# THE DATASHEET OF

# MAX5160LEUA+T

www.win-source.net 0086-755-83957316

19-1435; Rev 2a; 2/01

MAXIM

# Low-Power Digital Potentiometers



## 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: 50kΩ, 100kΩ, and 200kΩ. A nominal resistor temperature coefficient of 50ppm/°C end-to-end and only 5ppm/°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 µMAX 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°C).

## Applications

LCD Screen Adjustment

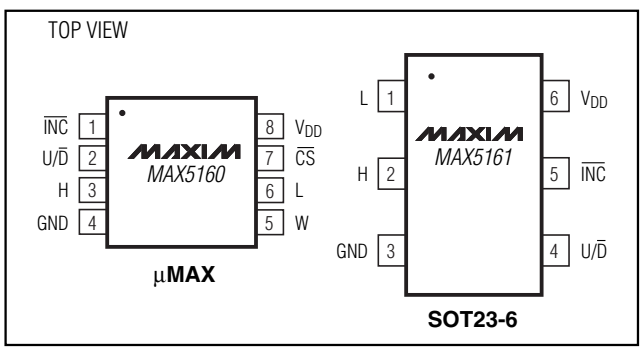
Volume Control

Mechanical Potentiometer Replacement

## Selector Guide

| PART | TOP MARK | R (kΩ) |
|---|---|---|
| **MAX5160**NEUA | — | 200 |
| MAX5160MEUA | — | 100 |
| MAX5160LEUA | — | 50 |
| **MAX5161**NEZT | AAAC | 200 |
| MAX5161MEZT | AAAB | 100 |
| MAX5161LEZT | AAAA | 50 |

## Pin Configurations



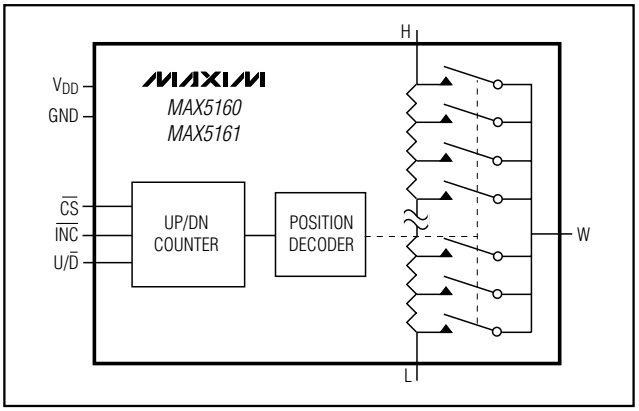

## Features

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

## Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE | R (kΩ) |
|---|---|---|---|
| **MAX5160**NEUA | -40°C to +85°C | 8 µMAX | 200 |
| MAX5160MEUA | -40°C to +85°C | 8 µMAX | 100 |
| MAX5160LEUA | -40°C to +85°C | 8 µMAX | 50 |
| **MAX5161**NEZT | -40°C to +85°C | 6 SOT23 | 200 |
| MAX5161MEZT | -40°C to +85°C | 6 SOT23 | 100 |
| MAX5161LEZT | -40°C to +85°C | 6 SOT23 | 50 |

## Functional Diagram






For price, delivery, and to place orders, please contact Maxim Distribution at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

# Low-Power Digital Potentiometers

## 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 .....±200mA
Maximum Continuous Current into H, L, and W
MAX516_ _ E_ _.....±1mA

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

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

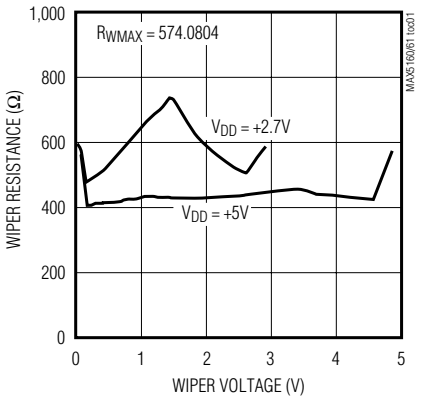
| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **DC PERFORMANCE** | | | | | | | |
| Resolution | | | | | 3 | | % |
| Integral Nonlinearity (Note 1) | INL | | | | | ±1/2 | LSB |
| Differential Nonlinearity (Note 1) | DNL | | | | | ±1 | LSB |
| End-to-End Resistor Tempco | $TC_R$ | | | | 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) | | | | | | | |
| $\overline{CS}$ to $\overline{INC}$ Setup Time | $t_{CI}$ | | | 25 | | | ns |
| $\overline{CS}$ to $\overline{INC}$ Hold Time | $t_{IC}$ | | | 0 | | | ns |
| $\overline{INC}$ Low Period | $t_{IL}$ | | | 25 | | | ns |
| $\overline{INC}$ High Period | $t_{IH}$ | | | 25 | | | ns |
| U/$\overline{D}$ to $\overline{INC}$ Hold | $t_{ID}$ | | | 0 | | | ns |
| U/$\overline{D}$ to $\overline{INC}$ Setup | $t_{DI}$ | | | 50 | | | ns |
| Wiper-Settling Time | $t_{IW}$ | | | | 1 | | µs |
| $\overline{INC}$ Frequency | $f_{IMAX}$ | | | | | 7 | MHz |
| **POWER SUPPLIES** | | | | | | | |
| Supply Voltage | $V_{DD}$ | | | 2.7 | | 5.5 | V |
| Supply Current | $I_{DD}$ | $\overline{CS}$ = $\overline{INC}$ = U/$\overline{D}$ = $V_{DD}$ 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.

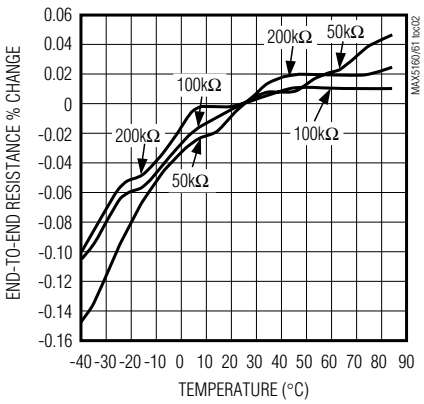
## Typical Operating Characteristics

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

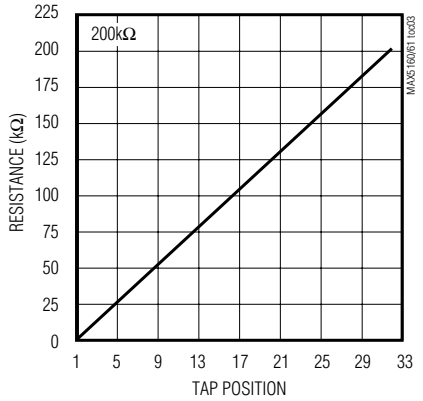
**WIPER RESISTANCE vs. WIPER VOLTAGE**



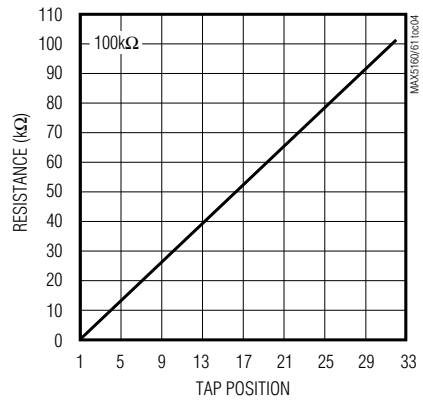

**END-TO-END RESISTANCE % CHANGE vs. TEMPERATURE**



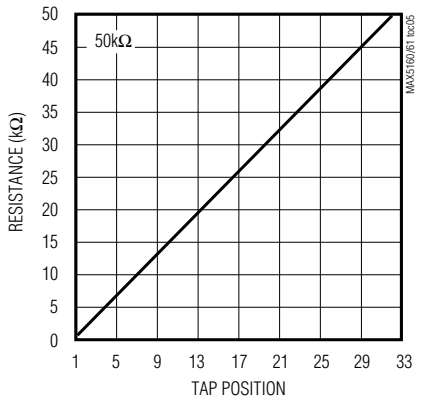

**END-TO-END RESISTANCE vs. TAP POSITION**




**END-TO-END RESISTANCE vs. TAP POSITION**




**END-TO-END RESISTANCE vs. TAP POSITION**

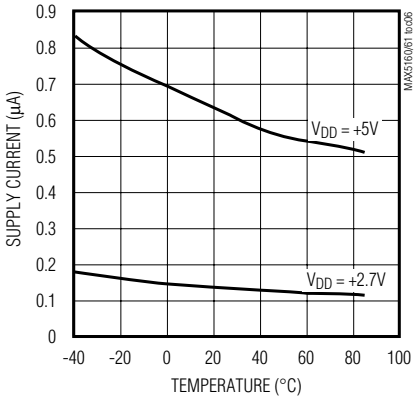


# Low-Power Digital Potentiometers

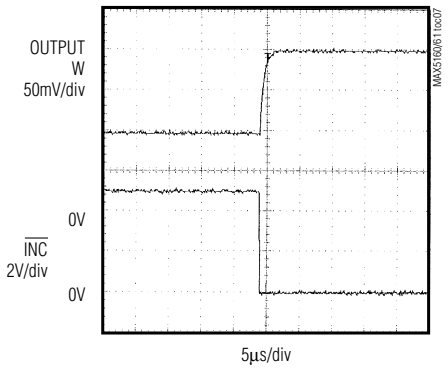
## Typical Operating Characteristics (continued)

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

**SUPPLY CURRENT vs. TEMPERATURE**




**TAP-TO-TAP SWITCHING TRANSIENT**




## Pin Description

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| MAX5160 | MAX5161 | | |
| 1 | 5 | $\overline{INC}$ | Wiper Increment Control Input. With $\overline{CS}$ low, a high-to-low transition increments (U/$\overline{D}$ high) or decrements (U/$\overline{D}$ low) the wiper position. |
| 2 | 4 | U/$\overline{D}$ | Up/Down Control Input. With $\overline{CS}$ low, a high-to-low $\overline{INC}$ transition increments (U/$\overline{D}$ high) or decrements (U/$\overline{D}$ 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 | — | $\overline{CS}$ | Chip-Select Input. Drive low to change the wiper position through $\overline{INC}$ and U/$\overline{D}$. |
| 8 | 6 | $V_{DD}$ | Power Supply |

## Detailed Description

The MAX5160/MAX5161 consist of resistor arrays with thirty-one resistive elements. Thirty-two tap points are accessible to the wiper along the resistor string between H and L. Logic inputs $\overline{CS}$, U/$\overline{D}$, and $\overline{INC}$ determine the position of the wiper. With $\overline{CS}$ low and U/$\overline{D}$ high, a high-to-low transition on $\overline{INC}$ increments the internal counter, increasing the resistance between W and L. When both $\overline{CS}$ and U/$\overline{D}$ are low, a high-to-low $\overline{INC}$ transition decrements the internal counter, decreasing the resistance between W and L. At either end (maximum or minimum positions), additional transitions in the direction of the end points will not change the counter value (the counter will not wrap around).

The H and L terminals of the MAX5160 are similar to the two end terminals of a mechanical potentiometer. The tap W is equivalent to the variable tap (wiper) of the potentiometer.

The MAX5161 is similar to the MAX5160 except that $\overline{CS}$ internally connects to ground and the wiper terminal (W) is shorted to the high terminal (H). The MAX5161 acts as a variable resistor (a potentiometer with the wiper and one end terminal shorted together).

The MAX5160/MAX5161 feature power-on reset circuitry that sets the wiper position to midscale at power-up.

## Applications Information

The MAX5160/MAX5161 are intended for circuits requiring digitally controlled adjustable voltage or adjustable gain, such as LCD contrast control, where voltage biasing adjusts the display contrast.

### Controlling a Switch-Mode LCD Bias Generator

Figure 1 shows an application where the MAX5161 is used with a MAX1771 to make an adjustable positive LCD-bias circuit. The output of the MAX1771 is a positive voltage that is digitally controlled through the MAX5160/MAX5161. Similarly, Figure 2 shows the application of the MAX5161 in a digitally controlled negative LCD-bias circuit along with the MAX774/MAX775/MAX776.

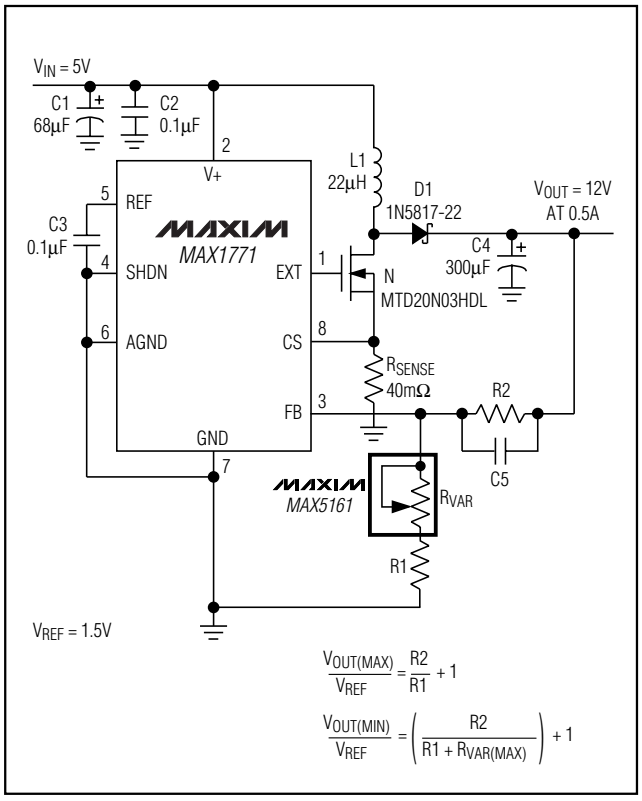



*Figure 1. Adjustable Positive LCD Bias*

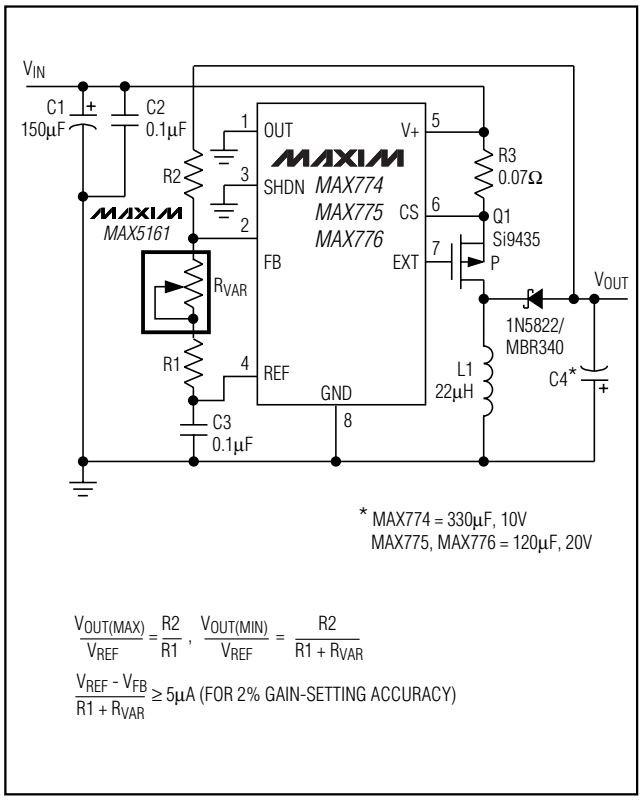



*Figure 2. Adjustable Negative LCD Bias*

# Low-Power Digital Potentiometers

### 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.

### 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.

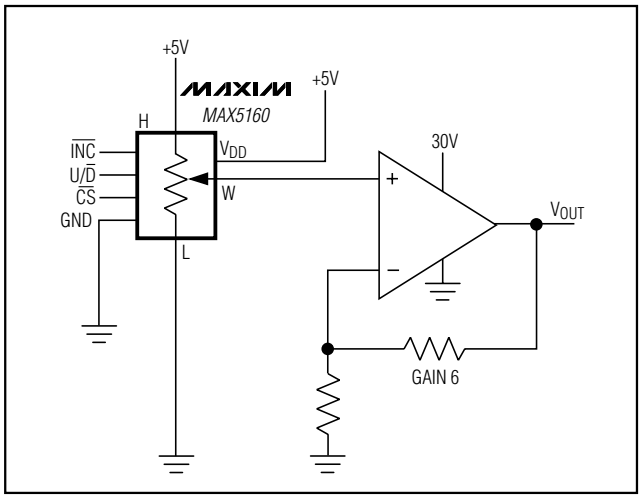



*Figure 3. MAX5160 Positive LCD Bias Control*

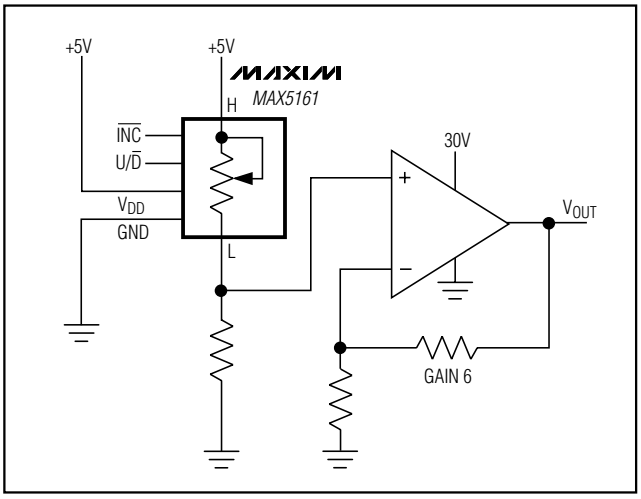



*Figure 4. MAX5161 Positive LCD Bias Control*

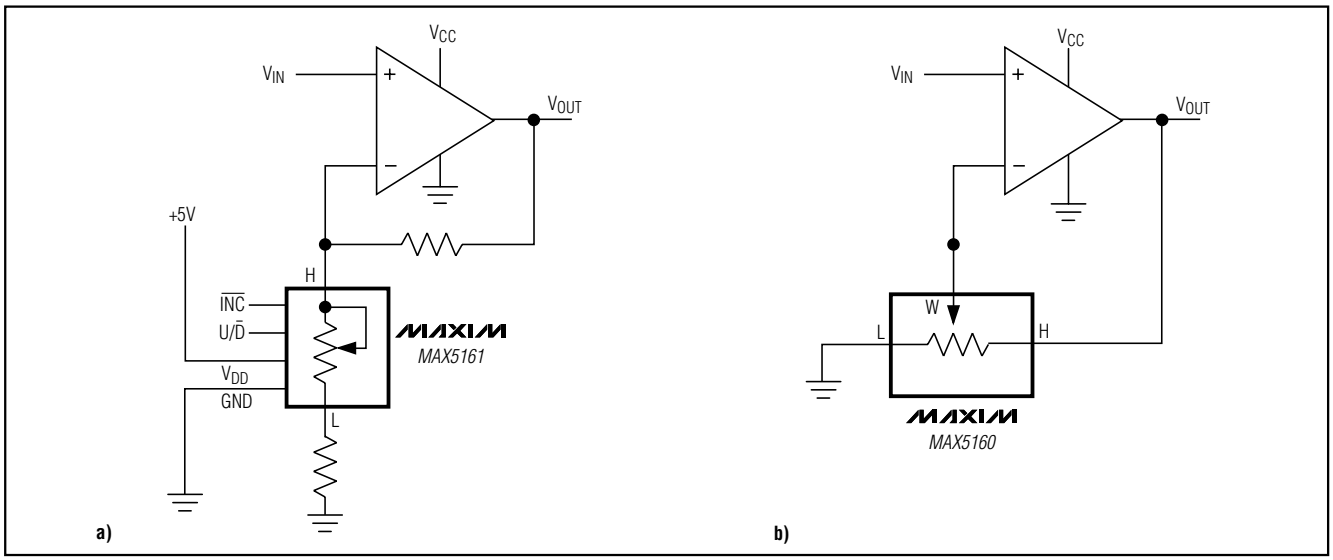



*Figure 5. Adjustable Gain Circuit: a) MAX5161; b) MAX5160*

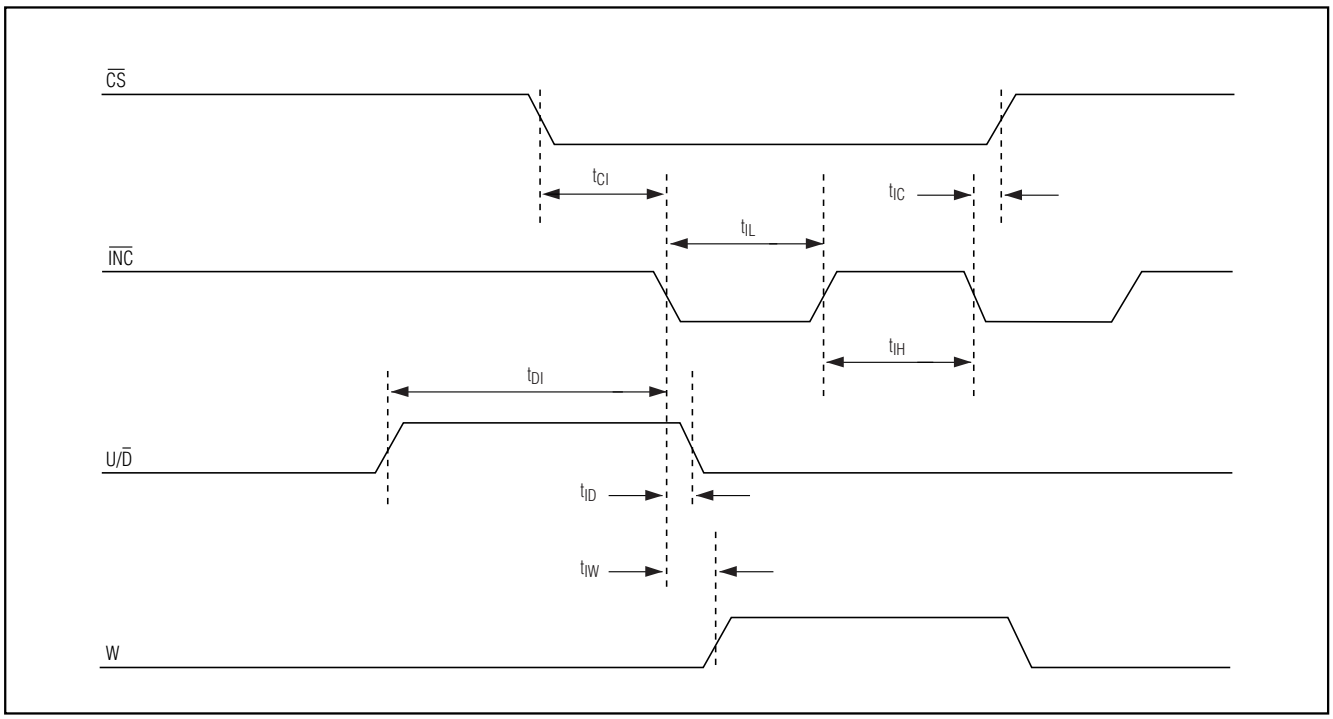



*Figure 6. Serial-Interface Timing Diagram*

## 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 | ↓ | + |

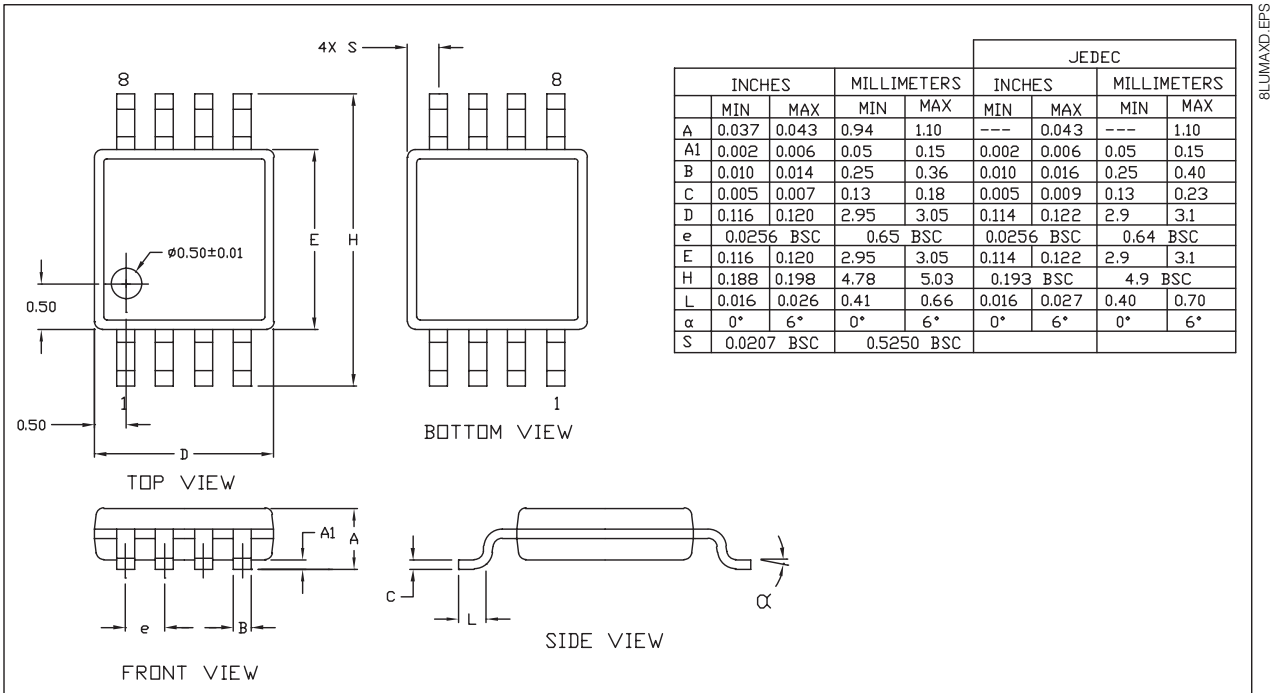
X = *Don't care*
O = *Previous state*
\+ = *Increment*
— = *Decrement*
↓ = *High-to-Low Transition*
↑ = *Low-to-High Transition*

## Chip Information

TRANSISTOR COUNT: 969

# Low-Power Digital Potentiometers

## Package Information




8LUMAXD.EPS

| | INCHES | | MILLIMETERS | | JEDEC INCHES | | JEDEC MILLIMETERS | |
|---|---|---|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX |
| A | 0.037 | 0.043 | 0.94 | 1.10 | --- | 0.043 | --- | 1.10 |
| A1 | 0.002 | 0.006 | 0.05 | 0.15 | 0.002 | 0.006 | 0.05 | 0.15 |
| B | 0.010 | 0.014 | 0.25 | 0.36 | 0.010 | 0.016 | 0.25 | 0.40 |
| C | 0.005 | 0.007 | 0.13 | 0.18 | 0.005 | 0.009 | 0.13 | 0.23 |
| D | 0.116 | 0.120 | 2.95 | 3.05 | 0.114 | 0.122 | 2.9 | 3.1 |
| e | 0.0256 BSC | | 0.65 BSC | | 0.0256 BSC | | 0.64 BSC | |
| E | 0.116 | 0.120 | 2.95 | 3.05 | 0.114 | 0.122 | 2.9 | 3.1 |
| H | 0.188 | 0.198 | 4.78 | 5.03 | 0.193 BSC | | 4.9 BSC | |
| L | 0.016 | 0.026 | 0.41 | 0.66 | 0.016 | 0.027 | 0.40 | 0.70 |
| α | 0° | 6° | 0° | 6° | 0° | 6° | 0° | 6° |
| S | 0.0207 BSC | | 0.5250 BSC | | | | | |

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187.

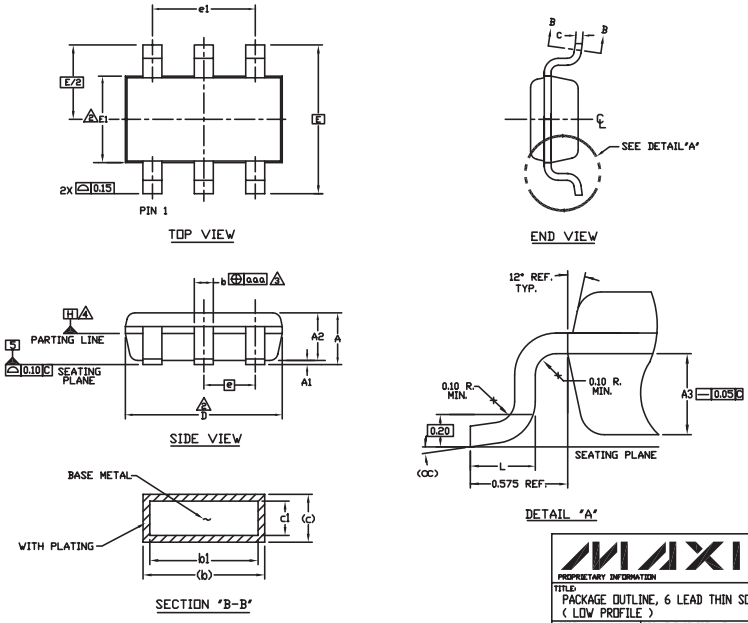
MAXIM
PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, 8L uMAX

| APPROVAL | DOCUMENT CONTROL NO. | REV | |
|---|---|---|---|
| | 21-0036 | I | 1/1 |

## Package Information (continued)

6 LEAD THIN SOT23.EPS




NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.

2. "D" AND "E1" ARE REFERENCE DATUM AND DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS, AND ARE MEASURED AT THE BOTTOM PARTING LINE. MOLD FLASH OR PROTRUSION SHALL NOT EXCEED 0.15mm ON "D" AND 0.25mm ON "E" PER SIDE.

3. THE LEAD WIDTH DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.07mm TOTAL IN EXCESS OF THE LEAD WIDTH DIMENSION AT MAXIMUM MATERIAL CONDITION.

4. DATUM PLANE "H" LOCATED AT MOLD PARTING LINE AND COINCIDENT WITH LEAD, WHERE LEAD EXITS PLASTIC BODY AT THE BOTTOM OF PARTING LINE.

5. THE LEAD TIPS MUST LINE WITHIN A SPECIFIED TOLERANCE ZONE. THIS TOLERANCE ZONE IS DEFINED BY TWO PARALLEL LINES. ONE PLANE IS THE SEATING PLANE, DATUM [-C-]; AND THE OTHER PLANE IS AT THE SPECIFIED DISTANCE FROM [-C-] IN THE DIRECTION INDICATED. FORMED LEADS SHALL BE PLANAR WITH RESPECT TO ONE ANOTHER WITH 0.10mm AT SEATING PLANE.

6. THIS PART IS COMPLIANT WITH JEDEC SPECIFICATION MO-193 EXCEPT FOR THE "e" DIMENSION WHICH IS 0.95mm INSTEAD OF 1.00mm. THIS PART IS IN FULL COMPLIANCE TO EIAJ SPECIFICATION SC-74.

| 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 | |
| cc | 0° | 4° | 8° |
| aaa | | 0.20 | |



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