UM11396

RD9Z1-638BJBEVM Reference Design

Rev. 1 — 15 April 2020 **User manual**

RD9Z1-638BJBEVM

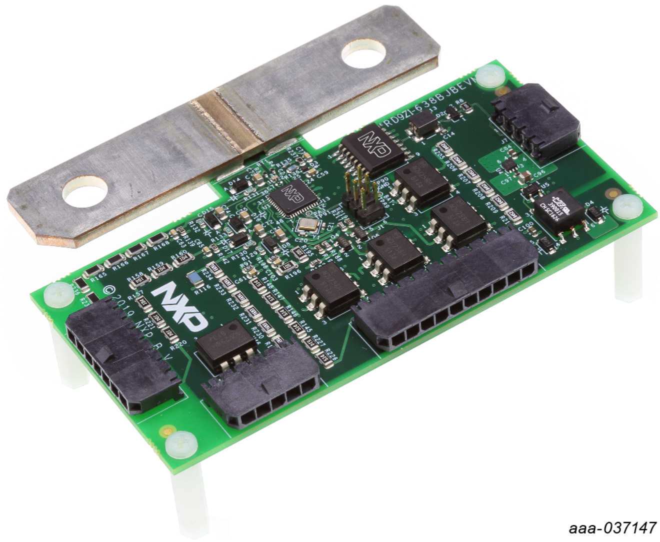

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Figure 1. RD9Z1-638BJBEVM

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1 Introduction

This user manual is intended for engineers who use the RD9Z1-638BJBEVM reference design kit to analyze and test designs that are built around NXP's MM9Z1_638 intellegent battery sensor device. The user manual provides all of the information required to use the reference design kit, including connecting the hardware, installing the associated software tools and configuring the evaluation environment.

2 Finding Kit Resources and Information on the NXP Web Site

NXP Semiconductors provides online resources for this evaluation board and its supported devices on http://www.nxp.com.

The tool summary page for the RD9Z1-638BJBEVM reference design is at http://www.nxp.com/RD9Z1-638BJBEVM. The tool summary page provides information related to buying and using the reference design kit. The page contains the following tabs:

- Overview – A brief summary of the reference design kit and its capabilities
- Specifications – An overview of the technical and functional specifications for the kit
- Buy – Purchasing information and a review of the reference design kit contents
- Design Resources – All of the information and resources required by users who have already purchased the RD9Z1-638BJBEVM reference design. This section includes:
  - RD9Z1-638BJBEVM - Getting Started – Click on this link for information on setting up the hardware, configuring the software and running an evaluation.
  - Schematics – Click on this link to download a .pdf version of the RD9Z1-638BJBEVM board schematics.
  - Design Files/BOM – Click on this link to download the RD9Z1-638BJBEVM board Bill of Materials, the Gerber files for the PCB assemblies and all of the design files for the CodeWarrior projects provided as examples.

2.1 Collaborate in the NXP community

The NXP community is for sharing ideas and tips, asking and answering technical questions and receiving input on various embedded design topics.

The NXP community is at http://community.nxp.com.

3 Getting Ready

Aside from the kit contents, working with the RD9Z1-638BJBEVM reference design requires additional hardware and software installed on a Windows PC workstation.

3.1 Kit contents

The RD9Z1-638BJBEVM reference design kit contains the following items:

- Evaluation board in an antistatic bag
- 10-pin high-voltage connector cable
- 7-pin high-voltage connector cable
- 5-pin high-voltage connector cable
- 4-pin low-voltage connector cable
- Quick Start Guide

3.2 Additional hardware

In addition to the kit contents, the following hardware components are required to support an evaluation.

- USB-enabled PC Workstation with Windows 7 or above
- Low-voltage DC power supply, 5 V to 12 V output with current limit set initially to 1.5 A
- High-voltage DC power supply, 0 V to 1000 V output
- Current load, 0 A to 500 A
- CAN card and cable (optional)
- PEmicro's Multilink Universal Debug Probe

3.3 Windows PC workstation

This evaluation board must be connected to a PC workstation running 32-bit and 64-bit versions of Windows 7 or above.

3.4 Software

Using the RD9Z1-638BJBEVM board requires that the software listed below be installed on the PC workstation. The reference design projects are available on the RD9Z1-638BJBEVM tool summary page at http://www.nxp.com/RD9Z1-638BJBEVM.

- Codewarrior 10.2 or above
- The RD9Z1-638BJBEVM reference design projects

4 Getting to Know the Hardware

The RD9Z1-638BJBEVM reference design kit provides a platform for evaluating designs that implement NXP’s MM9Z1_638 Battery Monitoring System device. It connects to a power distribution unit (PDU) and enables voltage sensing, current sensing, temperature sensing and diagnostics of the contactor status. The kit supports evaluations in conjunction with a CAN network and is ideal for prototyping High-Voltage Battery Junction Box (HV-BJB) systems.

4.1 RD9Z1-638BJBEVM features

- Power supply input from 5 VDC to 12 VDC
- Up to seven voltage sensing channels for high-voltage measurements
- One current sensing channel to measure charge current and discharge current
- One temperature sensing channel to measure shunt resistor temperature for calibration
- Integrated insulation resistance measurement
- One channel isolated CAN communication to BMU/VCU

4.2 Block diagram

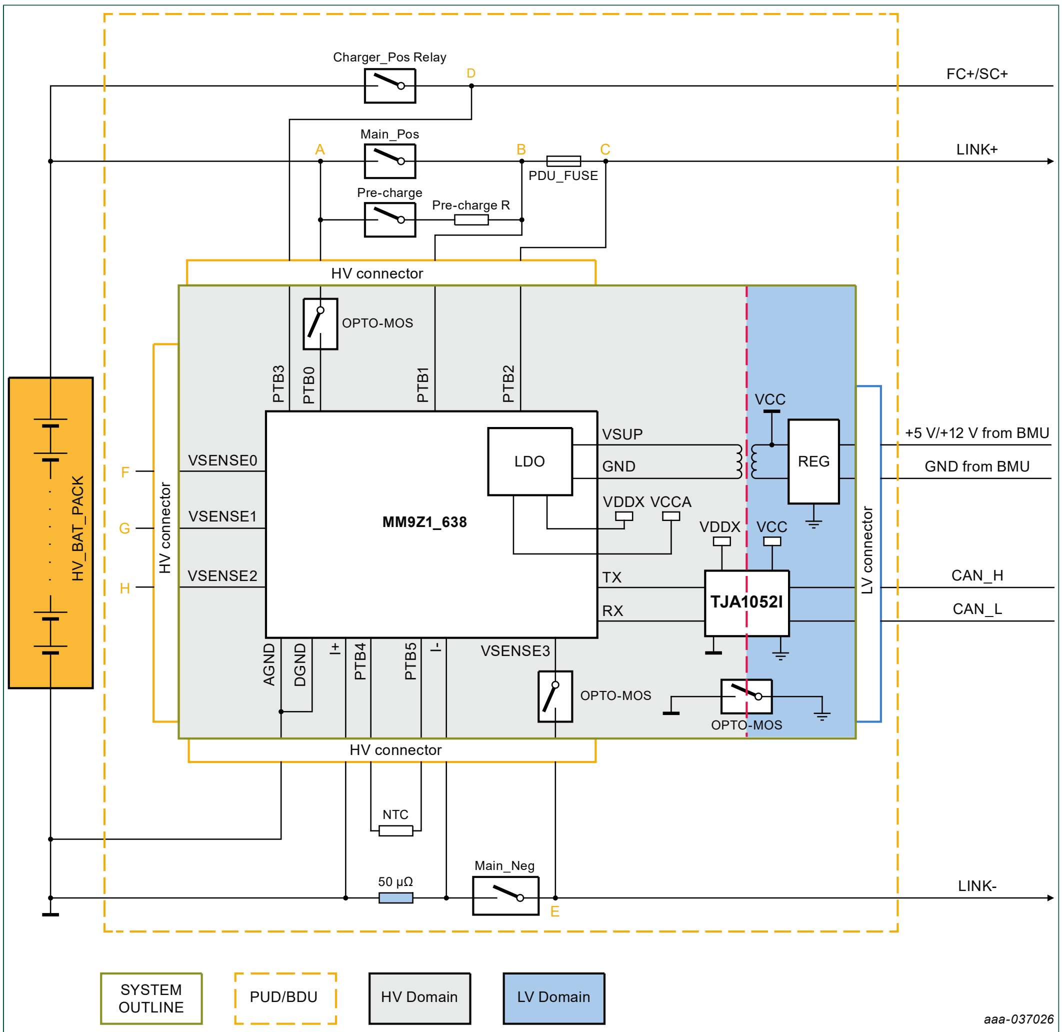

Figure 2. RD9Z1-638BJBEVM block diagram

4.3 Board components

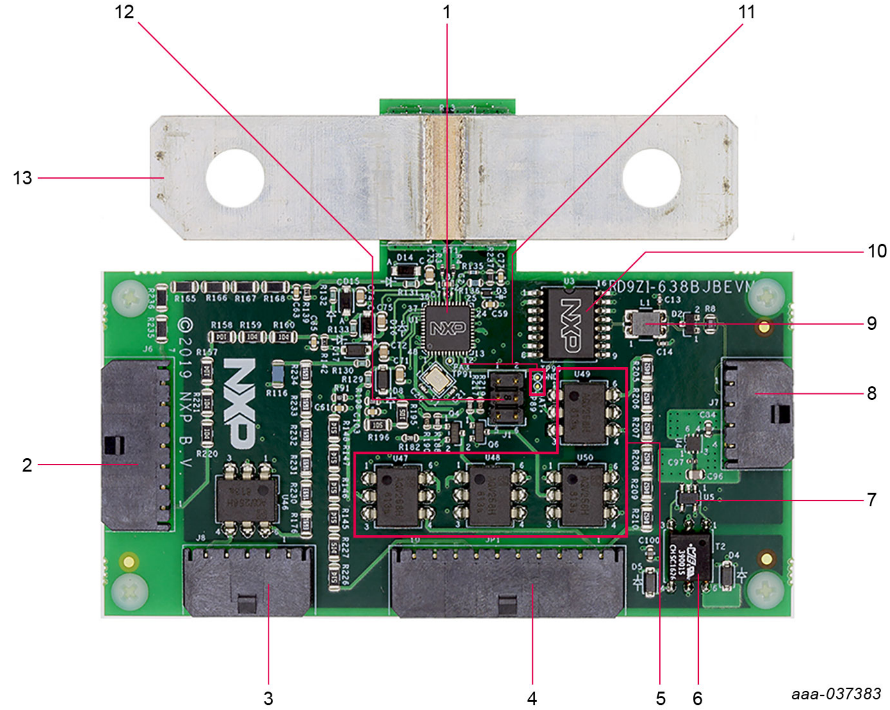

Figure 3. RD9Z1-638BJBEVM board components

Table 1. RD9Z1-638BJBEVM board components

No.	Label	Device	Description	Features
1	U1	MM9Z1_638	Intelligent Battery Sensor	• Wide range of battery current measurements; On-chip temperature measurement • Four battery voltage measurements with internal resistor dividers; Up to five direct voltage measurements for use with an external resistor divider • Measurement synchronization between voltage channels and current channels • Five external temperature sensor inputs with an internal supply for external sensors • Low-power modes with low-current operation • Multiple wake-up sources: LIN, timer, high-voltage input, external CAN interface, and current threshold and integration • Precision internal oscillator and connections for external crystal • LIN 2.2/ 2.1/ 2.0 protocol and physical interface • msCAN protocol controller and supply capability for 8 and 14 pin CAN interfaces • MM9Z1_638: S12Z microcontroller
2	J6	High-voltage connector 2	1x7 power plug connector	See Table 5

No.	Label	Device	Description	Features
3	J8	High-voltage connector 1	1x5 power plug connector	See Table 4
4	JP1	High-voltage connector 3	1x10 power plug connector	See Table 6
5	U46 −U50	Panasonic AQV258HAX	MOSFET relay	NA
6	T2	TI SN6501 QDBVRQ1	Push-pull driver for small transformers	AEC-Q qualified
7	U5	TI 760390015	PMIC transformer driver	AEC-Q qualified
8	J7	Low-voltage connector	1x4 power plug connector	See Table 3
9	L1	EPCOS/TDK B82789C 0104N002	Power line choke	AEC-Q qualified
10	U3	NXP TJA1052IT/5Y	High-speed CAN transceiver	• Isolator and Transceiver integrated into a single SO16 package, reducing board space • ISO 11898-2:2003 compliant • Flawless cooperation between the Isolator and the Transceiver – Fewer components improves reliability in applications – Guaranteed performance (eg. max loop delay <220 ns) • Electrical transient immunity of 45 kV/µs (typ) • AEC-Q100 qualified • Suitable for use in 12 V and 24 V systems; compatible with 3 V to 5 V microcontrollers • Bus common mode voltage (Vcm) = ±25 V • Low Electro Magnetic Emission (EME) and high Electro Magnetic Immunity (EMI) • Dark green product (halogen free and Restriction of Hazardous Substances (RoHS) compliant)
11	TP89, TP90, TP91	NA	Test points	See Table 7
12	J1	Connector	BDM connector	Connector for PEMicro's Multilink Debug Probe (See Table 2)
13	NA	NA	Shunt	Current measurement shunt

4.4 Connectors

The RD9Z1-638BJBEVM board has five user-accessible connectors. Table 2 – Table 6 describe the pin functions for each connector.

Table 2. BDM Connector (J1)

Pin	Signal name	Description
J1_1	BKGD	Connects to MM9Z1_638 BKGD pin to support background debug communication
J1_2	Ground	Low-voltage ground
J1_3	NC	Not connected
J1_4	RESET	Connects to MM9Z1_638 RESET pin
J1_5	NC	Not connceted
J1_6	VDDX	Connects to MM9Z1_638 VDDX pin for 5.0 V and External CAN Supply

Table 3. Low-voltage connector (J7)

Pin	Signal name	Description
J7_1	CAN-H	Connects to CAN communication cable
J7_2	CAN-L	Connects to CAN communication cable
J7_3	+12V_LV	Low-voltage power supply (5 V to 12 V)
J7_4	GND_LV	Low-voltage ground

Table 4. High-voltage connector 1 (J8)

Pin	Signal name	Description
J8_1	Ground	High-voltage ground
J8_2	NC	Not connected
J8_3	NC	Not connected
J8_4	NC	Not connected
J8_5	Main Neg-	Main negative contactor

Table 5. High-voltage connector 2 (J6)

Pin	Signal name	Description
J6_1	VSENSE2_HV	High-voltage connection to MM9Z1_638 VSENSE2 precision battery input pin
J6_2	NC	Not connected
J6_3	NC	Not connected
J6_4	VSENSE1_HV	High-voltage connection to MM9Z1_638 VSENSE1 precision battery input pin
J6_5	NC	Not connected

Pin	Signal name	Description
J6_6	NC	Not connected
J6_7	VSENSE0_HV	High-voltage connection to MM9Z1_638 VSENSE0 precision battery input pin

Table 6. High-voltage connector 3 (JP1)

Pin	Signal name	Description
JP1_1	HV+	High-voltage pack+
JP1_2	NC	Not connected
JP1_3	NC	Not connected
JP1_4	PTB1_HV	High-voltage connection to MM9Z1_638 PTB1 analog input and general purpose I/O pin
JP1_5	NC	Not connected
JP1_6	NC	Not connected
JP1_7	PTB2_HV	High-voltage connection to MM9Z1_638 PTB2 analog input and general purpose I/O pin
JP1_8	NC	Not connected
JP1_9	NC	Not connected
JP1_10	PTB3_HV	High-voltage connection to MM9Z1_638 PTB3 analog input and general purpose I/O pin

4.5 Test points

The RD9Z1-638BJBEVM board has three test points. Table 7 describes the function of each test point.

Table 7. Test points

Label	Signal name	Description
TP89	VSUP	Test point for power supply connection. In conjunction with TP90, serves as test point for power supply connected to MM9Z1_638
TP90	Ground	Test point for ground connection. In conjunction with TP89, serves as test point for ground connected to MM9Z1_638
TP91	PA3	Test point for connection to MM9Z1_638 PA3 general purpose port A

4.6 Configuring the hardware for setup using the RD9Z1-638BJBEVM board

This section describes how to configure the hardware required to use the RD9Z1-638BJBEVM board in an evaluation environment.

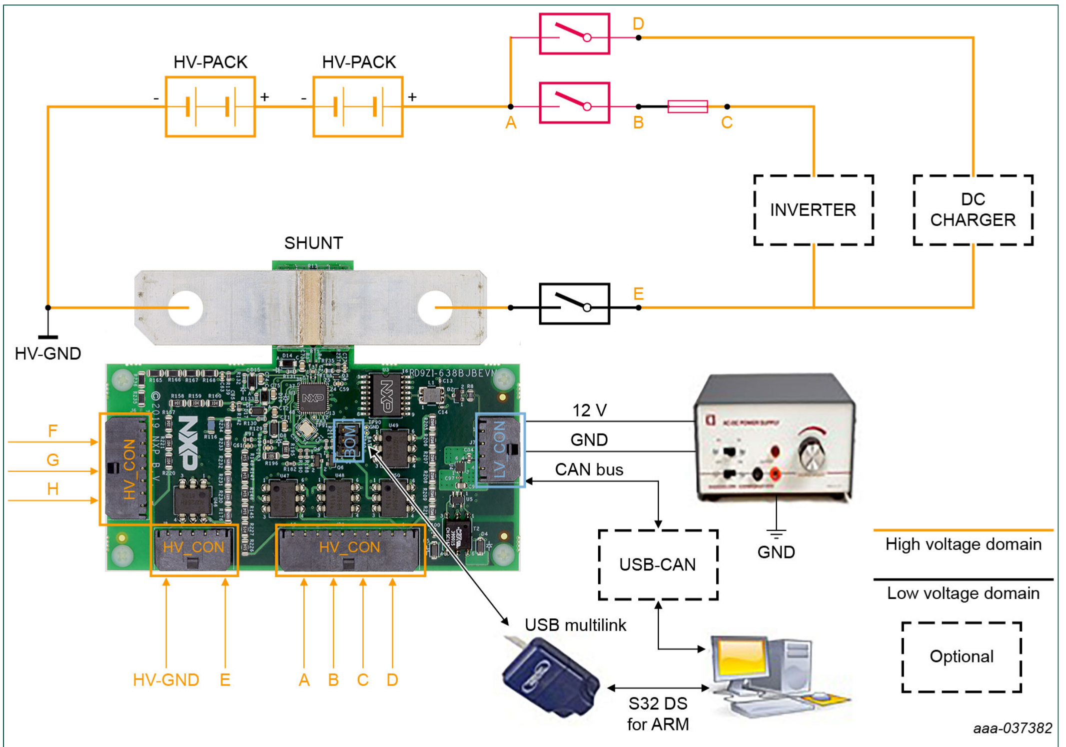

Figure 4. Hardware configuration

4.6.1 Connecting to the battery junction box

Batteries are connected to the board by means of the metal current shunt mounted on the board.

1. Connect the negative pole of the HV Battery Junction Box to one side of the board's metal shunt.
2. Connect the positive pole of the HV Battery Junction Box to the other side of the board's metal shunt.

4.6.2 Configuring the high-voltage domain

Configuring the kit's high-voltage components consists of the following steps.

1. Open high-voltage connector 1 (J8) on the RD9Z1-638BJBEVM board and attach the 5-pin connector cable as follows:
   - Connect J8_1 to the HV ground.
   - Connect J8_5 to the sensing position E.
2. Open high-voltage connector 2 (J6) on the RD9Z1-638BJBEVM board and attach the 7-pin connector cable as follows:
   - Connect J6_1 to high-voltage sensing position F.
   - Connect J6_4 to high-voltage sensing position G.
   - Connect J6_7 to high-voltage sensing position H.
3. Open high-voltage connector 3 (JP1)) on the RD9Z1-638BJBEVM board and attach the 10-pin connector cable as follows:
   - Connect JP1_1 to high-voltage sensing position A.
   - Connect JP1_4 to high-voltage sensing position B.

- Connect JP1_7 to high-voltage sensing position C.
- Connect JP1_7 to high-voltage sensing position D.

4.6.3 Configuring the low-voltage domain

The low-voltage domain consists of a low-voltage power supply connected to the RD9Z1-638BJBEVM board's low-voltage connector (J7). Note that two of the pins in the low-voltage connector are reserved for the CAN connection.

1. Open low-voltage connector (J7) on the RD9Z1-638BJBEVM board and attach the 4-pin connector cable as follows:
   - The first two terminals of the 4-pin cable are reserved for connecting to a CAN network. See Section 6 "Setting up a CAN GUI (Optional)" below.
   - Using the third terminal on the cable, connect J7_3 to the low-voltage power supply.
   - Using the fourth terminal on the cable, connect J7_4 to the low-voltage ground.

4.6.4 Connecting to the PC

Configuring the appropriate connections to link the evaluation environment to the PC workstation consists of the following steps:

1. Connecting the PEmicro Multilink Universal Debug Probe
   - Open the probe cover and attach PEmicro's six-pin ribbon cable to the probe's six-pin header (Port C).
   - Plug the other end of the 6-pin cable into the RD9Z1-638BJBEVM board's BDM connector (J1).
   - Plug the PEmicro's USB cable into the PEmicro Universal Debug Probe's USB port and connect the other end of the cable to a USB port on the PC workstation.
2. Connecting the CAN card (Optional)
   - Using the 4-pin cable, connect the cable's first terminal to pin J7_1 on the RD9Z1-638BJBEVM board's low-voltage connector (J7). Connect the other end of this line to the CANH connection on the CAN card.
   - Connect the 4-pin cable's second terminal to pin J7_2 on the evaluation board's low-voltage connector. Connect the other end of this line to the CANL connection on the CAN card.
   - Connect the CAN card to the PC workstation.

5 Installing the Software

The following section describes how to install and configure the Codewarrior Integrated Development Envionment (IDE) software required to run the demonstration examples and to exercise the RD9Z1-638BJBEVM in an evaluation environment.

5.1 Installing CodeWarrior

NXP's CodeWarrior provides an integrated environment that brings together all of the software resources and capabilites requried to use the RD9Z1-638BJBEVM reference design kit. If a previous version of CodeWarrior exists on the PC attached to the RD9Z1-638BJBEVM board, check to assure that the version is at least 10.2 or later. If CodeWarrior has not been installed, the following steps describe the installation process.

1. Go to http://www.nxp.com and navigate to the CodeWarrior Development Tools site.

2. In the Downloads section, select and download the latest version of CodeWarrior for MCU's.
3. Unzip the downloaded software and initiate the CodeWarrior installation Wizard.
4. When the **Choose Components** screen appears, select S12Z.
5. When the installation wizard completes, CodeWarrior is ready to import the reference design examples.

5.2 Importing the reference design software

The following steps describe how to download and import the reference design software and run the demo software in CodeWarrior.

1. Go to the RD9Z1-638BJBEVM tool summary page at http://www.nxp.com/RD9Z1-638BJBEVM and navigate to the Design Files / BOM section. Click on the link to download the design files to a local drive on the PC. Extract the design files.
2. Open CodeWarrior and import the software project.
   a. From the Files menu, select **Import**.
   b. Choose **General > Existing Project into Workspace**, and then click **Next**.
   c. Select **Select root directory**. Then locate the project from Step 2 above. Select **RD9Z1_638_BJB_CAN_demo_V2.0** project and click **Finish**.
3. Select **RD9Z1_638_BJB_CAN_demo_V2.0** project and Click **Project > Build Projec**t to build the project.

5.3 Debugging the reference design software

The following section describes how to begin debugging once the reference design software has been imported.

1. Go to **Run** > **Debug Configurations**.
2. Double-click on **CodeWarrior**.
3. Select the **Main** page and click on **Search Project**, then choose **RD9Z1_638_BJB_CAN_demo.elf** and click **OK**.
4. Click the **Connection Edit** button. After making sure that the USB Multilink is connected correctly, click **Target Edit** and choose **MM9Z1J638**.
5. Click on **Run**.

The software is now ready for use in debugging the demo functions. The data or variables can be monitored in the Codewarrior tool.

6 Setting up a CAN GUI (Optional)

The RD9Z1-638BJBEVM reference design kit provides a CAN bus interface and contains embedded software that supports the CAN communication protocol. CAN debugging can be handled more efficiently by a simple Graphical User Interface (GUI) than by a full-blown IDE such as CodeWarrior. Third-party USB-CAN tools and GUI development tools are available that allow RD9Z1-638BJBEVM reference design kit users to develop a GUI compatible with the RD9Z1-638BJBEVM board.

On the RD9Z1-638BJBEVM board, the CAN0 port in J7 serves as the communication interface for CAN evaluations. CAN0_high and CAN0_low must be correctly connected to the USB-CAN tool. The CAN communication protocol is shown in Table 8 below.

Notice that, in setting up the CAN evaluation, the host must be the device that sends CAN messages. Also, all voltage, current and temperature data are raw values from MM9Z1_638 registers. To convert to actual values, the raw values must be multiplied by the resolution, which can be found in the MM9Z1_638 product data sheet.

Table 8. CAN communication protocol

Host	Extended ID	Data							
		Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Evaluation board	0x83	VSENSE0 voltage		VSENSE1 voltage		VSENSE2 voltage		VSENSE3 voltage	
Evaluation board	0x84	ISENSE				TCHIP		TSENSE0 voltage	
Evaluation board	0x85	TSENSE1 voltage		TSENSE2 voltage		TSENSE3 voltage		TSENSE4 voltage	

7 Hardware Design Guidelines

The RD9Z1-638BJBEVM board is seperated into a low-voltage and a high-voltage domain. The board supports current measurement, high-voltage measurement, temperature measurement and insulation resistance measurement.

7.1 Power supply

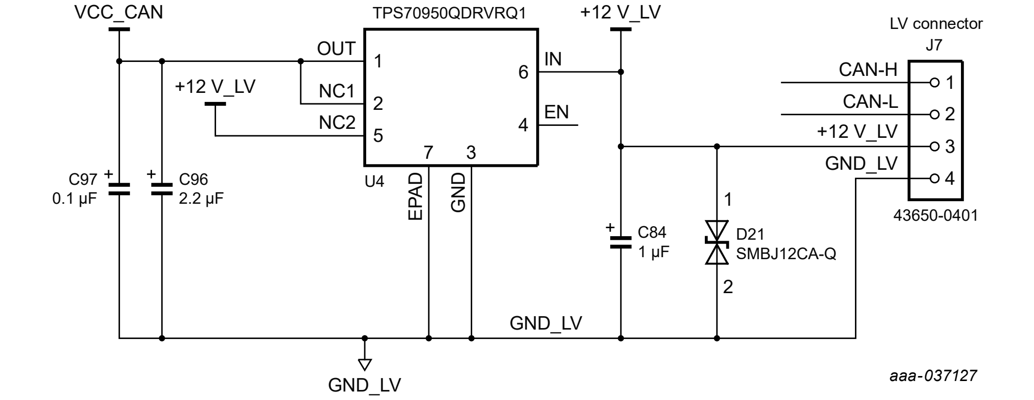

Figure 5. LDO

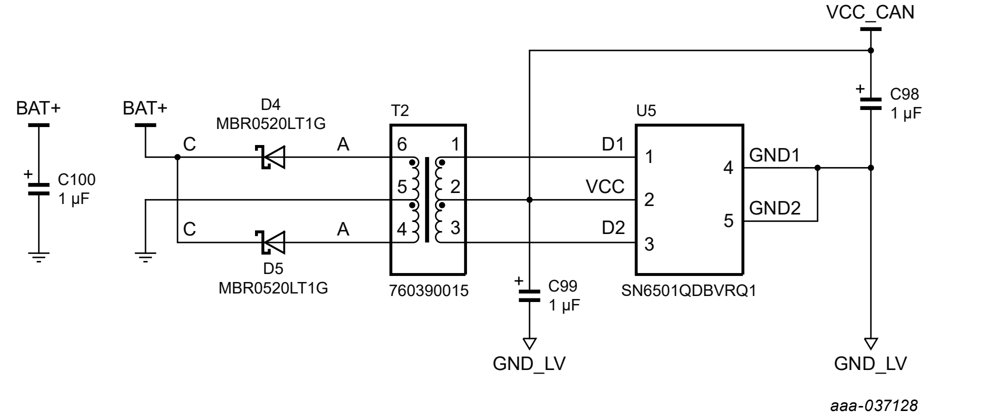

Figure 6. Power supply for MM9Z1_638

The normal operating range for the MM91Z1_638 is from 3.5 V to 28 V. To reduce the consumption and EMC affect, a ~10V power supply BAT+ has been designed for the MM9Z1_638. This means that the transformer T2 ratio is 1:2 and VCC_CAN = 5 V, yielding a BAT+ of approximately 10 V.

Ratings	Symbol	Value	Unit
Functional operating voltage – device is fully functional. All features are operating.	V_{SUP}	3.5 to 28	V

7.2 Current measuring

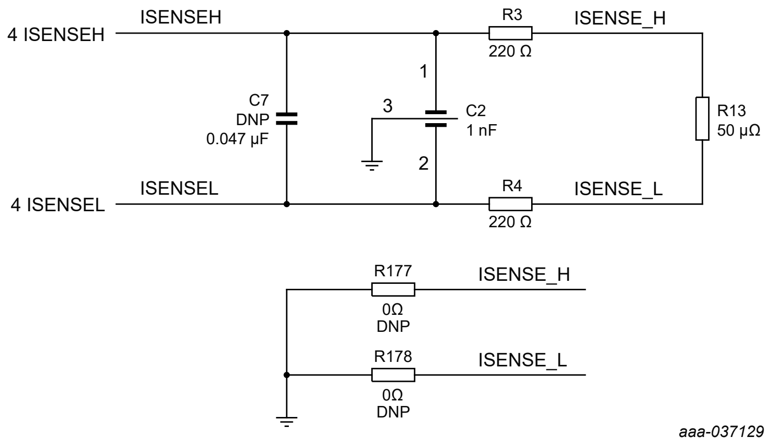

Figure 7. Current Sensing

1. The shunt resistor(R13) must be soldered on the top layer of the PCB with its groove side soldered to the PCB.
2. If the shunt cannot be soldered on the PCB according to the above requirement, the sensing wire ISENSE_H / ISENSE_L should be as short as possible.
3. EMC components and filter configurations can be changed according to system requirements.
4. R177 or R178 can be placed as shown in Figure 7 to measure the HV-load current or the HV load current + the RD9Z1-638BJBEVM board current.

7.3 Temperature measurement

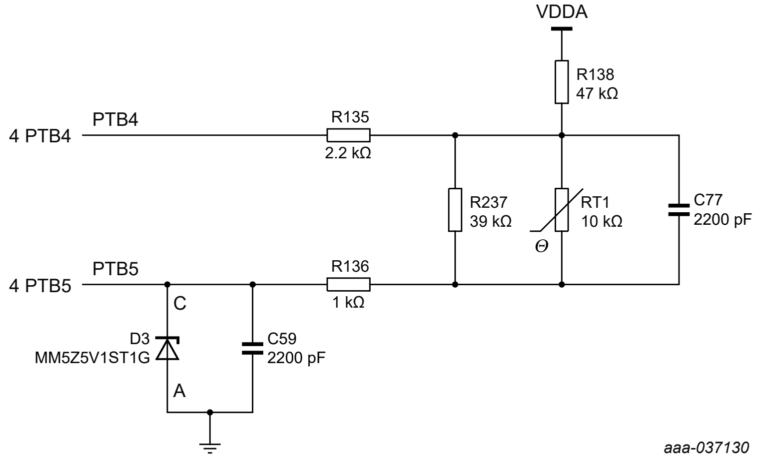

Figure 8. Onboard TSENSE

1. RT1 is a temperature sensor used to monitor the temperature of the SHUNT resistor. It must be placed close to the SHUNT resistor. R237 is used to modify a suitable range for RT1.
2. If PTB4 and PTB5 are used to monitor an external board temperature, D3 and C59 must be placed to use the EMC feature.

7.4 High-voltage measurement

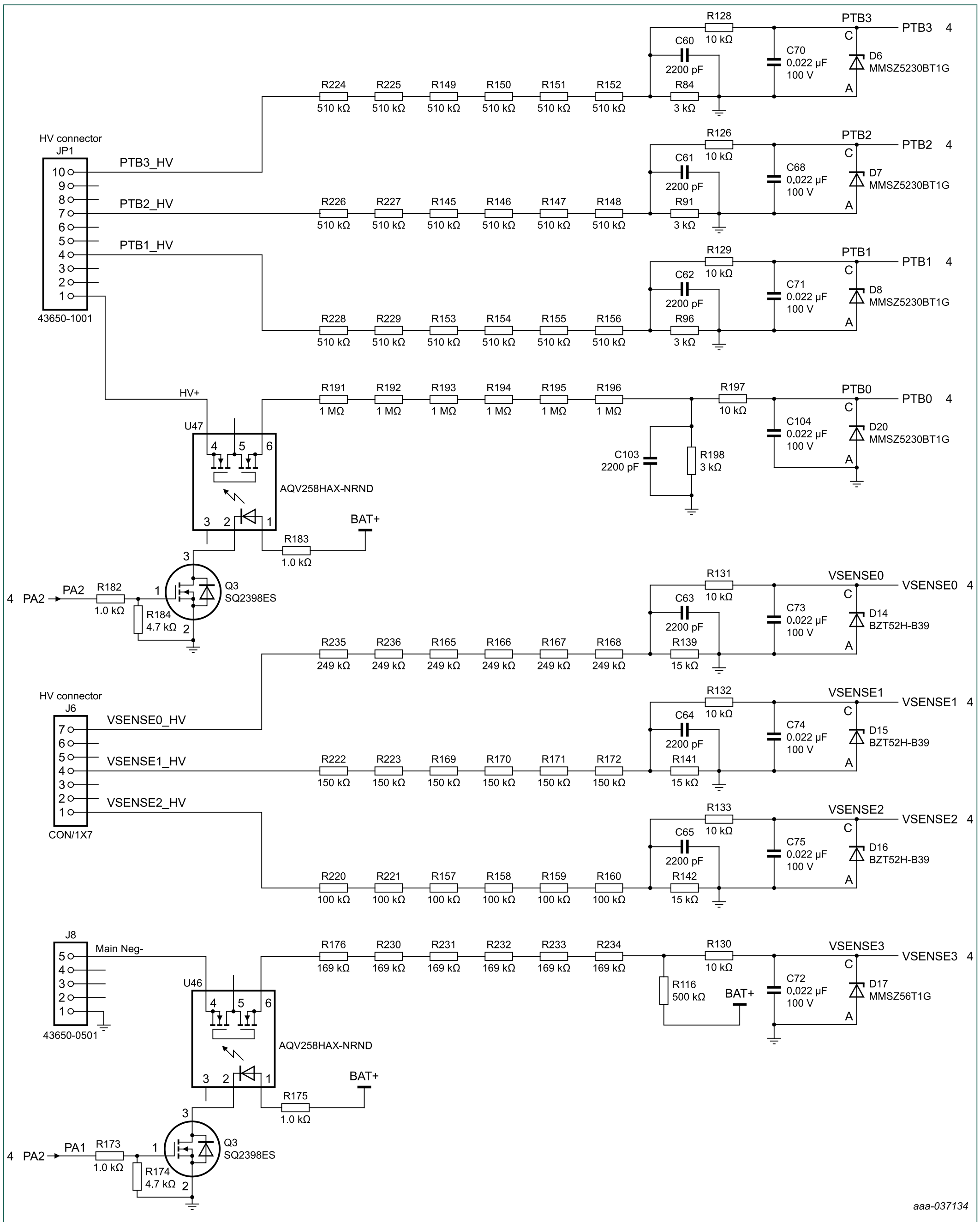

Figure 9. High-voltage measurement

1. High voltage sensing point A, B, C, D, E, F, G and H inputs are around 1000 V.
2. The voltage tolerance of the divider resistor must be considered. Use a footprint of 1206 or larger.
3. To reduce system consumption, OPTO-MOS or an optocoupler is used to open the circuit loop when no measurement function is requested.

7.5 Insulation resistance measurement

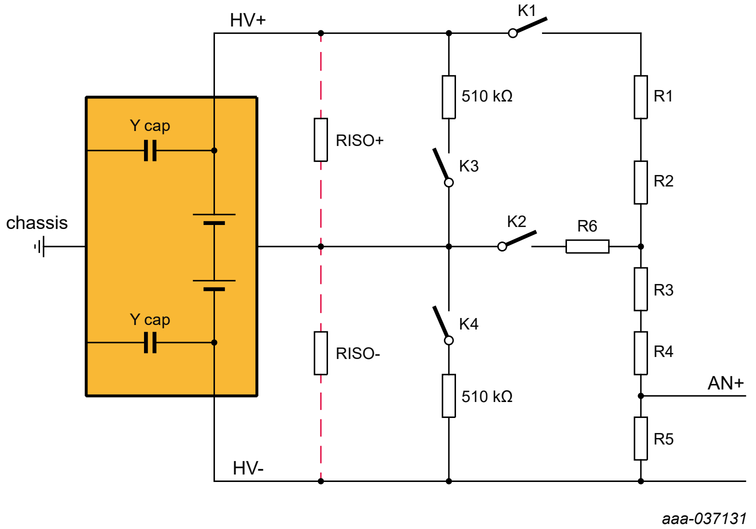

Figure 10. Insulation resistance measurement

1. Close K1 to measure the voltage of R5(UR5) by AN+, to get a voltage V1.

$$Vpack = \frac{V1}{R5} \times (R1 + R2 + R3 + R4 + R5)$$

2. Open K1, K4 and close K2, K3 to measure the voltage of R5(UR5) by AN+, to get a voltage V2.

$$Ua = \frac{V2}{R5} \times (R3 + R4 + R5 + R6)$$

3.

$$\frac{(Vpack - Ua)}{510\ K\ //Riso^{+}} = \frac{Ua}{Riso^{-}} + \frac{V2}{R5}$$

4. Open K1, K3 and close K2, K4 to measure the voltage of R5(UR5) by AN+, to get a voltage V3.
5.

$$\frac{Vpack - Ua}{RISO^{+}} = \frac{Ua}{510\ K\ //Riso^{-}} + \frac{V3}{R5}$$

6. The isolation resistance can now be calculated as the sum of $Riso^{+}$ and $Riso^{-}$

8 Software Guide

In depth programming information is beyond the scope of this user manual. For information on software algorithms, refer to the software code itself and the to software block below.

8.1 Software block

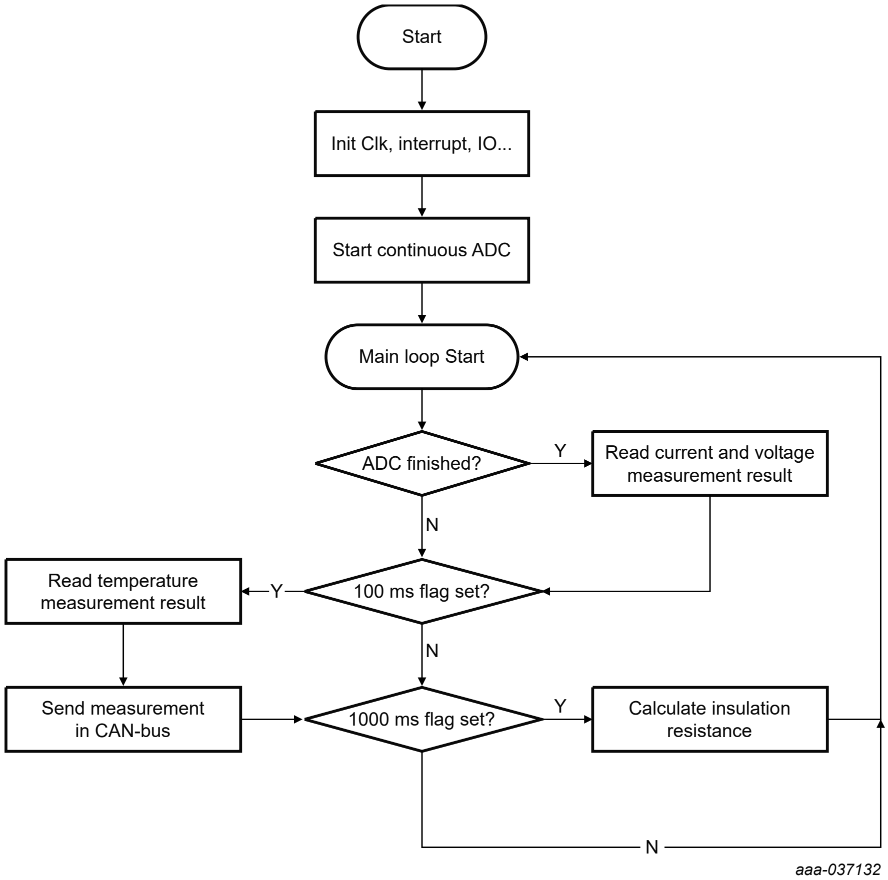

Figure 11. Software block

9 Revision History

Document ID	Release date	Descriptions
RD9Z1-638BJBEVM v.1	20200415	Initial release

10 Legal information

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