TPD2S703-Q1 Evaluation Module

This user's guide describes the characteristics, operation, and use of the TPD2S703-Q1 USB 2.0 Data Line Overvoltage Protection Evaluation Module (EVM). The TPD2S703-Q1 is a 2-Channel Data Line Short-to-Battery, Short-to-VBUS, and IEC61000-4-2 ESD protection device for automotive high-speed interfaces like USB2.0. This EVM contains multiple TPD2S703-Q1 devices in various configurations to allow the user to test the operation of the TPD2S703-Q1 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 TPD2S703-Q1 evaluation module helps designers evaluate the operation and performance of the TPD2S703-Q1 device. The TPD2S703-Q1 contains two data line nFET switches which ensure safe data communication while protecting the internal system circuits from any over-voltage conditions at the VD+ and VD– pins. See Figure 1. On these pins, this device can handle over-voltage protection up to 18-V DC. This provides sufficient protection for shorting the data lines to the car battery as well as the USB VBUS rail. This EVM allows the user to evaluate the operation of this device in a pass-through application, as well as to measure the ESD response and bandwidth of the device. In addition, this EVM offer, contains the device in both the DSK and DGS package offering, so that the device can be evaluated regardless of the preferred package option.

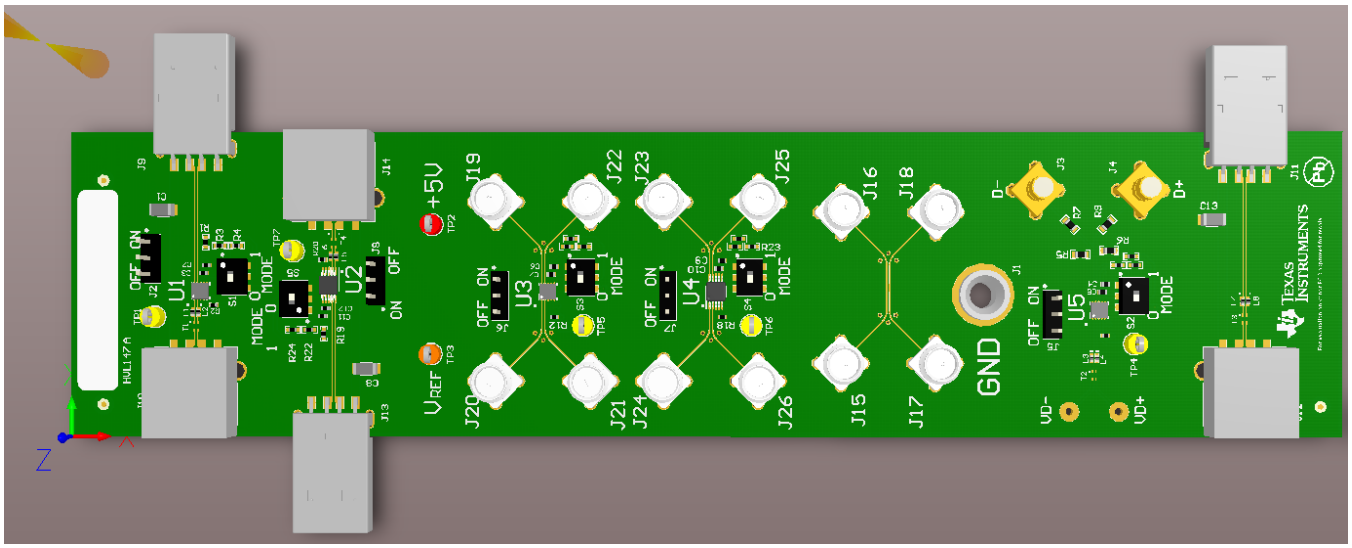

Figure 1. TPD2S703-Q1 EVM

2 Board Setup

The TPD2S703-Q1 EVM consists of 5 devices allowing for three different test setups.

2.1 Device Information

To power the EVM, apply 5 V to the pin labeled '+5V' on the EVM. If the user is testing a device in Mode 0, they will need to apply an additional voltage to the pin labeled 'Vref', but if testing is done in Mode 1 then the 'Vref' pin can be left unused. The functional devices modes are discussed in greater depth later, but for detailed information see the device data sheet.

Each TPD2S703-Q1 in this EVM contains headers for enabling the device and a mode switch to enable each mode of operation. Before using any of the devices, ensure that the particular device has a header between the center pin and the pin labeled 'On' for the corresponding set of pins. It is recommended that any devices not currently in use be disabled by moving the header between the center pin and the 'Off' pin.

In addition, the EVM allows testing of each device in either functional mode 0 or functional mode 1 by moving the switch corresponding to the device. The functional mode changes how the overvoltage set point of the TPD2S703-Q1 is determined. In order to operate properly, the device must be power-cycled when changing functional modes. We recommend only changing device modes while there is no power applied to the '+5V' board power to ensure that the device works properly.

In functional mode 0 the overvoltage set point is determined by an external voltage applied to the 'Vref' pin on the EVM. The correlation between the Vref voltage and the overvoltage set point is determined by a formula that can be found in the device datasheet. The voltage applied to the 'Vref' pin applies to all TPD2S703-Q1 devices on the EVM that are currently enabled and in mode 0.

If the switch is placed in position 1, the overvoltage set point is determined instead by external resistors and an internal voltage reference. In this mode, the device can operate with no external voltage applied to the 'Vref' pin. The EVM is designed with external resistors to always have a 3.6 V overvoltage set point in mode 1.

Each device also contains a yellow test point that allows the user to measure the corresponding devices FLT output. Measure the voltage on this pin to record when the device goes into an undervoltage, overvoltage, or thermal shutdown state to ensure that the device operates as expected.

2.2 Passthrough Evaluation

Devices U1 and U2 are in a configured to allow for USB 2.0 pass-through testing. The two devices are in a DSK and DGS package respectively, but otherwise are functionality identical. Each has a male and female USB port that can be plugged into any system with a USB 2.0 port to ensure that the device can protect existing systems. Plug J9 or J13 into a USB port and then plug a peripheral into J10 or J14 to ensure that during typical operation the TPD2S703-Q1 has no effect on standard USB operations. While plugged in, use a probe to apply a voltage above the overvoltage setpoint to one of the data lines and observe that the TPD2S703-Q1 isolates the system, preventing any data pass-through. After the voltage is removed, the TPD2S703-Q1 must remove the isolation and quickly re-allow data communications. See Figure 2.

By taking advantage of this pass-through evaluation, the user can quickly determine whether the TPD2S703-Q1 is optimal for their existing system without requiring any board changes or non-optimal test setups. There is an additional USB 2.0 pass-through setup at the bottom of the board that is designed for calibration. The board and trace add some parasitics and bandwidth loss that do not reflect how the TPD2S703-Q1 operates when designed into a system. This additional pass-through allows for calibration to account for those and get a more accurate picture of the TPD2S703-Q1.

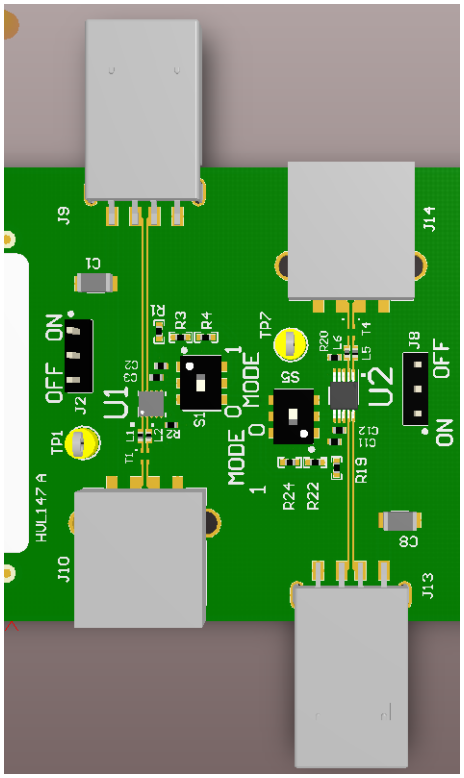

Figure 2. Passthrough Evaluation Configuration

2.3 Bandwidth Evaluation

Devices U3 and U4 are configured to allow for precise bandwidth measurements. The two devices are in a DSK and DGS package respectively, but otherwise are functionally identical. Each device has SMA connectors on both the connector and system side of the USB 2.0 Data line pins that offer a low attenuation way to connect a network analyzer and ensure that during typical operation the TPD2S703-Q1 capacitance and inductance do not impede signal speed past where the maximum line signal speed is. In addition, when U3 and U4 are placed into a fault state the bandwidth can be measured to ensure that the DC fault voltage is significantly attenuated. See Figure 3.

There is an additional bandwidth setup that is designed for calibration. The board and trace add some parasitics and bandwidth loss that do not reflect how the TPD2S703-Q1 operates when designed into a system. This additional pass-through allows for calibration to account for those and get a more accurate picture of the bandwidth of the TPD2S703-Q1.

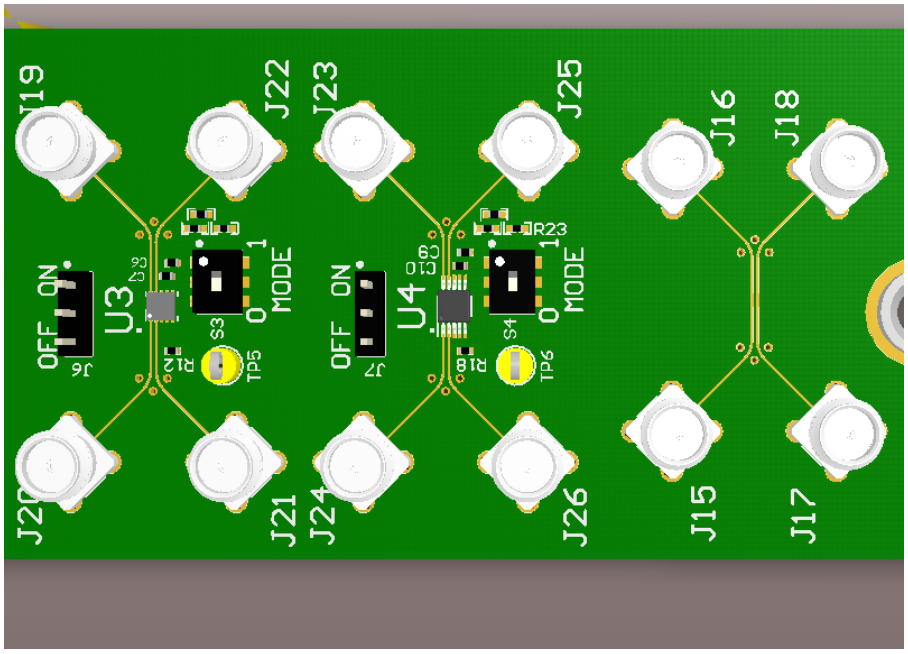

Figure 3. Bandwidth Evaluation Configuration

2.4 IEC ESD Evaluation

Device U5 is configured to be an optimal place to test the TPD2S703-Q1 IEC ESD strike response. This configuration contains the TPD2S703-Q1 in only the DSK package as there is no difference in the performance between the DSK and DGS packages. Test points VD+ and VD– offer strike points that can targeted with an external ESD simulator on the protected data lines. By measuring with attenuated scope probes on the SMB connecters labeled D+ and D– during an ESD strike, the user can capture a waveform of what the protected system is exposed to during an ESD strike. Resistors R7 and R9 are 150-Ω resistors in series with the ESD pulse to provide a 4x attenuation with the 50-Ω oscilloscope probe impedance. In addition to this, to ensure that the oscilloscope is not harmed a 10x attenuation probe must be used. See Figure 4.

For more information about Texas Instruments recommended ESD test setup, see the application report, *IEC 61000-4-x Tests for TI's Protection Devices*.

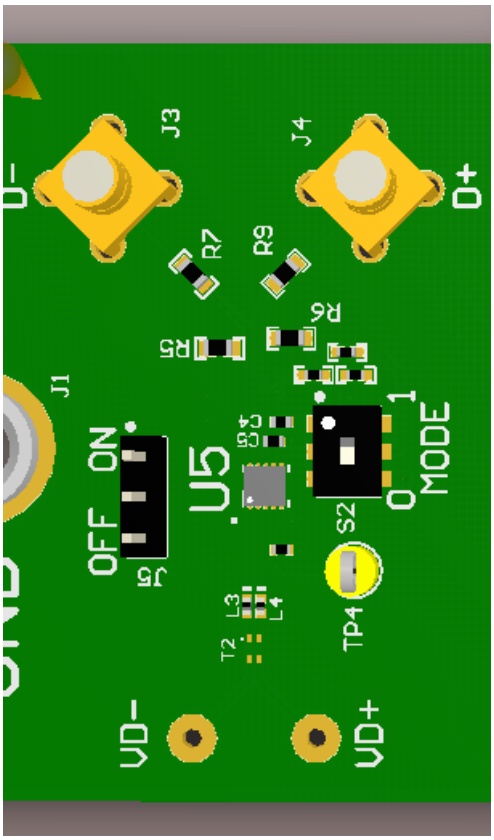

Figure 4. ESD Evaluation Configuration

3 Schematics

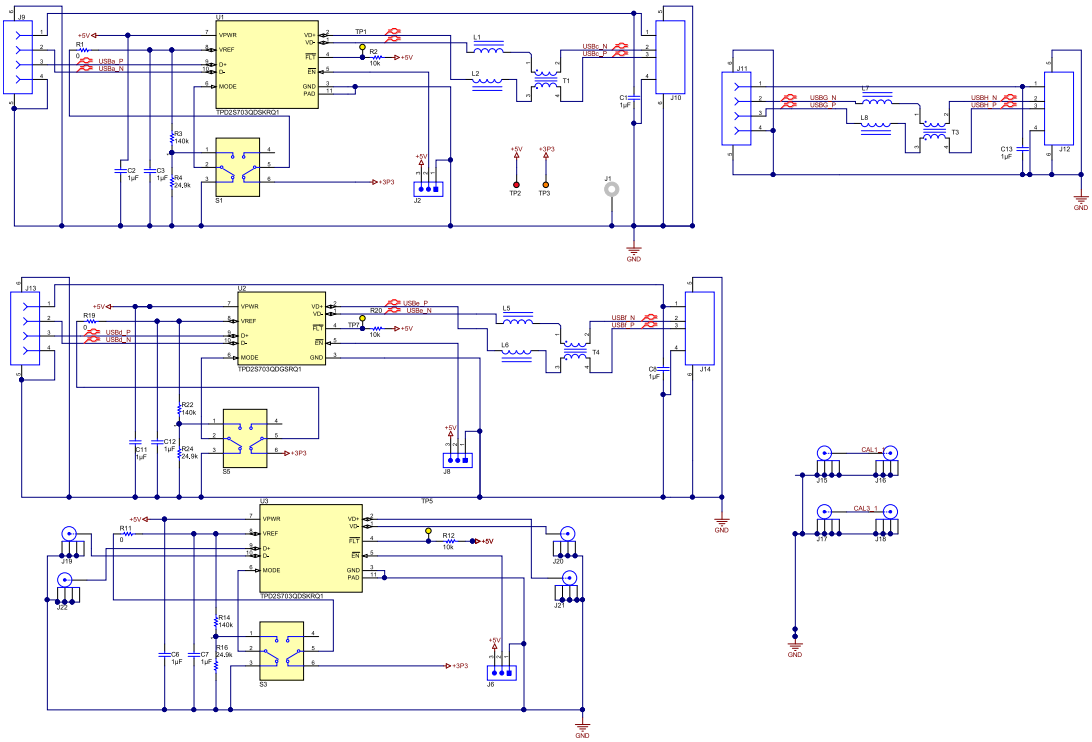

Figure 5. Schematic Page 1

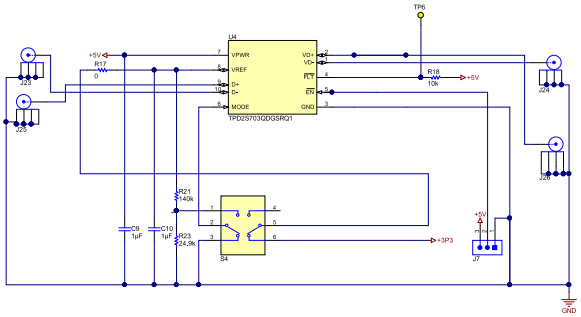

Figure 6. Schematic Page 2

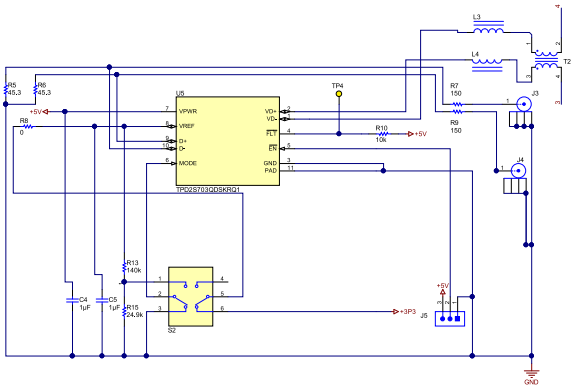

Figure 7. Schematic Page 3

4 Layout

The TPD2S703-Q1 EVM is a 4 layer board of FR4 with measurements of 7.92 inches by 1.9 inches with a thickness of 62 mil. Only the top and bottom layers are shown below, as the middle two layers are both ground planes.

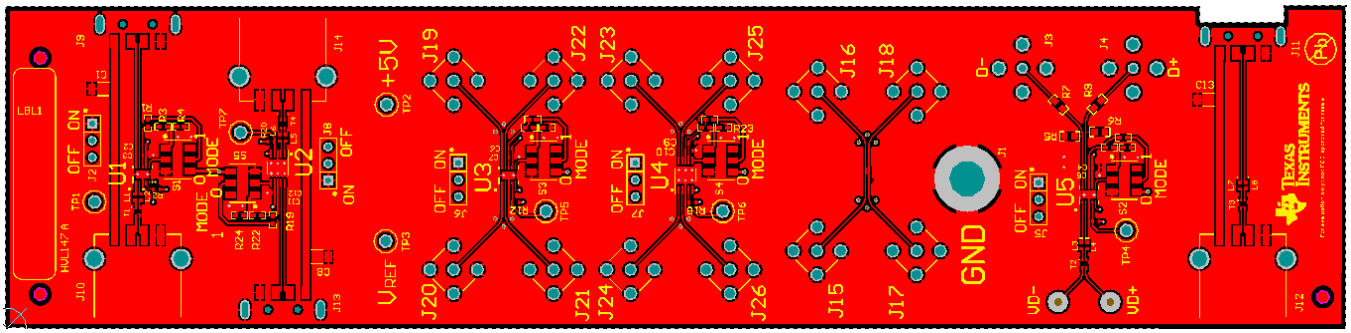

Figure 8. TPD2S703-Q1 Top Layer

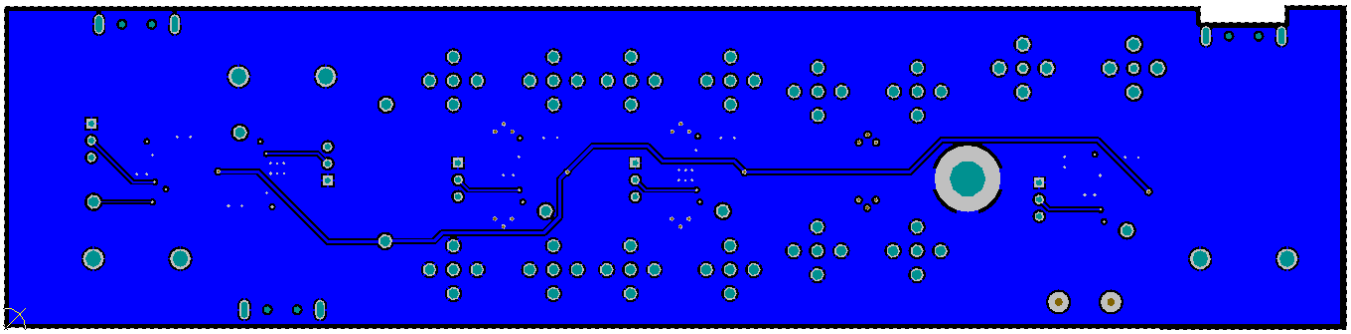

Figure 9. TPD2S703-Q1 Bottom Layer

5 Bill of Materials

Table 1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate PartNumber[1]	Alternate Manufacturer
PCB	1		Printed Circuit Board		HVL147	Any	—	—
C1, C8, C13	3	1 uF	CAP, CERM, 1 µF, 100 V, ±10%, X7R, AEC-Q200 Grade 1, 1206_190	1206_190	GCM31CR72A105KA03	MuRata		
C2, C3, C4, C5, C6, C7, C9, C10, C11, C12	10	1 uF	CAP, CERM, 1 µF, 10 V,±10%, X7S, AEC-Q200 Grade 1, 0402	0402	GCM155C71A105KE38D	MuRata		
J1	1		Standard Banana Jack, Uninsulated, 5.5 mm	Keystone_575-4	575-4	Keystone		
J2, J5, J6, J7, J8	5		Header, 100 mil, 3×1, Tin, TH	Header, 3 PIN, 100 mil, Tin	PEC03SAAN	Sullins Connector Solutions		
J3, J4	2		Connector, SMB,Vertical RCP 0-4 GHz, 50 Ω, TH	236×293×236mil	131-3701-261	Emerson Network Power		
J9, J11, J13	3		Connector, USB Type A, 4POS R/A, SMD	USB Type A right angle	0480371000	Molex		
J10, J12, J14	3		Connector, Receptacle, USB TYPE A, 4POS SMD	USB TYPE A CONNECTOR RECEPTACLE 4POS SMD	896-43-004-00-000000	Mill-Max		
J15, J16, J17, J18, J19, J20, J21, J22, J23, J24, J25, J26	12		SMA Straight PCB Socket Die Cast, 50 Ω, TH	SMA Straight PCB Socket Die Cast, TH	5-1814832-1	TE Connectivity		
L1, L2, L3, L4, L5, L6, L7, L8	8	10 nH	Inductor, Multilayer, Air Core, 10 nH, 0.3A, 0.26 Ω, SMD	0402 polarized	LQG15HS10NJ02D	MuRata		
LBL1	1		Thermal Transfer Printable Labels, 1.250" W × 0.250" H - 10,000 per roll	PCB Label 1.25 × 0.250 inch	THT-13-457-10	Brady		
R1, R8, R11, R17, R19	5	0	RES, 0, 5%, 0.063 W, 0402	0402	RC0402JR-070RL	Yageo America		
R2, R10, R12, R18, R20	5	10k	RES, 10 k, 5%, 0.063 W, 0402	0402	CRCW040210K0JNED	Vishay-Dale		

(1) Unless otherwise noted in the Alternate PartNumber and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.

Table 1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate PartNumber[1]	Alternate Manufacturer
R3, R13, R14, R21, R22	5	140k	RES, 140 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF1403X	Panasonic		
R4, R15, R16, R23, R24	5	24.9k	RES, 24.9 k, 1%, 0.063 W, 0402	0402	CRCW040224K9FKED	Vishay-Dale		
R5, R6	2	45.3	RES, 45.3, 1%, 0.1 W, 0603	0603	CRCW060345R3FKEA	Vishay-Dale		
R7, R9	2	150	RES, 150, 1%, 0.1 W, 0603	0603	RC0603FR-07150RL	Yageo America		
S1, S2, S3, S4, S5	5		SLIDE SWITCH DPDT .1A, SMT	SWITCH, 5.4×2.5×3.9 mm	CAS-220TA	Copal Electronics		
SH-J2, SH-J5, SH-J6, SH-J7, SH-J8	5		Shunt, 2.54 mm, Gold, Black	Shunt, 2.54 mm, Black	60900213421	Wurth Elektronik		
T1, T2, T3, T4	4		SMT Common Mode Choke		mcf12102g900	Taiyo Yuden	None	None
TP1, TP4, TP5, TP6, TP7	5		Test Point, Compact, Yellow, TH	Yellow Compact Testpoint	5009	Keystone		
TP2	1		Test Point, Compact, Red, TH	Red Compact Testpoint	5005	Keystone		
TP3	1	Orange	Test Point, Compact, Orange, TH	Orange Compact Testpoint	5008	Keystone		
U1, U3, U5	3		Automotive USB 2-Ch Date Line Short-to-Battery, Short-to-VBUS, and IEC ESD pritection, DSK0010A	DSK0010A	TPD2S703QDSKRQ1	Texas Instruments		Texas Instruments
U2, U4	2		Automotive USB 2-Ch Date Line Short-to-Battery, Short-to-VBUS, and IEC ESD pritection, DGS0010A	DGS0010A	TPD2S703QDGSRQ1	Texas Instruments		Texas Instruments
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount	Fiducial	N/A	N/A		

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      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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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.

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