



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



## FEATURES

- 0.3µA Ultra-low standby 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
- Low wiper resistance: 80Ω for CAT5123, CAT5124, CAT5125
- CAT5110, CAT5118, CAT5119 available in SC-70

## APPLICATIONS

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

For Ordering Information details, see page 11.

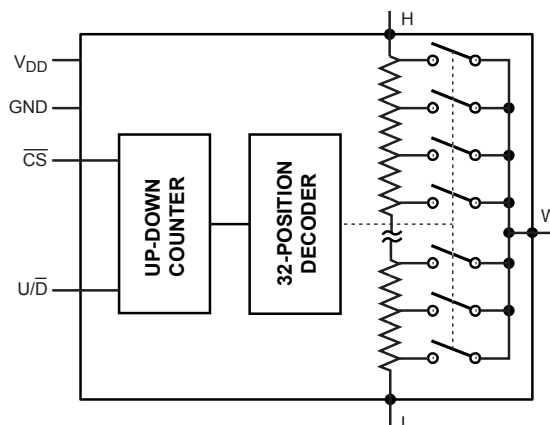
## DESCRIPTION

CAT5110/18/19/23/24/25 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 32-tap points that are digitally controlled through a 2-wire up/down serial interface.

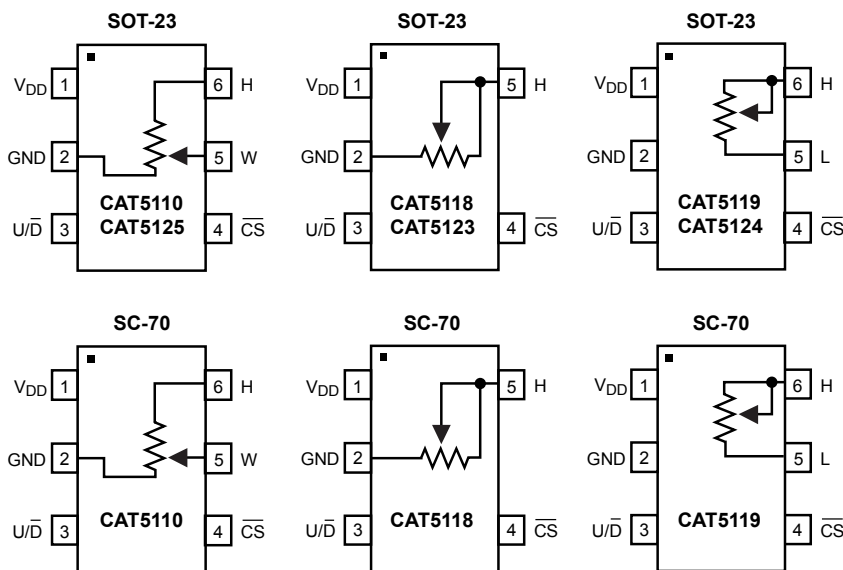
The CAT5110 and CAT5125 are configured as potentiometers. The CAT5118/19/23/24 are configured as variable resistors.

Three resistance values are available: 10kΩ, 50kΩ and 100kΩ. All devices are available in space-saving 5-pin and 6-pin SOT-23 packages. The CAT5110/18/19 are also available in the SC-70 package.

## FUNCTIONAL DIAGRAM



## PIN CONFIGURATION



**PIN DESCRIPTIONS**

Pin Number			Pin Name	Description
CAT5110/ CAT5125	CAT5118/ CAT5123	CAT5119/ CAT5124		
1	1	1	V <sub>DD</sub>	Power Supply
2	2	2	GND	Ground
3	3	3	U/ $\overline{D}$	Up/ $\overline{\text{Down}}$ Control Input. With $\overline{\text{CS}}$ low, a low-to-high transition increments or decrements the wiper position.
4	4	4	$\overline{\text{CS}}$	Chip Select Input. A high-to-low $\overline{\text{CS}}$ transition determines the mode: increment if U/ $\overline{D}$ is high, or decrement if U/ $\overline{D}$ is low.
-	-	5	L	Low Terminal of Resistor
5	-	-	W	Wiper Terminal of Resistor
6	6	6	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, 10sec)	+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

$V_{DD} = 2.7V$  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>DC Performance</b>						
Resolution			32			Taps
End-to-End Resistance (-00)			80	100	120	k $\Omega$
End-to-End Resistance (-50)			40	50	60	
End-to-End Resistance (-10)			8	10	12	
End-to-End Resistance Tempco	$TC_R$	CAT5110/18/19		200		ppm/ $^{\circ}C$
		CAT5123/24/25		30	300	
Ratiometric Resistance Tempco				5		ppm/ $^{\circ}C$
Integral Nonlinearity	INL			$\pm 0.5$	$\pm 1$	LSB
Differential Nonlinearity	DNL				$\pm 1$	LSB
Full-Scale Error				$\pm 0.1$		LSB
Zero-Scale Error					1	LSB
Wiper Resistance	$R_W$	CAT5110/18/19		200	600	$\Omega$
		CAT5123/24/25		80	200	
<b>Digital Inputs</b>						
Input High Voltage	$V_{IH}$		$0.7 \times V_{DD}$			V
Input Low Voltage	$V_{IL}$				$0.3 \times V_{DD}$	V
<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/Down 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>	$I_{SB}$	$V_{DD} = +5V$		0.3	1	$\mu A$

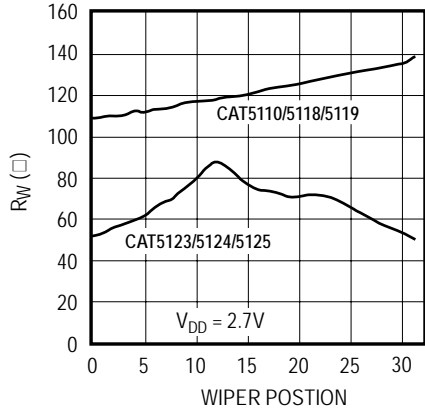
**Notes:**

- (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,  $f_{TOGGLE} = 1MHz$ .
- (4) Supply current measured while wiper position is fixed.

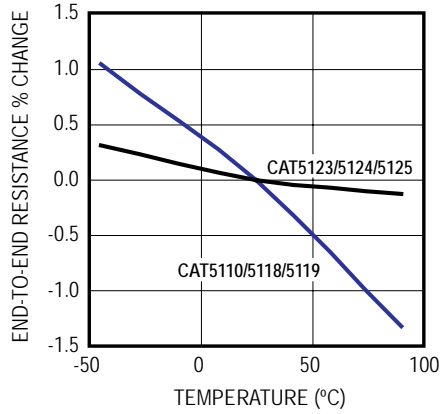
## TYPICAL OPERATING CHARACTERISTICS

T<sub>A</sub> = 25°C, unless otherwise noted.

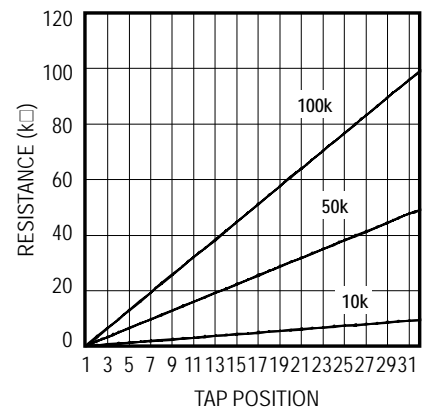
**WIPER RESISTANCE vs. WIPER POSITION**



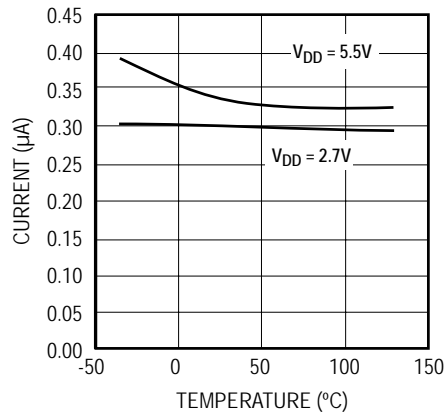
**CHANGE IN END-TO-END RESISTANCE vs. TEMPERATURE**



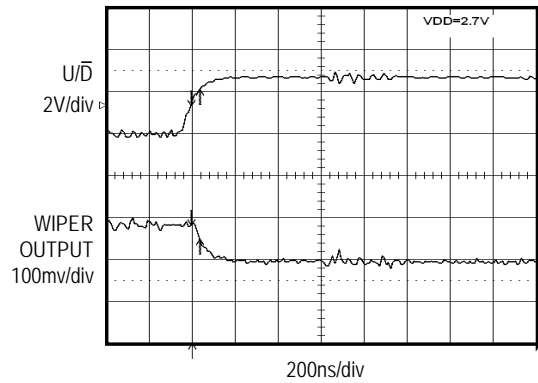
**W-T-O-L RESISTANCE vs. TAP POSITION**



**SUPPLY CURRENT vs. TEMPERATURE**



**TAP-TO-TAP SWITCHING TRANSIENT**



## FUNCTIONAL DESCRIPTION

The CAT5110/5118/5119/5123/5124/5125 consist of a fixed resistor and a wiper contact with 32-tap points that are digitally controlled through a 2-wire up/down serial interface. Three end-to-end resistance values are available: 10kΩ, 50kΩ and 100kΩ.

The CAT5110/5125 is designed to operate as a potentiometer. In this configuration, the low terminal of the resistor array is connected to ground (pin 2).

The CAT5118/5123 performs as a variable resistor. In this device, the wiper terminal and high terminal of the resistor array are connected at pin 5. The CAT5119/5124 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.

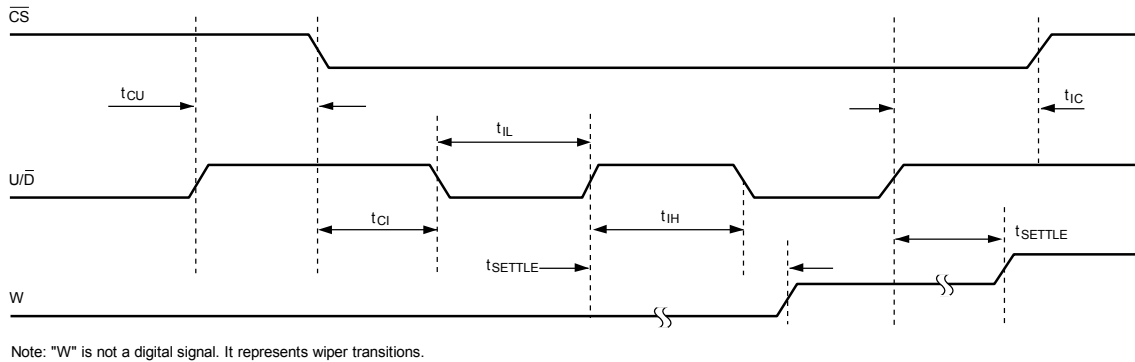


Figure 1. Serial Interface Timing Diagram, Increment Mode

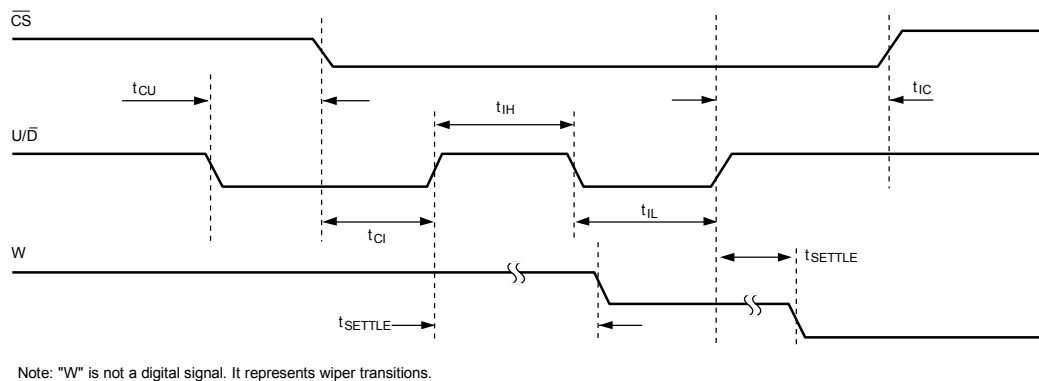


Figure 2. Serial Interface Timing Diagram, Decrement Mode

## 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

An op amp can be used to provide buffering and gain on the output of the CAT5110/CAT5125. This can be done by connecting the wiper output to the positive input of a noninverting op amp as shown in Figure 3. Figure 4 shows a similar circuit for the CAT5119/CAT5124.

### Adjustable Gain

Figure 5 shows how to use either a variable resistor or a potentiometer to digitally adjust the gain of a noninverting op amp configuration, by connecting the Minipot in series with a resistor to ground. The MiniPots have a low 5ppm/°C ratiometric tempo that allows for a very stable adjustable gain configuration over temperature.

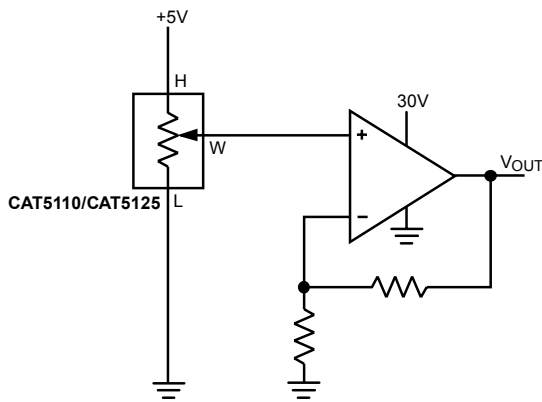


Figure 3. Positive LCD Bias Control

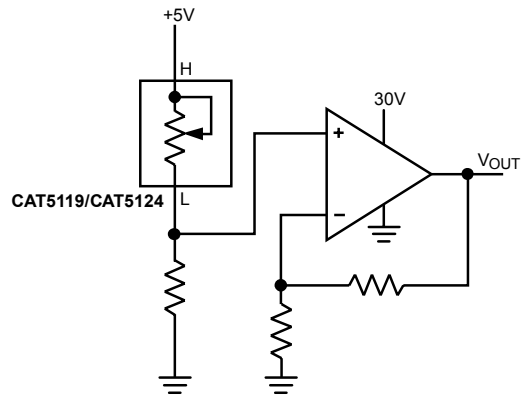


Figure 4. Positive LCD Bias Control

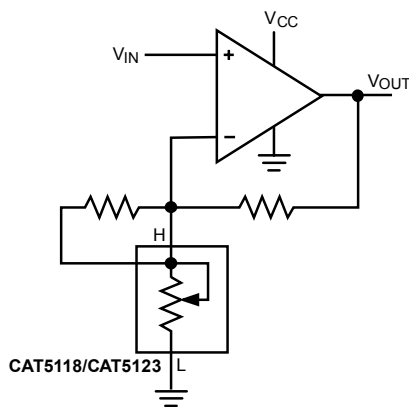


Figure 5a. Adjustable Gain Circuit

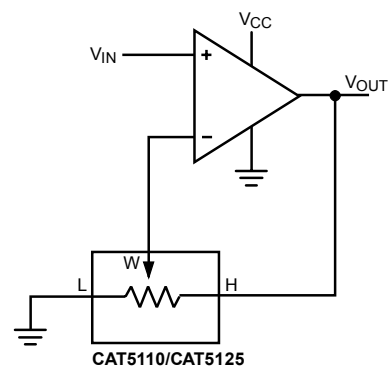
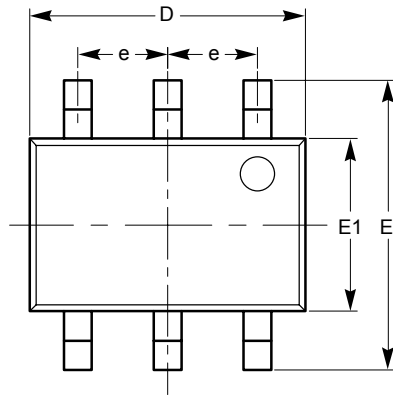


Figure 5b. Adjustable Gain Circuit

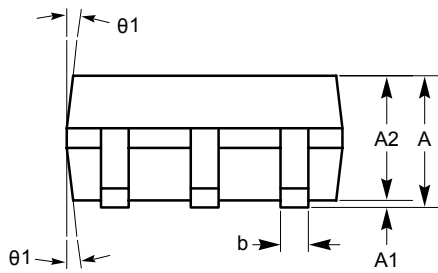
PACKAGE OUTLINE DRAWINGS

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

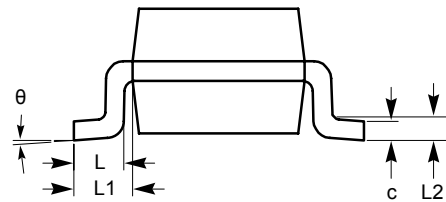


TOP VIEW

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

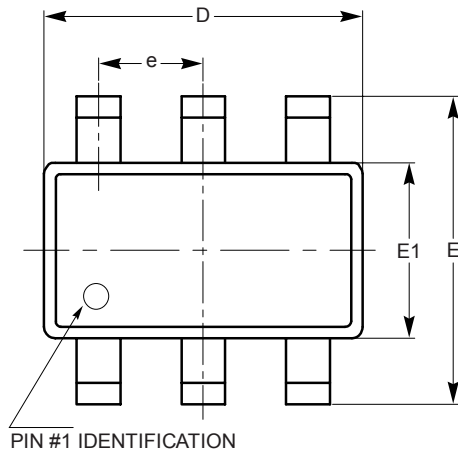


END VIEW

Notes:

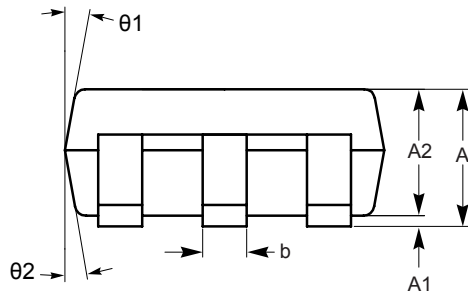
- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC standard MS-203.

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

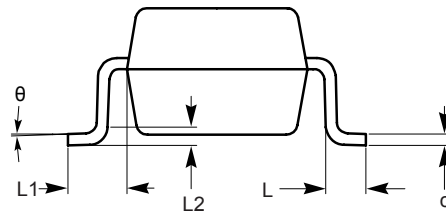


TOP VIEW

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



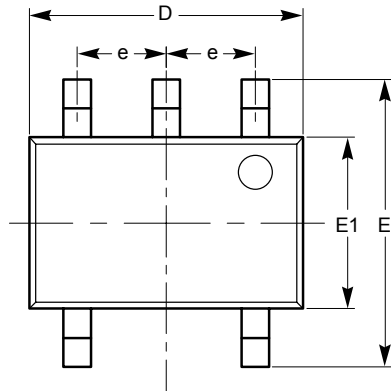
END VIEW

Notes:

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

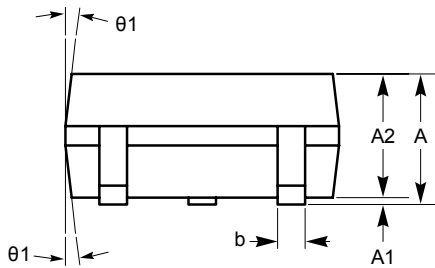


SC-70 5-Lead (SD) <sup>(1)(2)</sup>

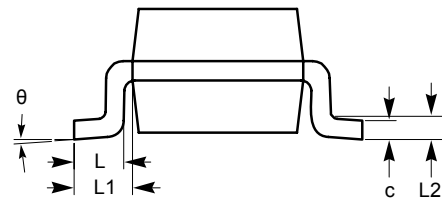


TOP VIEW

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

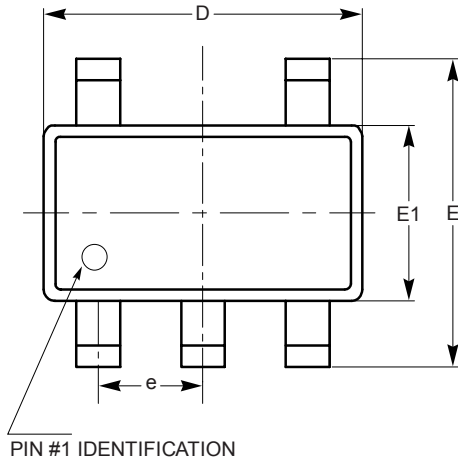


END VIEW

Notes:

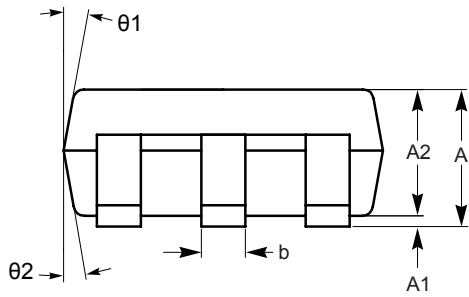
- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC standard MS-203.

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

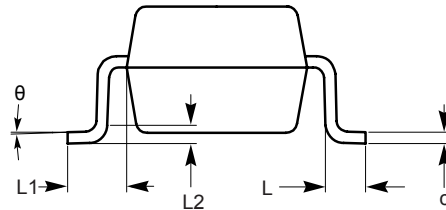


TOP VIEW

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

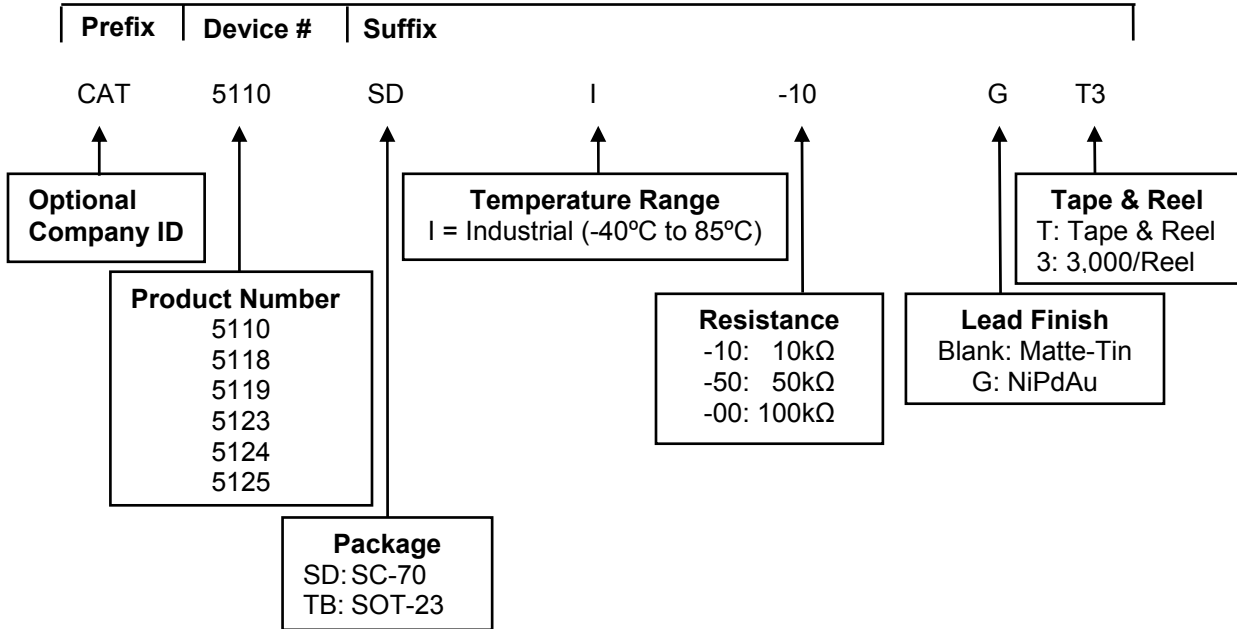


END VIEW

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 CAT5110SDI-10GT3 (SC-70, Industrial Temperature, 10kΩ, NiPdAu, Tape & Reel, 3,000/Reel).
- (4) For additional package and temperature options, please contact your nearest ON Semiconductor Sales office.

**ORDERING INFORMATION**

Device	Orderable Part Number	Resistor [kΩ]	Pin Package	Parts Per Reel
<b>CAT5110</b>	CAT5110SDI-10GT3	10	SC70-6	3,000
	CAT5110TBI-10-T3 <sup>(1)</sup>	10	SOT23-6	3,000
	CAT5110TBI-10GT3	10	SOT23-6	3,000
	CAT5110SDI-50GT3	50	SC70-6	3,000
	CAT5110TBI-50-T3 <sup>(1)</sup>	50	SOT23-6	3,000
	CAT5110TBI-50GT3	50	SOT23-6	3,000
	CAT5110SDI-00GT3	100	SC70-6	3,000
	CAT5110TBI-00-T3 <sup>(1)</sup>	100	SOT23-6	3,000
	CAT5110TBI-00GT3	100	SOT23-6	3,000
<b>CAT5118</b>	CAT5118SDI-10GT3	10	SC70-5	3,000
	CAT5118TBI-10-T3 <sup>(1)</sup>	10	SOT23-5	3,000
	CAT5118TBI-10GT3	10	SOT23-5	3,000
	CAT5118SDI-50GT3	50	SC70-5	3,000
	CAT5118TBI-50-T3 <sup>(1)</sup>	50	SOT23-5	3,000
	CAT5118TBI-50GT3	50	SOT23-5	3,000
	CAT5118SDI-00GT3	100	SC70-5	3,000
	CAT5118TBI-00-T3 <sup>(1)</sup>	100	SOT23-5	3,000
	CAT5118TBI-00GT3	100	SOT23-5	3,000
<b>CAT5119</b>	CAT5119SDI-10GT3	10	SC70-6	3,000
	CAT5119TBI-10-T3 <sup>(1)</sup>	10	SOT23-6	3,000
	CAT5119TBI-10GT3	10	SOT23-6	3,000
	CAT5119SDI-50GT3	50	SC70-6	3,000
	CAT5119TBI-50-T3 <sup>(1)</sup>	50	SOT23-6	3,000
	CAT5119TBI-50GT3	50	SOT23-6	3,000
	CAT5119SDI-00GT3	100	SC70-6	3,000
	CAT5119TBI-00-T3 <sup>(1)</sup>	100	SOT23-6	3,000
	CAT5119TBI-00GT3	100	SOT23-6	3,000

**Notes:**

(1) Part number is not exactly the same as the "Example of Ordering Information" shown on page 11. For part numbers marked with (1) there are two hyphens in the orderable part number.


Device	Orderable Part number	Resistor [kΩ]	Pin Package	Parts Per Reel
<b>CAT5123</b>	CAT5123TBI-10-T3 <sup>(1)</sup>	10	SOT23-5	3,000
	CAT5123TBI-10GT3	10	SOT23-5	3,000
	CAT5123TBI-50-T3 <sup>(1)(2)</sup>	50	SOT23-5	3,000
	CAT5123TBI-50GT3 <sup>(2)</sup>	50	SOT23-5	3,000
	CAT5123TBI-00-T3 <sup>(1)(2)</sup>	100	SOT23-5	3,000
	CAT5123TBI-00GT3 <sup>(2)</sup>	100	SOT23-5	3,000
<b>CAT5124</b>	CAT5124TBI-10-T3 <sup>(2)</sup>	10	SOT23-6	3,000
	CAT5124TBI-10GT3 <sup>(2)</sup>	10	SOT23-6	3,000
	CAT5124TBI-50-T3 <sup>(1)</sup>	50	SOT23-6	3,000
	CAT5124TBI-50GT3	50	SOT23-6	3,000
	CAT5124TBI-00-T3 <sup>(1)(2)</sup>	100	SOT23-6	3,000
	CAT5124TBI-00GT3 <sup>(2)</sup>	100	SOT23-6	3,000
<b>CAT5125</b>	CAT5125TBI-10-T3 <sup>(1)</sup>	10	SOT23-6	3,000
	CAT5125TBI-10GT3	10	SOT23-6	3,000
	CAT5125TBI-50-T3 <sup>(1)(2)</sup>	50	SOT23-6	3,000
	CAT5125TBI-50GT3 <sup>(2)</sup>	50	SOT23-6	3,000
	CAT5125TBI-00-T3 <sup>(1)(2)</sup>	100	SOT23-6	3,000
	CAT5125TBI-00GT3 <sup>(2)</sup>	100	SOT23-6	3,000

**Notes:**

- (1) Part number is not exactly the same as the "Example of Ordering Information" shown on page 11. For part numbers marked with (1) there are two hyphens in the orderable part number.
- (2) Contact factory for availability.

**REVISION HISTORY**

<b>Date</b>	<b>Rev.</b>	<b>Description</b>
10-Mar-04	A	Initial Issue
18-Mar-04	B	Update Typical Operating Characteristics Update SC70 package outline
19-Jul-04	C	Added SOT-23 package in all areas Update Description Update Electrical Characteristics Update Typical Operating Characteristics Update Functional Description
15-Dec-06	D	Added CAT5123, CAT5124, CAT5125 Update Features Update Description Update Pin Configuration Update Pin Description Update Electrical Characteristics Update Typical Operating Characteristics Update Functional Description Update Figures 3, 4, 5 and 6 Update Package Information Update Example of Ordering Information Update Ordering information
29-Jan-07	E	Update Electrical Characteristics
03-Aug-07	F	Update Package Outline Drawings Update Example of Ordering Information Update Ordering Information "Top Marking"
02-Nov-07	G	Update Electrical Characteristics Update Package Outline Drawings
29-Jan-08	H	Update Ordering Information
12-Mar-08	I	Add Top Mark Code link
29-May-08	J	Delete 10,000 per reel option Update Document Layout
20-Nov-08	K	Change logo and fine print to ON Semiconductor
20-May-09	L	Update Orderable Part Number

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