TPD2S300YFF Evaluation Module

This user guide describes the characteristics, operation, and use of the TPD2S300YFF USB Type C Short-to-VBUS and IEC ESD Protector Evaluation Module (EVM) for use with CC pins. This EVM is a TPD2S300YFF integrated chip set into a USB Type-C passthrough board to allow the user to test the operation of the TPD2S300YFF overvoltage protection and ESD protection in their own system. This user's guide includes setup instructions, schematic diagrams, a bill of materials, and printed-circuit board layout drawings for the EVM.

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1 Introduction

Texas Instrument's TPD2S300YFF evaluation module helps designers evaluate the operation and performance of the TPD2S300YFF device. The TPD2S300YFF is a single-chip solution for protection of the USB Type-C configuration channel (CC). The device provides Short-to-VBUS overvoltage protection up to 24 V for the CC1, CC2 pins to prevent damage caused by a faulty connecter or mechanical twist shorting pins. The TPD2S300YFF also provides 2-channels of IEC 61000-4-2 ESD protection for CC1, CC2 of the USB Type-C connecter.

1.1 Board Setup

Figure 1 shows the TPD2S300YFF-EVM Board. The pass-through EVM allows the user to ensure that the TPD2S300YFF does not impede typical operation of their USB port while also allowing the user to test the TPD2S300YFF protection during an overvoltage or ESD event. To test the TPD2S300YFF EVM, plug the male ("system side", J1) connector on the EVM into a USB Type-C female port and plug a typical USB Type-C cable or peripheral into the EVM's female connector ("connector side", J2).

The TPD2S300YFF is intended to be placed very close to the port in a typical system, so this setup closely simulates a designed in the TPD2S300YFF. When plugged in, the user can ensure that the TPD2S300YFF does not impede standard USB operation. By default, the C_CC1 and C_CC2 pins are used to self-bias the internal dead battery resistors of the TPD2S300YFF. This allows the TPD2S300YFF to serve as either a UFP or a DFP port.

The TPD2S300YFF has an integrated voltage mode pin, giving the user the ability to operate the EVM for CC and PD, or with VCONN capabilities as well. In the case that only CC/PD operation is desired, pins 2 and 3 on J3 can be shorted with a jumper, allowing the VM pin to use the VPWR voltage as input. If VCONN functionality is desired, pins 1 and 2 can be shorted on J3. The VM pin of the TPD2S300YFF can then be controlled by placing an external voltage source on TP4 (VM). In order for the device to function properly in this mode, the voltage level needs to be 8-V minimum, but must not exceed 22 V to keep in the boundaries of the recommended operating conditions.

With respect to powering the device, the EVM requires 3.3 V between the VPWR (TP1) and Ground (TP3) pins to power up the TPD2S300YFF. If the system supports USB charging from a dead battery condition, it is recommended that the EVM be powered from the protected USB Controller to show that the dead battery functionality works properly. The EVM includes a 0.1-uF (C2) capacitor to ground on the Vbias pin of the TPD2S300YFF, a 100-kΩ (R1) resistor to VPWR on the $\overline{\text{FLT}}$ pin, and a 1-uF (C1) capacitor to ground on the VPWR pin. These are recommended for proper operation of the TPD2S300YFF in all applications.

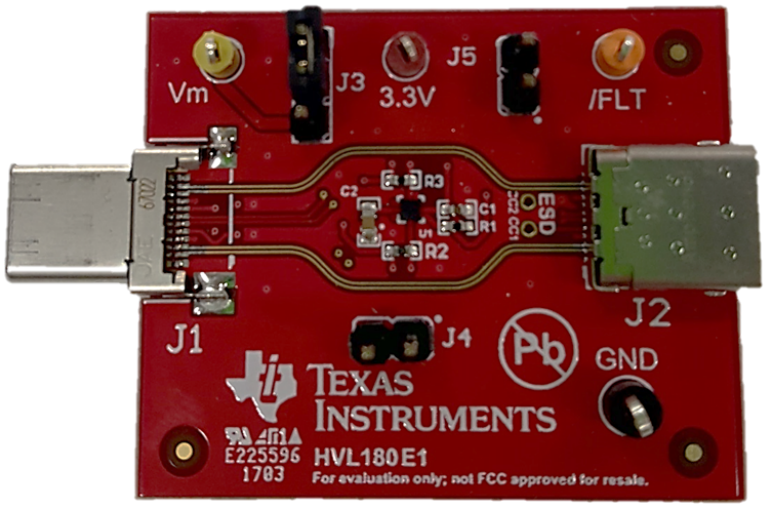


Figure 1. TPD2S300YFF-EVM Board

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2 Test Setup and Results

Section 2.1 and Section 2.2 outline the testing procedures for the TPS2S300YFF EVM along with their respective results. Care must be exercised when testing to avoid potential damage to the device and any connected peripherals.

2.1 Overvoltage Protection Testing

The EVM is designed to allow the user to ensure that the TPD2S300YFF can protect their system from overvoltage events. By shorting either CC line to a high voltage on the connecter side of the EVM, the user can confirm that the TPD2S300YFF protects their system. The short can be created by applying 20 V to one of the protected lines on a USB Type-C breakout board plugged into J2 or by using a custom board that discharges 20 V over a capacitor when plugged in. When the TPD2S300YFF sees a voltage over the overvoltage threshold on a CC line it isolates both CC lines within 100 ns to protect the system. Use an oscilloscope to measure the voltage on both the system side and the connector side of the EVM to view the clamped voltage that the protected system is seeing.

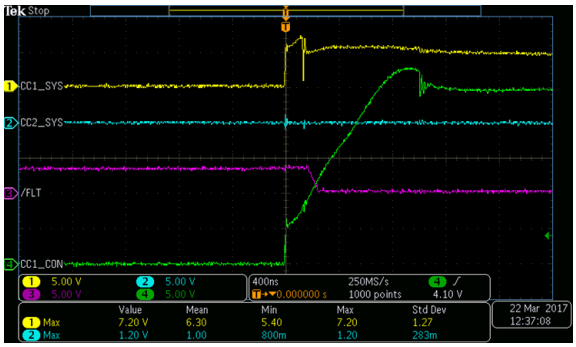


Figure 2. TPD2S300YFF-EVM Short-to-V_{BUS} Test

The waveform in Figure 2, where channels 1 and 2 are the system side of the TPD2S300YFF-EVM, and channel 4 is the connector side, was taken when CC1 from a TPD2S300YFF-EVM in DFP mode in series with a TPD8S300YFF-EVM was shorted to a 24-V V_{BUS} line. The event was created by a plugging in a one foot cable to a custom USB Type-C board that simulates a faulty peripheral, pulling V_{BUS} to 24 V and discharging the voltage to the CC line over a capacitor. Measuring the voltage over the TPD2S300YFF-EVM shows the device clamping the overvoltage event to a maximum voltage of 7.2 V.

2.2 ESD Testing

Figure 3 shows the TPD2S300YFF-EVM. The EVM has two ESD test points, one on each CC line which allows the user to use a ESD simulator in either contact or air-gap test mode to measure the ESD protection provided by the TPD2S300YFF-EVM. Probe points CC1 and CC2 correspond to the CC1 and CC2 lines respectively. See the *IEC 61000-4-x Tests for TI's Protection Devices* application report for specifics on proper ESD testing methods.

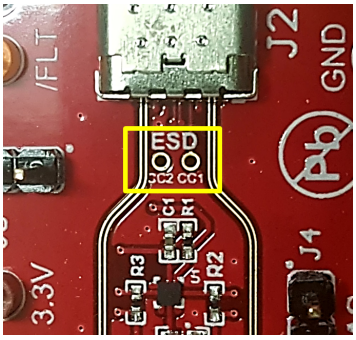


Figure 3. TPD2S300YFF-EVM

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3 Board Layout

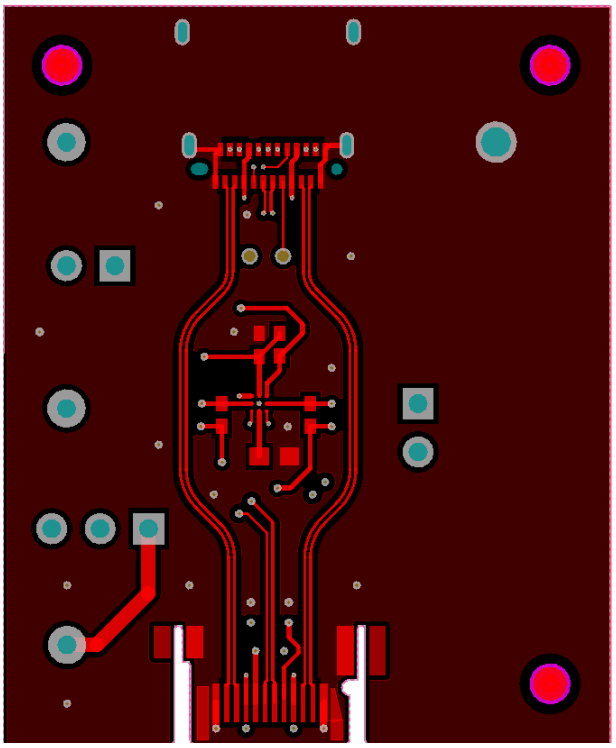


Figure 4. Top Layer

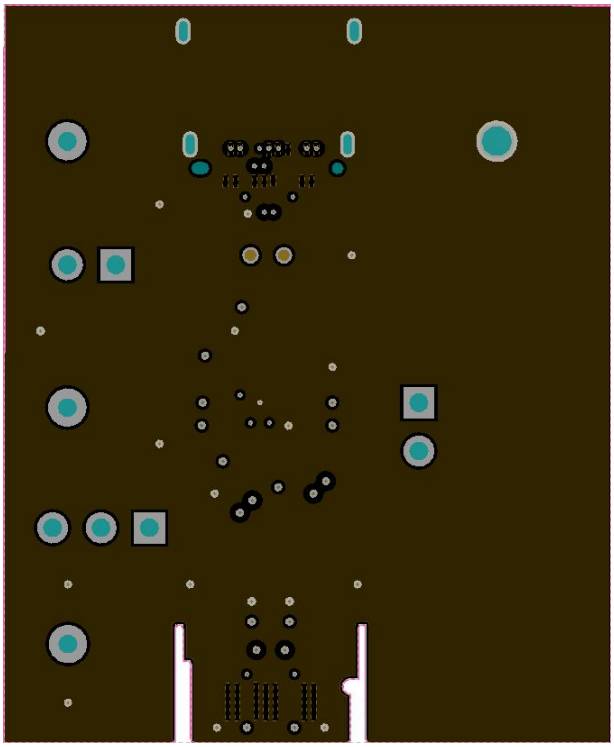


Figure 5. GND Layer 1

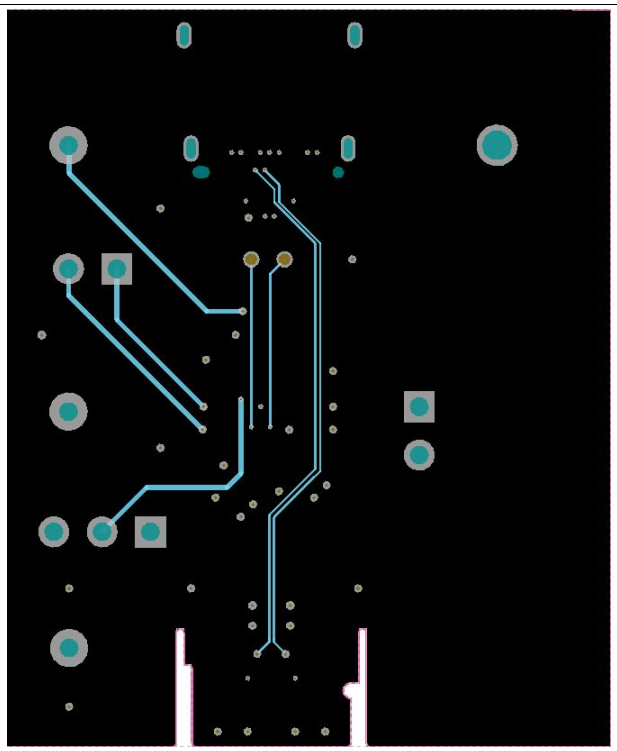


Figure 6. Mid-Layer 1

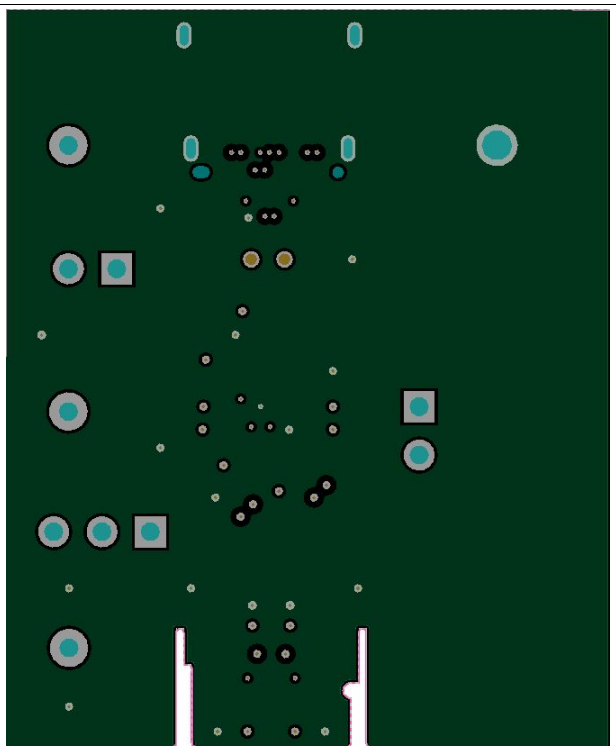


Figure 7. GND Layer 2

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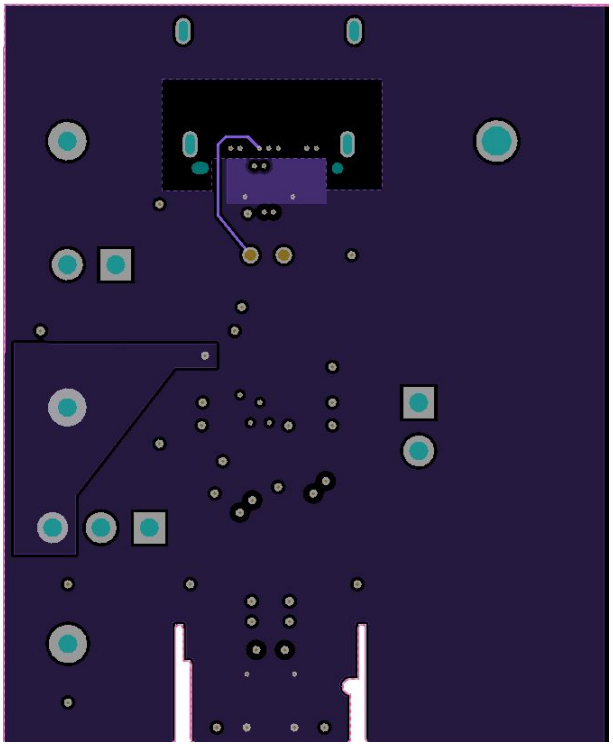


Figure 8. Power Plane

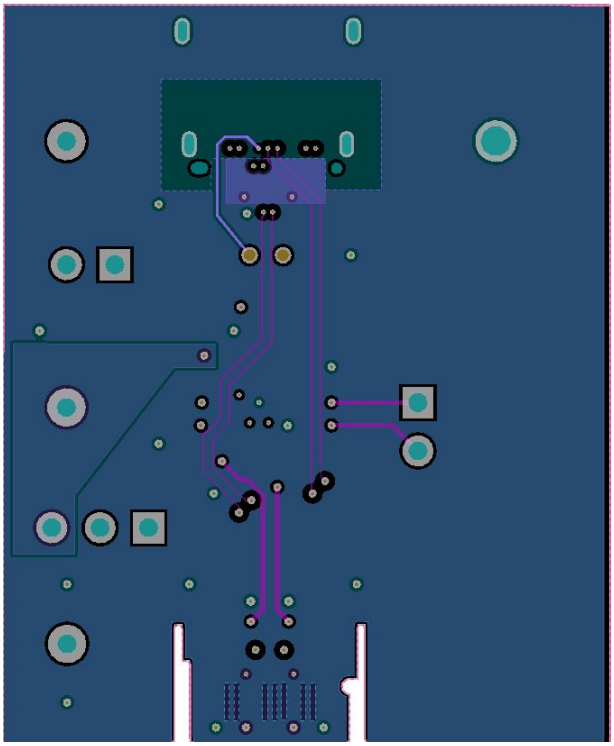


Figure 9. Mid-Layer 2

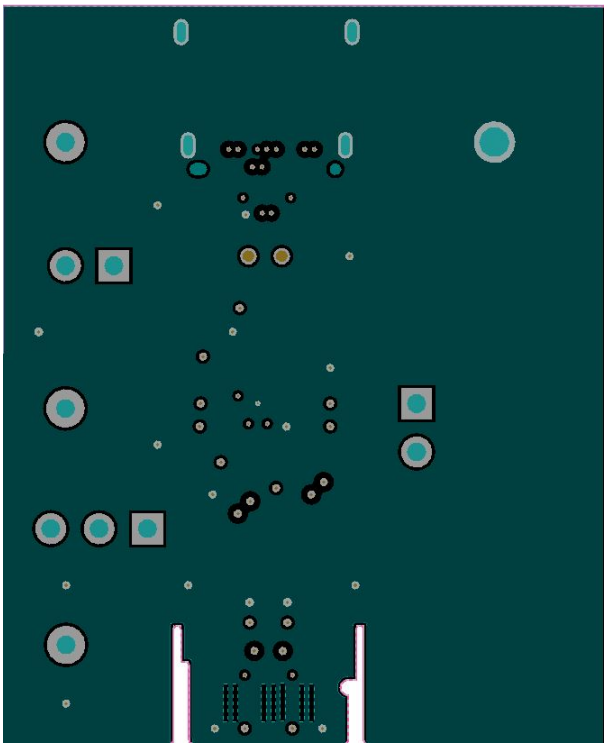


Figure 10. GND Plane 3

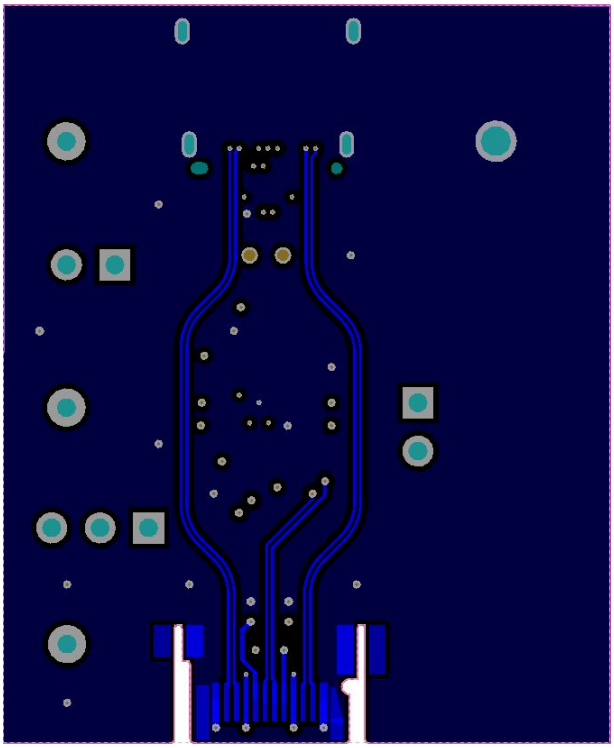


Figure 11. Bottom Plane

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4 Schematic

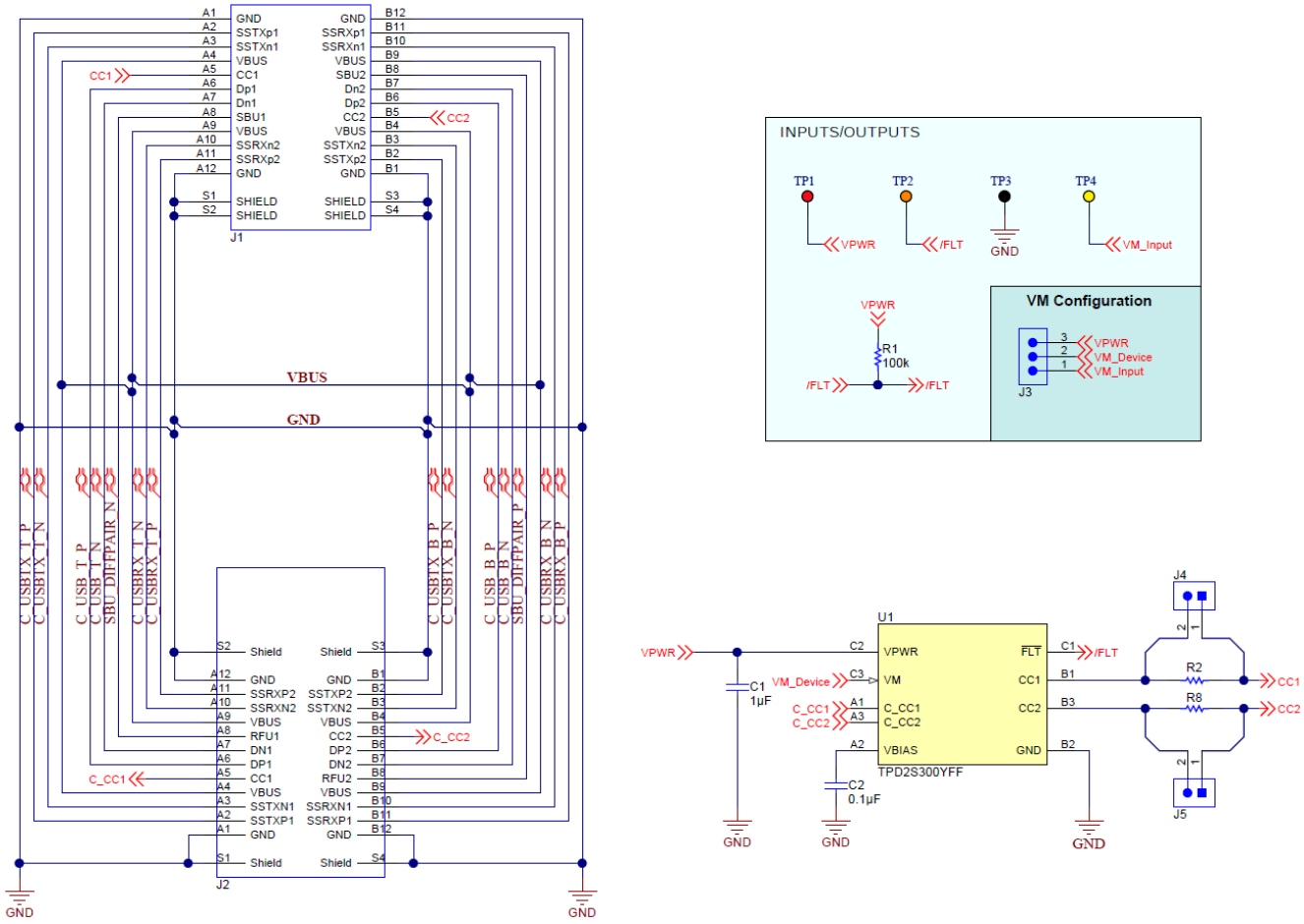


Figure 12. TPD2S300YFF-EVM Board Schematic

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5 Bill of Materials

The following is an itemized list of the components used in the TPD2S300YFF-EVM board.

Table 1. Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		HVL180	Any
C1	1	1 uF	CAP, CERM, 1 µF, 35 V, ±10%, JB, 0402	0402	C1005JB1V105K050BC	TDK
C2	1	0.1 uF	CAP, CERM, 0.1 µF, 50 V, ±10%, X7R, 0603	0603	GRM188R71H104KA93D	MuRata
J1	1		Plug, USB3.1, TYPE-C, R/A, SMT	Plug, USB3.1, TYPE-C, R/A, SMT	DX07P024MJ1R1500	JAE Electronics
J2	1		Receptacle, 0.5 mm, USB TYPE C, R/A, SMT	Receptacle, 0.5 mm, USB TYPE C, R/A, SMT	12401610E4#2A	Amphenol Canada
J3	1		Header, 100 mil, 3×1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
J4, J5	2		Header, 100 mil, 2×1, Gold, TH	Sullins 100 mil, 1×2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions
R1	1	100 k	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ104X	Panasonic
R2, R3	2	0.1	RES, 0.1, 1%, 0.125 W, 0402	0402	ERJ-2LWJR010X	Panasonic
TP1	1		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP2	1		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone
TP3	1		Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone
TP4	1		Test Point, Miniature, Yellow, TH	Yellow Miniature Testpoint	5004	Keystone
U1	1		USB Type C Short-to-VBUS and IEC ESD Protector for the CC Pins, YFF0009ALAL (DSBGA-9)	YFF0009ALAL	TPD2S300YFF	Texas Instruments
FID1, FID2, FID3	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.

   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.

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。
http://www.tij.co.jp/lsds/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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3.4 *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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