

Evaluation board for ADBMS2950B

FEATURES

- ▶ Fully featured evaluation board for 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
 - ▶ Pre-charge monitoring
 - ▶ Fuse monitoring
 - ▶ Charger monitoring
 - ▶ Link voltage monitoring
- ▶ Includes two isoSPI ports for daisy chain and reversible isoSPI support. The isoSPI connections can be done via simple DuraClick connectors.

EVALUATION KIT CONTENTS

The EVAL-ADBMS2950B evaluation kit is shipped with a EVAL-ADBMS2950B board and an isoSPI DuraClick™ cable.

DOCUMENTS NEEDED

- ▶ ADBMS2950B datasheet
- ▶ [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 program
 - ▶ [ADBMS2950B Software User guide](#)
 - ▶ Request through:https://form.analog.com/form_pages/software-modules/SRF.aspx

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 ADBMS2950B, a bidirectional current monitor, with 12 buffered high impedance voltage sense inputs, linked through a two-wire isolated serial interface (isoSPI). The demo circuit also features reversible isoSPI enabling a redundant communication path.

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

Design files for this circuit board are available.

TABLE OF CONTENTS

Features.....	1	High-Voltage Sense Inputs.....	5
Evaluation Kit Contents.....	1	Auxiliary IO Headers.....	6
Documents Needed.....	1	Overcurrent Outputs In Low-Voltage Domain.....	7
Equipment Needed.....	1	2 kB On-board EEPROM.....	7
Software Needed.....	1	isoSPI Connectors.....	7
Compatible Boards.....	1	Remote Shunt.....	8
Applications.....	1	Hardware Setup.....	9
General Description.....	1	Attaching Cable Lugs To Shunt Resistor.....	9
Functional Block Diagram.....	3	Connecting To The High-Voltage Input Clamps.....	9
Performance Summary.....	4	Board Power Supply.....	10
Component Features and Connections.....	5		
Current Sense Resistor.....	5		

REVISION HISTORY

/—Revision 0: Initial Version

FUNCTIONAL BLOCK DIAGRAM

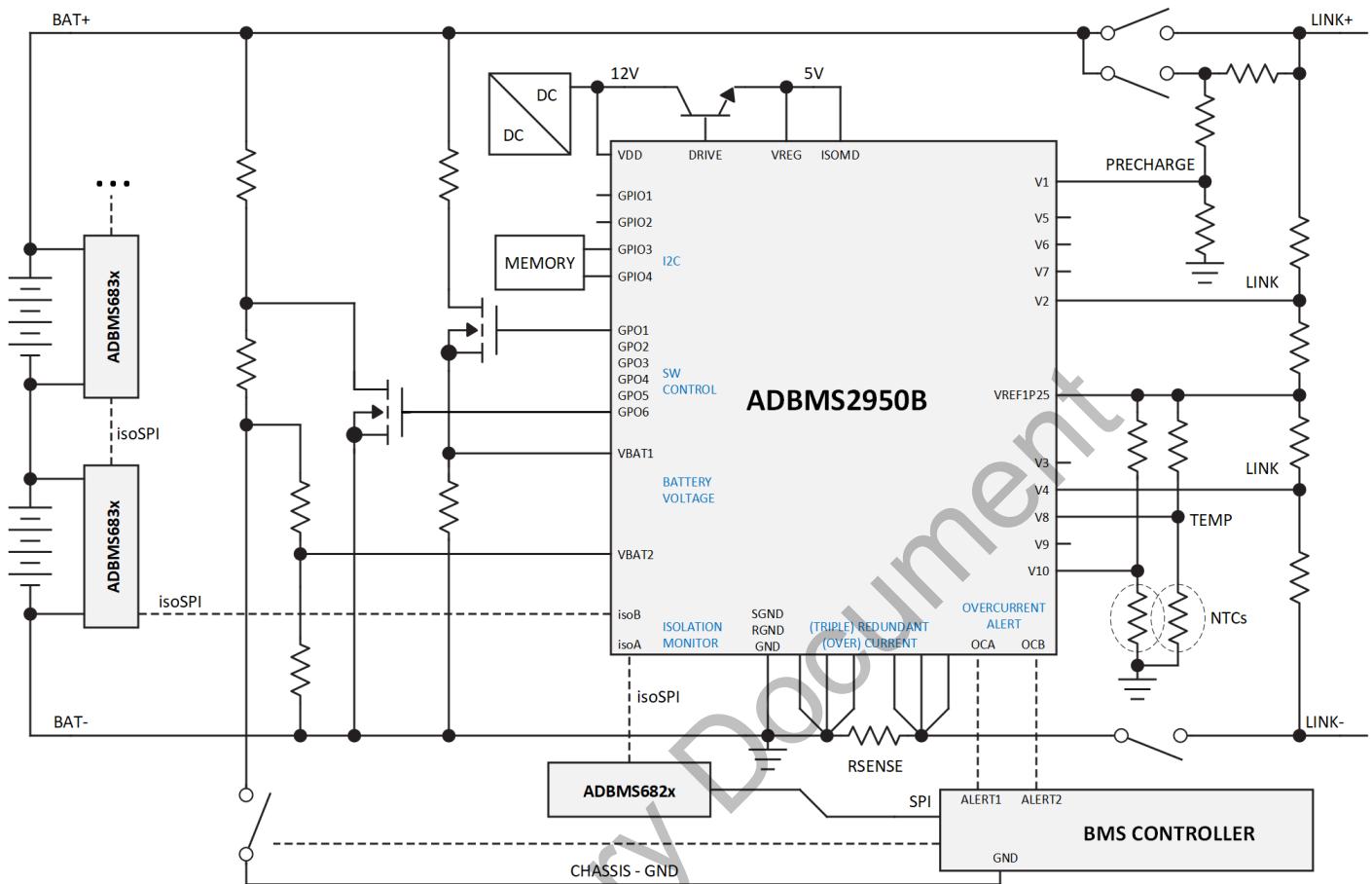


Figure 1. EVAL-ADBMS2950B Board System Architecture

PERFORMANCE SUMMARY

Table 1. Performance Summary

Parameter	Type	Min	Typ	Max	Unit
LOW VOLTAGE POWER SUPPLY INPUT					
Wide Range LV ¹ Input (J1)	PIN ²	6	15	V	
Alternative 5V LV ¹ Input (J10, J12)	PIN ²	4.5	5.5	V	
LOW VOLTAGE DIGITAL OUTPUTS					
Overcurrent Alert LVOCA, LVOCB	DOUT ³	0	5.5	V	
HIGH VOLTAGE SHUNT SENSE INPUT					
Current	AIN ⁴	-131	131	mV	
Overcurrent	AIN ⁴	-300	300	mV	
Shunt Resistance		50			μΩ
HIGH VOLTAGE POWER SUPPLY OUTPUT					
VDD to GND	POUT ⁵	14		V	
VREG to GND	POUT ⁵	5		V	
HIGH VOLTAGE ANALOG INPUT					
HVIS01 to GND	HVIN ⁶	0	1000	V	
HV1 to GND	HVIN ⁶	0	1000	V	
HV2 to GND	HVIN ⁶	-1000	1000	V	
HV3 to GND	HVIN ⁶	-1000	1000	V	
HV ⁷ TO LV ¹ ISOLATION					
GND to LGND			1000	V	

¹ isolated LGND (chassis GND) referred side

² Power Input

³ Digital Output

⁴ Analog Input

⁵ Power Output

⁶ High Voltage Input

⁷ GND (HV Battery BAT-) referred side

High current in/out of the High-Voltage battery applied between BAT- and Shunt-

See the [datasheet](#) of the shunt resistor for specifications such as tolerance and temperature drift.

COMPONENT FEATURES AND CONNECTIONS

CURRENT SENSE RESISTOR

EVAL-ADBMS2950B comes equipped with a high-current bus bar style current sense resistor BAS-M-R00005-AE-5.0 from Isabellen-huette (see the [datasheet](#) for recommended operating conditions). Currents of several hundreds of Amperes are possible, but power dissipation must be considered. The maximum power rating of the shunt resistor used is $P = 36 \text{ W}$.



Figure 2. Current Sense Resistor

Such high currents should be applied only for short times as the power dissipation will lead to significant temperature increase. Temperature of the shunt resistor can be monitored by the on-board NTC thermistors connected to the VxADC inputs, see tables in following chapters for the channel assignment.

The calculation above does not include additional resistance of the bus bar and the contact resistance of the cable.

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

HIGH-VOLTAGE SENSE INPUTS

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

The high-voltage input clamps are marked HVISO1, HV1, HV2, and HV3.

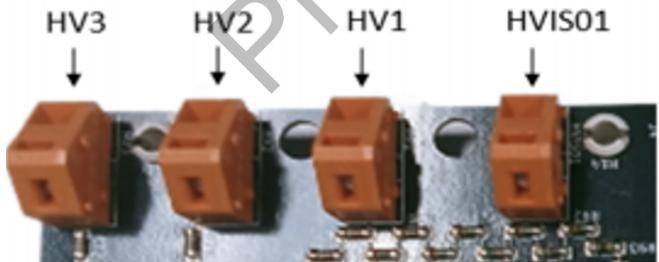


Figure 3. High Voltage Input clamps using WAGO connectors

The following table shows the assignments of the voltage inputs to the ADBMS2950B pins and ADCs.

Table 2. Voltage Input assignment to ADBMS2950B Pins and ADCs
(Continued)

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

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 ADBMS2950B and thus to VB1ADC and VB2ADC, respectively. The VBAT1 and VBAT2 voltage sense nodes are not biased via VREF1P25, thus the allowed HV1 input voltage range is positive only(0V to 1000V).

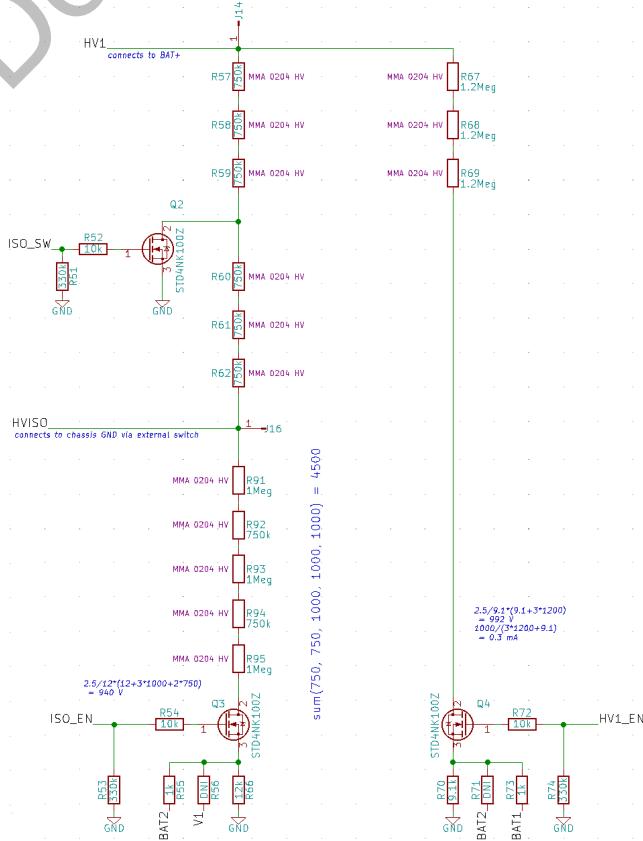


Figure 4. Circuit Diagram

Table 2. Voltage Input assignment to ADBMS2950B Pins and ADCs

Name	Enable	ADBMS2950B Pin	ADC

COMPONENT FEATURES AND CONNECTIONS

The HV1 voltage can be calculated from the VBAT1 voltage measurement versus SGND (see ADBMS2950B datasheet for VB1MUX setting) according to equation

$$V_{HV1} = \frac{3.6 \text{ } M\Omega + 9.1 \text{ } k\Omega}{9.1 \text{ } k\Omega} \times V_{BAT1, SGND}$$

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 versus SGND (see ADBMS2950B datasheet for VB2MUX setting) according to equation

$$V_{HVISO} = \frac{9 \text{ } M\Omega + 12 \text{ } k\Omega}{12 \text{ } k\Omega} \times V_{BAT2, SGND}$$

If isolation resistance measurement is performed (HVISO connected to LV = Chassis-GND), the HVISO voltage can be calculated from the VBAT2 voltage measurement versus SGND (see ADBMS2950B datasheet for VB2MUX setting) according to equation

$$V_{HVISO} = \frac{4.5 \text{ } M\Omega + 12 \text{ } k\Omega}{12 \text{ } k\Omega} \times V_{BAT2, SGND}$$

The VBAT1 voltage divider is activated by turning on the MOSFET Q4, which is done by asserting the signal HV1_EN connected to 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 ADBMS2950B GPO1 pin.

HV2, HV3: Auxiliary High-Voltage Inputs

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

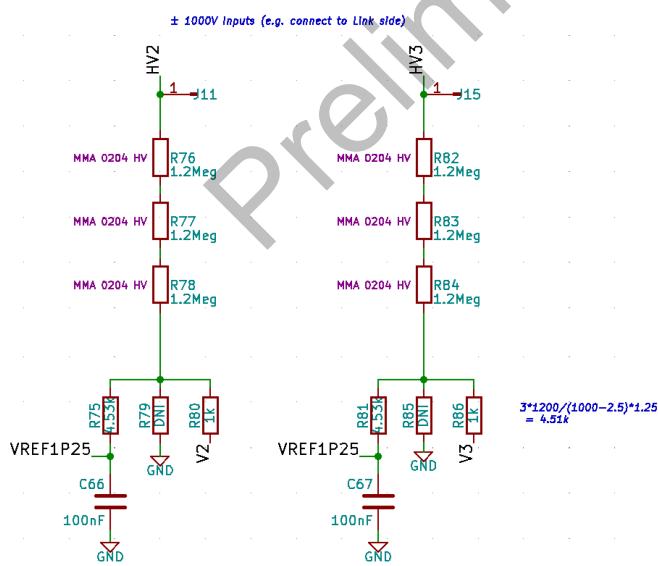


Figure 5. Circuit Diagram

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 1.25V (VREF1P25), so that the allowed input range of the HV2 and HV3 inputs is -1000V to +1000V.

The voltages at HV2 and HV3 can be evaluated from Vx (x = 2 or 3) ADC measurements versus VREF1P25 (see ADBMS2950B datasheet for VS2 and VS3 settings) according to the following equation

$$V_{HVx} = \frac{3.6 \text{ } M\Omega + 4.53 \text{ } k\Omega}{4.53 \text{ } k\Omega} \times V_{x, REF1P25} + V_{REF1P25}$$

HVISO1: Chassis-GND Connection for Isolation Measurements

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

In order to conduct isolation measurements the HVISO1 input shall be connected to chassis-GND through a controllable switch.

AUXILIARY IO HEADERS

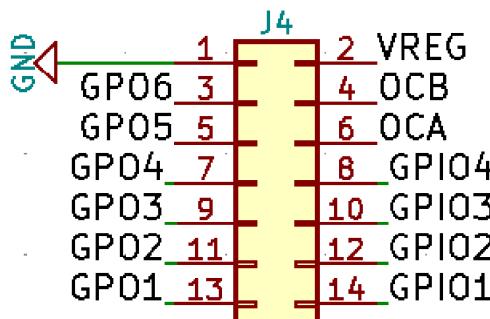


Figure 6. IO Connectors J4

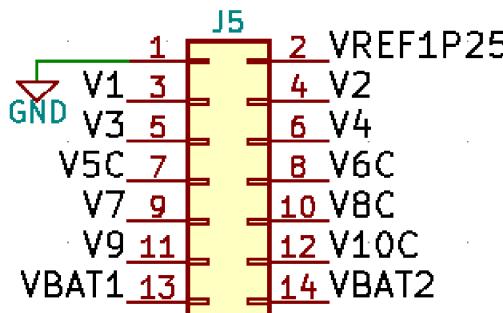


Figure 7. IO Connectors J5

COMPONENT FEATURES AND CONNECTIONS



Figure 8. Connections on Eval Board

EVAL-ADBMS2950B 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. Table

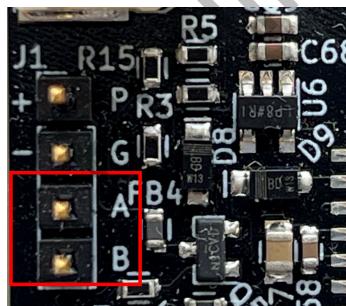
Vx	GPIO	GPO
V1	GPIO1	GPO4
V4	GPIO2	GPO5
V5C		GPO6
V6C		
V8C		
V10C		

If 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 aADuM225 part.

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



Signal A & B as OCA and OCB
in LV Domain

Figure 9. Eval board connections

2 KB ON-BOARD EEPROM

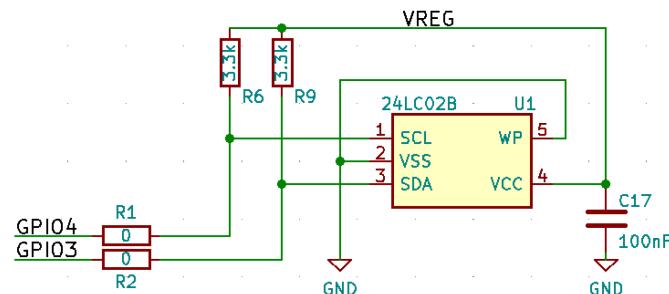


Figure 10. EEPROM

EVAL-ADBMS2950B features a [Microchip 24LC02B 2kBit I²C EEPROM](#) connected to ADBMS2950B's on-chip peripheral controller interface via pins GPIO3 and GPIO4.

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

ISOSPI CONNECTORS

EVAL-ADBMS2950B features two transformer-isolated isoSPI connectors enabling fully redundant reversible isoSPI functionality.

The isoSPI DuraClik cable supplied with EVAL-ADBMS2950B 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*.

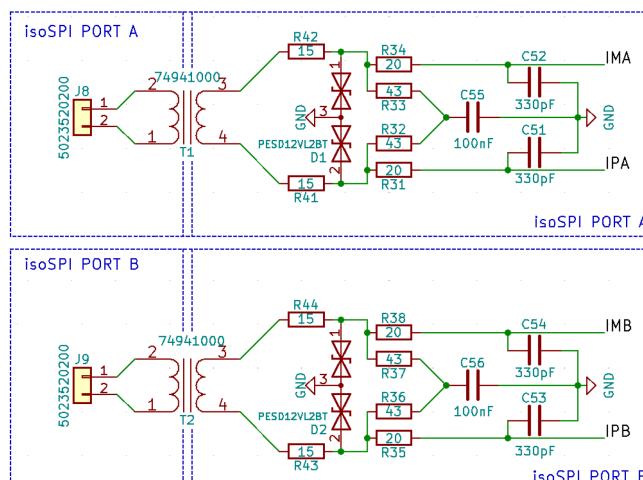


Figure 11. isoSPI Port A and isoSPI Port B Circuit Diagram

COMPONENT FEATURES AND CONNECTIONS

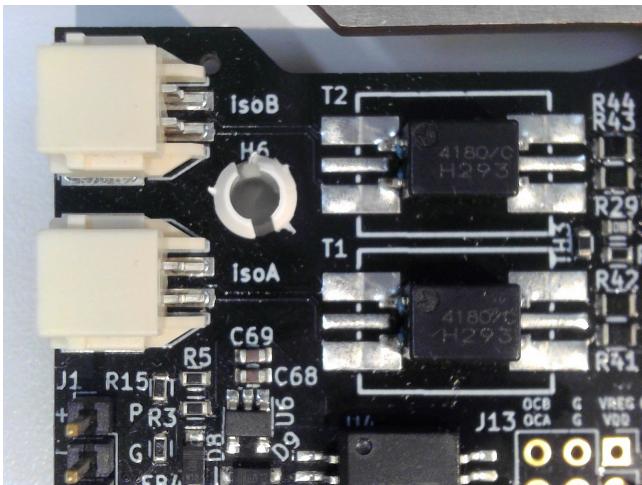


Figure 12. isoSPI Connections on Evaluation board

REMOTE SHUNT

EVAL-ADBMS2950B features unpopulated filter and protection circuitry for evaluation of remote shunt operation as per the ADBMS2950B datasheet.

In order to convert an EVAL-ADBMS2950B for remote shunt sensing run through the following modifications.

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 you find these at CURRENT SENSE SHUNT > optional common mode filter.

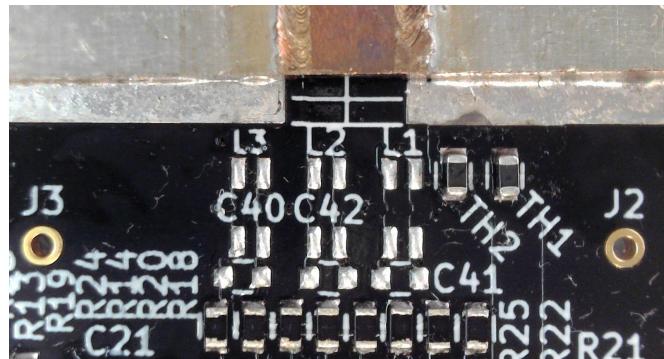


Figure 14. Common-mode Choke Bypass

Populate the common-mode chokes. The EVAL-ADBMS2950B was designed to accept a [Würth Elektronik WE-SL2 SMT Common Mode Line Filter](#).

TVS Protection Diodes

Unpopulated footprints for TVS diodes in SOT-23 package are located on the bottom layer of the EVAL-ADBMS2950B. The respective part in the schematics is located at *CURRENT SENSE SHUNT > Optional TVS for remote shunt*.

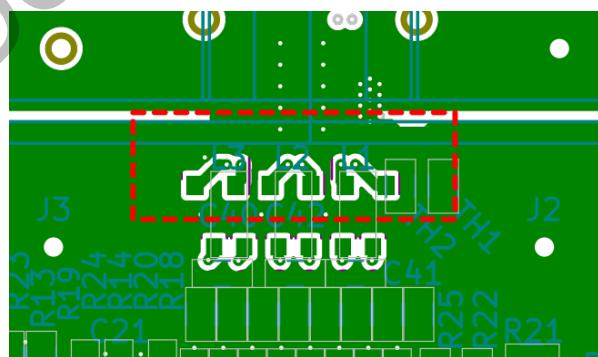


Figure 15. TVS Protection Diodes

HARDWARE SETUP

ATTACHING CABLE LUGS TO SHUNT RESISTOR

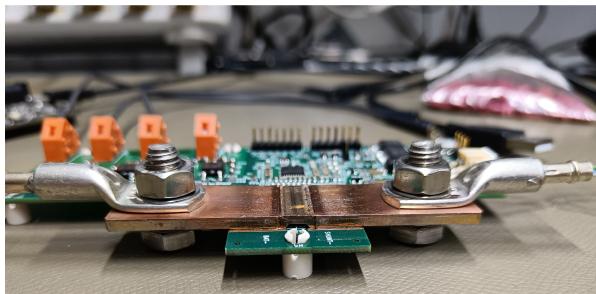


Figure 16.



Figure 17.

The cable lugs must be attached to the shunt resistor with high force using a wrench on the top. When doing so, a wrench should 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 should 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 $50 \mu\Omega$ current measurement shunt to the load and the battery. Large gauge wires should 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 will 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 datasheet.



Figure 18. Side view of the high-voltage clamp

A small flat-head screw driver of 3.5mm 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 below.

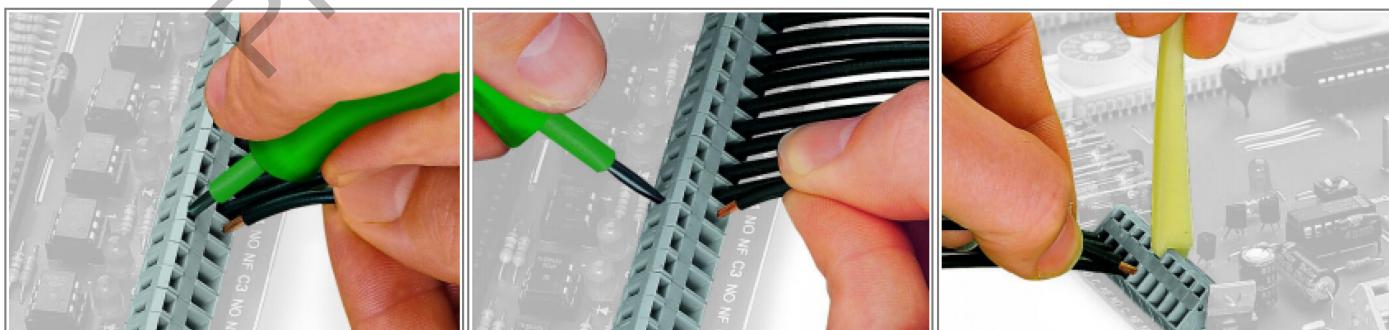


Figure 19. Connecting to the High Voltage Clamp

HARDWARE SETUP

BOARD POWER SUPPLY

In order to power the EVAL-ADBMS2950B board you have the following options sorted by recommended order from top to bottom.

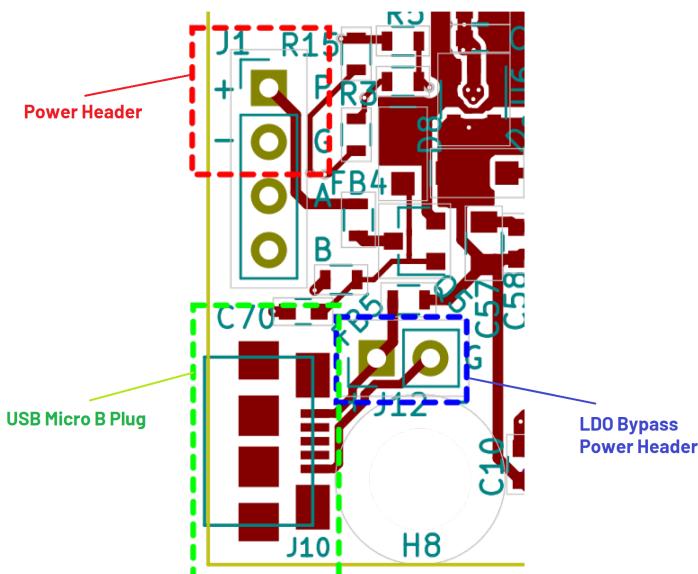


Figure 20. Connectors on Eval Board



Figure 21. Connectors on Eval Board

Table 4. Details of Connectors (Continued)

Type	Ref	Voltage	Notes
			<ul style="list-style-type: none"> ► 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	5V	Alternative 5V supply input via USB
LDO bypass power header	J12	4.5 - 5.5V	Alternative 5V supply input via 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 5V and as input overvoltage protection. Do not operate above 15V for extended periods of time to keep the ADP7142 within thermal limits.

Table 4. Details of Connectors

Type	Ref	Voltage	Notes
Power Header	J1	6 - 15V	Wide range supply input J1