User's Guide
SLUUAO3C–July 2015–Revised November 2016

bq2477x EVM User's Guide

The bq2477x evaluation module (EVM) is an SMBus controlled NVDC-1 charge controller with N-CH MOSFET Selector and Current Monitoring. The input voltage range, for the buck converter, is between 6 and 24 V, with a programmable output of 1–4 cells (bq2477x) and a charge output current range of 128 mA to 8.128 A. This EVM does not include the EV2400 interface device; this will have to be ordered separately to evaluate the bq2477x EVM.

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Trademarks

All trademarks are the property of their respective owners.

1 Introduction

1.1 EVM Features

Refer to the data sheet (SLUSC03) for detailed features and operation.

1.2 I/O Description

Table 1 contains the jumper connections for this EVM.

Table 1. EVM Connections

Jack	Description
J1–VIN	AC to VDC adapter positive input
J1–GND	AC to VDC adapter negative input
J2-SYS	System Load Positive connection
J2-GND	System Load Ground connection
J3-BAT	Battery Pack Positive connection
J3-GND	Battery Pack Negative connection
J4-PROCHOT	
J4-GND	
J4-PMON	
J4-ACOK	
J5–SCL	EV2400 SMBus clock line connection
J5–SDA	EV2400 SMBus Data line connection
J5– GND	EV2400 SMBus Ground line connection
J5-3.3V	3.3 VDC Supply positive connection
J6-CMPOUT	
J6– GND	3.3 VDC Supply Negative connection
J6-CMPIN	

1.3 Toggle Switch –S1

- Switch 1 – U1_bq-CMPIN – open (down position)
- Switch 2 – U1_bq-CMPOUT – open (down position)
- Switch 3 – U2_TPS-CMPOUT – closed (up position)
- Switch 4 – U2_TPS-CMPIN – closed (up position)

1.4 Recommended Operating Conditions

Table 2 lists the recommended operating conditions for this EVM.

Table 2. Recommended Operating Conditions

Symbol	Description	MIN	TYP	MAX	Unit
Supply voltage, V_{IN} (1)	Input voltage from ac adapter input	18	19-20	23	V
Battery voltage, V_{BAT}	Voltage applied at V_{BAT} terminal		3-16.8	17.408	V
Supply current, I_{AC} (2)	Maximum input current from ac adapter input			4.5	A
Output current, I_{OUT} (3)	Output current (SYS and CHG)			8	A
Operating junction temperature range, T_J		0		125	°C

(1) ACDET bias, R5 and R6, is set for this range. For lower adapter voltages, this divider has to be modified. With the proper bias, V_{IN_MIN} can be as low as 4.5 VDC. See the data sheet (SLUSC03) for more information.
(2) 8 A can be achieved by paralleling input FETS (install Q51).
(3) Q5 can be installed (parallel battery outputFET) for currents above 4.5 A.

2 Test Summary

Section 2.1 and Section 2.2 explain the equipment and the equipment setup.

2.1 Equipment

2.1.1 Power Supplies

Power supply #1 (PS#1): a power supply capable of supplying 20 V at 1 A is required.

Power supply #2 (PS#2): a power supply capable of supplying 3.3 V at 0.2 A is required.

2.1.2 Load #1

A 20-V (or above), 10-A (or above) electronic load that can operate at constant current mode.

2.1.3 Load #2

A Kepco BOP36-12M, 0 ≈±36 V / 0 ≈±12 A, bipolar operational power supply

Or: equivalent

2.1.4 Meters

Six Fluke 75 multimeters, (equivalent or better)

Or:

Four equivalent voltage meters and three equivalent current meters.

The current meters must be capable of measuring 5 A+ current.

2.1.5 Computer

A computer with at least one USB port and a USB cable. The EV2400 USB driver and the bq2477x SMB evaluation software must be properly installed.

2.1.6 Software

The bq2477x ICs are all compatible with the EV2300 hardware kit, but it is preferred to use the EV2400. There are two setup GUI install programs, the bq24770 Evaluation Software-2.0.0.2-Setup.exe (used for all SMB spins) program and the bq24773 Evaluation Software-2.0.0.2-Setup.exe program (used just for the I2C bq24773 version).

The launch executable file will load the EV2300 software first, followed by the bq2477x software. Verify if the GUI is configured for SMB or I2C by looking at the Mode listed above the Texas Instruments logo.

Now is a good time to copy the two GUI setup files to your hard drive and then run as administrator (right click on the file and select "Run as administrator") to install the GUI software, prior to connecting the hardware.

2.1.7 EV2400 Controller

The EV2400 controller is an MSP430F5529 running at 4 MHz. The controller firmware is stored in flash memory and is executed by the core at power-up. The controller communicates with target device(s) through either: a 2-wire SMBus communication port, a 1-wire HDQ port, or a 2-wire EEPROM I2C port. The 2-wire SMBus communication port supports both SMBus and I2C protocols. CRC-8 checksum verification for the data packets prevents data corruption over the USB. The controller interfaces with the computer through a USB port. Device software (GUI) loaded on the computer is used to communicate with the device via the EV2400 controller to write and read registers on the device.

2.2 Equipment Setup

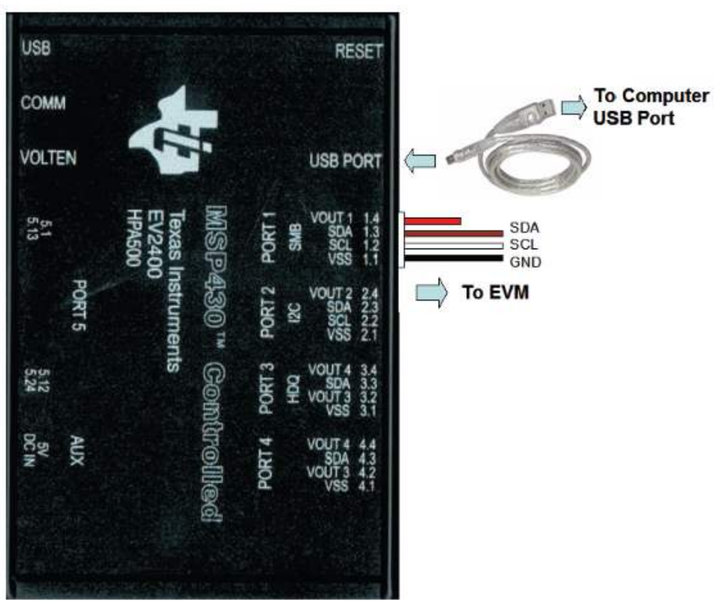
1. Set PS#1 for 0-V ±100 mV_{DC}, with the current limit set to > 5 A and then turn off the supply.
2. Connect the positive lead for PS#1 to J1-Vin and the negative lead to J1-GND via a current meter as shown in Figure 3.
3. Connect a voltage meter across J1 (V_{IN}, GND).
4. Set the power supply #2 for 3.3 V ±100 mVDC, 0.2 ±0.5 A current limit and then turn off supply.
5. Connect the output of the PS#2 to J5 (3.3 V) and J6 (GND).
6. Connect a voltage meter across J3 (BAT, GND).
7. Connect a voltage meter across J2 (SYS, GND).
8. It is preferred to use the EV2400, but one can use the EV2300 kit. The EV2400 and EV2300 kits have both SMB and I2C ports. The I2C port should be used to communicate with a bq24773 device and all other SMB IC spins should use the SMB port for communication.

   For the bq24773 I2C EVM, one should setup and use the bq24773 I2C GUI software and all the SMB IC spins should use the bq24770 SMB GUI setup software. See Section 2.1.6 for information on the two types of GUI software.

   Connect J5 (SDA, SCL) and J5 (GND) to the EV2400/EV2300 kit “SMB” port for bq24770 and bq24777 and to the “I2C" port for bq24773. Refer to Table 3 for a connection reference. Connect the USB port of the EV2400/2300 kit to the USB port of the computer. The connections for the SMB setup are shown in Figure 1 and Figure 2.

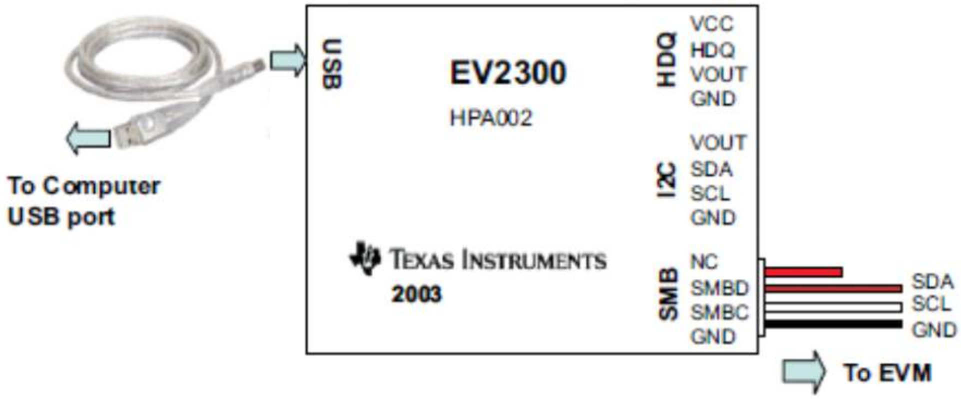
Table 3. EV2400 and bq2477x EVM Connections

bq2477xEVM-540	EV2400
GND (J5)	VSS 1.1
SCL (J5)	SCL 1.2
SDA (J5)	SDL 1.3



The connection on **Port 1** is for bq24770/7. Move the connector to **Port 2** for the bq24773.

Figure 1. SMB Connections of the EV2400 Kit



The **SMB** connection is for bq24770/7. Move the connector to **I2C** for the bq24773.

Figure 2. SMB Connections of the EV2300 Kit

9. Set toggle switch "S1" as per Section 1.3.

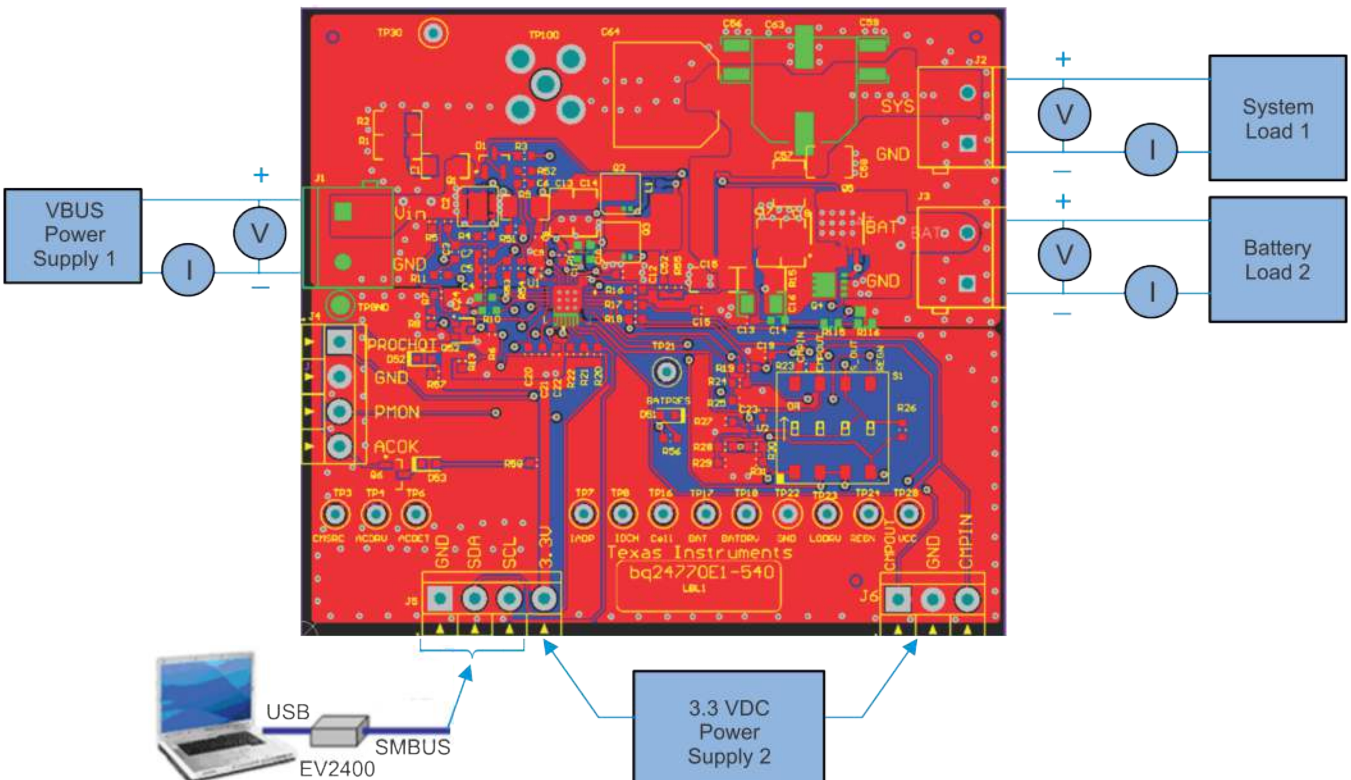


Figure 3. Original Test Setup for PWR540 (bq2477xEVM)

10. Turn on the computer. Launch the bqstudio evaluation software and select charger and 00-bq24770.bqz or 00-bq24773.bqz file. Examples of the GUI "SMB" software window prior to reading the registers and after reading the registers are shown in Figure 4 and Figure 6, respectively. Examples of the GUI "I2C" software window prior to reading the registers and after reading the registers are shown in Figure 5 and Figure 7, respectively. Make sure the address is 0x12 (for SMB mode) and 0xD4 (for I2C Mode) by clicking on Settings → SMB address. Change if necessary and click OK. The values will be read later in the procedure, after PS#2 is powered.

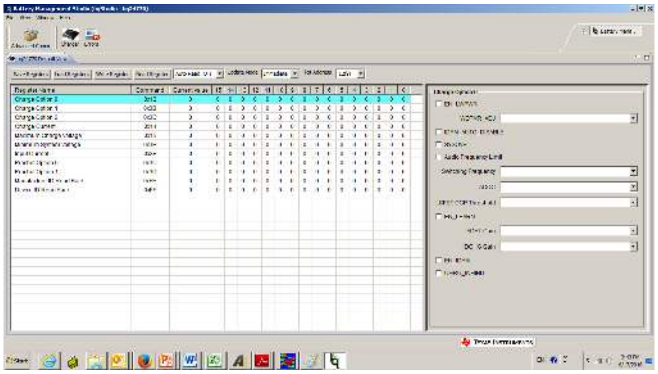


Figure 4. bq2477x GUI "SMB" Software Window Prior to Reading Registers

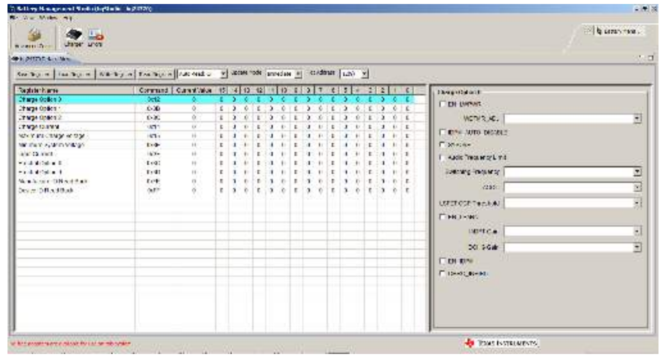


Figure 5. bq2477x GUI “I2C” Software Prior to Reading Registers

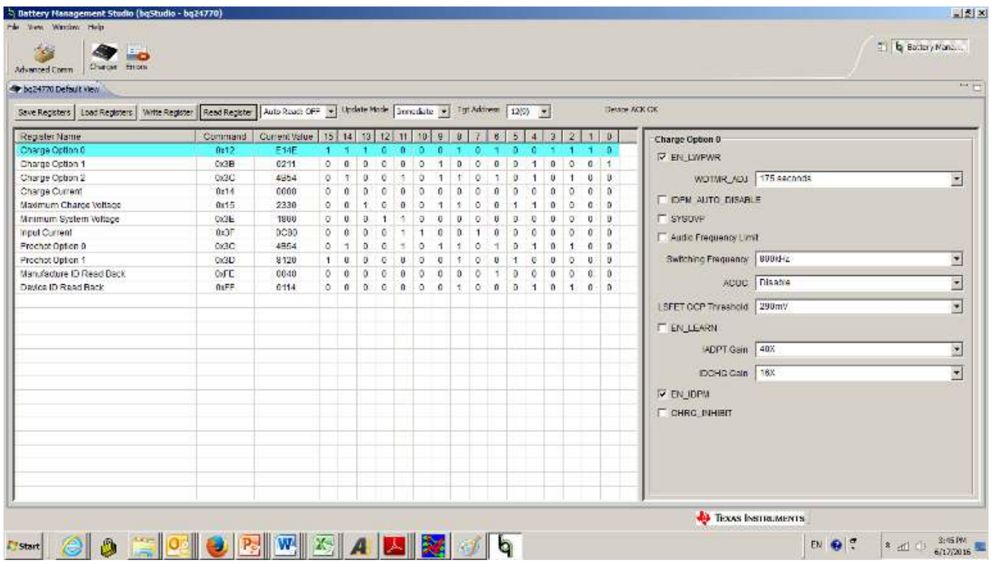


Figure 6. bq2477x GUI "SMB" Software Window (Three Cells Reading) After Reading Registers

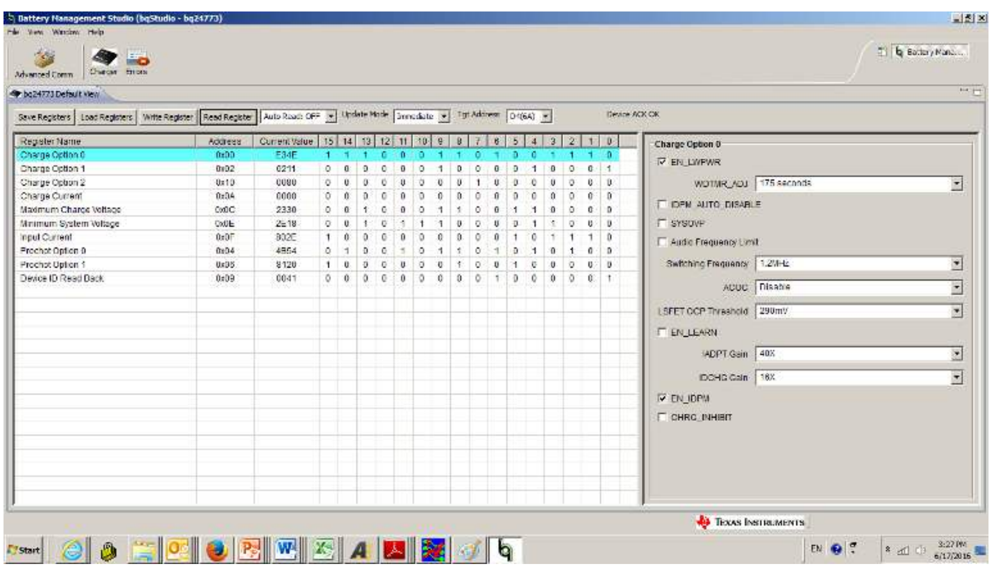


Figure 7. bq2477x GUI “I2C” (Two Cells Reading) Software After Reading Registers

2.2.1 Good Things To Know Going Forward to Help with Troubleshooting

There are a few signals to remember if you are having trouble and may solve your issue by verifying:

ACDET (TP7) should be around 2.6 V

REGN (TP15) should be around 5.5 V

VCC (TP16) should be around the input voltage applied

BATPRES (Measured at S1-2) should be low to indicate battery is present to allow charging. If using U2 as the BATPRES Comparator, the bias R31/R38 may not be set correctly for the number of cells you are using. If using the internal comparator R32/R39 may not be set correctly.

CELLS (TP11) may not be biased correctly, R26/R30. Wrong setting may overvoltage the battery pack.

The battery load connection has to be able to supply the voltage that it is programmed to for the BATPRES circuit to detect the battery present.

3 Procedure

3.1 Power-Up And Initial Checks

3.1.1 Make Sure EQUIPMENT SETUP steps are followed. Turn on PS#2.

NOTE: Load #1 and Load #2 are not connected during this step.

3.1.2 Turn on PS#1

Increase the output voltage of PS#1 to 19.5 V and measure values with regard to GND.

NOTE: The System reading is a function of the bias on the CELLS pin. Low represents 1 cell, float – 2 cell, and high 3 and 4 cells. The EVM may be set up with DNP on the bias divider, which would float the CELLS pin and program it to be 2 cells. This bias should be set prior to powering the EVM to get the correct readings below. One can leave floating, ground, or pull to 3.3 V via the Cells Test Point.

3.1.3 Verify the following default power-up parameters

Measure → V(TP11(CELLS)) = < 0.3 V for 1 cell, ≈1.4 V (float) for 2 cells and > 3 V for 3 and 4 Cells. Correct bias if necessary, remove and repower input.

Measure → V(TP7 (ACDET)) = 2.6 V ±0.1 V

Verify → D5 LED (ACOK) is LIT

Measure → V(TP15 (REGN)) = 5.5 V ±0.5 V

Measure → V(J3(BAT, GND)) = 1 V ±1.1 V

Measure → V((TP6(ACDRV) with regard to TP5 (CMSRC)) = 6 V ±0.5 V

Measure System Voltage for the number of cells the EVM is programmed for:

For 1 cell Setting → V(J2(SYS)) = 4.4 V ±0.2 V

For 2 cell Setting → V(J2(SYS)) = 9.2 V ±0.4 V

For 3/4 cells setting → V(J2(SYS)) = 13.5 V ±0.6 V

3.1.4 Default Parameters Setting

Click on Actions and Read all Registers in the GUI software. Make sure there is no error information generated. Verify reading for Figure 6 settings. Skip Section 3.2 if no errors exist. If there is error information window pop up: “USB Error. Insure USB cable is connected and Driver is working”. Please do the following step:

(a) Click OK and then close the main window that shows as Figure 6 and disconnect USB cable.

(b) Check 3.3-V power supply (PS#2) and power supply #1 (PS#1) voltage on the EVM board.

(c) Disconnect other unsure SMBus connection. Plug in USB cable back to the original EVM2400 installation USB port.

(d) Open the bq2477x_GUI evaluation software. The main window of the software is shown in Figure 6.

3.2 Charge Regulation and System Load Checks

1. For SMB Mode: type in “810E” into the 0x12 address, for I2C Mode type in E20E into the 01/11 address and click *Write*.
2. Connect the Load #2 in series with a current meter (multi-meter) to J3 (BAT, GND). Make sure a voltage meter is connected across J3 (BAT, GND). Turn on the Load #2. Use the constant voltage mode. Set the output voltage to 3.7 V for one cell, 7 V for 2 cells, 10 V for 3 and 4 cells.
3. Turn on the power of the Load #1. Set the load current to 1.0 A ±50 mA but disable the output. Connect the output of the Load #1 in series with a current meter (multi-meter) to J2 (SYS, GND). Make sure a voltage meter is connected across J2 (SYS, GND). Turn on Load #1. The setup is now like Figure 3 for PWR540.
4. Type in “3008” (mA) in the Charge Current DAC and click “Write”. This sets the battery charge current regulation threshold to 3.008 A and starts charging.
   - **Measure** → Ibat = 3000 mA ±300 mA
5. Click the “Actions” tab and Select Read all Registers and verify the correct MaxChargeVoltage and MinSystemVoltage for the cells setting on the EVM board.
   - 1S Cell (Cell pin low): Max Charge Voltage: 4208 mV; Min System Voltage: 3584 mV
   - 2S Cell (Cell pin float): Max Charge Voltage: 8400 mV; Min System Voltage: 6144 mV
   - 3S and 4S Cell (High): Max Charge Voltage: 21608 mV; Min System Voltage: 9216 mV

3.3 Input DPM Check

1. Measure the input current and verify it is well below the input current setting (SMB: 0x3F, I2C: 0x0F).
2. Program the input current setting (SMB: 0x3F, I2C: 0x0F) for 1152 mA.
3. Verify the charger has entered IDPM, giving priority to the system load and reducing the charge current.
   - **Measure** → I_{SYS} = 1000 mA ±100 mA
   - **Measure** → I_{BAT} = 1.25 A ±0.25 A (2S cell setting)

NOTE: Actual measured input current, when in input IDPM, is typically 20% less than the programmed value and does vary depending on the input ripple which is a function of Input/Output voltage and VBUS and PMID capacitance.

4. Turn off Load #2.

3.4 Equipment Shutdown

Turn off all the power supplies and remove connections to EVM.

4 PCB Layout Guideline

The switching node rise and fall times should be minimized for minimum switching loss. Proper layout of the components to minimize high frequency current path loop is important to prevent electrical and magnetic field radiation and high frequency resonant problems. Here is a PCB layout priority list for proper layout. Layout PCB according to this specific order is essential.

1. Place input capacitor as close as possible to switching MOSFET's supply and ground connections and use shortest copper trace connection. These parts should be placed on the same layer of PCB instead of on different layers and using vias to make this connection.
2. The IC should be placed close to the switching MOSFET's gate terminals and keep the gate drive signal traces short for a clean MOSFET drive. The IC can be placed on the other side of the PCB of switching MOSFETs.
3. Place inductor input terminal to switching MOSFET's output terminal as close as possible. Minimize the copper area of this trace to lower electrical and magnetic field radiation but make the trace wide enough to carry the charging current. Do not use multiple layers in parallel for this connection. Minimize parasitic capacitance from this area to any other trace or plane.
4. The charging current sensing resistor should be placed right next to the inductor output. Route the sense leads connected across the sensing resistor back to the IC in same layer, close to each other (minimize loop area) and do not route the sense leads through a high-current path. Place decoupling capacitor on these traces next to the IC.
5. Place output capacitor next to the sensing resistor output and ground.
6. Output capacitor ground connections need to be tied to the same copper that connects to the input capacitor ground before connecting to system ground.
7. Use single ground connection to tie charger power ground to charger analog ground. Just beneath the IC use analog ground copper pour but avoid power pins to reduce inductive and capacitive noise coupling.
8. Route analog ground separately from power ground. Connect analog ground and connect power ground separately. Connect analog ground and power ground together using power pad as the single ground connection point. Or using a 0-Ω resistor to tie analog ground to power ground (power pad should tie to analog ground in this case if possible).
9. Decoupling capacitors should be placed next to the IC pins and make trace connection as short as possible.
10. It is critical that the exposed power pad on the backside of the IC package be soldered to the PCB ground. Ensure that there are sufficient thermal vias directly under the IC, connecting to the ground plane on the other layers.

5 Board Layout, Schematic, and Bill of Materials

5.1 Bill of Materials

Table 4 contains the bill of materials.

Table 4. bq2477xEVM Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		PWR540	Any
C1, C19, C22, C30	4	1uF	CAP, CERM, 1uF, 25V, +/-10%, X7R, 0603	0603	GRM188R71E105KA12D	MuRata
C2, C3, C21, C23	4	10uF	CAP, CERM, 10uF, 25V, +/-10%, X5R, 1206	1206	GRM31CR61E106KA12L	MuRata
C4	1	100uF	CAP, OS-CON, 100uF, 20V, +/-20%, 0.024 ohm, 8x10 SMD	8x10	20SVP100M	Sanyo
C6	1	2.2uF	CAP, CERM, 2.2uF, 25V, +/-10%, X7R, 1206	1206	GRM31MR71E225KA93L	MuRata
C7, C8, C9, C10	4	22uF	CAP, CERM, 22uF, 25V, +/-10%, X5R, 1210	1210	GRM32ER61E226KE15L	MuRata
C14, C16, C17, C24, C25, C28, C31, C33	8	0.1uF	CAP, CERM, 0.1uF, 25V, +/-10%, X7R, 0603	0603	GRM188R71E104KA01D	MuRata
C18	1	2200pF	CAP, CERM, 2200pF, 25V, +/-10%, X7R, 0603	0603	GRM188R71E222KA01D	MuRata
C20	1	0.047uF	CAP, CERM, 0.047uF, 25V, +/-10%, X7R, 0603	0603	GRM188R71E473KA01D	MuRata
C29	1	470pF	CAP, CERM, 470pF, 50V, +/-5%, C0G/NP0, 0603	0603	GRM1885C1H471JA01D	MuRata
C32	1	0.01uF	CAP, CERM, 0.01uF, 25V, +/-10%, X7R, 0603	0603	GRM188R71E103KA01D	MuRata
C36, C37, C38	3	100pF	CAP, CERM, 100pF, 50V, +/-5%, C0G/NP0, 0603	0603	C0603C101J5GAC	Kemet
D2	1	0.65V	Diode, Schottky, 30V, 0.2A, SOT-23	SOT-23	BAT54C-7-F	Diodes Inc.
D3, D4, D5	3	Green	LED, Green, SMD	1.6x0.8x0.8mm	LTST-C190GKT	Lite-On
J1, J2, J3	3		TERMINAL BLOCK 5.08MM VERT 2POS	TERM_BLK, 2pos, 5.08mm	ED120/2DS	On-Shore Technology, Inc.
J4, J5	2		Terminal Block, 6A, 3.5mm Pitch, 4-Pos, TH	14x8.2x6.5mm	ED555/4DS	On-Shore Technology, Inc.
J6	1		Terminal Block, 6A, 3.5mm Pitch, 3-Pos, TH	10.5x8.2x6.5mm	ED555/3DS	On-Shore Technology, Inc.
L1	1	2.2uH	Inductor, Shielded, Powdered Iron, 2.2 µH, 10.5 A, 0.0137 ohm, SMD	322x158x322mil	IHLP3232DZER2R2M01	Vishay-Dale
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady
Q1	1	30V	MOSFET, N-CH, 30V, 27A, SON 3.3x3.3mm	SON 3.3x3.3mm	CSD87312Q3E	Texas Instruments
Q2, Q5	2	30V	MOSFET, N-CH, 30V, 47A, SON 3.3x3.3mm	SON 3.3x3.3mm	CSD17308Q3	Texas Instruments
Q3	1	-20V	MOSFET, P-CH, -20 V, -60 A, VSON-CLIP-8	DQG0008A	CSD25401Q3	Texas Instruments
Q6	1	50V	MOSFET, N-CH, 50V, 0.2A, SOT-323	SOT-323	BSS138W-7-F	Diodes Inc.
Q8	1	60V	MOSFET, N-CH, 60V, 0.26A, SOT-23	SOT-23	2N7002ET1G	ON Semiconductor
R1, R5	2	0.01	RES, 0.01 ohm, 1%, 1W, 1206	1206	WSLP1206R0100FEA	Vishay-Dale
R2, R3	2	3.9	RES, 3.9 ohm, 5%, 0.25W, 1206	1206	CRCW12063R90JNEA	Vishay-Dale
R4, R8, R9, R18, R20, R21, R29	7	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R6	1	4.7	RES, 4.7 ohm, 5%, 0.1W, 0603	0603	CRCW06034R70JNEA	Vishay-Dale
R10	1	430k	RES, 430k ohm, 1%, 0.1W, 0603	0603	RC0603FR-07430KL	Yageo America
R12, R13	2	4.02k	RES, 4.02k ohm, 1%, 0.1W, 0603	0603	CRCW06034K02FKEA	Vishay-Dale
R14	1	316k	RES, 316k ohm, 1%, 0.1W, 0603	0603	CRCW0603316KFKEA	Vishay-Dale
R15, R27, R39, R41	4	100k	RES, 100k ohm, 1%, 0.1W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale

Table 4. bq2477xEVM Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
R16	1	10.0	RES, 10.0 ohm, 1%, 0.25W, 1206	1206	CRCW120610R0FKEA	Vishay-Dale
R17	1	66.5k	RES, 66.5k ohm, 1%, 0.1W, 0603	0603	CRCW060366K5FKEA	Vishay-Dale
R22, R28, R33, R35, R36, R37	6	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R23	1	10.0	RES, 10.0 ohm, 1%, 0.1W, 0603	0603	CRCW060310R0FKEA	Vishay-Dale
R24	1	0	RES, 0 ohm, 5%, 0.125W, 0805	0805	CRCW08050000Z0EA	Vishay-Dale
R31	1	499k	RES, 499k ohm, 1%, 0.1W, 0603	0603	CRCW0603499KFKEA	Vishay-Dale
R32	1	140k	RES, 140k ohm, 1%, 0.1W, 0603	0603	CRCW0603140KFKEA	Vishay-Dale
R34	1	30.1k	RES, 30.1k ohm, 1%, 0.1W, 0603	0603	CRCW060330K1FKEA	Vishay-Dale
R38	1	49.9k	RES, 49.9k ohm, 1%, 0.1W, 0603	0603	CRCW060349K9FKEA	Vishay-Dale
R40	1	3.0Meg	RES, 3.0Meg ohm, 5%, 0.1W, 0603	0603	CRCW06033M00JNEA	Vishay-Dale
R42	1	1.00Meg	RES, 1.00Meg ohm, 1%, 0.1W, 0603	0603	CRCW06031M00FKEA	Vishay-Dale
R43, R44, R45	3	2.00k	RES, 2.00k ohm, 1%, 0.1W, 0603	0603	CRCW06032K00FKEA	Vishay-Dale
R46	1	3.01Meg	RES, 3.01Meg ohm, 1%, 0.1W, 0603	0603	CRCW06033M01FKEA	Vishay-Dale
S1	1		DIP Switch, 4 position slide actuator, SPST, SMD	SMT DIP switch	A6S-4104-H	Omron Electronic Components
TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16	15		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1	1		NVDC Battery Charge Controller with SMBus, RUY0028A	RUY0028A	bq24770RUY	Texas Instruments
U2	1		Single-Channel, Adjustable Supervisory Circuit in Ultra-Small Package, DRY0006A	DRY0006A	TPS3898ADRY	Texas Instruments
C5	0	100uF	CAP, OS-CON, 100uF, 16V, +/-20%, 0.035 ohm, 10x10.3 SMD	10x10.3	16SVP100M	Sanyo
C11, C12, C13	0	22uF	CAP, CERM, 22uF, 25V, +/-10%, X5R, 1210	1210	GRM32ER61E226KE15L	MuRata
C15, C34	0	0.1uF	CAP, CERM, 0.1uF, 25V, +/-10%, X7R, 0603	0603	GRM188R71E104KA01D	MuRata
C26, C27	0	10uF	CAP, CERM, 10uF, 25V, +/-10%, X5R, 1206	1206	GRM31CR61E106KA12L	MuRata
C35	0	0.01uF	CAP, CERM, 0.01uF, 25V, +/-10%, X7R, 0603	0603	GRM188R71E103KA01D	MuRata
D1	0	0.65V	Diode, Schottky, 30V, 0.2A, SOT-23	SOT-23	BAT54-7-F	Diodes Inc.
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
Q4	0	-20V	MOSFET, P-CH, -20V, 60A, PowerPAK SO-8	PowerPAK SO-8	SI7139DP-T1-GE3	Vishay-Semiconductor
Q7	0	30V	MOSFET, N-CH, 30V, 27A, SON 3.3x3.3mm	SON 3.3x3.3mm	CSD87312Q3E	Texas Instruments
R7, R11, R25, R26, R30	0	10.0M	RES, 10Meg ohm, 5%, 0.1W, 0603	0603	CRCW060310M0JNEA	Vishay-Dale
R19	0	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
TP1	0		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00	Tektronix

5.2 Schematic

Figure 8 illustrates the schematic for this EVM.

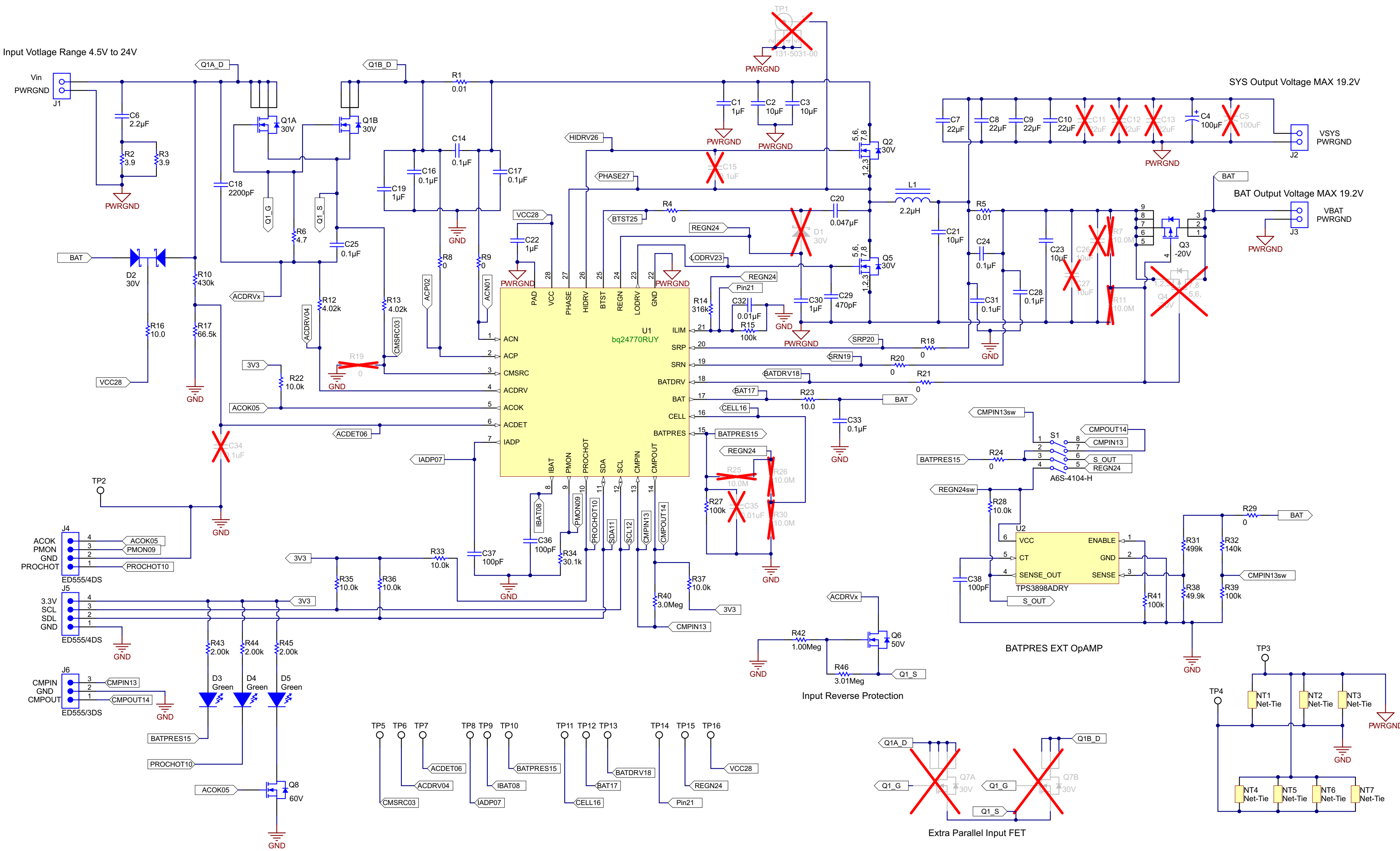


Figure 8. bq2477xEVM Schematic

5.3 Board Layout

Figure 9 through Figure 13 illustrate the board layouts for this EVM.

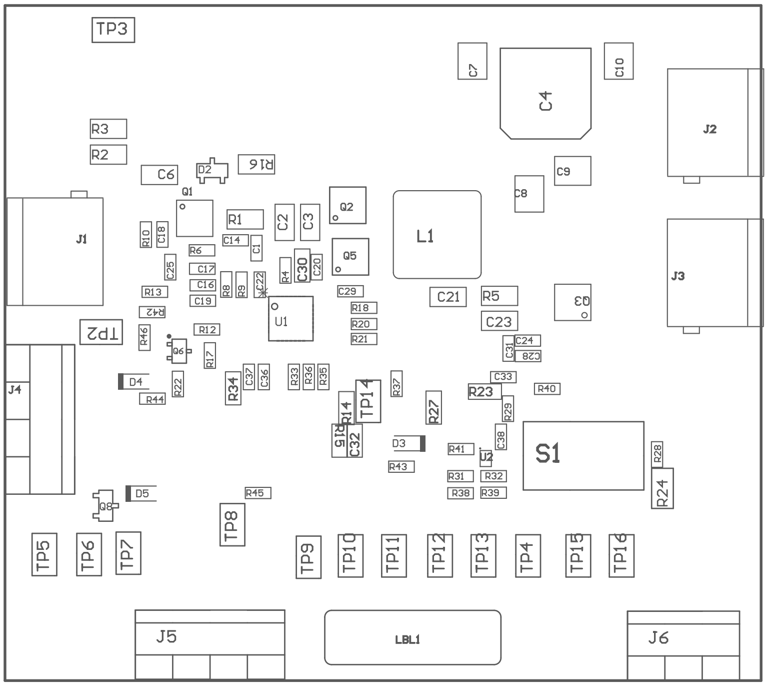


Figure 9. bq2477xEVM Assembly Layer

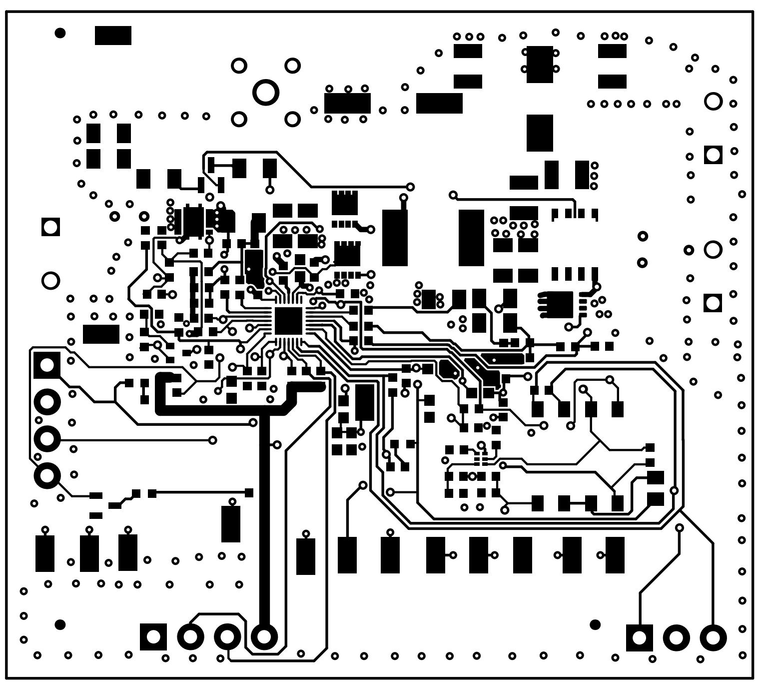


Figure 10. bq2477xEVM Top Layer

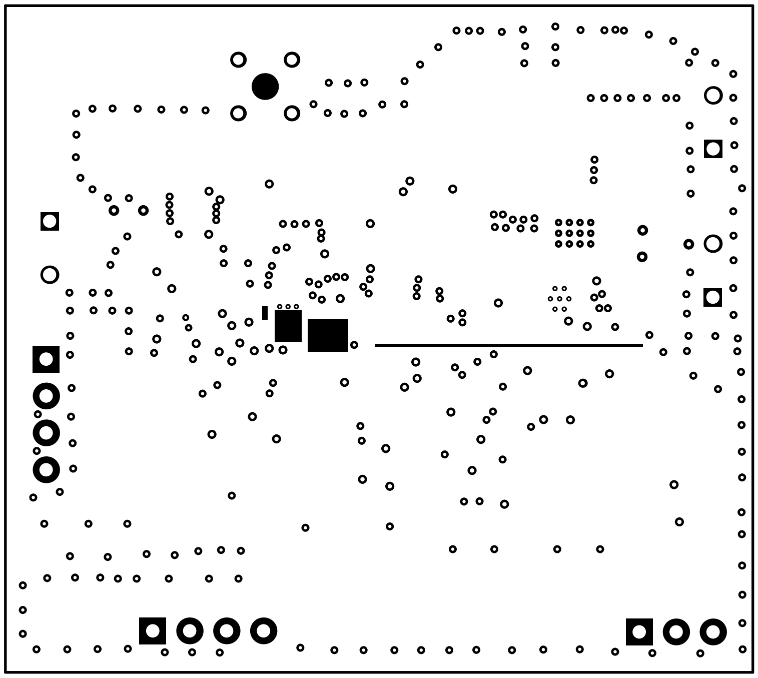


Figure 11. bq2477xEVM Layer 2

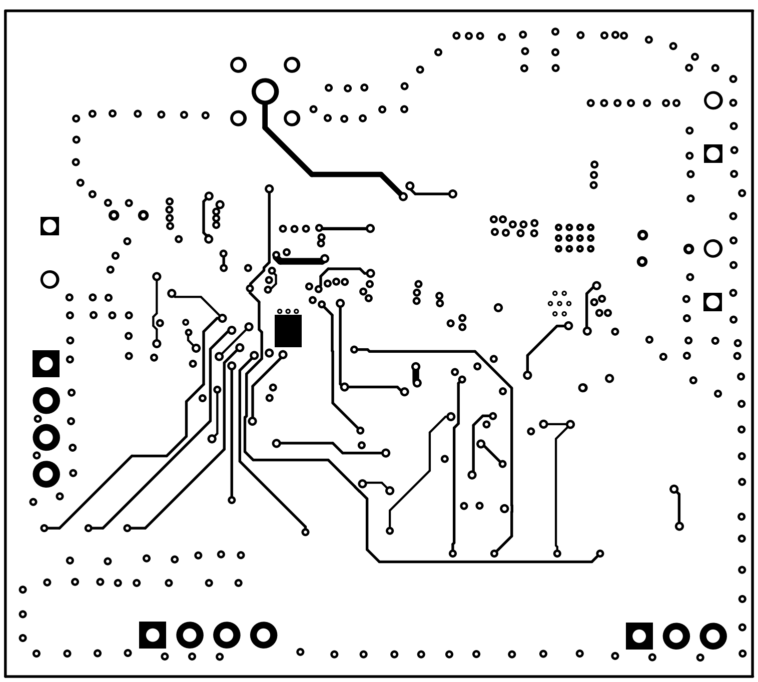


Figure 12. bq2477xEVM Layer 3

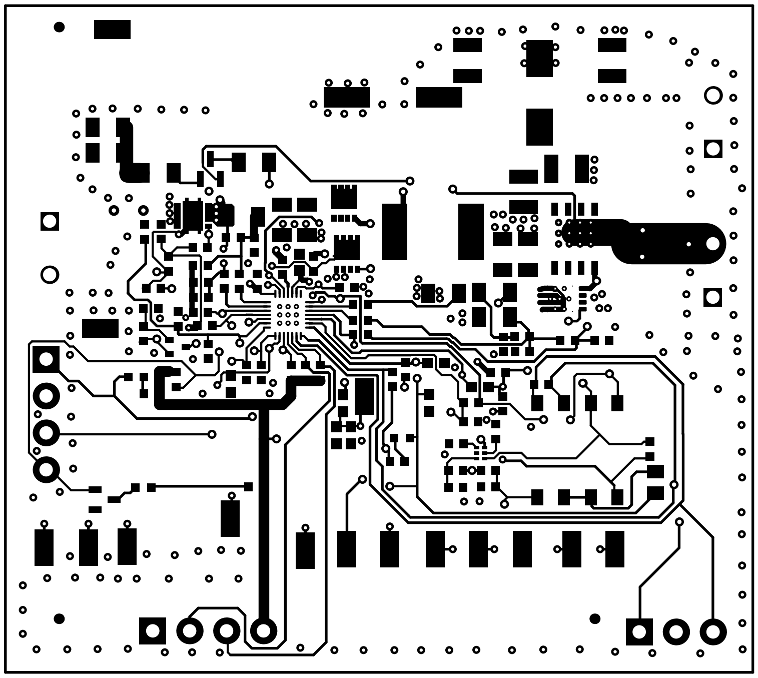


Figure 13. bq2477xEVM Bottom Layer

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from B Revision (July 2016) to C Revision **Page**

- Changed TP6 To: TP7, TP24 To: TP15, TP28 To: TP16, and TP16 To: TP11 in Section 2.2.1 8
- Changed R28/R29 To: R31/R38, R30/R31 To: R32/R39, and R24/R25 To: R26/R30 in Section 2.2.1 8
- Changed V(TP16(CELLS)) To: V(TP11(CELLS)), V(TP6 (ACDET)) To: V(TP7 (ACDET)), D53 LED (ACOK) To: D5 LED (ACOK), V(TP24 (REGN)) To: V(TP15 (REGN)), V((TP4(ACDRV) To: V((TP6(ACDRV), TP3 (CMSRC) To: TP5 (CMSRC) in Section 3.1.3 8
- Replaced Table 4, *Bill of Materials* 11
- Replaced Figure 8, *Schematic* image 13
- Replaced Figure 9 through Figure 13, *Board Layout* 14

Revision History

Changes from A Revision (June 2016) to B Revision **Page**

- Changed Table 4, *Bill of Materials* to PWR540B. 11
- Changed *Schematic* image to PWR540B. 13
- Changed all *Board Layout* images to PWR540B. 14

Revision History

Changes from Original (July 2015) to A Revision **Page**

- Changed Step 10 of *Section 2.2* 6
- Changed Figure 4 through Figure 7 of *Section 2.2* 7

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

      Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

      FCC Interference Statement for Class A EVM devices

      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d’usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered “Radio Frequency Products” in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry’s Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265