TPS2540EVM-623: Evaluation Module for TPS2540/40A and TPS2541/41A

This User's Guide describes the evaluation module (EVM) for the TPS2540/40A and TPS2541/41A. TPS2540/40A and TPS2541/41A are USB charging port power switch/ controllers for host charging ports and dedicated charging ports.

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1 Description

The TPS2540EVM-623 allows reference circuit evaluation of the TI TPS2540/40A and TPS2541/41A USB charging port power switch and controller. TPS2540EVM-623 orderable configuration is equipped with TPS2540RTE but the TPS2540A or TPS2541/41A may also be evaluated by replacing U1 with the appropriate device.

1.1 Features

- USB Charging Port Power Switch and Controller
- Meets Battery Charging Specification BC1.2 for DCP and CDP
- Meets Chinese Telecommunications Industry 2.0 Standard YD/T 1591-2009
- Compatible With USB 2.0 and 3.0 Power Switch Requirements
- Adjustable Current-limit, 230 mA – 2800 mA typical
- Fast Over-current Response – 1.5 µS Typical
- 73-mΩ High-Side MOSFET
- 2.6-GHz Bandwidth USB 2.0 Data Switch
- OUT Discharge Through CTLx=000 (TPS2540/40A) or DSC (TPS2541/41A)
- Longer Detach Detection Time (TPS2540A/41A) Supporting Additional Legacy Devices

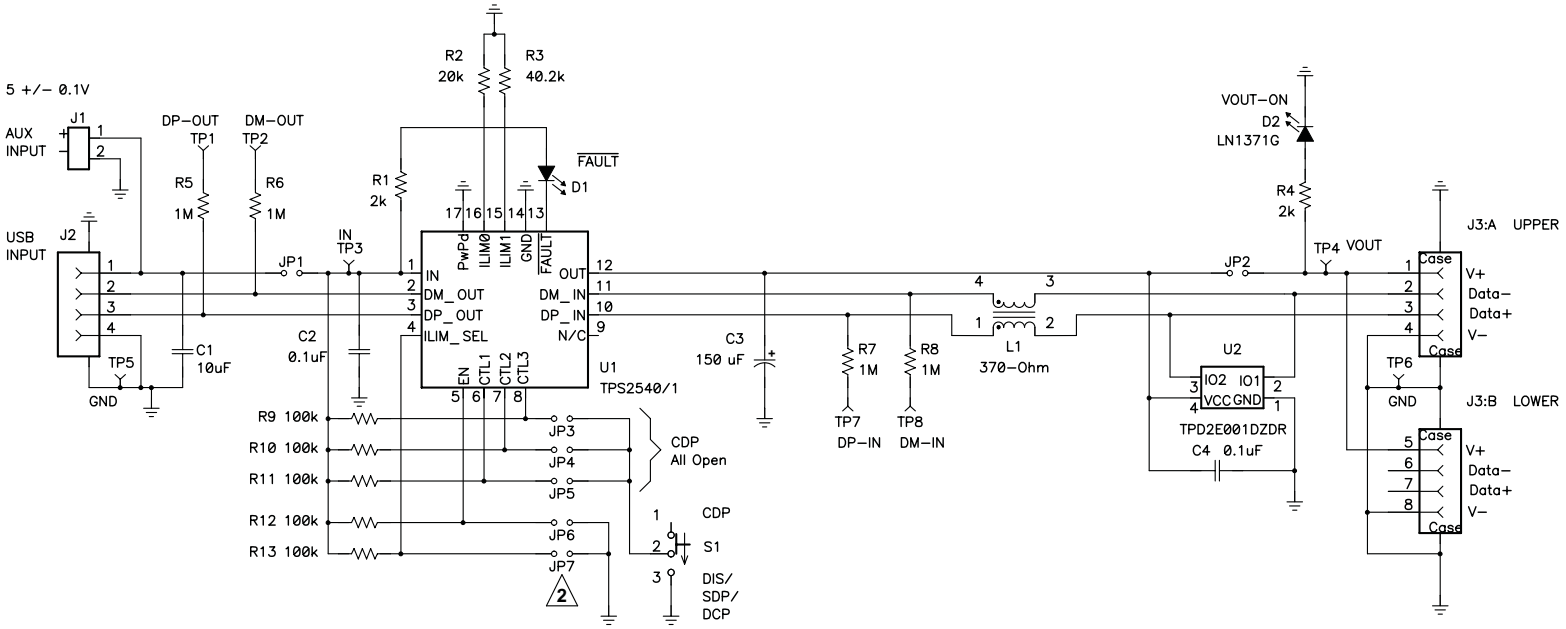
1.2 Applications

- USB Ports/Hubs
- Notebook PCs

1.3 Glossary of Terms

- Charging Downstream Port (CDP)
  - Downstream port complies with the USB 2.0 definition of a host or a hub, and additionally defines a handshake on DP/DM to identify a BC 1.1 compliant host to a BC 1.1 compliant portable device
  - BC 1.1 allows high-speed portable device to draw 900mA and low-speed or full-speed device to draw 1500mA
  - BC 1.2 intention is to allow all devices to draw 1500mA
  - BC 1.2 corrects BC 1.1 to ensure USB Host provides 5V at >1500mA
- Standard Downstream Port (SDP)
  - USB 2.0 defined port currently adopted by most USB ports
  - Portable device is allowed to draw 100mA initially and request additional current over USB communications in 100mA steps up to a maximum of 500mA
  - USB Host required to provide 5V at >500mA
  - Portable device must not draw >2.5mA when not USB in Suspend due to lack of USB communication
- Dedicated Charging Port as defined in BC 1.1
  - BC 1.1 defines a Dedicated Charging Port as a downstream port on a device that outputs power through a USB connector, but is not capable of enumerating a downstream device.
  - Wall adapter must source between 500mA and 1500mA
  - Portable Device may attempt to draw 1800mA in order to force the wall adapter into constant current mode
  - BC 1.2 intention is to allow DCP to current limit >1800mA to allow IC power switch device
- YD/T 1591-2006, updated 2009
  - PROC Telecommunications Standard
  - Defines wall-adapter requirements
  - Rated current between 500mA – 1500mA w/ defined I-V curve

2 Schematic



NOTES:

1. NOT INSTALLED
2. Install JP7 for ILIM = ILIM0 = 2.4A
   Remove JP7 for ILIM =I LIM1 = 1.2A

Figure 1. TPS2540EVM-623 Schematic

3 General Configuration and Description

3.1 Physical Access

Table 1 lists the TPS2540EVM-623 connector functionality, Table 2 describes the test point availability and Table 3 describes the jumper functionality.

Table 1. Connector Functionality

Connector	Label	Description
J1	AUX	Auxiliary high current input connector.
J2	USB INPUT	USB input port.
J3A	(UPPER)	Primary charging port (with data).
J3B	(LOWER)	Auxiliary charging port (no data).
D1 (RED)	FAULT	Fault LED
D2 (GREEN)	VOUT-ON	USB Output Powered
S1	S1	Mode switch used in conjunction with Table 4

Table 2. Test Points

Test Point	Color	Label	Description
TP3	RED	IN	Power bus input.
TP4	RED	VOUT	Power bus output.
TP5	SM	TP3	Power bus GND.
TP1	WHT	DP-OUT	Data+ out
TP2	WHT	DM-OUT	Data- out
TP6	SM	TP5	Power bus GND
TP7 (1)	ORG	DP-IN	Data+ in
TP8 (1)	ORG	DM-IN	Data- in

(1) TP7 and TP8 are isolated from U1 DP_IN (U1-11) and DM_IN (U1-10) respectively with 1MΩ resistors to minimize degradation of high speed signal quality. Static voltage measurements of U1 DP_IN or DM_IN through TP7 and TP8 will be affected by the loading of the test instrument and 1MΩ resistors.

Table 3. Jumpers

Jumper	Label	Description
JP1	VIN	Power bus input. Install shunt to allow charger source to power TPS2540/1 and downstream circuitry.
JP2	VOUT	Power bus output. Install shunt to allow charger source to power downstream devices.
JP3	CTL3	CTL3. See MODE truth table
JP4	CTL2	CTL2. See MODE truth table
JP5	CTL1	CTL1. See MODE truth table
JP6	EN	TPS2540/40A/41/41A Enable select. Install shunt to disable TPS2540/40A/41/41A (also discharges the output capacitor for TPS2541/41A).
JP7	ILIM	ILIM select. Install shunt to select ILIM0 (2.43A typical ILIM). Remove shunt to select ILIM1 (1.21A typical ILIM).

The CTL pins configure the device mode. Setting S1 to the CDP position (open) is equivalent to setting the CTL pins to the state in the last row of Table 4. Setting S1 to the DIS/SDP/DCP position allows the remaining rows to be configured.

Table 4. TPS2540/40A Mode Truth Table

CTL1 (JP5)	CTL2 (JP4)	CTL3 (JP3)	Mode
0	0	0	OUT discharge, power switch OFF
0	X	1	Dedicated Charging Port, Auto-detect
X	1	0	Standard Downstream Port, USB 2.0 Mode
1	0	0	Dedicated Charging Port, BC Specification 1.1 only

Table 4. TPS2540/40A Mode Truth Table (continued)

CTL1 (JP5)	CTL2 (JP4)	CTL3 (JP3)	Mode
1	0	1	Dedicated Charging Port, divider mode only
1	1	1	Charging Downstream Port, BC Specification 1.1

The CTL pins configure the device mode. Setting S1 to the CDP position (open) is equivalent to setting the CTL pins to the state in the last row of Table 5. Setting S1 to the DIS/SDP/DCP position allows the remaining rows to be configured.

Table 5. TPS2541/41A Mode Truth Table

CTL1 (JP5)	CTL2 (JP4)	CTL3 (JP3)	Mode
0	0	X	Dedicated Charging Port, Auto-detect
0	1	X	Dedicated Charging Port, BC 1.1 Specification Only
1	0	X	Dedicated Charging Port, divider mode only
1	1	0	Standard Charging Port, USB 2.0 Mode
1	1	1	Charging Downstream Port, BC Specification 1.1

3.2 Current Limit Setpoint

R2 and R3 configure the current limit setpoint for ILIM0 and ILIM1 respectively (see JP7 in Table 3). ILIM0 or ILIM1 setpoint can be adjusted using the following example by substituting R2 or R3 for R_{ILIMx}. In this example IOS = 2A.

The example below is an approximation only and does not take into account the resistor tolerance or the variation of ILIM. For exact variation of ILIM, see the TPS2540/40A/TPS2541/41/A data sheet, SLVSAG2.

IOS = 48000 / R_{ILIMx} = 2 A
R_{ILIMx} = 48000 / IOS = 48000 / 2 = 24000 Ω
Choose R_{ILIMx} = 23.7 kΩ
IOS = 48000 / 23700 = 2.03 A

3.3 Test Setup

Figure 2 shows a typical test setup for TPS2540EVM-623. Connect J2 to the PC either directly (insert J2 into available/accessible PC USB port) or using any Type A Male to Type A Female USB v2.0 extension cable. USB power and data are available at J3A and USB power only is available at J3B.

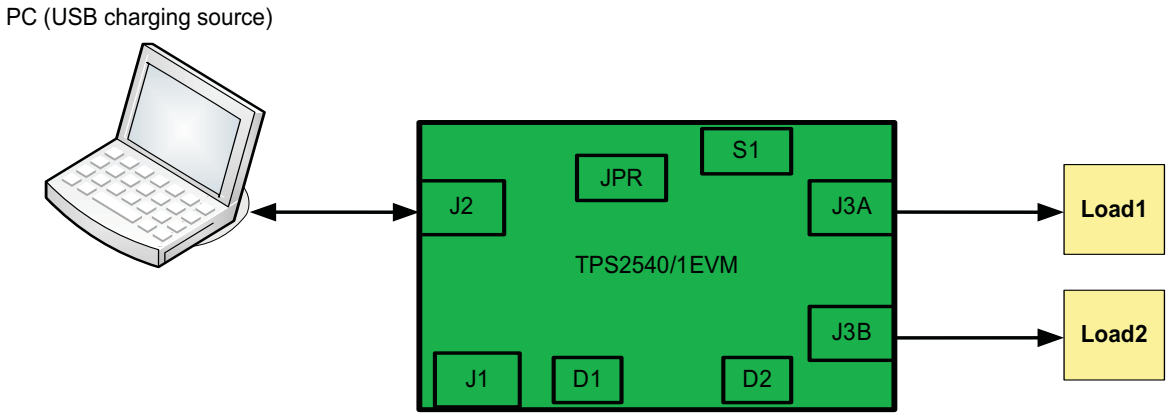


Figure 2. Typical TPS2540EVM-623 Test Setup

4 EVM Assembly Drawings and Layout Guidelines

4.1 Layout Guidelines

- TPS2540/40A/41/41A placement: Place the TPS2540/41 near the USB output connector and 150µF OUT pin filter capacitor. Connect the exposed pad to the GND pin and the system ground plane using an array of vias.
- IN pin bypass capacitance: Place the 0.1µF bypass capacitor near the IN pin and make the connection using a low inductance trace.
- DP-OUT/DM-OUT, 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 6 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 ohms. The reference plane is tied to GND and is shown in Figure 5. Ensure that the reference plane is void of cuts or splits above the differential pairs to prevent impedance discontinuities.
- ILIM0 and ILIM1 Pin Connections: Current-limit, set-point accuracy can be compromised by stray current leakage from a higher voltage source to the ILIM0 or ILIM1 pins. Ensure that there is adequate spacing between IN pin copper/trace and ILIM0 pin trace to prevent contaminant buildup during the PCB assembly process. If a low-current-limit set point is required (RILIMx > 200 kΩ), use ILIM1 for this case as it is further away from the IN pin.

4.2 PCB Drawings

The following figures show component placement and layout of the EVM.

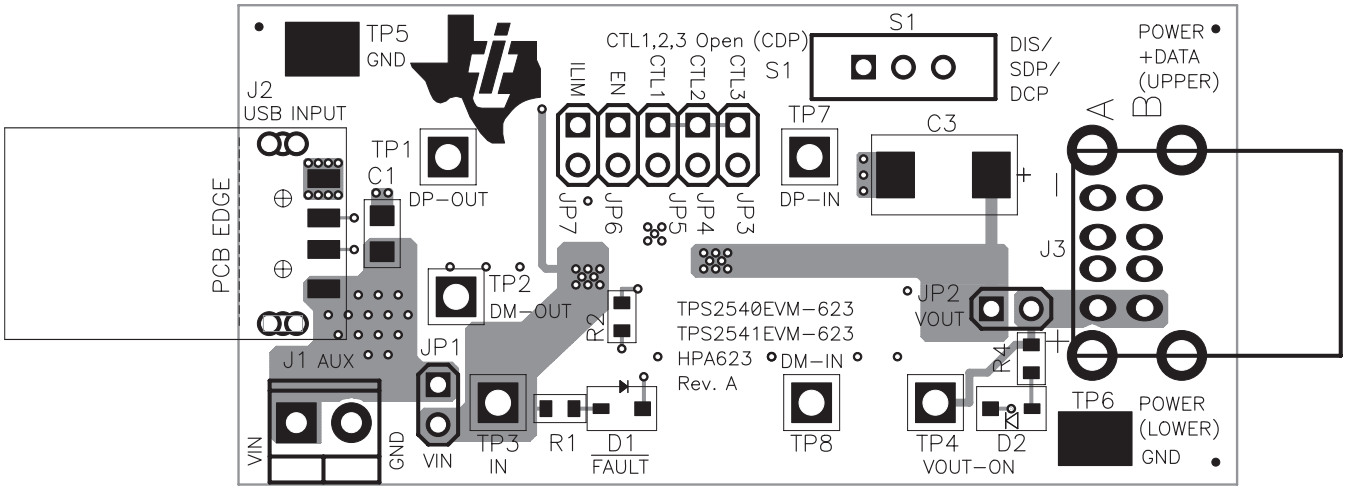


Figure 3. Top Side Placement and Routing

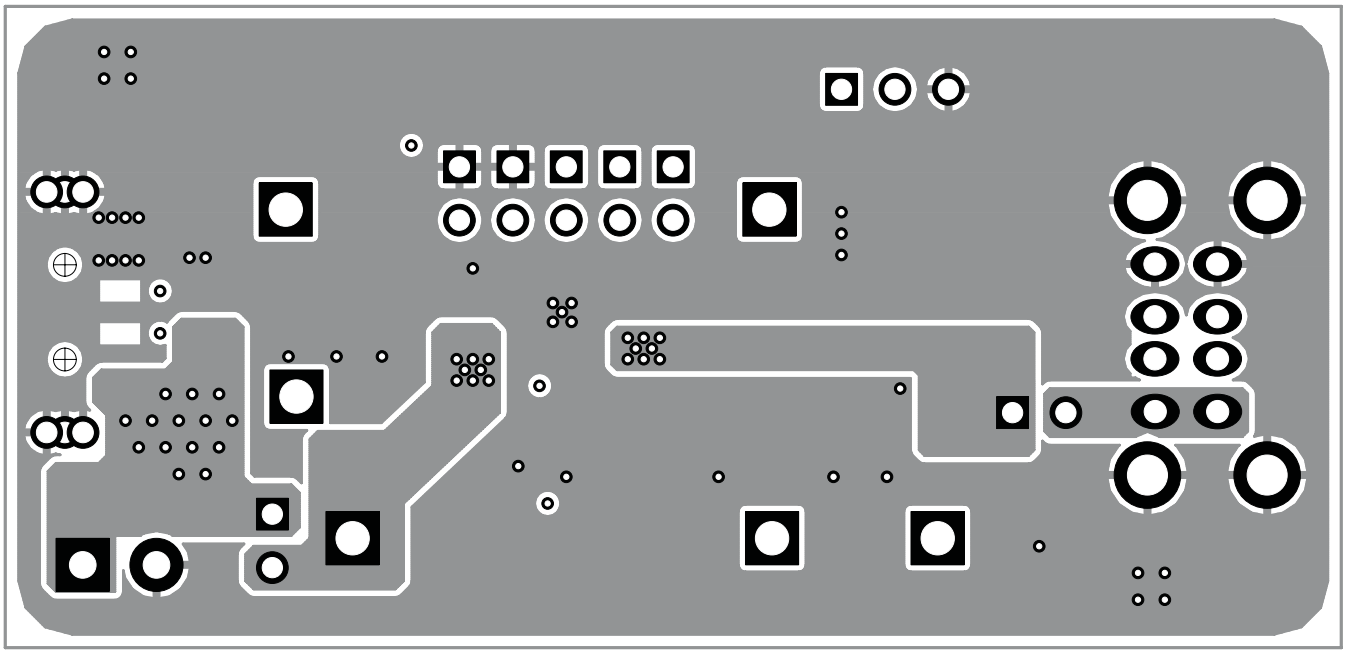


Figure 4. Layer Two Routing

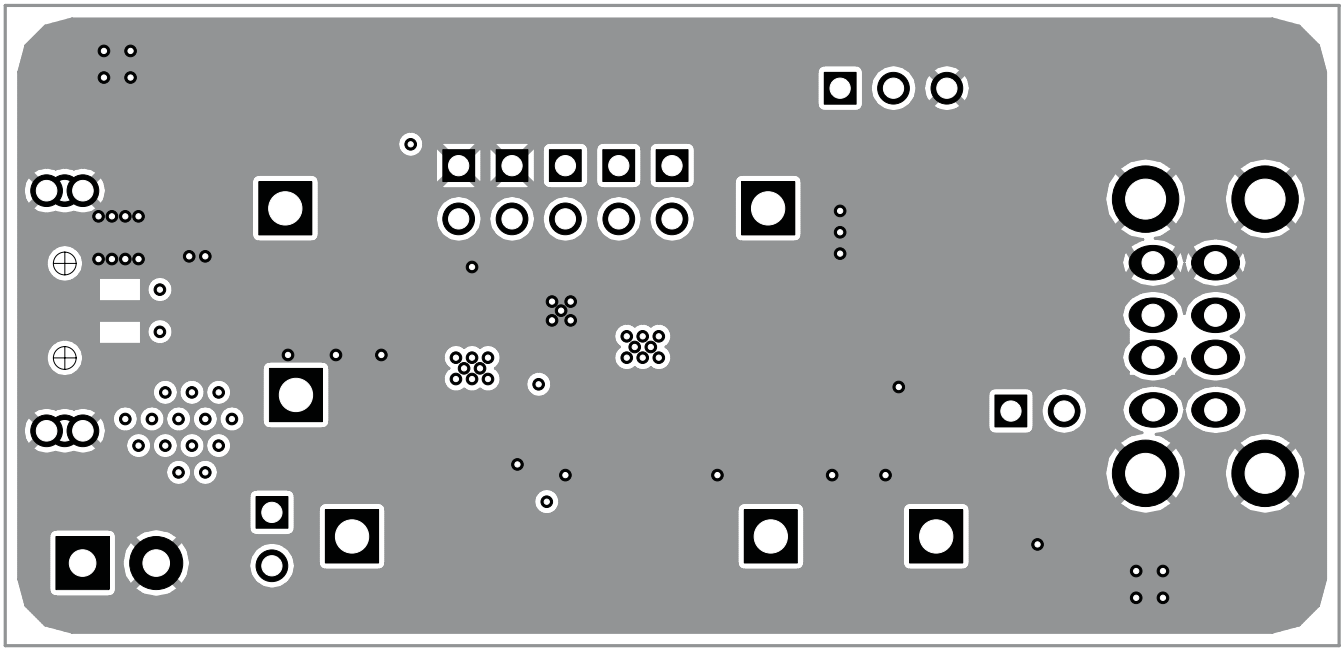


Figure 5. Layer Three Routing

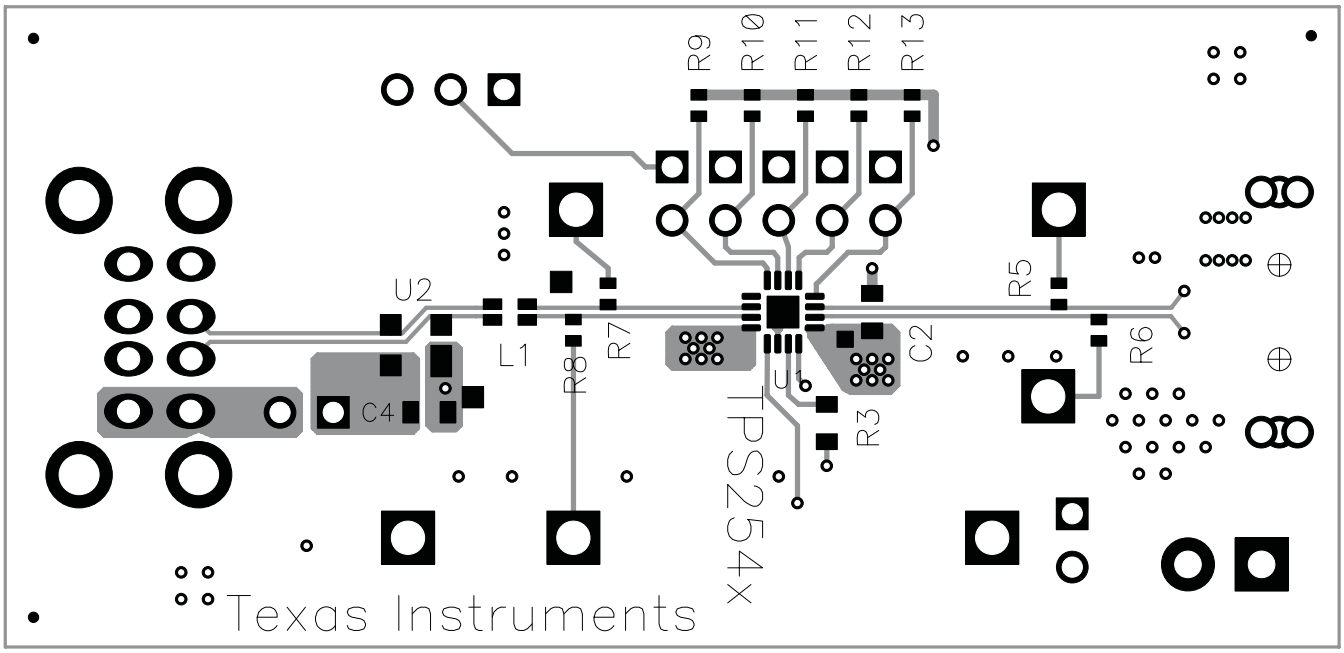


Figure 6. Bottom Side Placement and Routing

5 Bill of Materials

Table 6. TPS2540/40A/41/41A EVM Bill of Materials

Count	REFDES	Value	Description	Size	Part Number	Supplier
1	C1	10 µF	Capacitor, Ceramic, 10V, X5R, 10%	0805	Std	Std
2	C2, C4	0.1 µF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C3	150 µF	Capacitor, Tant, Low ESR, 10V, ±10%	7343 (D)	TPSD157K010R0100	AVX
1	D1	LN1271R	Diode, LED, Red, 10-mA, 0.4-mcd	0.114 X 0.049 inch	LN1271RTR	Panasonic
1	D2	LN1371G	Diode, LED, Green, 10-mA, 2.6-mcd	0.114 X 0.049 inch	LN1371GTR	Panasonic
1	J1	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25 inch	ED555/2DS	OST
1	J2	48037-1000	Connector, USB A, Plug RA, 4pin	0.500 X 0.740 inch	48037-1000	Molex
1	J3	896-43-008-90-000000	Connector, Dual USB Downstream (Type A)	0.52 x 0.67 inch	896-43-008-90-000000	Mill-Max
7	JP1, JP2, JP3, JP4, JP5, JP6, JP7	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
1	L1	370-Ohm	Inductor, Coupled	0.050 x 0.080 inch	0805USB-372ML	Coilcraft
2	R1, R4	2k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R2	20k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R3	40.2k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
4	R5, R6, R7, R8	1M	Resistor, Chip, 1/16W, 1%	0402	Std	Std
5	R9, R10, R11, R12, R13	100k	Resistor, Chip, 1/16W, 1%	0402	Std	Std
1	S1	EG1218	Switch, 1P2T, Slide, PC-mount, 200-mA	0.46 x 0.16	EG1218	E_Switch
2	TP1, TP2	5012	Test Point, White, Thru Hole	0.125 x 0.125 inch	5012	Keystone
2	TP3, TP4	5010	Test Point, Red, Thru Hole	0.125 x 0.125 inch	5010	Keystone
2	TP5, TP6	5016	Test Point, SM, 0.150 x 0.090	0.185 x 0.135 inch	5016	Keystone
2	TP7, TP8	5013	Test Point, Orange, Thru Hole	0.125 x 0.125 inch	5013	Keystone
1	U1	TPS2540	IC, USB Charging Port Power Switch and Controller	QFN-16	TPS2540RTE	TI
1	U2	TPD2E001DZDR	IC, Low-Capacitance 2-Chan ±15-kV ESD-Protection Array	SOP	TPD2E001DZDR	TI
5	—		Shunt, Black	100-mil	STC02SYAN	Sullins
1	—		PCB, 2.5 In x 1.20 In x 0.062 In		HPA623	Any

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It is important to operate this EVM within the input voltage range of 0 V to 5.5 V and the output voltage range of 0 V to 5.5 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 85°C. The EVM is designed to operate properly with certain components above 85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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

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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.

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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

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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.

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

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