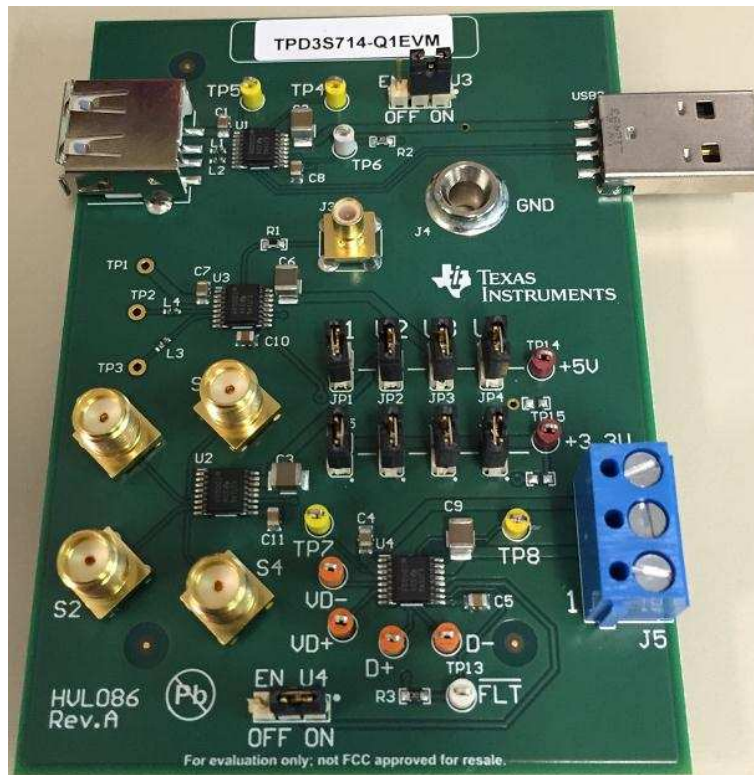


TPD3S714-Q1EVM

This user's guide describes the characteristics, operation, and use of the TPD3S714-Q1EVM evaluation module (EVM). This EVM includes four [TPD3S714-Q1](#) devices ([SLVSCG4](#)) in various configurations for testing.

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



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1 Introduction

Texas Instrument's [TPD3S714-Q1](#) evaluation module helps designers evaluate the operation and performance of the TPD3S714-Q1 device. The TPD3S714-Q1 is a single-chip solution for a V_{BUS} and data line protection on a USB connector. The nFET switch ensures safe current flow in host mode operation while protecting the internal system circuits from any over-voltage conditions at the V_{BUS_CON} , VD+, and VD- pins. On these pins, this device can handle over-voltage protection up to 18 V. The V_{BUS_CON} pin also handles short to ground protection. The TPD3S714-Q1 is characterized for operation over an ambient air temperature range of -40°C to 125°C.

The TPD3S714-Q1EVM contains four TPD3S714-Q1s labeled U1 through U4. U1 is configured with two USB2.0 Type A connectors (USB1 and USB2) for capturing system level tests. U2 is configured with four SMA (S1 – S4) connectors to allow 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 3.3](#). 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. EVM Configuration

Reference Designator	TI Part Number	Configuration
U1	TPD3S714-Q1	USB 2.0 System Level
U2	TPD3S714-Q1	S-Parameters
U3	TPD3S714-Q1	IEC61000-4-2 ESD Tests
U4	TPD3S714-Q1	Pinned out device

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 should 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]	I _{peak} ±15% [A]	Rise Time ±25% [nS]	Current at 30ns ±30% [A]	Current at 60ns ±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

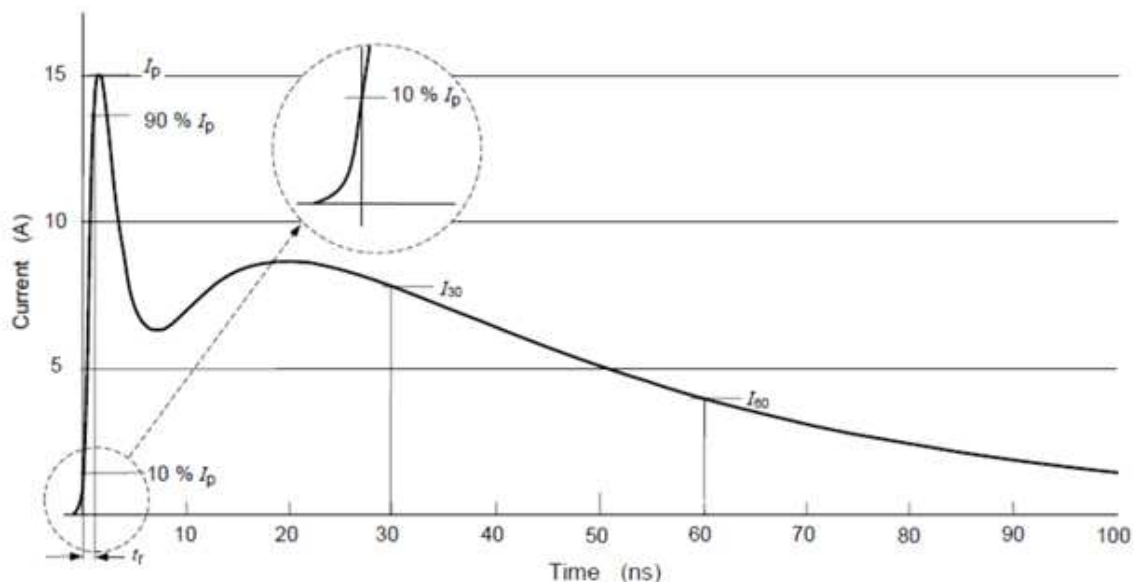


Figure 1. Ideal Contact Discharge Waveform of the Output Current of the ESD Simulator at 4 kV

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 should 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. /EN Jumper Configurations

Jumper	Off	On
EN_U1-U3	disable U1 – U3	enable U1 – U3
EN_U4	disable U4	enable U4

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

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

Power should be supplied to +5V, +3.3V, and GND connectors. Power can be distributed to each TPD3S714-Q1 by setting the shunts in place for each DUT (U1 – U4) according to [Table 5](#). When testing DUT U1 shunt both jumpers (JP1 and JP2) but V_{BUS} and /FLT can be supplied by either the test point labeled “+5V” or the USB male connector (USB2). Always supply 3.3V to the test point labeled “+3.3V.” All other DUTs require a power supply to be attached to the test points labeled “+3.3V” and “+5V” with the appropriate shunts set per [Table 5](#). All shunts in [Table 5](#) can be set at the same time or only for the device under test.

3.1 U1

A single TPD3S714-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 should use USB1 as the sink and USB2 as the source. +5V can be supplied to V_{BUS} using either the male USB connector (USB2) or by attaching 5V to the test point labeled “+5V.” If supplying 5V by connector (USB2) then do not attach a power supply to the test point labeled “+5V” and do shunt JP1 to supply the pull-up resistor for /FLT. Kelvin connections (TP4 and TP5) are provided for accurate voltage measurements of V_{BUS_SYS} and V_{BUS_CON} under load tests.

3.2 U2

TPD3S714-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

3.3 U3

One TPD3S714-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.

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 1GHz 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 should be set to 20 V.
 - Following [Section 3.3.2](#), strike contact ESD to TP2.
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 should be set to 20 V.
 - Following [Section 3.3.2](#), strike contact ESD to TP2.

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

The voltage levels of the ESD applied to TP2. should 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 (J4). 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.

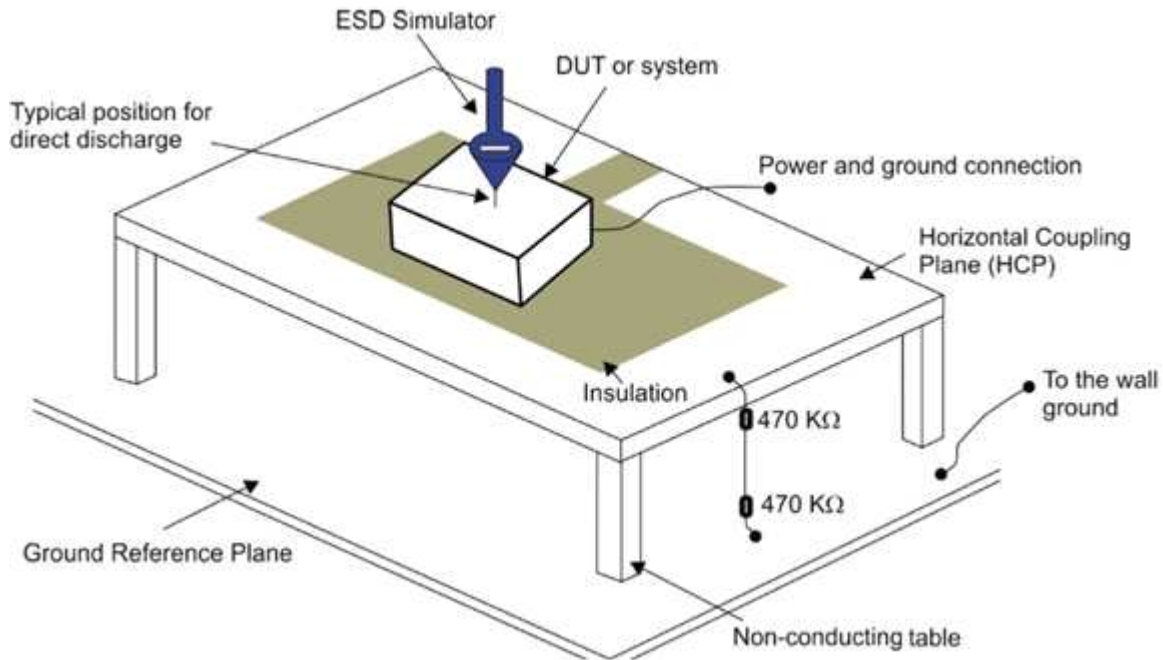


Figure 2. System Level ESD Test Setup

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 $\pm 0.1V$, or leakage current increases by a factor of ten, then the device is permanently damaged by ESD.

3.4 U4

TPD3S714-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} under load tests.

4 Board Layout

This section provides the TPD3S714-Q1EVM board layout. TPD3S714-Q1EVM is a 4-layer board of FR-4 at 0.062" thickness. Layers 2 and 3 are power planes and not shown here.

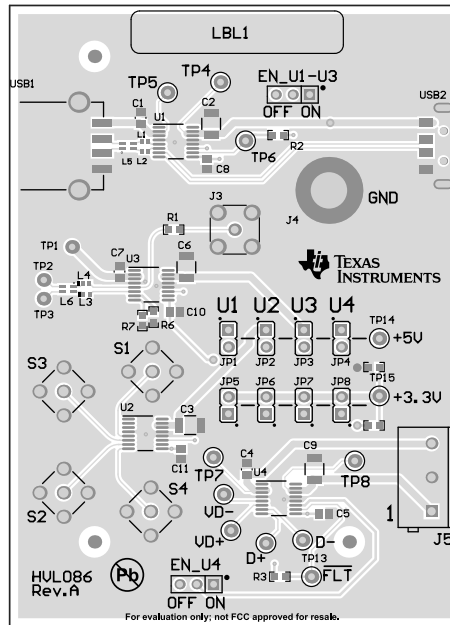


Figure 3. TPD3S714-Q1EVM Top Components and Silkscreen

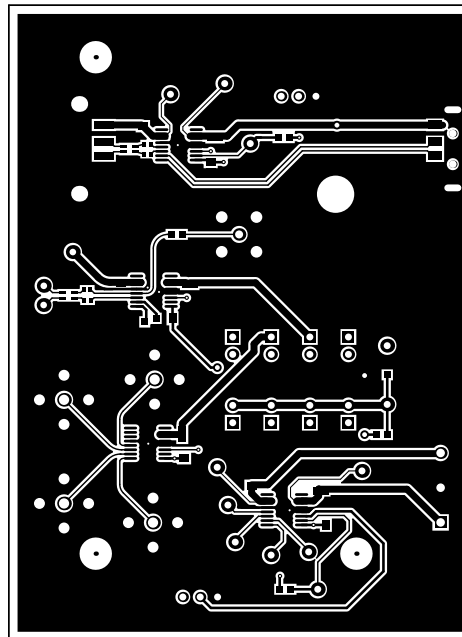


Figure 4. TPD3S714-Q1EVM Top Layer

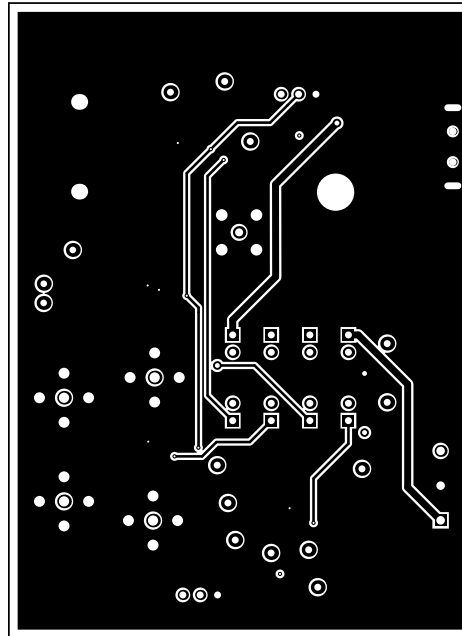
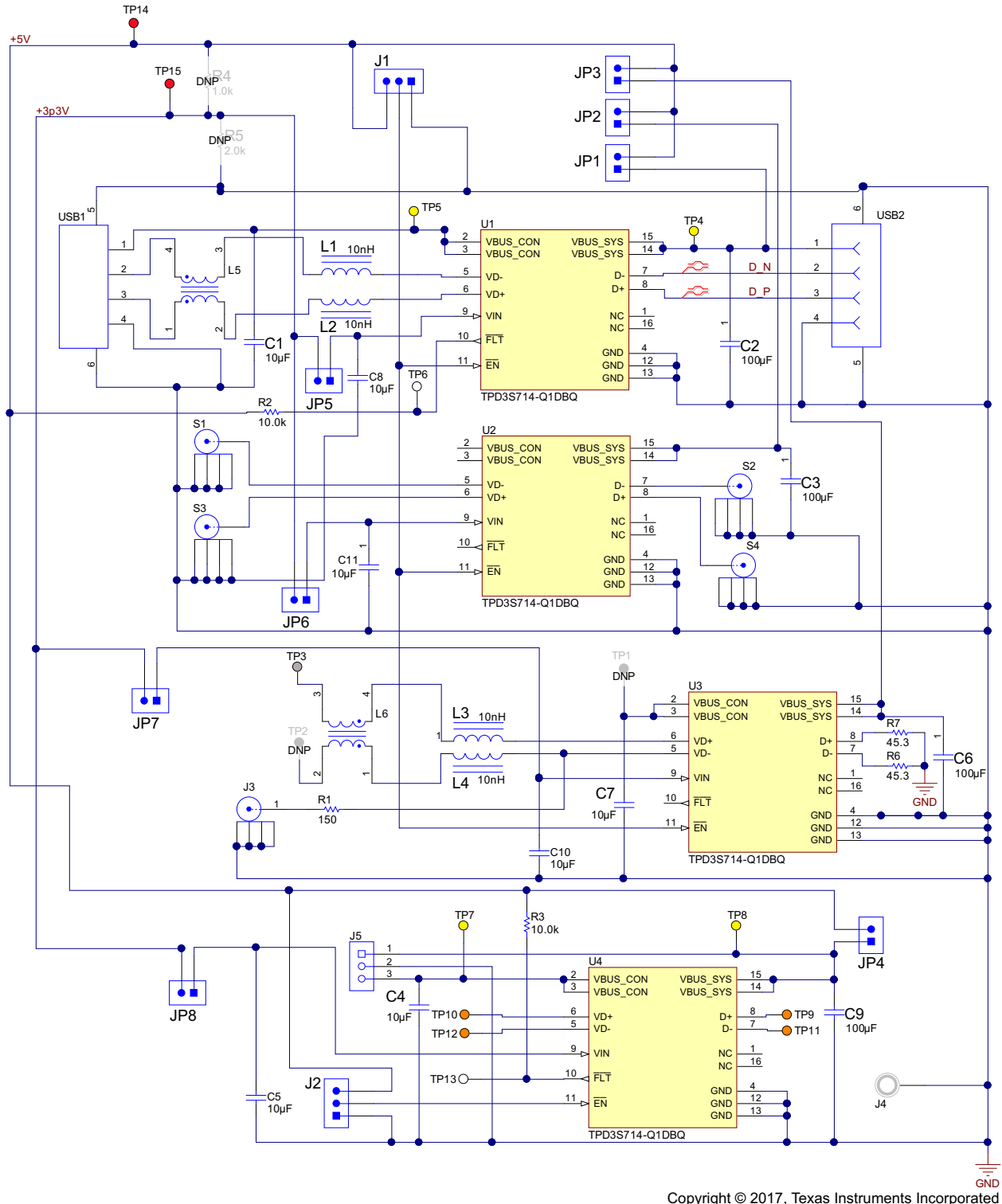


Figure 5. TPD3S714-Q1EVM Bottom Layer

5 Schematics and Bill Of Materials

5.1 Schematics

Figure 6 illustrates the TPD3S714-Q1EVM schematic.



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Figure 6. TPD3S714-Q1EVM Schematic

5.2 TPD3S714-Q1EVM

Table 6 illustrates the TPD3S714-Q1EVM bill of materials.

Table 6. Bill of Materials

Count	Designator	Description	Part Number	Manufacturer
3	C1, C4, C7	CAP, CERM, 1 μ F, 100 V, +/- 10%, X7S, 0805	C2012X7S2A105K125AB	TDK
4	C5, C8, C10, C11	CAP, CERM, 10 μ F, 25 V, +/- 10%, X5R, 0805	CL21A106KAFN3NE	Keystone
4	C2, C3, C6, C9	CAP, CERM, 100 μ F, 6.3 V, +/- 20%, X5R, 1206	GRM31CR60J107ME39L	Samsung
4	H1, H2, H3, H4	Bumpon, Hemisphere, 0.44 X 0.20, Clear	SJ-5303 (CLEAR)	3M
2	J1, J2	Header, Male 3-pin, 100mil spacing	PEC03SAAN	Sullins
1	J3	Connector, SMB, Vertical RCP 0-4GHz, 50 ohm, TH	131-3701-261	Emerson Network
1	J4	Standard Banana Jack, Uninsulated, 5.5mm	575-4	Keystone
1	J5	Terminal Block 5.08mm Vert 3pos, TH	ED120/3DS	On-Shore Technology
8	JP1, JP2, JP3, JP4, JP5, JP6, JP7, JP8	Header, Male 2-pin, 100mil spacing	PBC02SAAN	Sullins
4	L1, L2, L3, L4	Inductor, Multilayer, Air Core, 10 nH, 0.3 A, 0.26 ohm, SMD MuRata	Murata	LQG15HS10NJ02D
2	L5, L6	2 Line Common Mode Choke Surface Mount 90 ohm @ 100MHz 33mA DCR 350m ohm	Murata	DLW21HN900SQ2L
1	R1	RES, 150 ohm, 1%, 0.1W, 0603	CRCW0603150RFKEA	Vishay-Dale
2	R2, R3	RES, 10.0k ohm, 1%, 0.1W, 0603	CRCW060310K0FKEA	Vishay-Dale
2	R6, R7	RES, 45.3 ohm, 0.1W, 0603	RC0603FR-0745R3L	Yageo America
4	S1, S2, S3, S4	SMA Straight PCB Socket Die Cast, TH	5-1814832-1	TE Connectivity
10	SH-J1, SH-J2, SH-JP1, SH-JP2, SH-JP3, SH-JP4, SH-JP5, SH-JP6, SH-JP7, SH-JP8	Shunt, 2mm, Gold plated, Black	2SN-BK-G	Samtec
4	TP4, TP5, TP7, TP8	Test Point, Miniature, Yellow, TH	5004	Keystone
2	TP6, TP13	Test Point, Miniature, White, TH	5002	Keystone
4	TP9, TP10, TP11, TP12	Test Point, Miniature, Orange, TH	5003	Keystone
2	TP14, TP15	Test Point, Miniature, Red, TH	5000	Keystone
1	USB1	Receptacle, USB TYPE A, 4POS SMD	896-43-004-00-000000	Mill-Max
1	USB2	Connector, USB Type A, 4POS R/A, SMD	48037-1000	Molex
4	U1, U2, U3, U4	AUTOMOTIVE USB 2.0 Interface Protection	TPD3S714QDBQRQ1	Texas Instruments

Revision History

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

Changes from A Revision (December 2015) to B Revision	Page
• Changed <i>TPD3S714-Q1EVM Top Components and Silkscreen</i> to include 2-line common mode choke (CMC) (L5 and L6).	7
• Changed <i>TPD3S714-Q1EVM Schematic</i> to include 2-line CMC (L5 and L6).	9
• Changed bill of materials: added CMC on R6 and R7designator row, changed PD3S714-Q1-Q1DBQ to TPD3S714QDBQRQ1 on U1, U2, U3, U4 row.	10

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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.

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3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
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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:*

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4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

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