

## ISL94208EVZ (Rev B)

Evaluation Board

AN1857  
Rev 0.00  
Sep 17, 2013

### Introduction

This document is intended for use by individuals engaged in the development of hardware for a 4- to 6- series connected Li-ion battery pack using the ISL94208EVZ board.

The evaluation kit provides full battery pack operation as well as offering the ability to read and write the ISL94208 registers, set thresholds and timer values, read cell voltages, control cell balancing outputs, and control the power FETs.

The kit contains the following components:

- ISL94208EVZ board.
- ISL94208DB1EVZ cell balance daughter board.
- ISL94208DB2EVZ cell balance daughter board.
- GUI software for a PC running Windows XP.
- A power supply interface board for connecting a single power source or a battery stack.

Operation of the ISL94208EVZ board requires the use of a separate USB to I<sup>2</sup>C kit, part number "ISLI2C-KIT".

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-KIT](#).
- Download the software from the Intersil website on the ISL94208 page. This is a zip file titled: "[ISL94208EVZ Kit Software Release V2.10](#)".
- Unzip the software files to a directory of your choice.
- Prior to powering the ISL94208 (Rev B) board, install the USB to I<sup>2</sup>C board software and connect the DeVaSys board to the PC (see Appendix 1). However, do not connect the DeVaSys board to the ISL94208EVZ 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. The programming/debug module is needed if the board is going to be calibrated. See "Installing The DeVaSys USB to I<sup>2</sup>C

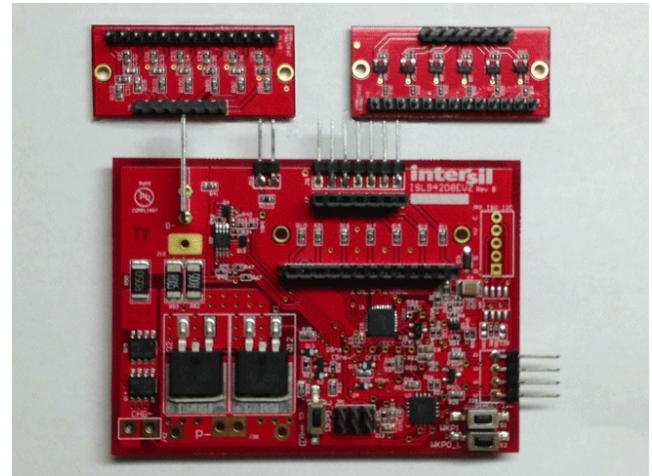


FIGURE 1. ISL94208EVZ KIT BOARDS

Board Software" on page 10. For this use, a License agreement is not needed.

- Set up a power supply for the board. The power supply should consist of a string of 4 to 6 batteries (see Figure 2), or a string of 4 to 6 resistors and a power supply, or 4 to 6 individual power supplies (see Figures 2, 3).

To facilitate the power connections, the kit includes a power supply board.

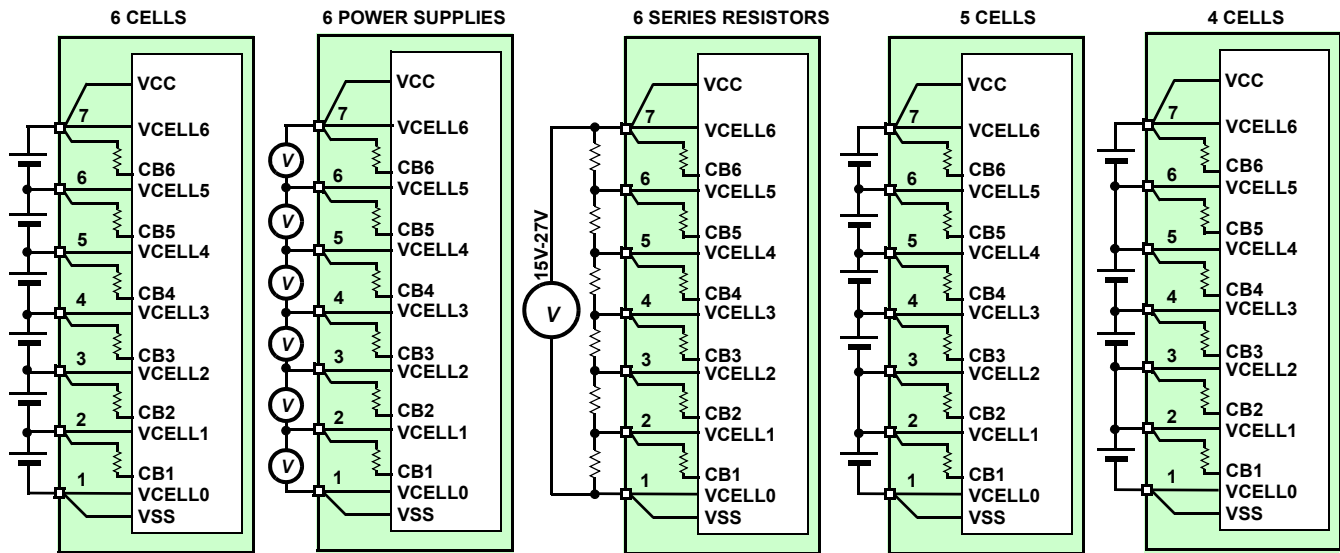
The kit operates without using either cell balance board, however, if cell balancing is desired, then one of the two daughter boards should be connected before powering the board.

### Battery/Power Supply Connection

When connecting battery packs or power supplies, use the recommended connections as shown in Figure 2. Make sure that the individual power supply voltages do not exceed the ISL94208 maximum input voltage differential of 5V per cell.

If using a string of resistors to emulate the battery cells, then limit the power supply voltage, so that the resistor divider outputs do not exceed the ISL94208 input maximum ratings.

It is recommended that, when using the resistor divider circuit (see Figure 2), the series resistors to be 100Ω or less and 2W minimum and balancing be disabled. Balancing should be disabled, because when activating the ISL94208 cell balance outputs, the current balance on the ISL94208 (Rev B) board lowers the voltage across balanced 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.



NOTES:

1. For the battery simulation resistors, use 100Ω/2W devices (maximum). If the divider resistors are more than 100Ω, then turning on the cell balance output can cause fluctuations in the cell input voltages that can violate the ISL94208 max specifications. If the series resistors are larger than 100Ω, we recommend removing the cell balance daughter board, to prevent accidental cell balancing, while monitoring the cell voltages and pack operation.
2. Before connecting the power supply to the board, check the voltages at the connector to verify that they are correct.
3. Multiple battery cells can be connected in parallel.

FIGURE 2. BATTERY CONNECTION OPTIONS

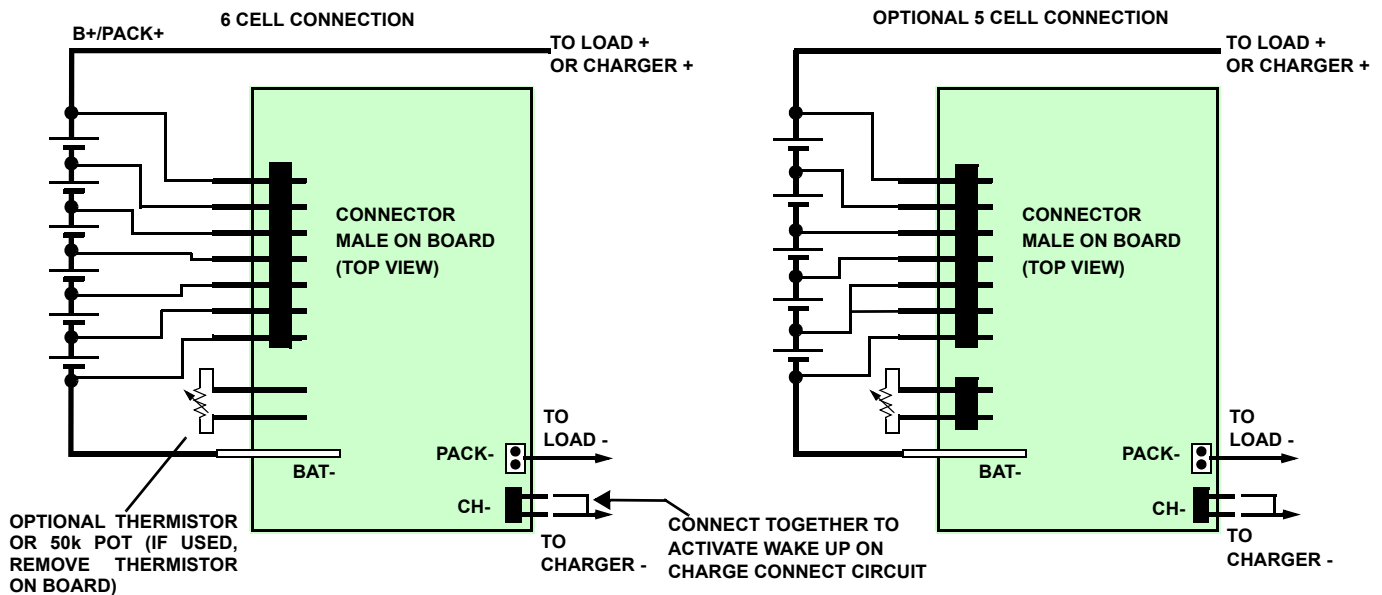


FIGURE 3. BATTERY CELL CONNECTION TO ISL94208 PCB

## Initial Testing

### Setup

- Figure 4 shows a green board is connects between a power supply and the evaluation board. This multi-option board supports the connection a single power supply (using an on-board resistor divider), or separate power supplies for each input, or battery cells.
- For this setup, connect a 20V supply to the power supply board with GND on J8 or J12 and the positive connected to J5 or J11. There should be a shunt on the “8-Cell” jumper. There is a jumper wire on the power supply board connecting the CELL8 input to the CELL6 input to provide a 6-cell source.
- Before connecting the PC to the ISL94208EVZ board (through the USB to I<sup>2</sup>C interface) turn off the power supply and then plug the ISL94208EVZ board into the power supply board as shown in Figure 4.
- Turn on the power supply.
- Once power is turned on (or Li-ion cells are connected to the ISL94208 (Rev B) board), the Green RGO LED should light. Use meter 1 to measure the RGO voltage. It should read about 3.3V.

### USB to I<sup>2</sup>C interface

- Once the power supply connections are verified, 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 DeVaSys board to the ISL94208EVZ board as shown in Figure 5. Use the 5- to 4-pin cable provided in the ISLI2C-KIT.

**CAUTION:** The I<sup>2</sup>C interface ground pin connects with the Battery negative terminal. If a load connected between the Pack + and Pack - pins has the same ground reference as the PC, then both sides of the power FETs will be connected together through the PC and load ground leads. The Power FETs provide no interruption in the power path. Also, without proper care, there can be problems with ground loops or excess voltage conditions as a result of this connection. If the ground connections are a concern, see “I<sup>2</sup>C Isolation” on page 9.

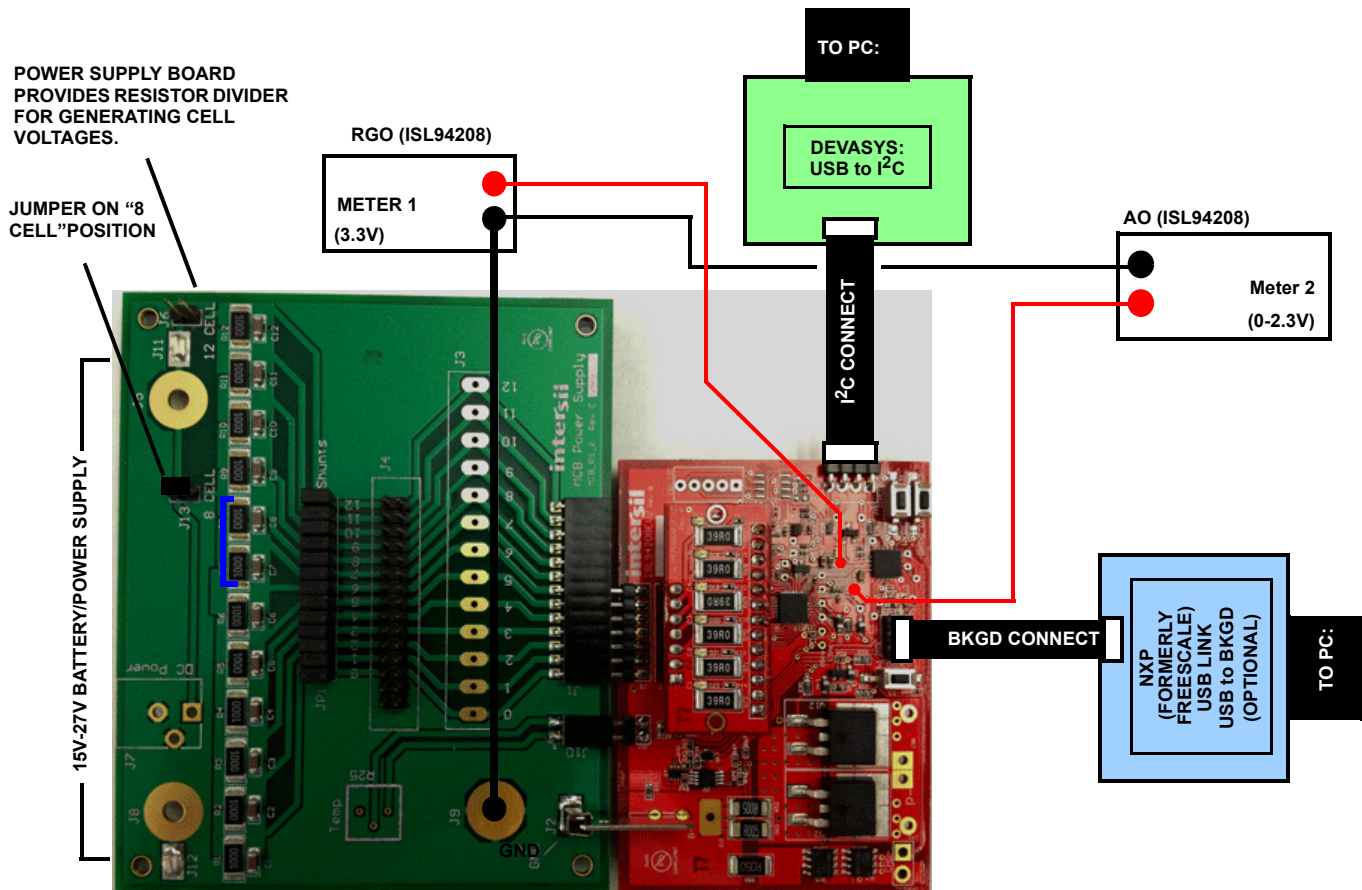


FIGURE 4. ISL94208EVZ EVALUATION BOARD TEST CONNECTION

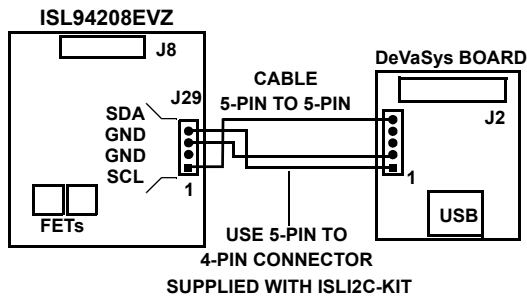


FIGURE 5. I<sup>2</sup>C CONNECTION TO ISL94208 PCB

## Testing the Board

- Power-up the board and start the GUI. The PC will be communicating with the microcontroller and the microcontroller will be communicating with the ISL94208.
- The GUI should power-up with some color. In this case, the FET controls should be GREEN and the indicators should all be green. If the GUI is all gray, then there is a communication problem (see the troubleshooting guide in the Appendix).
- If the FET indicators remain RED after power-up, it is likely that at least one input voltage or the temperature is out of range.

The microcontroller on the board performs in a number of automatic functions. These are as follows:

1. The cell inputs are monitored to high or low voltage. If any of the cell voltages go to high, the charge FET is turned off. If any of the cell voltages go to low, the discharge FET turns off. When voltage recovers from these excursions, back into the normal range, the FETs automatically turn on.
2. After an overcurrent or undervoltage 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 and power FETs if temperature is to 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.

In normal operation, the cell voltages are scanned four times per second. If monitoring the AO voltage (as shown in Figure 4), the meter will not be stable, since it sees an output of a series of voltages. A scope can be used to monitor the AO output, or use the GUI to select a specific voltage or temperature. This operation by the GUI stops the microcontroller from automatically scanning the voltages and puts the selected voltage on AO constantly. Automatic scanning will not start again until the GUI selects Monitor "All" (see Figure 6).

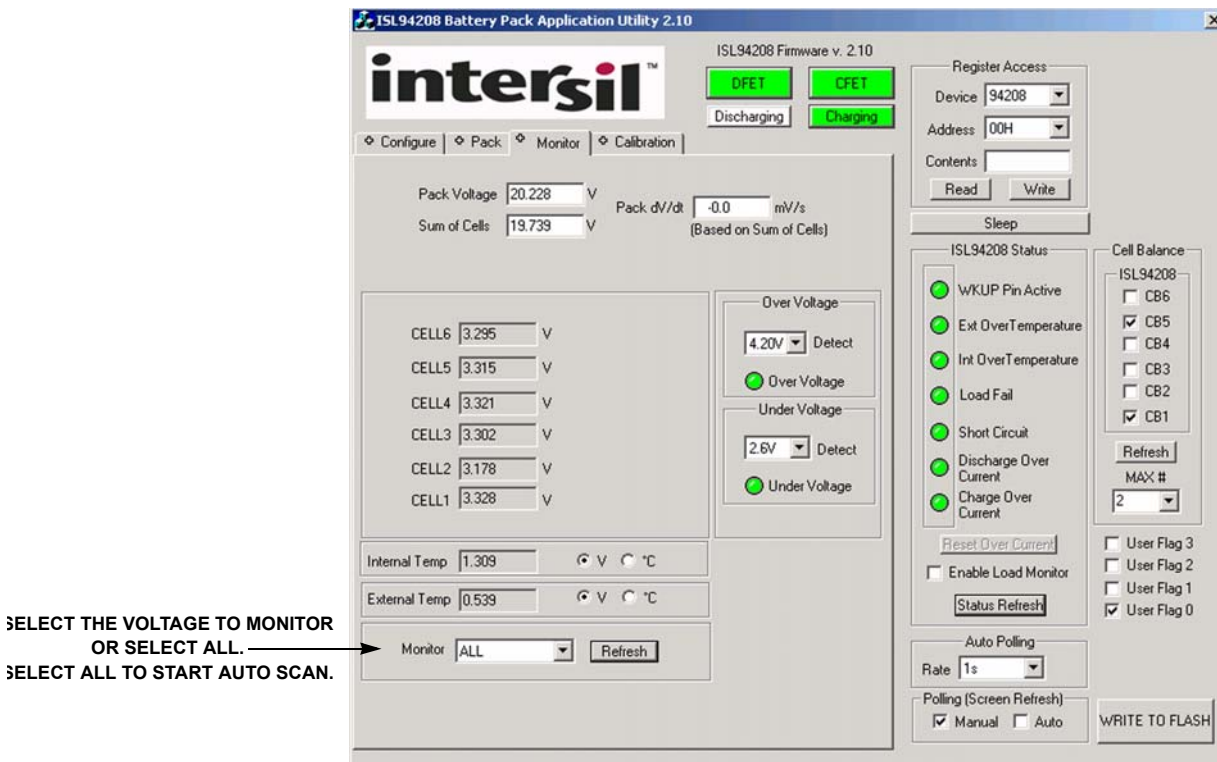


FIGURE 6. ISL94208 GUI MONITOR TAB



## Over/UnderVoltage Testing

- Test the overvoltage and undervoltage conditions by any of the following means. Monitoring the FET status using GUI, then a status update is required for the GUI to acquire the FET state. Setting an autoscan in the GUI is a quick way to check FET status. You can also use a meter to detect whether the ISL94208 is driving the FET gate or not.
  - If Li-ion cells are being used, discharge the pack until one or more of the cells reach 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 power supply until one or more of the cells reach 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 seven power supplies are used, then simply decrease or increase any individual supply until the thresholds are reached and the FET turns off (or on).

## Overcurrent Testing

- Testing the overcurrent settings with the ISL94208EVZ board is not easy without changing the values of the sense resistors on the board, because it was designed as a possible reference application.
- As delivered, the ISL94208EVZ board provides a discharge sense resistor of 2.5mΩ and a charge sense resistor of 50mΩ. To get a discharge short circuit condition requires 80A. To get a discharge overcurrent condition requires a load of 40A. To get a charge overcurrent condition requires 2A. Changing both resistors to 0.5Ω provides a mechanism for easily testing the current thresholds.
- To test the board in an application most likely requires that battery cells be used and there is a large load available. While the board was not extensively tested for these high load currents, the traces are short and wide enough to (theoretically) handle an overcurrent condition up to the 40A threshold.

## Cell Balance Testing

- Testing the cell balance operation requires the use of Li-ion cells or individual power supplies for each cell, or it requires modifying the daughter board to use 1kΩ cell balancing resistors instead of the 200Ω or 39Ω resistors on the standard boards. With 6 cells and VBAT = 20V, a string of 100Ω voltage divider resistors, and 39Ω cell balancing resistors, turning on one cell balance output drops the voltage on that cell to about 1V. At this voltage, the microcontroller puts the ISL94208 to sleep.
- As a quick test of the cell balance circuits, use the GUI to turn on or off any combination of cell balance FETs using the CB6:CB1 check boxes in the GUI Cell Balance frame.
- To test the software auto balance operation, 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, on the GUI, select the Cell Balance “Max #” to be “1”. This limits the balancing to only one cell (The one with the maximum voltage).
- Monitor the cell balance LEDs on the board or the GUI to track the cell balance operation. On the GUI, use the CB refresh button (or start auto update) to update the indicators to show which cell is being balanced, it should be the maximum voltage cell. The board is set that the microcontroller balances for 2s, then turn off balancing for 2 second, then balance again. 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 accuracy of the microcontroller A/D converter.
- For an application on, the balancing times may be too short. To set the balance timers for a different configuration, go to the “Pack Tab” in the GUI 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.
- Next, select the Cell Balance “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.

## Sleep/Wake Testing

The ISL94208 board can be put to sleep VIA commands from the PC listed as follow:

There are three ways to put the ISL94208 into the sleep mode:

1. The easy way is to use the “Sleep” button below the register access frame of the GUI.
2. You can also use the GUI register access window to write an 80H to the ISL94208 register 4.
3. Lowering the voltage on any cell below 2.3V for 1 second, (default microcontroller software settings) causes the microcontroller to put the ISL94208 to sleep. In case, the operation turns off the ISL94208 RGO output and LED.

To wake up the ISL94208 requires that the ISL94208 WKUP pin go below its wake up threshold. This can happen when a charger connects to the pack charge terminals or when a load is connected to the load terminals.

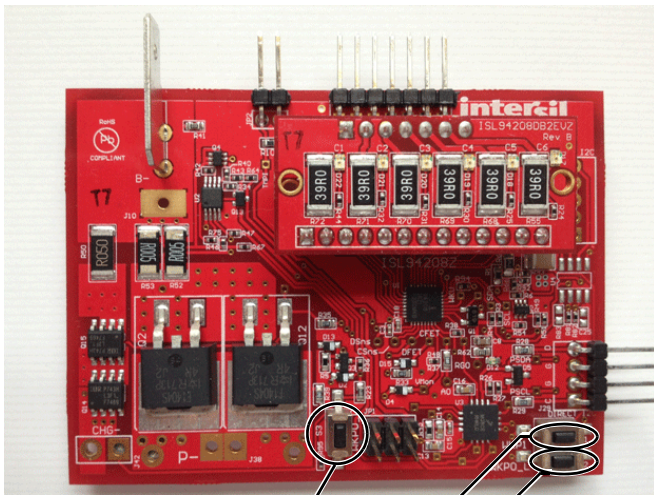
- The charger connection works, because it pulls the charger negative terminal to about the ISL94208 VSS voltage, the same as would an unloaded charger.
- The load connection works, because the load terminal is pulled high (in sleep mode, the power FETs are off, so the connection from the ISL94208 VSS pin to the Pack- pin is open.)
- Circuitry on the board inverts this signal to pull the ISL94208 WKUP pin low to wake the device.

The ISL94208 can be waken with real loads or chargers or by using the push buttons as shown in Figure 7.

There are three wake up push buttons. In the default setting, the ISL94208 WKPOL bit is 0. This forces a wake up when the WKUP pin goes low. The ISL94208EVZ board has one push button that pulls WKUP low, simulating the connection of a load (WKPO\_L) and one that pulls WKUP low simulating the connection of a charger (WKPO\_C). Pressing either button wakes the device.

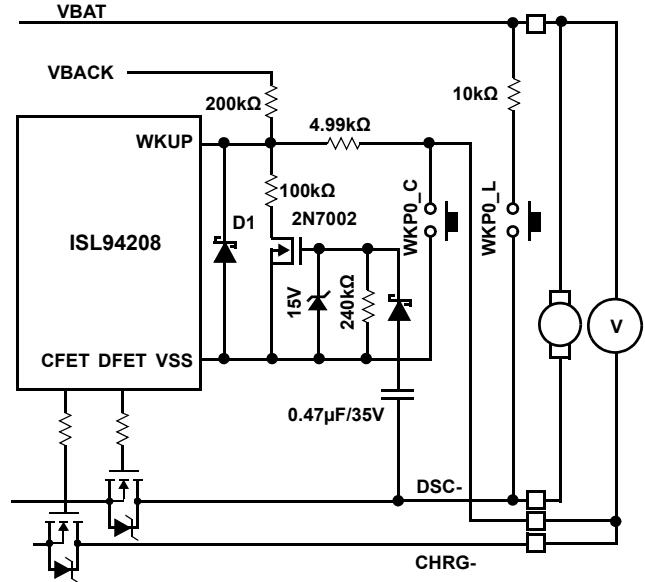
In the Configure Tab of the GUI, the WKPOL pin can be set to wake on a rising edge by checking the “WKUP Pin Active High” box. This sets the ISL94208 WKPOL bit to 1. When this option is selected, the ISL94208 wakens by a simulated microcontroller command using the WKP1 switch.

- When the ISL94208 wakes up it turns on the RGO output. This turns on the RGO LED.



Polarity 0 - SIMULATED CHARGER CONNECT  
 Polarity 1 - SIMULATED  $\mu$ C WAKE Up  
 Polarity 0 - SIMULATED LOAD CONNECT

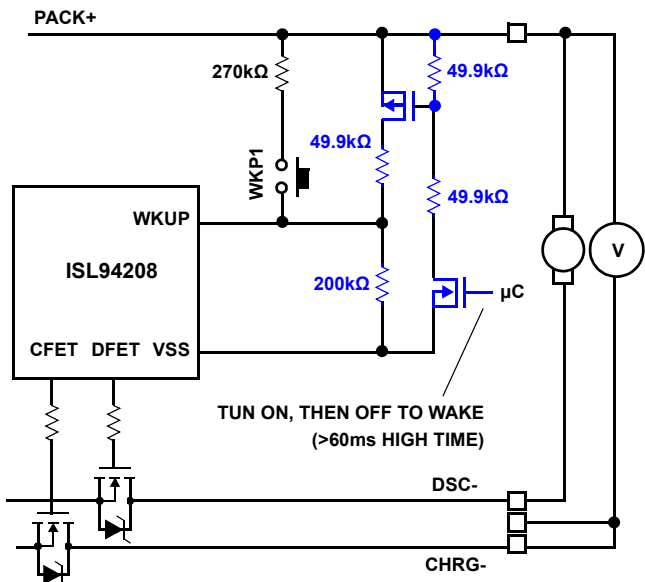
FIGURE 7. ISL94208EVZ WAKE UP BUTTONS



NOTES:

1. When the FETs are off, the WKPO\_C button pulls the DSC- pin high, as would connection to a load.
2. The WKPO\_C button brings the WKUP input to near VSS, as would connection to a load when the FETs are off. D1 prevents WKUP from going negative if the charger is at a much higher voltage than the cells.

FIGURE 1. EXTERNAL WAKE UP CIRCUIT; WKPOL = 0



NOTES:

3. The components in blue wake the pack under control of the microcontroller, however these are not included on the board.
4. The WKP1 switch simulates a wake up by the microcontroller.

FIGURE 1. EXTERNAL WAKE UP CIRCUIT; WKPOL = 1

### Additional Testing

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

## Other Board Features/Options

### Current Direction Detection

The ISL94208EVZ board has a circuit to detect a charge or discharge current (see Figure 8). This circuit is designed to detect a small current flowing into or out of the pack.

There are two main uses for the current direction detection circuit. The first is in power control. If the microcontroller does not see any current for a long period of time, it can put the pack hardware to sleep to extend battery life. Second, the cell balance routine is usually conducted only during a charge condition. To do this requires information that charge current is flowing.

The current direction detectors are comparators only, when the current is high enough, the indicators go high. For charge current, the threshold is about 100mA, for discharge the threshold is about 800mA. These thresholds can be changed by replacing a resistor, but making the thresholds much lower may cause problems due to the op amp input offset. To change the discharge current detection threshold, change the value of R46 as shown in Figure 8 (a lower value lowers the current threshold). To change the charge current detection threshold, change the value of R40 (a lower value lowers the current threshold).

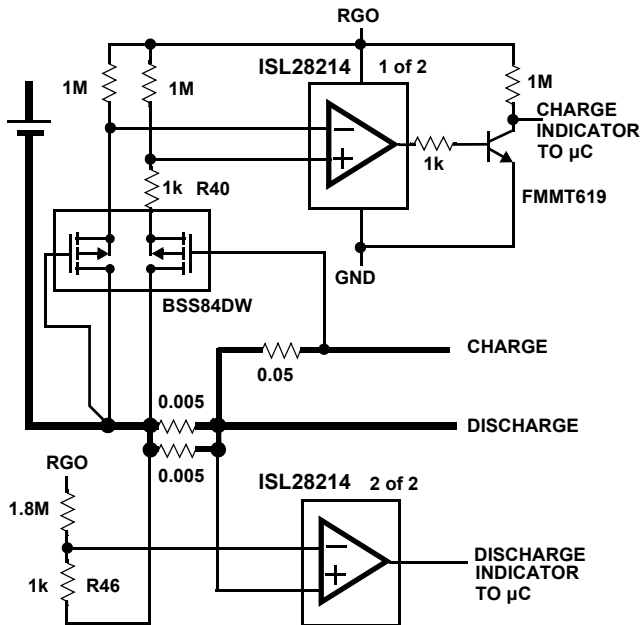


FIGURE 8. USING OP AMP AND FETS TO DETECT CHARGE AND DISCHARGE CURRENT

### Pack Voltage Monitoring

The ISL94208EVZ has a circuit that is activated by the microcontroller to monitor the pack voltage directly. The input to the microcontroller is the pack voltage divided by 16 as shown in Figure 9.

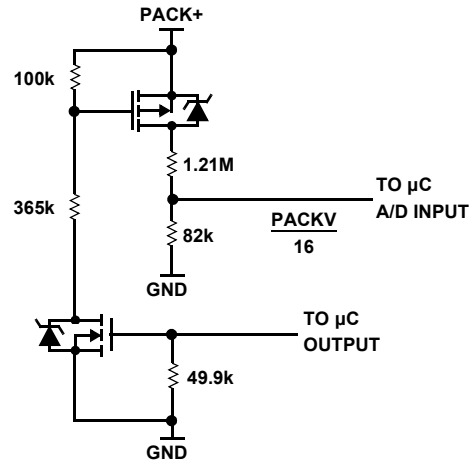


FIGURE 9. DIRECT MONITOR OF THE PACK VOLTAGE

The purpose of this circuit is to get an alternate reading of the pack voltage. Without this circuit, the pack voltage is determined by adding the individual cell voltages. Having a separate reading provides a "sanity check" that there are no gross cell measurement errors.

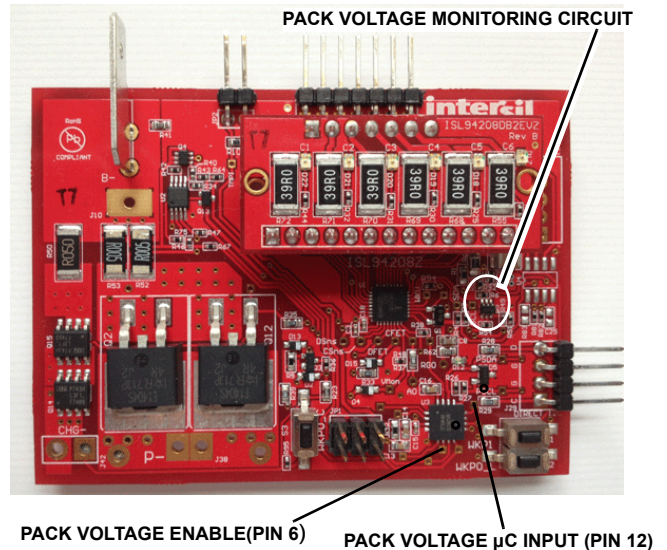


FIGURE 10. ISL94208EVZ PACK VOLTAGE MONITORING CONNECTIONS

## FET Drive Voltages

In the ISL94208EVZ board, a separate regulator provides the VFET1 and VFET2 reference voltages for the FET drive as shown in Figure 11.

There are three main reasons for doing this:

1. In a simple configuration where VCFET2 connects to VCELL3 and VFET1 connects to VCELL2, the FET reference current is drawn primarily from CELL3 of the pack. Depending on the FET drive current, this can unbalance the pack by having different load characteristics across the cells. Using a regulator supplies current from the top of the battery stack, better maintaining balance.
2. When the voltage differential between VFET2 and VFET1 drops below approximately 2.8V, the FET drive has difficulty providing enough current to fully drive the FETs. This gets worse over-temperature. If the cell voltages drop below 2.3V each, then a direct connection of the VFET pins to the CELL pins can result in the FETs turning off (or not turning on.) Using the regulator, it is possible to maintain the FET drive current to cell voltages below 1.5V (6-cell pack).
3. By having the FET currents coming from the regulator it is possible to better maintain measurement accuracy, since there is no extra current flowing on an individual cell input.

The 100k resistor on the 4.3V regulator does not allow enough current for the zener diode to regulate very well. Ideally, there would be a 3V zener and a 5.6k resistor (1mA zener current). However, this current significantly increases the pack current. By using a higher voltage zener and a larger resistor, a similar result is achieved with lower current. The actual differential voltage is not too significant. As long as the VFET pin limits are maintained, the differential does not drop below 2.8V

The VFET regulator is one from Intersil. This is not necessary, but the regulator should be one that can be disabled so current is very low when the ISL94208 goes to sleep and turns off RGO.

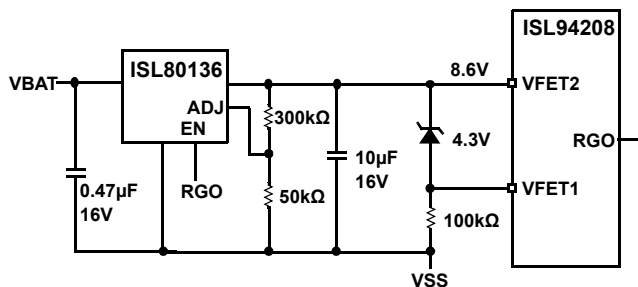


FIGURE 11. ISL94208 EXAMPLE ALTERNATIVE VFET POWER SUPPLY

## VCELL Input Schottky Diodes

The ISL94208EVZ schematic shows five Schottky diodes on the inputs between VCELLn and CB(n+1). These were added to help deal with input surge currents during hot plugging the board into a battery pack. However, with input resistors larger than 100Ω, these components are not needed.

## Cell Balance Daughter Boards

The ISL94208EVZ kit is provided with two daughter boards. The main board can be used without either board, but there will be no balancing. With no daughter boards, each VCELL input from the battery pack has a 1k series resistor and a 22nF filter resistor to ground.

### DB1 DAUGHTER BOARD

The DB1 daughter board uses the internal balancing FETs on the ISL94208. When it is installed, balancing is not practical with 1k input series resistors, because the voltage drops would be too big. This would cause voltage measurement inaccuracies and the µC on the board will interpret this as either an open circuit condition or an undervoltage cell and put the board to sleep. To get around this, this daughter board places a 20Ω resistor in parallel with the 1k on the main board and increases the filter capacitor to 1µF. The filter on the CB pins should have the same time constant as the VCELL pins.

The DB1 daughter board uses 200Ω balancing resistors. This is about the smallest resistor possible, without having trouble with voltage monitoring. When cell balance turns on between VCELLn and VCELLn-1, the voltage at VCELLn-1 increases by about 10% because of the 200Ω and 20Ω voltage divider between the cells, as shown in Figure 12. The DB1 daughter board has a balance current of about 16mA.

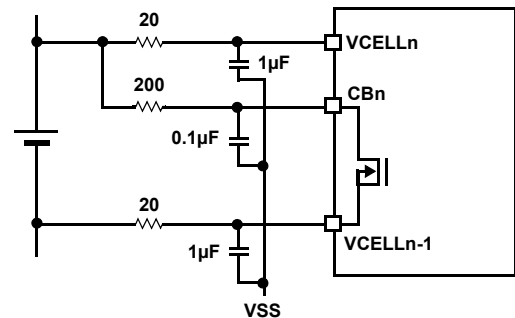


FIGURE 12. ISL94208DB1EVZ VCELL AND CB CONNECTION

### DB2 DAUGHTER BOARD

The DB2 daughter board uses external balancing FETs. These are p-channel devices driven by the CB outputs. When this board is installed, the main board filters are left as-is with a 1k series resistor and 22nF capacitor to ground. The daughter board only adds the extra components for balancing as shown in Figure 13.

Because the balance current does not pass through the input resistors, the monitored voltage does not change much when being balanced or not being balanced. However, there likely is some change. The DB2 balance circuit has about 100mA of balance current. Because of this, there will likely be some change in the source voltage (either a power supply or real cells). If the Li-Ion cell has 20mΩ internal resistance, then the 100mA of balance current will drop the measured voltage by 2mV. There will also be some error due to the current through 500k and two 1k resistors when the CB output turns on. This error is on the order of 7mV.



The DB2 board does not provide much heat sinking for the balance resistors. However, if five of the six balance outputs are on at the same time, there will be about 2W of power dissipated. This can cause the board to get hot. It is recommended that only a few cells be balanced at the same time, if the test extends over a long duration.

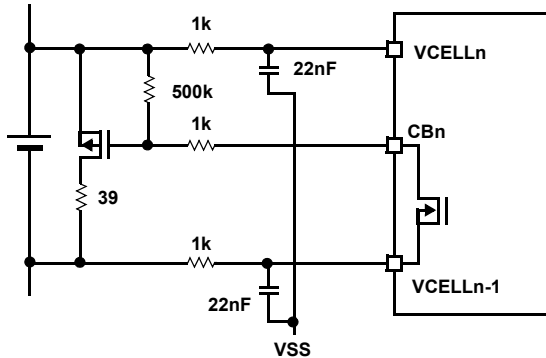


FIGURE 13. ISL94208DB1EVZ VCELL AND CB CONNECTION

### I<sup>2</sup>C Isolation

In some test conditions ground connections can cause problems. This is because the I<sup>2</sup>C ground, power supply, load, and perhaps an oscilloscope may all connect to ground. This can cause problems ranging from grounding both sides of the power FETs (taking them out of the circuit) to creating ground loops or unexpected voltage potentials that can damage components.

The ISL 94208EVZ (Rev B) board provides an option for the addition of an isolation device on the I<sup>2</sup>C interface, the Analog Device ADuM1250. This allows the PC to monitor a battery pack that is connected to a load without the grounding problems that can arise from direct connect. To use this option, the device and a header needs to be installed on the board, then the DeVaSys board needs to connect to the JP3 connector as shown in Figure 14.

The DeVaSys board will need to connect with a 5-pin-to-5-pin point-to-point connector (pin 3 is not used, but the ADuM1250 uses the 3.3V supply provided by the DeVaSys board).

### Microcontroller Options

The BKGD connection on the ISL94208 board (see Figure 14) allows development of new or modified code for the NXP (formerly Freescale) MC9S08QG8 microcontroller, which is supplied on the board.

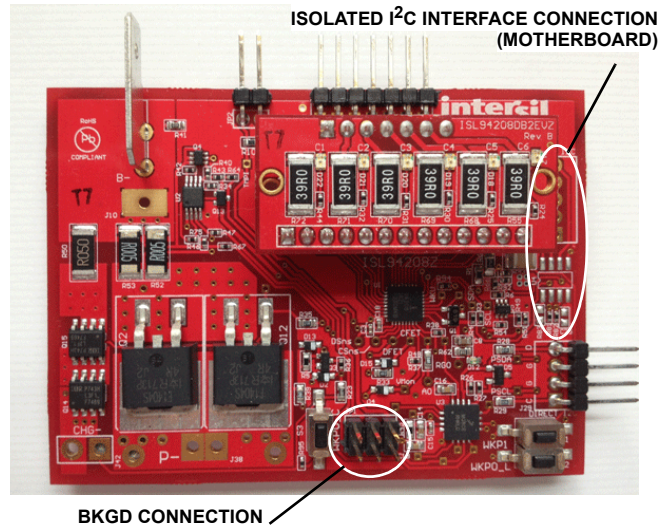


FIGURE 14. ISL94208EVZ ISOLATED INTERFACE AND BKGD CONNECTIONS

## Related Documentation

### From Intersil

#### SCHEMATICS/BILL OF MATERIAL

- ISL94208EVZ (rev B) board schematics
- ISL94208EVZ (rev B) board Bill of Material (BOM)
- ISL94208DB1EVZ (rev B) daughter board schematics
- ISL94208DB1EVZ (rev B) daughter board BOM
- ISL94208DB2EVZ (rev B) daughter board schematics
- ISL94208DB2EVZ (rev B) daughter board BOM
- MCB\_PS\_Z (rev B) board schematics
- MCB\_PS\_Z (rev B) board BOM

#### DOCUMENTS

ISL94208 Microcode Reference Guide

ISL94208 FN8306 Data Sheet.

ISL94208 Application Note.

ISL94208 GUI User Guide

DeVaSys USB-I2C software installation.

### From NXP (Formerly Freescale)

MC9S08QG8 microcontroller data sheet.

HCS08 Microcontrollers Family Reference Manual.

# Appendix 1

## Installing The DeVasys USB to I<sup>2</sup>C Board Software

Obtain the Devasys software along with the GUI code from the Intersil website on the ISL94208 page. Copy and extract the files from the “[ISL94208 Eval Kit Software Release V2.10](#)” zip file to the PC at whatever location is desired.

Disconnect the DeVasys board from the ISL94208 board.

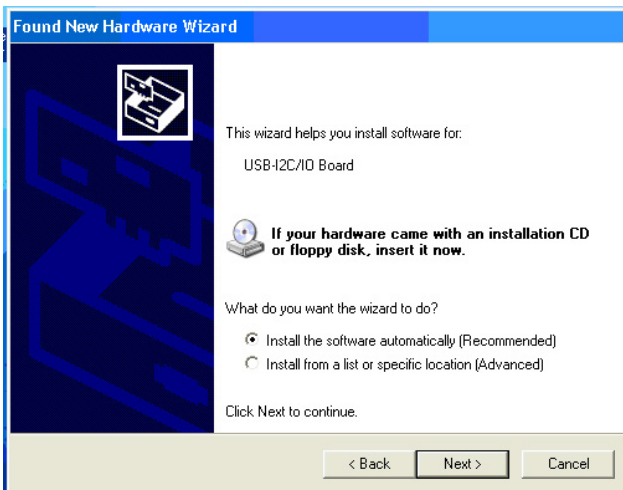
Then, plug in the DeVasys board into the USB port.

The following screen should pop up.

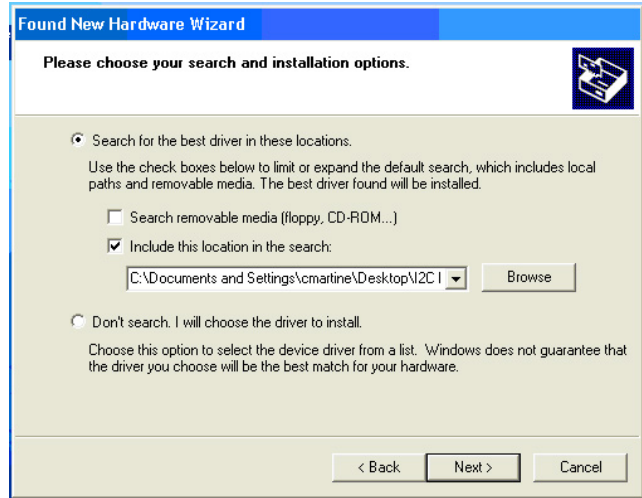


Select “Yes, this time only” and click “Next”.

The following screen will come up:



Select “Install from a list or specific location” and click “Next” a screen like the one shown will come up:



Browse for the “Software” directory in the “ISL94208 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

#### 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 lighted.
5. If the LEDs on the DeVasys board are not on, make sure that the DeVasys board is disconnected from the ISL94208 board when it is first plugged into the PC.
6. 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 ISL94208 status register. Set the scope to single trigger on the falling edge of SCL.

### Power Supply Troubleshooting

#### The RGO Does Not Have The Correct Voltage.

1. Check that the voltage on each of the input terminals are between 2.6V and 4.5V.
2. Check that there is no unexpected load on the RGO output.

### ISL94208 Troubleshooting

#### The AO Voltages Are Reading Incorrectly At The AO Pin.

1. Check that all cell balance outputs are off.
2. Make sure that there is minimal series resistance between the battery and the input pins of the ISL94208EVZ board and that the input voltages are between 2.6V and 4.3V.

### GUI Troubleshooting

#### The Voltages Are Reading Incorrectly On The GUI.

1. Check that the RGO output is 3.3V. The 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. Turn off the cell balancing. When using the DB1 daughter board (internal balancing FETs) turning on the cell balancing causes current flows into the CBN pin and out the VCELL(n-1) pin. The current flowing out the VCELL(n-1) pin causes a voltage drop across the input resistor on one side of the cell measurement, but not the other. This can cause a measurement error of up to 200mV to 300mV. This change happens external to the ISL94208. Using the DB2 daughter board, the voltage changes less, because the FET is external and there is no balance current through the input series resistors, however, the balancing current can cause the

battery or source voltage to drop some voltage through the leads connecting the supply to the board.

If the voltages changing during balance is a problem, then it is necessary to modify the code to turn off balance before taking a cell voltage reading, then turn it on again if conditions are still normal for balancing.

#### The Cell Voltages Are Not Updated Correctly During Refresh.

1. In the refresh function there is a bug when less than 6 cells are connected. The auto-polling function works correctly, but for manual update of cells 3, 4, and 5, it is necessary to select the connected cell, click refresh, then select the displayed cell and click refresh. For example, in a 4-cell pack CELL1, CELL2, CELL5, and CELL6 inputs are used. To refresh the CELL3 voltage on the display requires selecting CELL5, clicking “Refresh”, and then selecting CELL3 and clicking “Refresh” again.

#### After Writing A Configuration Value, And Doing A Refresh, The Value Returns To The Previous Setting.

1. There is a bug in the configuration write routine. It is supposed to set the Write enable bit prior to writing the new setting, but it does not do this properly. To ensure a proper operation, write “E0” to register 08H before changing the configuration value. This sets all write enable bits prior to write operation.
2. Another way that seems to work is to click on the Configuration Write button two times allowing enough time between clicks for the command to complete.

### Other Questions

Forward any ISL94208EVZ questions to the Intersil Application Engineer at [cmartine@intersil.com](mailto:cmartine@intersil.com).

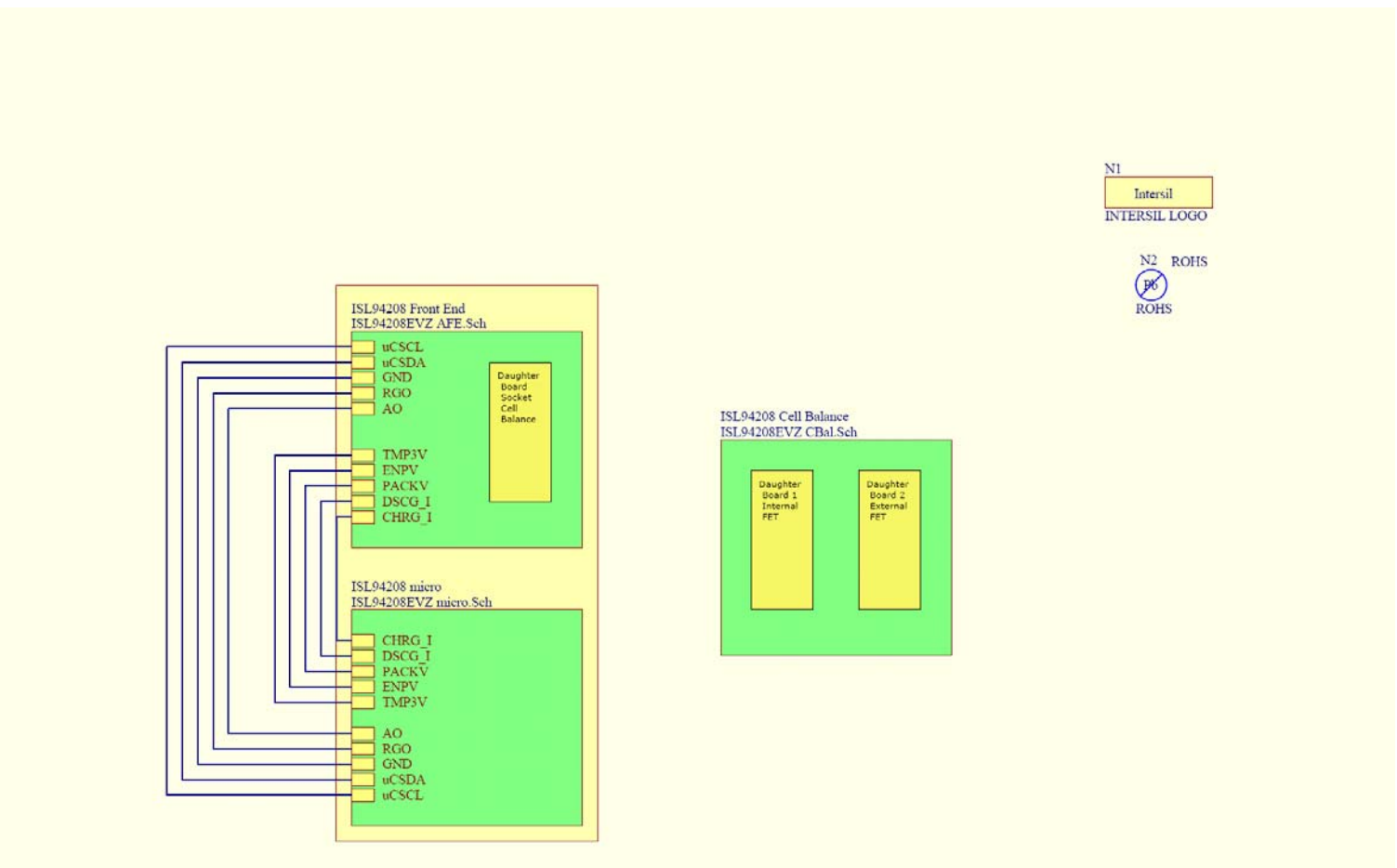


FIGURE 15. ISL94208EVZ (REV B) SCHEMATIC (PAGE 1 of 4)



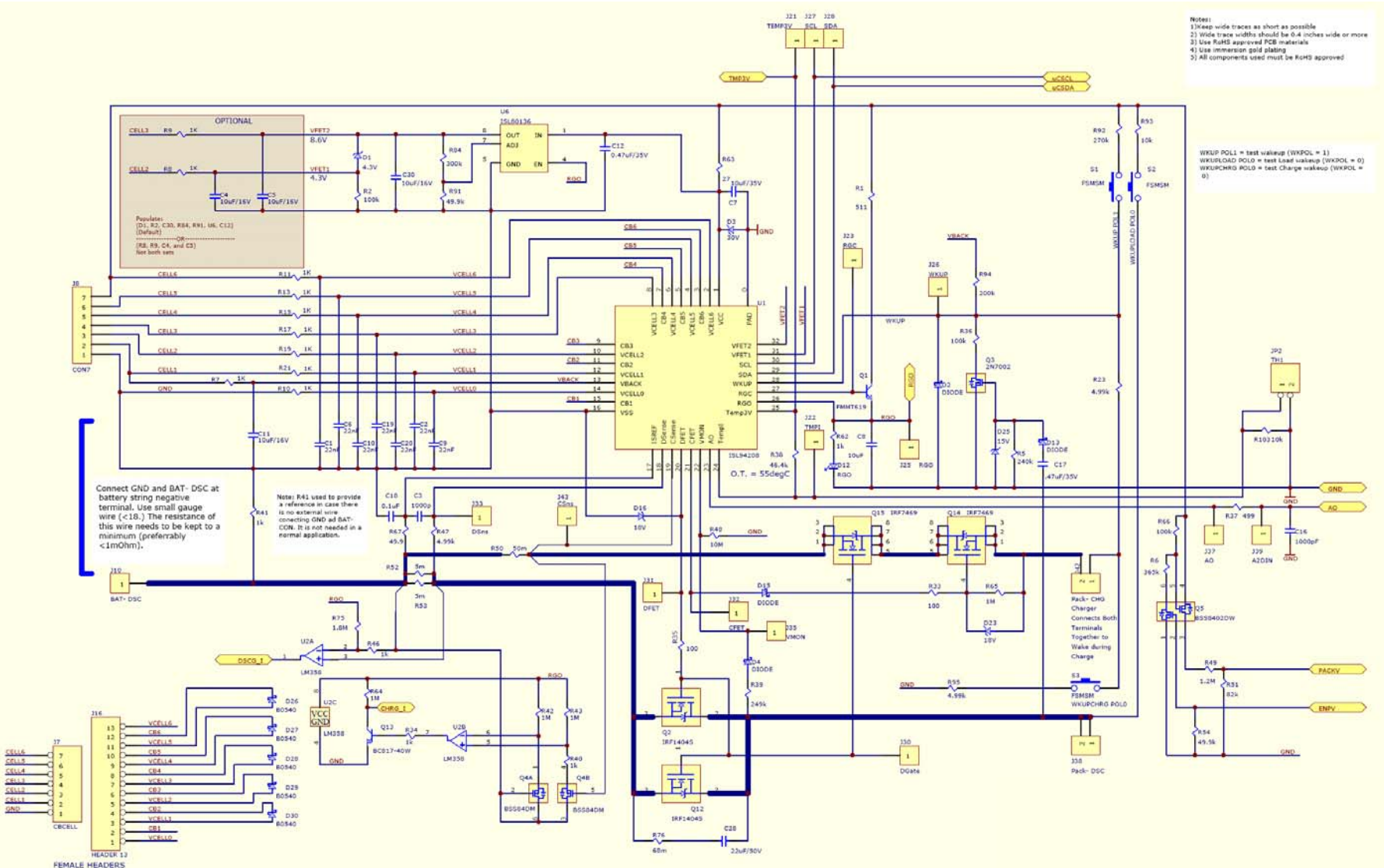
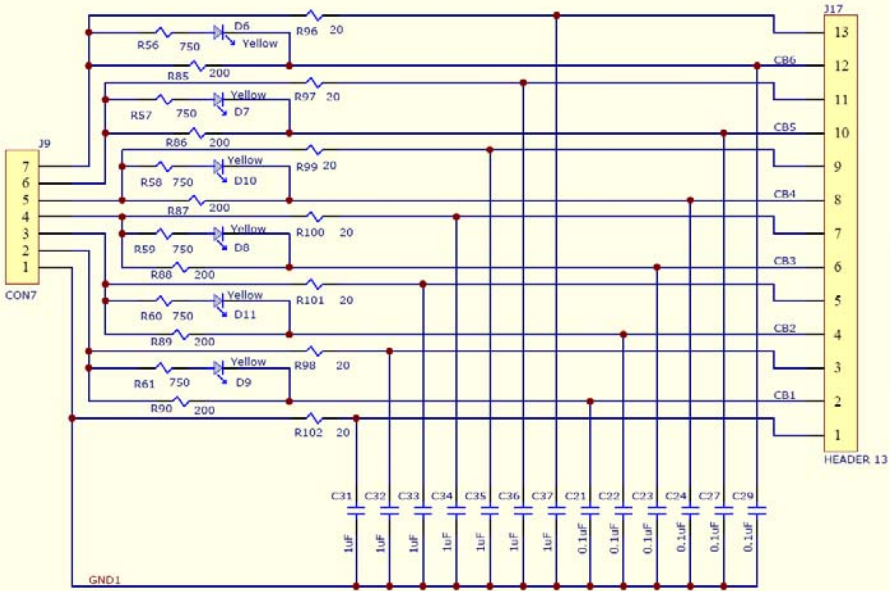
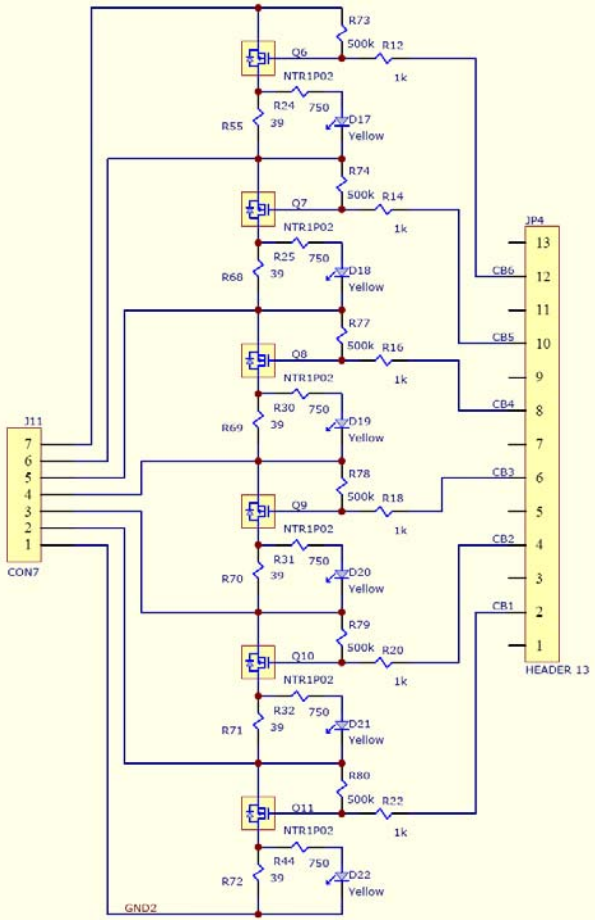


FIGURE 1. ISL94208EVZ (REV B) SCHEMATIC (PAGE 2 of 4)





**ISL94208EV1 Daughter Board 1**  
**Internal Balance Elements**  
**MALE HEADERS**

For the Internal Balance option, the 20 Ohm resistors parallel the input resistors on the main board to minimize the measurement errors when balancing. The 1uF capacitors to ground parallel the ones on the main board to maintain the same filtering.  
 In a real application, only one set of RC is needed and the daughter card would not be used.

FIGURE 16. ISL94208EVZ (REV B) SCHEMATIC (PAGE 4 of 4)

TABLE 1. ISL94208 BILL OF MATERIALS (MAIN BOARD)

Part Number	Qty	Units	Reference Designator	DESCRIPTION
ISL94208EVZREVBPCB	1	ea		PWB-PCB, ISL94208EVZ, REVB, ROHS
GMK212BJ474KG-T	2	ea	C12, C17	CAP, SMD, 0805, 0.47 $\mu$ F, 35V, 10%, X5R, ROHS
H1044-00102-25V10-T	1	ea	C3	CAP, SMD, 0402, 1000pF, 25V, 10%, X7R, ROHS
H1044-00103-16V10-T	1	ea	C15	CAP, SMD, 0402, 1 $\mu$ F, 16V, 10%, X7R, ROHS
H1044-00104-16V10-T	1	ea	C18	CAP, SMD, 0402, 0.1 $\mu$ F, 16V, 10%, X7R, ROHS
H1045-00102-25V10-T	1	ea	C16	CAP, SMD, 0603, 1000PF, 25V, 10%, X7R, ROHS
H1045-00104-16V10-T	2	ea	C13, C14	CAP, SMD, 0603, 0.1 $\mu$ F, 16V, 10%, X7R, ROHS
H1045-00106-6R3V20-T	1	ea	C8	CAP, SMD, 0603, 10 $\mu$ F, 6.3V, 20%, X5R, ROHS
H1045-00223-50V10-T	7	ea	C1, C2, C6, C9, C10, C19, C20	CAP, SMD, 0603, 0.022 $\mu$ F, 50V, 10%, X7R, ROHS
H1045-DNP	0	ea	C25, C26	CAP, SMD, 0603, DNP-PLACE HOLDER, ROHS
H1046-00106-16V8020-T	1	ea	C11, C30	CAP, SMD, 0805, 10 $\mu$ F, 16V, +80-20%, Y5V, ROHS
H1065-DNP	2	ea	C4, C5	CAP, SMD, 1206, DNP-PLACE HOLDER, ROHS
H1082-00105-50V10-T	1	ea	C7	CAP, SMD, 1210, 1 $\mu$ F, 50V, 10%, X7R, ROHS
1266	1	ea	B- (Located right of J10)	CONN-TERMINAL, TH, QUICK-FIT MALE TAB, 20.1x8.9, ROHS
22-28-8361-1X2	1	ea	JP2	CONN-HEADER, 1X2, BRK-AWAY 1X36, 2.54mm, R/A, ROHS
22-28-8361-1X4	1	ea	J29	CONN-HEADER, 1X4, BRK-AWAY 1X36, 2.54mm, R/A, ROHS
22-28-8361-1X7	1	ea	J8	CONN-HEADER, 1X7, BRK-AWAY 1X36, 2.54mm, R/A, ROHS
67996-272HLF-2X3	1	ea	JP1	CONN-HEADER, 2x3, BRKAWY 2X36, 2.54mm, VERTICAL, ROHS
929974-01-36-RK-1X7	1	ea	J7	CONN-SOCKET, TH, 1X7, BRKAWY 1X36, 2.54mm, INSULATED, ROHS
AZ23C3V3-7-F-T	1	ea	D5	DIODE-ZENER, DUAL, SMD, SOT23, 3.3V, 300mW, ROHS
BAT6203WE6327XT	4	ea	D2, D4, D13, D15	DIODE-SCHOTTKY, SMD, 2P, SOD323, 40V, 20mA, ROHS
MBR0540T1G-T	5	ea	D26-D30	DIODE-SHOTTKEY RECTIFIER, SMD, SOD-123, 40V, 0.5A, ROHS
MM3Z4V3T1G-T	1	ea	D1	DIODE-ZENER, SMD, SOD-323, 4.3V, 200mW, ROHS
MMSZ4702T1G-T	1	ea	D25	DIODE-ZENER, SMD, 2P, SOD-123, 15V, 500mW, ROHS
MMSZ4705T1G-T	2	ea	D16, D23	DIODE-ZENER, SMD, 2P, SOD-123, 18V, 500mW, ROHS
MMSZ4713T1G-T	1	ea	D3	DIODE-ZENER, SMD, 2P, SOD-123, 30V, 500mW, ROHS
LNJ326W83RA-T	1	ea	D12	LED, SMD, 0603, GREEN, 2.05V, 17mcd, 10mA, ROHS
ISL28214FUZ	1	ea	U2	IC-DUAL OP AMP, RRIO, 8P, MSOP, ROHS
ISL80136IBEAJZ	1	ea	U6	IC-40V LDO ADJ. LINEAR REGULATOR, 8P, EPSOIC, ROHS
ISL94208IRZ	1	ea	U1	IC-MULTI-CELL LI-ION BATTERY, 32P, QFN, 5X5, ROHS
MC9S08QG8CFFE	1	ea	U3	IC-MCU, FLASH, 8Kx8, 10MHz, 16P, QFN, ROHS
2N7002-7-F-T	1	ea	Q3	TRANSISTOR, N-CHANNEL, 3LD, SOT-23, 60V, 115mA, ROHS
BC817-40W-7-T	1	ea	Q13	TRANSISTOR-NPN, SMD, 3P, SOT-323, 45V, 500mA, ROHS
BSS8402DW-7-F-T	1	ea	Q5	TRANSIST-MOS, P-CHANNEL/N-CHANNEL, 6P, SOT-363, 200mW, ROHS
BSS84DW-7-F-T	1	ea	Q4	TRANSIST, DUAL P-CHANNEL, 6P, SOT-363, -50V, -130mA, ROHS
FMMT619TA-T	1	ea	Q1	TRANSISTOR, NPN, SOT23, 50V, 2A, ROHS
IRF1404SPBF	2	ea	Q2, Q12	TRANSIST-MOS, N-CHANNEL, TH, D2-PAK, 40V, 162A, ROHS
IRF7469PBF	2	ea	Q14, Q15	TRANSISTOR-MOS, SMPs, 8P, SOIC, 40V, 9A, ROHS
CSNL20.0051%R-T	2	ea	R52, R53	RES-CURR SENSE, SMD, 2512, 0.005ohm, 2W, 1%, MF, ROHS
CSRN20.051%-T	1	ea	R50	RES-CURR SENSE, SMD, 2512, 0.05ohm, 2W, 1%, TF, ROHS
H2510-01001-1/16W1-T	3	ea	R34, R40, R46	RES, SMD, 0402, 1k, 1/16W, 1%, TF, ROHS
H2510-01002-1/16W1-T	3	ea	R93	RES, SMD, 0402, 10k, 1/16W, 1%, TF, ROHS
H2510-01003-1/16W1-T	3	ea	R2, R36, R66	RES, SMD, 0402, 100k, 1/16W, 1%, TF, ROHS
H2510-01004-1/16W1-T	5	ea	R26, R27, R42, R43, R64	RES, SMD, 0402, 1MEG, 1/16W, 1%, TF, ROHS
H2510-01005-1/16W1-T	1	ea	R48	RES, SMD, 0402, 10M, 1/16W, 1%, TF, ROHS
H2510-01204-1/16W1-T	1	ea	R49	RES, SMD, 0402, 1.2MEG, 1/16W, 1%, TF, ROHS



TABLE 1. ISL94208 BILL OF MATERIALS (MAIN BOARD) (Continued)

H2510-01804-1/16W1-T	1	ea	R75	RES, SMD, 0402, 1.8M, 1/16W, 1%, TF, ROHS
H2510-02003-1/16W1-T	3	ea	R94	RES, SMD, 0402, 200k, 1/16W, 1%, TF, ROHS
H2510-02703-1/16W1-T	3	ea	R92	RES, SMD, 0402, 270k, 1/16W, 1%, TF, ROHS
H2510-03003-1/16W1-T	3	ea	R84	RES, SMD, 0402, 300k, 1/16W, 1%, TF, ROHS
H2510-03653-1/16W1-T	1	ea	R6	RES, SMD, 0402, 365k, 1/16W, 1%, TF, ROHS
H2510-04642-1/16W1-T	1	ea	R38	RES, SMD, 0402, 46.4k, 1/16W, 1%, TF, ROHS
H2510-04701-1/16W1-T	4	ea	R3, R4, R81, R82	RES, SMD, 0402, 4.7k, 1/16W, 1%, TF, ROHS
H2510-04991-1/16W1-T	2	ea	R47, R95	RES, SMD, 0402, 4.99k, 1/16W, 1%, TF, ROHS
H2510-04992-1/16W1-T	2	ea	R54, R91	RES, SMD, 0402, 49.9k, 1/16W, 1%, TF, ROHS
H2510-049R9-1/16W1-T	1	ea	R67	RES, SMD, 0402, 49.9Ω, 1/16W, 1%, TF, ROHS
H2510-08202-1/16W1-T	1	ea	R51	RES, SMD, 0402, 82k, 1/16W, 1%, TF, ROHS
H2511-01000-1/10W1-T	4	ea	R28, R29, R33, R35	RES, SMD, 0603, 100Ω, 1/10W, 1%, TF, ROHS
H2511-01001-1/10W1-T	0	ea	DNP - R8, R9	RES, SMD, 0603, 1k, 1/10W, 1%, TF, ROHS
H2511-01001-1/10W1-T	10	ea	R7, R10, R11, R13, R15, R17, R19, R21, R41, R62.	RES, SMD, 0603, 1k, 1/10W, 1%, TF, ROHS
H2511-01002-1/10W1-T	2	ea	R45, R103	RES, SMD, 0603, 10k, 1/10W, 1%, TF, ROHS
H2511-01004-1/10W1-T	1	ea	R65	RES, SMD, 0603, 1M, 1/10W, 1%, TF, ROHS
H2511-02403-1/10W1-T	1	ea	R5	RES, SMD, 0603, 240k, 1/10W, 1%, TF, ROHS
H2511-02493-1/10W1-T	1	ea	R39	RES, SMD, 0603, 249k, 1/10W, 1%, TF, ROHS
H2511-04990-1/10W1-T	1	ea	R37	RES, SMD, 0603, 499Ω, 1/10W, 1%, TF, ROHS
H2511-04991-1/10W1-T	1	ea	R23	RES, SMD, 0603, 4.99k, 1/10W, 1%, TF, ROHS
H2511-05110-1/10W1-T	1	ea	R1	RES, SMD, 0603, 511Ω, 1/10W, 1%, TF, ROHS
H2511-DNP	0	ea	R83	RES, SMD, 0603, DNP-PLACE HOLDER, ROHS
H2512-00270-1/8W1-T	1	ea	R63	RES, SMD, 0805, 27Ω, 1/8W, 1%, TF, ROHS
FSMSMTR-T	3	ea	S1, S2, S3	SWITCH-TACTILE, SMD, 6X3.5, 12V, 0.05A, SPST-NO, ROHS
DNP	0	ea	C28	DO NOT POPULATE OR PURCHASE
DNP	0	ea	J10, J42	DO NOT POPULATE OR PURCHASE
DNP	0	ea	JP3 (22-23-2051)	DO NOT POPULATE OR PURCHASE
DNP	0	ea	R76	DO NOT POPULATE OR PURCHASE
DNP	0	ea	U4 (ADUM1250ARZ)	DO NOT POPULATE OR PURCHASE
DNP	0	ea	a) CSns, DSns, CFET, DFET, TMPI, RGO, RGC, AO,	DO NOT POPULATE OR PURCHASE
DNP	0	ea	b) SCL, SDA, PSCL, PSDA, VMon, WKUP	DO NOT POPULATE OR PURCHASE
DNP	0	ea	c) Dgate, TEMP3V, Pack-DSC, Pack-CHG, A2DIN	DO NOT POPULATE OR PURCHASE
DNP	0	ea	d) μCP1, μCP2, ENI, ENPV, CHI, DCI, PV	DO NOT POPULATE OR PURCHASE

**TABLE 2. ISL94208 BILL OF MATERIALS (DAUGHTER BOARD 1)**

PART NUMBER	QTY	UNITS	REFERENCE DESIGNATOR	DESCRIPTION
ISL94208DB1EVZREVBPCB	1	ea		PWB-PCB, ISL94208DB1EVZ, REVB, ROHS
H1045-00104-50V10-T	6	ea	C21-C24, C27, C29	CAP, SMD, 0603, 0.1 $\mu$ F, 50V, 10%, X7R, ROHS
H1045-00105-50V10-T	6	ea	C31-C37	CAP, SMD, 0603, 1 $\mu$ F, 50V, 10%, X7R, ROHS
929834-01-36-RK-1X13	1	ea	J17	CONN-HEADER, TH, 1x13, BRKAWY 1x36, 2.54mm, ROHS
929834-01-36-RK-1X7	1	ea	J9	CONN-HEADER, TH, 1x7, BRKAWY 1x36, 2.54mm, ROHS
LNJ826W83RA-T	6	ea	D6-D11	LED, SMD, 0603, ORANGE, 19mcd, 5mA, 1.9V, 620nm, ROHS
H2510-07500-1/16W1-T	6	ea	R56-R61	RES, SMD, 0402, 750 $\Omega$ , 1/16W, 1%, TF, ROHS
H2515-02000-1W5-T	6	ea	R85-R90	RES, SMD, 2512, 200 $\Omega$ , 1W, 5%, TF, ROHS
H2511-00200-1/10W1-T	4	ea	R96-R102	RES, SMD, 0603, 20 $\Omega$ , 1/10W, 1%, TF, ROHS

**TABLE 3. ISL94208 BILL OF MATERIALS (DAUGHTER BOARD 2)**

PART NUMBER	QTY	UNITS	REFERENCE DESIGNATOR	DESCRIPTION
ISL94208DB2EVZREVBPCB	1	ea		PWB-PCB, ISL94208DB2EVZ, REVB, ROHS
929834-01-36-RK-1X13	1	ea	J24	CONN-HEADER, TH, 1x13, BRKAWY 1x36, 2.54mm, ROHS
929834-01-36-RK-1X7	1	ea	J11	CONN-HEADER, TH, 1x7, BRKAWY 1x36, 2.54mm, ROHS
LNJ826W83RA-T	6	ea	D17-D22	LED, SMD, 0603, ORANGE, 19mcd, 5mA, 1.9V, 620nm, ROHS
MMBT3906K-T	6	ea	Q6-Q11	TRANSISTOR, PNP, 3P, SOT-23, -40V, -200mA, ROHS
H2510-01001-1/16W1-T	6	ea	R12, R14, R16, R18, R20, R22	RES, SMD, 0402, 1k, 1/16W, 1%, TF, ROHS
H2510-04993-1/16W1-T	6	ea	R73, R74, R77-R80	RES, SMD, 0402, 499k, 1/16W, 1%, TF, ROHS
H2510-07500-1/16W1-T	6	ea	R24, R25, R30, R31, R32, R44	RES, SMD, 0402, 750 $\Omega$ , 1/16W, 1%, TF, ROHS
H2515-00390-1W1-T	6	ea	R55, R68-R72	RES, SMD, 2512, 39 $\Omega$ , 1W, 1%, TF, ROHS

## Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.  
"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.  
"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.  
Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.  
(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.  
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



### SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

**Renesas Electronics America Inc.**  
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.  
Tel: +1-408-432-8888, Fax: +1-408-434-5351

**Renesas Electronics Canada Limited**  
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3  
Tel: +1-905-237-2004

**Renesas Electronics Europe Limited**  
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K.  
Tel: +44-1628-651-700, Fax: +44-1628-651-804

**Renesas Electronics Europe GmbH**  
Arcadiastrasse 10, 40472 Düsseldorf, Germany  
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

**Renesas Electronics (China) Co., Ltd.**  
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China  
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

**Renesas Electronics (Shanghai) Co., Ltd.**  
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China  
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

**Renesas Electronics Hong Kong Limited**  
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong  
Tel: +852-2265-6688, Fax: +852-2886-9022

**Renesas Electronics Taiwan Co., Ltd.**  
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan  
Tel: +886-2-8175-9600, Fax: +886-2-8175-9670

**Renesas Electronics Singapore Pte. Ltd.**  
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949  
Tel: +65-6213-0200, Fax: +65-6213-0300

**Renesas Electronics Malaysia Sdn.Bhd.**  
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia  
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

**Renesas Electronics India Pvt. Ltd.**  
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India  
Tel: +91-80-67208700, Fax: +91-80-67208777

**Renesas Electronics Korea Co., Ltd.**  
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea  
Tel: +82-2-558-3737, Fax: +82-2-558-5338