

# 16-Tap MiniPot™ Digitally Programmable Potentiometers with 2-Wire Interface



## FEATURES

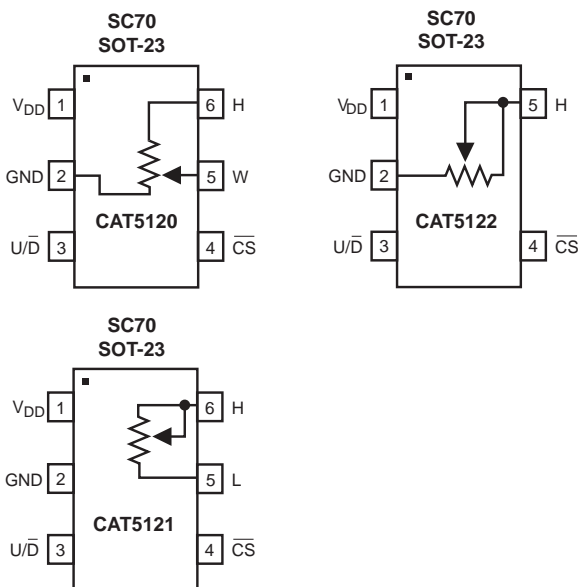
- 0.3μA Ultra-low supply current
- Single-supply operation: 2.7V to 5.5V
- Glitchless switching between resistor taps
- Power-on reset to midscale
- 2-Wire up/down serial interface
- Resistance values: 10kΩ, 50kΩ and 100kΩ
- Available in SC70 and SOT-23 packages

## APPLICATIONS

- LCD screen adjustment
- Volume control
- Mechanical potentiometer replacement
- Gain adjustment
- Line impedance matching

For Ordering Information details, see page 10.

## PIN CONFIGURATION



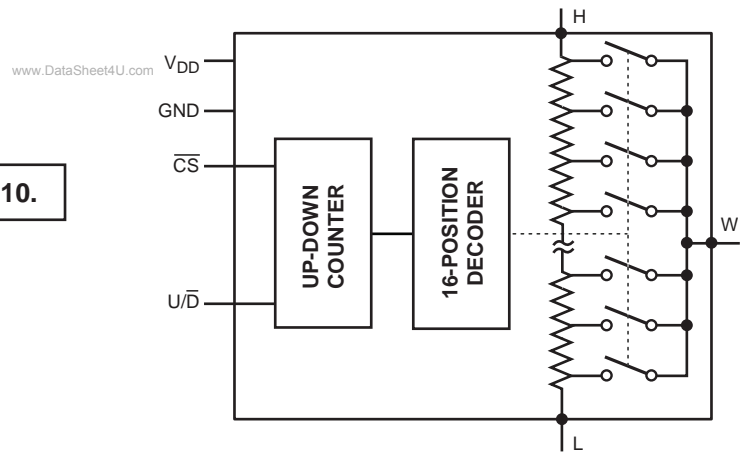
## DESCRIPTION

CAT5120/5121/5122 linear-taper digitally programmable potentiometers perform the same function as a mechanical potentiometer or a variable resistor. These devices consist of a fixed resistor and a wiper contact with 16-tap points that are digitally controlled through a 2-wire up/down serial interface.

The CAT5120 is configured as a potentiometer. The CAT5121 and CAT5122 are configured as variable resistors. See *Pin Configurations* for part functionality.

Three resistance values are available: 10kΩ, 50kΩ and 100kΩ. These are available in space-saving 5-pin and 6-pin SC70 and SOT-23 packages.

## FUNCTIONAL DIAGRAM



## PIN DESCRIPTIONS

| Name            | Description   |
|-----------------|---|
| V <sub>DD</sub> | Power Supply  |
| GND             | Ground  |
| U/ $\bar{D}$    | Up/Down Control Input. With $\bar{CS}$ low, a low-to-high transition increments or decrements the wiper position.                                   |
| $\bar{CS}$      | Chip Select Input. A high-to-low $\bar{CS}$ transition determines the mode: increment if U/ $\bar{D}$ is high, or decrement if U/ $\bar{D}$ is low. |
| L               | Low Terminal of Resistor  |
| W               | Wiper Terminal of Resistor  |
| H               | High Terminal of Resistor   |

**CAT5120, CAT5121, CAT5122**
**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

|   |                                   |
|---|-----------------------------------|
| V <sub>DD</sub> to GND                                | -0.3V to +6V                      |
| All Other Pins to GND                                 | -0.3V to (V <sub>DD</sub> + 0.3)V |
| Input and Output Latch-Up Immunity                    | ±200mA                            |
| Maximum Continuous Current into H, L and W            |                                   |
| 100kΩ   | ±0.6mA                            |
| 50kΩ  | ±1.3mA                            |
| 10kΩ  | ±1.3mA                            |
| Continuous Power Dissipation (T <sub>A</sub> = +70°C) |                                   |
| 5-pin SC70 <sup>(2)</sup>                             | 247mW                             |
| 6-pin SC70 <sup>(2)</sup>                             | 245mW                             |
| Operating Temperature Range                           | -40°C to +85°C                    |
| Junction Temperature                                  | +150°C                            |
| Storage Temperature Range                             | -65°C to +150°C                   |
| Soldering Temperature (soldering, 10s)                | +300°C                            |

**Notes:**

- (1) Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions outside of those listed in the operational sections of this specification is not implied. Exposure to any absolute maximum rating for extended periods may affect device performance and reliability.
- (2) Derate 3.1mW/°C above T<sub>A</sub> = +70°C

**ELECTRICAL CHARACTERISTICS**

V<sub>DD</sub> = 2.7V to 5.5V, V<sub>H</sub> = V<sub>DD</sub>, V<sub>L</sub> = 0, T<sub>A</sub> = -40°C to 85°C. Typical values are at V<sub>DD</sub> = 2.7V, T<sub>A</sub> = 25°C, unless otherwise noted.

| Parameter                     | Symbol          | Conditions | Min                   | Typ  | Max                   | Units  |
|-------------------------------|-----------------|------------|-----------------------|------|-----------------------|--------|
| <b>DC Performance</b>         |                 |            |                       |      |                       |        |
| Resolution                    |                 |            | 16                    |      |                       | Taps   |
| End-to-End Resistance (-00)   |                 |            | 75                    | 100  | 125                   | kΩ     |
| End-to-End Resistance (-50)   |                 |            | 37.5                  | 50   | 62.5                  |        |
| End-to-End Resistance (-10)   |                 |            | 7.5                   | 10   | 12.5                  |        |
| End-to-End Resistance Tempco  | TC <sub>R</sub> |            |                       | 200  |                       | ppm/°C |
| Ratiometric Resistance Tempco |                 |            |                       | 5    |                       | ppm/°C |
| Integral Nonlinearity         | INL             |            |                       |      | ±0.5                  | LSB    |
| Differential Nonlinearity     | DNL             |            |                       |      | ±0.5                  | LSB    |
| Zero/Full-Scale Error         |                 |            |                       | ±0.1 | ±0.5                  | LSB    |
| Wiper Resistance              | R <sub>W</sub>  |            |                       | 200  | 600                   | Ω      |
| <b>Digital Inputs</b>         |                 |            |                       |      |                       |        |
| Input High Voltage            | V <sub>IH</sub> |            | 0.7 x V <sub>DD</sub> |      |                       | V      |
| Input Low Voltage             | V <sub>IL</sub> |            |                       |      | 0.3 x V <sub>DD</sub> | V      |

**ELECTRICAL CHARACTERISTICS** (continued)

$V_{DD} = 2.7V$  to  $5.5V$ ,  $V_H = V_{DD}$ ,  $V_L = 0$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$ . Typical values are at  $V_{DD} = 2.7V$ ,  $T_A = 25^{\circ}C$ , unless otherwise noted.

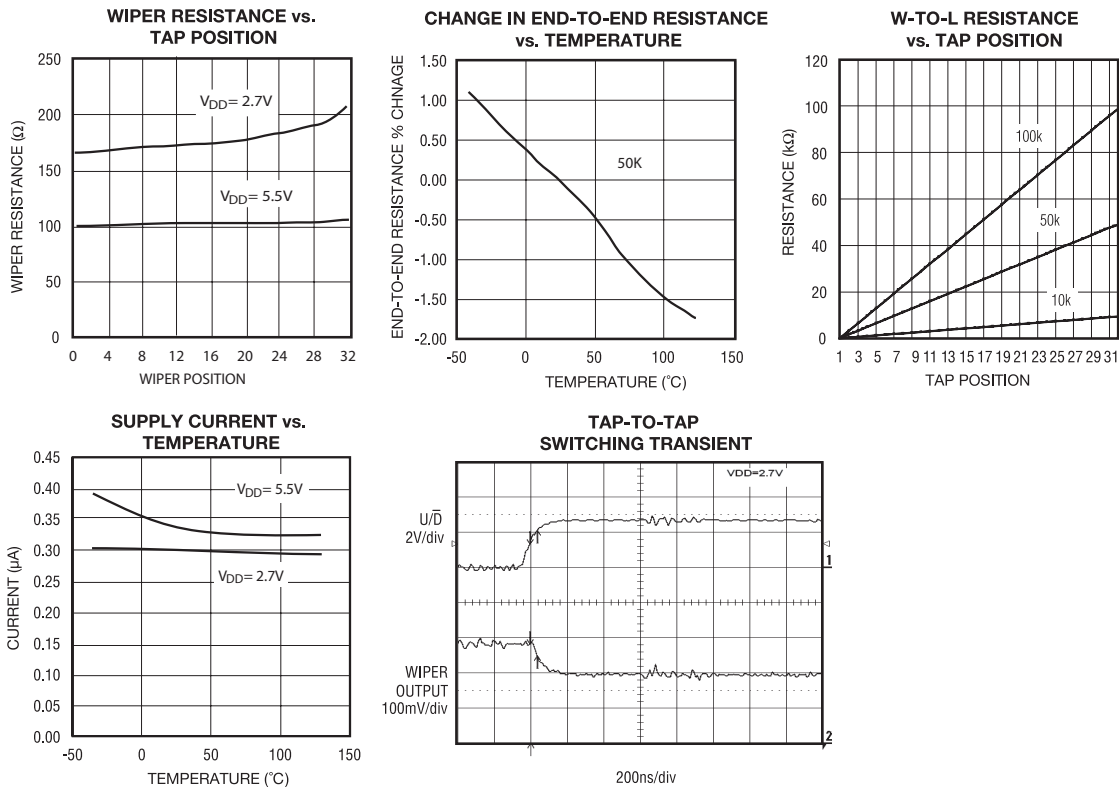
| Parameter                                    | Symbol       | Conditions  | Min | Typ  | Max | Units   |
|--|--------------|---|-----|------|-----|---------|
| <b>Timing Characteristics (Figures 1, 2)</b> |              |   |     |      |     |         |
| U/ $\bar{D}$ Mode to $\bar{CS}$ Setup        | $t_{CU}$     |   | 25  |      |     | ns      |
| $\bar{CS}$ to U/ $\bar{D}$ Step Setup        | $t_{CI}$     |   | 50  |      |     | ns      |
| $\bar{CS}$ to U/ $\bar{D}$ Step Hold         | $t_{IC}$     |   | 25  |      |     | ns      |
| U/ $\bar{D}$ Step Low Period                 | $t_{IL}$     |   | 25  |      |     | ns      |
| U/ $\bar{D}$ Step High Period                | $t_{IH}$     |   | 25  |      |     | ns      |
| Up/ $\bar{D}$ Toggle Rate <sup>(1)</sup>     | $f_{TOGGLE}$ |   |     | 1    |     | MHz     |
| Output Settling Time <sup>(2)</sup>          | $t_{SETTLE}$ | 100k $\Omega$ variable resistor configuration, $C_L = 10pF$ |     | 1    |     | $\mu s$ |
|  |              | 100k $\Omega$ potentiometer configuration, $C_L = 10pF$     |     | 0.25 |     |         |
| <b>Power Supply</b>                          |              |   |     |      |     |         |
| Supply Voltage                               | $V_{DD}$     |   | 2.7 |      | 5.5 | V       |
| Active Supply Current <sup>(3)</sup>         | $I_{DD}$     |   |     |      | 25  | $\mu A$ |
| Standby Supply Current <sup>(4)</sup>        | $I_{SD}$     | $V_{DD} = +5V$  |     | 0.3  | 1   | $\mu A$ |

**Notes:**

- (1) Up/Down Toggle Rate:  $f_{TOGGLE} = 1/t_{SETTLE}$
- (2) Typical setting times are dependant on end-to-end resistance.
- (3) Supply current taken while changing wiper tap,  $f_{TOGGLE} = 1MHz$ .
- (4) Supply current taken while wiper position is fixed.

**TYPICAL OPERATING CHARACTERISTICS**

$T_A = 25^{\circ}C$ , unless otherwise noted.



## CAT5120, CAT5121, CAT5122

### FUNCTIONAL DESCRIPTION

The CAT5120/5121/5122 consist of a fixed resistor and a wiper contact with 16-tap points that are digitally controlled through a 2-wire up/down serial interface. Three end-to-end resistance values are available: 10k $\Omega$ , 50k $\Omega$  and 100k $\Omega$ .

The CAT5120 is designed to operate as a potentiometer. In this configuration, the low terminal of the resistor array is connected to ground (pin 2).

The CAT5122 performs as a variable resistor. In this device, the wiper terminal and high terminal of the resistor array is connected at pin 5. The CAT5121 is a similar variable resistor, except the low terminal is connected to pin 5.

### DIGITAL INTERFACE OPERATION

The Minipots have two modes of operation when the serial interface is active: increment and decrement mode. The serial interface is only active when  $\overline{CS}$  is low.

The  $\overline{CS}$  and  $U/\overline{D}$  inputs control the position of the wiper along the resistor array. When  $\overline{CS}$  transitions from high to low, the part will go into increment mode if  $U/\overline{D}$  input is high, and into decrement mode when  $U/\overline{D}$  input is low. Once the mode is set, the device will remain in that mode until  $\overline{CS}$  goes high again. A low-to-high transition at the  $U/\overline{D}$  pin will increment or decrement the wiper position depending on the current mode (Figures 1 and 2).

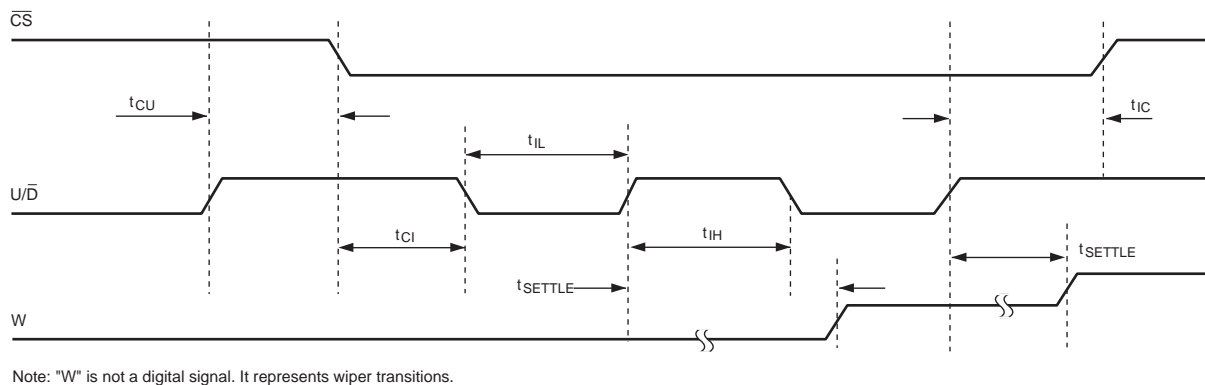
When the  $\overline{CS}$  input transitions to high (serial interface inactive), the value of the counter is stored and the wiper position is maintained.

Note that when the wiper reaches the maximum (or minimum) tap position, the wiper will not wrap around to the minimum (or maximum) position.

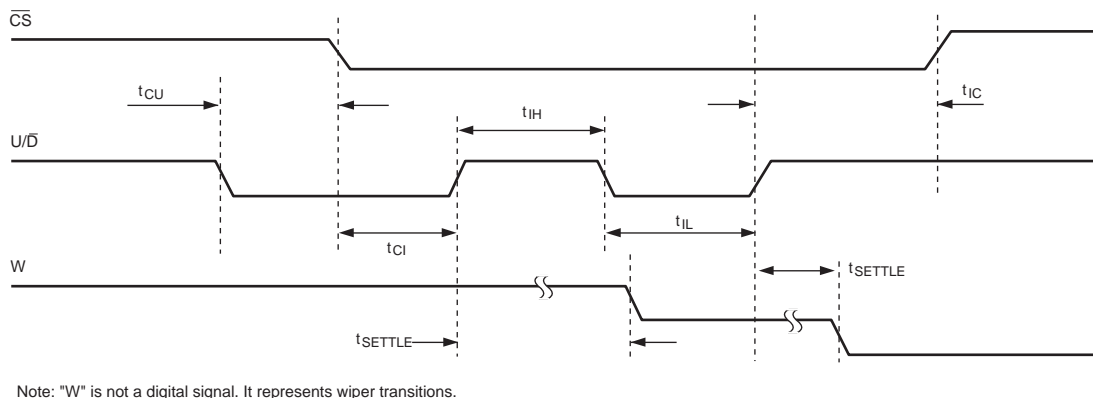
### POWER-ON RESET

All parts in this family feature power-on reset (POR) circuitry that sets the wiper position to midscale at power-up. By default, the chip is in the increment mode.

**Figure 1. Serial Interface Timing Diagram, Increment Mode**



**Figure 2. Serial Interface Timing Diagram, Decrement Mode**



**APPLICATIONS INFORMATION**

The Minipots are intended for circuits requiring digitally controlled adjustable resistance, such as LCD contrast control, where voltage biasing adjusts the display contrast.

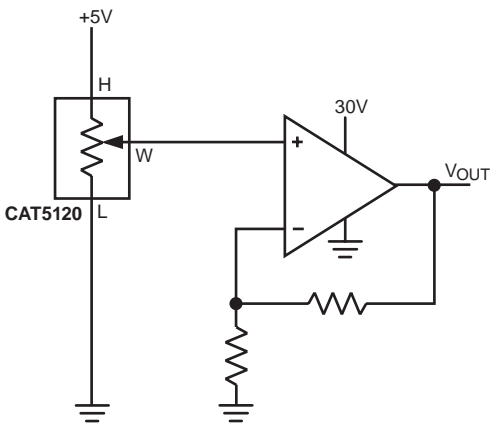
**ALTERNATIVE POSITIVE LCD BIAS CONTROL**

Use an op amp to provide buffering and gain on the output of the CAT5120. Connect the mechanical potentiometer to the positive input of a noninverting op amp (Figure 3) to select a portion of the input signal by digitally controlling the wiper terminal. Figure 4 shows a similar circuit for the CAT5121.

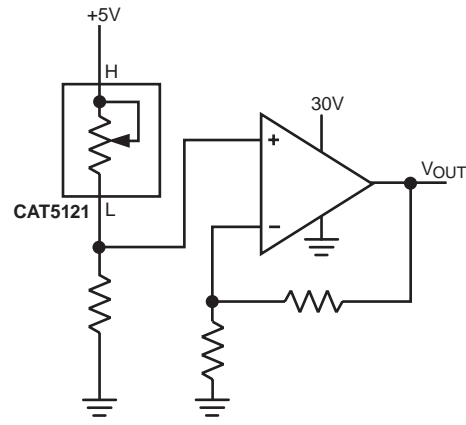
**ADJUSTABLE GAIN**

Figure 5 shows how to use the variable resistor to digitally adjust the gain of a noninverting op amp configuration. Connect the CAT5121 in series with a resistor to ground to form the adjustable gain control of a noninverting amplifier. The Minipots have a low 5ppm/°C ratiometric tempco that allows for a very stable adjustable gain configuration over temperature.

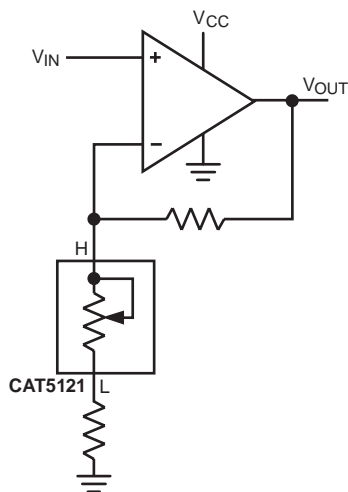
**Figure 3. Positive LCD Bias Control**



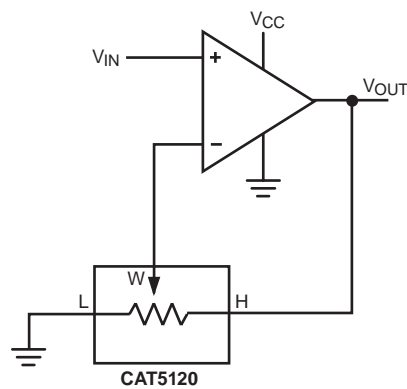
**Figure 4. Positive LCD Bias Control**



**Figure 5a. Adjustable Gain Circuit**



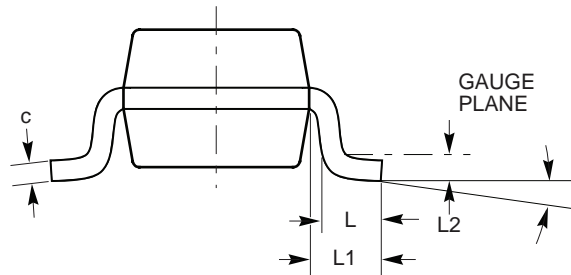
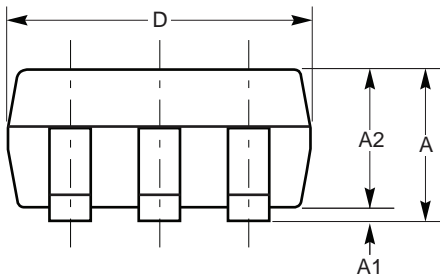
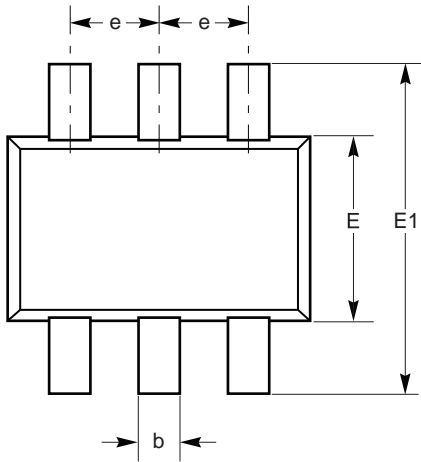
**Figure 5b. Adjustable Gain Circuit**



**CAT5120, CAT5121, CAT5122**

**PACKAGE INFORMATION**

**SC-70 6 LEAD**



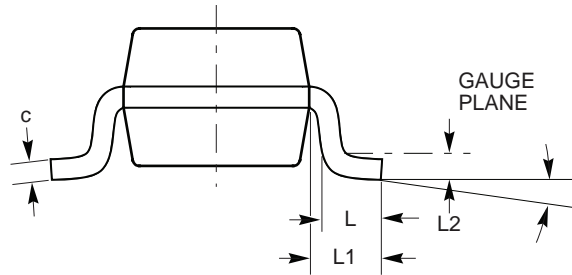
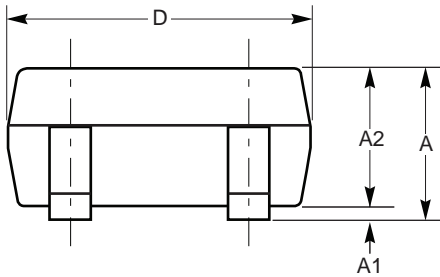
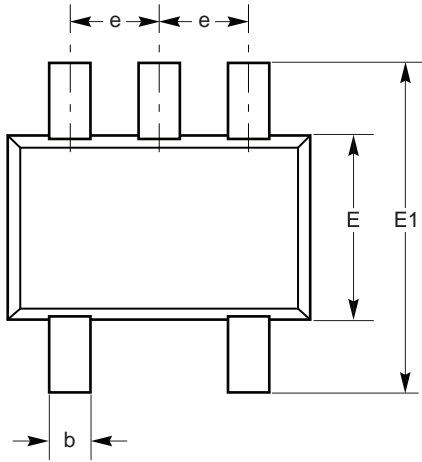
| SYMBOL | MIN      | NOM  | MAX  |
|--------|----------|------|------|
| A      | 0.80     |      | 1.10 |
| A1     | 0.00     |      | 0.10 |
| A2     | 0.70     | 0.90 | 1.00 |
| b      | 0.15     |      | 0.30 |
| c      | 0.08     | 0.20 | 0.25 |
| D      | 2.00 BSC |      |      |
| E      | 2.10 BSC |      |      |
| E1     | 1.25 BSC |      |      |
| e      | 0.65 BSC |      |      |
| L      | 0.26     | 0.36 | 0.46 |
| L1     | 0.42 REF |      |      |
| L2     | 0.15 BSC |      |      |
|        | 0°       |      | 8°   |

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**Notes:**

1. Dimension are in mm.
2. Dimension are inclusive of planting.
3. Dimension are exclusive of mold flash & metal burr.
4. All specification comply to JDEC M0-203

**SC-70 5 LEAD**



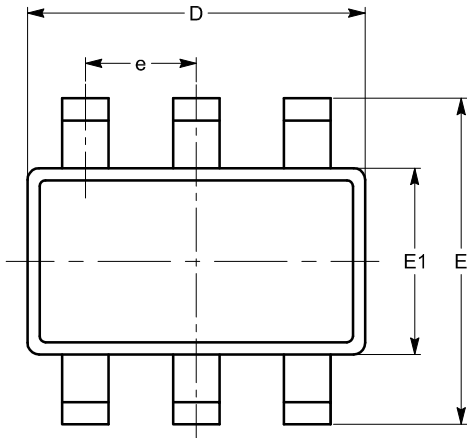
| SYMBOL | MIN  | NOM      | MAX  |
|--------|------|----------|------|
| A      | 0.80 |          | 1.10 |
| A1     | 0.00 |          | 0.10 |
| A2     | 0.80 |          | 1.00 |
| b      | 0.15 |          | 0.30 |
| c      | 0.10 |          | 0.18 |
| D      | 1.80 | 2.00     | 2.20 |
| E      | 1.15 | 1.25     | 1.35 |
| E1     | 1.80 | 2.10     | 2.40 |
| e      |      | 0.65 BSC |      |
| L      | 0.26 | 0.36     | 0.46 |
| L1     |      | 0.42 REF |      |
| L2     |      | 0.15 BSC |      |
|        | 0°   |          | 8°   |

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**Notes:**

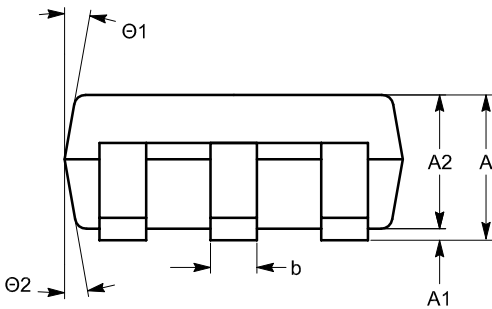
- (1) Dimension are in millimeter.
- (2) All specification comply to JDEC M0-203

**SOT-23 6 LEAD**

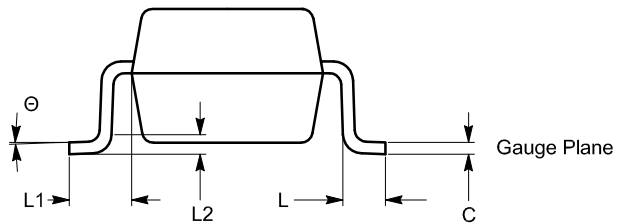


**TOP VIEW**

| SYMBOL     | MIN      | NOM  | MAX  |
|------------|----------|------|------|
| A          | 0.90     |      | 1.45 |
| A1         | 0.00     |      | 0.15 |
| A2         | 0.90     |      | 1.30 |
| b          | 0.30     |      | 0.50 |
| c          | 0.08     |      | 0.22 |
| D          | 2.90 BSC |      |      |
| E          | 2.80 BSC |      |      |
| E1         | 1.60 BSC |      |      |
| e          | 0.95 BSC |      |      |
| L          | 0.30     | 0.45 | 0.60 |
| L1         | 0.60 REF |      |      |
| L2         | 0.25 BSC |      |      |
| $\theta$   | 0°       |      | 8°   |
| $\theta 1$ |          | 10°  |      |
| $\theta 2$ |          | 10°  |      |



**SIDE VIEW**



**END VIEW**

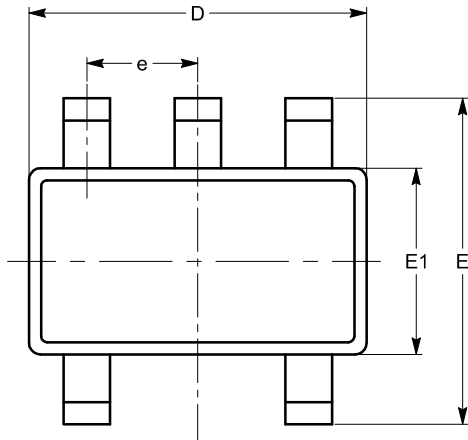
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**Notes:**

- (1) All dimensions in millimeters. Angles in degrees.
- (2) Complies with JEDEC standard MO-178.

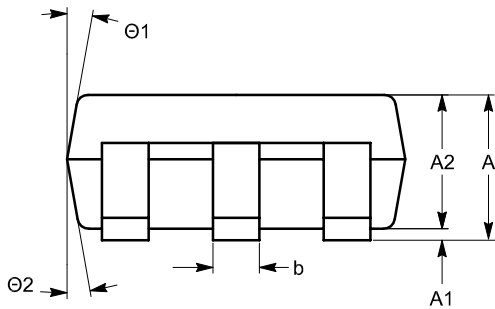


**SOT-23 5 LEAD**

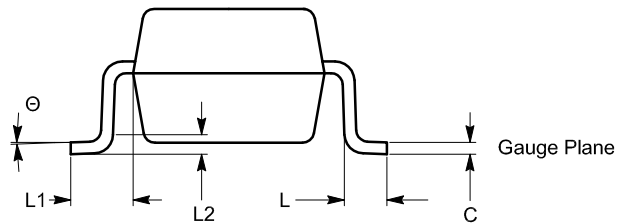


**TOP VIEW**

| SYMBOL     | MIN      | NOM  | MAX  |
|------------|----------|------|------|
| A          | 0.90     |      | 1.45 |
| A1         | 0.00     |      | 0.15 |
| A2         | 0.90     |      | 1.30 |
| b          | 0.30     |      | 0.50 |
| c          | 0.08     |      | 0.22 |
| D          | 2.90 BSC |      |      |
| E          | 2.80 BSC |      |      |
| E1         | 1.60 BSC |      |      |
| e          | 0.95 BSC |      |      |
| L          | 0.30     | 0.45 | 0.60 |
| L1         | 0.60 REF |      |      |
| L2         | 0.25 BSC |      |      |
| $\theta$   | 0°       |      | 8°   |
| $\theta 1$ |          | 10°  |      |
| $\theta 2$ |          | 10°  |      |



**SIDE VIEW**



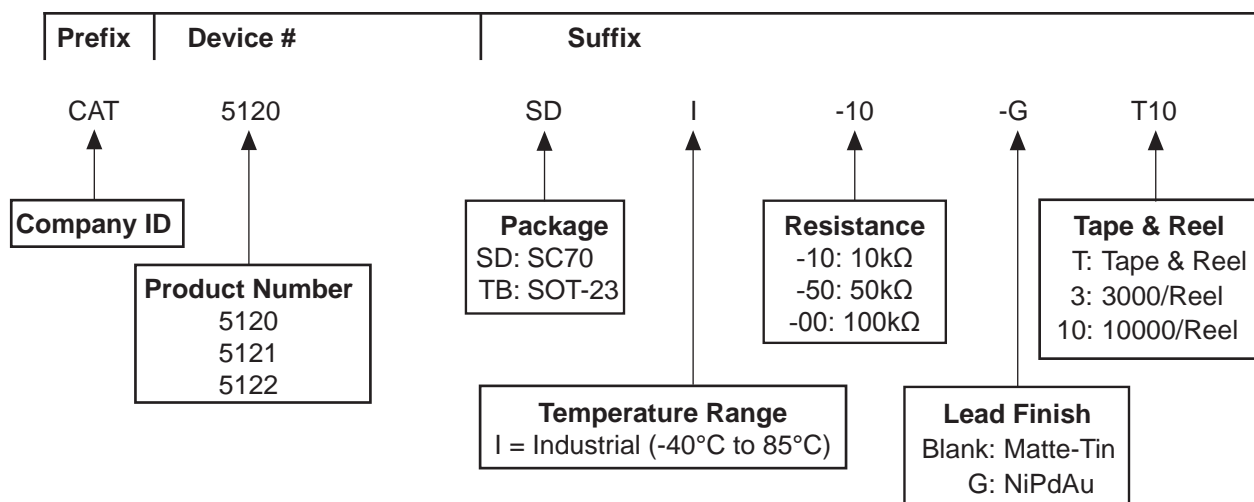
**END VIEW**

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**Notes:**

- (1) All dimensions in millimeters. Angles in degrees.
- (2) Complies with JEDEC standard MO-178.

**EXAMPLE OF ORDERING INFORMATION**



**Notes:**

- (1) All packages are RoHS-compliant (Lead-free, Halogen-free).
- (2) The standard lead finish is NiPdAu.
- (2) The device used in the example above is a CAT5120SDI-10-GT10 (SC70, Industrial Temperature range, NiPdAu, Tape and Reel).
- (3) For additional package and temperature options, please contact your nearest Catalyst Semiconductor Sales office.

**ORDERING INFORMATION**

| Part Number        | Resistor [kΩ] | Package Marking | Pin Package | Quantity per Reel |
|--------------------|---------------|-----------------|-------------|-------------------|
| CAT5120SDI-10-GT3  | 10            | KC_             | SC70-6      | 3,000             |
| CAT5120SDI-10-GT10 | 10            | KC_             | SC70-6      | 10,000            |
| CAT5120TBI-10-T3   | 10            | KCYM            | SOT23-6     | 3,000             |
| CAT5120TBI-10-T10  | 10            | KCYM            | SOT23-6     | 10,000            |
| CAT5120TBI-10-GT3  | 10            | KCYM            | SOT23-6     | 3,000             |
| CAT5120TBI-10-GT10 | 10            | KCYM            | SOT23-6     | 10,000            |
| CAT5120SDI-50-GT3  | 50            | KD_             | SC70-6      | 3,000             |
| CAT5120SDI-50-GT10 | 50            | KD_             | SC70-6      | 10,000            |
| CAT5120TBI-50-T3   | 50            | KDYM            | SOT23-6     | 3,000             |
| CAT5120TBI-50-T10  | 50            | KDYM            | SOT23-6     | 10,000            |
| CAT5120TBI-50-GT3  | 50            | KDYM            | SOT23-6     | 3,000             |
| CAT5120TBI-50-GT10 | 50            | KDYM            | SOT23-6     | 10,000            |
| CAT5120SDI-00-GT3  | 100           | KE_             | SC70-6      | 3,000             |
| CAT5120SDI-00-GT10 | 100           | KE_             | SC70-6      | 10,000            |
| CAT5120TBI-00-T3   | 100           | KEYM            | SOT23-6     | 3,000             |
| CAT5120TBI-00-T10  | 100           | KEYM            | SOT23-6     | 10,000            |
| CAT5120TBI-00-GT3  | 100           | KEYM            | SOT23-6     | 3,000             |
| CAT5120TBI-00-GT10 | 100           | KEYM            | SOT23-6     | 10,000            |
| CAT5121SDI-10-GT3  | 10            | KF_             | SC70-6      | 3,000             |
| CAT5121SDI-10-GT10 | 10            | KF_             | SC70-6      | 10,000            |
| CAT5121TBI-10-T3   | 10            | KFYM            | SOT23-6     | 3,000             |
| CAT5121TBI-10-T10  | 10            | KFYM            | SOT23-6     | 10,000            |
| CAT5121TBI-10-GT3  | 10            | KFYM            | SOT23-6     | 3,000             |
| CAT5121TBI-10-GT10 | 10            | KFYM            | SOT23-6     | 10,000            |
| CAT5121SDI-50-GT3  | 50            | KG_             | SC70-6      | 3,000             |
| CAT5121SDI-50-GT10 | 50            | KG_             | SC70-6      | 10,000            |
| CAT5121TBI-50-T3   | 50            | KGYM            | SOT23-6     | 3,000             |
| CAT5121TBI-50-T10  | 50            | KGYM            | SOT23-6     | 10,000            |
| CAT5121TBI-50-GT3  | 50            | KGYM            | SOT23-6     | 3,000             |
| CAT5121TBI-50-GT10 | 50            | KGYM            | SOT23-6     | 10,000            |
| CAT5121SDI-00-GT3  | 100           | KH_             | SC70-6      | 3,000             |
| CAT5121SDI-00-GT10 | 100           | KH_             | SC70-6      | 10,000            |
| CAT5121TBI-00-T3   | 100           | KHYM            | SOT23-6     | 3,000             |
| CAT5121TBI-00-T10  | 100           | KHYM            | SOT23-6     | 10,000            |
| CAT5121TBI-00-GT3  | 100           | KHYM            | SOT23-6     | 3,000             |
| CAT5121TBI-00-GT10 | 100           | KHYM            | SOT23-6     | 10,000            |

**CAT5120, CAT5121, CAT5122**
**ORDERING INFORMATION (CONTINUE)**

| Part Number        | Resistor [kΩ] | Package Marking | Pin Package | Quantity per Reel |
|--------------------|---------------|-----------------|-------------|-------------------|
| CAT5122SDI-10-GT3  | 10            | KY_             | SC70-5      | 3,000             |
| CAT5122SDI-10-GT10 | 10            | KY_             | SC70-5      | 10,000            |
| CAT5122TBI-10-T3   | 10            | KYYM            | SOT23-5     | 3,000             |
| CAT5122TBI-10-T10  | 10            | KYYM            | SOT23-5     | 10,000            |
| CAT5122TBI-10-GT3  | 10            | KYYM            | SOT23-5     | 3,000             |
| CAT5122TBI-10-GT10 | 10            | KYYM            | SOT23-5     | 10,000            |
| CAT5122SDI-50-GT3  | 50            | KA_             | SC70-5      | 3,000             |
| CAT5122SDI-50-GT10 | 50            | KA_             | SC70-5      | 10,000            |
| CAT5122TBI-50-T3   | 50            | KAYM            | SOT23-5     | 3,000             |
| CAT5122TBI-50-T10  | 50            | KAYM            | SOT23-5     | 10,000            |
| CAT5122TBI-50-GT3  | 50            | KAYM            | SOT23-5     | 3,000             |
| CAT5122TBI-50-GT10 | 50            | KAYM            | SOT23-5     | 10,000            |
| CAT5122SDI-00-GT3  | 100           | KB_             | SC70-5      | 3,000             |
| CAT5122SDI-00-GT10 | 100           | KB_             | SC70-5      | 10,000            |
| CAT5122TBI-00-T3   | 100           | KBYM            | SOT23-5     | 3,000             |
| CAT5122TBI-00-T10  | 100           | KBYM            | SOT23-5     | 10,000            |
| CAT5122TBI-00-GT3  | 100           | KBYM            | SOT23-5     | 3,000             |
| CAT5122TBI-00-GT10 | 100           | KBYM            | SOT23-5     | 10,000            |

## REVISION HISTORY

| Date       | Rev. | Reason   |
|------------|------|--|
| 03/10/2005 | A    | Initial Issue  |
| 09/27/2006 | B    | Update Electrical Characteristics  |
| 03/12/2007 | C    | Update Ordering Information<br>Update Package Outlines<br>Add Example of Ordering Information<br>Add SOT-23 5 Lead package drawing<br>Update SOT-23 6 Lead package drawing |

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