

## 1.Description

TPD 4E1U06 Is an electrostatic discharge (ESD) protection diode based on a four-channel one-way transient voltage suppressor (TVS), with ultra-low capacitance. The ESD shock dissipation value of this device is higher than the highest level stipulated by the IEC 61000-4 -2 international standard.

## 3.Features

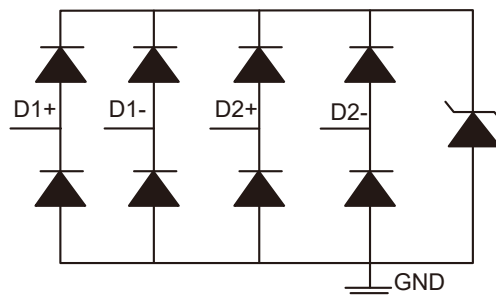
- IEC 61000-4-2 4 ESD protection
  - $\pm 15\text{kV}$ , with contact discharge
  - $\pm 15\text{kV}$ , air-gap discharge
- IEC61000-4-4 Transient discharge (EFT) protection
  - $80\text{A}$  ( $5/50\text{ns}$ )
- IEC61000-4-5 Surge protection
  - $3\text{A}$  ( $8/20\mu\text{s}$ )

## 2.Application

- USB 2.0
- Ethernet
- Differential signaling (LVDS)
- HD Multimedia interface (HDMI) control line Mobile
- industry processor interface (MIPI) bus Low Pressure

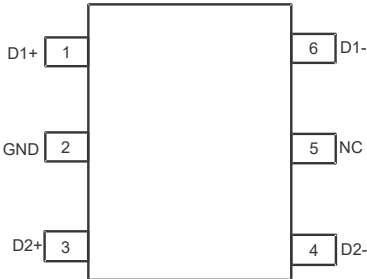
- IO capacitance:  $0.8\text{ pF}$  (typical value)
- DC breakdown voltage:  $6.5\text{V}$  (minimum)
- Ultra-low leakage current:  $10\text{ nA}$  (max.)
- Low ESD clamp voltage
- easy-to-wire DCK and DBV packages
- Industrial temperature range:  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  Small

## 4.Pinning information

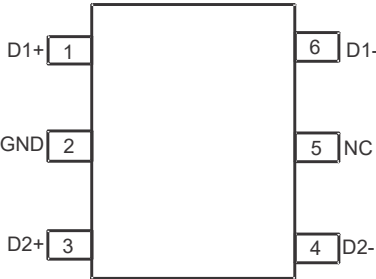




5.Pin Configuration and Functions



DCK Package 6-Pin  
SC70-6 Top View



DBV Package 6-Pin  
SOT-23 Top View

| PIN  |    | I/O | DESCRIPTION                                                                       |
|------|----|-----|-----------------------------------------------------------------------------------|
| NAME | NO |     |                                                                                   |
| D1+  | 1  | I/O | ESD protected channel. Connect to data line as close to the connector as possible |
| D1-  | 6  | I/O |                                                                                   |
| D2-  | 4  | I/O |                                                                                   |
| D2+  | 3  | I/O |                                                                                   |
| GND  | 2  | GND | Ground. Connect to ground                                                         |
| NC   | 5  | I/O | No connect. Can be left floating, grounded, or connected to V <sub>CC</sub>       |



## 6. Absolute Maximum Ratings

| Parameter                                                        | Symbol    | MIN | MAX | Units |
|------------------------------------------------------------------|-----------|-----|-----|-------|
| IEC 61000-4-4 EFT protection (5/50 ns)                           |           |     | 80  | A     |
| IEC 61000-4-5 surge protection (8/20 $\mu$ s) peak pulse current | $I_{PP}$  |     | 3   | A     |
| IEC 61000-4-5 surge protection (8/20 $\mu$ s) peak pulse power   | $P_{PP}$  |     | 45  | W     |
| Junction temperature                                             |           | -40 | 125 | °C    |
| Storage temperature                                              | $T_{STG}$ | -65 | 115 | °C    |

## 7. ESD Ratings

|                                        |                                                                                         | Value | Units |
|----------------------------------------|-----------------------------------------------------------------------------------------|-------|-------|
| $V_{(ESD)}$<br>Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>             | ±4000 | V     |
|                                        | Charged device model (CDM), per JEDEC specification JESD22-C101 all pins <sup>(2)</sup> | ±1500 | V     |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

## 8. ESD Ratings - IEC Specification

|                                     |                           | Value  | Units |
|-------------------------------------|---------------------------|--------|-------|
| $V_{(ESD)}$ Electrostatic discharge | IEC 61000-4-2 contact ESD | ±15000 | V     |
|                                     | IEC 61000-4-2 air-gap ESD | ±15000 | V     |

## 9. Recommended Operating Conditions

|          |                                | MIN | MAX | Units |
|----------|--------------------------------|-----|-----|-------|
| $V_{IO}$ | Input pin voltage              | 0   | 5.5 | V     |
| $T_A$    | Operating free-air temperature | -40 | 125 | °C    |

over operating free-air temperature range (unless otherwise noted)



## 10. Thermal Information

| THERMAL METRIC <sup>(1)</sup>                | Symbol               | DBV (SOT-23) | DCK (SC-70) | Units |
|----------------------------------------------|----------------------|--------------|-------------|-------|
|                                              |                      | 6 PINS       | 6 PINS      |       |
| Junction-to-ambient thermal resistance       | $R_{\theta JA}$      | 224.3        | 274.3       | °C/W  |
| Junction-to-case (top) thermal resistance    | $R_{\theta JC(top)}$ | 166.1        | 113.8       | °C/W  |
| Junction-to-board thermal resistance         | $R_{\theta JB}$      | 68.4         | 76.7        | °C/W  |
| Junction-to-top characterization parameter   | $\Psi_{JT}$          | 57.3         | 3.6         | °C/W  |
| Junction-to-board characterization parameter | $\Psi_{JB}$          | 67.9         | 75.9        | °C/W  |



## 11. Electrical Characteristic ( $T_A=25^\circ\text{C}$ unless otherwise noted)

| Parameter                              | Symbol                | Conditions                                                                                               | Min         | Typ   | Max   | Units    |
|----------------------------------------|-----------------------|----------------------------------------------------------------------------------------------------------|-------------|-------|-------|----------|
| Reverse stand-off voltage              | $V_{RWM}$             | $I_{IO}=10\mu\text{A}$                                                                                   |             |       | 5.5   | V        |
| Clamp voltage with ESD strike          | $V_{CLAMP}$           | $I_{PP}=1\text{A}$ , $t_p=8/20\mu\text{s}$ , from I/O to GND <sup>(1)</sup>                              |             | 11    |       | V        |
|                                        |                       | $I_{PP}=3\text{A}$ , $t_p=8/20\mu\text{s}$ , from I/O to GND <sup>(1)</sup>                              |             | 15    |       | V        |
| Dynamic resistance                     | $R_{DYN}$             | Pin x to GND pin <sup>(2)</sup>                                                                          |             | 1     |       | $\Omega$ |
|                                        |                       | GND to pin x                                                                                             |             | 0.6   |       | $\Omega$ |
| Line capacitance                       | $C_L$                 | $f=1\text{MHz}$ , $V_{BIAS}=2.5\text{V}$ , $25^\circ\text{C}$                                            |             | 0.8   | 1     | pF       |
| Channel to channel input capacitance   | $C_{CROSS}$           | Pin2=0V, $f=1\text{MHz}$ , $V_{BIAS}=2.5\text{V}$<br>between channel pins                                | DCK package | 0.006 | 0.015 | pF       |
|                                        |                       |                                                                                                          | DBV package | 0.01  | 0.025 | pF       |
| Variation of channel input capacitance | $\Delta_{CIO-TO-GND}$ | Pin2=0V, $f=1\text{MHz}$ , $V_{BIAS}=2.5\text{V}$ , channel_x<br>pin to ground – channel_y pin to ground |             | 0.025 | 0.07  | pF       |
| Break-down voltage, IO to GND          | $V_{BR}$              | $I_{IO}=1\text{mA}$                                                                                      | 6.5         |       | 8.5   | V        |
| Leakage current                        | $I_{LEAK}$            | $V_{IO}=2.5\text{V}$                                                                                     |             | 1     | 10    | nA       |

(1) Non-repetitive current pulse 8/20  $\mu\text{s}$  exponentially decaying waveform according to IEC61000-4-5.

(2) Extraction of  $R_{DYN}$  using least squares fit of TLP characteristics between  $I = 10\text{ A}$  and  $I = 20\text{ A}$ .

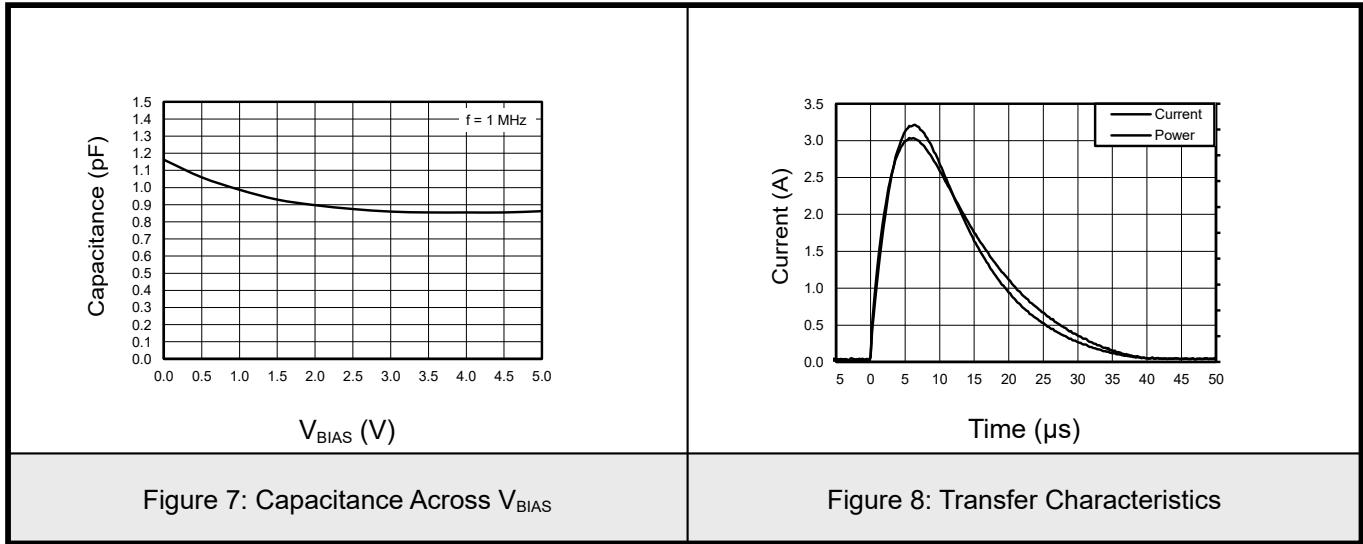


12.1Typical characteristic

|                                                        |                                            |
|--------------------------------------------------------|--------------------------------------------|
|                                                        |                                            |
| Figure 1: TLP, Data to GND                             | Figure 2: TLP, GND to Data                 |
|                                                        |                                            |
| Figure 3: IEC 61000-4-2 Clamping Voltage, 8-kV Contact | Figure 4: Capacitance                      |
|                                                        |                                            |
| Figure 5: Diode Curve                                  | Figure 6: I <sub>LEAK</sub> vs Temperature |



12.2Typical characteristic





### 13. Detailed Description

The TPD4E1U06 is a quad channel unidirectional TVS ESD protection diode with ultra low capacitance. This device can dissipate ESD strikes above the maximum level specified by the IEC 61000-4-2 international standard. Typical application areas include HDMI, USB2.0, MHL, and DisplayPort. Its 0.8-pF line capacitance makes it suitable for a wide range of applications.

#### Functional Block Diagram

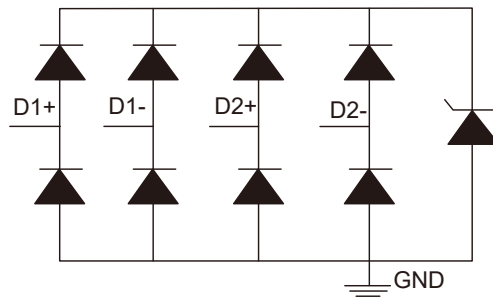


Figure 9. Circuit Schematic Diagram

#### Feature Description

##### IEC 61000-4-2 Level 4 ESD Protection

The I/O pins can withstand ESD events up to  $\pm 15$ -kV contact and air. An ESD/surge clamp diverts the current to ground.

##### IEC 61000-4-5 Surge Protection

The IO pins can withstand surge events up to 3 A and 45 W (8/20- $\mu$ s waveform). An ESD-surge clamp diverts this current to ground.

##### IEC 61000-4-4 EFT Protection

The IO pins can withstand an electrical fast transient burst of up to 80 A (5/50-ns waveform, 4 kV with 50- $\Omega$  impedance). An ESD-surge clamp diverts the current to ground.

##### IO Capacitance

The capacitance between each I/O pin to ground is 0.8 pF.

##### DC Breakdown Voltage

The DC breakdown voltage of each I/O pin is a minimum of 6.5 V. This ensures that sensitive equipment is protected from surges above the reverse standoff voltage of 5.5 V.

##### Ultra Low Leakage Current

The I/O pins feature an ultra-low leakage current of 10 nA (Maximum) with a bias of 2.5 V.

##### Low ESD Clamping Voltage

The I/O pins feature an ESD clamp that is capable of clamping the voltage to 11 V ( $I_{PP} = 1$  A).

##### Industrial Temperature Range

This device features an industrial operating range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .





## 14. Typical Application(continued)

Given the USB 2.0 application, the parameters in Table 1 are known.

**Table 1. Design Parameters**

| Parameter                          | Parameter  |
|------------------------------------|------------|
| Signal range on pins 1, 3, 4, or 6 | 0 V to 5 V |
| Operating frequency                | 240 MHz    |

### Detailed Design Procedure

Signal Range on Pins 1, 3, 4, or 6

The TPD4E1U06 has 4 identical protection channels for signal lines. The symmetry of the device provides flexibility when selecting which of the 4 I/O channels protect which signal lines. Any I/O supports a signal range of 0 to 5.5 V.

### Operating Frequency

The TPD4E1U06 has a capacitance of 0.8 pF (typical), supporting USB 2.0 data rates.

### Application Curve

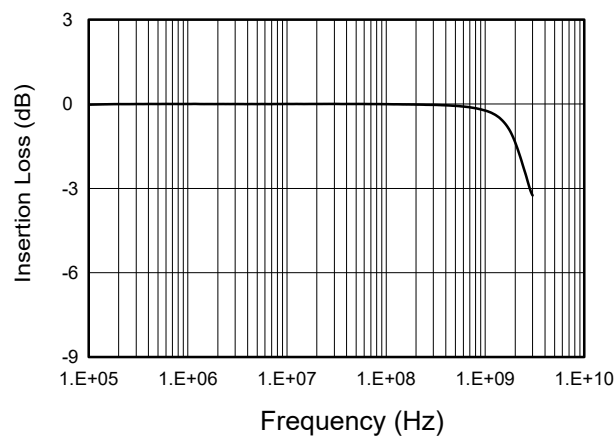
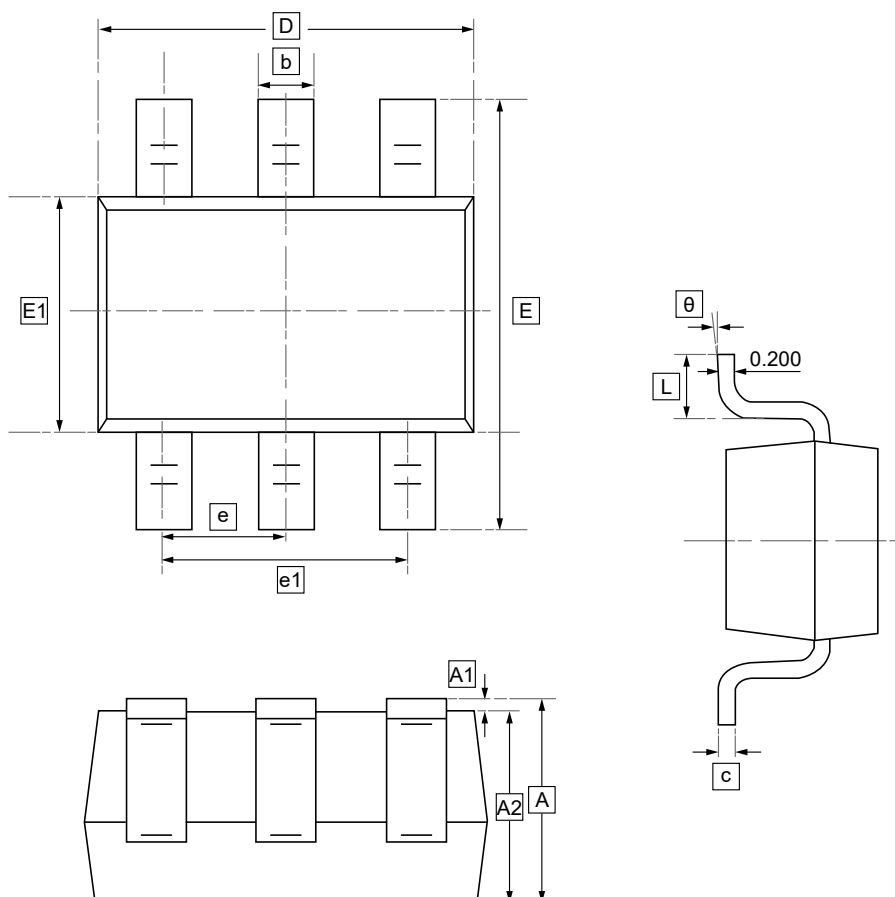


Figure 11: Insertion Loss Graph



## 15.1SOT-23-6 Package Outline Dimensions

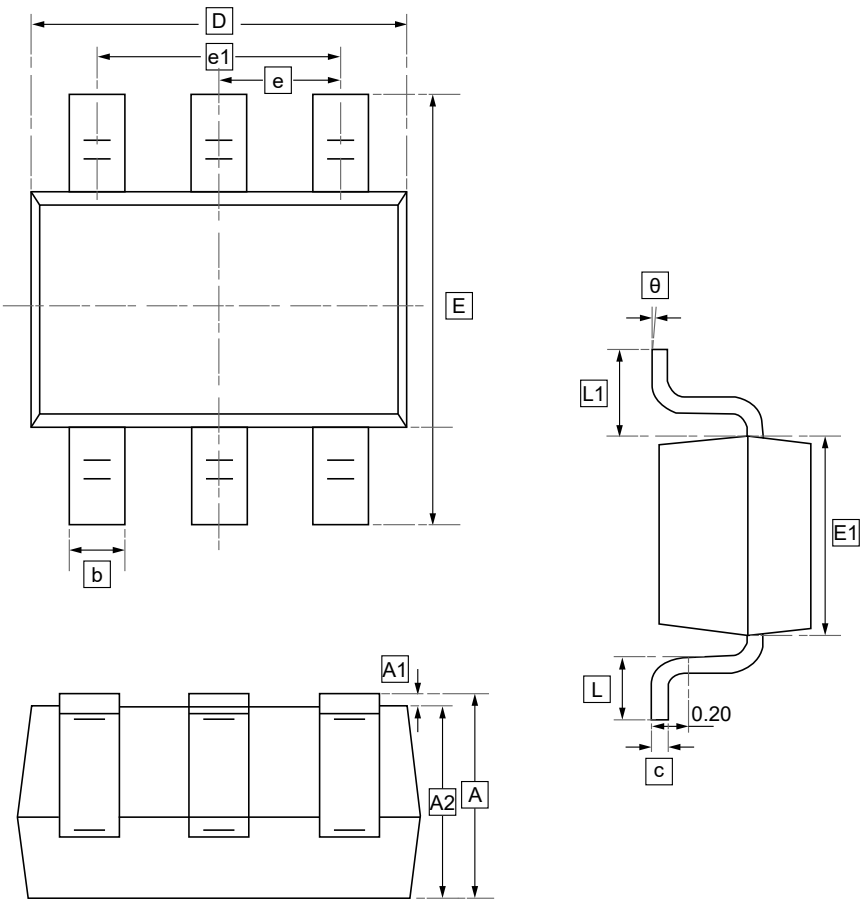


### DIMENSIONS (mm are the original dimensions)

| Symbol | A     | A1    | A2    | b     | c     | D     | E1    | E     | e     | e1    | L     | $\theta$ |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
| Min    | 1.050 | 0.000 | 1.050 | 0.300 | 0.100 | 2.820 | 1.500 | 2.650 | 0.950 | 1.800 | 0.300 | 0°       |
| Max    | 1.250 | 0.100 | 1.150 | 0.500 | 0.200 | 3.020 | 1.700 | 2.950 | BSC   | 2.000 | 0.600 | 8°       |



15.2SC70-6 Package Outline Dimensions



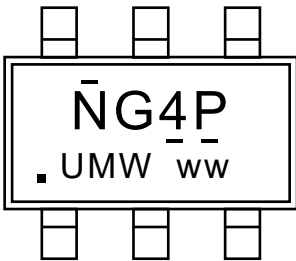
DIMENSIONS (mm are the original dimensions)

| Symbol | A    | A1   | A2   | b    | c    | D    | E    | E1   | e    | e1  | L    | L1    |
|--------|------|------|------|------|------|------|------|------|------|-----|------|-------|
| Min    | 0.90 | 0.00 | 0.90 | 0.15 | 0.08 | 2.05 | 2.15 | 1.15 | 0.65 | 1.2 | 0.26 | 0.525 |
| Max    | 1.10 | 0.10 | 1.00 | 0.35 | 0.15 | 2.25 | 2.45 | 1.35 | TYP. | 1.4 | 0.46 | REF.  |

| Symbol | $\theta$ |
|--------|----------|
| Min    | 0°       |
| Max    | 8°       |



16.Ordering information



ww: Batch Code

| Order Code        | Marking | Package | Base QTY | Delivery Mode |
|-------------------|---------|---------|----------|---------------|
| UMW TPD4E1U06DBVR | NG4P    | SOT23-6 | 3000     | Tape and reel |
| UMW TPD4E1U06DCKR | BPS     | SC70-6  | 3000     | Tape and reel |



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