TPD3S716-Q1 Evaluation Module

This user's guide describes the characteristics, operation, and use of the TPD3S716-Q1EVM evaluation module (EVM). This EVM includes four TPD3S716-Q1s in various configurations for testing.

- IEC61000-4-2 compliance testing on the connector-side pin
- USB 2.0 Type A input and output connectors for throughput analysis
- ESD clamping waveforms during an electrostatic discharge (ESD) event

Contents

1 Introduction 2
2 Definitions 3
3 Setup 3
4 Board Layout 7
5 Schematics 9
6 Bill Of Materials 10

List of Figures

1 Ideal Contact Discharge Waveform of the Output Current of the ESD Simulator at 4-kV 3
2 System Level ESD Test Setup 6
3 TPD3S716-Q1EVM Top Components Silkscreen 7
4 TPD3S716-Q1EVM Top Layer 7
5 TPD3S716-Q1EVM Bottom Layer 7
6 TPD3S716-Q1EVM Schematic 9

List of Tables

1 EVM Configuration 2
2 IEC61000-4-2 Test Levels 3
3 Waveform Parameters in Contact Discharge Mode 3
4 $\overline{VEN}$ and $\overline{EN}$ Jumper Configurations 4
5 +5-V and +3.3-V Jumper Configurations 4
6 Bill of Materials 10

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1 Introduction

Texas Instrument's TPD3S716-Q1 evaluation module helps designers evaluate the operation and performance of the TPD3S716-Q1 device. The TPD3S716-Q1 is a single-chip solution for a USB connector's V_{BUS} and data line protection. The nFET switch ensures safe current flow in host mode operation while protecting the internal system circuits from any overvoltage conditions at the V_{BUS_CON}, VD, and VD– pins. On these pins, this device can protect against overvoltage up to 18 V. The V_{BUS_CON} pin also protects against shorts to ground. The TPD3S716-Q1 is designed to operate over an ambient air temperature range of –40°C to +125°C.

The TPD3S716-Q1EVM contains four TPD3S716-Q1s labeled U1 through U4. U1 is configured with two USB2.0 connectors (USB1 and USB2) for capturing system level tests. U2 is configured with four SMA (S1 – S4) connectors for 4-port analysis with a vector network analyzer. U3 is configured with test points for striking ESD to the protection pins. U3 is also configured for capturing clamping waveforms using J3 with an oscilloscope during an ESD test. Caution must be taken when capturing clamping waveforms during an ESD event so as not to damage the oscilloscope. A proper procedure is outlined in Section 3. U4 is pinned out for device level tests. Devices U1 and U4 have Kelvin connections (TP4 – TP5 and TP7 – TP8) around the nFET for measuring R_{ON}.

Table 1 shows the TPD3S716-Q1 EVM Configuration.

Table 1. EVM Configuration

Reference Designator	TI Part Number	Configuration
U1	TPD3S716-Q1	USB 2.0 System level
U2	TPD3S716-Q1	S-Parameters
U3	TPD3S716-Q1	IEC61000-4-2 ESD tests
U4	TPD3S716-Q1	Pinned out device

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2 Definitions

Contact Discharge — a method of testing in which the electrode of the ESD simulator is held in contact with the device-under-test (DUT).

Air Discharge — a method of testing in which the charged electrode of the ESD simulator approaches the DUT, and a spark to the DUT actuates the discharge.

ESD simulator — a device that outputs IEC61000-4-2 compliance ESD waveforms shown in Figure 1 with adjustable ranges shown in Table 2 and Table 3.

IEC61000-4-2 has 4 classes of protection levels. Classes 1 – 4 are shown in Table 2. Stress tests must be incrementally tested to level 4 as shown in Table 3 until the point of failure. If the DUT does not fail at 8 kV, testing can continue in 2-kV increments until failure.

Table 2. IEC61000-4-2 Test Levels

Contact Discharge		Air Discharge	
Class	Test Voltage [± kV]	Class	Test Voltage [± kV]
1	2	1	2
2	4	2	4
3	6	3	8
4	8	4	15

Table 3. Waveform Parameters in Contact Discharge Mode

Stress Level Step	Simulator Voltage [kV]	Ipeak ±15% [A]	Rise Time ±25% [ns]	Current at 30-ns ±30% [A]	Current at 60-ns ±30% [A]
1	2	7.5	0.8	4	2
2	4	15	0.8	8	4
3	6	22.5	0.8	12	6
4	8	30	0.8	16	8

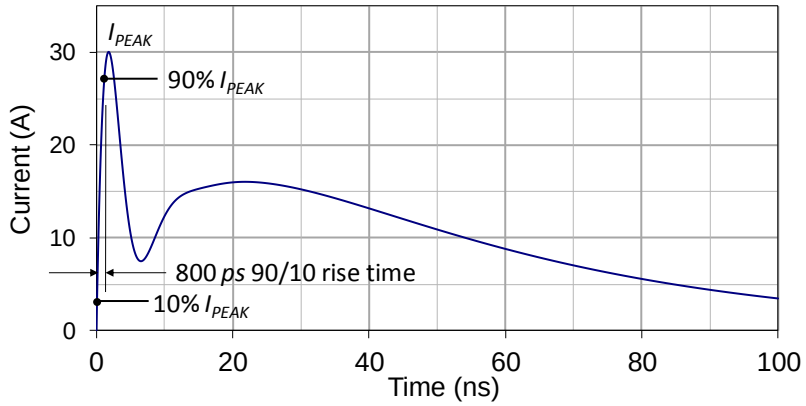


Figure 1. Ideal Contact Discharge Waveform of the Output Current of the ESD Simulator at 4-kV

3 Setup

This section describes the intended use of the EVM. A generalized outline of the procedure given in IEC 61000-4-2 is described here. IEC 61000-4-2 must be referred to for a more specific testing outline. Basic configurations for collecting s-parameters, eye diagrams, and ESD clamping waveforms are outlined as well. Table 4 shows the $\overline{VEN}$ and $\overline{EN}$ jumper configurations.

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Table 4. $\overline{VEN}$ and $\overline{EN}$ Jumper Configurations

Jumper	Off	On
(U1, U2, U3) /VEN	disable the V_{BUS} switch for U1 – U3	enable the V_{BUS} switch for U1 – U3
(U1, U2, U3) /DEN	disable the data switch for U1 – U3	enable the data switch for U1 – U3
$\overline{VEN}$_U4	disable the V_{BUS} switch for U4	enable the V_{BUS} switch for U4
$\overline{DEN}$_U4	disable the data switch for U4	enable the data switch for U4

Table 5. +5-V and +3.3-V Jumper Configurations

U1	U2	U3	U4	Power Supply Connection
Shunt to supply 5 V to U1	Shunt to supply 5 V to U2	Shunt to supply 5 V to U3	Shunt to supply 5 V to U4	**+5 V**
Shunt to supply 3.3 V to U1	Shunt to supply 3.3 V to U2	Shunt to supply 3.3 V to U3	Shunt to supply 3.3 V to U4	**+3.3 V**

Power must be supplied to +5 V, +3.3 V, and GND connectors, except if powering U1 through the USB connector. When testing DUT U1 shunt both jumpers (JP1 and JP5) **but** 5 V can **only** be supplied by **either** the test point labeled “+5 V” **or** the USB male connector (USB2) on V_{BUS}. All other DUTs require a power supply to be attached to both test points labeled “+3.3 V” and “+5 V” with the appropriate shunts set per Table 5. Power can be distributed to each TPD3S716-Q1 by setting the shunts in place for each DUT (U1 – U4) according to Section 3.3.1. All shunts in Table 5 can be set at the same time or only for the device under test.

3.1 U1

A single TPD3S716-Q1 (U1) is configured with two USB2.0 Type A connectors (USB1 and USB2) for capturing Eye Diagrams and other system level tests. All system level tests must use USB1 as the sink and USB2 as the source. +5 V can be supplied to V_{BUS} using either the male USB connector (USB2) or by attaching 5 V to the test point labeled “+5 V.” **If supplying 5 V by the USB connector (USB2) then do not attach a power supply to the test point labeled “+5 V**” and do shunt JP1 to supply the pull-up resistor for $\overline{FLT}$. Kelvin connections (TP4 and TP5) are provided for accurate voltage measurements of V_{BUS_SYS} and V_{BUS_CON} during load tests.

Different resistor values are provided to connect to pin 16, I_{adj}, to ground by setting a shunt on one of the jumpers J9 – J11. Pin 16 can also be connected directly to +5 V or ground using J6. **Only one shunt must be connected at a time.**

3.2 U2

The TPD3S716-Q1 (U2) is configured with four SMA (S1 – S4) connectors to allow 4-port analysis with a vector network analyzer. Connect Port 1 to S1, Port 2 to S2, Port 3 to S3, and Port 4 to S4. This configuration allows for the following terminology in 4 port analysis:

- S_{11}: Return loss
- S_{21}: Insertion loss
- S_{31}: Near end cross talk
- S_{41}: Far end cross talk

A calibration section is included using four SMA (SP1 – SP4) connectors with the same PCB trace geometry

3.3 U3

One TPD3S716-Q1 (U3) can be used for destructive IEC 61000-4-2 ESD pass/fail ESD strikes. TP2 has an added SMB (J3) connector for capturing clamping waveforms with an oscilloscope during an ESD strike. Caution must be taken when capturing clamping waveforms during an ESD event so as not to damage the oscilloscope.

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3.3.1 Oscilloscope Setup for Clamping Waveforms

Without a proper procedure, capturing ESD clamping waveforms exposes the oscilloscope to potential voltages higher than the rating of the equipment. Proper methodology can mitigate any risk in this operation.

Recommended equipment:

- Minimum of 1-GHz bandwidth oscilloscope.
- Either of the following:
  - Two 10X 50 Ω attenuators and a 0 Ω resistor (to be installed at R1).
  - One 10X 50 Ω attenuator and a 150 Ω resistor (already installed at R1).
- 50 Ω shielded SMB cable.

Procedure

In order to protect the oscilloscope, attenuation of the measured signal is required. Here are two possible procedures for testing U3:

1. Using two 10X attenuators:
   - Install a 0-Ω resistor in R1.
   - Attach two 10X attenuators to the oscilloscope channel being used.
   - Attach the 50-Ω shielded SMB cable between J5 and the attenuator.
   - Set the scope attenuation factor to 100X.
   - Set the oscilloscope to trigger on a positive edge for (+) ESD and a negative edge for (–) ESD strikes. The magnitude must be set to 20 V.
   - Following Section 3.3.2, strike contact ESD to TP1.
2. Using one 10X attenuator:
   - Attach one 10X attenuator to the oscilloscope.
   - Attach the 50-Ω shielded SMB cable between J5 and the attenuator.
   - Set the scope attenuation factor to 40X.
   - Set the oscilloscope to trigger on a positive edge for (+) ESD and a negative edge for (–) ESD strikes. The magnitude must be set to 20 V.
   - Following Section 3.3.2, strike contact ESD to TP1.

   Recommended settings for the time axis is 20 ns/division and for the voltage axis is 10-V/division.

   The voltage levels of the ESD applied to TP2 must not exceed 8 kV while capturing clamping waveforms.

3.3.2 IEC 61000-4-2 Test Method and Set-Up

An example test setup is shown in Figure 2. Details of the testing table and ground planes can be found in the IEC 61000-4-2 test procedure. Ground the EVM using the banana connector labeled GND. Discharge the ESD simulator on any of the Test Points TP1 – TP3. Contact and air-gap discharge are tested using the same simulator with the same discharge waveform. While the simulator is in direct contact with the test point during contact, it is not during air-gap.

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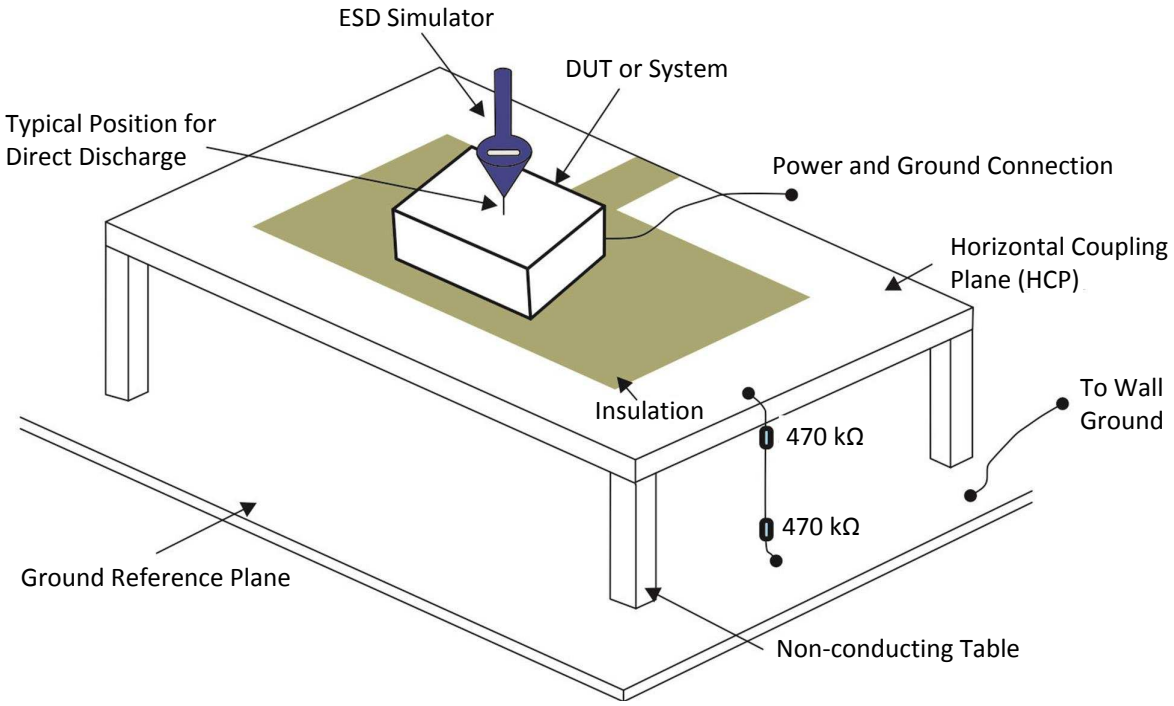


Figure 2. System Level ESD Test Setup

3.3.2.1 Evaluation of Test Results

Connect the tested device on the EVM to a curve tracer both before and after ESD testing. After each incremental level, if the IV-curve of the ESD protection diode shifts ±0.1 V, or the leakage current increases by a factor of ten, then the device is permanently damaged by ESD.

3.4 U4

TPD3S716-Q1 (U4) is fully pinned out for easy access to device level tests. V_{BUS_SYS} and V_{BUS_CON} are pinned out using a 3-pin terminal block (J5) for high current tests. Pin J5.1 is V_{BUS_SYS}, J5.2 is GND, and J5.3 is V_{BUS_CON}. Kelvin connections (TP7 and TP8) are provided for accurate voltage measurements of V_{BUS_SYS} and V_{BUS_CON} during load tests.

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4 Board Layout

This section provides the TPD3S716-Q1EVM board layout. TPD3S716-Q1EVM is a 4-layer board of FR-4 at 0.062” thickness.

Different resistor values are provided to connect to I_{adj} (pin 16), to ground by setting a shunt on one of the jumpers J9 – J11. I_{adj} can also be connected directly to +5 V or ground using J6. **Only one shunt must be connected at a time.**

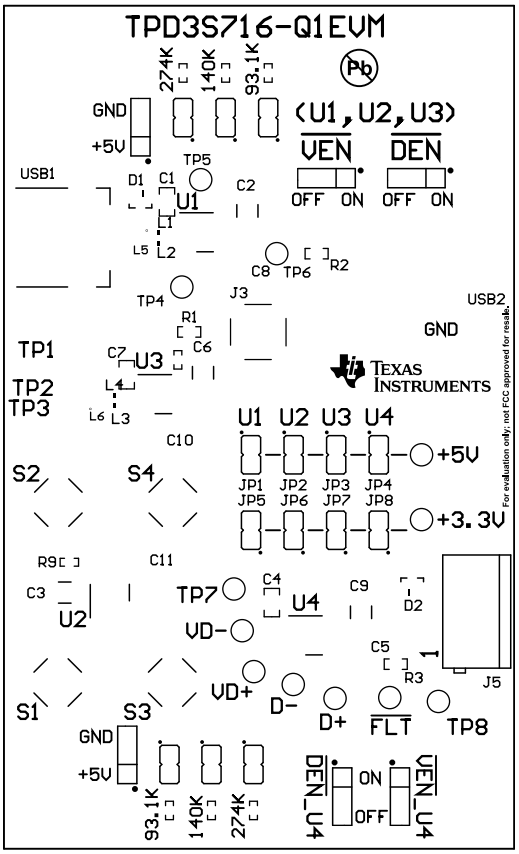


Figure 3. TPD3S716-Q1EVM Top Components Silkscreen

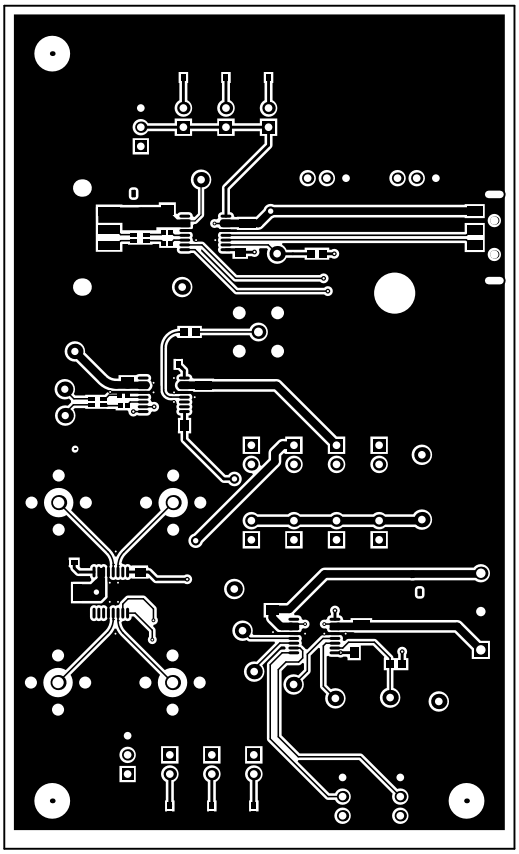


Figure 4. TPD3S716-Q1EVM Top Layer

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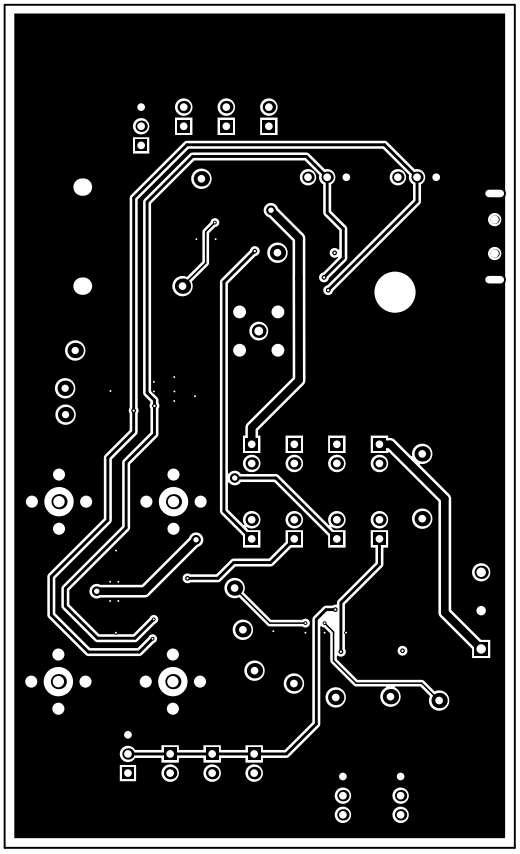
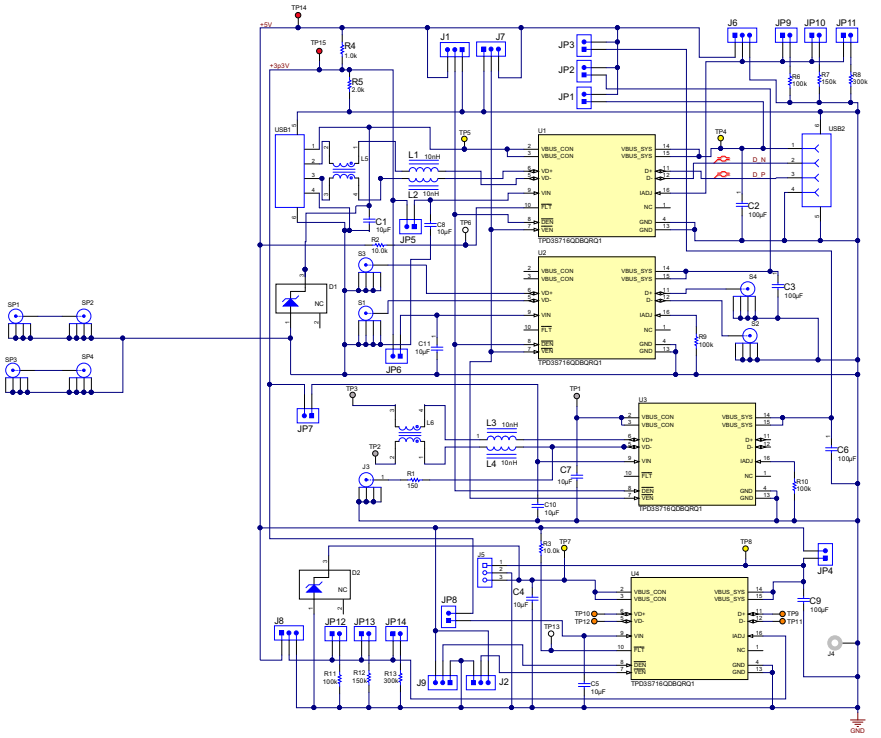


Figure 5. TPD3S716-Q1EVM Bottom Layer

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5 Schematics



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Figure 6. TPD3S716-Q1EVM Schematic

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6 Bill Of Materials

Table 6. Bill of Materials

Quantity	Designator	Description	Part Number	Manufacturer
1	!PCB	Printed Circuit Board		Any
1	J3	Connector, SMB,Vertical RCP 0-4GHz, 50 ohm, TH	131-3701-261	Emerson Network Power
1	J4	Standard Banana Jack, Uninsulated, 5.5mm	575-4	Keystone
1	J5	Terminal Block, 5.08 mm, 3x1, Brass, TH	ED120/3DS	On-Shore Technology
1	R1	RES, 150 ohm, 1%, 0.1W, 0603	CRCW0603150RFKEA	Vishay-Dale
1	USB1	Connector, Receptacle, USB TYPE A, 4POS SMD	896-43-004-00-000000	Mill-Max
1	USB2	Connector, USB Type A, 4POS R/A, SMD	0480371000	Molex
2	D1, D2	Diode, Zener, 20 V, 225 mW, SOT-23	BZX84C20LT1G	ON Semiconductor
4	L1, L2, L3, L4	Inductor, Multilayer, Air Core, 10 nH, 0.3 A, 0.26 ohm, SMD	LQG15HS10NJ02D	MuRata
2	L5, L6	Coupled Inductor, 0.33A, 0.35Ω, SMD	DLW21HN900SQ2L	MuRata
2	R12, R13	RES, 0, 5%, 0.063 W, 0402	CRCW04020000Z0ED	Vishay-Dale
2	R2, R3	RES, 10.0k ohm, 1%, 0.1W, 0603	CRCW060310K0FKEA	Vishay-Dale
2	R4, R9	RES, 140 k, 1%, 0.063 W, 0402	CRCW0402140KFKED	Vishay-Dale
2	R5, R10	RES, 274 k, 1%, 0.063 W, 0402	CRCW0402274KFKED	Vishay-Dale
2	R6, R11	RES, 93.1 k, 1%, 0.063 W, 0402	CRCW040293K1FKED	Vishay-Dale
2	R7, R8	RES, 100 k, 5%, 0.063 W, 0402	CRCW0402100KJNED	Vishay-Dale
2	TP14, TP15	Test Point, Miniature, Red, TH	5000	Keystone
2	TP6, TP13	Test Point, Miniature, White, TH	5002	Keystone
3	C1, C4, C7	CAP, CERM, 1 µF, 100 V, +/- 10%, X7S, 0805	C2012X7S2A105K125AB	TDK
3	TP1, TP2, TP3	TEST POINT. No entry in BOM.		
4	C2, C3, C6, C9	CAP, CERM, 100 µF, 10 V, +/- 20%, X5R, 1210	C1210C107M8PACTU	Wurth Elektronik
4	C5, C8, C10, C11	CAP, CERM, 10 µF, 6.3 V, +/- 20%, X7R, 0805	C2012X7R0J106M125AB	TDK
4	H1, H2, H3, H4	Bumpon, Hemisphere, 0.44 X 0.20, Clear	SJ-5303 (CLEAR)	3M
4	S1, S2, S3, S4	SMA Straight PCB Socket Die Cast, 50 Ohm, TH	5-1814832-1	TE Connectivity
4	TP4, TP5, TP7, TP8	Test Point, Miniature, Yellow, TH	5004	Keystone
4	TP9, TP10, TP11, TP12	Test Point, Miniature, Orange, TH	5003	Keystone
4	U1, U2, U3, U4	AUTOMOTIVE USB 2.0 Interface Protection with Short-to-Battery, Short-to-Ground Protection, and Adjustable Current Limit, DBQ0016A	TPD3S716QDBQRQ1	Texas Instruments
6	J1, J2, J6, J7, J8, J9	Header, 100mil, 3x1, Tin, TH	PEC03SAAN	Sullins Connector Solutions
14	JP1, JP2, JP3, JP4, JP5, JP6, JP7, JP8, JP9, JP10, JP11, JP12, JP13, JP14	Header, 100mil, 2x1, Gold, TH	PBC02SAAN	Sullins Connector Solutions
14	SH-J1, SH-J2, SH-JP1, SH-JP2, SH-JP3, SH-JP4, SH-JP5, SH-JP6, SH-JP7, SH-JP8, SH-JP9, SH-JP10, SH-JP11, SH-JP12	Shunt, 100mil, Gold plated, Black	969102-0000-DA	3M

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Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (April 2017) to A Revision	Page
• Updated Board Layout	7
• Updated Schematic	9
• Updated Bill of Materials	10

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STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   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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2. 実験局の免許を取得後ご使用いただく。
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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

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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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