**SP3012 Series**  
0.5pF Diode Array for USB3.0

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**Description**  
The SP3012 Series integrates 6 channels of ultra low capacitance rail-to-rail diodes and an additional zener diode to provide protection for electronic equipment that may experience destructive electrostatic discharges (ESD). These robust devices can safely absorb repetitive ESD strikes above the maximum level specified in the IEC 61000-4-2 international standard (±8kV contact discharge) without performance degradation. The extremely low loading capacitance also makes it ideal for protecting high speed signal lines such as USB3.0, HDMI, USB2.0, and eSATA.

**Features**  
- ESD, IEC 61000-4-2, ±12kV contact, ±25kV air  
- EFT, IEC 61000-4-4, 40A (tP=5/50ns)  
- Lightning, IEC 61000-4-5 2nd edition, 4A (tP=8/20μs)  
- Low capacitance of 0.5pF (TYP) per I/O  
- Low leakage current of 1.5μA (MAX) at 5V  
- Small form factor μDFN (JEDEC MO-229) package provides flow through routing to simplify PCB layout  
- AEC-Q101 Qualified  
- Halogen free, lead free and RoHS compliant

**Applications**  
- LCD/PDP TVs  
- External Storages  
- DVD/Blu-ray Players  
- Desktops  
- MP3/PMP  
- Set Top Boxes  
- Smartphones  
- Ultrabooks/Notebooks  
- Digital Cameras  
- Automotive Electronics

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**Additional Information**

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**Pinout**

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**Functional Block Diagram**
SP3012 Series
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Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>I_{PP}</td>
<td>Peak Current (t_p=8/20μs)</td>
<td>4.0</td>
<td>A</td>
</tr>
<tr>
<td>T_{OP}</td>
<td>Operating Temperature</td>
<td>-40 to 125</td>
<td>°C</td>
</tr>
<tr>
<td>T_{STOR}</td>
<td>Storage Temperature</td>
<td>-55 to 150</td>
<td>°C</td>
</tr>
</tbody>
</table>

Caution: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Electrical Characteristics (T_{OP}=25°C)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse Standoff Voltage</td>
<td>V_{RWV}</td>
<td>I_{R} ≤ 1µA</td>
<td></td>
<td>5.0</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Breakdown Voltage</td>
<td>V_{BR}</td>
<td>I_{B} = 1mA</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Reverse Leakage Current</td>
<td>I_{LEAK}</td>
<td>V_{B}=5V, Any I/O to GND</td>
<td>6.0</td>
<td></td>
<td>1.5</td>
<td>µA</td>
</tr>
<tr>
<td>Clamp Voltage&lt;sup&gt;1&lt;/sup&gt;</td>
<td>V_{C}</td>
<td>I_{C}=1A, t_{p}=8/20μs, Fwd</td>
<td>6.6</td>
<td>7.9</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I_{C}=2A, t_{p}=8/20μs, Fwd</td>
<td>7.0</td>
<td>8.4</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Dynamic Resistance</td>
<td>R_{DYN}</td>
<td>(V_{C2} - V_{C1}) / (I_{PP2} - I_{PP1})</td>
<td>0.4</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>ESD Withstand Voltage&lt;sup&gt;1&lt;/sup&gt;</td>
<td>V_{ESD}</td>
<td>IEC61000-4-2 (Contact)</td>
<td>±12</td>
<td></td>
<td></td>
<td>kV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IEC61000-4-2 (Air)</td>
<td>±25</td>
<td></td>
<td></td>
<td>kV</td>
</tr>
<tr>
<td>Diode Capacitance&lt;sup&gt;1&lt;/sup&gt;</td>
<td>C_{iO,GND}</td>
<td>Reverse Bias=0V, f=1 MHz</td>
<td>0.5</td>
<td>0.65</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>Diode Capacitance&lt;sup&gt;1&lt;/sup&gt;</td>
<td>C_{iO,iO}</td>
<td>Reverse Bias=0V, f=1 MHz</td>
<td>0.3</td>
<td>0.4</td>
<td></td>
<td>pF</td>
</tr>
</tbody>
</table>

Note: <sup>1</sup> Parameter is guaranteed by design and/or device characterization.

Capacitance vs. Bias Voltage

Insertion Loss (S21) I/O to GND

Clamping Voltage vs. IPP

Transmission Line Pulsing(TLP) Plot
SP3012 Series
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Pulse Waveform

Product Characteristics

Lead Plating
Pre-Plated Frame (µDFN)

Lead Material
Copper Alloy

Lead Coplanarity
0.0004 inches (0.102mm)

Substrate Material
Silicon

Body Material
Molding Compound

Flammability
UL Recognized compound meeting flammability rating V-0

Notes:
1. All dimensions are in millimeters.
2. Dimensions include solder plating.
3. Dimensions are exclusive of mold flash & metal burr.
4. Blo is facing up for mold and facing down for trim/form, i.e. reverse trim/form.

Soldering Parameters

Reflow Condition
Pb – Free assembly

Pre Heat
- Temperature Min (T_{min})
  150°C
- Temperature Max (T_{max})
  200°C
- Time (min to max) (t_s)
  60 – 120 secs

Average ramp up rate (Liquidus) Temp (T_L) to peak
- Temperature (T_L) (Liquidus)
  217°C
- Temperature (T_P)
  3°C/second max

Ramp-up Rate
60 – 150 seconds

Peak Temperature (T_P)
260$^{±0.5}$ °C

Time within 5°C of actual peak Temperature (t_s)
30 seconds

Ramp-down Rate
6°C/second max.

Time 25°C to peak Temperature (T_P)
8 minutes Max.

Do not exceed
260°C

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Min. Order Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP3012-06UTG</td>
<td>µDFN-14</td>
<td>3000</td>
</tr>
</tbody>
</table>

Part Numbering System

**SP** 3012 - **XX**

TVS Diode Arrays
(SPA® Diodes)

Series
Number of Channels
06 = 6 channel

Part Marking System

Product Series
V = SP3012

Assembly Site

Number of Channels

G= Green

T= Tape & Reel

U= µDFN-14
SP3012 Series
0.5pF Diode Array for USB3.0

Application Information

Signal Integrity of High-Speed Data Interfaces

Adding external ESD protection to a high-speed data port is not trivial for a variety of reasons.

1. ESD protection devices will add parasitic capacitance to each data line from line to GND and line to line causing impedance mismatches between the differential pairs. This ultimately affects the signal eye-diagram and whether or not the transceiver can distinguish a “1” from a “0”.

2. ESD devices should be placed as close as possible to the port being protected to maximize their effect (i.e. clamping capability) and minimize the effect that PCB trace inductance can have during an ESD transient. Depending on the package size and pinout this could be challenging and the bigger the package, the larger the land pattern must be, which adds more parasitic capacitance.

3. Stub traces can add another element of discontinuity adversely affecting signal integrity so ESD protection is best employed when it’s “overlaid” on the data lines or when the signals can simply pass underneath the device.

Taking all of this into account Littelfuse developed the SP3012 Series which was designed specifically for protection of high-speed data ports such as HDMI 1.3/1.4 and USB 3.0. They present less than 0.5pF from line to GND and only 0.3pF from line to line minimizing impedance mismatch between the differential pairs.

Furthermore, the SP3012 is rated up to ±12kV (contact discharge) which far exceeds the maximum requirement of the IEC 61000-4-2 standard.

SP3012-06UTG is housed in leadless µDFN packages so the data lines can pass directly underneath the device to reduce discontinuities and maintain signal integrity.

USB 3.0 Eye Diagram Data

Figure 1 shows the layout used for the SP3012-06UTG in a USB 3.0 application. The traces routed toward the top are the two legacy USB 2.0 lines (D+/D-) that run at the slower speed of 480Mbps and therefore are not as critical as the 5Gbps Super-Speed traces.
**SP3012 Series**

0.5pF Diode Array for USB3.0

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**Package Dimensions — µDFN-14 (3.5x1.35x0.5mm)**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Millimeters</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.45</td>
<td>0.05</td>
</tr>
<tr>
<td>A1</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>A2</td>
<td>0.203 Ref</td>
<td>0.008 Ref</td>
</tr>
<tr>
<td>b</td>
<td>0.15</td>
<td>0.02</td>
</tr>
<tr>
<td>D</td>
<td>3.40</td>
<td>0.134</td>
</tr>
<tr>
<td>D2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>E</td>
<td>1.25</td>
<td>0.050</td>
</tr>
<tr>
<td>E1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>e</td>
<td>0.500 BSC</td>
<td>0.020 BSC</td>
</tr>
<tr>
<td>L</td>
<td>0.35</td>
<td>0.045</td>
</tr>
</tbody>
</table>

**Notes:**
2. Controlling dimensions: Millimeter. Converted inch dimensions are not necessarily exact.

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**Soldering Pad Layout Dimensions**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Millimeters</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>3.30</td>
<td>0.1299</td>
</tr>
<tr>
<td>E</td>
<td>1.65</td>
<td>0.0571</td>
</tr>
<tr>
<td>b</td>
<td>0.30</td>
<td>0.0118</td>
</tr>
<tr>
<td>L</td>
<td>0.50</td>
<td>0.0197</td>
</tr>
<tr>
<td>e</td>
<td>0.50 typ</td>
<td>0.020 typ</td>
</tr>
<tr>
<td>s</td>
<td>0.20</td>
<td>0.0078</td>
</tr>
<tr>
<td>s1</td>
<td>0.65</td>
<td>0.0256</td>
</tr>
</tbody>
</table>

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**Embossed Carrier Tape & Reel Specification — µDFN-14**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Millimeters</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0</td>
<td>1.58 +/- 0.10</td>
<td></td>
</tr>
<tr>
<td>B0</td>
<td>3.73 +/- 0.10</td>
<td></td>
</tr>
<tr>
<td>D0</td>
<td>Ø 1.50 +/- 0.10</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>Ø 0.60 +/- 0.05</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>1.75 +/- 0.10</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>5.50 +/- 0.05</td>
<td></td>
</tr>
<tr>
<td>K0</td>
<td>0.68 +0.12/-0.10</td>
<td></td>
</tr>
<tr>
<td>P0</td>
<td>2.00 +/- 0.05</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>4.00 +/- 0.10</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>4.00 +/- 0.10</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>0.28 +0.02/-0.05</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>12.00 +/- 0.30</td>
<td></td>
</tr>
</tbody>
</table>

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