



CAT5120, CAT5121, CAT5122

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

FEATURES

- 0.3µA Ultra-low supply 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: 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

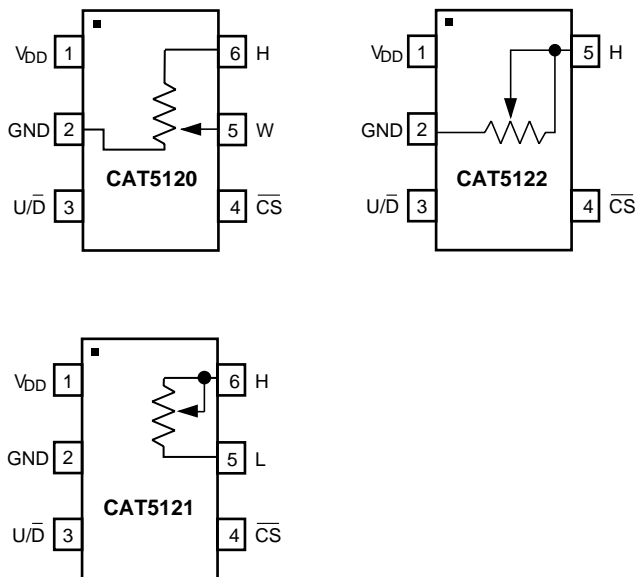
DESCRIPTION

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 32-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.

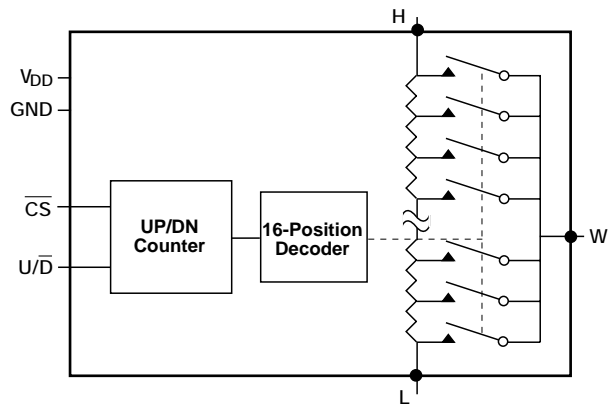
Three resistance values are available: 10kΩ, 50kΩ and 100kΩ. These are available in space-saving 5-pin and 6-pin SC70 and SOT-23 packages.

PIN CONFIGURE



Top View

FUNCTIONAL DIAGRAM



PIN DESCRIPTION

Pin Number			Pin Name	Pin Function
CAT5120	CAT5121	CAT5122		
1	1	1	V _{DD}	Power Supply
2	2	2	GND	Ground
3	3	3	U/ \overline{D}	Up/ $\overline{\text{Down}}$ Control Input. With \overline{CS} low, a low-to-high transition increments or decrements the wiper position.
4	4	4	\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.
-	5	-	L	Low Terminal of Resistor
5	-	-	W	Wiper Terminal of Resistor
6	6	5	H	High Terminal of Resistor

ORDERING INFORMATION

Ordering Part Number	Resistor K	Top Mark	Pin Package	Parts Per Reel
CAT5120SBI-10-T	10	JE_	6 Lead SC70	3k
CAT5120SBI-10-T10	10	JE_	6 Lead SC70	10k
CAT5120TPI-10-T	10	JEYM	6 Lead SOT-23	3k
CAT5120TPI-10-T10	10	JEYM	6 Lead SOT-23	10k
CAT5120SBI-50-T	50	JF_	6 Lead SC70	3k
CAT5120SBI-50-T10	50	JF_	6 Lead SC70	10k
CAT5120TPI-50-T	50	JFYM	6 Lead SOT-23	3k
CAT5120TPI-50-T10	50	JFYM	6 Lead SOT-23	10k
CAT5120SBI-00-T	100	JGYM	6 Lead SC70	3k
CAT5120SBI-00-T10	100	JG_	6 Lead SC70	10k
CAT5120TPI-00-T	100	JGYM	6 Lead SOT-23	3k
CAT5120TPI-00-T10	100	JGYM	6 Lead SOT-23	10k
CAT5121SBI-10-T	10	JH_	6 Lead SC70	3k
CAT5121SBI-10-T10	10	JH_	6 Lead SC70	10k
CAT5121TPI-10-T	10	JHYM	6 Lead SOT-23	3k
CAT5121TPI-10-T10	10	JHYM	6 Lead SOT-23	10k
CAT5121SBI-50-T	50	JJ_	6 Lead SC70	3k
CAT5121SBI-50-T10	50	JJ_	6 Lead SC70	10k
CAT5121TPI-50-T	50	JJYM	6 Lead SOT-23	3k
CAT5121TPI-50-T10	50	JJYM	6 Lead SOT-23	10k
CAT5121SBI-00-T	100	JK_	6 Lead SC70	3k
CAT5121SBI-00-T10	100	JK_	6 Lead SC70	10k
CAT5121TPI-00-T	100	JKYM	6 Lead SOT-23	3k
CAT5121TPI-00-T10	100	JKYM	6 Lead SOT-23	10k
CAT5122SBI-10-T	10	JB_	5 Lead SC70	3k
CAT5122SBI-10-T10	10	JB_	5 Lead SC70	10k
CAT5122TPI-10-T	10	JBYM	5 Lead SOT-23	3k
CAT5122TPI-10-T10	10	JBYM	5 Lead SOT-23	10k
CAT5122SBI-50-T	50	JC_	5 Lead SC70	3k
CAT5122SBI-50-T10	50	JC_	5 Lead SC70	10k
CAT5122TPI-50-T	50	JCYM	5 Lead SOT-23	3k
CAT5122TPI-50-T10	50	JCYM	5 Lead SOT-23	10k
CAT5122SBI-00-T	100	JD_	5 Lead SC70	3k
CAT5122SBI-00-T10	100	JD_	5 Lead SC70	10k
CAT5122TPI-00-T	100	JDYM	5 Lead SOT-23	3k
CAT5122TPI-00-T10	100	JDYM	5 Lead SOT-23	10k

ORDERING INFORMATION (CON'T)

Ordering Part Number	Resistor K	Top Mark	Pin Package	Parts Per Reel
CAT5120SDI-10-T	10	KC_	6 Lead SC70 green	3k
CAT5120SDI-10-T10	10	KC_	6 Lead SC70 green	10k
CAT5120TBI-10-T	10	KCYM	6 Lead SOT-23 green	3k
CAT5120TBI-10-T10	10	KCYM	6 Lead SOT-23 green	10k
CAT5120SDI-50-T	50	KD_	6 Lead SC70 green	3k
CAT5120SDI-50-T10	50	KD_	6 Lead SC70 green	10k
CAT5120TBI-50-T	50	KDYM	6 Lead SOT-23 green	3k
CAT5120TBI-50-T10	50	KDYM	6 Lead SOT-23 green	10k
CAT5120SDI-00-T	100	KE_	6 Lead SC70 green	3k
CAT5120SDI-00-T10	100	KE_	6 Lead SC70 green	10k
CAT5120TBI-00-T	100	KEYM	6 Lead SOT-23 green	3k
CAT5120TBI-00-T10	100	KEYM	6 Lead SOT-23 green	10k
CAT5121SDI-10-T	10	KF_	6 Lead SC70 green	3k
CAT5121SDI-10-T10	10	KF_	6 Lead SC70 green	10k
CAT5121TBI-10-T	10	KFYM	6 Lead SOT-23 green	3k
CAT5121TBI-10-T10	10	KFYM	6 Lead SOT-23 green	10k
CAT5121SDI-50-T	50	KG_	6 Lead SC70 green	3k
CAT5121SDI-50-T10	50	KG_	6 Lead SC70 green	10k
CAT5121TBI-50-T	50	KGYM	6 Lead SOT-23 green	3k
CAT5121TBI-50-T10	50	KGYM	6 Lead SOT-23 green	10k
CAT5121SDI-00-T	100	KH_	6 Lead SC70 green	3k
CAT5121SDI-00-T10	100	KH_	6 Lead SC70 green	10k
CAT5121TBI-00-T	100	KHYM	6 Lead SOT-23 green	3k
CAT5121TBI-00-T10	100	KHYM	6 Lead SOT-23 green	10k
CAT5122SDI-10-T	10	KY_	5 Lead SC70 green	3k
CAT5122SDI-10-T10	10	KY_	5 Lead SC70 green	10k
CAT5122TBI-10-T	10	KYYM	5 Lead SOT-23 green	3k
CAT5122TBI-10-T10	10	KYYM	5 Lead SOT-23 green	10k
CAT5122SDI-50-T	50	KA_	5 Lead SC70 green	3k
CAT5122SDI-50-T10	50	KA_	5 Lead SC70 green	10k
CAT5122TBI-50-T	50	KAYM	5 Lead SOT-23 green	3k
CAT5122TBI-50-T10	50	KAYM	5 Lead SOT-23 green	10k
CAT5122SDI-00-T	100	KB_	5 Lead SC70 green	3k
CAT5122SDI-00-T10	100	KB_	5 Lead SC70 green	10k
CAT5122TBI-00-T	100	KBYM	5 Lead SOT-23 green	3k
CAT5122TBI-00-T10	100	KBYM	5 Lead SOT-23 green	10k

ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND.....	-0.3 V to +6 V	Operating Temperature Range	-40°C to +85°C
All Other Pins to GND	-0.3 V to ($V_{DD} + 0.3$) V	Junction Temperature	+150°C
Input and Output Latch-Up Immunity.....	± 200 mA	Storage Temperature Range	-65°C to +150°C
Maximum Continuous Current into H, L and W		Soldering Temperature (soldering, 10s)	+300°C
100k Ω	± 0.6 mA	*(derate 3.1mW/°C above $T_A = +70^\circ\text{C}$)	
50k Ω	± 1.3 mA	COMMENT	
10k Ω	± 1.3 mA	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.	
Continuous Power Dissipation ($T_A = +70^\circ\text{C}$)			
5-pin SC70*	247 mW		
6-pin SC70*	245 mW		

ELECTRICAL CHARACTERISTICS

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

Symbol	Parameter	Conditions	Min	Typ	Max	Units
DC Performance						
	Resolution		16			Taps
	End-to-End Resistance	CAT5120	80	100	120	k Ω
		CAT5121	40	50	60	
		CAT5122	8	10	12	
TC_R	End-to-End Resistance Tempco			200		ppm/° C
	Ratiometric Resistance Tempco			5		ppm/° C
INL	Integral Nonlinearity				± 0.5	LSB
DNL	Differential Nonlinearity				± 0.5	LSB
	Zero/Full-Scale Error			± 0.1	± 0.5	LSB
R_W	Wiper Resistance			200	600	Ω
Digital Inputs						
V_{IH}	Input High Voltage		$0.7 \times V_{DD}$			V
V_{IL}	Input Low Voltage				$0.3 \times V_{DD}$	V
Timing Characteristics (Figures 1, 2)						
t_{CU}	U/ \bar{D} Mode to CS Setup		25			ns
t_{CI}	CS to U/ \bar{D} Step Setup		50			ns
t_{tC}	CS to U/ \bar{D} Step Hold		25			ns
t_{tL}	U/ \bar{D} Step Low Period		25			ns
t_{tH}	U/ \bar{D} Step High Period		25			ns
f_{TOGGLE}	Up/ \bar{D} Toggle Rate ⁽¹⁾			1		MHz
t_{SETTLE}	Output Settling Time ⁽²⁾	100k Ω variable resistor configuration, CL = 10pF		1		μs
		100k Ω potentiometer configuration, CL = 10pF		0.25		

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.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Power Supplies						
V_{DD}	Supply Voltage		2.7		5.5	V
I_{DD}	Active Supply Current ⁽³⁾				25	μA
I_{SD}	Standby Supply Current ⁽⁴⁾	$V_{DD} = +5\text{V}$		0.3	1	μA

Notes:

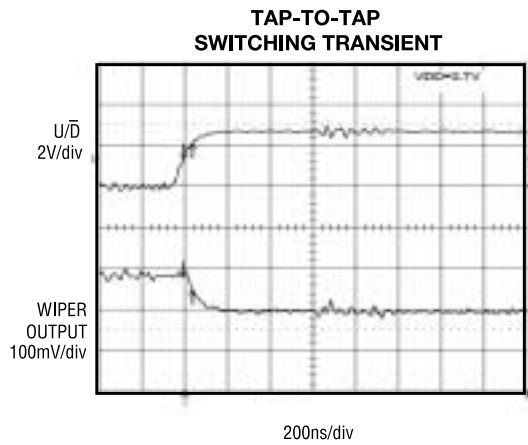
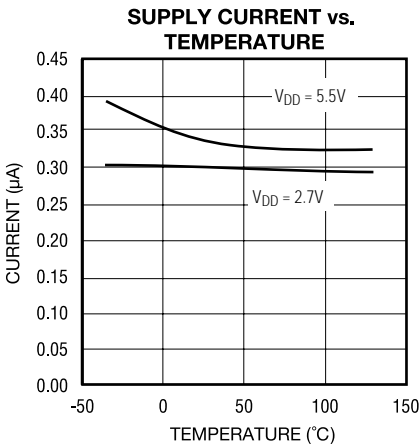
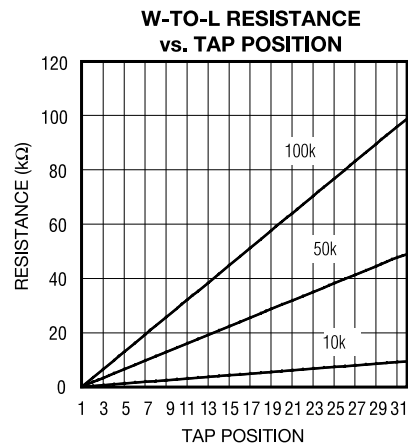
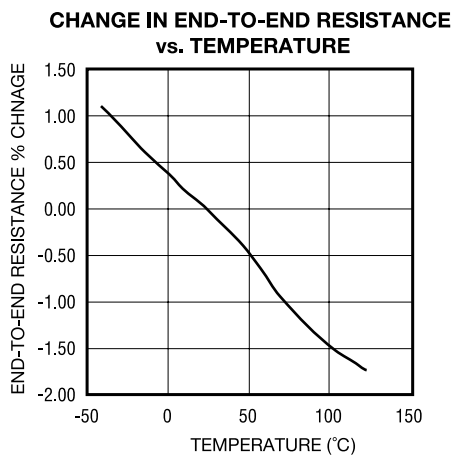
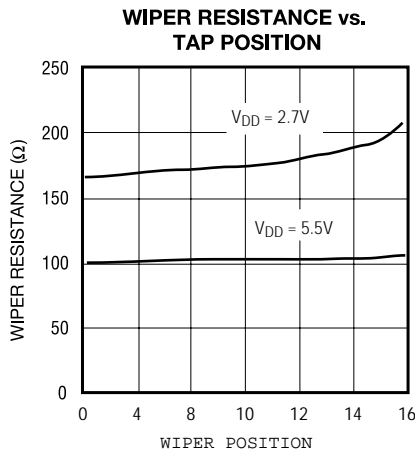
1. Up/Down Toggle Rate:

$$f_{\text{TOGGLE}} = \frac{1}{t_{\text{SETTLE}}}$$

2. Typical setting times are dependant on end-to-end resistance.
3. Supply current taken while changing wiper tap, $f_{\text{TOGGLE}} = 1\text{MHz}$.
4. Supply current taken while wiper position is fixed.

TYPICAL OPERATING CHARACTERISTICS

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



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: 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).

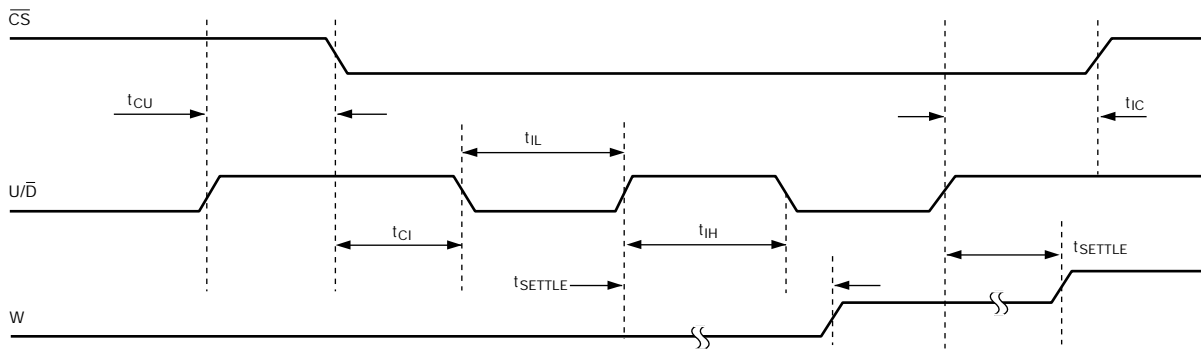
When the \overline{CS} input transitions to high (serial interface inactive), the value of the counter is stored and the wiper position is maintained.

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

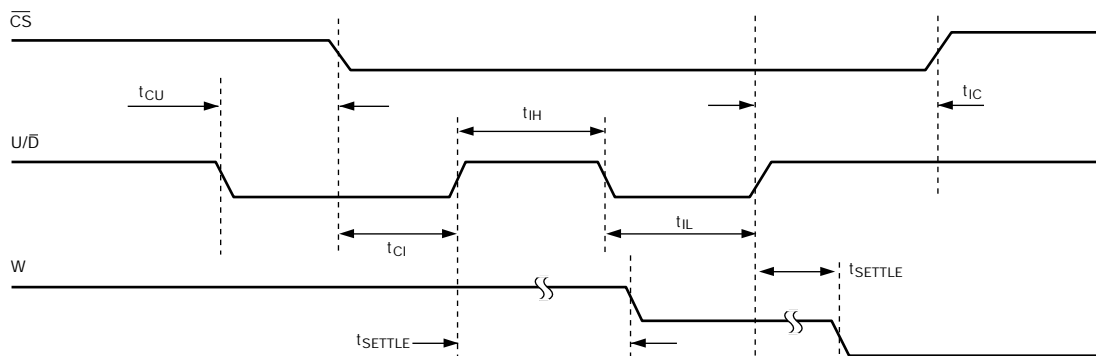
All parts in this family feature power-on reset (POR) circuitry that sets the wiper position to midscale at power-up. By default, the chip is in the increment mode.

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

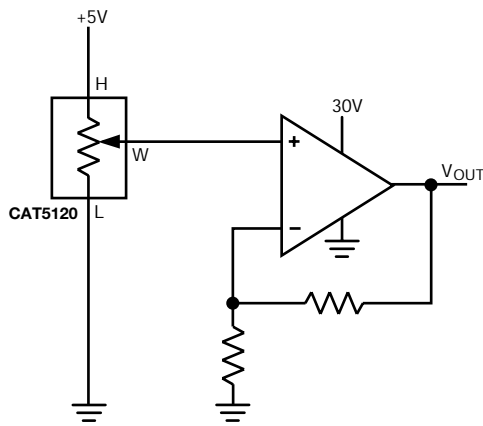


Figure 4. Positive LCD Bias Control

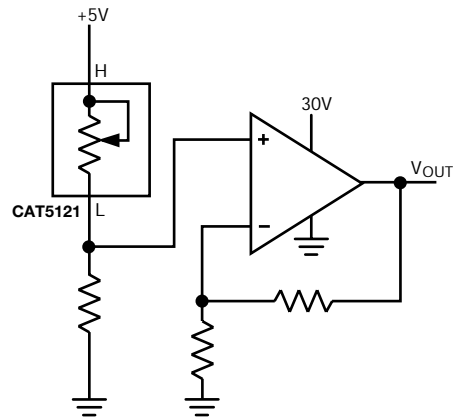


Figure 5a. Adjustable Gain Circuit

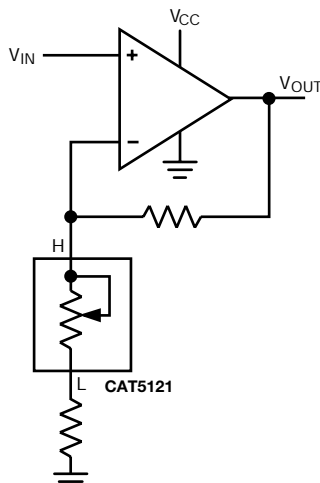
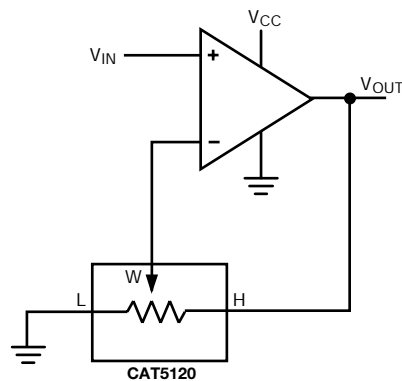
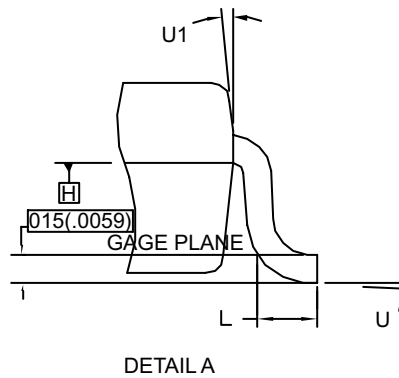
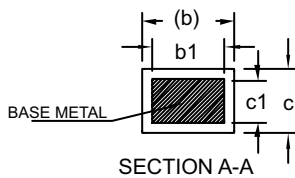
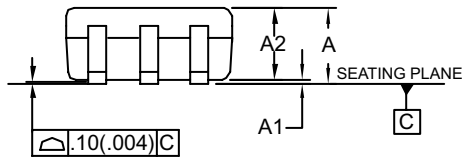
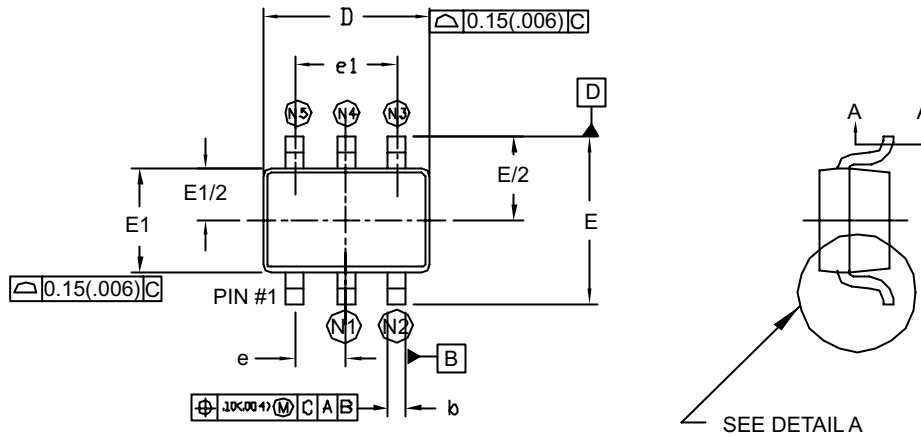


Figure 5b. Adjustable Gain Circuit



PACKAGE OUTLINES

SC70



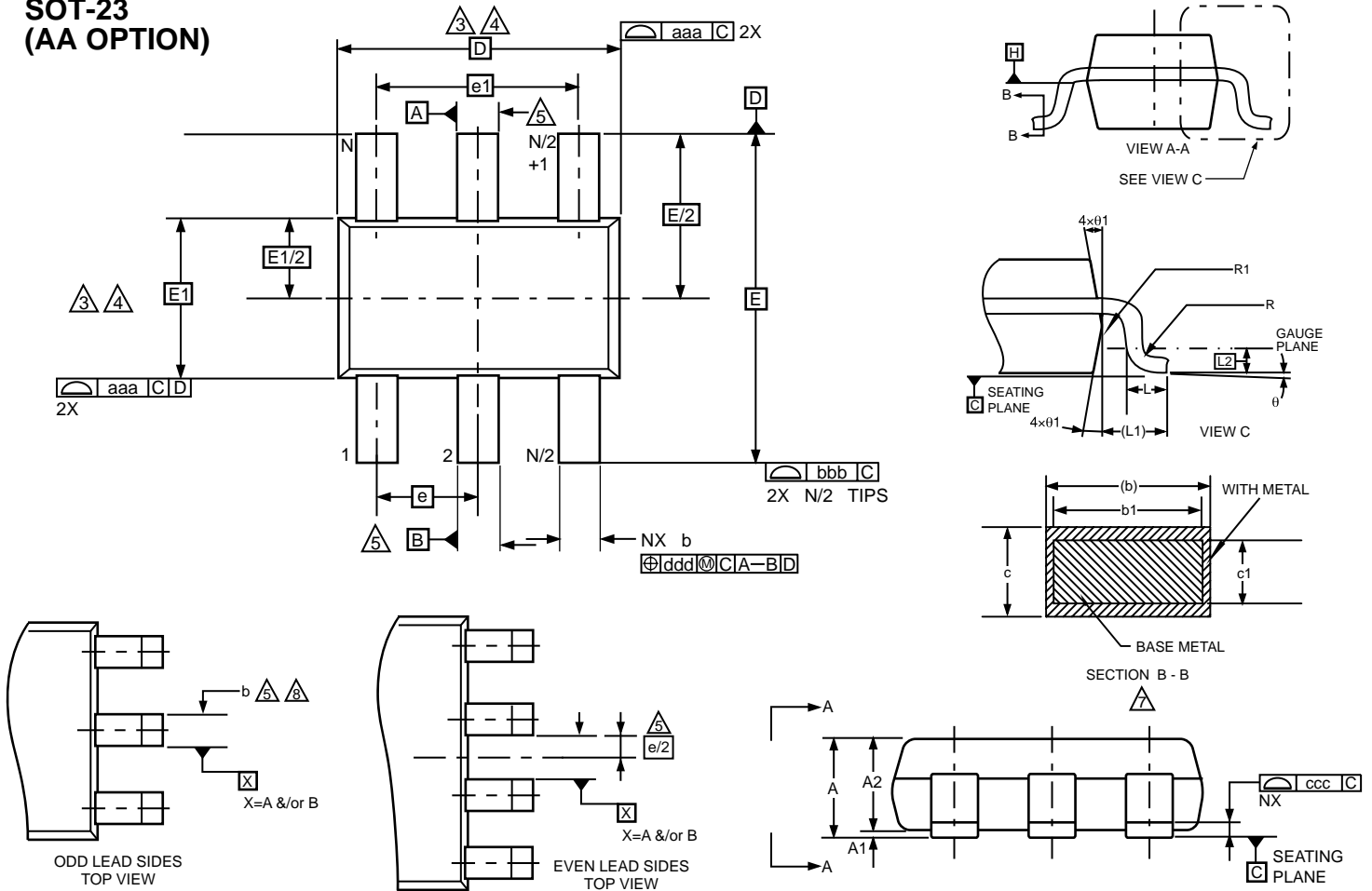
PIN CODE	LEAD COUNT	
	5	6
N1	2	2
N2	3	3
N3	4	4
N4	-	5
N5	5	6

SYMBOL	COMMON					
	DIMENSIONS MILLIMETER			DIMENSIONS INCH		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.80	-	1.10	0.031	-	0.043
A1	0	-	0.10	0	-	0.004
A2	0.80	0.90	1.00	0.031	0.035	0.040
b	0.15	-	0.30	0.006	-	0.012
b1	0.15	0.20	0.25	0.006	0.008	0.010
c	0.08	-	0.25	0.003	-	0.010
c1	0.08	0.13	0.20	0.003	0.005	0.008
D	1.90	2.10	2.15	0.074	0.082	0.084
E	2.00	2.10	2.20	0.078	0.082	0.086
E1	1.15	1.25	1.35	0.045	0.050	0.055
e	0.65 BSC			0.0255 BSC		
e1	1.30 BSC			0.0512 BSC		
L	0.26	0.36	0.46	0.010	0.014	0.018
U	0°	-	8°	0°	-	8°
U1	4°	-	10°	4°	-	10°

NOTE:

1. CONTROLLING DIMENSION: MILLIMETER. CONVERTED INCH DIMENSION ARE NOT NECESSARILY EXACT.
2. DIMENSION "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURR. MOLD FLASH, PROTRUSION OR GATE BURR SHALL NOT EXCEED 0.15MM (0.006") PER END. DIMENSION "E1" DOES NOT INCLUDE INTER-LEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.15MM (0.006") PER SIDE.
3. THE PACKAGE TOP IS SMALLER THAN THE PACKAGE BOTTOM. DIMENSION D AND E1 ARE DETERMINED AT THE OUTERMOST EXPTREMES OF THE PLASTIC BODY EXCLUSIVE OF MOLD FLASH, TIE BAR BURRS, GATE BURRS ADN INTERLEAD FLASH, BUT INCLUDING ANY MISMATCH BETWEEN THE TOP AND BOTTOM OF THE PLASTIC BODY.

**SOT-23
(AA OPTION)**



All Dimensions are in Millimeters

	Min	Nom	Max	Notes
A	—	—	1.00	
A1	0.01	0.05	0.10	
A2	0.84	0.87	0.90	
c	0.12	0.15	0.20	7
c1	0.08	0.13	0.16	7
D	2.90BSC			3,4
E	2.80BSC			3,4
E1	1.60BSC			3,4
L	0.30	0.40	0.50	
L1	0.60REF			
L2	0.25BSC			
R	0.10	—	—	
R1	0.10	—	0.25	
theta	0°	4°	8°	
theta1	4°	10°	12°	

Tolerances of Form and Position							Notes			
aaa	0.15						1,2			
bbb	0.25						1,2			
ccc	0.10						1,2			
Variations										
	AA			6 AB			BA			
	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Notes
b	0.30	—	0.45	0.30	—	0.45	0.22	—	0.36	7,8
b1	0.31	0.35	0.39	0.31	0.35	0.39	0.22	0.26	0.30	
e	0.95BSC			0.95BSC			0.65BSC			
e1	1.90BSC			1.90BSC			1.95BSC			
N	6			5			8			
Tolerances of Form and Position										
ddd	0.20			0.20			0.13			1,2

Notes:
 1. Dimensions and tolerancing per ASME Y14.5M - 1994
 2. Dimension are in mm.
 Dimension D does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15mm per end. Dimension E1 does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.15mm per side. D and E1 dimensions are determined at Datum H.

- Ⓐ The package top may be smaller than the package bottom. Dimensions D and E1 are determined at the outermost extremes of the plastic body exclusive of mold flash, the bar burrs, gate burrs and interlead flash, but including any mismatch between the top and bottom of the plastic body. D and E1 dimensions are determined at Datum H.
- Ⓒ Datums A & B to be determined at Datum H.
- Ⓓ Package variation "AB" is a 5 lead version of the 6 lead variation "AA" where lead #5 has been removed from the 6 lead "AA" variation.
- Ⓔ These dimensions apply to the flat section of the lead between 0.08mm and 0.15mm from the lead tip.
- Ⓕ Dimension "b" does not include dambar protrusion. Allowable dambar protrusion shall be 0.08mm total in excess of the "b" dimension at maximum material condition. The dambar cannot be located on the lower radius of the foot. Minimum space between protrusion and an adjacent lead shall not be less than 0.07mm.

REVISION HISTORY

Date	Rev.	Reason
3/18/2004	A	Initial Issue
7/19/2004	B	Added SOT-23 package in all areas Updated Description Updated Ordering Information Updated Electrical Characteristics Updated Typical Operating Characteristics Updated Functional Description

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