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**
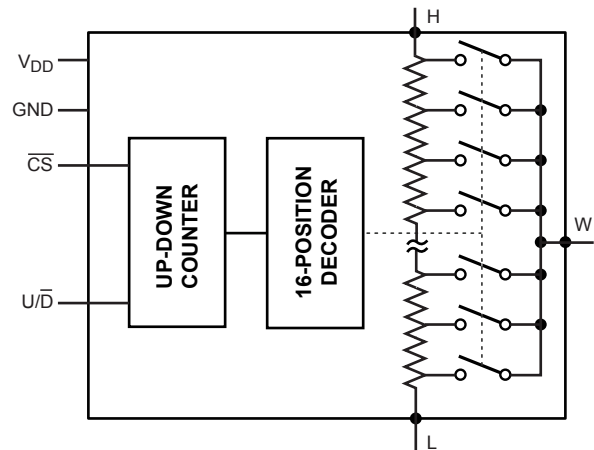
For Ordering Information details, see page 10.
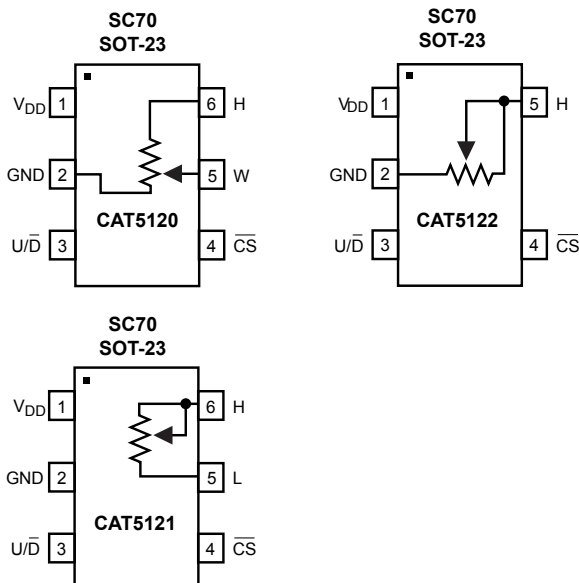
DESCRIPTION

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 CONFIGURATION

PIN DESCRIPTIONS

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

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ABSOLUTE MAXIMUM RATINGS[1]

V_{DD} to GND	-0.3V to +6V
All Other Pins to GND	-0.3V to $(V_{DD}$ + 0.3)V
Input and Output Latch-Up Immunity	±200mA

Maximum Continuous Current into H, L and W
        100kΩ
         50kΩ
         10kΩ
	
	±0.6mA
	±1.3mA
	±1.3mA

Continuous Power Dissipation (T_A = +70ºC)
        5-pin SC70[2]
        6-pin SC70[2]
	
	247mW
	245mW

Operating Temperature Range	-40ºC to +85ºC
Junction Temperature	+150ºC
Storage Temperature Range	-65ºC to +150ºC
Soldering Temperature (soldering, 10s)	+300ºC

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/ºC above T_A = +70ºC

ELECTRICAL CHARACTERISTICS

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

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

ELECTRICAL CHARACTERISTICS (continued)

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

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

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 = 25ºC, unless otherwise noted.

WIPER RESISTANCE vs. TAP POSITION

CHANGE IN END-TO-END RESISTANCE vs. TEMPERATURE

W-TO-L RESISTANCE vs. TAP POSITION

SUPPLY CURRENT vs. TEMPERATURE

TAP-TO-TAP SWITCHING TRANSIENT
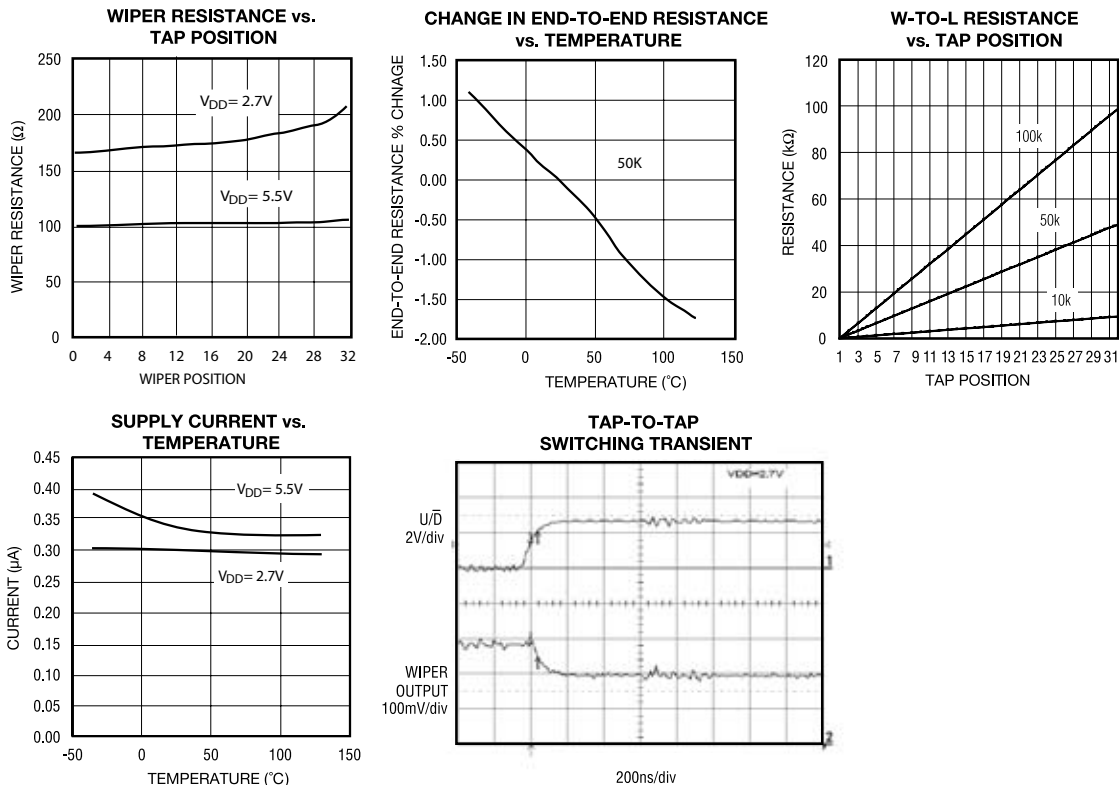
FUNCTIONAL DESCRIPTION

The CAT5120/5121/5122 consist of a fixed resistor and a wiper contact with 16-tap points that are digitally controlled through a2-wire up/down serial interface. Three end-to-end resistance values are available: 10kΩ, 50kΩ and 100kΩ.

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.
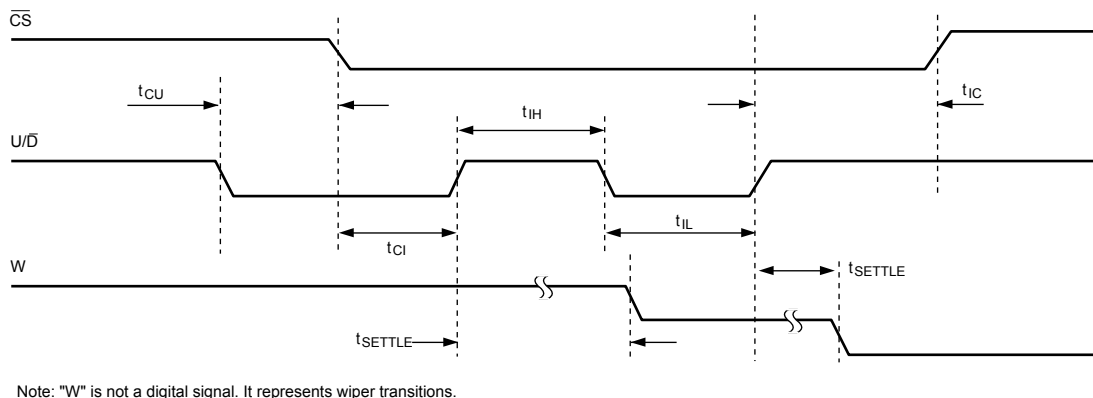
POWER-ON RESET

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

Note: "W" is not a digital signal. It represents wiper transitions.
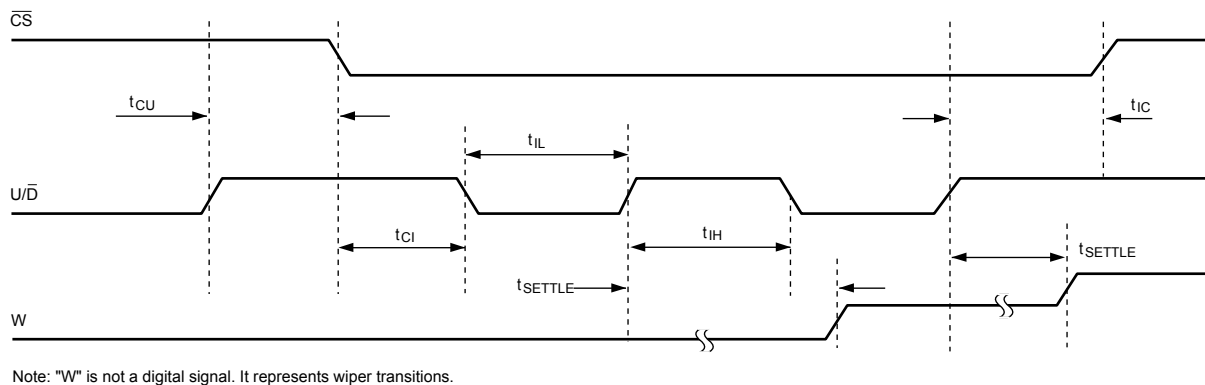
Figure 2. Serial Interface Timing Diagram, Decrement Mode

Note: "W" is not a digital signal. It represents wiper transitions.

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.
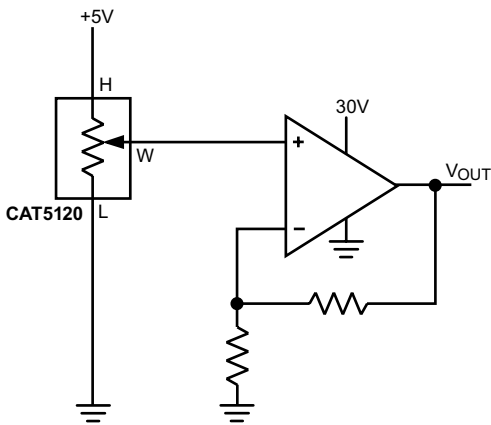
ALTERNATIVE POSITIVE LCD BIAS CONTROL

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
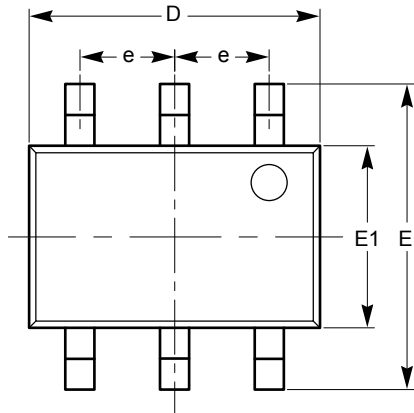

Figure 4. Positive LCD Bias Control
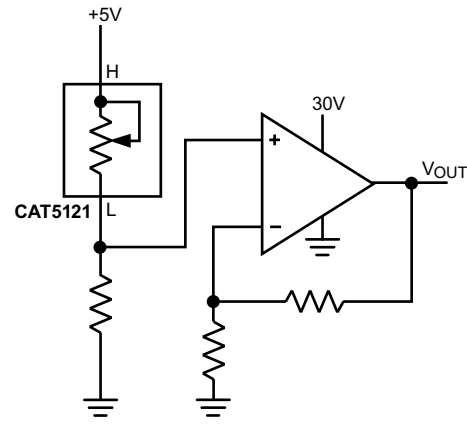
Figure 5a. Adjustable Gain Circuit
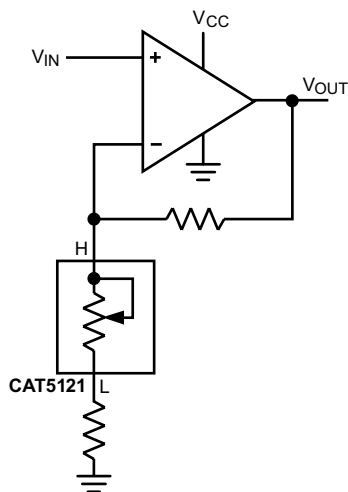
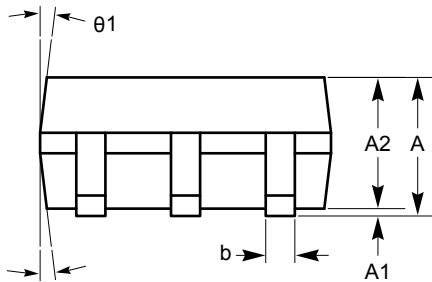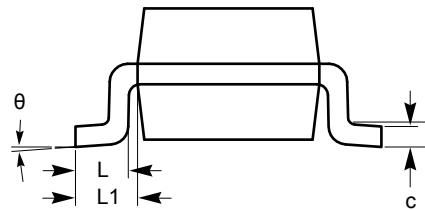**Figure 5b. Adjustable Gain Circuit**

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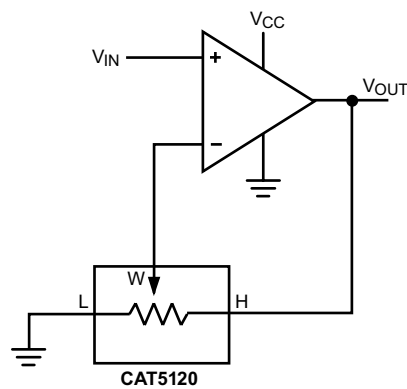
PACKAGE OUTLINE DRAWINGS

SC-70 6-Lead (SD)

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	
θ	0°		8°
θ1	4°		10°

SIDE VIEW

END VIEW

For current Tape and Reel information, download the PDF file from:
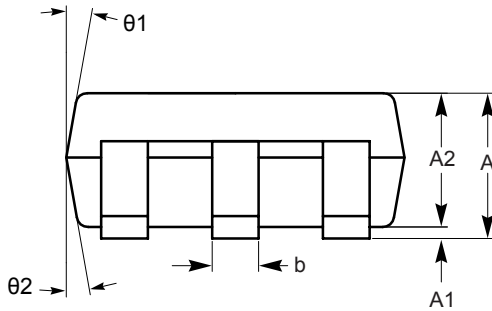www.catsemi.com/documents/tapeandreel.pdf

Notes:

(1) All dimensions are milimeters. Angles in degrees.

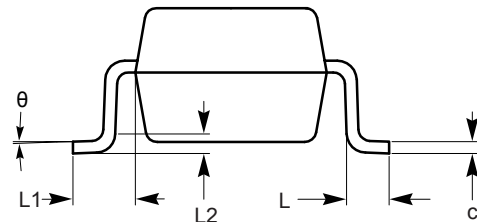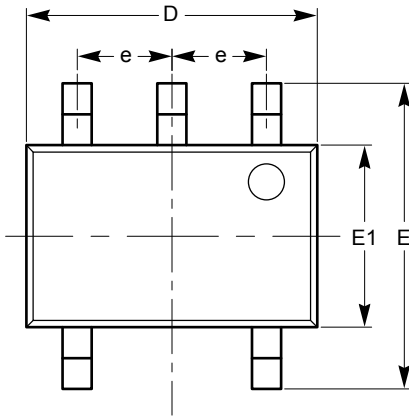(2) Complies with JEDEC standard MO-203.

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SOT-23 6-Lead (TB)

TOP VIEW

PIN #1 IDENTIFICATION

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	
θ	0º	4º	8º
θ1	5º	10º	15º
θ2	5º	10º	15º

SIDE VIEW

END VIEW

For current Tape and Reel information, download the PDF file from: www.catsemi.com/documents/tapeandreel.pdf

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

SC-70 5-LEAD (SD)

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		
θ	0°		8°
θ1	4°		10°

SIDE VIEW

END VIEW

For current Tape and Reel information, download the PDF file from:
www.catsemi.com/documents/tapeandreel.pdf

Notes:
(1) All dimensions are milimeters. Angles in degrees.
(2) Complies with JEDEC standard MO-203.

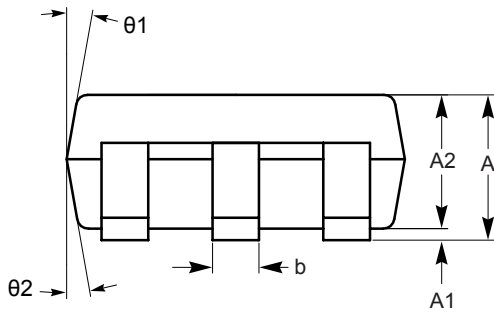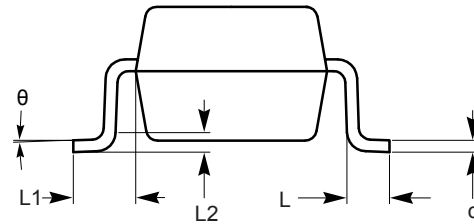**SOT-23 5-Lead (TB)**

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	
θ	0º	4º	8º
θ1	5º	10º	15º
θ2	5º	10º	15º

SIDE VIEW

END VIEW

For current Tape and Reel information, download the PDF file from:
www.catsemi.com/documents/tapeandreel.pdf

Notes:

(1) All dimensions are in millimeters. Angles in degrees.

(2) Complies with JEDEC standard MO-178.

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EXAMPLE OF ORDERING INFORMATION

Prefix	Device #	Suffix				

CAT   5120   SD   I   -10   -G   T10

Company ID

Product Number
5120
5121
5122

Package
SD: SC70
TB: SOT-23

Temperature Range
I = Industrial (-40°C to 85°C)

Resistance
-10: 10kΩ
-50: 50kΩ
-00: 100kΩ

Lead Finish
Blank: Matte-Tin
G: NiPdAu

Tape & Reel
T: Tape & Reel
3: 3,000/Reel
10: 10,000/Reel

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, 10,000/Reel).

(3) For additional package and temperature options, please contact your nearest Catalyst Semiconductor Sales office.

ORDERING INFORMATION

Part Number	Resistor [kΩ]	Pin Package	Quantity per Reel
CAT5120SDI-10-GT3	10	SC70-6	3,000
CAT5120SDI-10-GT10	10	SC70-6	10,000
CAT5120TBI-10-T3	10	SOT23-6	3,000
CAT5120TBI-10-T10	10	SOT23-6	10,000
CAT5120TBI-10-GT3	10	SOT23-6	3,000
CAT5120TBI-10-GT10	10	SOT23-6	10,000
CAT5120SDI-50-GT3	50	SC70-6	3,000
CAT5120SDI-50-GT10	50	SC70-6	10,000
CAT5120TBI-50-T3	50	SOT23-6	3,000
CAT5120TBI-50-T10	50	SOT23-6	10,000
CAT5120TBI-50-GT3	50	SOT23-6	3,000
CAT5120TBI-50-GT10	50	SOT23-6	10,000
CAT5120SDI-00-GT3	100	SC70-6	3,000
CAT5120SDI-00-GT10	100	SC70-6	10,000
CAT5120TBI-00-T3	100	SOT23-6	3,000
CAT5120TBI-00-T10	100	SOT23-6	10,000
CAT5120TBI-00-GT3	100	SOT23-6	3,000
CAT5120TBI-00-GT10	100	SOT23-6	10,000
CAT5121SDI-10-GT3	10	SC70-6	3,000
CAT5121SDI-10-GT10	10	SC70-6	10,000
CAT5121TBI-10-T3	10	SOT23-6	3,000
CAT5121TBI-10-T10	10	SOT23-6	10,000
CAT5121TBI-10-GT3	10	SOT23-6	3,000
CAT5121TBI-10-GT10	10	SOT23-6	10,000
CAT5121SDI-50-GT3	50	SC70-6	3,000
CAT5121SDI-50-GT10	50	SC70-6	10,000
CAT5121TBI-50-T3	50	SOT23-6	3,000
CAT5121TBI-50-T10	50	SOT23-6	10,000
CAT5121TBI-50-GT3	50	SOT23-6	3,000
CAT5121TBI-50-GT10	50	SOT23-6	10,000
CAT5121SDI-00-GT3	100	SC70-6	3,000
CAT5121SDI-00-GT10	100	SC70-6	10,000
CAT5121TBI-00-T3	100	SOT23-6	3,000
CAT5121TBI-00-T10	100	SOT23-6	10,000
CAT5121TBI-00-GT3	100	SOT23-6	3,000
CAT5121TBI-00-GT10	100	SOT23-6	10,000

For Product Top Mark Codes, click here:
http://www.catsemi.com/techsupport/producttopmark.asp

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ORDERING INFORMATION (CONTINUE)

Part Number	Resistor [kΩ]	Pin Package	Quantity per Reel
CAT5122SDI-10-GT3	10	SC70-5	3,000
CAT5122SDI-10-GT10	10	SC70-5	10,000
CAT5122TBI-10-T3	10	SOT23-5	3,000
CAT5122TBI-10-T10	10	SOT23-5	10,000
CAT5122TBI-10-GT3	10	SOT23-5	3,000
CAT5122TBI-10-GT10	10	SOT23-5	10,000
CAT5122SDI-50-GT3	50	SC70-5	3,000
CAT5122SDI-50-GT10	50	SC70-5	10,000
CAT5122TBI-50-T3	50	SOT23-5	3,000
CAT5122TBI-50-T10	50	SOT23-5	10,000
CAT5122TBI-50-GT3	50	SOT23-5	3,000
CAT5122TBI-50-GT10	50	SOT23-5	10,000
CAT5122SDI-00-GT3	100	SC70-5	3,000
CAT5122SDI-00-GT10	100	SC70-5	10,000
CAT5122TBI-00-T3	100	SOT23-5	3,000
CAT5122TBI-00-T10	100	SOT23-5	10,000
CAT5122TBI-00-GT3	100	SOT23-5	3,000
CAT5122TBI-00-GT10	100	SOT23-5	10,000

For Product Top Mark Codes, click here:
http://www.catsemi.com/techsupport/producttopmark.asp

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 Update Package Outlines Add Example of Ordering Information Add SOT-23 5 Lead package drawing Update SOT-23 6 Lead package drawing
03/12/2008	D	Update Package Outline Drawings Update Ordering Information Add MD- to document number Add Top Mark Code link

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