



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



## FEATURES

- 0.3µA Ultra-low standby current
- Single-supply operation: 2.7 V to 5.5 V
- Glitchless switching between resistor taps
- Power-on reset to midscale
- 2-wire up/down serial interface
- Resistance values: 10 kΩ, 50 kΩ and 100 kΩ
- Available in SC-70 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.

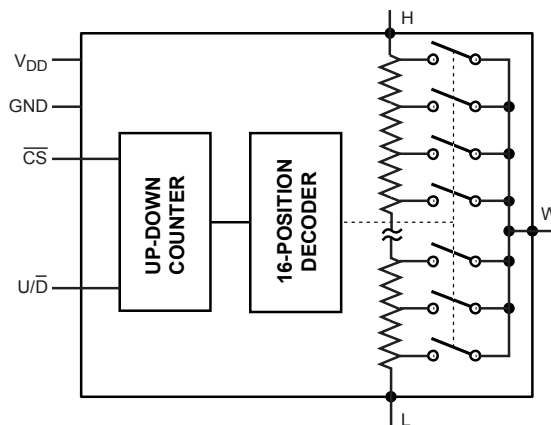
## DESCRIPTION

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.

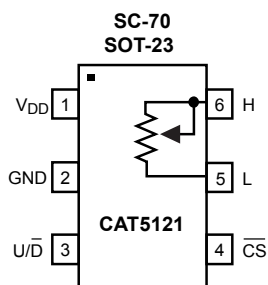
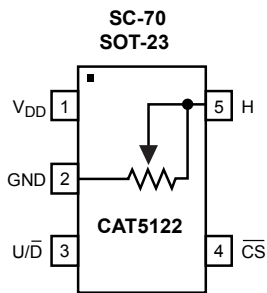
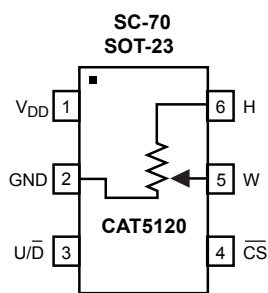
The CAT5120 is configured as a potentiometer. The CAT5121 and CAT5122 are configured as variable resistors. See *Pin Configurations* for part functionality.

Three resistance values are available: 10 kΩ, 50 kΩ and 100 kΩ. These are available in space-saving 5-pin and 6-pin SC-70 and SOT-23 packages.

## FUNCTIONAL DIAGRAM



## PIN CONFIGURATION



## 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

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

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

## ELECTRICAL CHARACTERISTICS

V<sub>DD</sub> = 2.7 V to 5.5 V, 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> = 2.7 V, 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

### Notes:

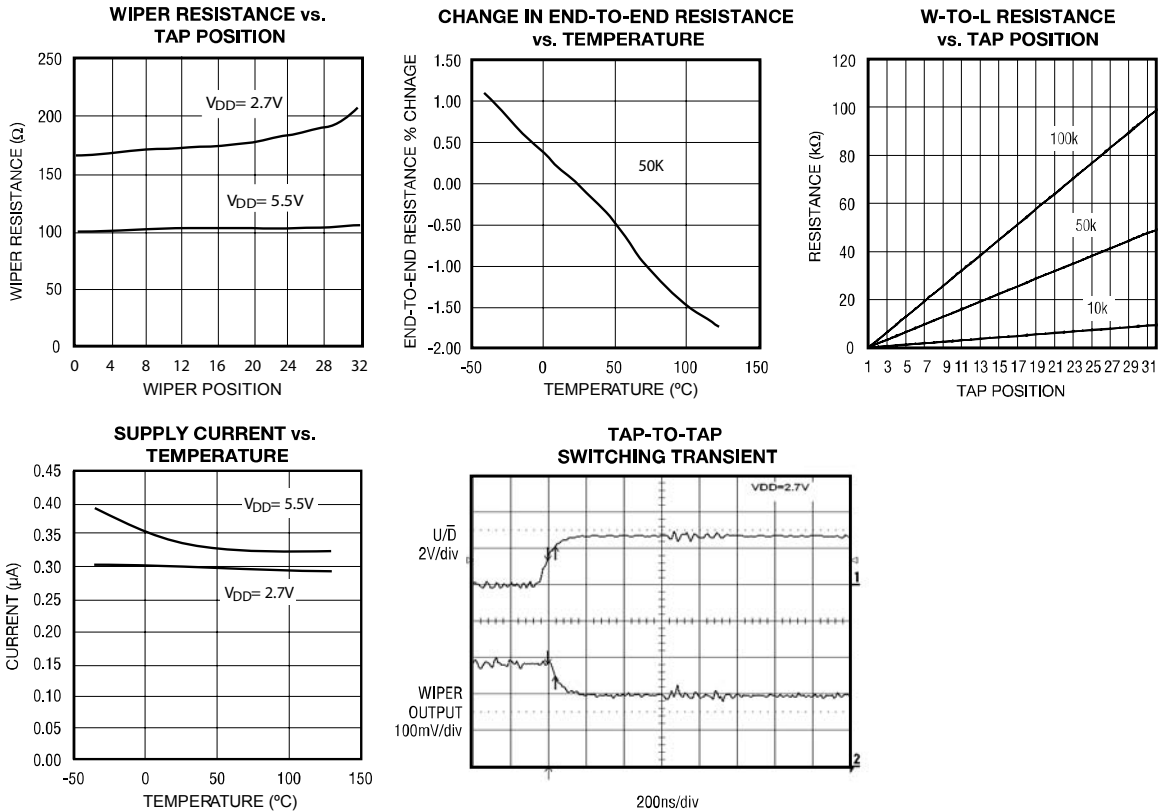
- (1) Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions outside of those listed in the operational sections of this specification is not implied. 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** (continued)

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

**TYPICAL OPERATING CHARACTERISTICS**

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



**Notes:**

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

## 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: 10 k $\Omega$ , 50 k $\Omega$  and 100 k $\Omega$ .

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.

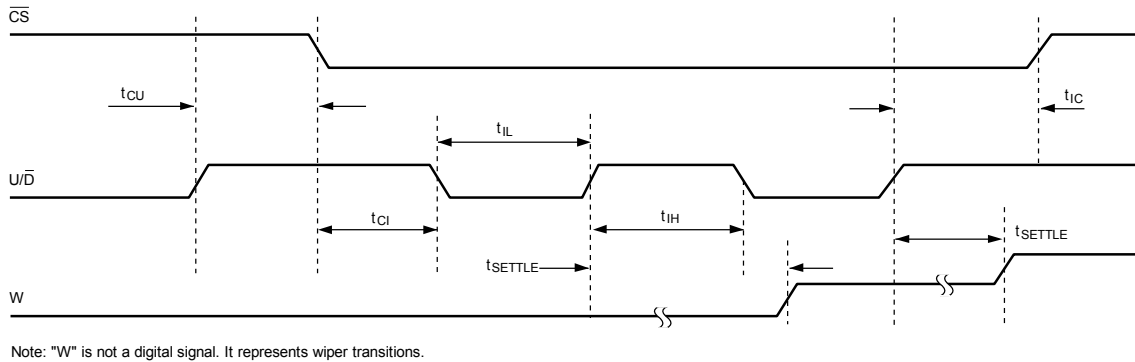


Figure 1. Serial Interface Timing Diagram, Increment Mode

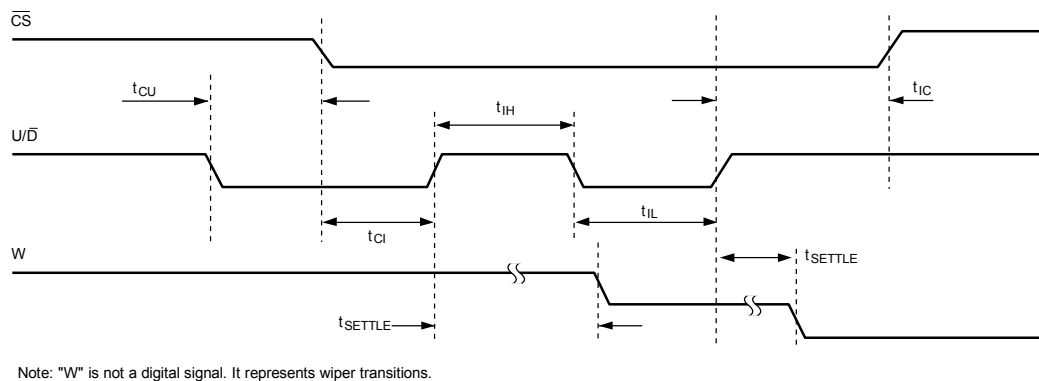


Figure 2. Serial Interface Timing Diagram, Decrement Mode

## 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.

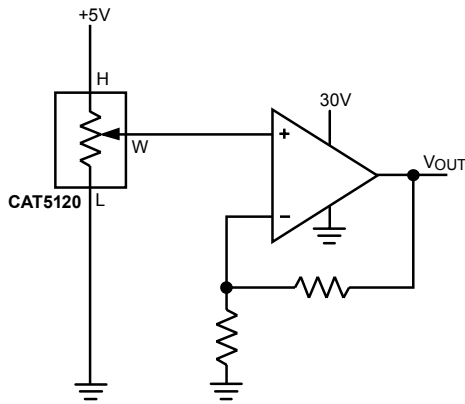


Figure 3. Positive LCD Bias Control

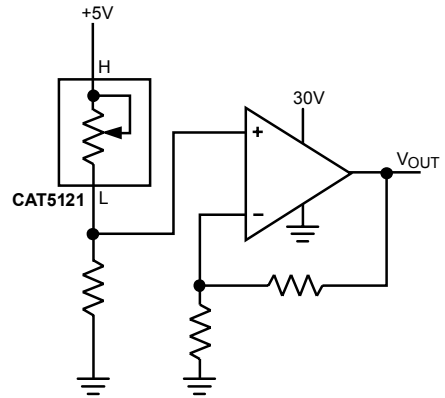


Figure 4. Positive LCD Bias Control

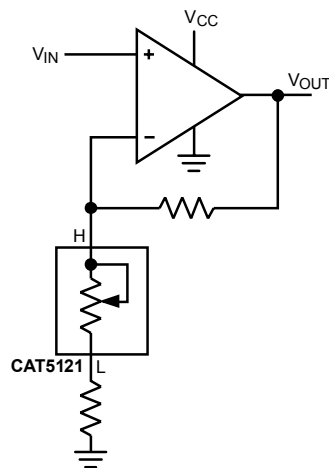


Figure 5a. Adjustable Gain Circuit

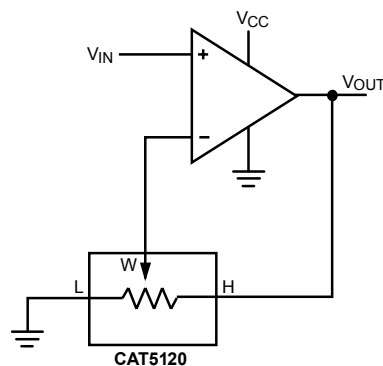
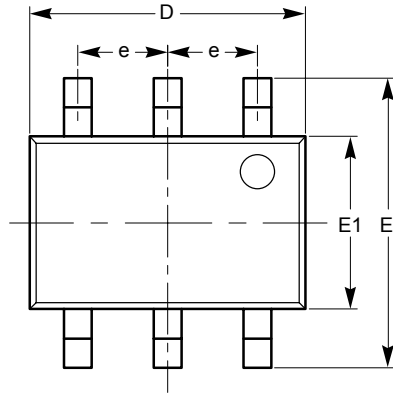


Figure 5b. Adjustable Gain Circuit

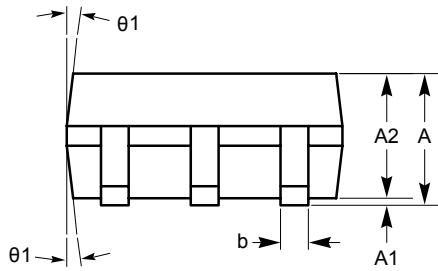
PACKAGE OUTLINE DRAWINGS

SC-70 6-Lead (SD) <sup>(1)(2)</sup>

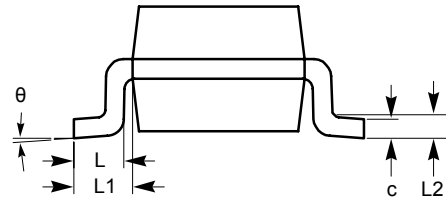


TOP VIEW

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	1.80	2.10	2.40
E1	1.15	1.25	1.35
e	0.65 BSC		
L	0.26	0.36	0.46
L1	0.42 REF		
L2	0.15 BSC		
$\theta$	0°		8°
$\theta_1$	4°		10°



SIDE VIEW

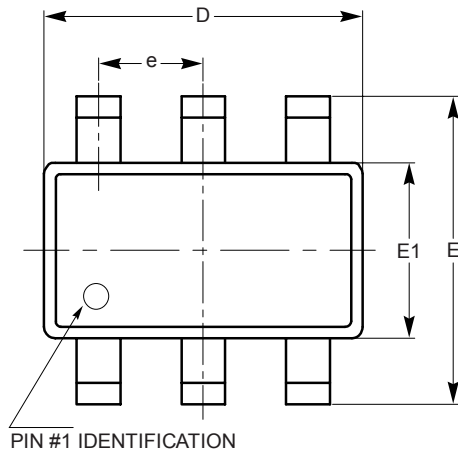


END VIEW

Notes:

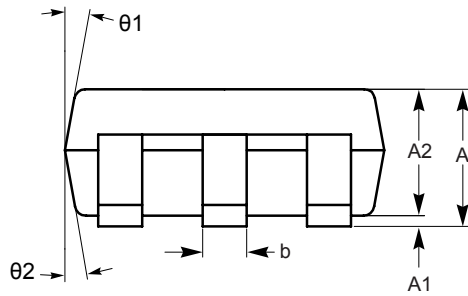
- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC standard MS-203.

SOT-23 6-Lead (TB) <sup>(1)(2)</sup>

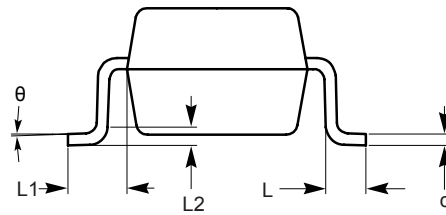


TOP VIEW

SYMBOL	MIN	NOM	MAX
A	0.90		1.45
A1	0.00		0.15
A2	0.90	1.15	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 REF		
$\theta$	0°	4°	8°
$\theta_1$	5°	10°	15°
$\theta_2$	5°	10°	15°



SIDE VIEW

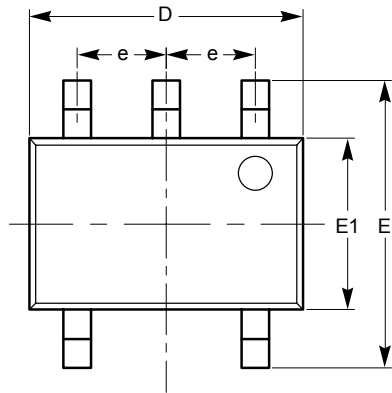


END VIEW

Notes:

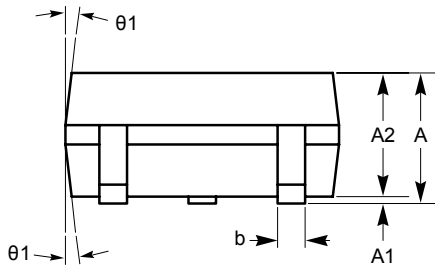
- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC standard MO-178.

SC-70 5-Lead (SD) <sup>(1)(2)</sup>

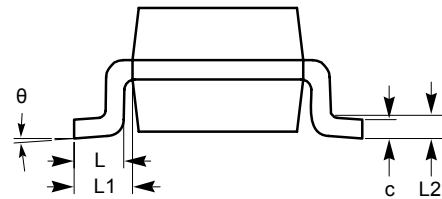


TOP VIEW

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	1.80	2.10	2.40
E1	1.15	1.25	1.35
e	0.65 BSC		
L	0.26	0.36	0.46
L1	0.42 REF		
L2	0.15 BSC		
$\theta$	0°		8°
$\theta_1$	4°		10°



SIDE VIEW



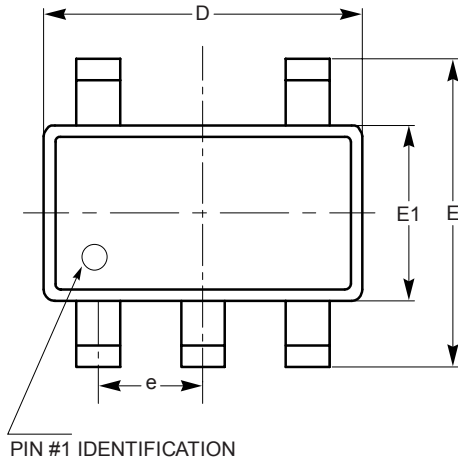
END VIEW

Notes:

- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC standard MS-203.

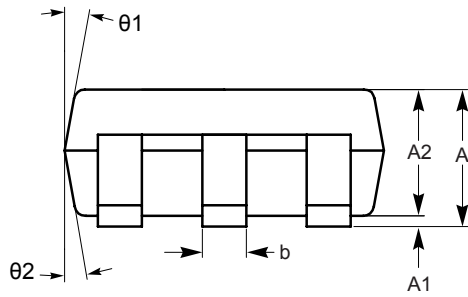


SOT-23 5-Lead (TB) <sup>(1)(2)</sup>

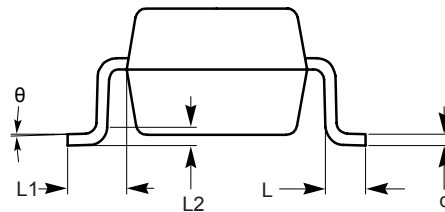


TOP VIEW

SYMBOL	MIN	NOM	MAX
A	0.90		1.45
A1	0.00		0.15
A2	0.90	1.15	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 REF		
$\theta$	0°	4°	8°
$\theta 1$	5°	10°	15°
$\theta 2$	5°	10°	15°



SIDE VIEW

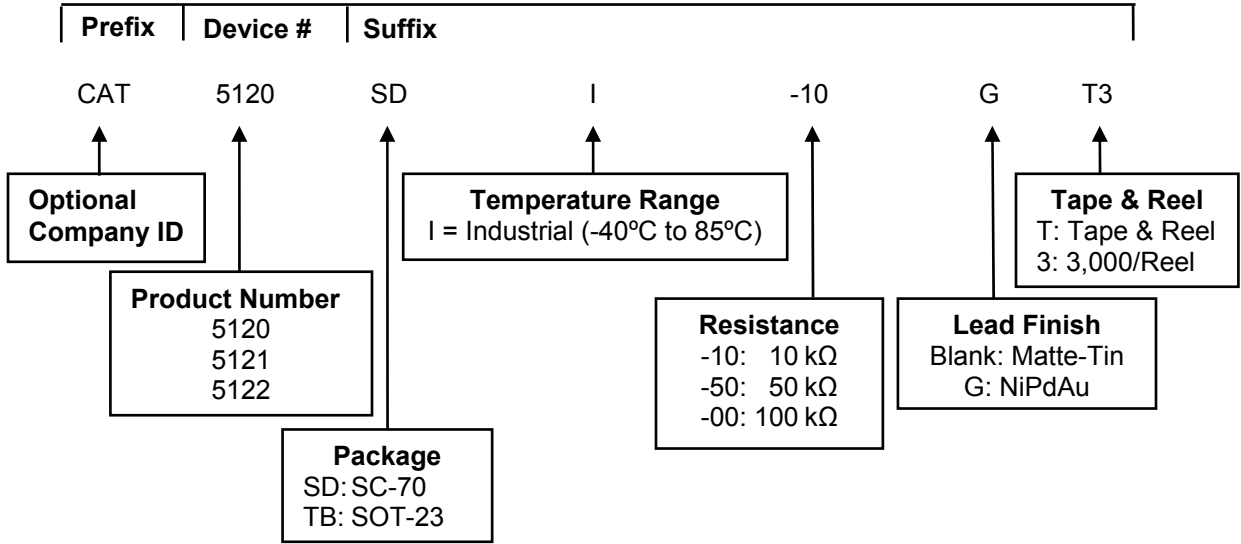


END VIEW

Notes:

- (1) All dimensions are 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 finish is NiPdAu.
- (3) The device used in the example above is a CAT5120SDI-10GT3 (SC-70, Industrial Temperature, 10 kΩ, NiPdAu, Tape & Reel, 3,000/Reel).
- (4) For additional package and temperature options, please contact your nearest ON Semiconductor Sales office.


## ORDERING INFORMATION

Orderable Part Number	Resistor [kΩ]	Pin Package	Quantity per Reel
CAT5120SDI-10GT3	10	SC70-6	3,000
CAT5120TBI-10-T3 <sup>(1)</sup>	10	SOT23-6	3,000
CAT5120TBI-10GT3	10	SOT23-6	3,000
CAT5120SDI-50GT3	50	SC70-6	3,000
CAT5120TBI-50-T3 <sup>(1)</sup>	50	SOT23-6	3,000
CAT5120TBI-50GT3	50	SOT23-6	3,000
CAT5120SDI-00GT3	100	SC70-6	3,000
CAT5120TBI-00-T3 <sup>(1)</sup>	100	SOT23-6	3,000
CAT5120TBI-00GT3	100	SOT23-6	3,000
CAT5121SDI-10GT3	10	SC70-6	3,000
CAT5121TBI-10-T3 <sup>(1)</sup>	10	SOT23-6	3,000
CAT5121TBI-10GT3	10	SOT23-6	3,000
CAT5121SDI-50GT3	50	SC70-6	3,000
CAT5121TBI-50-T3 <sup>(1)</sup>	50	SOT23-6	3,000
CAT5121TBI-50GT3	50	SOT23-6	3,000
CAT5121SDI-00GT3	100	SC70-6	3,000
CAT5121TBI-00-T3 <sup>(1)</sup>	100	SOT23-6	3,000
CAT5121TBI-00GT3	100	SOT23-6	3,000
CAT5122SDI-10GT3	10	SC70-5	3,000
CAT5122TBI-10-T3 <sup>(1)</sup>	10	SOT23-5	3,000
CAT5122TBI-10GT3	10	SOT23-5	3,000
CAT5122SDI-50GT3	50	SC70-5	3,000
CAT5122TBI-50-T3 <sup>(1)</sup>	50	SOT23-5	3,000
CAT5122TBI-50GT3	50	SOT23-5	3,000
CAT5122SDI-00GT3	100	SC70-5	3,000
CAT5122TBI-00-T3 <sup>(1)</sup>	100	SOT23-5	3,000
CAT5122TBI-00GT3	100	SOT23-5	3,000

(1) Part number is not exactly the same as the "Example of Ordering Information" shown on page 10. For part numbers marked with (1) there are two hyphens in the orderable part number.

**REVISION HISTORY**

Date	Rev.	Description
10-Mar-05	A	Initial Issue
27-Sep-06	B	Update Electrical Characteristics
12-Mar-07	C	Update Ordering Information Update Package Outlines Add Example of Ordering Information Add SOT-23 5 Lead package drawing Update SOT-23 6 Lead package drawing
12-Mar-08	D	Update Package Outline Drawings Update Ordering Information Add MD- to document number Add Top Mark Code link
29-May-08	E	Delete 10,000 per reel option Update Document Layout
21-Nov-08	F	Change logo and fine print to ON Semiconductor
013-Jul-09	G	Update Ordering Information table

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