware

The EVM supports both the bq78PL114 and the bq78PL114S12. In this document both versions are referred to as the bq78PL114 unless there are specific differences. The bq78PL114S12 is available as a firmware update for the bq78PL114.

1.1 Kit Contents

- A DIMM module with one bq78PL114 and two bq76PL102 devices
- An 8-cell EVM base module with two bq29410 devices
- Temperature sensor assemblies (8 sensors)

Table 1. Ordering Information

EVM Part Number	Chemistry	Configuration	Capacity
bq78PL114EVM-001	Li-ion	Three-to-eight cells	65000 mAh maximum

1.2 Required Equipment

The following equipment is required in addition to the TI PowerLAN™ EVM. The equipment models listed in parentheses have been used successfully in the TI laboratory. The equipment chosen must be capable of working safely with the voltages and currents supported by the design.

- bqWizard™ software 2.5.7 or greater available from http://focus.ti.com/docs/toolsw/folders/print/bqwizard.html
- Computer interface dongle compatible with bqWizard™ software
  - TI USB-TO-GPIO interface adapter with compatible firmware for bqWizard™ version 2.5 or newer
  - MCC iPort/USB™ for bqWizard™ 2.5.7 or newer version
- USB cable compatible with the interface
- Dongle interface cable
- Safety glasses or other eye protection
- Adjustable laboratory power supply (B&K 1698)
- Electronic load (B&K 8500)
- DVM with thermocouple probe (Fluke 189)
- PC compatible w/ WinXP (1.6 GHz, 1-GB RAM, two USB ports)

- Hookup wire, asst. colors (16-24 ga.)
- Assorted wire lugs for #10 screw
- Resistors, 10-Ω, 3-W minimum, eight required
- Connector, receptacle, 10-pin 0.1-inch spacing, 0.025-inch square socket with pin 6 plugged (Tyco #4-643814-0 with key insert Tyco# 641994-1)

2 PowerLAN™ 8S EVM Overview and Interfaces

This section provides an overview of the PowerLAN™ EVM hardware and describes the interface connectors. For more detailed information, see Section 8.

The PowerLAN™ EVM consists of a base board, a DIMM card, and temperature sensor assembly. The communication to the Windows-based computer is through the a communication interface using a USB cable and cable assembly for the SMBus.

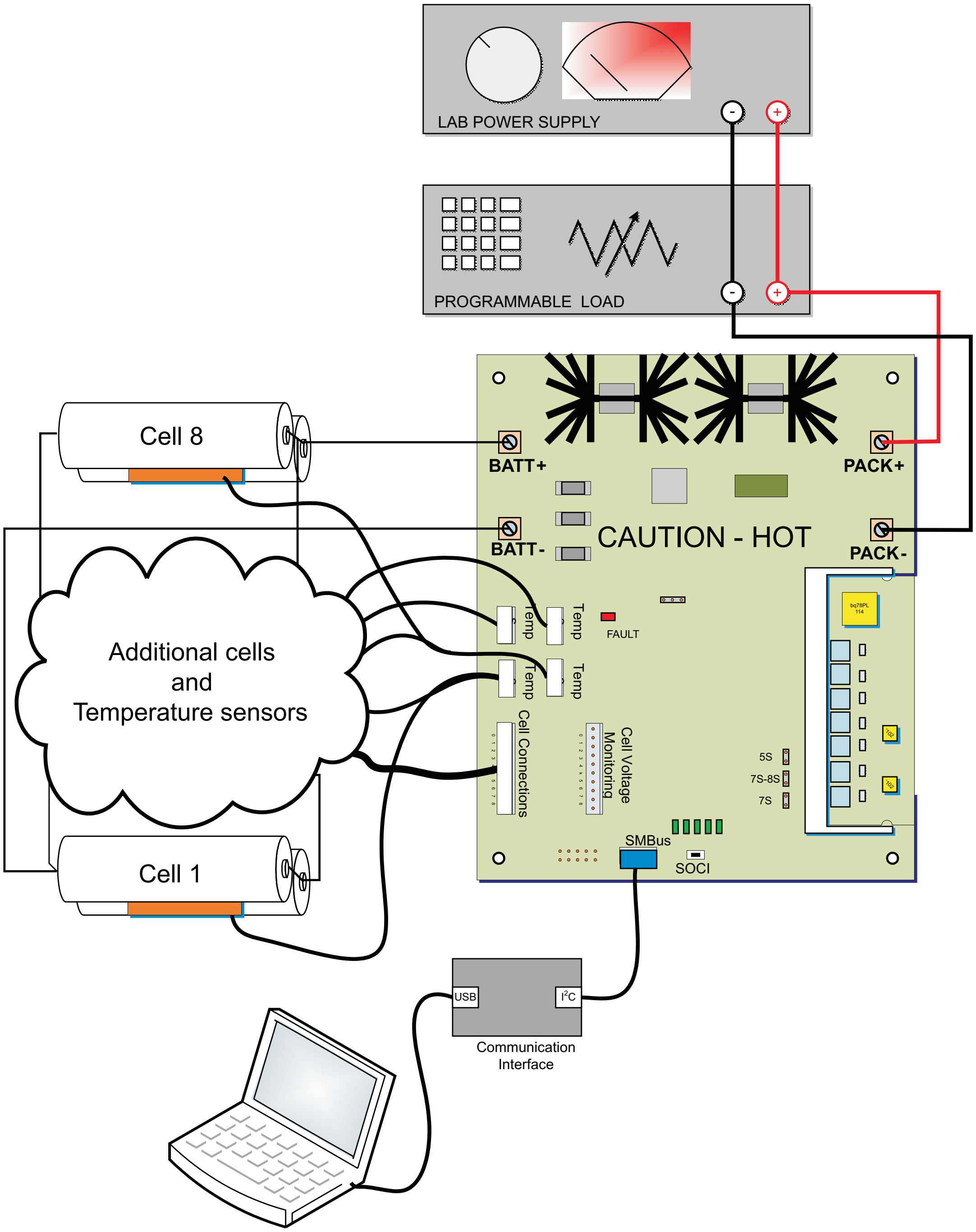


Figure 1. EVM Components and Basic Connections

The bq78PL114 Battery Management Controller and bq76PL102 Dual-Cell Li-Ion Battery Monitor are located on a DIMM module. This module plugs into the connector on the base circuit card assembly. EVM modular design allows users to design an application-specific base board and plug the DIMM board into it for fast prototyping.

The temperature sensor assemblies plug into the base circuit module. If fewer than eight cells are used, the extra temperature sensors can be disconnected or left in place. The bq78PL114 can be configured to ignore unused sensors.

The power FETs are located on the base circuit card assembly, along with the secondary voltage protectors. Connectors, configuration, and user interfaces are located on the base circuit card assembly. See Figure 1 for typical connections. The bq78PL114 supports 3-8 cells, and the bq78PL114S12 supports 3-12 cells. The PowerLAN™ 8S EVM can be configured for three-to-eight series cells.

2.1 Circuit Module Connections

Connections are provided for the following interfaces:

- Direct cell connections
- Load connection
- Cell temperature sensors
- SMBus
- EFCI connection
- Configuration headers

2.2 Signal Descriptions

Signals available on the EVM are described in this section. For details on the location and connector types, see the physical construction section.

Cell connections are described in Table 2. J11 is intended for connection of the cell voltages, and J12 is provided for test points. See Section 5 for the proper connection sequence.

Table 2. Cell Connections

Reference Designator	Pin Number	Signal	Description
J3	—	BATT–	High-current connection for negative (bottom) of the cell stack
J11, J12	10	CELL0	Negative connection of first (bottom) cell, low current connection for cell monitoring and balancing
	9	CELL1	Positive connection of first (bottom) cell
	8	CELL2	Positive connection of second cell
	7	CELL3	Positive connection of third cell
	6	CELL4	Positive connection of fourth cell
	5	—	Key, pin removed
	4	CELL5	Positive connection of fifth cell
	3	CELL6	Positive connection of sixth cell
	2	CELL7	Positive connection of seventh cell
	1	CELL8	Positive connection of eighth cell
J1	—	BATT+	High-current connection for positive (top) of the cell stack

Load connections are described in Table 3.

Table 3. Load Connections

Reference Designator	Pin Number	Signal	Description
J2	—	PACK+	Positive output of evaluation board, connect load, or charger
J4	—	PACK–	Negative output of evaluation board, connect load, or charger

The temperature sense interface signals are provided on J7–J10 (Table 4). Each connector supports a pair of temperature sensors. See signal use in Table 5; see the schematic for more information. Note that the board uses opposite pin numbering from the mating receptacle.

Table 4. Temperature Sensor Connections

Reference Designators	Board Pin Number	Receptacle Contact Number	Signal	Description
J7–J10	1	4	CELLn+1TEMP	Anode signal for cell n+1 temperature sense diode pair
	2	3	(temp reference n+1)	Cathode signal reference for cell n+1 temperature sense diode pair
	3	2	CELLnTEMP	Anode signal for the cell n temperature sense diode pair
	4	1	(temp reference n)	Cathode signal reference for cell n temperature sense diode pair

The SMBus communication interface signals are provided on J16 and are described in Table 5. Other signals are not used.

Table 5. SMBus Interface Connections

Reference Designator	Board Pin Number	Signal	Description
J16	6	GND	Signal reference for the IC
	9	SMBCLK	Serial interface clock connection
	10	SMBDAT	Serial interface data connection

An EFCI connector is not populated, signals are described in Table 6.

Table 6. EFCI Connections

Reference Designator	Pin number	Signal	Description
J5	1	EFCID	Discharge control signal
	2	EFCIC	Charge control signal
	3	GND	Signal reference for the IC

J17 is not used and is not populated.

CAUTION

J15 and J13 allow a direct short across cell terminals when shunts are installed. Shorting these signals with cells attached results in high current and can damage the board, interconnect, or cell.

2.3 User Switches and Indicators

Depressing the SOCI switch enables the LED drivers and signals the bq78PL114 to display the state of charge to LEDs 1-5. Each LED represents approximately 20% capacity.

The LED indicators display a boot code during reset. Refer to the technical reference manual for information on the display.

A RESET switch pattern is provided on the board. Reset is not normally used in evaluation and the switch is not populated.

The red FAULT LED, D6, is located near the left center of the board. When illuminated, it indicates an overvoltage detected by the secondary voltage monitors, or that the SPROT output from the bq78PL114 has been set.

2.4 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the PowerLAN™ EVM circuit modules.

Typical voltage depends on the number of cells configured. Typical current depends on the application. Board cooling may be required for continuous operation at or below maximum current.

Table 7. Performance Specification Summary

Specification	Min	Typ	Max	Unit
Input voltage PACK+ to PACK–	7.5	—	50	V
Continuous charge and discharge current	0	—	30	A

3 Software Installation and Interface

The TI bqWizard™ software is a Windows™-based application designed for laboratory use by engineers to configure and program the bq78PL114 IC. It also provides many features for monitoring and logging cell and pack data. This software is available on the TI Web site from http://focus.ti.com/docs/toolsw/folders/print/bqwizard.html or searching from power.ti.com. The bqWizard™ software installation and operation is described in its user's guide (SLUU336). Use of bqWizard™ version 2.5.7 or newer is required.

The bqWizard™ version 2.5 can support one of two communication interfaces, the TI USB-TO-GPIO (default) or the MCC iPort/USB™. Selecting the adapter is done using a utility program included in the bqWizard™ installation. The TI USB-TO-GPIO interface will connect to the EVM with its provided cable. When using the iPort/USB™ a cable will need to be fabricated. Refer to Table 5 and the iPort/USB™ documentation.

CAUTION

The MCC dongle, although compatible with the existing bqWizard™ software, is not preferred. bqWizard™ compatibility with this hardware may be obsolete in the future.

The interface must provide the pull up resistors for the SMBus lines. The USB-TO-GPIO provides internal control of the pull up resistors, when using the iPort/USB™, set the "Pullups" switch on the side of the unit to "ON".

CAUTION

When using the TI USB-TO-GPIO interface, it must have compatible firmware installed. Refer to the bqWizard™ installation for information. Once the interface firmware is updated, the interface will no longer respond to the API for the original interface firmware.

4 Preparing a Battery for the EVM

The PowerLAN™ 8S EVM can be operated with either cell simulation or cells. For initial evaluation, TI suggests that power supplies be used for cell simulation to observe the behavior of the devices.

Whether power supplies or cells are used, inductance in the high-current path must be minimized. Inductance in this wired path can cause voltage transients at IC devices when the load current is stopped or when the bq78PL114 opens the discharge FET with current flow. Use a heavy-gauge wire suitable for the expected load for the high-current connections; minimize inductances by keeping leads close together.

The individual cell monitor connections must be connected to a mate to the J11 connector using 24 AWG or heavier wire and a compatible connector. The Tyco connection in the Required Equipment list is an IDC-type connector for 24 AWG wire. Other compatible connectors are available in industry. Lighter gauge wire is not recommended due to the possibility of breakage. These wires carry the cell balance currents and must be reasonably short. Keying the connector is recommended to reduce the risk of damage to the EVM components due to accidental improper connection.

Consider the board layout when planning wire lengths for either a cell simulator or cell connections to the EVM.

4.1 Simulating Cells

A power supply and a series of 10-Ω resistors must be used to power the EVM for the first time. Each resistor creates a simulated cell voltage. The resistor value must not deviate more than a few ohms from 10 and the power rating must be at least 3 W to minimize heat generation. TI has a prototype design named PR942 that is an 8-cell simulator PCB. Contact TI to obtain design files.

WARNING

The cell simulation resistors dissipate 1 to 2 watts each and can become hot depending on the component selected. Avoid contact with these resistors.

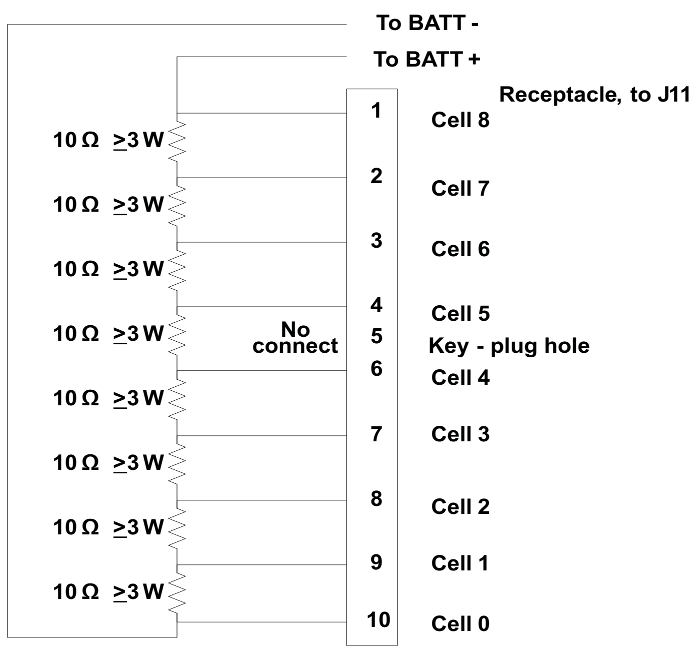


Figure 2. Cell Simulator Connection

WARNING

PowerPump™ currents pump back into the resistors and cause voltage fluctuations up to (0.10 A × R) VDC. With a 10-Ω resistor, set the power supply to 3.5 V/cell if PowerPump™ Balancing is active. This ensures that cell voltages do not exceed the IC rating.

4.2 Using Cells

The EVM is preconfigured for support for 2P chemistry 0101 cells (these parameter settings can be adjusted). Connection with the default configuration is shown in Figure 3. The cell assembly must be prepared as previously described, considering the wire gauge and placement of the connections.

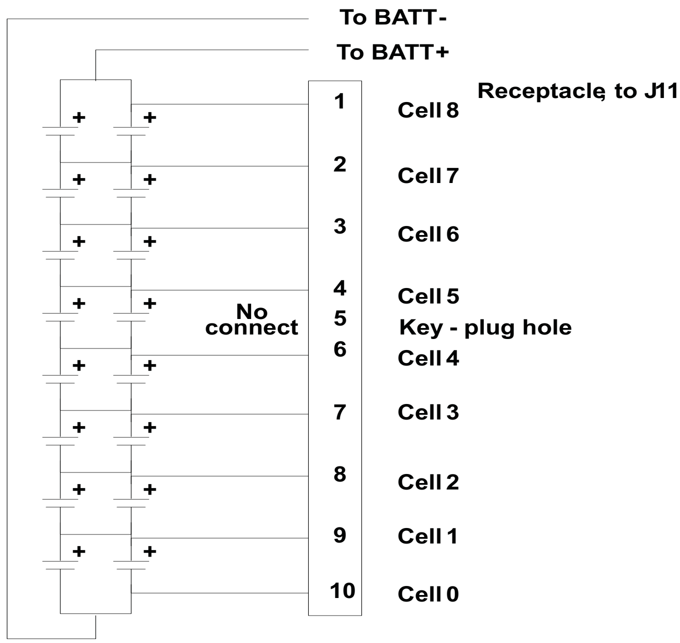


Figure 3. Battery Cell Connections

4.3 Temperature Sensors

The eight temperature sensors provided with the EVM can be mounted to the cells or left unattached for simulation. If mounting to the cells, provide electrical insulation between the temperature sensor board connections and the cell connections. See Section 8.3 for details of the temperature sensors.

> **CAUTION**
>
> The temperature sensors contain a reference to cell voltages. Care should be taken to not allow the sensors to touch other voltage reference points.

Due to the heat generated by the cell simulation resistors, it is not recommended to mount the temperature sensors on the resistors.

5 PowerLAN™ 8S EVM Hardware Connection and Operation

This section describes the recommended steps that all users must take the first time they use the EVM. Initial power up with cell-simulating resistors and the default bq78PL114 firmware is recommended. Ensure that the EVM is working properly prior to changing the EVM configuration (firmware and hardware) for operation as a bq78PL114S12. Familiarize yourself with the bqWizard™ software and basic operation of the EVM before making changes.

5.1 Initial Considerations

Boards are tested after assembly with a basic functional test. This test may not check every connection on the board. Boards must be properly configured and checked for function in the user's environment before relying on the safety features of the board.

Observe limits and cautions in this document and from the cell manufacturer.

5.2 Insert the DIMM Module

Insert the DIMM module into the base board, and press until it latches securely. The DIMM module must not be removed during operation of the EVM.

CAUTION

Do not remove or install the DIMM module with power applied to the EVM.

5.3 Serial Cell Count Configuration

Configure the jumpers on the base board for the number of cells to be used. Table 9 shows configuration settings for different cell counts.

Although designed for convenient configuration with 5 to 8 series cells, the EVM can also be used with 3 or 4 series cells by using the 5-cell configuration. To use the EVM with 4 series cells, short the CELL4 and CELL5 connections on the mate to J11 or on J12. To use the EVM for 3 series cells, select the 5-cell configuration and short the CELL3, CELL4, and CELL5 connections together on the mate to J11 or on J12. For 3- or 4-cell operations, remove R39 on the base board.

CAUTION

J15, J13, and any shunt installed on J12 allow shorting of cells. Connecting both cells and shunts corresponding to those cells can damage the cells, boards, or interconnect.

Table 8. Cell Count Configuration Jumper Positions

Cell Count	J15 Cell 8 Header	J13 Cell 6 Header	J14 LAN 4 Header
8	Leave open	Leave open	Install shunt
7	Install shunt	Leave open	Install shunt
6	Leave open	Leave open	Leave open
5	Leave open	Install shunt	Leave open

5.4 Temperature Sensor Connections

The default configuration requires all temperature sensors to be connected. When using cell-simulating resistors, position the sensors in the original PCB assembly away from electrically conductive surfaces.

5.5 Battery Connection

The bq78PL114 is powered from cell voltages not from the battery pack. Cell connections must be made in sequence from lowest to highest voltage as described in the following steps for the EVM:

1. Connect the high-current wire from the lowest potential (bottom) of the battery cell stack to the EVM BATT- terminal
2. Connect the cell monitor connection to J11 of the EVM base board
3. Connect the high current wire from the highest potential (top) of the battery cell stack to the EVM BATT+ terminal

When power is applied to the cell monitor connections, the SOCI LEDs flash. When using a cell simulator, the power supply is typically enabled after the aforementioned connections are made.

5.6 SMBus Connection

Connect the supplied USB cable from the computer to the USB-TO-GPIO adapter. Connect the supplied ribbon cable between the USB-TO-GPIO adapter and the EVM at header J16. Avoid having the USB-TO-GPIO adapter connected to the EVM when power to the EVM is not present.

5.7 Parameter Configuration

The PowerLAN™ 8S EVM is shipped with the configuration set for 8S2P using chemistry 101 cells. The system configuration may need to be modified for your cell type, cell configuration, and system limits. Parameters are configured and files are loaded using the bqWizard™ software. Cell configuration is changed by loading a pack configuration (.tmap) file, cell type is changed by loading a chemistry (.chem) and an associated auxiliary chemistry (.aux) files. Other parameters can be changed by editing in the bqWizard™ parameter tabs or by loading a .ppcsv file.

The cell stack configuration information is loaded to the bq78PL114 through a pack configuration file with the .tmap extension. Tmap configuration files for supported series cell counts are found in the *C:\Program Files\Texas Instruments\bqWizard\Configuration Files* directory of a typical bqWizard™ installation in either the *bq78PL114* or *bq78PL114S12* subdirectories. These files are specific to the device (firmware) and describe a 1 or 2-parallel count configuration. The parallel cell count is an important value for the bq78PL114 to properly reflect the capacity of the pack and perform gauging. To change the number of parallel cells in the configuration, see *Configuring the bq78PL114 Cell Count* (SLUA495). The pack configuration file will set the series and parallel configuration.

To configure the bq78PL114, follow these steps:

1. Start the bqWizard™ software.
2. Set the Wired bit using the Toggle Wired Bit command
3. Load the appropriate pack configuration (tmap) file to the device with the bqWizard™ menu item: File → Pack Configuration → Load Configuration from File and Relearn.
4. Use the Connect to Pack command to reset the bqWizard™ display to the new number of serial cells.
5. Use the Read All Parameters command to display parameters in the bqWizard™ display.
6. Edit the safety and other device parameters by editing in the parameter tabs of bqWizard™, using the device data sheet, the cell data sheet, and other system information. Parameters also can be changed by saving, editing, and re-loading a ppcsv file:
   (a) Select the menu item File → Data-Set → Save Data-Set and save the .ppcsv file
   (b) Edit the desired parameters .ppcsv file using Notepad, Excel™, or similar editor. Save the file as a text file with a .ppcsv extension.
   (c) Load the file to the device using the File → Data-Set → Load Data-Set to Device menu selection. If the chemistry was changed in the .ppcsv file, select Yes to the Override Learned Chemistry Data box, and select the proper .aux file; otherwise, select No.
7. Use the Write Pending Changes to RAM command to save parameter changes.
8. If the chemistry is to be changed and was not loaded into the .ppcsv file, select the menu item File → Load Chemistry Data.
   (a) Select the proper chemistry from the list.
   (b) Select the .aux file for the chemistry and cell stack construction. A pack specific aux file for the cell chemistry type and cell stack configuration is always recommended for best performance. Failure to select a proper .aux file for the chemistry results in an invalid device configuration. However, in early evaluation, a pack specific aux file may not be available. If a pack specific .aux file for the chemistry is not available, select the most appropriate file from the *chemistry* directory, or use the default data. Realize that a pack specific aux file will need to be prepared and loaded to obtain good gas gauge performance. For more information on preparing an aux file, see the document *Chemistry Selection for the bq78PL114* (SLUA505)
9. For the base bq78PL114 set the Configured bit using the Toggle Configure Bit command.
10. Select the Relearn/Initialize command.

The pack is now configured and ready for initial evaluation. To turn on the FETs, go to the Pack Configuration tab, edit the Algorithm Enable register, and clear the checkbox in the Inhibit Safety Rules box. Use the Write Pending Changes to RAM command to save the setting. Finally, execute the Read All Parameters command, and the FETs are on.

5.8 Load Connections

A load or charger is connected to the PACK terminals using the screw terminals on the EVM base board. TI recommends that the load or charger be connected with the current switched off to prevent arcing or transients during connection of the wires to the terminal blocks.

The board is designed for 30-A continuous operation. The heatsinks have a noticeable temperature rise with higher currents. The user must monitor the temperature of the board and components during evaluation and provide cooling air as required for operation. The thermal sensor on the board may not respond to protect the FETs from damaging temperatures due to its location and possible thermal gradients on the board.

WARNING

The PowerLAN™ base circuit module heatsinks can become hot during operation due to dissipation of heat. Avoid contact with the board. Follow all safety procedures applicable to your laboratory.

5.9 Basic Operation

The following steps are suggested for demonstrating basic operation with a board having the default configuration.

1. Configure the EVM, connect cells or cell simulator, SMBus, and disabled load and charger power supply as previously described.
2. Start bqWizard™ program.
3. Start polling using the bqWizard™ Poll Data command.
4. In the right top corner of the bqWizard™ Plot view, select the V, T, and C displays.
5. Right-click on the X-axis of the Plot view, and select Zoom to Fit.
6. Set the load to approximately 1 A, and enable the load. Observe the current in the Pack panel of the bqWizard™ display and on the Plot.
7. Disable the load.
8. Observe the cell voltage in the Cells panel of the bqWizard™ display. Compare these values to readings using the DMM.
9. Enable the charger power supply and adjust the voltage to the charge voltage for the connected cells (if cell voltage is low enough to accept charge) or just above the cell simulator voltage. Observe the current in the Pack panel and on the Plot view.
10. Disable the charger power supply.
11. If using a cell simulator power supply,
    (a) Reduce the voltage to bring a cell below the CUV threshold.
    (b) Observe the flag and FET behavior in the Status View
    (c) Increase the voltage to bring the cell voltage above the CUV recovery and Pre-Charge recovery thresholds, observe the FET, and observe the flag and FET behavior in the Status View.
12. If cell temperature sensors are not mounted to the cells, direct warm or cool air at one of the temperature sensors and observe the Temp value in the Cells panel and Plot view.
13. Stop data polling using the Stop Polling command.
14. Continue with other evaluation or proceed to the disconnection sequence

5.10 Disconnection

When disconnecting the EVM, the following sequence is recommended.

1. Disable and disconnect the load and/or charger.
2. Toggle the Wired bit to the Unwired state.
3. Send the Safe Disconnect command.
4. Remove the SMBus cable from J16.
5. If using a power supply and resistors for cell simulation, turn it off, or if using cells, disconnect them using the following sequence.
6. Remove BATT+
7. Remove the cell monitor connector from J11
8. Remove BATT–

Applying a charger voltage without cells or cell simulation resistors connected is not recommended.

6 Calibration

The EVM is calibrated at manufacturing test. Voltage calibration is performed on the devices at the factory, and has been loaded for use at manufacturing test. Voltage calibration is not needed on the EVM. Cell simulation is required for voltage calibration. Temperature sensors are disconnected from the EVM for shipment and may not be installed in the same position as during manufacturing test. Temperature and current are system-level calibrations and must be performed on the EVM or other system. Temperature and current calibration can be performed with either cell simulation or cells. Calibration must be performed in this order: temperature and then current.

Pack configuration should be loaded before calibration so proper sections are calibrated.

Calibration of the EVM is supported by bqWizard™ calibration utility. Execute the following general steps for calibration:

1. Start the bqWizard™ software.
2. If the System Status shows Unwired, toggle the Wired bit. The System Status then changes to Wired. Writing calibration parameters to flash cannot occur if the device is Unwired.
3. Issue the command to Read all Parameters.
4. Configure the EVM to have Safety Rules Disabled. If not already the case, the safety rules can be turned off by:
   (a) Open the Algorithm Enable register.
   (b) Check the checkbox next to the Safety Rules Disabled bit.
   (c) Close the Algorithm Enable register.
   (d) Then issue a write command.
5. Configure the EVM to have Cell Balancing disabled. If not already the case, cell balancing can be turned off by
   (a) Open the Hardware Configuration register.
   (b) Check the checkbox next to the Balancing Disabled bit.
   (c) Close the Hardware Configuration register.
   (d) Then issue a write command.
6. Open the calibration window.
7. Execute the following steps.
8. When calibration is complete, exit the calibration utility. Values are automatically saved.

6.1 Voltage Calibration

Devices have voltage calibration saved during production test. During the EVM test, voltage calibration data for the attached bq76PL102 parts is transferred to the bq78PL114 for use. No further voltage calibration is normally needed on the EVM. If devices are replaced, the voltage calibration transfer from the external devices will need to be repeated. Voltage calibration is supported by the utility. If voltage calibration is lost, it needs to be re-run. Voltage calibration requires a cell simulation setup to provide two voltage levels for each cell. Each cell must be calibrated in sequence before proceeding to the next cell. If parameters are driven out of range, it may take several cycles to bring the values back in range, reloading a saved calibration file for the device may be faster if one is available.

6.1.1 Voltage Calibration Transfer

Voltage calibration transfer is needed when using more than 4 series cells. The process involves reading the calibration data from the attached bq76PL102 devices and storing it for use in the bq78PL114. When using FW5000, voltage calibration transfer occurs each time the Relearn/Initialize command is executed.

When using FW4452, use the following sequence to transfer the voltage calibration data.

1. Set the Calibration Transfer Enable Bit: This is bit 7 in the Hardware Configuration register, it may be labeled reserved. Check the box next to it, ignore any warnings. Write the register change to memory using the Write Changes command.
2. Update the flash and relearn: Execute the Relearn/Initialize command followed by the Reset Fuse command.
3. Clear the Calibration Transfer Enable bit (use the same method as above)
4. Clear the Wired bit using the Toggle Wired Bit command
5. Reset the device by closing the bqWizard™ software and cycling power to the device; wait 10 seconds, and then open the bqWizard program.

6.1.2 Voltage Calibration of Cells

Cell voltage calibration is unnecessary with normal, correct operation and configuration.

1. Connect the EVM with cell simulation resistors, and turn on the power supply.
2. Calibrate Cell Voltages. (Follow on-screen instructions.)
   (a) Set the Power Supply to 22.4 V (2.8 V/cell), and enter the value of cell 1 as read by the DMM into the provided box. Then click the adjacent calibration button.
   (b) Set the Power Supply to 33.6 V (4.2 V/cell), and enter the value of cell 1 as read by the DMM into the provided box. Then click the adjacent calibration button.
   (c) Repeat steps a and b for cells 2 through 8.
   (d) Leave the power supply set to 33.6 V (4.2 V/cell) for the remainder of the calibration.

6.2 Temperature Calibration

Temperature calibration applies to all temperatures. The EVM must be allowed to reach the ambient temperature before calibration.

1. Use a thermocouple connected to the DMM to measure room temperature. The assumption is that the PCB and the temperature sensors are at the same temperature as ambient.
2. Enter the measured value into the box provided, and then click the adjacent calibration button.

6.3 Current Calibration

1. Calibrate Zero Current Offset. (Follow on-screen instructions.)
   (a) Make sure nothing is connected to the PACK connector.
   (b) Click the calibration button.
2. Calibrate Current Gain. (Follow on-screen instructions.)
   (a) Connect the electronic load to the PACK+ and PACK– terminals. The battery voltage appears on the voltage display of the load.
   (b) Set the load to constant current mode of 2500 mA.
   (c) Enter the milliampere value displayed on the electronic load in the box provided. Use a negative sign in the number.
   (d) Click the calibration button.

7 Configuration for bq78PL114S12

The EVM was tested prior to shipment in the 8cell configuration with the base FW4452. It is recommended the user confirm operation of the board in their setup prior to converting the board configuration for the S12 firmware and loading the FW5000. Recommend steps:

1. Evaluate the board as delivered configuring it for the desired number of cells and proceeding through enough of the subsections of Section 5 with the base firmware (FW4452) installed in the device to satisfy the user that the software is communicating with the device and the boards are functional.
2. Turn off the EVM and modify its boards for the S12 circuit changes described in the next subsection.
3. Power on the EVM and load the S12 firmware (FW5000). S12 firmware is included in the bqWizard installation, typically *C:\Program Files\Texas Instruments\bqWizard 2.5\Configuration Files\Firmware*. Using the "preserve calibration" check box is recommended. More information may be found in the bqWizard installation files or the bqWizard User's Guide.
4. Configure and evaluate the device using the process described in Section 5 using S12 compatible files.

7.1 EVM Modifications for S12 Operation

The following modifications must be performed on the boards for the EVM to work properly with the bq78PL114S12. These are listed here for identification. It is recommended that the EVM be brought up and operation be checked before modifying the boards and updating the firmware so that the user can confirm operation of the boards and evaluation setup in the configuration tested before making changes. The user will be prompted in a later section when this information is recommended to be used.

Refer to the Physical Construction section for location of components.

- Base Board Modifications (040-00028 Rev 4):
  – Remove capacitive coupling of SOCi pushbutton and switched drive of LEDs:
    1. Populate R60, located near SOCI button, with either a 0 Ohm resistor or a short (solder-bridge).
    2. Bridge the solder bridge SB (near the center of the board) with solder.
  – Remove multiplexing of temperature sensors:
    1. Install 0 Ohm resistor at R51, R53, R55, R57 and R59.
    2. Remove resistors at R48, R50, R52, R54 and R56.
    3. Remove D1 and C2.
  – Change sense resistors to an equivalent resistance of either 1, 3 or 10 milliohms:
    1. Change Resistors R10, R11 and R47 so that the parallel combination is either 1, 3 or 10 milliohms, depending on your planned system configuration.
- DIMM Board Modifications (040-00029 Rev 6):
  – Remove multiplexing of the temperature sensors:
    1. Install 0 Ohm resistor at R57, R45 and R46.
    2. Remove D1 and C42.

8 PowerLAN™ 8S EVM Circuit Module Physical Construction

8.1 DIMM Circuit Module

8.1.1 Board Layout

The PowerLAN™ 8S EVM DIMM circuit module is a six-layer circuit card assembly. Its design allows moving the configured ICs to a new platform without the complexity of layout or configuration. The board layouts are shown in Figure 4 through Figure 13.

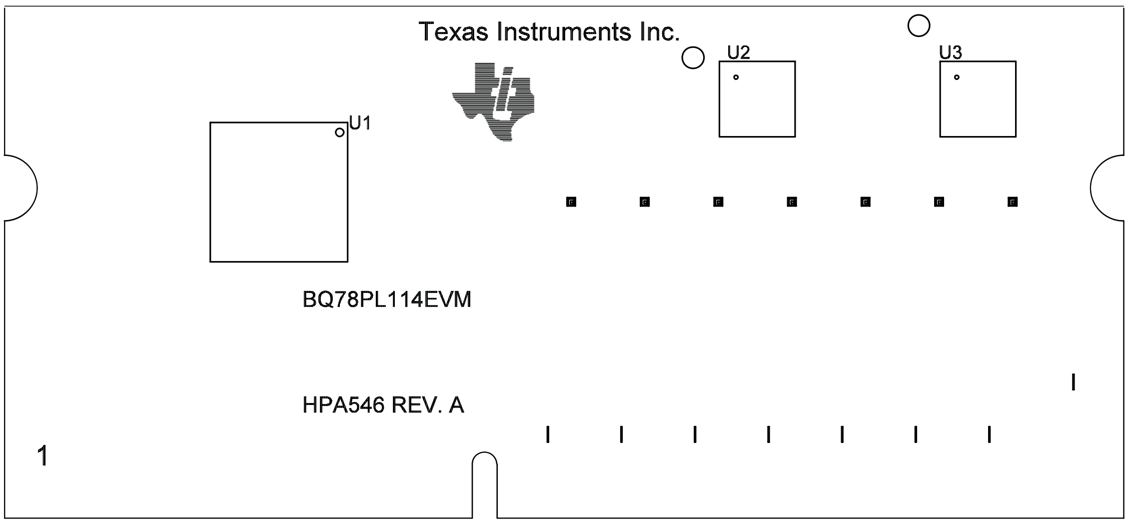


Figure 4. DIMM Top Silk Screen with Outlines

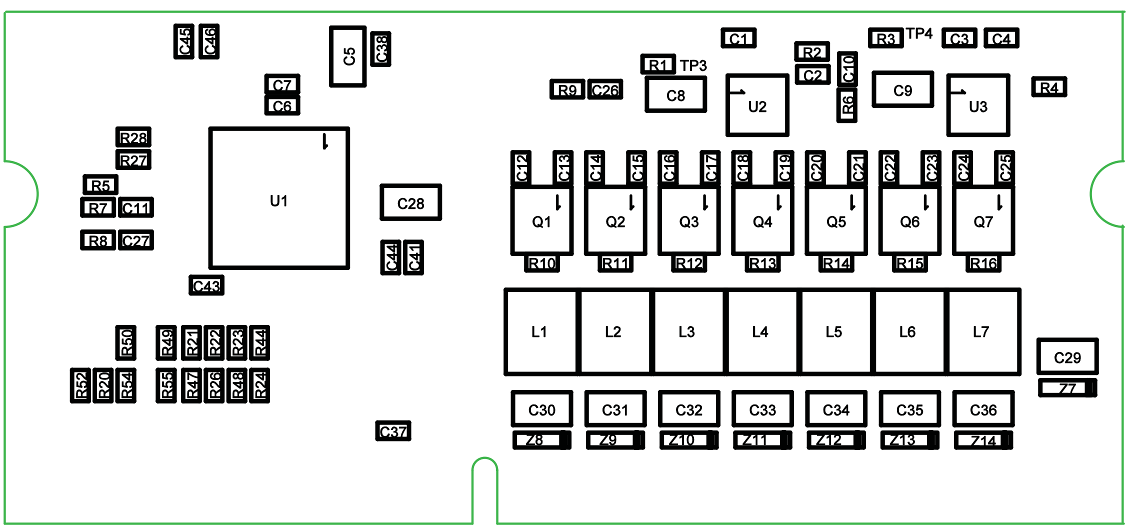


Figure 5. DIMM Top Assembly

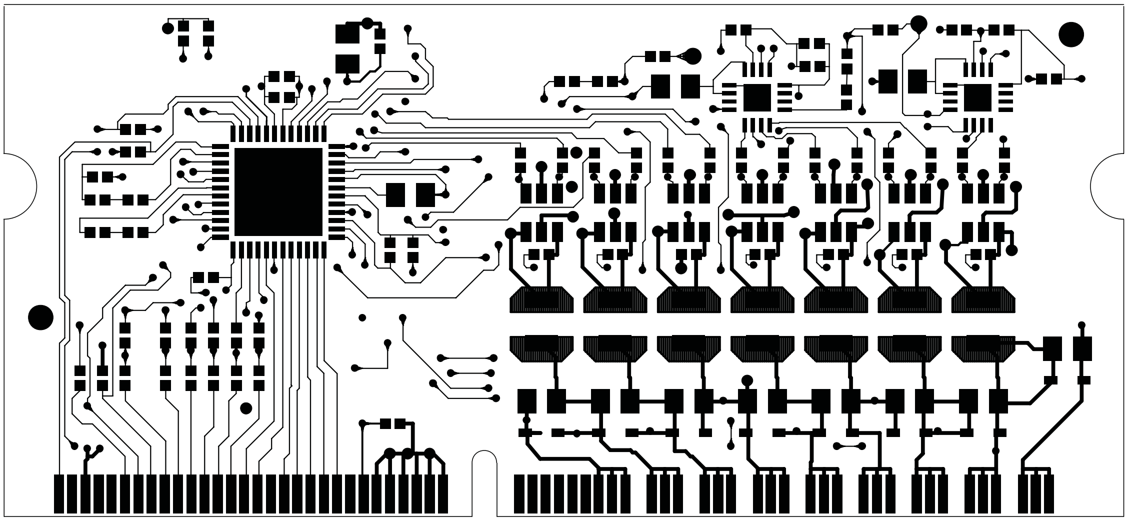


Figure 6. DIMM Top Layer

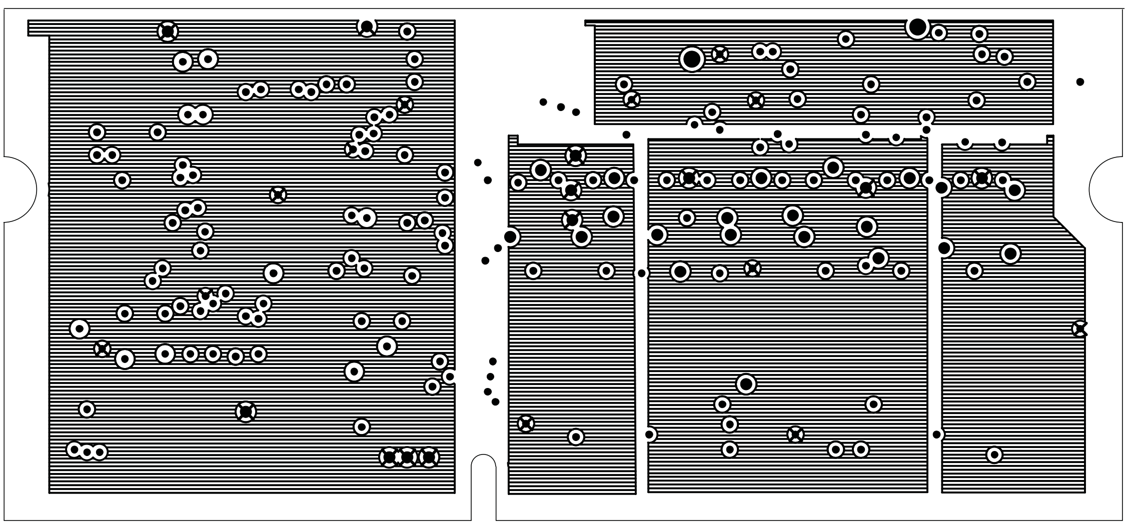


Figure 7. DIMM Layer 2

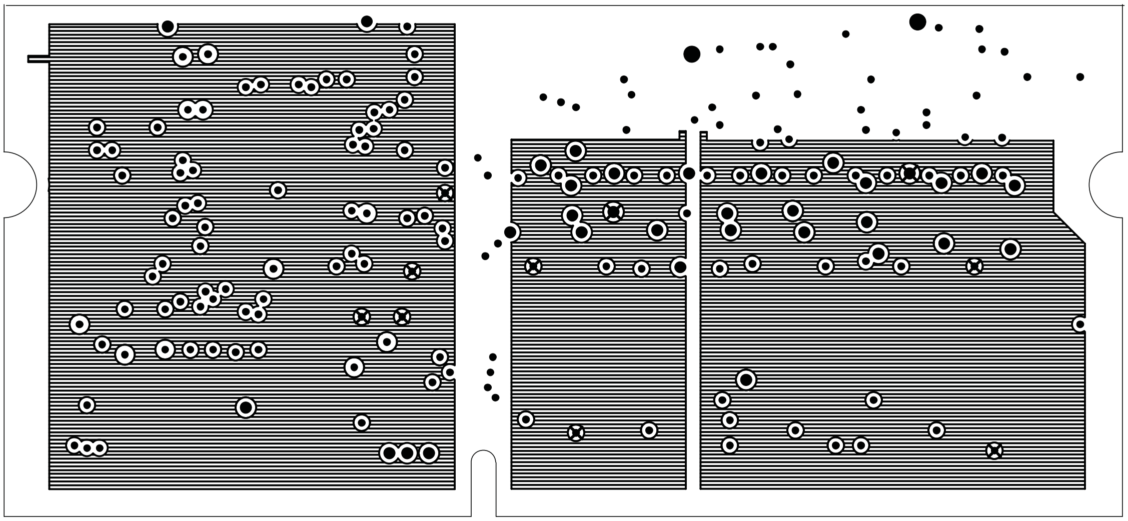


Figure 8. DIMM Layer 3

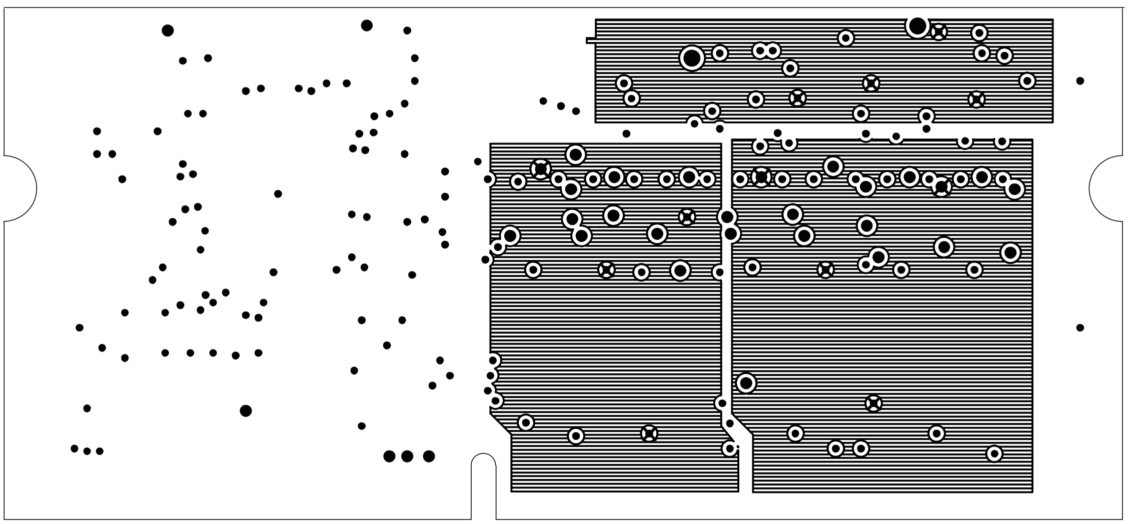


Figure 9. DIMM Layer 4

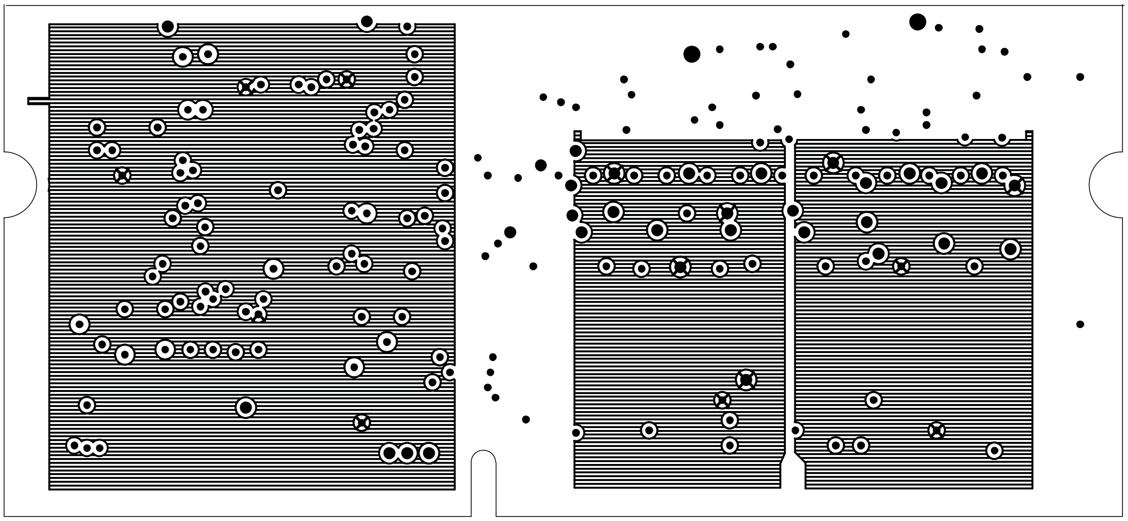


Figure 10. DIMM Layer 5

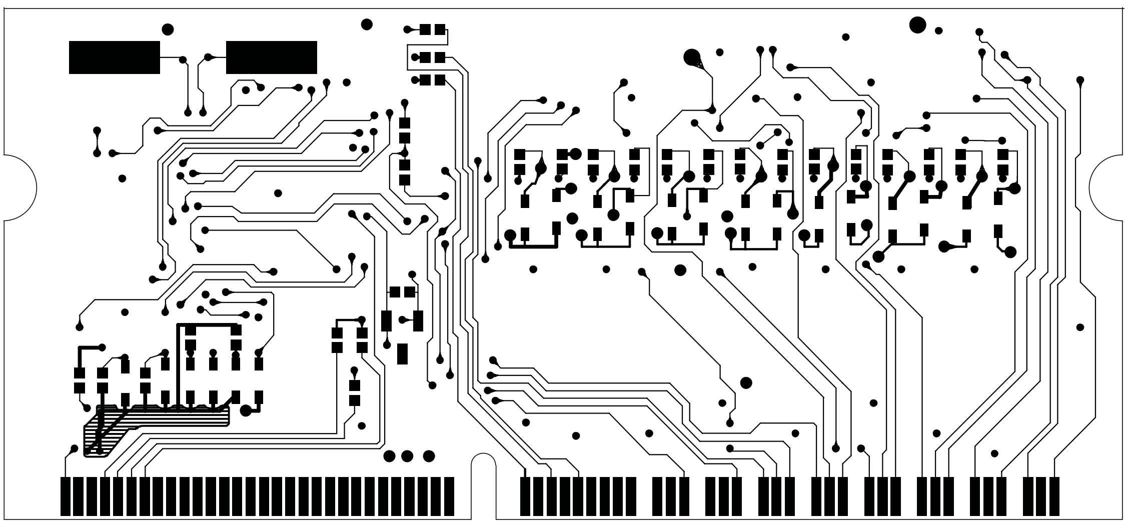


Figure 11. DIMM Bottom Layer

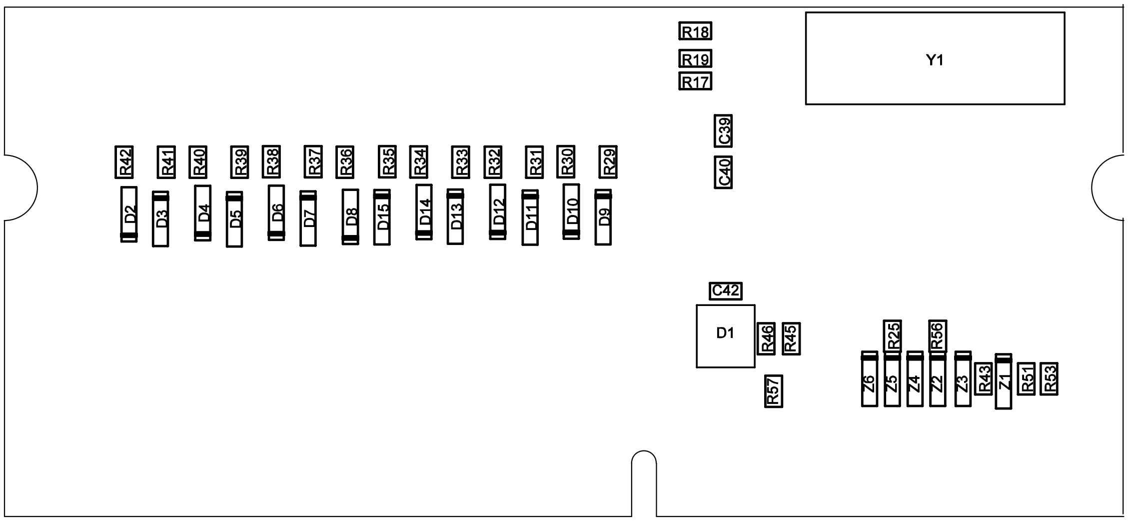


Figure 12. DIMM Bottom Assembly

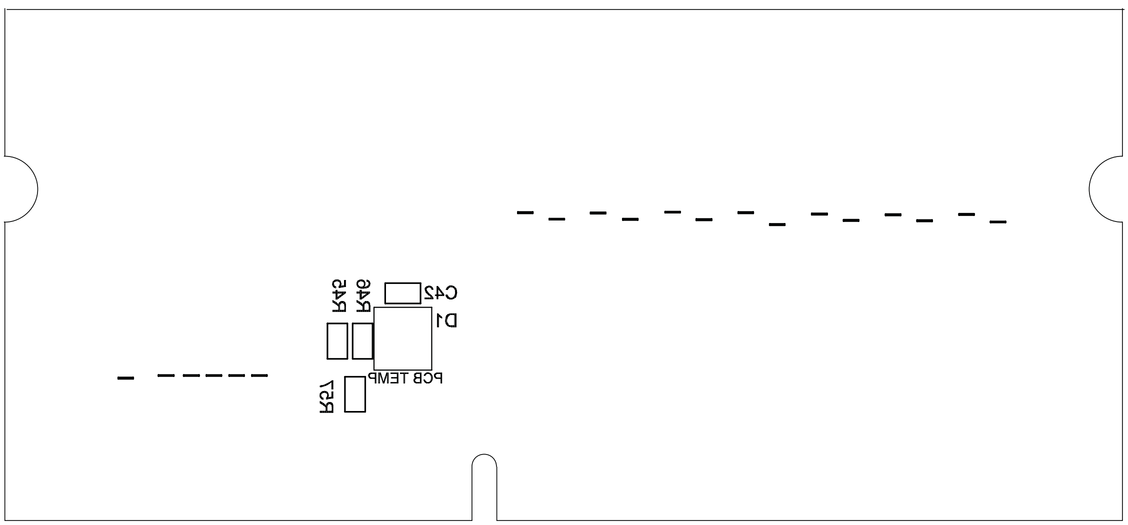


Figure 13. DIMM Bottom Silk Screen with Outlines

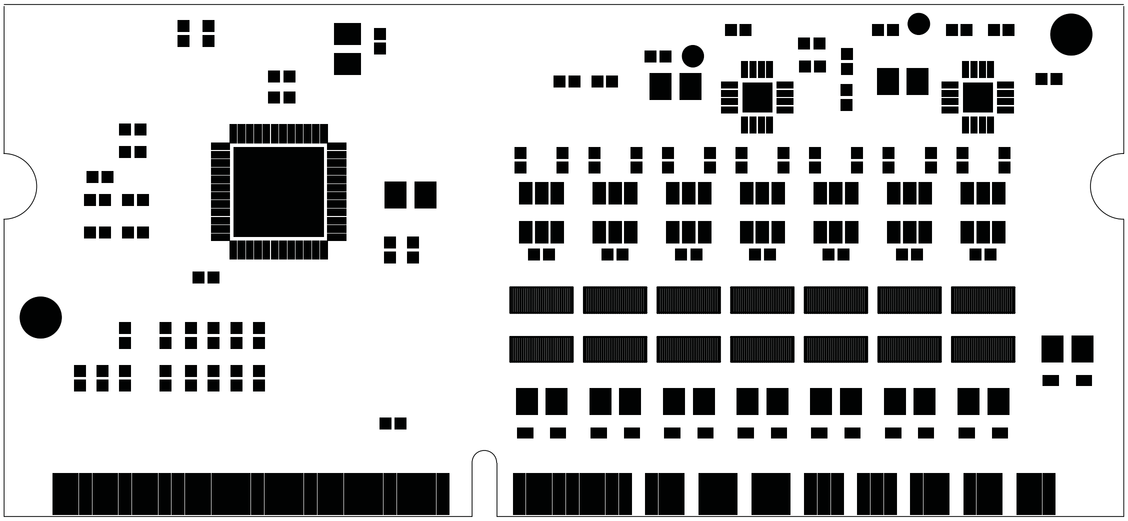


Figure 14. DIMM Top Solder

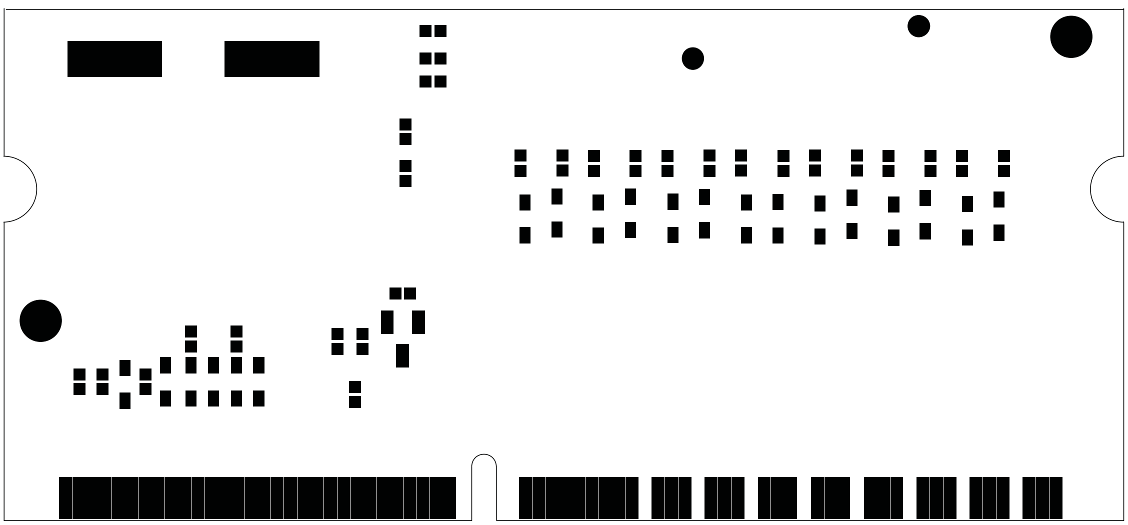


Figure 15. DIMM Bottom Solder

8.1.2 Bill of Materials

The bill of materials for the DIMM circuit module is shown in Table 9. Substitute parts may be used in the manufacturing of the assembly.

Table 9. DIMM Circuit Module Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
10	C1-4 C7 C37 C39-41 C44	1.0µF	Capacitor, Ceramic , SMD, X5R, ±20%, 10V	402	Standard	Standard
14	C12-25	3300pF	Capacitor, Ceramic , SMD, X7R, ±10%, 50V	402	Standard	Standard
2	C38 C43	0.1µF	Capacitor, Ceramic, SMD, X5R, ±20%, 10V	402	Standard	Standard
5	C10-11 C26-27 C42	1000pF	Capacitor, Ceramic, SMD, X7R, ±10% 50V	402	Standard	Standard
1	C6	10000pF	Capacitor, Ceramic, SMD, X7R, ±10%, 16V	402	Standard	Standard
4	R7-9 R6	0R	Resistor, SMD, 1/16W, 5%	402	Standard	Standard
2	R46 R45	0	Resistor, SMD, 1/16W, 5%	402	Standard	Standard
15	R17-19 R21-24 R26 R47-50 R52 R54-55	100	Resistor, SMD, 1/16W, 5%	402	Standard	Standard
1	R44	10K	Resistor, SMD, 1/16W, 5%	402	Standard	Standard
1	R5	100K	Resistor, SMD, 1/16W, 5%	402	Standard	Standard
6	R20 R25 R43 R51 R53 R56	1.0M	Resistor, SMD, 1/16W, 5%	402	Standard	Standard
7	R10-16	2K	Resistor, SMD, 1/16W, 5%	402	Standard	Standard
14	R29-42	20K	Resistor, SMD, 1/16W, 5%	402	Standard	Standard
2	R27-28	4.7K	Resistor, SMD, 1/16W, 5%	402	Standard	Standard
8	C29-36	22µF	Capacitor, Ceramic , SMD, X5R ±20% 6.3V	805	Standard	Standard
4	C5 C8-9 C28	10µF	Capacitor, Ceramic, SMD, Y5V, +80/–20%, 10V	805	Standard	Standard
7	(L1-7)**	4.7µH	Inductor, SMD	4mm x 4mm	VLCF4020T-4R7N1R2	TDK
2	(U2-3)**		IC, PowerLAN Dual Cell Monitor	QFN-16	bq76PL102RGT	Texas Instruments
1	U1**		IC, Battery Management Controller	QFN-48	BQ78PL114RGZ	Texas Instruments
28	D2-15 Z1-14		Diode, Zener, 200mW, 5.6VDC	SOD-523F	MM5Z5V6	Fairchild
1	D1**		Diode, Dual Package, 100V, 200mA	SOT-23	MMBD4148SE	Fairchild
7	(Q1-7)**		MOSFET, Pair, N/P Channel	TSSOP-6	FDC6327C	Fairchild Semiconductor
1	PCB		Printed Circuit Board		HPA546A	
0	C45-46		Ceramic Capacitor SMT 0402 C0G			
0	R1-4 R57		Resistor, SMD, 1/16W, 5%			
0	Y1		SMD Crystal HC-49US			

Notes:
1. These assemblies are ESD sensitive, ESD precautions shall be observed.
2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.

8.1.3 Schematic

The schematic for the DIMM circuit module is shown in Figure 16 and Figure 17.

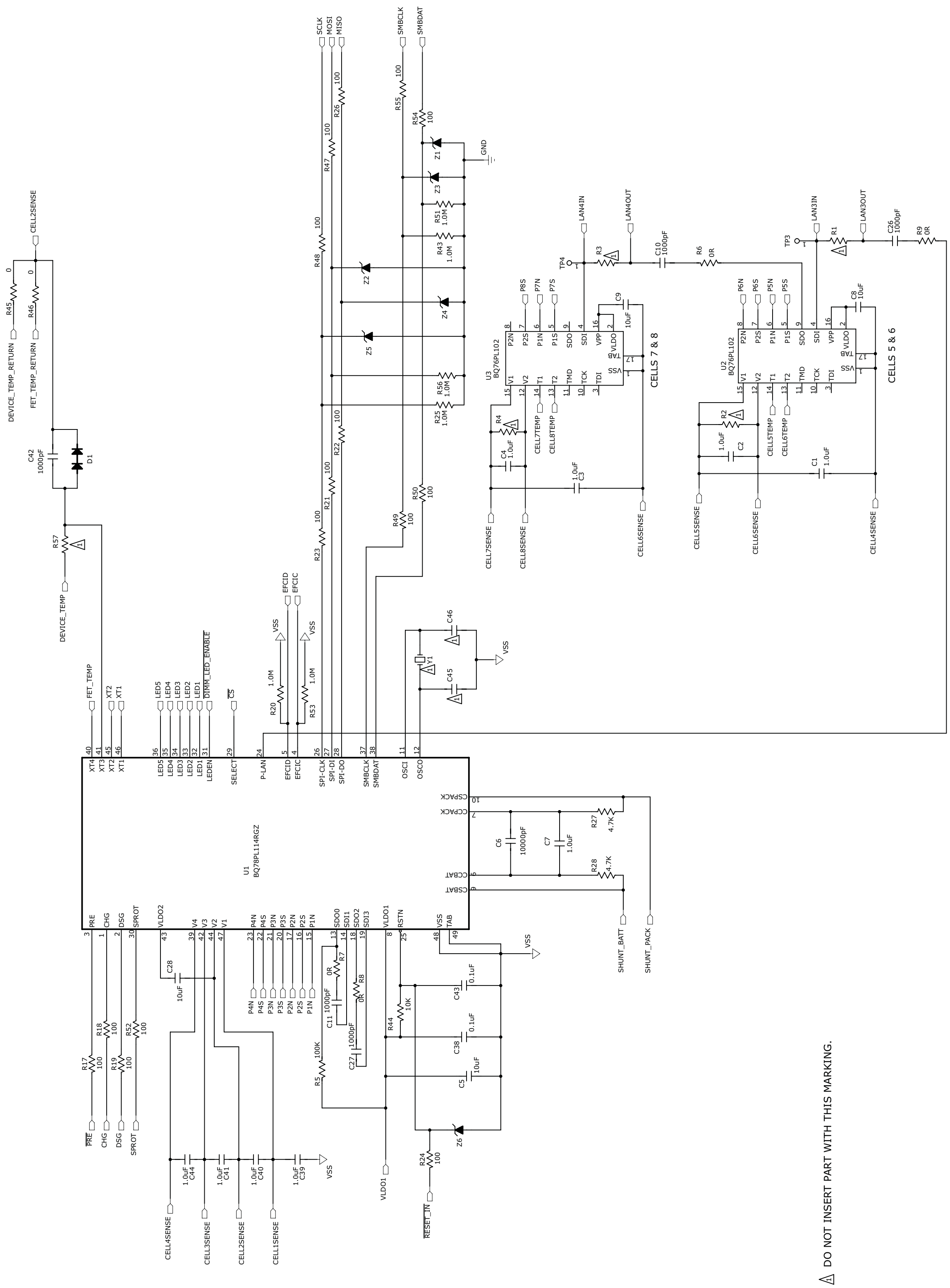


Figure 16. DIMM Circuit Module Schematic, Sheet 1

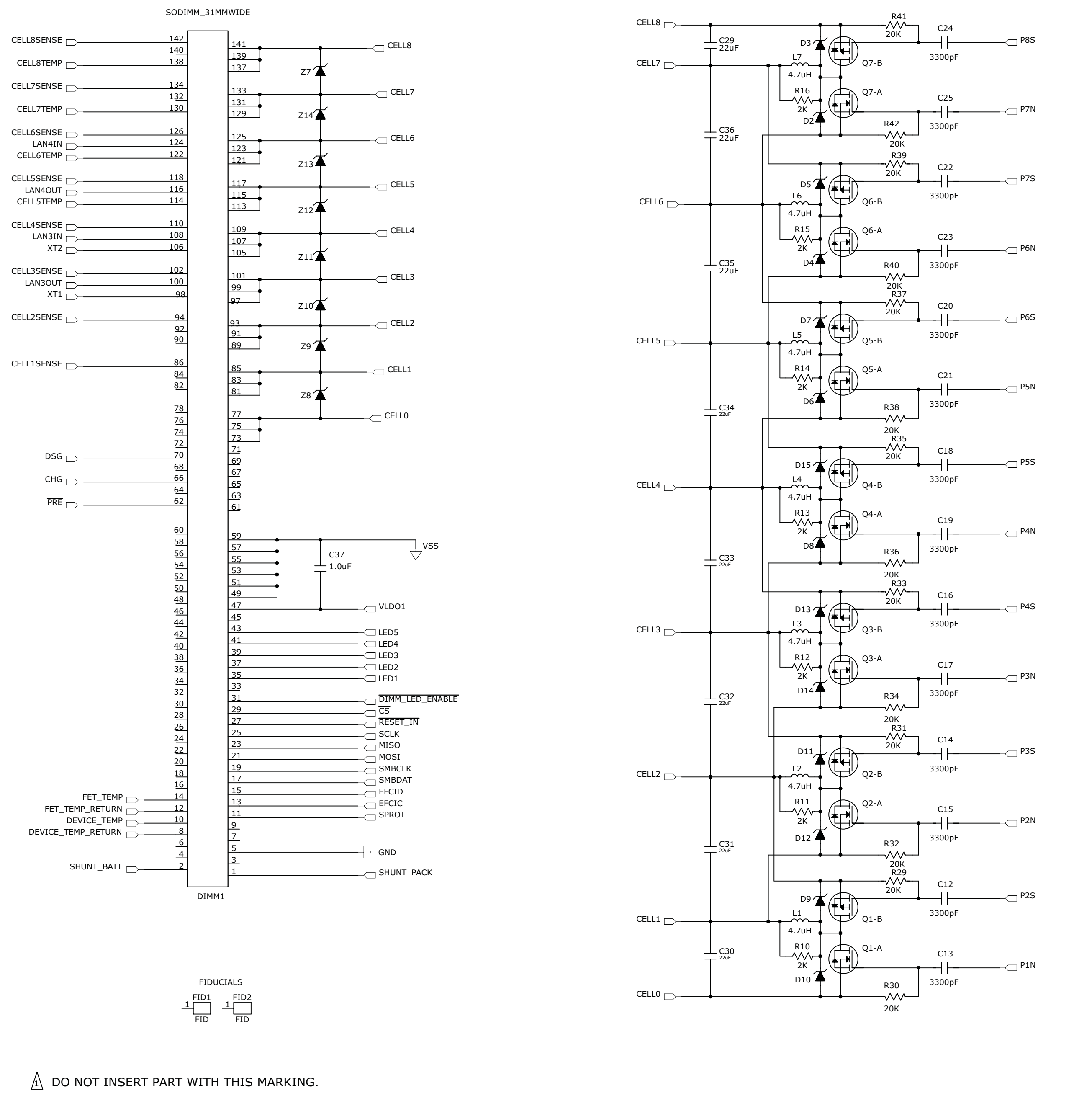


Figure 17. DIMM Circuit Module Schematic, Sheet 2

8.2 Base Circuit Module

8.2.1 Board Layout

The PowerLAN™ 8S EVM base circuit module is a four-layer circuit card assembly. It is designed for easy connection with cell and temperature sensor connections on the left side and load connection on the right. The DIMM module is inserted in a socket on the right side. Dual FETs are used to reduce resistance for a design 30-A current flow. Wide trace areas and multiple layers are used to reduce voltage drops. High-current terminals are close together to reduce inductance. The heatsinks normally provide adequate cooling for the FETs without forced air cooling. The board layouts are shown in Figure 18 through Figure 23.

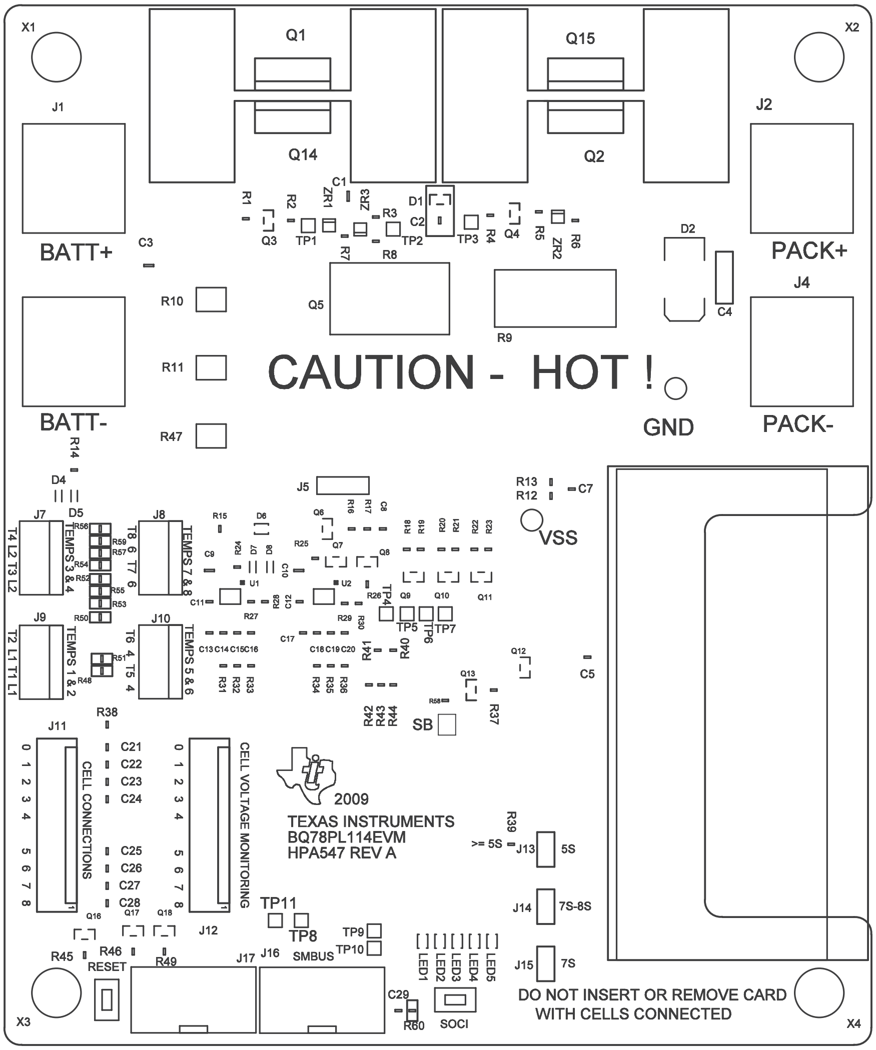


Figure 18. Top Silk Screen

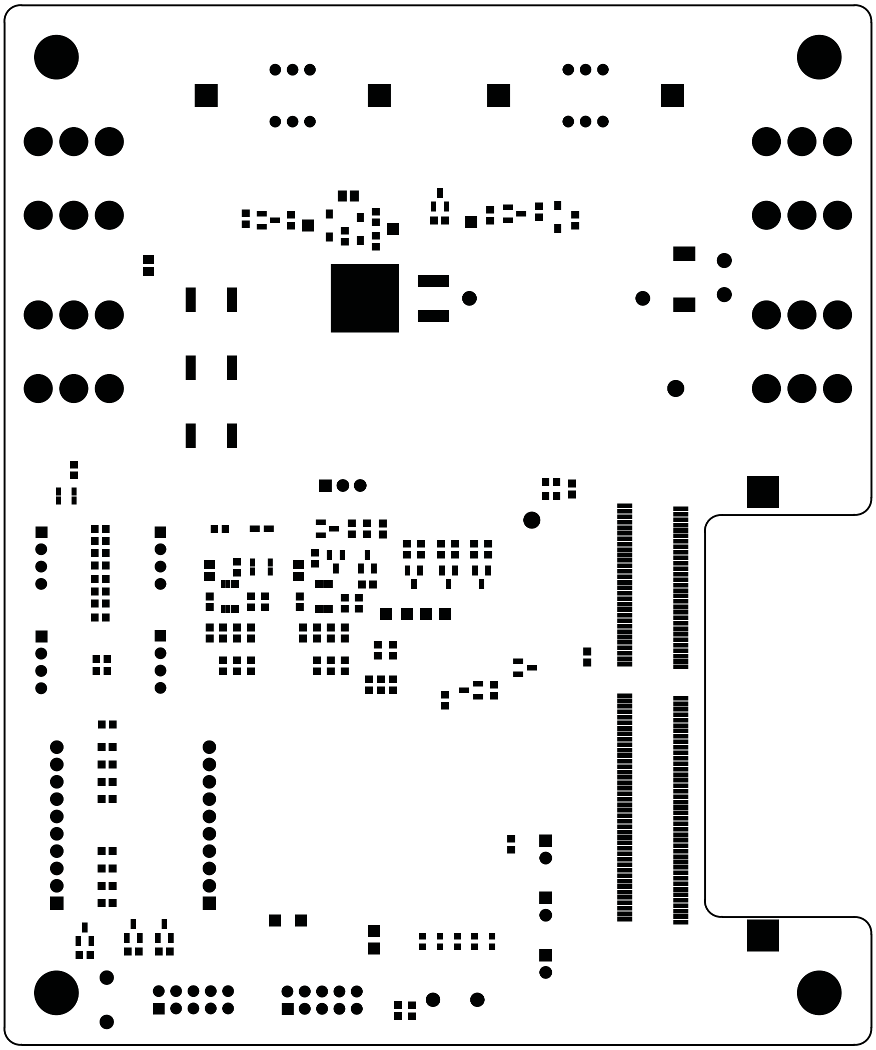


Figure 19. Base Top Assembly

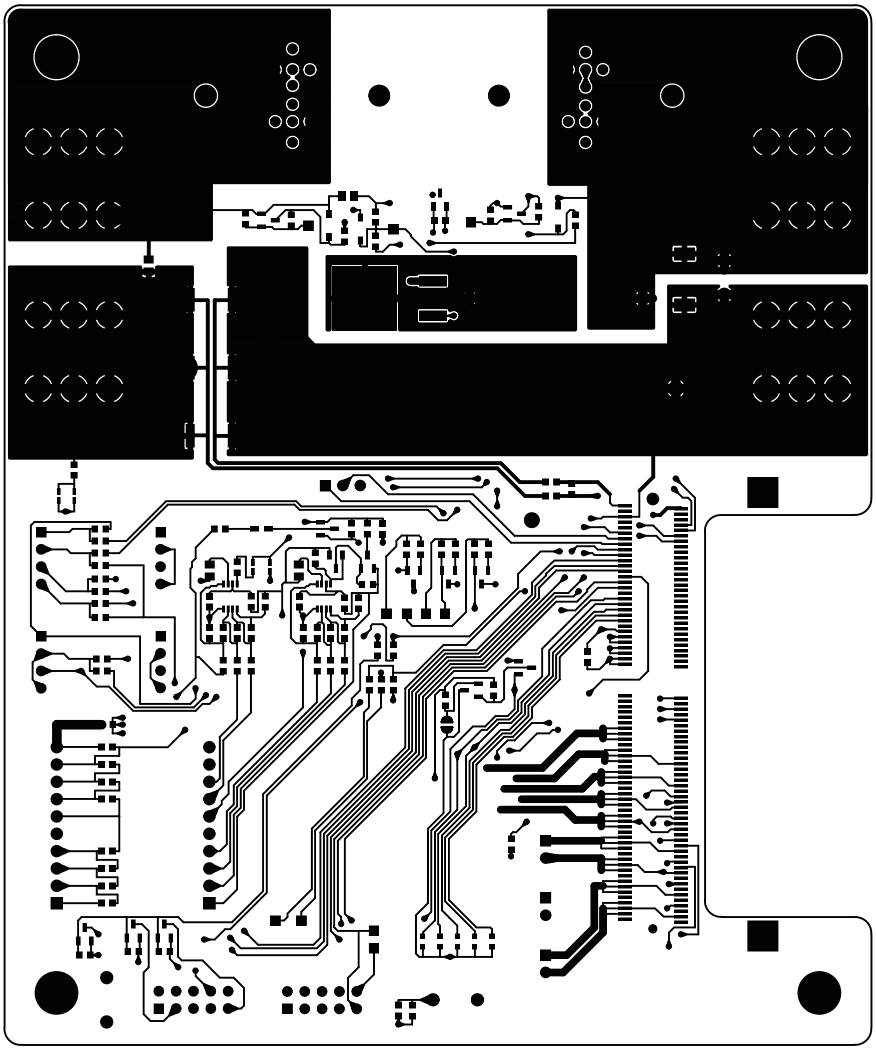


Figure 20. Base Top Layer

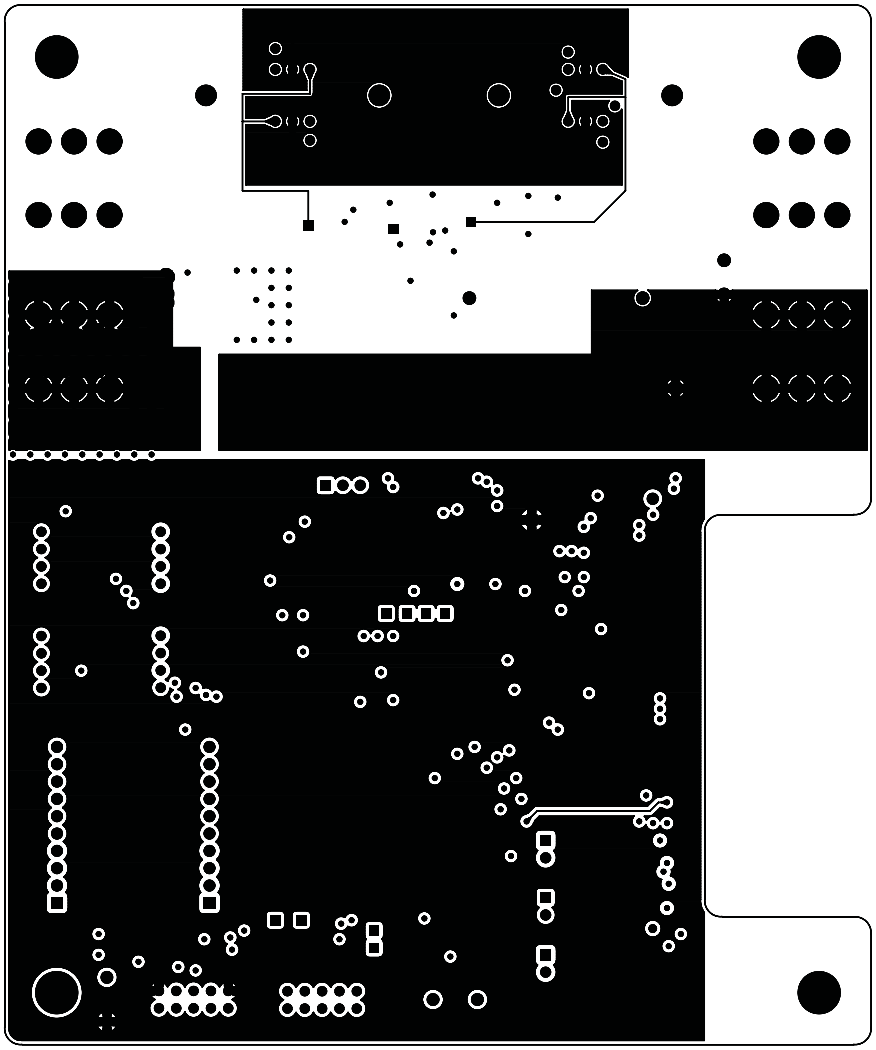


Figure 21. Base Layer 2

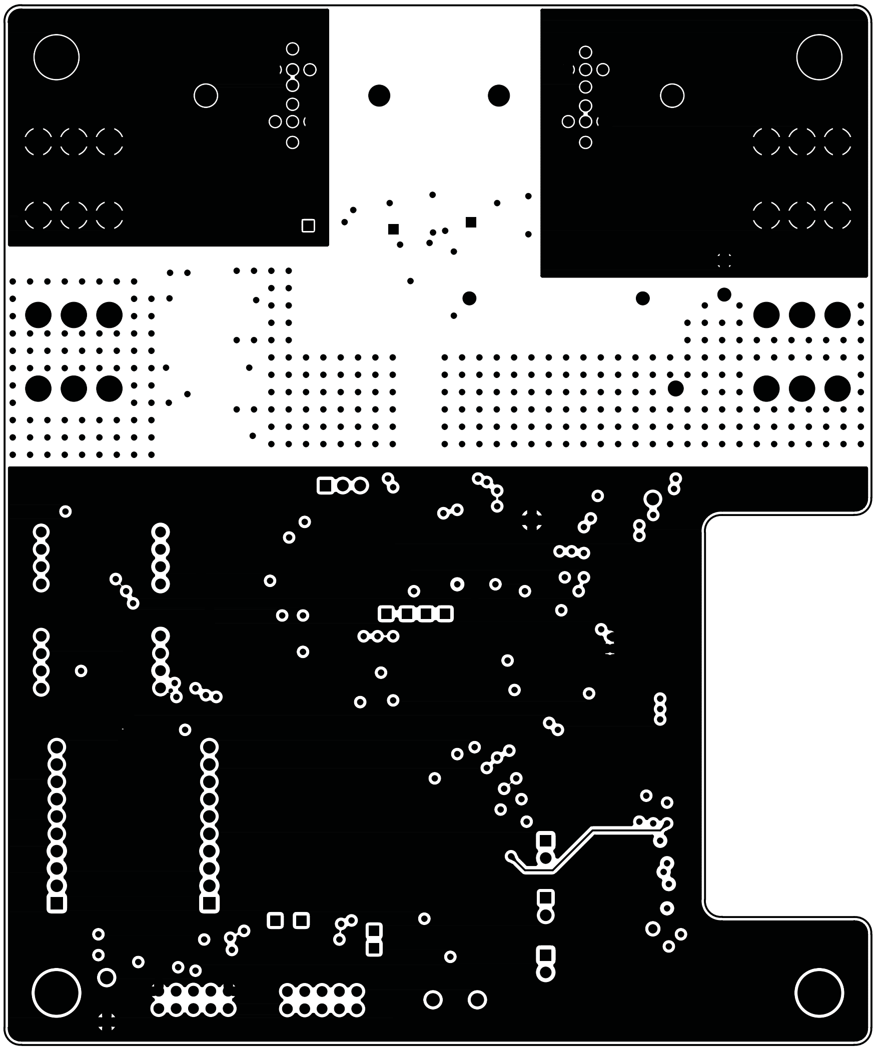


Figure 22. Base Layer 3

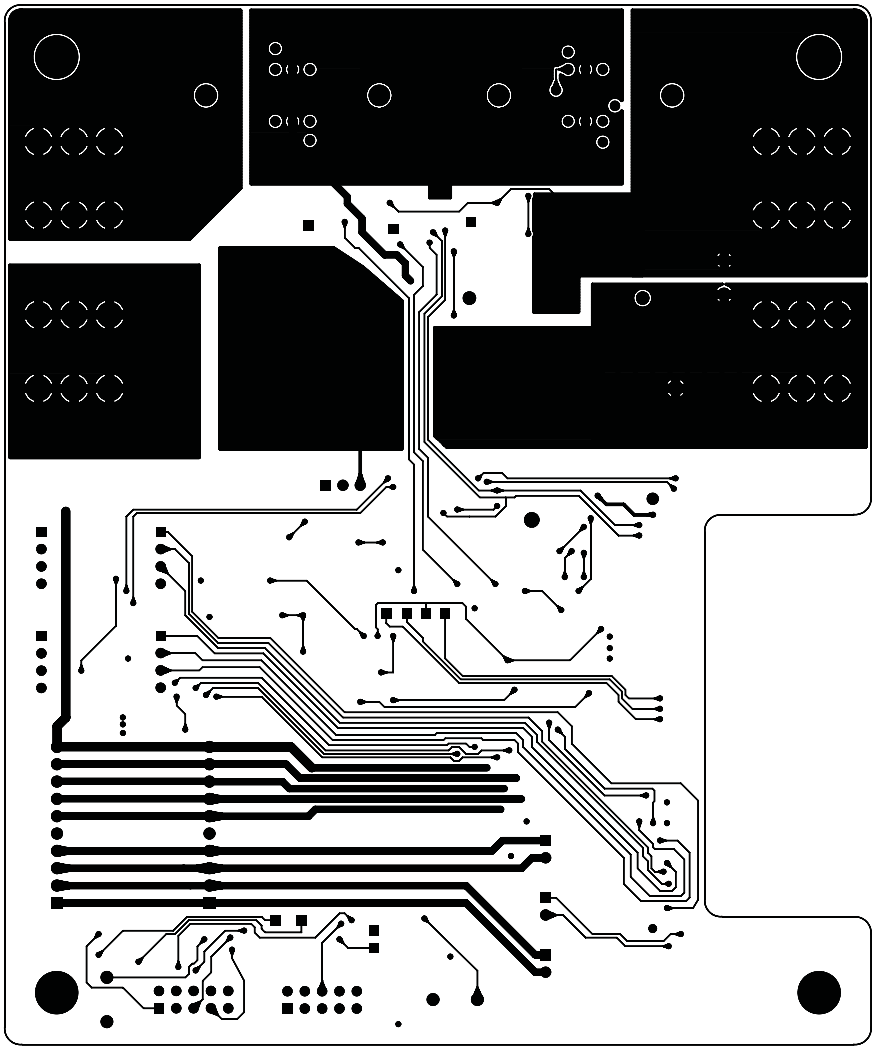


Figure 23. Base Layer 4

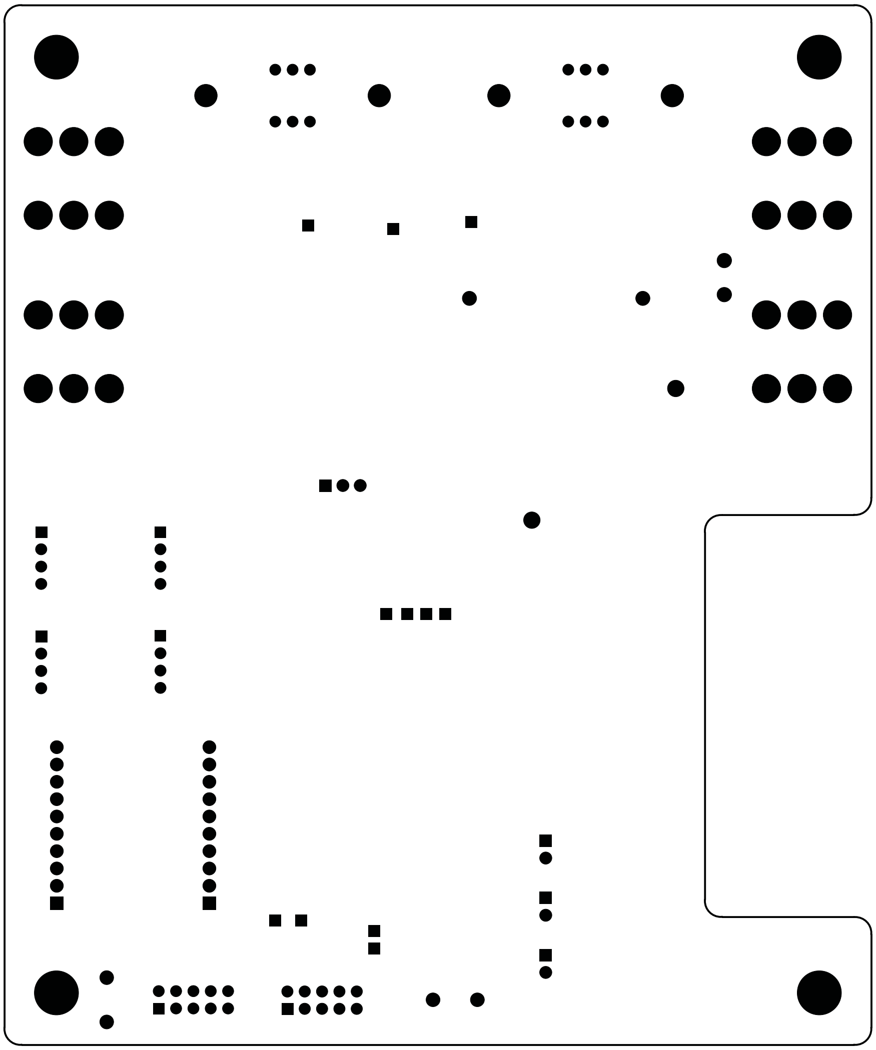


Figure 24. Bottom Layer

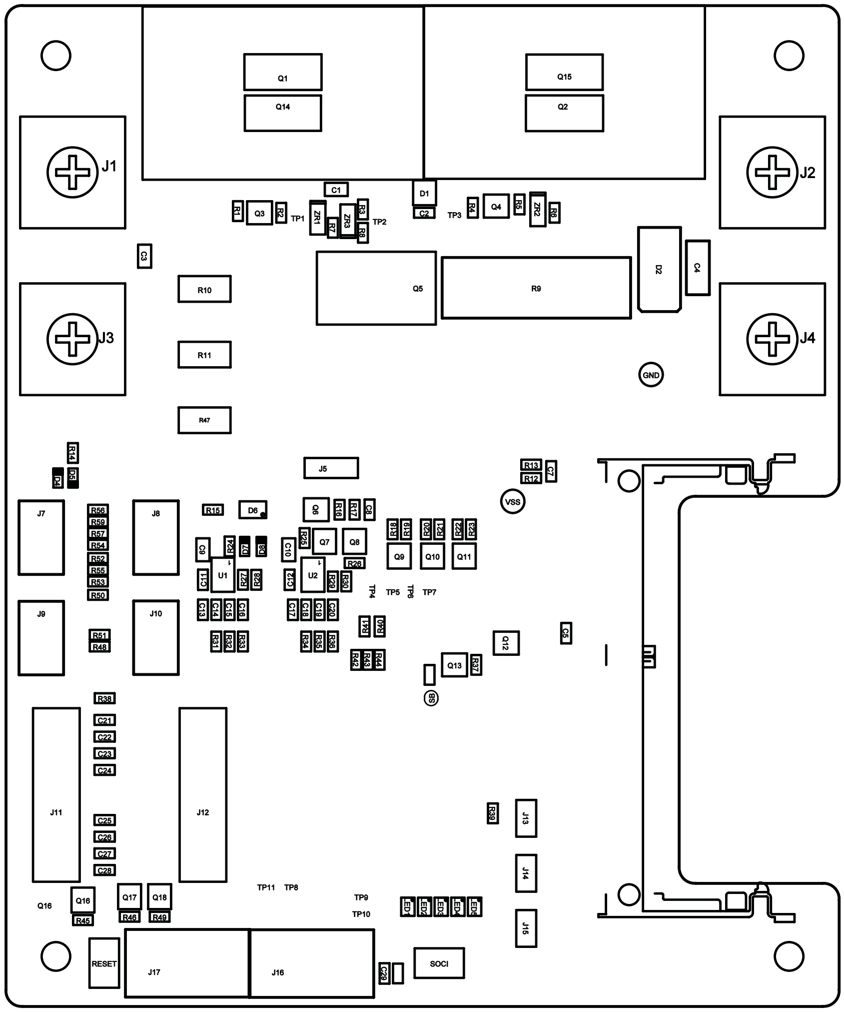


Figure 25. Base Outline

8.2.2 Bill of Materials

The bill of materials for the base circuit module is shown in Table 10. Substitute parts may be used in the manufacturing of the assembly.

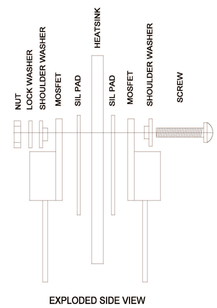
Table 10. Base Circuit Module Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
5	LED1-5		LED, Super Ultra Green, Milk White Diff., 45 mcd	603	SML-LX0603SUGW-TR	Lumex
1	D6		LED, Red Diffused, SMT, 2.6VF	603	SML-LX0603IW-TR	Lumex
13	R12-14 R38-40 R44 R48 R50 R52 R54 R56 R60	0	Resistor, SMD, ±5%, 1/10W	603	Standard	Standard
19	C6 C11-28	0.1µF	Capacitor, Ceramic SMD, ±10%, X7R, 50V	603	Standard	Standard
10	R27-36	1.0K	Resistor, SMD, ±5%, 1/10W	603	Standard	Standard
5	R3 R8 R18 R20 R22	1.0M	Resistor, SMD, ±5%, 1/10W	603	Standard	Standard
5	R15	2.0K	Resistor, SMD, ±5%, 1/10W	603	Standard	Standard
5	R6-7 R19 R23	30K	Resistor, SMD, ±5%, 1/10W	603	Standard	Standard
5	R58	100	Resistor, SMD, ±5%, 1/10W	603	Standard	Standard
5	R16 R21 R24-26 R37	100K	Resistor, SMD, ±5%, 1/10W	603	Standard	Standard
5	R2 R5 R17	200K	Resistor, SMD, ±5%, 1/10W	603	Standard	Standard
5	R1 R4	560K	Resistor, SMD, ±5%, 1/10W	603	Standard	Standard
5	C2 C8	1000pF	Capacitor, Ceramic SMD, ±10% X7R, 50V	603	Standard	Standard
5	C1 C3	0.1µF	Capacitor, Ceramic SMD, ±10%, X7R, 100V	805	Standard	Standard
5	C9-10	0.47µF	Capacitor, Ceramic SMD, ±10%, X5R, 25V	805	Standard	Standard
5	(R10-11 R47)**	0.015	Resistor, SMD, ±1%, 1W, ±100ppm/°C	2512	ERJ-M1WSF15MU	Panasonic
5	GND VSS		Header, Test Clip Point, Through Hole, 0.062" Dia.	0.062"	5011	Keystone
5	J13-15		Header, 0.100", Single Row, Vertical, Tin	0.100"	90120-0122	Molex
5	J11-12		Header, MTA, Vert., 30Au, 0.100"	0.225"x1.0"x0.395"	4-641213-0	Tyco/Amp
5	J7-10		Header, MTA, 0.100", Straight, Vertical, Friction Lock, Tin	0.255"x0.400"x0.395"	640454-4	AMP
5	R9	360	Resistor, 5W Ceramic, +/-5%	0.295" x 0.709"	2322 329 05361	Vishay
5	J16		Header, Shrouded, Gold, Vertical	0.338"x0.708"x390	5103309-1	AMP
5	J1-4		Header, Screw Terminal 470 mils x 470 mils	0.470"x0.470"x0.453"	8196	keystone
5	C4	0.1µF	Capacitor, Radial, MetalPoly, ±5%, 100V	2.5mmx6.5mmx7.2mm	B32529C1104J	EPCOS
5	J6		Header, SODIMM Socket, UL94V-0, Gold	2.77"x1.18"x0.390"	390322-1	Amp
5	SOCI		Pushbutton, Tactile Momentary, Through hole	6mmx3.5mm	EVQ-PE504K	Panasonic
5	(U1-2)**		Voltage Protection for 2-3-4 Cell LiIon Batteries	8MSOP, JEDEC MO-187DA	BQ29410DCT3R	TI
5	Q5		MOSFET, N-CH, 16 Amp, 60VDSS	D2PAK	STB16NF06LT4	ST
5	D2		Transient Suppressor, Bidirectional, SMT, 1500W	SMC	SMCJ36CA-13-F	Diodes, Inc.
5	ZR1-3		Zener Diode, SMT, 500mW	SOD-123	BZT52C12-7-F	Diodes, Inc
5	Q9-11		Transistor, NPN, 100mA, 65Vce	SOT-23	BC846ALT1G	ON Semi.
5	Q8		MOSFET, P-CH Enhance. Mode, -50Vdss, ±20Vgs	SOT-23	BSS84	Fairchild Semiconductor
5	Q6-7 Q12		MOSFET, N-CH, 50Vdss	SOT-23	BSS138	Fairchild Semiconductor
5	(Q3-4)**		JFET, N-CH, General Purpose 40VDG	SOT-23	MMBFJ201	Fairchild Semiconductor
5	Q13		MOSFET, P-CH, SMT -25VDSS	SOT-23	FDV304P	Fairchild Semiconductor
5	D1		Diode, Dual, Silicon, SMT, SE Configuration	SOT-23	MMBD4148SE	Fairchild
5	D3-5 D7		Diode, Schottky, SMT, 30V	SS-Mini 2P	MA2S72800L	Panasonic
5	SOCI		Pushbutton, Tactile Momentary, Through hole	6mmx3.5mm	EVQ-PE504K	Panasonic
5	Q1-2, Q14-15		MOSFET, P-CH, -55VDSS	TO-220	IRF4905PBF	IRF
5	Q1 / Q14 Assembly, Q2/Q15 Assembly	See Drawing	Heatsink 50.8mm x 25.4mm x 41.91mm		529902B02500G	Aavid Thermalloy
5	Q1 / Q14 Assembly, Q2/Q15 Assembly	See Drawing	1/2", 2-56 Machine Screw Zinc Plated, Philips head		Dist P/N 90272A081	McMaster-Carr
5	Q1 / Q14 Assembly, Q2/Q15 Assembly	See Drawing	2-56, Hex Head, Zinc Plated Nut	#2 Screw Size	Dist P/N 90480A003	McMaster-Carr
5	Q1 / Q14 Assembly, Q2/Q15 Assembly	See Drawing	Lock washer	#2 Screw Size	Dist P/N 92146A520	McMaster-Carr
5	Q1 / Q14 Assembly, Q2/Q15 Assembly	See Drawing	Shoulder Washer, 0.091" x 0.062" x 0.312" (ID x L x OD)	#2 Screw Size	Dist P/N 93835A310	McMaster-Carr

Table 10. Base Circuit Module Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
5	Q1 / Q14 Assembly, Q2/Q15 Assembly	See Drawing	Heat Sink Pad, Sil-Pad 600		SP600-54	Berquist
5	Q1 / Q14 Assembly, Q2/Q15 Assembly	See Drawing	Heat Sink Pad, Sil-Pad 600		SP600-54	Berquist
5	X1-4		Bumpons, Dome, 0.44 diameter, 0.20 height, clear	0.44 x 0.20	2566	Voltrex
5	PCB		Printed Circuit Board		HPA547A	Any
5	PCB Assembly		Printed Circuit Board Assembly		HPA546A	Any
5	PCB Assembly		Printed Circuit Board Assembly		HPA548A	Any

Notes:
1. These assemblies are ESD sensitive, ESD precautions shall be observed.
2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
4. Cut pin 5 of connectors J11 and J12 after they are insertion and soldered to PCB.
5. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.
6. Install a shunt on J14 to short pins. Shunt is Sullins Part No. SPC02SYAN, or equal.
7. Install a shunt on J13 to hang off of pin 1. Shunt is Sullins Part No. SPC02SYAN, or equal.
8. Install a shunt on J15 to hang off of pin 1. Shunt is Sullins Part No. SPC02SYAN, or equal.
9. Bumpons are located on bottom side of PCB located at X1, X2, X3, X4.



8.2.3 Schematic

The schematic for the base circuit module appears at the end of this document.

8.3 Temperature Sensor Circuit Board

8.3.1 Sensor Cable Assembly

Eight external temperature sensors are provided with the EVM. These may be assembled as a separable group of boards. The reference designators used in this section are for a single board and may vary from board to board in the assembly grouping. For initial evaluation the sensors may be left as a group, later these may be separated for mounting to cells. When separating the sensors, cut any tape necessary to separate the boards at the scribe lines and be sure to insulate any exposed traces or connections after separation.

The temperature sensors are attached to the base EVM in pairs using 4-pin connectors. The recommended wiring is 26 AWG twisted-pair wiring with a Tyco 3-640442-4 receptacle. Two pad options are provided on the temperature sensor board, J1 or J2. The EVM is assembled using J1, but J2 can also be used if it better fits the sensor mounting location. Table 11 describes the connections.

Table 11. Temperature Sensor Cable Wiring

Receptacle Contact Number	Board J1 or J2 Pad Number	Description
1	2	Negative connection for the first temperature sense board
2	1	Positive connection for the first temperature sense board
3	2	Negative connection for the second temperature sense board
4	1	Positive connection for the second temperature sense board

8.3.2 Board Layout

The PowerLAN™ 8S EVM temperature sensor circuit module is a two-layer circuit card assembly. It is designed to allow mounting on a cell. The board layouts are shown in Figure 26 to Figure 31.

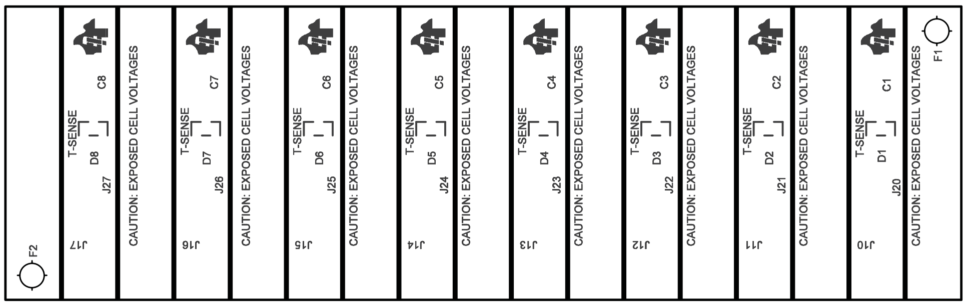


Figure 26. Temperature Sensor Top Silk Screen and Assembly

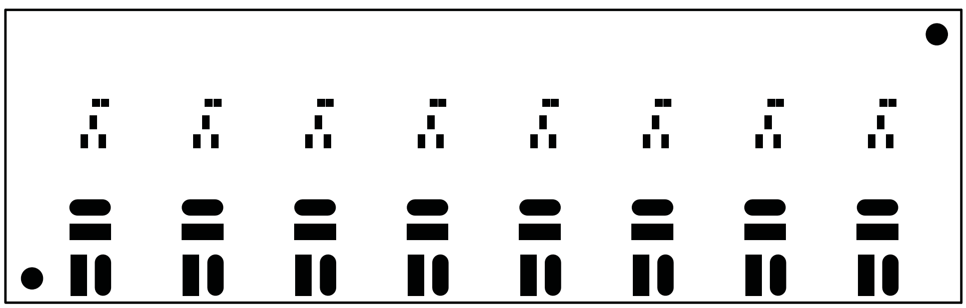


Figure 27. Temperature Sensor Top layer

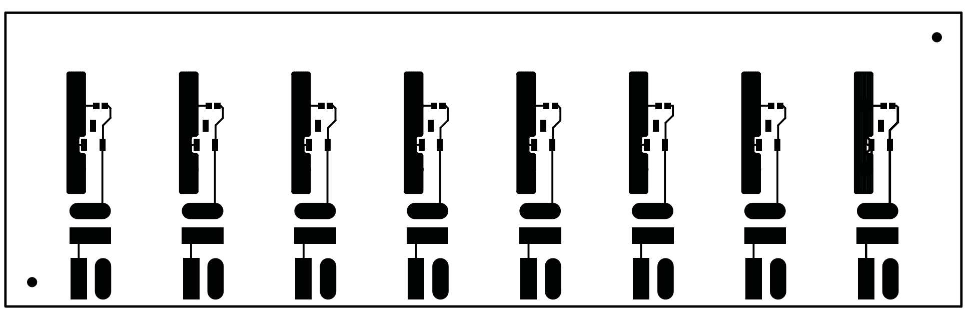


Figure 28. Temperature layer 1

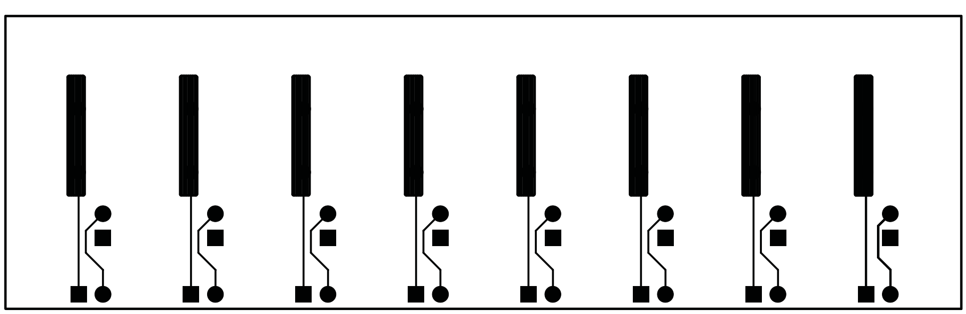


Figure 29. Temperature Bottom layer

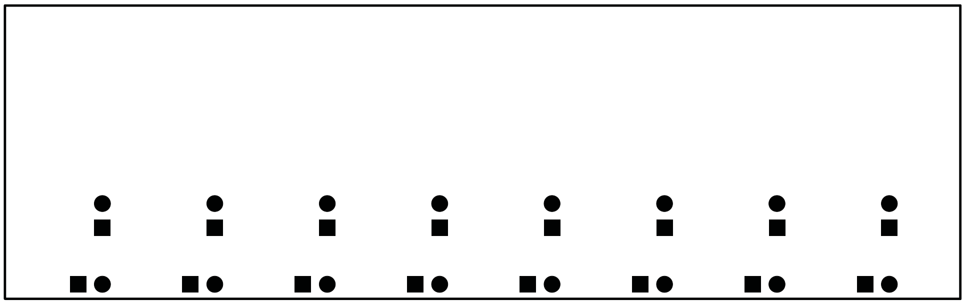


Figure 30. Temperature Bottom Solder

Figure 31. Temperature Bottom Silk Screen

8.3.3 Bill of Materials

The bill of materials for the temperature sensor circuit module is shown in Table 12. Substitute parts can be used in manufacturing the assembly.

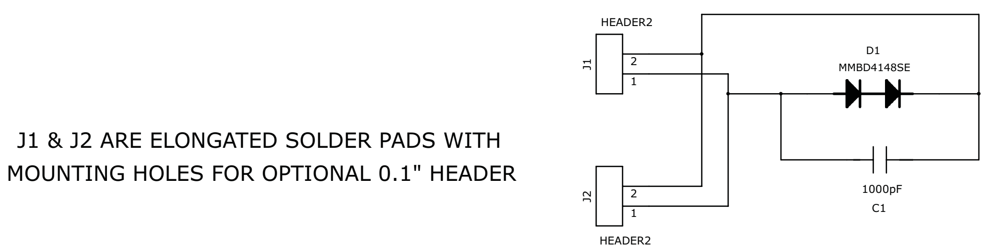
Table 12. Temperature Sensor Circuit Module Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
8	D1–D8		Dual Diode SE Configuration	SOT-23	MMBD4148SE	Fairchild
8	C1–C8	1000pF	Capacitor, Ceramic SMT, ±10% X7R, 50V	0603	Standard	Standard
8	RED		Wire, Insulated, Stranded, 26AWG, Red Color	12"	3049 RD005	Alpha Wire Co.
8	BLK		Wire, Insulated, Stranded, 26AWG, Black Color	12"	3049 BK005	Alpha Wire Co.
4	CONN		MTA 100 Connector Assembly		3-640442-4	Tyco Electronics
1	TAPE		Polyimide Tape, standard thickness	1" Wide	1206 × 1"	3M
1	PCB		Printed Circuit Board		HPA548	
0	J10–J17, J20–J27		Header			

Notes
1. These assemblies are ESD sensitive, ESD precautions shall be observed.
2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.
5. The complete assembly includes all of the above mounted and connected to a single PCB.
6. TAPE should cover exposed copper on top and bottom side of PCB. See assembly drawing for details.

8.3.4 Schematic

The schematic for the temperature sensor circuit module is shown in Figure 32.



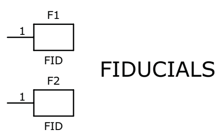


Figure 32. Schematic Diagram

9 Related Documents from Texas Instruments

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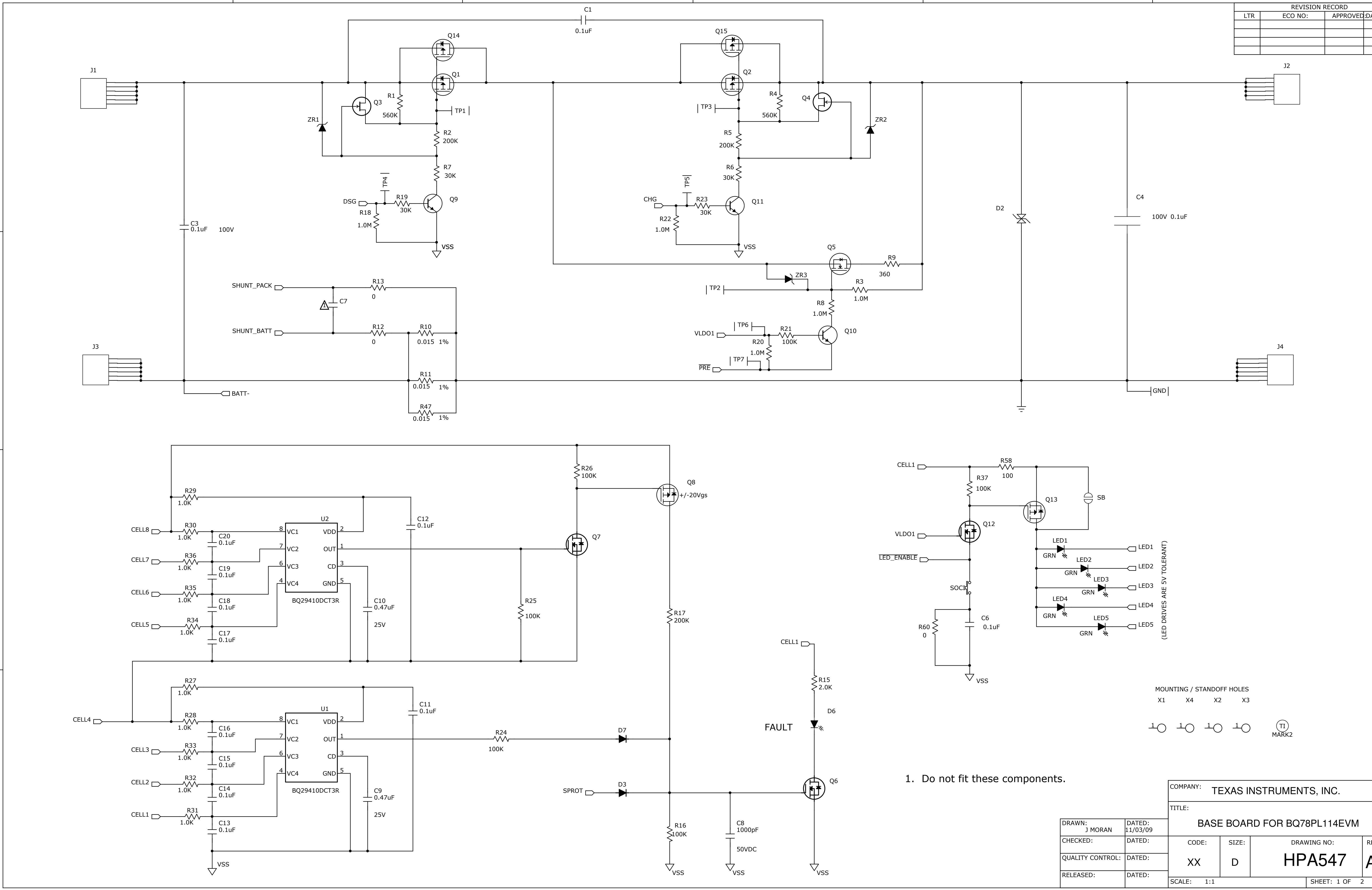
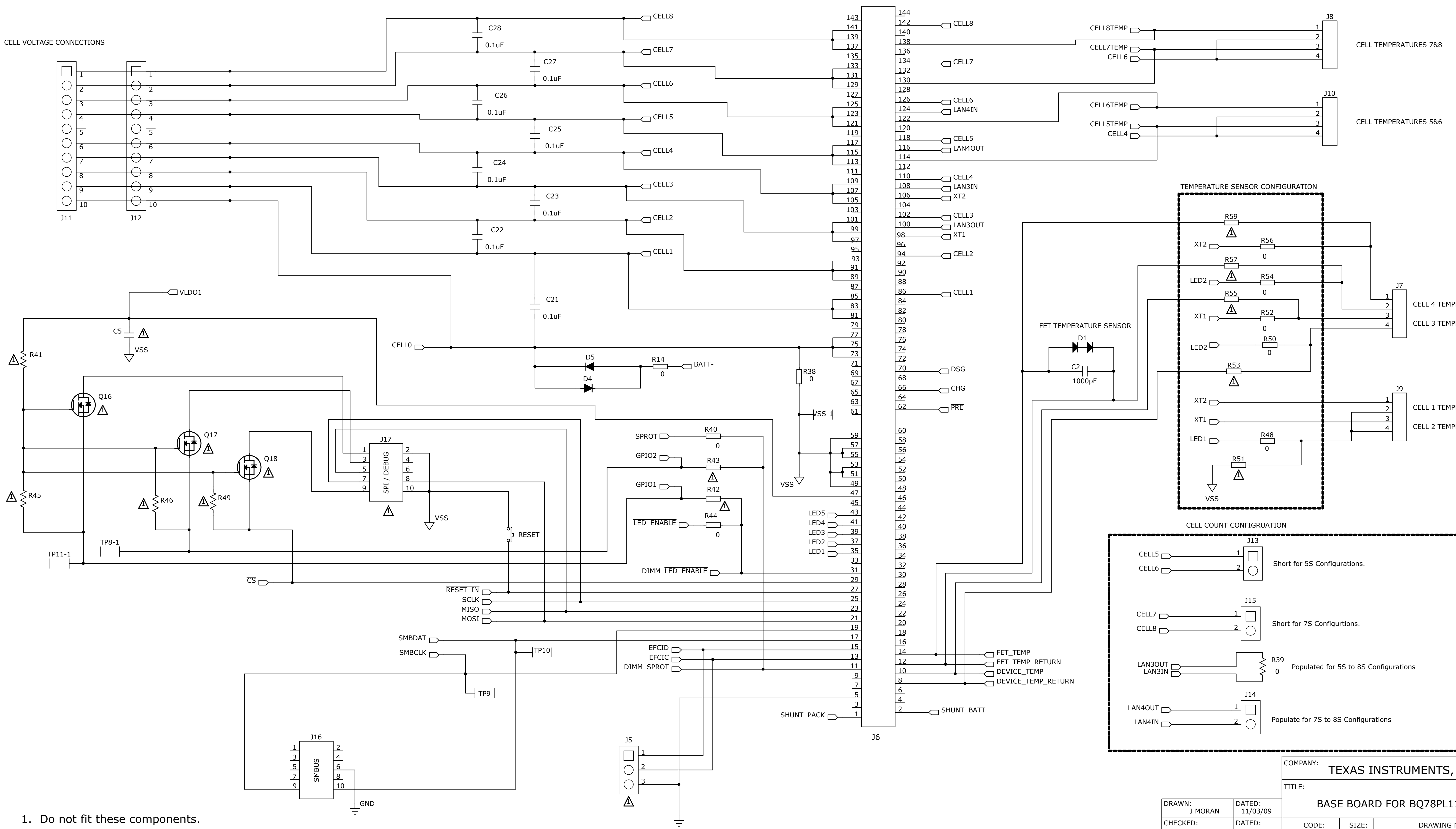
1. *bq78PL114, PowerLAN™ Master Gateway Battery Management Controller With PowerPump™ Cell Balancing Technology* data sheet (SLUS850)
2. *bq78PL114 Technical Reference Manual* (SLUU330)
3. *bq29410/11/12/13/14/15/19, Voltage Protection for 2-, 3-, or 4-Cell Li-Ion Batteries* data sheet (SLUS669)
4. *bqWizard User's Guide* (SLUU336)
5. *Configuring the bq78PL114 Cell Count* application report (SLUA495)
6. *Chemistry Selection for the bq78PL114* application report (SLUA505)
7. *bq78PL114 System Design Guidelines* application report (SLUA537)
8. *PowerPump™ Balancing* application report (SLUA524)
9. *PowerLAN™ Dual-Cell Li-Ion Battery Monitor with PowerPump™ Cell Balancing* data sheet (SLUS887)
10. *USB Interface Adapter Evaluation Module User’s Guide* (SLLU093)
11. *What is a .tmap file?* application report (SLUA542)



1. Do not fit these components.

COMPANY:	TEXAS INSTRUMENTS, INC.
TITLE:	BASE BOARD FOR BQ78PL114EVM
DRAWN: J MORAN	DATED: 11/03/09
CHECKED:	DATED:
QUALITY CONTROL:	DATED:
RELEASED:	DATED:
CODE: XX	SIZE: D
DRAWING NO: HPA547	REV: A
SCALE: 1:1	SHEET: 1 OF 2

REVISION RECORD			
LTR	ECO NO:	APPROVED:	DATE:



1. Do not fit these components.

		COMPANY: TEXAS INSTRUMENTS, INC.			
		TITLE: BASE BOARD FOR BQ78PL114EVM			
DRAWN: J MORAN	DATED: 11/03/09	CODE: XX	SIZE: D	DRAWING NO: HPA547	REV: A
CHECKED:	DATED:				
QUALITY CONTROL:	DATED:				
RELEASED:	DATED:	SCALE: 1:1		SHEET:2 OF 2	

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