EV2651-VT-00A

I²C-Controlled 1-Cell to 4-Cell Buck-Boost Charger with Reverse Source Mode Evaluation Board

DESCRIPTION

The EV2651-VT-00A is an evaluation board designed to demonstrate the capabilities of the MP2651, a buck-boost charger IC designed for battery packs with 1 cell to 4 cells in series. The device can accept a wide 4V to 22V input voltage (V_{IN}) range to charge the battery. It also supplies a wide 3V to 21V voltage range at the IN pin in source mode. This function is compliant to the USB PD specifications.

When input power is present, the board charges the battery with a maximum 6A charge current. When source mode is enabled, the device has an output current (I_{OUT}) limit up to 6A.

With the I²C/SMBus interface, the MP2651 can flexibly configure the charge and discharge parameters. The I²C interface can also provide the device and fault statuses through the registers.

PERFORMANCE SUMMARY (1) (2)

Specifications are at T_A = 25°C, unless otherwise noted.

Parameters	Conditions	Value
Input voltage (V_{IN}) range		4V to 22V
Battery charge regulation voltage (V_{BATT_REG})	2 cells	8.4V (I²C-configurable)
Fast charge current (I_{CC})	V_{IN} = 9V to 22V	2A (I²C-configurable)
Output voltage in source mode (V_{IN_SRC}) range		3V to 21V
Output voltage in source mode (V_{IN_SRC})		4.98V (I²C-configurable)
Output current limit in source mode (I_{IN_SRC})		2A (I²C-configurable)
Charge typical efficiency	V_{IN} = 20V, V_{BATT} = 8V, I_{CC} = 2A	93.09%
Charge peak efficiency	V_{IN} = 12V, V_{BATT} = 8V, I_{CC} = 2A	96.27%
Source mode typical efficiency	V_{BATT} = 7.4V,V_{IN_SRC} = 20V, I_{IN_SRC} = 1.5A	93.5%
Source mode peak efficiency	V_{BATT} = 8.4V, V_{IN_SRC} = 12V, I_{IN_SRC} = 1.5A	96.37%
Switching frequency (f_{SW})		600kHz (I²C-configurable)

Note:

1) Refer to the MP2651 datasheet for more details.

MPL Optimized Performance with the MPS Inductor MPL-AL5030 Series

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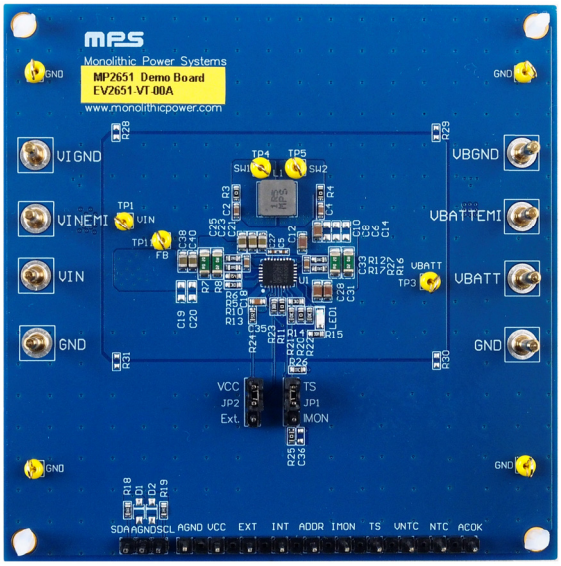
EVALUATION BOARD



LxWxH (8.9cmx8.9cmx0.8cm)

Board Number	MPS IC Number
EV2651-VT-00A	MP2651GVT-000A

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QUICK START GUIDE

This evaluation board is designed for MP2651 when the MP2651 is used as a buck-boost charger to charge a 2-cell battery pack. Its layout accommodates most commonly used resistors and capacitors. This board is preset for charge mode, and the full-charge voltage is preset to 8.4V. In charge mode, the IC can work in buck or buck-boost mode automatically, according to the input and battery voltages.

Follow the steps below to prepare the evaluation board:

1. Ensure that the computer has at least one USB port and a USB cable. The MP2651 evaluation software must be properly installed.
2. Connect the USB-to-I²C communication kit (EVKT-USBI2C-02) (see Figure 1).



Figure 1: USB-to-I²C Communication Kit

3. To enable the software, double-click on the “MP2651 Evaluation Kit” .exe file to run the MP2651 evaluation software. The software supports Windows 7 and Windows 10 operating systems.

   The MP2651 evaluation kit.exe file can be downloaded from the MPS website.

Original Test Set-Up for the MP2651

1. Connect the battery terminals to:
   a. Positive (+): VBATT
   b. Negative (-): GND

   If using a battery simulator, preset the battery voltage between 0V and 8.4V, then turn the battery off. Connect the battery simulator outputs to the VBATT and GND pins, respectively.
2. Ensure that the battery voltage is present (if using a battery simulator, turn the simulator on after making the connection).
3. For charge mode testing, connect the input terminals to:
   a. Positive (+): VIN
   b. Negative (-): GND
4. For source mode testing, connect the load terminals to:
   a. Positive (+): VIN
   b. Negative (-): GND
5. For EMI testing, connect the input or load terminals to:
   a. Positive (+): VINEMI
   b. Negative (-): VIGND
6. For EMI testing, connect the battery terminals to:
   a. Positive (+): VBATTEMI

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b. Negative (-): VBGND

7. Remove all other connectors (VIN, GND, VBATT, and GND) and pin headers.

Figure 2 shows the charge mode testing set-up.

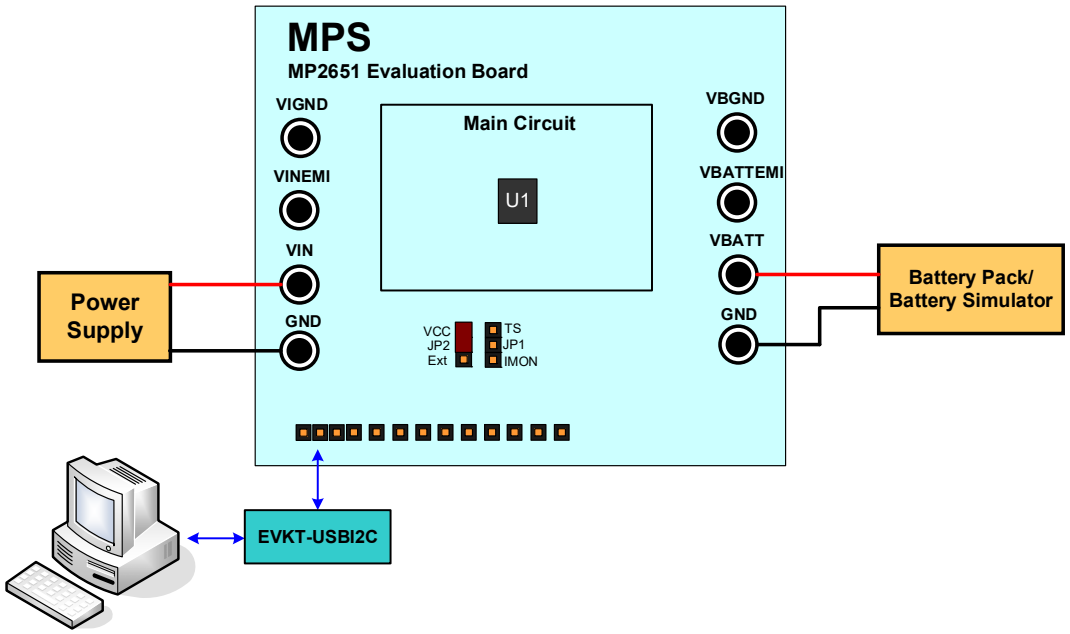

Figure 2: MP2651 Charge Mode Test Set-Up

Table 1 shows how to set the jumpers.

Table 1: Jumper Connections

Jack	Description	Default Setting
JP1 (2)	To select the pull-voltage, pull JP1 up to VCC or an external power source.	Pull JP1 up to VCC
JP2 (3)	For the TS/IMON connection, connect pin 7 to different external circuitry depending on the TS/IMON selection.	Open

Notes:

2) If JP1 is pulled up to an external source, add an external power source (e.g. 3.3V) to AGND. Otherwise, no other actions are required.
3) If TS/IMON has different external circuity, connect the TS/IMON pin to the corresponding circuit with I^2C control.

8. Launch the MP2651 evaluation software. The main software window should show up on the screen (see Figure 3 on page 5).

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Figure 3: MP2651 Evaluation Software

9. Turn on the VIN pin. The MP2651 should work to charge the battery with the default settings.

Modifying Parameters via the GUI

To use MPS's GUI, ensure that all connections are successful, such as the connections between the computer, USB-to-I²C communication kit, and the evaluation board.

BASIC Page

Figure 4 shows the MP2651's basic settings.



Figure 4: MP2651 Basic Settings

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The general settings include the PWM switching frequency, battery cell count, safety charge timer, the charge mode control and DC/DC converter control (see Figure 5).

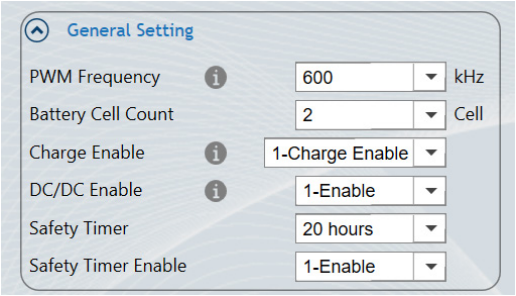

Figure 5: General Settings

Note that the recommended switching frequency (f_{SW}) is between 500kHz and 800kHz.

Charge Mode Settings

The charge mode parameters include the battery-full voltage, fast charge current, pre-charge threshold, recharge threshold, trickle charge current, pre-charge current, and termination current. The power path management parameters include the input minimum voltage limit and input current limit (see Figure 6).

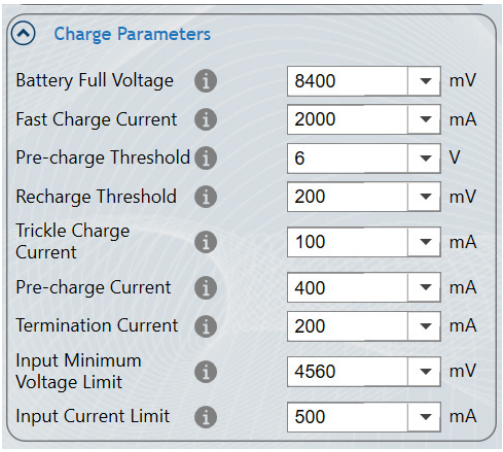

Figure 6: Charge Mode Settings

All parameters can be input using the keyboard. Figure 7 shows the JEITA parameters for battery thermal protection.

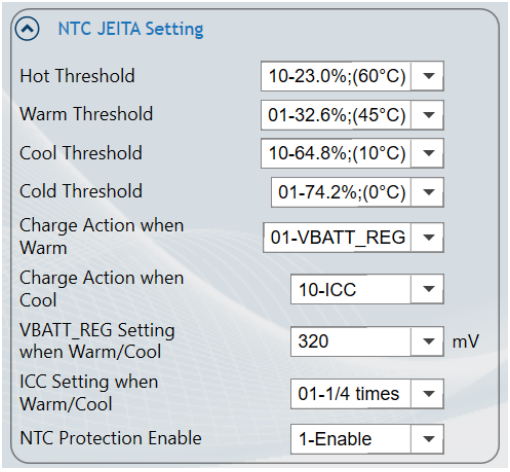

Figure 7: Battery Thermal Protection Parameters

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Source Mode Settings

The MP2651 can work in source mode. In source mode, the battery supplies power to the IN pin. The discharge parameters include the SRC mode (enabled or disabled), SRC output voltage, and SRC output current limit (see Figure 8).

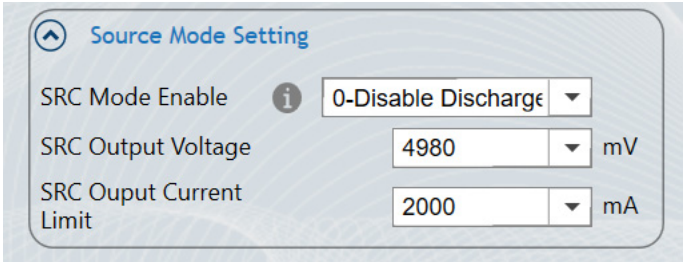

Figure 8: Discharge Parameters

CONFIG Page

Figure 9 shows the MP2651's configuration settings.

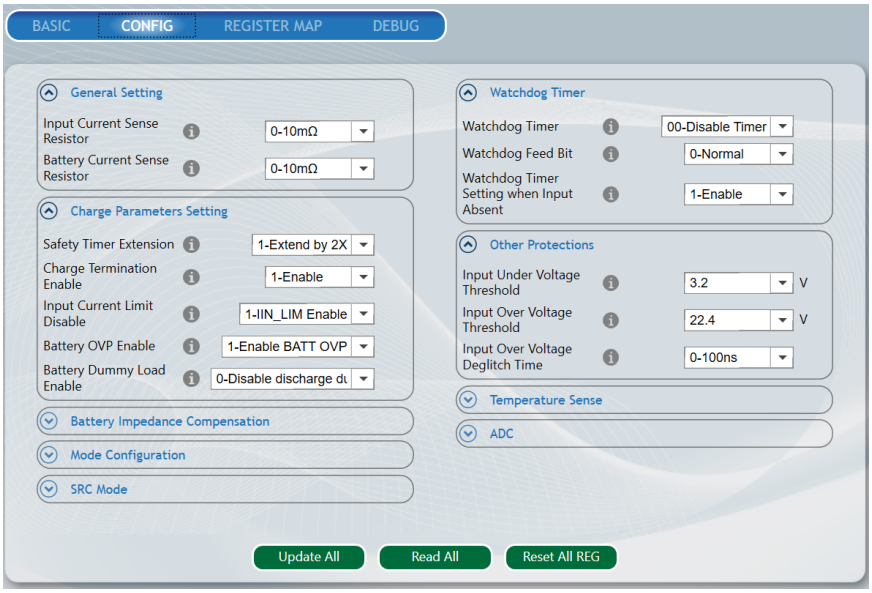

Figure 9: **MP2651 Configuration Settings**

General Settings

Figure 10 shows how to select the current-sense resistors.

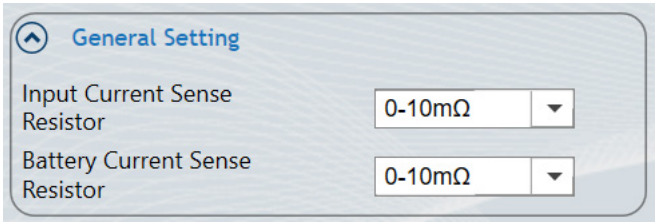

Figure 10: Setting the Current-Sense Resistors

Charge Protection Settings

Safety timer extension control enables the user to control parameters such as charge termination, the input current limit, battery over-voltage protection (OVP), and the battery dummy load (when V_{BATT} is below 10V) (see Figure 11 on page 8).

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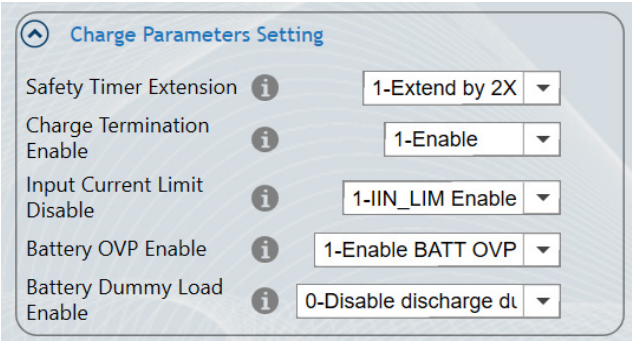

Figure 11: Charge Parameter Settings

1. Select the battery impedance compensation and the voltage limit (see Figure 12).

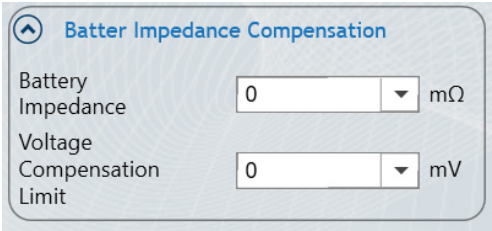

Figure 12: Battery Impedance Compensation

2. Select the external MOSFET mode configuration (input connection) (see Figure 13).

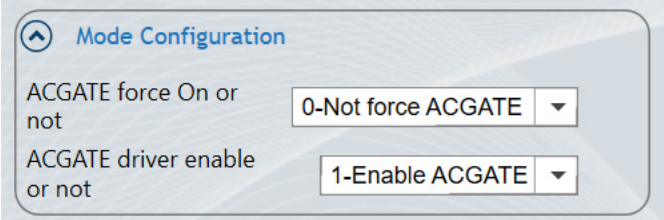

Figure 13: External MOSFET Mode Configuration

3. Select the parameters for SRC mode control, such as the SRC output voltage configuration and additional protections (see Figure 14).

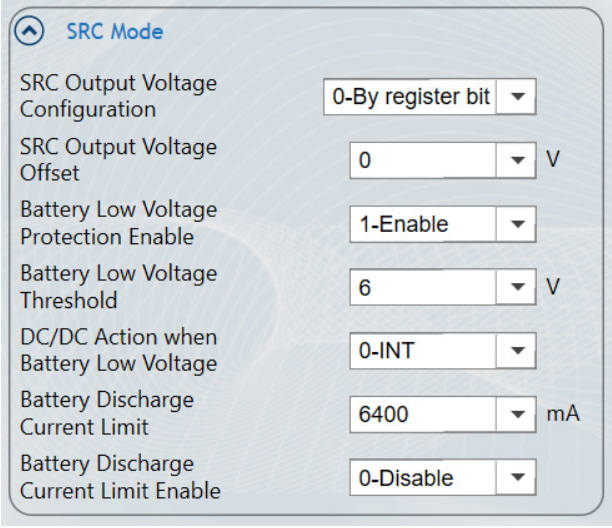

Figure 14: SRC Mode Configurations

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4. Select the watchdog timer settings (see Figure 15).

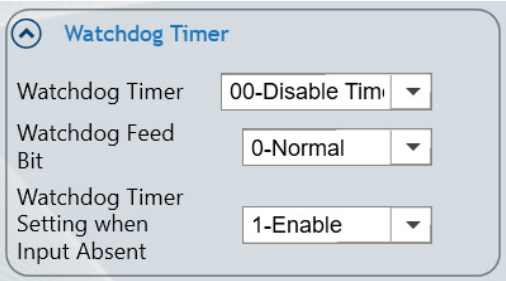

Figure 15: Watchdog Timer Settings

Additional Protections

Additional threshold settings, such as the input under-voltage threshold, input over-voltage threshold, and input over-voltage deglitch time, can also be set (see Figure 16)

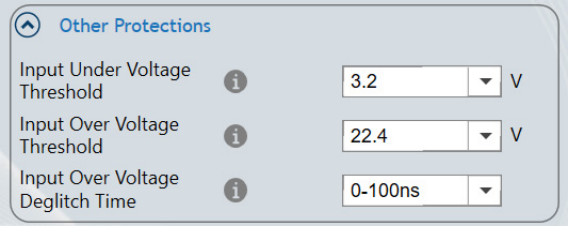

Figure 16: Additional Protections

1. Select the parameters for temperature-sense control. The TS/IMON pin can be set as either the temperature-sense pin (TS) or the battery monitor pin (IMON) (see Figure 17).

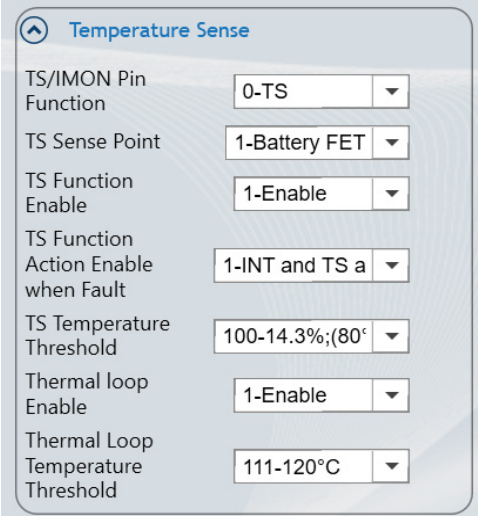

Figure 17: Temperature-Sense Settings

2. Select the ADC operation mode settings (Figure 18).

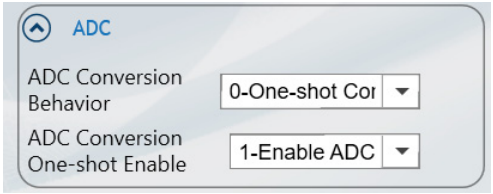

Figure 18: ADC Settings

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REGISTER MAP Page

The REGISTER MAP page shows all the registers results, which are matched with the display on BASIC and CONFIG page (see Figure 19).

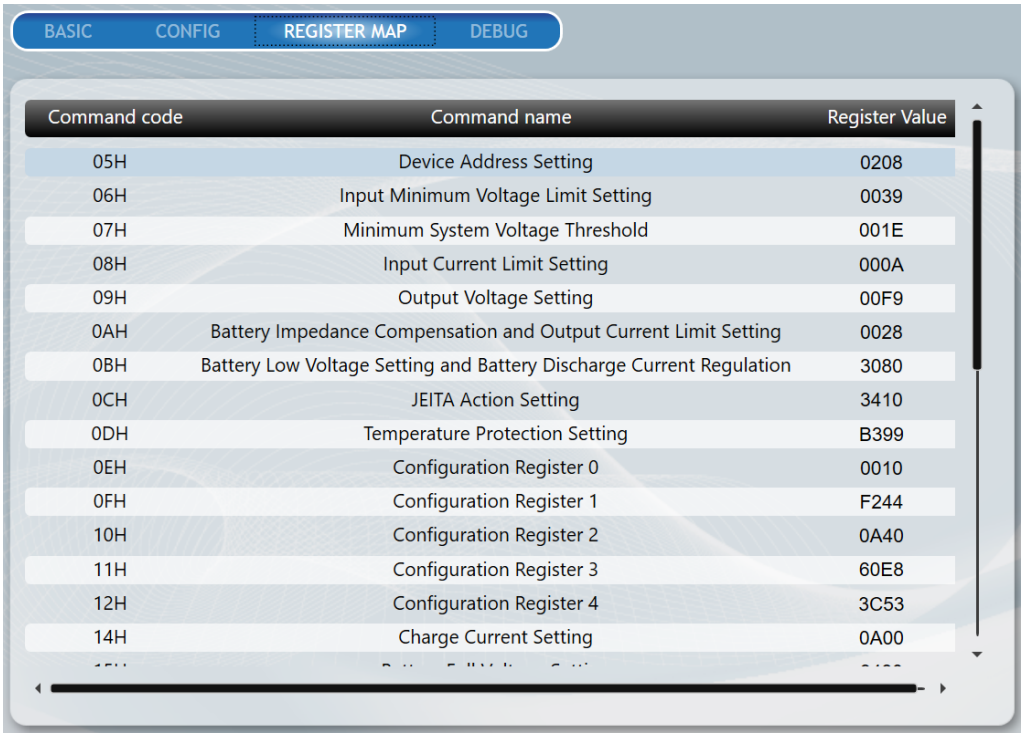

Figure 19: MP2651 Register Map Sheet

MONITOR Page

The MONITOR page reports certain devices statuses (see Figure 20).

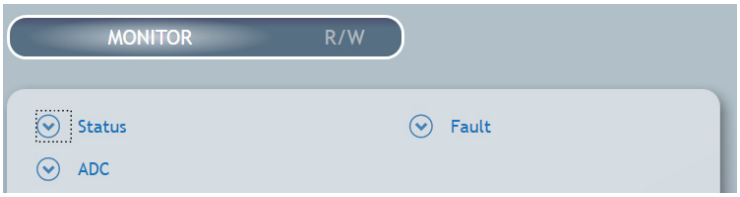

Figure 20: MP2651 Monitor Sheet

The MONITOR page indicates the general statuses (see Figure 21 on page 11).

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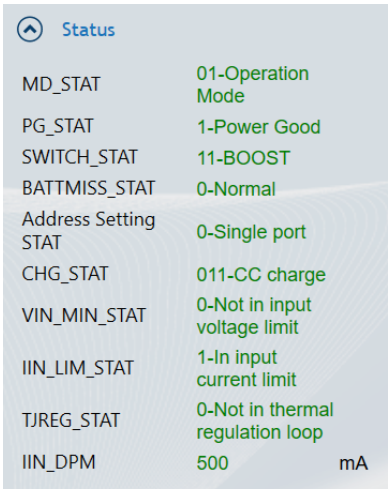

Figure 21: General Statuses

The MONITOR page also reports the fault statuses (see Figure 22).

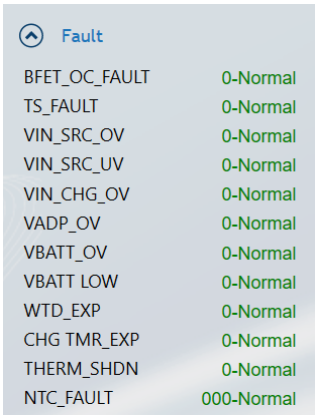

Figure 22: Fault Statuses

The MONITOR page indicates the ADC statuses (see Figure 23).



Figure 23: ADC Statuses

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EVALUATION BOARD SCHEMATIC

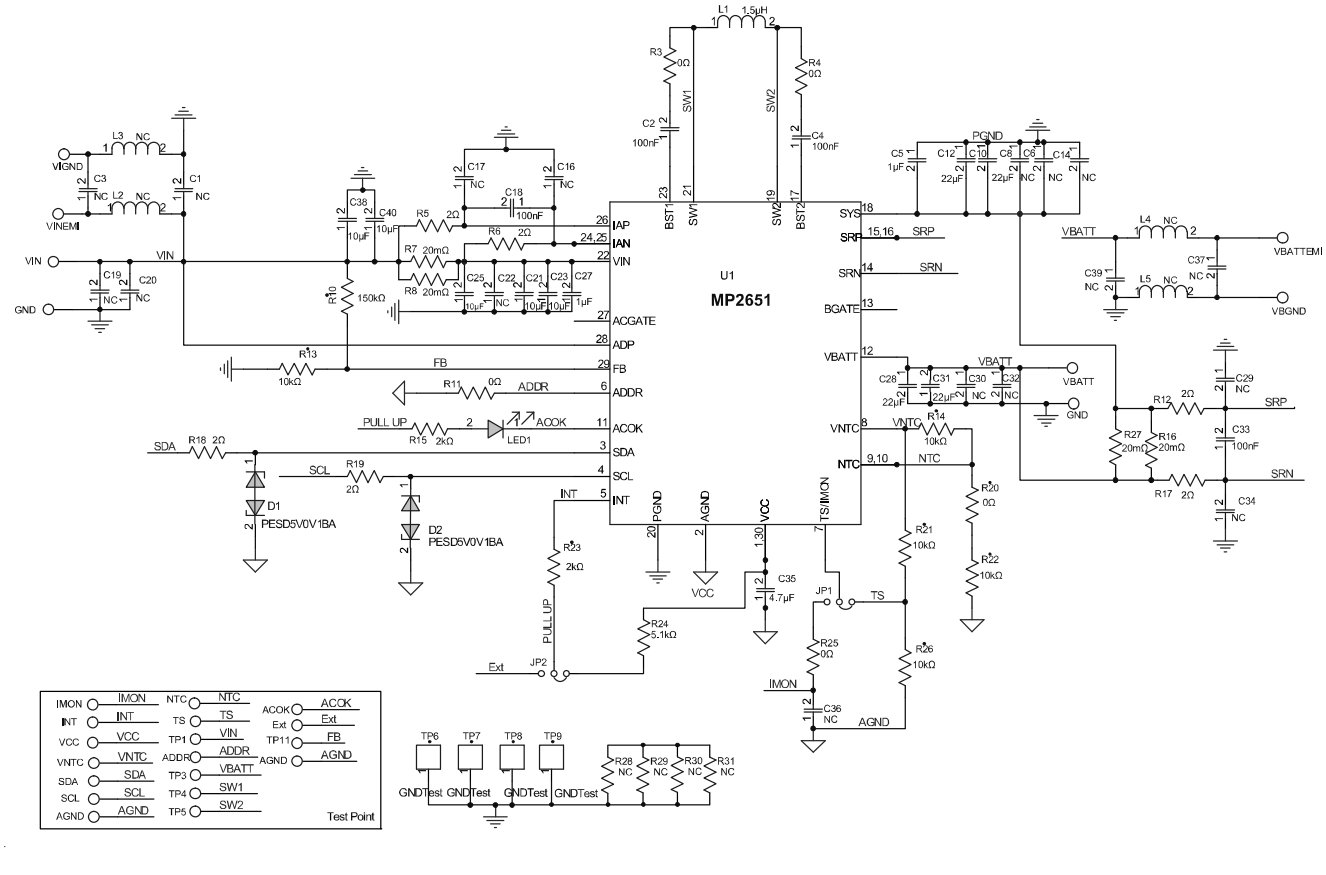

Figure 24: Evaluation Board Schematic

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EV2651-VT-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
4	L2, L3, L4, L5	NC				
5	R3, R4, R11, R20, R25	0Ω	Film resistor, 5%;	0603	Yageo	RC0603JR-070RL
6	R5, R6, R12, R17, R18, R19	2Ω	Film resistor, 5%;	0603	Liz	CR0603JA02R0G
4	R7, R8, R16, R27	20mΩ	Film resistor, 1%, 1/4W	1206	Cyntec	RL1632H-R020-FN
1	R10	150kΩ	Film resistor, 5%, 1/10W	0603	Yageo	RC0603JR-07150KL
5	R13, R14, R21, R22, R26	10kΩ	Film resistor, 1%, 1/10W	0603	Yageo	RC0603FR-0710KL
2	R15, R23	2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-072KL
1	R24	5.1kΩ	Film resistor, 5%	0603	Yageo	RC0603JR-075K1L
4	R28, R29, R30, R31	NC				
10	C1, C3, C16, C17, C22, C29, C34, C36, C37, C39	NC				
4	C2, C4,C18, C33	100nF	Ceramic capacitor, 25V, X7R	0603	Wurth	885012206071
2	C5, C27	1μF	Ceramic capacitor, 25V, X5R	0402	Murata	GRM155R61E105KA12
7	C6, C8, C14, C19, C20, C30, C32	NC				
4	C10, C12, C28, C31	22μF	Ceramic capacitor, 25V, X5R	0805	Murata	GRM21BR61E226ME44L
5	C21, C23, C25, C38, C40	10μF	Ceramic capacitor, 25V, X7S	0805	Murata	GRM21BC7E106KE11L
1	C35	4.7μF	Capacitor, 25V, X5R	0603	Murata	GRM188R61E475KE11D
1	LED1	Red	Red LED	0805	Bright LED	BL-HUE35A-AV-TRB
2	D1, D2	NC				
13	ACOK, ADDR, AGND, AGND, Ext, IMON, INT, NTC, TS, VCC, VNTC, SCL, SDA	2.54mm	Pin header	DIP	Any	
9	TP6 (GND), TP7 (GND), TP8 (GND), TP9 (GND), TP1, TP11, TP4, TP5, TP3	TH	Test point	DIP	Any	
4	VIN, VBATT, GND, GND	2mm	Connector	DIP	Any	
4*	VINEMI, VBATTEMI, VIGND, VBGND	2mm	Connector	DIP	Any	
2	JP1, JP2	2.54mm	Pin header	DIP	Any	
2	JP1, JP2	2.54mm	Mini jumper	Shunt	Any	
1	U1	MP2651	Buck-boost charger	TQFN-30 (4mmx 5mm)	MPS	MP2651GVT-000A
1	L1	1.5μH	Inductor, 1.5μH, 9.7mΩ, 9A	SMD	MPS	MPL-AL5030-1R5

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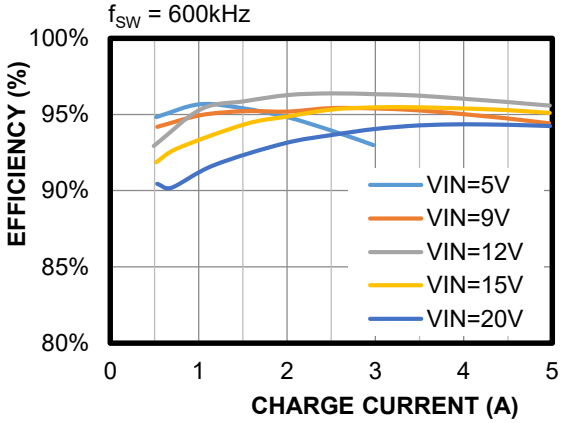
EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. The default setting is for a 2-cell battery, I_{IN_LIM} = 3A, V_{BATT} = 7.4V, I_{CC} = 3A, T_A = 25°C, unless otherwise noted.

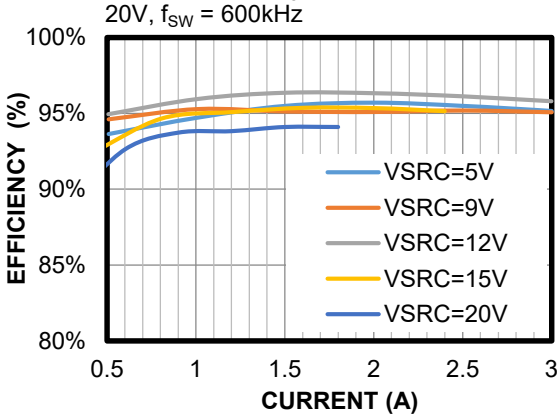
Efficiency vs. Charge Current

Charge mode, 2-cell battery,
V_{BATT} = 8V, V_{IN} = 5V, 9V, 12V, 15V, or 20V,
f_{SW} = 600kHz



Efficiency vs. Source Current

Source mode, 2-cell battery,
V_{BATT} = 8.4V, V_{SRC} = 5V, 9V, 12V, 15V, or 20V, f_{SW} = 600kHz



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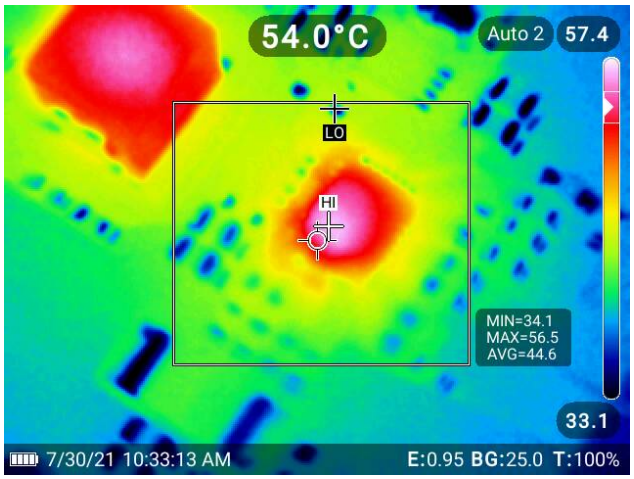
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. The default setting is for a 2-cell battery, I_{IN_LIM} = 3A, V_{BATT} = 7.4V, I_{CC} = 3A, T_A = 25°C, unless otherwise noted.

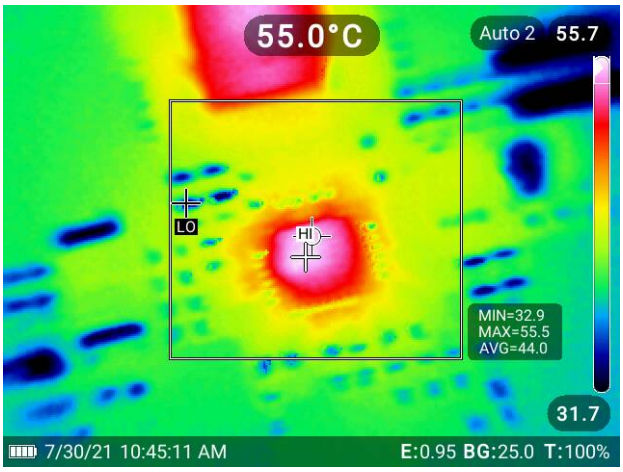
Thermal Performance

Charge mode, V_{IN} = 20V, V_{BATT} = 8.2V, I_{CC} = 5A, no forced airflow, T_{CASE} = 56.5°C



Thermal Performance

Source mode, V_{BATT} = 8.2V, V_{IN_SRC} = 20V, I_{IN_SRC} = 1.8A, no forced airflow, T_{CASE} = 55.5°C



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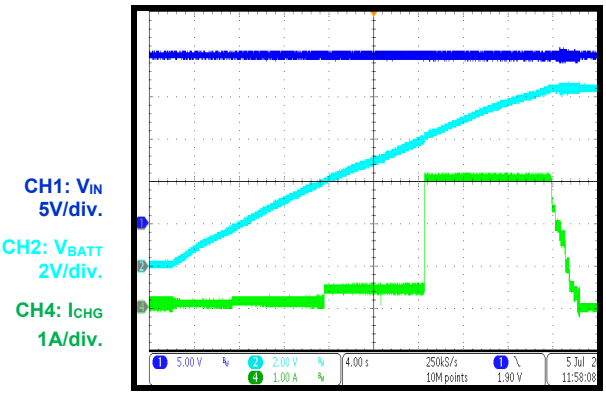
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. The default setting is for a 2-cell battery, I_{IN_LIM} = 3A, V_{BATT} = 7.4V, I_{CC} = 3A, T_A = 25°C, unless otherwise noted.

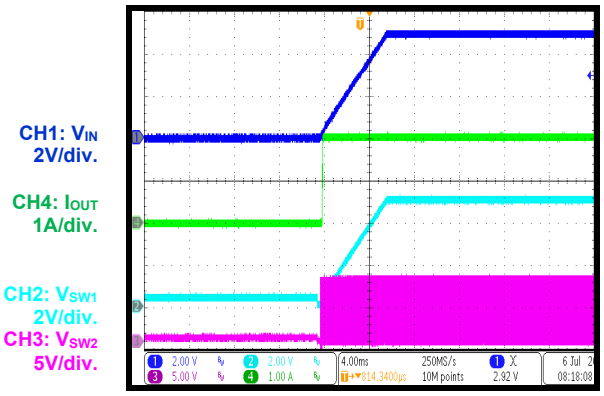
Charge Profile

V_{IN} = 20V ,$V_{BATT\ REG}$ = 8.4V



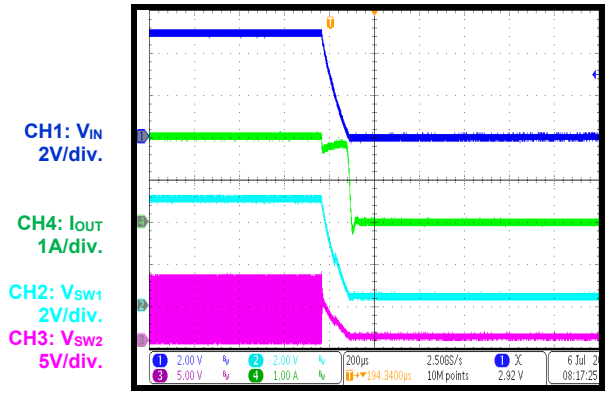
Source Mode Enabled

V_{IN_SRC} = 5V, I_{IN_SRC} = 2A (CC load).



Source Mode Disabled

V_{IN_SRC} = 5V, I_{IN_SRC} = 2A (CC load).



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PCB LAYOUT

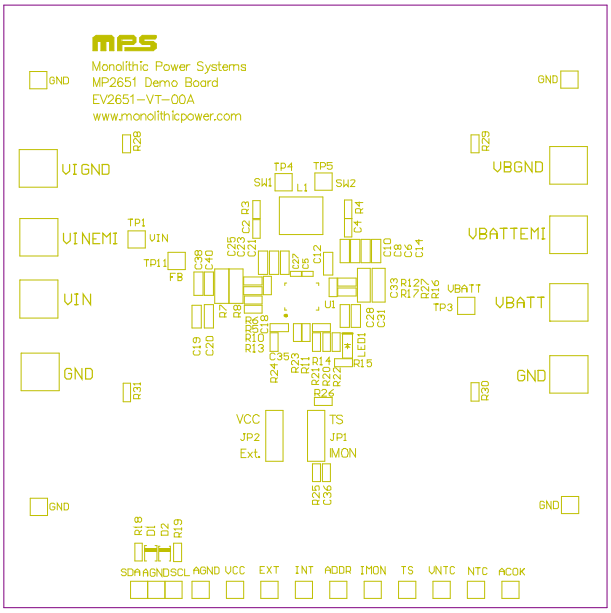

Figure 25: Top Silk

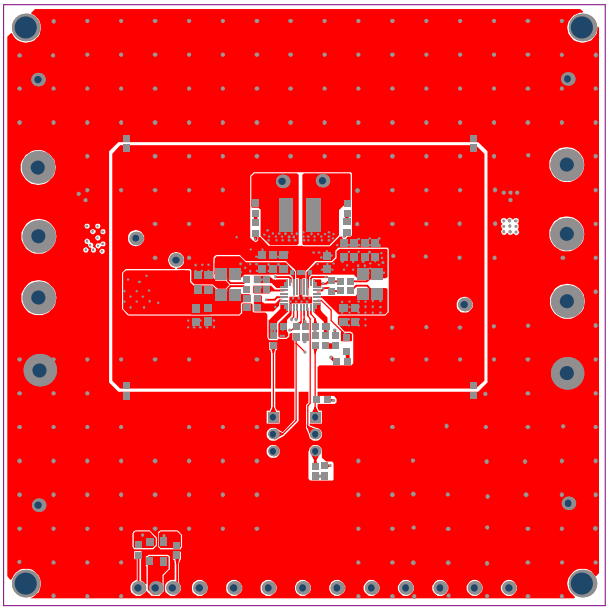

Figure 26: Top Layer

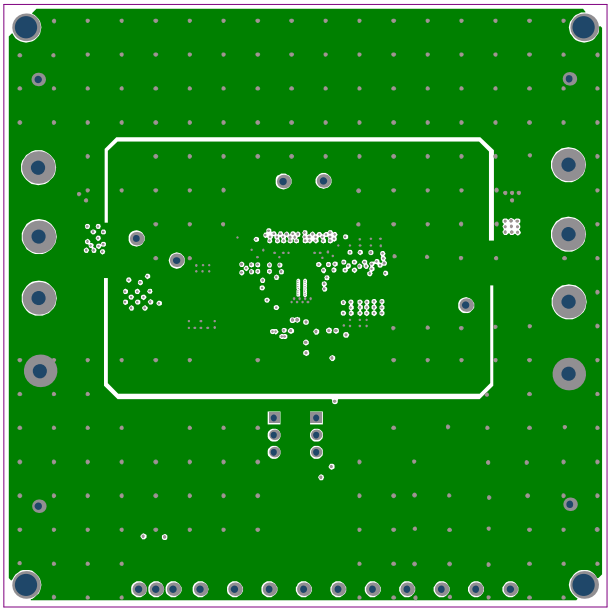

Figure 27: Mid-Layer 1

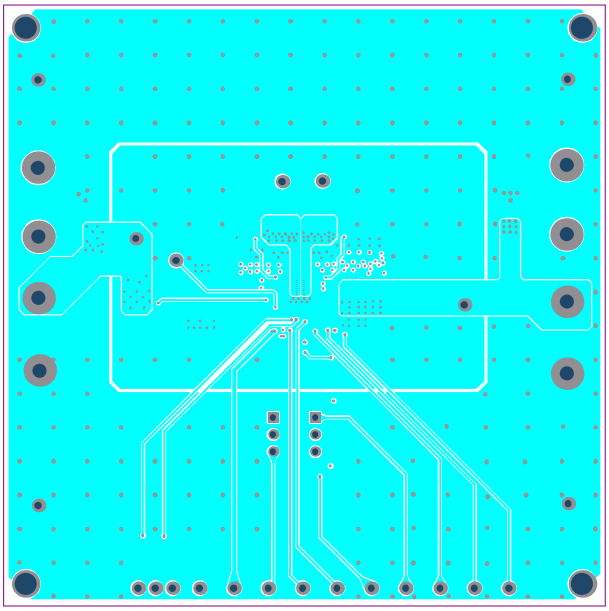

Figure 28: Mid-Layer 2

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PCB LAYOUT *(continued)*

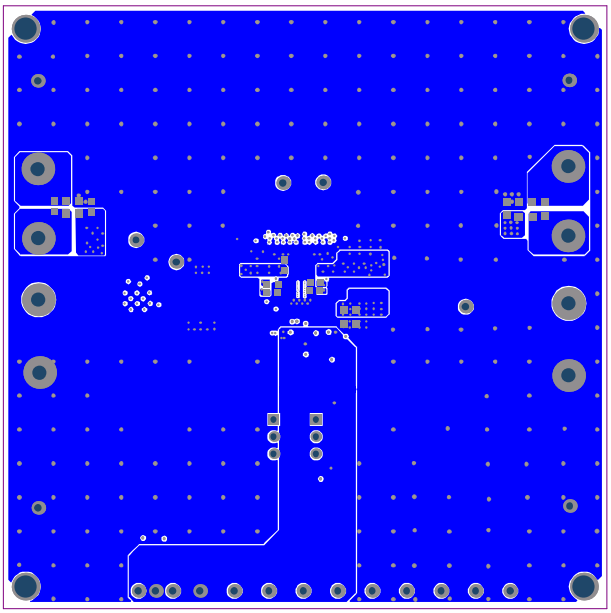

Figure 29: Bottom Layer



Figure 30: Bottom Silk

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REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	2/15/2022	Initial Release	-
1.1	1/26/2024	Updated the MPS IC Number from MP2651GVT-0000 to MP2651GVT-000A.	2
		Updated the following in Figure 24 to be consistent with the EVB images and BOM: • C25 = 10μF • R14 = 10kΩ • R20 = 0Ω • Updated the VBEMI connector to VBATTEMI • Updated the PGND connectors to GND • Updated FB to TP11 • Updated TP2 to ADDR • Added the test points, TP4 (SW1) and TP5 (SW2) • Removed the ACGATE test point • Added R28 = R29 = R30 = R31 = NC	12
		Updated GND (4) to TP6 (GND), TP7 (GND), TP8 (GND), and TP9 (GND), and updated the MP2651's manufacturer PN from MP2651GVT-0000 to MP2651GVT-000A in the EV2651-VT-00A Bill of Materials section.	13

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