Evaluating the ADBMS2950B Battery Pack Monitor

FEATURES

- Fully-featured evaluation board for the ADBMS2950B
- Bidirectional high-accuracy current measurement with on board shunt
- Increased input-range overcurrent measurement and alert
- Battery stack measurements
  - Battery stack voltage monitoring
  - Isolation measurement
  - Precharge monitoring
  - Fuse monitoring
  - Charger monitoring
  - Link voltage monitoring
- Includes two isoSPI ports for daisy chain and reversible isoSPI support, and the isoSPI connections can be done through simple DuraClick™ connectors

EVALUATION KIT CONTENTS

- EVAL-ADBMS2950B evaluation board and an isoSPI DuraClick cable

DOCUMENTS NEEDED

- ADBMS2950B data sheet
- ADBMS2950B hardware user guide

EQUIPMENT NEEDED

- To ease basic evaluation task with the EVAL-ADBMS2950B, the following supplementary products are recommended
  - EVAL-SDP-CK1Z controller board
  - EVAL-ADBMS6822 dual-controller isoSPI add-on board
  - EVAL-ADBMS6830BMSW 16-cell monitoring board

SOFTWARE NEEDED

- Evaluation software for the ADBMS2950B
  - BMS browser Windows-based graphical user Interface (GUI) program
  - ADBMS2950B software user guide
  - To request the software modules, refer to the form

COMPATIBLE BOARDS

- EVAL-ADBMS6822 dual-controller isoSPI
- Add-on board EVAL-ADBMS6830B 16-channel cell monitor board
- EVAL-ADBMS6832 18-channel cell monitor board
- EVAL-SDP-CK1Z MCU board for software control and data analysis
  - Supported by Arm Mbed OS
  - Supported by ADBMS GUI
  - Supported by pyBMS

APPLICATIONS

- Mobile robot systems
- E-scooter/E-bikes/Light electric vehicle
- Power tools
- Portable-energy storage system
- Backup-battery system monitoring
- Grid energy storage

GENERAL DESCRIPTION

The EVAL-ADBMS2950B evaluation board features the ADBMS2950B, a bidirectional current monitor, with 12 buffered high-impedance voltage sense inputs, linked through a 2-wire isolated serial interface (isoSPI). The demo circuit also features reversible isoSPI, which enables a redundant communication path.

The EVAL-ADBMS2950B can communicate to a PC over isoSPI by attaching a EVAL-ADBMS6822 dual-controller isoSPI add-on board to the expansion headers of a EVAL-SDP-CK1Z, and then connecting the EVAL-SDP-CK1Z to a host PC through USB.

The EVAL-ADBMS2950B evaluation board can be operated on the same isoSPI daisy chain with other ADBMS2950B, and ADBMS6830B devices.

Full specifications on the ADBMS2950B are available in the ADBMS2950B data sheet available from Analog Devices, Inc., and must be consulted with this user guide when using the EVAL-ADBMS2950B evaluation board.

Design files for this circuit board are available on the product webpage.

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REVISION HISTORY

7/2024—Revision 0: Initial Version

FUNCTIONAL BLOCK DIAGRAM

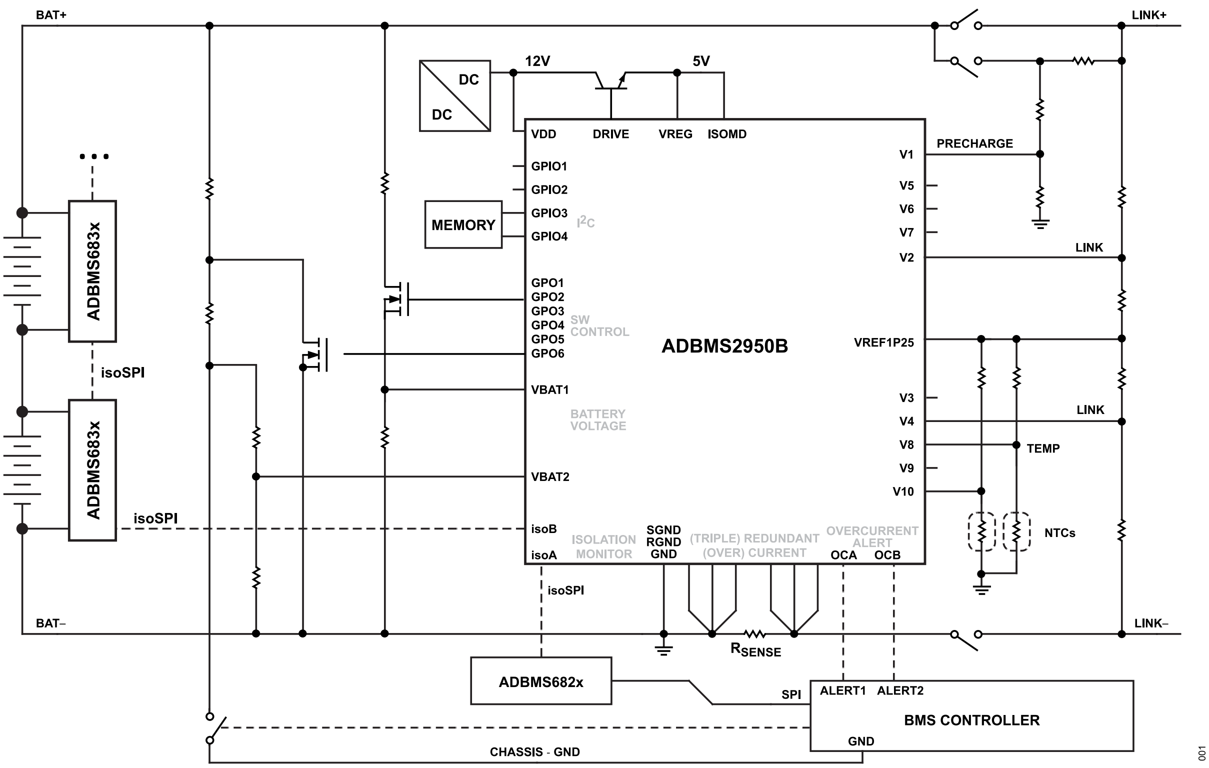

Figure 1. EVAL-ADBMS2950B Evaluation Board System Architecture

PERFORMANCE SUMMARY

Table 1. Performance Summary[1, 2]

Parameter	Type	Min	Typ	Max	Unit
LOW-VOLTAGE POWER SUPPLY INPUT					
Wide Range LV[3] Input (J1)	PIN[4]	6		15	V
Alternative 5 V LV[3] Input (J10, J12)	PIN[4]	4.5		5.5	V
LOW-VOLTAGE DIGITAL OUTPUTS					
Overcurrent Alert LVOCA, LVOCB	DOUT[5]	0		5.5	V
HIGH-VOLTAGE SHUNT SENSE INPUT					
Current	AIN[6]	−131		+131	mV
Overcurrent	AIN[6]	−300		+300	mV
Shunt Resistance			50		μΩ
HIGH-VOLTAGE POWER SUPPLY OUTPUT					
V_{DD} to GND	POUT[7]		14		V
V_{REG} to GND	POUT[7]		5		V
HIGH-VOLTAGE ANALOG INPUT					
HVISO1 to GND	HVIN[8]	0		1000	V
HV1 to GND	HVIN[8]	0		1000	V
HV2 to GND	HVIN[8]	−1000		+1000	V
HV3 to GND	HVIN[8]	−1000		+1000	V
HV[9] TO LV[3] ISOLATION					
GND to LGND				1000	V

1 High current in/out of the high-voltage battery applied between BAT− and Shunt−.

2 For the specifications such as tolerance and temperature drift, refer to the ISA-WELD//Precision Resistors (BAS//Size 8420 (Metric)) data sheet from the Isabellenhütte website.

3 Isolated LGND (chassis GND) referred side.

4 Power Input.

5 Digital Output.

6 Analog Input.

7 Power Output.

8 High Voltage Input.

9 GND (HV Battery BAT−) referred side.

COMPONENT FEATURES AND CONNECTIONS

CURRENT SENSE RESISTOR

The EVAL-ADBMS2950B evaluation board comes equipped with a high-current bus bar style current-sense resistor BAS-M-R00005-AE-5.0. For recommended operating conditions, refer to the ISA-WELD//Precision Resistors (BAS//Size 8420 (Metric)) data sheet from the Isabellenhütte website. Currents of several hundreds of amperes are possible, but power dissipation must be considered. The maximum power rating of the shunt resistor used is P = 36 W.

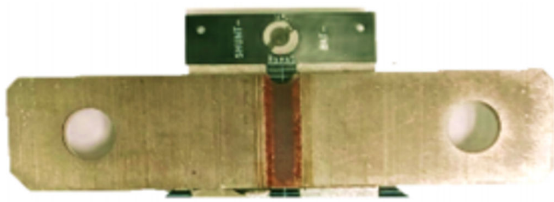

Figure 2. Current Sense Resistor

Such high currents must be applied only for short times as the power dissipation leads to significant temperature increase. Temperature of the shunt resistor can be monitored by the on-board NTC thermistors connected to the VxADC inputs, for the channel assignment, see Table 2.

The bus bar resistance usually can be neglected but the contact resistance between the bus bar and the cable lugs can be significant. Oxidation on the contact surfaces of the shunt resistor must be removed by polishing with very fine sandpaper.

HIGH-VOLTAGE SENSE INPUTS

The EVAL-ADBMS2950B evaluation board comes equipped with four clamps that allow application and monitoring of high input voltages up to 1000 V.

The high-voltage input clamps are marked HVISO1, HV1, HV2, and HV3, as shown in Figure 3.

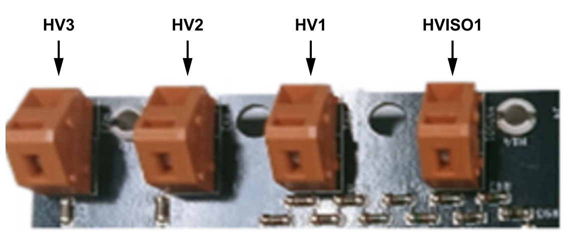

Figure 3. High-Voltage Input Clamps using WAGO Connectors

Table 2 shows the assignments of the voltage inputs to the ADBMS2950B pins and ADCs.

Table 2. Voltage Input Assignment to ADBMS2950B Pins and ADCs

Name	Enable	ADBMS2950B Pin	ADC
HV1 (BAT+)	GPO2	VBAT1	VB1ADC
	GPO1	VBAT2	VB2ADC
HVISO1	GPO1	VBAT2	VB2ADC
HV2	N/A[1]	V2	V1ADC, V2ADC
HV3	N/A[1]	V3	V1ADC, V2ADC
NTC1	N/A[1]	V7	V1ADC
NTC2	N/A[1]	V9	V2ADC

[1] N/A means not applicable.

HV1: Battery Stack Voltage Input

The HV1 input is connected to two on-board voltage dividers to enable redundant monitoring of the full battery stack voltage and to perform LV to HV isolation resistance measurement. The voltage dividers transform the high input voltage applied to HV1 to the VB1ADC and VB2ADC input range. The voltage dividers connect to the VBAT1 and VBAT2 inputs of the ADBMS2950B and thus to VB1ADC andVB2ADC, respectively. The VBAT1 and VBAT2 voltage sense nodes are not biased through VREF1P25, thus the allowed HV1 input voltage range is positive only (0 V to 1000 V).

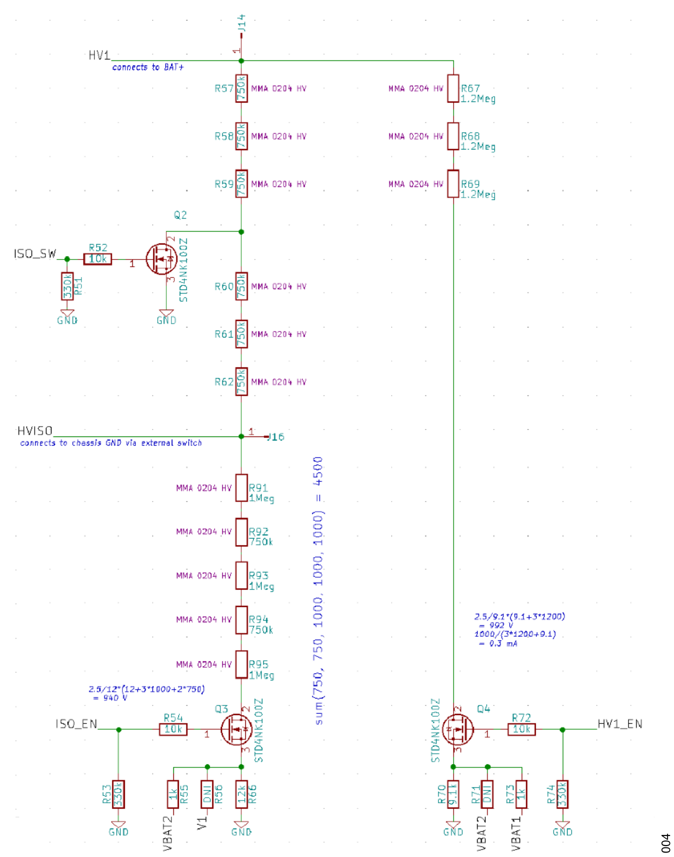

Figure 4. Circuit Diagram

COMPONENT FEATURES AND CONNECTIONS

The HV1 voltage can be calculated from the VBAT1 voltage measurement vs. SGND (for VB1MUX setting, refer to the ADBMS2950B data sheet), according to the following equation:

$$V_{HV1} = \frac{3.6M\Omega + 9.1k\Omega}{9.1k\Omega} \times V_{BAT1,SGND} \quad (1)$$

If no isolation resistance measurement is performed (GPO3 low leading to Q2 open and no connection to HVISO), the HV1 voltage can be calculated from the redundant VBAT2 voltage measurement vs. SGND (for VB2MUX setting, refer to the ADBMS2950B data sheet), according to the following equation:

$$V_{HVISO} = \frac{9M\Omega + 12k\Omega}{12k\Omega} \times V_{BAT2,SGND} \quad (2)$$

If isolation resistance measurement is performed (HVISO connected to LV = Chassis-GND), the HVISO voltage can be calculated from the VBAT2 voltage measurement vs. SGND (for VB2MUX setting, refer to the ADBMS2950B data sheet), according to the following equation:

$$V_{HVISO} = \frac{4.5M\Omega + 12k\Omega}{12k\Omega} \times V_{BAT2,SGND} \quad (3)$$

The VBAT1 voltage divider is activated by turning on the MOSFET Q4, which is done by asserting the signal HV1_EN connected to the ADBMS2950B GPO2 pin.

The VBAT2 voltage divider is activated by turning on the MOSFET Q3, which is done by asserting the signal ISO_EN connected to the ADBMS2950B GPO1 pin.

HV2, HV3: Auxiliary High-Voltage Inputs

The EVAL-ADBMS2950B evaluation board features two additional high-voltage inputs, HV2 and HV3, that are transformed into the input ranges of the V1ADC and V2ADC.

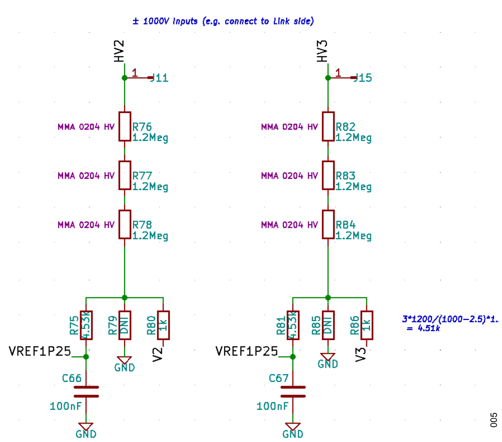

Figure 5. Circuit Diagram

The HV2 and HV3 inputs enable the monitoring of high voltages in the battery system, such as LINK, FUSE, PRECHG, and DCFC. HV2 and HV3 are mapped to the ADBMS2950B inputs V2 and V3, respectively.

The V2 and V3 voltage sense nodes are biased to 1.25 V (VREF1P25), so that the allowed input range of the HV2 and HV3 inputs is −1000 V to +1000 V.

The voltages at HV2 and HV3 can be evaluated from V_X (x = 2 or 3) ADC measurements vs. VREF1P25 (for VS2 and VS3 settings, refer to the ADBMS2950B data sheet), according to the following equation:

$$V_{HVx} = \frac{3.6M\Omega + 4.53k\Omega}{4.53k\Omega} \times V_{x,REF1P25} + V_{REF1P25} \quad (4)$$

HVISO1: Chassis-GND Connection for Isolation Measurements

HVISO1 is a special-function input that is used to evaluate isolation measurements using the EVAL-ADBMS2950B evaluation board.

To conduct isolation measurements, connect the HVISO1 input to Chassis-GND through a controllable switch.

AUXILIARY IO HEADERS

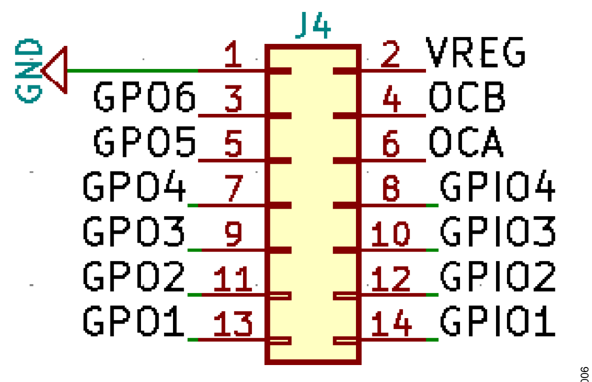

Figure 6. IO Connectors J4

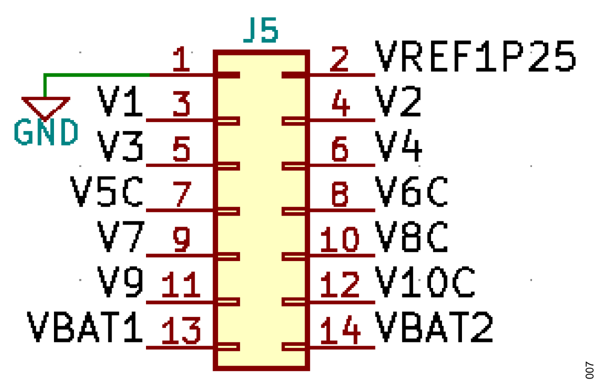

Figure 7. IO Connectors J5

COMPONENT FEATURES AND CONNECTIONS

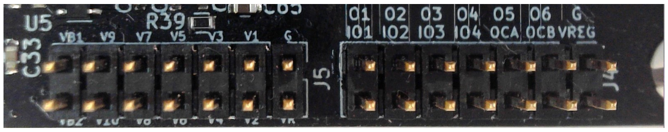

Figure 8. Connections on the EVAL-ADBMS2950B Evaluation Board

The EVAL-ADBMS2950B evaluation board features two headers, J4 and J5, that make the ADBMS2950B voltage inputs, GPO, GPIO, and power outputs available for probing and as additional inputs and outputs.

The following signals on the auxiliary headers J4 and J5 may be used as additional inputs and outputs.

Table 3. Connections on the EVAL-ADBMS2950B Evaluation Board

V_x	GPIO	GPO
V1	GPIO1	GPO4
V4	GPIO2	GPO5
V5C	N/A[1]	GPO6
V6C	N/A[1]	N/A[1]
V8C	N/A[1]	N/A[1]
V10C	N/A[1]	N/A[1]

[1] N/A means not applicable.

If the voltage inputs of the auxiliary IO headers J4 and J5 are used the measured voltage signals must be transformed into the input range of the ADBMS2950B V1ADC and V2ADC, respectively. Thus, external resistive dividers similar to those used for HV1 to HV3 are required for measuring high-voltage signals.

OVERCURRENT OUTPUTS IN LOW-VOLTAGE DOMAIN

The ADBMS2950B overcurrent outputs OCA and OCB are transferred from the high-voltage domain into the low-voltage using a ADuM225 part.

They are available as signals A and B at the header J1.

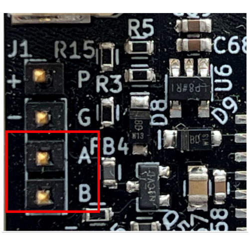

Figure 9. EVAL-ADBMS2950B Evaluation Board Connections

2 kb ON-BOARD EEPROM

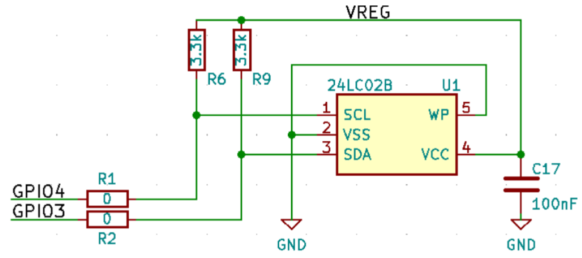

Figure 10. EEPROM

The EVAL-ADBMS2950B evaluation board features a 24LC02B 2 kb I²C EEPROM (for more details, refer to the 24AA02/24LC02B, 2 kb I²C Serial EEPROM data sheet from Microchip website) connected to ADBMS2950B's on-chip peripheral controller interface through Pins GPIO3 and GPIO4.

The on-board EEPROM may be used for data storage (for example, to store shunt-resistor calibration information).

ISOSPI CONNECTORS

The EVAL-ADBMS2950B evaluation board features two transformer-isolated isoSPI connectors, which enable the fully-redundant reversible isoSPI functionality.

The isoSPI DuraClik cable supplied with the EVAL-ADBMS2950B evaluation board may be plugged into any of the connectors J8 or J9, marked isoA and isoB, respectively.

An evaluation board featuring another ADBMS2950B, or ADBMS6830B device may be connected to the second isoSPI connector to build an isoSPI daisy chain. Due to the reversible isoSPI feature, it is also allowed to swap connections to isoA and isoB.

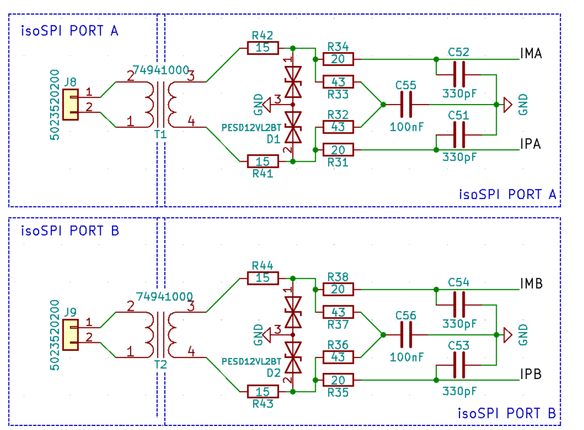

Figure 11. isoSPI Port A and isoSPI Port B Circuit Diagram

COMPONENT FEATURES AND CONNECTIONS

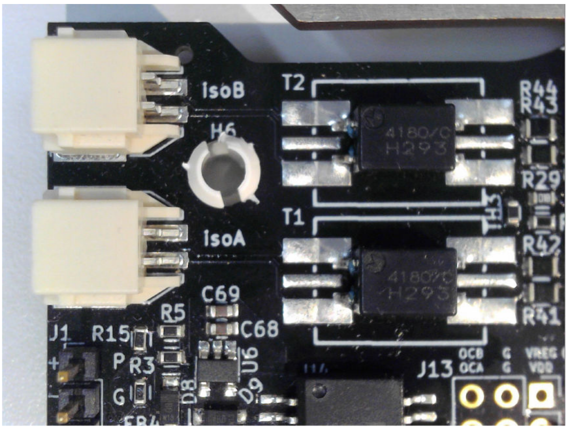

Figure 12. isoSPI Connections on EVAL-ADBMS2950B Evaluation Board

REMOTE SHUNT

The EVAL-ADBMS2950B evaluation board features an unpopulated filter and protection circuitry for evaluation of remote shunt operation as per the ADBMS2950B data sheet.

To convert an EVAL-ADBMS2950B evaluation board for remote shunt sensing, run through the following modifications, as shown in On-board Shunt Removal, Common-mode Choke Bypass, and TVS Protection Diodes sections.

On-board Shunt Removal

Remove the sense shunt resistor and solder on wires between the sense pads and the remote shunt.

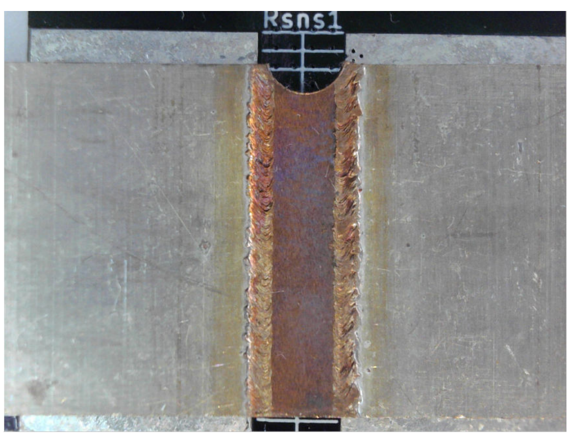

Figure 13. On-board Shunt Removal

Common-mode Choke Bypass

Cut the bypass traces of the footprints for the common-mode chokes.

In the board schematics, find these at *CURRENT SENSE SHUNT > Optional common mode filter*, for more details, refer to the Design files for this circuit board available on the product webpage.

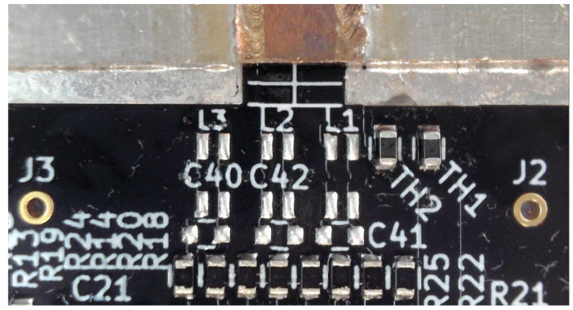

Figure 14. Common-Mode Choke Bypass

Populate the common-mode chokes. The EVAL-ADBMS2950B evaluation board is designed to accept a WE-SL2 SMT Common Mode Line Filter, for more details, refer to the Würth Elektronik website.

TVS Protection Diodes

Unpopulated footprints for TVS diodes in SOT-23 package are located on the bottom layer of the EVAL-ADBMS2950B evaluation board. The respective part in the schematics is located at *CURRENT SENSE SHUNT > Optional TVS for remote shunt*, for more details, refer to the Design files for this circuit board available on the product webpage.

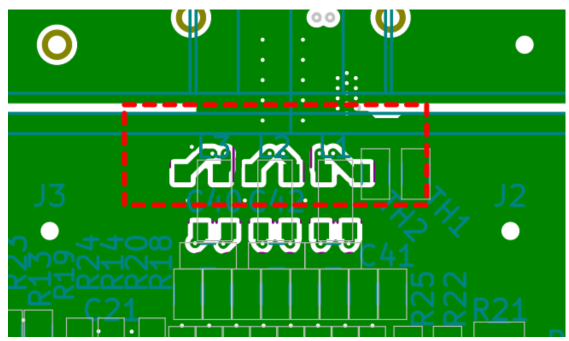

Figure 15. TVS Protection Diodes

HARDWARE SETUP

ATTACHING CABLE LUGS TO SHUNT RESISTOR

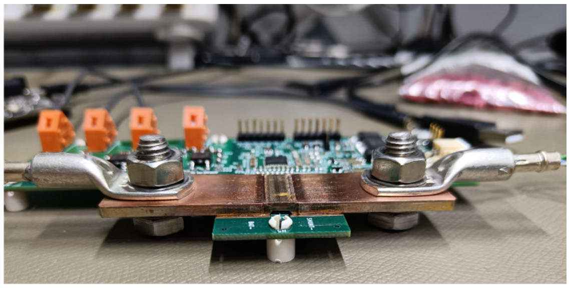

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Figure 16. Attaching Cable Lugs to Shunt Resistor, Part 1

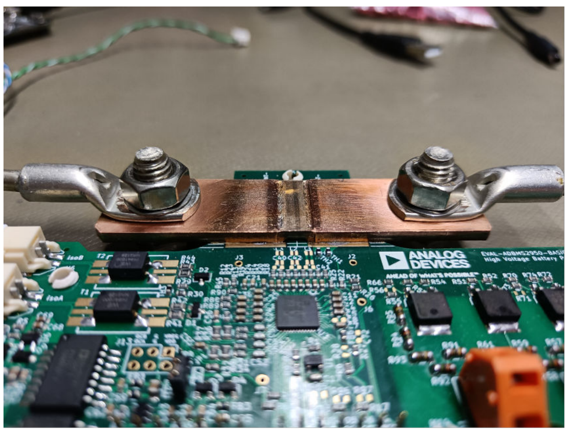

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Figure 17. Attaching Cable Lugs to Shunt Resistor, Part 2

The cable lugs must be attached to the shunt resistor with high force using a wrench on the top. When doing so, a wrench must also be attached to the hex screw head at the bottom to prevent it from rotating and thus putting too much force on the PCB.

The contact surfaces of the shunt resistor and cable lugs must be polished and cleaned before attaching the wrench. Oxidation and residue may increase contact resistance and heat dissipation.

Lug connectors are used to connect the 50 μΩ current measurement shunt to the load and the battery. Large gauge wires must be used for this connection.

For several hundreds of amperes, copper cables with a diameter of at least 10 mm (AWG000) are recommended. Using bigger cables, or using more than one cable in parallel help to minimize power dissipation and heating.

CONNECTING TO THE HIGH-VOLTAGE INPUT CLAMPS

The operation of the high-voltage clamps HVISO1, HV1, HV2, and HV3 is described in the ADBMS2950B data sheet.

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Figure 18. Side View of the High-Voltage Clamp

A small flat-head screw driver of 3.5 mm bit width is required to operate the high-voltage clamp.

To connect a wire to the clamp, loosen the clamp with the screwdriver, insert the wire and tighten the clamp, as shown in Figure 19.

HARDWARE SETUP

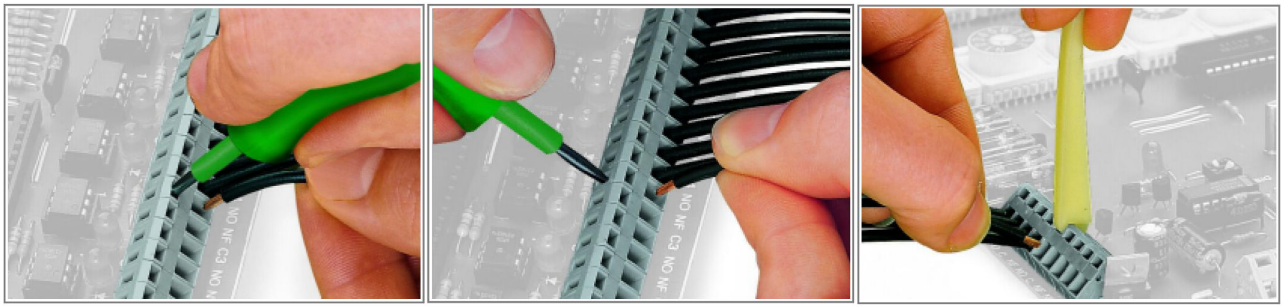

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Figure 19. Connecting to the High-Voltage Clamp

HARDWARE SETUP

BOARD POWER SUPPLY

To power the EVAL-ADBMS2950B evaluation board, see the following options (Figure 20 and Figure 21) sorted by recommended order from top to bottom.

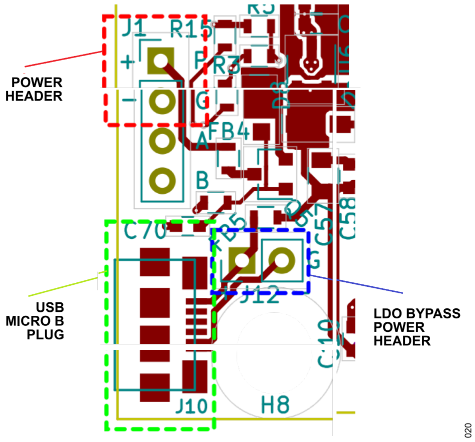

Figure 20. Connectors Options on EVAL-ADBMS2950B Evaluation Board

Figure 21. Connectors Options on EVAL-ADBMS2950B Evaluation Board

Table 4. Details of Connectors

Type	Ref	Voltage	Notes
Power Header	J1	6 V to 15 V	Wide-range supply input J1: ▶ Apply positive terminal of voltage source to pin marked + (LVCC, Pin 1). ▶ Apply negative terminal of voltage source to pin marked − (LGND, Pin 2).
USB micro B plug	J10	5 V	Alternative 5 V supply input through USB.
LDO bypass power header	J12	4.5 V to 5.5 V	Alternative 5 V supply input through pin header.

J10 and J12 bypass the on-board LDO used for the wide-range supply input and instead connect directly to the ADuM6020 isolated power-supply module.

J1 power input is connected to an ADP7142 LDO to regulate input voltage to 5 V and as input overvoltage protection. Note that do not operate above 15 V for extended periods of time to keep the ADP7142 within thermal limits.

NOTES

I^{2}C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

ANALOG DEVICES

One Analog Way, Wilmington, MA 01887-2356, U.S.A.