UM12132

PACK-BJBEMUL battery junction box emulator

Rev. 1.0 — 14 April 2025 User manual

Document information

Information	Content
Keywords	battery junction box, emulator, measurement, isolation, current, accuracy, temperature
Abstract	This user manual targets the PACK-BJBEMUL board. This board emulates the different elements of a battery junction box (BJB). It offers an easy way to evaluate NXP BJB solutions.

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1 Introduction

NXP provides BJB integrated circuits (for example, the MC33777A). The PACK-BJBEMUL emulates different elements of a BJB (for example, high voltage, battery current, pyrotechnic switch) to ease the evaluation of the BJB devices.

This document describes the emulator features.

2 Getting to know the hardware

2.1 Board features

The emulator offers the following features:

- Four current outputs, representing the voltage drop across a shunt resistor (from −250 mV to +250 mV)
- Advanced current emulation feature [custom waveform with a digital-to-analog converter (DAC), button to emulate a quick rise of the current]
- Two temperature sensor emulators
- Eight positive voltage outputs (from 0 V to 11 V)
- Two bipolar voltage outputs (from −11 V to +11 V)
- Isolation failure emulation between the chassis and the high-voltage section
- Two pyrotechnic switch igniter emulators with an LED showing the status
- Two digital signal outputs

2.2 Connectors

Figure 1 shows the location of the PACK-BJBEMUL connectors, interfacing with a power supply and the evaluation hardware.

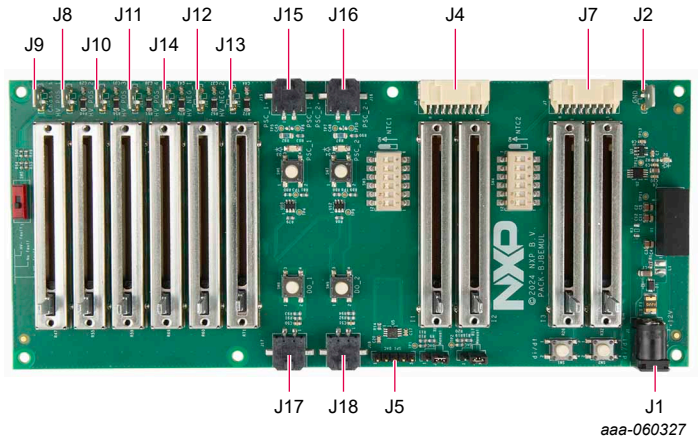

Figure 1. Connector location

Table 1 describes the connectors.

Table 1. Connector description

Pin	Connection	Description
Power supply connector (J1)		
J1.1	+12 V	positive power supply input

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Table 1. Connector description*...continued*

Pin	Connection	Description
J1.2	GND_SUPPLY	negative power supply input
J1.3	GND_SUPPLY	negative power supply input
Voltage emulation connectors		
J9	CHASSIS	chassis emulation
J8	HV_POS_1	positive voltage 1 output
J10	HV_POS_2	positive voltage 2 output
J11	HV_POS_3	positive voltage 3 output
J14	HV_POS_4	positive voltage 4 output
J12	HV_NEG_1	bipolar voltage 1 output
J13	HV_NEG_2	bipolar voltage 2 output
J2	GND	ground
Current 1 emulation connector (J4)		
J4.1	I2_NEG	current 2 negative output
J4.2	I2_POS	current 2 positive output
J4.3	GND	ground
J4.4	I1_NEG	current 1 negative output
J4.5	I1_POS	current 1 positive output
J4.6	GND	ground
J4.6	NTC1_NEG	temperature sensor 1 negative output
J4.8	NTC1_POS	temperature sensor 1 positive output
Current 2 emulation connector (J7)		
J7.1	I4_NEG	current 4 negative output
J7.2	I4_POS	current 4 positive output
J7.3	GND	ground
J7.4	I3_NEG	current 3 negative output
J7.5	I3_POS	current 3 positive output
J7.6	GND	ground
J7.6	NTC2_NEG	temperature sensor 2 negative output
J7.8	NTC2_POS	temperature sensor 2 positive output
Communication connector for DAC (J5)		
J5.1	GND	ground
J5.2	SDI	DAC data input
J5.3	SCK	DAC clock input
J5.4	!CS	DAC chip select
J5.5	5 V	5 V output

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Table 1. Connector description...*continued*

Pin	Connection	Description
Pyrotechnic switch 1 emulation connector (J15)		
J15.1	PSC_1+	pyrotechnic switch 1 positive input
J15.2	PSC_1-	pyrotechnic switch 1 negative input
Pyrotechnic switch 2 emulation connector (J16)		
J16.1	PSC_2+	pyrotechnic switch 2 positive input
J16.2	PSC_2-	pyrotechnic switch 2 negative input
Digital output 1 connector (J17)		
J17.1	DO_1	digital signal 1 output
J17.2	GND	GND
Digital output 2 connector (J18)		
J18.1	DO_2	digital signal 2 output
J18.2	GND	GND

Table 2 lists the reference of the connectors and their mating part number.

Table 2. Connector part number

Connector	Manufacturer	Part number	Mating connector
J1	-	PJ-202BH jack connector, male, 2.5 mm center pin, 5.5 mm external diameter	-
J2, J8, J9, J10, J11, J12, J13, J14	TE Connectivity	63824-1	2-520405-2
J15, J16, J17, J18	Molex	436500213	436450200
J4, J7	Molex	5023520800	5023510800

2.3 Sliders and switches

The user controls the board features with sliders and switches.

Figure 2 shows the location of the sliders and the switches.

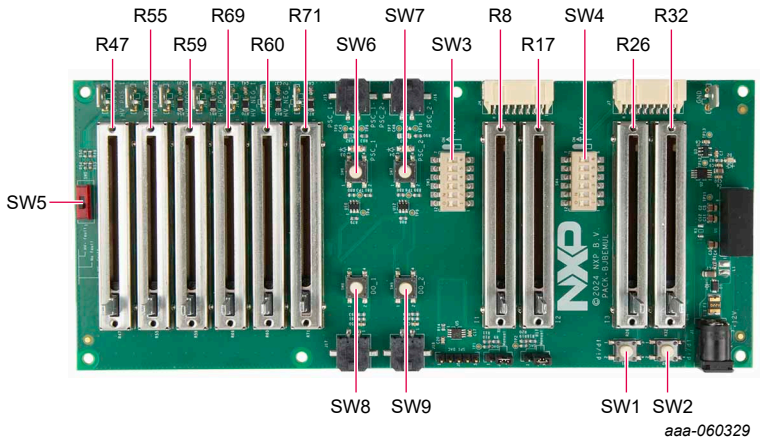

Figure 2. Slider and switch location

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Table 3 describes the sliders and switches.

Table 3. Slider and switch description

Component	Name	Description
Voltage emulation control		
R47	HV_POS_1	positive voltage 1 control
R55	HV_POS_2	positive voltage 2 control
R59	HV_POS_3	positive voltage 3 control
R69	HV_POS_4	positive voltage 4 control
R60	HV_NEG_1	bipolar voltage 1 control
R71	HV_NEG_2	bipolar voltage 2 control
SW5	ISO_FAULT	isolation fault emulation
Pyrotechnic switch emulation control		
SW6	PSC_1	reset pyrotechnic switch 1 status LED
SW7	PSC_2	reset pyrotechnic switch 2 status LED
Temperature sensor emulation control		
SW3	NTC1	temperature sensor 1 control
SW4	NTC2	temperature sensor 2 control
Current emulation control		
R8	I1	current 1 control
R17	I2	current 2 control
R26	I3	current 3 control
R32	I4	current 4 control
SW1	DIDT_I3	current 3 short-circuit emulation
SW2	DIDT_I4	current 4 short circuit emulation
Digital output control		
SW8	DO_1	digital output 1 control
SW9	DO_2	digital output 2 control

2.4 Jumpers

The board embeds two jumpers to select the current emulation mode (with slider, or with DAC):

- J3 to control current 1 mode
- J6 to control current 2 mode

2.5 LEDs

The battery junction box embeds three LEDs:

- D2 turns on when the board is supplied
- D3 turns on when a firing occurs with pyrotechnic switch 1
- D4 turns on when a firing occurs with pyrotechnic switch 2

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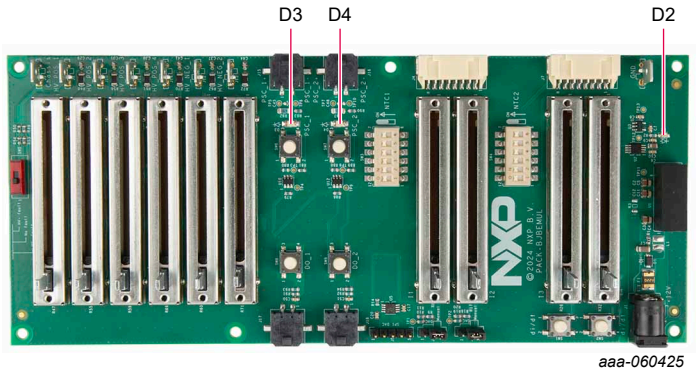

Figure 3. LED location

2.6 Kit contents

Table 4 lists the components included in the kit.

Table 4. Kit contents

Description	Quantity
High-voltage measurement cable (orange)	10
Chassis connection cable (black)	1
Two points general-purpose cable (pyrotechnic switch connection, crash signal connection)	4
Current measurement and temperature measurement cable	2

2.7 Extra hardware

The PACK-BJBEMUL requires an external +12 V power supply (see Section 3.1).

2.8 Configure the hardware

This section describes the typical setup to configure the PACK-BJBEMUL to evaluate the RDA777T2 reference design.

The RDA777T2 can measure the emulator current, voltage, and temperature. It can also trigger the pyrotechnic switch emulation circuitry.

The setup shows a KIT-PC2TPLEVB board to interface the RDA777T2 with the computer via NXP software tools [for example, battery management system (BMS) ScriptGUI].

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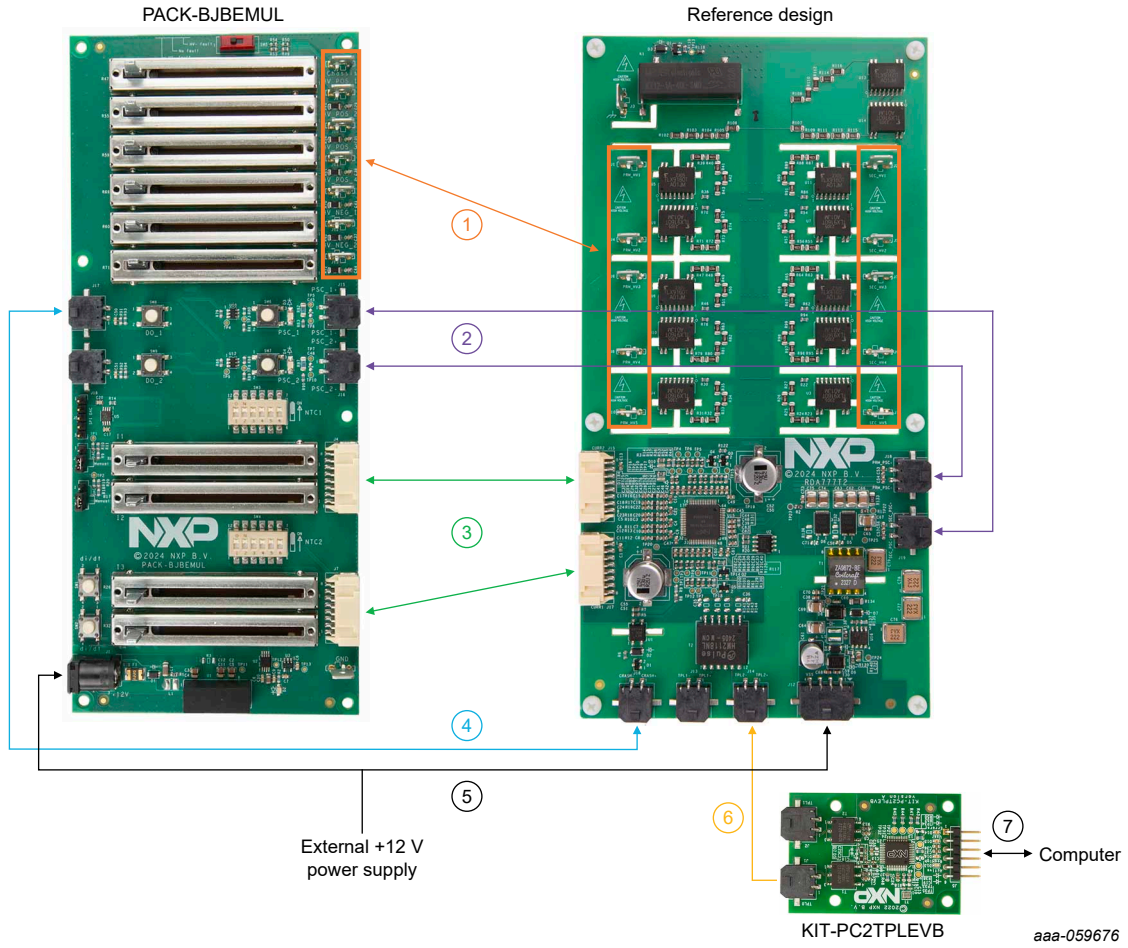

Figure 4. Hardware setup

Table 5 lists the material required to set up the test.

Table 5. Bill of materials

Identifier	Description	Comment
PACK-BJBEMUL	battery junction box emulator	
RDA777T2	battery junction box reference design	
KIT-PC2TPLEVB	communication board	
Power supply	+12 V power supply	
1	voltage measurement cable	included in the kit
2	pyrotechnic switch cable	included in the kit
3	current and temperature measurement cable	included in the kit
4	crash signal cable	included in the kit
5	power supply cable	included in the kit
6	electrical transport protocol link (ETPL) communication cable	included in the kit
7	USB to universal asynchronous receiver/transmitter (UART) cable	included in the KIT-PC2TPLEVB kit

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2.9 Schematic, board layout, and bill of materials

The schematic, board layout, and bill of materials for the PACK-BJBEMUL are available at www.nxp.com/PACK-BJBEMUL.

3 Feature description

3.1 Power supply

The PACK-BJBEMUL receives power on the connector J1. When the board is operational, the LED D2 is on.

The power supply must follow the characteristics described in Table 6.

Table 6. Power supply characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage		-	12	-	V
I_{CC}	supply current		500	-	-	mA

3.2 Current emulation

The PACK-BJBEMUL emulates up to four currents. It generates voltages that represent the voltage drop in a shunt resistor due to current flowing through it.

3.2.1 Current emulation characteristics

Table 7 describes the current emulation characteristics.

Table 7. Current emulation characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{I(max)}$	current emulation maximum output	slider set to maximum position; voltage between positive and negative outputs	-	230	-	mV
$V_{I(min)}$	current emulation minimum output	slider set to minimum position; voltage between positive and negative outputs	-	−250	-	mV
V_{sc}	short-circuit emulation output	between positive and negative outputs	-	−250	-	mV
$t_{s(sc)}$	short-circuit emulation settling time	from switch pressed to 63 % of the final value	-	1	-	ms

3.2.2 Current emulation with slider

The PACK-BJBEMUL provides four sliders to emulate four currents.

Moving the slider position changes the current emulation value (between positive and negative outputs):

- By setting the slider to the maximum position (slider close to connectors J4 and J7), the emulator outputs $V_{I(max)}$.
- By setting the slider to the minimum position (slider far from connectors J4 and J7), the emulator outputs $V_{I(min)}$.

For slider control, current 1 and current 2 outputs require a specific jumper configuration as shown in Table 8.

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Table 8. Current emulation with slider

Current	Slider	Jumper configuration
Current 1	R8	jumper between J3.2 and J3.3
Current 2	R17	jumper between J6.2 and J6.3
Current 3	R26	no configuration needed
Current 4	R32	no configuration needed

3.2.3 Current emulation with DAC

The PACK-BJBEMUL offer the possibility to control current 1 and current 2 outputs with a 16-bit DAC.

The board embeds an LTC2602. The user can communicate with the device using serial peripheral interface (SPI) lines on the connector J5.

Changing the output code of the DAC changes the current emulation value (between positive and negative outputs):

- By setting the maximum code (FFh), the emulator outputs $V_{I(max)}$.
- By setting the minimum code (00h), the emulator outputs $V_{I(min)}$.

For DAC control, current 1 and current 2 outputs require a specific jumper configuration as shown in Table 9.

Table 9. Current emulation with DAC

Current	DAC output	Jumper configuration
Current 1	output A	jumper between J3.1 and J3.2
Current 2	output B	jumper between J6.1 and J6.2
Current 3	not available	-
Current 4	not available	-

3.2.4 Short-circuit emulation

The PACK-BJBEMUL can emulate a short circuit on current 3 and current 4 outputs. By pressing a switch, the output jumps to V_{sc} no matter the slider position. The time to reach the output voltage is $t_{s(sc)}$.

The following switches control the short-circuit emulation:

- SW1 for current 3
- SW2 for current 4

3.3 Temperature emulation

The PACK-BJBEMUL emulates two temperature sensors (negative temperature coefficient resistors).

Figure 5 describes the temperature emulation circuitry.

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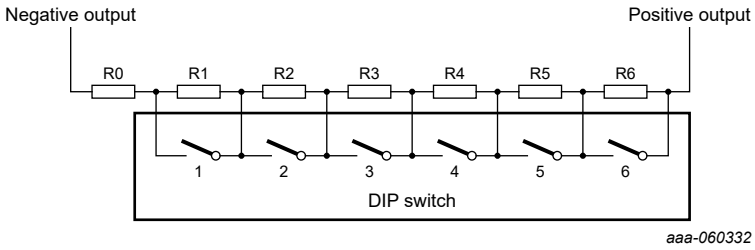

Figure 5. Temperature emulation circuitry

The following DIP switches control the temperature:

- SW3 for temperature 1
- SW4 for temperature 2

By changing the position of a DIP switch, the user can change the resistance between the temperature emulation outputs. Table 10 describes the resistor values.

Table 10. Temperature emulation resistors

Resistor	DIP switch position	Resistor value
R0	no switch in parallel	330 Ω
R1	1	470 Ω
R2	2	1 kΩ
R3	3	3.6 kΩ
R4	4	10 kΩ
R5	5	33 kΩ
R6	6	270 kΩ

Table 11 shows different examples of DIP switch configurations. It calculates the resistance value on the output of the PACK-BJBEMUL. It also estimates the temperature value of a real negative temperature coefficient (NTC) resistor (for example, NTCLE100E3103).

Table 11. Example of temperature emulation output

DIP switch positions						Output resistor	Equivalent temperature
1	2	3	4	5	6		
ON	ON	ON	ON	ON	ON	330 Ω	125 °C
OFF	ON	ON	ON	ON	ON	800 Ω	95 °C
OFF	OFF	ON	ON	ON	ON	1.8 kΩ	70 °C
OFF	OFF	OFF	ON	ON	ON	5.4 kΩ	40 °C
OFF	OFF	OFF	OFF	ON	ON	15.4 kΩ	15 °C
OFF	OFF	OFF	OFF	OFF	ON	48.4 kΩ	−5 °C
OFF	OFF	OFF	OFF	OFF	OFF	320 kΩ	−40 °C
OFF	ON	OFF	OFF	OFF	OFF	1.22 kΩ	80 °C
OFF	OFF	ON	OFF	OFF	OFF	3.82 kΩ	50 °C
OFF	OFF	OFF	ON	OFF	OFF	10.2 kΩ	25 °C
OFF	OFF	OFF	OFF	ON	OFF	33.2 kΩ	0 °C

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Table 11. Example of temperature emulation output*...continued*

DIP switch positions						Output resistor	Equivalent temperature
1	2	3	4	5	6		
OFF	OFF	OFF	OFF	OFF	ON	270 kΩ	−35 °C

3.4 Voltage emulation

The PACK-BJBEMUL generates six voltages (positive or bipolar). They emulate the high voltages in the system.

3.4.1 Voltage emulation characteristics

Table 12 describes the voltage emulation characteristics.

Table 12. Voltage emulation characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{V(pos)max}$	positive voltage maximum output	slider set to maximum position; between output and ground	-	10.5	-	V
$V_{V(pos)min}$	positive voltage minimum output	slider set to minimum position; between output and ground	-	0	-	V
$V_{V(bi)max}$	bipolar voltage maximum output	between output and ground	-	10.5	-	V
$V_{V(bi)min}$	bipolar voltage minimum output	between output and ground	-	−10.5	-	V

3.4.2 Positive voltage emulation

The PACK-BJBEMUL provides four sliders to emulate four positive voltages.

Moving the slider position changes the voltage value (between the output and the board ground):

- By setting the slider to the maximum position (slider close to connectors J8 to J14), the emulator outputs $V_{V(pos)max}$.
- By setting the slider to the minimum position (slider far from connectors J8 to J14), the emulator outputs $V_{V(pos)min}$.

3.4.3 Bipolar voltage emulation

The PACK-BJBEMUL provides two sliders to emulate two bipolar voltages.

Moving the slider position changes the voltage value (between the output and the board ground):

- By setting the slider to the maximum position (slider close to connectors J8 to J14), the emulator outputs $V_{V(bi)max}$.
- By setting the slider to the minimum position (slider far from connectors J8 to J14), the emulator outputs $V_{V(bi)min}$.

3.5 Digital signal emulation

The PACK-BJBEMUL generates two digital outputs controlled by a switch.

The following switches control the output:

- SW8 for digital output 1
- SW9 for digital output 2

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Table 13 describes the digital output characteristics.

Table 13. Digital signal characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{OH}	HIGH-level output voltage	switch pressed	-	5	-	V
V_{OL}	LOW-level output voltage	switch released	-	0	-	V
$I_{OH(max)}$	HIGH-level maximum output current		-	1.5	-	mA

3.6 Pyrotechnic switch emulation

The PACK-BJBEMUL emulates two pyrotechnic switch igniters.

Table 14 describes the pyrotechnic switch emulation characteristics.

Table 14. Pyrotechnic switch emulation characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$R_{igniter}$	igniter resistance emulation	between positive and negative inputs	-	47	-	Ω
$I_{th(det)}$	detection threshold current	minimum current in $R_{igniter}$ that triggers the red LED	-	50	-	mA
V_I	input voltage	from positive input to ground or negative input to ground	-	-	36	V

A resistor emulates the pyrotechnic switch igniter. The resistor value is higher than standard igniter values. It limits the deployment current, and ensures that the lifetime of the triggering device is not impacted.

The PACK-BJBEMUL detects when a current higher than $I_{th(det)}$ flows in the resistor (for example, when the pyrotechnic switch deployment is ongoing). Then, a red LED is switched on.

The LED remains on until the user press the reset switch. It ensures to detect short time current pulses (for example, the LED remains on after the end of the deployment current pulse).

To guarantee the reliability of the current detection, the user must connect the PACK-BJBEMUL ground with the pyrotechnic switch controller ground. Ground connections are available on J4, J7, and J2.

Table 14 details the emulation circuitry.

Table 15. Pyrotechnic switch emulation circuitry

Pyrotechnic switch emulation	Input connector	Red LED	LED reset switch
Pyrotechnic switch 1	J15	D3	SW6
Pyrotechnic switch 2	J16	D4	SW7

3.7 Isolation failure emulation

The PACK-BJBEMUL emulates an isolation failure between the high-voltage and low-voltage sections.

Figure 6 describes the isolation failure emulation circuitry.

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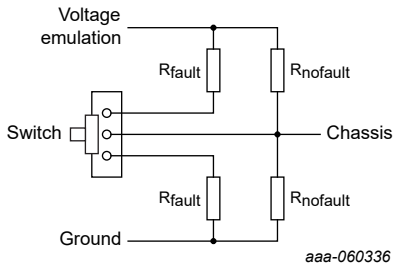

Figure 6. Isolation failure emulation circuitry

The circuitry is linked to positive voltage emulation 1 (output on J8, controlled with the slider R47). NXP recommends configuring the slider to the maximum position to have $V_{V(pos)max}$ on the voltage emulation node. It represents the battery pack voltage.

The circuitry is also linked to the emulator ground (connections available on J4, J7, and J2). It represents the battery pack negative terminal.

The chassis node is accessible on the connector J9.

The switch SW5 controls the isolation failure emulation as described in Table 16.

Table 16. Isolation failure resistance

Switch position	Resistance between the voltage emulation and the chassis	Resistance between the ground and the chassis
Top position	R_{fault} = 200 kΩ	$R_{nofault}$ = 10 MΩ
Middle position	$R_{nofault}$ = 10 MΩ	$R_{nofault}$ = 10 MΩ
Bottom position	$R_{nofault}$ = 10 MΩ	R_{fault} = 200 kΩ

4 Revision history

Table 17. Revision history

Document ID	Release date	Description
UM12132 v.1.0	14 April 2025	initial version

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