



Low-Power Digital Potentiometers

MAX5160/MAX5161

General Description

The MAX5160/MAX5161 linear-taper digital potentiometers perform the same function as a mechanical potentiometer or a variable resistor. They consist of a fixed resistor and a wiper contact with 32 tap points that are digitally controlled by three lines for the 8-pin MAX5160 or by two lines for the 6-pin MAX5161.

These parts are ideal for applications requiring digitally controlled resistors. Three resistance values are available for each part type: 50k Ω , 100k Ω , and 200k Ω . A nominal resistor temperature coefficient of 50ppm/ $^{\circ}$ C end-to-end and only 5ppm/ $^{\circ}$ C ratiometric makes the MAX5160 ideal for applications requiring a low-temperature-coefficient variable resistor, such as low-tempco, adjustable-gain circuit configurations.

The MAX5160 is available in an 8-pin μ MAX package, and the MAX5161 is available in a 6-pin SOT23 package. Both devices are guaranteed over the extended-industrial temperature range (-40° C to $+85^{\circ}$ C).

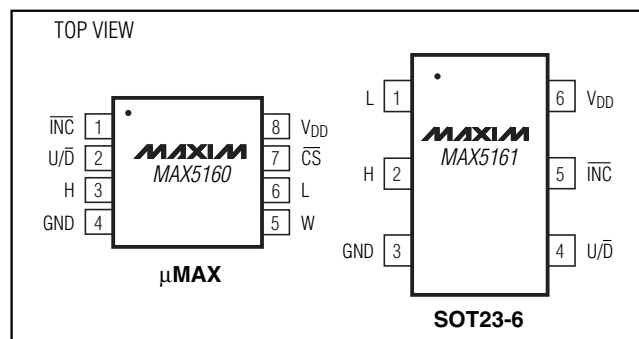
Applications

LCD Screen Adjustment
Volume Control
Mechanical Potentiometer Replacement

Selector Guide

PART	TOP MARK	R (k Ω)
MAX5160NEUA	—	200
MAX5160MEUA	—	100
MAX5160LEUA	—	50
MAX5161NEZT	AAAC	200
MAX5161MEZT	AAAB	100
MAX5161LEZT	AAAA	50

Pin Configurations



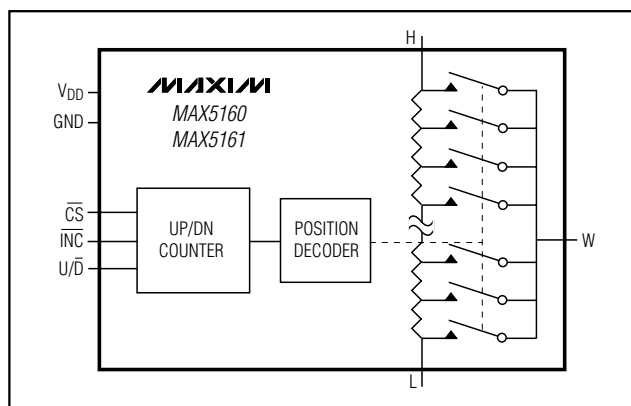
Features

- ◆ 32 Tap Positions
- ◆ 50k Ω , 100k Ω , and 200k Ω Resistance Values
- ◆ 400 Ω Wiper Resistance
- ◆ $\pm 25\%$ Resistance Tolerance
- ◆ 3-Wire Serial Data Input
- ◆ ± 1 LSB DNL
- ◆ ± 0.5 LSB INL
- ◆ 100nA Supply Current
- ◆ +2.7V to +5.5V Single-Supply Operation
- ◆ Power-On Reset: Wiper Goes to Midscale (position 16)
- ◆ ± 2 kV ESD Protection
- ◆ Small-Footprint Packages
 - 6-Pin SOT23 (MAX5161)
 - 8-Pin μ MAX (MAX5160)
- ◆ Glitchless Switching Between the Resistor Taps

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	R (k Ω)
MAX5160NEUA	-40° C to $+85^{\circ}$ C	8 μ MAX	200
MAX5160MEUA	-40° C to $+85^{\circ}$ C	8 μ MAX	100
MAX5160LEUA	-40° C to $+85^{\circ}$ C	8 μ MAX	50
MAX5161NEZT	-40° C to $+85^{\circ}$ C	6 SOT23	200
MAX5161MEZT	-40° C to $+85^{\circ}$ C	6 SOT23	100
MAX5161LEZT	-40° C to $+85^{\circ}$ C	6 SOT23	50

Functional Diagram



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ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND	-0.3V to +6V
$\overline{CS}$, $\overline{INC}$, $U/\overline{D}$ to GND	-0.3V to +6V
H, L, W to GND	-0.3V to (V_{DD} + 0.3V)
Input and Output Latchup Immunity	± 200 mA
Maximum Continuous Current into H, L, and W MAX516__E__	± 1 mA

Continuous Power Dissipation ($T_A = +70^\circ\text{C}$)	
6-Pin SOT23 (derate 6.25mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)	500mW
8-Pin μMAX (derate 4.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)	330mW
Operating Temperature Range	-40°C to $+85^\circ\text{C}$
Storage Temperature Range	-65°C to $+150^\circ\text{C}$
Lead Temperature (soldering, 10s)	$+300^\circ\text{C}$

Stresses beyond 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 beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

($V_{DD} = +2.7\text{V}$ to $+5.5\text{V}$, $V_H = V_{DD}$, $V_L = 0$, $T_A = T_{MIN}$ to T_{MAX} . Typical values are at $V_{DD} = +5\text{V}$, $T_A = +25^\circ\text{C}$, unless otherwise noted.)

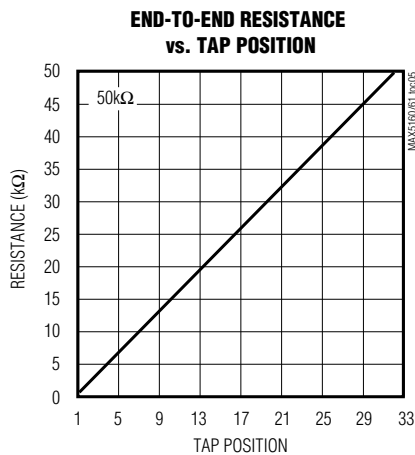
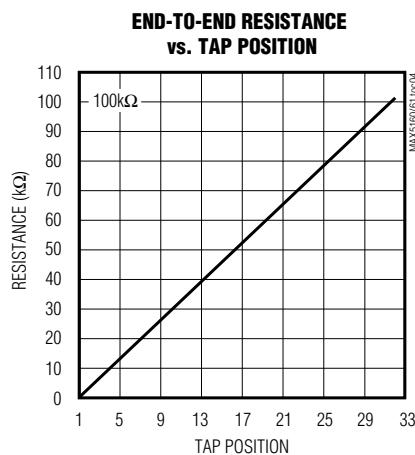
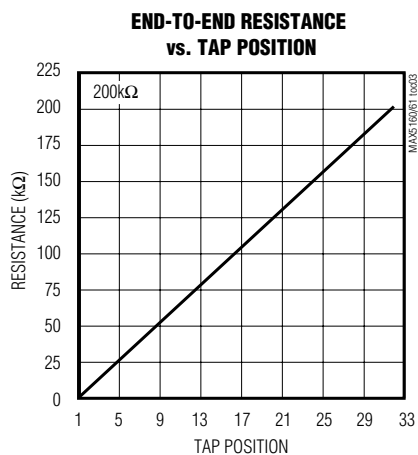
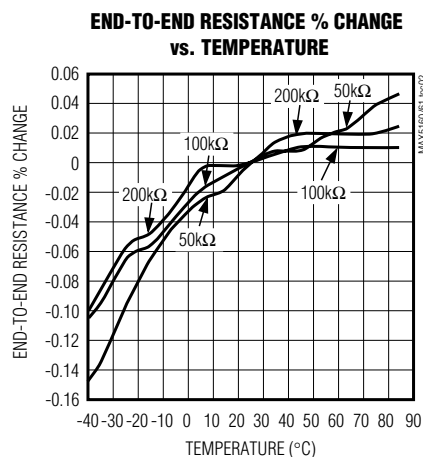
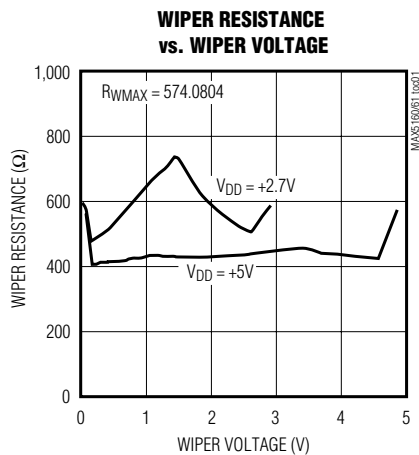
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DC PERFORMANCE							
Resolution				3			%
Integral Nonlinearity (Note 1)	INL			±1/2			LSB
Differential Nonlinearity (Note 1)	DNL			±1			LSB
End-to-End Resistor Tempco	TCR			50			ppm/°C
Ratiometric Resistor Tempco				5			ppm/°C
Full-Scale Error				-0.1			LSB
Zero-Scale Error				+0.1			LSB
Wiper Resistance	R _W			400	1700		Ω
Wiper Capacitance	C _W			10			pF
End-to-End Resistance	HL	MAX516_NE__		150	200	250	kΩ
		MAX516_ME__		75	100	125	
		MAX516_LE__		37.5	50	62.5	
DIGITAL INPUTS							
Input High Voltage	V _{IH}			0.7 × V _{DD}			V
Input Low Voltage	V _{IL}			0.3 × V _{DD}			V
Input Leakage Current				±1			μA
Input Capacitance				5			pF
TIMING CHARACTERISTICS (Figure 6)							
$\overline{\text{CS}}$ to $\overline{\text{INC}}$ Setup Time	t _{CI}			25			ns
$\overline{\text{CS}}$ to $\overline{\text{INC}}$ Hold Time	t _{IC}			0			ns
$\overline{\text{INC}}$ Low Period	t _{IL}			25			ns
$\overline{\text{INC}}$ High Period	t _{IH}			25			ns
U/ $\overline{\text{D}}$ to $\overline{\text{INC}}$ Hold	t _{ID}			0			ns
U/ $\overline{\text{D}}$ to $\overline{\text{INC}}$ Setup	t _{DI}			50			ns
Wiper-Settling Time	t _{IW}			1			μs
$\overline{\text{INC}}$ Frequency	f _{IMAX}			7			MHz
POWER SUPPLIES							
Supply Voltage	V _{DD}			2.7		5.5	V
Supply Current	I _{DD}	$\overline{\text{CS}} = \overline{\text{INC}} = \text{U}/\overline{\text{D}} = \text{V}_{\text{DD}}$ or GND	V _{DD} = +5V	0.6	10		μA
			V _{DD} = +2.7V	135			nA

Note 1: For the MAX5160, linearity is defined in terms of H to L code-dependent resistance.

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Typical Operating Characteristics

($V_{DD} = +5V$, $T_A = +25^\circ C$, unless otherwise noted.)

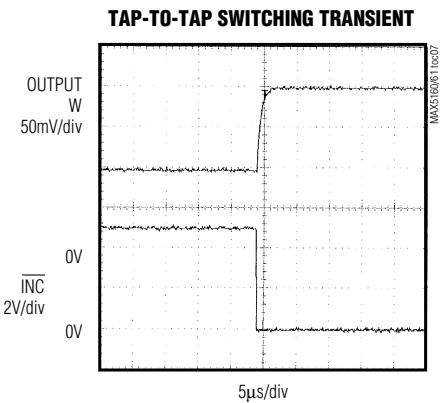
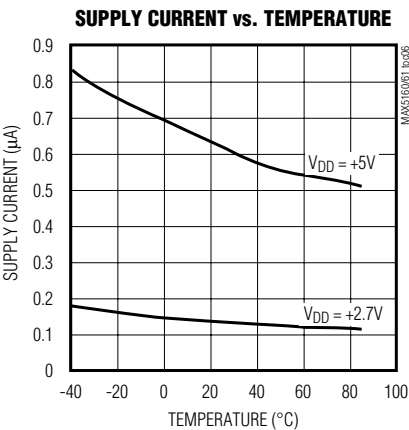


MAX5160/MAX5161

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Typical Operating Characteristics (continued)

(V_{DD} = +5V, T_A = +25°C, unless otherwise noted.)



Pin Description

PIN		NAME	FUNCTION
MAX5160	MAX5161		
1	5	$\overline{\text{INC}}$	Wiper Increment Control Input. With $\overline{\text{CS}}$ low, a high-to-low transition increments ($\text{U}/\overline{\text{D}}$ high) or decrements ($\text{U}/\overline{\text{D}}$ low) the wiper position.
2	4	$\text{U}/\overline{\text{D}}$	Up/Down Control Input. With $\overline{\text{CS}}$ low, a high-to-low $\overline{\text{INC}}$ transition increments ($\text{U}/\overline{\text{D}}$ high) or decrements ($\text{U}/\overline{\text{D}}$ low) the wiper position.
3	2	H	High Terminal of Resistor
4	3	GND	Ground
5	—	W	Wiper Terminal of Resistor
6	1	L	Low Terminal of Resistor
7	—	$\overline{\text{CS}}$	Chip-Select Input. Drive low to change the wiper position through $\overline{\text{INC}}$ and $\text{U}/\overline{\text{D}}$.
8	6	V _{DD}	Power Supply

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Alternative Positive LCD Bias Control

Alternatively, use an op amp to provide buffering and gain to the output of the MAX5160/MAX5161. Connect the MAX5160 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 MAX5161.

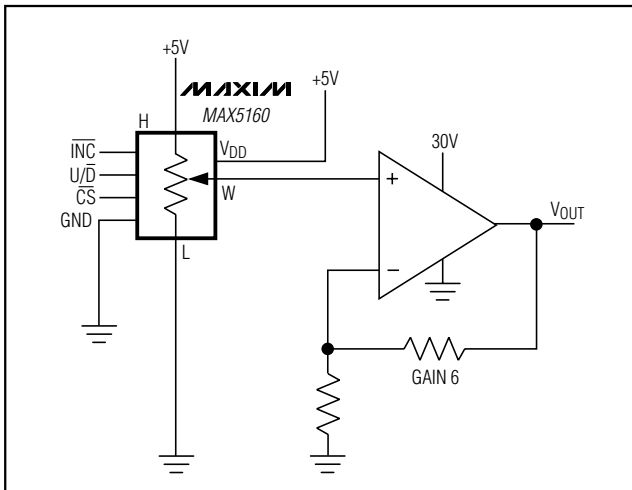


Figure 3. MAX5160 Positive LCD Bias Control

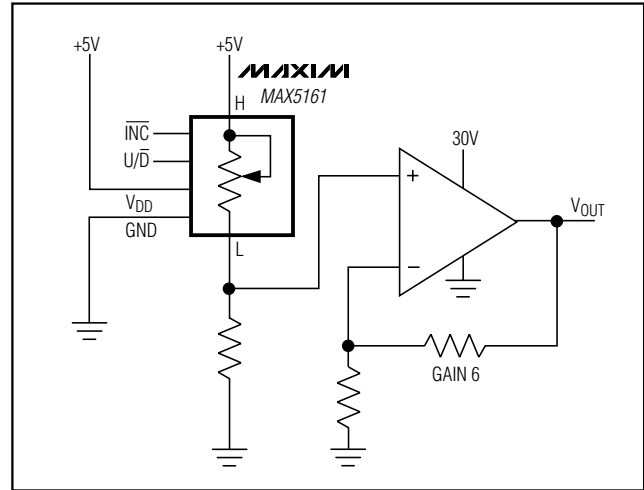


Figure 4. MAX5161 Positive LCD Bias Control

Adjustable Gain

Figure 5 shows how to use the MAX5161 to digitally adjust the gain of a noninverting op amp configuration. Connect the MAX5161 in series with a resistor to ground to form the adjustable gain control of a noninverting amplifier. The MAX5160/MAX5161 have a low 5ppm/°C ratiometric tempco that allows for a very stable adjustable gain configuration over temperature.

Serial Interface

Figure 6 is the serial-interface timing diagram.

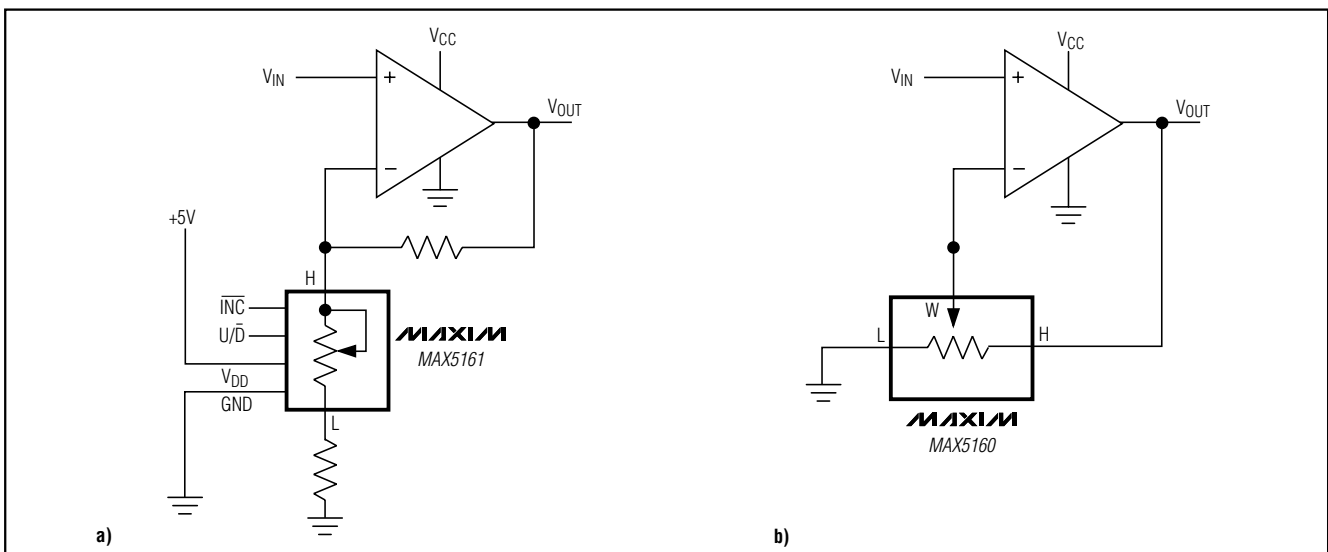


Figure 5. Adjustable Gain Circuit: a) MAX5161; b) MAX5160

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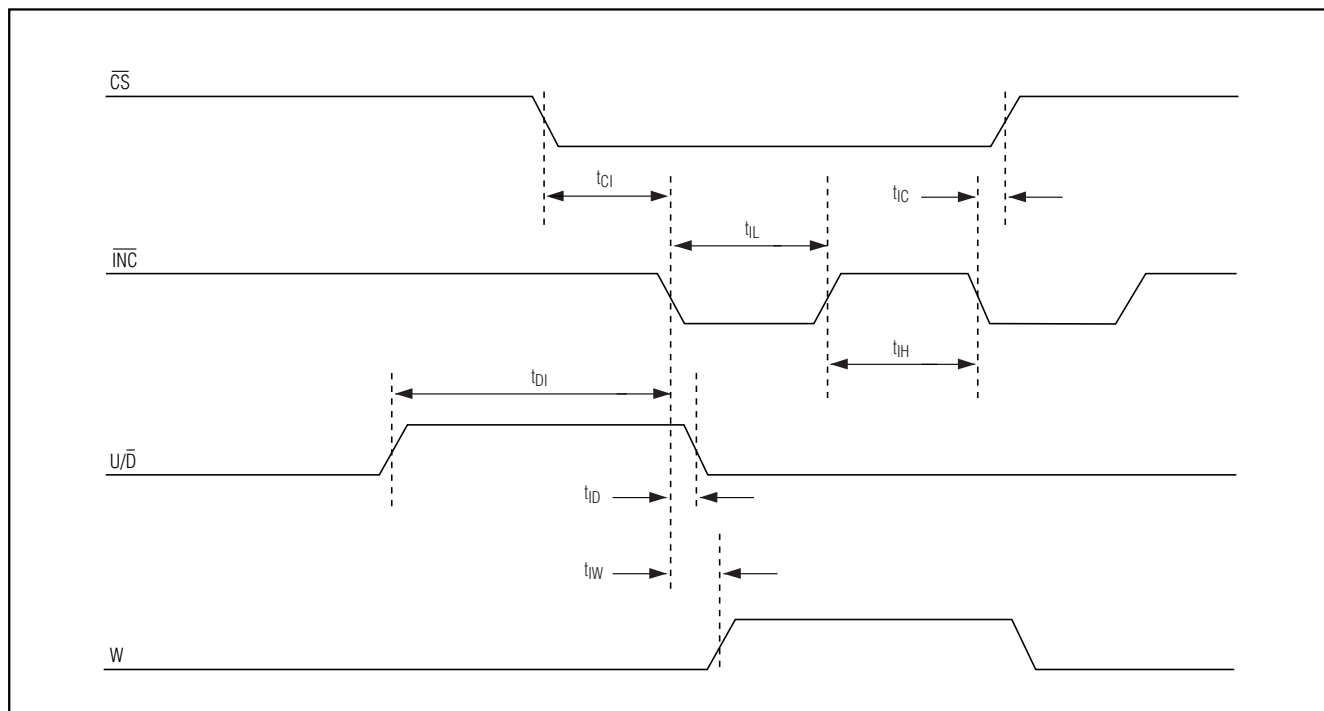


Figure 6. Serial-Interface Timing Diagram

Truth Table

$\overline{CS}$	$U/\overline{D}$	$\overline{INC}$	R_W
H	xx-X	X	O
L	L	↑	O
L	H	↑	O
L	L	↓	—
L	H	↓	+

X = Don't care

O = Previous state

+ = Increment

— = Decrement

↓ = High-to-Low Transition

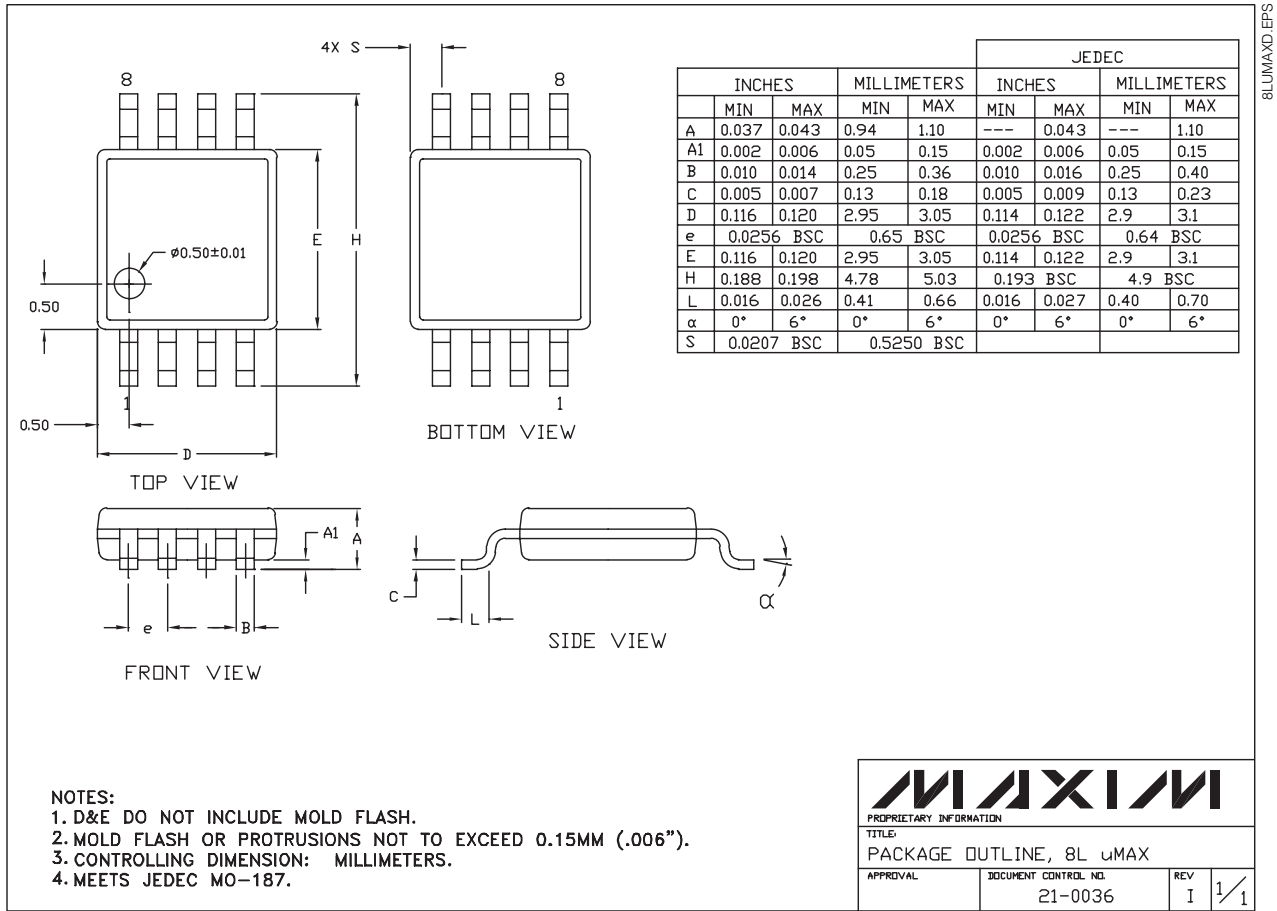
↑ = Low-to-High Transition

Chip Information

TRANSISTOR COUNT: 969

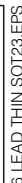
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Package Information



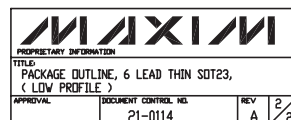
MAX5160/MAX5161

S LEAD THIN SOT23 EPS



1. ALL DIMENSIONS ARE IN MILLIMETERS.

- | SYMBOLS | | | |
|---------|----------|-------|------|
| | MIN | NOM | MAX |
| A | — | — | 1.10 |
| A1 | 0.05 | 0.075 | 0.10 |
| A2 | 0.85 | 0.88 | 0.90 |
| A3 | 0.50 BSC | | |
| b | 0.30 | — | 0.45 |
| b1 | 0.25 | 0.35 | 0.40 |
| c | 0.15 | — | 0.20 |
| c1 | 0.12 | 0.127 | 0.15 |
| D | 2.80 | 2.90 | 3.00 |
| E | 2.75 BSC | | |
| E1 | 1.55 | 1.60 | 1.65 |
| L | 0.30 | 0.40 | 0.50 |
| e1 | 1.90 BSC | | |
| e | 0.95 BSC | | |
| OC | 0° | 4° | 8° |
| aaa | 0.20 | | |



Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600 _____ **9**