

TPS25830-Q1 Evaluation Module

This user's guide describes the TPS25830-Q1 evaluation module (TPS25830Q1EVM-040). This document contains the EVM schematics, EVM configuration, bill of materials(BOM), board layout drawing and assembly drawing.

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Trademarks

USB Type-C is a trademark of USB Implementers Forum.
All other trademarks are the property of their respective owners.

1 Introduction

The TPS25830Q1EVM-040 is an evaluation module (EVM) for TI's TPS25830-Q1 USB Type-C™ and BC1.2 5-V, 3.5-A output and 36-V input synchronous buck with cable compensation. The EVM operates over a range from 6 V to 36 V and provides USB Type-C connectors to evaluate BC1.2, USB Type-C charging and USB2.0 data communication functions. The value of cable compensation, current limit and switching frequency can be adjusted by resistors on the EVM.

1.1 Features

The following features are available on this EVM:

- 6-V to 36-V input range, 3.5-A continuous output current buck converter
- Forced PWM operation with *Spread-Spectrum Dithering*
- Fully AEC-Q100 qualified
- $\pm 8\%$ *Current Sense Accuracy* ($I_{OUT} > 1.5$ A) for *Precision Cable Droop Compensation*
- USB battery charging specification Rev. 1.2 and USB Type-C Rev. 1.3 compliant
- CC1, CC2, D+ and D– Short-to-VBAT, and VBUS protection
- User-programmable VBUS current limit and internal VCONN current limiting
- High bandwidth DP, DM USB switches

1.2 Applications

The EVM is used in the following applications:

- Automotive: Infotainment, USB hubs, aftermarket USB chargers

2 Schematic

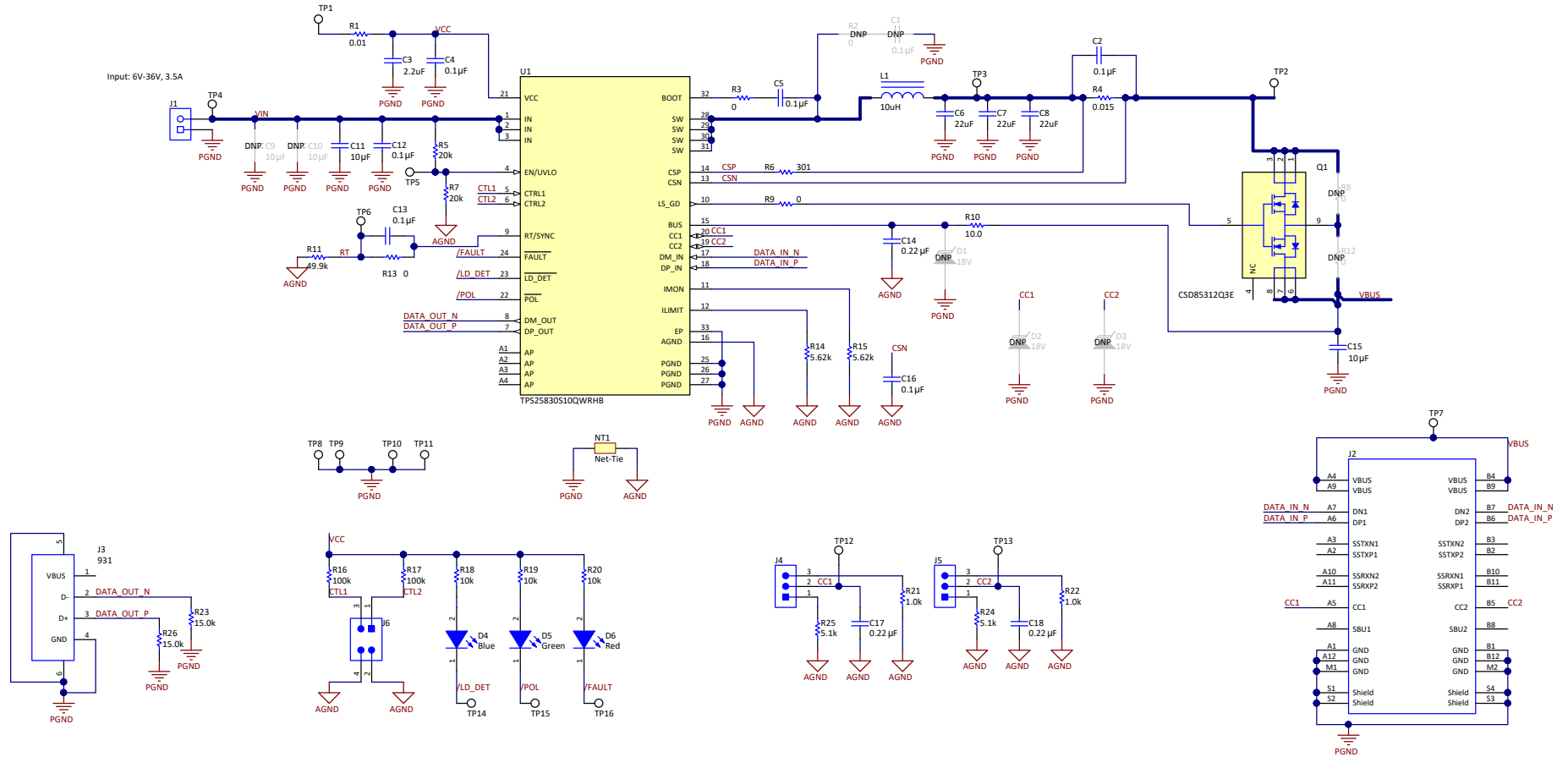


Figure 1. TPS25830Q1EVM-040 Schematic

3 General Configuration and Description

This section describes the connectors, jumpers, LED and test points on the EVM and how to properly connect, set up and use the TPS25830Q1EVM-040.

3.1 Physical Access

Table 1 lists the TPS25830Q1EVM-040 connector functionality, Table 2 describes the jumper configuration, Table 3 shows LED labels and description and Table 4 describes the test point availability.

Table 1. Connectors

Connector	Component Type	Description
J1	Terminal block	Power input connector for TPS25830-Q1. Connect to a 6-V to 36-V power supply.
J3	USB Type-A connector, plug	Upstream facing USB 2.0 Type A connector. Connect to the USB 2.0 host for data pass through to J4 or J8. The power pin of this connector is float.
J2	USB Type-C connector, receptacle	Downstream facing USB Type-C connector. Connect to the USB Type-C slave for data pass through from J4 and BC1.2 or USB Type-C identification. USB output power is provided to the slave from the buck converter of the TPS25830-Q1 device.

Table 2. Jumpers

Jumper	Label	Description
J4	CC1	3 × 1 header. Install shunt to connect Ra or Rd on CC1. Remove shunt to float CC1.
J5	CC2	3 × 1 header. Install shunt to connect Ra or Rd on CC2. Remove shunt to float CC2.
J6	CTRL1	Install shunt to select CTRL1 as LOW. Remove shunt to select CTRL1 as HIGH.
	CTRL2	Install shunt to select CTRL2 as LOW. Remove shunt to select CTRL2 as HIGH.

Table 3. LED

LED	Label	Description
D4	LD_DET	LD_DET signal LED. Turn on when LD_DET asserts.
D5	POL	POL signal LED. Turn on when POL asserts.
D6	FAULT	FAULT signal LED. Turn on when FAULT asserts.

Table 4. Test Points

Test Point	Label	Description
TP1	VCONN	VCC pin test point via R1 or external Vconn input
TP2	CSN/OUT	CSN pin test point and DC-DC output test point
TP3	CSP	Test point of voltage between inductor and sense resistor.
TP4	VIN	VIN pin test point
TP5	EN	EN pin test point or external EN input.
TP6	RT	RT pin test point or external clock input.
TP7	VBUS	USB Type-A and USB Type-C connector, VBUS test point
TP8, TP9, TP10, TP11	GND	Power ground test point
TP12	CC1	CC1 pin test point
TP13	CC2	CC2 pin test point
TP14	LD_DET	LD_DET pin test point
TP15	POL	POL pin test point
TP16	FAULT	FAULT pin test point

3.2 Adjusting the Switching Frequency

If other frequencies are desired, within the frequency range of 400 kHz to 2.2 MHz, the R_i resistor (R11) value can be changed. Consult the datasheet for proper selection of the R_i resistor (R11). Change the inductor (L1) and the total output capacitance for proper control loop operation.

The RT/SYNC pin can also be used to synchronize the internal oscillator to an external clock. The TPS25830EVMQ1-040 allows users to synchronize the internal oscillator to both Lo-Z clock source and Hi-Z clock source by configuring R11, R13, and C13. Refer to the datasheet for detailed information.

3.3 Adjusting the Current Limit Value

If other current limit values are desired, the R_i resistor (R14) value can be changed. Consult the datasheet for proper selection of the R_i resistor (R14).

3.4 Adjusting the Cable Compensation Value

If other cable compensation values are desired, the R_m resistor (R15) value can be changed. Consult the datasheet for proper selection of the R_m resistor (R15).

3.5 Test Setup

Figure 2 shows a typical test setup for charging the USB Type-C device. Connect J1 to the 13.5-V power supply. Connect USB Type-C device to J2 connector. Shunts do not need to be installed on J4 or J5.

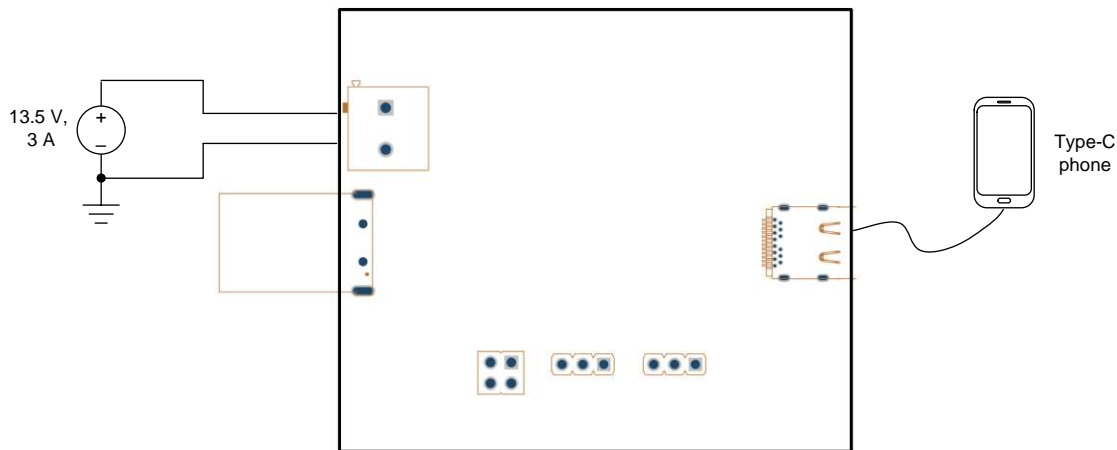


Figure 2. EVM Setup for Charging USB Type-C™ Device

4 Board Layout

Figure 3 and Figure 4 show the top and bottom assembly. Figure 5 and Figure 6 show the top side and bottom side 3D view. Figure 7 to Figure 10 show the layout of the EVM.

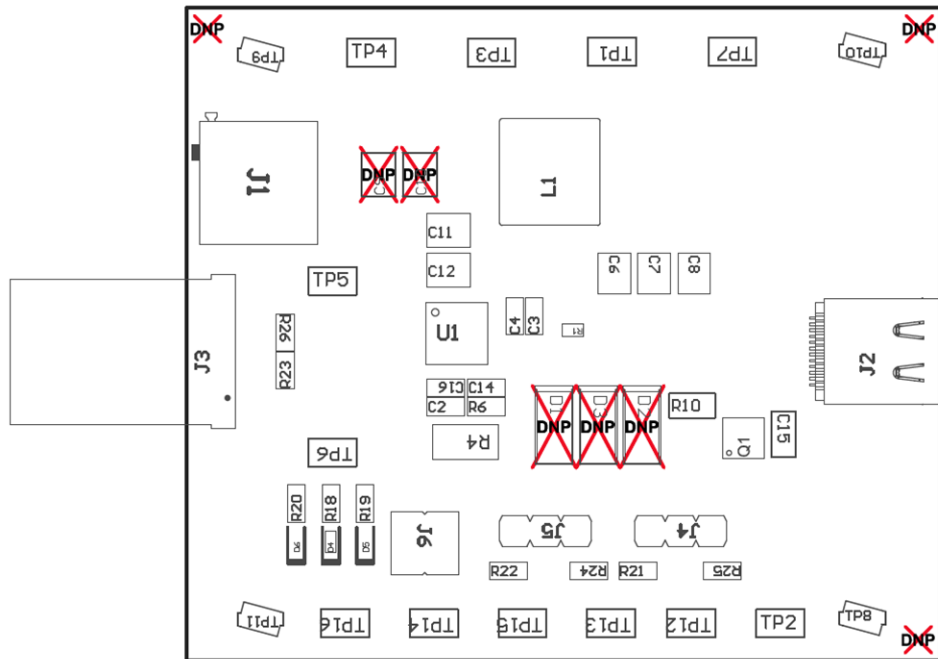


Figure 3. Top Side Assembly

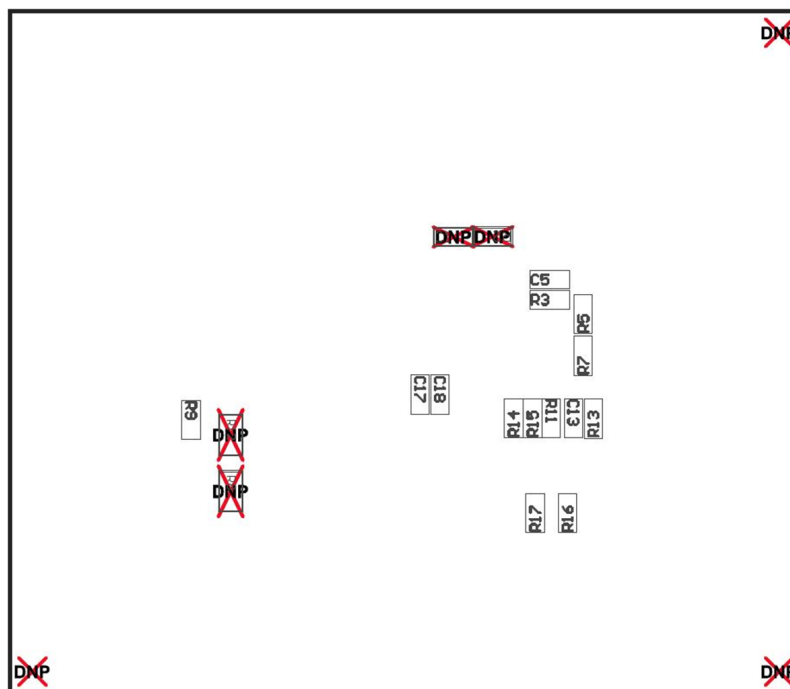


Figure 4. Bottom Side Assembly

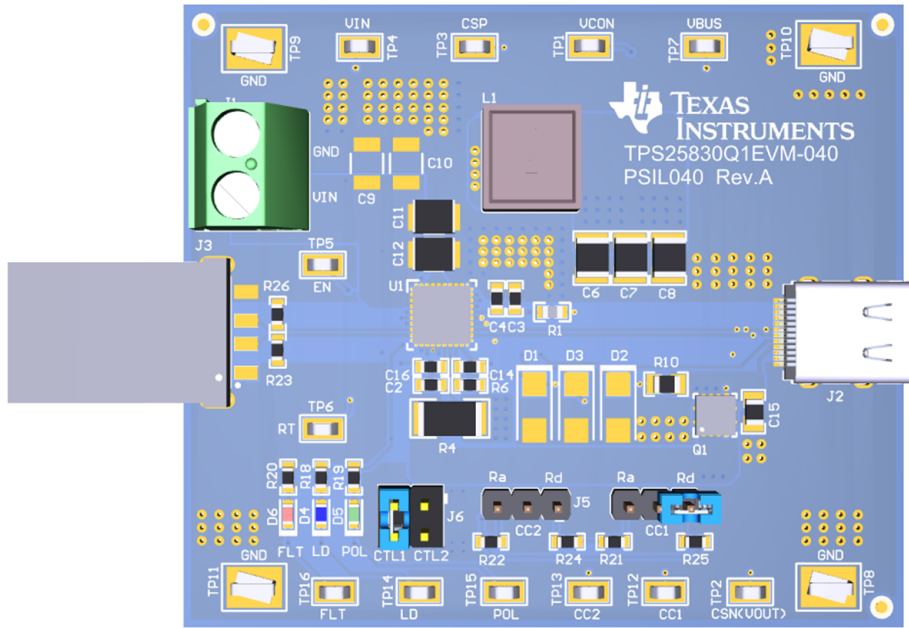


Figure 5. Top Side 3D View

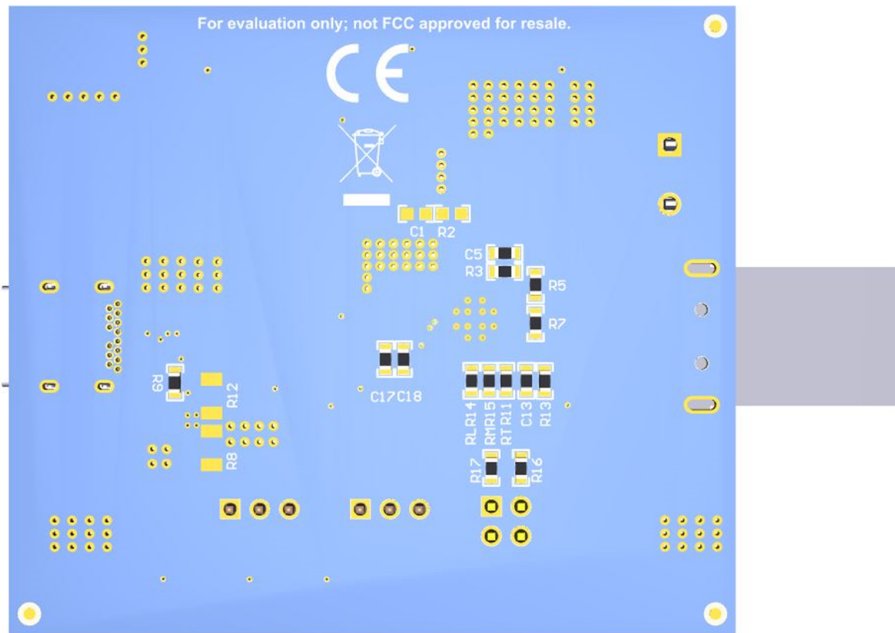


Figure 6. Bottom Side 3D View

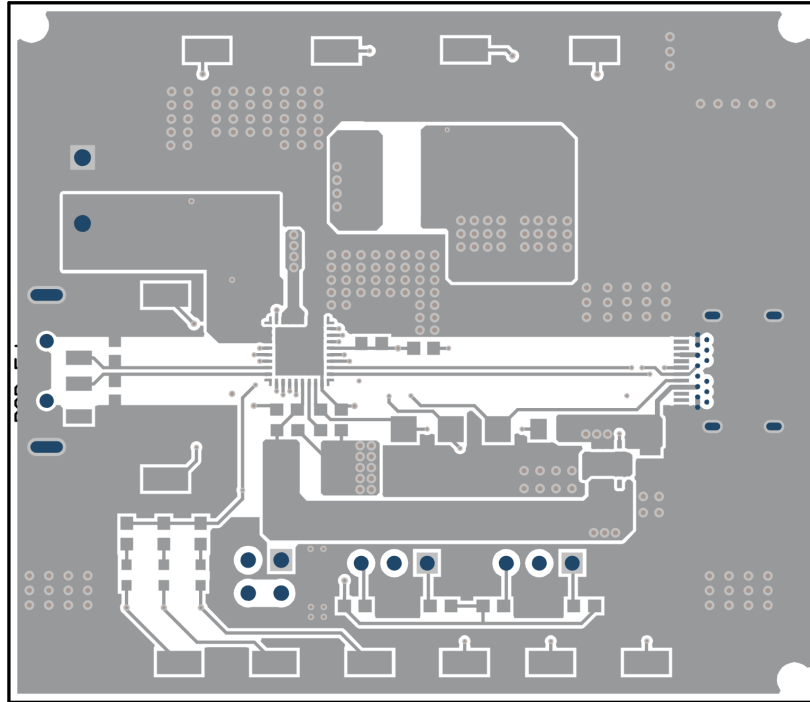


Figure 7. Top Layer Layout

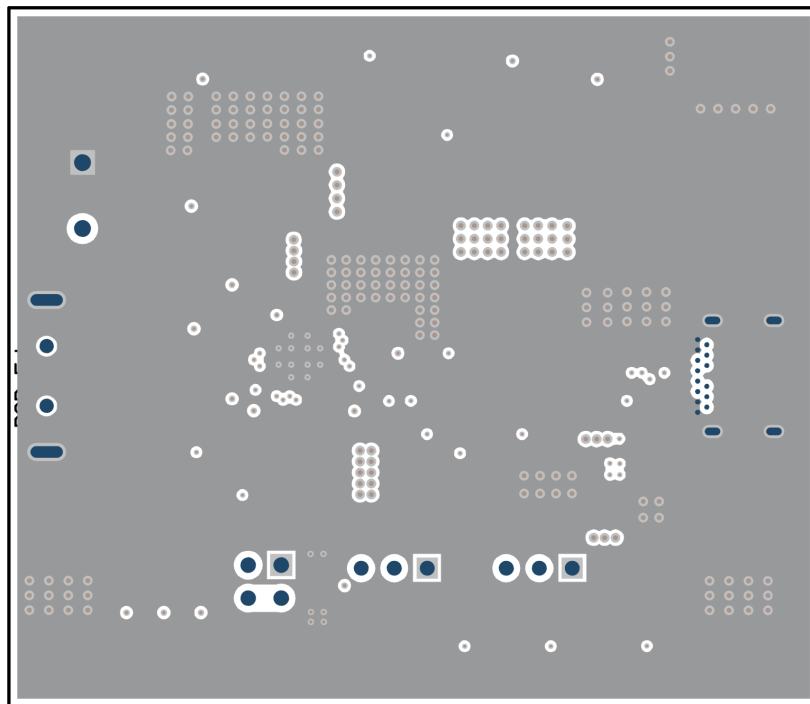


Figure 8. Middle Layer 1 Layout

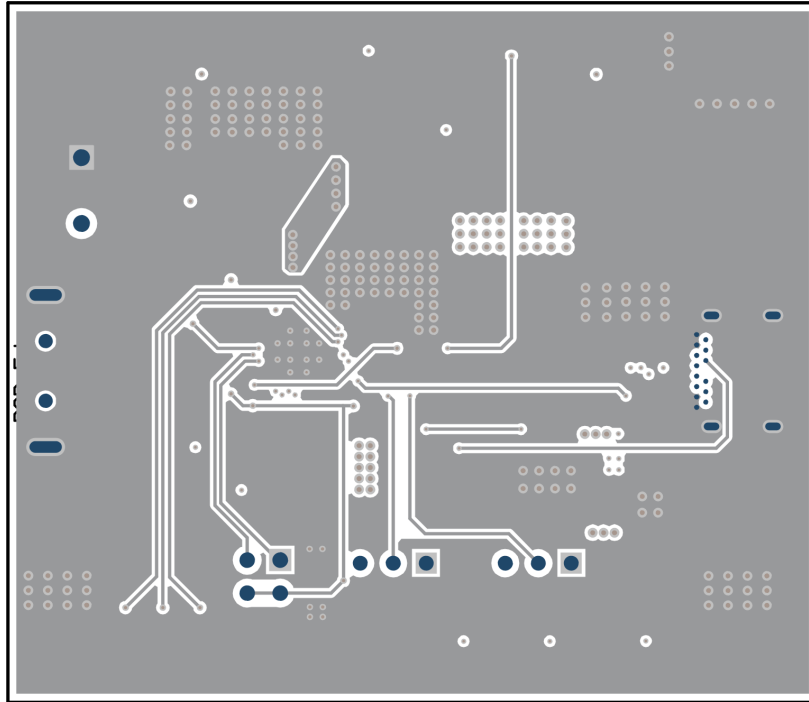


Figure 9. Middle Layer 2 Layout

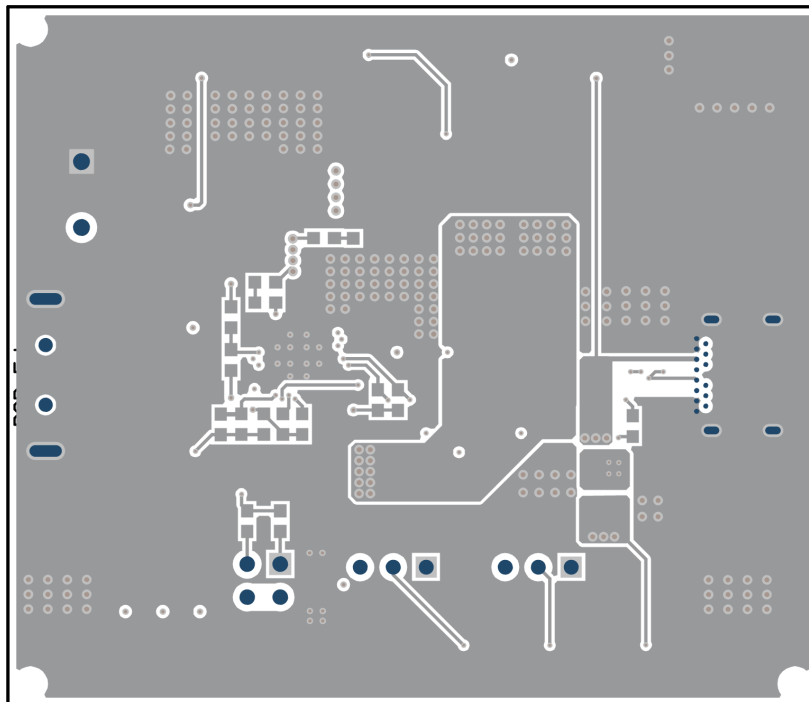


Figure 10. Bottom Layer Layout

5 Bill of Materials

Table 5 details the EVM bill of materials.

Table 5. Bill of Materials

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
C2, C4, C5, C13, C16	5	0.1 uF	CAP, CERM, 0.1 uF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C104K5RACAUTO	Kemet
C3	1	2.2 uF	CAP, CERM, 2.2 uF, 16 V, +/- 20%, X5R, 0603	0603	885012106018	Würth Elektronik
C6, C7, C8	3	22 uF	CAP, CERM, 22 uF, 25 V, +/- 10%, X7R, 1210	1210	GRM32ER71E226KE15L	MuRata
C11	1	10 uF	CAP, CERM, 10 uF, 50 V,+/- 20%, X7R, AEC-Q200 Grade 1, 1210	1210	UMJ325KB7106MMHP	Taiyo Yuden
C12	1	0.1 uF	CAP, CERM, 0.1 uF, 50 V,+/- 5%, C0G/NP0, 1210	1210	C3225C0G1H104J250AA	TDK
C14, C17, C18	3	0.22 uF	CAP, CERM, 0.22 uF, 16 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CL10B224K08VPNC	Samsung
C15	1	10 uF	CAP, CERM, 10 uF, 16 V,+/- 10%, X6S, 0805	0805	GRM21BC81C106KA73L	MuRata
D4	1	Blue	LED, Blue, SMD	LED_0603	150060BS75000	Würth Elektronik
D5	1	Green	LED, Green, SMD	LED_0603	150060GS75000	Würth Elektronik
D6	1	Red	LED, Red, SMD	LED_0603	150060RS75000	Würth Elektronik
J1	1		Terminal Block, 5.08 mm, 2x1, TH	2POS Terminal Block	1715721	Phoenix Contact
J2	1		Connector, Receptacle, USB Type C, R/A	Connector, Receptacle, USB Type C, R/A, THT/SMT	632723300011	Würth Elektronik
J3	1		Connector, Plug, USB Type A, R/A, Top Mount SMT	USB 2.0, SMT Plug, 18.65x4.5x12mm	931	Keystone
J4, J5	2		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54 mm, 3x1, TH	61300311121	Würth Elektronik
J6	1		Header, 2.54 mm, 2x2, Gold, TH	Header, 2.54 mm, 2x2, TH	PBC02DAAN	Sullins Connector Solutions
L1	1	10 uH	Inductor, Shielded, Composite, 10 uH, 5.8 A, 0.022 ohm, SMD	8.8x8.3mm	74439358100	Würth Elektronik
Q1	1	20 V	MOSFET, 2-CH, N-CH, 20 V, 12 A, DPA0008A (VSON-8)	DPA0008A	CSD85312Q3E	Texas Instruments
R1	1	0.01	RES, 0.01, 1%, 0.1 W, 0603	0603	WSL0603R0100FEA	Vishay-Dale
R3, R9, R13	3	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R4	1	0.015	RES, 0.015, 1%, 0.5 W, 2010	2010	WSL2010R0150FEA	Vishay-Dale
R5, R7	2	20 k	RES, 20 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060320K0JNEA	Vishay-Dale
R6	1	301	RES, 301, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603301RFKEA	Vishay-Dale
R10	1	10.0	RES, 10.0, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW080510R0FKEA	Vishay-Dale
R11	1	49.9 k	RES, 49.9 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060349K9FKEA	Vishay-Dale
R14, R15	2	5.62 k	RES, 5.62 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06035K62FKEA	Vishay-Dale
R16, R17	2	100 k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R18, R19, R20	3	10 k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0JNEA	Vishay-Dale
R21, R22	2	1.0 k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031K00JNEA	Vishay-Dale
R23, R26	2	15.0 k	RES, 15.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060315K0FKEA	Vishay-Dale
R24, R25	2	5.1 k	RES, 5.1 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06035K10JNEA	Vishay-Dale
SH-J1, SH-J2	2		Shunt, 2.54 mm, Gold, Blue	Shunt, 2.54 mm, Blue	60900213621	Würth Elektronik

Table 5. Bill of Materials (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP12, TP13, TP14, TP15, TP16	12		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
TP8, TP9, TP10, TP11	4		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone
U1	1		USB Type-C and BC1.2 5V 3.5A Output, 36V Input Synchronous Buck with Cable Compensation, RHB0032R (VQFN-32)	RHB0032R	TPS25830S10QWRHB	Texas Instruments
C1	0	0.1 uF	CAP, CERM, 0.1 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C104K5RACAUTO	Kemet
C9, C10	0	10 uF	CAP, CERM, 10 µF, 50 V,+/- 20%, X7R, AEC-Q200 Grade 1, 1210	1210	UMJ325KB7106MMHP	Taiyo Yuden
D1, D2, D3	0	18 V	Diode, TVS, Uni, 18 V, 28.3 Vc, AEC-Q101, SMA	SMA	SMA6J18AHM3/5A	Vishay-Semiconductor
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R2	0	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R8, R12	0	0	RES, 0, 1%, 0.5 W, 1206	1206	5108	Keystone

Revision History

Changes from Original (April 2018) to A Revision	Page
• First public release	1

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.
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 - 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 DEGRADATION 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/lstds/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/lstds/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 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.

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3. 技術基準適合証明を取得後ご使用いただく。

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

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.

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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.
 6. *Disclaimers:*
 - 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
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8. *Limitations on Damages and Liability:*

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8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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