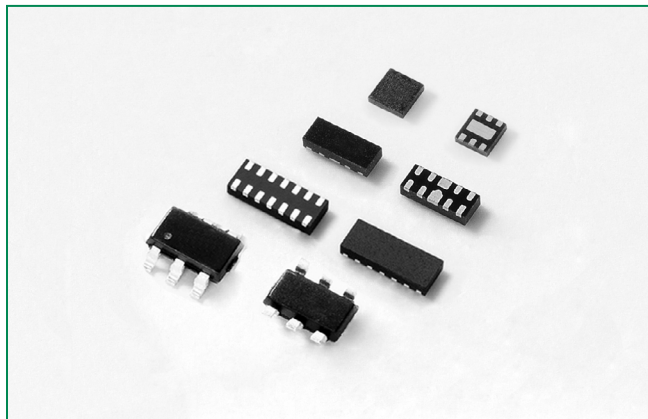
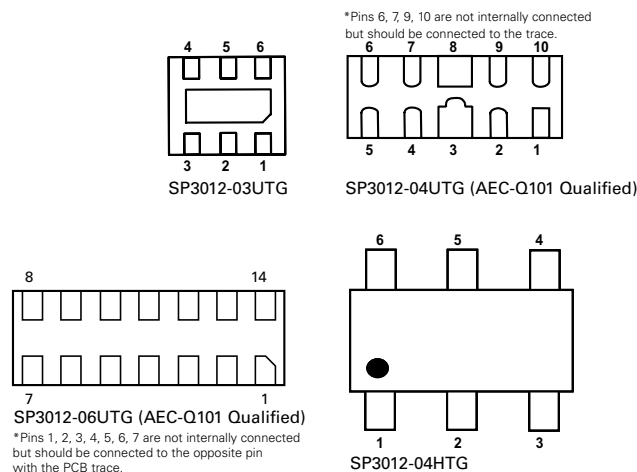


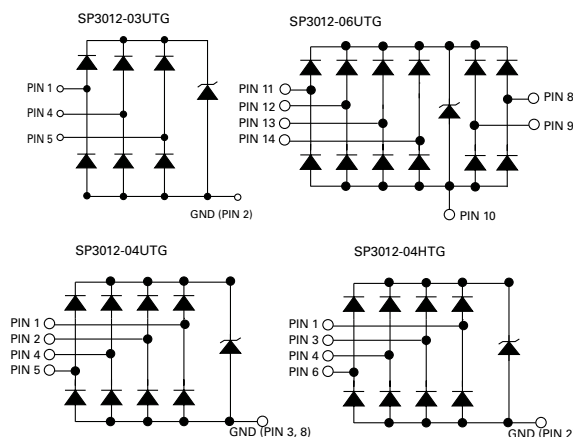
## SP3012 Series 0.5pF Diode Array for USB3.0



### Pinout



### Functional Block Diagram



### Additional Information



Datasheet



Resources



Samples

### Description

The SP3012 Series integrates either 3, 4 or 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 ( $\pm 8\text{kV}$  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.

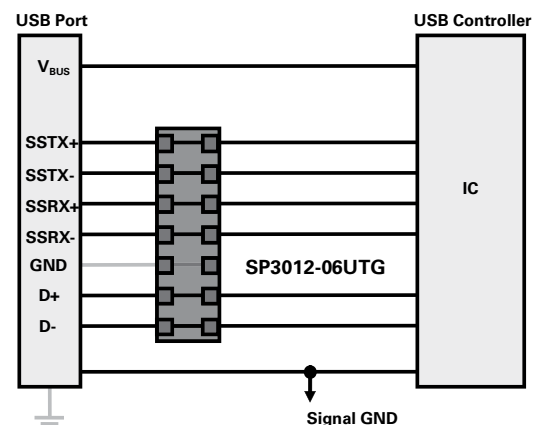
### Features

- ESD, IEC 61000-4-2,  $\pm 12\text{kV}$  contact,  $\pm 25\text{kV}$  air
- EFT, IEC 61000-4-4, 40A ( $t_p=5/50\text{ns}$ )
- Lightning, IEC 61000-4-5 2nd edition, 4A ( $t_p=8/20\mu\text{s}$ )
- Low capacitance of 0.5pF (TYP) per I/O
- Low leakage current of 1.5 $\mu\text{A}$  (MAX) at 5V
- Small form factor  $\mu\text{DFN}$  (JEDEC MO-229) and SOT23-6 (JEDEC MO-178AB) packages provide flow through routing to simplify PCB layout
- AEC-Q101 Qualified ( $\mu\text{DFN}10$  and  $\mu\text{DFN}14$ )
- RoHS compliant and lead-free

### Applications

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

### Application Example for USB3.0



Life Support Note:

**Not Intended for Use in Life Support or Life Saving Applications**

The products shown herein are not designed for use in life sustaining or life saving applications unless otherwise expressly indicated.

### Absolute Maximum Ratings

| Symbol     | Parameter                        | Value      | Units |
|------------|----------------------------------|------------|-------|
| $I_{PP}$   | Peak Current ( $t_p=8/20\mu s$ ) | 4.0        | A     |
| $T_{OP}$   | Operating Temperature            | -40 to 125 | °C    |
| $T_{STOR}$ | Storage Temperature              | -55 to 150 | °C    |

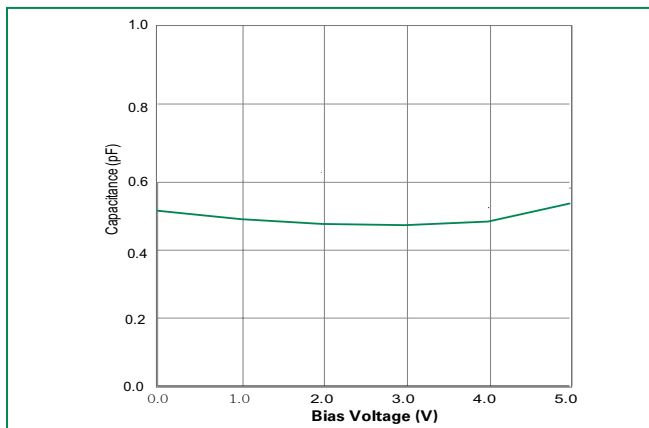
CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

### Electrical Characteristics ( $T_{OP}=25^\circ C$ )

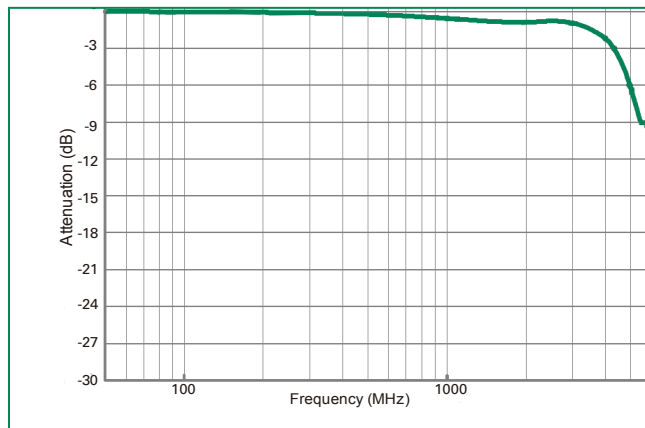
| Parameter                          | Symbol        | Test Conditions                           | Min      | Typ | Max  | Units    |
|------------------------------------|---------------|-------------------------------------------|----------|-----|------|----------|
| Reverse Standoff Voltage           | $V_{RWM}$     | $I_R \leq 1\mu A$                         |          |     | 5.0  | V        |
| Reverse Leakage Current            | $I_{LEAK}$    | $V_R=5V$ , Any I/O to GND                 |          |     | 1.5  | $\mu A$  |
| Clamp Voltage <sup>1</sup>         | $V_C$         | $I_{PP}=1A$ , $t_p=8/20\mu s$ , Fwd       |          | 6.6 | 7.9  | V        |
|                                    |               | $I_{PP}=2A$ , $t_p=8/20\mu s$ , Fwd       |          | 7.0 | 8.4  | V        |
| Dynamic Resistance                 | $R_{DYN}$     | $(V_{C2} - V_{C1}) / (I_{PP2} - I_{PP1})$ |          | 0.4 |      | $\Omega$ |
| ESD Withstand Voltage <sup>1</sup> | $V_{ESD}$     | IEC61000-4-2 (Contact)                    | $\pm 12$ |     |      | kV       |
|                                    |               | IEC61000-4-2 (Air)                        | $\pm 25$ |     |      | kV       |
| Diode Capacitance <sup>1</sup>     | $C_{I/O-GND}$ | Reverse Bias=0V, f=1 MHz                  |          | 0.5 | 0.65 | pF       |
| Diode Capacitance <sup>1</sup>     | $C_{I/O-I/O}$ | Reverse Bias=0V, f=1 MHz                  |          | 0.3 | 0.4  | pF       |

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

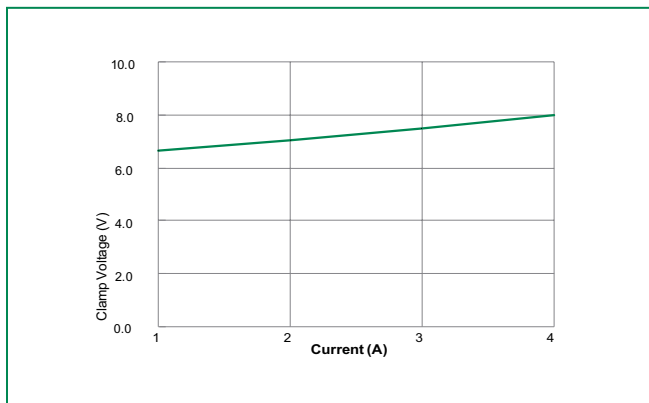
### Capacitance vs. Bias Voltage



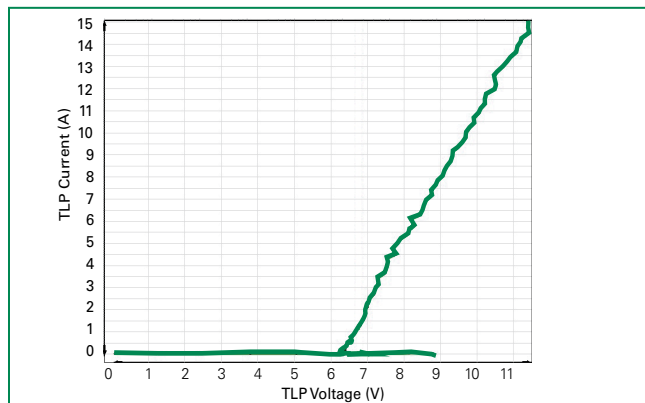
### Insertion Loss (S21) I/O to GND



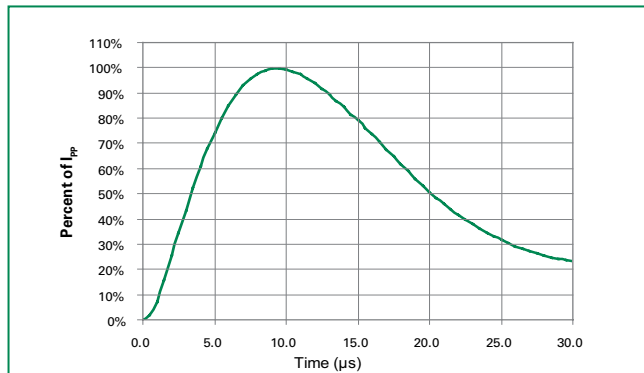
### Clamping Voltage vs. $I_{PP}$



### Transmission Line Pulsing (TLP) Plot



### Pulse Waveform



### Product Characteristics

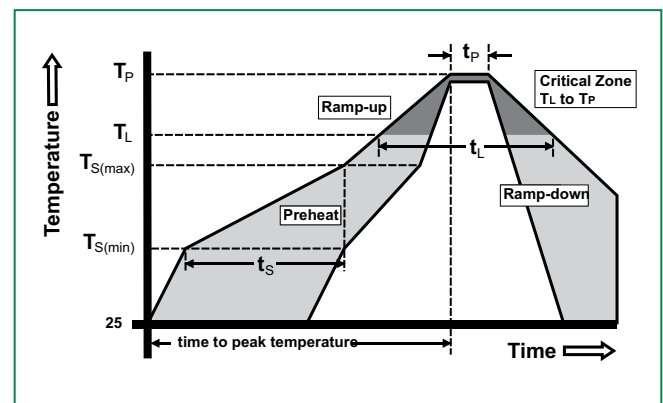
|                            |                                                    |
|----------------------------|----------------------------------------------------|
| <b>Lead Plating</b>        | Pre-Plated Frame ( $\mu$ DFN)<br>Matte Tin (SOT23) |
| <b>Lead Material</b>       | Copper Alloy                                       |
| <b>Lead Coplanarity</b>    | 0.0004 inches (0.102mm)                            |
| <b>Substitute Material</b> | Silicon                                            |
| <b>Body Material</b>       | Molded Epoxy                                       |
| <b>Flammability</b>        | UL 94 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.
5. Package surface matte finish VDI 11-13.

### Soldering Parameters

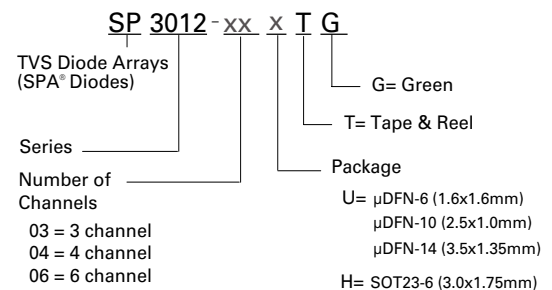
|                                                        |                                    |                    |
|--------------------------------------------------------|------------------------------------|--------------------|
| <b>Reflow Condition</b>                                |                                    | Pb – Free assembly |
| <b>Pre Heat</b>                                        | - Temperature Min ( $T_{s(min)}$ ) | 150°C              |
|                                                        | - Temperature Max ( $T_{s(max)}$ ) | 200°C              |
|                                                        | - Time (min to max) ( $t_s$ )      | 60 – 180 secs      |
| Average ramp up rate (Liquidus) Temp ( $T_L$ ) to peak |                                    | 3°C/second max     |
| $T_{s(max)}$ to $T_L$ - Ramp-up Rate                   |                                    | 3°C/second max     |
| <b>Reflow</b>                                          | - Temperature ( $T_L$ ) (Liquidus) | 217°C              |
|                                                        | - Temperature ( $t_L$ )            | 60 – 150 seconds   |
| Peak Temperature ( $T_p$ )                             |                                    | 260 $^{+0/-5}$ °C  |
| Time within 5°C of actual peak Temperature ( $t_p$ )   |                                    | 20 – 40 seconds    |
| Ramp-down Rate                                         |                                    | 6°C/second max     |
| Time 25°C to peak Temperature ( $T_p$ )                |                                    | 8 minutes Max.     |
| Do not exceed                                          |                                    | 260°C              |



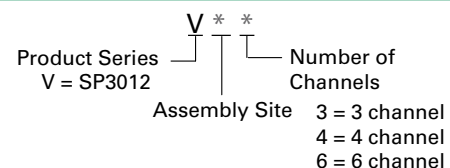
### Ordering Information

| Part Number  | Package      | Marking | Min. Order Qty. |
|--------------|--------------|---------|-----------------|
| SP3012-03UTG | $\mu$ DFN-6  | V*3     | 3000            |
| SP3012-04UTG | $\mu$ DFN-10 | V*4     | 3000            |
| SP3012-06UTG | $\mu$ DFN-14 | V*6     | 3000            |
| SP3012-04HTG | SOT23-6      | V*4     | 3000            |

### Part Numbering System



### Part Marking System



## 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  $\pm 12\text{kV}$  (contact discharge) which far exceeds the maximum requirement of the IEC 61000-4-2 standard.

There are two options available (4 channel and 6 channel) and both are housed in leadless  $\mu\text{DFN}$  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.

Figure 1: PCB Layout of the SP3012-06UTG for USB 3.0

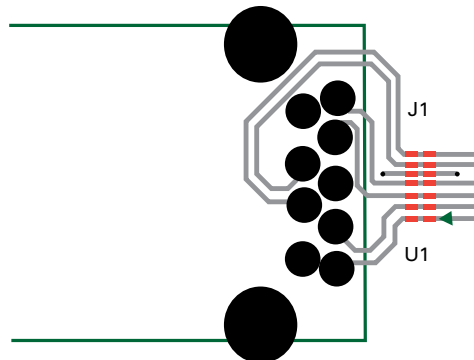


Figure 2 shows the USB 3.0 eye diagram that resulted from the PCB layout above with the SP3012-06UTG soldered on the landing pattern.

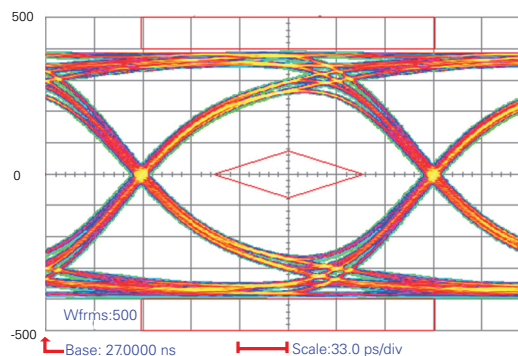


Figure 2: USB 3.0 Eye Diagram with the SP3012-06UTG

Using a similar layout as above, Figure 3 shows the eye diagram that resulted using the SP3012-04UTG to protect the Super-Speed data lines and the SP3003-02UTG to protect the legacy data pair.

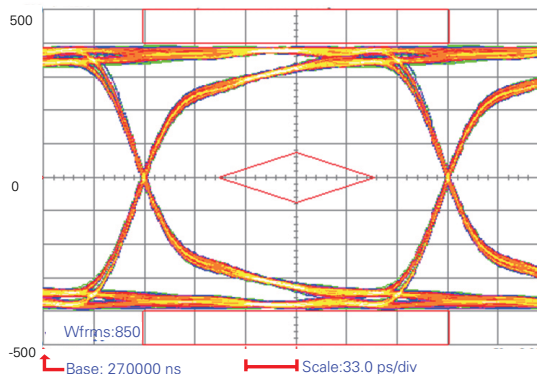
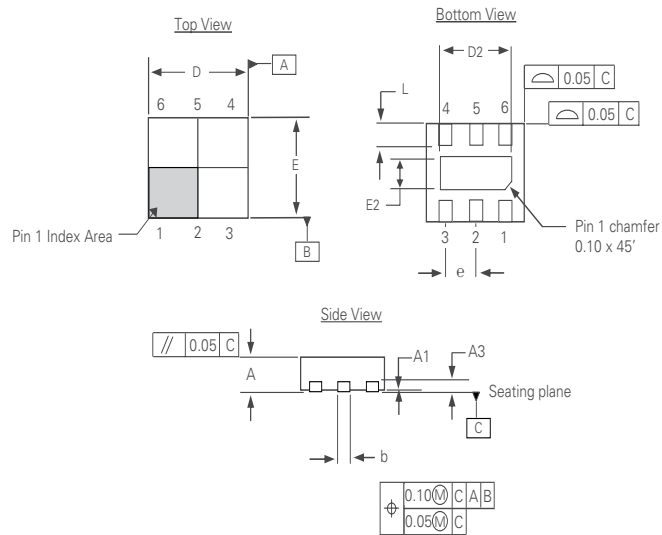


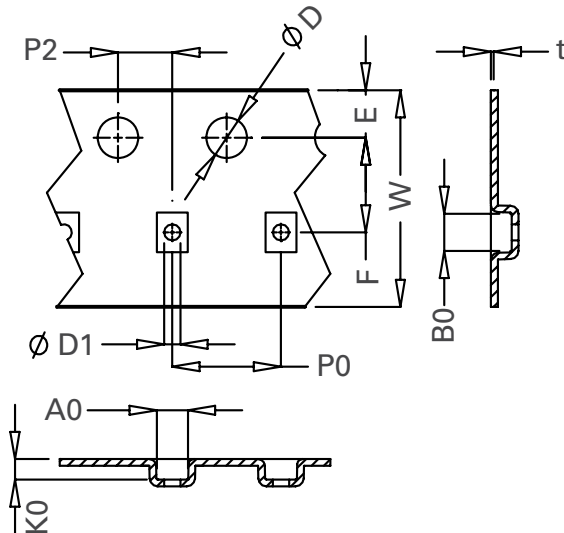
Figure 3: USB 3.0 Eye Diagram with the SP3012-04UTG

### Package Dimensions — $\mu$ DFN-6



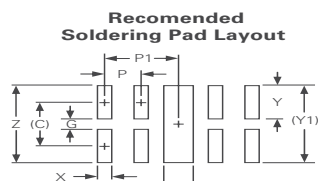
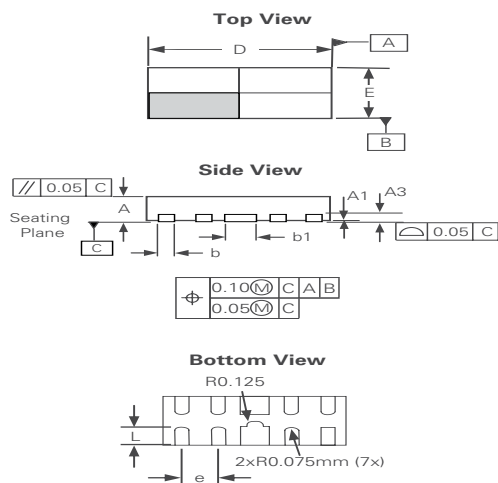
| Package   | $\mu$ DFN-6 (1.6x1.6x0.5mm) |       |           |       |
|-----------|-----------------------------|-------|-----------|-------|
| JEDEC     | MO-229                      |       |           |       |
| Symbol    | Millimeters                 |       | Inches    |       |
|           | Min                         | Max   | Min       | Max   |
| <b>A</b>  | 0.45                        | 0.55  | 0.018     | 0.022 |
| <b>A1</b> | 0.00                        | 0.05  | 0.000     | 0.002 |
| <b>A3</b> | 0.152Ref                    |       | 0.006 Ref |       |
| <b>b</b>  | 0.20                        | 0.30  | 0.008     | 0.012 |
| <b>D</b>  | 1.55                        | 1.65  | 0.061     | 0.065 |
| <b>D2</b> | 1.05                        | 1.30  | 0.042     | 0.052 |
| <b>E</b>  | 1.50                        | 1.70  | 0.060     | 0.067 |
| <b>E2</b> | 0.40                        | 0.65  | 0.016     | 0.026 |
| <b>e</b>  | 0.50 BSC                    |       | 0.020BSC  |       |
| <b>L</b>  | 0.164                       | 0.316 | 0.006     | 0.012 |

### Embossed Carrier Tape & Reel Specification — $\mu$ DFN-6

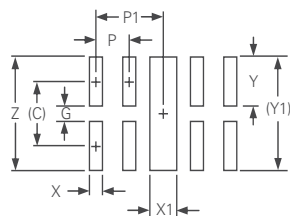


| Symbol      | Millimetres  |      | Inches      |      |
|-------------|--------------|------|-------------|------|
|             | Min          | Max  | Min         | Max  |
| <b>E</b>    | 1.65         | 1.85 | 0.06        | 0.07 |
| <b>F</b>    | 3.45         | 3.55 | 0.14        | 0.14 |
| <b>D1</b>   | 1.00         | 1.25 | 0.04        | 0.05 |
| <b>D</b>    | 1.50 MIN     |      | 0.06 MIN    |      |
| <b>P0</b>   | 3.90         | 4.10 | 0.15        | 0.16 |
| <b>10P0</b> | 40.0+/- 0.20 |      | 1.57+/-0.01 |      |
| <b>W</b>    | 7.90         | 8.30 | 0.31        | 0.33 |
| <b>P2</b>   | 1.95         | 2.05 | 0.08        | 0.08 |
| <b>A0</b>   | 1.78         | 1.88 | 0.07        | 0.07 |
| <b>B0</b>   | 1.78         | 1.88 | 0.07        | 0.07 |
| <b>K0</b>   | 0.84         | 0.94 | 0.03        | 0.04 |
| <b>t</b>    | 0.25 TYP     |      | 0.01 TYP    |      |

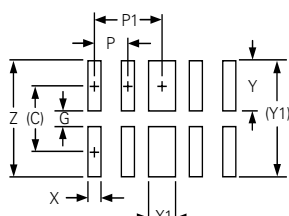
**Package Dimensions —  $\mu$ DFN-10 (2.5x1.0x0.5mm)**



**Recommended Soldering Pad Layout**



**Alternative Soldering Pad Layout**

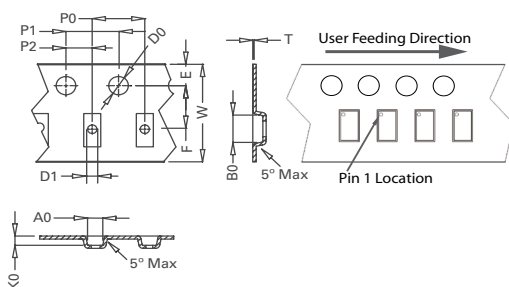


| Package | $\mu$ DFN-10 (2.5x1.0x0.5mm) |       |      |           |       |       |
|---------|------------------------------|-------|------|-----------|-------|-------|
| JEDEC   | MO-229                       |       |      |           |       |       |
| Symbol  | Millimeters                  |       |      | Inches    |       |       |
|         | Min                          | Nom   | Max  | Min       | Nom   | Max   |
| A       | 0.48                         | 0.515 | 0.55 | 0.019     | 0.020 | 0.021 |
| A1      | 0.00                         | —     | 0.05 | 0.000     |       | 0.022 |
| A3      | 0.125 Ref                    |       |      | 0.005 Ref |       |       |
| b       | 0.15                         | 0.20  | 0.25 | 0.006     | 0.008 | 0.012 |
| b1      | 0.35                         | 0.40  | 0.45 | 0.014     | 0.016 | 0.018 |
| D       | 2.40                         | 2.50  | 2.60 | 0.094     | 0.098 | 0.102 |
| E       | 0.90                         | 1.00  | 1.10 | 0.035     | 0.039 | 0.043 |
| e       | 0.50 BSC                     |       |      | 0.020 BSC |       |       |
| L       | 0.30                         | 0.365 | 0.43 | 0.012     | 0.014 | 0.016 |

**Soldering Pad Layout Dimensions**

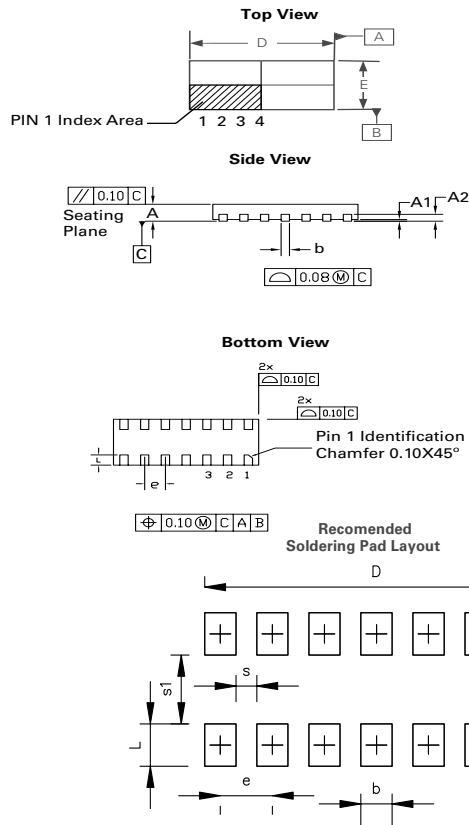
|    | Inch    | Millimeter |
|----|---------|------------|
| C  | (0.034) | (0.875)    |
| G  | 0.008   | 0.20       |
| P  | 0.020   | 0.50       |
| P1 | 0.039   | 1.00       |
| X  | 0.008   | 0.20       |
| X1 | 0.016   | 0.40       |
| Y  | 0.027   | 0.675      |
| Y1 | (0.061) | (1.55)     |
| Z  | 0.061   | 1.55       |

**Embossed Carrier Tape & Reel Specification —  $\mu$ DFN-10**



| Package | $\mu$ DFN-10 (2.5x1.0x0.5mm) |
|---------|------------------------------|
| Symbol  | Millimeters                  |
| A0      | 1.30 +/- 0.10                |
| B0      | 2.83 +/- 0.10                |
| D0      | Ø 1.50 + 0.10                |
| D1      | Ø 1.00 + 0.25                |
| E       | 1.75 +/- 0.10                |
| F       | 3.50 +/- 0.05                |
| K0      | 0.65 +/- 0.10                |
| P0      | 4.00 +/- 0.10                |
| P1      | 4.00 +/- 0.10                |
| P2      | 2.00 +/- 0.05                |
| T       | 0.254 +/- 0.02               |
| W       | 8.00 + 0.30 /- 0.10          |

**Package Dimensions —  $\mu$ DFN-14 (3.5x1.35x0.5mm)**



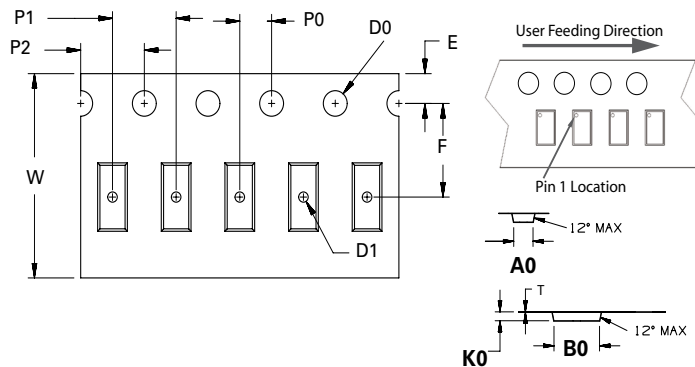
| $\mu$ DFN-14 (3.5x1.35x0.5mm) |             |      |      |           |       |       |
|-------------------------------|-------------|------|------|-----------|-------|-------|
| JEDEC MO-229                  |             |      |      |           |       |       |
| Symbol                        | Millimeters |      |      | Inches    |       |       |
|                               | Min         | Nom  | Max  | Min       | Nom   | Max   |
| A                             | 0.45        | 0.50 | 0.55 | 0.018     | 0.020 | 0.022 |
| A1                            | 0.00        | 0.02 | 0.05 | 0.000     | 0.001 | 0.002 |
| A2                            | 0.203 Ref   |      |      | 0.008 Ref |       |       |
| b                             | 0.15        | 0.20 | 0.25 | 0.006     | 0.008 | 0.012 |
| D                             | 3.40        | 3.50 | 3.60 | 0.134     | 0.138 | 0.142 |
| D2                            | -           | -    | -    | -         | -     | -     |
| E                             | 1.25        | 1.35 | 1.45 | 0.050     | 0.054 | 0.058 |
| E1                            | -           | -    | -    | -         | -     | -     |
| e                             | 0.500 BSC   |      |      | 0.020 BSC |       |       |
| L                             | 0.25        | 0.30 | 0.35 | 0.010     | 0.012 | 0.014 |

Notes:

1. Dimension and tolerancing conform to ASME Y14.5M-1994.
2. Controlling dimensions: Millimeter. Converted Inch dimensions are not necessarily exact.

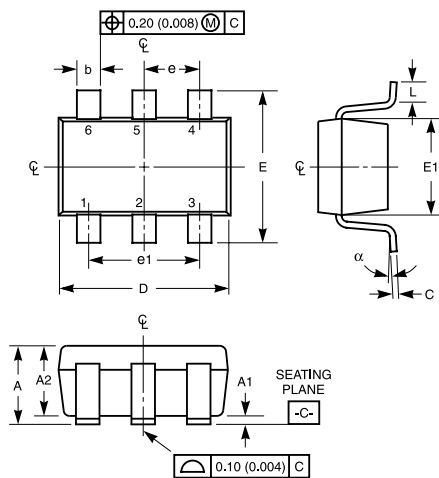
| Soldering Pad Layout Dimensions |             |           |
|---------------------------------|-------------|-----------|
| Symbol                          | Millimeters | Inches    |
|                                 | Nom         | Nom       |
| D                               | 3.30        | 0.1299    |
| E                               | 1.65        | 0.0571    |
| b                               | 0.30        | 0.0118    |
| L                               | 0.50        | 0.0197    |
| e                               | 0.50 typ    | 0.020 typ |
| s                               | 0.20        | 0.0078    |
| s1                              | 0.65        | 0.0256    |

**Embossed Carrier Tape & Reel Specification —  $\mu$ DFN-14**

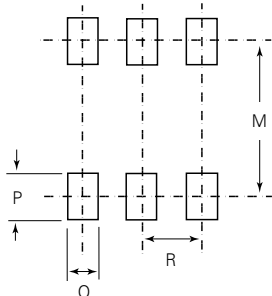


| Symbol | Millimeters        |
|--------|--------------------|
| A0     | 1.58 +/- 0.10      |
| B0     | 3.73 +/- 0.10      |
| D0     | Ø 1.50 + 0.10      |
| D1     | Ø 0.60 +/- 0.05    |
| E      | 1.75 +/- 0.10      |
| F      | 5.50 +/- 0.05      |
| K0     | 0.68 + 0.12/-0.10  |
| P0     | 2.00 +/- 0.05      |
| P1     | 4.00 +/- 0.10      |
| P2     | 4.00 +/- 0.10      |
| T      | 0.28 + 0.02/-0.05  |
| W      | 12.00 + 0.30/-0.10 |

## Package Dimensions — SOT23-6



### Recommended Solder Pad Layout



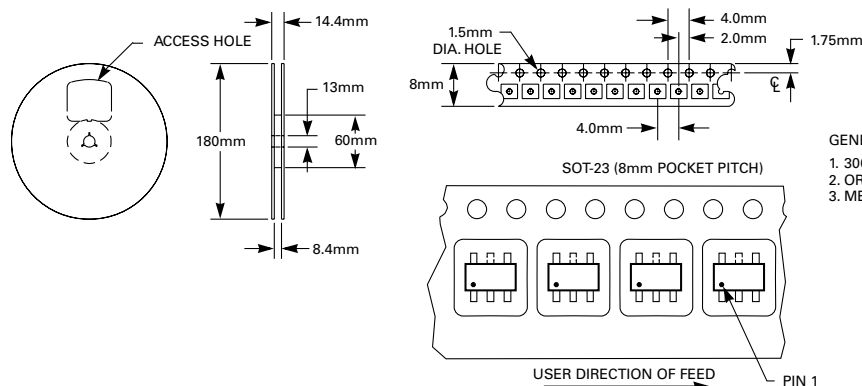
| Package | SOT23       |       |            |        |       |
|---------|-------------|-------|------------|--------|-------|
| Pins    | 6           |       |            |        |       |
| JEDEC   | MO-178AB    |       |            |        |       |
|         | Millimeters |       | Inches     |        | Notes |
|         | Min         | Max   | Min        | Max    |       |
| A       | 0.900       | 1.450 | 0.035      | 0.057  | -     |
| A1      | 0.000       | 0.150 | 0.000      | 0.006  | -     |
| A2      | 0.900       | 1.300 | 0.035      | 0.051  | -     |
| b       | 0.350       | 0.500 | 0.0138     | 0.0196 | -     |
| C       | 0.080       | 0.220 | 0.0031     | 0.009  | -     |
| D       | 2.800       | 3.000 | 0.11       | 0.118  | 3     |
| E       | 2.600       | 3.000 | 0.102      | 0.118  | -     |
| E1      | 1.500       | 1.750 | 0.06       | 0.069  | 3     |
| e       | 0.95 Ref    |       | 0.0374 ref |        | -     |
| e1      | 1.9 Ref     |       | 0.0748 Ref |        | -     |
| L       | 0.30        | 0.600 | 0.012      | 0.023  | 4,5   |
| N       | 6           |       | 6          |        | 6     |
| α       | 0°          | 8°    | 0°         | 8°     | -     |
| M       | 2.590       |       | 0.102      |        | -     |
| O       | 0.690       |       | .027 TYP   |        | -     |
| P       | 0.990       |       | .039 TYP   |        | -     |
| R       | 0.950       |       | 0.038      |        | -     |

### Notes:

1. Dimensioning and tolerancing Per ASME Y14.5M-1994.
2. Package conforms to EIAJ SC-74 (1992).
3. Dimensions D and E1 are exclusive of mold flash, protrusions, or gate burrs.
4. Foot length L measured at reference to seating plane.
5. "L" is the length of flat foot surface for soldering to substrate.
6. "N" is the number of terminal positions.
7. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

## Embossed Carrier Tape & Reel Specification — SOT23-6

### 8mm TAPE AND REEL



### GENERAL INFORMATION

1. 3000 PIECES PER REEL.
2. ORDER IN MULTIPLES OF FULL REELS ONLY.
3. MEETS EIA-481 REVISION "A" SPECIFICATIONS.

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