EVM User's Guide: BQ25856EVM
BQ25856 Evaluation Module

Description

The BQ25856EVM evaluation module (EVM) is a complete evaluation system for the BQ25856 IC, a buck-boost battery charge controller with a wide input range of 4.2V - 70V, a wide output voltage range of up to 70V, bi-directional capabilities, and AEC-Q100 qualification.

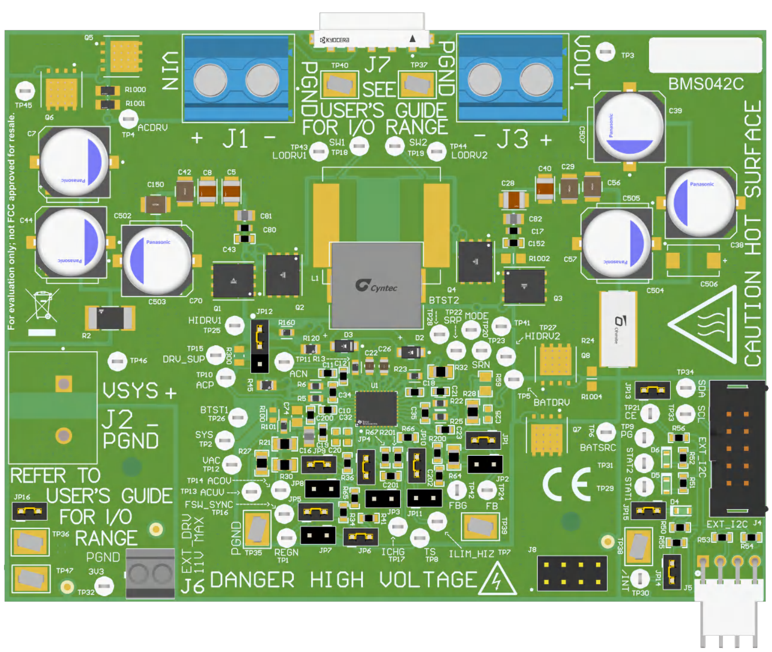
The BQ25856EVM has a max input and output of 55V and a max charge current of 10A.

Get Started

1. Order the EVM on ti.com
2. Order the EV2400 to communicate with the EVM
3. Download the BQ25856 BQZ file
4. Download the BQ25856 EVM design files on ti.com

Features

- Wide input voltage operating range: 4.2 V–55 V
- Wide output operating range: up to 55V with CC/CV support for:
  - 2– to 13–Cell Li-Ion
  - 2– to 14–Cell LiFePO4
- Synchronous buck-boost DC/DC charge controller with NFET drivers
  - Adjustable switching frequency from 200kHz to 600kHz
  - Optional synchronization to external clock
  - Optional gate driver supply input for optimized efficiency
- Resistor-programmable standalone with added I2C Mode
- Built in MPPT to maximize power from solar panel arrays
- Power up from battery (reverse mode) output 4V to 55V
- High safety integration
  - Adjustable input overvoltage and undervoltage protection
  - Output Overvoltage and overcurrent protection
- AEC-Q100 qualification



1 Evaluation Module Overview

1.1 Introduction

The BQ25856EVM can be evaluated for the full 240 W range of USB Extended Power Range (EPR) and up to 13 cell Li-Ion battery charging implementing CC/CV profile. Typical applications include USB-PD extended power range applications, docking station, monitor, and dual-battery charging.

This EVM does not include the EV2400 or USB2ANY interface device and does not provide any electrical isolation for the digital interfaces. EV2400 or USB2ANY must be ordered separately to evaluate the BQ25856EVM and electrical safety considerations must be considered when interfacing between the PC and the EVM board. When interfacing the EVM to the PC through the digital interfaces, digital isolators with isolation boundary is recommended.

The BQ25856EVM has smaller clearance and creepage than normally used on high voltage boards as well as not having an isolation boundary. If applying high voltage to this board, then all terminals must be considered high voltage and hazardous live. Electric shock is possible when connecting the board to live wire. The board must be handled with care by a professional. For safety, use of isolated test equipment with various protection features (such as overvoltage and overcurrent) is recommended.

1.2 Kit Contents

This EVM kit includes:

- 1 BQ25856 EVM

1.3 Device Information

The BQ25856EVM evaluation module (EVM) is an evaluation system for the BQ25856 IC. The BQ25856 IC is a buck-boost battery charge controller with a wide input range of 4.2V - 70V, a wide output voltage range of up to 70V, and bi-directional capabilities.

The device offers high-efficiency battery charging over a wide voltage range with output CC-CV control. The device integrates all the loop compensation for the buck-boost converter, thereby providing a high density method with ease of use.

Besides the I2C host-controlled charging mode, the device also supports programmable hardware limits. Input current, and output current regulation targets can be set with single resistor on the IIN, and IOUT pins, respectively.

1.4 General Texas Instruments High Voltage Evaluation (TI HV EMV) User Safety Guidelines

WARNING

Always follow TI's set-up and application instructions, including use of all interface components within the recommended electrical rated voltage and power limits. Always use electrical safety precautions to help verify your personal safety and those working around you. Contact TI's Product Information Center http://ti.com/ customer support for further information.

Save all warnings and instructions for future reference.

> **WARNING**
> Failure to follow warnings and instructions can result in personal injury, property damage or death due to electrical shock and burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is *intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments.* If you are not suitably qualified, then you need to immediately stop from further use of the HV EVM.

1. Work Area Safety:
   a. Keep work area clean and orderly.
   b. Qualified observers must be present anytime circuits are energized.
   c. Effective barriers and signage must be present in the area where the TI HV EVM and the interface electronics are energized, indicating operation of accessible high voltages can be present, for the purpose of protecting inadvertent access.
   d. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
   e. Use stable and non-conductive work surface.
   f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
2. Electrical Safety:
   a. As a precautionary measure, a good engineering practice to assume is that the entire EVM can have fully accessible and active high voltages.
   b. De-energize the TI HV EVM and all the inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   c. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
   d. Once EVM readiness is complete, energize the EVM as intended.

   > **WARNING**
   > While the EVM is energized, never touch the EVM or the electrical circuits, as the electrical circuits and EVM can be at high voltages capable of causing electrical shock hazard.
3. Personal Safety
   a. Wear personal protective equipment e.g. latex gloves or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.

Limitation for safe use:

EVMs are not to be used as all or part of a production unit.

1.4.1 General Safety Information

The following warnings and cautions are noted for the safety of anyone using or working close to the BQ25756EVM. Observe all safety precautions.

Warning

The BQ25756EVM circuit module can become hot during operation due to dissipation of heat. Avoid contact with the board. Follow all applicable safety procedures applicable to your laboratory.

> **CAUTION**
> Hot surface. Contact can cause burns. Do not touch!

Warning

The BQ25756EVM has smaller clearance and creepage than normally used on high voltage boards as well as not having an isolation boundary. If the user applies high voltage to this board, then all terminals are considered high voltage and hazardous live. Electric shock is possible when connecting the board to live wire. The board needs to be handled with care by a professional. For safety, use of isolated test equipment with various protection features (such as overvoltage and overcurrent) is recommended.

Warning

High voltages that can cause injury exist on this evaluation module (EVM). Please verify all safety procedures are followed when working on this EVM. Never leave a powered EVM unattended.

Warning

High voltage can be present on board capacitors after power down. Properly check and discharge all on-board energy reservoir after EVM power down.

Caution

Do not leave EVM powered when unattended.

> **CAUTION**
> The communication interfaces are not isolated on the EVM. The use of digital isolators is recommended. Verify all high voltage safety precautions are observed during testing.

> **CAUTION**
> Connections for rated current must be made at the terminal block. Test points are not rated for the board current.

> **CAUTION**
> The circuit module can be damaged by over temperature. To avoid damage, monitor the temperature during evaluation and provide cooling, as needed, for your system environment. Do not operate beyond the current and voltage limits in the Section 2.3.

> **CAUTION**
> Test equipment can be damaged by application of external voltages. Check your equipment requirements and use blocking diodes or other isolation techniques, as needed, to prevent damage to your equipment.

> **CAUTION**
> The circuit module has signal traces, components, and component leads on the bottom of the board. This can result in exposed voltages, hot surfaces or sharp edges. Do not reach under the board during operation.

CAUTION
The default settings of the BQ25756 is possibly not designed for the user's application. Verify the EVM settings are set appropriately for test setup before device power up. Set all protections appropriately and limit current for safe operation.

CAUTION
The board has no fuse installed and relies on the external voltage source current limit to verify circuit protection.

2 Hardware

2.1 Board Parameters

Table 2-1. Default Board Setup for BQ25856EVM

	Description	Value	Unit
ACUV	Input undervoltage	4.2	V
ACOV	Input overvoltage	55	V
ILIM_HIZ	Input current of the EVM	8	A
ICHG	Output current of the EVM	10	A
FSW_SYNC	Switching frequency of the power stage	250	KHz
VBAT_REG	Battery charge voltage	14.4	V
IAC Sense Resistor	Input current sense resistor	2	mΩ

Table 2-2. PCB and Mechanical Parameters

	Value	Unit
Board size (X dimension, or length)	112	mm
Board size (Y dimension, or width)	84	mm
IC + power stage max height	5	mm
Total copper layers	6	layer
Copper weight per layer	2	oz
Total board thickness	62	mil

2.2 IO and Jumper Descriptions

Table 2-3. Connector/Port Description

Jack	Description
J1-VIN	Input: positive terminal
J1-PGND	Input: negative terminal (ground terminal)
J3-VOUT	Connected to battery pack output
J3-PGND	Ground
J4-EXT_I2C	Communication port for the USB2ANY
J5-I2C	Communication port for the EV2400
J6-EXT_DRV	Connection for external gate drive
J7-Power Connector	Connection for VAC and BAT
J8-Communication Port	Connection for EXT_DRV, /INT, I2C, /PG, and 3.3V

Table 2-4. Jumper Description

Jumper	Description	Factory Default
JP1	Use JP1 to connect the default feedback resistor and set the charger to the default 7 cell battery.	Installed
JP2	Use JP2 to connect a new feedback resistor to program a different cell count.	Not installed
JP3	Use JP3 to connect external ICHG resistor. JP3 can be shorted to PGND to disable hardware output current limiting.	Not installed
JP4	Shunt JP4 to use default ICHG resistor. By closing JP4, the default ICHG current is set to 10A.	Installed
JP5	Shunt JP5 to bias TS.	Installed
JP6	With JP5 shunted (REGN connected for voltage divider). Shunt JP6 to set TS status to normal.	Installed
JP7	With JP5 shunted (REGN connected for voltage divider). Use JP7 to connect external resistor to change TS status.	Not installed
JP8	Use JP8 to connect external FSW_SYNC resistor.	Not installed
JP9	Shunt JP9 to use default FSW_SYNC resistor. By closing JP9, the default switching frequency is set to 250kHz.	Installed
JP10	Shunt JP10 to use default ILIM_HIZ resistor. By closing JP10, the maximum input current is set to 8A.	Installed
JP11	Use JP11 to connect external ILIM_HIZ resistor. JP11 can be shorted to PGND to disable hardware input current limiting.	Not installed
JP12	Use JP12 to select the gate driver source. Shunt pin1 to pin2 to use IC internal LDO REGN output. Shunt pin2 to pin3 to use external gate drive supply. Maximum external gate drive supply can be up to 11V.	Pin1 and pin2 shunted
JP13	Shunt JP13 to enable controller in forward mode. Open JP13 to disable controller. The /CE pin can also be used as a general purpose indicator.	Installed
JP14	Shunt JP14 to connect /INT to a pullup rail.	Installed
JP15	Shunt JP15 to connect STAT1 to a pullup rail. The STAT1 pin can also be used as a general purpose indicator.	Installed
JP16	Shunt JP16 to generate on board 3.3V pullup rail.	Installed

2.3 Recommended Operating Conditions

Table 2-5. Recommended Operating Conditions for BQ25856EVM

	Description	MIN	TYP	MAX	UNIT
VIN (J1)	Input voltage to the EVM	4.2		55(1)	V
VOUT (J3)	Output voltage of the EVM	3.3		55(1)	V
ILIM_HIZ (J1)	Input current of the EVM			10(3) (4)	A
ICHG (J3)	Output current of the EVM			10(3)	A
Regulator output power	Output power of the EVM			400(3)	W
EXT_DRV (J6)	Voltage applied to DRV_SUP pin of the regulator	4		11	V
IAC Sense Resistor	Input current sense resistor	2	2(5)	10	mΩ
EVM Operating Ambient Temperature (TA)			25(2)		°C

(1) Due to the high di/dt and dv/dt electrical flow associated with switch-mode power supplies, nodes on the EVM can have high spike above input voltage (in buck mode) or output voltage (in boost mode) level. Switch node voltage can swing up to "input or output + inductive spike" level. High side gate drives can swing up to "switch node voltage + 11V (DRV_SUP supply voltage dependent) + gate drive inductive spike" level. Safety precautions must be observed at all times.
(2) Connectors, bump-ons, jumpers on the EVM are not a good choice for evaluation under temperature greatly deviated from room temperature of 25°C. Please refer to BOM for temperature rating of board components.
(3) Thermal monitoring (for example, using a thermal camera) is recommended if power stage output current > 5A or total output power > 100W.
(4) Default EVM input current limit is set to 8A through the IIN pin. The current limiting feature can be disabled by setting EN_IIN_PIN bit to '0', changing IIN pin resistor, or shorting IIN pin to PGND through JP11.
(5) The input sense resistor is optional and the sense resistor can be removed. For an USB-C EPR operation, a 5mΩ sense resistor is needed.

2.4 Equipment

There are two recommended ways to test the EVM. The first and preferred way to test the EVM is to use a four-quadrant power supply. The second is to use a electronic load in constant voltage mode. Testing with a constant voltage load is covered in a later section. The following list of equipment is recommended when testing with a four-quadrant power supply.

1. **Power Supplies:**

   A power supply capable of supplying 40V at 8A is required. While this part can handle larger voltage and current, larger power levels are not necessary for this procedure.

2. **Load #1:**

   A Kepco load: BOP36-6M, DC 0 to ±36 V, 0 to ±6 A (or higher), or equivalent. When testing without a real battery, connect 2000 uF of capacitance across the input.

3. **Meters:**

   Six Fluke 75 multimeters, (equivalent or better) or: Three equivalent voltage meters and three equivalent current meters.

4. **Computer:**

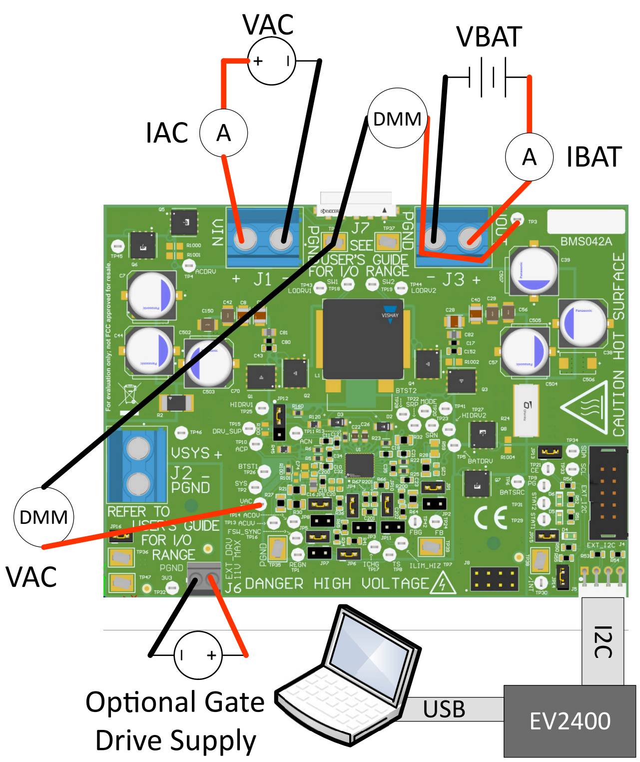
   A computer with at least one USB port and a USB cable.

5. **EV2400 Communication Kit:**

6. **Software:**

   Download and properly install bqStudio from https://www.ti.com/tool/BQSTUDIO.

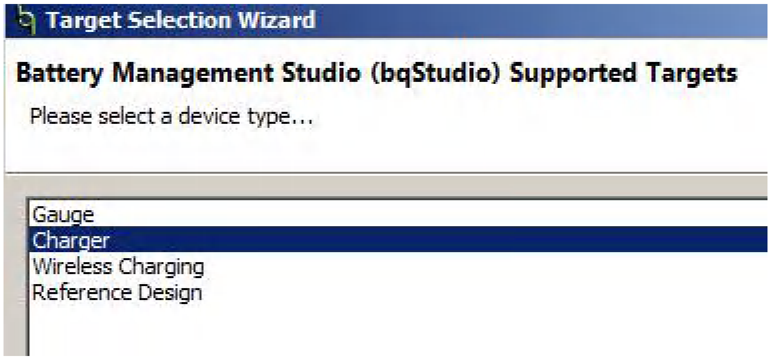
2.4.1 Equipment Set Up



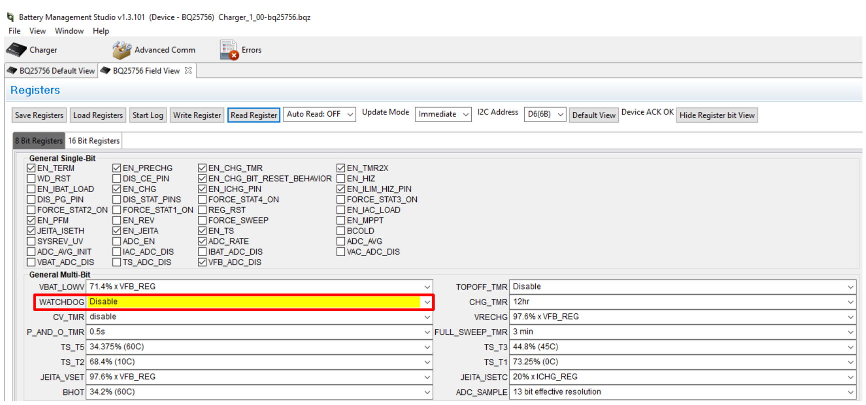
Use the following guidelines to set up and test the equipment:

1. Set power supply #1 for 10V DC, 8A current limit and then turn off the supply.
2. Connect the output of power supply #1 in series with a current meter to J1 (VIN and PGND).
3. Connect a voltage meter across J1 (VIN) and J1 (PGND).

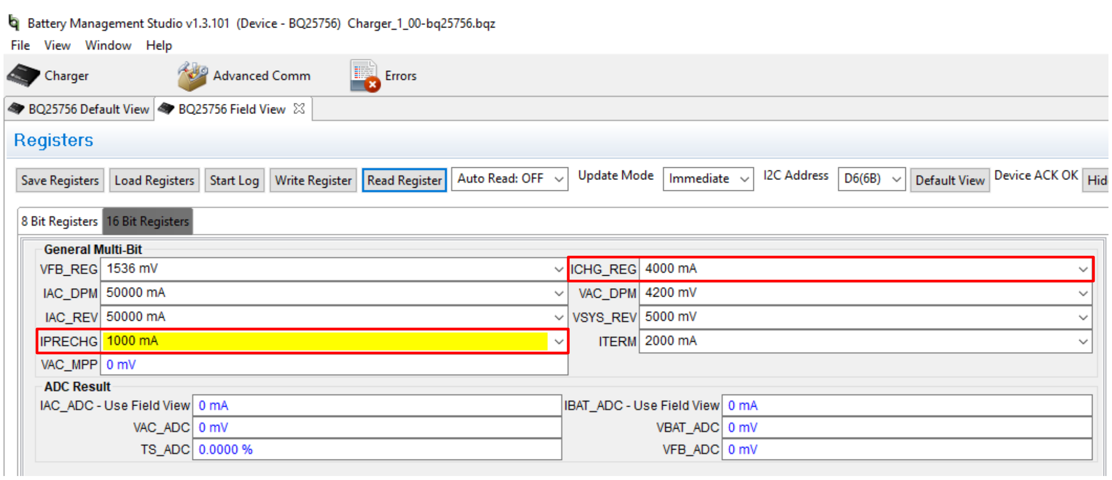
4. Connect load #1 in series with a current meter to J3 (VBAT and PGND).
5. Connect a voltage meter across J3 (VBAT and PGND).
6. Set 23V at KEPCO load output. Limit KEPCO to 6A. Use load #1 to power EVM from the VOUT output.
7. Connect J5 to the EV2400. Connect J5 to the I²C PORT 2 on the EV2400.
8. Make sure the jumpers are installed as indicated in IO and Jumper Descriptions.
9. Turn on the computer and load #2. Open the bqStudio software.
   a. Select *Charger* and click the *Next* button.



   b. Select *Charger_1_00_BQ25756.bqz* on the *Select a Target Page*. Both the BQ25756 bqz file or the BQ25856 bqz file work for this test.
   c. After selecting the target device, click *Field View* and then click the *Read Register* button.



10. Set WATCHDOG and EN_CHG to disabled.



11. In *16 Bit Registers*, set ICHG_REG to 4000mA.
12. Turn on power supply #1, measure:

    V(J1(VAC)) = 10V ± 0.5V

    I(J1(IAC)) = 5.4A ± 0.5A

    V(J3(VBAT)) = 13V ± 0.5V

    I(J3(IBAT)) = 3.9A ± 0.5A
13. Set power supply #1 for 13V, measure:

    V(J1(VAC)) = 13V ± 0.5V

    I(J1(IAC)) = 4.1A ± 0.5A

    V(J3(VBAT)) = 13V ± 0.5V

    I(J3(IBAT)) = 3.9A ± 0.5A
14. Set power supply #1 for 40V, measure:

    V(J1(VAC)) = 40V ± 0.5V

    I(J1(IAC)) = 1.4A ± 0.5A

    V(J3(VBAT)) = 13V ± 0.5V

    I(J3(IBAT)) = 3.9A ± 0.5A

2.4.2 Equipment - Using a CV Load

The following list of equipment is recommended when testing with a constant voltage electronic load.

1. **Power Supplies:**

   A power supply capable of supplying 40V at 8A is required. While this part can handle larger voltage and current, larger power levels are not necessary for this procedure.

2. **Load #1:**

   Kikusui PLZ164WA 0-150V, 0-33A, or equivalent. When testing without a real battery, connect 2000 uF of capacitance across the input.

3. **Meters:**

   Six Fluke 75 multimeters, (equivalent or better) or: Three equivalent voltage meters and three equivalent current meters.

4. **Computer:**

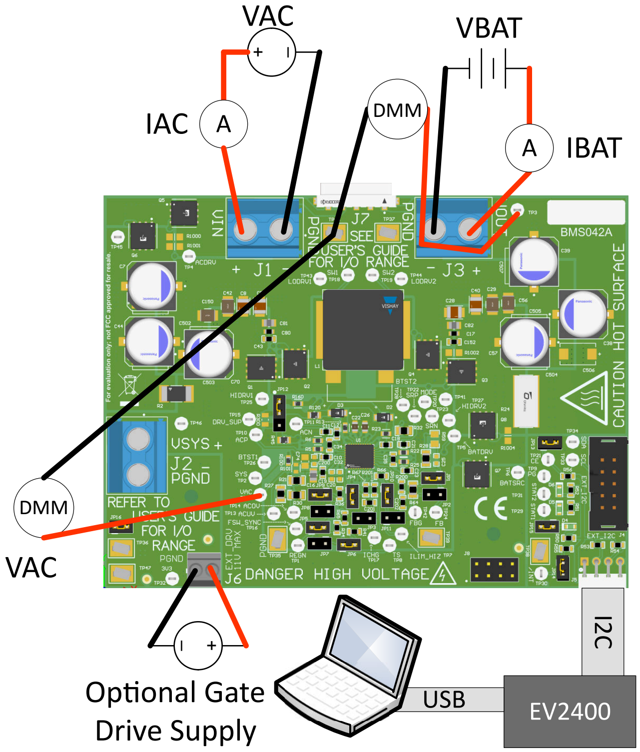
   A computer with at least one USB port and a USB cable.

5. **EV2400 Communication Kit:**

6. **Software:**

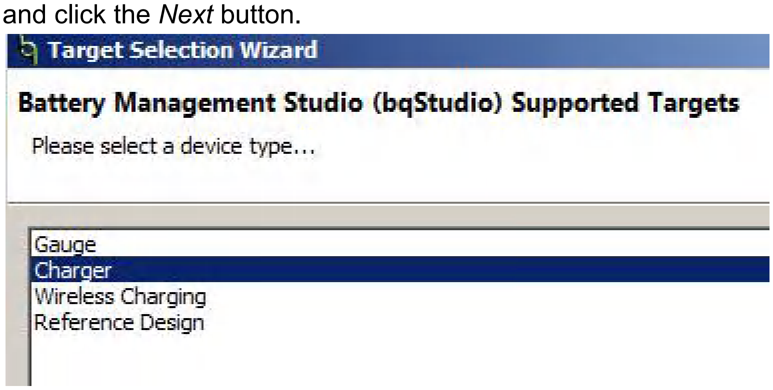
   Download and properly install bqStudio from https://www.ti.com/tool/BQSTUDIO.

2.4.3 Equipment Setup - Using a CV Load

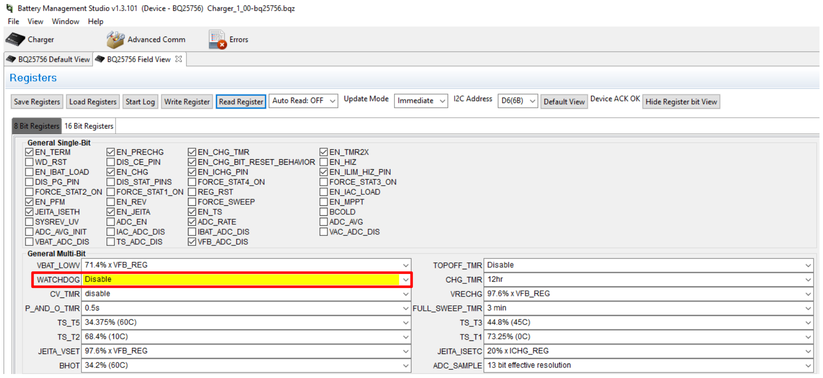


Use the following guidelines to set up and test the equipment:

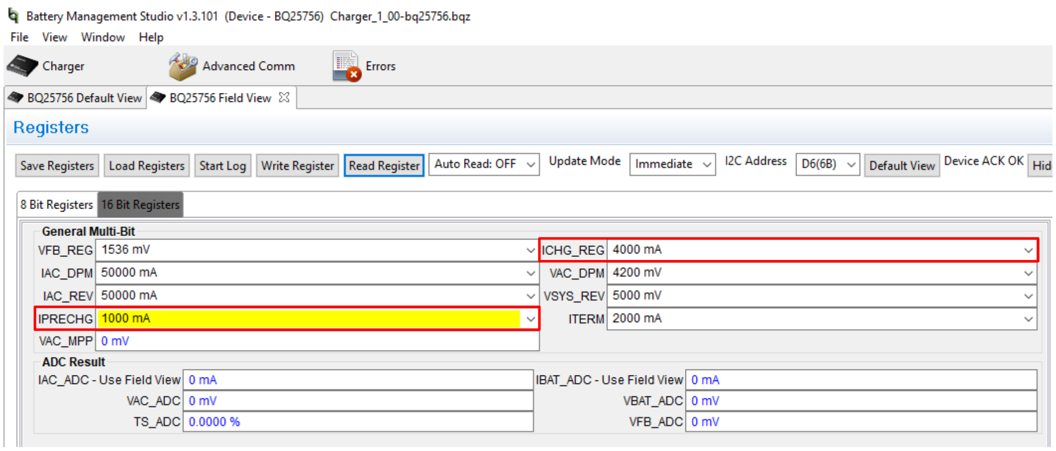
1. Set power supply #1 for 10VDC, 6A current limit and then turn off the supply.
2. Connect the output of power supply #1 in series with a current meter to J1 (VIN and PGND).
3. Connect a voltage meter across J1 (VIN) and J1 (PGND).
4. Connect load #1 in series with a current meter to J3 (VBAT and PGND).
5. Connect a voltage meter across J5 (VBAT and PGND).
6. Set 13V at electronic load input.
7. Connect J5 to the EV2400. Connect J5 to the I^{2}C PORT 2 on the EV2400.
8. Make sure the jumpers are installed as indicated in IO and Jumper Descriptions.
9. Unplug Jumper 13.
10. Turn on the computer and power supply #1. Open the bqStudio software.
    a. Select *Charger* and click the *Next* button.



    b. Select *Charger_1_00_BQ25756.bqz* on the *Select a Target Page*. Both the BQ25756 bqz file or the BQ25856 bqz file work for this test.
    c. After selecting the target device, click *Field View* and then click the *Read Register* button.



11. Set WATCHDOG and EN_CHG to disabled.



12. In *16 Bit Registers*, set ICHG_REG to 4000mA and IPRECHG to 1000mA.
13. Set EN_CHG to enabled. Plug in Jumper 13.
14. Set power supply #1 to 10V, measure

    V(J1(VAC)) = 10V ± 0.5V

    I(J1(IAC)) = 5.4A ± 0.5A

    V(J3(VBAT)) = 13V ± 0.5V

    I(J3(IBAT)) = 3.9A ± 0.5A
15. Set power supply #1 for 13V, measure

    V(J1(VAC)) = 13V ± 0.5V

    I(J1(IAC)) = 4.1A ± 0.5A

    V(J3(VBAT)) = 13V ± 0.5V

    I(J3(IBAT)) = 3.9A ± 0.5A
16. Set power supply #1 for 40V, measure

    V(J1(VAC)) = 40V ± 0.5V

    I(J1(IAC)) = 1.4A ± 0.5A

    V(J3(VBAT)) = 13V ± 0.5V

    I(J3(IBAT)) = 3.9A ± 0.5A

3 Hardware Design Files

The following sections includes the hardware design files for BQ25756EVM. This section includes the schematics, board layouts, and Bill of Materials (BOM).

3.1 Schematic

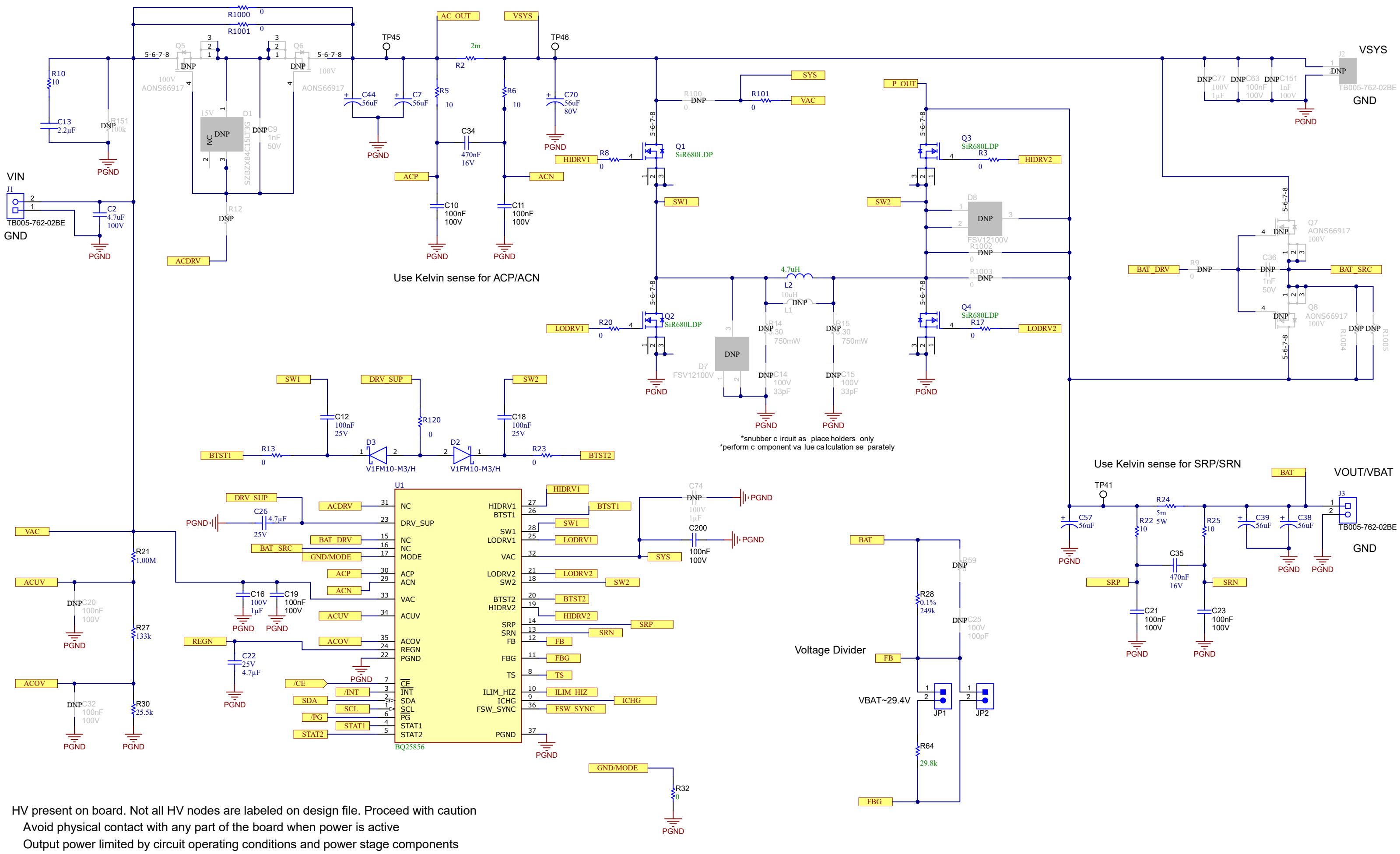
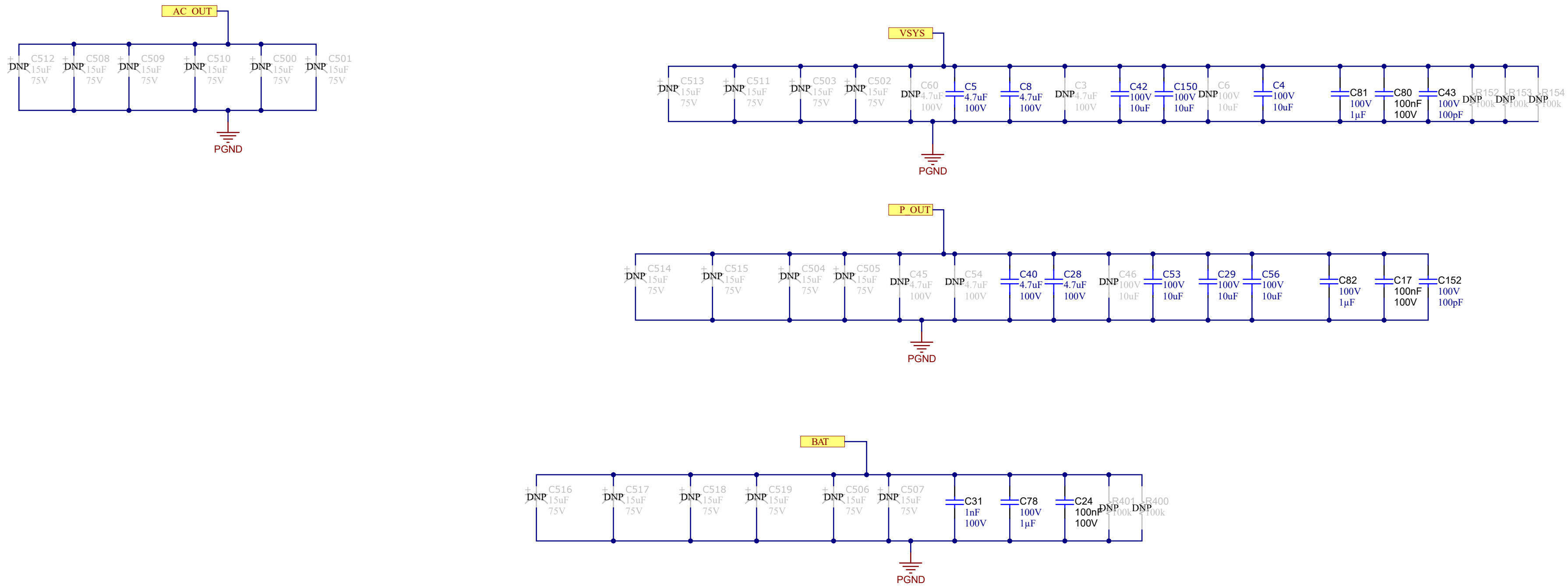
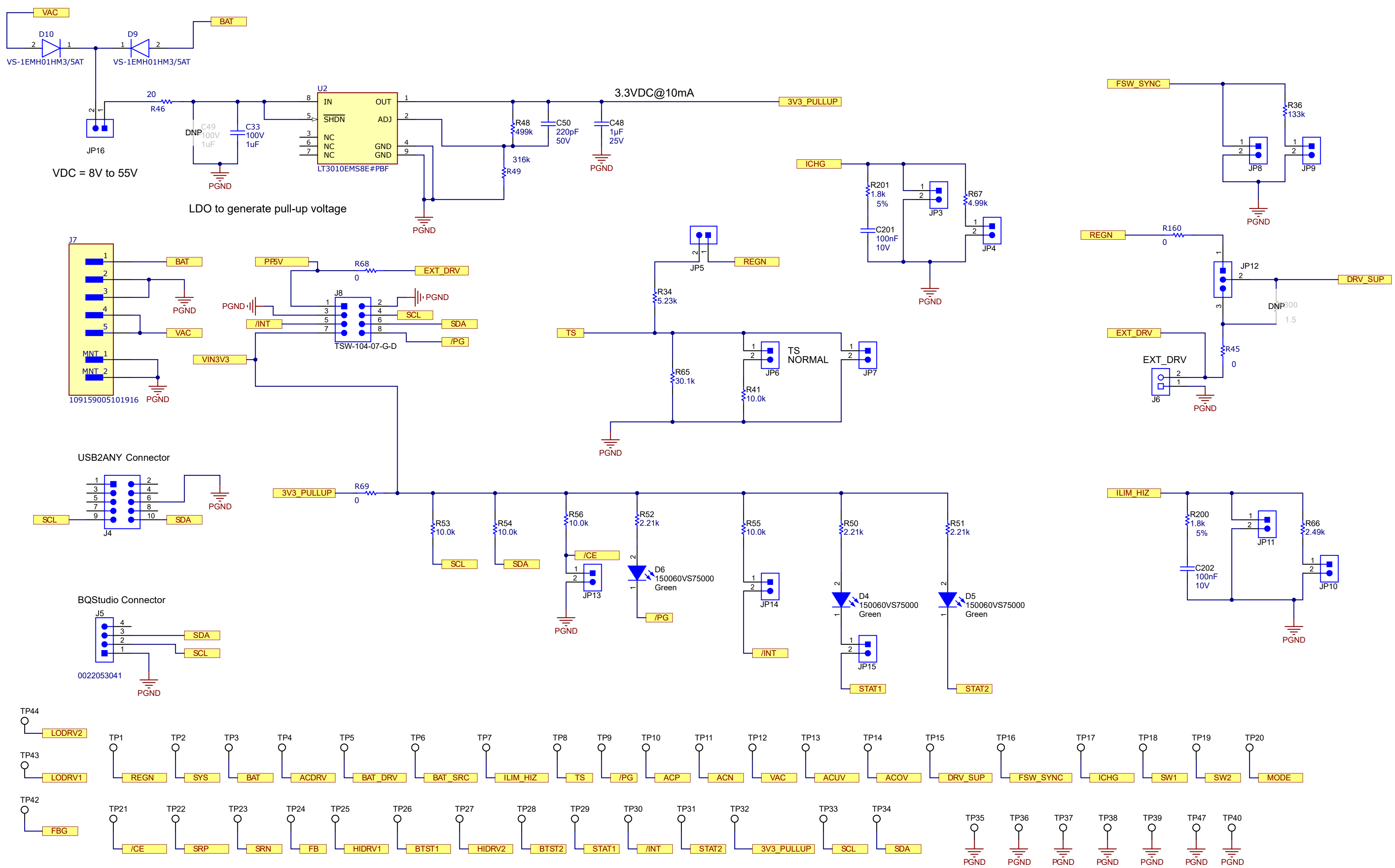
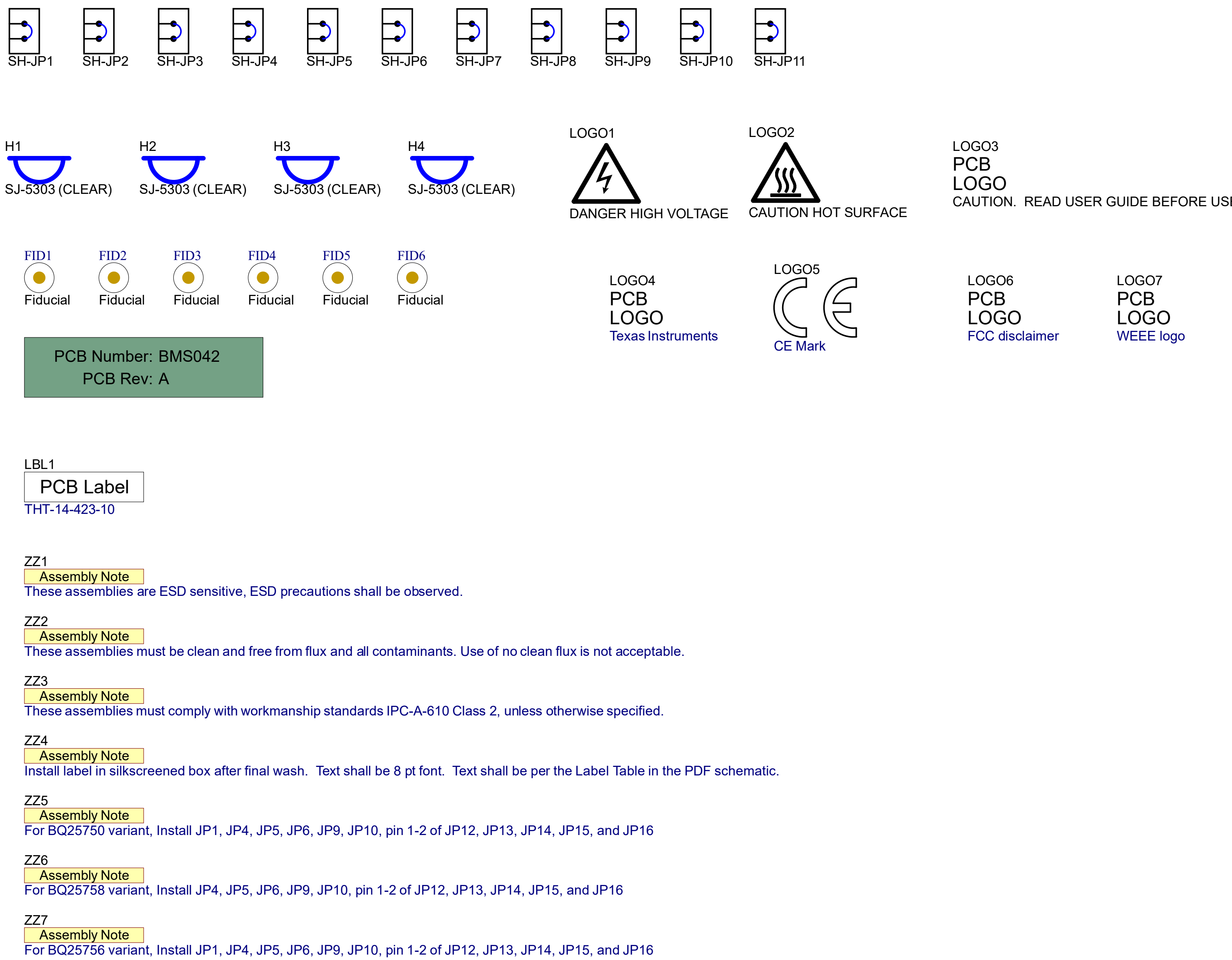


Figure 3-1. BQ25856 EVM Schematic


AC_OUT
C512 15uF 75V DNP
C508 15uF 75V DNP
C509 15uF 75V DNP
C510 15uF 75V DNP
C500 15uF 75V DNP
C501 15uF 75V DNP
PGND
VSYS
C513 15uF 75V DNP
C511 15uF 75V DNP
C503 15uF 75V DNP
C502 15uF 75V DNP
C60 4.7uF 100V DNP
C5 4.7uF 100V
C8 4.7uF 100V
C3 4.7uF 100V DNP
C42 100V 10uF
C150 100V 10uF
C6 100V 10uF DNP
C4 100V 10uF
C81 100V 1µF
C80 100nF 100V
C43 100V 100pF
R152 100k DNP
R153 100k DNP
R154 100k DNP
PGND
P_OUT
C514 15uF 75V DNP
C515 15uF 75V DNP
C504 15uF 75V DNP
C505 15uF 75V DNP
C45 4.7uF 100V DNP
C54 4.7uF 100V DNP
C40 4.7uF 100V
C28 4.7uF 100V
C46 100V 10uF DNP
C53 100V 10uF
C29 100V 10uF
C56 100V 10uF
C82 100V 1µF
C17 100nF 100V
C152 100V 100pF
PGND
BAT
C516 15uF 75V DNP
C517 15uF 75V DNP
C518 15uF 75V DNP
C519 15uF 75V DNP
C506 15uF 75V DNP
C507 15uF 75V DNP
C31 1nF 100V
C78 100V 1µF
C24 100nF 100V
R401 100k DNP
R400 100k DNP
PGND


VAC
BAT
D10
D9
VS-1EMH01HM3/5AT
VS-1EMH01HM3/5AT
JP16
VDC = 8V to 55V
R46
20
U2
LT3010EMS8E#PBF
IN
OUT
SHDN
ADJ
NC
GND
3.3VDC@10mA
3V3_PULLUP
C49 100V 1uF DNP
C33 100V 1uF
R48 499k
C50 220pF 50V
C48 1µF 25V
R49 316k
PGND
LDO to generate pull-up voltage
J7
109159005101916
EXT_DRV
PP5V
R68 0
J8
TSW-104-07-G-D
SCL
SDA
/INT
/PG
VIN3V3
USB2ANY Connector
J4
BQStudio Connector
J5
0022053041
R69 0
R53 10.0k
R54 10.0k
R56 10.0k
R52 2.21k
R55 10.0k
R50 2.21k
R51 2.21k
/CE
JP13
D6 150060VS75000 Green
JP14
D4 150060VS75000 Green
D5 150060VS75000 Green
JP15
STAT1
STAT2
TS
JP5
REGN
R34 5.23k
R65 30.1k
R41 10.0k
JP6
TS NORMAL
JP7
ICHG
R201 1.8k 5%
C201 100nF 10V
JP3
R67 4.99k
JP4
FSW_SYNC
R36 133k
JP8
JP9
R160 0
JP12
DRV_SUP
DNP
R45 0
EXT_DRV
J6
ILIM_HIZ
R200 1.8k 5%
C202 100nF 10V
JP11
R66 2.49k
JP10
TP44 LODRV2
TP43 LODRV1
TP42 FBG
TP1 REGN
TP2 SYS
TP3 BAT
TP4 ACDRV
TP5 BAT_DRV
TP6 BAT_SRC
TP7 ILIM_HIZ
TP8 TS
TP9 /PG
TP10 ACP
TP11 ACN
TP12 VAC
TP13 ACUV
TP14 ACOV
TP15 DRV_SUP
TP16 FSW_SYNC
TP17 ICHG
TP18 SW1
TP19 SW2
TP20 MODE
TP21 /CE
TP22 SRP
TP23 SRN
TP24 FB
TP25 HIDRV1
TP26 BTST1
TP27 HIDRV2
TP28 BTST2
TP29 STAT1
TP30 /INT
TP31 STAT2
TP32 3V3_PULLUP
TP33 SCL
TP34 SDA
TP35 TP36 TP37 TP38 TP39 TP47 TP40
PGND



1. DNP means "Do Not Populate".

3.2 PCB Layout

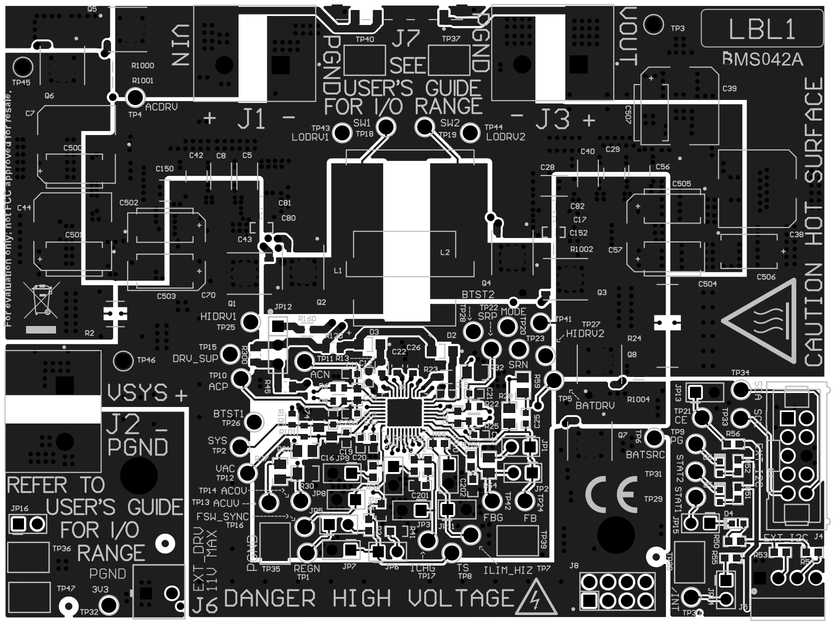


Figure 3-2. Top Layer and Overlay

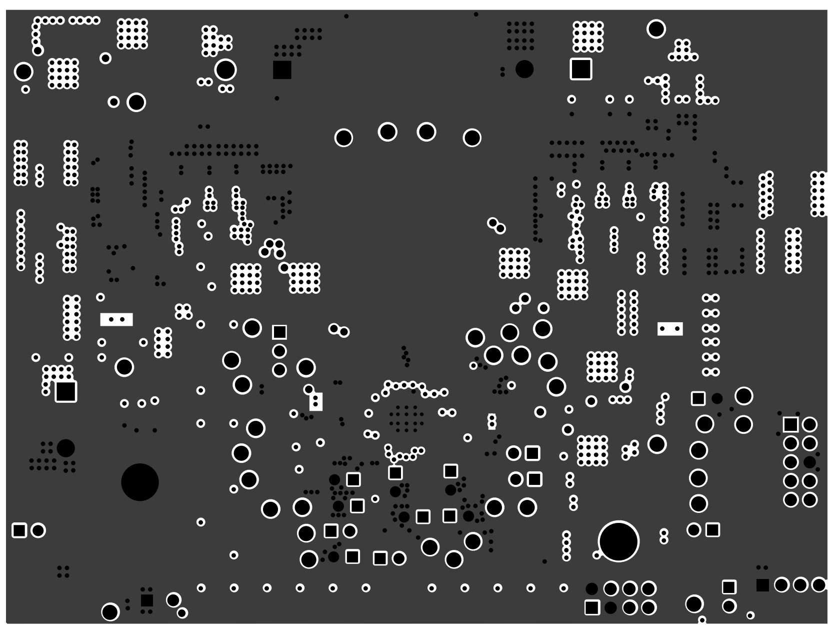


Figure 3-3. Layer 2 -GND

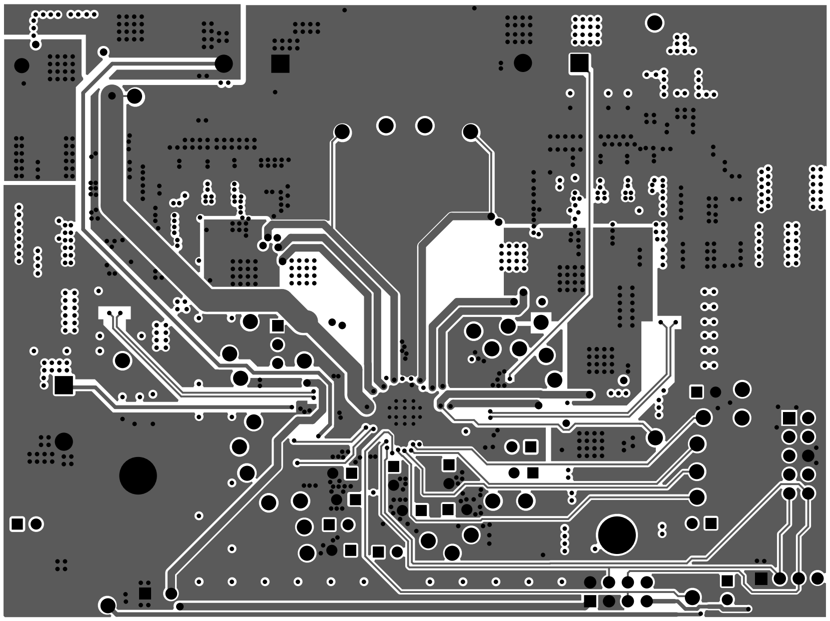


Figure 3-4. Signal Layer 1

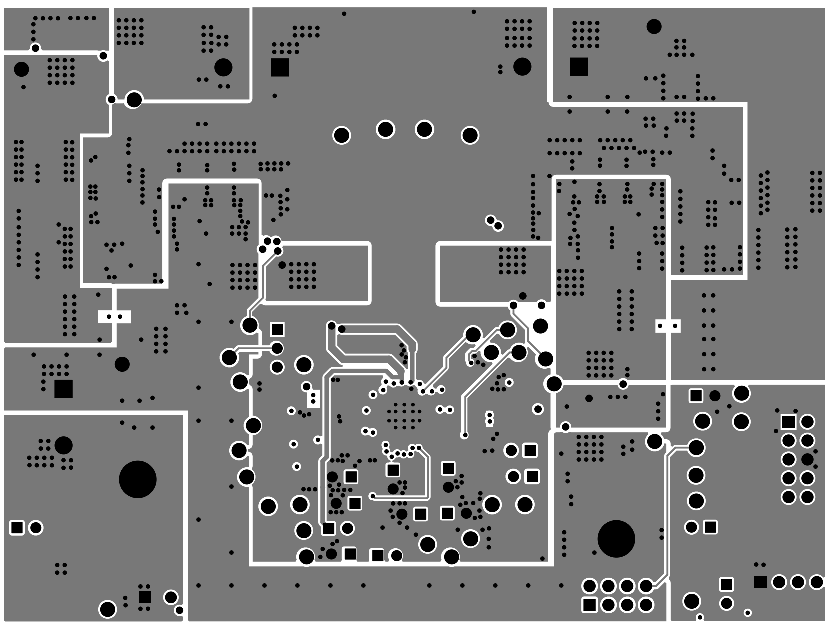


Figure 3-5. Signal Layer 2

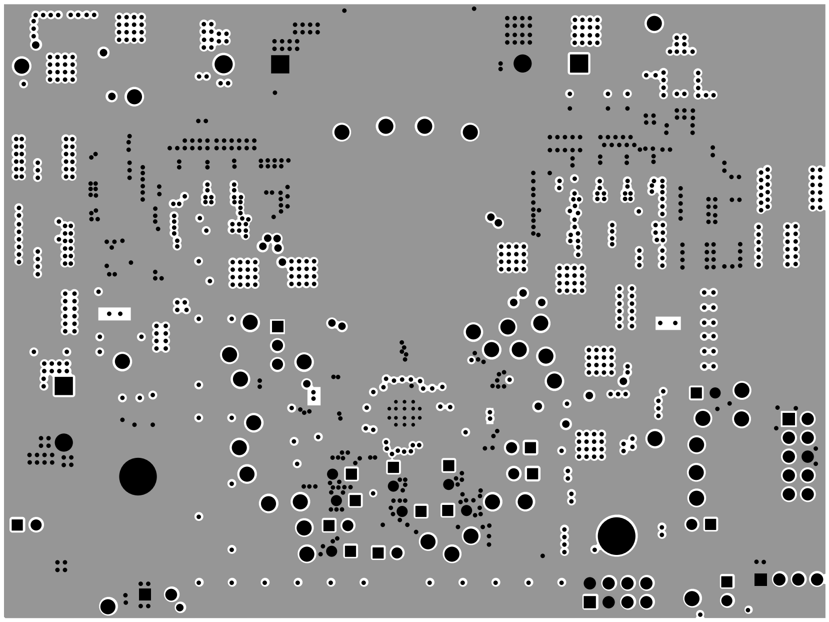


Figure 3-6. Layer 5 - GND

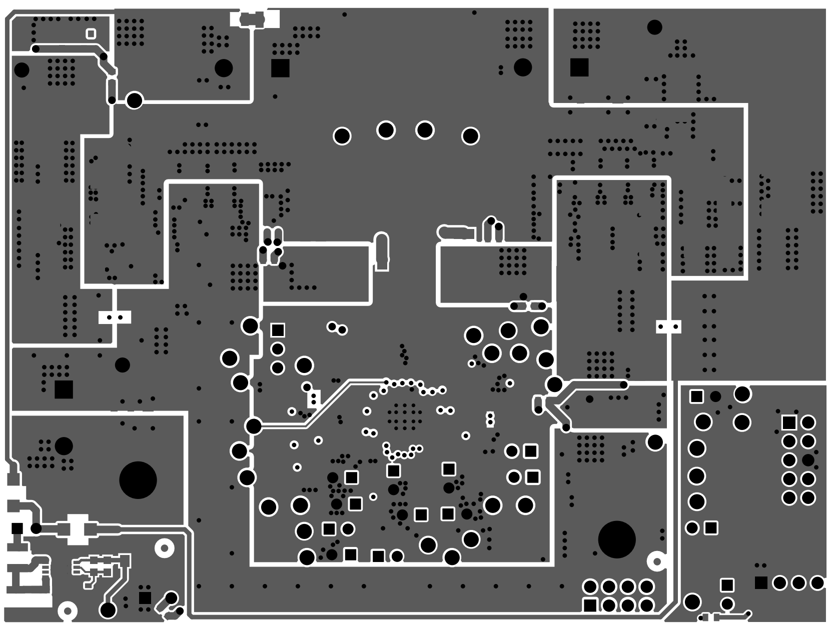


Figure 3-7. Bottom Layer

3.3 Bill of Materials

Table 3-1. Bill of Materials

Item Number	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
1	C2, C5, C8, C28, C40	5	4.7µF	GCJ32DC72A475KE01L	Murata	4.7uF ±10% 100V Ceramic Capacitor X7S 1210 (3225 Metric)	1210
2	C4, C29, C42, C53, C56, C150	6	10µF	C3225X7R2A106K250AC	TDK	10µF ±10% 100V Ceramic Capacitor X7R 1210 (3225 Metric)	1210
3	C7, C38, C39, C44, C57, C70	6	56uF	80SXV56M	Panasonic	56µF80 V Aluminum - Polymer Capacitors Radial, Can - SMD 28mOhm 1000 Hrs @ 125°C	SMT
4	C10, C11, C17, C19, C21, C23, C24, C80, C200	8	0.1uF	HMK107B7104KAHT	Taiyo Yuden	CAP, CERM, 0.1µF, 100V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	603
5	C12, C18	2	0.1uF	06033C104KAT2A	AVX	CAP, CERM, 0.1uF, 25V, +/- 10%, X7R, 0603	603
6	C13	1	2.2uF	CGA6N3X7R2A225K230AE	TDK Corporation	Cap Ceramic 2.2uF 100V X7R 10% SMD 1210 FlexiTerm 125C Plastic T/R	1210
7	C16, C78, C81, C82	4	1uF	08051C105K4Z2A	AVX	CAP, CERM, 1µF, 100V,+/- 10%, X7R, AEC-Q200 Grade 1, 0805	805
8	C22, C26	2	4.7µF	CGA4J1X7R1E475K125AE	TDK Corporation	Cap Ceramic 4.7uF 25V X7R 10% Pad SMD 0805 +125°C Automotive T/R	805
9	C31	1	1000pF	CGA3E2X7R2A102K080AA	TDK	Multilayer Ceramic Capacitors MLCC - SMD/SMT CGA 0603 100V 1000pF X7R 10% AEC-Q200	603
10	C33	1	1µF	12101C105KAT2A	AVX	General Purpose Ceramic Capacitor, 1210, 1uF, 10%, X7R, 15%, 100V	1210
11	C34, C35	2	0.47uF	C0603C474K4RACTU	Kemet	CAP, CERM, 0.47uF, 16V, +/- 10%, X7R, 0603	603
12	C43, C152	2	100pF	CGA3E2C0G2A101J080AA	TDK	Multilayer Ceramic Capacitors MLCC - SMD/SMT CGA 0603 100V 100pF C0G 5% AEC-Q200	603
13	C48	1	1uF	C0805C105K3RACTU	Kemet	CAP, CERM, 1 uF, 25V, +/- 10%, X7R, 0805	805
14	C50	1	220pF	C0603C221K5RACTU	Kemet	CAP, CERM, 220pF, 50V, +/- 10%, X7R, 0603	603
15	C201, C202	2	0.1uF	C0603C104K8RACTU	Kemet	CAP, CERM, 0.1uF, 10V, +/- 10%, X7R, 0603	603
16	D2, D3	2		V1FM10-M3/H	Vishay	Diode Schottky 1A Surface Mount DO-219AB (SMF)	DO-219AB
17	D4, D5, D6	3	Green	150060VS75000	Wurth Elektronik	LED, Green, SMD	LED_0603

Table 3-1. Bill of Materials (continued)

Item Number	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
18	D9, D10	2		VS-1EMH01HM3/5AT	Vishay	Diode Standard 100V 1A Surface Mount DO-214AC (SMA)	DO-214AC
20	H1, H2, H3, H4	4		SJ-5303 (CLEAR)	3M	Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon
21	J1, J3	2		TB005-762-02BE	CUI Devices		TERM_CONN
22	J4	1		N2510-6002-RB	3M	Header (shrouded), 100mil, 5x2, High-Temperature, Gold, TH	5x2 Shrouded header
23	J5	1		22053041	Molex	Header (friction lock), 100mil, 4x1, R/A, TH	4x1 R/A Header
24	J6	1		393570002	Molex	Terminal Block, 3.5mm, 2x1, Tin, TH	Terminal Block, 3.5mm, 2x1, TH
25	J7	1		109159005101916	KYOCERA AVX	Conn Board to Board HDR 5 POS 3mm Solder RA SMD T/R	CONN_SSL_PLUG5
26	J8	1		TSW-104-07-G-D	Samtec	Header, 100mil, 4x2, Gold, TH	4x2 Header
27	JP1, JP2, JP3, JP4, JP5, JP6, JP7, JP8, JP9, JP10, JP11, JP13, JP14, JP15, JP16	15		PEC02SAAN	Sullins Connector Solutions	Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin
28	JP12	1		PEC03SAAN	Sullins Connector Solutions	Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin
29	L2	1	10uH	SRP1050WA-4R7M	Bourns	Power Inductors - SMD Ind,11x10x5.1mm,4.7uH+/-20%,14.5A,shd	3939 (1010 metric)
30	LBL1	1		THT-14-423-10	Brady	Thermal Transfer Printable Labels, 0.650	PCB Label 0.650 x 0.200 inch
32	Q1, Q2, Q3, Q4	4		SIR680LDP-T1-RE3	Vishay	N-Channel 80V 31.8A (Ta), 130A (Tc) 6.25W (Ta), 104W (Tc) Surface Mount PowerPAK® SO-8	SO-8
33	R2	1	2m	WSLF25122L000FEA	Vishay	Current Sense Resistors - SMD 6watt .002ohms 1%	2512
34	R3, R8, R13, R17, R20, R23, R68, R69, R101, R160	10	0	CRCW06030000Z0EA	Vishay	Thick Film Resistors - SMD 1/10watt ZEROohm Jumper	603
35	R5, R6, R22, R25	4	10	CRCW060310R0FKEB	Vishay	RES Thick Film, 10Ω, 1%, 0.1W, 100ppm/°C, 0603	603
36	R10	1	10	CRCW120610R0FKEAHP	Vishay Dale	RES Thick Film, 10Ω, 1%, 0.75W, 100ppm/°C, 1206	1206
37	R21	1	1.00Meg	CRCW08051M00FKEAC	Vishay / Dale	Thick Film Resistors - SMD 1/8Watt 1MΩ 1% Commercial Use	805

Table 3-1. Bill of Materials (continued)

Item Number	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
38	R24	1	5m	FCSL110R005FER	Ohmite	5 mOhms ±1% 5W Chip Resistor Wide 4320 (11050 Metric), 2043 Current Sense, Moisture Resistant Metal Foil	WIDE_4320
39	R27	1	133k	ERJ-6ENF1333V	Panasonic	RES, 133kΩ, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	805
40	R28	1	249k	ERJ-PB6B2493V	Panasonic	Thick Film Resistors - SMD 0805 Anti-Surge Res. 0.1%, 249KΩ	805
41	R30	1	25.5k	ERJ-6ENF2552V	Panasonic	RES, 25.5kΩ, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	805
42	R32	1	0	CRCW08050000Z0EA	Vishay	Thick Film Resistors - SMD 1/8watt ZEROohm Jumper	805
43	R34	1	5.23k	RC0603FR-075K23L	Yageo	RES, 5.23kΩ, 1%, 0.1W, 0603	603
44	R36	1	133k	CRCW0603133KFKEA	Vishay-Dale	RES, 133k, 1%, 0.1W, AEC-Q200 Grade 0, 0603	603
45	R41, R53, R54, R55, R56	5	10.0k	RC0603FR-0710KL	Yageo	RES, 10.0k, 1%, 0.1W, 0603	603
46	R45, R120	2	0	CRCW08050000Z0EA	Vishay	Thick Film Resistors - SMD 1/8watt ZEROohm Jumper	805
47	R46	1	20	CRCW121020R0FKEAHP	Vishay Dale	Thick Film Resistors - SMD 3/4watt 20ohms 1% High Power AEC-Q200	1210
48	R48	1	499k	RC0603FR-07499KL	Yageo	RES, 499 k, 1%, 0.1 W, 0603	603
49	R49	1	316k	CR0603-FX-3163ELF	Bourns	Thick Film Chip Resistors 0603 316kΩ 0.1W 1% 100ppm/°C	603
50	R50, R51, R52	3	2.21k	RC0603FR-072K21L	Yageo	RES, 2.21k, 1%, 0.1W, 0603	603
51	R64	1	29.8k	RN73R2ATTD2982B50	KOA Speer Electronics	RES 29.8K OHM 0.1% 1/8W 0805	805
52	R65	1	30.1k	RC0603FR-0730K1L	Yageo	RES, 30.1k, 1%, 0.1W, 0603	603
53	R66	1	2.49k	RC0603FR-072K49L	Yageo	RES, 2.49k, 1%, 0.1W, 0603	603
54	R67	1	4.99k	CRCW06034K99FKEAC	Vishay-Dale	RES, 4.99k, 1%, 0.1W, 0603	603
55	R200, R201	2	1.8k	RC0603JR-071K8L	Yageo	RES, 1.8k, 5%, 0.1W, 0603	603
56	R1000, R1001	2	0	JR0805X35E	Ohmite	0 Ohms Jumper 0.245W Chip Resistor 0805 (2012 Metric) - Metal Element	805
57	SH-JP1, SH-JP2, SH-JP3, SH-JP4, SH-JP5, SH-JP6, SH-JP7, SH-JP8, SH-JP9, SH-JP10, SH-JP11	11	1x2	SNT-100-BK-G	Samtec	Shunt, 100mil, Gold plated, Black	Shunt

Table 3-1. Bill of Materials (continued)

Item Number	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
58	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP24, TP25, TP26, TP27, TP28, TP29, TP30, TP31, TP32, TP33, TP34, TP41, TP42, TP43, TP44, TP45, TP46	40		5002	Keystone	Test Point, Miniature, White, TH	White Miniature Test point
59	TP35, TP36, TP37, TP38, TP39, TP40, TP47	7		5016	Keystone	Test Point, Compact, SMT	Test point_Keystone_Compact
60	U1	1		BQ25756RRVT	Texas Instruments	BQ25756RRVT	VQFN36
61	U2	1		LT3010EMS8E-PBF	Analog Devices	Linear Voltage Regulator IC Positive Adjustable 1 Output 50mA 8-MSOP-EP	MSOP8

4 Additional Information

4.1 Trademarks

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