



Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

MAX4541-MAX4544

General Description

The MAX4541-MAX4544 are precision, dual analog switches designed to operate from a single +2.7V to +12V supply. Low power consumption (5μW) makes these parts ideal for battery-powered equipment. These switches offer low leakage currents (100pA max) and fast switching speeds (t_{ON} = 150ns max, t_{OFF} = 100ns max).

When powered from a +5V supply, the MAX4541-MAX4544 offer 2Ω max matching between channels, 60Ω max on-resistance (R_{ON}), and 6Ω max R_{ON} flatness.

These switches also offer 5pC max charge injection and a minimum of 2000V ESD protection per Method 3015.7.

The MAX4541/MAX4542/MAX4543 are dual single-pole/single-throw (SPST) devices and the MAX4544 is a single-pole/double-throw (SPDT) device. The MAX4541 has two normally open (NO) switches and the MAX4542 has two normally closed (NC) switches. The MAX4543 has one NO and one NC switch and can be used as an SPDT, while the MAX4544 is an SPDT. The MAX4541/MAX4542/MAX4543 are available in tiny SOT23-8 and QFN-8 packages, and the MAX4544 is available in a SOT23-6 package.

Applications

| | |
|------------------------------|------------------------|
| Battery-Operated Systems | Test Equipment |
| Sample-and-Hold Circuits | Communications Systems |
| Heads-Up Displays | +3V/+5V DACs and ADCs |
| Guidance and Control Systems | PBX, PABX |
| Audio and Video Switching | Cell Phones |
| | Ultrasound |
| | Pagers |
| Military Radios | |

Features

- ◆ Low R_{ON}: 60Ω max (33Ω typ)
- ◆ R_{ON} Matching Between Channels: 2Ω max
- ◆ R_{ON} Flatness: 6Ω max
- ◆ Guaranteed Charge Injection: 5pC max
- ◆ +2.7V to +12V Single-Supply Operation
- ◆ Low Power Consumption: <5μW
- ◆ Low Leakage Current Over Temperature: 10nA max at +85°C
- ◆ Fast Switching: t_{ON} = 35ns, t_{OFF} = 25ns
- ◆ Guaranteed Break-Before-Make (MAX4543/MAX4544 only)
- ◆ TTL/CMOS-Logic Compatible
- ◆ Pin Compatible with MAX323/MAX324/MAX325
- ◆ MAX4541/42/43 Available in SOT23-8
MAX4544 Available in SOT23-6

Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|--------------|----------------|---------------|----------|
| MAX4541CUA | 0°C to +70°C | 8 μMAX | — |
| MAX4541CSA | 0°C to +70°C | 8 SO | — |
| MAX4541CPA | 0°C to +70°C | 8 Plastic DIP | — |
| MAX4541C/D | 0°C to +70°C | Dice* | — |
| MAX4541EKA-T | -40°C to +85°C | 8 SOT23-8 | AAAE |
| MAX4541EGA | -40°C to +85°C | 8 QFN | — |
| MAX4541EUA | -40°C to +85°C | 8 μMAX | — |
| MAX4541ESA | -40°C to +85°C | 8 SO | — |

Ordering Information continued at end of data sheet.

*Dice are specified at T_A = +25°C.

Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW

MAX4544
μMAX/SO/DIP/QFN

MAX4544
SOT23-6*

MAX4544
AAAM

N.C. = NOT INTERNALLY CONNECTED
MAX4541/MAX4542/MAX4543
APPEAR AT END OF DATA SHEET.

| MAX4544 | | |
|---------|-----|-----|
| LOGIC | NC | NO |
| 0 | ON | OFF |
| 1 | OFF | ON |

SWITCHES SHOWN FOR "0" INPUT

*NOTE: SOT23-6 PACKAGE
HAS LETTERING NEAREST PIN 6



Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to GND

| | |
|--|---------------------------|
| V+ |-0.3V to +13V |
| IN_, COM_, NC_, NO_ (Note 1) |-0.3V to (V+ + 0.3V) |
| Continuous Current (any terminal) |±10mA |
| Peak Current, COM_, NO_, NC_ (pulsed at 1ms, 10% duty cycle max) |±20mA |
| ESD per Method 3015.7 |>2000V |
| Continuous Power Dissipation | |
| SOT23-6 (derate 7.1mW/°C above +70°C) |571mW |
| SOT23-8 (derate 5.3mW/°C above +70°C) |421mW |

| | |
|--|----------------------|
| QFN (derate 24.4mW/°C above +70°C) |1951mW |
| μMAX (derate 4.10mW/°C above +70°C) |330mW |
| Narrow SO (derate 5.88mW/°C above +70°C) |471mW |
| Plastic DIP (derate 9.09mW/°C above +70°C) |727mW |
| Operating Temperature Ranges | |
| MAX454_C_ |0°C to +70°C |
| MAX454_E_ |-40°C to +85°C |
| Storage Temperature Range |-65°C to +150°C |
| Lead Temperature (soldering, 10s) |+300°C |

Note 1: Signals on NC, NO, COM, or IN 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—Single +5V Supply

(V+ = +5V ±10%, GND = 0, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.) (Notes 2, 3)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|----------------------|--|-------------------|------|------|-------|
| ANALOG SWITCH | | | | | | |
| Analog Signal Range | VCOM, VNO, VNC | (Note 4) | 0 | | V+ | V |
| On-Resistance | RON | V+ = 4.5V, ICOM = 1.0mA, VNO or VNC = 3.5V | TA = +25°C | 30 | 60 | Ω |
| | | | TA = TMIN to TMAX | | 75 | |
| On-Resistance Match Between Channels (Note 5) | ΔRON | V+ = 5V, ICOM = 1.0mA, VNO or VNC = 3.5V | TA = +25°C | 0.8 | 2 | Ω |
| | | | TA = TMIN to TMAX | | 4 | |
| On-Resistance Flatness (Note 6) | RFLAT(ON) | V+ = 5V; ICOM = 1.0mA; VNO or VNC = 1V, 2V, 3V | TA = +25°C | 2 | 6 | Ω |
| | | | TA = TMIN to TMAX | | 8 | |
| NO or NC Off-Leakage Current (Note 7) | INO(OFF) or INC(OFF) | V+ = 5.5V; VCOM = 1V, 4.5V; VNO or VNC = 4.5V, 1V | TA = +25°C | -0.1 | 0.01 | nA |
| | | | TA = TMIN to TMAX | C, E | -5 | |
| COM Off-Leakage Current (Note 7) | ICOM(OFF) | V+ = 5.5V; VCOM = 4.5V, 1V; VNO or VNC = 1V, 4.5V | TA = +25°C | -0.1 | 0.1 | nA |
| | | | TA = TMIN to TMAX | C, E | -5 | |
| COM On-Leakage Current (Note 7) | ICOM(ON) | V+ = 5.5V; VCOM = 1V, 4.5V or VNO or VNC = 1V, 4.5V, or floating | TA = +25°C | -0.2 | 0.2 | nA |
| | | | TA = TMIN to TMAX | C, E | -10 | |

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

MAX4541-MAX4544

ELECTRICAL CHARACTERISTICS—Single +5V Supply (continued)

(V+ = +5V ±10%, GND = 0, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.) (Notes 2, 3)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---------------------------------------|-----------------------|--|-------------------|--------|-----|-------|
| DYNAMIC | | | | | | |
| Turn-On Time | tON | VNO or VNC = 3V, Figure 2 | TA = +25°C | 35 | 100 | ns |
| | | | TA = TMIN to TMAX | | 240 | |
| Turn-Off Time | tOFF | VNO or VNC = 3V, Figure 2 | TA = +25°C | 25 | 75 | ns |
| | | | TA = TMIN to TMAX | | 150 | |
| Break-Before-Make Time Delay (Note 4) | tD | MAX4543/MAX4544 only, RL = 300Ω, CL = 35pF | 2 | 10 | | ns |
| Charge Injection (Note 4) | Q | CL = 1.0nF, VGEN = 0, RGEN = 0, TA = +25°C, Figure 4 | | 1 | 5 | pC |
| Off-Isolation (Note 8) | OIRR | RL = 50Ω, CL = 5pF, f = 1MHz, TA = +25°C, Figure 5 | | -76 | | dB |
| Crosstalk (Note 9) | | RL = 50Ω, CL = 5pF, f = 1MHz, TA = +25°C, Figure 6 | | -90 | | dB |
| NC or NO Capacitance | C _{OFF} | f = 1MHz, TA = +25°C, Figure 7 | | 8 | | pF |
| COM Off-Capacitance | C _{COM(OFF)} | f = 1MHz, TA = +25°C, Figure 7 | | 8 | | pF |
| COM On-Capacitance | C _{COM(ON)} | f = 1MHz, TA = +25°C, Figure 7 | MAX4541/2/3 | 13 | | pF |
| | | | MAX4544 | 20 | | |
| SUPPLY | | | | | | |
| Power-Supply Range | V+ | | 2.7 | | 12 | V |
| Positive Supply Current | I+ | V+ = 5.5V, VIN = 0 or V+, all channels on or off | -1 | 0.0001 | 1 | μA |
| LOGIC INPUT | | | | | | |
| Input Voltage Low | VINL | | | | 0.8 | V |
| Input Voltage High | VINH | | 2.4 | | | V |

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

ELECTRICAL CHARACTERISTICS—Single +3.3V Supply

(V+ = +3.0V to +3.6V, GND = 0, V_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Notes 2, 3)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---------------------------------------|--|--|---|-----|-----|-----|-------|
| ANALOG SWITCH | | | | | | | |
| Analog Signal Range | V _{COM} , V _{NO} , V _{NC} | (Note 3) | | 0 | | V+ | V |
| Channel On-Resistance | R _{ON} | V+ = 3V, I _{COM} = 1.0mA, V _{NO} or V _{NC} = 1.5V | T _A = +25°C | 50 | 125 | | Ω |
| | | | T _A = T _{MIN} to T _{MAX} | | | 275 | |
| DYNAMIC | | | | | | | |
| Turn-On Time (Note 3) | t _{ON} | V _{NO} or V _{NC} = 1.5V | T _A = +25°C | 80 | 400 | | ns |
| | | | T _A = T _{MIN} to T _{MAX} | | | 500 | |
| Turn-Off Time (Note 3) | t _{OFF} | V _{NO} or V _{NC} = 1.5V | T _A = +25°C | 50 | 125 | | ns |
| | | | T _A = T _{MIN} to T _{MAX} | | | 175 | |
| Break-Before-Make Time Delay (Note 3) | t _D | MAX4543/MAX4544 only, R _L = 300Ω, C _L = 35pF, T _A = +25°C | | 2 | 30 | | ns |
| Charge Injection (Note 3) | Q | C _L = 1.0nF, V _{GEN} = 0, R _{GEN} = 0, T _A = +25°C | | | 1 | 5 | pC |
| SUPPLY | | | | | | | |
| Positive Supply Current | I+ | V+ = 3.6V, V _{IN} = 0 or V+, all channels on or off | | -1 | | 1 | μA |

Note 2: QFN and SOT-packaged parts are 100% tested at +25°C only and guaranteed by correlation at the full hot rated temperature.

Note 3: The algebraic convention, where the most negative value is a minimum and the most positive value a maximum, is used in this data sheet.

Note 4: Guaranteed by design.

Note 5: $\Delta R_{ON} = \Delta R_{ON\ max} - \Delta R_{ON\ min}$.

Note 6: Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal range.

Note 7: Leakage parameters are 100% tested at maximum rated hot temperature and guaranteed by correlation at +25°C.

Note 8: Off Isolation = $20\log_{10} [V_{COM} / (V_{NC} \text{ or } V_{NO})]$; V_{COM} = output, V_{NC} or V_{NO} = input to off switch.

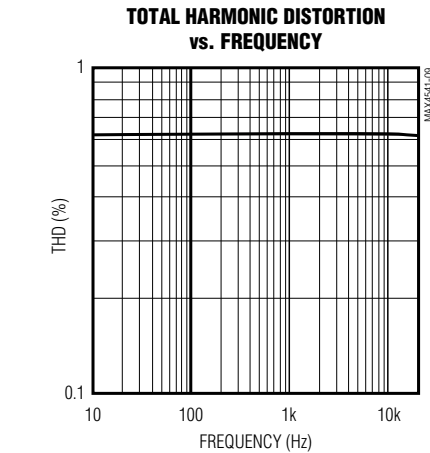
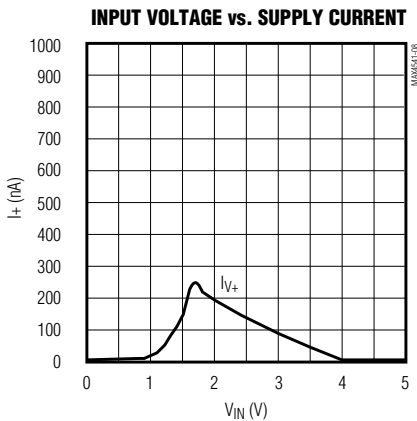
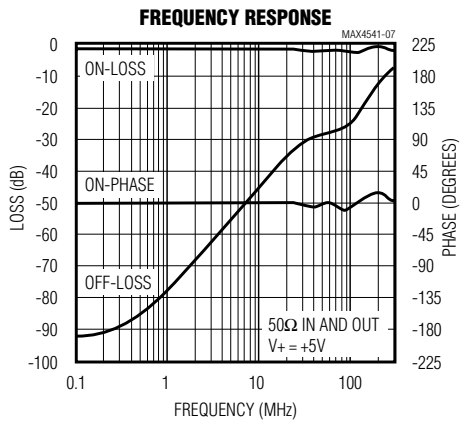
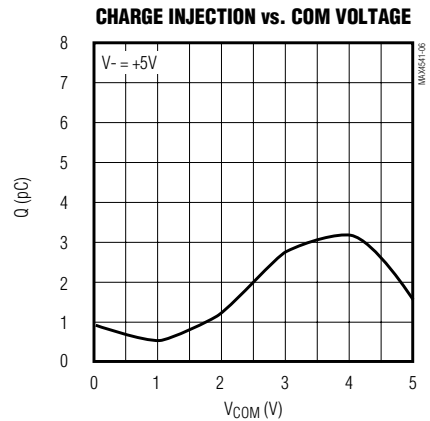
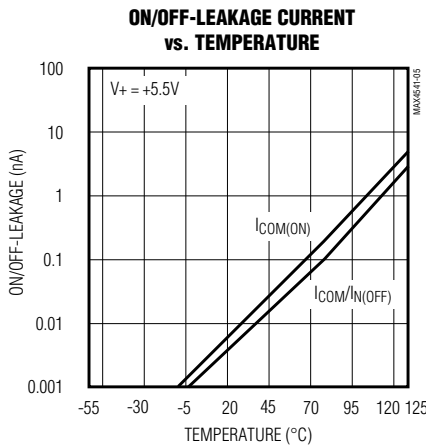
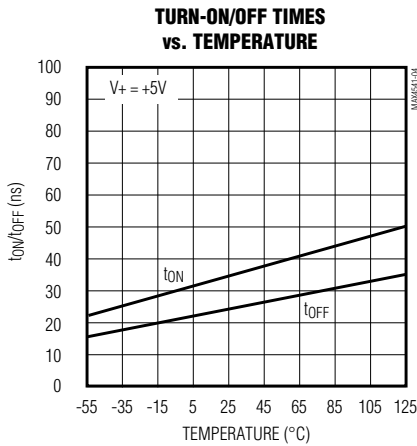
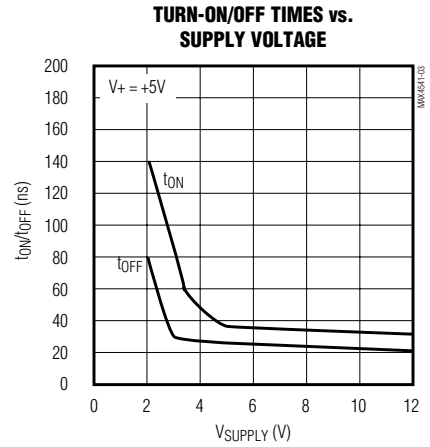
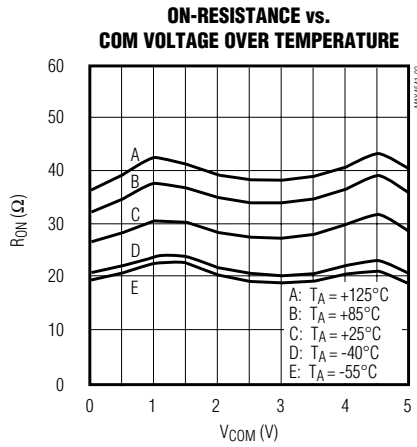
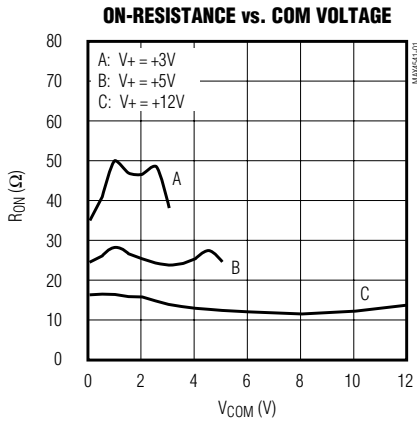
Note 9: Between the two switches, MAX4541/MAX4542/MAX4543 only.

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

Typical Operating Characteristics

($T_A = +25^\circ\text{C}$, unless otherwise noted.)

MAX4541-MAX4544



Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

Pin Description

| PIN | | | | | | | | NAME | FUNCTION |
|-------------------------|---------|-------------------------|---------|-------------------------|---------|-------------------------|---------|------|---------------------------------|
| MAX4541 | | MAX4542 | | MAX4543 | | MAX4544 | | | |
| DIP/SO/ μMAX/ QFN | SOT23-8 | DIP/SO/ μMAX/ QFN | SOT23-8 | DIP/SO/ μMAX/ QFN | SOT23-8 | DIP/SO/ μMAX/ QFN | SOT23-6 | | |
| 1 | 1 | — | — | 1 | 1 | — | — | NO1 | Analog Switch 1—Normally Open |
| 2 | 8 | 2 | 8 | 2 | 8 | — | — | COM1 | Analog Switch 1—Common |
| 3 | 3 | 3 | 3 | 3 | 3 | — | — | IN2 | Digital Control Input 2 |
| 4 | 6 | 4 | 6 | 4 | 6 | 4 | 3 | GND | Ground—Negative Supply Input |
| 5 | 5 | — | — | — | — | — | — | NO2 | Analog Switch 2—Normally Open |
| 6 | 4 | 6 | 4 | 6 | 4 | — | — | COM2 | Analog Switch 2—Common |
| 7 | 7 | 7 | 7 | 7 | 7 | — | — | IN1 | Digital Control Input 1 |
| 8 | 2 | 8 | 2 | 8 | 2 | 8 | 2 | V+ | Positive Supply Voltage Input |
| — | — | 1 | 1 | — | — | — | — | NC1 | Analog Switch 1—Normally Closed |
| — | — | 5 | 5 | 5 | 5 | — | — | NC2 | Analog Switch 2—Normally Closed |
| — | — | — | — | — | — | 1 | 6 | NO | Analog Switch—Normally Open |
| — | — | — | — | — | — | 2 | 5 | COM | Analog Switch—Common |
| — | — | — | — | — | — | 3 | 4 | NC | Analog Switch—Normally Closed |
| — | — | — | — | — | — | 5, 6 | — | N.C. | Not Connected (open circuit) |
| — | — | — | — | — | — | 7 | 1 | IN | Digital Control Input |

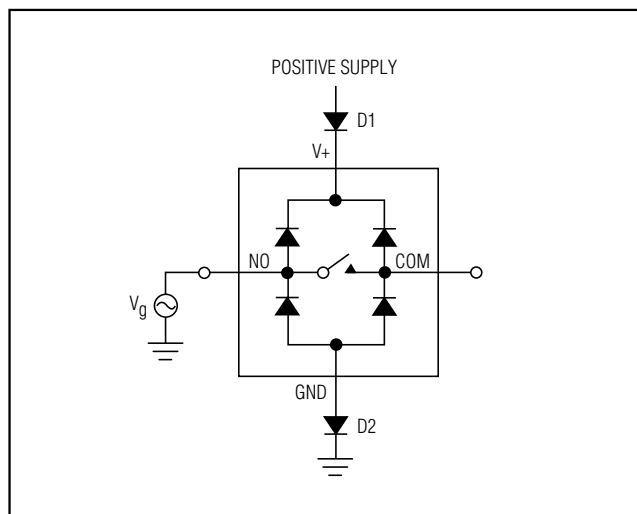


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

Applications Information

Logic Levels

The MAX4541–MAX4544 are TTL compatible when powered from a single +5V supply. When powered from other supply voltages, TTL compatibility is guaranteed and the logic inputs can be driven Rail-to-Rail®. For example, with a +12V supply, IN1 and IN2 can be driven low to 0 and high to 12V. With a +3.3V supply, IN1 and IN2 should be driven low to 0 and high to 3.3V.

Driving IN1 and IN2 rail-to-rail minimizes power consumption.

Analog Signal Levels

Analog signals that range over the entire supply voltage (V+ to GND) can be switched with very little change in on-resistance over the entire voltage range (see *Typical Operating Characteristics*). All the switches are bidirectional, so the NO_, NC_, and COM_ pins can be used as either inputs or outputs.

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

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

MAX4541-MAX4544

Power-Supply Sequencing and Overvoltage Protection

Do not exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the devices.

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 $<10\text{mA}$, 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), and to a diode drop above ground (for D2). Leakage is unaffected by adding the diodes. On-resistance increases by a small amount at low supply voltages. Maximum supply voltage ($V+$) must not exceed 13V .

Adding protection diodes causes the logic thresholds to be shifted relative to the power-supply rails. This can be significant when low supply voltages ($+5\text{V}$ or less) are used. With a $+5\text{V}$ supply, TTL compatibility is not guaranteed when protection diodes are added. Driving IN1 and IN2 all the way to the supply rails (i.e., to a diode drop higher than the $V+$ pin, or to a diode drop lower than the GND pin) is always acceptable.

Protection diodes D1 and D2 also protect against some overvoltage situations. With Figure 1's circuit, if the supply voltage is below the absolute maximum rating, and if a fault voltage up to the absolute maximum rating is applied to an analog signal pin, no damage will result.

Test Circuits/Timing Diagrams

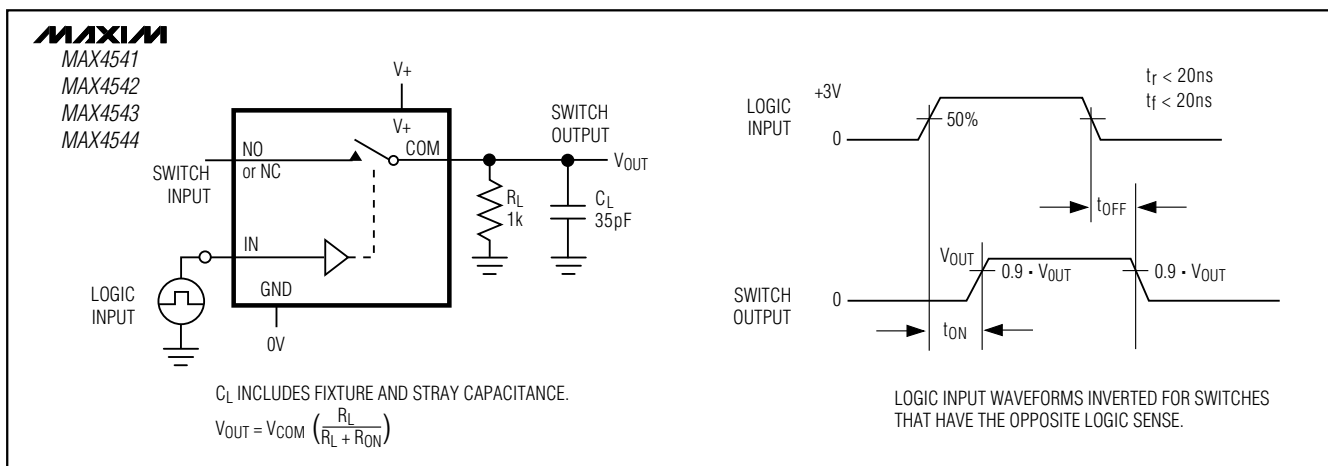


Figure 2. Switching Time

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

Test Circuits/Timing Diagrams (continued)

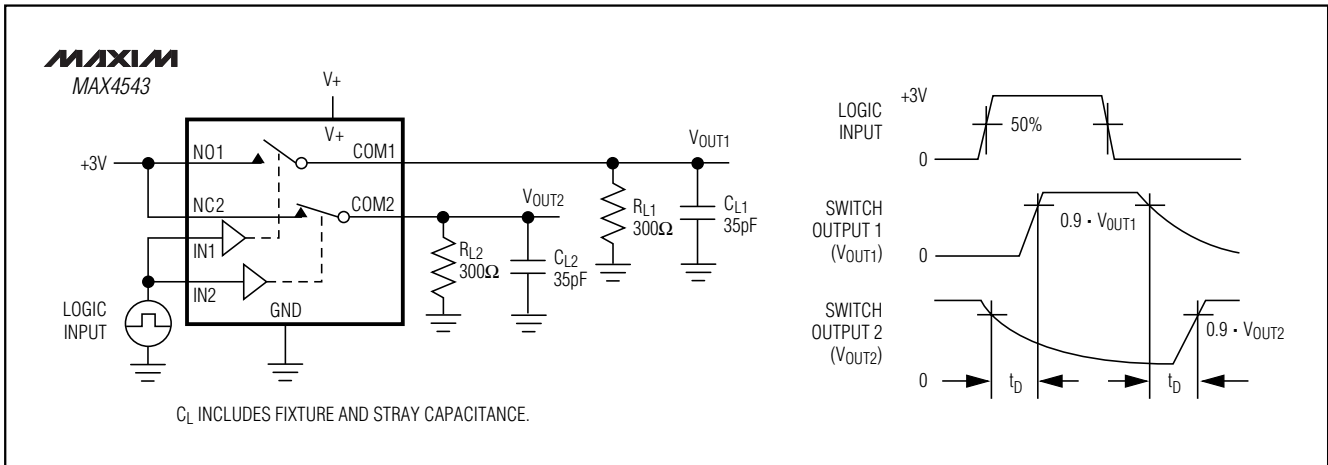


Figure 3a. Break-Before-Make Interval (MAX4543 only)

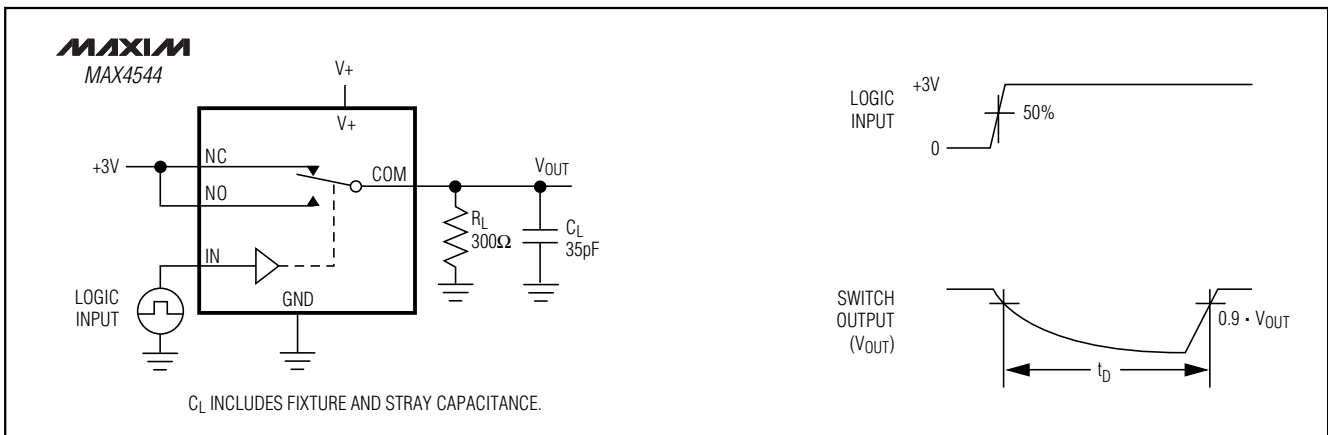


Figure 3b. Break-Before-Make Interval (MAX4544 only)

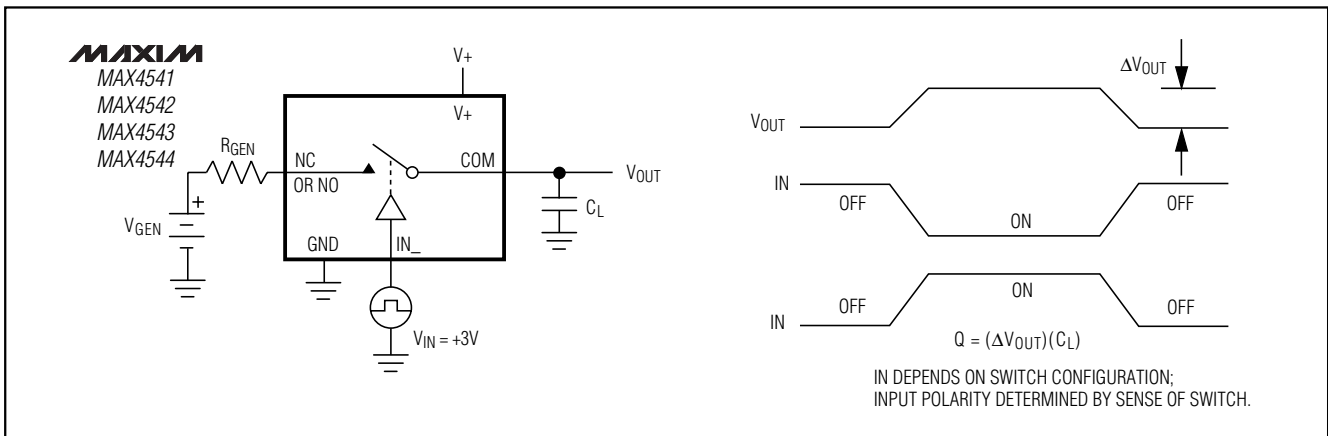


Figure 4. Charge Injection

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

Test Circuits/Timing Diagrams (continued)

MAX4541-MAX4544

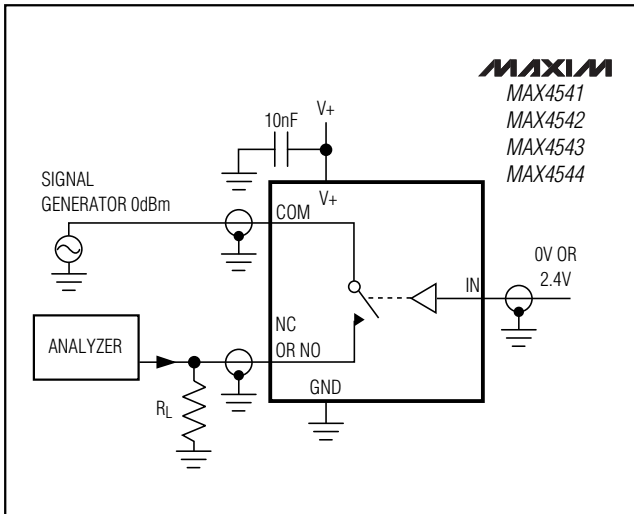


Figure 5. Off-Isolation

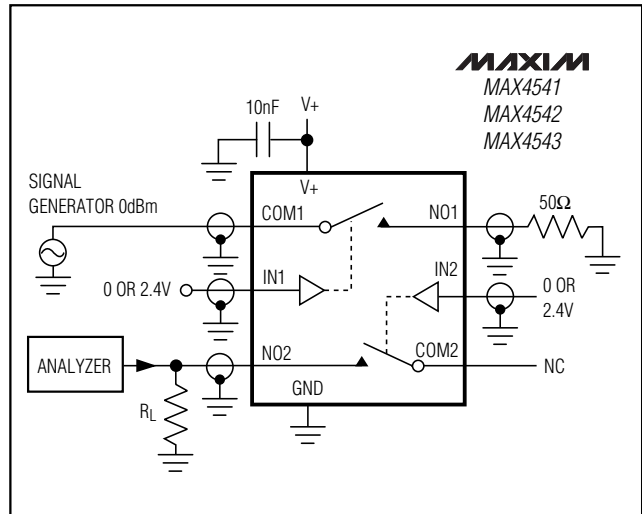


Figure 6. Crosstalk

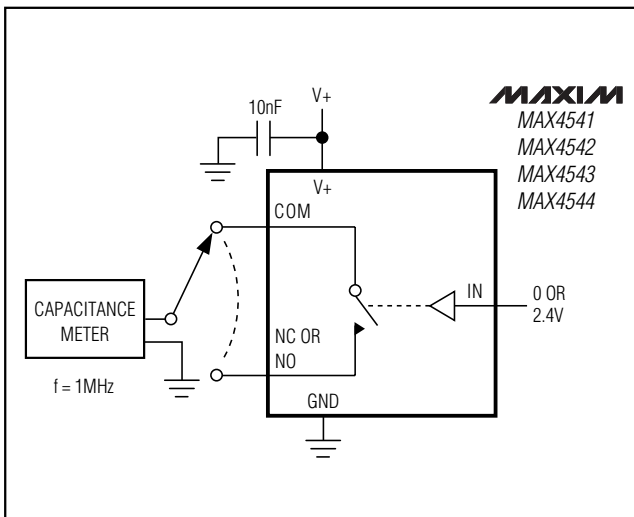


Figure 7. Channel Off/On-Capacitance

Chip Information

TRANSISTOR COUNT: 76

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

Ordering Information (continued)

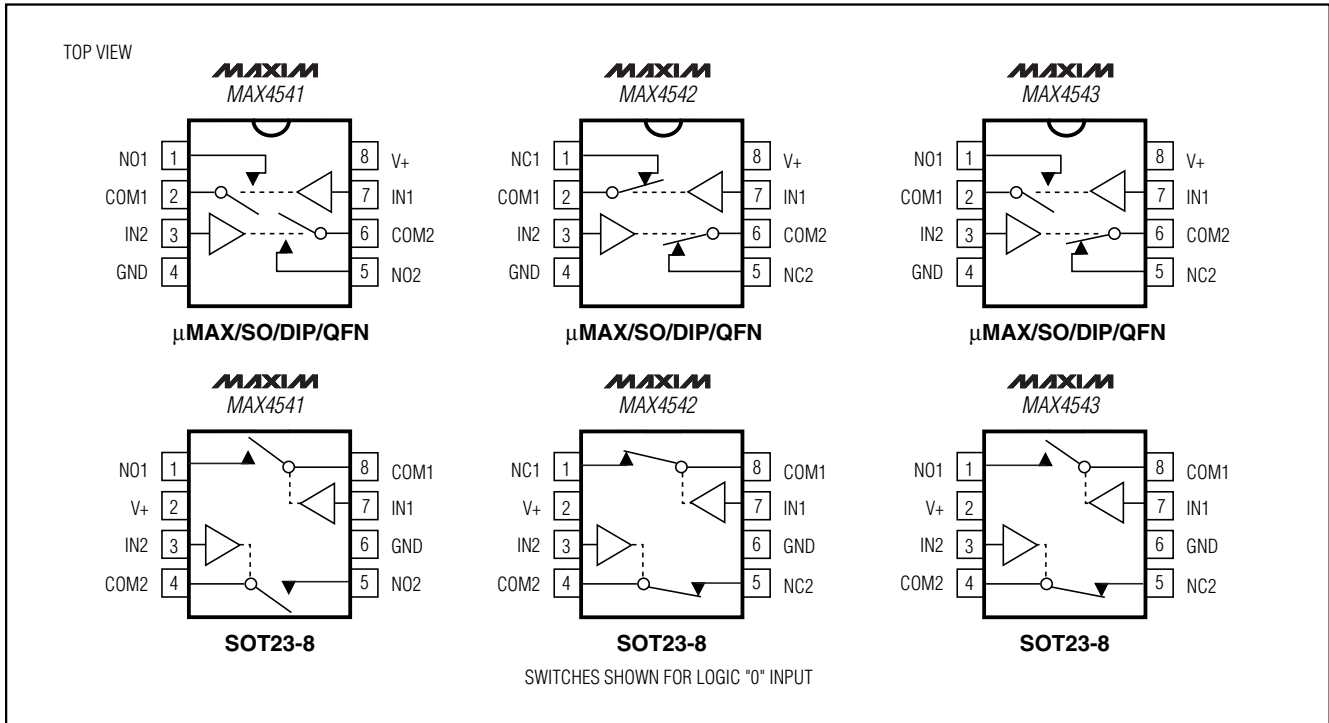
| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|--------------------|----------------|---------------|----------|
| MAX4541EPA | -40°C to +85°C | 8 Plastic DIP | — |
| MAX4542 CUA | 0°C to +70°C | 8 μ MAX | — |
| MAX4542CSA | 0°C to +70°C | 8 SO | — |
| MAX4542CPA | 0°C to +70°C | 8 Plastic DIP | — |
| MAX4542C/D | 0°C to +70°C | Dice* | — |
| MAX4542EKA-T | -40°C to +85°C | 8 SOT23-8 | AAAF |
| MAX4542EGA | -40°C to +85°C | 8 QFN | — |
| MAX4542EUA | -40°C to +85°C | 8 μ MAX | — |
| MAX4542ESA | -40°C to +85°C | 8 SO | — |
| MAX4542EPA | -40°C to +85°C | 8 Plastic DIP | — |
| MAX4543 CUA | 0°C to +70°C | 8 μ MAX | — |
| MAX4543CSA | 0°C to +70°C | 8 SO | — |
| MAX4543CPA | 0°C to +70°C | 8 Plastic DIP | — |
| MAX4543C/D | 0°C to +70°C | Dice* | — |
| MAX4543EKA-T | -40°C to +85°C | 8 SOT23-8 | AAAG |
| MAX4543EGA | -40°C to +85°C | 8 QFN | — |
| MAX4543EUA | -40°C to +85°C | 8 μ MAX | — |
| MAX4543ESA | -40°C to +85°C | 8 SO | — |
| MAX4543EPA | -40°C to +85°C | 8 Plastic DIP | — |
| MAX4544 CUA | 0°C to +70°C | 8 μ MAX | — |
| MAX4544CSA | 0°C to +70°C | 8 SO | — |
| MAX4544CPA | 0°C to +70°C | 8 Plastic DIP | — |
| MAX4544C/D | 0°C to +70°C | Dice* | — |
| MAX4544EUT-T | -40°C to +85°C | 6 SOT23-6 | AAAM |
| MAX4544EGA | -40°C to +85°C | 8 QFN | — |
| MAX4544EUA | -40°C to +85°C | 8 μ MAX | — |
| MAX4544ESA | -40°C to +85°C | 8 SO | — |
| MAX4544EPA | -40°C to +85°C | 8 Plastic DIP | — |

*Dice are specified at $T_A = +25^\circ\text{C}$.

Low-Voltage, Single-Supply Dual SPST/SPDT Analog Switches

Pin Configurations/Functional Diagrams/Truth Tables (continued)

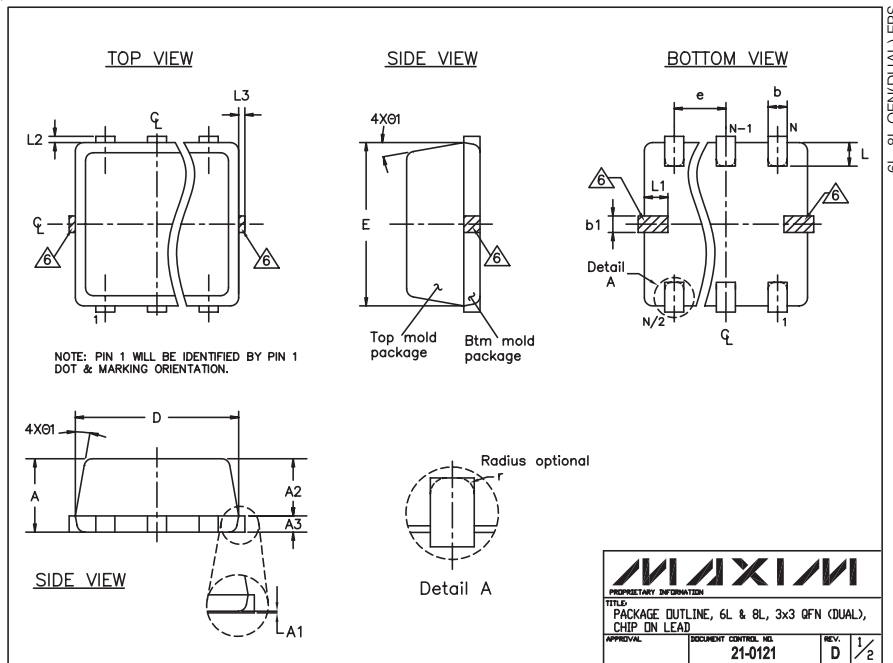
MAX4541-MAX4544



Low-Voltage, Single-Supply Dual SPST/SPDT 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.)



| COMMON DIMENSIONS | | | VARIATIONS | | | | |
|-------------------|------|------|------------|----------|------|------------------------|------|
| SYMBOL | MIN | MAX | SYMBOL | MIN | MAX | MIN | MAX |
| A | 0.80 | 1.00 | D | 2.90 | 3.10 | 2.90 | 3.10 |
| A1 | 0 | 0.05 | E | 2.90 | 3.10 | 2.90 | 3.10 |
| A2 | 0.65 | 0.90 | N | 6 | | 8 | |
| A3 | 0.15 | 0.25 | e | 0.95 BSC | | 0.65 BSC | |
| L2 | 0 | 0.10 | b | 0.27 | 0.43 | 0.25 | 0.40 |
| L3 | 0 | 0.10 | L | 0.21 | 0.44 | 0.21 | 0.44 |
| b1 | 0.17 | 0.30 | L1 | 0.21 | 0.37 | 0.21 | 0.37 |
| Ø1 | 0" | 12" | JEDEC SPEC | — | | MO-220 VARIATION EEC-2 | |

Note:

- All dimensions are in mm.
- Package outline exclusive of mold flash & metal burr.
- Package outline inclusive of plating.
- N is the total number of terminals.
- Package surface finishing of Ra0.4µm max.

⚠ Shaded areas are not leads. Do not make electrical contact in this area. Use numbered leads for electrical contact.

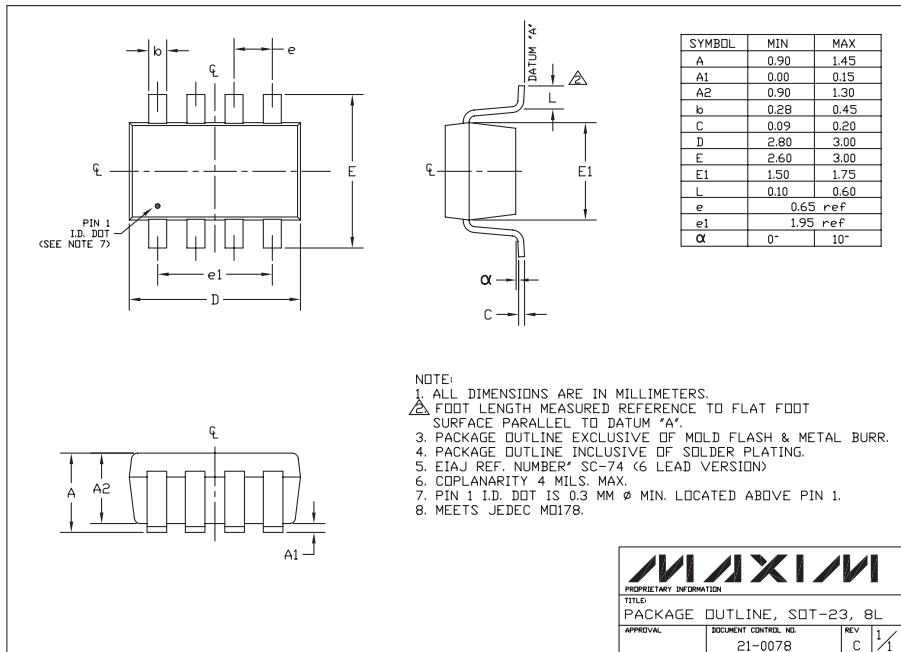
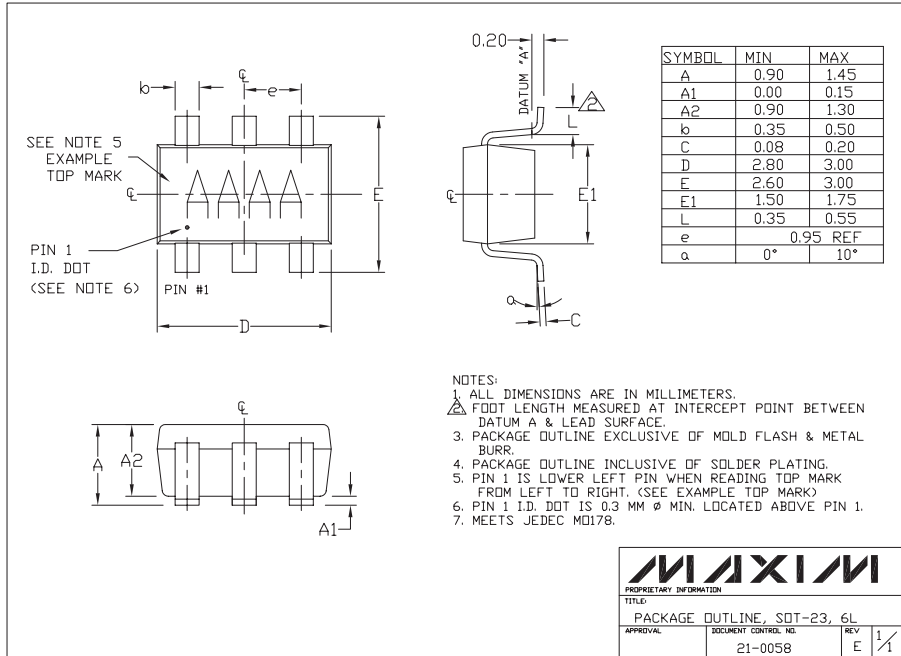
| | |
|---|---|
| MAXIM | |
| PROPRIETARY INFORMATION | |
| TITLE: PACKAGE OUTLINE, 6L & 8L, 3x3 QFN (DUAL), CHIP ON LEAD | |
| APPROVAL | DOCUMENT CONTROL NO. 21-0121 REV. D 2/2 |

Low-Voltage, Single-Supply Dual SPST/SPDT 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.)

MAX4541-MAX4544



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.

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600 _____ 13