

TPS254900AQ1EVM-003 Evaluation Module

This user's guide describes the evaluation module (EVM) for the TPS254900A-Q1 (TPS254900AQ1EVM-003). The TPS254900A-Q1 is a USB charging port controller with an integrated power switch and USB 2.0 high-speed data line (DP and DM) switches.

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Trademarks

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1 Introduction

The TPS254900AQ1EVM-003 allows reference circuit evaluation of TI's TPS254900A-Q1 automotive USB charging port controller with integrated power switch, cable compensation, and short-to-battery protection. The TPS254900AQ1EVM-003 provides the electrical signatures on DP_IN and DM_IN to support all current charging schemes. The TPS254900A-Q1 incorporates USB cable voltage drop compensation by linearly sensing the port current and automatically adjusting the output voltage of the LMR14030SDDAR to keep the cable end device voltage within the normal operating range. The TPS254900A-Q1 incorporates up to an 18-V short to battery protection for VBUS, DP_IN and DM_IN.

1.1 Features

The EVM supports the following features:

- TPS254900A-Q1 built-in IEC 61000-4-2 ESD protection on DP_IN and DM_IN pins
- Linear USB cable voltage droop compensation
- The TPS254900A-Q1 is fully AEC Q100 qualified
- Built-in short to battery protection and notification on VBUS, DP_IN and DM_IN
- LMR14030SDDAR high-performance 2.2-MHz automotive-qualified DC/DC converter

1.2 Applications

The EVM can be used in the following applications:

- Automotive infotainment system
- Automotive USB charging box

2 Description

The TPS254900AQ1EVM-003 enables full evaluation of the TPS254900A-Q1 device. Refer to the schematic in [Figure 1](#). An automotive voltage range input is applied at the J1 connector. The input voltage is regulated by the LMR14030SDDAR buck regulator (U1) and associated circuitry. This provides a nominal 5-V, 3-A output at +5 V_{DC} for the TPS254900A-Q1 (U2).

The TPS254900A-Q1 internal power switch connects +5 V_{DC} furnished by the LMR14030SDDAR regulator to VBUS at the downstream facing USB connector, J5. When the internal power switch is ON, the D6 LED (green) illuminates. USB 2.0 data can be passed through the TPS254900AQ1EVM-003 from J5 to J4 when the TPS254900A-Q1 is configured for either SDP or CDP mode using the J6 header. The TPS254900A-Q1 status and fault conditions can be detected using the D3 (blue) and D2 (red) LEDs, respectively.

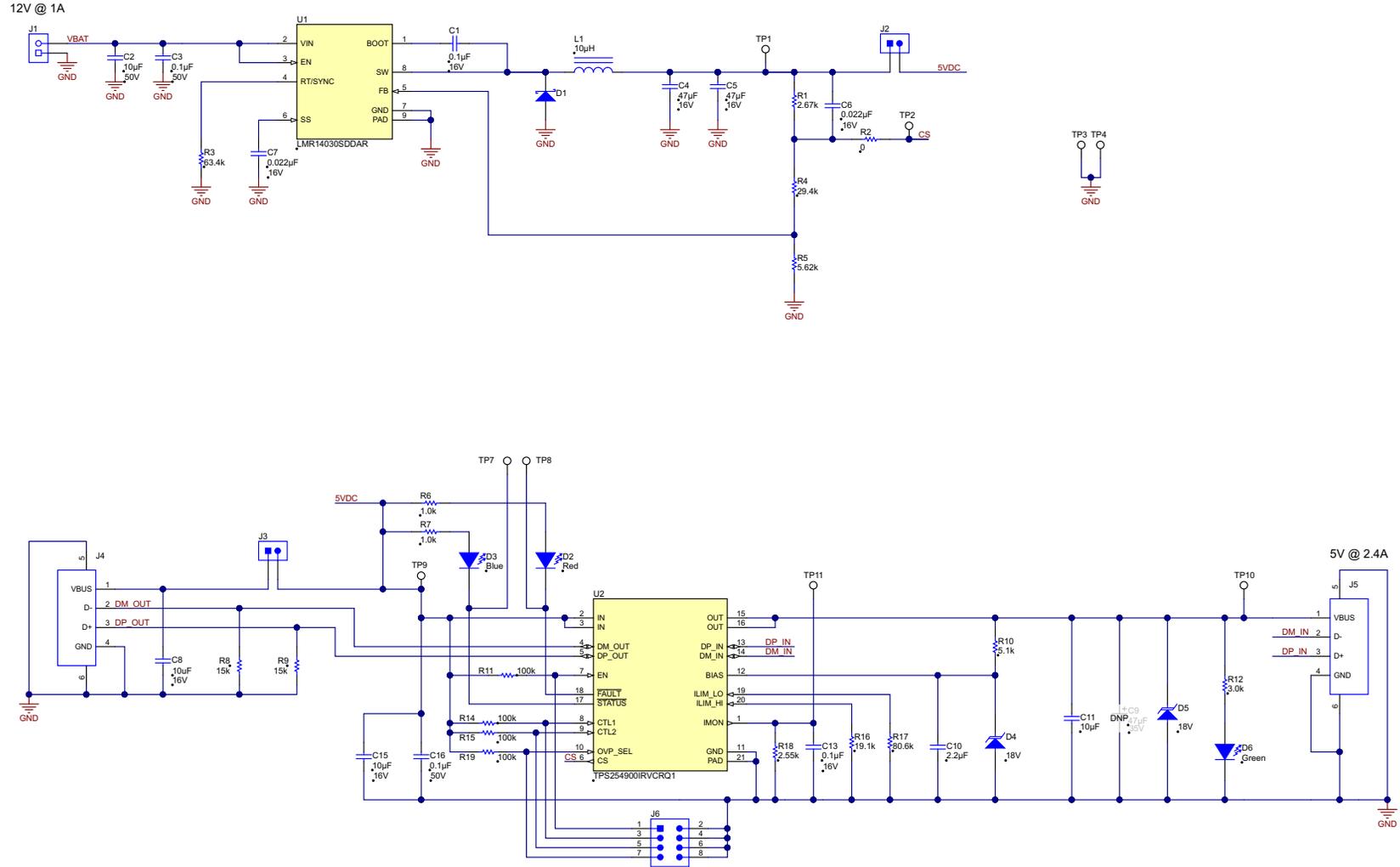
The TPS254900A-Q1 provides system-level ESD protection in accordance with IEC 61000-4-2 up to ±8-kV contact and ±15-kV air discharge at the DP_IN and DM_IN signals going to J5. These pins as well as VBUS pin will also provide detection of shorts to the battery by triggering the FAULT logic and illuminating D2.

The TPS254900A-Q1 provides USB cable voltage droop compensation at the load through the use of the CS pin. Sinking current into the CS pin mirrors the current through the TPS254900A-Q1 power switch at a rate of 82 μA/A. The CS pin current is summed with the LMR14030SDDAR regulator feedback current through R1 causing the voltage at +5 V_{DC} to change with USB downstream load current. The +5 V_{DC} increases linearly as load current increases. This compensation will keep the load end voltage close to 5 V_{DC}. The default compensation resistor values (R1 and R4) target a USB cable resistance of 200 mΩ. Refer to the TPS254900A-Q1 data sheet for more information.

The TPS254900A-Q1 provides a current detection function through the use of the IMON pin. Connect a resistor between IMON and GND. The system can detect the load current in real time by monitoring the IMON voltage.

3 Schematic

Figure 1 illustrates the EVM schematic.



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Figure 1. TPS254900AQ1EVM-003 Schematic

4 General Configuration and Description

4.1 Physical Access

Table 1 lists the TPS254900AQ1EVM-003 connector functionality, Table 2 describes the test point availability and Table 3 describes the jumper functionality.

Table 1. Connector Functionality

Connector	Label	Description
J5	J5	Downstream facing USB 2.0 connector. Connect to the USB 2.0 slave for data pass through from J4. USB output power is also provided to the slave.
J4	J4	Upstream facing USB 2.0 connector. Connect to the USB 2.0 host for data pass through to J5. USB input power can also be provided by the host when the J3 shunt is installed.
J1	J1	Automotive input voltage range connector. Connect to a 7 V–18 V, 1.5-A voltage source according to the polarity marked on the EVM.
D2 (RED)	D2	TPS254900A-Q1 FAULT output is triggered
D3 (BLUE)	D3	TPS254900A-Q1 STATUS output is triggered
D6 (GREEN)	D6	TPS254900A-Q1 output powered

Table 2. Test Points

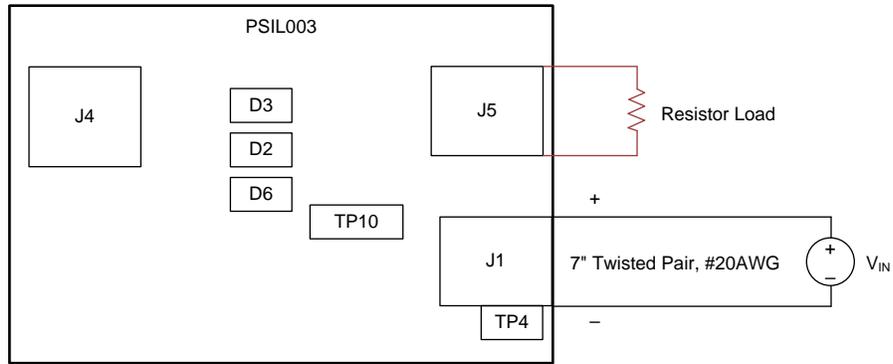
Test Point	Color	Label	Description
TP1	SM-L	VDC	TPS254900A-Q1 power switch input from DC-DC converter
TP2	SM-L	CS	Loop injection point
TP3	SM-L	GND	GND Test point
TP4	SM-L	GND	GND Test point
TP7	SM-L	STATUS	TPS254900A STATUS pin test point
TP8	SM-L	FAULT	TPS254900A FAULT pin test point
TP9	SM-L	VIN	TPS254900A VIN pin test point
TP10	SM-L	OUT	TPS254900A VBUS pin test point
TP11	SM-L	IMON	TPS254900A IMON pin test point

Table 3. Jumpers

Jumper	Label	Description
J2	J2	Install to power TPS254900A-Q1 with a DC/DC
J3	J3	USB host furnished input voltage. Install to power TPS254900A-Q1 with a USB host.
J6	J6	TPS254900A-Q1 mode select jumper block. Install shunt at EN (1-2) to disable TPS254900A-Q1. C1, C2, OVP_SEL positions select the charging mode for TPS254900A-Q1. Refer to the data sheet for more information.

4.2 Test Setup

Figure 2 shows a typical test setup for TPS254900AQ1EVM-003. Connect J1 to the 14-V power supply. The TPS254900A-Q1 output load can be applied either between TP10 and TP4 or via the USB 2.0 cable plugged into J5.



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Figure 2. Typical TPS254900AQ1EVM-003 Test Setup

5 EVM Assembly Drawings and Layout Guidelines

5.1 PCB Drawings

Figure 3 through Figure 8 show component placement and layout of the EVM.

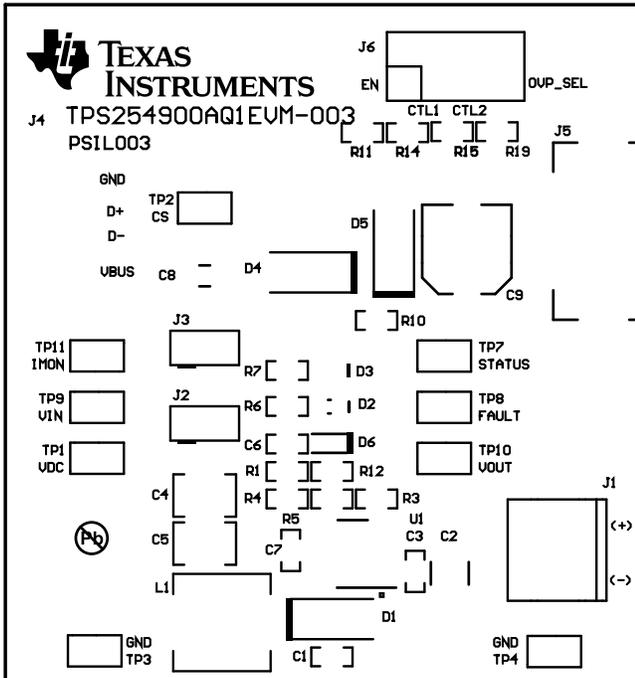


Figure 3. Top Side Placement

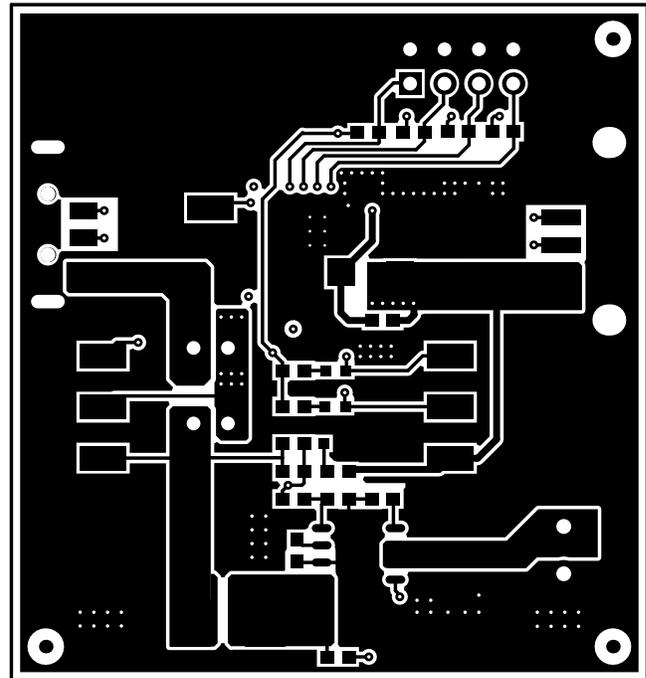


Figure 4. Top Side Routing

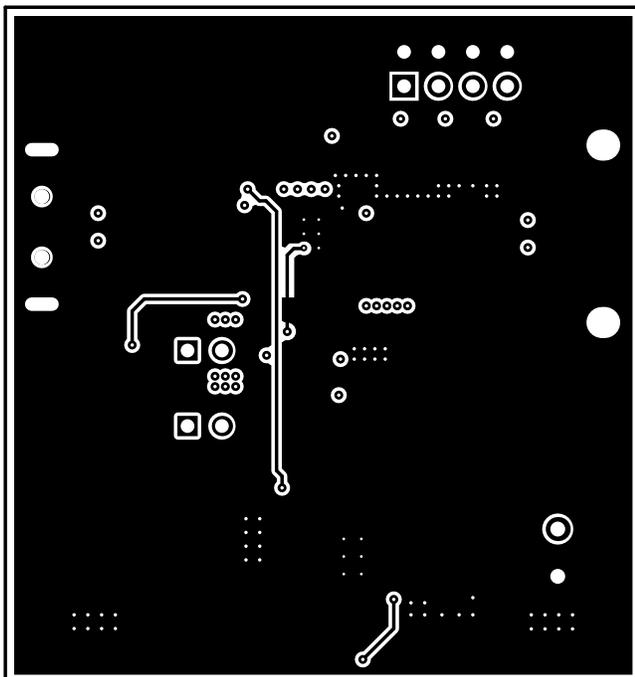


Figure 5. Layer Two Routing

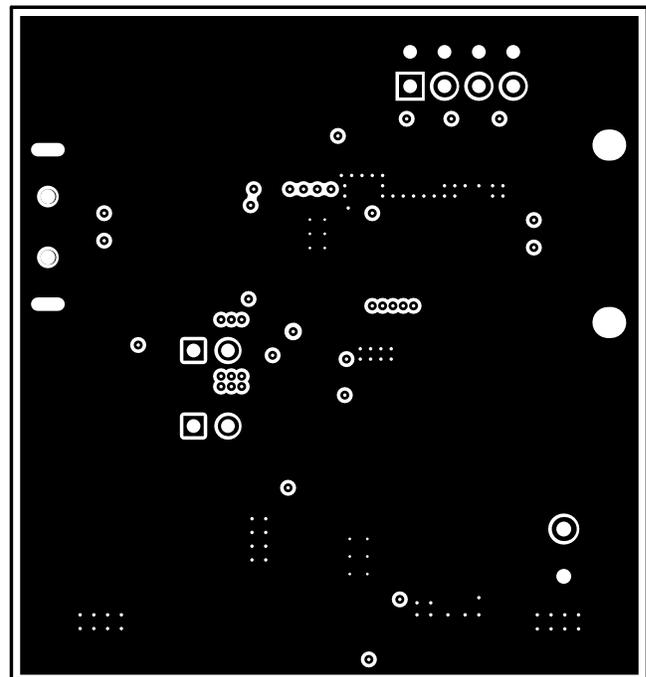


Figure 6. Layer Three Routing

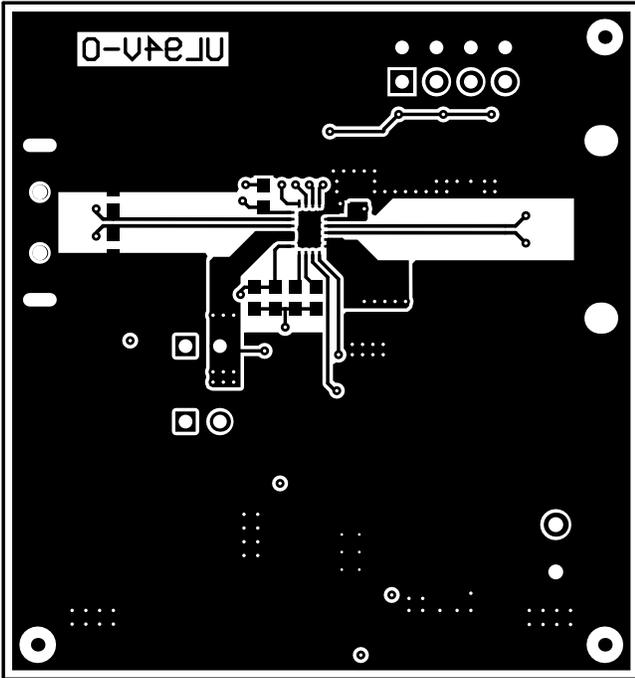


Figure 7. Bottom Side Routing

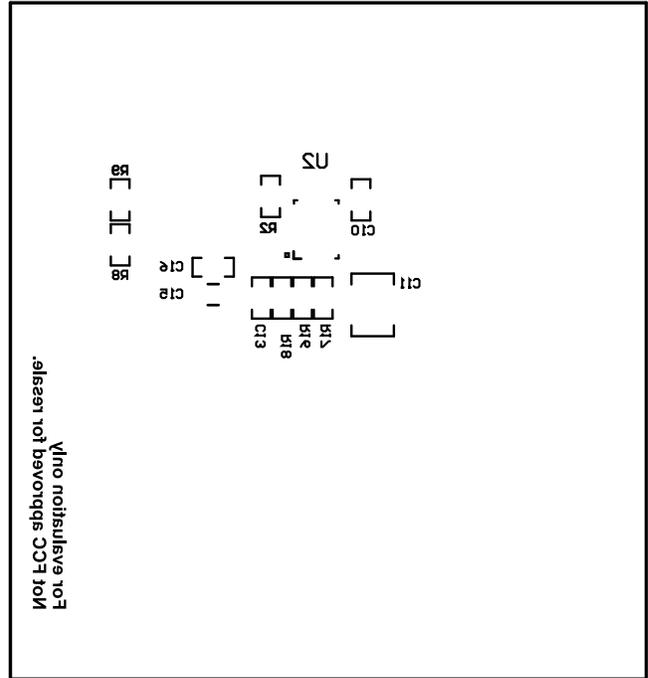


Figure 8. Bottom Side Placement

5.2 Layout Guidelines

Use the following layout guidelines:

- **TPS254900A-Q1 placement:** Place the TPS254900A-Q1 near the USB output connector and OUT pin filter capacitors. Connect the exposed pad to the GND pin and the system ground plane using an array of vias.
- **IN pin bypass capacitance:** Place the 0.1- μ F bypass capacitor near the IN pin and make the connection using a low inductance trace.
- **DP-OUT, DM-OUT and DP-IN, DM-IN traces:** Route these traces as controlled impedance differential pairs per the USB-2.0 specification. Minimize the use of vias in the high-speed data lines. [Figure 7](#) provides a good signal routing example for the high-speed data traces. In this example, the data pairs are routed as edge-coupled microstrips with nominal differential impedance of 90 Ω . The reference plane is tied to GND and is shown in [Figure 6](#). Ensure that the reference plane is void of cuts or splits above the differential pairs to prevent impedance discontinuities.
- **ILIM_LO and ILIM_HI pin connections:** Current-limit, set-point accuracy can be compromised by stray current leakage from a higher voltage source to the ILIM_LO or ILIM_HI pins. Ensure that there is adequate spacing between IN pin copper/trace and ILIM_LO pin trace to prevent contaminant buildup during the PCB assembly process.
- The capacitor on BIAS helps improve IEC ESD performance, a 2.2- μ F capacitor should be placed close to BIAS and the whole “current” path from BIAS to GND across this capacitor should be as short as possible. Do not use a via along the connection traces.
- A 10- μ F output capacitor should be placed close to the OUT pin and TVS.

5.3 EMI Containment

EMI containment methods are shown in the following list:

- Use compact loops for dv/dt and di/dt circuit paths (power loops and gate drives)
- Use minimal, yet thermally adequate, copper areas for heat sinking of components tied to switching nodes (minimize exposed radiating surface).
- Use copper ground planes (possible stitching) and top-layer copper floods (surround circuitry with ground floods)
- Use a 4-layer PCB, if economically feasible (for better grounding)
- Minimize the amount of copper area associated with input traces (to minimize radiated pickup)
- Maintain physical separation between input-related circuitry and power circuitry (use ferrite beads as boundary line)
- Possible use of common-mode inductors

6 Bill of Materials

Table 4 lists the EVM bill of materials.

Table 4. TPS254900AQ1EVM-003 Bill of Materials⁽¹⁾

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB	1		Printed Circuit Board		PSIL003	Any	-	-
C1, C13, C16	3	0.1uF	CAP, CERM, 0.1 µF, 16 V, +/- 10%, X7R, 0603	0603	GRM188R71C104KA01D	Murata		
C2	1	10uF	CAP, CERM, 10 µF, 50 V, +/- 10%, X5R, 1210	1210	C3225X5R1H106K250AB	TDK		
C3	1	0.1uF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0603	0603	GRM188R71H104KA93D	Murata		
C4, C5	2	47uF	CAP, CERM, 47 µF, 16 V, +/- 20%, X5R, 1210	1210	GRM32ER61C476ME15L	Murata		
C6, C7	2	0.022uF	CAP, CERM, 0.022 µF, 16 V, +/- 10%, X7R, 0603	0603	C0603C223K4RACTU	Kemet		
C8, C15	2	10uF	CAP, CERM, 10 µF, 16 V, +/- 10%, X7R, 1206	1206	GRM31CR71C106KAC7L	Murata		
C10	1	2.2uF	CAP, CERM, 2.2 µF, 50 V, +/- 10%, X5R, 0603	0603	GRM188R61H225KE11D	Murata		
C11	1	10uF	CAP, CERM, 10 µF, 35 V, +/- 10%, X7R, 1210	1210	GRM32ER7YA106KA12L	Murata		
D1	1	50V	Diode, Schottky, 50 V, 3 A, SMA	SMA	B350A-13-F	Diodes Inc.		
D2	1	Red	LED, Red, SMD	SMD, 2-Leads, Body 1.3x0.8mm	LS L29K-G1J2-1-Z	OSRAM		
D3	1	Blue	LED, Blue, SMD	BLUE 0603 LED	LB Q39G-L2N2-35-1	OSRAM		
D4, D5	2	18V	Diode, TVS, Uni, 18 V, 400 W, SMA	SMA	SMAJ18A	Littelfuse		
D6	1	Green	LED, Green, SMD	0.8x1.6mm	HSMG-C190	Avago		
J1	1		Conn Term Block, 2POS, 3.5mm, TH	11x8.5x7.3mm	1751248	Phoenix Contact		
J2, J3	2		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin	PEC02SAAN	Sullins Connector Solutions		
J4	1		Connector, Plug, USB Type A, R/A, Top Mount SMT	USB Type A right angle	48037-1000	Molex		
J5	1		Connector, Receptacle, USB TYPE A, R/A, Top Mount SMT	USB TYPE A CONNECTOR RECEPTACLE 4POS SMD	896-43-004-00-000000	Mill-Max		
J6	1		Header, 100mil, 4x2, Tin, TH	Header, 4x2, 100mil, Tin	PEC04DAAN	Sullins Connector Solutions		
L1	1	10uH	Inductor, Shielded Drum Core, Powdered Iron, 10 µH, 3 A, 0.075 ohm, SMD	Inductor, 6.6x3x6.6mm	74437346100	Würth Elektronik eiSos		
R1	1	2.67k	RES, 2.67 k, 1%, 0.1 W, 0603	0603	CRCW06032K67FKEA	Vishay-Dale		
R2	1	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
R3	1	63.4k	RES, 63.4 k, 1%, 0.1 W, 0603	0603	RC0603FR-0763K4L	Yageo America		
R4	1	29.4k	RES, 29.4 k, 1%, 0.1 W, 0603	0603	CRCW060329K4FKEA	Vishay-Dale		
R5	1	5.62k	RES, 5.62 k, 1%, 0.1 W, 0603	0603	CRCW06035K62FKEA	Vishay-Dale		
R6, R7	2	1.0k	RES, 1.0 k, 5%, 0.1 W, 0603	0603	CRCW06031K00JNEA	Vishay-Dale		
R8, R9	2	15k	RES, 15 k, 5%, 0.1 W, 0603	0603	CRCW060315K0JNEA	Vishay-Dale		
R10	1	5.1k	RES, 5.1 k, 5%, 0.1 W, 0603	0603	CRCW06035K10JNEA	Vishay-Dale		
R11, R14, R15, R19	4	100k	RES, 100 k, 1%, 0.1 W, 0603	0603	RC0603FR-07100KL	Yageo America		
R12	1	3.0k	RES, 3.0 k, 5%, 0.1 W, 0603	0603	CRCW06033K00JNEA	Vishay-Dale		
R16	1	19.1k	RES, 19.1 k, 1%, 0.1 W, 0603	0603	CRCW060319K1FKEA	Vishay-Dale		

⁽¹⁾ Unless otherwise noted in the *Alternate Part Number* or *Alternate Manufacturer* columns, all parts may be substituted with equivalents.

Table 4. TPS254900AQ1EVM-003 Bill of Materials⁽¹⁾ (continued)

Designator	QTY	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
R17	1	80.6k	RES, 80.6 k, 1%, 0.1 W, 0603	0603	CRCW060380K6FKEA	Vishay-Dale		
R18	1	2.55k	RES, 2.55 k, 1%, 0.1 W, 0603	0603	CRCW06032K55FKEA	Vishay-Dale		
SH-J2, SH-J3	2	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
TP1, TP2, TP3, TP4, TP7, TP8, TP9, TP10, TP11	9	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Minature	5015	Keystone		
U1	1		SIMPLE SWITCHER 40 V 3.5 A, 2.2 MHz Step-Down Converter with 40 uA IQ, DDA0008E	DDA0008E	LMR14030SDDAR	Texas Instruments	LMR14030SDDA	Texas Instruments
U2	1		Automotive USB Charging Port Controller and Power Switch with Short to BAT protection, RVC0020A	RVC0020A	TPS254900IRVCRQ1	Texas Instruments	TPS254900IRVCTQ1	Texas Instruments
C9	0	47uF	CAP, AL, 47 μ F, 35 V, +/- 20%, 0.44 ohm, SMD	6.3x5.8	UUD1V470MCL1GS	Nichicon		
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		

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

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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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