



## Precision, Dual, High-Speed Analog Switches

### General Description

The MAX301/MAX303/MAX305 are precision, dual, high-speed analog switches. The single-pole single-throw (SPST) MAX301 and double-pole single-throw (DPST) MAX305 dual switches are normally open (NO). The single-pole double-throw (SPDT) MAX303 has two NO and two normally closed (NC) poles. All three parts offer low on resistance (less than  $35\Omega$ ), guaranteed to match to within  $2\Omega$  between channels and to remain flat over the full analog signal range ( $\Delta 3\Omega$  max). They also offer low leakage (less than  $250\text{pA}$  at  $+25^\circ\text{C}$  and less than  $6\text{nA}$  at  $+85^\circ\text{C}$ ) and fast switching (turn-on time less than  $150\text{ns}$  and turn-off time less than  $100\text{ns}$ ).

The MAX301/MAX303/MAX305 are fabricated with Maxim's new improved silicon-gate process for high system accuracy. Design improvements guarantee extremely low charge injection ( $15\text{pC}$ ) and low power consumption ( $35\mu\text{W}$ ). A  $44\text{V}$  maximum breakdown voltage allows rail-to-rail analog signal capability.

These monolithic switches operate with a single positive supply ( $+10\text{V}$  to  $+30\text{V}$ ) or with split supplies ( $\pm 4.5\text{V}$  to  $\pm 20\text{V}$ ) while retaining CMOS-logic input compatibility and fast switching. CMOS inputs provide reduced input loading.

### Applications

|                              |                          |
|------------------------------|--------------------------|
| Sample-and-Hold Circuits     | Military Radios          |
| Test Equipment               | Communication Systems    |
| Heads-Up Displays            | Battery-Operated Systems |
| Guidance and Control Systems | PBX, PABX                |

### Features

- ♦ Low On Resistance  $<22\Omega$  Typical ( $35\Omega$  Max)
- ♦ Guaranteed Matched On Resistance Between Channels  $<2\Omega$
- ♦ Guaranteed Flat On Resistance over Full Analog Signal Range  $\Delta 3\Omega$  Max
- ♦ Guaranteed Charge Injection  $<15\text{pC}$
- ♦ Guaranteed Off-Channel Leakage  $<6\text{nA}$  at  $+85^\circ\text{C}$
- ♦ Single-Supply Operation ( $+10\text{V}$  to  $+30\text{V}$ )  
Bipolar-Supply Operation ( $\pm 4.5\text{V}$  to  $\pm 20\text{V}$ )
- ♦ TTL-/CMOS-Logic Compatible
- ♦ Rail-to-Rail Analog Signal Handling Capability

### Ordering Information

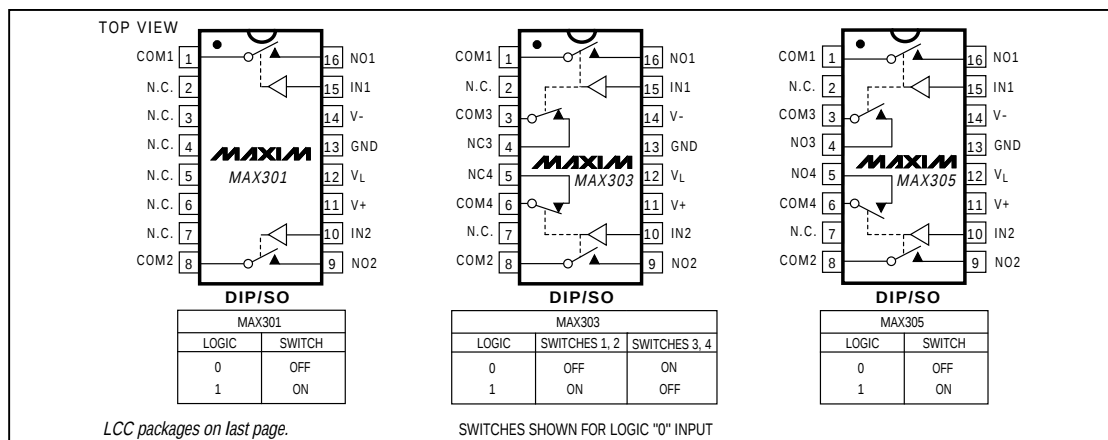
| PART      | TEMP. RANGE                                 | PIN-PACKAGE    |
|-----------|---------------------------------------------|----------------|
| MAX301CPE | $0^\circ\text{C}$ to $+70^\circ\text{C}$    | 16 Plastic DIP |
| MAX301CSE | $0^\circ\text{C}$ to $+70^\circ\text{C}$    | 16 Narrow SO   |
| MAX301CJE | $0^\circ\text{C}$ to $+70^\circ\text{C}$    | 16 CERDIP      |
| MAX301C/D | $0^\circ\text{C}$ to $+70^\circ\text{C}$    | Dice*          |
| MAX301EPE | $-40^\circ\text{C}$ to $+85^\circ\text{C}$  | 16 Plastic DIP |
| MAX301ESE | $-40^\circ\text{C}$ to $+85^\circ\text{C}$  | 16 Narrow SO   |
| MAX301EJE | $-40^\circ\text{C}$ to $+85^\circ\text{C}$  | 16 CERDIP      |
| MAX301MJE | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ | 16 CERDIP      |
| MAX301MLP | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ | 20 LCC**       |

Ordering Information continued on last page.

\* Contact factory for dice specifications.

\*\* Contact factory for package availability.

### Pin Configurations/Block Diagrams/Truth Tables



Maxim Integrated Products 1

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MAX301/MAX303/MAX305

# Precision, Dual, High-Speed Analog Switches

## ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-

|                                                                                                                 |                                                           |
|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| V+ .....                                                                                                        | 44V                                                       |
| GND .....                                                                                                       | 25V                                                       |
| V <sub>L</sub> .....                                                                                            | (GND-0.3V) to (V+) +0.3V                                  |
| NO <sub>-</sub> , NC <sub>-</sub> , IN <sub>-</sub> , COM <sub>-</sub> .....                                    | (V- - 2V) to (V+ + 2V) or 30mA,<br>whichever occurs first |
| Continuous Current, COM <sub>-</sub> , NO <sub>-</sub> , NC <sub>-</sub> .....                                  | 30mA                                                      |
| Peak Current, COM <sub>-</sub> , NO <sub>-</sub> , NC <sub>-</sub><br>(pulsed at 1ms, 10% duty cycle max) ..... | 100mA                                                     |

Continuous Power Dissipation (T<sub>A</sub> = +70°C) (Note 2)

|                                                          |       |
|----------------------------------------------------------|-------|
| 16-Pin Plastic DIP (derate 10.53mW/°C above +70°C) ..... | 842mW |
| 16-Pin Narrow SO (derate 8.70mW/°C above +70°C) .....    | 696mW |
| 16-Pin CERDIP (derate 10.00mW/°C above +70°C) .....      | 800mW |
| 20-Pin LCC (derate 9.09mW/°C above +70°C) .....          | 727mW |

Operating Temperature Ranges:

|                                           |                 |
|-------------------------------------------|-----------------|
| MAX30_C .....                             | 0°C to +70°C    |
| MAX30_E .....                             | -40°C to +85°C  |
| MAX30_M .....                             | -55°C to +125°C |
| Storage Temperature Range .....           | -65°C to +150°C |
| Lead Temperature (soldering, 10sec) ..... | +300°C          |

**Note 1:** Signals on NO<sub>-</sub>, NC<sub>-</sub>, or COM<sub>-</sub> beyond V+ or V- are clamped by internal diodes. Limit forward 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

(V+ = 15V, V- = -15V, V<sub>L</sub> = +5V, GND = 0V, 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.)

| PARAMETER                                     | SYMBOL                                             | CONDITIONS                                                                                                                    | TEMP. RANGE                                           | MIN     | TYP<br>(Note 2) | MAX   | UNITS |
|-----------------------------------------------|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|---------|-----------------|-------|-------|
| <b>SWITCH</b>                                 |                                                    |                                                                                                                               |                                                       |         |                 |       |       |
| Analog-Signal Range                           | V <sub>ANA</sub>                                   | (Note 3)                                                                                                                      |                                                       | V-      |                 | V+    | V     |
| On Resistance                                 | R <sub>ON</sub>                                    | I <sub>(NC or NO)</sub> = -10mA,<br>V <sub>COM<sub>-</sub></sub> = ±10V<br>V <sub>INH</sub> = 2.4V, V <sub>INL</sub> = 0.8V   | T <sub>A</sub> = +25°C                                | C, E    | 20              | 35    | Ω     |
|                                               |                                                    |                                                                                                                               |                                                       | M       | 20              | 30    |       |
|                                               |                                                    |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | C, E    |                 | 55    |       |
|                                               |                                                    |                                                                                                                               |                                                       | M       |                 | 45    |       |
| On Resistance Match Between Channels (Note 4) | R <sub>ON</sub>                                    | I <sub>(NC or NO)</sub> = -10mA,<br>V <sub>COM<sub>-</sub></sub> = ±10V<br>V+ = 15V, V- = -15V                                | T <sub>A</sub> = +25°C                                | C, E, M | 0.5             | 2     | Ω     |
|                                               |                                                    |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | C, E, M |                 | 3     |       |
| On Resistance Flatness (Note 4)               | R <sub>ON</sub>                                    | I <sub>S</sub> = -10mA<br>V <sub>COM<sub>-</sub></sub> = ±5V<br>V+ = 15V, V- = -15V                                           | T <sub>A</sub> = +25°C                                | C, E, M |                 | 3     | Ω     |
|                                               |                                                    |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | C, E, M |                 | 5     |       |
| NC or NO Off Leakage Current                  | NC <sub>-(OFF)</sub><br>or<br>NO <sub>-(OFF)</sub> | V <sub>COM<sub>-</sub></sub> = ±15.5V,<br>V <sub>NC<sub>-</sub> or VNO<sub>-</sub></sub> = ±15.5V,<br>V+ = 16.5V, V- = -16.5V | T <sub>A</sub> = +25°C                                | C, E    | -0.50           | -0.01 | nA    |
|                                               |                                                    |                                                                                                                               |                                                       | M       | -0.25           | -0.01 |       |
|                                               |                                                    |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | C, E    | -6              | 6     |       |
|                                               |                                                    |                                                                                                                               |                                                       | M       | -20             | 20    |       |
| COM Off Leakage Current                       | COM <sub>OFF</sub>                                 | V <sub>COM<sub>-</sub></sub> = ±15.5V,<br>V <sub>NC<sub>-</sub> or VNO<sub>-</sub></sub> = ±15.5V,<br>V+ = 16.5V, V- = -16.5V | T <sub>A</sub> = +25°C                                | C, E    | -0.50           | -0.01 | nA    |
|                                               |                                                    |                                                                                                                               |                                                       | M       | -0.25           | -0.01 |       |
|                                               |                                                    |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | C, E    | -6              | 6     |       |
|                                               |                                                    |                                                                                                                               |                                                       | M       | -20             | 20    |       |
| COM On Leakage Current                        | COM <sub>ON</sub>                                  | V <sub>COM<sub>-</sub></sub> = ±15.5V,<br>V <sub>NC<sub>-</sub> or VNO<sub>-</sub></sub> = ±15.5V,<br>V+ = 16.5V, V- = -16.5V | T <sub>A</sub> = +25°C                                | C, E    | -1.0            | -0.04 | nA    |
|                                               |                                                    |                                                                                                                               |                                                       | M       | -0.4            | -0.04 |       |
|                                               |                                                    |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | C, E    | -20             | 20    |       |
|                                               |                                                    |                                                                                                                               |                                                       | M       | -40.0           | 40.0  |       |

# Precision, Dual, High-Speed Analog Switches

## ELECTRICAL CHARACTERISTICS (continued)

(V+ = 15V, V- = -15V, V<sub>L</sub> = +5V, GND = 0V, 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.)

| PARAMETER                             | SYMBOL                | CONDITIONS                                                                    |                                                       | MIN    | TYP<br>(Note 2) | MAX   | UNITS |
|---------------------------------------|-----------------------|-------------------------------------------------------------------------------|-------------------------------------------------------|--------|-----------------|-------|-------|
| INPUT                                 |                       |                                                                               |                                                       |        |                 |       |       |
| Input Current with Input Voltage High | I <sub>INH</sub>      | V <sub>IN_</sub> = 2.4V, all others = 0.8V                                    |                                                       | -1.000 | 0.005           | 1.000 | μA    |
| Input Current with Input Voltage Low  | I <sub>INH</sub>      | V <sub>IN_</sub> = 0.8V, all others = 2.4V                                    |                                                       | -1.000 | 0.005           | 1.000 | μA    |
| SUPPLY                                |                       |                                                                               |                                                       |        |                 |       |       |
| Power-Supply Range                    |                       |                                                                               |                                                       | ±4.5   |                 | ±20   | V     |
| Positive Supply Current               | I+                    | All channels on or off, V <sub>IN</sub> = 0V or 5V, V+ = 16.5V, V- = -16.5V   | T <sub>A</sub> = +25°C                                | -1.00  | 0.01            | 1.00  | μA    |
|                                       |                       |                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -5.00  |                 | 5.00  |       |
| Negative Supply Current               | I-                    | All channels on or off, V <sub>IN</sub> = 0V or 5V, V+ = 16.5V, V- = -16.5V   | T <sub>A</sub> = +25°C                                | -1.00  | -0.01           | 1.00  | μA    |
|                                       |                       |                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -5.00  |                 | 5.00  |       |
| Logic Supply Current                  | I <sub>L</sub>        | All channels on or off, V <sub>IN</sub> = 0V or 5V, V+ = 16.5V, V- = -16.5V   | T <sub>A</sub> = +25°C                                | -1.00  | 0.01            | 1.00  | μA    |
|                                       |                       |                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -5.00  |                 | 5.00  |       |
| Ground Current                        | I <sub>GND</sub>      | All channels on or off, V <sub>IN</sub> = 0V or 5V, V+ = 16.5V, V- = -16.5V   | T <sub>A</sub> = +25°C                                | -1.00  | -0.01           | 1.00  | μA    |
|                                       |                       |                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -5.00  |                 | 5.00  |       |
| DYNAMIC                               |                       |                                                                               |                                                       |        |                 |       |       |
| Turn-On Time                          | t <sub>ON</sub>       | Figure1                                                                       | T <sub>A</sub> = +25°C                                | 100    | 150             |       | ns    |
| Turn-Off Time                         | t <sub>OFF</sub>      | Figure 1                                                                      | T <sub>A</sub> = +25°C                                | 60     | 100             |       | ns    |
| Break-Before-Make Time Delay (Note 3) | t <sub>D</sub>        | MAX303 only, Figure 2                                                         | T <sub>A</sub> = +25°C                                | 10     | 20              |       | ns    |
| Charge Injection (Note 3)             | Q                     | C <sub>L</sub> = 10nF, V <sub>GEN</sub> = 0V, R <sub>GEN</sub> = 0Ω, Figure 3 | T <sub>A</sub> = +25°C                                | 10     | 15              |       | pC    |
| Off Isolation (Note 5)                | OIRR                  | R <sub>L</sub> = 100Ω, C <sub>L</sub> = 5pF, f = 1MHz, Figure 4               | T <sub>A</sub> = +25°C                                | 72     |                 |       | dB    |
| Crosstalk (Note 6)                    |                       | R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, f = 1MHz, Figure 5                | T <sub>A</sub> = +25°C                                | 90     |                 |       | dB    |
| Off Capacitance                       | C <sub>OFF</sub>      | f = 1MHz, Figure 6                                                            | T <sub>A</sub> = +25°C                                | 12     |                 |       | pF    |
| COM Off Capacitance                   | C <sub>COM(OFF)</sub> | f = 1MHz, Figure 6                                                            | T <sub>A</sub> = +25°C                                | 12     |                 |       | pF    |
| Channel-On Capacitance                | C <sub>COM(ON)</sub>  | f = 1MHz, Figure 7                                                            | T <sub>A</sub> = +25°C                                | 39     |                 |       | pF    |

**Note 2:** The algebraic convention, where the most negative value is a minimum and the most positive value a maximum, is used on this data sheet.

**Note 3:** Guaranteed by design.

**Note 4:** ΔR<sub>ON</sub> = ΔR<sub>ON</sub>MAX - ΔR<sub>ON</sub>MIN. On resistance match between channels and flatness are guaranteed only with specified voltages.

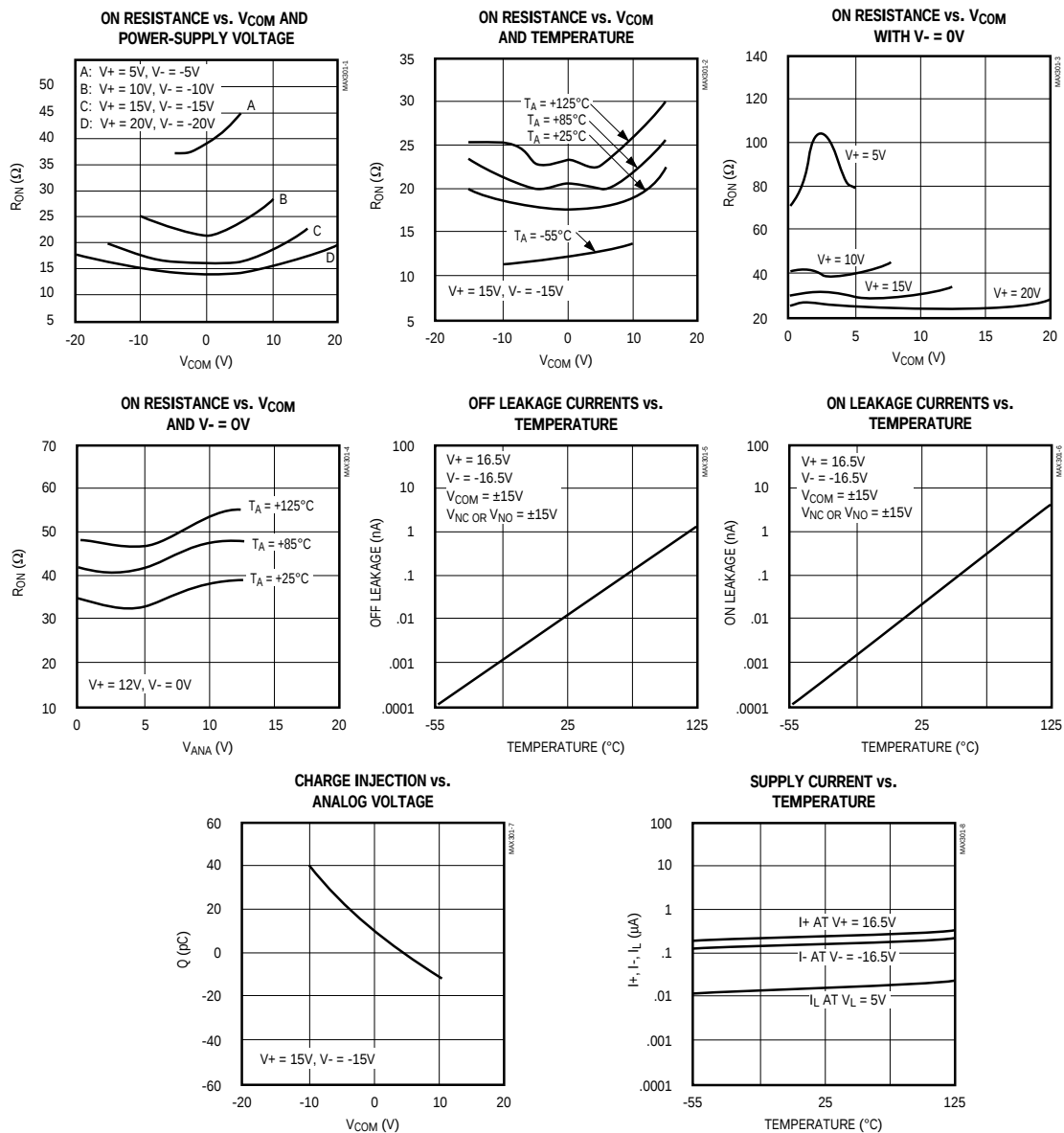
**Note 5:** See Figure 4. Off isolation = 20log<sub>10</sub> V<sub>COM</sub>/V<sub>NC</sub> or V<sub>NO</sub>, V<sub>COM</sub> = output, V<sub>NC</sub> or V<sub>NO</sub> = input to off switch.

**Note 6:** Between any two switches. See Figure 5.

# Precision, Dual, High-Speed Analog Switches

## Typical Operating Characteristics

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



# Precision, Dual, High-Speed Analog Switches

## Pin Descriptions

| MAX301 PIN  |                    | NAME                              | FUNCTION                                             |
|-------------|--------------------|-----------------------------------|------------------------------------------------------|
| DIP/SO      | LCC                |                                   |                                                      |
| 1, 8        | 2, 10              | COM1, COM2                        | Drain (Analog Signal)                                |
| 2-7         | 1, 3-9, 11, 16     | N.C.                              | Not internally connected                             |
| 9, 16       | 5, 7, 12, 20       | NC1, NC2                          | Source (Analog Signal)                               |
| 10, 15      | 13, 19             | IN2, IN1                          | Digital Logic Inputs                                 |
| 11          | 14                 | V+                                | Positive Supply-Voltage Input—connected to substrate |
| 12          | 15                 | V <sub>L</sub>                    | Logic Supply-Voltage Input                           |
| 13          | 17                 | GND                               | Ground                                               |
| 14          | 18                 | V-                                | Negative Supply Voltage Input                        |
| MAX303 PIN  |                    | NAME                              | FUNCTION                                             |
| DIP/SO      | LCC                |                                   |                                                      |
| 1, 8, 3, 6  | 2, 4, 8, 10        | COM <sub>-</sub>                  | Drain (Analog Signal)                                |
| 2-7         | 1, 3, 6, 9, 11, 16 | N.C.                              | Not internally connected                             |
| 11          | 14                 | V+                                | Positive Supply-Voltage Input—connected to substrate |
| 12          | 15                 | V <sub>L</sub>                    | Logic Supply-Voltage Input                           |
| 13          | 17                 | GND                               | Ground                                               |
| 14          | 18                 | V-                                | Negative Supply Voltage Input                        |
| 15, 10      | 19, 13             | IN1, IN2                          | Digital Logic Inputs                                 |
| 16, 9, 5, 4 | 5, 7, 12, 20       | NC <sub>-</sub> , NO <sub>-</sub> | Source (Analog Signal)                               |
| MAX305 PIN  |                    | NAME                              | FUNCTION                                             |
| DIP/SO      | LCC                |                                   |                                                      |
| 1, 8, 3, 6  | 2, 4, 8, 10        | COM <sub>-</sub>                  | Drain (Analog Signal)                                |
| 2-7         | 1, 3, 6, 9, 11, 16 | N.C.                              | Not internally connected                             |
| 11          | 14                 | V+                                | Positive Supply-Voltage Input—connected to substrate |
| 12          | 15                 | V <sub>L</sub>                    | Logic Supply-Voltage Input                           |
| 13          | 17                 | GND                               | Ground                                               |
| 14          | 18                 | V-                                | Negative Supply Voltage Input                        |
| 15, 10      | 19, 13             | IN1, IN2                          | Digital Logic Inputs                                 |
| 16, 9, 5, 4 | 5, 7, 12, 20       | NO <sub>-</sub>                   | Source (Analog Signal)                               |

## Applications Information

### Operation with Supply Voltages Other than ±15V

The MAX301/MAX303/MAX305 switches operate with ±4.5V to ±20V bipolar supplies and a +10V to +30V single supply. In either case, analog signals ranging from V<sub>+</sub> to V<sub>-</sub> can be switched. The *Typical Operating Characteristics* graphs show the typical on-resistance variation with analog signal and supply voltage. The usual on-resistance temperature coefficient is 0.5%/°C (typ).

### Logic Inputs

The MAX301/MAX303/MAX305 operate with a single positive supply or with bipolar supplies. The devices maintain TTL compatibility with supplies anywhere in the ±4.5V to ±20V range as long as V<sub>L</sub> = +5V. If V<sub>L</sub> is connected to V<sub>+</sub> or another supply at voltages other than +5V, the devices will operate at CMOS-logic level inputs.

### Overvoltage Protection

Proper power-supply sequencing is recommended for all CMOS devices. It is important not to exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the devices. Always sequence V<sub>+</sub> on first, followed by V<sub>L</sub>, V<sub>-</sub>, and logic inputs. If power-supply sequencing is not possible, add two small signal diodes in series with the supply pins for overvoltage protection (Figure 1). Adding diodes reduces the analog signal range to 1V below V<sub>+</sub> and 1V below V<sub>-</sub>, but low switch resistance and low leakage characteristics are unaffected. Device operation is unchanged, and the difference between V<sub>+</sub> to V<sub>-</sub> should not exceed +44V.

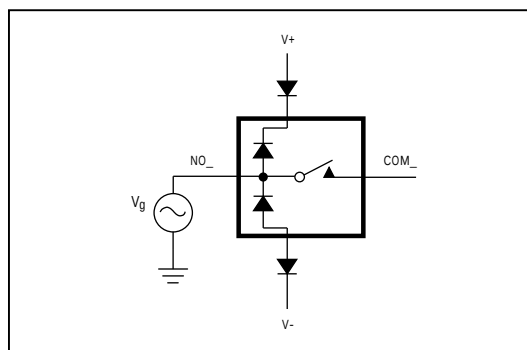


Figure 1. Overvoltage Protection Using Blocking Diodes

MAX301/MAX303/MAX305

# Precision, Dual, High-Speed Analog Switches

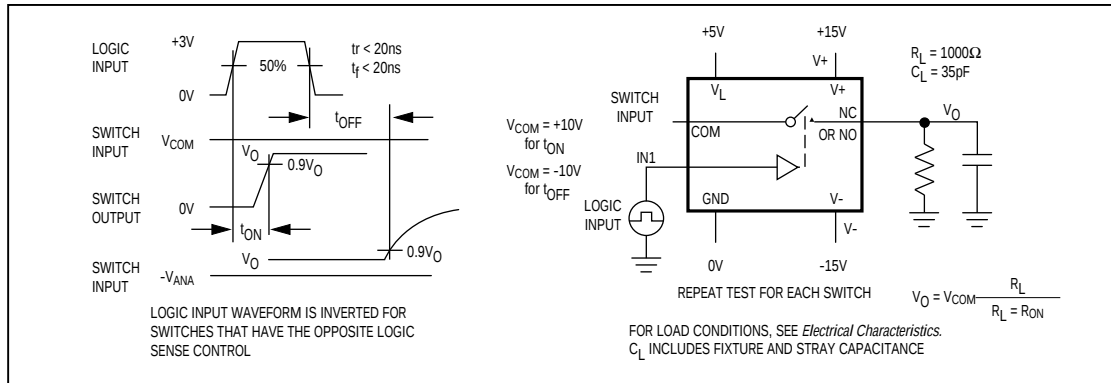


Figure 2. Switching-Time Test Circuit

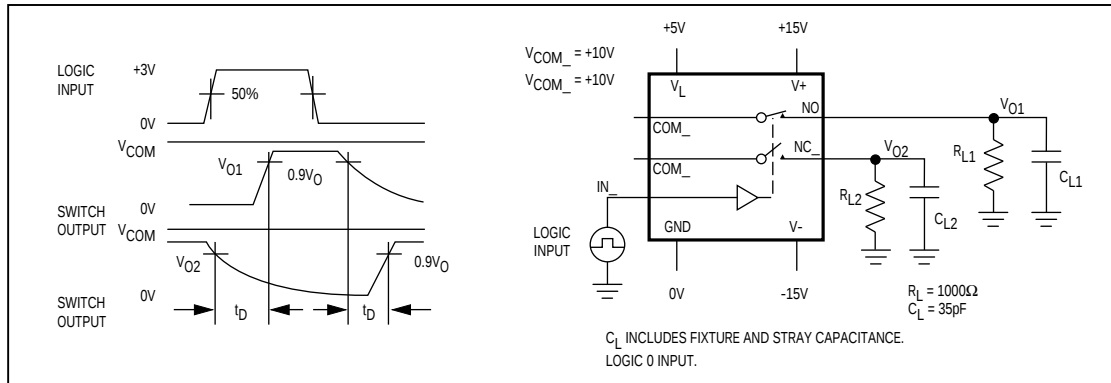


Figure 3. Break-Before-Make Test Circuit

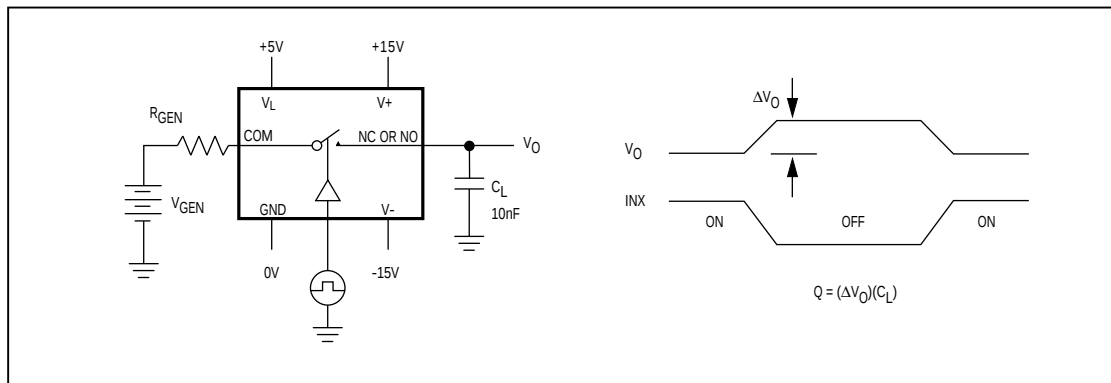
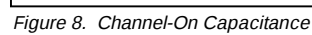
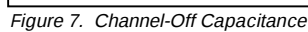
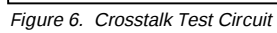
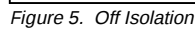


Figure 4. Charge-Injection Test Circuit

## MAX301/MAX303/MAX305



# Precision, Dual, High-Speed Analog Switches

MAX301/MAX303/MAX305

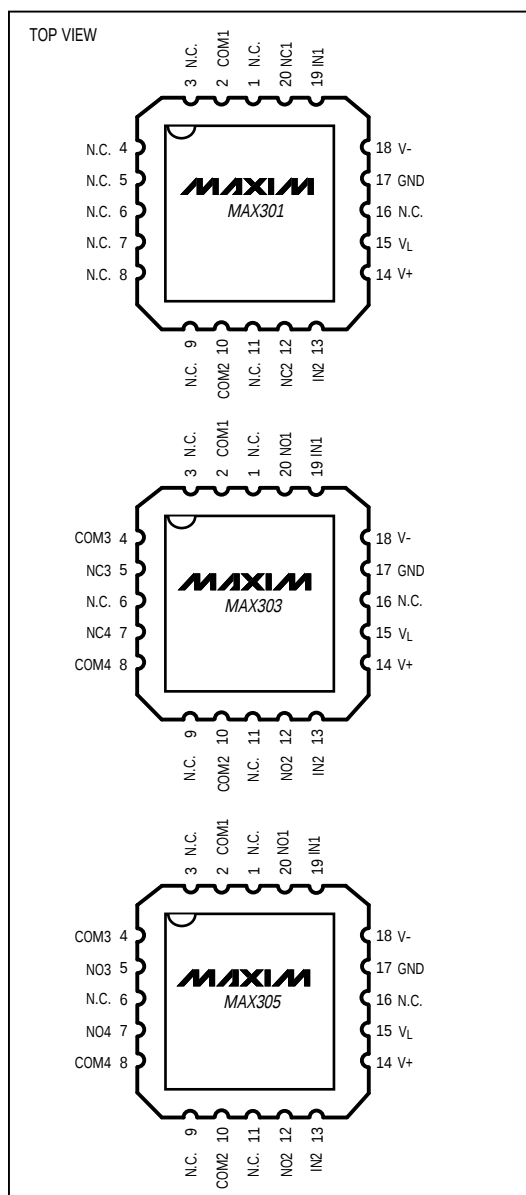
## Ordering Information (continued)

| PART      | TEMP. RANGE     | PIN-PACKAGE    |
|-----------|-----------------|----------------|
| MAX303CPE | 0°C to +70°C    | 16 Plastic DIP |
| MAX303CSE | 0°C to +70°C    | 16 Narrow SO   |
| MAX303CJE | 0°C to +70°C    | 16 CERDIP      |
| MAX303C/D | 0°C to +70°C    | Dice*          |
| MAX303EPE | -40°C to +85°C  | 16 Plastic DIP |
| MAX303ESE | -40°C to +85°C  | 16 Narrow SO   |
| MAX303EJE | -40°C to +85°C  | 16 CERDIP      |
| MAX303MJE | -55°C to +125°C | 16 CERDIP      |
| MAX303MLP | -55°C to +125°C | 20 LCC**       |
| MAX305CPE | 0°C to +70°C    | 16 Plastic DIP |
| MAX305CSE | 0°C to +70°C    | 16 Narrow SO   |
| MAX305CJE | 0°C to +70°C    | 16 CERDIP      |
| MAX305C/D | 0°C to +70°C    | Dice*          |
| MAX305EPE | -40°C to +85°C  | 16 Plastic DIP |
| MAX305ESE | -40°C to +85°C  | 16 Narrow SO   |
| MAX305EJE | -40°C to +85°C  | 16 CERDIP      |
| MAX305MJE | -55°C to +125°C | 16 CERDIP      |
| MAX305MLP | -55°C to +125°C | 20 LCC**       |

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

\*\* Contact factory for availability.

## Pin Configuration (continued)



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