Quick-Start Guide for bq78PL114 With bq76PL102 Family Gas Gauges

This application report gives an overview of the implementation and testing of Texas Instruments bq78PL114 with companion bq76PL102 high-cell-count battery gas gauge and protector. It explores the hardware and software graphical user interface (GUI) setup.

This document begins with the discussion of the communication setup between the chipset and the personal computer. TI's USB Interface Adapter communications box is used with the provided bqWizard™ software. The examples in this document show the S12 version of the firmware. The updated S12 version has programming and hardware differences from the original S8 firmware. See the *bq78PL114 and bq78PL114S12 Technical Reference Manual* (SLUU330) for those differences.

See the application report *Chemistry Selection for bq78PL114* (SLUA505) for additional information on configuring the gas gauge, as well as on the data collection process for defining a .AUX for your battery pack. The .AUX file is provided by Texas Instruments.

Additionally, review the application report *What is a .tmap File?* (SLUA542) to understand the nuances of the different programming files for the gas gauge. of this document includes questions on your pack configuration required by TI to create a .tmap file. Automatic .AUX file generation is now available through bqWizard™ software version 2.5.18.

The examples used in this quick-start guide are based on the hardware implementation shown in the schematic and build of materials. Collateral on the bq78PL114 8S standard evaluation module (EVM) offered by TI is available (SLUU335). Note that hardware changes are required moving from the S8 firmware to S12. Do not update the firmware on the bq78PL114 8S standard EVM unless you understand the implications.

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1 Getting Started With the bq78PL114 Graphical User Interface

The USB Interface Adapter box must be connected to your computer before the GUI can open. The default firmware on the standard EVM and early production product supports up to 8 cells in series (called 8s). The latest release of the bq78PL114 firmware is called S12 and supports up to 12 cells in series. The interface box used to communicate with the bq78PL114 is called USB-to-GPIO Adapter EVM. Note that it is not included with the bq78PL114EVM-001 evaluation module and must be purchased separately.

2 Software Communication and Troubleshooting

When trying to connect to the gas gauge chipset, you may see the following screen message (Figure 1) presented by the GUI software, "Unable to connect to device." Check the connections to the hardware, and try to reconnect. Additionally, the "LAN is not built!" warning message (Figure 2) appears in the lower right corner of your screen.

In some cases, everything is fine, and you need to close and open the software again. (LEDs blinking is a good sign that the part is functional.) If not, check for voltage on VLDO1, V1, and V2 pins. Also, check for shorts across the battery cell connections. A 10-second initialization period occurs after power up (POR) during which communication with the device may fail.

Proper communication is indicated by the following screen captures (Figure 3 and Figure 4).

Note that the S8 firmware may be preprogrammed into your EVM or integrated circuit when you receive it. The S8 firmware has been referred to as FW4452 throughout TI documentation. The S8 firmaware is programmed at the factory as the default firmware. Follow the process in on updating the firmware to the S12 version. Because hardware configurations are different for the different firmware versions, review the *bq78PL114 and bq78PL114S12 Technical Reference Manual* (SLUU330) for those differences.

Figure 1. Unable to Connect to Chipset Warning.

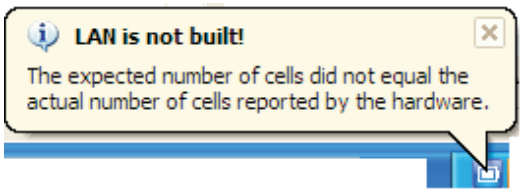


Figure 2. LAN is not built! Warning.

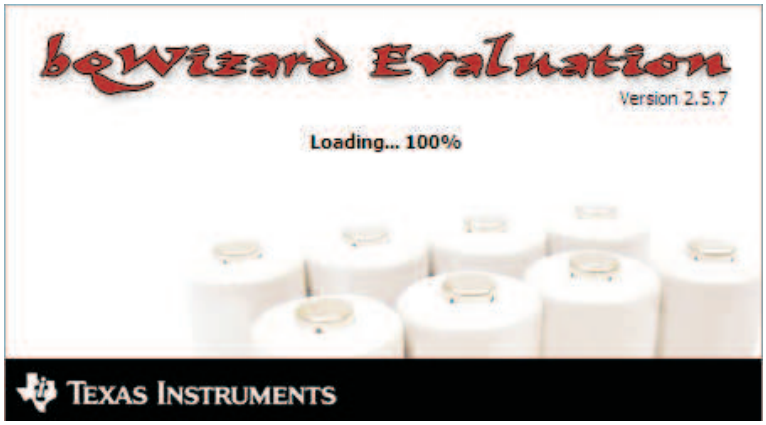


Figure 3. Proper "Loading" Percentage Start-up Screen

Figure 4. Proper "8 cells found" Start-up Screen.

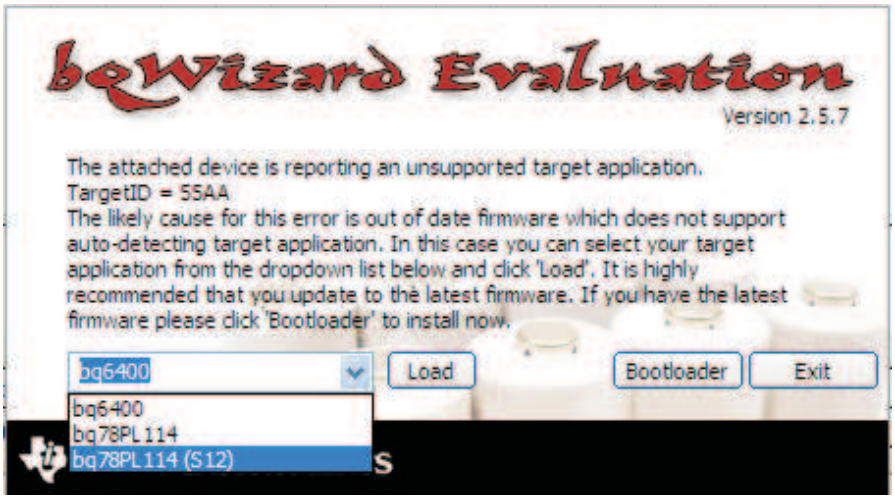


Figure 5. Choose Appropriate Firmware Configuration if Communication is Lost

3 Updating the Firmware to S12 Configuration

To update the device firmware, open the Instruction README text file located at: C:\Program Files\Texas Instruments\bqWizard 2.5\Documentation\Firmware Update Procedure.txt (This folder *C:\Program Files\Texas Instruments\bqWizard 2.5* folder is the default path created by the installation of the bqWizard™ software.)

The following excerpts and screen captures are copied beginning with Step 5 to show the process step-by-step. A detailed firmware update procedure is available on TI's E2E community Web site.

5) To load new firmware
   - Go to Bootstrap Loader dialog box: Main menu → Utilities → Bootstrap Loader Main menu → Commands → Read All Parameters - Turn on "Wired bit": Main Menu → Comma
   - Click on Select File button.
   - Browse to C:\Program Files\Texas Instruments\bqWizard 2.x\Configuration Files\Firmware.
   - Select FW_0001_0000_5000_0012.enc, and click on Open.
   - After returning to Bootstrap Loader dialog box, select Preserve Calibration box.
   - Click on Download button.
   - Save calibration data to a file.
   - After download is complete, approximately 50 s, close the Bootstrap Loader dialog box. Control returns to the bqWizard™ software.
   - Read all parameters: Main menu → Commands → Read All Parameters.
   - Turn on Wired bit: Main Menu → Commands → Toggle Wired Bit.
6) Configure Target Board
   - Configure temperature sensors and cell count: Main Menu → File → Pack Configuration → Load Configuration from File and Relearn.
   - Browse to C:\Program Files\Texas Instruments\bqWizard 2.x\Configuration Files\bq78PL114S12.
   - Select file that corresponds to your specific board configuration.
   - After download, the bqWizard™ software restarts and initializes
   - Read all parameters: Main menu → Commands → Read All Parameters
   - Go to Pack Configuration tab and verify that the parameters Actual Number of Cells and Temperature Sensor Count match your expectations.
   - Note that the temperature sensor count includes the sensor in the bq78PL114 package.

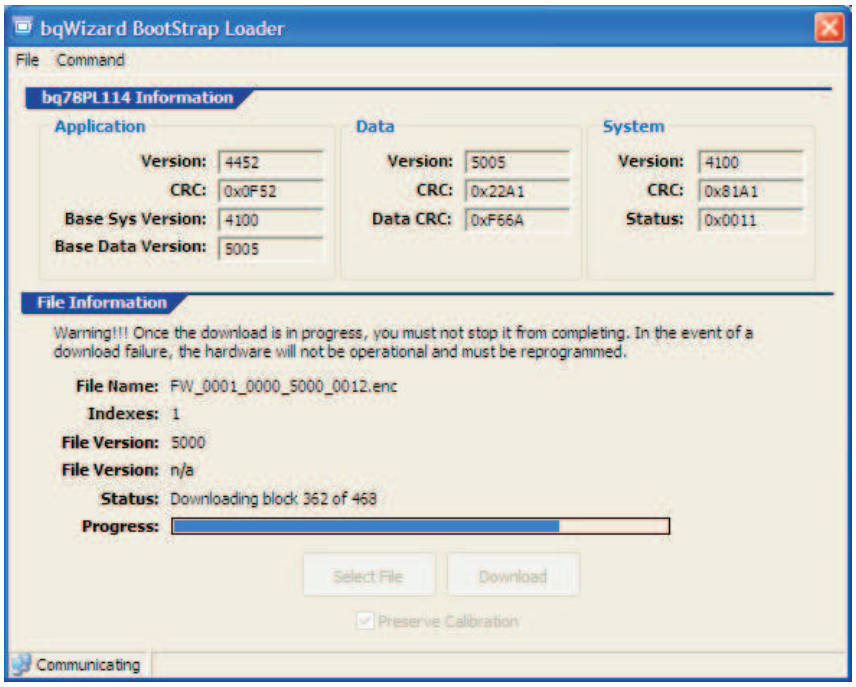


Figure 6. bqWizard BootStrap Loader to Program S12 Firmware.

Concerning Figure 6, be sure to choose the Preserve Calibration box as individual IC voltage readings are calibrated during assembly-test at TI.

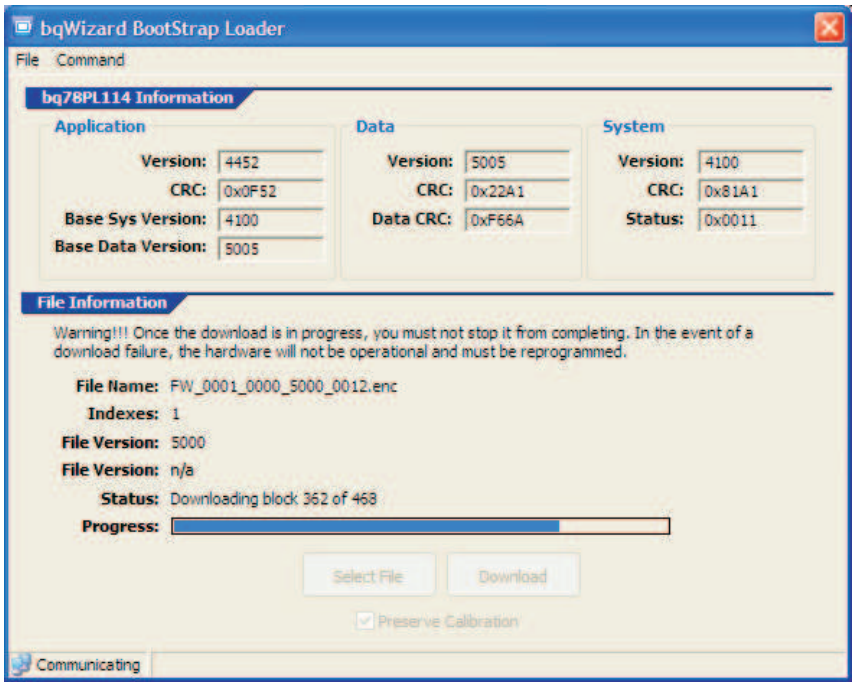


Figure 7. Progress Screen While Programming New Firmware S12

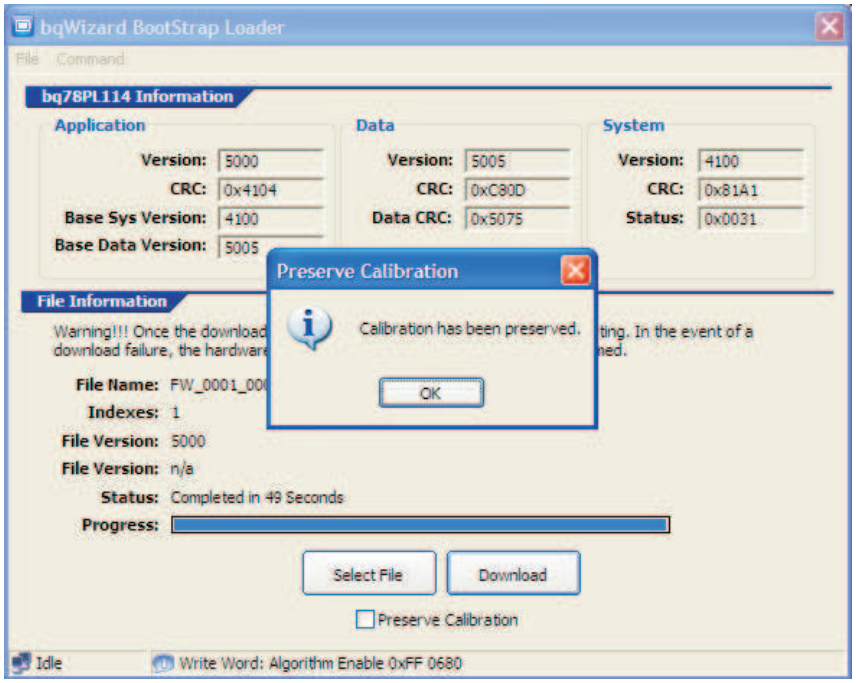


Figure 8. Firmware Process Completed Successfully

Figure 9. Click the Red X

As Figure 9 shows, close the Bootstrap Loader Window by clicking the red X in the upper right corner of the window.

Some issues may occur when trying to program the firmware. These errors can manifest themselves with error messages described via the five onboard LED indicators. The *bq78PL114 and bq78PL114S12 Technical Reference Manual* (SLUU330) explains the LED indicator messages.

4 Exploring the GUI Software Screens

Once the firmware has been updated, the user can start setting up the gas gauge with the proper configuration files.

The first step is to set the Wired Bit with the software.
Choose Commands from the File Menu, then choose Toggle Wired Bit or press the F7 key.

Next choose File → Pack Configuration → Load Configuration from File and Relearn…

In this example, a TMAP file is loaded for an 11s configuration. Figure 12 is the Home Screen after completing this operation.

shows individual screen captures of the different tabs that are selectable in the lower right portion of the screen (all tabs shown in Figure 13).

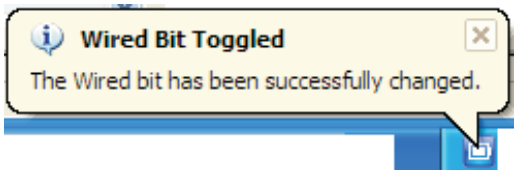


Figure 10. Successful Wired Bit Toggled Message

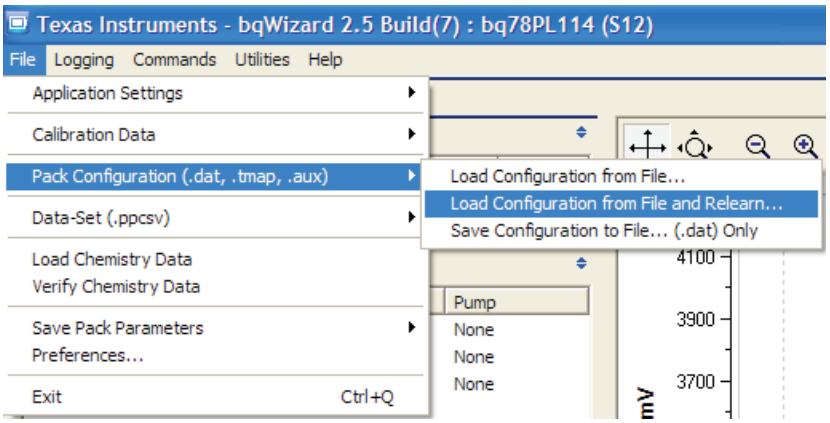


Figure 11. Loading Proper TMAP File for Your Pack's Configuration.

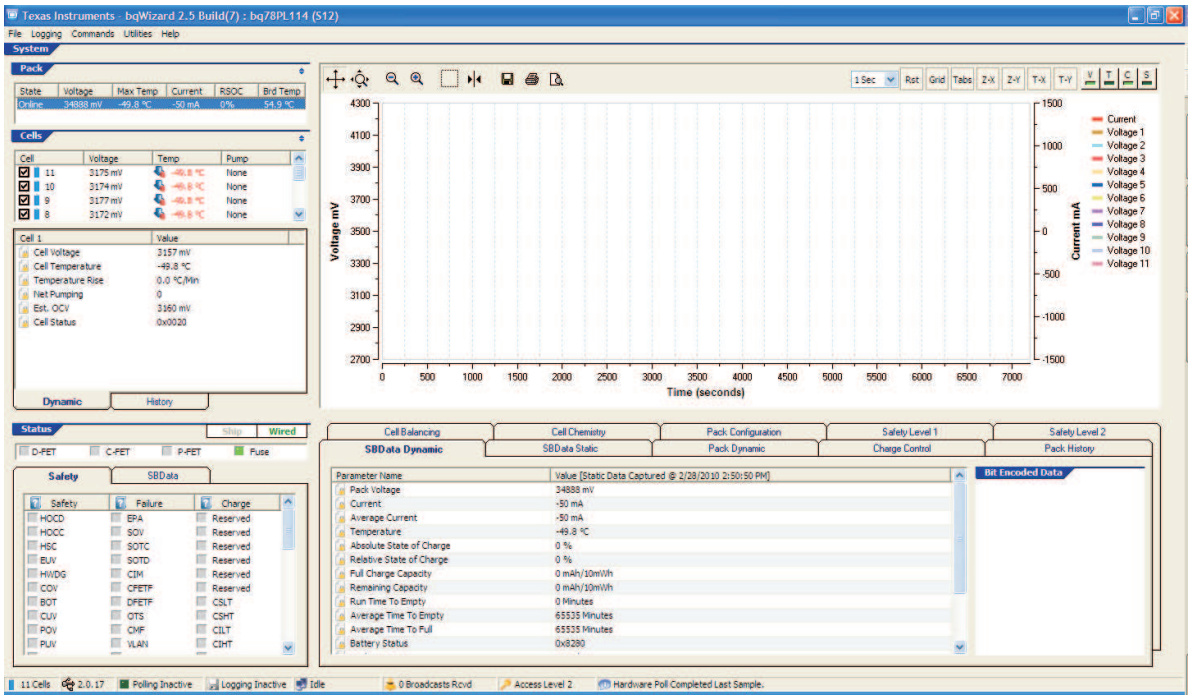


Figure 12. Home Screen After Loading 11s Configuration .TMAP File

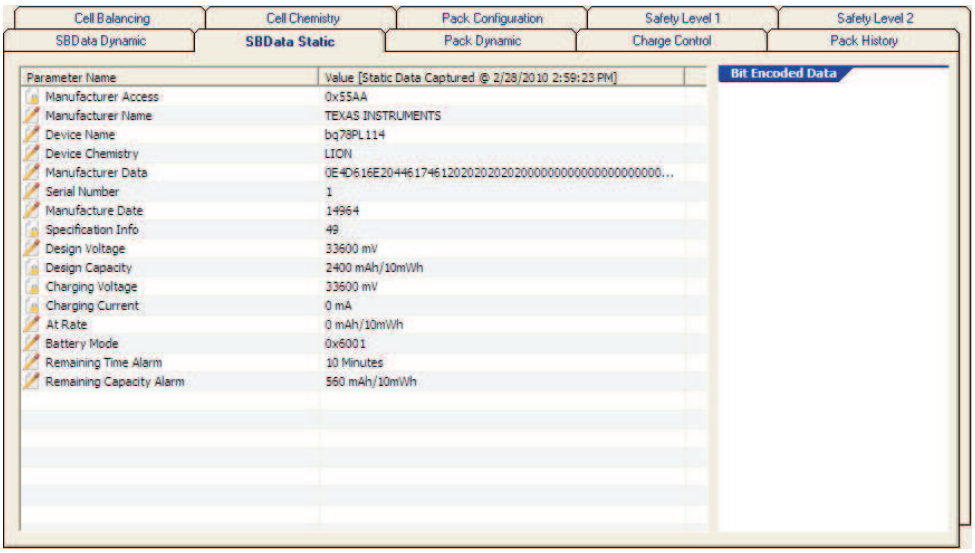


Figure 13. Pack Parameter and Settings Tabs

5 Updating the Chemistry File

To update the pack's chemistry identification file, choose File → Load Chemistry Data.

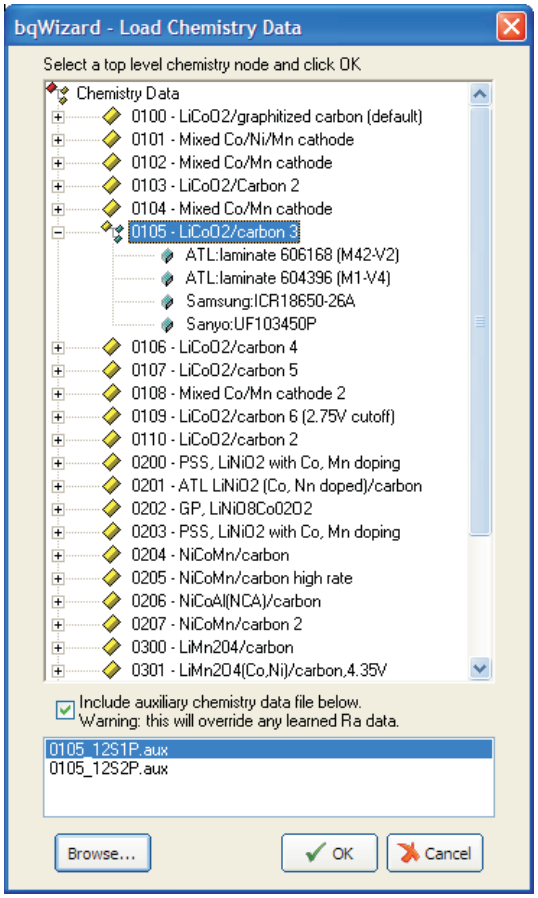


Figure 14. Chemistry Selection Window

6 Configuring the Gas Gauge

Initial communication with the gas gauge shows the external temperature measurements as 90°C which causes a safety fault condition. Several Safety flags are set in Figure 15. Note this home screen is for S12 version of Firmware.

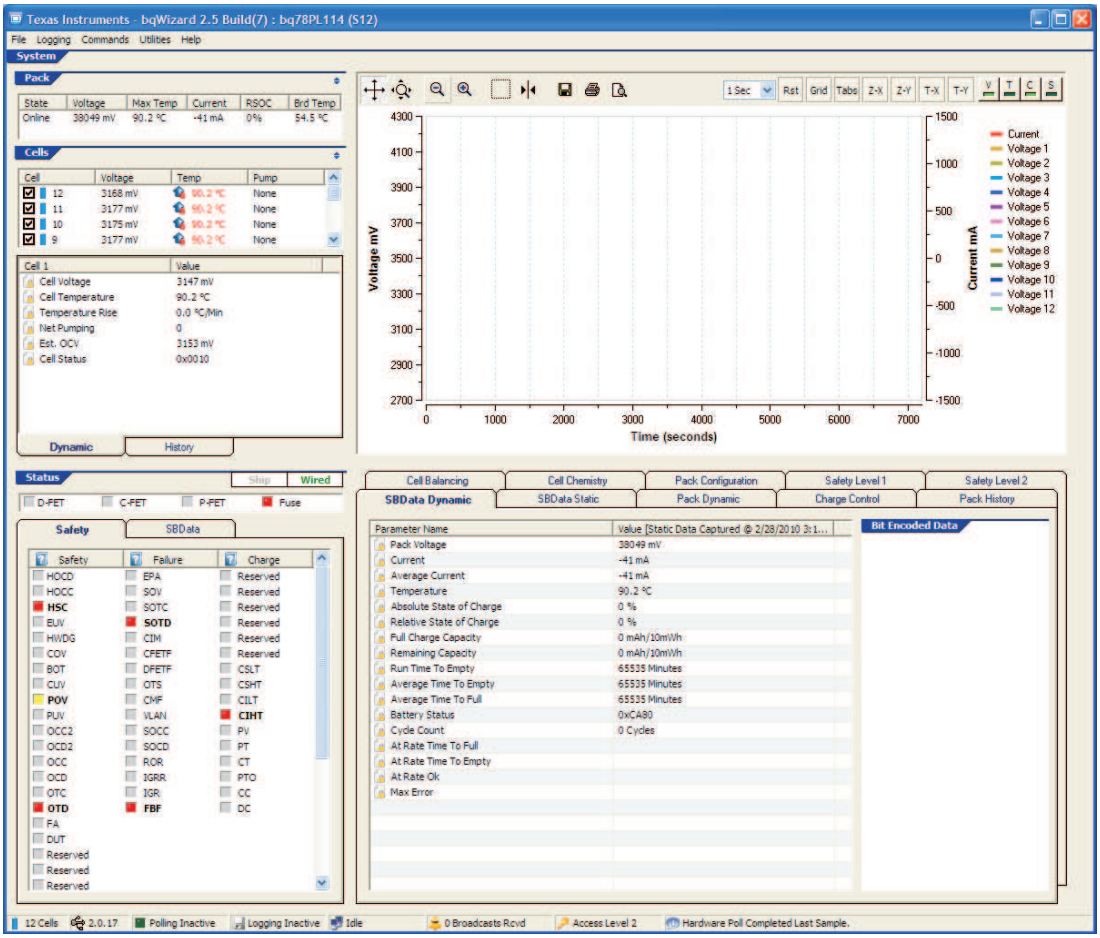
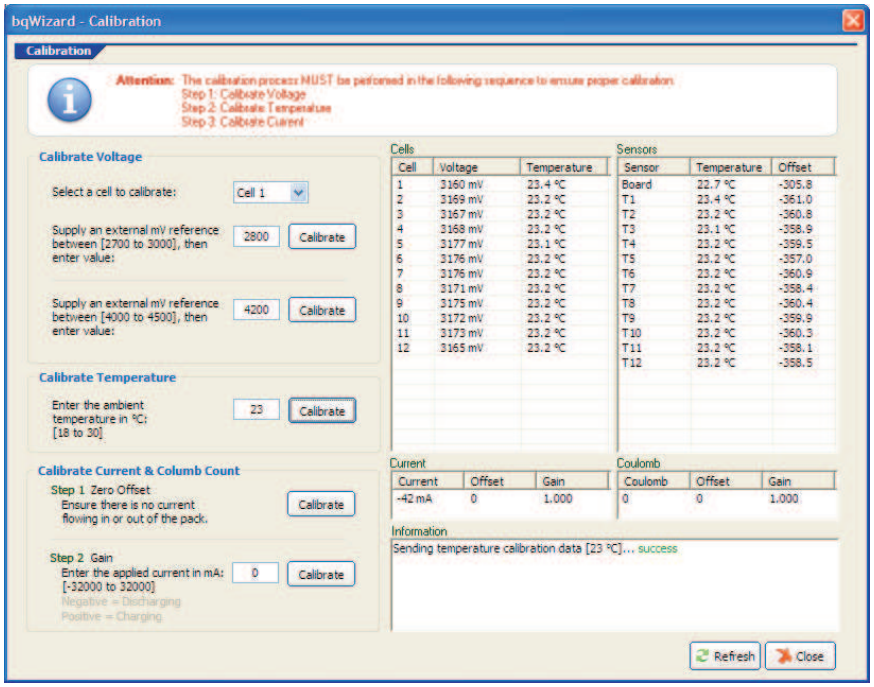


Figure 15. S12 Home Screen Showing Temperature Fault Condition

To fix this issue, choose Utilities → Calibration. Type the appropriate ambient temperature under the Calibrate Temperature section. In this example, 23°C ambient temperature has been entered. Voltage reading for the IC are calibrated during production at TI; so, do not attempt to calibrate the voltage unless necessary. The Calibrate Screen is shown in Figure 16. A relearn/initialize command overwrites any manual calibration that a user may have entered in cells 5-12 with the values stored in the bq76PL102s.

Close the calibrate screen, and then choose Read All Parameters or Poll Data. Figure 17 shows the updated home screen with proper temperature sensing.

Next, choose Commands → Reset Fuse. Figure 18 shows the updated home screen with the Fuse Status flag set green and no Safety flags set.



NOTE: Do NOT calibrate Voltage of IC unless necessary; voltage is calibrated during production.

Figure 16. Calibration Screen, Used to Update Temperature Reading to Room Temperature

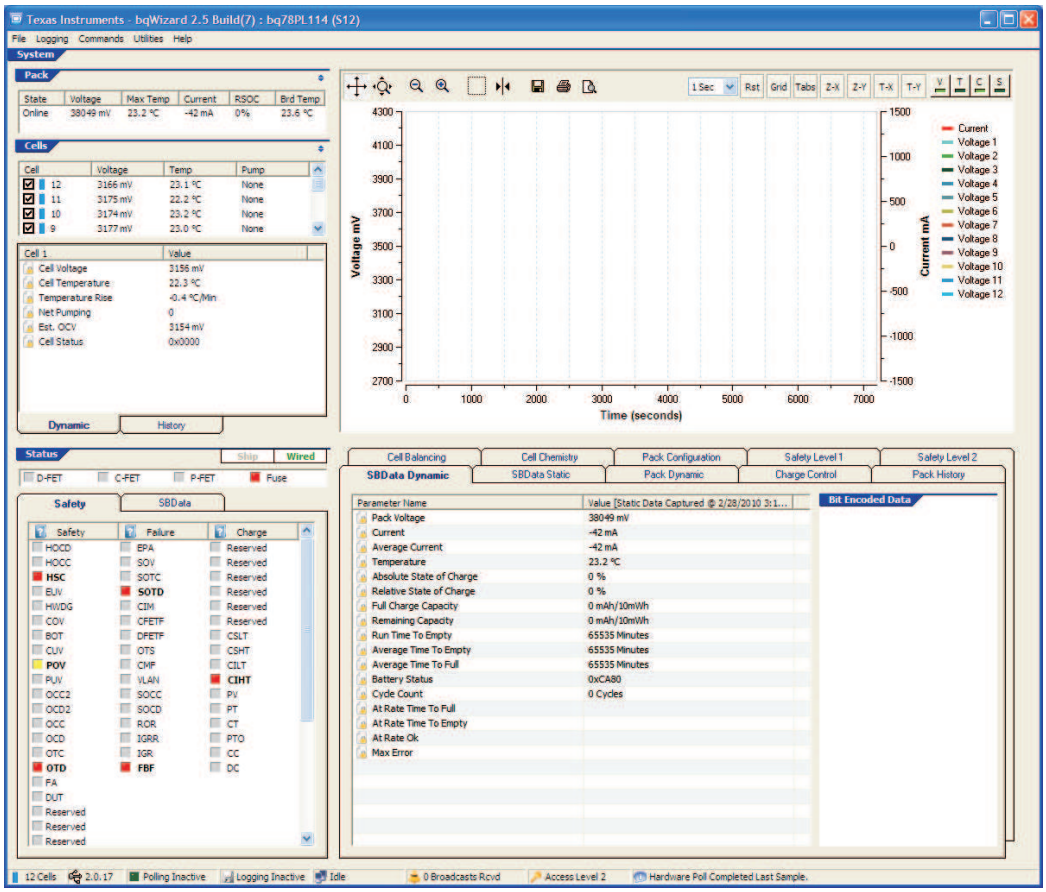


Figure 17. Home Screen Showing Correct Temperature Reading

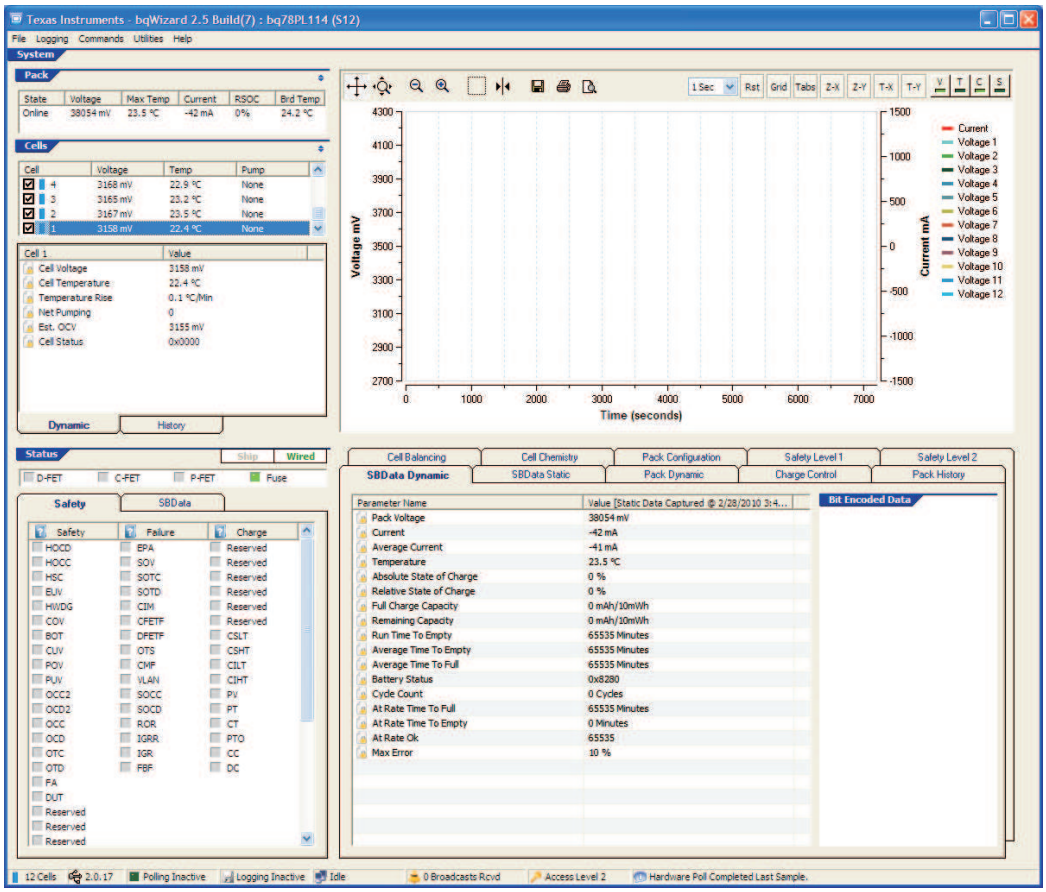


Figure 18. Home Screen Showing Fuse Reset and no Safety Flags

If the pack is at rest (not charging or discharging), the reported current is 0 mA. The Zero Offset current now can be calibrated. [Ensure that the pack is not being charged or discharged while calibrating the Zero Offset parameter.] Also, ensure that the sense resistor bits are programmed correctly for either (10 mΩ, 3 mΩ, or 1 mΩ) sense resistor. While using 1-mΩ sense resistor, all parameters are reported in tenths (i.e., a 1-A charge current is reported as 100 mA.

Click on the Calibrate button from Step 1 Zero Offset (Figure 19). Current Gain is also calibrated.

Next choose File → Read All Parameters from the Commands Menu (or Ctrl + R as the quick key.)

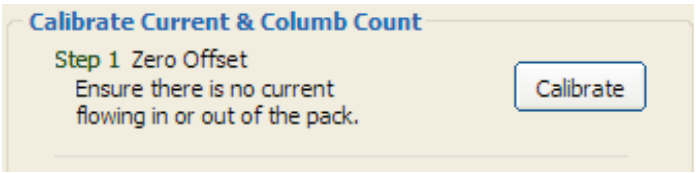


Figure 19. Calibrating 0-mA Offset While Pack is at Rest (no Charging or Discharging)

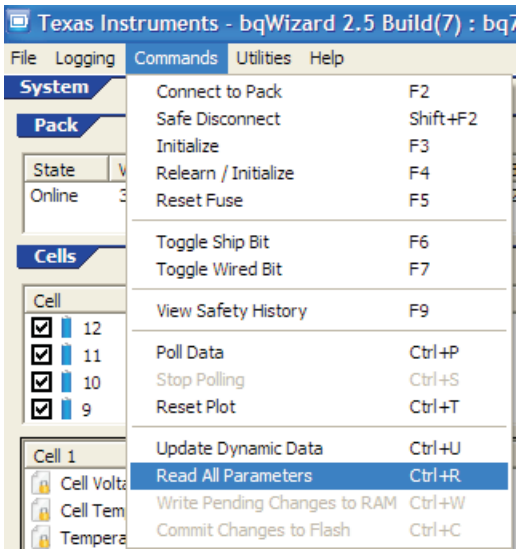


Figure 20. Read All Parameters to See All Data-Set Settings

All the Data-Set parameter settings for the gas gauge can be accessed through the .PPCSV file. Save the default .PPCSV by choosing File → Data-Set (.ppcsv) → Save Data-Set.

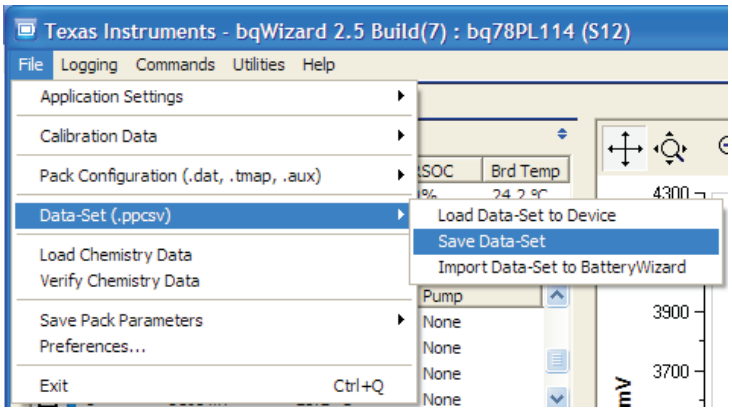


Figure 21. Save Data-Set Menu

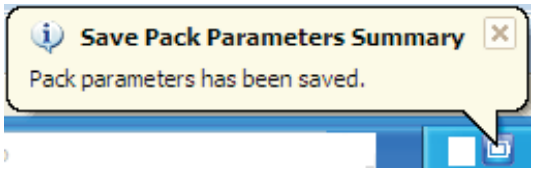


Figure 22. GUI Indication That .PPCSV File Has Been Successfully Saved

Now, modify the data-set settings in the .PPCSV file as appropriate for your pack, and then choose File → Load Data-Set (.ppcsv) → Load Data-Set To Device.

Pay special attention to the following Data-Set settings. The following example is configured for 12 series cells of standard 4.2-V, Li-ion chemistry (using S12 firmware version).

An entry that is "-1" or "0 seconds" indicates that a feature is disabled. (See Table 1)

Pay special attention to the following Data-Set parameters in the .PPCSV file.

Table 1. Data-Set Parameters to Review in Your S12 Design

Design Voltage,mV,44000
Charge Completion Pack Voltage Qualifier,mV,49200
Discharge Completion Pack Voltage Qualifier,mV,39600
<Charge Control>,3,
...
Charge Completion Pack Voltage Qualifier,mV,49200
...
Discharge Completion Pack Voltage Qualifier,mV,42000
...
FC Set SOC Threshold,%,98
FC Clear SOC Threshold,%,97
FD Set SOC Threshold,%,3
FD Clear SOC Threshold,%,4
FD Set Voltage,mV,40000
FD Clear Voltage,mV,40010
FD Set Voltage Time,Seconds,2
...
TDA Set SOC Threshold,%,4
TDA Set Voltage Threshold,mV,40000
TDA Set Voltage Time,Seconds,1
TDA Clear SOC Threshold,%,5
TDA Clear Voltage,mV,40020
TCA Set SOC Threshold,%,100
TCA Clear SOC Threshold,%,99
OCA Set Voltage,mV,51000
<Cell Chemistry>,6,
...
Default Charging Voltage,mV,50400
Default Charging Current,mA,2400
Capacity Algorithm,,0x0003
<Safety Level 1>,8,
...
POV Threshold,mV,51000
POV Recovery,mV,50400
POV Time,Seconds,6
PUV Threshold,mV,33600
PUV Recovery,mV,33700
PUV Time,Seconds,1

After loading the new Data-Set file, be sure to select Read All Parameters from the Commands drop-down menu.

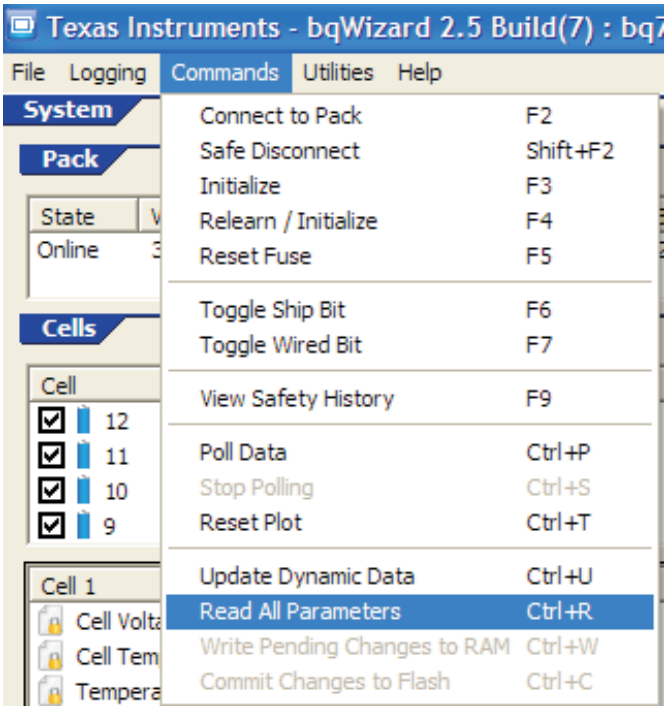


Figure 23. Select Read All Parameters Command After Importing a Data-Set .PPCSV File

7 Final Setup Steps for Evaluation

7.1 To Initialize Gas Gauge and Turn On Charge and Discharge FETs

1. Choose the Pack Configuration tab in the Data-Set. (Figure 24)
   Note: Ensure that the Wired bit is toggled on.
2. Double-click the Algorithm Enable line with the mouse. A secondary window opens. (Figure 25)
3. Uncheck the Inhibit Safety Rules box, and click OK. (Figure 25)
4. Next, from the Commands drop-down menu, choose Write Pending Changes to RAM CTRL+W (Choosing the Ctrl + W keys is the quick-key sequence to write changes to RAM.)
5. Finally, select Read All Parameters to update the home screen. (Figure 26 and Figure 27)

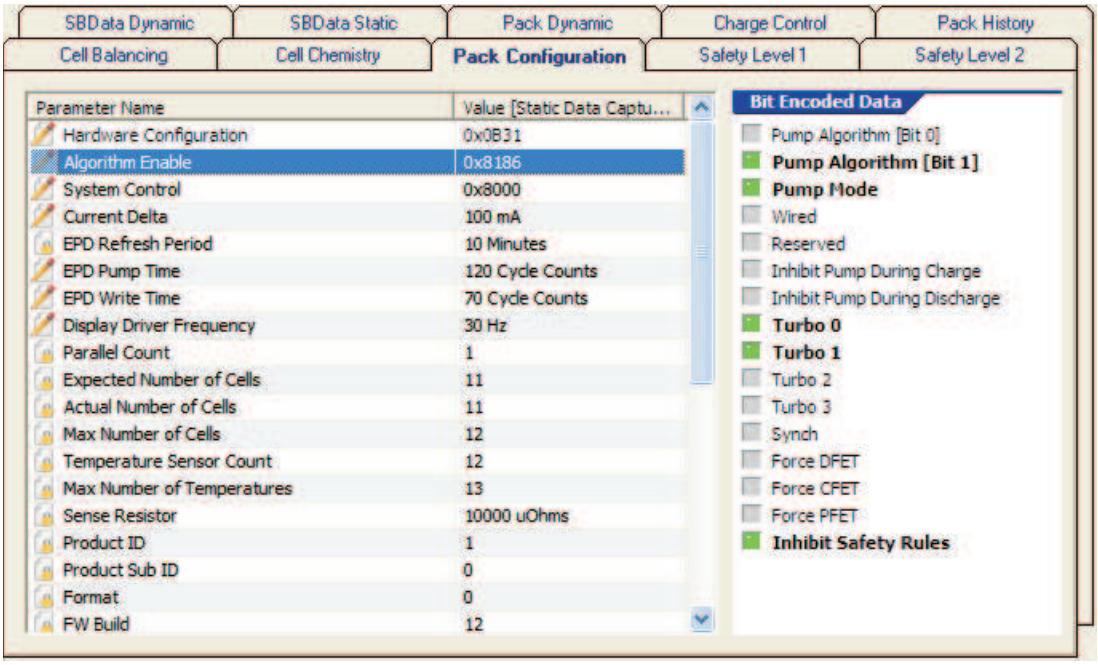


Figure 24. Algorithm Enable Configuration

Double-click Algorithm Enable parameter to open selection box.

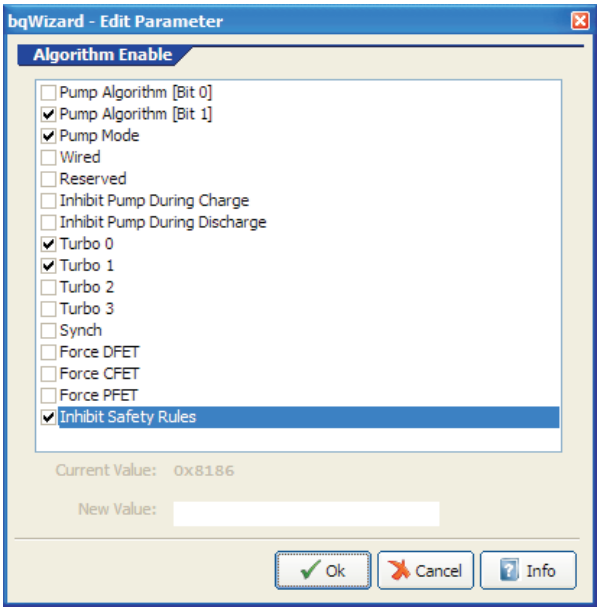


Figure 25. Enabling Charge and Discharge FETs

Uncheck Inhibit Safety Rules to enable Charge and Discharge FETs.

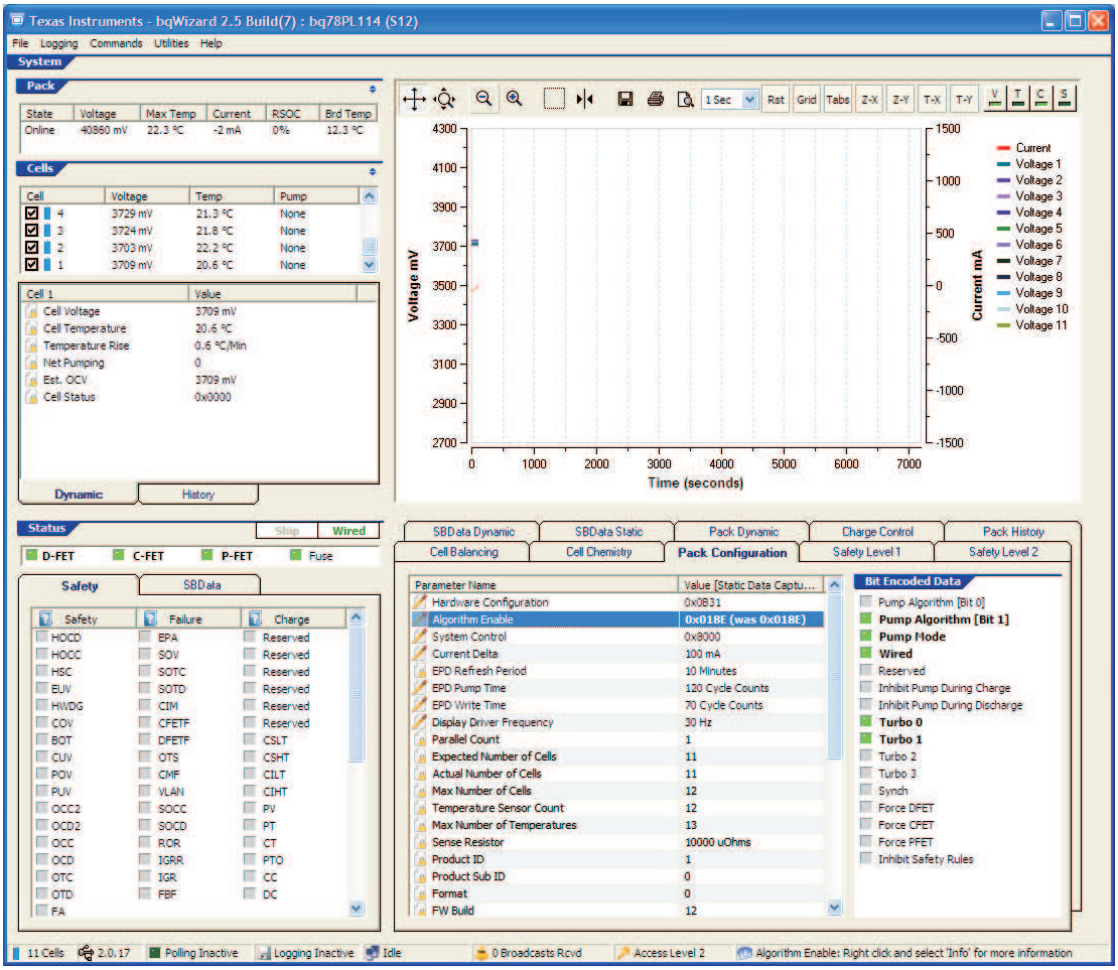


Figure 26. S12 Home Screen

Figure 26 shows the S12 home screen with the properly initialized gauge having the Charge and Discharge FETs turned on.

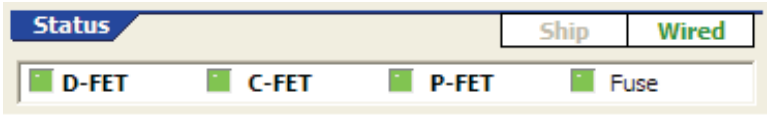


Figure 27. Zoom-in on Status Field

Figure 27 is a zoom-in on the Status field. Discharge (D-FET), Charge (C-FET) and Pre-charge (P-FET) MOSFETs are all on. Also, no FUSE error is indicated.

7.2 To Enable PowerPump™ Cell Balancing Feature:

1. Choose the Pack Configuration tab in the Data-Set. (Figure 24)
   Note: Ensure that the Wired bit is toggled on.
2. Double-click the System Control line with the mouse. A secondary window opens. (Figure 28)
3. Un-check the "Pump Disable" box and click OK. (Figure 28)
4. Next choose Commands → Write Pending Changes to RAM Ctrl + W
5. Select Read All Parameters to update the home screen. (Figure 26 and Figure 27)
6. Figure 29 shows cells 3 and 4 actively being balanced because their resting voltage is greater than Minimum Cell Differential For Balancing (default = 10 mV).

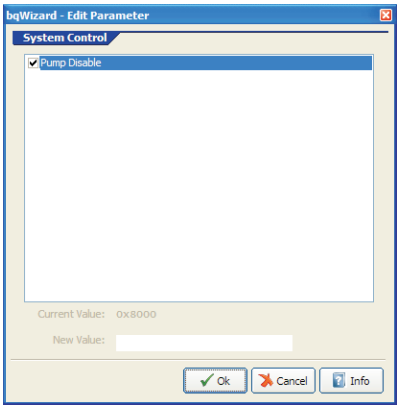


Figure 28. Enabling PowerPump™ Cell Balancing

Uncheck Pump Disable to enable PowerPump™ cell balancing.

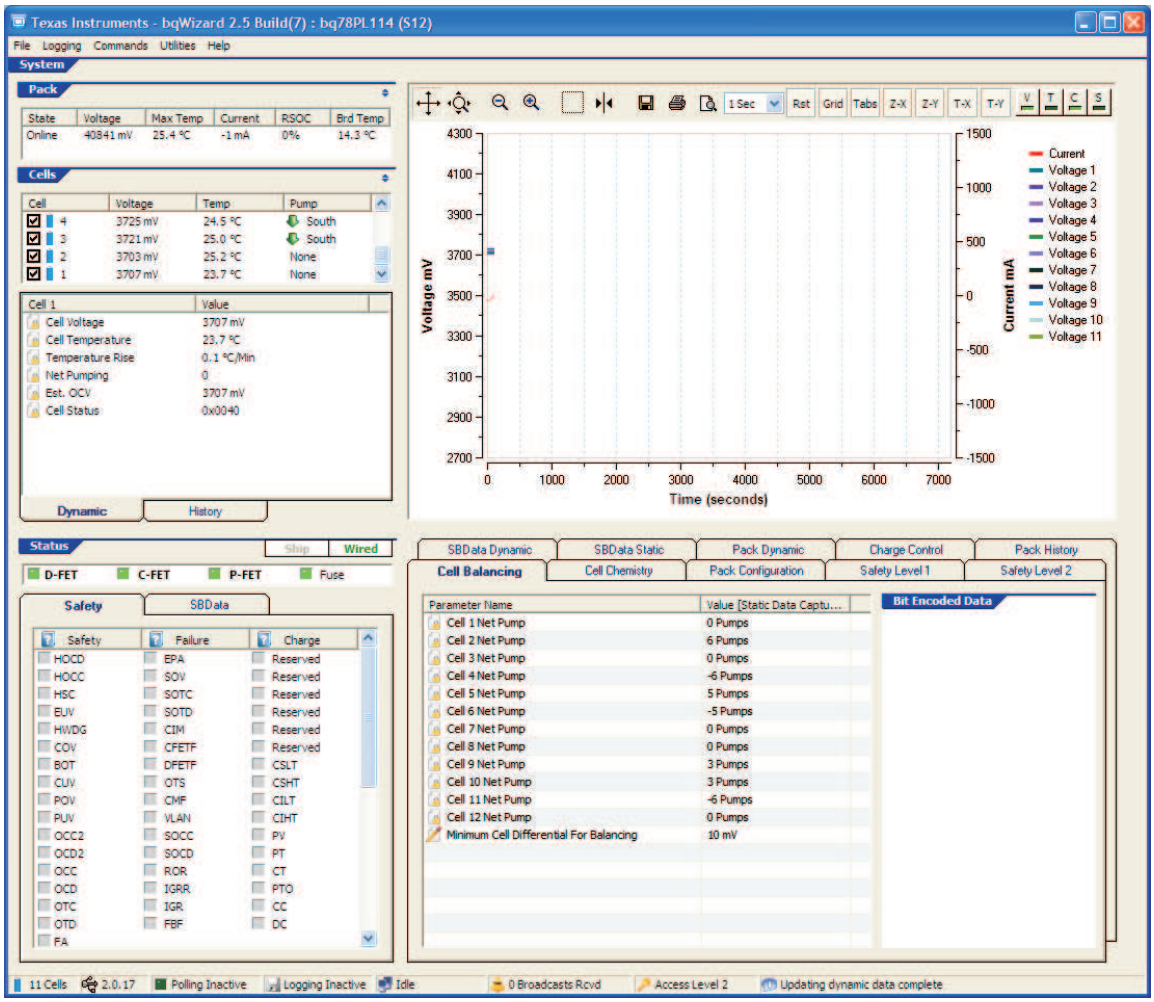


Figure 29. Home Screen Showing PowerPump™ Cell Balancing Active

Figure 29 shows that the PowerPump™ Cell Balancing is active. Cells 3 and 4 are actively balanced because their resting voltage is greater than Minimum Cell Differential For Balancing (default = 10 V).

7.3 Initializing the Pack

After completing configuration settings, choose Commands → Relearn / Initialize.

8 Setting Up Logging Data

Now that the pack is properly configured, it is time to set up the log files prior to exercising the pack.

8.1 Setup of Dynamic Data Log Definition File

This is done by choosing Logging → Generate Log Definition File. Scroll between available Logging Parameters by clicking the left or right arrow next to Available Parameters" heading.

Figure 30 shows the default/blank Log Definition Tool. After you create this file once, it can be reused. Figure 31 highlights the scroll-through arrows in the Log File Definition Tool.

Click on Generate File after choosing the Data-Set logging parameters. Only 30 parameters can be continuously monitored during logging. The 31st parameter indicated by the tool is a tick parameter that is automatically added to each file.

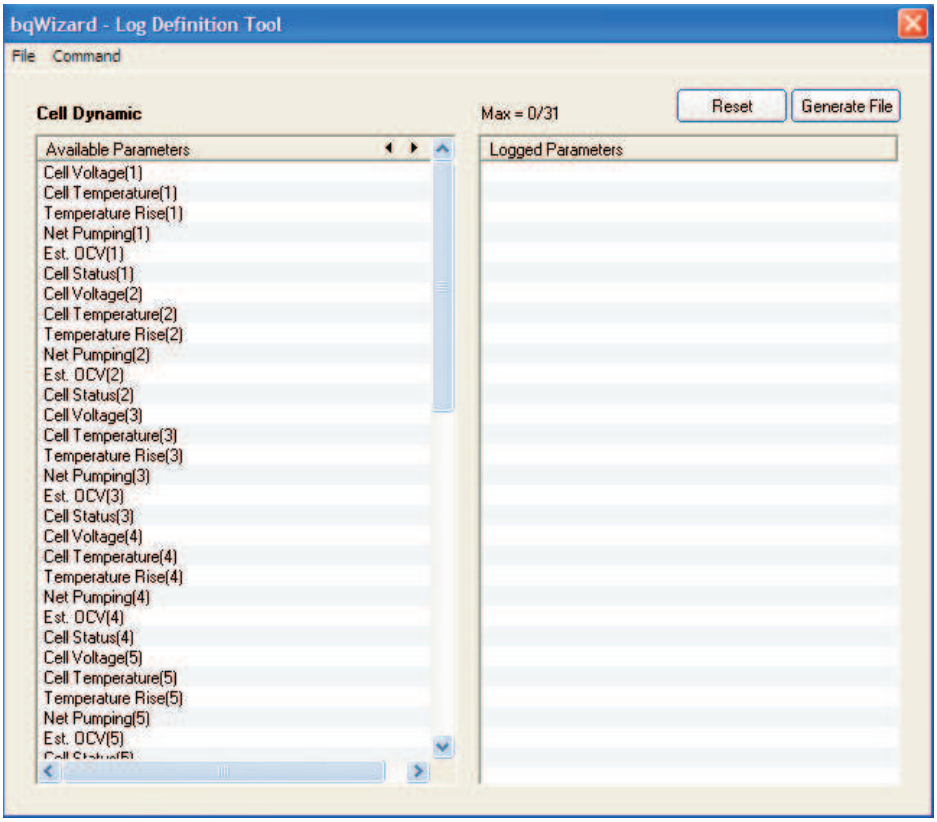


Figure 30. Default/Blank Log Definition Tool

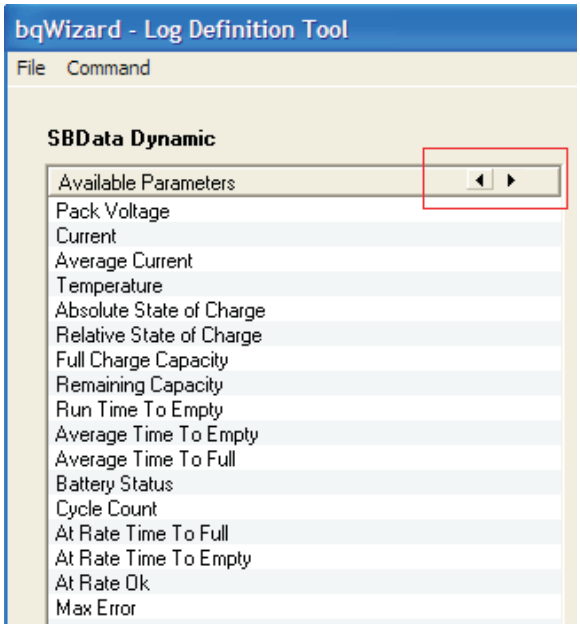


Figure 31. Available Logging Parameters

In Figure 31, scroll between available Logging Parameters by clicking the arrows highlighted by the red box.

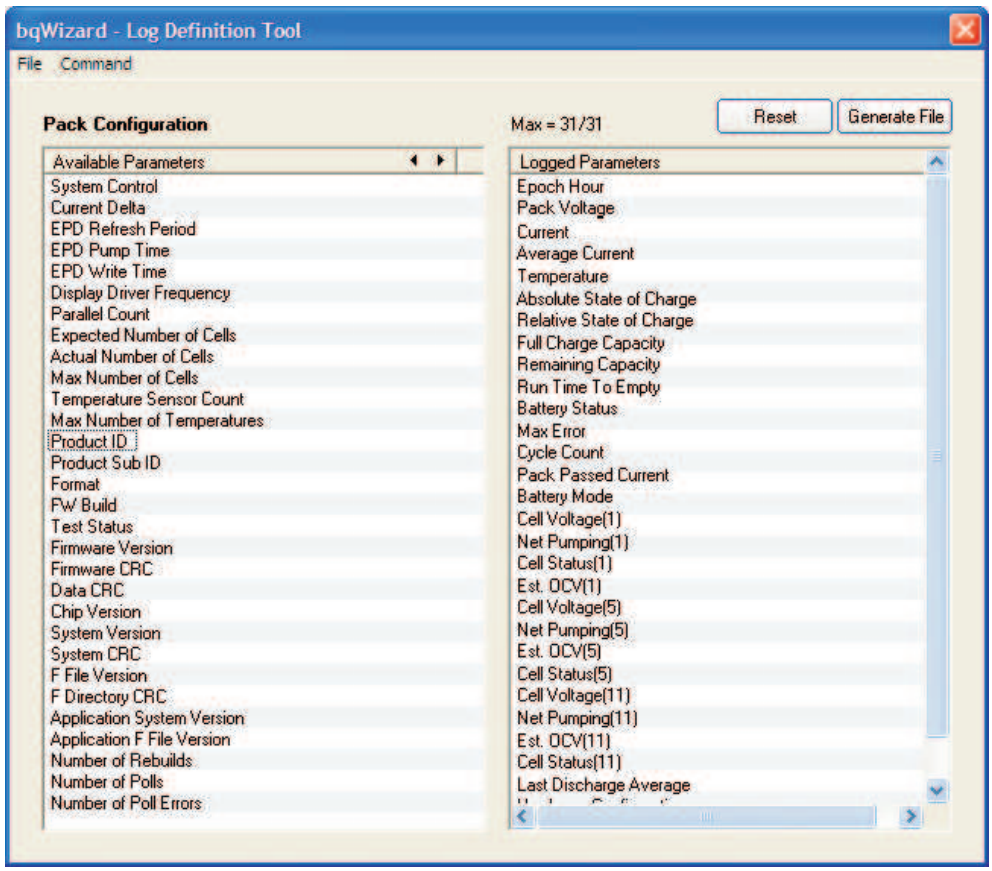


Figure 32. Configured Dynamic Log Definition File

Click Generate File when complete. Choose up to 31 parameters to log (Figure 32).

8.2 Data Logging Setup

This is done by choosing Logging → Configure…

Under the Dynamic Data Log Definition File section, click on the Select button and choose the .DLOG file you created in the preceding steps.

Under the Data Logging File section, click on the Select button and choose a filename with which to save your Data-Set log file.

Finally, choose Commands → Poll Data to begin the data logging process (Figure 34). The bqWizard™ software allows you to add comments to the log file during testing. This can be done by choosing Logging → Add Comment.

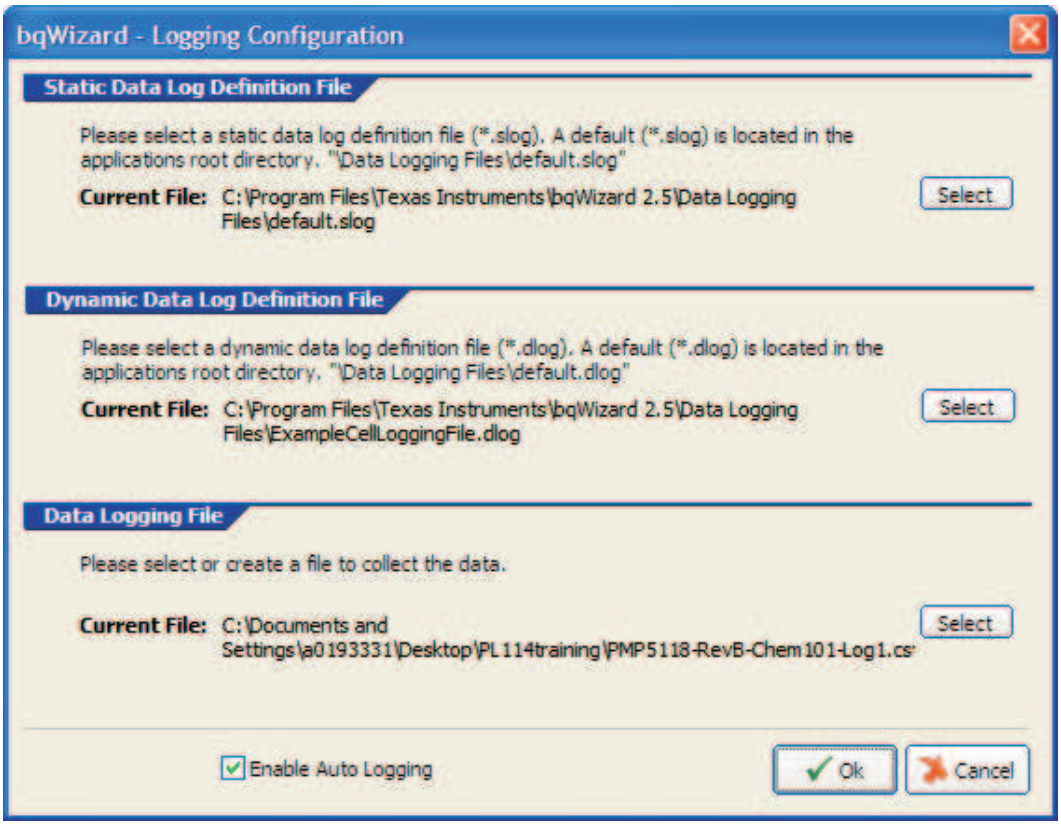


Figure 33. Data Logging Configuration Window in bqWizard™ Software

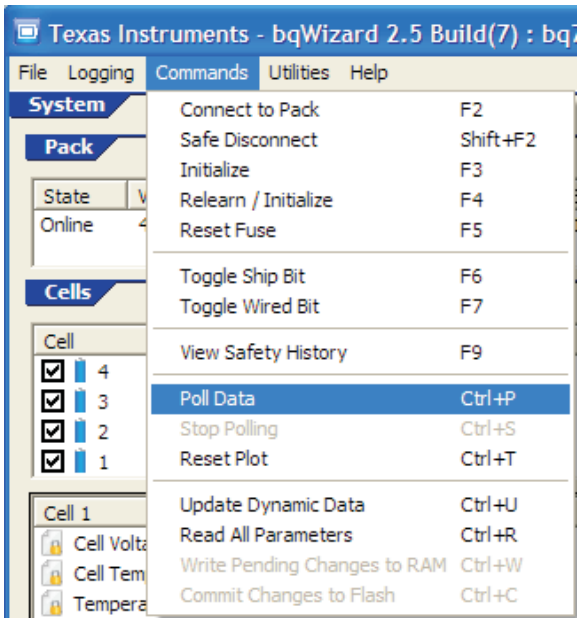


Figure 34. Choosing Poll Data From Commands Menu to Begin Logging

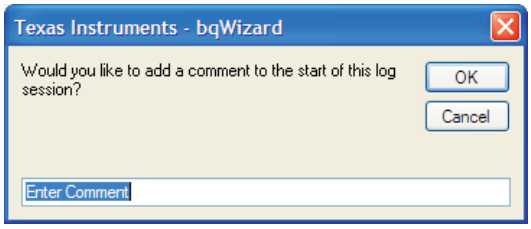


Figure 35. Entering Comments via bqWizard™ Software

The bqWizard™ software allows the designer to enter comments throughout the log process. To add more comments, the designer chooses the Logging → Add Comment menu during testing (Figure 35).

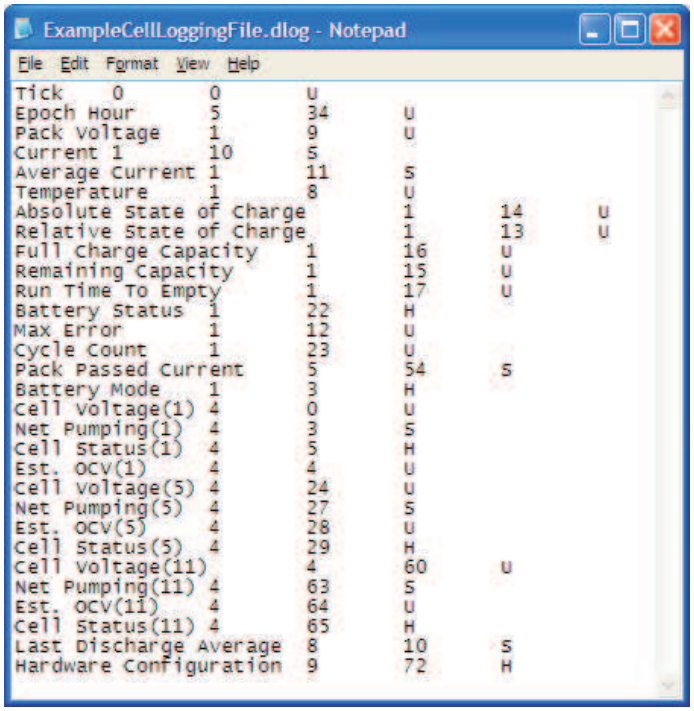


Figure 36. Example of Dynamic Log File for an 11s Battery Pack

9 Final Comments Concerning Evaluation

Always be sure to log data during testing. Confirm that the log file content is correct by copying and pasting the .CSV file, and opening with Microsoft™ Excel™.

Use a standard bench power supply for charging your battery and testing functionality with the simulation resistor string on PMP5118-RevB. First, set the voltage of the bench supply using a precise digital multimeter to precisely 4.2 V/cell multiplied by the number of cells (or whatever the appropriate charge voltage is for your specific cell, 4.1 V, etc.). After you have set the appropriate charge voltage, next short-circuit the positive and negative leads from the bench power supply and limit the current to an appropriate level (usually not greater than a 1C rate determined by the packs battery cells). If the current limit is set high, you may see a spark. After this procedure, you can connect to PACK+ and GND connections (shown in PMP5118-RevB) and properly charge a Li-ion battery with constant current, followed by constant voltage profile.

See the application report *Chemistry Selection for bq78PL114* (SLUA505) for additional information on configuring the gas gauge, as well as the data collection process for defining a .AUX for your battery pack.

Appendix A .PPCSV Data-Set File Export From S12 Firmware

Table 2. .PPCSV Data-Set File Export From S12 Firmware

<SBData Static>,1,
Manufacturer Name,,TEXAS INSTRUMENTS
Device Name,,bq78PL114
Device Chemistry,,LION
Manufacturer Data,,0E4D616E204461746120202020202000000000000000000000000000000000000000
Serial Number,,1
Manufacture Date,,14964
Design Voltage,mV,33600
At Rate,mAh/10mWh,0
Battery Mode,,0x6001
Remaining Time Alarm,Minutes,10
Remaining Capacity Alarm,mAh/10mWh,560
<Charge Control>,3,
Pre-Charge Temperature,Kelvin,273
Pre-Charge Voltage,mV,3000
Pre-Charge Recovery,mV,3100
Pre-Charge Current,mA,240
Charge Inhibit Temperature Low,Kelvin,273
Charge Inhibit Temperature High,Kelvin,318
Charge Inhibit Recovery Temperature Low,Kelvin,278
Charge Inhibit Recovery Temperature High,Kelvin,313
Charge Suspend Temperature Low,Kelvin,278
Charge Suspend Recovery Temperature Low,Kelvin,283
Charge Suspend Temperature High,Kelvin,333
Charge Suspend Recovery Temperature High,Kelvin,328
Charge Completion Pack Voltage Qualifier,mV,32800
Charge Completion Taper Current Qualifier,mA,240
Charge Completion Time,Seconds RDTE,10
Charge Completion FET Activation Time,Seconds RDTE,10
Discharge Completion Pack Voltage Qualifier,mV,24800
Discharge Completion Time,Seconds RDTE,4
Discharge Completion FET Activation Time,Seconds RDTE,6
Discharge Under Temperature,Kelvin,263
Discharge Under Temperature Recovery,Kelvin,273
Discharge Under Temperature Time,Seconds RDTE,2
FC Set SOC Threshold,%,-1
FC Clear SOC Threshold,%,-1
FD Set SOC Threshold,%,-1
FD Clear SOC Threshold,%,-1
FD Set Voltage,mV,24800
FD Clear Voltage,mV,25600
FD Set Voltage Time,Seconds,0
Transition to Idle Current,mA,50
Transition to Idle Time,Seconds,30
Transition to Discharge Current,mA,-75
Transition to Charge Current,mA,75
Cell Shutdown Voltage,mV,2500
Design Capacity mAh,mAHrs,2400
Design Capacity 10mWh,10mWh,6912

Table 2. .PPCSV Data-Set File Export From S12 Firmware (continued)

TDA Set SOC Threshold,%,-1
TDA Set Voltage Threshold,mV,25600
TDA Set Voltage Time,Seconds,0
TDA Clear SOC Threshold,%,-1
TDA Clear Voltage,mV,29600
TCA Set SOC Threshold,%,-1
TCA Clear SOC Threshold,%,-1
OCA Set Voltage,mV,34400
OCA Activation Time,Seconds RDTE,2

<Cell Balancing>,5,
Minimum Cell Differential For Balancing,mV,10

<Cell Chemistry>,6,
Chemistry ID,,105
FCC Learn Qualifier,%,30
Cycle Fade,%,0.05
Min OCV Slope,mV/% RSOC,2
OCV Idle Qualifier,Minutes,30
Stale FCC Timeout,Minutes,2880
Default Charging Voltage,mV,33600
Default Charging Current,mA,1680
Capacity Algorithm,,0x0003
User Rate,mA,1000

<Pack Configuration>,7,
Hardware Configuration,,0x0731
Algorithm Enable,,0x800E
System Control,,0x8000
Current Delta,mA,100
EPD Pump Time,Cycle Counts,120
EPD Write Time,Cycle Counts,70
Display Driver Frequency,Hz,30
Product Sub ID,,0

<Safety Level 1>,8,
COV Threshold,mV,4250
COV Recovery,mV,4100
COV High Temperature Threshold,mV,4250
COV High Temperature Adjust,Kelvin,323
COV Time,Seconds,2
CUV Threshold,mV,2700
CUV Recovery,mV,3000
CUV Time,Seconds,1
POV Threshold,mV,34000
POV Recovery,mV,32800
POV Time,Seconds,6
PUV Threshold,mV,22400
PUV Recovery,mV,24000
PUV Time,Seconds,1
OC Charge Tier 1 Threshold,mA,4800
OC Charge Tier 1 Recovery,Seconds,2
OC Charge Tier 1 Time,Seconds,6
OC Discharge Tier 1 Threshold,mA,-7200
OC Discharge Tier 1 Recovery,Seconds,2
OC Discharge Tier 1 Time,Seconds,8

Table 2. .PPCSV Data-Set File Export From S12 Firmware (continued)

OC Charge Tier 2 Threshold,mA,5200
OC Charge Tier 2 Recovery,Seconds,8
OC Charge Tier 2 Time,Seconds,2
OC Discharge Tier 2 Threshold,mA,-9600
OC Discharge Tier 2 Recovery,Seconds,8
OC Discharge Tier 2 Time,Seconds,1
OC Max Attempts,,3
Hardware OC Charge Threshold,,211
Hardware OC Charge Recovery,Seconds,1
Hardware OC Charge Time,,60
Hardware OC Discharge Threshold,,98
Hardware OC Discharge Recovery,Seconds,1
Hardware OC Discharge Time,,37
HOC Max Attempts,,3
Hardware Short Circuit Threshold,,47
Hardware Short Circuit Recovery,Seconds,8
Hardware Short Circuit Time,,3
HSC Max Attempts,,3
EUV Threshold,mV,2500
EUV Time,Seconds,2
EUV Recovery,mV,2900
OT Charge Threshold,Kelvin,323
OT Charge Recovery,Kelvin,318
OT Charge Time,Seconds RDTE,2
OT Discharge Threshold,Kelvin,333
OT Discharge Recovery,Kelvin,323
OT Discharge Time,Seconds RDTE,2
Host Watchdog Timeout,Seconds RDTE,0
Board Over Temperature,Kelvin,358
Board Over Temperature Recovery,Kelvin,338
Board Over Temperature Time,Seconds RDTE,2
Hardware LP Discharge Threshold,,32
Hardware LP Discharge Duration,,127
Hardware LP Charge Threshold,,224
Hardware LP Charge Duration,,127

<Safety Level 2>,9,
SOV Threshold,mV,4350
SOV Time,Seconds RDTE,8
Cell Imbalance Current,mA,50
Cell Imbalance Fail Voltage,mV,500
Cell Imbalance Time,Seconds,180
Cell Imbalance SOC Inhibit Threshold,%,30
SOC Charge Threshold,mA,6000
SOC Charge Time,Seconds RDTE,2
SOC Discharge Threshold,mA,-12000
SOC Discharge Time,Seconds RDTE,2
SOT Charge Threshold,Kelvin,343
SOT Charge Time,Seconds RDTE,2
SOT Discharge Threshold,Kelvin,343
SOT Discharge Time,Seconds RDTE,2
Open Temperature Sensor Threshold,Kelvin,233
Open Temperature Sensor Time,Seconds RDTE,2
FET Fail Time,Seconds RDTE,2

Table 2. .PPCSV Data-Set File Export From S12 Firmware (continued)

Fuse Fail Limit,mA,40
Fuse Fail Time,Seconds RDTE,2
VLAN Fail Time,Seconds RDTE,2
Current Measurement Fail Time,Seconds RDTE,10
Pre-Charge Voltage Timeout,Seconds RDTE,900
Charge Duration Timeout,Seconds RDTE,14400
IGR Limit,,200
IGR Fail Count,,255
IGR Ratio Limit,,120
IGR Ratio Fail Count,,255
Rate Limit Threshold,,200
Rate Limit Activation Count,,100

Appendix B Default Data-Set Screen Captures From bqWizard™ GUI for S12 Firmware

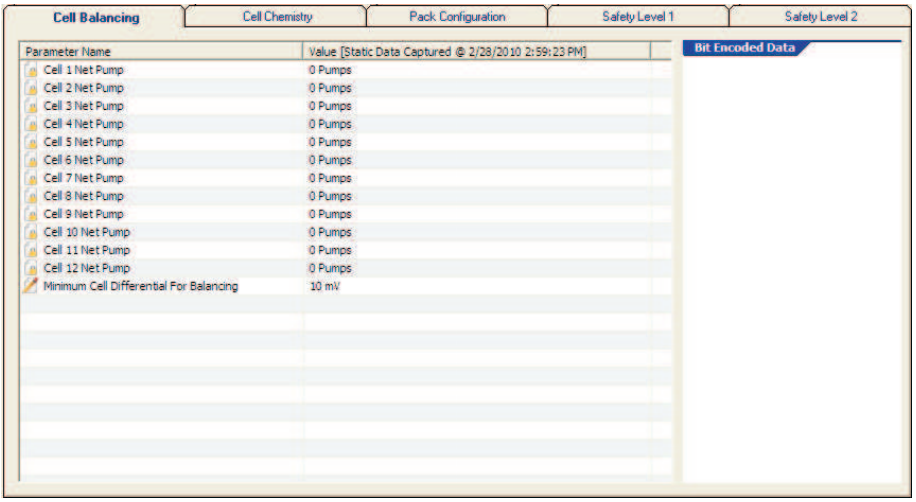


Figure 37. Cell Balancing Data-Set Tab

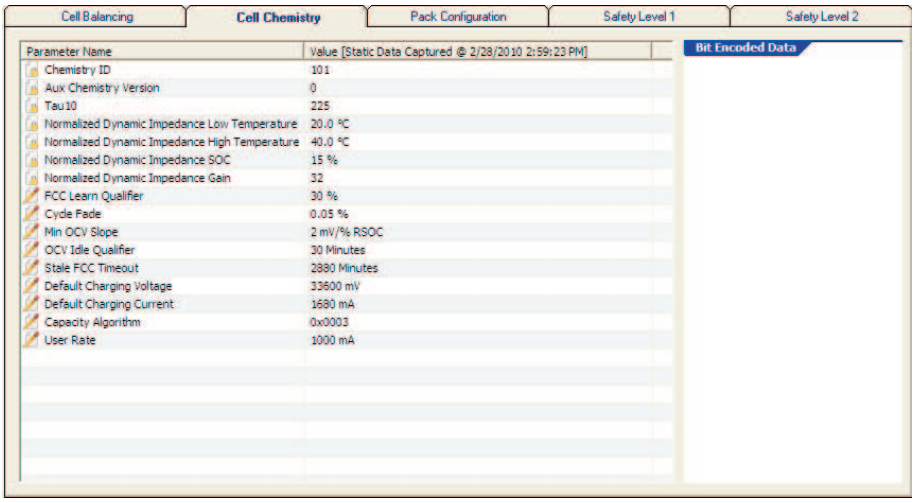


Figure 38. Cell Chemistry Data-Set Tab

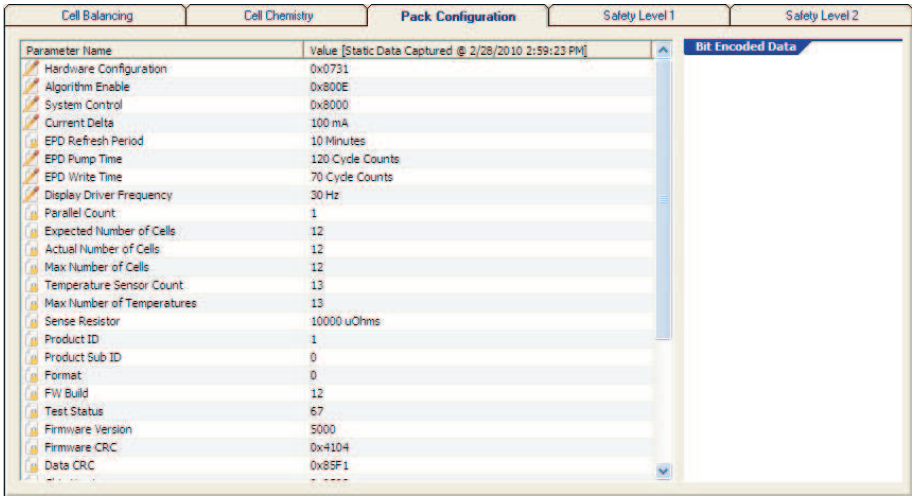


Figure 39. Pack Configuration Data-Set Tab

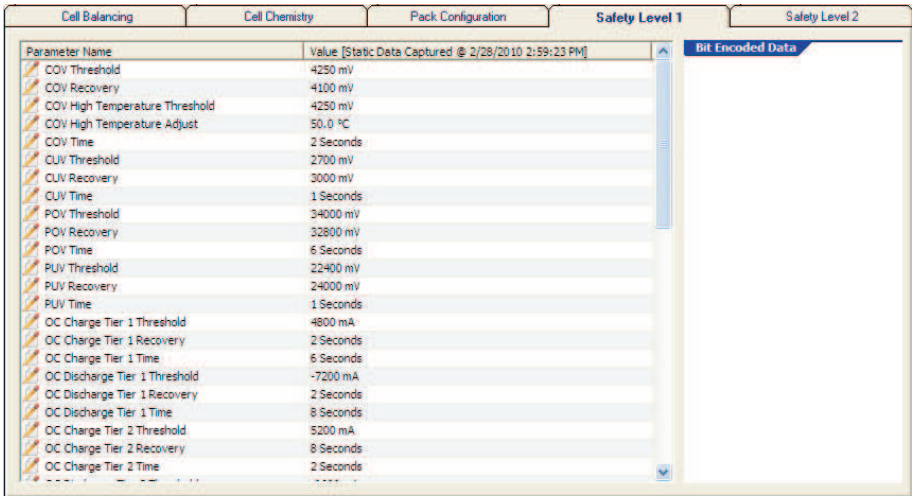


Figure 40. Safety Level 1 Data-Set Tab

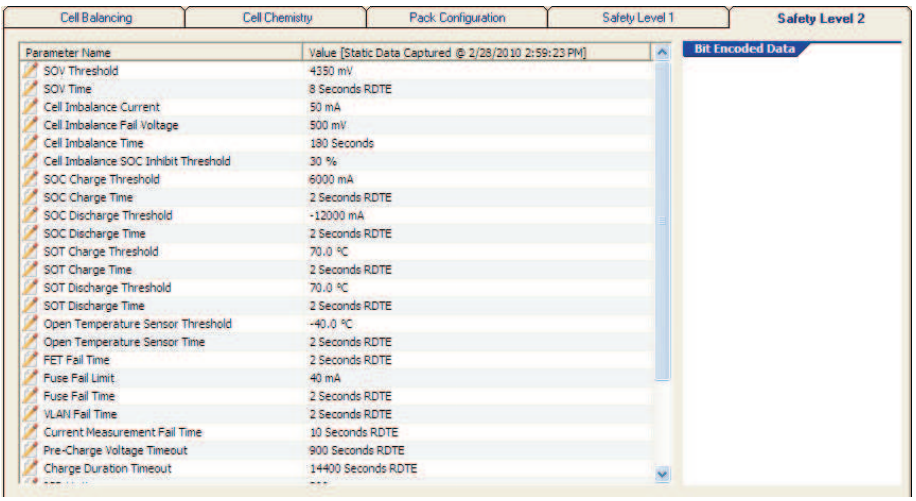


Figure 41. Safety Level 2 Data-Set Tab

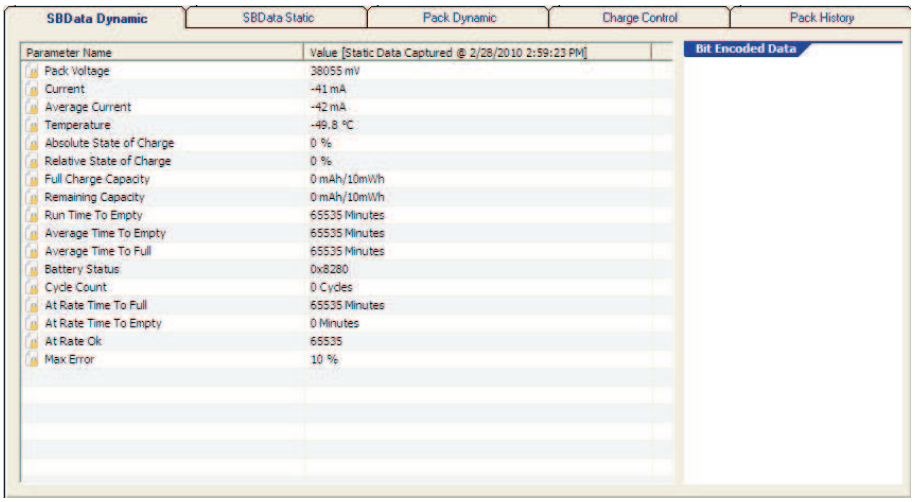


Figure 42. SBData Dynamic Data-Set Tab

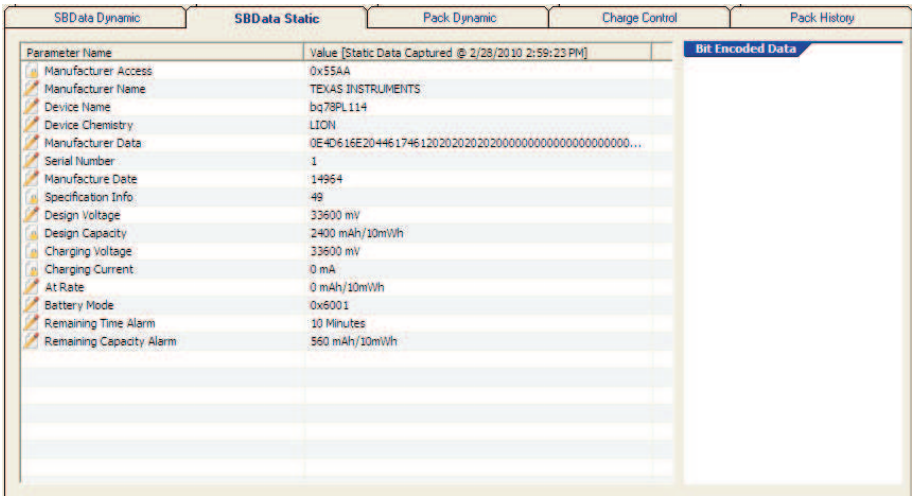


Figure 43. SBData Static Data-Set Tab

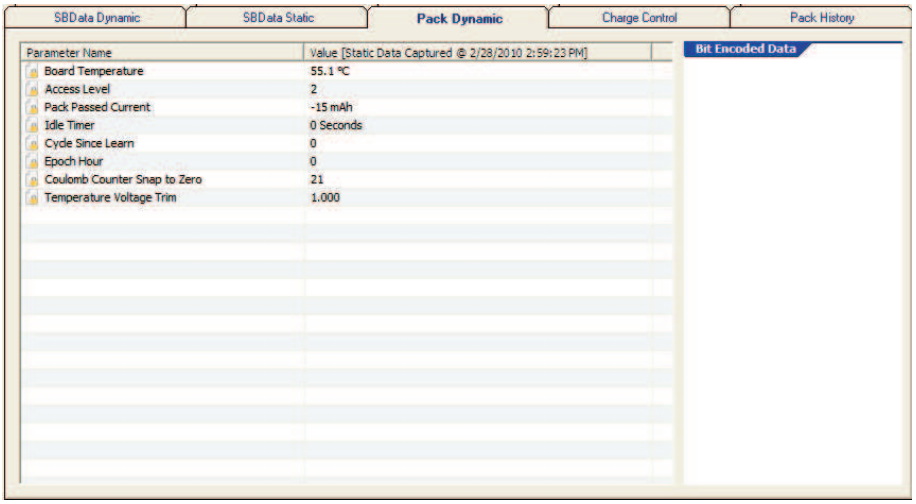


Figure 44. Pack Dynamic Data-Set Tab

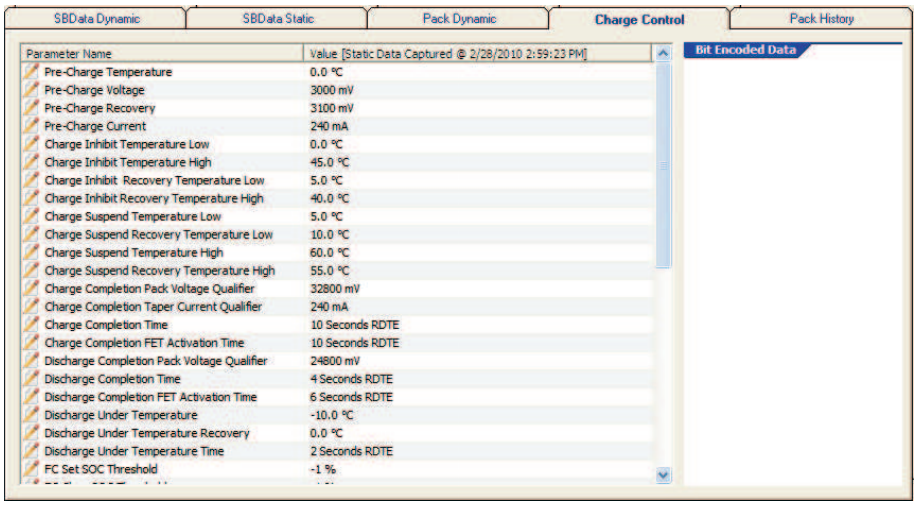


Figure 45. Charge Control Data-Set Tab

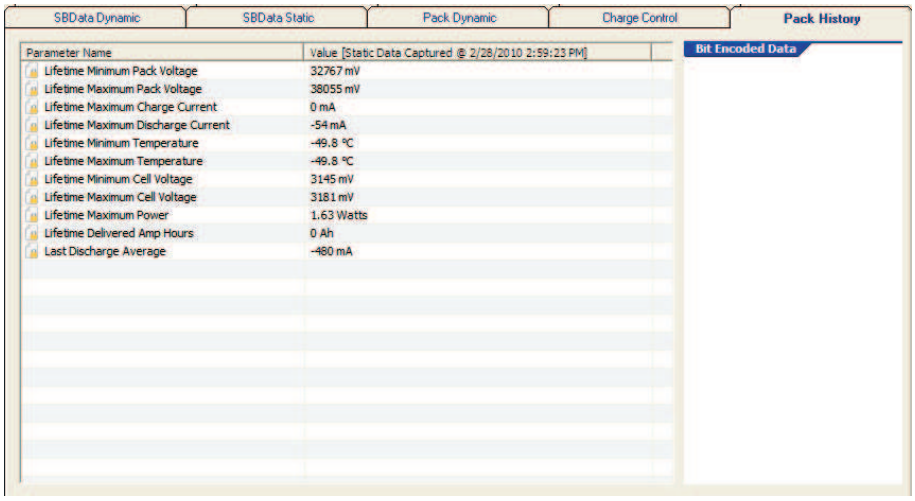
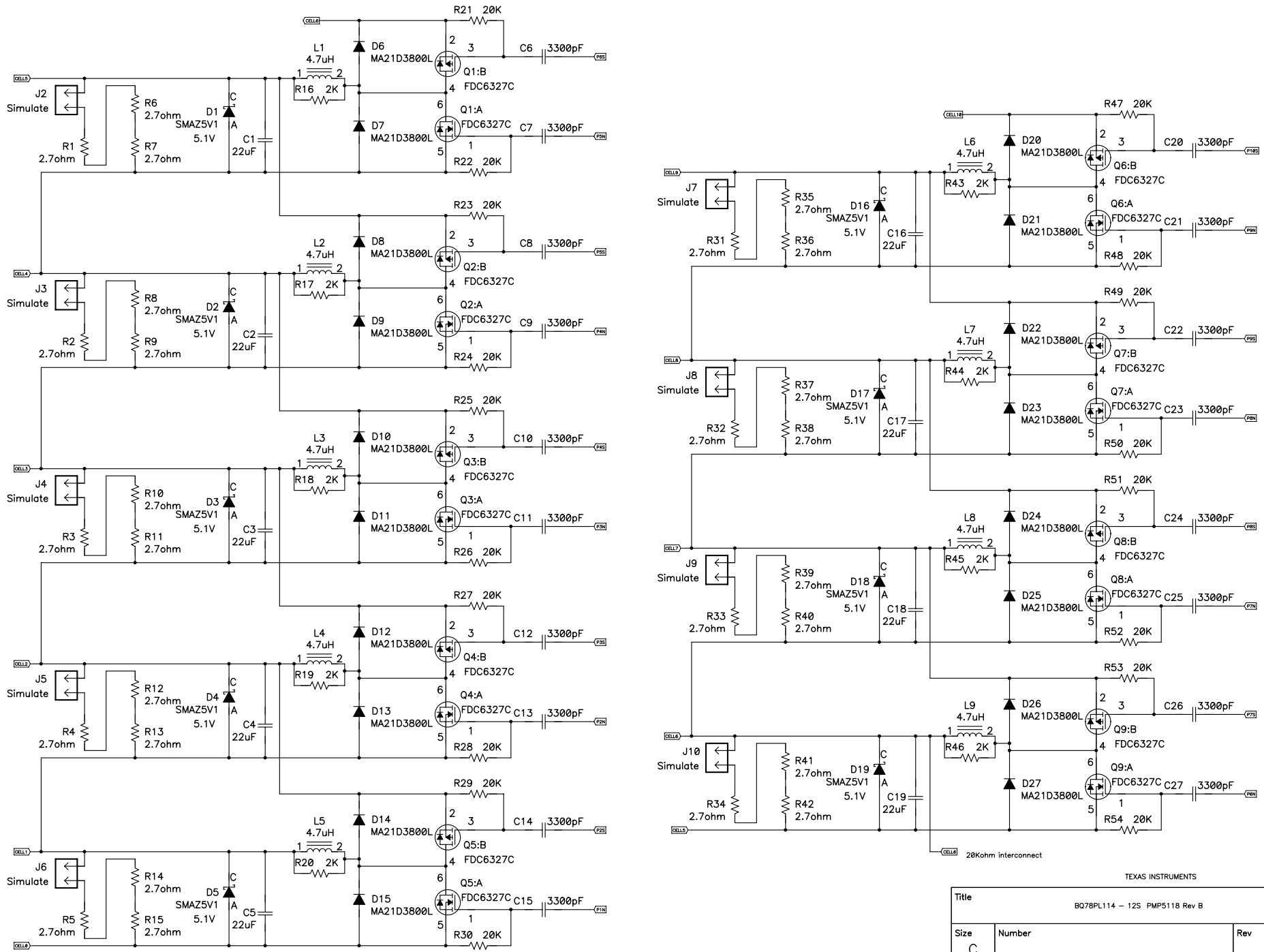


Figure 46. Pack History Data-Set Tab

Appendix C Reference Design and Reference Design Bill of Materials

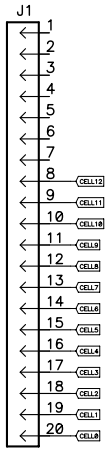
C.1 PMP5118-RevB Reference Design Schematic in S12 Hardware Configuration

The reference design schematic is appended to the following pages.

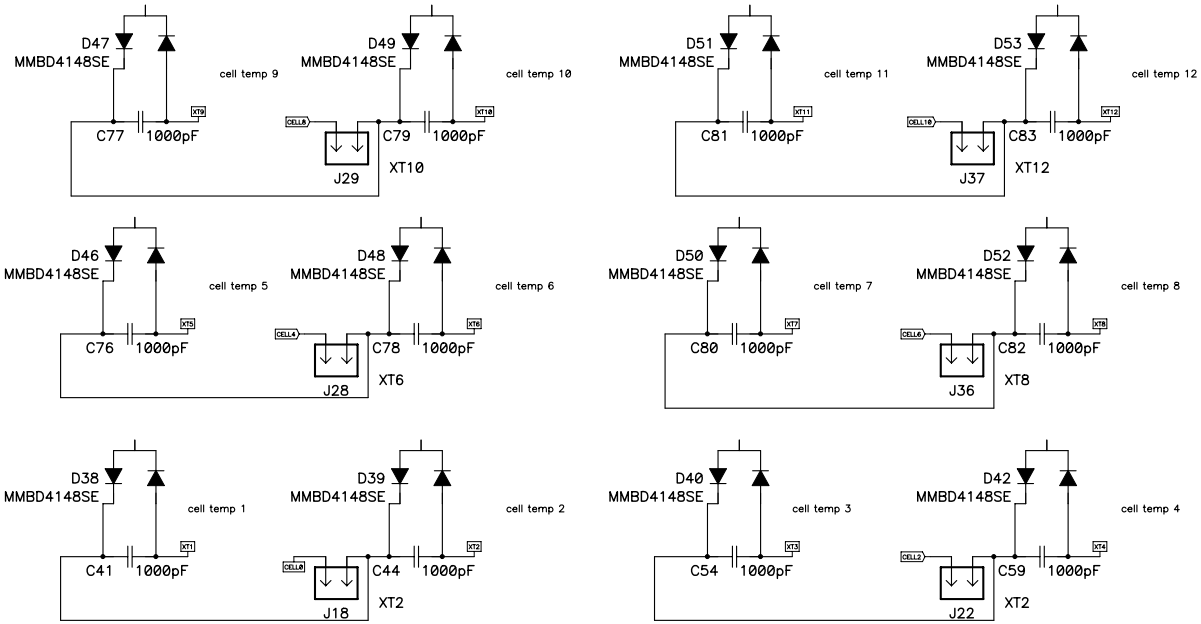


TEXAS INSTRUMENTS

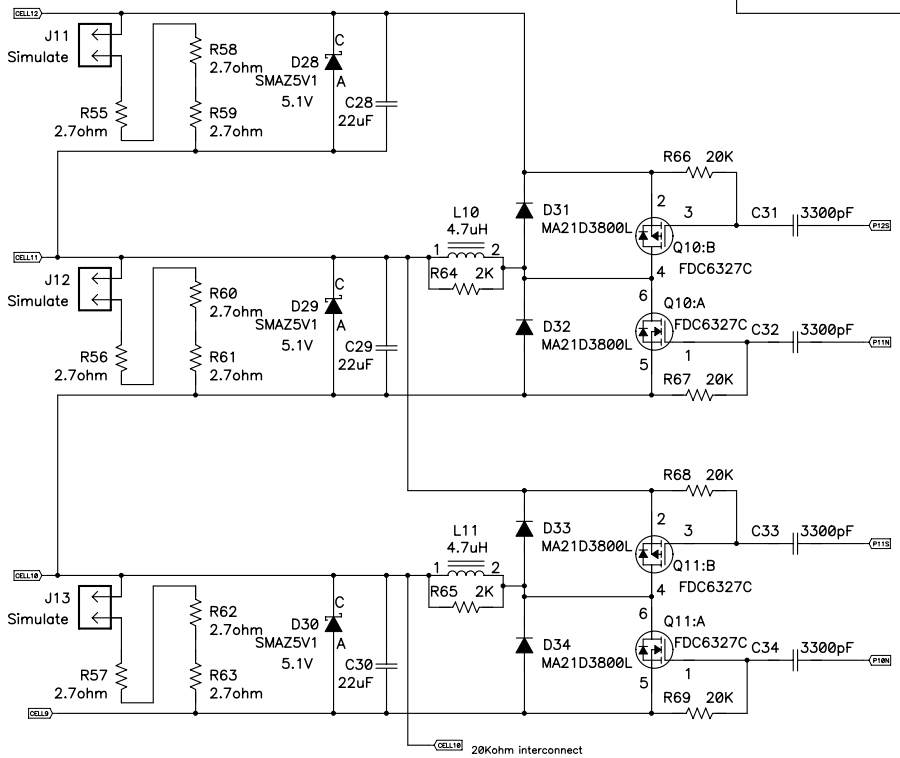
Title	BQ78PL114 – 12S PMP5118 Rev B	
Size C	Number	Rev
Date 11/25/2009	Drawn by K KELLER	
Filename PL114-12-revB4.SCH	Sheet 1 of 6	



Warning:
Connect Cells from Cell 0, Cell2, Cell1, then Cell3 thru 12

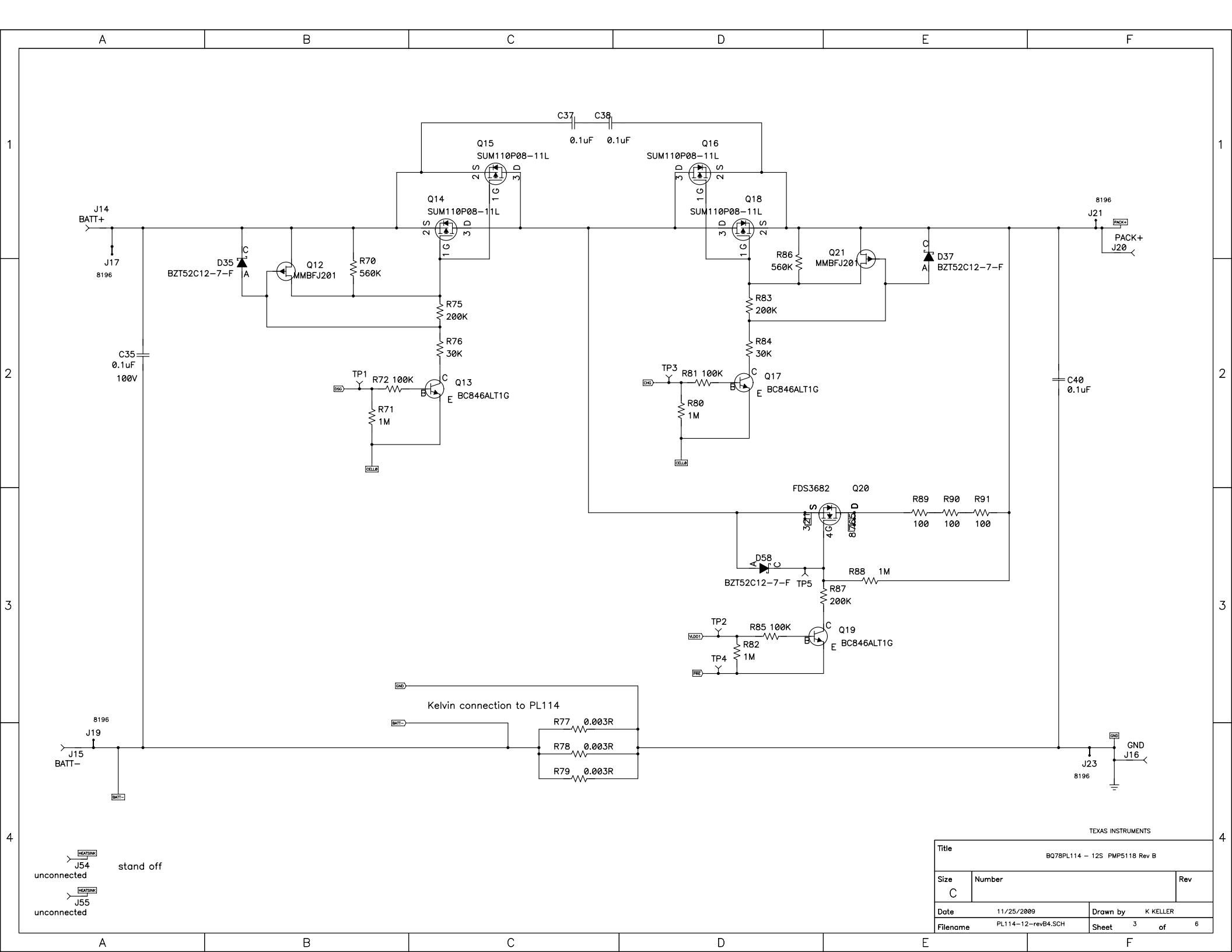


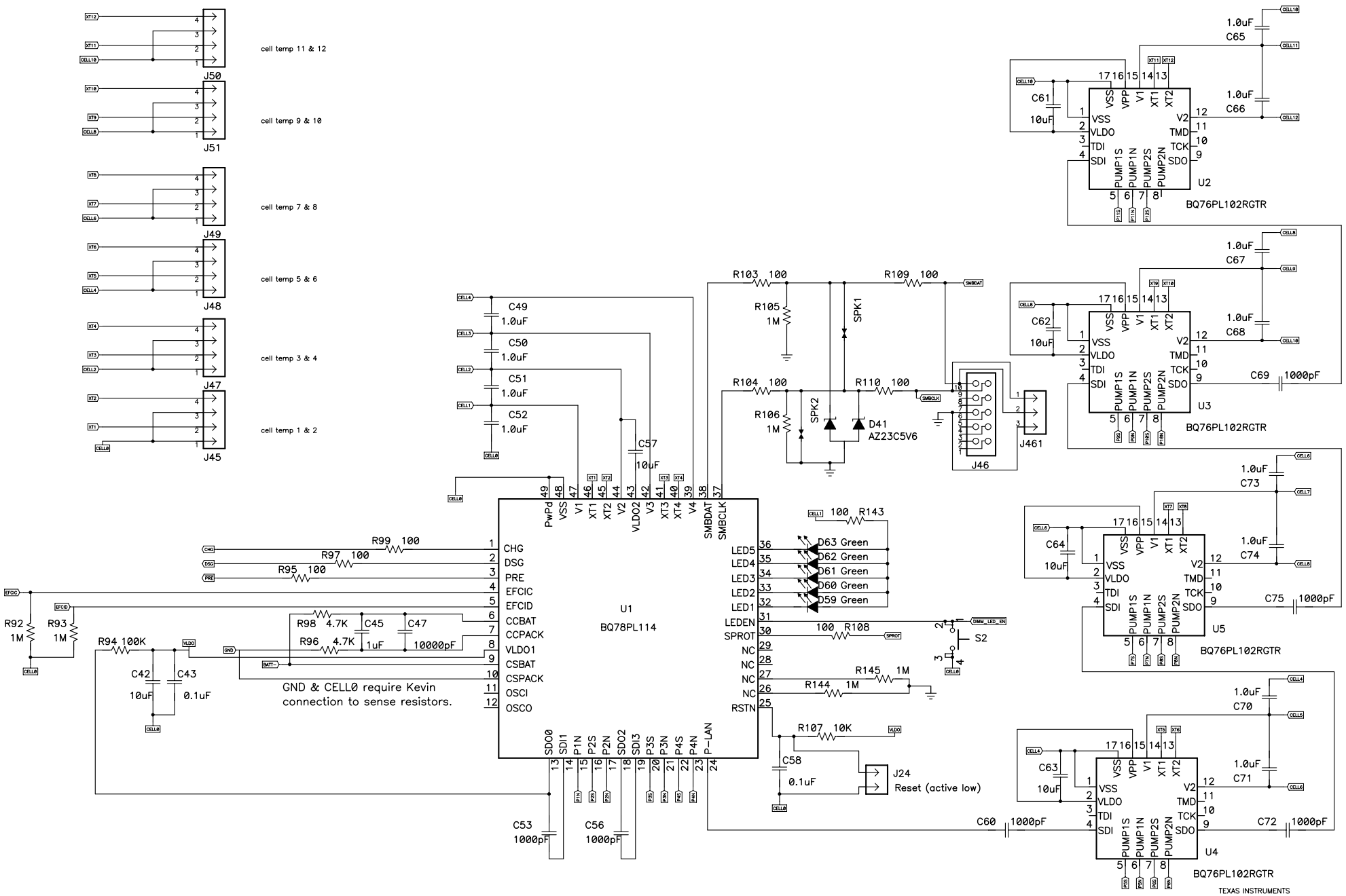
To use on-board temperature sensors, short headers



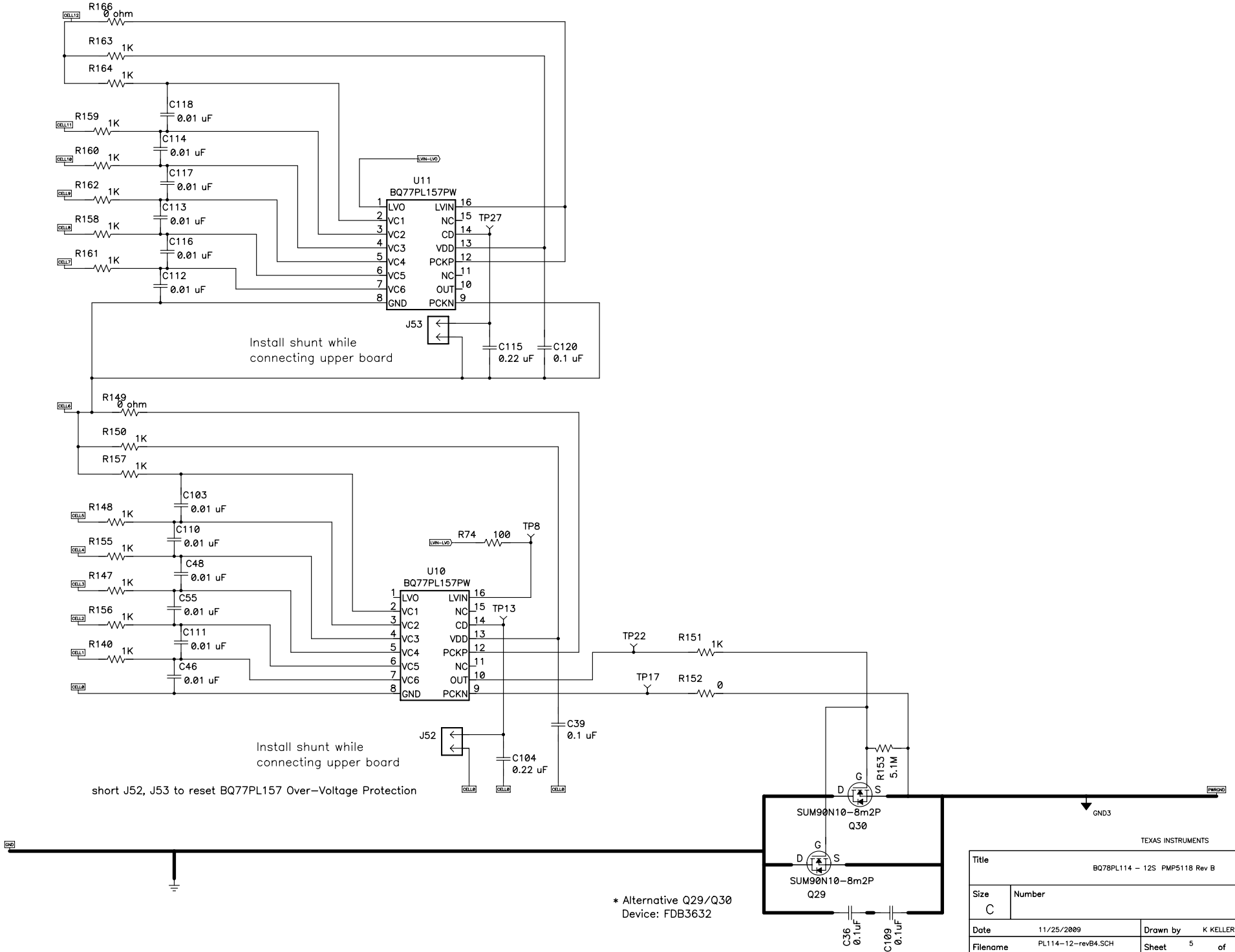
TEXAS INSTRUMENTS

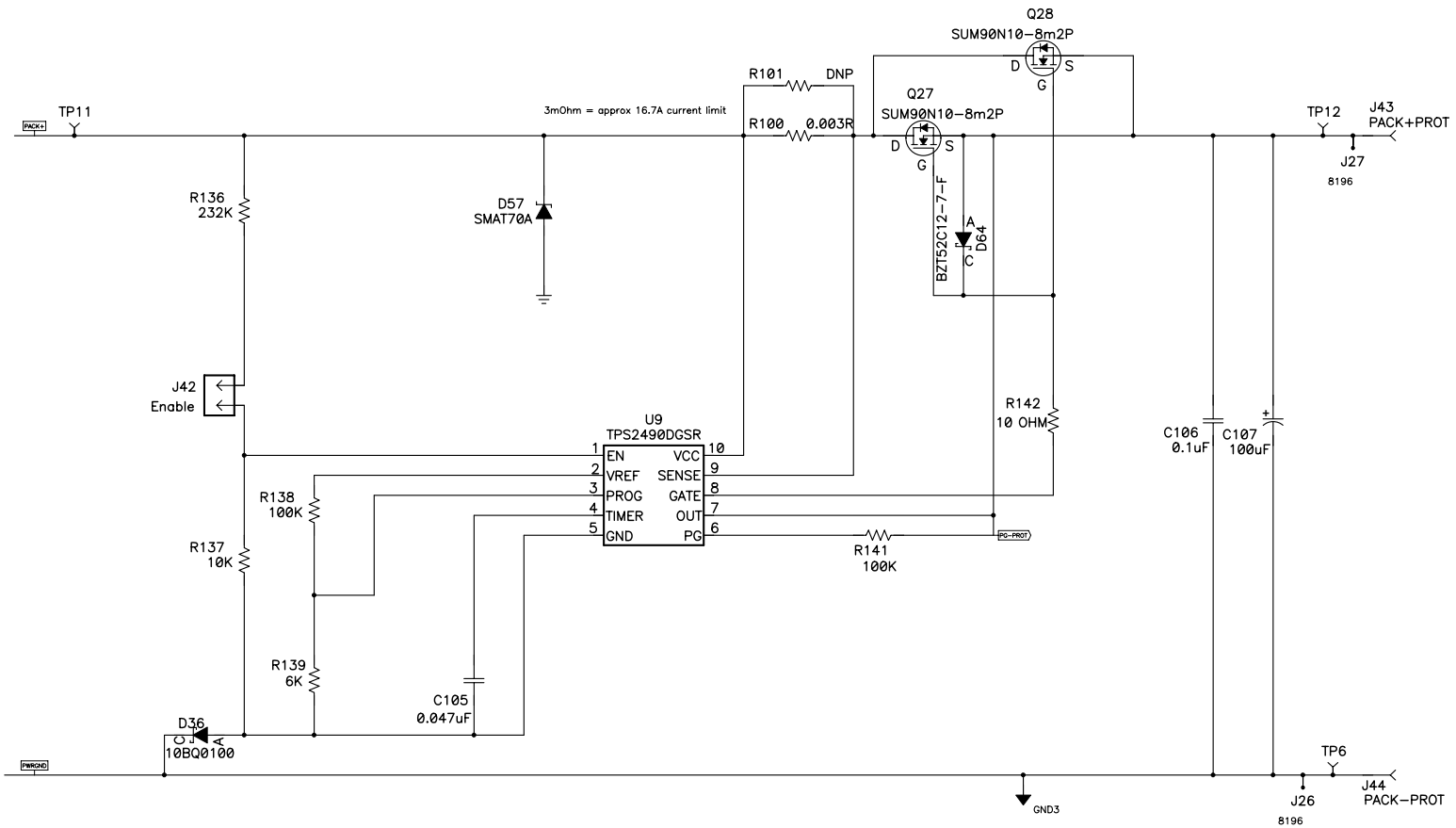
Title	BQ78PL114 – 12S PMP5118 Rev B	
Size C	Number	Rev
Date 11/25/2009		Drawn by K KELLER
Filename PL114-12-revB4.SCH		Sheet 2 of 6


C37 0.1uF
C38 0.1uF
Q15 SUM110P08-11L
Q16 SUM110P08-11L
Q14 SUM110P08-11L
Q18 SUM110P08-11L
J14 BATT+
J17 8196
D35 BZT52C12-7-F
Q12 MMBFJ201
R70 560K
R75 200K
R76 30K
C35 0.1uF 100V
TP1
R72 100K
Q13 BC846ALT1G
R71 1M
R86 560K
Q21 MMBFJ201
D37 BZT52C12-7-F
R83 200K
R84 30K
TP3
R81 100K
Q17 BC846ALT1G
R80 1M
8196 J21
PACK+ J20
C40 0.1uF
FDS3682 Q20
R89 100
R90 100
R91 100
D58 BZT52C12-7-F
TP5
R88 1M
R87 200K
TP2
R85 100K
Q19 BC846ALT1G
R82 1M
TP4
Kelvin connection to PL114
R77 0.003R
R78 0.003R
R79 0.003R
8196 J19
J15 BATT-
J23 8196
GND J16
J54 HEATSINK unconnected
stand off
J55 HEATSINK unconnected
TEXAS INSTRUMENTS
Title BQ78PL114 – 12S PMP5118 Rev B
Size C
Number
Rev
Date 11/25/2009
Drawn by K KELLER
Filename PL114-12-revB4.SCH
Sheet 3 of 6



Title	BQ78PL114 – 12S PMP5118 Rev B	
Size: C	Number	Rev
Date: 11/25/2009		Drawn by: K KELLER
Filename: PL114-12-revB4.SCH		Sheet 4 of 6


R166 0 ohm
R163 1K
R164 1K
C118 0.01 uF
R159 1K
C114 0.01 uF
R160 1K
C117 0.01 uF
R162 1K
C113 0.01 uF
R158 1K
C116 0.01 uF
R161 1K
C112 0.01 uF
U11
BQ77PL157PW
LVO
VC1
VC2
VC3
VC4
VC5
VC6
GND
LVIN
NC
CD
VDD
PCKP
NC
OUT
PCKN
TP27
J53
Install shunt while connecting upper board
C115 0.22 uF
C120 0.1 uF
R149 0 ohm
R150 1K
R157 1K
C103 0.01 uF
R148 1K
C110 0.01 uF
R155 1K
C48 0.01 uF
R147 1K
C55 0.01 uF
R156 1K
C111 0.01 uF
R140 1K
C46 0.01 uF
R74 100
TP8
U10
BQ77PL157PW
TP13
TP22
R151 1K
TP17
R152 0
J52
Install shunt while connecting upper board
C104 0.22 uF
C39 0.1 uF
short J52, J53 to reset BQ77PL157 Over-Voltage Protection
R153 5.1M
SUM90N10-8m2P
Q30
SUM90N10-8m2P
Q29
* Alternative Q29/Q30
Device: FDB3632
C36 0.1uF
C109 0.1uF
GND3
TEXAS INSTRUMENTS
Title
BQ78PL114 – 12S PMP5118 Rev B
Size C
Number
Rev
Date 11/25/2009
Drawn by K KELLER
Filename PL114-12-revB4.SCH
Sheet 5 of 6



TEXAS INSTRUMENTS

Title	BQ78PL114 – 12S PMP5118 Rev B	
Size C	Number	Rev
Date 11/25/2009	Drawn by K KELLER	
Filename PL114-12-revB4.SCH	Sheet 6 of 6	

C.2 PMP5118-Rev B Bill of Materials

Table 3. Bill of Materials

Count	RefDes	Part Number	Value	Description	Mfr	Size
4	U2	BQ76PL102RGTR	BQ76PL102RGTR	IC, Power-LAN Dual-Cell Li-Ion Batterry Monitor W/ Powerpump	TI	VQFN
	U3	BQ76PL102RGTR	BQ76PL102RGTR	IC, Power-LAN Dual-Cell Li-Ion Batterry Monitor W/ Powerpump	TI	VQFN
	U4	BQ76PL102RGTR	BQ76PL102RGTR	IC, Power-LAN Dual-Cell Li-Ion Batterry Monitor W/ Powerpump	TI	VQFN
	U5	BQ76PL102RGTR	BQ76PL102RGTR	IC, Power-LAN Dual-Cell Li-Ion Batterry Monitor W/ Powerpump	TI	VQFN
2	U10	BQ77PL157PW	BQ77PL157PW	IC, Secondary Voltage Protection for 3-6 Series Li-Ion Cells	TI	TSSOP-16
	U11	BQ77PL157PW	BQ77PL157PW	IC, Secondary Voltage Protection for 3-6 Series Li-Ion Cells	TI	TSSOP-16
1	U1	BQ78PL114RGZR	BQ78PL114	IC, PowerLAN Master Gateway Battery Management Controller With PowerPump Cell Balancing Technology	TI	VQFN
12	C46	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C48	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C55	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C103	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C110	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C111	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C112	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C113	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C114	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C116	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C117	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
	C118	Std	0.01 µF	Capacitor, Ceramic, 10V, X7R, 10%	Std	603
2	C36	Std	0.1 µF	Capacitor, Ceramic, 50V, X7R, 10%	Std	603
	C109	Std	0.1 µF	Capacitor, Ceramic, 50V, X7R, 10%	Std	603
1	C58	STD	0.1 µF	Capacitor, Ceramic, Low Inductance, 6.3V, X7R, 20%	STD	603
12	C49	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C50	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C51	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C52	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C65	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C66	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C67	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C68	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C70	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
	C71	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C73	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C74	STD	1.0 µF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
2	C53	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
	C56	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 10V, X5R, 10%	STD	603
16	C41	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C44	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C54	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C59	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C60	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C69	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C72	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C75	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C76	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C77	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C78	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C79	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C80	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C81	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C82	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C83	STD	1000 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
22	C6	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C7	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C8	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C9	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C10	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C11	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C12	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C13	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C14	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C15	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C20	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C21	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C22	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
	C23	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C24	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C25	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C26	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C27	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C31	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C32	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C33	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
	C34	STD	3300 pF	Capacitor, Ceramic, Low Inductance, 50V, X7R, 10%	STD	603
1	C105	ECJ-ZVF1C104Z	0.047 µF	Capacitor, Ceramic, 0 .047-uF, 16-V, Y5V, +80/-20%	Panasonic	805
2	C39	Std	0.1 µF	Capacitor, Ceramic, 50V, X7R, 10%	Std	805
	C120	Std	0.1 µF	Capacitor, Ceramic, 50V, X7R, 10%	Std	805
1	C35	100V	0.1 µF	Capacitor, Ceramic, 100V, X7R, 10%	STD	805
2	C37	C0805C104K1RACTU	0.1 µF	Capacitor, Ceramic, 100V, X7R, 10%	KEMET	805
	C38	C0805C104K1RACTU	0.1 µF	Capacitor, Ceramic, 100V, X7R, 10%	KEMET	805
1	C43	STD	0.1 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
2	C104	Std	0.22 µF	Capacitor, Ceramic, 16V, X7R, 10%	Std	805
	C115	Std	0.22 µF	Capacitor, Ceramic, 16V, X7R, 10%	Std	805
1	C45	STD	1 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
1	C57	STD	10 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
5	C42	STD	10 µF	Capacitor, Ceramic, 10V, X5R, 10%	STD	805
	C61	STD	10 µF	Capacitor, Ceramic, 10V, X5R, 10%	STD	805
	C62	STD	10 µF	Capacitor, Ceramic, 10V, X5R, 10%	STD	805
	C63	STD	10 µF	Capacitor, Ceramic, 10V, X5R, 10%	STD	805
	C64	STD	10 µF	Capacitor, Ceramic, 10V, X5R, 10%	STD	805
12	C1	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C2	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C3	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C4	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C5	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C16	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C17	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C18	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C19	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
	C28	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C29	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
	C30	STD	22 µF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
1	C47	STD	10000 pF	Capacitor, Ceramic, 6.3V, X5R, 10%	STD	805
1	C106	ECJ-3YBZA104K	0.1 µF	Capacitor, Ceramic, 0.1-uF, 100-V, X7R, +-10%	Panasonic	1206
1	C40	B32529C1104J	0.1 µF	Capacitor, Leaded, 100V, [temp], [tol]	Epcos	0.177 x 0.287 in.
1	C107	ECA-ZAM101	100 µF	Capacitor, Panasonic, 100-uF, 100-V, , 20%	Panasonic	0.315
1	J14	3267	BATT+	Connector, Banana Jack, Uninsulated	Pomona	0.500 dia
1	J15	3267	BATT–	Connector, Banana Jack, Uninsulated	Pomona	0.500 dia
1	J16	3267	GND	Connector, Banana Jack, Uninsulated	Pomona	0.500 dia
1	J20	3267	PACK+	Connector, Banana Jack, Uninsulated	Pomona	0.500 dia
1	J43	3267	PACK+PROT	Connector, Banana Jack, Uninsulated	Pomona	0.500 dia
1	J44	3267	PACK-PROT	Connector, Banana Jack, Uninsulated	Pomona	0.500 dia
2	J54	3267	unconnected	Connector, Banana Jack, Uninsulated	Pomona	0.500 dia
	J55	3267	unconnected	Connector, Banana Jack, Uninsulated	Pomona	0.500 dia
12	D38	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D39	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D40	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D42	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D46	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D47	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D48	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D49	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D50	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D51	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D52	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
	D53	MMBD4148SE	MMBD4148SE	Diode, Dual Ultra Fast, Series, 200-mA, 100-V	Fairchild	SOT23
22	D6	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D7	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D8	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D9	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D10	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D11	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D12	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
	D13	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D14	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D15	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D20	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D21	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D22	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D23	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D24	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D25	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D26	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D27	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D31	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D32	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D33	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
	D34	MA21D3800L	MA21D3800L	Diode, Switching, 1A, 30-V	Panasonic	0.067 x 0.049 in.
5	D59	160-1183-1-ND	Green	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	Liteon	603
	D60	160-1183-1-ND	Green	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	Liteon	603
	D61	160-1183-1-ND	Green	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	Liteon	603
	D62	160-1183-1-ND	Green	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	Liteon	603
	D63	160-1183-1-ND	Green	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	Liteon	603
4	D35	BZT52C12	BZT52C12-7-F	Diode, Zener, 12V	Diodes Inc.	SOD-123
	D37	BZT52C12	BZT52C12-7-F	Diode, Zener, 12V	Diodes Inc.	SOD-123
	D58	BZT52C12	BZT52C12-7-F	Diode, Zener, 12V	Diodes Inc.	SOD-123
	D64	BZT52C12	BZT52C12-7-F	Diode, Zener, 12V	Diodes Inc.	SOD-123
1	D16	5.1V	SMAZ5V1	Diode, Zener 100-mA, 5.1-V	Diodes Inc	SMA
11	D1	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
	D2	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
	D3	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
	D4	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
	D5	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
	D17	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
	D18	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
	D19	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
	D28	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
	D29	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
	D30	5.1V	SMAZ5V1	Diode, Zener, 100-mA, 5.1-V	Diodes Inc	SMA
1	D36	IRF	10BQ0100	Diode, Schottky, 1-A, 100-V	STD	SMB
1	D41	AZ23C5V6	AZ23C5V6	Diode, Dual, Zener, 5.6 V, 300mW	Diodes	SOT23
1	D57	SMAT70A	SMAT70A	Diode, 100V transient voltage supressor	Diodes Inc.	SMA
1	J42	PTC36SAAN	Enable	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
1	J24	PTC36SAAN	Reset (active low)	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
12	J2	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J3	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J4	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J5	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J6	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J7	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J8	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J9	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J10	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J11	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J12	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J13	PTC36SAAN	Simulate	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
2	J18	PTC36SAAN	XT2	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J22	PTC36SAAN	XT2	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
1	J28	PTC36SAAN	XT6	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
1	J36	PTC36SAAN	XT8	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
1	J29	PTC36SAAN	XT10	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
1	J37	PTC36SAAN	XT12	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
2	J52	PTC36SAAN		Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
	J53	PTC36SAAN		Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	0.100 x 2
1	J461	PEC03SAAN	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	Sullins	0.100 in. x 3
1	J1	PEC36SAAN	PEC36SAAN	Header, Male 20-pin, 100mil spacing, (36-pin strip)	STD	0.100 in. x 20
6	J45	640454-4	640454-4	Header, Polarized Notched, 4 Pin 100 mil Pitch	Tyco	0.400 x 0.225 in.
	J47	640454-4	640454-4	Header, Polarized Notched, 4 Pin 100 mil Pitch	Tyco	0.400 x 0.225 in.
	J48	640454-4	640454-4	Header, Polarized Notched, 4 Pin 100 mil Pitch	Tyco	0.400 x 0.225 in.
	J49	640454-4	640454-4	Header, Polarized Notched, 4 Pin 100 mil Pitch	Tyco	0.400 x 0.225 in.
	J50	640454-4	640454-4	Header, Polarized Notched, 4 Pin 100 mil Pitch	Tyco	0.400 x 0.225 in.

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
	J51	640454-4	640454-4	Header, Polarized Notched, 4 Pin 100 mil Pitch	Tyco	0.400 x 0.225 in.
1	J46	C-5103309-1	C-5103309-1	Connector, 10 pin Shrouded Vertical	Tyco	0.388 x 0.400 in.
11	L1	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 mΩ	Coilcraft	0.153 x 0.153 in.
	L2	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 mΩ	Coilcraft	0.153 x 0.153 in.
	L3	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 mΩ	Coilcraft	0.153 x 0.153 in.
	L4	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 mΩ	Coilcraft	0.153 x 0.153 in.
	L5	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 mΩ	Coilcraft	0.153 x 0.153 in.
	L6	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 mΩ	Coilcraft	0.153 x 0.153 in.
	L7	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 mΩ	Coilcraft	0.153 x 0.153 in.
	L8	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 mΩ	Coilcraft	0.153 x 0.153 in.
	L9	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 m	Coilcraft	0.153 x 0.153 in.
	L10	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 m	Coilcraft	0.153 x 0.153 in.
	L11	LPS4012-472ML	4.7 µH	Inductor, SMT, 1.8A, 175 m	Coilcraft	0.153 x 0.153 in.
10	R71	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
	R80	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
	R82	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
	R88	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
	R92	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
	R93	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
	R105	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
	R106	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
	R144	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
	R145	Std	1M	Resistor, Chip, 1/16W, 5%	Std	603
11	R16	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R17	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R18	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R19	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R20	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R43	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R44	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R45	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R46	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R64	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603
	R65	Std	2K	Resistor, Chip, 1/16W, 5%	Std	603

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
2	R96	Std	4.7K	Resistor, Chip, 1/16W, 5%	Std	603
	R98	Std	4.7K	Resistor, Chip, 1/16W, 5%	Std	603
1	R107	Std	10K	Resistor, Chip, 1/16W, 5%	Std	603
22	R21	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R22	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R23	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R24	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R25	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R26	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R27	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R28	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R29	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R30	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R47	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R48	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R49	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R50	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R51	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R52	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R53	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R54	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R66	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R67	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R68	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
	R69	Std	20K	Resistor, Chip, 1/16W, 5%	Std	603
2	R76	Std	30K	Resistor, Chip, 1/16W, 5%	Std	603
	R84	Std	30K	Resistor, Chip, 1/16W, 5%	Std	603
9	R95	Std	100	Resistor, Chip, 1/16W, 5%	Std	603
	R97	Std	100	Resistor, Chip, 1/16W, 5%	Std	603
	R99	Std	100	Resistor, Chip, 1/16W, 5%	Std	603
	R103	Std	100	Resistor, Chip, 1/16W, 5%	Std	603
	R104	Std	100	Resistor, Chip, 1/16W, 5%	Std	603
	R108	Std	100	Resistor, Chip, 1/16W, 5%	Std	603
	R109	Std	100	Resistor, Chip, 1/16W, 5%	Std	603

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
	R110	Std	100	Resistor, Chip, 1/16W, 5%	Std	603
	R143	Std	100	Resistor, Chip, 1/16W, 5%	Std	603
4	R72	Std	100K	Resistor, Chip, 1/16W, 5%	Std	603
	R81	Std	100K	Resistor, Chip, 1/16W, 5%	Std	603
	R85	Std	100K	Resistor, Chip, 1/16W, 5%	Std	603
	R94	Std	100K	Resistor, Chip, 1/16W, 5%	Std	603
3	R75	Std	200K	Resistor, Chip, 1/16W, 5%	Std	603
	R83	Std	200K	Resistor, Chip, 1/16W, 5%	Std	603
	R87	Std	200K	Resistor, Chip, 1/16W, 5%	Std	603
2	R70	Std	560K	Resistor, Chip, 1/16W, 5%	Std	603
	R86	Std	560K	Resistor, Chip, 1/16W, 5%	Std	603
1	R152	Std	0 Ω	Resistor, Chip, 1/16W, 5%	Any	603
2	R149	Std	0 Ω	Resistor, Chip, 1/16W, 5%	Any	603
	R166	Std	0 Ω	Resistor, Chip, 1/16W, 5%	Any	603
15	R140	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R147	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R148	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R150	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R151	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R155	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R156	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R157	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R158	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R159	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R160	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R161	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R162	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R163	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
	R164	Std	1K	Resistor, Chip, 1/16W, 5%	Any	603
1	R153	STD	5.1M	Resistor, Chip, 1/16W, 5%	Std	603
1	R74	Std	100	Resistor, Chip, 1/16W, 5%	Any	603
1	R139	Std	6K	Resistor, Chip, 6 kΩ, 1/10-W, 1%	Std	805
1	R137	Std	10K	Resistor, Chip, 10 kΩ, 1/10-W,1%	Std	805
1	R138	Std	100K	Resistor, Chip, 100 kΩ, 1/10-W,1%	Std	805

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
1	R136	Std	232K	Resistor, Chip, 232 kΩ, 1/10-W,1%	Std	805
1	R142	Std	10 Ω	Resistor, Chip, 10-Ω, 1/8-W, 5%	Std	1206
1	R141	Std	100K	Resistor, Chip, 100 kΩ, 1/8-W, 5%	Std	1206
9	R1	STD	2.7 Ω	Resistor, 2.7 mΩ, 1W, 5%	STD	2512
	R2	STD	2.7 Ω	Resistor, 2.7 mΩ, 1W, 5%	STD	2512
	R3	STD	2.7 Ω	Resistor, 2.7 mΩ, 1W, 5%	STD	2512
	R4	STD	2.7 Ω	Resistor, 2.7 mΩ, 1W, 5%	STD	2512
	R5	STD	2.7 Ω	Resistor, 2.7 mΩ, 1W, 5%	STD	2512
	R31	STD	2.7 Ω	Resistor, 2.7 mΩ, 1W, 5%	STD	2512
	R32	STD	2.7 Ω	Resistor, 2.7 mΩ, 1W, 5%	STD	2512
	R33	STD	2.7 Ω	Resistor, 2.7 mΩ, 1W, 5%	STD	2512
	R34	STD	2.7 Ω	Resistor, 2.7 mΩ, 1W, 5%	STD	2512
27	R6	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R7	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R8	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R9	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R10	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R11	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R12	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R13	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R14	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R15	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R35	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R36	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R37	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R38	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R39	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R40	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R41	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R42	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R55	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R56	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R57	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R58	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
	R59	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R60	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R61	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R62	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
	R63	STD	2.7 Ω	Resistor, 2.7 mΩ, 2W, 5%	STD	2512
3	R89	STD	100	Resistor, 100 Ω, 1W, 5%	STD	2512
	R90	STD	100	Resistor, 100 Ω, 1W, 5%	STD	2512
	R91	STD	100	Resistor, 100 Ω, 1W, 5%	STD	2512
1	R100	ERJ-M1WSF3M0U	0.003R	Resistor, Chip, 1W, 1%, 350ppm	Panasonic	2512
3	R77	PR2512FKF070R003L (Digikey 311-0.003AGCT-ND)	0.003R	Resistor, Chip, 0.003 Ω, 1W, 1%, 100ppm	Yageo	2512
	R78	PR2512FKF070R003L (Digikey 311-0.003AGCT-ND)	0.003R	Resistor, Chip, 0.003 Ω, 1W, 1%, 100ppm	Yageo	2512
	R79	PR2512FKF070R003L (Digikey 311-0.003AGCT-ND)	0.003R	Resistor, Chip, 0.003 Ω, 1W, 1%, 100ppm	Yageo	2512
1	R101	ERJ-M1WSF3M0U	DNP	Resistor, Chip, 1W, 1%, 350ppm	Panasonic	2512
6	J17	8196	8196	Terminal, PC Screw #10-32, 30A	Keystone	0.470 x 0.470 in.
	J19	8196	8196	Terminal, PC Screw #10-32, 30A	Keystone	0.470 x 0.470 in.
	J21	8196	8196	Terminal, PC Screw #10-32, 30A	Keystone	0.470 x 0.470 in.
	J23	8196	8196	Terminal, PC Screw #10-32, 30A	Keystone	0.470 x 0.470 in.
	J26	8196	8196	Terminal, PC Screw #10-32, 30A	Keystone	0.470 x 0.470 in.
	J27	8196	8196	Terminal, PC Screw #10-32, 30A	Keystone	0.470 x 0.470 in.
2	SPK1	Spark Gap	{Value}	Spark Gap, 0.010 inch space	mfg	0.050 x 0.070 in.
	SPK2	Spark Gap	{Value}	Spark Gap, 0.010 inch space	mfg	0.050 x 0.070 in.
1	S2	FSM4JSMA	FSM4JSMA	Switch, Micro Push Button xxV, xxA	ITT	0.394 x 0.200 in.
3	TP8	STD	STD	Test Point, O.032 Hole	STD	
	TP17	STD	STD	Test Point, O.032 Hole	STD	
	TP22	STD	STD	Test Point, O.032 Hole	STD	
2	TP11	5000	5000	Test Point, Red, Thru Hole Color Keyed	Keystone	0.100 x 0.100 in.
	TP12	5000	5000	Test Point, Red, Thru Hole Color Keyed	Keystone	0.100 x 0.100 in.
6	TP1	5001	5001	Test Point, Black, Thru Hole Color Keyed	Keystone	0.100 x 0.100 in.
	TP2	5001	5001	Test Point, Black, Thru Hole Color Keyed	Keystone	0.100 x 0.100 in.
	TP3	5001	5001	Test Point, Black, Thru Hole Color Keyed	Keystone	0.100 x 0.100 in.
	TP4	5001	5001	Test Point, Black, Thru Hole Color Keyed	Keystone	0.100 x 0.100 in.
	TP5	5001	5001	Test Point, Black, Thru Hole Color Keyed	Keystone	0.100 x 0.100 in.

Table 3. Bill of Materials (continued)

Count	RefDes	Part Number	Value	Description	Mfr	Size
	TP6	5001	5001	Test Point, Black, Thru Hole Color Keyed	Keystone	0.100 x 0.100 in.
2	TP13	STD	STD	Test Point, 0.020 Hole	STD	
	TP27	STD	STD	Test Point, 0.020 Hole	STD	
1	U9	TPS2490DGS	TPS2490DGSR	IC,	TI	DGS10
11	Q1	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q2	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q3	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q4	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q5	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q6	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q7	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q8	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q9	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q10	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
	Q11	FDC6327C	FDC6327C	Transistor, Dual N&P-Channel 2.5V Specified PowerTrench	Fairchild	SuperSOT-6
1	Q30	SUM90N10-8m2P	SUM90N10-8m2P	Transistor, NFET, 100V, 97A, 8 mΩ	Vishay	D2PAK
1	Q28	SUM90N10-8m2P	SUM90N10-8m2P	Transistor, NFET, 100V, 97A, 8 mΩ	Vishay	D2PAK
1	Q29	SUM90N10-8m2P	SUM90N10-8m2P	Transistor, NFET, 100V, 97A, 8 mΩ	Vishay	D2PAK
1	Q27	SUM90N10-8m2P	SUM90N10-8m2P	Transistor, NFET, 100V, 97A, 8 mΩ	Vishay	D2PAK
2	Q12	MMBFJ201	MMBFJ201	JFET, NChan -40V, 50mA	Fairchild	SOT-23
	Q21	MMBFJ201	MMBFJ201	JFET, NChan -40V, 50mA	Fairchild	SOT-23
1	Q20	FDS3682	FDS3682	MOSFET, N-ch, 100-V, 6-A, 35-mΩ	Fairchild	SO8
3	Q13	BC846ALT1G	BC846ALT1G	Bipolar, NPN, -65-V, 100-mA, 100-mW	Vishay	SOT23
	Q17	BC846ALT1G	BC846ALT1G	Bipolar, NPN, -65-V, 100-mA, 100-mW	Vishay	SOT23
	Q19	BC846ALT1G	BC846ALT1G	Bipolar, NPN, -65-V, 100-mA, 100-mW	Vishay	SOT23
4	Q14	SUM110P08-11L	SUM110P08-11L	MOSFET, Pch, -80V, 109 A, 11mΩ (Vgs=-10V), 14.5mΩ (Vgs=-4.5V)	Vishay	D2PAK
	Q15	SUM110P08-11L	SUM110P08-11L	MOSFET, Pch, -80V, 109 A, 11mΩ (Vgs=-10V), 14.5mΩ (Vgs=-4.5V)	Vishay	D2PAK
	Q16	SUM110P08-11L	SUM110P08-11L	MOSFET, Pch, -80V, 109 A, 11mΩ (Vgs=-10V), 14.5mΩ (Vgs=-4.5V)	Vishay	D2PAK
	Q18	SUM110P08-11L	SUM110P08-11L	MOSFET, Pch, -80V, 109 A, 11mΩ (Vgs=-10V), 14.5mΩ (Vgs=-4.5V)	Vishay	D2PAK

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