

## Evaluating the **ADP5063** Linear LiFePO<sub>4</sub> Battery Charger with Power Path and USB Compatibility in LFCSP

### FEATURES

- Input voltage 4 V to 6.7 V
- High current terminals for **ADP5063** power connection (VINx), system voltage (ISO\_Sx), and battery voltage (ISO\_Bx) pins
- ADP5063** operation configurable via I<sup>2</sup>C interface
- Evaluation software included

### PACKAGE CONTENTS

- ADP5063CP-EVALZ** evaluation board
- Evaluation CD: **ADP5063** evaluation software installer

### HARDWARE REQUIREMENTS

- USB-to-serial-I/O interface **USB-SDP-CABLEZ** (**USB-SDP-CABLEZ** is not supplied in the evaluation kit and should be ordered separately from Analog Devices, Inc.)

### SOFTWARE REQUIREMENTS

- Analog Devices **ADP5063** SDP evaluation software

### GENERAL DESCRIPTION

The **ADP5063** charger evaluation system is composed of an evaluation board and a USB-to-serial-I/O interface (**USB-SDP-CABLEZ**). All evaluation board functions and circuits are controlled via one I<sup>2</sup>C bus connector. The I<sup>2</sup>C bus interfaces with the **ADP5063** directly, and the digital input/output signals are controlled through an on-board input/output expander circuit on the I<sup>2</sup>C bus. The evaluation board also features a 3.4 V regulator for VDDIO generation. The board contains jumpers and numerous test points for easy evaluation.

The **ADP5063CP-EVALZ** evaluation kit contains a CD with the **ADP5063** graphical user interface (GUI) 3.0 installer. Use the GUI in conjunction with the **USB-SDP-CABLEZ** USB-to-serial-I/O interface.

Full performance details are provided in the **ADP5063** data sheet, and the **ADP5063** data sheet should be consulted in conjunction with this user guide.

### ADP5063 EVALUATION BOARD

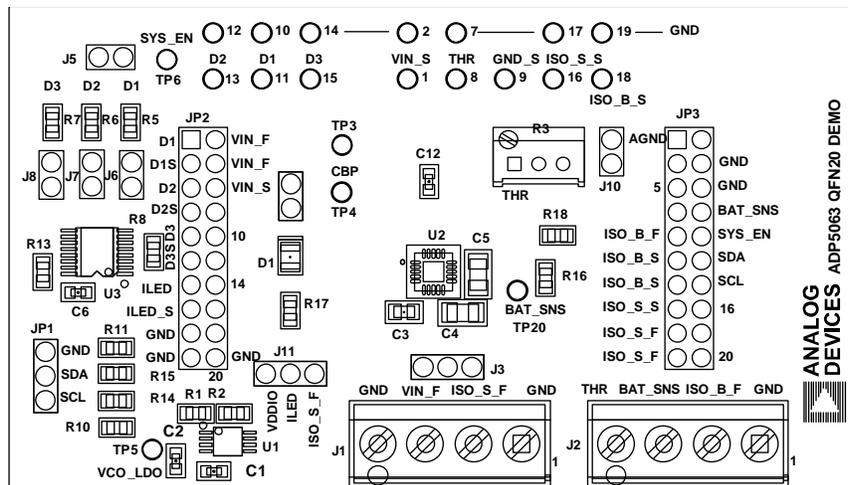


Figure 1.

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## REVISION HISTORY

10/13—Revision 0: Initial Version

## EVALUATION BOARD SOFTWARE

### INSTALLING ADP5063 EVALUATION SOFTWARE

Before installing the ADP5063 evaluation software, the drivers for the USB-SDP-CABLEZ must be installed. The software drivers are included on the ADP5063CP-EVALZ setup CD and the instructions can be obtained from [www.analog.com/usb-sdp-cablez](http://www.analog.com/usb-sdp-cablez). After proper installation of USB-SDP-CABLEZ drivers, insert the ADP5063CP-EVALZ setup CD and run the Setup.exe file.

### USING THE SOFTWARE GRAPHICAL USER INTERFACE (GUI)

The following are the GUI operation controls and status tools (see Figure 2):

1. Operation parameter controls
2. Functional enables
3. Interrupt register indicator (Register 0x0A)
4. Charger status
5. Battery status
6. Fault indicators
7. Watchdog control
8. Digital I/O controls
9. I<sup>2</sup>C communication status indicators

### OPERATING THE BOARD WITH THE GUI

Complete the following steps to use the board:

1. Before running the software, ensure that the Analog Devices USB-SDP-CABLEZ is plugged into the USB port of the PC.
2. Connect a 5 V power supply to VIN\_F.
3. Click **START > All Programs > ADP506x GUI 3Vx SDP > ADP506x GUI SDP**. Once this step is done, the software is ready to use.

VIN must be above 2.5 V in order for the I<sup>2</sup>C communication of the ADP5063 to start working. The VIN voltage level is monitored, and the indicators are shown in the charger status indicators (see Number 4 in Figure 2). The GUI automatically reads the content of the registers after every 0.3 seconds from the last action and updates the status of the registers on screen.

If there is a problem in the I<sup>2</sup>C communication, the status indicators show an error message (see Number 9 in Figure 2). When I<sup>2</sup>C communication is operational, status indicators show I2C\_STATUS\_OK (see Figure 2).

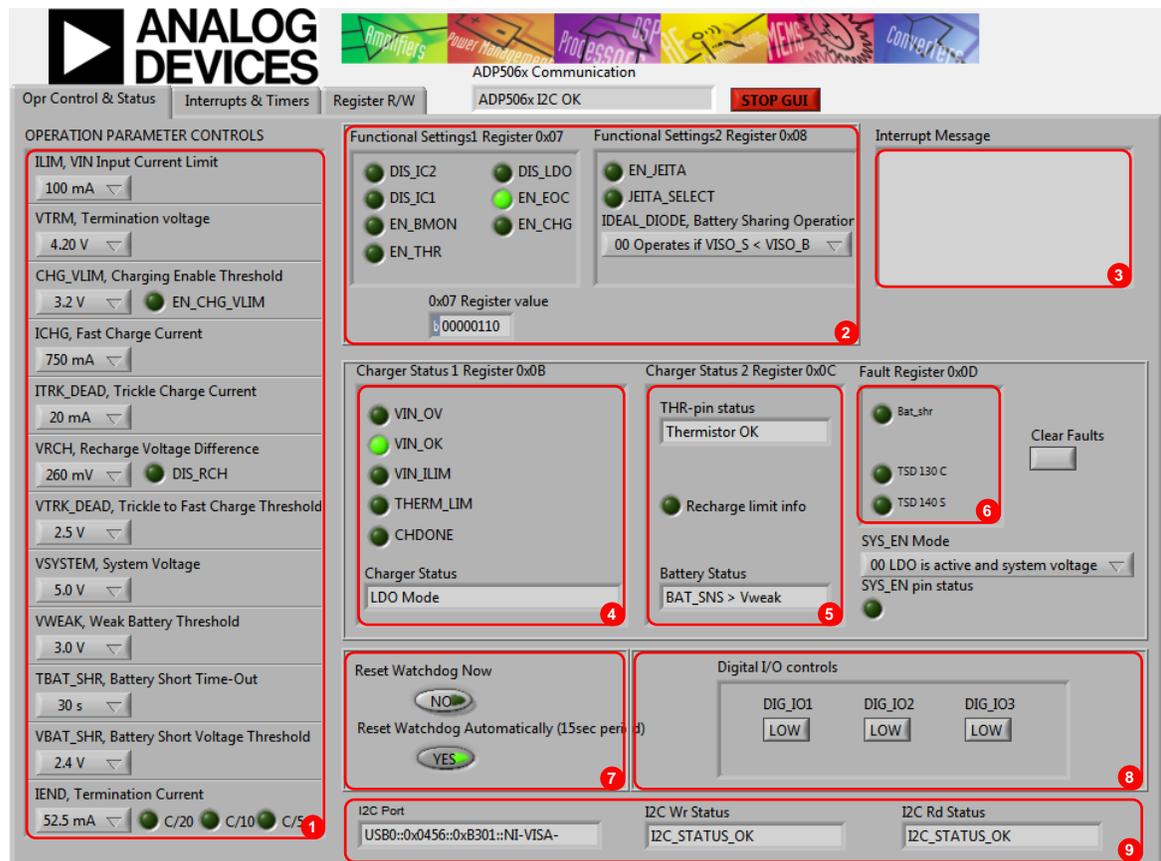


Figure 2. ADP5063 GUI Operation Control and Status Tab

**BASIC CHARGING PARAMETER SETTINGS**

After the input power supply is connected and is between 4.0 V and 6.7 V, the ADP5063 is operational and capable of charging the battery. Charging starts with default operational parameter settings. It is possible to change settings using the controls on the left side of the **Opr Control & Status** tab.

**SETTING INTERRUPTS**

The ADP5063 includes several interrupt flags to inform the system microcontroller of a status change in the corresponding charger function. All interrupts are disabled by default, and each interrupt can be separately enabled by issuing an I<sup>2</sup>C write to Register 0x09.

The **Interrupts & Timers** tab (see Figure 3) in the GUI controls the register settings. Register 0x0A is automatically read after every 0.3 second timeout from the last user action involving the GUI. When a certain interrupt is enabled, and there is a status change in the corresponding function during charging, an interrupt message is shown in the **Opr Control & Status** tab (see Number 3 in Figure 2).

**SETTING TIMERS**

The default settings of the timers are shown in Figure 3. Changing the timer settings can be done by clicking items in the **Timer Settings (Write to Register 0x06)** box.

Register 0x09 controls the interrupt enables, and Register 0x06 controls the timer settings.

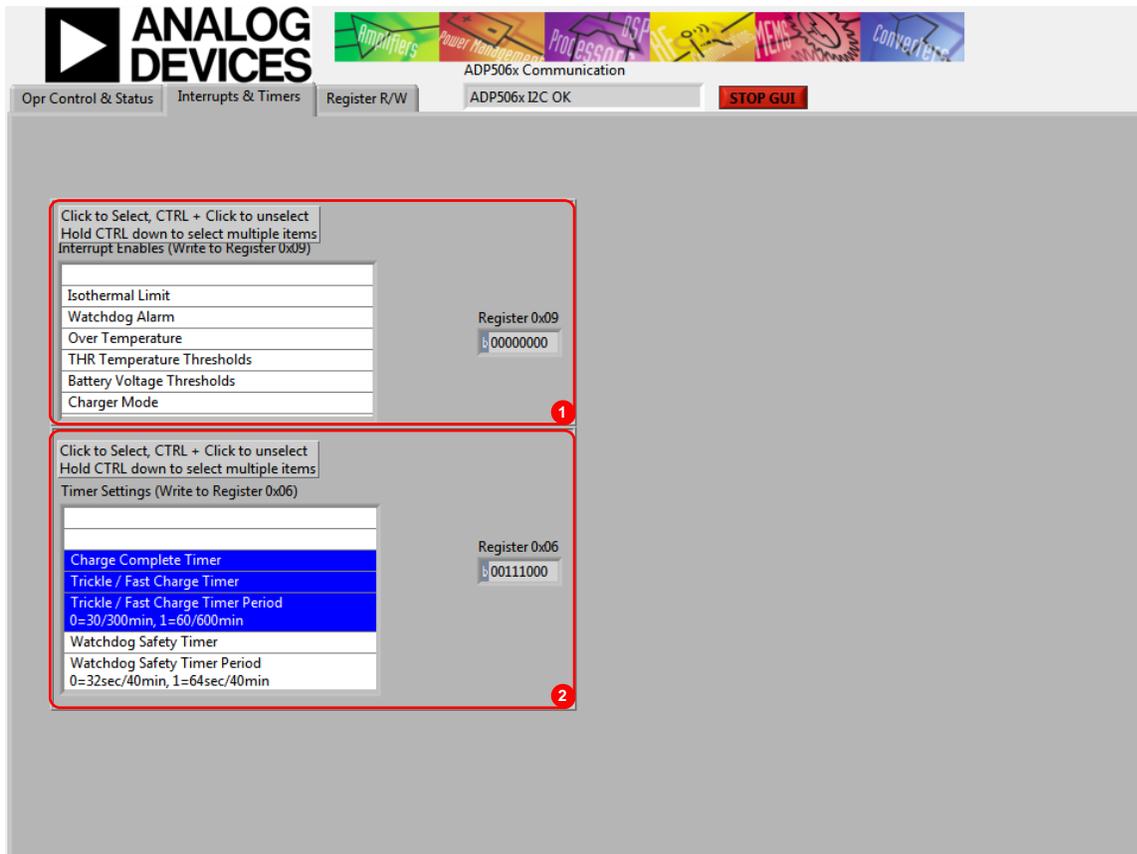


Figure 3. ADP5063 Evaluation Software GUI, **Interrupts & Timers** Tab

**DIRECT REGISTER READ AND WRITE**

It is possible to read and write the content of each register using the **Register R/W** tab as indicated in the GUI. Click **READ ALL** to update the contents of each register in the GUI. A single register read or write can be done using the controls on the right side of the **Register R/W** tab of the GUI. Type the I<sup>2</sup>C sub address in the **Sub Address for READ or WRITE (0x00)**

box, and then press the **Enter** key. Click **READ** to read the binary data, or click **WRITE** to write the binary data. Type the binary data for an I<sup>2</sup>C write, and then press the **Enter** key. Note that some registers, such as Register 0x00 and Register 0x01, are read only registers and cannot be overwritten.

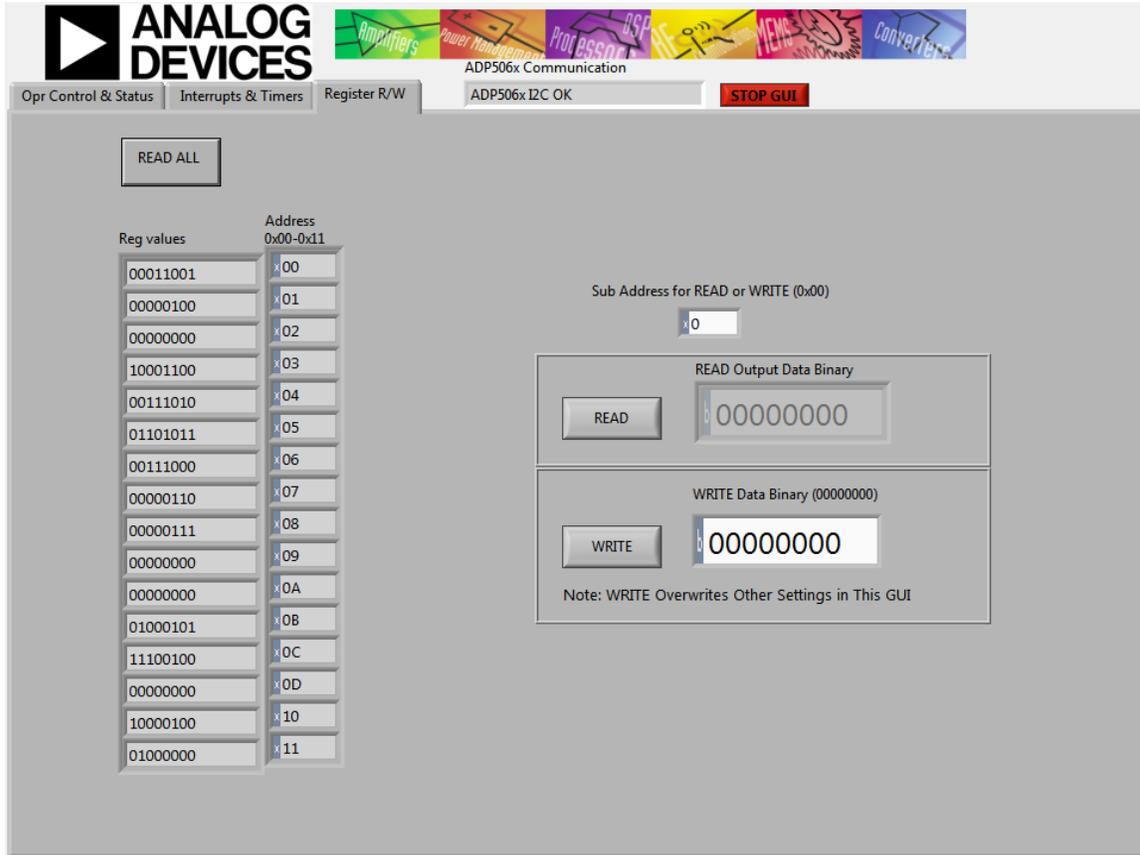


Figure 4. ADP5063 Evaluation Software GUI, Register R/W Tab

## EVALUATION BOARD OVERVIEW

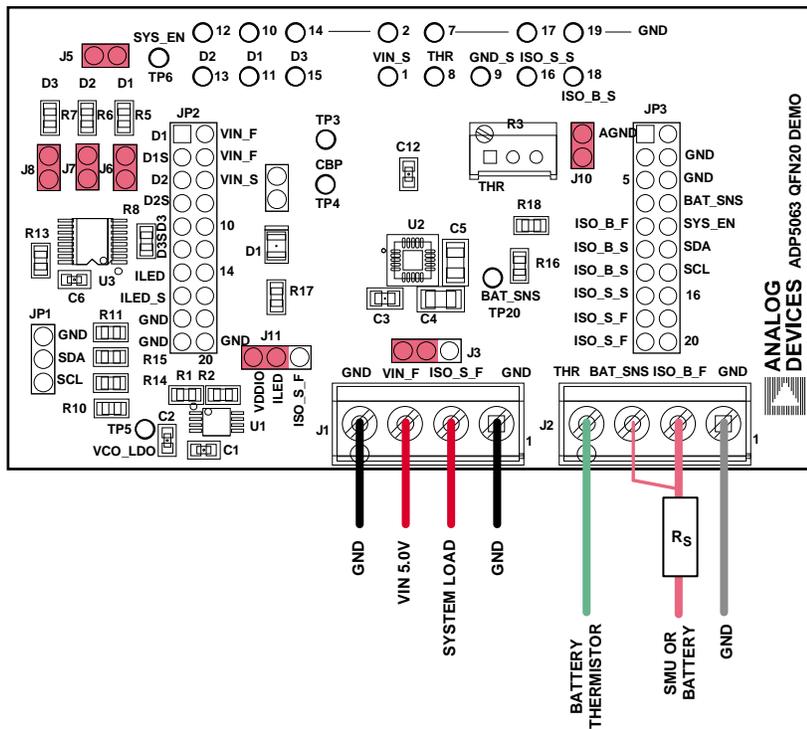


Figure 5. ADP5063 LFCSP Demo Board Typical Operation Setup

### TYPICAL OPERATION

The typical test setup for the ADP5063 charger consists of a dc power supply unit (PSU) for VIN\_F, a source meter unit (SMU) or a battery simulator for the ISO\_Bx pins, and a variable power resistor or electronic load for the ISO\_Sx pins.

The SMU at the ISO\_B\_F node must have a 100 mΩ to 250 mΩ resistor (R<sub>S</sub>) in series with its positive lead. The resistor emulates the equivalent series resistance of a real battery. Some SMU models that have been successfully used for the ISO\_x\_F node include the following:

- Keithley 2306 battery simulator
- Keithley 2602A SMU
- Agilent 6784A/6762A SMU

## INPUT CURRENT

### Measuring Total Input Current ( $I_{VIN}$ )

When measuring  $V_{INx}$  input quiescent currents, take into account that the evaluation board includes an LDO (U1) and I<sup>2</sup>C input/output (I/O) expander (U2, U3A in Figure 7). The LDO generates a 3.4 V  $V_{DDIO}$  voltage for the I<sup>2</sup>C bus and  $SYS\_EN$  open-drain output, and the I/O expander controls digital inputs  $DIG\_IO1$ ,  $DIG\_IO2$ , and  $DIG\_IO3$ .

In the ADP5063 evaluation board typical setup, U1 and U3 are powered through a pin header, J3. Typically, the combined current consumption of the U1 and the U3 are in the range of 1 mA to 2 mA. To separate the evaluation board quiescent current from the ADP5063  $V_{INx}$  quiescent current, leave J3 open and connect a second dc power supply (3.5 V to 5.0 V) to the test-point TP5 (see Figure 6).

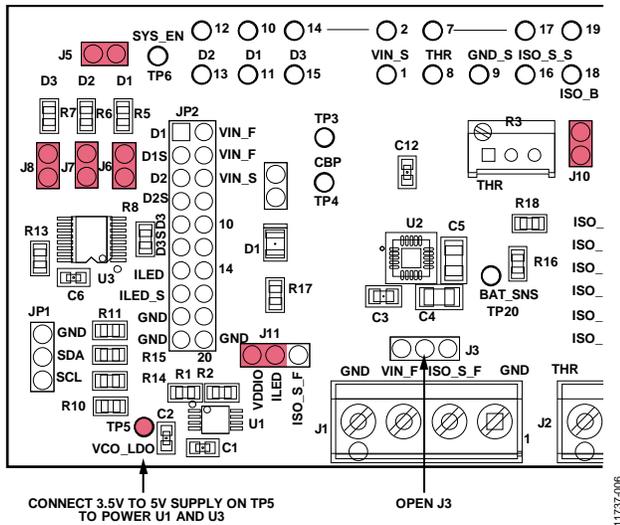


Figure 6. Board Setup for  $V_{INx}$  Quiescent Current Measurement

### $V_{INx}$ Current Limit

The  $V_{INx}$  current limit of the ADP5063 can be evaluated in charging mode. Note that the maximum programming for the charge current into the battery ( $ISO\_Bx$ ) is 1300 mA. For measuring the input current limit across the full programming range from 100 mA to 2100 mA, an additional system load has to be connected to the  $ISO\_Sx$  pins.

To measure the  $V_{INx}$  current limit, complete the following steps:

1. Set the  $V_{VIN}$  supply voltage to 5.0 V.
2. Set the  $V_{ISO\_B}$  voltage to 3.3 V on SMU B.
3. Enable charging by setting Register 0x07, Bit D0 ( $EN\_CHG$ ), high.
4. Confirm the ADP5063 charging mode:
  - The **Battery Status** indicator on the GUI must show  $BAT\_SNS > V_{weak}$  (see Figure 2).
  - The ADP5063 must start charging 80 mA to 90 mA current into the battery.
5. Measure the current on  $V_{INx}$  supply.
6. Use the GUI to change the input current limit programming and repeat the measurement.

A 1300 mA charge current into the battery may not be large enough to drive the input current up to the limit when the current-limit programming values of 1200 mA or higher are used. Connect an additional load on the  $ISO\_Sx$  node to evaluate the higher end of the input current limit programming range.

### TRICKLE CHARGE CURRENT

Trickle charge can only be activated during a battery charging start-up sequence, if the voltage level at the  $ISO\_Bx$  pins is lower than the  $V_{TRK\_DEAD}$  threshold (typically 2.0 V). When  $V_{VIN}$  is 5.0 V, initiate a charge start-up sequence by setting an I<sup>2</sup>C write of Register 0x07, Bit D0 ( $EN\_CHG$ ), high. To measure the trickle charge current level, complete the following steps:

1. Set the  $V_{ISO\_B}$  voltage (SMU or battery simulator) to 1.8 V.
2. Set the  $V_{VIN}$  supply voltage to 5.0 V.
3. Check that the GUI **Charger Status** indicator shows **Trickle Charge**.
4. Check that the GUI **Battery Status** indicator shows  $BAT\_SNS < V_{trk}$ .
5. Check the battery short detection:
  - Wait for a 30 second timeout to expire.
  - Check that the GUI shows that the I<sup>2</sup>C fault register (Register 0x0D, Bit D3)  $BAT\_SHR$  flag is set.
  - Use the GUI to change the battery short timeout setting from 1 second to 180 second.
6. Measure the trickle charge current level to the battery. The default value for  $I_{TRK\_DEAD}$  is 20 mA. It is possible to change the trickle charge current setting from 5 mA to 80 mA using the GUI.
7. Adjust the  $V_{ISO\_B}$  voltage up until the **Battery Status** indicator shows  $V_{trk} < BAT\_SNS < V_{weak}$ .
8. The **Charger Status** indicator on the GUI should show **Fast Charge (CC-Mode)**. The charge current is now programmed  $I_{CHG} + I_{TRK\_DEAD}$ , if it is not limited by the input current limit.

## FAST CHARGE CURRENT

To measure the fast charge current, complete the following steps:

1. Set the  $V_{VIN}$  supply voltage to 5.0 V.
2. Set  $V_{ISO\_B}$  to 3.3 V.
3. Verify that the GUI **Battery Status** indicator shows **BAT\_SNS > Vweak**.
4. Set the  $V_{INx}$  input current limit to the maximum value 2100 mA.
5. Measure the charge current into the battery. The default value for the fast charge current is 750 mA. It is possible to change the fast charge current setting from 50 mA to 1300 mA using the GUI.
6. The fast charge current may be reduced because of the following conditions:
  - The  $V_{BAT\_SNS}$  level is close to the termination voltage  $V_{TRM}$  (default 3.60 V).
  - The die temperature,  $T_J$ , exceeds the isothermal charging temperature,  $T_{LIM}$ , (typically 115°C).

## TERMINATION VOLTAGE AND END OF CHARGE (EOC) CURRENT

### Measuring Termination Voltage Using SMU or Battery Simulator

The **ADP5063** fast charge constant voltage (CV) regulation is optimized for batteries with series resistance in the 100 m $\Omega$  to 250 m $\Omega$  range. When using a SMU or a battery simulator connected to the  $ISO\_Bx$ , set the series resistance ( $R_s$  in Figure 5) within this range.

Some battery simulators, such as the Keithley 2306, have programmable source resistance integrated in the instrument itself. For SMU units, use an external resistor to obtain accurate measurement results of the termination voltage.

To measure the termination voltage, complete the following steps:

1. Set the  $V_{VIN}$  supply voltage to 5.0 V.
2. Set the termination voltage to 3.60 V using the GUI.
3. Disable the EOC by setting the  $EN\_EOC$  bit (D2) to low in the functional settings register, Register 0x07.
4. Disable charge complete timer register, Register 0x06, using the GUI (see Figure 3).
5. Sweep  $V_{ISO\_B}$  up until the **Charger Status** indicator in the GUI shows **Fast Charge (CV-Mode)**.
6. Sweep  $V_{ISO\_B}$  up until the charge current has dropped to 50 mA. In fast charge CV mode, 1 mV step up of  $V_{ISO\_B}$  can reduce the charge current by several mA.
7. Measure termination voltage between the  $BAT\_SNS$  (TP20) and  $GND\_S$  (TP9) nodes.

### Measuring EOC Current

To measure the EOC current, complete the following steps:

8. Use the GUI to set the termination current to 52.5 mA.
9. Step  $V_{ISO\_B}$  down 100 mV.
10. Enable the EOC by setting the  $EN\_EOC$  bit (D2) to high in the functional settings register, Register 0x07.
11. Step  $V_{ISO\_B}$  up and monitor the charge current for each step until the **Charger Status** indicator in the GUI shows **Charge Complete**. The last charge current value before **Charge Complete** is the charge complete current threshold. Charging stops and there is no current flowing into the  $ISO\_B\_x$  node.

### Measuring Recharge Voltage

To measure the recharge voltage, complete the following steps:

12. Step  $V_{ISO\_B}$  down and monitor the voltage until the **Charger Status** indicator on the GUI shows **Fast Charge (CC-Mode)** and charge current flows to the  $ISO\_B\_x$  node. The last value before the charger status change is the recharge voltage level. With default settings, the recharge voltage threshold is 3.34 V ( $V_{ISO\_B}$ ).
13. Use the GUI to change the termination current and recharge voltage programming. Repeat Step 9 to Step 12 to evaluate different settings.

## THR INPUT AND JEITA SETTINGS

The THR input of the [ADP5063](#) evaluation board is equipped with the 50 k $\Omega$  trimmer resistor (R3) and Jumper J10. When using an actual Li-Ion NTC thermistor terminal, configure the board according to Figure 5.

1. Remove Jumper J10.
2. Connect the Li-Ion battery NTC thermistor to the screw terminal, J2, at Pin 4.

### *Evaluating THR Input Using Typical Board Setup*

To evaluate the THR input using the typical board setup, complete the following steps:

1. Set the  $V_{VIN}$  supply voltage to 5.0 V.
2. Set  $V_{ISO\_B}$  to 3.3 V.
3. Set the charge current setting to 750 mA using the GUI.
4. Set  $V_{VIN}$  input current limit to 1500 mA.
5. Enable charging (EN\_CHG = high).
6. Measure current to ISO\_Bx, value should be 750 mA.
7. Adjust the trimmer resistor until the **THR-pin status** indicator on the GUI shows **BatCool**.
8. Enable JEITA by setting the EN\_JEITA bit high in functional settings register, Register 0x08.
9. Measure current to ISO\_Bx. Charging current must now be half of the fast charge current setting.
10. Change the trimmer resistor setting to evaluate the JEITA thresholds. The THR input resistance thresholds are specified in the [ADP5063](#) data sheet.
11. The **THR-pin status** indicator in the GUI must show **BatCold**, **BatCool**, **Thermistor OK**, **BatWarm**, or **BatHot** when adjusting the trimmer resistance from 50 k $\Omega$  to 0  $\Omega$ .



**ORDERING INFORMATION****BILL OF MATERIALS**

Table 1.

Qty	Reference Designator	Description	Manufacturer/Vendor	Vendor P/N
2	C1, C2	Capacitors, MLCC, 1 $\mu$ F, 10 V, 0805, X7R	Murata	GRM21BR71A105KA01
1	C3	Capacitor, MLCC, 10 $\mu$ F, 25 V, 0805, X5R	Murata	GRM21BR61E106MA73
2	C4, C5	Capacitors, MLCC, 22 $\mu$ F, 6.3 V, 1206, X5R	Murata	GRM31CR60J2226ME19
2	C6, C12	Capacitor, MLCC, 100 nF, 16 V, 0402, X7R	Murata	GRM155R71C104KA88
5	C7, C8, C9, C10, C11	Capacitors, size 1206	Not assembled	Not assembled
1	D1	LED 636 nm super red 0805 SMD	Lumex	SML-LX0805SIC-TR
1	JP1	Connector header, 3 pins $\times$ 1 pin	Sullins Electronics	PEC36SAAN
2	JP2, JP3	Connector headers, 10 pins $\times$ 2 pins	Not assembled	Not assembled
2	J1, J2	Terminal block PCB connector, 4 position	Tyco Electronics	282836-4
2	J3, J11	Connector headers, 3 pins $\times$ 1 pin	Sullins Electronics	PEC36SAAN
6	J5, J6, J7, J8, J9, J10	Connector headers, 2 pins $\times$ 1 pin	Sullins Electronics	PEC36SAAN
1	R1	Resistor, 56 k $\Omega$ , 1%, 0805, SMD	Vishay or equivalent	CRCW080556K0FKEA
1	R2	Resistor, 100 k $\Omega$ , 1%, 0805, SMD	Panasonic	ERJ-6ENF1003V
1	R3	Resistor, 3296 - 3/8" square trimming potentiometer 50 k $\Omega$	Burns or equivalent	3296 W - 1 - 503 LF
3	R5, R6, R7	Resistors, 0805, SMD, no assembly	Not applicable	Not applicable
4	R8, R13, R14, R15	Resistors, 1.5 k $\Omega$ , 1%, 0805, SMD	Vishay or equivalent	CRCW08051K50FKEA
3	R10, R11, R16	Resistors, 0 $\Omega$ , 1%, 0805, SMD	Vishay or equivalent	CRCW08050000Z0EA
1	R17	Resistor, 470 $\Omega$ , 1%, 0805, SMD	Vishay or equivalent	CRCW0805470RFKEA
1	R18	Resistor, 0.150 $\Omega$ , 1%, 0805, SMD	Rohm	MCR10EZHFLR150
20	TP1 to TP20	Test point, test header, 1.0 mm hole	Vero Technologies	20-2137
1	U1	<a href="#">ADP1720</a> 50 mA high voltage, micropower linear regulator, 8-lead MSOP	Analog Devices, Inc.	<a href="#">ADP1720ARMZ-R7</a>
1	U2	ADP5063 linear LiFePO <sub>4</sub> battery charger with power path and USB compatibility in LFCSP data	Analog Devices, Inc.	<a href="#">ADP5063</a>
1	U3A	8-bit I <sup>2</sup> C-bus I/O port with reset	NXP	PCA9557PW,112

## NOTES

**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.

**Legal Terms and Conditions**

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