EVM User's Guide: BQ25853EVM

BQ25853-Q1 Evaluation Module

Description

The BQ25853EVM evaluation module (EVM) is a complete evaluation system for the BQ25853-Q1 IC, a buck-boost supercapacitor charge controller with a wide input range of 4.2V - 70V, a wide output voltage range of up to 70V, and bi-directional capabilities.

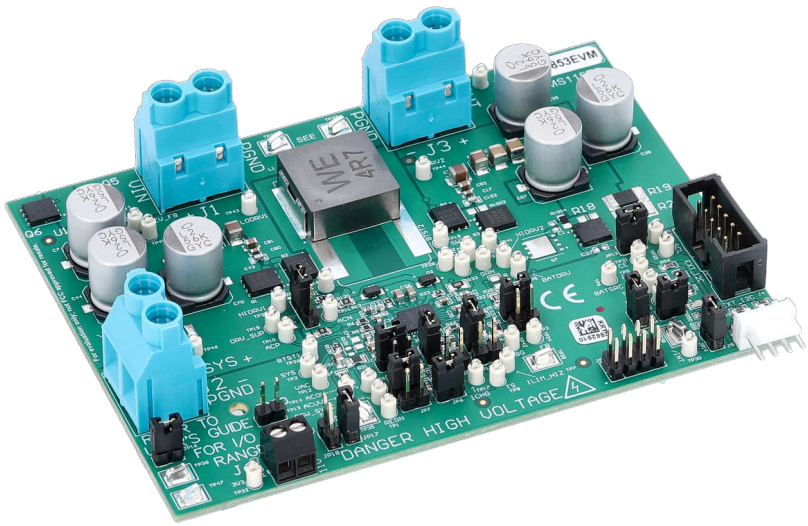
The BQ25853EVM has a max input and output of 55V and a max charge current of 10A.

Get Started

1. Order the EVM on ti.com
2. Order the EV2500 to communicate with the EVM
3. Download the BQ25853 BQZ file
4. Download the BQ25853 EVM design files on ti.com

Features

- Wide input voltage operating range: 4.2V-55V
- Wide output operating range: up to 55V with CC/CV support for:
  - 2 to 20-Cell Supercapacitor
  - 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
- Power up from supercapacitor (reverse mode) output 2.5V to 55V
- High safety integration
  - Adjustable input overvoltage and undervoltage protection
  - Output Overvoltage and overcurrent protection



BQ25853EVM Top View

1 Evaluation Module Overview

1.1 Introduction

The BQ25853EVM can be evaluated for up to 20 cell supercapacitor charging implementing CC/CV profile. Typical applications include Low voltage battery system, Battery management unit, Domain Gateway, ADAS Domain Controller, and Front Door Module.

This EVM does not include the EV2500 or USB2ANY interface device and does not provide any electrical isolation for the digital interfaces. EV2500 or USB2ANY must be ordered separately to evaluate the BQ25853EVM 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 BQ25853EVM has a smaller clearance and creepage than normally used on high voltage boards as well as not having an isolation boundary. If high voltage is applied to this board, all terminals must be considered high voltage and hazardous live. Electric shock is possible when connecting the board to a 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) BQ25853EVM

1.3 Device Information

The BQ25853EVM evaluation module (EVM) is an evaluation system for the BQ25853-Q1 IC. The BQ25853-Q1 IC is a buck-boost supercapacitor 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 supercapacitor 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 and output current regulation targets can be set with single resistor on the ILIM and ICHG pins, respectively.

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

Always follow TI's set-up and application instructions, including use of all interface components within their 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 BQ25853EVM. Observe all safety precautions.

 **Warning**	The BQ25853EVM 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 BQ25853EVM 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 a live wire. The board needs to be handled with care by a professional. For safety, the use of isolated test equipment with various protection features (such as overvoltage and overcurrent protection) 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 the board-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 BQ25853 are 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 BQ25853EVM

	Description	Value	Unit
ACUV	Input undervoltage	10	V
ACOV	Input overvoltage	55	V
ILIM_HIZ	Input current of the EVM	Disabled	A
ICHG	Output current of the EVM	5	A
FSW_SYNC	Switching frequency of the power stage	250	KHz
VCAP_REG	Capacitor charge voltage	29.4	V
IAC Sense Resistor	Input current sense resistor	0	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	7	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)
J2-VSYS	System: positive terminal
J2-PGND	System: negative terminal
J3-VOUT	Connect to supercapacitor positive terminal
J3-PGND	Connect to supercapacitor negative terminal
J4-EXT_I2C	Communication port for the USB2ANY
J5-I2C	Communication port for the EV2500
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 charge voltage to 29.4V.	Installed
JP2	Use JP2 to connect a new feedback resistor to program a different charge voltage.	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 5A.	Installed
JP5	Shunt JP5 to bias TS with REGN	Installed
JP6	With JP5 shunted, REGN is connected for the TS voltage divider. Shunt JP6 to set the TS status to normal.	Installed
JP7	Use JP7 to connect external resistor or thermistor to change the TS status. Disconnect JP6 when adding an external resistor.	Not installed
JP8	Use JP8 to connect an external FSW_SYNC resistor. Disconnect JP9 when using an external FSW_SYNC resistor	Not installed
JP9	Shunt JP9 to use the default FSW_SYNC resistor. By closing JP9, the default switching frequency is set to 600kHz.	Installed
JP10	Shunt JP10 to use on-board ILIM_HIZ resistor. By closing JP10, the maximum input current is set to 10A with 5 mOhm sense resistor. The sense resistor is not populated on the board by default.	Not installed
JP11	Use JP11 to connect external ILIM_HIZ resistor. JP11 can be shorted to PGND to disable hardware input current limiting.	Installed
JP12	Use JP12 to select the gate driver voltage source. Shunt pin1 to pin2 to use the IC internal LDO REGN output. Shunt pin2 to pin3 to use an external gate drive supply. The maximum external gate drive supply can be up to 11V.	Pin1 and Pin2 shunted
JP13	Shunt JP13 to enable the controller in forward mode. Open JP13 to disable the 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
JP17	Shunt JP17 to set reverse mode output to 12V.	Installed
JP18	Use JP18 to connect custom resistor for reverse mode output voltage setting.	Not installed
JP19	Shunt JP19 to enable reverse mode operation.	Installed
JP20	Shunt JP20 to set reverse mode output to 7V.	Not installed

2.3 Recommended Operating Conditions

Table 2-5. Recommended Operating Conditions for BQ25853EVM

	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			300(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	5(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 a high spike above the input voltage (in buck mode) or output voltage (in boost mode) level. Switch node voltage can swing up to the "input or output + inductive spike" level. High side gate drives can swing up to the "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 disabled through the ILIM_HIZ pin. The current limiting feature can be disabled by setting EN_ILIM_HIZ_PIN bit to '0', changing ILIM_HIZ pin resistor, or shorting ILIM_HIZ pin to PGND through JP11. The current limiting feature can be enabled through installing a sense resistor on the pad for R2 and removing resistors R1000 and R1001
(5) The input sense resistor is optional and the sense resistor has been removed.

2.4 Equipment

There are two recommended ways to test the EVM. The first and preferred way is to use a four-quadrant or two-quadrant power supply. The second is to use an electronic load in constant voltage mode. Testing with a constant voltage load is covered in Section 2.4.2. 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 Voltage from 0 to ±36V, DC current from 0 to ±6A (or higher), or equivalent. When testing without a real supercapacitor, connect 2000µF 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. **EV2500 Communication Kit**

6. **Software:**

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

2.4.1 Equipment Setup

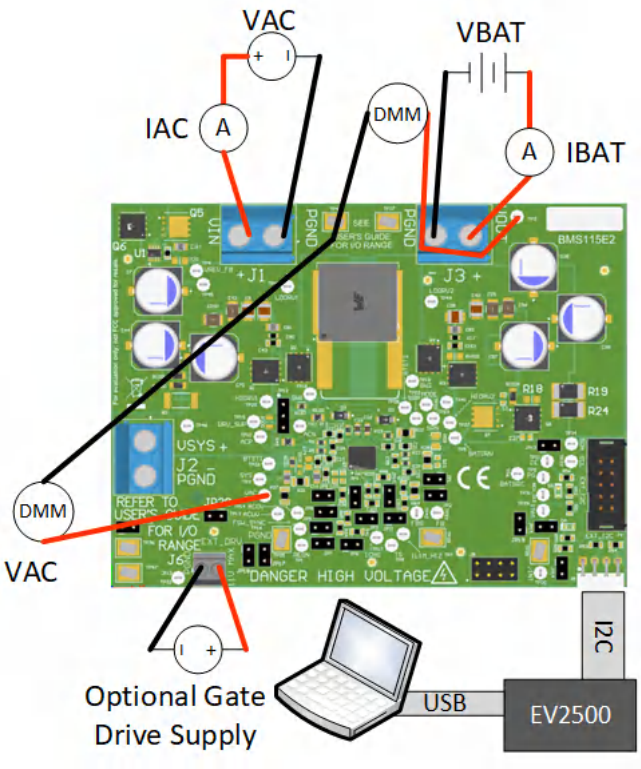
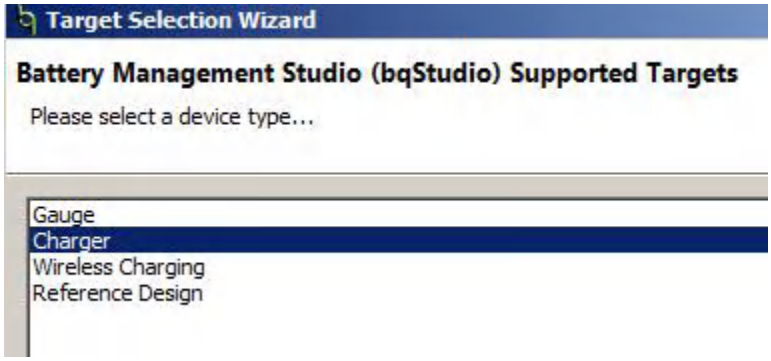


Figure 2-1. Equipment Setup

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

1. Set power supply #1 for 30V DC, 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 J3 (VBAT and PGND).
6. Unplug jumper JP19.
7. Set 23V at KEPCO load output. Limit KEPCO to 6A. Use load #1 to power EVM from the VOUT output.
8. Connect J5 to the EV2500. Connect J5 to the I^2C PORT 2 on the EV2500.
9. Make sure the jumpers are installed as indicated in IO and Jumper Descriptions.
10. Turn on the computer and load #1. Open the bqStudio software.
    a. Select *Charger* and select the *Next* button.



    b. Select *Charger_1_00_BQ25853.bqz* on the *Select a Target Page*.
    c. After selecting the target device, select *Field View* and then select the *Read Register* button.

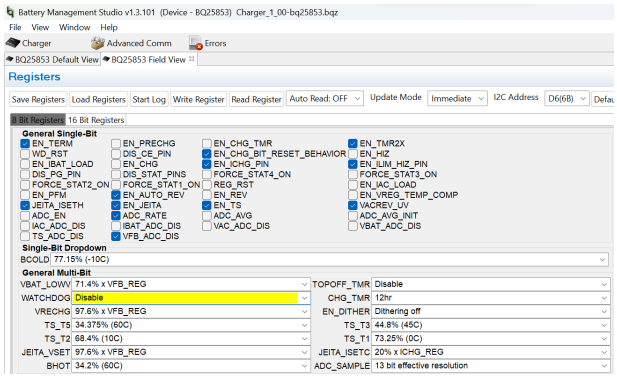
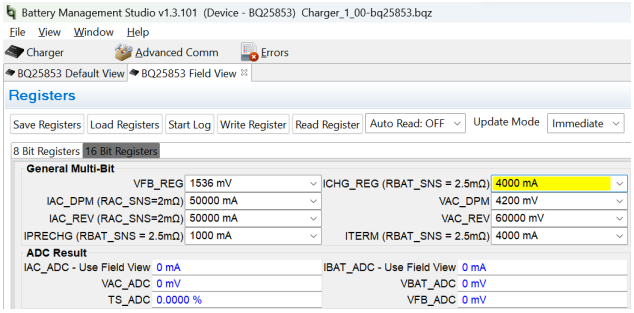


Figure 2-2. Equipment Set Up

11. Set WATCHDOG and EN_CHG to disabled.



12. In *16 Bit Registers*, set ICHG_REG to 4000mA.
13. Set EN_CHG to enabled.
14. Turn on power supply #1, measure:

    V(J1(VAC)) = 30V ± 0.5V

    I(J1(IAC)) = 3.2A ± 0.5A

    V(J3(VBAT)) = 23V ± 0.5V

    I(J3(IBAT)) = 4.0A ± 0.5A
15. Set power supply #1 for 23V, measure:

    V(J1(VAC)) = 23V ± 0.5V

    I(J1(IAC)) = 4.2A ± 0.5A

    V(J3(VBAT)) = 23V ± 0.5V

    I(J3(IBAT)) = 4.0A ± 0.5A
16. Set power supply #1 for 15V, measure:

    V(J1(VAC)) = 15V ± 0.5V

    I(J1(IAC)) = 6.4A ± 0.5A

    V(J3(VBAT)) = 23V ± 0.5V

    I(J3(IBAT)) = 4.0A ± 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 supercapacitor, connect 2000µF 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. **EV2500 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

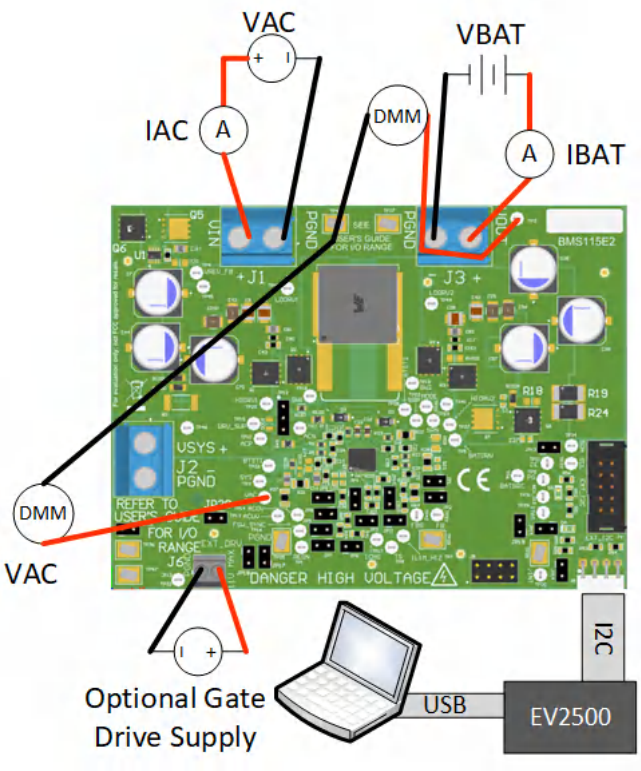
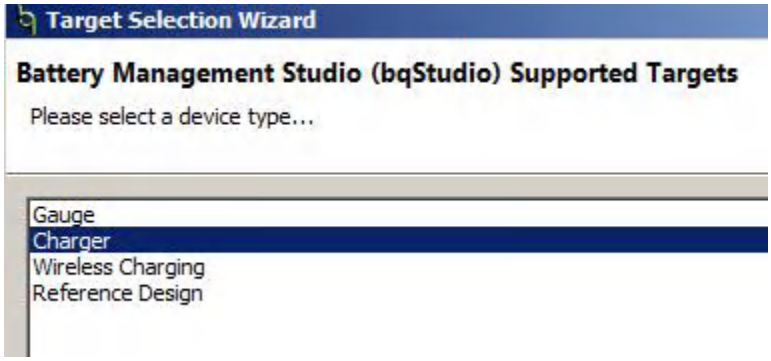


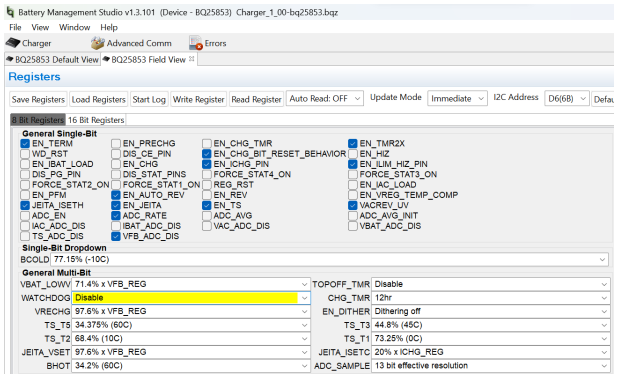
Figure 2-3. Equipment Set Up Using a CV Load

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

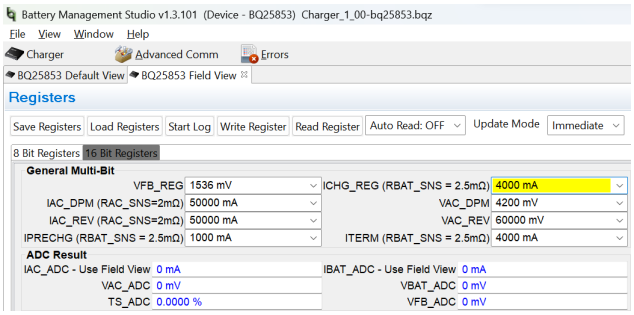
1. Set power supply #1 for 40VDC, 6A current limit and then turn off the supply.
2. Connect the output of power supply #1 in series with a current meter to J1 (VIN and PGND).
3. Connect a voltage meter across J1 (VIN) and J1 (PGND).
4. Connect load #1 in series with a current meter to J3 (VBAT and PGND).
5. Connect a voltage meter across J5 (VBAT and PGND).
6. Set 23.5V at electronic load input.
7. Connect J5 to the EV2500. Connect J5 to the I^2C PORT 2 on the EV2500.
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 select the *Next* button.



    b. Select *Charger_1_00_BQ25853.bqz* on the *Select a Target Page*.
    c. After selecting the target device, select *Field View* and then select the *Read Register* button.



11. Set WATCHDOG and EN_CHG to disabled.



12. In *16 Bit Registers*, set ICHG_REG to 4000mA.
13. Plug in Jumper 13. Set EN_CHG to enabled.
14. Set power supply #1 to 40V, measure

    V(J1(VAC)) = 40V ± 0.5V

    I(J1(IAC)) = 2.4A ± 0.5A

    V(J3(VBAT)) = 23.5V ± 0.5V

    I(J3(IBAT)) = 4.0A ± 0.5A
15. Set power supply #1 for 23V, measure

    V(J1(VAC)) = 23V ± 0.5V

    I(J1(IAC)) = 4.1A ± 0.5A

    V(J3(VBAT)) = 23.5V ± 0.5V

    I(J3(IBAT)) = 4.0A ± 0.5A
16. Set power supply #1 for 19V, measure

    V(J1(VAC)) = 19V ± 0.5V

    I(J1(IAC)) = 5A ± 0.5A

    V(J3(VBAT)) = 23.5V ± 0.5V

    I(J3(IBAT)) = 4.0A ± 0.5A

3 Hardware Design Files

The following sections includes the hardware design files for BQ25853EVM. This section includes the schematics, board layouts, and Bill of Materials (BOM).

3.1 Schematic

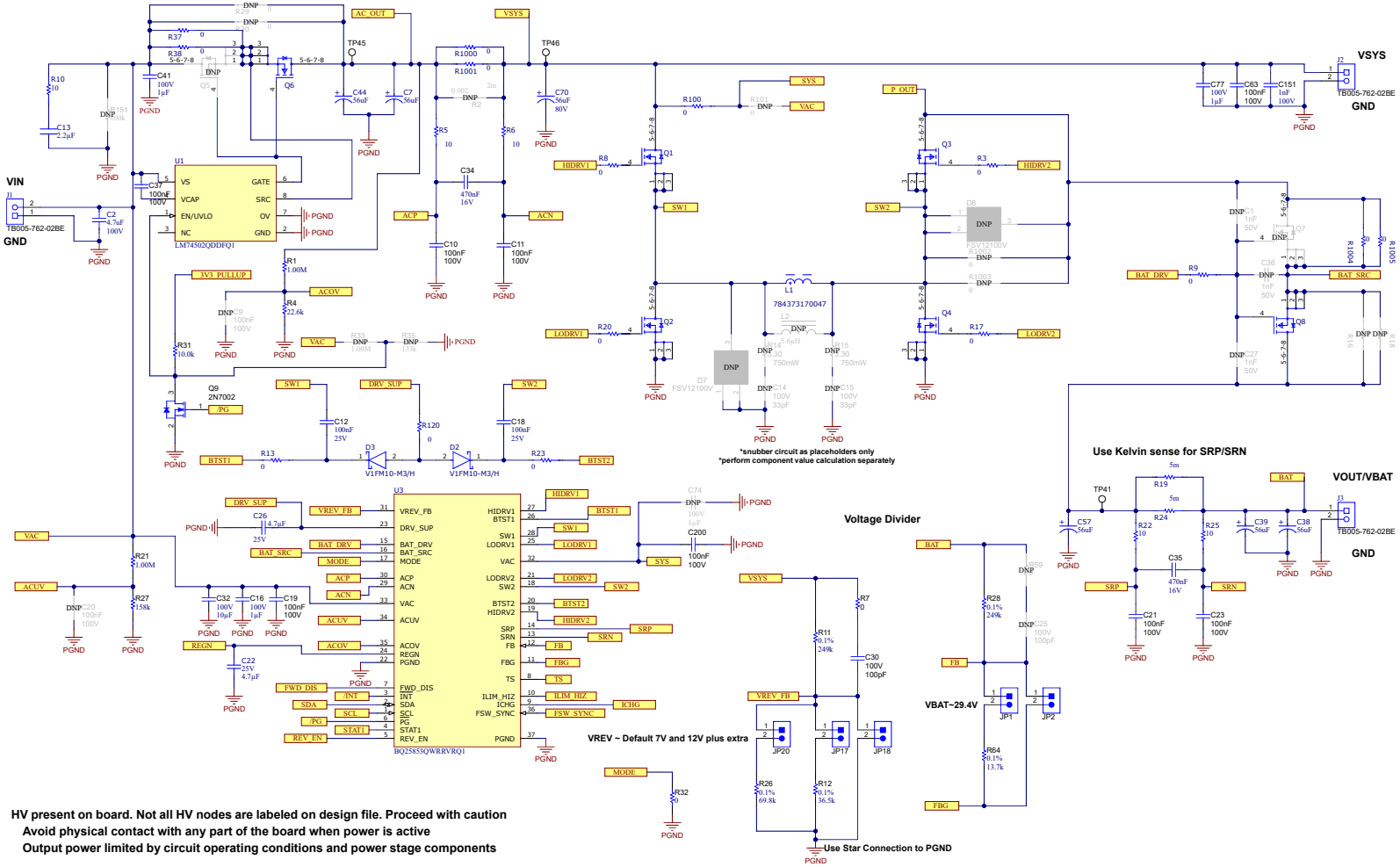
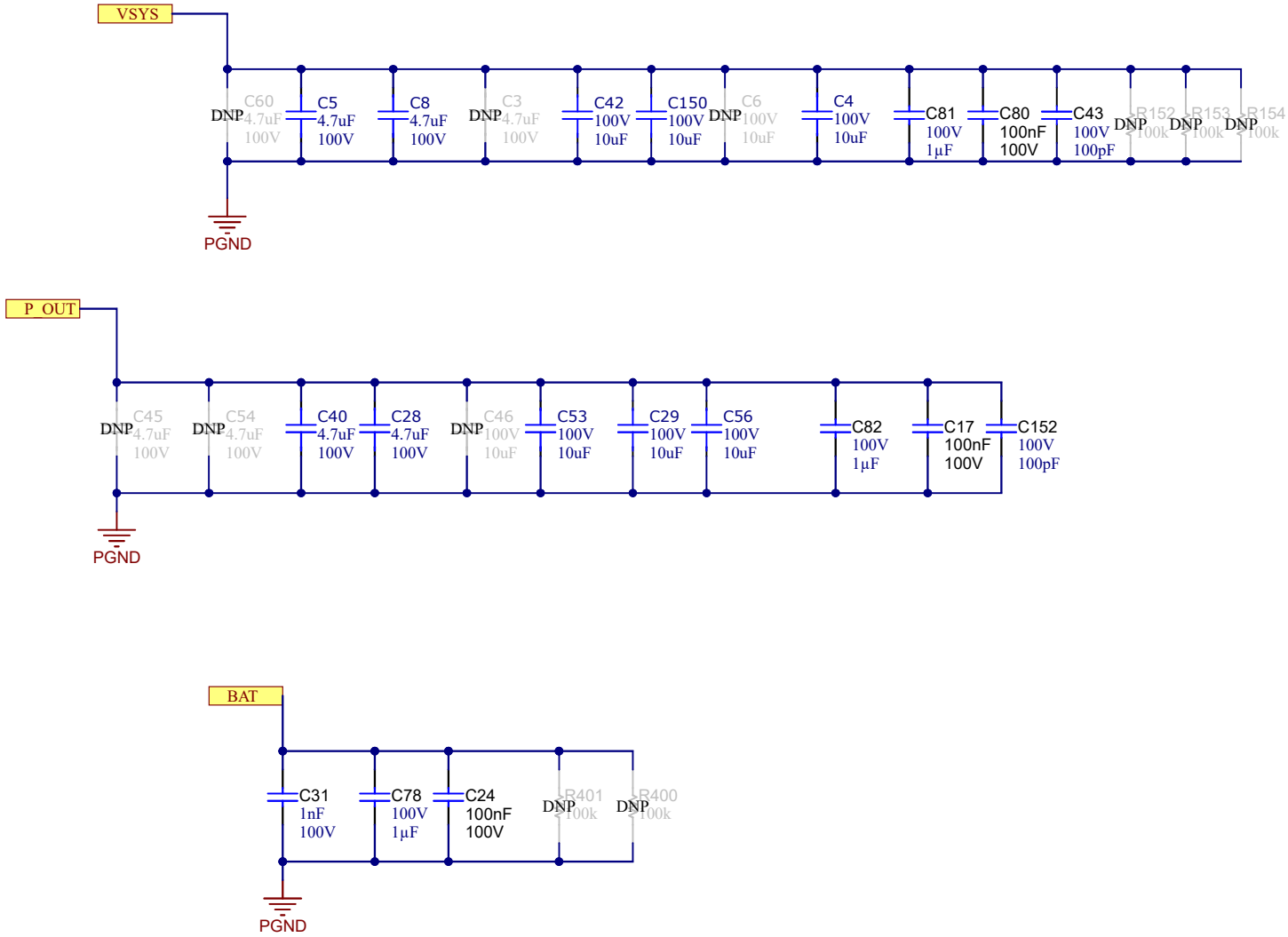
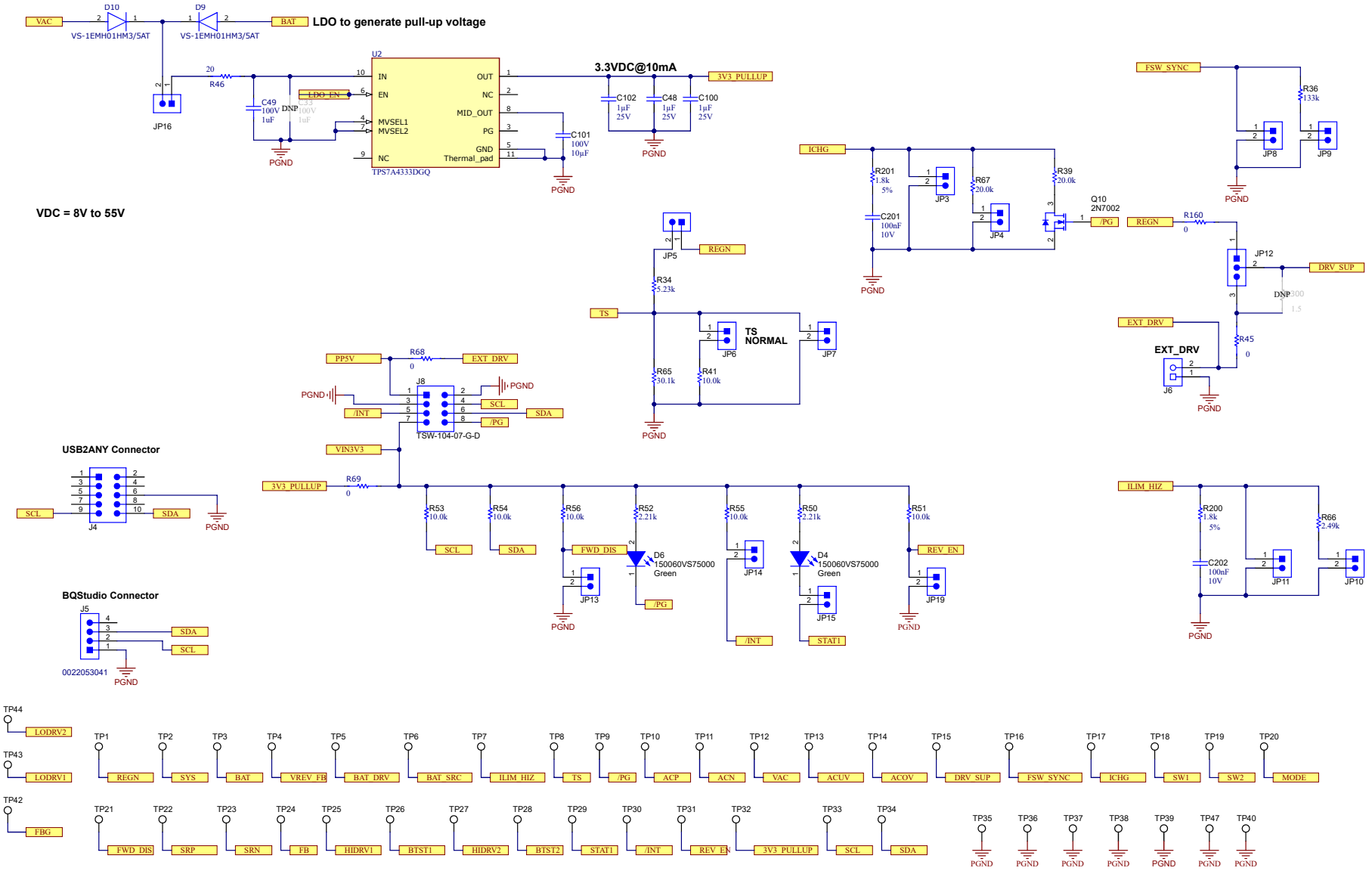
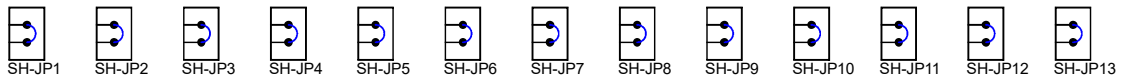


Figure 3-1. BQ25853EVM Schematic







H1 SJ-5303 (CLEAR)
H2 SJ-5303 (CLEAR)
H3 SJ-5303 (CLEAR)
H4 SJ-5303 (CLEAR)

LOGO1
DANGER HIGH VOLTAGE

LOGO2
CAUTION HOT SURFACE

LOGO3
PCB
LOGO
CAUTION. READ USER GUIDE BEFORE USE

FID1 Fiducial
FID2 Fiducial
FID3 Fiducial
FID4 Fiducial
FID5 Fiducial
FID6 Fiducial

LOGO4
PCB
LOGO
Texas Instruments

LOGO5
CE Mark

LOGO6
PCB
LOGO
FCC disclaimer

LOGO7
PCB
LOGO
WEEE logo

PCB Number: BMS115
PCB Rev: A

LBL1
PCB Label
THT-14-423-10

ZZ1
Assembly Note
These assemblies are ESD sensitive, ESD precautions shall be observed.

ZZ2
Assembly Note
These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.

ZZ3
Assembly Note
These assemblies must comply with workmanship standards IPC-A-610 Class 2, unless otherwise specified.

ZZ4
Assembly Note
Install label in silkscreened box after final wash. Text shall be 8 pt font. Text shall be per the Label Table in the PDF schematic.

ZZ5
Assembly Note
For BQ25853-Q1 variant, Install JP1, JP4, JP5, JP6, JP9, JP11, pin 1-2 of JP12, JP13, JP14, JP15, JP16, JP17, and JP19

Label Table

Variant	LBL1 Label Text
BQ25853-Q1	BQ25853Q1EVM

1. DNP means "Do Not Populate".

3.2 PCB Layout

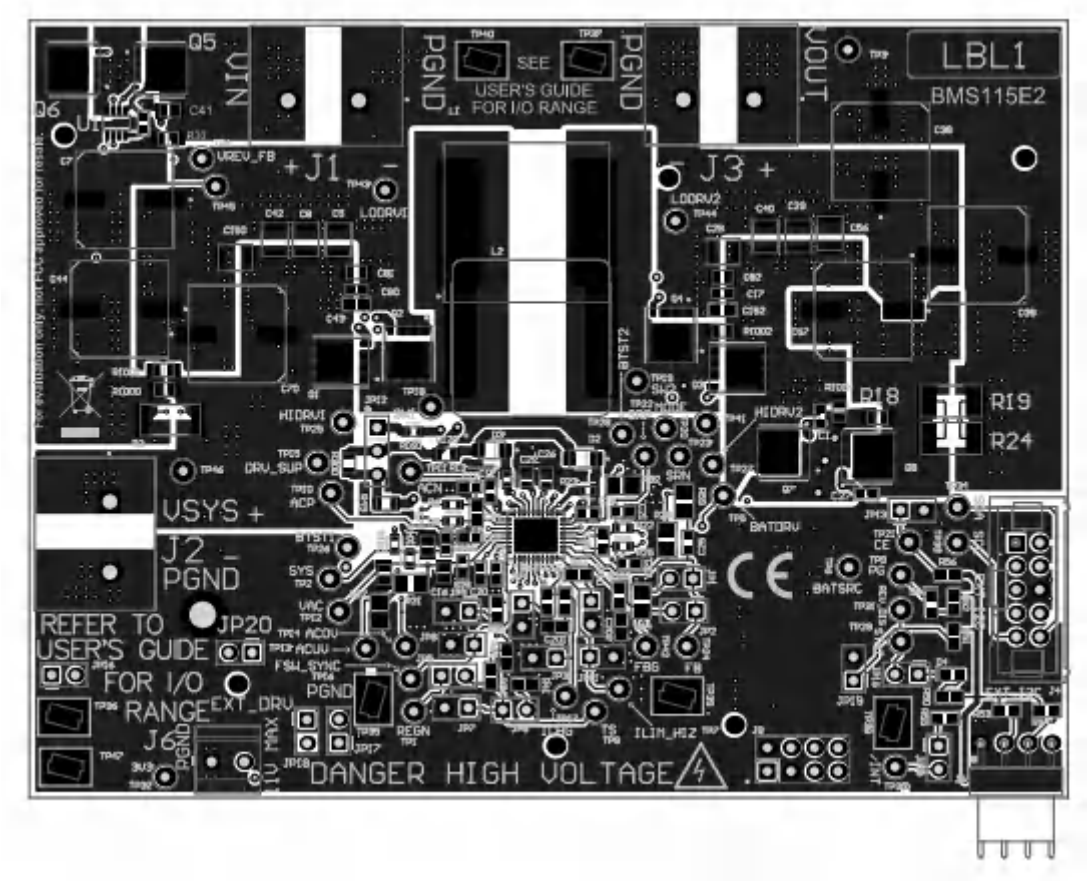


Figure 3-2. Top Layer and Overlay

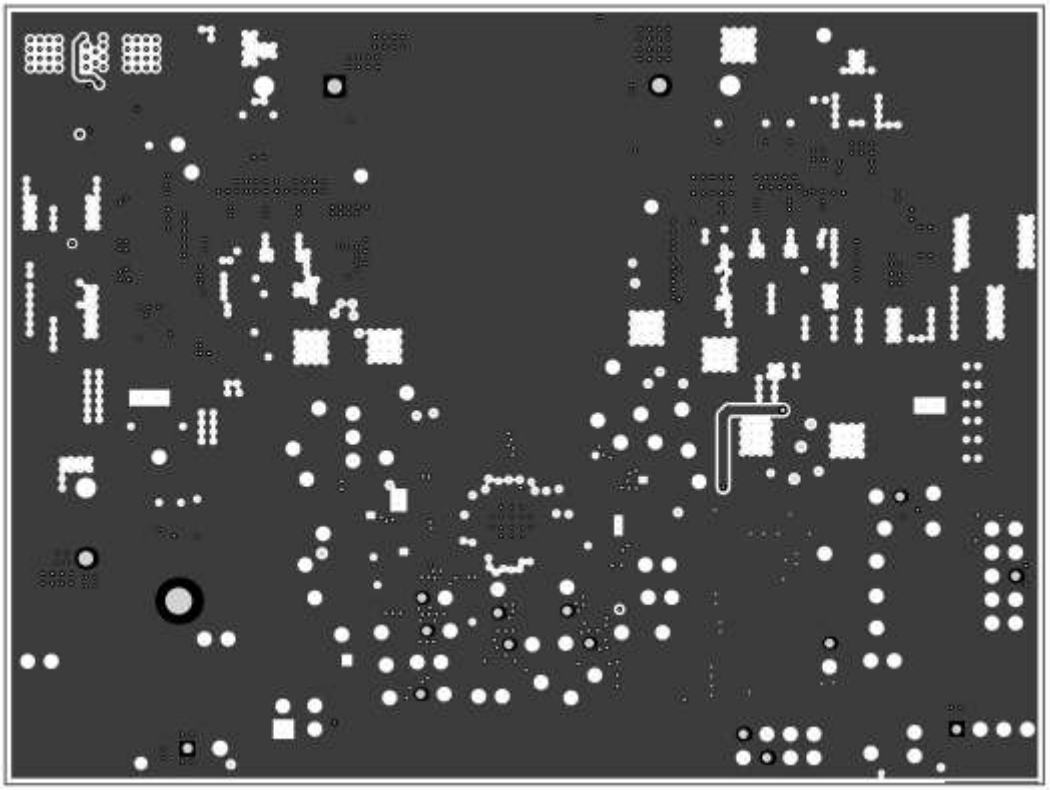


Figure 3-3. Layer 2 - GND

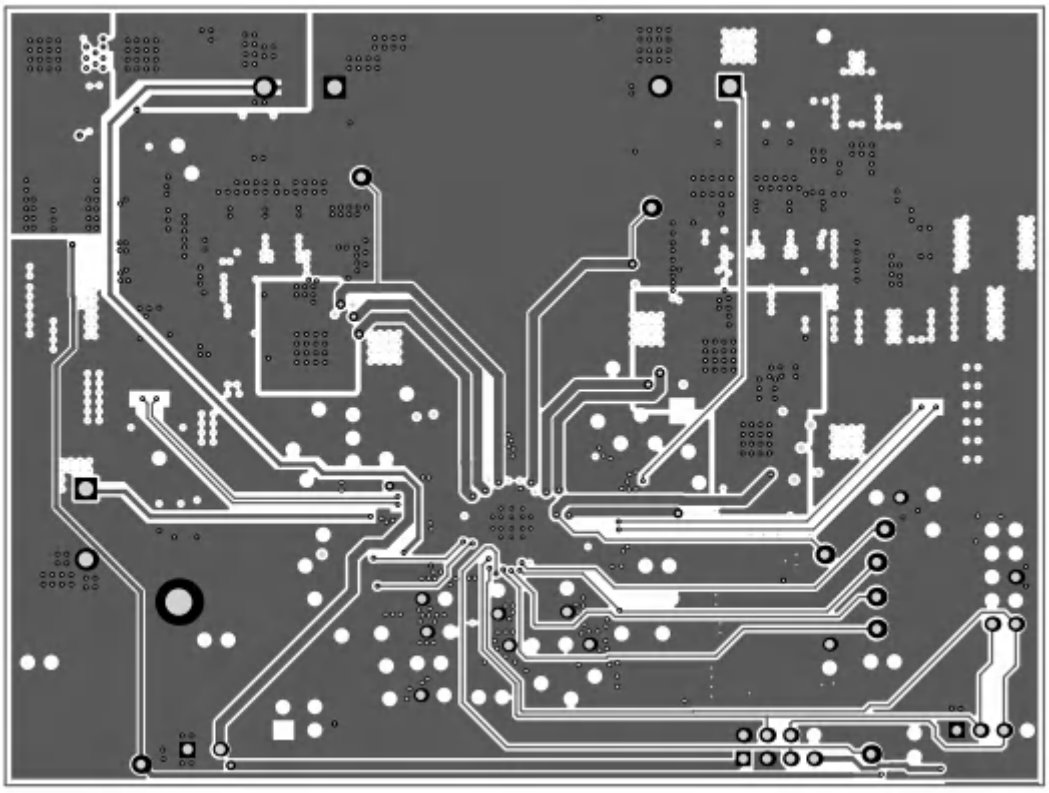


Figure 3-4. Signal Layer 1

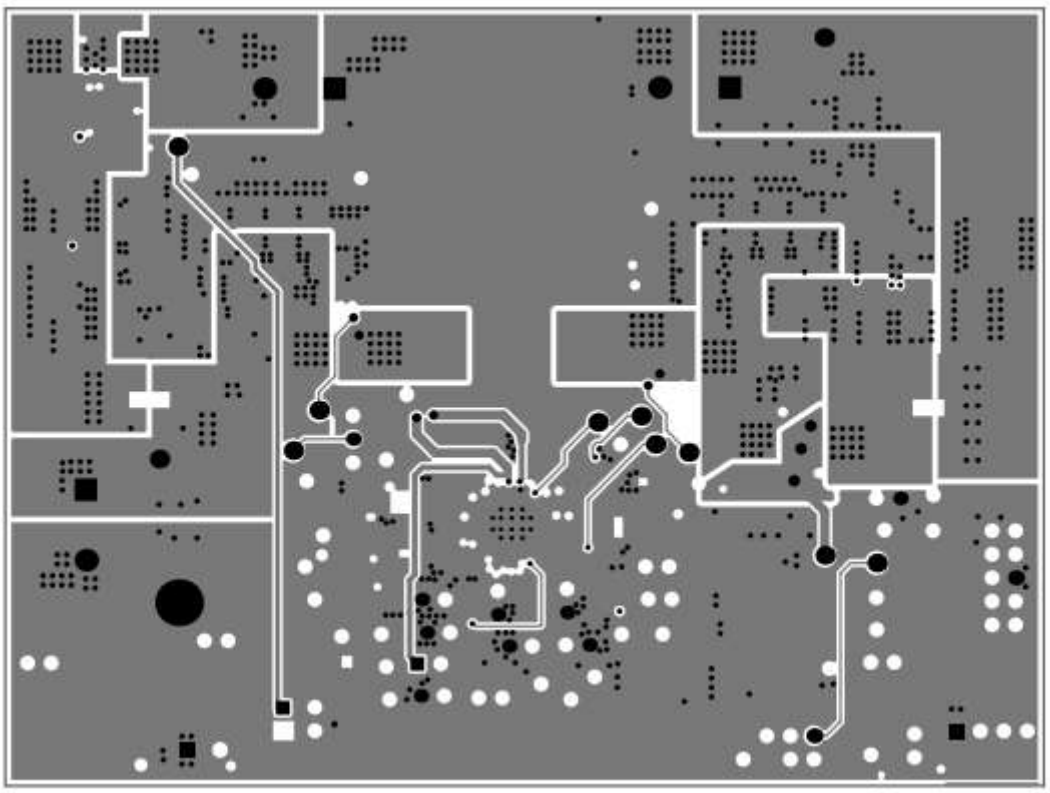


Figure 3-5. Signal Layer 2

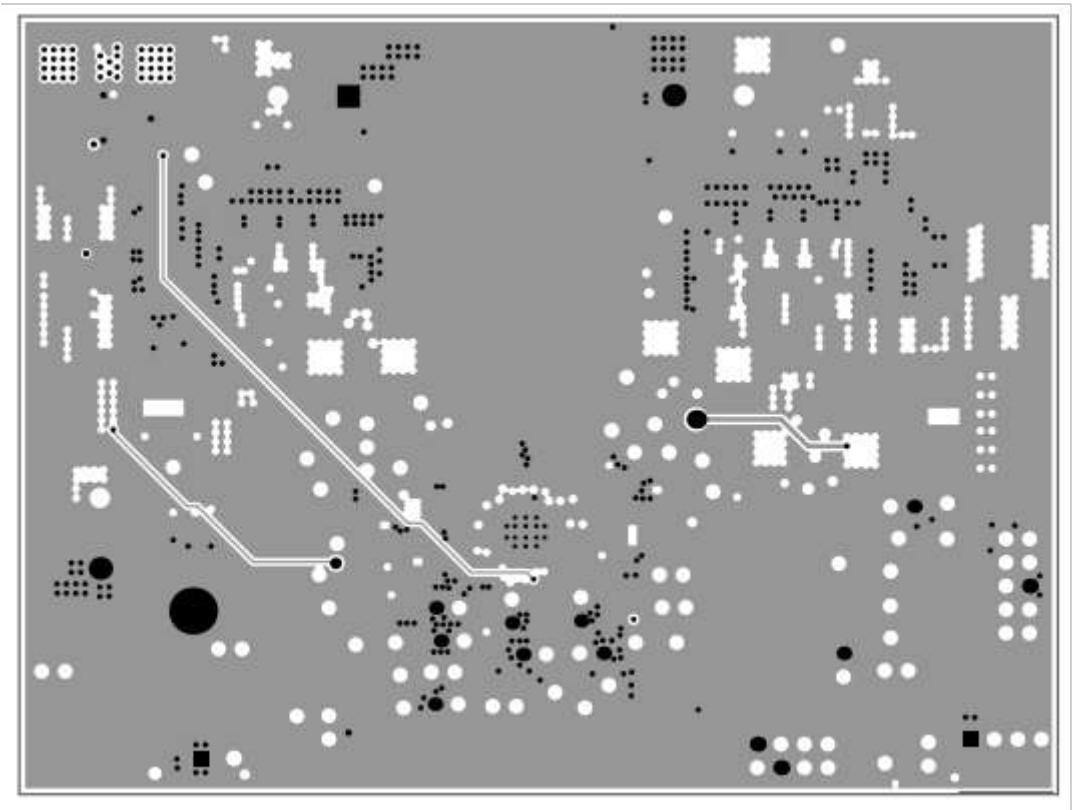


Figure 3-6. Layer 5 - GND

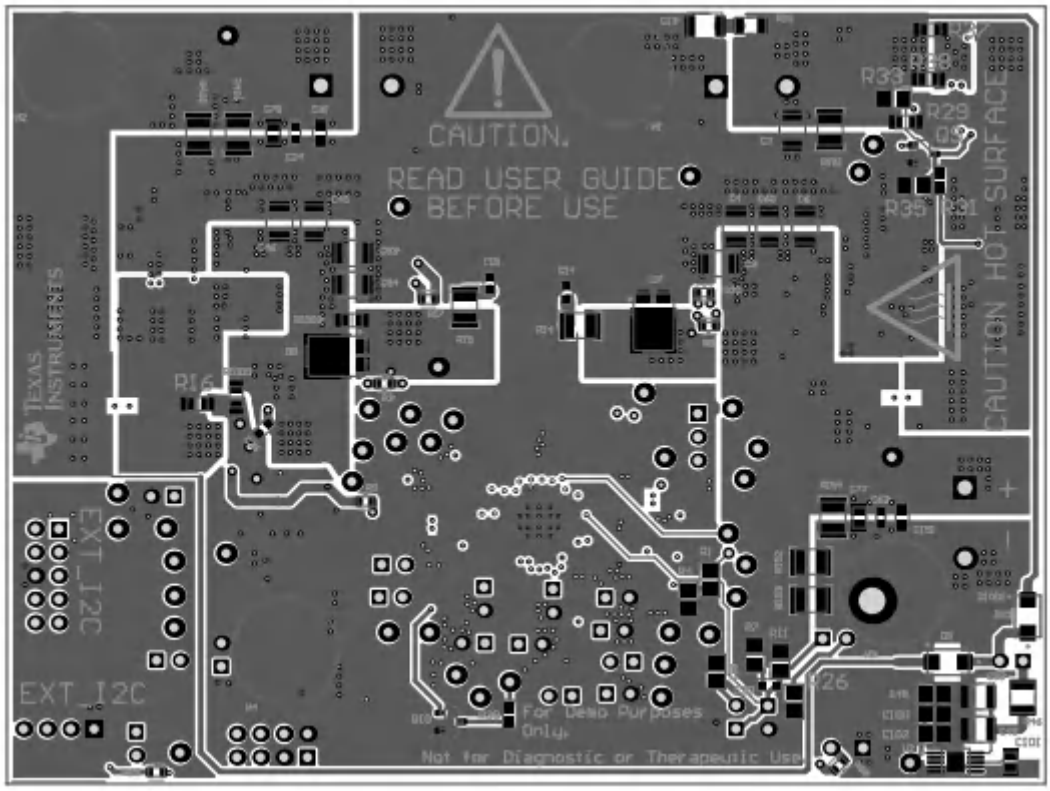


Figure 3-7. Bottom Layer and Overlay

3.3 Bill of Materials

Table 3-1. Bill of Materials

Item Number	Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReference
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	56µF	80SXV56M	Panasonic	56µF 80V Aluminum - Polymer Capacitors Radial, Can - SMD 28mΩ 1000 Hrs @ 125°C	SMT_CAP_10MM3_10MM3
4	C10, C11, C17, C19, C21, C23, C24, C37, C63, C80, C200	11	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		CGA6N3X7R2A225K230AE	TDK Corporation	Cap Ceramic 2.2uF 100V X7R 10% SMD 1210 FlexiTerm 125C Plastic T/R	1210
7	C16, C32, C41, C77, C78, C81, C82, C101	8	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	C30	1	100pF	GCM1885C2A101JA16D	MuRata	CAP, CERM, 100pF, 100V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	603
10	C31, C151	2	1000pF	CGA3E2X7R2A102K080AA	TDK	Multilayer Ceramic Capacitors MLCC - SMD/SMT CGA 0603 100V 1000pF X7R 10% AEC-Q200	603
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, C100, C102	3	1uF	C0805C105K3RACTU	Kemet	CAP, CERM, 1uF, 25V, +/- 10%, X7R, 0805	805
14	C49	1	1µF	12101C105KAT2A	AVX	General Purpose Ceramic Capacitor, 1210, 1uF, 10%, X7R, 15%, 100V	1210
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, D6	2	Green	150060VS75000	Wurth Elektronik	LED, Green, SMD	LED_0603
18	D9, D10	2		VS-1EMH01HM3/5AT	Vishay	Diode Standard 100V 1A Surface Mount DO-214AC (SMA)	DO-214AC

Table 3-1. Bill of Materials (continued)

Item Number	Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReference
19	FID1, FID2, FID3, FID4, FID5, FID6	6		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	N/A
20	H1, H2, H3, H4	4		SJ-5303 (CLEAR)	3M	Bumpon, Hemisphere, 0.44 × 0.20, Clear	Transparent Bumpon
21	J1, J2, J3	3		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, 3.5 mm, 2x1, TH
25	J8	1		TSW-104-07-G-D	Samtec	Header, 100mil, 4x2, Gold, TH	4x2 Header
26	JP1, JP2, JP3, JP4, JP5, JP6, JP7, JP8, JP9, JP10, JP11, JP13, JP14, JP15, JP16, JP17, JP18, JP19, JP20	19		PEC02SAAN	Sullins Connector Solutions	Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin
27	JP12	1		PEC03SAAN	Sullins Connector Solutions	Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin
28	L1	1	4.7uH	784373170047	Wurth Electronics	4.7µH Shielded Molded Inductor 27.5A 5.2mΩ Max Nonstandard	SMT_IND_17MM45_16MM95
29	LBL1	1		THT-14-423-10	Brady	Thermal Transfer Printable Labels, 0.650" W × 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch
30	PCB1	1		BMS115	Any	Printed Circuit Board	
31	Q1, Q2, Q3, Q4	4		IAUC50N08S5L096ATMA1	Infineon Technologies	N-Channel 80V 50A 60W (Tc) Surface Mount PG-TDSON-8-33	PG-TDSON-8-33
32	Q6, Q8	2		IAUC50N08S5L096ATMA1	Infineon Technologies	N-Channel 80V 50A 60W (Tc) Surface Mount PG-TDSON-8-33	PG-TDSON-8-33
33	Q9, Q10	2	60V	2N7002	Fairchild Semiconductor	MOSFET, N-CH, 60V, 115A, SOT-23	SOT-23
34	R1, R21	2	1.00Meg	CRCW08051M00FKEAC	Vishay / Dale	Thick Film Resistors - SMD 1/8Watt 1Mohms 1% Commercial Use	805
35	R3, R8, R9, R13, R17, R20, R23, R68, R69, R100, R160	11	0	CRCW06030000Z0EA	Vishay	Thick Film Resistors - SMD 1/10watt ZEROohm Jumper	603
36	R4	1	22.6k	ERJ-6ENF2262V	Panasonic	RES, 22.6 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	805
37	R5, R6, R22, R25	4	10	CRCW060310R0FKEB	Vishay	RES Thick Film, 10Ω, 1%, 0.1W, 100ppm/°C, 0603	603

Table 3-1. Bill of Materials (continued)

Item Number	Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReference
38	R7	1	0	RC0805JR-070RL	Yageo America	RES, 0, 5%, 0.125 W, 0805	805
39	R10	1	10	CRCW120610R0FKEAHP	Vishay Dale	RES Thick Film, 10Ω, 1%, 0.75W, 100ppm/°C, 1206	1206
40	R11, R28	2	249k	ERJ-PB6B2493V	Panasonic	Thick Film Resistors - SMD 0805 Anti-Surge Res. 0.1%, 249Kohm	805
41	R12	1	36.5k	RT0805BRD0736K5L	Yageo America	RES, 36.5 k, 0.1%, 0.125 W, 0805	805
42	R19, R24	2	5m	WSL25125L000FEA	Vishay	Res Metal Strip 2512 0.005Ω 1% 1W 110ppm/C Molded SMD SMD Embossed Plastic T/R	2512
43	R26	1	69.8k	RT0805BRD0769K8L	Yageo America	RES, 69.8 k, 0.1%, 0.125W, 0805	805
44	R27	1	158k	ERJ-6ENF1583V	Panasonic	RES, 158 k, 1%, 0.125W, AEC-Q200 Grade 0, 0805	805
45	R31, R41, R51, R53, R54, R55, R56	7	10.0k	RC0603FR-0710KL	Yageo	RES, 10.0 k, 1%, 0.1W, 0603	603
46	R32	1	0	PMR10EZPJ000	Rohm	RES, 0, 0%, W, AEC-Q200 Grade 0, 0805	805
47	R34	1	5.23k	RC0603FR-075K23L	Yageo	RES, 5.23 k, 1%, 0.1W, 0603	603
48	R36	1	133k	CRCW0603133KFKEA	Vishay-Dale	RES, 133 k, 1%, 0.1W, AEC-Q200 Grade 0, 0603	603
49	R37, R38, R1000, R1001, R1004, R1005	6	0	JR0805X35E	Ohmite	0Ω Jumper 0.245W Chip Resistor 0805 (2012 Metric) - Metal Element	805
50	R39, R67	2	20.0k	ERJ-3EKF2002V	Panasonic	RES, 20.0 k, 1%, 0.1W, AEC-Q200 Grade 0, 0603	603
51	R45, R120	2	0	CRCW08050000Z0EA	Vishay	Thick Film Resistors - SMD 1/8watt ZEROohm Jumper	805
52	R46	1	20	CRCW121020R0FKEAHP	Vishay Dale	Thick Film Resistors - SMD 3/4watt 20ohms 1% High Power AEC-Q200	1210
53	R50, R52	2	2.21k	RC0603FR-072K21L	Yageo	RES, 2.21 k, 1%, 0.1W, 0603	603
54	R64	1	13.7k	RG2012P-1372-B-T5	Susumu Co Ltd	RES, 13.7 k, 0.1%, 0.125W, 0805	805
55	R65	1	30.1k	RC0603FR-0730K1L	Yageo	RES, 30.1 k, 1%, 0.1W, 0603	603
56	R66	1	2.49k	RC0603FR-072K49L	Yageo	RES, 2.49 k, 1%, 0.1W, 0603	603
57	R200, R201	2	1.8k	RC0603JR-071K8L	Yageo	RES, 1.8 k, 5%, 0.1W, 0603	603

Table 3-1. Bill of Materials (continued)

Item Number	Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReference
58	SH-JP1, SH-JP2, SH-JP3, SH-JP4, SH-JP5, SH-JP6, SH-JP7, SH-JP8, SH-JP9, SH-JP10, SH-JP11, SH-JP12, SH-JP13	13	1x2	SNT-100-BK-G	Samtec	Shunt, 100mil, Gold plated, Black	Shunt
59	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 Testpoint
60	TP35, TP36, TP37, TP38, TP39, TP40, TP47	7		5016	Keystone	Test Point, Compact, SMT	Testpoint_Keystone_Compact
61	U1	1		LM74502QDDFQ1	Texas Instruments	Reverse Polarity Protection Controller with Over Voltage Protection	SOT23-8
62	U2	1		TPS7A4333DGQ	Texas Instruments	LDO, Fixed Output, Dual, 3.3V, 10/12/15V, 50mA, Precision Enable, Power-Good, HVSSOP10	HVSSOP10
63	U3	1		BQ25853QWRRVRQ1	Texas Instruments	BQ25853QWRRVRQ1	VQFN36

4 Additional Information

4.1 Trademarks

All trademarks are the property of their respective owners.

5 Revision History

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

Changes from Revision * (March 2026) to Revision A (July 2026)	Page
• Updated hardware image	1
• Added schematic and PCB Layout images	14
• Updated FETs, Inductor, and FSW_SYNC resistor	22

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying 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 set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   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 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 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 a nonconforming EVM if (a) the nonconformity was 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, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, 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.

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

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

FCC NOTICE: 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 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. 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。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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.

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