

# CAT5120, CAT5121, CAT5122

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

### 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 k $\Omega$ , 50 k $\Omega$  and 100 k $\Omega$ . These are available in space-saving 5-pin and 6-pin SC-70 and SOT-23 packages.

### Features

- 0.3  $\mu$ A 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 k $\Omega$ , 50 k $\Omega$  and 100 k $\Omega$
- Available in SC-70 and SOT-23 Packages
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

### Applications

- LCD Screen Adjustment
- Volume Control
- Mechanical Potentiometer Replacement
- Gain Adjustment
- Line Impedance Matching



ON Semiconductor®

<http://onsemi.com>



SC-70  
SD SUFFIX  
CASE 419AD



SOT-23  
TB SUFFIX  
CASE 527AJ

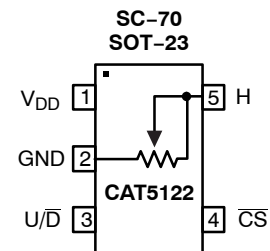
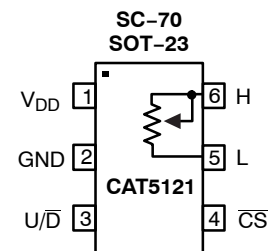
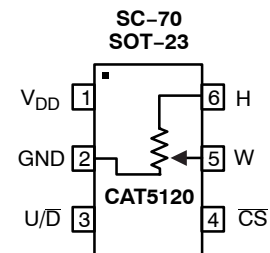


SC-70  
SD SUFFIX  
CASE 419AC



SOT-23  
TB SUFFIX  
CASE 527AH

### PIN CONFIGURATIONS



### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 7 of this data sheet.

# CAT5120, CAT5121, CAT5122

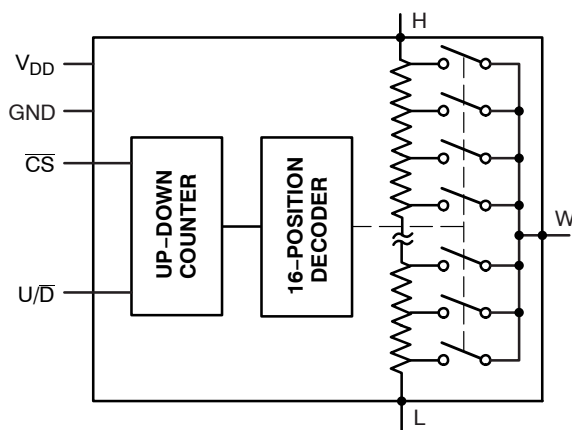


Figure 1. Functional Diagram

Table 1. PIN DESCRIPTIONS

Name	Description
V <sub>DD</sub>	Power Supply
GND	Ground
U/ $\bar{D}$	Up/ $\bar{D}$ own 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

Table 2. ABSOLUTE MAXIMUM RATINGS

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		mA
100 k $\Omega$	±0.6	
50 k $\Omega$	±1.3	
10 k $\Omega$	±1.3	
Continuous Power Dissipation (T <sub>A</sub> = +70°C)		mW
5-pin SC-70 (Note 1)	247	
6-pin SC-70 (Note 1)	245	
Operating Temperature Range	-40 to +85	°C
Junction Temperature	+150	°C
Storage Temperature Range	-65 to +150	°C
Soldering Temperature (soldering, 10 s)	+300	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Derate 3.1 mW/°C above T<sub>A</sub> = +70°C

# CAT5120, CAT5121, CAT5122

**Table 3. ELECTRICAL CHARACTERISTICS**

( $V_{DD} = 2.7\text{ V to }5.5\text{ V}$ ,  $V_H = V_{DD}$ ,  $V_L = 0$ ,  $T_A = -40^\circ\text{C to }+85^\circ\text{C}$ . Typical values are at  $V_{DD} = 2.7\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , 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	k $\Omega$
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	$TC_R$			200		ppm/ $^\circ\text{C}$
Ratiometric Resistance Tempco				5		ppm/ $^\circ\text{C}$
Integral Nonlinearity	INL				$\pm 0.5$	LSB
Differential Nonlinearity	DNL				$\pm 0.5$	LSB
Zero/Full-Scale Error				$\pm 0.1$	$\pm 0.5$	LSB
Wiper Resistance	$R_W$			200	600	$\Omega$

## DIGITAL INPUTS

Input High Voltage	$V_{IH}$		$0.7 \times V_{DD}$			V
Input Low Voltage	$V_{IL}$				$0.3 \times V_{DD}$	V

## TIMING CHARACTERISTICS (Figures 7, 8)

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	$t_{CH}$		25			ns
U/ $\bar{D}$ Step Low Period	$t_{L}$		25			ns
U/ $\bar{D}$ Step High Period	$t_{H}$		25			ns
Up/Down Toggle Rate (Note 2)	$f_{TOGGLE}$			1		MHz
Output Settling Time (Note 3)	$t_{SETTLE}$	100 k $\Omega$ variable resistor configuration, $C_L = 10\text{ pF}$		1		$\mu\text{s}$
		100 k $\Omega$ potentiometer configuration, $C_L = 10\text{ pF}$		0.25		

## POWER SUPPLY

Supply Voltage	$V_{DD}$		2.7		5.5	V
Active Supply Current (Note 4)	$I_{DD}$				25	$\mu\text{A}$
Standby Supply Current (Note 5)	$I_{SB}$	$V_{DD} = +5\text{ V}$		0.3	1	$\mu\text{A}$

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

# CAT5120, CAT5121, CAT5122

## TYPICAL OPERATING CHARACTERISTICS

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

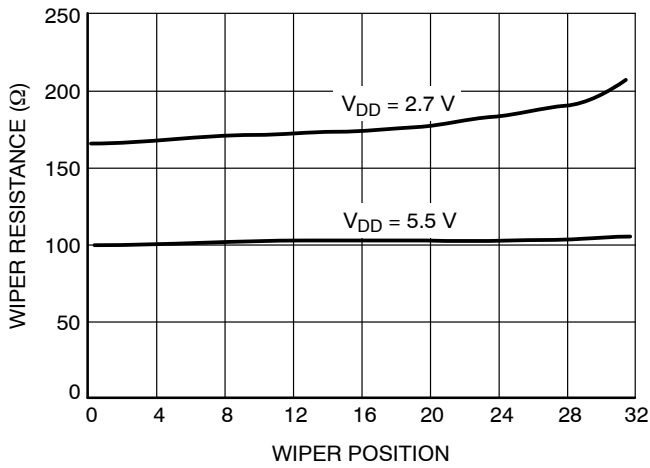


Figure 2. Wiper Resistance vs. Tap Position

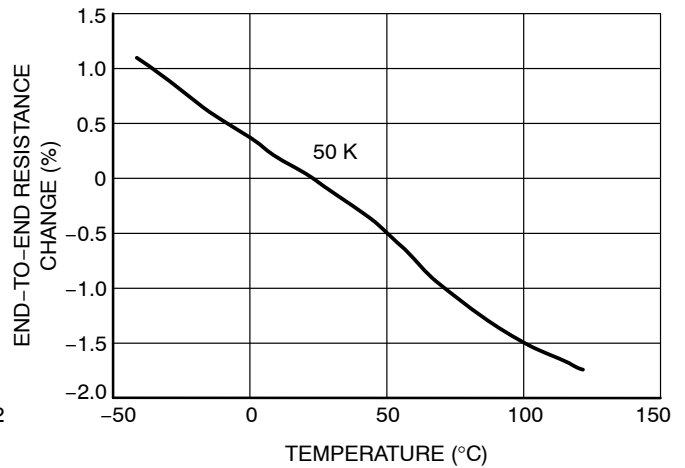


Figure 3. Change in End-to-End Resistance vs. Temperature

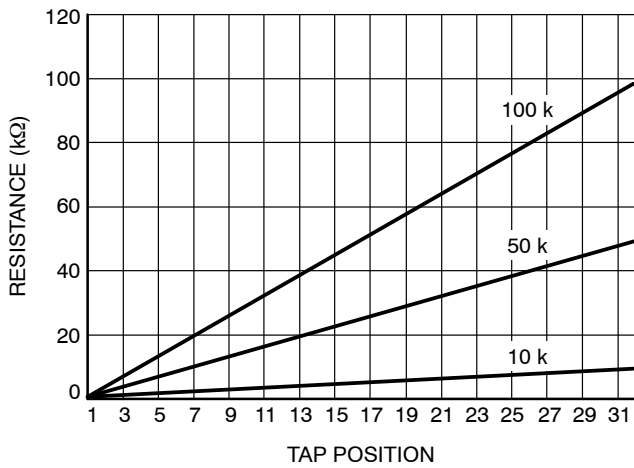


Figure 4. W-to-L Resistance vs. Tap Position

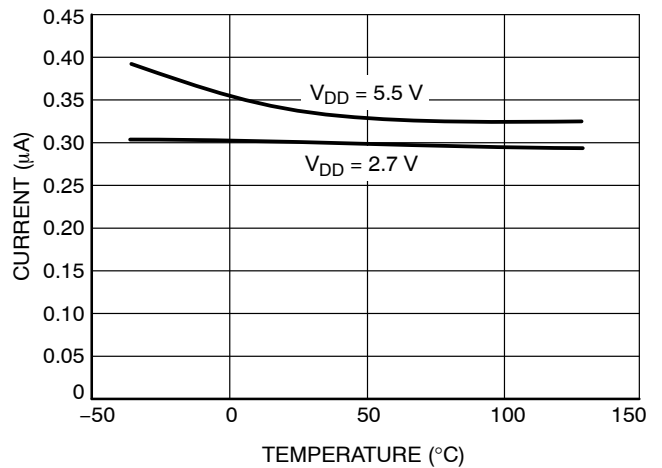


Figure 5. Supply Current vs. Temperature

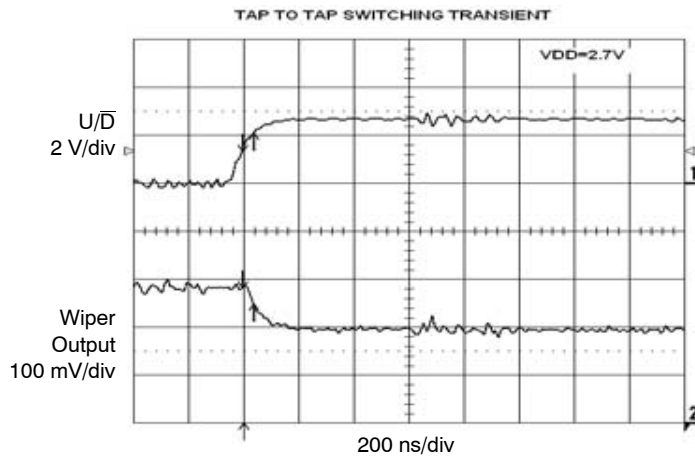


Figure 6. Tap-to-Tap Switching Transient

# 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: 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 devices 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 7 and 8).

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.

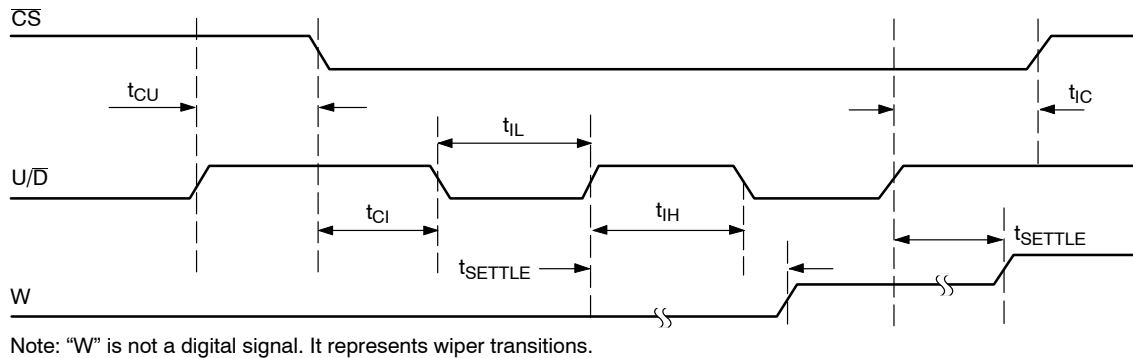


Figure 7. Serial Interface Timing Diagram, Increment Mode

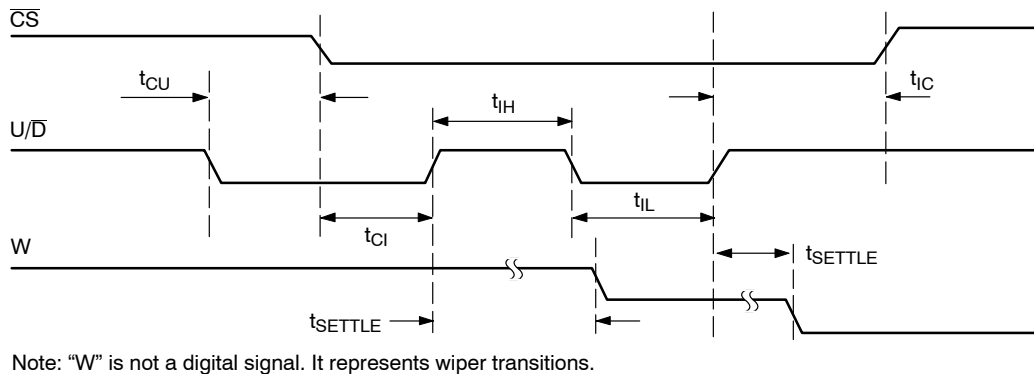


Figure 8. Serial Interface Timing Diagram, Decrement Mode

# CAT5120, CAT5121, CAT5122

## Applications Information

The devices 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 9) to select a portion of the input signal by digitally controlling the wiper terminal. Figure 10 shows a similar circuit for the CAT5121.

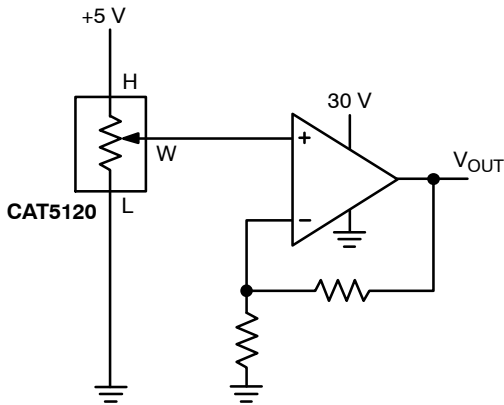


Figure 9. Positive LCD Bias Control

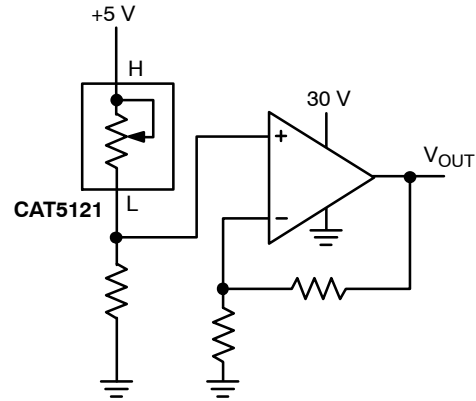


Figure 10. Positive LCD Bias Control

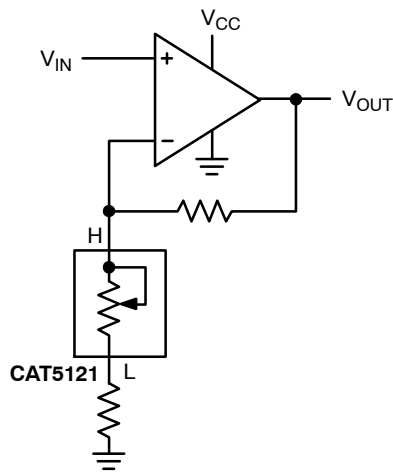


Figure 11. Adjustable Gain Circuit

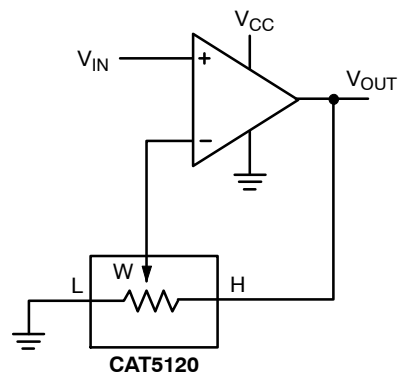


Figure 12. Adjustable Gain Circuit

### Adjustable Gain

Figures 11 and 12 show 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 devices have a low 5 ppm/°C ratiometric tempco that allows for a very stable adjustable gain configuration over temperature.

## CAT5120, CAT5121, CAT5122

**Table 4. ORDERING INFORMATION**

Orderable Part Number	Resistor [kΩ]	Package	Shipping <sup>†</sup>
CAT5120SDI-10GT3	10	SC70-6 (Pb-Free)	3000 / Tape & Reel
CAT5120TBI-10-T3	10	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5120TBI-10GT3	10	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5120SDI-50GT3	50	SC70-6 (Pb-Free)	3000 / Tape & Reel
CAT5120TBI-50-T3	50	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5120TBI-50GT3	50	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5120SDI-00GT3	100	SC70-6 (Pb-Free)	3000 / Tape & Reel
CAT5120TBI-00-T3	100	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5120TBI-00GT3	100	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5121SDI-10GT3	10	SC70-6 (Pb-Free)	3000 / Tape & Reel
CAT5121TBI-10-T3	10	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5121TBI-10GT3	10	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5121SDI-50GT3	50	SC70-6 (Pb-Free)	3000 / Tape & Reel
CAT5121TBI-50-T3	50	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5121TBI-50GT3	50	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5121SDI-00GT3	100	SC70-6 (Pb-Free)	3000 / Tape & Reel
CAT5121TBI-00-T3	100	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5121TBI-00GT3	100	SOT23-6 (Pb-Free)	3000 / Tape & Reel
CAT5122SDI-10GT3	10	SC70-5 (Pb-Free)	3000 / Tape & Reel
CAT5122TBI-10-T3	10	SOT23-5 (Pb-Free)	3000 / Tape & Reel
CAT5122TBI-10GT3	10	SOT23-5 (Pb-Free)	3000 / Tape & Reel
CAT5122SDI-50GT3	50	SC70-5 (Pb-Free)	3000 / Tape & Reel
CAT5122TBI-50-T3	50	SOT23-5 (Pb-Free)	3000 / Tape & Reel
CAT5122TBI-50GT3	50	SOT23-5 (Pb-Free)	3000 / Tape & Reel
CAT5122SDI-00GT3	100	SC70-5 (Pb-Free)	3000 / Tape & Reel
CAT5122TBI-00-T3	100	SOT23-5 (Pb-Free)	3000 / Tape & Reel
CAT5122TBI-00GT3	100	SOT23-5 (Pb-Free)	3000 / Tape & Reel

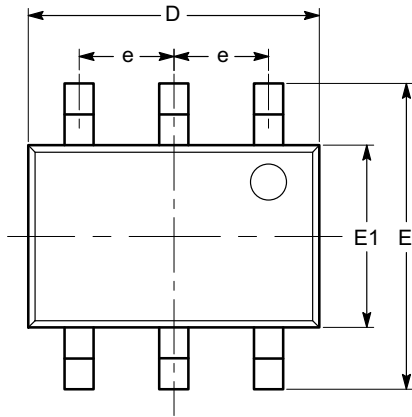
<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

6. For detailed information and a breakdown of device nomenclature and numbering systems, please see the ON Semiconductor Device Nomenclature document, TND310/D, available at [www.onsemi.com](http://www.onsemi.com).

# CAT5120, CAT5121, CAT5122

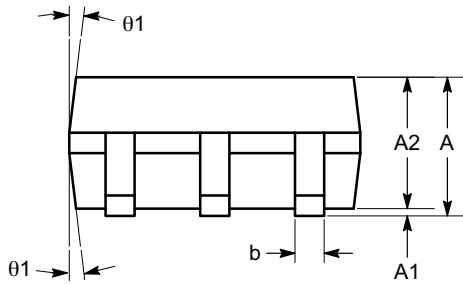
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SC-88 (SC-70 6 Lead), 1.25x2  
 CASE 419AD-01  
 ISSUE A

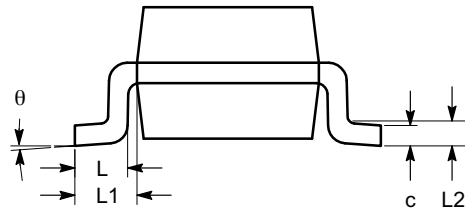


TOP VIEW

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:**

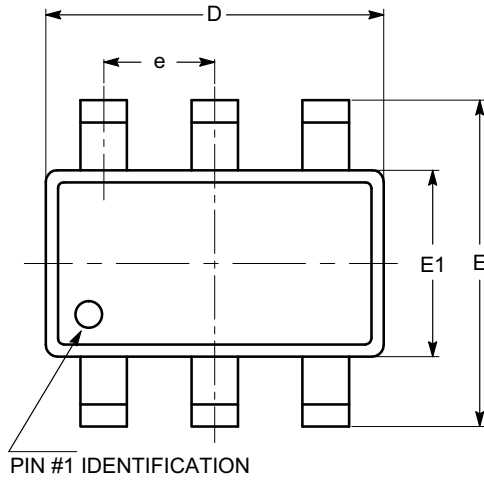
- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MO-203.



# CAT5120, CAT5121, CAT5122

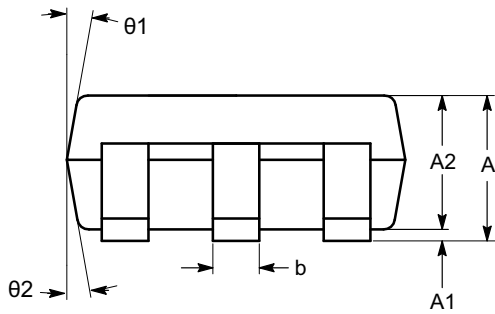
## PACKAGE DIMENSIONS

SOT-23, 6 Lead  
CASE 527AJ-01  
ISSUE O

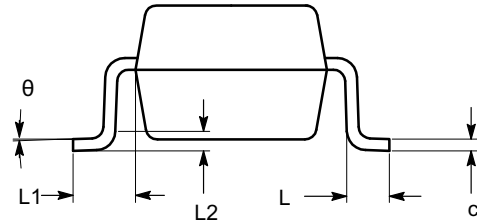


TOP VIEW

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



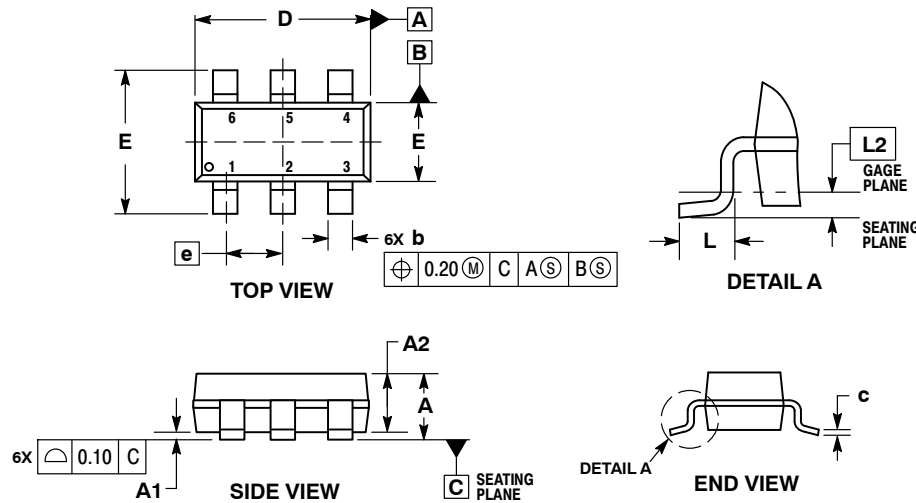
END VIEW

**Notes:**

- (1) All dimensions in millimeters. Angles in degrees.
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# CAT5120, CAT5121, CAT5122

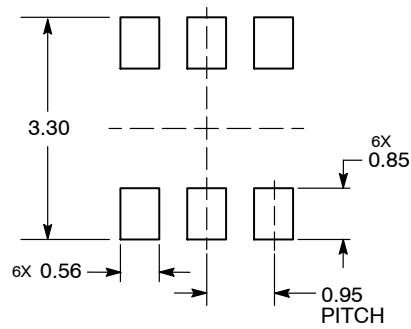
SOT-23, 6 Lead  
CASE 527AJ-01  
ISSUE A



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  2. CONTROLLING DIMENSION: MILLIMETERS.
  3. DATUM C IS THE SEATING PLANE.

MILLIMETERS		
DIM	MIN	MAX
A	---	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.20	0.50
c	0.08	0.26
D	2.70	3.00
E	2.50	3.10
E1	1.30	1.80
e	0.95 BSC	
L	0.20	0.60
L2	0.25 BSC	

## RECOMMENDED SOLDERING FOOTPRINT\*



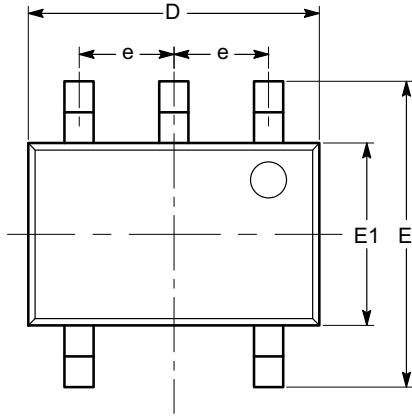
DIMENSIONS: MILLIMETERS

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# CAT5120, CAT5121, CAT5122

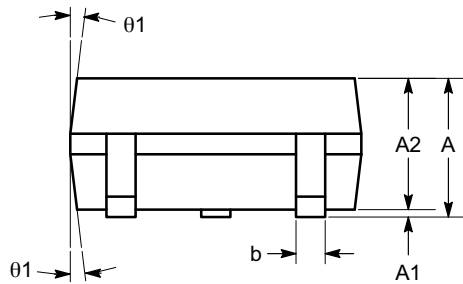
## PACKAGE DIMENSIONS

SC-88A (SC-70 5 Lead), 1.25x2  
CASE 419AC-01  
ISSUE A

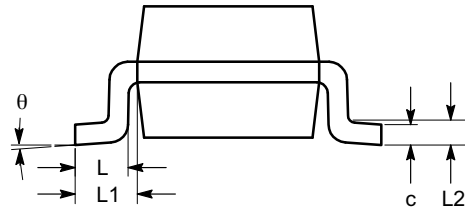


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$\theta$	0°		8°
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SIDE VIEW



END VIEW

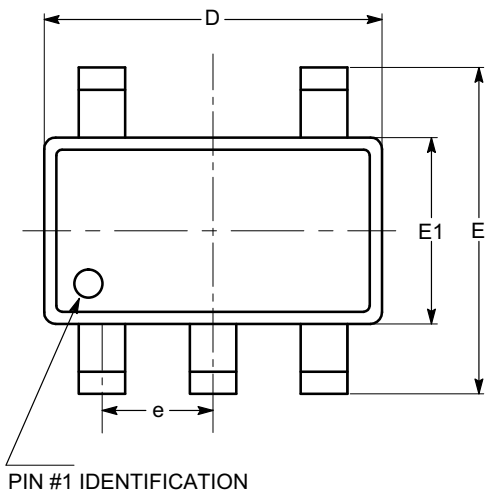
**Notes:**

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

# CAT5120, CAT5121, CAT5122

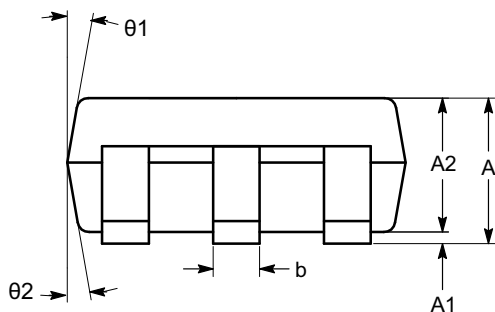
## PACKAGE DIMENSIONS

SOT-23, 5 Lead  
CASE 527AH-01  
ISSUE O

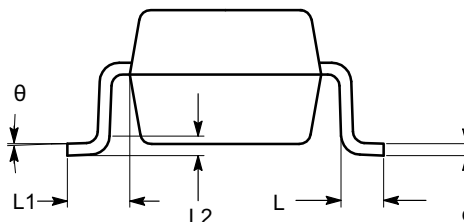


TOP VIEW

SYMBOL	MIN	NOM	MAX
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E	2.80 BSC		
E1	1.60 BSC		
e	0.95 BSC		
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L1	0.60 REF		
L2	0.25 REF		
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$\theta 1$	5°	10°	15°
$\theta 2$	5°	10°	15°



SIDE VIEW



END VIEW

**Notes:**

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

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