



## USB Downstream Port Terminator

### Features

- A low-capacitance USB downstream port terminator, EMI filter, and transient over-voltage (ESD) protector in a single surface-mounted package
- ESD protection to  $\pm 20\text{kV}$  contact discharge, per MIL-STD-883D, Method 3015
- ESD protection to  $\pm 15\text{kV}$  contact discharge, per IEC 61000-4-2 International Standard
- Compact SOT23-5 and SC70-5 package options save board space and lower manufacturing costs compared to discrete solutions
- Capacitors matched to a precision exceeding the USB specification
- Pin-compatible with ST Microelectronics USBDFxxW5 USB Downstream Port Terminator

### Applications

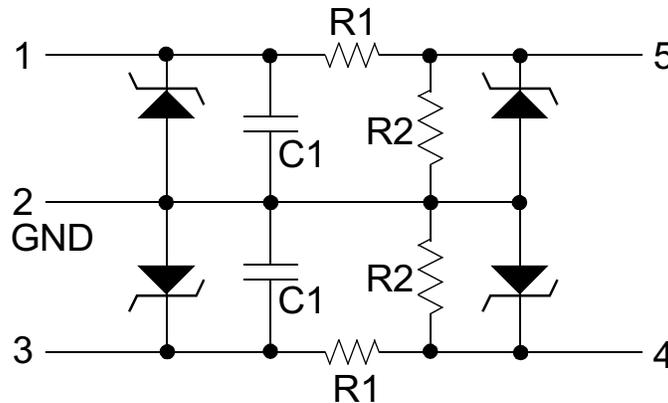
- ESD protection and termination of USB downstream ports
- Desktop PCs
- Notebooks
- Set-top boxes
- USB hubs

### Product Description

The PACUSB-D1/D2/D3 is a single-channel USB downstream-port termination network. It integrates EMI/RFI filter components R1 and C1, as recommended by the USB specification as well as the required  $15\text{k}\Omega$  pull-down resistors (R2) to GND. In addition, PACUSB-D1/D2/D3 provides a very high level of protection for sensitive electronic components that may be subjected to electrostatic discharge (ESD). The device pins will safely dissipate ESD strikes of  $\pm 15\text{kV}$ , exceeding the maximum requirements of the IEC 61000-4-2 international standard. Using the MIL-STD-883D (Method 3015) specification for Human Body Model (HBM) ESD, all pins are protected from contact discharges to  $\pm 20\text{kV}$ .

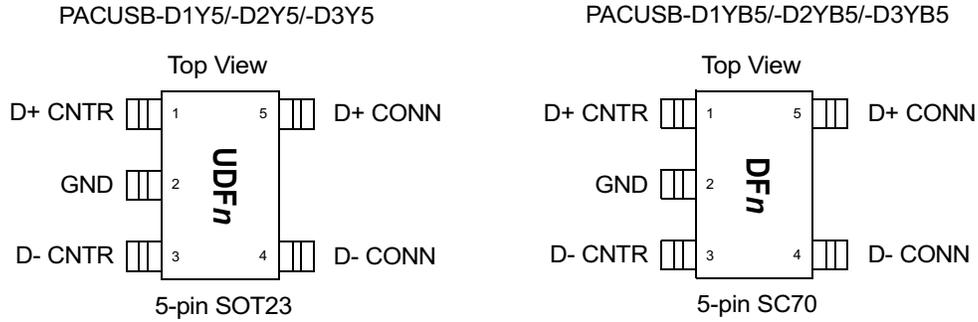
There are three options for the value of the series resistor R1:  $15\Omega$ ,  $22\Omega$ , and  $33\Omega$ . This series resistance, plus the USB driver output resistance, must be close to the USB cable's characteristic impedance of  $45\Omega$  (each side) to minimize transmission line reflections.

### Electrical Schematic





**PACKAGE / PINOUT DIAGRAMS**



Note 1: The "n" shown in part markings above represents either the digit "1," "2," or "3."  
 Note 2: SOT23 and SC70 package sizes may differ. These drawings are not to scale.

**PIN DESCRIPTIONS**

| PINS | NAME    | DESCRIPTION                             |
|------|---------|---|
| 1    | D+ CNTR | D+ Data to the USB controller circuitry |
| 2    | GND     | Ground Pin                              |
| 3    | D- CNTR | D- Data to the USB controller circuitry |
| 4    | D- CONN | D- Data to the USB connector            |
| 5    | D+ CONN | D+ Data to the USB connector            |

**Ordering Information**

**PART NUMBERING INFORMATION**

| Ordering Part Number <sup>1</sup> | Pins | R1 Value | Package | Part Marking |
|-----------------------------------|------|----------|---------|--------------|
| PACUSB-D2Y5                       | 5    | 15 Ω     | SOT23-5 | UDF2         |
| PACUSB-D3Y5                       |      | 22 Ω     |         | UDF3         |
| PACUSB-D1Y5                       |      | 33 Ω     |         | UDF1         |
| PACUSB-D2YB5                      | 5    | 15 Ω     | SC70-5  | DF2          |
| PACUSB-D3YB5                      |      | 22 Ω     |         | DF3          |
| PACUSB-D1YB5                      |      | 33 Ω     |         | DF1          |

Note 1: Parts are shipped in Tape & Reel form unless otherwise specified.



### Specifications

| ABSOLUTE MAXIMUM RATINGS       |             |       |
|--------------------------------|-------------|-------|
| PARAMETER                      | RATING      | UNITS |
| Storage Temperature Range      | -65 to +150 | °C    |
| Power Dissipation per Resistor | 100         | mW    |
| Package Power Dissipation      | 200         | mW    |
| Voltage on any pin (DC)        | 6           | V     |

| STANDARD OPERATING CONDITIONS |            |       |
|-------------------------------|------------|-------|
| PARAMETER                     | RATING     | UNITS |
| Operating Temperature         | -40 to +85 | °C    |



## Specifications (cont'd)

| ELECTRICAL OPERATING CHARACTERISTICS <sup>1</sup> |  |  |      |       |      |            |
|---|--|--|------|-------|------|------------|
| SYMBOL  | PARAMETER  | CONDITIONS                                       | MIN  | TYP   | MAX  | UNITS      |
| R1  | Resistance of R1 Resistor<br>(PACUSB-D2Y5, -D2YB5)   | T <sub>A</sub> = 25°C                            | 12   | 15    | 18   | Ω          |
| R1  | Resistance of R1 Resistor<br>(PACUSB-D3Y5, -D3YB5)   | T <sub>A</sub> = 25°C                            | 17.6 | 22    | 26.4 | Ω          |
| R1  | Resistance of R1 Resistor<br>(PACUSB-D1Y5, -D1YB5)   | T <sub>A</sub> = 25°C                            | 26.4 | 33    | 39.6 | Ω          |
| R2  | Resistance of R2 Resistor  | T <sub>A</sub> = 25°C                            |      | 15    |      | kΩ         |
| TCR   | Temperature Coefficient of Resistance  | Note 1   |      | ±1300 |      | ppm/<br>°C |
| C1  | Capacitance of C1 Capacitor  | 0 VDC; 30 mVAC; 1MHz; 25°C                       | 37.6 | 47    | 56.4 | pF         |
|   |  | 2.5 VDC; 30 mVAC; 1MHz; 25°C                     | 25.6 | 32    | 38.4 | pF         |
| TOL <sub>CM</sub>                                 | Matching Tolerance of C1 Capacitors  | 1MHz; 25°C                                       |      |       | ±2   | %          |
| I <sub>LEAK</sub>                                 | Diode Leakage Current to GND   | Measured at 3.3 VDC, 25°C                        |      | 1     | 100  | nA         |
| V <sub>RB</sub>                                   | Diode Reverse Bias Voltage   | I <sub>LOAD</sub> = 10μA; T <sub>A</sub> = 25°C  | 5.5  |       |      | V          |
| V <sub>SIG</sub>                                  | Signal Voltage:<br>Positive Clamp<br>Negative Clamp  | I <sub>LOAD</sub> = 10mA; T <sub>A</sub> = 25°C  | 5.6  | 6.8   | 9.0  | V          |
|   |  | I <sub>LOAD</sub> = 10mA; T <sub>A</sub> = 25°C  | -0.4 | -0.8  | -1.5 | V          |
| V <sub>ESD</sub>                                  | In-system ESD Withstand Voltage<br>MIL-STD-883D, Method 3015<br>(HBM)<br>IEC 61000-4-2 Contact Discharge | Pins 1, 3; Notes 2 and 3                         | ±4   |       |      | kV         |
|   |  | Pins 4, 5; Notes 2 and 3                         | ±20  |       |      | kV         |
|   |  | Pins 4, 5; Notes 2 and 3                         | ±15  |       |      | kV         |
| V <sub>CL</sub>                                   | Clamping voltage under ESD discharge   | MIL-STD-883D, Method 3015 +8kV;<br>Notes 2 and 5 |      | 12    |      | V          |
|   |  | MIL-STD-883D, Method 3015 -8kV;<br>Notes 2 and 5 |      | -7    |      | V          |

Note 1: Electrical operating characteristics guaranteed over standard operating conditions unless specified otherwise.

Note 2: Guaranteed by design and characterization.

Note 3: ESD voltage applied to pins with respect to GND, one at a time; unused pins are left open.

Note 4: Pins 1 and 3 are not connected to the USB port connector, and therefore are not exposed to external ESD hazards. Thus, they do not require the high ESD protection levels provided for pins 4 and 5.

Note 5: ESD Clamping Voltage is measured at the opposite end of R1 from the pin to which the ESD discharge is applied (e.g., if ESD is applied to pin 6, then the clamping voltage is measured at pin 1).



### Performance Information

#### Capacitance vs. Voltage

The C1 capacitance value as a function of DC voltage across it is presented in Figure 1. The curve is normalized to a capacitance of 1.0 capacitance units at 2.5 VDC.

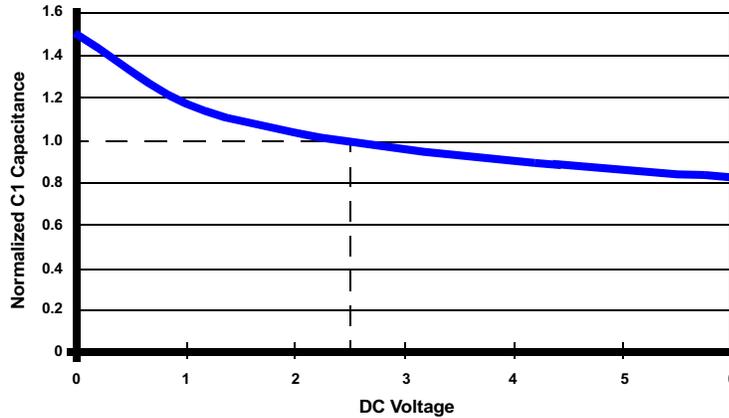


Figure 1. Diode Capacitance vs. DC Voltage (Normalized)

#### Insertion Loss vs. Frequency Characteristics

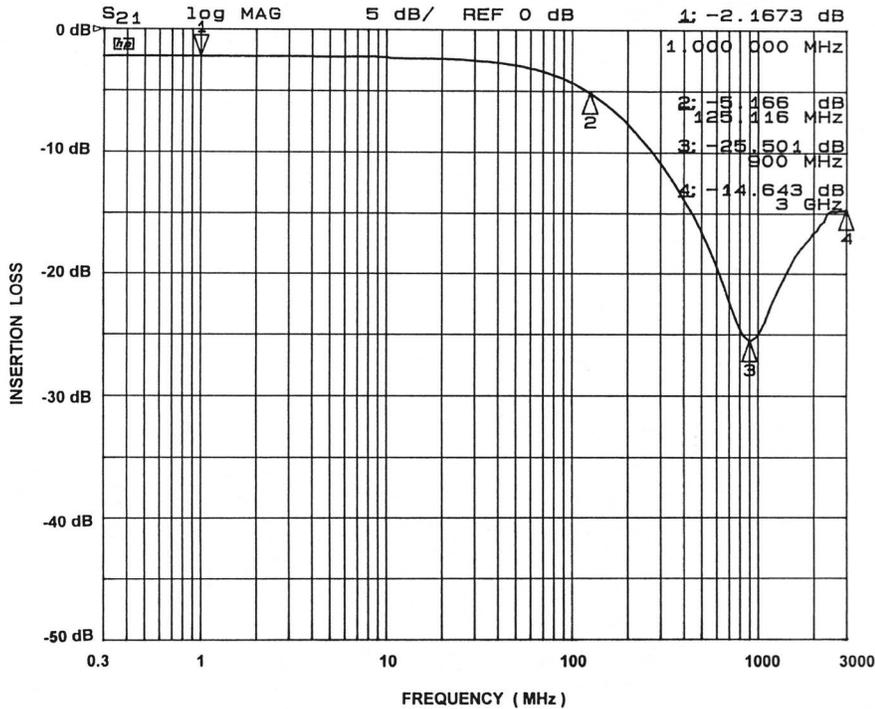


Figure 2. Insertion Loss vs. Frequency Performance Curve, PACUSB-D1(SOT23-6)



### Performance Information (cont'd)

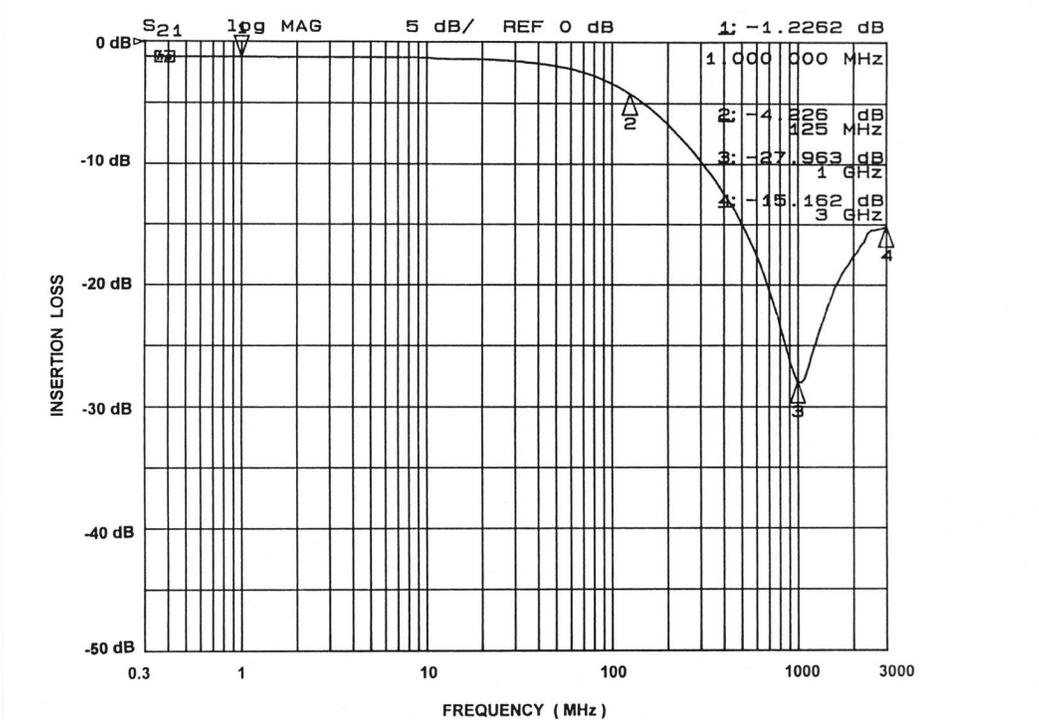


Figure 3. Insertion Loss vs. Frequency Performance Curve, PACUSB-D2(SOT23-6)

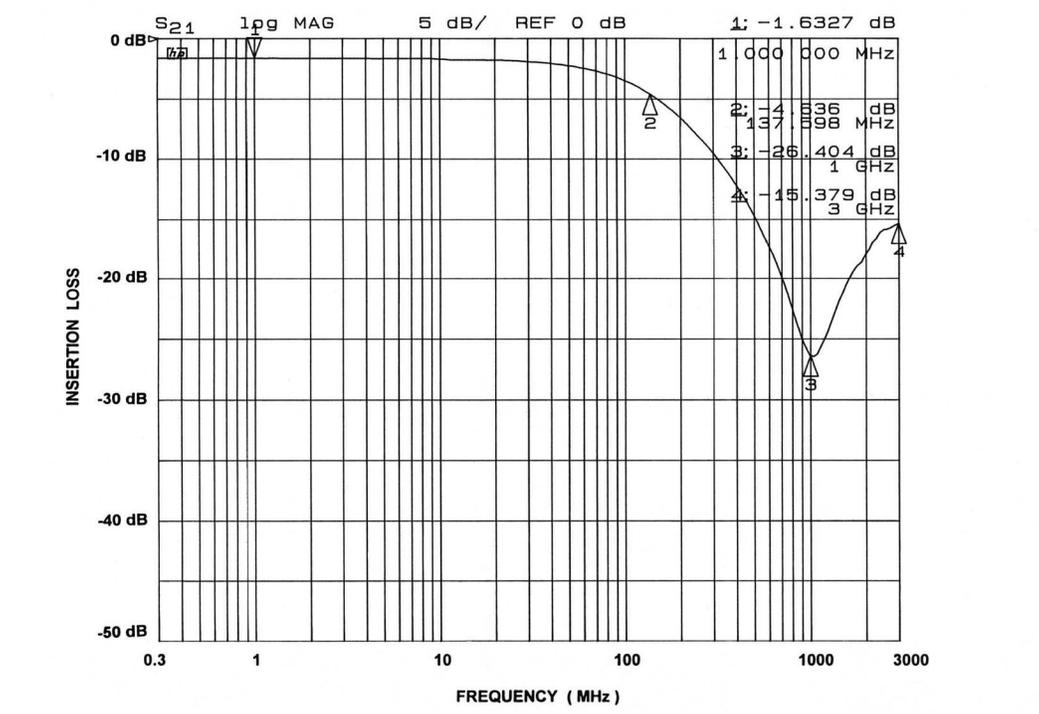


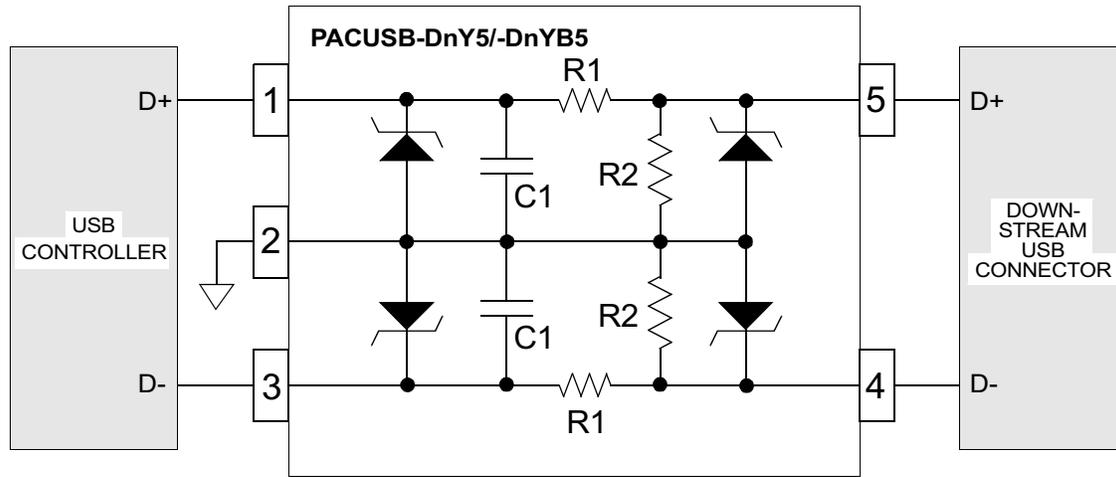
Figure 4. Insertion Loss vs. Frequency Performance Curve, PACUSB-D3(SOT23-6)

### Application Information

The PACUSB-D1/D2/D3 provides a complete interface for a single downstream USB port typically found in computers and USB hubs. It integrates the series resistors (R1) and the 15kΩ pull-down resistors (R2) for both USB data lines (D+ and D-) as well as the capacitors to ground for EMI suppression. Zener diodes provide ESD protection up to 15kV contact dis-

charge per the IEC 61000-4-2 standard and protect the USB controller on both data lines.

The PACUSB-D1/D2/D3 should be placed on the PCB between the USB controller and the USB connector, as shown on the Connection Diagram [Figure 5](#).



**Figure 5. Connection Diagram for PACUSB-D1/D2/D3 Devices**

To guarantee the best ESD and filtering performance, it is recommended to physically locate the PACUSB-D1/D2/D3 close to the USB connector. Also, the trace lengths between the PACUSB-D1/D2/D3 and the USB controller should be kept as short as possible.



### Mechanical Details

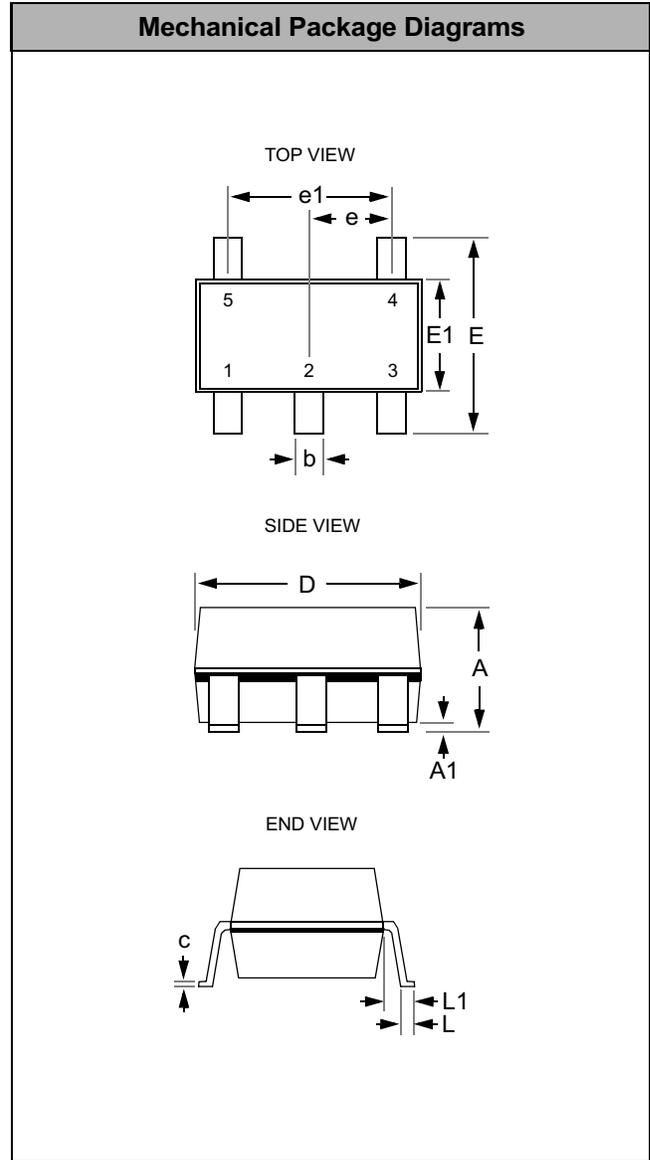
PACUSB-D1/D2/D3 devices are packaged in SOT23-5 and SC70-5 packages.

#### SOT23-5 Mechanical Specifications:

Dimensions for PACUSB-D1/D2/D3 devices packaged in a 5-pin SOT23 package are presented below.

For complete information on the SOT23-5 package, see the California Micro Devices SOT23 Package Information document.

| PACKAGE DIMENSIONS                 |                                |      |            |       |
|------------------------------------|--------------------------------|------|------------|-------|
| Package                            | SOT23-5 (JEDEC name is MO-178) |      |            |       |
| Pins                               | 5                              |      |            |       |
| Dimensions                         | Millimeters                    |      | Inches     |       |
|                                    | Min                            | Max  | Min        | Max   |
| A                                  | --                             | 1.45 | --         | 0.057 |
| A1                                 | 0.00                           | 0.15 | 0.000      | 0.006 |
| b                                  | 0.30                           | 0.50 | 0.012      | 0.020 |
| c                                  | 0.08                           | 0.22 | 0.003      | 0.009 |
| D                                  | 2.75                           | 3.05 | 0.108      | 0.120 |
| E                                  | 2.60                           | 3.00 | 0.102      | 0.118 |
| E1                                 | 1.45                           | 1.75 | 0.057      | 0.069 |
| e                                  | 0.95 BSC                       |      | 0.0374 BSC |       |
| e1                                 | 1.90 BSC                       |      | 0.0748 BSC |       |
| L                                  | 0.30                           | 0.60 | 0.0236     | 0.024 |
| L1                                 | 0.60 REF                       |      | 0.024 REF  |       |
| # per tape and reel                | 3000 pieces*                   |      |            |       |
| Controlling dimension: millimeters |                                |      |            |       |



Package Dimensions for SOT23-5.

\* This is an approximate amount which may vary.



### Mechanical Details (continued)

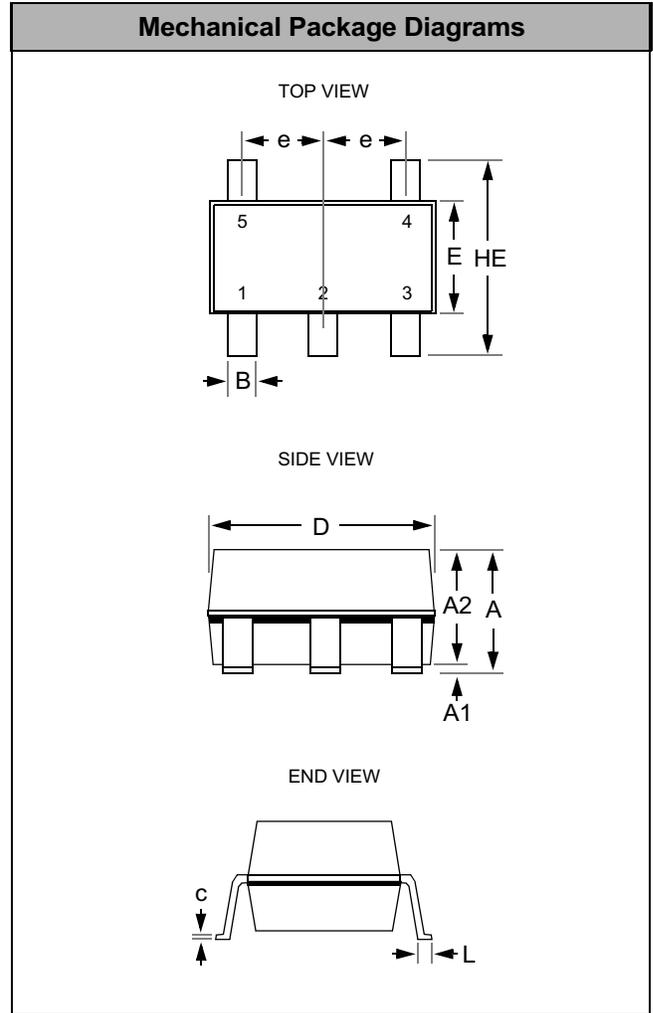
#### SC70-5 Mechanical Specifications:

Dimensions for PACUSB-D1/D2/D3 devices packaged in a 5-pin SC70 package are presented below.

For complete information on the SC70-5 package, see the California Micro Devices SC70 Package Information document.

| PACKAGE DIMENSIONS |  |      |
|--------------------|--|------|
| Package            | SC70-5<br>(JEDEC name is MO-203 Issue A) |      |
| Pins               | 5  |      |
| Dimensions         | Millimeters                              |      |
|                    | Min                                      | Max  |
| A                  | 0.80                                     | 1.10 |
| A1                 | 0.00                                     | 0.10 |
| A2                 | 0.70                                     | 1.00 |
| B                  | 0.15                                     | 0.30 |
| c                  | 0.08                                     | 0.25 |
| D                  | 1.85                                     | 2.25 |
| E                  | 1.15                                     | 1.35 |
| e                  | 0.65 BSC                                 |      |
| HE                 | 2.00                                     | 2.40 |
| L                  | 0.26                                     | 0.46 |
| # / bag            | 1000 pieces*                             |      |
| # / tape and reel  | 3000 pieces*                             |      |

\* This is an approximate amount which may vary.



Package Dimensions for SC70-5.