



# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

## General Description

The MAX4503/MAX4504 are low-voltage, dual-supply, single-pole/single-throw (SPST), CMOS analog switches. The MAX4503 is normally open (NO). The MAX4504 is normally closed (NC).

These CMOS switches can operate continuously with dual supplies between  $\pm 1\text{V}$  and  $\pm 6\text{V}$ . Each switch can handle rail-to-rail analog signals. The off-leakage current is only 1nA at +25°C or 10nA at +85°C.

The digital input is CMOS-logic compatible when using  $\pm 5\text{V}$  supplies. A unique logic input architecture allows this even though the parts have no ground pin.

For single-supply operation, use the MAX4501/MAX4502, which are pin-for-pin equivalents.

## Features

- ◆ Available in SOT23-5 Package
- ◆ Dual-Supply Operation from  $\pm 1\text{V}$  to  $\pm 6\text{V}$
- ◆ Guaranteed On-Resistance:  
250 $\Omega$  with  $\pm 5\text{V}$  Supplies
- ◆ Guaranteed Low Off-Leakage Currents:  
1nA at +25°C  
10nA at +85°C
- ◆ Guaranteed Low On-Leakage Currents:  
2nA at +25°C  
20nA at +85°C
- ◆ Guaranteed Low Charge Injection: 10pC Max
- ◆ Fast Switching Speed:  $t_{\text{ON}} = 150\text{ns}$ ,  $t_{\text{OFF}} = 100\text{ns}$
- ◆ CMOS-Logic Compatible Input

## Applications

Battery-Operated Equipment  
Audio and Video Signal Routing  
Low-Voltage Data-Acquisition Systems  
Communications Circuits  
Cellular Phones  
PCMCIA Cards  
Modems

## Ordering Information

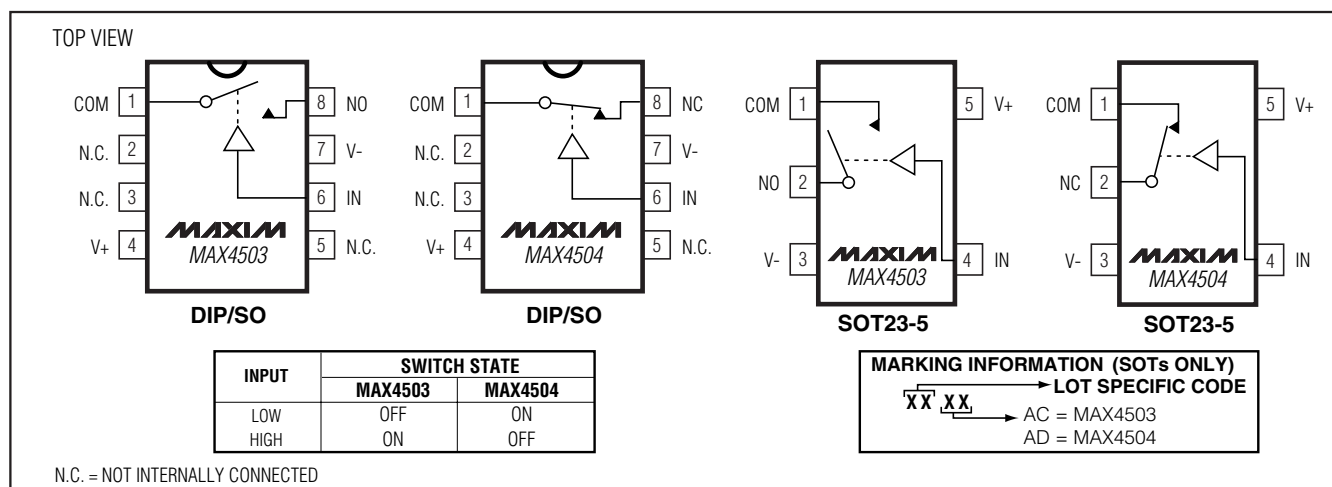
| PART       | TEMP RANGE      | PIN-PACKAGE   |
|------------|-----------------|---------------|
| MAX4503CPA | 0°C to +70°C    | 8 Plastic DIP |
| MAX4503CSA | 0°C to +70°C    | 8 SO          |
| MAX4503CUK | 0°C to +70°C    | 5 SOT23-5     |
| MAX4503C/D | 0°C to +70°C    | Dice*         |
| MAX4503EPA | -40°C to +85°C  | 8 Plastic DIP |
| MAX4503ESA | -40°C to +85°C  | 8 SO          |
| MAX4503EUK | -40°C to +85°C  | 5 SOT23-5     |
| MAX4503MJA | -55°C to +125°C | 8 CERDIP**    |

Ordering Information continued at end of data sheet.

\*Contact factory for dice specifications.

\*\*Contact factory for availability.

## Pin Configurations



# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

## ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to V-)

V+ .....-0.3V, +13V  
 Voltage into Any Terminal (Note 1) .....-0.3V to (V+ + 0.3V) or  
 ±10mA (whichever occurs first)  
 Continuous Current into Any Terminal .....±10mA  
 Peak Current, NO<sub>1</sub> or COM<sub>1</sub>  
 (pulsed at 1ms, 10% duty cycle) .....±20mA  
 Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
 8-Pin Plastic DIP (derate 9.09mW/°C above +70°C) ...727mW  
 8-Pin SO (derate 5.88mW/°C above +70°C) .....471mW

5-Pin SOT23-5 (derate 7.1mW/°C above +70°C) .....571mW  
 8-Pin Cerdip (derate 8.00mW/°C above +70°C) .....640mW  
 Operating Temperature Ranges  
 MAX4503C<sub>1</sub>/MAX4504C<sub>1</sub> .....0°C to +70°C  
 MAX4503E<sub>1</sub>/MAX4504E<sub>1</sub> .....-40°C to +85°C  
 MAX4503MJA/MAX4504MJA .....-55°C to +125°C  
 Storage Temperature Range .....-65°C to +150°C  
 Lead Temperature (soldering, 10sec) .....+300°C

**Note 1:** Voltages on any signal terminal exceeding V+ or V- 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- = -4.5V to -5.5V, V<sub>INH</sub> = 3.5V, V<sub>INL</sub> = 1.5V, 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<br>(Note 2) | MAX                     | UNITS |
|------------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|------|-------------------------|-----------------|-------------------------|-------|
| ANALOG SWITCH                            |                                                         |                                                                                                                            |                                                          |      |                         |                 |                         |       |
| Analog Signal Range                      | V <sub>COM</sub> , V <sub>NO</sub> ,<br>V <sub>NC</sub> |                                                                                                                            |                                                          |      | V-                      |                 | V+                      | V     |
| COM to NO or NC<br>On-Resistance         | R <sub>ON</sub>                                         | V <sub>COM_</sub> = 3.5V, I <sub>COM</sub> = 1mA                                                                           | T <sub>A</sub> = +25°C                                   |      | 60                      |                 | 250                     | Ω     |
|                                          |                                                         |                                                                                                                            | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>    |      | 350                     |                 |                         |       |
| NO or NC Off Leakage<br>Current (Note 3) | I <sub>NO(OFF)</sub> ,<br>I <sub>NC(OFF)</sub>          | V <sub>+</sub> = 5.5V, V <sub>-</sub> = -5.5V,<br>V <sub>COM_</sub> = ±4.5V,<br>V <sub>NO</sub> or V <sub>NC</sub> = ∓4.5V | T <sub>A</sub> = +25°C                                   |      | -1                      | 0.01            | 1                       | nA    |
|                                          |                                                         |                                                                                                                            | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, E | -10                     |                 | 10                      |       |
|                                          |                                                         |                                                                                                                            |                                                          | M    | -100                    |                 | 100                     |       |
| COM Off Leakage Current<br>(Note 3)      | I <sub>COM(OFF)</sub>                                   | V <sub>+</sub> = 5.5V, V <sub>-</sub> = -5.5V,<br>V <sub>COM_</sub> = ±4.5V,<br>V <sub>NO</sub> or V <sub>NC</sub> = ∓4.5V | T <sub>A</sub> = +25°C                                   |      | -1                      | 0.01            | 1                       | nA    |
|                                          |                                                         |                                                                                                                            | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, E | -10                     |                 | 10                      |       |
|                                          |                                                         |                                                                                                                            |                                                          | M    | -100                    |                 | 100                     |       |
| COM On Leakage Current<br>(Note 3)       | I <sub>COM(ON)</sub>                                    | V <sub>+</sub> = 5.5V, V <sub>-</sub> = -5.5V,<br>V <sub>COM</sub> = ±4.5V,<br>V <sub>NO</sub> or V <sub>NC</sub> = ±4.5V  | T <sub>A</sub> = +25°C                                   |      | -2                      | 0.01            | 2                       | nA    |
|                                          |                                                         |                                                                                                                            | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, E | -20                     |                 | 20                      |       |
|                                          |                                                         |                                                                                                                            |                                                          | M    | -200                    |                 | 200                     |       |
| DIGITAL I/O                              |                                                         |                                                                                                                            |                                                          |      |                         |                 |                         |       |
| IN Input Logic High                      | V <sub>IH</sub>                                         |                                                                                                                            |                                                          |      | (V <sub>+</sub> ) - 1.5 |                 | V <sub>+</sub>          | V     |
| IN Input Logic Low                       | V <sub>IL</sub>                                         |                                                                                                                            |                                                          |      | V-                      |                 | (V <sub>+</sub> ) - 3.5 | V     |
| IN Input Current Logic<br>High or Low    | I <sub>IH</sub> , I <sub>IL</sub>                       | V <sub>IN</sub> = V <sub>+</sub> , 0V                                                                                      |                                                          |      | -1                      | 0.03            | 1                       | μA    |

# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

MAX4503/MAX4504

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

(V+ = +4.5V to +5.5V, V- = -4.5V to -5.5V, VINH = 3.5V, VINL = 1.5V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

| PARAMETER                             | SYMBOL    | CONDITIONS                                                            | MIN               | TYP<br>(Note 2) | MAX | UNITS |
|---------------------------------------|-----------|-----------------------------------------------------------------------|-------------------|-----------------|-----|-------|
| <b>SWITCH DYNAMIC CHARACTERISTICS</b> |           |                                                                       |                   |                 |     |       |
| Turn-On Time                          | tON       | VIN = 3V, RL = 1kΩ<br>VNO or VNC = 3V, Figure 1                       | TA = +25°C        | 30              | 150 | ns    |
|                                       |           |                                                                       | TA = TMIN to TMAX |                 | 240 |       |
| Turn-Off Time                         | tOFF      | VIN = 3V, RL = 1kΩ<br>VNO or VNC = 3V, Figure 1                       | TA = +25°C        | 20              | 100 | ns    |
|                                       |           |                                                                       | TA = TMIN to TMAX |                 | 150 |       |
| Charge Injection<br>(Note 4)          | Q         | CL = 1nF, VNO_ = 0V, RS = 0Ω,<br>TA = +25°C, Figure 2                 |                   | 1               | 10  | pC    |
| Off Isolation                         | VISO      | RL = 50Ω, CL = 15pF, VNO = 1VRMS,<br>f = 100kHz, TA = +25°C, Figure 3 |                   | <-90            |     | dB    |
| NO or NC Off Capacitance              | CNO(OFF)  | f = 1MHz, TA = +25°C, Figure 4                                        |                   | 3               |     | pF    |
| COM Off Capacitance                   | COFF(COM) | f = 1MHz, TA = +25°C, Figure 4                                        |                   | 3               |     | pF    |
| COM On Capacitance                    | CON(COM)  | f = 1MHz, TA = +25°C, Figure 4                                        |                   | 9               |     | pF    |
| <b>POWER SUPPLY</b>                   |           |                                                                       |                   |                 |     |       |
| V+, V- Supply Current                 | I+, I-    | VIN = 0V or V+                                                        | TA = +25°C        | -125            | 40  | μA    |
|                                       |           |                                                                       | TA = TMIN to TMAX | -200            | 200 |       |

# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

## ELECTRICAL CHARACTERISTICS—±3V Supply

(V+ = +2.7V to +3.3V, V- = -2.7V to -3.3V, 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<br>(Note 2) | MAX | UNITS |
|----------------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------|------|-----------------|-----|-------|
| ANALOG SWITCH                                |                                                         |                                                                                                    |                                                          |      |                 |     |       |
| Analog Signal Range                          | V <sub>COM</sub> , V <sub>NO</sub> ,<br>V <sub>NC</sub> |                                                                                                    |                                                          | 0    |                 | V+  | V     |
| COM to NO or NC<br>On-Resistance             | R <sub>ON</sub>                                         | V <sub>COM_</sub> = 1.5V, I <sub>COM</sub> = 0.1mA                                                 | T <sub>A</sub> = +25°C                                   | 100  | 400             |     | Ω     |
|                                              |                                                         |                                                                                                    | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>    | 500  |                 |     |       |
| NO or NC Off Leakage<br>Current (Notes 3, 4) | I <sub>NO(OFF)</sub> ,<br>I <sub>NC(OFF)</sub>          | V <sub>COM_</sub> = ±1.5V,<br>V <sub>NO</sub> or V <sub>NC</sub> = ∓1.5V,<br>V+ = 3.3V, V- = -3.3V | T <sub>A</sub> = +25°C                                   | -1   | 1               |     | nA    |
|                                              |                                                         |                                                                                                    | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, E | -10             | 10  |       |
|                                              |                                                         |                                                                                                    |                                                          | M    | -100            | 100 |       |
| COM Off Leakage Current<br>(Notes 3, 4)      | I <sub>COM(OFF)</sub>                                   | V <sub>COM_</sub> = ±1.5V,<br>V <sub>NO</sub> or V <sub>NC</sub> = ∓1.5V,<br>V+ = 3.3V, V- = -3.3V | T <sub>A</sub> = +25°C                                   | -1   | 1               |     | nA    |
|                                              |                                                         |                                                                                                    | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, E | -10             | 10  |       |
|                                              |                                                         |                                                                                                    |                                                          | M    | -100            | 100 |       |
| COM On Leakage Current<br>(Notes 3, 4)       | I <sub>COM(ON)</sub>                                    | V <sub>NO</sub> or V <sub>NC</sub> = ±1.5V,<br>V <sub>COM_</sub> = ±1.5V,<br>V+ = 3.3V, V- = -3.3V | T <sub>A</sub> = +25°C                                   | -2   | 2               |     | nA    |
|                                              |                                                         |                                                                                                    | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, E | -20             | 20  |       |
|                                              |                                                         |                                                                                                    |                                                          | M    | -200            | 200 |       |
| DIGITAL I/O                                  |                                                         |                                                                                                    |                                                          |      |                 |     |       |
| IN Input Logic High                          | V <sub>INH</sub>                                        |                                                                                                    |                                                          | 2.4  |                 | V+  | V     |
| IN Input Logic Low                           | V <sub>INL</sub>                                        |                                                                                                    |                                                          | V-   |                 | 0.4 | V     |
| IN Input Current Logic High<br>or Low        | I <sub>IH</sub> , I <sub>IL</sub>                       |                                                                                                    |                                                          | -1   | 0.03            | 1   | μA    |
| POWER SUPPLY                                 |                                                         |                                                                                                    |                                                          |      |                 |     |       |
| V+, V- Supply Current                        | I+, I-                                                  | IN = 0V or V+                                                                                      | T <sub>A</sub> = +25°C                                   | -100 | 25              | 100 | μA    |
|                                              |                                                         |                                                                                                    | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>    | -175 |                 | 175 |       |

**Note 2:** The algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

**Note 4:** Guaranteed, not production tested.

**Note 3:** Leakage parameters are 100% tested at maximum rated hot operating temperature, and guaranteed by correlation at +25°C.

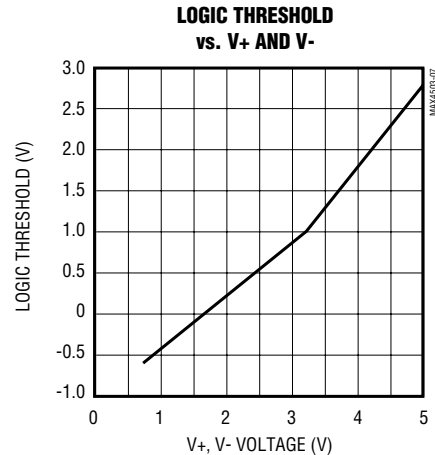
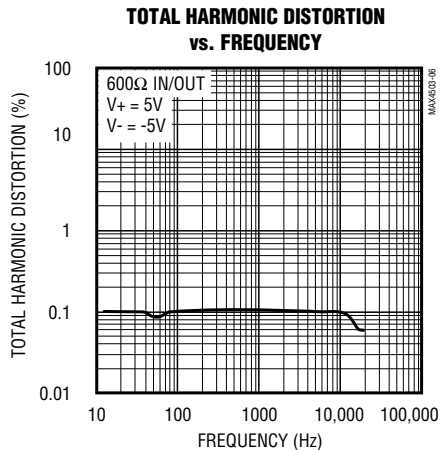
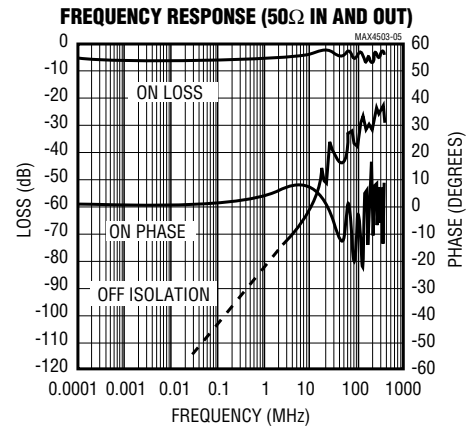
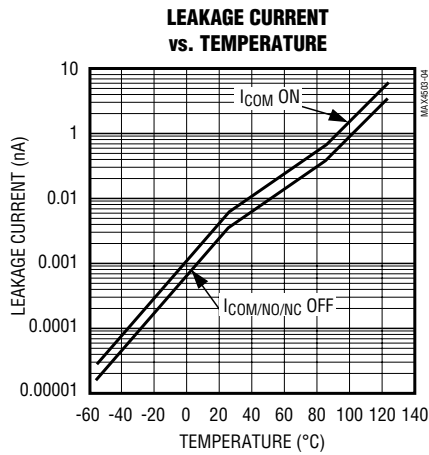
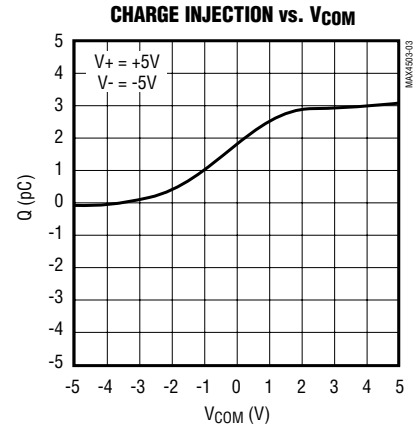
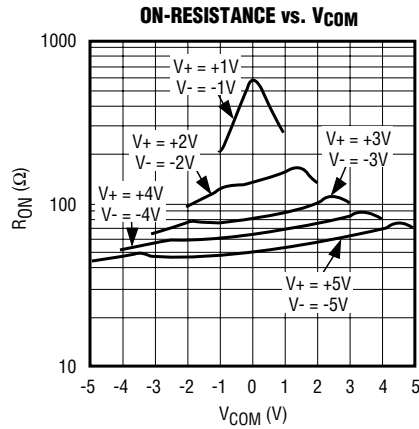
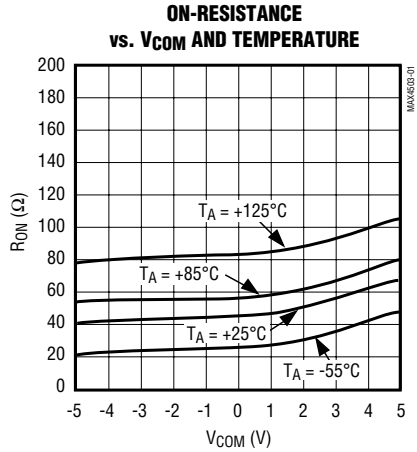
**Note 5:** SOT packaged parts are 100% tested at +25°C. Limits at maximum and minimum rated temperature are guaranteed by design and correlation limits at +25°C.

# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

## Typical Operating Characteristics

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

MAX4503/MAX4504



# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

## Pin Description

| PIN     |         |         |         | NAME | FUNCTION                                           |
|---------|---------|---------|---------|------|----------------------------------------------------|
| MAX4503 |         | MAX4504 |         |      |                                                    |
| DIP/SO  | SOT23-5 | DIP/SO  | SOT23-5 |      |                                                    |
| 1       | 1       | 1       | 1       | COM  | Analog Switch Common Terminal                      |
| 2, 3, 5 | —       | 2, 3, 5 | —       | N.C. | No Connect (not internally connected)              |
| 4       | 5       | 4       | 5       | V+   | Positive (analog and digital) Supply Voltage Input |
| 6       | 4       | 6       | 4       | IN   | Digital Control Input                              |
| 7       | 3       | 7       | 3       | V-   | Negative (analog) Supply Voltage Input             |
| 8       | 2       | —       | —       | NO   | Analog Switch Normally Open Terminal               |
| —       | —       | 8       | 2       | NC   | Analog Switch Normally Closed Terminal             |

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

## Applications Information

### Power-Supply Considerations

The MAX4503/MAX4504's construction is typical of most CMOS analog switches, except they have only two supply pins: V+ and V-. These voltages set the analog voltage limits of the switch. Reverse ESD-protection diodes are internally connected between IN and each analog signal pin and both V+ and V-. If any analog signal exceeds V+ or V-, one of these diodes will conduct. During normal operation, these (and other) reverse-biased ESD diodes leak, forming the only current drawn from V-. Additional current flows through V+ from the logic-level translator.

Virtually all the analog leakage current is provided through the ESD diodes. 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 V- 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 V- 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 either the same or opposite polarity.

There is no connection between the analog signal paths and V+ or V-.

V+ and V- also power the internal logic and logic-level translators. Since there is no ground pin, the logic input

has a low-current pull-up to V+ and the logic limit is set by an internal comparator referenced to V+. The logic-level translators convert the logic levels to switched V+ and V- signals, to drive the gates of the analog signals. This drive signal is the only connection between the logic supplies (and signals) and the analog supplies. COM, NO, and NC pins have ESD-protection diodes to V+ and V-.

The logic is CMOS compatible when V+ is +5V. CMOS compatibility is maintained with all V+ values, assuming that the CMOS logic is operated from the same V+ supply. Since the MAX4503/MAX4504 have no ground pins, the logic levels are internally referenced to V+.

**Do not connect the MAX4503/MAX4504 V+ to +3V and connect the logic-level pins to TTL-logic-level signals. TTL levels can exceed +3V and violate the absolute maximum ratings, damaging the part and/or external circuits.**

### High-Frequency Performance

In 50Ω systems, signal response is reasonably flat up to 50MHz. (see *Typical Operating Characteristics*). Above 20MHz the on-response has several minor peaks which are highly layout dependent. The problem is not in turning the switch on, but in turning it off. The off-state switch acts like a capacitor, and passes higher frequencies with less attenuation. At 10MHz, off isolation is about -65dB in 50Ω systems, becoming worse (approximately 20dB per decade) as frequency increases. Higher circuit impedances also make off isolation worse.

# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

## Test Circuits/Timing Diagrams

MAX4503/MAX4504

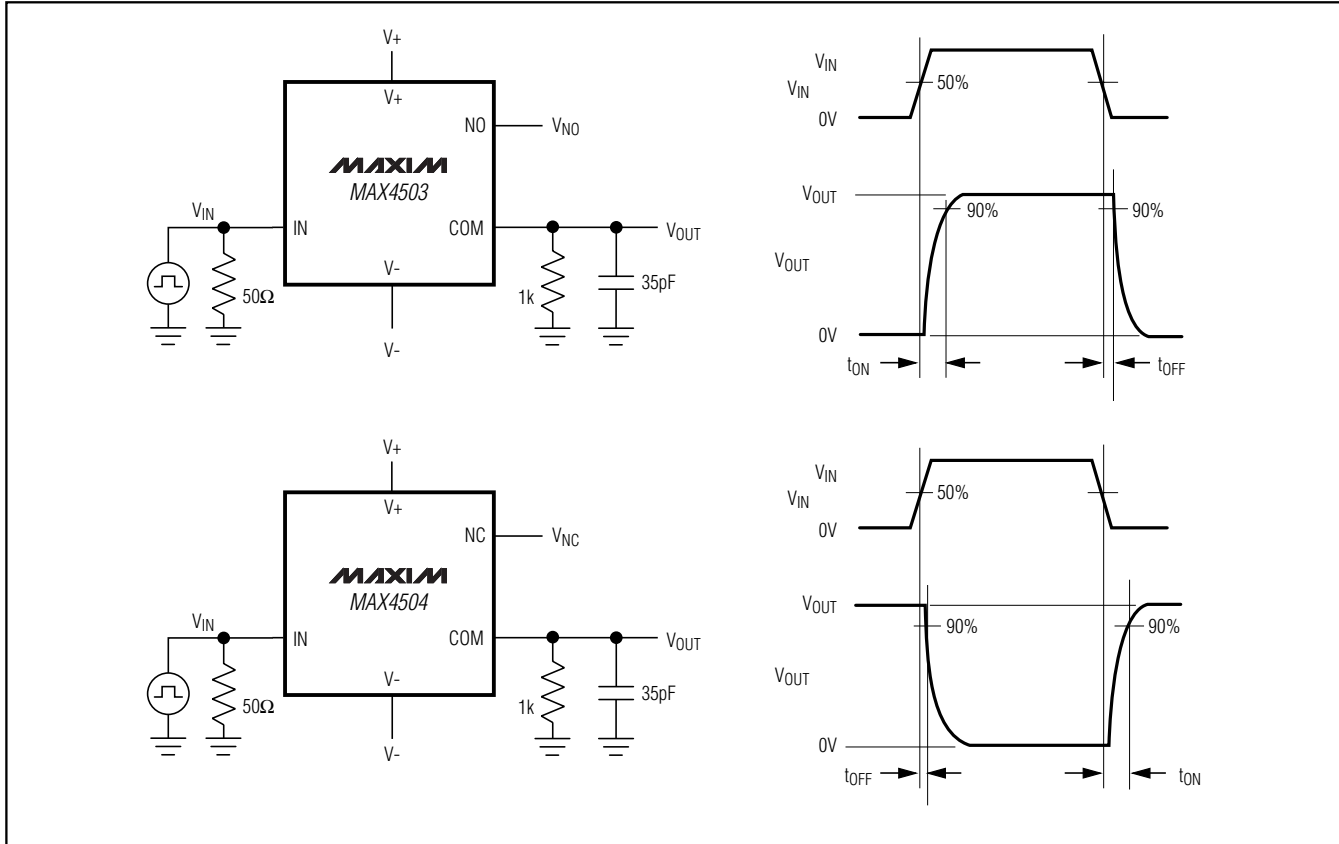


Figure 1. Switching Times

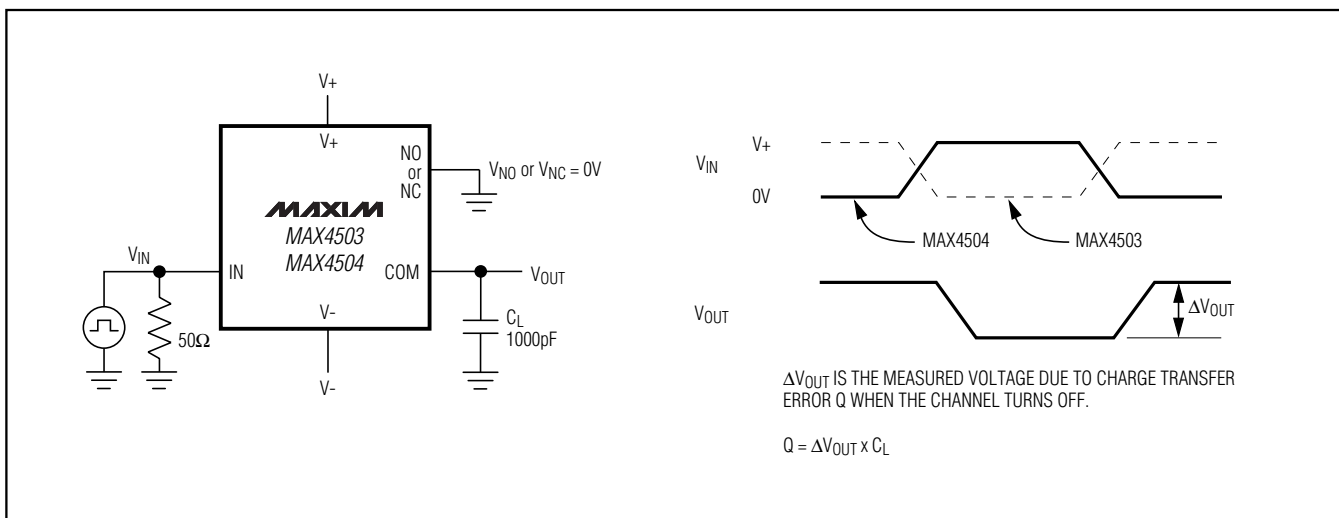


Figure 2. Charge Injection

# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

## Test Circuits/Timing Diagrams (continued)

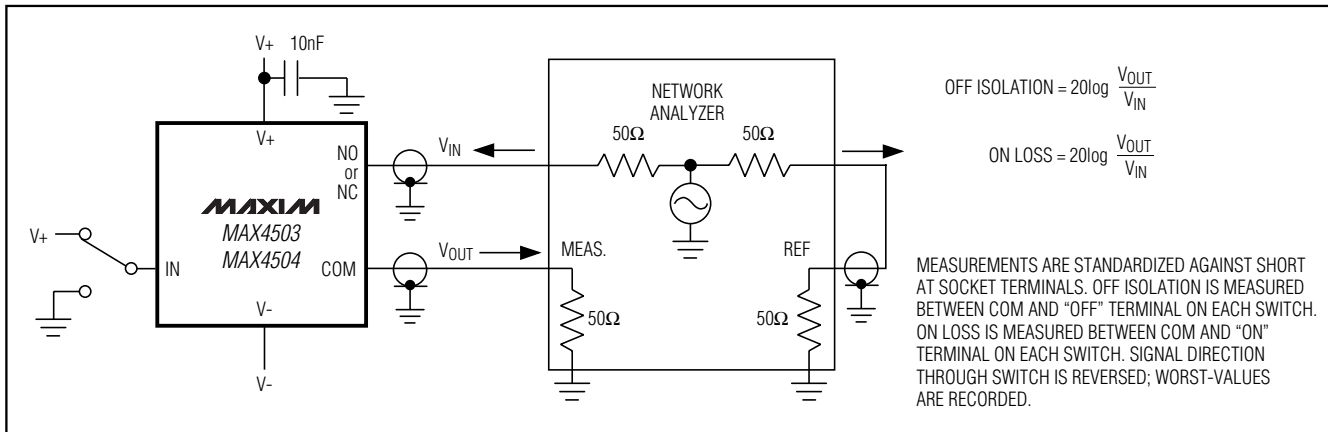


Figure 3. Off Isolation and On Loss

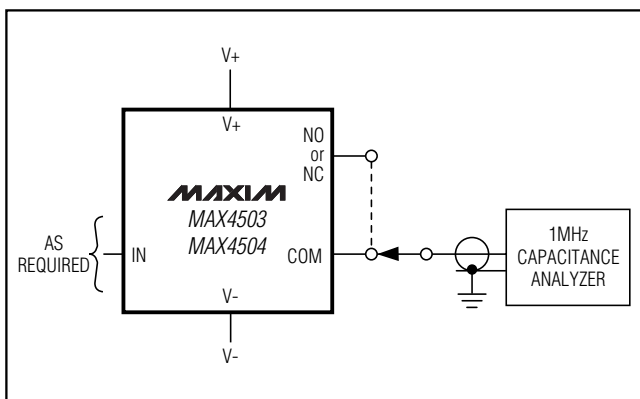


Figure 4. NO, NC, and COM Capacitance

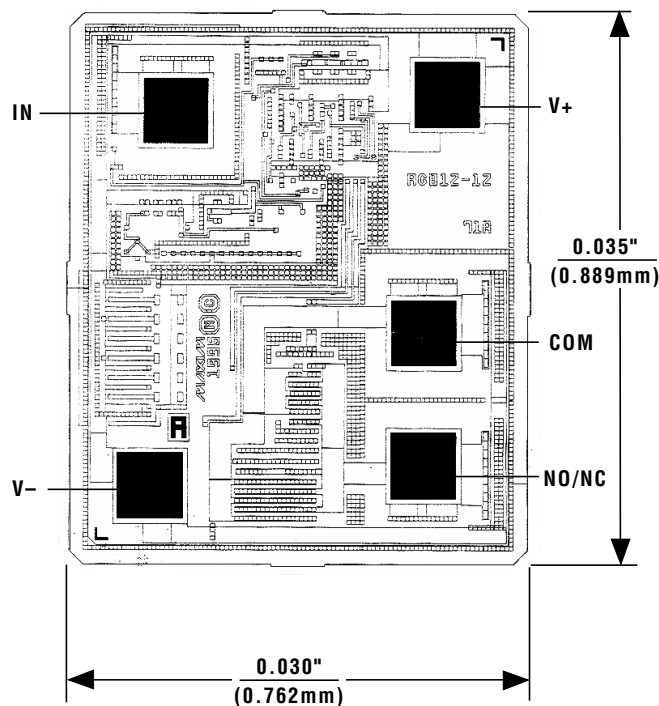
## Ordering Information (continued)

| PART       | TEMP. RANGE     | PIN-PACKAGE   |
|------------|-----------------|---------------|
| MAX4504CPA | 0°C to +70°C    | 8 Plastic DIP |
| MAX4504CSA | 0°C to +70°C    | 8 SO          |
| MAX4504CUK | 0°C to +70°C    | 5 SOT23-5     |
| MAX4504C/D | 0°C to +70°C    | Dice*         |
| MAX4504EPA | -40°C to +85°C  | 8 Plastic DIP |
| MAX4504ESA | -40°C to +85°C  | 8 SO          |
| MAX4504EUK | -40°C to +85°C  | 5 SOT23-5     |
| MAX4504MJA | -55°C to +125°C | 8 CERDIP**    |

\*Contact factory for dice specifications.

\*\*Contact factory for availability.

## Chip Topography



TRANSISTOR COUNT: 36

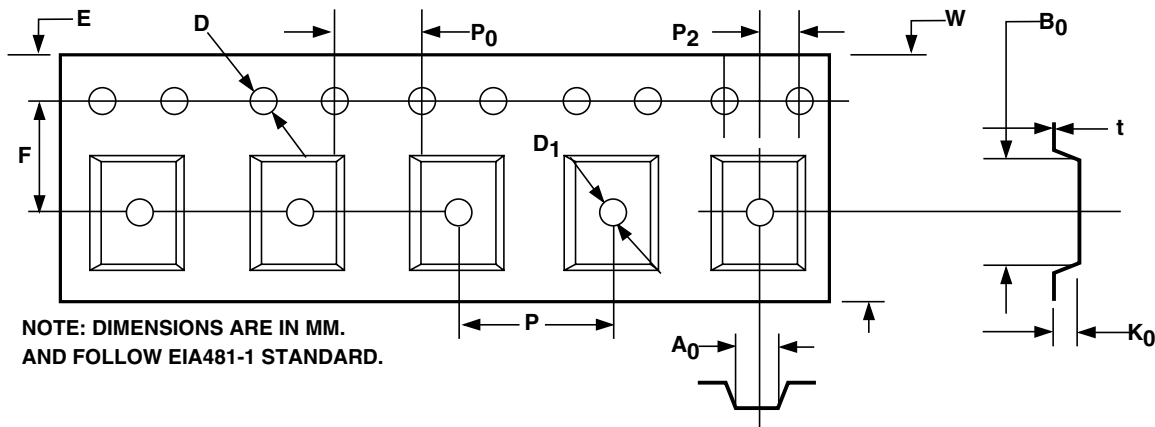
SUBSTRATE IS INTERNALLY CONNECTED TO V+



# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

## Tape-and-Reel Information

MAX4503/MAX4504



|                |       |                  |
|----------------|-------|------------------|
| A <sub>0</sub> | 3.200 | ±0.102           |
| B <sub>0</sub> | 3.099 | ±0.102           |
| D              | 1.499 | +0.102<br>+0.000 |
| D <sub>1</sub> | 0.991 | +0.254<br>+0.000 |

|                |       |        |
|----------------|-------|--------|
| E              | 1.753 | ±0.102 |
| F              | 3.505 | ±0.051 |
| K <sub>0</sub> | 1.397 | ±0.102 |
| P              | 3.988 | ±0.102 |

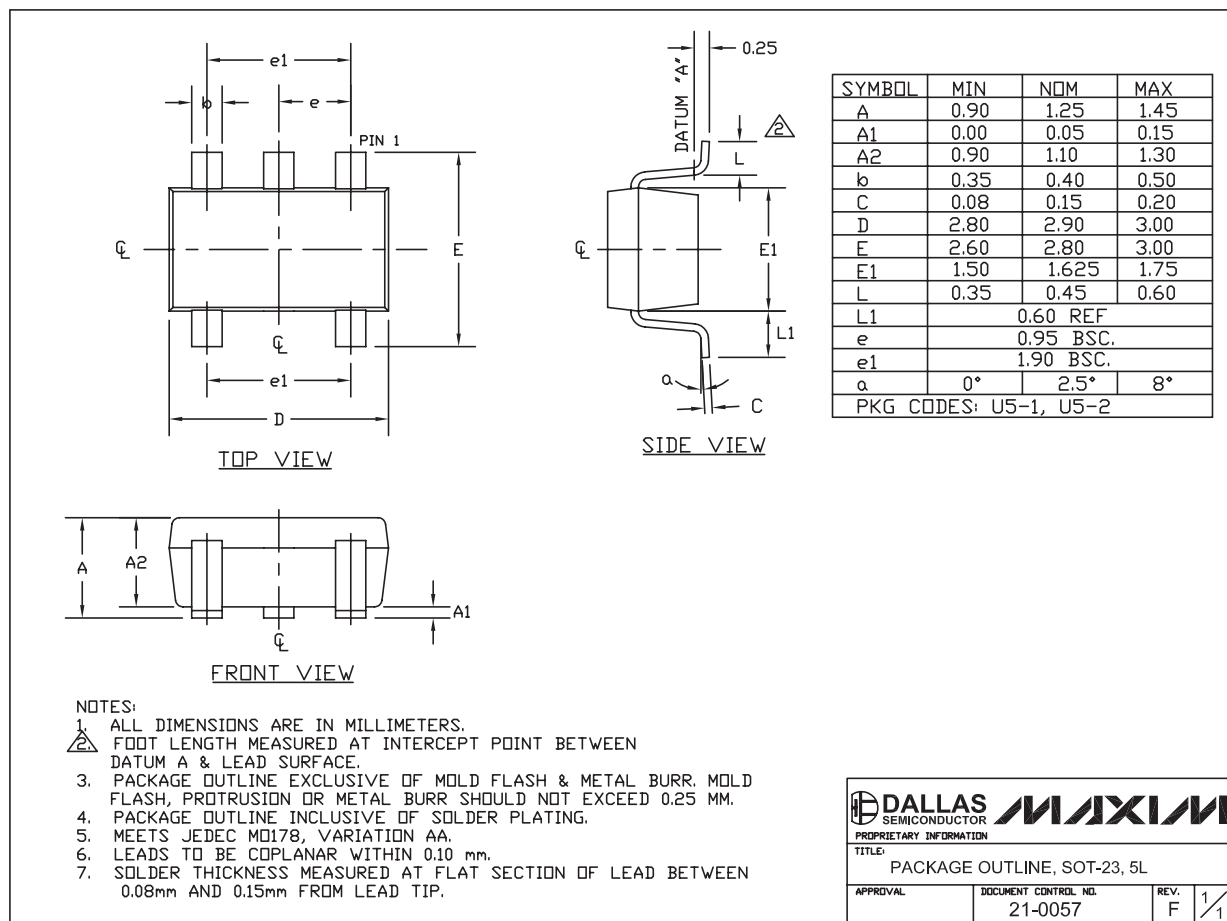
|                   |        |                  |
|-------------------|--------|------------------|
| P <sub>0</sub>    | 3.988  | ±0.102           |
| P <sub>0</sub> 10 | 40.005 | ±0.203           |
| P <sub>2</sub>    | 2.007  | ±0.051           |
| t                 | 0.254  | ±0.127           |
| W                 | 8.001  | +0.305<br>-0.102 |

5 SOT23-5

# Low-Voltage, Dual-Supply, 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).)

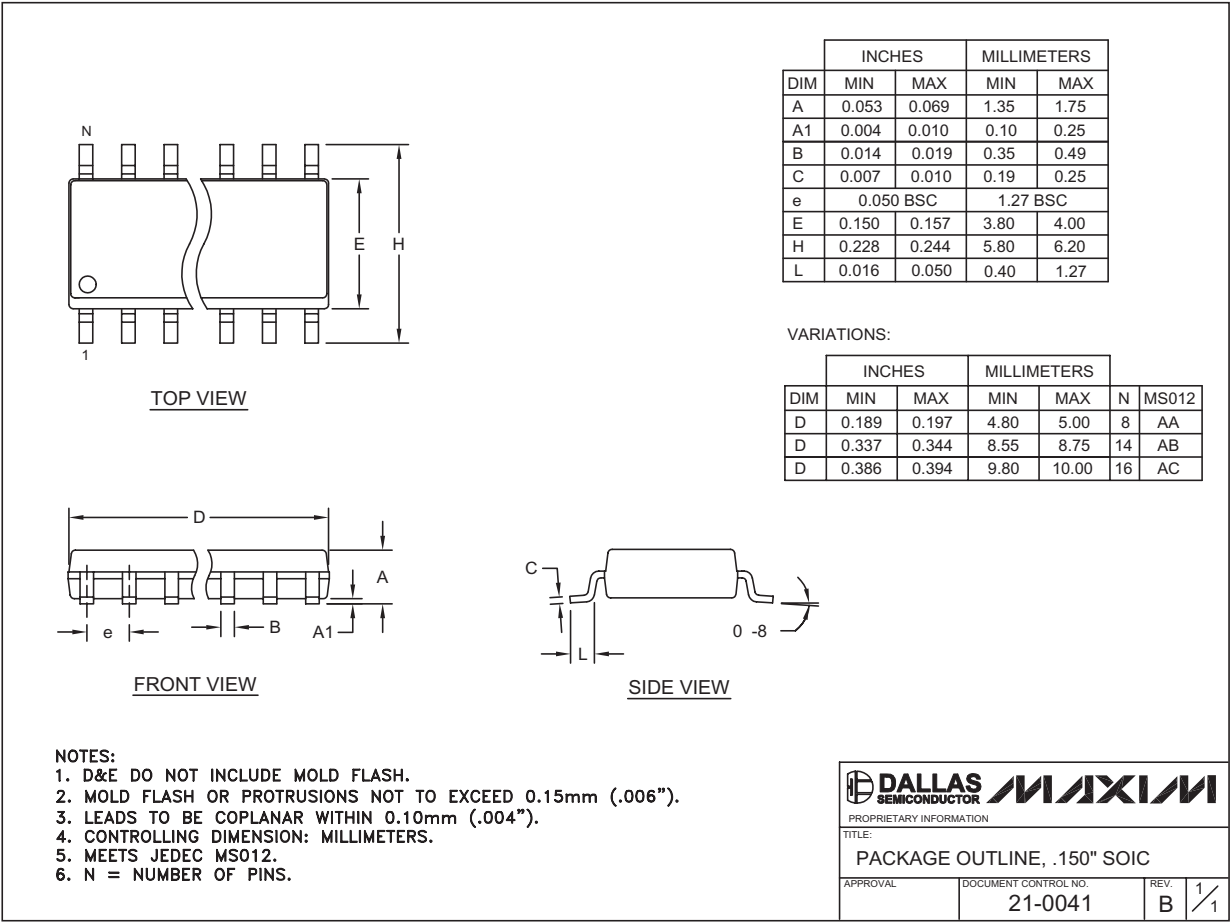


SOT-23 5L .EPS

# Low Voltage, Dual-Supply, 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).)



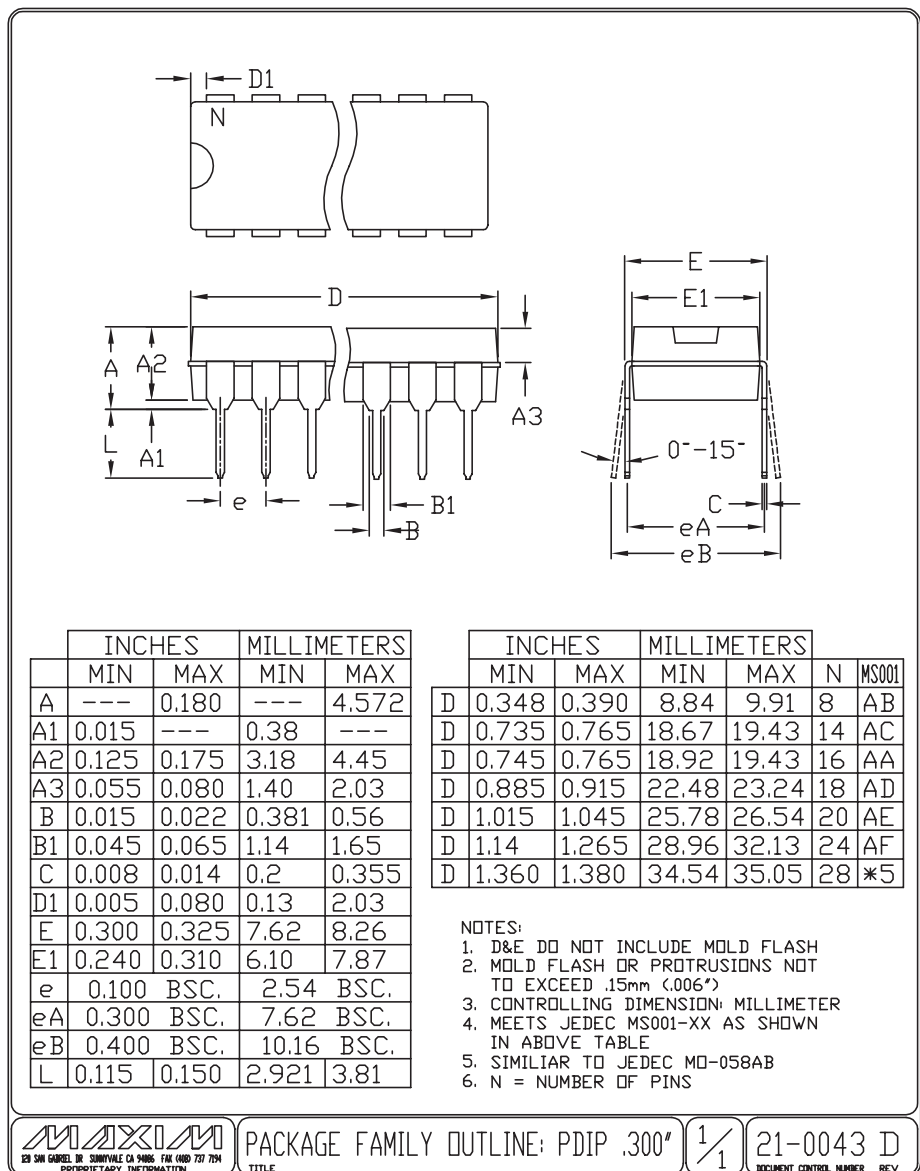
SOICN EPS

MAX4503/MAX4504

# Low-Voltage, Dual-Supply, SPST, CMOS Analog Switches

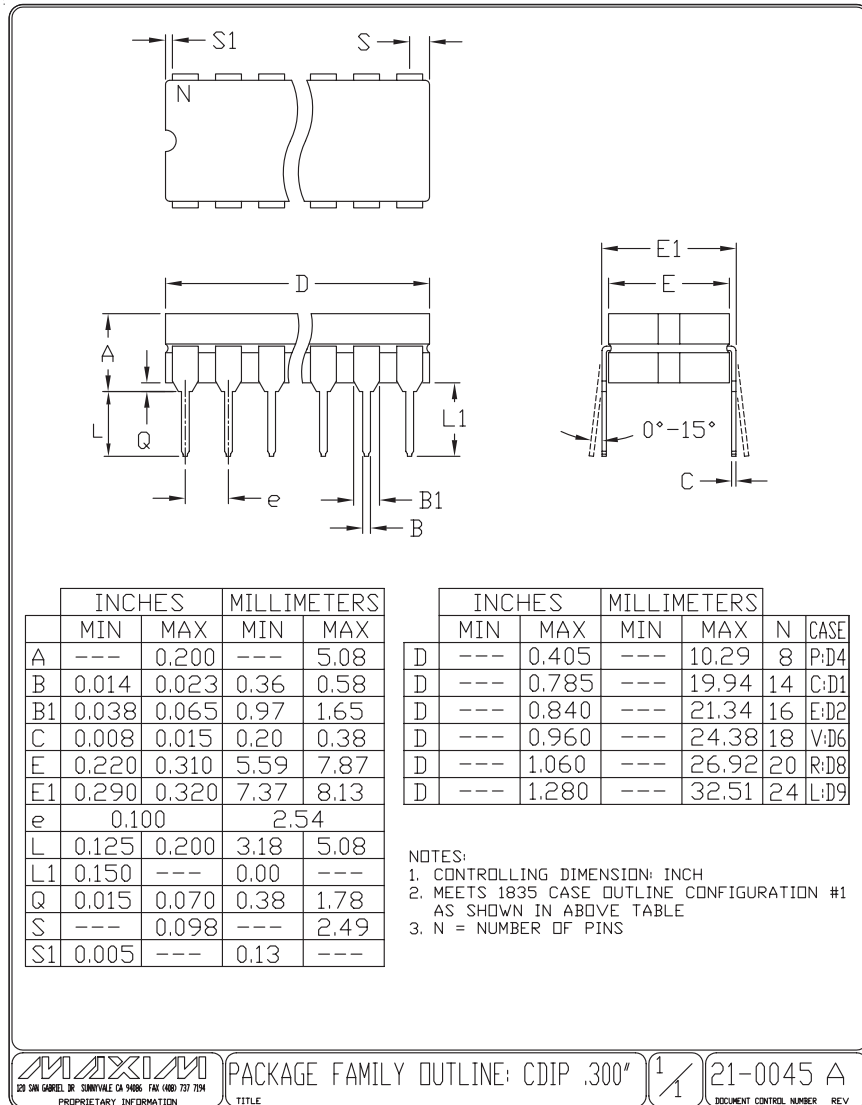
## Package Information (continued)

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## Package Information (continued)

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## Revision History

Changes made at Rev 1: 1, 4, 10, 11, 12

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