



# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

MAX4594-MAX4597

## General Description

The MAX4594–MAX4597 single-pole/single-throw (SPST) analog switches operate from a single +2.0V to +5.5V supply. The MAX4594/MAX4596 switches are normally open (NO), and the MAX4595/MAX4597 are normally closed (NC). The MAX4596/MAX4597 pinouts are optimized for the highest SC70 package off-isolation available.

These switches have 10Ω max on-resistance ( $R_{ON}$ ), with 1.5Ω max  $R_{ON}$  flatness over the analog signal range when powered from a +5V supply. The MAX4594–MAX4597 offer low 0.5nA leakage currents and fast switching times less than 40ns. They are packaged in an ultra-small 5-pin SC70 and 6-pin μDFN.

## Features

- ◆ Available in 5-Pin SC70 and 6-Pin μDFN Packages
- ◆ 10Ω max On-Resistance
- ◆ 1.5Ω max On-Resistance Flatness
- ◆ Fast Switching  
 $t_{ON} = 35ns$  max  
 $t_{OFF} = 40ns$  max
- ◆ Guaranteed 5pC max Charge Injection
- ◆ +2.0V to +5.5V Single-Supply Operation
- ◆ 300MHz -3dB Bandwidth at +25°C
- ◆ TTL/CMOS-Logic Compatible
- ◆ -80dB Off-Isolation at 1MHz
- ◆ 0.5nA max Off-Leakage
- ◆ 0.05% THD

## Applications

- Cellular Phones
- Battery-Operated Equipment
- Audio and Video Signal Routing
- Communications Circuits
- PCMCIA Cards
- DSL Modems

## Ordering Information

| PART         | TEMP RANGE     | PIN-PACKAGE | TOP MARK |
|--------------|----------------|-------------|----------|
| MAX4594EXK-T | -40°C to +85°C | 5 SC70-5    | AAH      |
| MAX4594ELT-T | -40°C to +85°C | 6 μDFN-6    | AB       |
| MAX4595EXK-T | -40°C to +85°C | 5 SC70-5    | AAI      |
| MAX4595ELT-T | -40°C to +85°C | 6 μDFN-6    | AC       |
| MAX4596EXK-T | -40°C to +85°C | 5 SC70-5    | AAJ      |
| MAX4596ELT-T | -40°C to +85°C | 6 μDFN-6    | AD       |
| MAX4597EXK-T | -40°C to +85°C | 5 SC70-5    | AAK      |
| MAX4597ELT-T | -40°C to +85°C | 6 μDFN-6    | AE       |

## Pin Configurations/Functional Diagrams/Truth Table

TOP VIEW

MAX4594  
SC70

MAX4595  
SC70

MAX4596  
SC70

MAX4597  
SC70

| INPUT | SWITCH STATE    |                 |
|-------|-----------------|-----------------|
|       | MAX4594/MAX4596 | MAX4595/MAX4597 |
| LOW   | OFF             | ON              |
| HIGH  | ON              | OFF             |

SWITCHES SHOWN FOR LOGIC 0 INPUT.

Pin Configurations/Functional Diagrams/Truth Table continued at end of data sheet.



**For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).**

# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

## ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to GND)

|   |                      |
|---|----------------------|
| V+  | -0.3V to +6V         |
| Voltage into Any Terminal (Note 1)                              | -0.3V to (V+ + 0.3V) |
| Continuous Current into Any Terminal                            | ±20mA                |
| Peak Current, NO, NC, or COM<br>(pulsed at 1ms, 10% duty cycle) | ±40mA                |

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

|  |                 |
|--|-----------------|
| 5-Pin SC70 (derate 3.1mW/°C above +70°C) | 247mW           |
| 6-Pin μDFN (derate 2.1mW/°C above +70°C) | 168mW           |
| Operating Temperature Range              |                 |
| MAX459_EXK                               | -40°C to +85°C  |
| Storage Temperature Range                | -65°C to +150°C |
| Lead Temperature (soldering, 10s)        | +300°C          |

**Note 1:** Voltages exceeding V+ or GND on any signal terminal 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—+5V Supply

(V+ = +4.5V to +5.5V, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = +0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V+ = +5V, T<sub>A</sub> = +25°C.) (Notes 2, 3)

| PARAMETER                       | SYMBOL   | CONDITIONS   | MIN   | TYP  | MAX  | UNITS |    |
|---------------------------------|--|--|---|------|------|-------|----|
| <b>ANALOG SWITCH</b>            |  |  |   |      |      |       |    |
| Analog Signal Range             | V <sub>COM</sub> , V <sub>NO</sub> , V <sub>NC</sub> |  | 0   |      | V+   | V     |    |
| On-Resistance                   | R <sub>ON</sub>                                      | V+ = 4.5V, V <sub>NO</sub> , or V <sub>NC</sub> = 3.5V; I <sub>COM</sub> = 10mA                    | T <sub>A</sub> = +25°C                                | 6.5  | 10   | Ω     |    |
|                                 |  |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | 12   |       |    |
| On-Resistance Flatness (Note 4) | R <sub>FLAT(ON)</sub>                                | V <sub>NO</sub> or V <sub>NC</sub> = 1.5V, 2.5V, 3.5V; V+ = 4.5V; I <sub>COM</sub> = 10mA          | T <sub>A</sub> = +25°C                                | 0.5  | 1.5  | Ω     |    |
|                                 |  |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | 2    |       |    |
| NO or NC Off-Leakage Current    | I <sub>NO(OFF)</sub><br>I <sub>NC(OFF)</sub>         | V+ = 5.5V; V <sub>COM</sub> = 1V, 4.5V; V <sub>NO</sub> or V <sub>NC</sub> = 4.5V, 1V              | T <sub>A</sub> = +25°C                                | -0.5 | 0.01 | 0.5   | nA |
|                                 |  |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -5   |      | 5     |    |
| COM Off-Leakage Current         | I <sub>COM(OFF)</sub>                                | V+ = 5.5V; V <sub>COM</sub> = 1V, 4.5V; V <sub>NO</sub> or V <sub>NC</sub> = 4.5V, 1V              | T <sub>A</sub> = +25°C                                | -0.5 | 0.01 | 0.5   | nA |
|                                 |  |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -5   |      | 5     |    |
| COM On-Leakage Current          | I <sub>COM(ON)</sub>                                 | V+ = 5.5V; V <sub>COM</sub> = 1V; 4.5V; V <sub>NO</sub> or V <sub>NC</sub> = 1V, 4.5V, or floating | T <sub>A</sub> = +25°C                                | -1   | 0.01 | 1     | nA |
|                                 |  |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -10  |      | 10    |    |
| <b>DIGITAL I/O</b>              |  |  |   |      |      |       |    |
| Input Logic High                | V <sub>IH</sub>                                      |  | 2.4   |      |      | V     |    |
| Input Logic Low                 | V <sub>IL</sub>                                      |  |   |      | 0.8  | V     |    |
| Input Logic Current             | I <sub>IH</sub> , I <sub>IL</sub>                    | V <sub>IN</sub> = V+, 0  | -1  | 0.03 | 1    | μA    |    |
| <b>DYNAMIC</b>                  |  |  |   |      |      |       |    |
| Turn-On Time                    | t <sub>ON</sub>                                      | V <sub>NO</sub> or V <sub>NC</sub> = 3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 3    | T <sub>A</sub> = +25°C                                | 20   | 35   | ns    |    |
|                                 |  |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | 45   |       |    |
| Turn-Off Time                   | t <sub>OFF</sub>                                     | V <sub>NO</sub> or V <sub>NC</sub> = 3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 3    | T <sub>A</sub> = +25°C                                | 25   | 40   | ns    |    |
|                                 |  |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | 50   |       |    |
| On-Channel -3dB Bandwidth       | BW   | Signal = 0dBm, 50Ω in and out, Figure 4  | T <sub>A</sub> = +25°C                                | 300  |      | MHz   |    |

# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

MAX4594-MAX4597

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

(V<sub>+</sub> = +4.5V to +5.5V, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = +0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>+</sub> = +5V, T<sub>A</sub> = +25°C.) (Notes 2, 3)

| PARAMETER                               | SYMBOL   | CONDITIONS  |   | MIN | TYP  | MAX | UNITS |
|---|--|---|---|-----|------|-----|-------|
| Charge Injection<br>(Note 5)            | Q  | V <sub>NO</sub> or V <sub>NC</sub> = 0, C <sub>L</sub> = 1nF,<br>Figure 2   | T <sub>A</sub> = +25°C                                |     | 2    | 5   | pC    |
| Off-Isolation<br>(Note 6)               | VISO   | V <sub>NO</sub> or V <sub>NC</sub> = 1V <sub>RMS</sub> ,<br>R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF,<br>f = 1MHz, Figure 4 | T <sub>A</sub> =<br>+25°C                             |     | 80   |     | dB    |
|   |  |   |   |     | 83   |     |       |
| NO or NC Off-Capacitance                | C <sub>NO(OFF)</sub> ,<br>C <sub>NC(OFF)</sub> | V <sub>NO</sub> or V <sub>NC</sub> = 0, f = 1MHz,<br>Figure 5   | T <sub>A</sub> = +25°C                                |     | 8    |     | pF    |
| COM Off-Capacitance                     | C <sub>COM(OFF)</sub>                          | V <sub>COM</sub> = 0, f = 1MHz,<br>Figure 5   | T <sub>A</sub> = +25°C                                |     | 8    |     | pF    |
| COM On-Capacitance                      | C <sub>COM(ON)</sub>                           | V <sub>COM</sub> = 0, f = 1MHz,<br>Figure 5   | T <sub>A</sub> = +25°C                                |     | 20   |     | pF    |
| Total Harmonic Distortion<br>Plus Noise | THD  | V = 5Vp-p, R <sub>L</sub> = 600Ω,<br>f = 20Hz to 20kHz  | T <sub>A</sub> = +25°C                                |     | 0.05 |     | %     |
| <b>POWER SUPPLY</b>                     |  |   |   |     |      |     |       |
| Power-Supply Range                      | V <sub>+</sub>                                 |   |   | 2.0 |      | 5.5 | V     |
| V <sub>+</sub> Supply Current           | I <sub>+</sub>                                 | V <sub>+</sub> = 5.5V, V <sub>IN</sub> = 0 or V <sub>+</sub>  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -1  |      | 1   | μA    |

## ELECTRICAL CHARACTERISTICS—+3V Supply

(V<sub>+</sub> = +2.7V to +3.6V, V<sub>IH</sub> = +2.0V, V<sub>IL</sub> = +0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>+</sub> = +3.0V, T<sub>A</sub> = +25°C.) (Notes 2, 3)

| PARAMETER                    | SYMBOL  | CONDITIONS   |   | MIN | TYP  | MAX            | UNITS |
|------------------------------|---|--|---|-----|------|----------------|-------|
| <b>ANALOG SWITCH</b>         |   |  |   |     |      |                |       |
| Analog Signal Range          | V <sub>COM</sub> , V <sub>NO</sub> ,<br>V <sub>NC</sub> |  |   | 0   |      | V <sub>+</sub> | V     |
| On-Resistance                | R <sub>ON</sub>   | V <sub>NO</sub> or V <sub>NC</sub> = 1.5V, I <sub>COM</sub> =<br>10mA, V <sub>+</sub> = 2.7V       | T <sub>A</sub> = +25°C                                |     | 10   | 20             | Ω     |
|                              |   |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |     |      | 25             |       |
| <b>DIGITAL I/O</b>           |   |  |   |     |      |                |       |
| Input Logic High             | V <sub>IH</sub>   |  |   | 2.0 |      |                | V     |
| Input Logic Low              | V <sub>IL</sub>   |  |   |     |      | 0.8            | V     |
| Input Logic Current          | I <sub>IH</sub> , I <sub>IL</sub>                       | V <sub>IN</sub> = V <sub>+</sub> , 0   |   | -1  | 0.03 | 1              | μA    |
| <b>DYNAMIC</b>               |   |  |   |     |      |                |       |
| Turn-On Time                 | t <sub>ON</sub>   | V <sub>NO</sub> or V <sub>NC</sub> = 2V, R <sub>L</sub> =<br>300Ω, C <sub>L</sub> = 35pF, Figure 3 | T <sub>A</sub> = +25°C                                |     | 25   | 45             | ns    |
|                              |   |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |     |      | 55             |       |
| Turn-Off Time                | t <sub>OFF</sub>  | V <sub>NO</sub> or V <sub>NC</sub> = 2V, R <sub>L</sub> =<br>300Ω, C <sub>L</sub> = 35pF, Figure 3 | T <sub>A</sub> = +25°C                                |     | 30   | 50             | ns    |
|                              |   |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |     |      | 60             |       |
| Charge Injection<br>(Note 5) | Q   | V <sub>NO</sub> or V <sub>NC</sub> = 0, C <sub>L</sub> = 1nF,<br>Figure 2                          | T <sub>A</sub> = +25°C                                |     | 2    | 4              | pC    |

# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

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

( $V_+ = +2.7V$  to  $+3.6V$ ,  $V_{IH} = +2.0V$ ,  $V_{IL} = +0.8V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_+ = +3.0V$ ,  $T_A = +25^\circ C$ .) (Notes 2, 3)

| PARAMETER            | SYMBOL | CONDITIONS                           | MIN                          | TYP | MAX | UNITS   |
|----------------------|--------|--------------------------------------|------------------------------|-----|-----|---------|
| <b>POWER SUPPLY</b>  |        |                                      |                              |     |     |         |
| $V_+$ Supply Current | $I_+$  | $V_+ = 3.6V$ , $V_{IN} = 0$ or $V_+$ | $T_A = T_{MIN}$ to $T_{MAX}$ | -1  | 1   | $\mu A$ |

**Note 2:** Parameters are 100% tested at  $+25^\circ C$  only, and guaranteed by correlation at the full-rated temperature.

**Note 3:** Algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

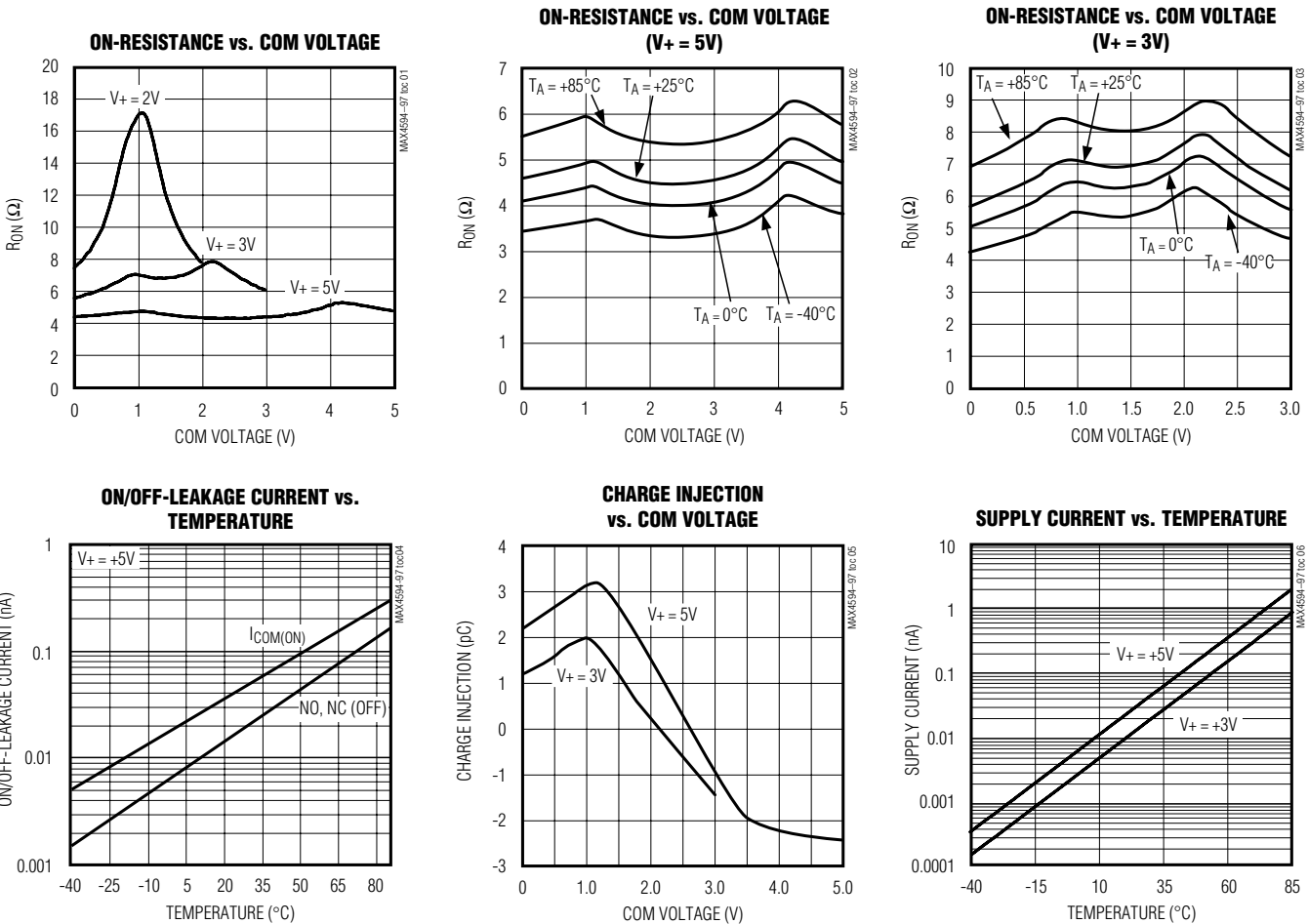
**Note 4:** Flatness is defined as the difference between the maximum and minimum values of on-resistance as measured over the specified analog signal ranges.

**Note 5:** Guaranteed by design.

**Note 6:** Off-Isolation =  $20\log_{10}(V_{COM} / V_{NO})$ ,  $V_{COM}$  = output,  $V_{NO}$  = input to off switch.

## Typical Operating Characteristics

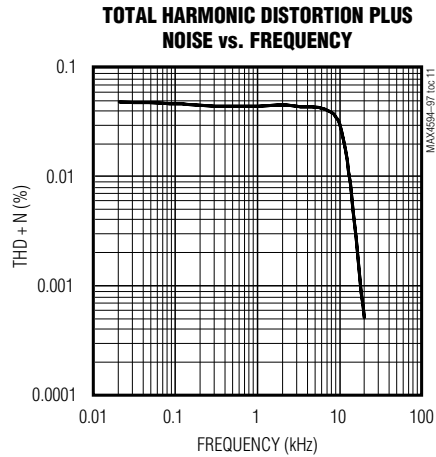
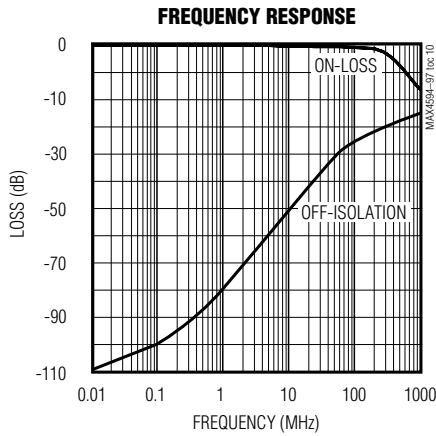
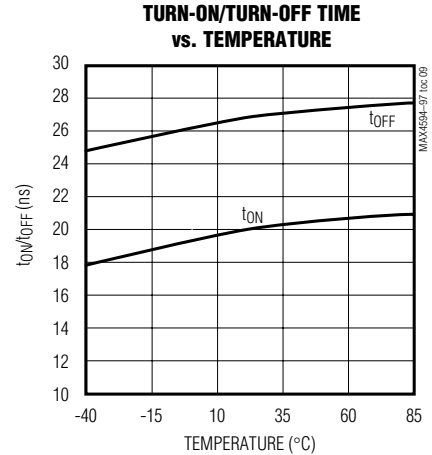
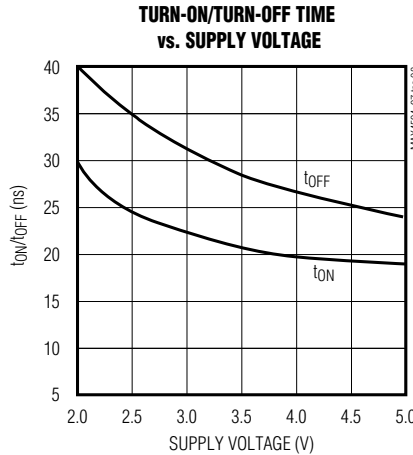
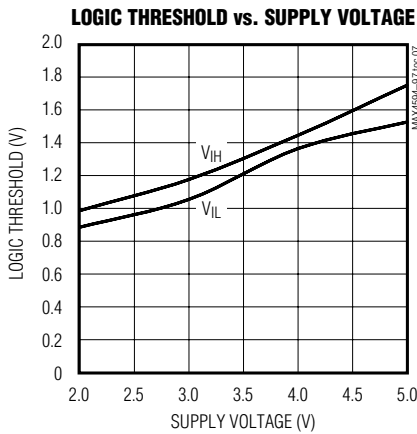
( $V_+ = +5V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

## Typical Operating Characteristics (continued)

(V+ = +5V, TA = +25°C, unless otherwise noted.)



## Pin Description

| PIN     |      |         |      |         |      |         |      | NAME | FUNCTION                                 |
|---------|------|---------|------|---------|------|---------|------|------|--|
| MAX4594 |      | MAX4595 |      | MAX4596 |      | MAX4597 |      |      |  |
| SC70    | μDFN | SC70    | μDFN | SC70    | μDFN | SC70    | μDFN |      |  |
| 1       | 1    | 1       | 1    | 2       | 2    | 2       | 2    | COM  | Analog Switch, Common                    |
| 2       | 2    | —       | —    | 4       | 4    | —       | —    | NO   | Analog Switch, Normally Open             |
| 3       | 3    | 3       | 3    | 3       | 3    | 3       | 3    | GND  | Ground                                   |
| 4       | 4    | 4       | 4    | 1       | 1    | 1       | 1    | IN   | Digital Control Input                    |
| 5       | 6    | 5       | 6    | 5       | 6    | 5       | 6    | V+   | Positive Supply Voltage                  |
| —       | —    | 2       | 2    | —       | —    | 4       | 4    | NC   | Analog Switch, Normally Closed           |
| —       | 5    | —       | 5    | —       | 5    | —       | 5    | N.C. | No Connection. Not internally connected. |
| EP      | EP   | EP      | EP   | EP      | EP   | EP      | EP   | PAD  | Exposed Pad. Connect to GND (μDFN only.) |

**Note:** NO, NC, and COM pins are identical and interchangeable. Any pin may be considered as an input or an output; signals pass equally well in both directions.

# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

## Applications Information

### Analog Signal Levels

Analog signals can range over the supply voltage ( $V_+$  to GND) with on-resistance changing very little over the entire range (see *Typical Operating Characteristics*). The MAX4594-MAX4597 are bidirectional, so the NO, NC, and COM pins can be used either as inputs or outputs.

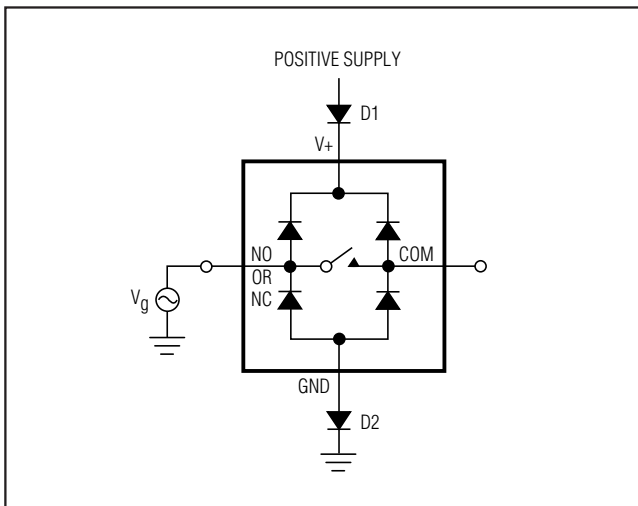


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

### Power-Supply Sequencing and Overvoltage Protection

Proper power-supply sequencing is recommended for all CMOS devices. Always apply  $V_+$  before applying analog signals or logic inputs, especially if the analog or logic signals are not current limited. If this sequencing is not possible, and if the analog or logic inputs are not current limited to  $<20\text{mA}$ , add a small-signal diode (D1) as shown in Figure 1. If the analog signal can dip below GND, add D2. Adding protection diodes reduces the analog signal range to a diode drop (about 0.7V) below  $V_+$  for D1 or to a diode drop above ground for D2. The addition of diodes does not affect leakage. On-resistance increases by a small amount at low supply voltages. Maximum supply voltage ( $V_+$ ) must not exceed 6V.

Protection diodes D1 and D2 also protect against some overvoltage situations. A fault voltage up to the absolute maximum rating at an analog signal input does not damage the device, even if the supply voltage is below the signal voltage.

## Test Circuits/Timing Diagrams

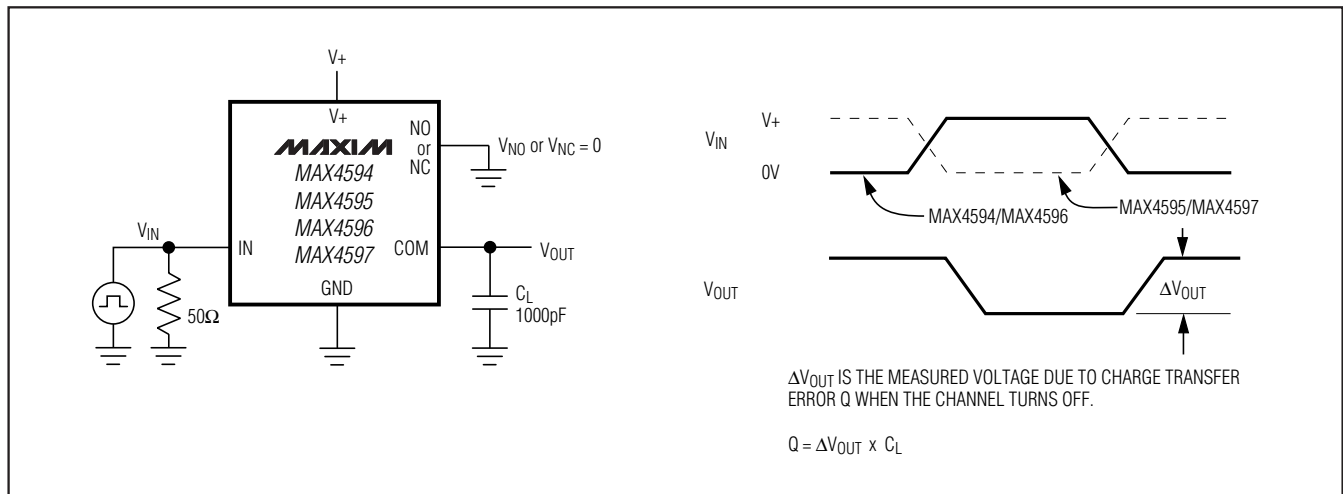


Figure 2. Charge Injection

# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

## Test Circuits/Timing Diagrams (continued)

MAX4594-MAX4597

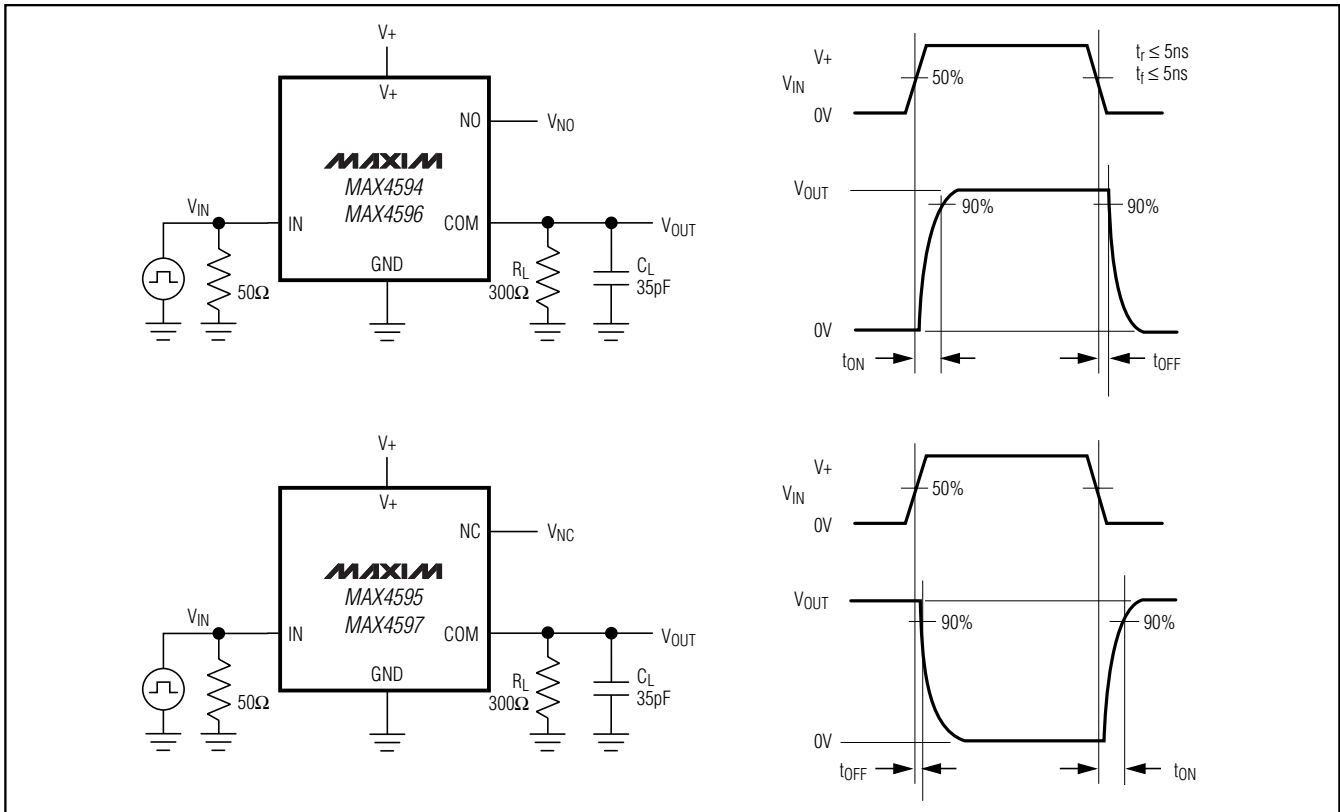


Figure 3. Switching Times

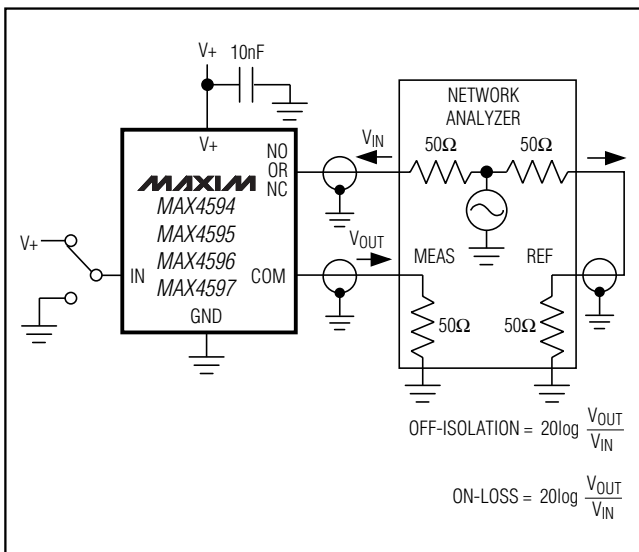


Figure 4. Off-Isolation and On-Channel Bandwidth

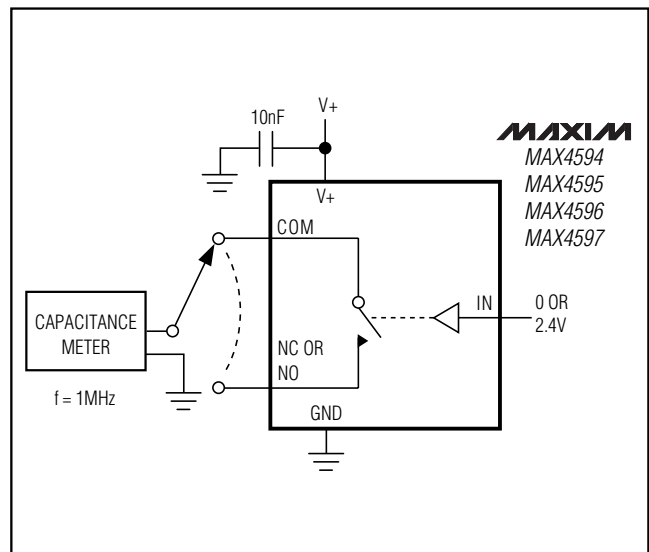
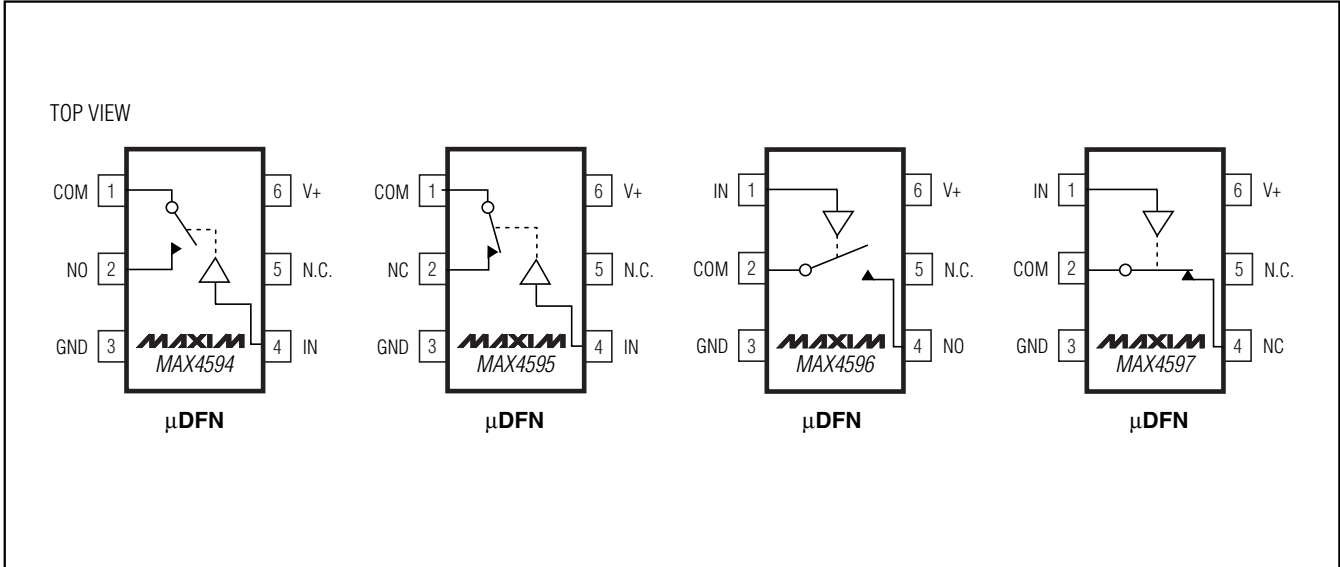


Figure 5. Channel On-/Off-Capacitance

# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

## Pin Configurations/Functional Diagrams/Truth Table (continued)



### Chip Information

TRANSISTOR COUNT: 50

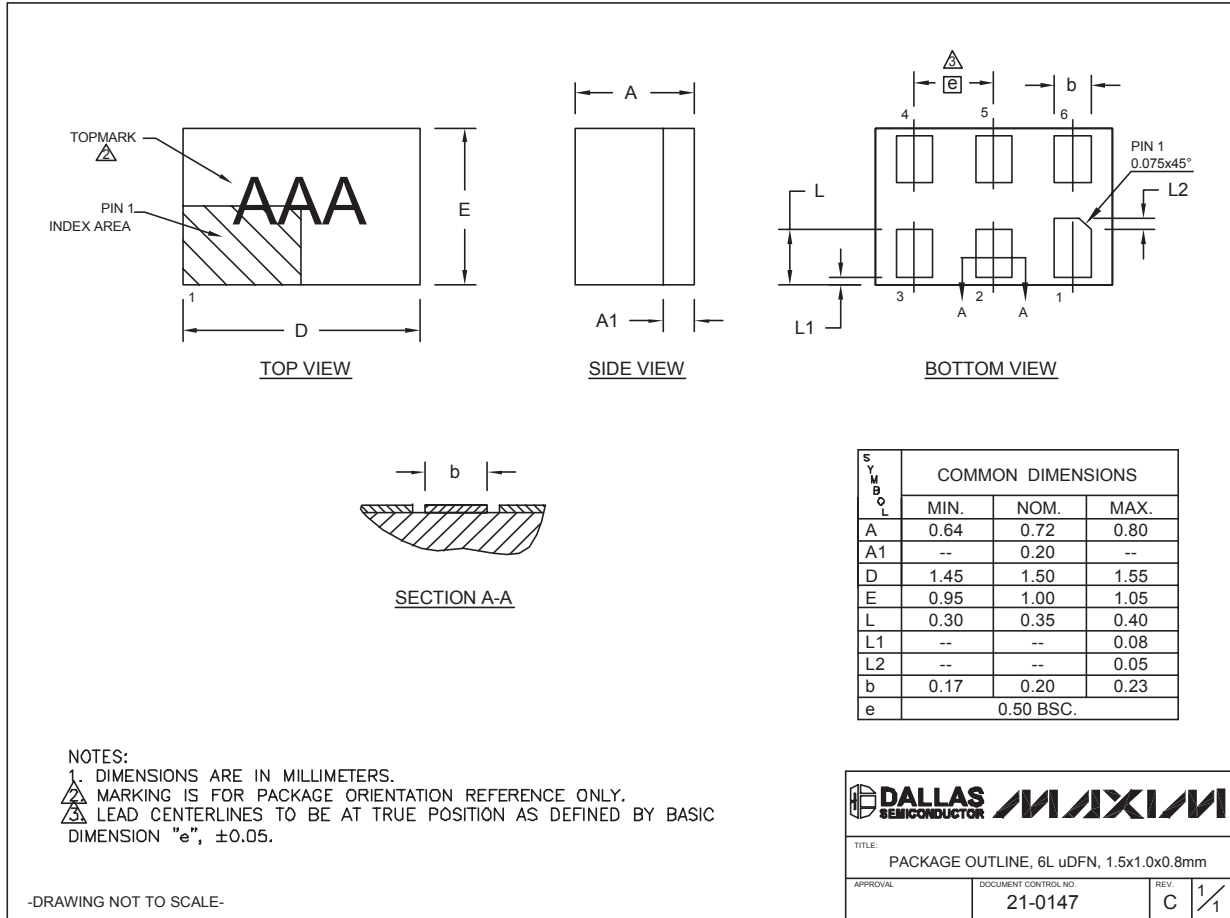


# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

MAX4594-MAX4597



6L uDFN.EPS

# Low-Voltage, Single-Supply, 10Ω SPST CMOS Analog Switches

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

| COMMON DIMENSIONS |            |      |
|-------------------|------------|------|
| SYMBOL            | MIN        | 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       | 2.20 |
| e                 | 0.65 BSC.  |      |
| E                 | 1.15       | 1.35 |
| HE                | 1.80       | 2.40 |
| L                 | 0.10       | 0.40 |
| L1                | 0.425 TYP. |      |
| Q1                | 0.10       | 0.40 |

NOTE:

- ALL DIMENSIONS ARE IN MILLIMETERS.
- DIMENSIONS ARE INCLUSIVE OF PLATING.
- DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.
- COMPLY TO EIAJ SC70 EXCEPT FOR PIN COUNT AND DIMENSION "b".
- COPLANARITY 4 MILS. MAX.
- FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM "A" AND LEAD SURFACE.
- MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
- LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.

SC70, 5LEPS

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE, 5L SC70

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| APPROVAL | DOCUMENT CONTROL NO.<br>21-0076 | REV.<br>C | 1/1 |
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