



# High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch

MAX4644

## General Description

The MAX4644 is a single-pole/double-throw (SPDT) switch that operates from a single supply ranging from +1.8V to +5.5V. It provides low 4Ω on-resistance (RON) as well as 1Ω RON flatness over the entire analog signal range. The MAX4644 offers fast switching times of less than 20ns while ensuring break-before-make operation. It typically consumes only 0.01μW of quiescent power, making it suitable for use in low-power, portable applications.

The MAX4644's features include low leakage currents over the entire temperature range, TTL/CMOS-compatible digital logic, and excellent AC characteristics. It is packaged in either a small 8-pin μMAX or a tiny 6-pin SOT23.

## Applications

- Battery-Operated Equipment
- Audio and Video Signal Routing
- Low-Voltage Data-Acquisition Systems
- Sample-and-Hold Circuits
- Communications Circuits

*Rail-to-Rail is a trademark of Nippon Motorola, Ltd.*

## Features

- ◆ +1.8V to +5.5V Single-Supply Operation
- ◆ Rail-to-Rail® Analog Signal Range
- ◆ Guaranteed RON
  - 4Ω max (+5V supply)
  - 8Ω max (+3V supply)
- ◆ +1.8V Operation
  - RON 30Ω typ Over Temperature
  - TON 18ns typ, TOFF 12ns typ
- ◆ Guaranteed RON Flatness: 0.75Ω typ (+5V supply)
- ◆ Guaranteed RON Match Between Channels: 0.1Ω typ (+5V supply)
- ◆ Low Leakage (<0.35nA) Over Entire Temperature Range
- ◆ Excellent AC Characteristics
  - Low Crosstalk: -82dB at 1MHz
  - High Off-Isolation: -80dB at 1MHz
  - 0.018% Total Harmonic Distortion
- ◆ Low Power Consumption: < 0.01μW

## Ordering Information

| PART         | TEMP. RANGE    | PIN-PACKAGE | TOP MARK |
|--------------|----------------|-------------|----------|
| MAX4644EUT-T | -40°C to +85°C | 6 SOT23-6   | AAHQ     |
| MAX4644EUA   | -40°C to +85°C | 8 μMAX      | —        |

## Pin Configurations/Functional Diagrams/Truth Table

TOP VIEW

**SOT23-6**

**μMAX**

| MAX4644 |     |     |
|---------|-----|-----|
| IN      | NC  | NO  |
| 0       | ON  | OFF |
| 1       | OFF | ON  |



# High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch

## ABSOLUTE MAXIMUM RATINGS

All Voltages Referenced to GND

|   |                      |
|---|----------------------|
| V+  | -0.3V to +6V         |
| IN, COM, NO, NC (Note 1)                                      | -0.3V to (V+ + 0.3V) |
| Continuous Current (any terminal)                             | ±20mA                |
| Continuous Current (NO, NC, and COM)                          | ±50mA                |
| Peak Current (NO, NC, and COM, pulsed at 1ms, 10% duty cycle) | ±100mA               |

Continuous Power Dissipation (T<sub>A</sub> = +70°C)

|   |                 |
|---|-----------------|
| 6-Pin SOT23 (derate 8.7mW/°C above +70°C) | 696mW           |
| 8-Pin μMAX (derate 4.5mW/°C above +70°C)  | 362mW           |
| Operating Temperature Range               | -40°C to +85°C  |
| Junction Temperature                      | +150°C          |
| Storage Temperature Range                 | -65°C to +150°C |
| Lead Temperature (soldering, 10s)         | +300°C          |

**Note 1:** Signals on NO, NC, COM, or IN exceeding V+ or GND are clamped by internal diodes. Limit forward-diode current to maximum current rating.

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—Single +5V Supply

(V+ = +4.5V to +5.5V, V<sub>INH</sub> = 2.4V, V<sub>INL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

| PARAMETER                                     | SYMBOL   | CONDITIONS  | MIN   | TYP   | MAX   | UNITS |    |
|---|--|---|---|-------|-------|-------|----|
| <b>ANALOG SWITCH</b>                          |  |   |   |       |       |       |    |
| Analog Signal Range                           | V <sub>COM</sub> ,<br>V <sub>NO</sub> ,<br>V <sub>NC</sub> |   | 0   |       | V+    | V     |    |
| On-Resistance                                 | R <sub>ON</sub>  | V+ = 4.5V, I <sub>COM</sub> = 10mA, V <sub>NO</sub> or V <sub>NC</sub> = 0 to V+          | T <sub>A</sub> = +25°C                                | 2.5   | 4     | Ω     |    |
|   |  |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       | 4.75  |       |    |
| On-Resistance Match Between Channels (Note 2) | ΔR <sub>ON</sub>   | V+ = 4.5V, I <sub>COM</sub> = 10mA, V <sub>NO</sub> or V <sub>NC</sub> = 0 to V+          | T <sub>A</sub> = +25°C                                | 0.1   |       | Ω     |    |
|   |  |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       | 0.4   |       |    |
| On-Resistance Flatness (Note 3)               | R <sub>FLAT</sub>  | V+ = 4.5V, I <sub>COM</sub> = 10mA, V <sub>NO</sub> or V <sub>NC</sub> = 0 to V+          | T <sub>A</sub> = +25°C                                | 0.75  | 1     | Ω     |    |
|   |  |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       | 1.2   |       |    |
| NO, NC Off-Leakage Current (Note 4)           | I <sub>NO(OFF)</sub> ,<br>I <sub>NC(OFF)</sub>             | V+ = 5.5V, V <sub>COM</sub> = 1V or 4.5V, V <sub>NO</sub> or V <sub>NC</sub> = 4.5V or 1V | T <sub>A</sub> = +25°C                                | -0.25 | 0.01  | 0.25  | nA |
|   |  |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       | -0.35 | 0.35  |    |
| COM Off-Leakage Current (Note 4)              | I <sub>COM(OFF)</sub>                                      | V+ = 5.5V, V <sub>COM</sub> = 1V or 4.5V, V <sub>NO</sub> or V <sub>NC</sub> = 4.5V or 1V | T <sub>A</sub> = +25°C                                | -0.25 | 0.01  | 0.25  | nA |
|   |  |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       | -0.35 | 0.35  |    |
| COM On-Leakage Current (Notes 4, 5)           | I <sub>COM(ON)</sub>                                       | V+ = 5.5V, V <sub>COM</sub> = 1V or 4.5V  | T <sub>A</sub> = +25°C                                | -0.25 | 0.01  | 0.25  | nA |
|   |  |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       | -0.35 | 0.35  |    |
| <b>DIGITAL INPUTS</b>                         |  |   |   |       |       |       |    |
| Input Logic High                              | V <sub>IH</sub>  |   | 2.4   |       |       | V     |    |
| Input Logic Low                               | V <sub>IL</sub>  |   |   |       | 0.8   | V     |    |
| Input Current                                 | I <sub>IN</sub>  | V <sub>IN</sub> = 0.8V or 2.4V  | -0.1  | 0.005 | 0.1   | μA    |    |

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## ELECTRICAL CHARACTERISTICS—Single +5V Supply (continued)

(V+ = +4.5V to +5.5V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

| PARAMETER                  | SYMBOL             | CONDITIONS                                       | MIN               | TYP   | MAX | UNITS |
|----------------------------|--------------------|--|-------------------|-------|-----|-------|
| <b>DYNAMIC</b>             |                    |  |                   |       |     |       |
| Turn-On Time (Note 4)      | tON                | RL = 300Ω; CL = 35pF; VNO, VNC = 3V; Figure 2    | TA = +25°C        | 11    | 15  | ns    |
|                            |                    |  | TA = TMIN to TMAX |       | 18  |       |
| Turn-Off Time (Note 4)     | tOFF               | RL = 300Ω; CL = 35pF; VNO, VNC = 3V; Figure 2    | TA = +25°C        | 3     | 5   | ns    |
|                            |                    |  | TA = TMIN to TMAX |       | 6   |       |
| Break-Before-Make (Note 4) | tBBM               | RL = 300Ω; CL = 35pF; VNO or VNC = +3V; Figure 2 | TA = +25°C        | 8     |     | ns    |
|                            |                    |  | TA = TMIN to TMAX | 1     |     |       |
| Charge Injection           | Q                  | VGEN = 0, RGEN = 0, CL = 1nF, Figure 4           |                   | 5     |     | pC    |
| NO, NC Off-Capacitance     | CNO(OFF), CNC(OFF) | NO or NC = GND, f = 1MHz, Figure 5               |                   | 12    |     | pF    |
| Switch On-Capacitance      | C(ON)              | f = 1MHz, Figure 5                               |                   | 34    |     | pF    |
| Off-Isolation (Note 6)     | VISO               | CL = 5pF, RL = 50Ω, Figure 3                     | f = 10MHz         | -55   |     | dB    |
|                            |                    |  | f = 1MHz          | -80   |     |       |
| Crosstalk (Note 7)         | VCT                | CL = 5pF, RL = 50Ω, Figure 3                     | f = 10MHz         | -62   |     | dB    |
|                            |                    |  | f = 1MHz          | -82   |     |       |
| Total Harmonic Distortion  | THD                | RL = 600Ω, 0.5Vp-p, f = 20Hz to 20kHz            |                   | 0.018 |     | %     |
| <b>SUPPLY</b>              |                    |  |                   |       |     |       |
| Positive Supply Current    | I+                 | V+ = 5.5V, VIN = 0 or V+                         |                   | 0.001 | 1.0 | μA    |

## ELECTRICAL CHARACTERISTICS—Single +3V Supply

(V+ = +2.7V to +3.3V, VINH = 2.0V, VINL = 0.4V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

| PARAMETER                                     | SYMBOL         | CONDITIONS                                   | MIN               | TYP | MAX | UNITS |
|---|----------------|--|-------------------|-----|-----|-------|
| <b>ANALOG SWITCH</b>                          |                |  |                   |     |     |       |
| Analog Signal Range                           | VCOM, VNO, VNC |  | 0                 |     | V+  | V     |
| On-Resistance                                 | RON            | V+ = 2.7V, ICOM = 10mA, VNO or VNC = 0 to V+ | TA = +25°C        | 6   | 8   | Ω     |
|   |                |  | TA = TMIN to TMAX |     | 9   |       |
| On-Resistance Match Between Channels (Note 2) | ΔRON           | V+ = 2.7V, ICOM = 10mA, VNO or VNC = 0 to V+ | TA = +25°C        | 0.1 |     | Ω     |
|   |                |  | TA = TMIN to TMAX |     | 0.4 |       |
| On-Resistance Flatness (Note 3)               | RFLAT          | V+ = 2.7V, ICOM = 10mA, VNO or VNC = 0 to V+ | TA = +25°C        | 1.5 | 3   | Ω     |
|   |                |  | TA = TMIN to TMAX |     | 3.5 |       |

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## ELECTRICAL CHARACTERISTICS—Single +3V Supply (continued)

(V<sub>+</sub> = +2.7V to +3.3V, V<sub>INH</sub> = 2.0V, V<sub>INL</sub> = 0.4V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

| PARAMETER                  | SYMBOL                                      | CONDITIONS   | MIN   | TYP   | MAX | UNITS |
|----------------------------|---|--|---|-------|-----|-------|
| <b>DIGITAL INPUTS</b>      |   |  |   |       |     |       |
| Input Logic High           | V <sub>IH</sub>                             |  | 2.0   |       |     | V     |
| Input Logic Low            | V <sub>IL</sub>                             |  |   |       | 0.4 | V     |
| Input Current              | I <sub>IN</sub>                             | V <sub>IN</sub> = 0.4V or 2.0V   | -0.1  | 0.005 | 0.1 | μA    |
| <b>DYNAMIC</b>             |   |  |   |       |     |       |
| Turn-On Time (Note 4)      | t <sub>ON</sub>                             | R <sub>L</sub> = 300Ω; C <sub>L</sub> = 35pF; V <sub>NO</sub> , V <sub>NC</sub> = 2V; Figure 2 | T <sub>A</sub> = +25°C                                | 14    | 20  | ns    |
|                            |   |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       |     |       |
| Turn-Off Time (Note 4)     | t <sub>OFF</sub>                            | R <sub>L</sub> = 300Ω; C <sub>L</sub> = 35pF; V <sub>NO</sub> , V <sub>NC</sub> = 2V; Figure 2 | T <sub>A</sub> = +25°C                                | 4     | 7.5 | ns    |
|                            |   |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       |     |       |
| Break-Before-Make (Note 4) | t <sub>BBM</sub>                            | R <sub>L</sub> = 300Ω; C <sub>L</sub> = 35pF; V <sub>NO</sub> , V <sub>NC</sub> = 2V; Figure 2 | T <sub>A</sub> = +25°C                                | 8     |     | ns    |
|                            |   |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | 1     |     |       |
| Charge Injection           | Q   | V <sub>GEN</sub> = 0, R <sub>GEN</sub> = 0, C <sub>L</sub> = 1nF, Figure 4                     |   | 5     |     | pC    |
| NO, NC Off-Capacitance     | C <sub>NO(OFF)</sub> , C <sub>NC(OFF)</sub> | NO or NC = GND, f = 1MHz, Figure 5   |   | 12    |     | pF    |
| Switch On-Capacitance      | C <sub>(ON)</sub>                           | f = 1MHz, Figure 5   |   | 34    |     | pF    |
| Off-Isolation (Note 6)     | V <sub>ISO</sub>                            | C <sub>L</sub> = 5pF, R <sub>L</sub> = 50Ω, Figure 3   | f = 10MHz   | -55   |     | dB    |
|                            |   |  | f = 1MHz  | -80   |     |       |
| Crosstalk (Note 7)         | V <sub>CT</sub>                             | C <sub>L</sub> = 5pF, R <sub>L</sub> = 50Ω, Figure 3   | f = 10MHz   | -62   |     | dB    |
|                            |   |  | f = 1MHz  | -82   |     |       |
| <b>SUPPLY</b>              |   |  |   |       |     |       |
| Positive Supply Current    | I <sub>+</sub>                              | V <sub>+</sub> = 3.3V, V <sub>IN</sub> = 0 or V <sub>+</sub>                                   |   | 0.001 | 1.0 | μA    |

**Note 2:**  $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$ .

**Note 3:** R<sub>ON</sub> flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal range.

**Note 4:** Guaranteed by design.

**Note 5:** On-Leakage performed with voltage applied to COM, with NO and NC left floating.

**Note 6:** Off-Isolation = 20log<sub>10</sub> (V<sub>O</sub> / V<sub>I</sub>), where V<sub>O</sub> is V<sub>COM</sub> and V<sub>I</sub> is either V<sub>NC</sub> or V<sub>NO</sub> from the network analyzer.

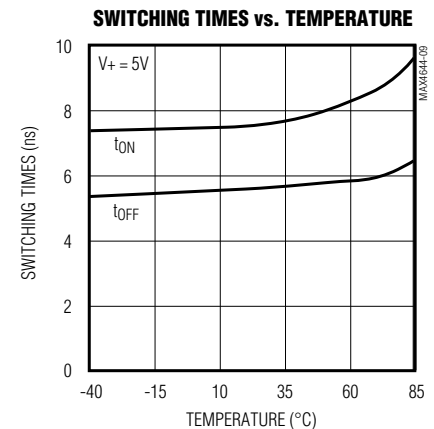
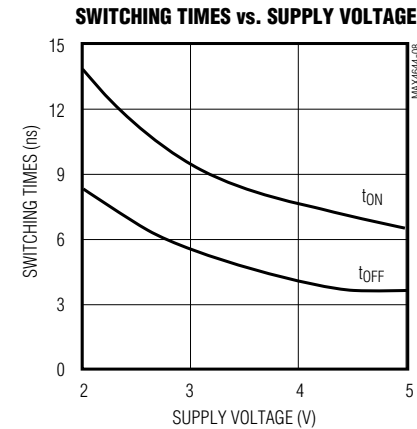
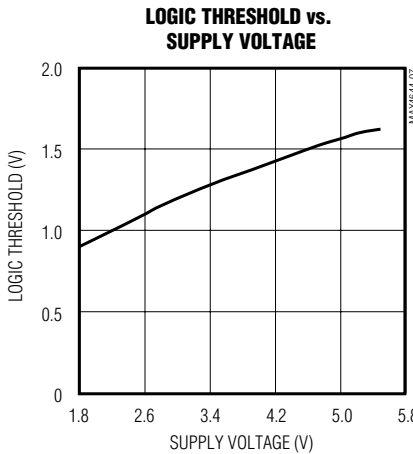
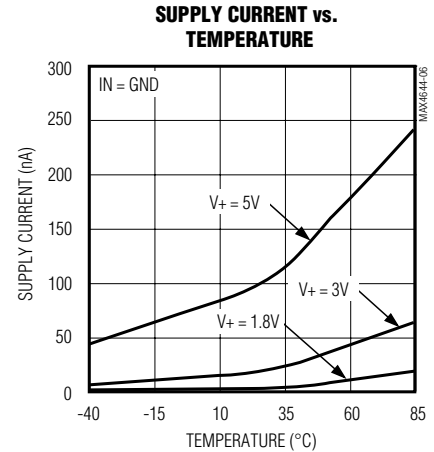
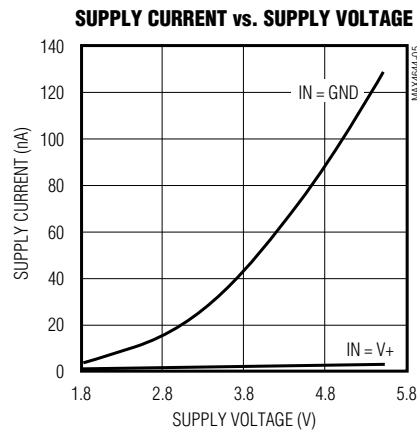
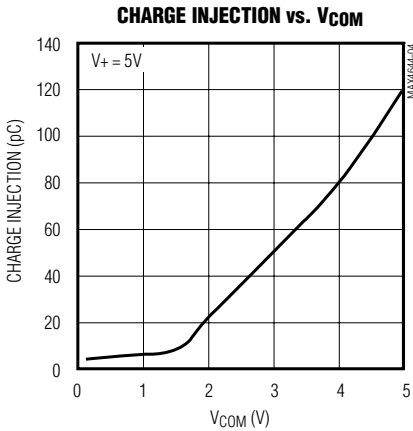
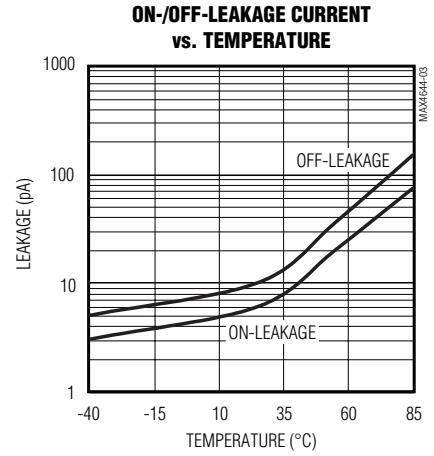
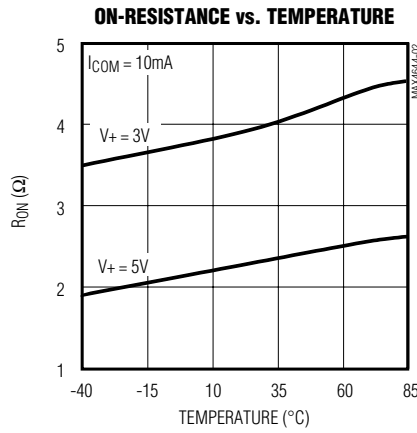
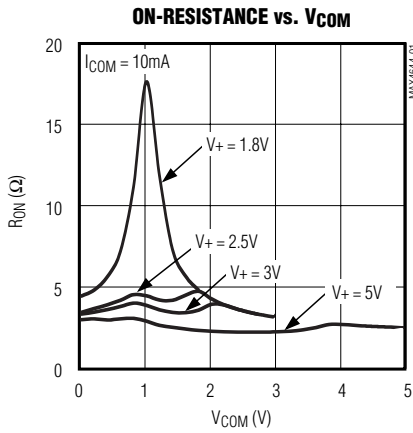
**Note 7:** Crosstalk is measured between the two switches.

# High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch

## Typical Operating Characteristics

( $V_+ = +5V$  or  $+3V$ ,  $V_{INH} = V_+$ ,  $V_{INL} = GND$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

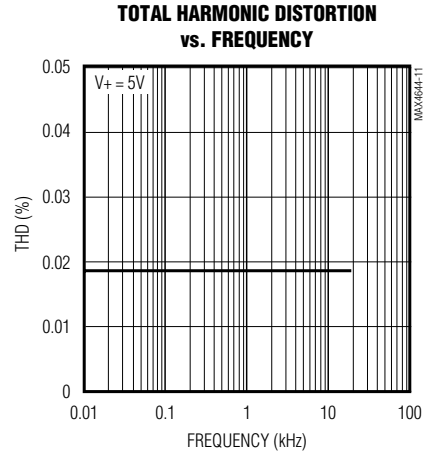
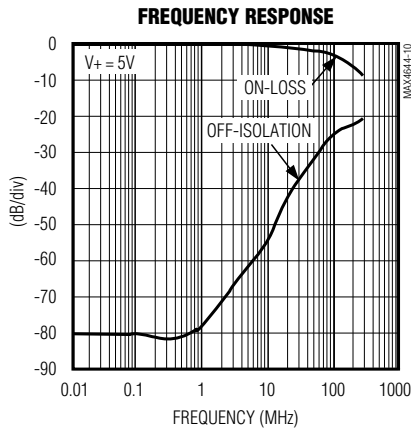
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# High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch

## Typical Operating Characteristics (continued)

(V+ = +5V or +3V, VINH = V+, VINL = GND, TA = +25°C, unless otherwise noted.)



## Pin Description

| MAX4644 |      | NAME | FUNCTION   |
|---------|------|------|--|
| SOT23   | μMAX |      |  |
| 1       | 6    | IN   | Logic-Controlled Input   |
| 2       | 4    | V+   | Positive Supply Voltage Input. Bypass with a 0.1μF capacitor to GND. |
| 3       | 3    | GND  | Ground   |
| —       | 5, 7 | N.C. | No Connection. Not internally connected.                             |
| 4       | 2    | NC   | Analog Switch Normally Closed Terminal                               |
| 5       | 1    | COM  | Analog Switch Common Terminal  |
| 6       | 8    | NO   | Analog Switch Normally Open Terminal                                 |

**Note:** The switches are bidirectional, which means that a signal can be passed through either side of the on switch. However, the typical off-capacitances differ as shown in the *Electrical Characteristics*.

# High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch

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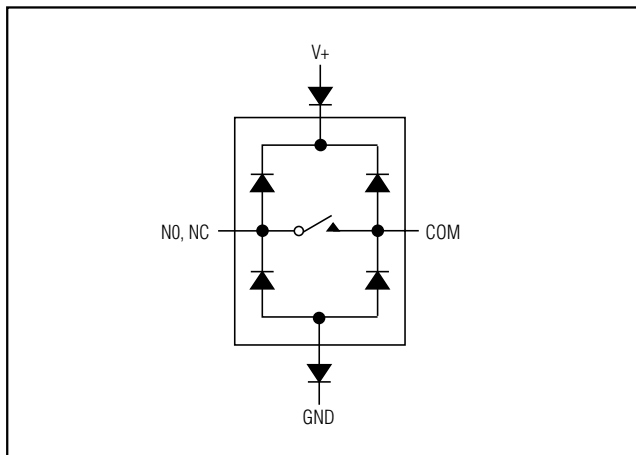


Figure 1. Overvoltage Protection Using External Blocking Diodes

## Applications Information

The MAX4644 operates from a single supply ranging from +1.8V to +5.5V. The device is guaranteed to be functional over that supply range, but TTL/CMOS compatibility is only valid for operation using a +5V supply. All voltage levels are referenced to GND. Positive and negative DC analog inputs or AC signals can be accommodated by shifting V+ and GND.

ESD-protection diodes are internally connected between each analog-signal pin and both V+ and GND. One of these diodes conducts if any analog signal exceeds V+ or GND (Figure 1). Virtually all of the analog leakage current comes from the ESD diodes to V+ or GND. Although the ESD diodes on a given signal pin are identical, and therefore fairly well balanced, they are reverse biased differently. Each is biased by either V+ or GND and the analog signal. This means their leakages will vary as the signal varies. The difference in the two diode leakages to the V+ and GND pins constitutes the analog-signal-path leakage current. All analog leakage current flows between each pin and one of the supply terminals, not to the other switch terminal. This is why both sides of a given switch can show leakage currents of the same or opposite polarity.

There is no normal current path between the analog-signal paths and V+ or GND. V+ and GND also power the internal logic and logic-level translators. The logic-level translators convert the logic level into switched V+ and GND signals to drive the analog signal gates.

## Chip Information

TRANSISTOR COUNT: 105

# High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch

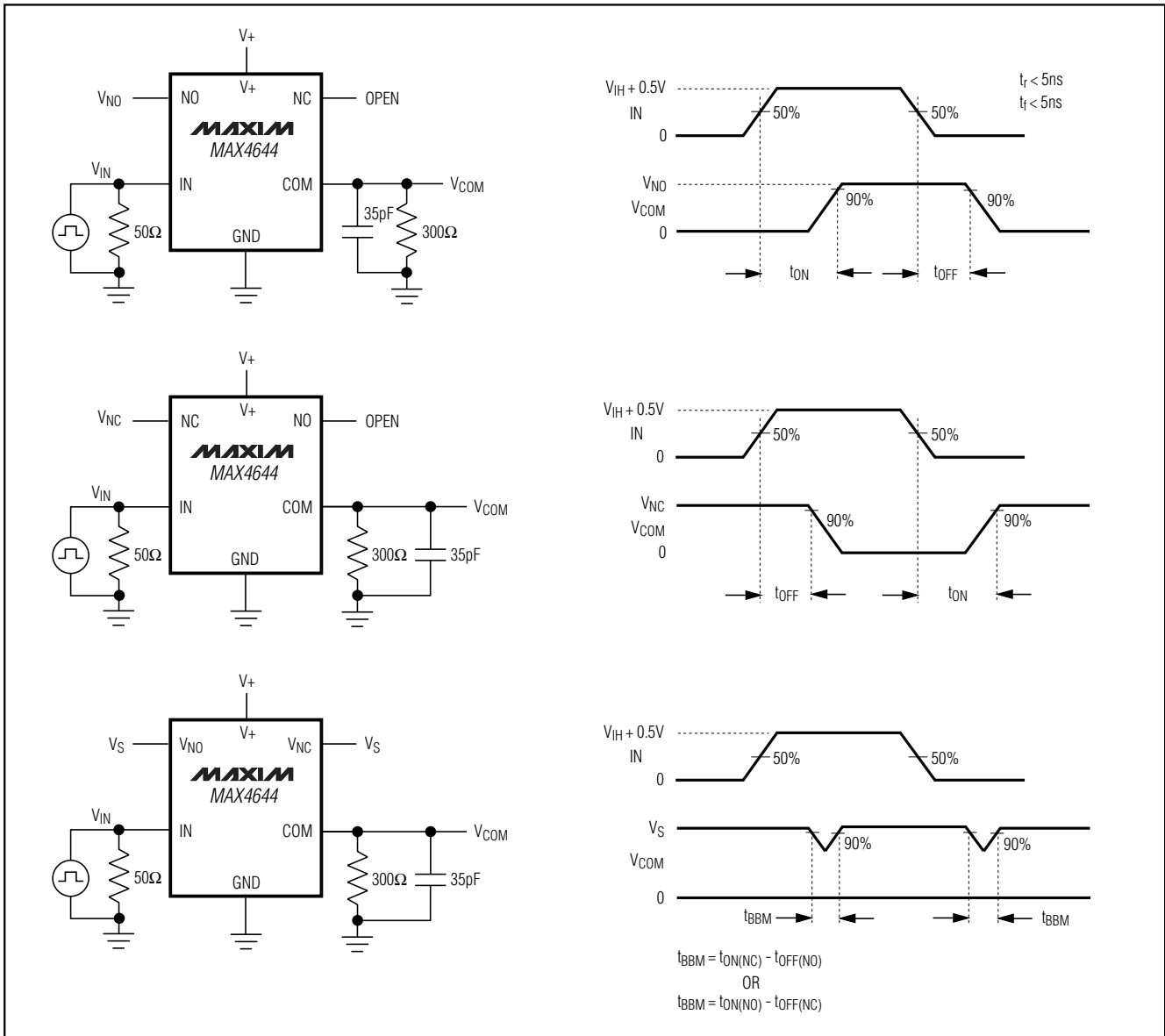


Figure 2. Switching Times



# High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch

**MAX4644**

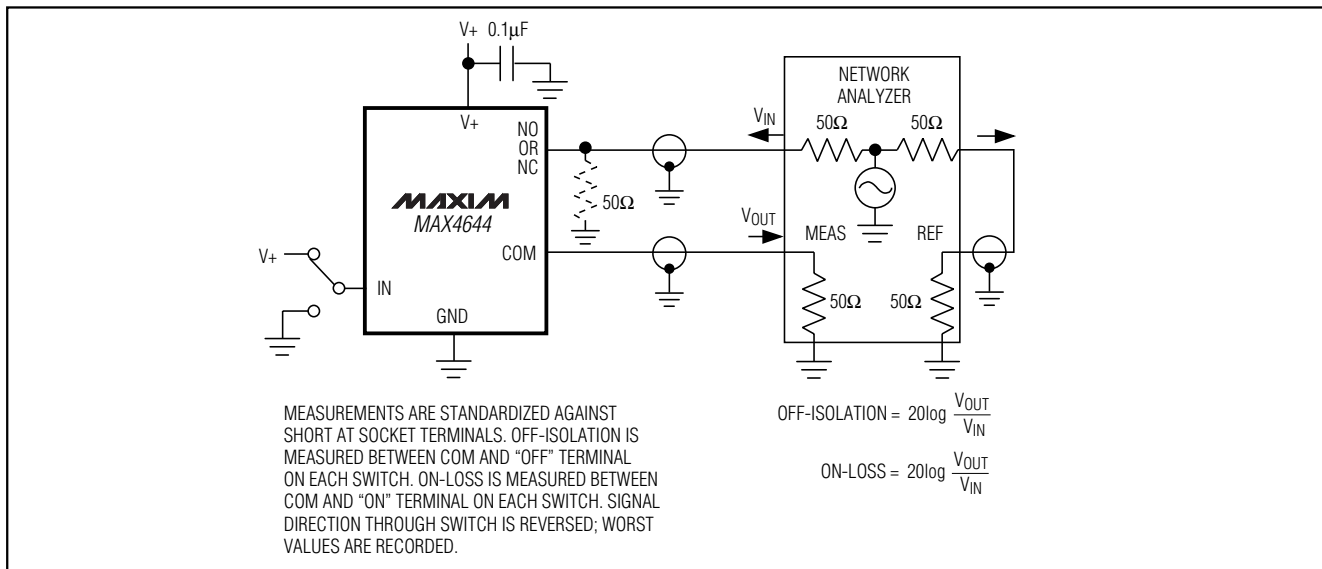


Figure 3. Off-Isolation and On-Loss

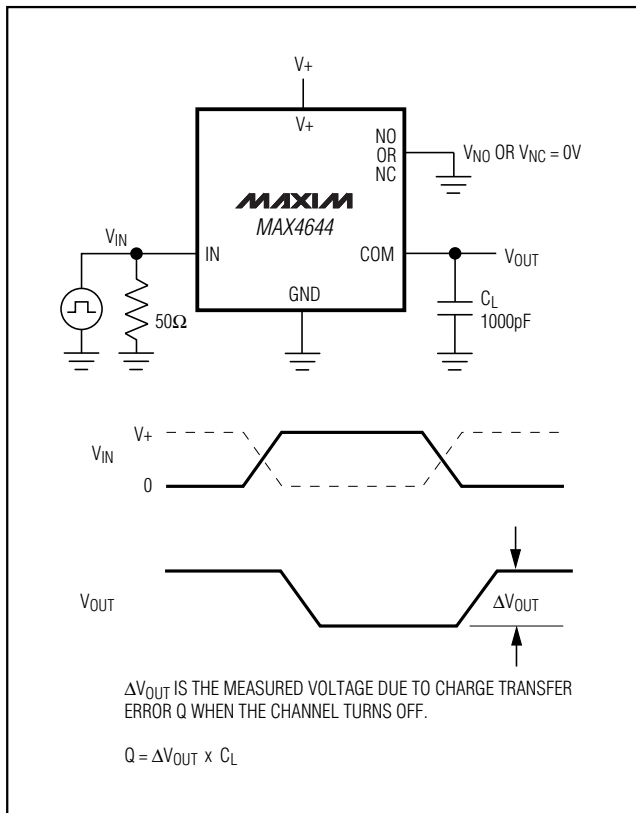


Figure 4. Charge Injection

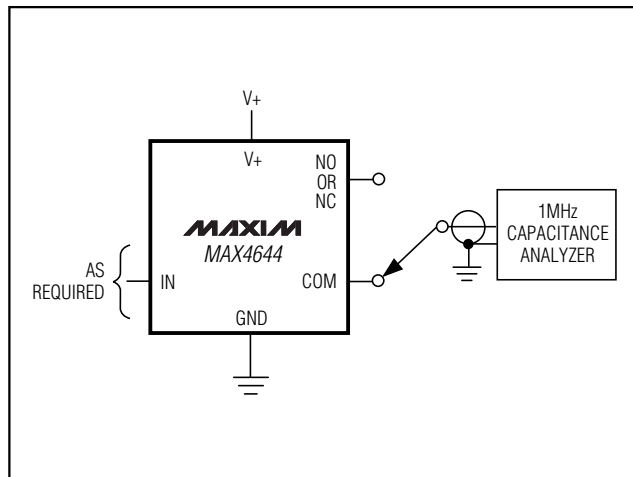
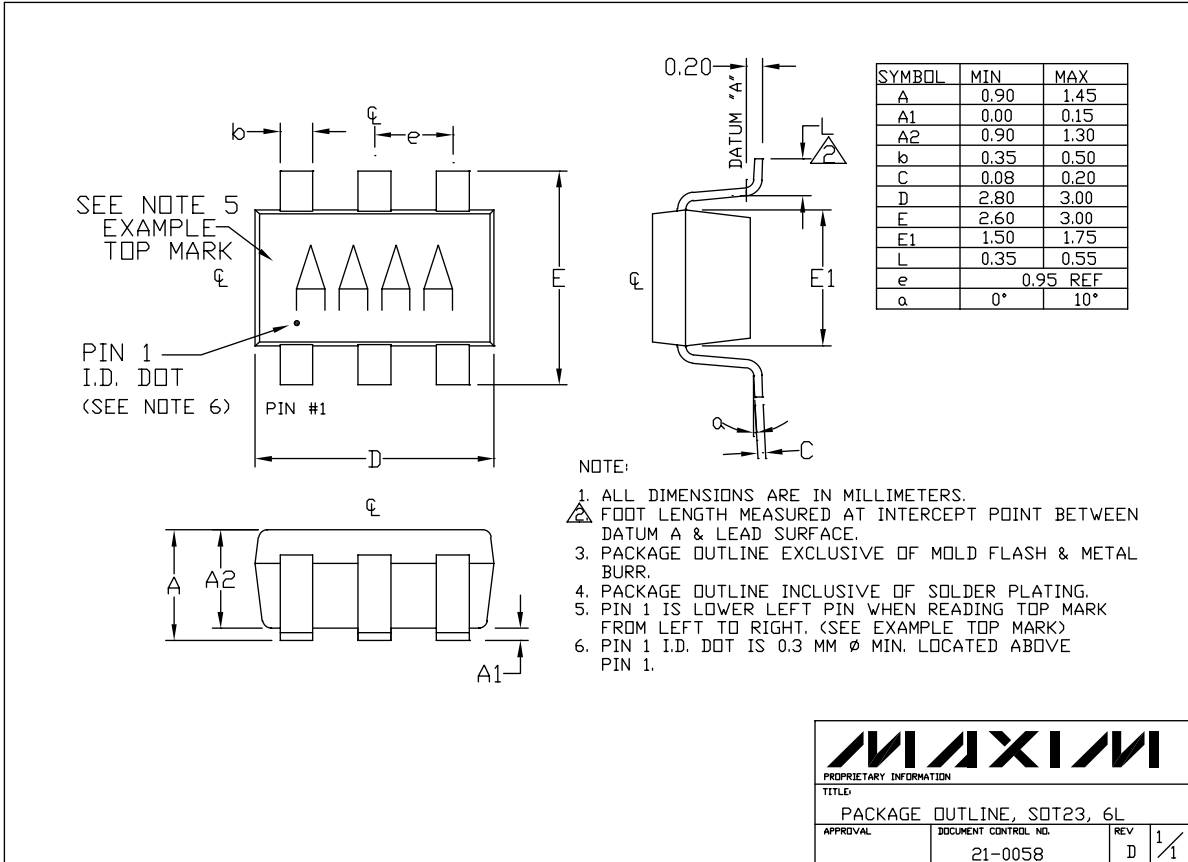


Figure 5. NO, NC, and COM Capacitance

# High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch

## Package Information



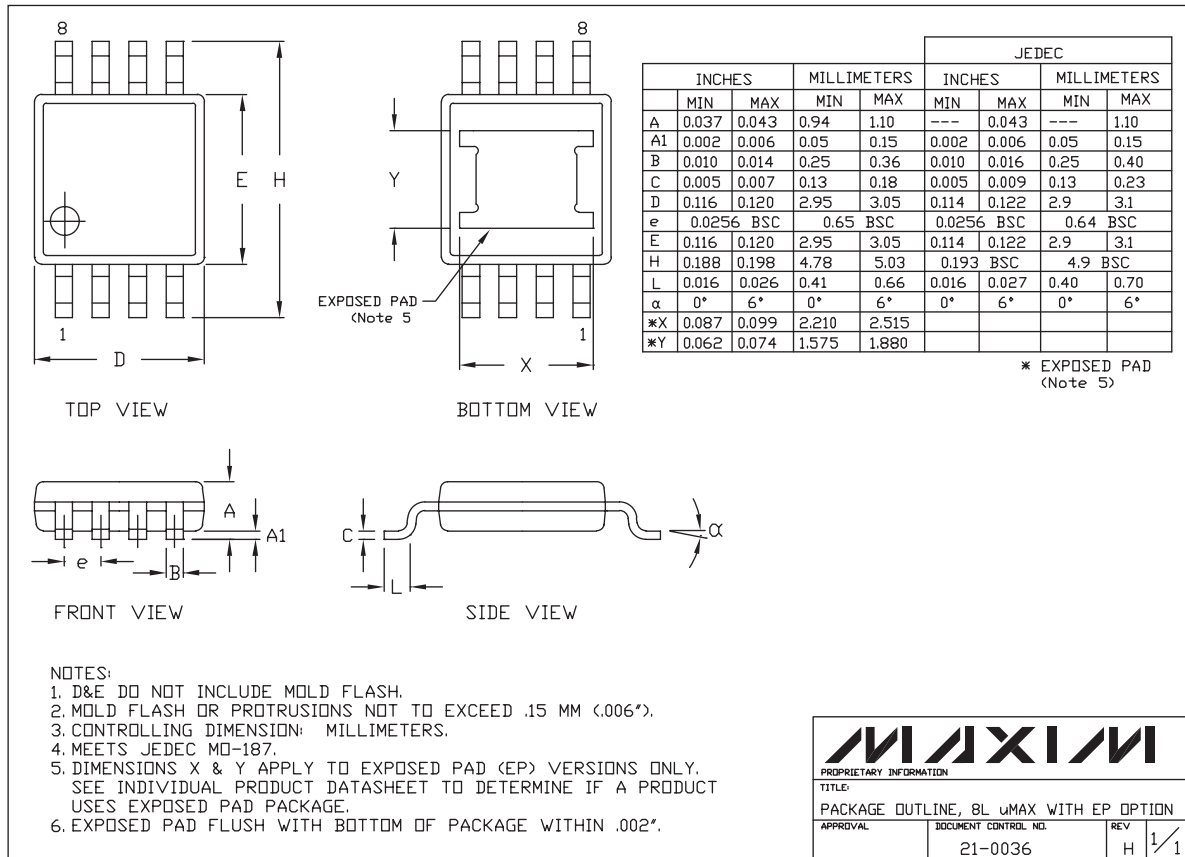
6LSOT.EPS

|                            |                      |     |     |
|----------------------------|----------------------|-----|-----|
| <b>MAXIM</b>               |                      |     |     |
| PROPRIETARY INFORMATION    |                      |     |     |
| TITLE:                     |                      |     |     |
| PACKAGE OUTLINE, SOT23, 6L |                      |     |     |
| APPROVAL                   | DOCUMENT CONTROL NO. | REV | 1/1 |
|                            | 21-0058              | D   |     |

# High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch

## Package Information (continued)

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# **High-Speed, Low-Voltage, 4Ω, SPDT CMOS Analog Switch**

## **NOTES**

*Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.*

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