

ISL9208EVAL1Z

Rev D Evaluation Board

AN1355  
Rev 0.00  
Oct 10, 2007

**Description**

This document is intended for use by individuals engaged in the development of hardware for a 4 to 7 series connected Li-ion battery pack using the ISL9208EVAL1Z (Rev D) board.

The evaluation kit consists of the ISL9208EVAL1Z (Rev D) board, a power supply cable and an I<sup>2</sup>C cable. Operation of the ISL9208EVAL1Z (Rev D) board requires the use of a USB to I<sup>2</sup>C kit and part number "ISLI2C-Cable2", which is ordered separately. An optional link between the PC and the microcontroller BKGD connector is available from NXP (formerly Freescale) for monitoring and debugging the microcontroller code.

**First Steps**

- If not already available, acquire the DeVasys USB to I<sup>2</sup>C interface cable and module. This is available from Intersil in the ISLI2C-Cable kit.
- Download the software from the Intersil website on the ISL9208 page. This is a zip file entitled: "ISL92xx Eval Kit Software Release V1.41".
- Unzip the software files to a directory of your choice.
- Prior to powering the ISL9208 board, install the USB to I<sup>2</sup>C board software and connect the DeVasys board to the PC (see Appendix 1). However, don't connect the DeVasys board to the ISL9208EVAL1Z (Rev D) board, yet. This is just preparation of 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 NXP (formerly 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.

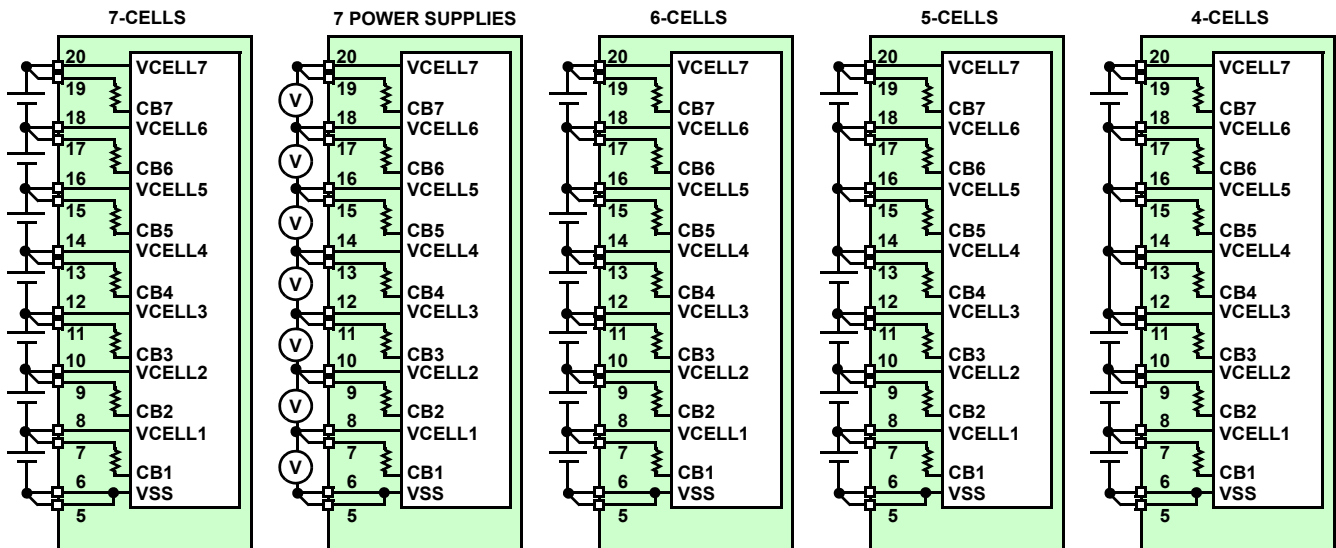
- Set-up a power supply for the board. The power supply should consist of a string of 4 to 7 batteries (see Figure 1), or a string of 4 to 7 resistors and a power supply, or 4 to 7 individual power supplies (see Figure 1 or Figure 2).

**Battery/Power Supply Connection**

When connecting battery packs or power supplies, use the connections of Figure 1 and Figure 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 ISL9208 maximum input voltage differential of 5V per cell.

If using a string of resistors to emulate the battery cells, then use the connection in Figure 2. In this case, limit the power supply voltage so that the resistor divider outputs do not exceed the ISL9208 input maximum ratings.

It is recommended that, when using the circuit of Figure 2, the series resistors be 20Ω or less and 2W minimum. Resistors with higher resistance can be used, but when activating the ISL9208 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. If using series resistors greater than 20Ω, the cell balance resistors on the ISL9208EVAL1Z (Rev D) board (R<sub>14</sub> to R<sub>20</sub>) should be replaced with higher values (1kΩ recommended).



NOTE: MULTIPLE CELLS CAN BE CONNECTED IN PARALLEL

FIGURE 1. BATTERY CONNECTION OPTIONS

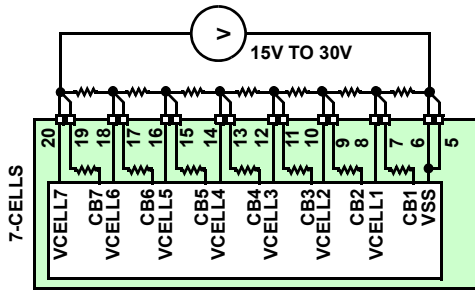


FIGURE 2. USING RESISTOR/POWER SUPPLY COMBINATION TO EMULATE A STRING OF BATTERIES

NOTES:

1. For the battery simulation resistors, use  $20\Omega/2W$  devices (minimum). If the resistors are more than  $100\Omega$ , then turning on the cell balance resistors cause fluctuations in the cell input voltages that can violate the ISL9208 max specifications. If the series resistors are larger than  $20\Omega$ , we recommend replacing the cell balance resistors on the board with  $1k\Omega$  devices.
2. Switch the power supplies on at the same time, or if this cannot be guaranteed, turn them on from bottom to top.
3. Before connecting the cable to the board, check the voltages at the connector to verify that they are correct.

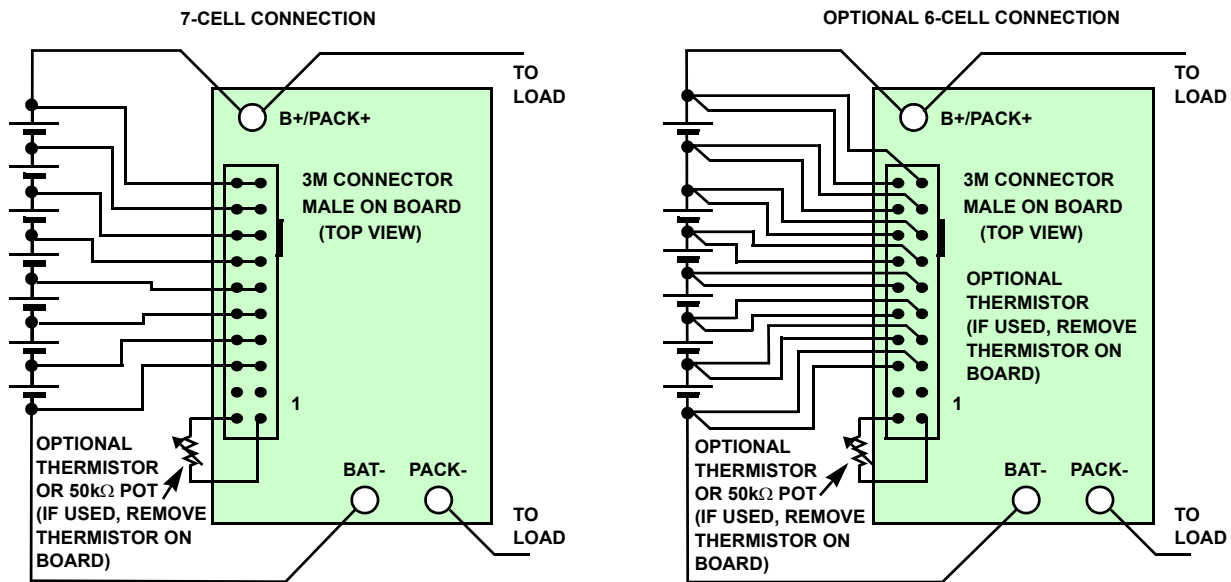


FIGURE 3. BATTERY CELL CONNECTION TO ISL9208 PCB

## Initial Testing

### Set-up (See Figure 4)

- Make sure the following jumpers are on: IC GND JMPR, RGO LED JMPR, WKUP JMPR, I<sup>2</sup>C GND JMPR and the I<sup>2</sup>C Jumpers.
- For initial testing, set the I<sup>2</sup>C jumpers (SCL and SDA) to the PC position. This configures the board such that the PC communicates directly with the ISL9208.
- Before connecting the PC to the ISL9208EVAL1Z (Rev D) board (through the USB to I<sup>2</sup>C interface), turn off the power supply and then connect the power supply to the ISL9208EVAL1Z (Rev D) board.
- Turn on the power to the board. Once power is turned on (or Li-ion cells are connected to the ISL9208EVAL1Z (Rev D) board) the RGO LED should light. Use meter 1 to measure the RGO voltage. It should read about 3.3V.

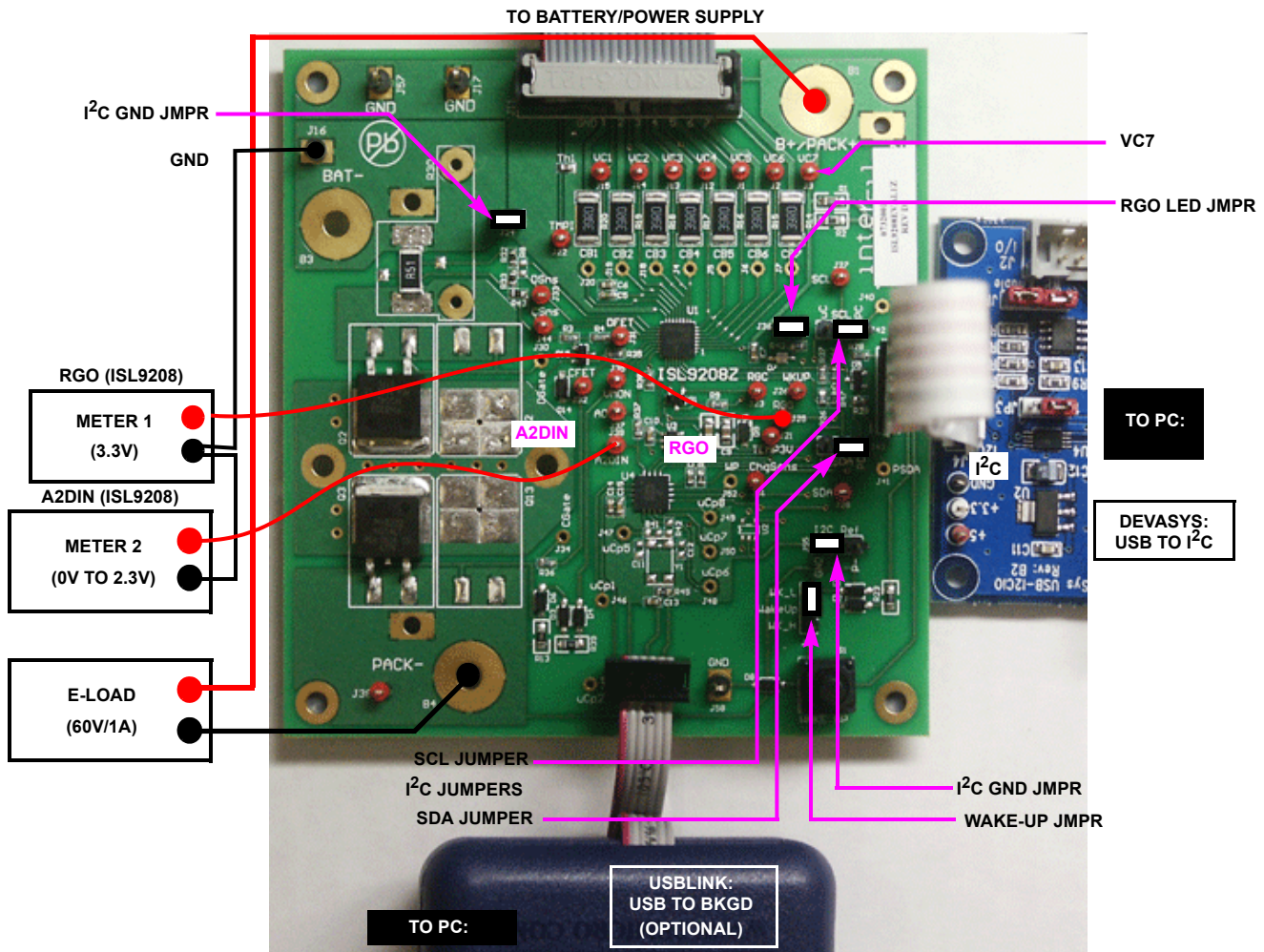


FIGURE 4. ISL9208EVAL1Z (REV D) EVALUATION BOARD TEST CONNECTION

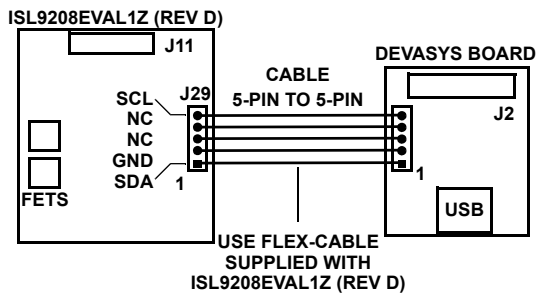


FIGURE 5. I<sup>2</sup>C CONNECTION TO ISL9208 PCB

**USB to I<sup>2</sup>C Interface**

- Once the power supply connections are verified, power-down the ISL9208EVAL1Z (Rev D) boards and make the PC connection to the board, via the USB port, the DeVaSys board and the I<sup>2</sup>C cable. Before making this connection, make sure that the USB to I<sup>2</sup>C interface software is installed (see software installation guide).
- Connect the I<sup>2</sup>C cable from the interface board to the ISL9208EVAL1Z (Rev D), as in Figure 5. The kit may come with a 5-pin to 5-pin cable or a 5-pin to 4-pin cable. Use the 5-pin to 5-pin cable.

**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 6). Except for the ISL9208 automatic response to overcurrent and over-temperature, all other actions of the board are manual and controlled through the GUI.
- Make the I<sup>2</sup>C 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 the Appendix.

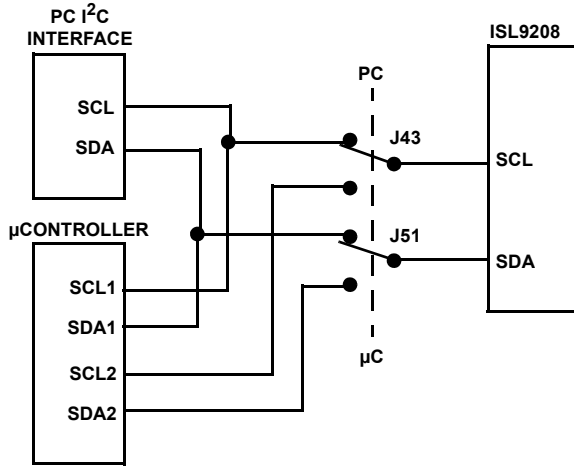


FIGURE 6. I<sup>2</sup>C JUMPERS: PC OR μC CONNECTION TO THE ISL9208

- Use the GUI to read register 0 from the ISL9208. The ISL9208 should return the value 20H. This verifies communication to the device.
- Next, move to the “MONITOR” tab of the GUI.
- Set the ISL9208 to monitor the VCELL1 input by 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 VC1 to GND) and measure the voltage on the ISL9208 analog output (from AO to GND). The AO voltage, times 2, should equal the CELL1 voltage. Any errors in this measurement are due to the ISL9208. (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. This A/D converter is an ADS1100 from Texas Instruments. Its output is determined by Equation 1:

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

Since, the reference for the A/D converter is supplied by the ISL9208 RGO voltage, any difference between 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 ISL9208.

### Discharge Overcurrent Testing

- Select an E-load that is able to handle up to 30V and sink 1A minimum.
- With the e-load output off, connect the positive terminal to Test Point VC7 (Battery + terminal) and the negative terminal to test point P- (Battery - terminal).
- Use the GUI “CONFIGURATION” screen to set the desired discharge overcurrent and short circuit levels and time delays in the ISL9208.
- To test overcurrent, a pulse load or a continuous load can be used. A continuous load has the advantage of showing the load monitor operation (see the following).
- Set the e-load current such that it will exceed the expected overcurrent threshold for more than the selected time delay interval.
- Turn on both FETs by clicking on the FET buttons in the GUI. When the FETs are on, the GUI indicators will turn 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 1, 5, 10, or 30 seconds, however, this might cause an update when not expected).
- Turn on the e-load output. This should cause the FETs to turn off (see Figure 7).

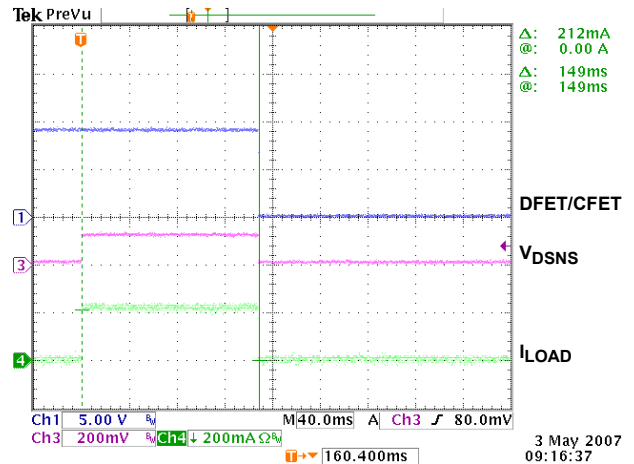


FIGURE 7. DISCHARGE OVERCURRENT TEST (0.1V THRESHOLD, 160ms TIME DELAY, 0.5Ω SENSE)

- 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 and 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 ISL9208 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 ISL9208, the bits are reset by a read (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 ISL9208 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 ISL9208 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 the FETs are on, the GUI indicators 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 2.5A limit, but will only need to provide 1.5V max).
- Connect the charge emulation power supply positive terminal to the board GND pin and connect the charge emulation power supply negative terminal to the board P pin. See Figure 8. A current probe can be used to monitor the overcurrent details.
- Turn the charge emulation power supply output on. This causes the ISL9208 to detect an overcurrent condition, which turns the FETs off. Figure 9 shows a charge overcurrent condition where the charger turns on with current too high.
- The charge emulation power supply could have been connected across the Pack output pins (as in a “real world” operation). However, doing this requires that both the “charger” and “battery” power supplies sink current, that the “charger” supply needs to be floating when turned off (not shorted), and that the “charger” supply needs to handle a higher voltage than the input.

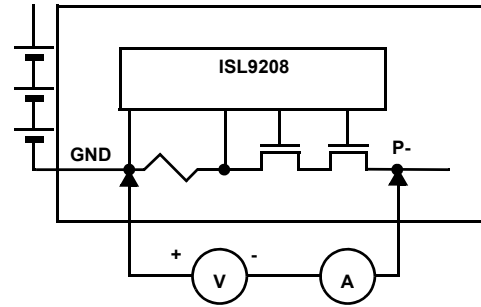


FIGURE 8. CHARGE OVERCURRENT TEST CONNECTION

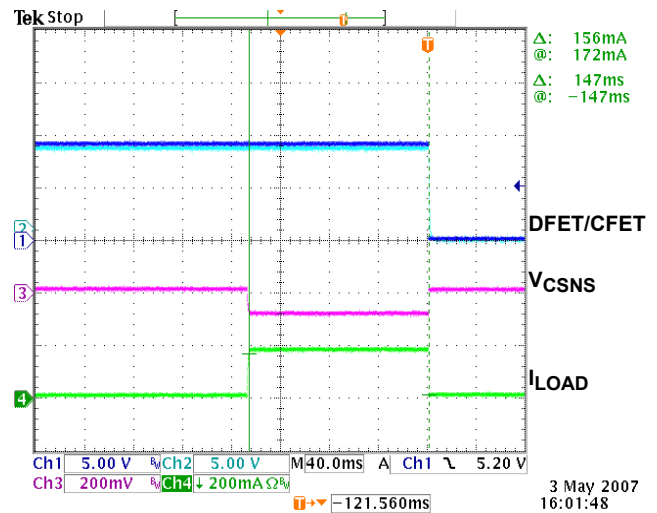


FIGURE 9. CHARGE OVERCURRENT TEST (0.1V THRESHOLD, 160ms TIME DELAY, 0.5Ω SENSE RESISTOR)

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

The ISL9208 board can be put to sleep via commands from the PC. This sequence is described in the following paragraphs.

- To put the ISL9208 into the sleep mode, use the Register Access window to write an 80H to the ISL9208 register 4. This turns off the ISL9208 RGO output and LED.
- To wake-up the ISL9208 requires that the ISL9208 WKUP pin go below its wakeup threshold. Normally, a charger would connect to the pack terminals to generate a wake-up signal. This works because the unloaded charger voltage is equal to, or greater than, the voltage on a fully charged pack. This makes the charger voltage higher than the voltage on the cells in any charge state. So, connecting the charger forces the WKUP pin low, causing the part to wake-up. However, in a test set-up, it is not always desirable to connect the charger. In the test set-up, it is possible to force a wake-up by connecting a jumper from GND to the P pin. Alternatively, a jumper can be connected between GND and the WKUP pin to wake the ISL9208. When using these techniques, don't leave the jumper in place.

- When the WKUP pin is pulled low, the ISL9208 wakes up and turns on the RGO output. This turns on the RGO LED.

### **Sleep/Wake Testing (WKPOL = 1)**

- 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 ISL9208 in sleep mode as before.
- This time, the device can be awakened 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<sup>2</sup>C jumpers to the  $\mu$ C 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 ISL9208.
- 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. (Note: there is a 5s delay after power-up before the microcontroller turns on the FETS, so the indicators may be red when initially powered up. Clicking on the “refresh button” after 5s should change the FET indicators to green). If the GUI is all gray, then there is a communication problem. If there is a communication problem, see the troubleshooting guide in the Appendix.
- If the FET indicators remain red after 5 seconds, 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, thus the voltage readings 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 power supply is being used, lower the voltage on the power supply 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 7 power supplies are used, then simply decrease or increase any 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. To get an indication of the operation, monitor the voltage at the VMON test point with a scope.
  - Testing the cell balance operation requires the use of Li-ion cells or requires modifying the board to use 1000 $\Omega$  cell balancing resistors. (With 7-cells, a string of 20 $\Omega$  voltage divider resistors, and 39 $\Omega$  cell balancing resistors, turning on one cell balance output drops the voltage on that cell to less than 2.5V. At this voltage, the microcontroller puts the ISL9208 to sleep).
  - Start the cell balance test by first observing if the cell with the maximum cell 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<sup>1</sup>, 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.
1. If this is too long to wait, go to the “Pack Tab” and change the cell balance on/off times. Setting 1s on and 1s off is the minimum setting for cell balancing, but 2s on, 2s off is the recommended minimum, only because an autoscan of 1s can cause confusion due to the asynchronous nature of cell balance and autoscan.

Further tests on the board will likely follow the lines of battery pack testing, so they can become quite involved and be very specific to the application. Therefore, 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 ISL9208EVAL1Z (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.

### **Microcontroller Options**

The BKGD connection on the ISL9208 board allows development of new or modified code for the NXP (formerly 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<sup>2</sup>C address of “1001 010x.”

### **Use with an External Microcontroller**

The ISL9208 board can be used as a platform for developing code for a microcontroller other than the NXP (formerly Freescale) microcontroller on the board. To do this, set the I<sup>2</sup>C jumpers in the PC mode and use the I<sup>2</sup>C interface for communication with the external microcontroller.

To get good communication between the external microcontroller and the ISL9208, connect the “I<sup>2</sup>C 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 ISL9208EVAL1Z (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 ISL9208EVAL1Z (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.

## **Related Documentation**

### **From Intersil**

- ISL9208, ISL9216, ISL9217 Microcode Reference Guide
- ISL9208 Data Sheet
- ISL9208 Application Note
- ISL9208, ISL9216 GUI User Guide
- DeVaSys USB-I<sup>2</sup>C Software Installation

### **From Texas Instruments**

- ADS1100 Data Sheet

### **From NXP (formerly Freescale)**

- MC9S08QG8 Microcontroller Data Sheet
- HCS08 Microcontrollers Family Reference Manual

# ISL9208EVAL1Z Schematic

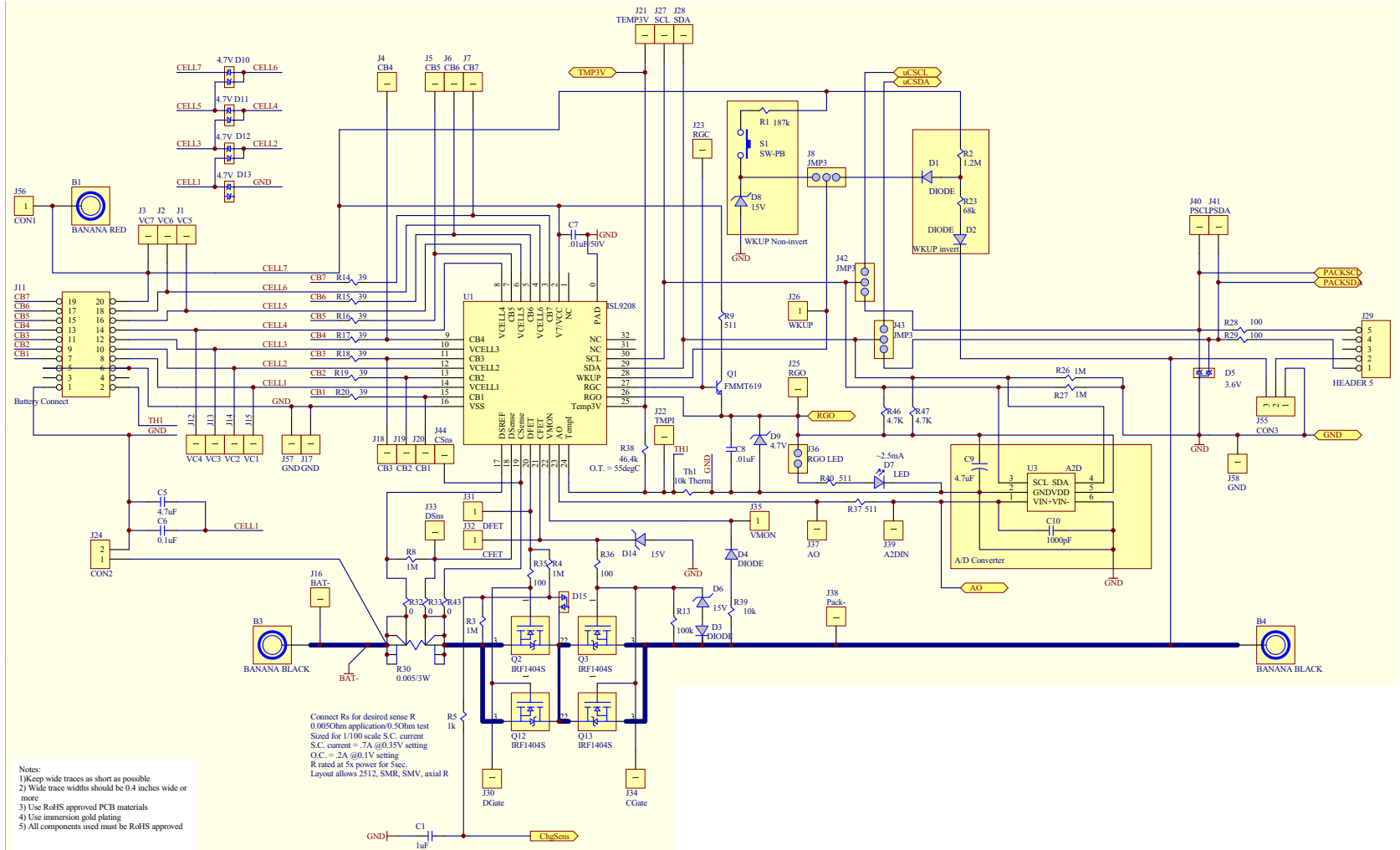






TABLE 1. ISL9208EVAL1Z (REV D) BILL OF MATERIALS

QTY	PART TYPE	DESIGNATOR	FOOTPRINT	DESCRIPTION	PART FIELD 1	PART FIELD 2
1	1 $\mu$ F	C1	603		*	*
1	1000pF	C10	603		*	*
1	0.01 $\mu$ F	C15	603		*	*
1	4.7 $\mu$ F	C5	603		*	*
3	0.1 $\mu$ F	C6, C13, C14	603		*	*
1	0.01 $\mu$ F/50V	C7	603		*	*
1	0.01 $\mu$ F	C8	805		*	*
1	4.7 $\mu$ F	C9	805		*	*
4	DIODE	D1, D2, D3, D4	SOD-123		Digikey: B0540WDICT-ND	DIODES: Schottky diode
4	4.7V	D11	SOT23-6		Digikey: MMBZ5230BS-FDICT-ND	DIODES: MMBZ5230BS
1	DUAL DIODE	D15	SOT23		Digikey: 568-1624-1-ND	Philips: BAV99
1	3.6V	D5	SOT23		Digikey: AZ23C3V6-FDICT-NDD	DIODES: 3.6V Zener-dual, common anode
3	15V	D6, D8, D14	SOD-123		Digikey: MMSZ4702T10SCT-ND	On Semi: 15V Zener SOD-123
1	LED	D7	LED_GW		Digikey: 490CT-ND	Panasonic: LN1271RTR
1	4.7V	D9	SOD-123		Digikey: BZT52C4V7-FDICT- ND	*
23	VC5, VC4, VC3, VC2, VC1, VC6, TEMP3V, TMPI, RGC, RGO, WKUP, SCL, SDA, VC7, DFET, CFET, DSns, VMON, AO, Pack-, A2DIN, CSns, ChgSens	J1, J12, J13, J14, J15, J2, J21, J22, J23, J25, J26, J27, J28, J3, J31, J32, J33, J35, J37, J38, J39, J44, J51	TP	Connector	Digikey 5000K-ND	*
1	Battery-Connect (Male - On board)	J11	HEADER 10x2 3M		Digikey MHC20K-ND	*
4	BAT-, GND, GND, GND	J16, J17, J57, J58	TP SM	Connector	Digikey 5011K-ND	*
2	CON2, RGO_LED	J24, J36	JP_2	Connector	*	*
1	HEADER 5	J29	HEADER 5x1		*	*
4	JMP3, JMP3, CON3, JMP3	J42, J43, J55, J8	JP_3		*	*
1	BKGD	JP1	HEADER 3x2		*	*
1	FMMT619	Q1	SOT23 - NPN		Digikey: FMMT619CT-ND	ZETEX: NPN 50V hfe = 100min
2	IRF1404S	Q2, Q3	D2PAK		Digikey: IRF1404S-ND	Or: Philips PHB222NQ04LT
1	187k $\Omega$	R1	805		*	*
1	100k $\Omega$	R13	805		*	*
7	39	R14, R15, R16, R17, R18, R19, R20	2512		*	*
1	1.2M $\Omega$	R2	805		*	*

TABLE 1. ISL9208EVAL1Z (REV D) BILL OF MATERIALS (Continued)

QTY	PART TYPE	DESIGNATOR	FOOTPRINT	DESCRIPTION	PART FIELD 1	PART FIELD 2
1	68.1kΩ	R23	805		*	*
4	100	R28, R29, R35, R36	603		*	*
4	1MΩ	R3, R4, R26, R27	603		*	*
1	0.51Ω	R30	2512			
3	0	R32, R33, R43	603		*	*
1	46.4kΩ	R38	603		*	*
1	10kΩ	R39	805		*	*
1	10kΩ	R45	603		*	*
2	4.7kΩ	R46, R47	603		*	*
1	1kΩ	R5	603		*	*
3	511	R9, R37, R40	603		*	*
1	SW-PB	S1	B3WN-6002		Digikey: SW425TB-ND	Omron: B3WN-6002
1	10k Therm	Th1	603		*	MuRata: NCPxxXH103F
1	ISL9208	U1	QFN32		*	*
1	A2D	U3	SOT23-6		Digikey: 296-14299-1-ND	TI: ADS1100A2
1	MC9S08QG8	U4	QFN16		*	*
	CAPNP	C11	603		Not populated	*
	CAPNP	C12	603		Not Populated	*
	RESIST	R41	603		Not populated	*
	RESIST	R42	603		Not populated	*
	1M	R8	603		Not Populated	*
	IRF1404S	Q13	D2PAK		Not populated	*
	IRF1404S	Q12	D2PAK		Not populated	*
	EEPROM	U2	SOT23-5		Not populated	Atmel: AT24C16
	CB1	J20	TP	Connector	Not populated	*
	CB2	J19	TP	Connector	Not populated	*
	CB3	J18	TP	Connector	Not populated	*
	CB4	J4	TP	Connector	Not populated	*
	CB5	J5	TP	Connector	Not populated	*
	CB6	J6	TP	Connector	Not populated	*
	CB7	J7	TP	Connector	Not populated	*
	CGate	J34	TP	Connector	Not populated	*
	DGate	J30	TP	Connector	Not populated	*
	PSCL	J40	TP	Connector	Not populated	*
	PSDA	J41	TP	Connector	Not populated	*
	μCp1	J46	TP	Connector	Not populated	*

**TABLE 1. ISL9208EVAL1Z (REV D) BILL OF MATERIALS (Continued)**

QTY	PART TYPE	DESIGNATOR	FOOTPRINT	DESCRIPTION	PART FIELD 1	PART FIELD 2
	μCp2	J45	TP	Connector	Not populated	*
	μCp5	J47	TP	Connector	Not populated	*
	μCp6	J48	TP	Connector	Not populated	*
	μCp7	J50	TP	Connector	Not populated	*
	μCp8	J49	TP	Connector	Not populated	*
	WP	J52	TP	Connector	Not populated	*
	CON1	J56	TPAD	Connector	Not populated	*
	CRYSTAL	Y1	32k XTAL	Crystal	Digikey: 300-8038-1-ND (Not populated)	Citizen: CM155-32.768KDFTR
	BANANA BLACK	B3	BANANA		Not populated	*
	BANANA BLACK	B4	BANANA		Not populated	*
	BANANA RED	B1	BANANA		Not populated	*

**Appendix 1**

**Installing the DeVasys USB to PC Board Software**

Obtain the DeVasys software along with the GUI code from the Intersil website on the ISL9208 page. Copy and extract the files from the “ISL92xx Eval Kit Software Release V1.41” zip file to the PC at whatever location is desired.

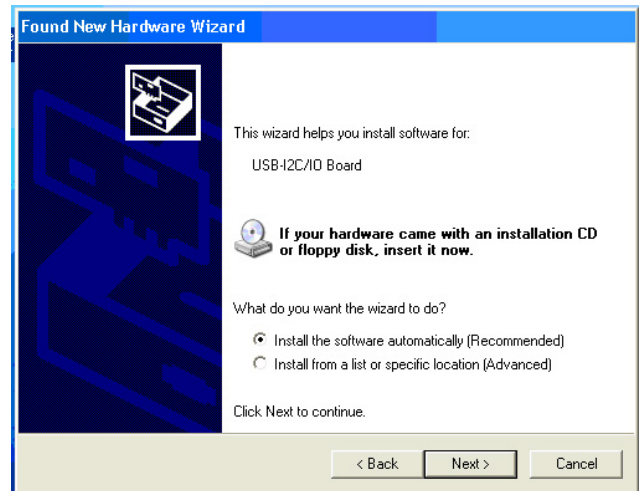
Disconnect the DeVasys board from the ISL9208/ISL9216 board, then, plug in the DeVasys board into the USB port.

The following screen should pop up:



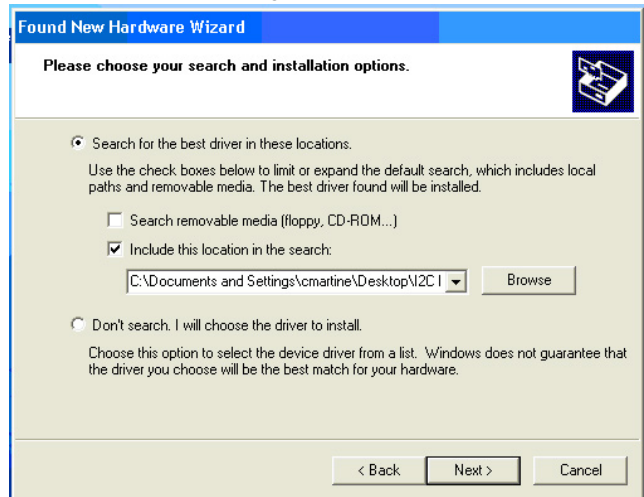
Select “Yes, this time only” and click “Next”.

The following screen will come up:



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

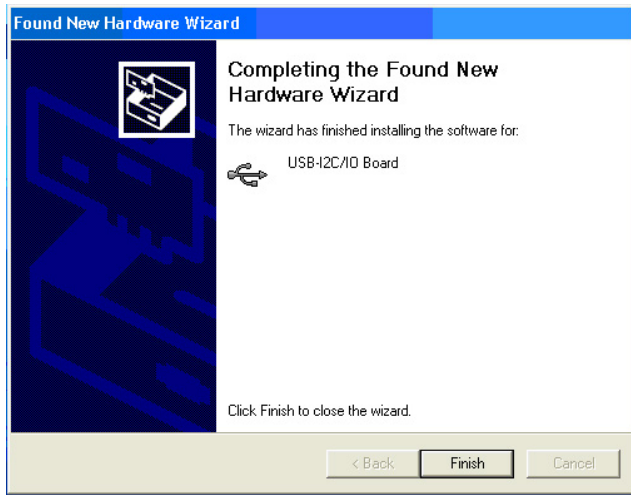
A screen like the following will come up:





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<sup>2</sup>C cable is connected properly.
2. Check that the board is powered and that the RGO voltage is ~3.3V.
3. If the RGO voltage is not powered to the right voltage, move to the power supply troubleshooting section.
4. Make sure that the board drivers are installed correctly. On the DeVaSys USB to I<sup>2</sup>C interface board, there should be one red LED and one green LED lit.
5. Use a scope to see that the I<sup>2</sup>C communication is correct at the board. Monitor the SCL and the SDA lines while initiating a read of the ISL9208 status register. Set the scope to single trigger on the falling edge of SCL.
6. Check that the SCL and SDA jumpers (J42 and J43) have shunts on the “PC” side.
7. Check to see that the “I<sup>2</sup>C GND” jumper is in place in the “GND” position.
8. Check that the “I<sup>2</sup>C GND” jumper (J24) is in place.

### Power Supply Troubleshooting

#### IF RGO DOES NOT HAVE THE CORRECT VOLTAGE

1. Check that the voltage on each of the input terminals are correct.
2. Check that there is no unexpected load on the RGO output.

## ISL9208 Troubleshooting

#### IF THE AO VOLTAGES ARE READING INCORRECTLY AT THE AO PIN

1. Make sure that the I<sup>2</sup>C 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 ISL9208 and that the input voltage 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<sup>2</sup>C Jumpers in the  $\mu$ C 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 ISL9208 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 20 $\mu$ A, but over time it could lead to reduced pack life.

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

When ISL9208 turns both FETs on, there is a current path from the CFET gate to VSS through the charge FET pull-up resistor R<sub>13</sub>. This 100k $\Omega$  resistor and a 12V gate voltage results in about 120 $\mu$ A of current into the VCELL3 input when no cells are being monitored. This can be reduced by increasing the value of R<sub>13</sub>, but this slows down the charge FET turn-off. The pack can also be designed without the charge FET. This removed 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 current.

#### ***There is excessive current flowing into the 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 output is applied to the CFET pin. This causes some circuit elements inside the ISL9208 to turn on, causing current to flow into the VCELL1 input. This current is on the order of  $120\mu\text{A}$  at a pack voltage of 28V (less at other pack voltages). The current can be stopped by turning on the VMON output. This pulls the 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 10. When this diode is added, the zener diode D<sub>14</sub> and diode D<sub>3</sub> can be removed as they have no functionality.

***There is about  $10\mu\text{A}$  of current flowing into the 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<sub>23</sub> to  $136\text{k}\Omega$  (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 29.4V, a charger with a voltage of 30.9V or more is required to wake-up the pack.

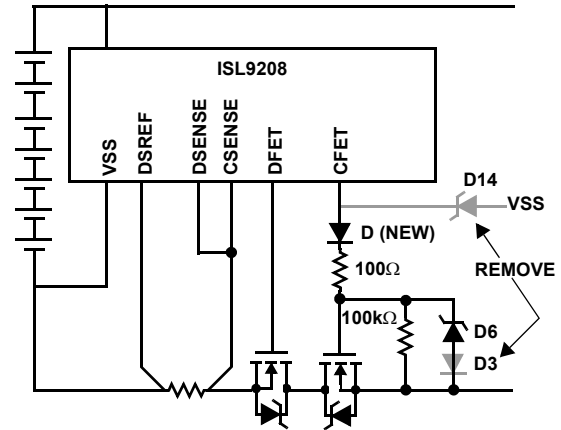


FIGURE 10. BLOCKING CELL1 CURRENT WHEN DFET IS OFF AND CFET IS ON

***One also notices about  $12\mu\text{A}$  of current into 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<sub>3</sub>, R<sub>4</sub>, and D<sub>15</sub>. Disconnect R<sub>4</sub> to eliminate this current. Of course, this also disables the current monitor feature.

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(Rev.4.0-1 November 2017)



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