This user's guide describes the characteristics, operation, and use of the TPD1E04U04DPL EVM evaluation module (EVM). This EVM includes six TPD1E04U04DPLs in various configurations for testing.

Five TPD1E04U04DPLs are configured for IEC 61000-4-2 compliance testing and one is configured for 2-port s-parameter analysis. This user's guide includes setup instructions, schematic diagrams, a bill of materials, and printed-circuit board layout drawings for the evaluation module.

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1 Introduction

Texas Instrument's TPD1E04U04DPL evaluation module helps designers evaluate the operation and performance of the TPD1E04U04DPL device. The TPD1E04U04DPL is a unidirectional TVS ESD protection diode for HDMI 2.0 and USB 3.0 high speed data line protection. The TPD1E04U04DPL is rated to dissipate ESD strikes at the maximum level specified in the IEC 61000-4-2 international standard (Level 4).

The EVM contains six TPD1E04U04DPLs. Five TPD1E04U04DPLs (D1 – D5) are configured with test points for striking ESD to the protection pins. One TPD1E04U04DPL (D6) is configured with 2 SMA (J1 and J2) connectors for 2-port analysis with a vector network analyzer. The TPD1E04U04DPL (D6) can also be used for capturing clamping waveforms 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 3.3.1.

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 IEC 61000-4-2 compliance ESD waveforms shown in Figure 1 with adjustable ranges shown in Table 1 and Table 2.

IEC 61000-4-2 has 4 classes of protection levels. Classes 1 – 4 are shown in Table 1. Stress tests should be incrementally tested to level 4 as shown in Table 2 until the point of failure. If the DUT does not fail at 8-kV, testing can continue in 2-kV increments until failure.

Table 1. IEC 61000-4-2 Test Levels

<table>
<thead>
<tr>
<th>Class</th>
<th>Test Voltage [± kV]</th>
<th>Class</th>
<th>Test Voltage [± kV]</th>
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</thead>
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<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
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<td>4</td>
<td>2</td>
<td>4</td>
</tr>
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<td>3</td>
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</tr>
<tr>
<td>4</td>
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Table 2. Waveform Parameters in Contact Discharge Mode

<table>
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<tr>
<td>2</td>
<td>4</td>
<td>15</td>
<td>0.8</td>
<td>8</td>
<td>4</td>
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<td>0.8</td>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>
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 and ESD clamping waveforms are outlined as well.

3.1 IEC 61000-4-2 ESD Rating Tests

TPD1E04U04DPL (D1 – D5) can be used for destructive electrostatic discharge (ESD) pass or fail ESD strikes. Specifically, they can be used for both IEC 61000-4-2 air and contact discharge tests. The procedure in Section 3.1.1 ensures proper testing setup and method for both discharge tests. Each IO has a Test Pad (TP1 – TP5) directly connected to it for striking ESD.

3.1.1 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 J3. Discharge the ESD simulator on any of the test points TP1 – TP5. 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 1. Ideal Contact Discharge Waveform of the Output Current of the ESD Simulator at 4-kV
3.1.2 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 leakage current increases by a factor of ten, then the device is permanently damaged by ESD.

3.2 Scattering Parameters

A TPD1E04U04DPL (D6) is configured with 2 SMA (J1 and J2) connectors to allow 2-port analysis with a vector network analyzer. Connect Port 1 to J1 and Port 2 to J2. This configuration allows for the following terminology in 2-port analysis:

- $S_{11}$: Return loss
- $S_{21}$: Insertion loss

3.3 ±8-kV ESD Clamping Waveforms

A TPD1E04U04DPL (D6) has two SMA connectors (J1 and J2) which can be used 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. The following procedures outlines a proper method.
3.3.1 Oscilloscope Setup

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 Measurement Equipment:**

- One 2-GHz bandwidth (minimum of 1 GHz) oscilloscope.
- Two 10X 50-Ω attenuators
- One 50-Ω shielded SMA cable.

**Procedure**

In order to protect the oscilloscope, attenuation of the measured signal is required. Here is a procedure for testing D3:

1. Ground the EVM using the banana connector J3.
2. Attach two 10X attenuators in series to the oscilloscope channel being used.
3. Attach the 50-Ω shielded SMA cable between J2 and the attenuators.
4. Set the scope attenuation factor to 100X.
5. Set the oscilloscope to trigger on a positive edge for (+) ESD and a negative edge for (–) ESD strikes. The trigger voltage magnitude should be set to 20 V.
6. Following Section 3.1.1, strike contact ESD to J1.Pin1.

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 J1.Pin1 should not exceed ±8 kV while capturing clamping waveforms.
4  Board Layout

This section provides the TPD1E04U04DPLEVM board layout. TPD1E04U04DPLEVM is a 4-layer board of FR408HR at 0.062 inch thickness. Layers 2, 3, and 4 are ground planes and not shown here.

Figure 3. TPD1E04U04DPLEVM Top Layer and Silkscreen

5  Schematic

Figure 4. TPD1E04U04DPLEVM Schematic
### Table 3. Bill of Materials

<table>
<thead>
<tr>
<th>Count</th>
<th>RefDes</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>MFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>D1, D2, D3, D4, D5, D6</td>
<td>1-Channel ESD Protection Device for Super-Speed (up to 6 Gbps) Interface, DPL0002A</td>
<td>DPL0002A</td>
<td>TPD1E04J04DPL</td>
<td>Texas Instruments</td>
</tr>
<tr>
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<td>Johnson</td>
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<td>J3</td>
<td>Standard Banana Jack, Insulated, Black</td>
<td>6092</td>
<td>6092</td>
<td>Keystone</td>
</tr>
</tbody>
</table>
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**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**

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- 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

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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 maximum 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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http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_01.page

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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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東京都新宿区西新宿6丁目24番1号
西新宿三井ビル

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No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use. Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have not been so designated is solely at the Buyer’s risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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