ESD7004, SZESD7004

SD Protection Diode
Low Capacitance ESD Protection Diode for High Speed Data Line

The ESD7004 surge protection is designed to protect high speed data lines from ESD. Ultra-low capacitance and low ESD clamping voltage make this device an ideal solution for protecting voltage sensitive high speed data lines. The flow-through style package allows for easy PCB layout and matched trace lengths necessary to maintain consistent impedance between high speed differential lines such as USB 3.0 and HDMI.

Features
- Low Capacitance (0.4 pF Typical, I/O to GND)
- Protection for the Following IEC Standards: IEC 61000-4-2 (Level 4)
- Low ESD Clamping Voltage
- SZ Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable
- This is a Pb-Free Device

Typical Applications
- USB 3.0
- HDMI
- Display Port
- eSATA

MAXIMUM RATINGS (TJ = 25°C unless otherwise noted)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Junction Temperature Range</td>
<td>TJ</td>
<td>-55 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>Tstg</td>
<td>-55 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>Lead Solder Temperature - Maximum (10 Seconds)</td>
<td>TL</td>
<td>260</td>
<td>°C</td>
</tr>
<tr>
<td>IEC 61000-4-2 Contact (ESD)</td>
<td>ESD</td>
<td>±15</td>
<td>kV</td>
</tr>
<tr>
<td>IEC 61000-4-2 Air (ESD)</td>
<td>ESD</td>
<td>±15</td>
<td>kV</td>
</tr>
</tbody>
</table>

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

See Application Note AND8308/D for further description of survivability specs.
**ELECTRICAL CHARACTERISTICS** \( (T_A = 25^\circ C \text{ unless otherwise specified}) \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse Working Voltage</td>
<td>( V_{RWM} )</td>
<td>I/O Pin to GND</td>
<td>5.0</td>
<td>V</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Breakdown Voltage</td>
<td>( V_B )</td>
<td>( I_T = 1 ) mA, I/O Pin to GND</td>
<td>5.5</td>
<td>V</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Reverse Leakage Current</td>
<td>( I_R )</td>
<td>( V_{RWM} = 5 ) V, I/O Pin to GND</td>
<td>1.0</td>
<td>( \mu A )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clamping Voltage (Note 1)</td>
<td>( V_C )</td>
<td>( I_{PP} = 1 ) A, I/O Pin to GND (8 x 20 ( \mu ) s pulse)</td>
<td>10</td>
<td>V</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Clamping Voltage (Note 2)</td>
<td>( V_C )</td>
<td>IEC61000–4–2, ±8 KV Contact</td>
<td></td>
<td>See Figures 1 and 2</td>
<td>11.4</td>
<td>15.6</td>
</tr>
<tr>
<td>Junction Capacitance</td>
<td>( C_J )</td>
<td>( V_R = 0 ) V, ( f = 1 ) MHz between I/O Pins</td>
<td>0.2</td>
<td>0.3</td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td>Junction Capacitance</td>
<td>( C_J )</td>
<td>( V_R = 0 ) V, ( f = 1 ) MHz between I/O Pins and GND</td>
<td>0.4</td>
<td>0.5</td>
<td>pF</td>
<td></td>
</tr>
</tbody>
</table>

1. Surge current waveform per Figure 5.
2. For test procedure see Figures 3 and 4 and application note AND8307/D.
   TLP conditions: \( Z_0 = 50 \) \( \Omega \), \( I_p = 100 \) ns, \( t_r = 4 \) ns, averaging window; \( t_1 = 30 \) ns to \( t_2 = 60 \) ns.

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**Figure 1. IEC61000–4–2 +8 KV Contact ESD Clamping Voltage**

**Figure 2. IEC61000–4–2 –8 KV Contact Clamping Voltage**
IEC 61000–4–2 Spec.

<table>
<thead>
<tr>
<th>Level</th>
<th>Test Voltage (kV)</th>
<th>First Peak Current (A)</th>
<th>Current at 30 ns (A)</th>
<th>Current at 60 ns (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>7.5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>15</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>22.5</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>30</td>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>

Figure 3. IEC61000–4–2 Spec

The following is taken from Application Note AND8308/D – Interpretation of Datasheet Parameters for ESD Devices.

ESD Voltage Clamping

For sensitive circuit elements it is important to limit the voltage that an IC will be exposed to during an ESD event to as low a voltage as possible. The ESD clamping voltage is the voltage drop across the ESD protection diode during an ESD event per the IEC61000–4–2 waveform. Since the IEC61000–4–2 was written as a pass/fail spec for larger systems such as cell phones or laptop computers it is not clearly defined in the spec how to specify a clamping voltage at the device level. ON Semiconductor has developed a way to examine the entire voltage waveform across the ESD protection diode over the time domain of an ESD pulse in the form of an oscilloscope screenshot, which can be found on the datasheets for all ESD protection diodes. For more information on how ON Semiconductor creates these screenshots and how to interpret them please refer to AND8307/D.

Figure 4. Diagram of ESD Clamping Voltage Test Setup

Figure 5. 8 x 20 μs Pulse Waveform
Transmission Line Pulse (TLP) Measurement

Transmission Line Pulse (TLP) provides current versus voltage (I–V) curves in which each data point is obtained from a 100 ns long rectangular pulse from a charged transmission line. A simplified schematic of a typical TLP system is shown in Figure 8. TLP I–V curves of ESD protection devices accurately demonstrate the product’s ESD capability because the 10s of amps current levels and under 100 ns time scale match those of an ESD event. This is illustrated in Figure 9 where an 8 kV IEC 61000–4–2 current waveform is compared with TLP current pulses at 8 A and 16 A. A TLP I–V curve shows the voltage at which the device turns on as well as how well the device clamps voltage over a range of current levels. A typical TLP I–V curve for the ESD7004 is shown in Figures 6 and 7.
Figure 9. Comparison Between 8 kV IEC 61000–4–2 and 8 A and 16 A TLP Waveforms
Figure 10. USB3.0 Eye Diagram with and without ESD7004. 5.0 Gb/s, 400 mV_{pp}

Figure 11. HDMI1.4 Eye Diagram with and without ESD7004. 3.4 Gb/s, 400 mV_{pp}

Figure 12. ESATA3.0 Eye Diagram with and without ESD7004. 6 Gb/s, 400 mV_{pp}
Figure 13. USB TDR Measurement. 90 $\Omega$ Differential Impedance Target, 200 ps Rise Time

** USB spec requirement is 90 $\Omega \pm 10\%$  

** HDMI spec requirement is 100 $\Omega \pm 15\%$  

TDR max = 92.7 $\Omega$

TDR min = 97 $\Omega$
Figure 15. ESD7004 Insertion Loss
ESD7004, SZESD7004

Figure 16. USB3.0 Standard A Connector Layout Diagram

Figure 17. USB3.0 Micro B Connector Layout Diagram
Figure 18. HDMI Layout Diagram

Figure 19. eSATA Layout Diagram
ESD7004, SZESD7004

PACKAGE DIMENSIONS

UDFN10 2.5 x 1, 0.5P
CASE 517BB
ISSUE O

NOTES:
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b applies to plated TERMINAL and is measured between 0.15 and 0.30mm from TERMINAL.

RECOMMENDED SOLDERING FOOTPRINT*

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

Published Error Report: RC20069