ISL9216EVAL1Z (Rev D) User Guide

Application Note | October 10, 2007 | AN1357.0

Description

This document is intended for use by individuals engaged in the development of hardware and software for an 8 to 12 series Li-ion battery pack hardware using the ISL9216EVAL1Z (Rev D) board. This board contains the ISL9216 and ISL9217 chipset.

The evaluation kit consists of the main ISL9216EVAL1Z (Rev D) PCB, and a power supply cable for connecting to the board to a battery or or other power supply. Operation of the kit requires the use of a USB to I^2C interface and cables, which is available by ordering the "ISLI2C-KIT" kit from Intersil. This interface kit allows a PC to talk to the ISL9216EVAL1Z (Rev D) board. An optional link between a PC USB port and the microcontroller BKGD connector is available from Freescale for monitoring and debugging the microcontroller code.

First Steps

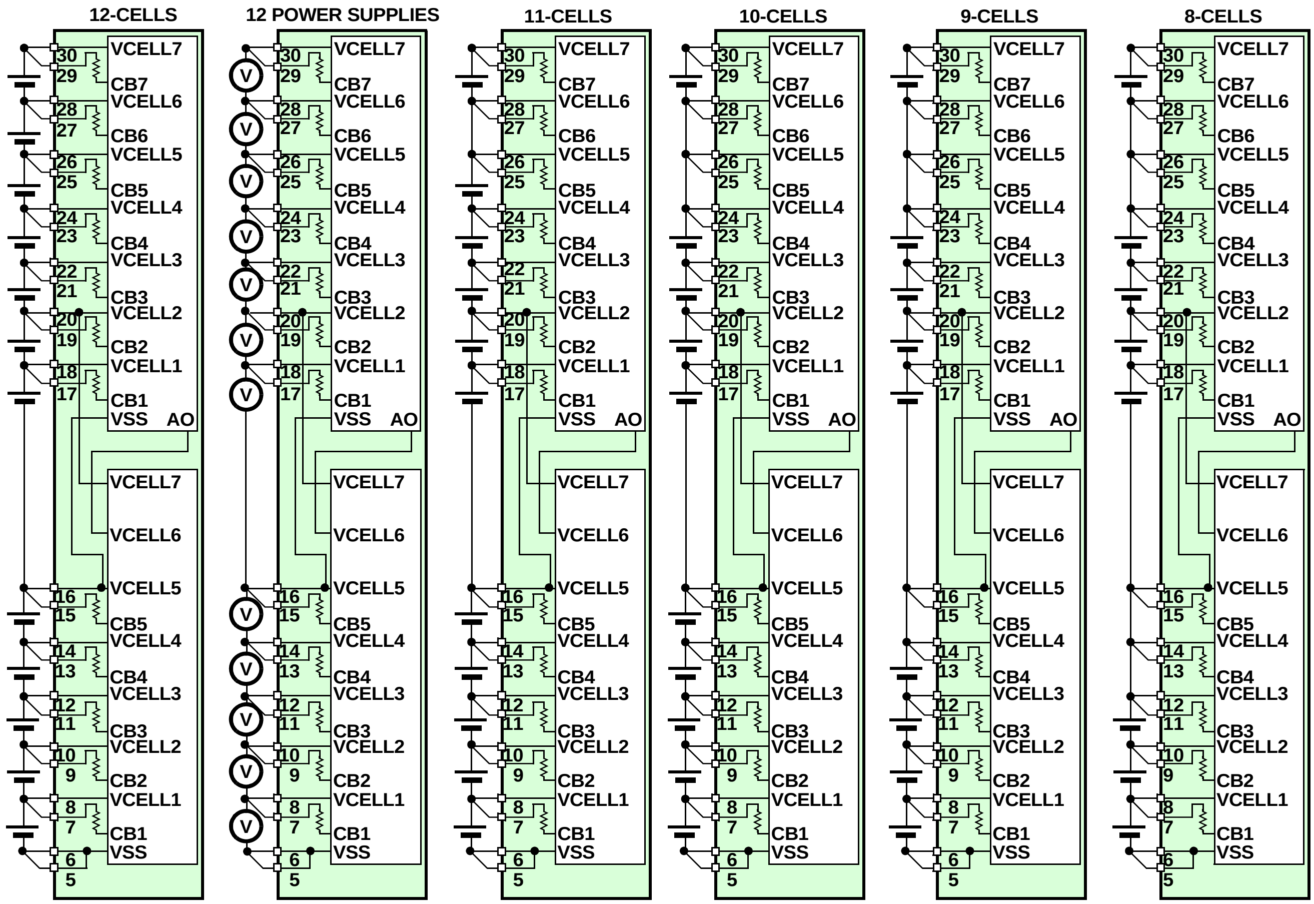
- If not already available, aquire the DeVaSys USB to I^2C board, USB interface, and I^2C cable. These are available from Intersil in the ISLI2C-KIT.
- Download the software from the Intersil website on the ISL9216 page. This is a zip file titled: "ISL92xx Eval Kit Software Release".
- Unzip the software files to a directory of your choice.
- Prior to powering the ISL9216 board, install the USB to I^2C board software and connect the DeVaSys board to the PC (see Appendix 1). However, don't connect the DeVaSys board to the ISL9216EVAL1Z (Rev D) board yet. This is just preparation for the test set-up. With these pieces in place, the PC interface can then quickly be used to monitor the operation of the board once power is applied.
- If changes to the microcontroller code are desired, then it will be necessary to order a programming/debug module from Freescale (part number USBMULTILINKBDME). This kit also contains the Code Warrior development tools. To get the source code, contact Intersil and sign the license agreement.
- Set-up a power supply for the board. The power supply should consist of a string of 8 to 12 batteries (see Figure 1), or a string of 8 to 12 resistors and three power supplies, or 8 to 12 individual power supplies (see Figure 1 or Figure 2).

Battery/Power Supply Connection

When connecting battery packs or power supplies, use the connections of Figures 1 and 2. If individual power supplies are being used to replace battery cells, then connect the power supplies identically to the battery connections (see Figure 1). Also, make sure that the individual power supply voltages do not exceed the ISL9216/ISL9217 maximum input voltage differential of 5V per cell.

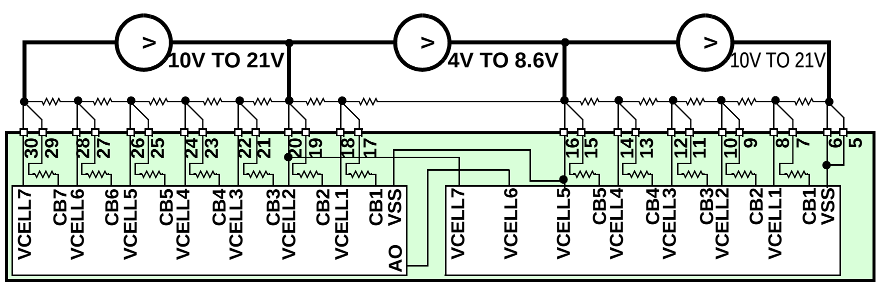
If using a string of resistors to emulate the battery cells, then use the connection in Figures 2 and 3. In this case, limit the supply voltages so that the resistor divider outputs do not exceed the ISL9216/ISL9217 input maximum ratings.

It is recommended that the series power supply resistors be 20Ω maximum and 2W minimum. Resistors with higher resistance can be used, but when activating the ISL9216/ISL9217 cell balance outputs, the 39Ω cell balance resistor on the board will lower the voltage across that series power supply resistor while raising the voltage on all of the other series resistors. Turning on multiple cell balance outputs could then result in one or more of the VCELLN input voltages, exceeding their maximum specified limit.



Note: Multiple cells can be connected in parallel

FIGURE 1. BATTERY CONNECTION OPTIONS



NOTES:

1. For the battery simulation resistors, use 20Ω/5W units. If the resistors are more than 100Ω, then turning on the cell balance resistors cause fluctuations in the cell input voltages that can violate the ISL9216 max specifications.
2. Switch the power supplies on at the same time, or if this cannot be guaranteed, turn them on from bottom to top.
3. This connection (using 3 power supplies) is required for proper inter-IC communication.

FIGURE 2. USING A STRING OF RESISTORS AND THREE POWER SUPPLIES TO EMULATE A STRING OF BATTERIES

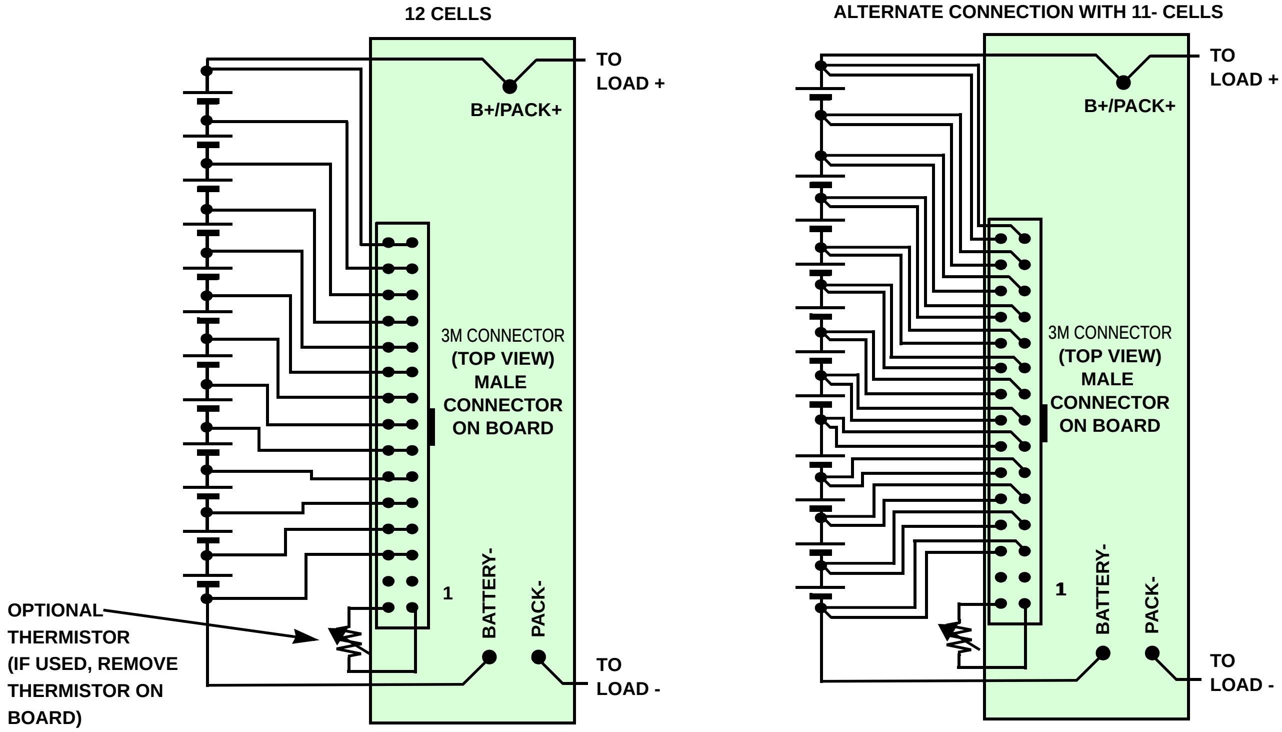


FIGURE 3. BATTERY CONNECTIONS TO THE ISL9216EVAL1Z (REV D) BOARD

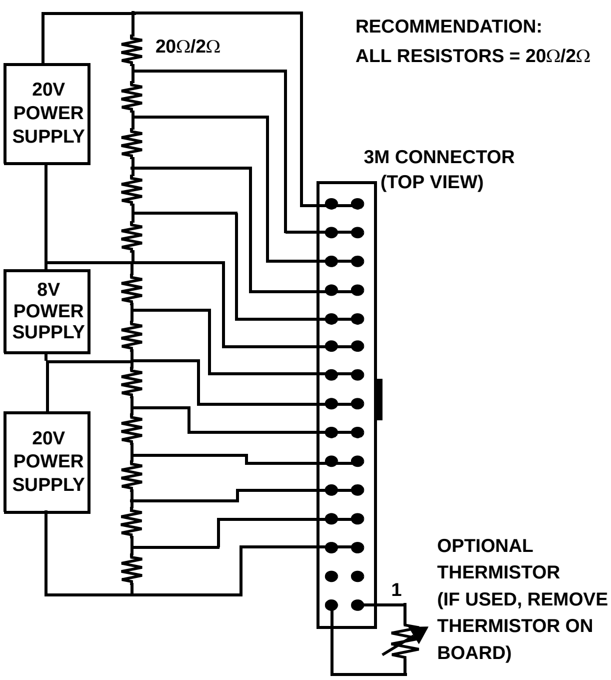


FIGURE 4. POWER SUPPLY/RESISTOR CONNECTION TO ISL9216 PCB

Initial Testing

Setup

- For initial testing, set the I^2C jumpers (SCL and SDA) to the PC position. This configures the board such that the PC communicates directly with the ISL9216.
- Before connecting the PC to the ISL9216EVAL1Z (Rev D) board (through the USB to I^2C interface), connect the power supply to the ISL9216EVAL1Z (Rev D) board.
- The power supply should consist of a string of 8 to 12 batteries, or a string of 8 to 12 resistors with three power supplies, or 12 individual power supplies (see Figures 3 or Figure 4).
- Once power is turned on (or Li-ion cells are connected to the ISL9216EVAL1Z (Rev D) cell inputs, the RGO and RGO2 LEDs should light. Use meter 1 and meter 2 (as shown in Figure 5) to measure the RGO voltages. They should each read about 3.3V.

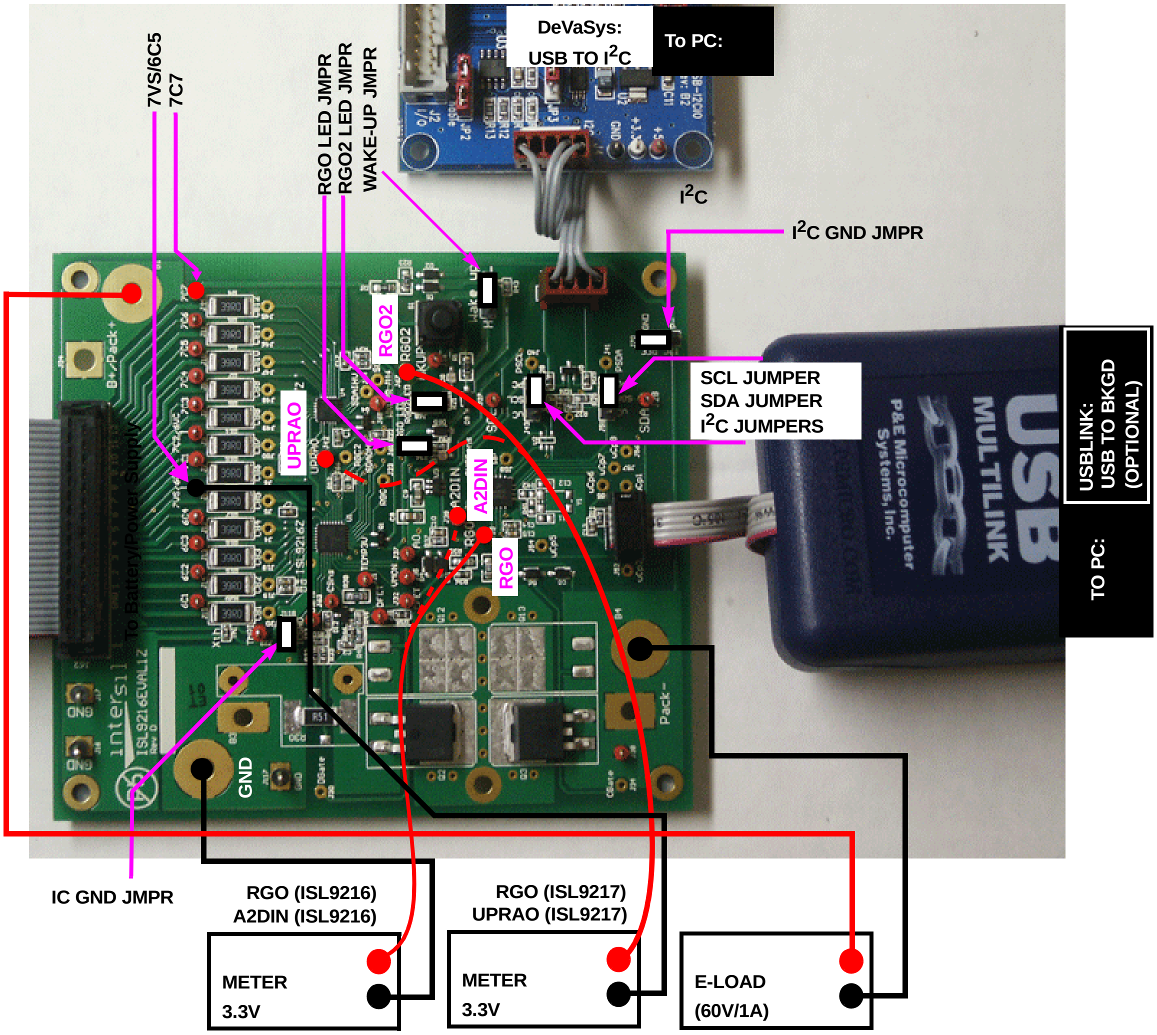


FIGURE 5. ISL9216EVAL1Z (Rev D) BOARD CONNECTION

USB to I^{2}C Interface

- Once the power supply connections are verified, power-down the ISL9216EVAL1Z (Rev D) boards and make the PC connection. Before making this connection, make sure that the USB to I^{2}C interface software is installed (see software installation guide).
- Connect the I^{2}C cable from the interface board to the ISL9216EVAL1Z (Rev D), as in Figure 6.

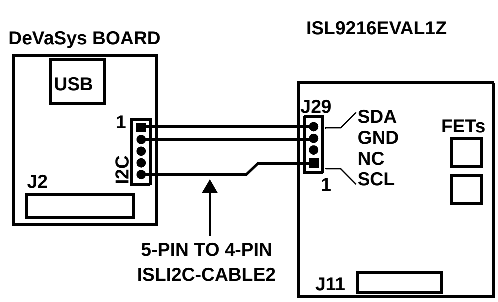


FIGURE 6. I^{2}C CONNECTION TO ISL9216 PCB

Testing Without the Microcontroller

Cell Voltage Monitor Accuracy Check

- For this test, make sure the SCL and SDA jumpers are set to the PC position. In this case, the PC has full control of the board and the microcontroller function is disabled. (See Figure 7). Except for the ISL9216 automatic response to and over-temperature, all other actions of the board are manual and controlled through the GUI.

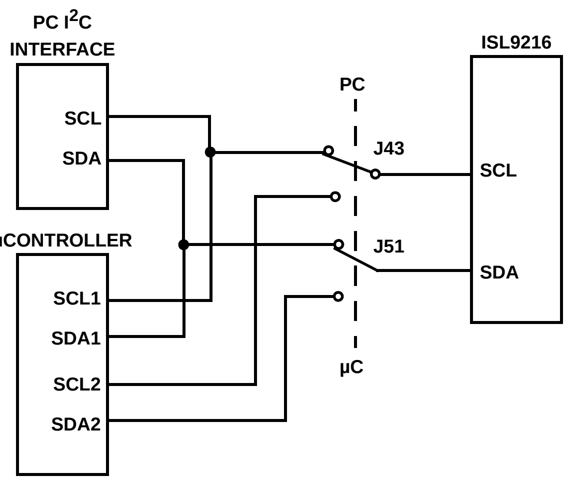


FIGURE 7. PC OR µC CONNECTION TO THE ISL9216

- Make the I^2C port connection to the PC.
- Power-up the board and re-check the RGO voltages. Since RGO is the voltage reference for the on-board A/D converter, this voltage may be needed in the accuracy calculations.
- Start the GUI. Execute the program BATTERYPACK.EXE from the Software directory.
- The GUI should power-up with some color. That is, the FET controls should be red and the indicators should be green or red. If the GUI is all gray, then there is a communication problem. If there is a communication problem; see the troubleshooting guide in “Appendix 2” on page 18.
- Use the GUI to read register 0 from both the ISL9216 and ISL9217. The ISL9216 should return the value 50H and the ISL9217 should return 80H. This verifies communication to both devices.
- Next, move to the “MONITOR” tab of the GUI.
- Set the ISL9216 to monitor the VCELL1 input by selecting the ISL9216 radio button and choosing VCELL1 in the Monitor drop down box. Execute this command by clicking “refresh.” This operation connects the VCELL1 input to the AO output (through a level shifter and divider). Any changes on VCELL1 appear on AO.
- Using a meter, measure the CELL1 voltage (from test point 6C1 to GND) and measure the ISL9216 analog output voltage (test point AO to GND). The AO voltage, (x 2), should equal the VCELL1 voltage. Any errors in this measurement are due to the ISL9216. (Note: make sure that all of the cell balance outputs are off because cell balance current will cause inaccurate measurements).
- Also, read the GUI value for CELL1. In this configuration (without the µC) the cell voltage is converted to digital using a 15-bit A/D converter. Its output is determined by Equation 1:

$$\frac{DigValue_D}{32768} \times 3.3 = A2DIN \quad \text{(EQ. 1)}$$

  Since, the reference for the A/D converter is supplied by the ISL9216 RGO voltage, any difference in the RGO voltage and 3.3V turns up as an accuracy error.

- Proceed, in sequence, to read the AO voltage for each cell connected to the ISL9216.
- To monitor the voltages of the cells connected to the ISL9217, first set the ISL9216 to read VCELL6. Then, set the ISL9217 to read VCELL1. In this case, the ISL9216 AO voltage is a reflection of the ISL9217 VCELL1 voltage. The VCELL1 voltage is shifted within the ISL9217, divided by 2, and applied to the ISL9217 AO pin. The ISL9217 AO pin connects to the ISL9216 VCELL6 pin and the voltage is level shifted again to ground reference. It is not divided within the ISL9216. The voltage at AO, times 2, should equal the ISL9217:CELL1 voltage. Any errors are due to the inaccuracies in the ISL9216 and ISL9217 devices.
- Monitor the remaining cells connected to the ISL9217, by selecting (with the GUI) the individual ISL9217 cells. (keep the ISL9216 set to monitor VCELL6).

Discharge Overcurrent Testing

- With the output off, connect an electronic load between Test Point 7C7 (Battery + terminal) and P- (Pack - terminal). The E-load should be able to handle up to 60V and sink 1A minimum.
- Use the GUI “CONFIGURATION” screen to set the desired discharge and short circuit levels and time delays. Remember, the evaluation board comes with a 0.5Ω sense resistor. As such, a 0.1V setting will cause an shutdown at 200mA. If higher range of current is desired, change the sense resistor.
- To test, a pulse load or a continuous load can be used. A continuous load has the advantage of showing the load monitor operation.
- Set the e-load current such that it will exceed the expected overcurrent threshold.
- Turn on both FETs by clicking on the FET buttons in the GUI. When they are on, they will indicate green. Periodically click on the “Status Refresh” button on the lower right of the screen to make sure that the GUI reflects the latest status of the device. (An automatic scan can also be started that updates all parameters every 1s, 5s, 10s, or 30s, however, this might cause an update when not expected).
- Turn on the load. This should cause the FETs to turn off (see Figure 8).

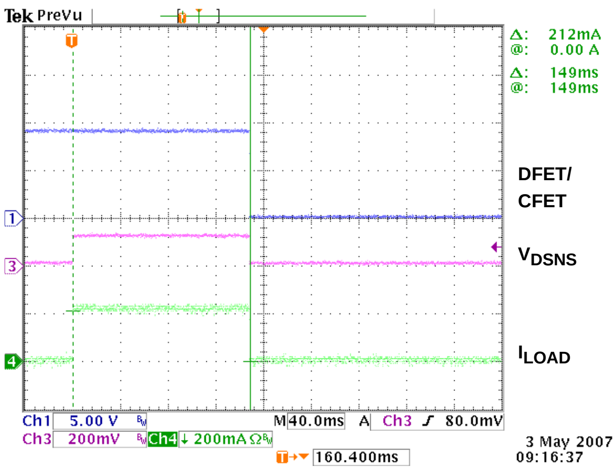


FIGURE 8. DISCHARGE OVERCURRENT TEST (0.1V THRESHOLD, 160ms TIME DELAY, 0.5Ω SENSE RESISTOR)

- Do a refresh of the GUI and the FET buttons should have gone to red. Also, the "Discharge Overcurrent" indicator should now be red.
- Leave the load on and click on the "Enable Load Monitor" button in the lower right corner of the screen. This turns on the load monitor output.
- Click on the "Status Refresh" button. In this case, the "Load Fail" indicator should now also be red.
- Turn off or remove the load and again click on "Status Refresh". The "Load Fail" indicator should go to green. Click on the "Reset Overcurrent" button to reset the "Discharge Overcurrent" indicator. It should also go to green. If the indicators are still red, it is because the remaining resistance on the load keeps the voltage on the ISL9216 load monitor (VMON) pin above its input threshold. Try disconnecting the load.
- Note: In the GUI, the discharge overcurrent, discharge short circuit and charge overcurrent indicators are latched by the GUI. Internal to the ISL9216, the bit is reset by a read operation (if the condition has been resolved). The GUI latch is provided because the overcurrent condition goes away as soon as the FETs turn off and the bits in the ISL9216 are reset by reading the registers. Therefore, without the latch, the indicator would not stay on long enough for the user to monitor. Reset the latch by clicking on the "Clear Overcurrent" button.

Charge Overcurrent Testing

- Turn off the power to the board.
- Remove any load on the board Pack+ and Pack- pins.
- Turn on the ISL9216 board power supply (or connect the Li-ion cells to the pack).
- Use the GUI "CONFIGURATION" screen to set the desired charge overcurrent level and time delay.
- Turn on both FETs by clicking on the FET buttons in the GUI. When they are on, they will indicate green.

Periodically click on the "Status Refresh" button on the lower right of the screen to make sure that the GUI reflects the latest status of the device.

- Use another power supply for charge emulation. With the output off and not connected to the board, set the output to just over the chosen overcurrent detect voltage threshold. (This supply should have a 1.5A limit, but will only need to provide 0.2V maximum).
- Connect the charge emulation power supply positive terminal to the board GND pin and the charge emulation power supply negative terminal connected to the board P- pin. See Figure 9. A current probe can be used to monitor the overcurrent details.

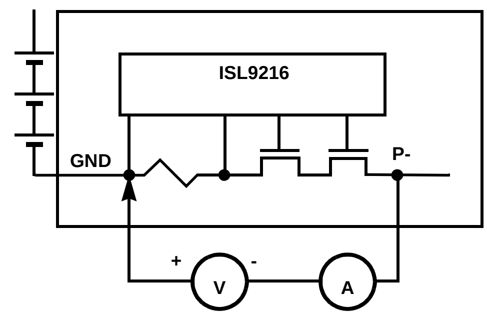


FIGURE 9. CHARGE OVERCURRENT TEST CONNECTION

- Turn the charge emulation power supply output on. This causes the ISL9216 to detect an overcurrent condition, which turns the FETs off. Figure 10 shows a charge overcurrent condition where the charger turns on with current too high.

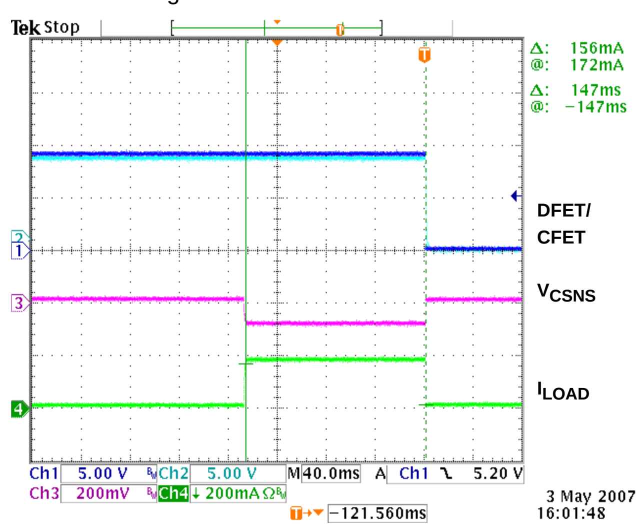


FIGURE 10. CHARGE OVERCURRENT TEST (0.1V THRESHOLD, 160ms TIME DELAY, 0.5Ω SENSE RESISTOR)

- The charge emulation power supply could have been connected across the Pack output pins - as in a "real world" operation. However, both the load and input power supplies need to sink current, the output supply would need to be floating when turned off (not shorted), and the load supply would need to handle a higher voltage than the input.

Sleep/Wake Testing (Default Setting - WKPOL = 0)

The ISL9216EVAL1Z (Rev D) board can be put to sleep via commands from the PC. This sequence is described in the following paragraphs.

- Use the Register Access window of the GUI to write the value 80H to register 4 of the ISL9217. This sets the ISL9217 sleep bit.
- Note that the RGO2 LED goes off. This indicates that ISL9217 has gone to sleep and turned off its output regulator.
- Next, click on the ISL9208/ISL9216 Cell Balance CB6 box. This sets the ISL9216 WKUPR output low. This wakes-up the ISL9217 causing the regulator to turn on, lighting the RGO2 LED. Click on the ISL9208/ISL9216 CB6 box again to turn off the WKUPR signal.
- To put the ISL9216 into the sleep mode, write an 80H to the ISL9216 register 4. This turns off the ISL9216 RGO output and LED.
- To wake up the ISL9216 requires that the ISL9216 WKUP pin go below its wake-up threshold. Normally, in a pack, a charger would be connected to the pack terminals. The higher voltage on the charger would pull the WKUP pin low, causing the part to wake-up. However, in a test setup, it is not always advisable to connect the charger. Another way to do this is to connect a jumper from GND to the WKUP pin. When using this technique, don't leave the jumper in place.
- When the WKUP pin is pulled low, the ISL9216 wakes up and turns on its RGO output. This turns on the RGO LED.

Sleep/Wake Testing (WKPOL = 1)

- This section only applies to the ISL9216. DON'T set the ISL9217 WKPOL bit to "1", or the device will not wake-up once placed into the sleep mode. (Power cycling would be required to wake it up).
- Set the WKUP jumper to the active high position (shunt on the side closest to the push-button switch).
- Use the GUI to set the "WKUP Pin Active High" in the Configure Tab, feature set window.
- Put the ISL9216 in sleep mode as before.
- This time, the device can be waken by the press of the WKUP button on the board.

Testing with the Microcontroller

- To operate the board using the microcontroller, power-down the board.
- Set the I^2C jumpers to the µC position.
- Power-up the board and restart the GUI. Now, the PC will be communicating with the microcontroller and the microcontroller will be communicating with the ISL9216.
- The GUI should power-up with some color. In this case, the FET controls should be green and the indicators should be green or red. If the GUI is all gray, then there is a communication problem. If there is a communication problem, see the troubleshooting guide in "Appendix 2" on page 18.
- If the FET indicators are red, then it is likely that at least one input voltage is out of range.

With the microcontroller in place, the board performs a number of automatic functions. These are:

1. The cell inputs are monitored for too high or too low voltage. If any of the cell voltages go too high, the charge FET is turned off. If any of the cell voltages go too low, the discharge FET turns off. When the voltage recovers from these excursions, back into the normal range, the FETs automatically turn on.
2. After an overcurrent condition, the microcontroller monitors the load and turns the FETs back on when the load is released.
3. The microcontroller monitors the temperature and turns off the cell balance if the temperature is too high or low.
4. The microcontroller performs cell balancing (once it is enabled through the GUI).
5. The microcontroller monitors the cell voltages and reports these voltages to the GUI. The microcontroller A/D converter accuracy is only 10-bits, so the voltage reading are not as accurate as when using only the PC interface.

- Test the overvoltage and undervoltage conditions by:
  - If Li-ion cells are being used, discharge the pack until one or more of the cells reach the undervoltage limit and the discharge FET turns off. Then, charge the pack until the FETs turn on again and continue charging until a cell overvoltage condition is reached.
  - If one of the three power supplies with resistor string is being used, lower the voltage on one of the power supplies until one or more of the cells reach the undervoltage limit and the discharge FET turns off. Then, increase the voltage until the FETs turn on again and continue increasing the voltage until a cell overvoltage condition is reached.
  - If twelve power supplies are used, then simply decrease or increase each individual supply until the thresholds are reached and the FET turns off (or on).
- Test the overcurrent in the same way as before, but this time, when the load is removed the FETs should automatically turn back on. In this case, with the microcontroller operating, the status indicators in the GUI may not prove to be very useful, because the microcontroller is often doing things too quickly to display on the screen.
- Testing the cell balance operation requires the use of Li-ion cells or the replacement of the cell balance resistors with lower resistance devices. With the suggested resistor string, turning on one cell balance output will likely drop the voltage on that cell to less than the 2.5V sleep threshold and the microcontroller will put the ISL9216 and ISL9217 (and the board) to sleep.

- Start the cell balance test by first observing if the cell with the maximum voltage exceeds the cell with the minimum voltage by more than 30mV. If so, note the cell number of the maximum voltage cell.
- Next, select “CB Max #” to be “1”. This limits the balancing to only one cell (the one with the maximum voltage).
- Use the CB refresh button (or start auto update) to update the indicators to see which cell is being balanced (it should be the maximum voltage cell). Be patient, because the microcontroller will balance for 10s, then turn off balancing for 2s, then balance again. Also, if the maximum voltage cell is very close to the next highest voltage cell, or if there are many cells within a narrow voltage range, then any of these cells could be balanced, due to the limited accuracy of the microcontroller A/D converter.
- Next, select “CB Max #” to be “2”. This limits the balancing to two cells - the highest two voltage cells. Again refresh the CB screen periodically to see the operation of the cell balance code.
- Open the pack tab in the GUI and change some of the settings for overvoltage, undervoltage, or cell balance and re-test. Remember to click on “Write” to send the new parameters to the microcontroller.

Further tests on the board will likely follow the lines of battery pack testing, so it can become quite involved and be very specific to the application. Thus, before setting up the tests, see the “GUI user Manual” for information on using the interface and see the “Microcode Reference Guide” for information about how the software works.

Other Board Features/Options

Sense Resistor

The ISL9216EVAL1Z (Rev D) board has three basic sense resistor “footprints” for different types of sense resistors. The basic footprint is a standard 2512 surface mount. The board uses a 0.5Ω resistor in this form factor as the default.

A second footprint is for an axial lead sense resistor. In this case, remove the resistor that was shipped with the board.

The third footprint is for a 4-terminal sense resistor with Kelvin connections. These are higher precision sense resistor devices, but are more costly.

In summary, in addition to a standard 2512 footprint, the board is laid out to handle the following resistors:

Isotek:

- SMV-R005-1.0
- SMR-R005-1.0
- LMSR005-5.0
- BVS-A-R004-1.0

TT electronics (IRC):

- OAR-5 0.005 5% LF (Mouser 66-OAR5R005JLF)

Additional FETs

The board has extra pads on the top of the board to handle additional power FETs. As shown in the schematic, these parallel the ones provided with the board. While this can be used to test very high discharge current applications, the primary purpose of adding these optional FETs to the PCB was to test the performance of the FET drive circuitry in applications where higher capacitance FETs or multiple FETs are used.

If the FETs are added to the board, monitor the FET gate drive voltage during FET turn on and turn off to determine if the response times are suitable for the application.

No tests have been made to determine if the board traces can handle the amount of current or power dissipation supported by the FETs on the board. Additional heat sinking for the power FETS is recommended if a large current current is being tested.

Microcontroller Options

The BKGD connection on the ISL9216 board allows development of new or modified code for the Freescale MC9S08QG8 microcontroller, which is supplied on the board.

The PCB provides optional connections for an external crystal for the microcontroller and brings all microcontroller terminals out for use in other application modes.

The external, 15-bit, A/D converter is not used by the microcontroller, but it could be, if changes are made to the microcontroller code. To use this, refer to the Texas Instruments ADS1100 data sheet. The version of the A/D converter used on the ISL9208 board is the ADS1100A2, which has an I^2C address of “1001 010x.”

Use with an External Microcontroller

The ISL9216 board can be used as a platform for developing code for a microcontroller other than the Freescale microcontroller on the board. To do this, set the I^2C jumpers in the PC mode and use the I^2C interface for communication with the external microcontroller.

To get good communication between the external microcontroller and the ISL9216, connect the “I^2C GND jumper” to the GND position. However, in this case, make sure that the external microcontroller is isolated from earth ground before connecting a load or charger to the pack. This is because the board GND terminal and the P- terminal are not the same when the FETs are off.

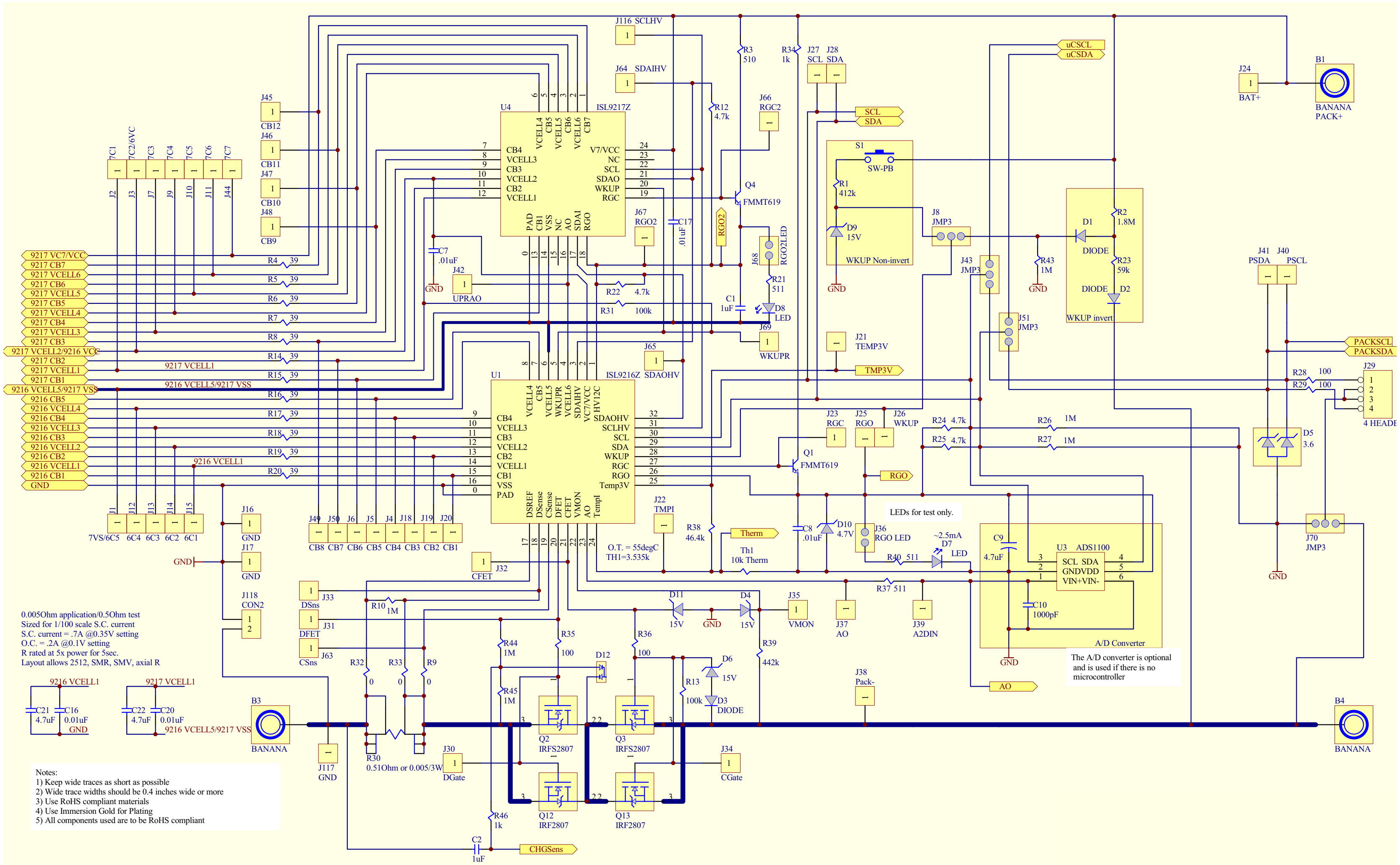
Charge Detection

The ISL9216EVAL1Z (Rev D) board has an optional circuit to detect a charge condition. The voltage is monitored on the ChgSens test point. This voltage should drop as charge current is applied. This signal connects to one of the microcontroller A/D inputs, however, the initial release microcontroller software does not make use of this signal.

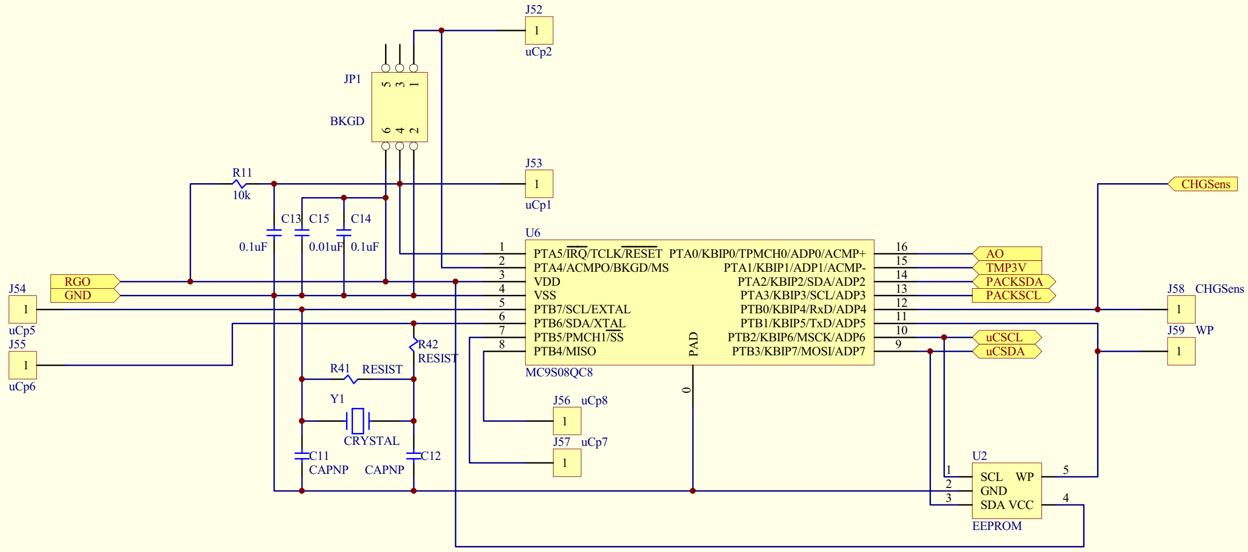
EEPROM

For applications that require non-volatile storage or require calibration and the microcontroller flash is no longer available, the ISL9216EVAL1Z (Rev D) board provides a serial EEPROM connection to the microcontroller. An example EEPROM device is the AT24C16 from Atmel. This is not populated as shipped and there is no code in the microcontroller to support this device.

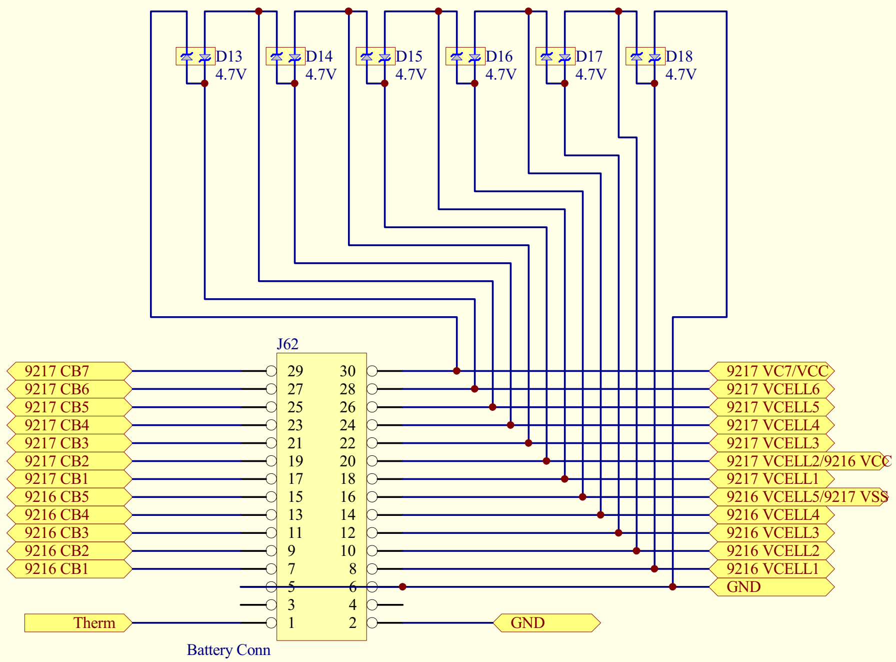
AFE Schematic



Microcontroller Schematic



Battery Connection Schematic



ISL9216EVAL1Z (Rev D) Bill of Materials

ITEM	QTY	PART TYPE	DESIGNATOR	FOOTPRINT	DESCRIPTION	PART FIELD 1	PART FIELD 2
1	2	1µF	C1, C2	603		*	*
2	1	1000pF	C10	603		*	*
3	2	0.1µF	C13, C14	603		*	*
4	2	4.7µF	C21, C22	603		*	*
5	5	0.01µF	C7, C15, C16, C17, C20	603		*	*
6	1	0.01µF	C8	805		*	*
7	1	4.7µF	C9	805		*	*
8	3	DIODE	D1, D2, D3	SOD-123		Digikey: B0540WDICT ND	DIODES: Schottky diode
9	1	4.7V	D10	SOD-123		Digikey: BZT52C4V7-FDICT-ND	*
10	1	DUAL DIODE	D12	SOT23		Digikey: 568-1624-1-ND	Philips: BAV99
11	6	4.7V	D13, D14, D15, D16, D17, D18	SOT-363		Digikey: MMBZ5230BS-FDICT-ND	DIODES: MMBZ5230BS
12	4	15V	D4, D6, D9, D11	SOD-123		Digikey: MMSZ4702T10SCT-ND	On Semi: 15V Zener - SOD-123
13	1	3.6V	D5	SOT23		Digikey: AZ23C3V6-FDICT-NDD	DIODES: 3.6V Zener-dual, common anode
14	2	LED	D7, D8	LED_GW		Panasonic: LN1271RTR	*
15	1	CON2	J118	JP_2	Connector	*	*
16	3	GND	J16, J17, J117	TP SM	Connector	Digikey 5011K-ND	*
17	1	HEADER 4	J29	HEADER 4X1		*	*
18	2	RGO LED	J36, J68	JP_2		*	*
19	1	Battery Connection	J62	HEADER 15X2 3M		*	*
20	4	JMP3	J8, J43, J51, J70	JP_3		*	*
21	1	BKGD	JP1	HEADER 3X2		*	*
22	2	FMMT619	Q1, Q4	SOT23 - NPN		Digikey: FMMT619CT-ND	ZETEX: NPN 50V hfe = 100min
23	2	IRFS2807	Q2, Q3	D2PAK		*	*
24	1	412kΩ	R1	805		*	*
25	6	1MΩ	R10, R26, R27, R43, R44, R45	603		*	*
26	1	10kΩ	R11	603		*	*
27	4	4.7kΩ	R12, R22, R24, R25	603		*	*
28	1	100kΩ	R13	805		*	*
29	1	1.8MΩ	R2	805		*	*
30	1	59kΩ	R23	805		*	*
31	4	100Ω	R28, R29, R35, R36	603		*	*
32	4	511Ω	R3, R21, R37, R40	603		*	*
33	1	0.51Ω	R30	2512		Digikey: PT.51YCT-ND	Panasonic: ERJ-1TRQF.51U

ISL9216EVAL1Z (Rev D) Bill of Materials (Continued)

ITEM	QTY	PART TYPE	DESIGNATOR	FOOTPRINT	DESCRIPTION	PART FIELD 1	PART FIELD 2
34	1	100kΩ	R31	603		*	*
35	2	1kΩ	R34, R46	603		*	*
36	1	46.4kΩ	R38	805		*	*
37	1	442kΩ	R39	805		*	*
38	12	39Ω	R4, R5, R6, R7, R8, R14, R15, R16, R17, R18, R19, R20	2512		*	*
39	3	0Ω	R9, R32, R33	603		*	*
40	1	SW-PB	S1	B3WN-6002		*	*
41	1	10k Therm	Th1	603		*	MuRata: NCPxxXH103F
42	1	ISL9216Z	U1	QFN32		*	*
43	1	ADS1100	U3	SOT23-6		*	*
44	1	ISL9217Z	U4	QFN24		*	*
45	1	MC9S08QC8	U6	QFN16		*	*
46	30	6C1	J15	TP	Test Point	Digikey 5000K-ND	*
		6C2	J14				
		6C3	J13				
		6C4	J12				
		7C1	J2				
		7C2/6VC	J3				
		7C3	J7				
		7C4	J9				
		7C5	J10				
		7C6	J11				
		7C7	J44				
		7VS/6C5	J1				
		A2DIN	J39				
		AO	J37				
		BAT+	J24				
		CFET	J32				
		CSns	J63				
		DFET	J31				
		DSns	J33				
		Pack-	J38				
		RGO	J25				
		SCL	J27				
		SDA	J28				
		TEMP3V	J21				
		TMPI	J22				
		UPRAO	J42				

ISL9216EVAL1Z (Rev D) Bill of Materials (Continued)

ITEM	QTY	PART TYPE	DESIGNATOR	FOOTPRINT	DESCRIPTION	PART FIELD 1	PART FIELD 2
		VMON	J35				
		WKUP	J26				
		WKUPR	J69				
		RGO2	J67				
	129						
1	1	BANANA RED	B1	BANANA		*DNP	*
2	2	BANANA BLACK	B3, B4	BANANA		*DNP	*
3	2	CAPNP	C11, C12	603		*DNP	*
4	2	IRFS2807	Q12, Q13	D2PAK		*DNP	*
5	2	RESIST	R41, R42	603		*DNP	*
6	1	EEPROM	U2	SOT23-5		*DNP	AT24C16
7	1	CRYSTAL	Y1	32k XTAL	Crystal	*DNP	*
8	28	SCLHV	J116	TP	Test Point	*DNP	*
		CB3	J18			*DNP	
		CB2	J19			*DNP	
		CB1	J20			*DNP	
		RGC	J23			*DNP	
		CGate	J34			*DNP	
		DGate	J30			*DNP	
		CB4	J4			*DNP	
		PSCL	J40			*DNP	
		PSDA	J41			*DNP	
		CB12	J45			*DNP	
		CB11	J46			*DNP	
		CB10	J47			*DNP	
		CB9	J48			*DNP	
		CB8	J49			*DNP	
		CB5	J5			*DNP	
		CB7	J50			*DNP	
		µCp2	J52			*DNP	
		µCp1	J53			*DNP	
		µCp5	J54			*DNP	
		µCp6	J55			*DNP	
		µCp8	J56			*DNP	

ISL9216EVAL1Z (Rev D) Bill of Materials (Continued)

ITEM	QTY	PART TYPE	DESIGNATOR	FOOTPRINT	DESCRIPTION	PART FIELD 1	PART FIELD 2
		µCp7	J57			*DNP	
		CHGSens	J58			*DNP	
		WP	J59			*DNP	
		CB6	J6			*DNP	
		SDAIHV	J64			*DNP	
		SDAOHV	J65			*DNP	
		RGC2	J66			*DNP	
	39					*DNP	

Appendix 1

Installing the DeVaSys USB to I²C board software

Copy and extract the files from the "PC_software.zip" to the PC at whatever location is desired.

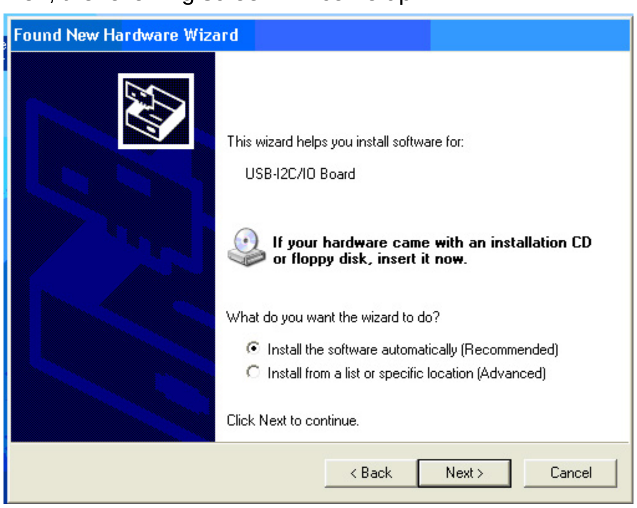
Disconnect the DeVaSys board from the ISL9208/ISL9216 board.

Then, plug in the DeVaSys board into the USB port.

The following screen should pop up:.

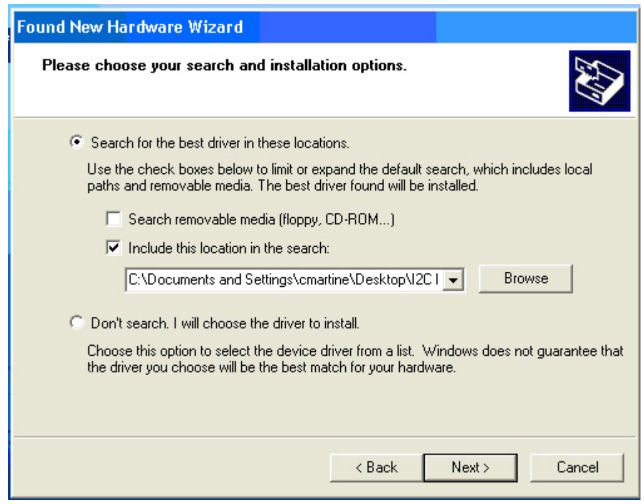
Select "Yes, this time only" and click "Next".

Then, the following screen will come up:



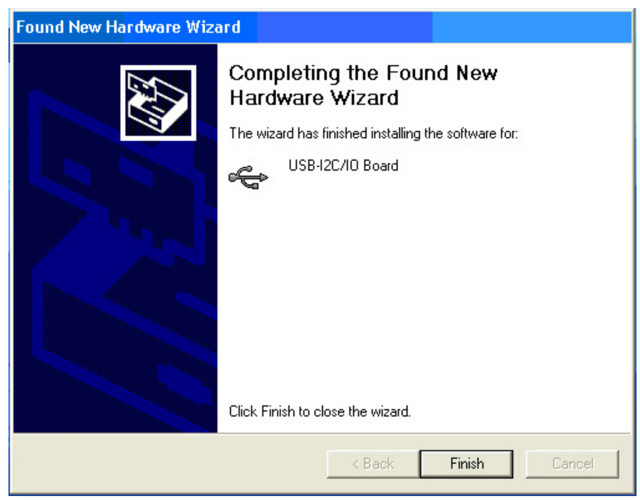
Select "Install from a list or specific location" and click "Next".

A screen like the following will come up:



Browse for the "Software" directory in the "ISL9208_16 Eval Kit SW and docs" folder then click "Next".

This should install the software, eventually bringing up the following screen:



Click "Finish" and you're done.

Appendix 2

Communication Troubleshooting

IF THE GUI STARTS UP WITH ALL ITEMS “GRAYED OUT”

1. Check that the I^2C cable is connected properly.
2. Check that the board is powered-up and that the RGO voltages are 3.3V (relative to their device VSS pins).
3. If the RGO voltages are not powered to the right voltage, move to the “Power Supply Troubleshooting” on page 18.
4. Make sure that the board drivers are installed correctly. When using the DeVaSys USB to I^2C interface board, there should be one red LED and one green LED lit.
5. Use a scope to see that the I^2C communication is correct at the board. Monitor the SCL and the SDA lines while initiating a read of the ISL9216 status register. Set the scope to single trigger on the falling edge of SCL.
6. If the I^2C communication is correct at the SCL and SDA pins, check that the communication is correct at the ISL9217. Connect the scope to the SCL terminal and the SCLHV terminal. The SCLHV terminal should follow the SCL voltage, but be shifted to ~3.3V above the ISL9217 VSS terminal (and be slightly delayed). Also check the SDA and SDAOHV test points. SDAOHV should follow SDA, but be shifted in voltage and slightly delayed.
7. Check that the SDA and SCL jumpers (J51 and J43) have shunts on the “PC” side.
8. Check to see that the “I^2C GND” jumper is in place in the “GND” position.
9. Check that the “IC GND” jumper (J118) is in place.

Power Supply Troubleshooting

IF RGO OR RGO2 DO NOT HAVE THE CORRECT VOLTAGE

1. Check that the voltage on each of the input terminals are correct.
2. Check that all cell balance outputs are off.
3. Check that there is no unexpected load on the RGO outputs.

ISL9216/ISL9217 Troubleshooting

IF THE AO VOLTAGES ARE READING INCORRECTLY AT THE AO PIN

1. Make sure that the I^2C jumpers are in the “PC” position.
2. Check that all cell balance outputs are off.
3. Make sure that there is no series resistance between the battery and the input of the ISL9216 and ISL9217 and that the input voltage on each cell is between 2.3V and 4.3V.

IF THE AO VOLTAGES ARE READING INCORRECTLY ON THE GUI

1. Check that the RGO output is 3.3V. GUI and microcontroller calculations assume the RGO voltage is 3.3V. Any variation translates directly into errors in the GUI screen value.
2. Power down the board and stop the GUI. power-up the board and restart the GUI. This should clear any communication problems.
3. If operating with the I^2C Jumpers in the µC position, make sure that the “Partition” setting in the Pack Tab matches the battery connection on the board.

Excessive Current Troubleshooting

INPUT “PROTECTION” DIODES

Input protection zener diodes are added to the evaluation board to minimize the chance of exceeding the input voltage range of the ISL9216 and ISL9217 cell monitoring inputs during experimentation (especially during testing of the cell balance operation) when using a string of resistors to simulate the batteries. In an actual application, however, when the board is connected to a string of batteries, these zener diodes “leak” at higher cell voltages. This may not be a big problem as the currents are less than 20µA, but over time it could lead to reduced pack life.

There is excessive current flowing into the ISL9216 VCELL3 input when both FETs are on and no cells are being monitored.

When ISL9216 turns both FETs on, there is a current path from the CFET gate to VSS through the charge FET pull-up resistor R_{13}. This 100kΩ resistor and a 12V gate voltage results in about 120µA of current into the VCELL3 input when no cells are being monitored. This can be reduced by increasing the value of R_{13}, but this slows down the charge FET turn off. The pack can also be designed without the charge FET. This removes the charge FET current. Alternatively, when there is no current flow into or out of the pack, the charge FET can be turned off, removing this CELL3 current.

There is excessive current flowing into the ISL9216 VCELL1 input when the discharge FET is off, the charge FET is on, and no cells are being monitored.

When the discharge FET is off and the charge FET is on, and the pack voltage is sufficiently high, a voltage greater than the CFET ouput is applied to the CFET pin. This causes some circuit elements inside the ISL9216 to turn on causing current to flow into the VCELL1 input. This current is on the order of 120µA. The current can be stopped by turning on the VMON output. This pulls the CFET voltage low enough that the internal circuits do not turn on. Alternatively, a schottky diode can be added in series with the CFET output as shown in Figure 11. When this diode is added, the zener diode D_{14} and diode D_3 can be removed as they have no functionality.

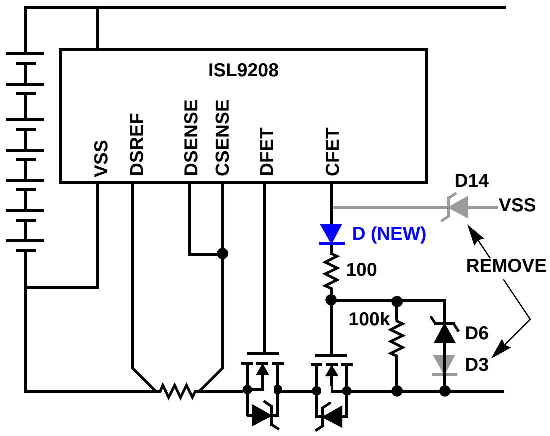


FIGURE 11. BLOCKING CELL1 CURRENT WHEN DFET IS OFF AND CFET IS ON

There is about 10µA of current flowing into the ISL9216 VCELL1 input when the both FETs are on and no cells are being monitored.

When the wake-up voltage is below the falling edge threshold, the WKUP input turns on some ISL9208 internal circuits that draw current through the VCELL1 input. This current can be eliminated by increasing the value of R_{23} to 113kΩ (7-cell operation). This sets the voltage on the WKUP pin above the falling edge threshold). The consequence of doing this is that when the cells are fully charged to 50.4V, a charger with a voltage of 52.3V or more is required to wake the pack.

There is about 12µA of current into the ISL9216 VCELL3 when the discharge FET is on and the charge FET is off and no cells are being monitored.

This current is caused by the current monitor circuit consisting of R_{44}, R_{45}, and D_{12}. Disconnect R_{44} to eliminate this current. Of course this also disables the current monitor feature.