



# 10Ω, Quad, SPST, CMOS Analog Switches

MAX312/MAX313/MAX314

## General Description

Maxim's MAX312/MAX313/MAX314 analog switches feature low on-resistance (10Ω max) and 1.5Ω on-resistance matching between channels. These switches conduct equally well in either direction. They offer low leakage over temperature (2.5nA at +85°C). Low power consumption and ESD tolerance greater than 2000V per Method 3015.7 are guaranteed.

The MAX312/MAX313/MAX314 are quad, single-pole/single-throw (SPST) analog switches. The MAX312 is normally closed (NC), and the MAX313 is normally open (NO). The MAX314 has two NC switches and two NO switches. All three devices operate from a single supply of +4.5V to +30V or from dual supplies of ±4.5V to ±20V.

## Applications

- Test Equipment
- Communication Systems
- PBX, PABX Systems
- Audio Signal Routing
- Avionics
- Sample-and-Hold Circuits
- Data Acquisition Systems

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

## Features

- ◆ Pin Compatible with DG411/DG412/DG413
- ◆ Low On-Resistance (6.5Ω typical)
- ◆ Guaranteed  $R_{ON}$  Match Between Channels (1.5Ω max)
- ◆ Guaranteed  $R_{ON}$  Flatness over Specified Signal Range (2Ω max)
- ◆ Guaranteed ESD Protection > 2000V per Method 3015.7
- ◆ Crosstalk > 96dB at 20kHz
- ◆ Single-Supply Operation: +4.5V to +30V  
Dual-Supply Operation: ±4.5V to ±20V
- ◆ Rail-to-Rail® Signal Handling

## Ordering Information

| PART      | TEMP RANGE      | PIN-PACKAGE    |
|-----------|-----------------|----------------|
| MAX312CPE | 0°C to +70°C    | 16 Plastic DIP |
| MAX312CSE | 0°C to +70°C    | 16 Narrow SO   |
| MAX312CUE | 0°C to +70°C    | 16 TSSOP       |
| MAX312C/D | 0°C to +70°C    | Dice*          |
| MAX312EPE | -40°C to +85°C  | 16 Plastic DIP |
| MAX312ESE | -40°C to +85°C  | 16 Narrow SO   |
| MAX312EUE | -40°C to +85°C  | 16 TSSOP       |
| MAX312MJE | -55°C to +125°C | 16 CERDIP**    |

Ordering Information continued at end of data sheet.

\* Contact factory for dice specifications.

\*\*Contact factory for availability.

## Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW

**DIP/SO/TSSOP**

| SO/MAX312 |        |
|-----------|--------|
| LOGIC     | SWITCH |
| 0         | ON     |
| 1         | OFF    |

**DIP/SO/TSSOP**

| MAX313 |        |
|--------|--------|
| LOGIC  | SWITCH |
| 0      | OFF    |
| 1      | ON     |

**DIP/SO/TSSOP**

| MAX314 |               |               |
|--------|---------------|---------------|
| LOGIC  | SWITCHES 1, 4 | SWITCHES 2, 3 |
| 0      | OFF           | ON            |
| 1      | ON            | OFF           |

SWITCHES SHOWN FOR LOGIC "0" INPUT

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## ABSOLUTE MAXIMUM RATINGS

Voltages Referenced to GND

|   |  |
|---|--|
| V+ .....                                  | -0.3V to +44V  |
| V- .....                                  | +0.3V to -44V  |
| V+ to V- .....                            | -0.3V to +44V  |
| VL .....                                  | (GND - 0.3V) to (V+ + 0.3V)                                |
| All Other Pins (Note 1) .....             | (V- - 2V) to (V+ + 2V)<br>or 30mA (whichever occurs first) |
| Continuous Current (COM_, NO_, NC_) ..... | ±100mA   |
| Peak Current (COM_, NO_, NC_) .....       | ±300mA   |

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

|   |       |
|---|-------|
| Plastic DIP (derate 10.53mW/°C above +70°C) ..... | 842mW |
| Narrow SO (derate 8.70mW/°C above +70°C) .....    | 696mW |
| CERDIP (derate 10.00mW/°C above +70°C) .....      | 800mW |
| TSSOP (derate 6.7mW/°C above +70°C) .....         | 457mW |

Operating Temperature Ranges

|                |                 |
|----------------|-----------------|
| MAX31_C_ ..... | 0°C to +70°C    |
| MAX31_E_ ..... | -40°C to +85°C  |
| MAX31_M_ ..... | -55°C to +125°C |

Storage Temperature Range .....

Lead Temperature (soldering, 10s) .....

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.

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

## ELECTRICAL CHARACTERISTICS—Dual Supplies

(V+ = 15V, V- = -15V, VL = 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 |    |
|---|---|---|---|------|-----------------|-------|-------|----|
| <b>ANALOG SWITCH</b>                          |   |   |   |      |                 |       |       |    |
| Analog Signal Range                           | V <sub>COM_</sub> ,<br>V <sub>NO_</sub> ,<br>V <sub>NC_</sub> | (Note 3)  |   | V-   |                 | V+    | V     |    |
| On-Resistance                                 | R <sub>ON</sub>   | I <sub>COM</sub> = 10mA,<br>V <sub>NO_</sub> or V <sub>NC_</sub> = ±10V           | T <sub>A</sub> = +25°C                                | C, E | 6.5             | 10    | Ω     |    |
|   |   |   |   | M    |                 | 9     |       |    |
|   |   |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      |                 | 15    |       |    |
| On-Resistance Match Between Channels (Note 4) | ΔR <sub>ON</sub>  | I <sub>COM</sub> = 10mA,<br>V <sub>NO_</sub> or V <sub>NC_</sub> = ±10V           | T <sub>A</sub> = +25°C                                |      | 0.3             | 1.5   | Ω     |    |
|   |   |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      |                 | 3     |       |    |
| On-Resistance Flatness (Note 5)               | R <sub>FLAT(ON)</sub>   | I <sub>COM</sub> = 10mA,<br>V <sub>NO_</sub> or V <sub>NC_</sub> = -5V,<br>0V, 5V | T <sub>A</sub> = +25°C                                |      | 0.2             | 2     | Ω     |    |
|   |   |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      |                 | 4     |       |    |
| Off Leakage Current (NO_ or NC_) (Note 6)     | I <sub>NO</sub><br>I <sub>NC</sub>                            | V <sub>COM</sub> = ±10V,<br>V <sub>NO_</sub> or V <sub>NC_</sub> = ±10V           | T <sub>A</sub> = +25°C                                |      | -0.5            | -0.02 | 0.5   | nA |
|   |   |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | C, E | -2.5            |       | 2.5   |    |
|   |   |   |   | M    | -40             |       | 40    |    |
| COM Off Leakage Current (Note 6)              | I <sub>NC(OFF)</sub>  | V <sub>COM</sub> = ±10V,<br>V <sub>NO_</sub> or V <sub>NC_</sub> = ±10V           | T <sub>A</sub> = +25°C                                |      | -0.5            | -0.02 | 0.5   | nA |
|   |   |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | C, E | -2.5            |       | 2.5   |    |
|   |   |   |   | M    | -40             |       | 40    |    |
| COM On Leakage Current (Note 6)               | I <sub>COM(ON)</sub>  | V <sub>COM</sub> = ±10V,<br>V <sub>NO_</sub> or V <sub>NC_</sub> = ±10V           | T <sub>A</sub> = +25°C                                |      | -1              | -0.04 | 1     | nA |
|   |   |   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | C, E | -5              |       | 5     |    |
|   |   |   |   | M    | -100            |       | 100   |    |

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## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = 15V, V- = -15V, VL = 5V, GND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

| PARAMETER                             | SYMBOL             | CONDITIONS  | MIN               | TYP<br>(Note 2) | MAX     | UNITS |    |
|---------------------------------------|--------------------|---|-------------------|-----------------|---------|-------|----|
| <b>LOGIC INPUT</b>                    |                    |   |                   |                 |         |       |    |
| Input Current with Input Voltage High | I <sub>INH</sub>   | IN <sub>-</sub> = 2.4V, all others = 0.8V                               | -0.500            | 0.005           | 0.500   | μA    |    |
| Input Current with Input Voltage Low  | I <sub>INL</sub>   | IN <sub>-</sub> = 0.8V, all others = 2.4V                               | -0.500            | 0.005           | 0.500   | μA    |    |
| <b>POWER SUPPLY</b>                   |                    |   |                   |                 |         |       |    |
| Power-Supply Range                    |                    |   | ±4.5              |                 | ±20.0   | V     |    |
| Positive Supply Current               | I <sub>+</sub>     | All channels on or off,<br>VIN = 0V or 5V,<br>V+ = 16.5V<br>V- = -16.5V | TA = +25°C        | -1              | 0.0001  | 1     | μA |
|                                       |                    |   | TA = TMIN to TMAX | -5              |         | 5     |    |
| Negative Supply Current               | I <sub>-</sub>     | All channels on or off,<br>VIN = 0V or 5V,<br>V+ = 16.5V<br>V- = -16.5V | TA = +25°C        | -1              | 0.0001  | 1     | μA |
|                                       |                    |   | TA = TMIN to TMAX | -5              |         | 5     |    |
| Logic Supply Current                  | IL                 | All channels on or off,<br>VIN = 0V or 5V,<br>V+ = 16.5V<br>V- = -16.5V | TA = +25°C        | -1              | 0.0001  | 1     | μA |
|                                       |                    |   | TA = TMIN to TMAX | -5              |         | 5     |    |
| Ground Current                        | IGND               | All channels on or off,<br>VIN = 0V or 5V,<br>V+ = 16.5V<br>V- = -16.5V | TA = +25°C        | -1              | -0.0001 | 1     | μA |
|                                       |                    |   | TA = TMIN to TMAX | -5              |         | 5     |    |
| <b>DYNAMIC</b>                        |                    |   |                   |                 |         |       |    |
| Turn-On Time                          | t <sub>ON</sub>    | Figure 2,<br>VCOM = ±10V  | TA = +25°C        |                 | 70      | 225   | ns |
|                                       |                    |   | TA = TMIN to TMAX |                 |         | 275   |    |
| Turn-Off Time                         | t <sub>OFF</sub>   | Figure 2,<br>VCOM = ±10V  | TA = +25°C        |                 | 65      | 185   | ns |
|                                       |                    |   | TA = TMIN to TMAX |                 |         | 235   |    |
| Break-Before-Make Time Delay          | t <sub>D</sub>     | MAX314 only, Figure 3,<br>RL = 300Ω,<br>CL = 35pF                       | TA = +25°C        | 1               | 5       | ns    |    |
| Charge Injection (Note 3)             | V <sub>CTE</sub>   | CL = 1.0nF<br>VGEN = 0V,<br>RGEN = 0Ω, Figure 4                         | TA = +25°C        | -30             | 20      | 30    | pC |
| Off Isolation (Note 7)                | V <sub>ISO</sub>   | RL = 50Ω,<br>CL = 5pF,<br>f = 1MHz, Figure 5                            | TA = +25°C        |                 | -65     |       | dB |
| Crosstalk (Note 8)                    | V <sub>CT</sub>    | RL = 50Ω,<br>CL = 5pF,<br>f = 1MHz, Figure 6                            | TA = +25°C        |                 | -85     |       | dB |
| NC or NO Capacitance                  | C <sub>(OFF)</sub> | f = 1MHz, Figure 7  | TA = +25°C        |                 | 15      |       | pF |
| COM Off Capacitance                   | C <sub>(COM)</sub> | f = 1MHz, Figure 7  | TA = +25°C        |                 | 15      |       | pF |
| On Capacitance                        | C <sub>(COM)</sub> | f = 1MHz, Figure 7  | TA = +25°C        |                 | 47      |       | pF |

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## ELECTRICAL CHARACTERISTICS—Single Supply

(V+ = 12V, V- = 0V, VL = 5V, GND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

| PARAMETER                                | SYMBOL  | CONDITIONS  | MIN               | TYP<br>(Note 2) | MAX     | UNITS |    |
|--|---|---|-------------------|-----------------|---------|-------|----|
| <b>ANALOG SWITCH</b>                     |   |   |                   |                 |         |       |    |
| Analog Signal Range                      | VCOM <sub>-</sub> ,<br>VNO <sub>-</sub> ,<br>VNC <sub>-</sub> | (Note 3)  | 0                 |                 | V+      | V     |    |
| Channel On-Resistance                    | RON   | ICOM = 10mA,<br>VNC <sub>-</sub> or VNO <sub>-</sub> +10V |                   | 12.5            | 25      | Ω     |    |
|  |   |   | TA = +25°C        |                 | 35      |       |    |
|  |   |   | TA = TMIN to TMAX |                 |         |       |    |
| <b>POWER SUPPLY</b>                      |   |   |                   |                 |         |       |    |
| Positive Supply Current                  | I+  | V+ = 13.2V<br>all channels on or off,<br>VIN = 0V or 5V   | TA = +25°C        | -1              | 0.0001  | 1     | μA |
|  |   |   | TA = TMAX         | -5              |         | 5     |    |
| Logic Supply Current                     | IL  | VL = 5.5V<br>all channels on or off,<br>VIN = 0V or 5V    | TA = +25°C        | -1              | 0.0001  | 1     | μA |
|  |   |   | TA = TMAX         | -5              |         | 5     |    |
| Ground Current                           | IGND  | VL = 5.5V<br>all channels on or off,<br>VIN = 0V or 5V    | TA = +25°C        | -1              | -0.0001 | 1     | μA |
|  |   |   | TA = TMAX         | -5              |         | 5     |    |
| <b>DYNAMIC</b>                           |   |   |                   |                 |         |       |    |
| Turn-On Time<br>(Note 3)                 | tON   | Figure 2,<br>VNO <sub>-</sub> or VNC <sub>-</sub> = 8V    | TA = +25°C        | 100             |         | 325   | ns |
|  |   |   | TA = TMIN to TMAX |                 |         | 425   |    |
| Turn-Off Time<br>(Note 3)                | tOFF  | Figure 2,<br>VNO <sub>-</sub> or VNC <sub>-</sub> = 8V    | TA = +25°C        | 95              |         | 175   | ns |
|  |   |   | TA = TMIN to TMAX |                 |         | 225   |    |
| Break-Before-Make Time Delay<br>(Note 3) | tD  | MAX314 only, Figure 3<br>RL = 300Ω,<br>CL = 35pF          | TA = +25°C        | 5               |         |       | ns |
| Charge Injection<br>(Note 3)             | VCTE  | Figure 4,<br>CL = 1.0nF,<br>VGEN = 0V,<br>RGEN = 0V       | TA = +25°C        | -5              |         |       | pC |

**Note 2:** 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 3:** Guaranteed by design.

**Note 4:**  $\Delta R_{ON} = \Delta R_{ON\ max} - \Delta R_{ON\ min}$ .

**Note 5:** Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal range.

**Note 6:** Leakage parameters are 100% tested at maximum-rated hot temperature and guaranteed by correlation at +25°C.

**Note 7:** Off isolation =  $20\log_{10} [V_{COM} / (V_{NC} \text{ or } V_{NO})]$ , VCOM = output, VNC or VNO = input to off switch.

**Note 8:** Between any two switches.

**Note 9:** Leakage testing at single supply is guaranteed by testing with dual supplies.

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## Typical Operating Characteristics

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

MAX312/MAX313/MAX314

**ON-RESISTANCE vs.  $V_{COM}$   
(BIPOLAR SUPPLIES)**



**ON-RESISTANCE vs.  $V_{COM}$  AND  
TEMPERATURE**



**ON-RESISTANCE vs.  $V_{COM}$   
(SINGLE SUPPLY,  $V_- = 0\text{V}$ )**



**ON-RESISTANCE vs.  $V_{COM}$  AND  
TEMPERATURE**



**OFF LEAKAGE CURRENT  
vs. TEMPERATURE**



**ON LEAKAGE CURRENT  
vs. TEMPERATURE**



**CHARGE INJECTION  
vs.  $V_{COM}$**



**SUPPLY CURRENT  
vs. TEMPERATURE**



# 10Ω, Quad, SPST, CMOS Analog Switches

## Typical Operating Characteristics (continued)

(T<sub>A</sub> = +25°C, unless otherwise noted.)



## Pin Description

| PIN             |                 |                 | NAME                      | FUNCTION  |
|-----------------|-----------------|-----------------|---------------------------|---|
| MAX312          | MAX313          | MAX314          |                           |   |
| 1, 8,<br>9, 16  | 1, 8,<br>9, 16  | 1, 8,<br>9, 16  | IN2, IN4,<br>IN3, IN2     | Logic Level Inputs  |
| 2, 7,<br>10, 15 | 2, 7,<br>10, 15 | 2, 7,<br>10, 15 | COM1, COM4,<br>COM3, COM2 | Analog Signal Common Terminals  |
| 3, 6,<br>11, 14 | —               | —               | NC1, NC4,<br>NC3, NC2     | Analog Signal Normally Closed Terminals                                   |
| —               | 3, 6,<br>11, 14 | —               | NO1, NO4,<br>NO3, NO2     | Analog Signal Normally Open Terminals                                     |
| —               | —               | 3, 6            | NO1, NO4                  | Analog Signal Normally Open Terminals                                     |
| —               | —               | 11, 14          | NC3, NC2                  | Analog Signal Normally Closed Terminals                                   |
| 4               | 4               | 4               | V-                        | Negative Analog Supply Input (connect to GND for single-supply operation) |
| 5               | 5               | 5               | GND                       | Logic Level Ground  |
| 12              | 12              | 12              | VL                        | Logic Supply Voltage  |
| 13              | 13              | 13              | V+                        | Positive Analog Supply Input  |

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MAX312/MAX313/MAX314

## Applications Information

### Low-Distortion Audio

The MAX312/MAX313/MAX314, having very low  $R_{ON}$  and very low  $R_{ON}$  variation with signal amplitude, are well suited for low-distortion audio applications. The *Typical Operating Characteristics* show Total Harmonic Distortion (THD) vs. Frequency graphs for several signal amplitudes and impedances. Higher source and load impedances improve THD, but reduce off isolation.

### Off Isolation at High Frequencies

In 50Ω systems, the high-frequency on-response of these parts extends from DC to above 100MHz with a typical loss of -2dB. When the switch is turned off, however, it behaves like a capacitor, and off isolation decreases with increasing frequency. (Above 300MHz, the switch actually passes more signal turned off than turned on.) This effect is more pronounced with higher source and load impedances.

Above 5MHz, circuit board layout becomes critical, and it becomes difficult to characterize the response of the switch independent of the circuit. The graphs shown in the *Typical Operating Characteristics* were taken using a 50Ω source and load connected with BNC connec-

tors to a circuit board deemed “average”; that is, designed with isolation in mind, but not using strip-line or other special RF circuit techniques. For critical applications above 5MHz, use the MAX440, MAX441, and MAX442, which are fully characterized up to 160MHz.



Figure 1. Overvoltage Protection Using External Blocking Diodes



Figure 2. Switching-Time Test Circuit

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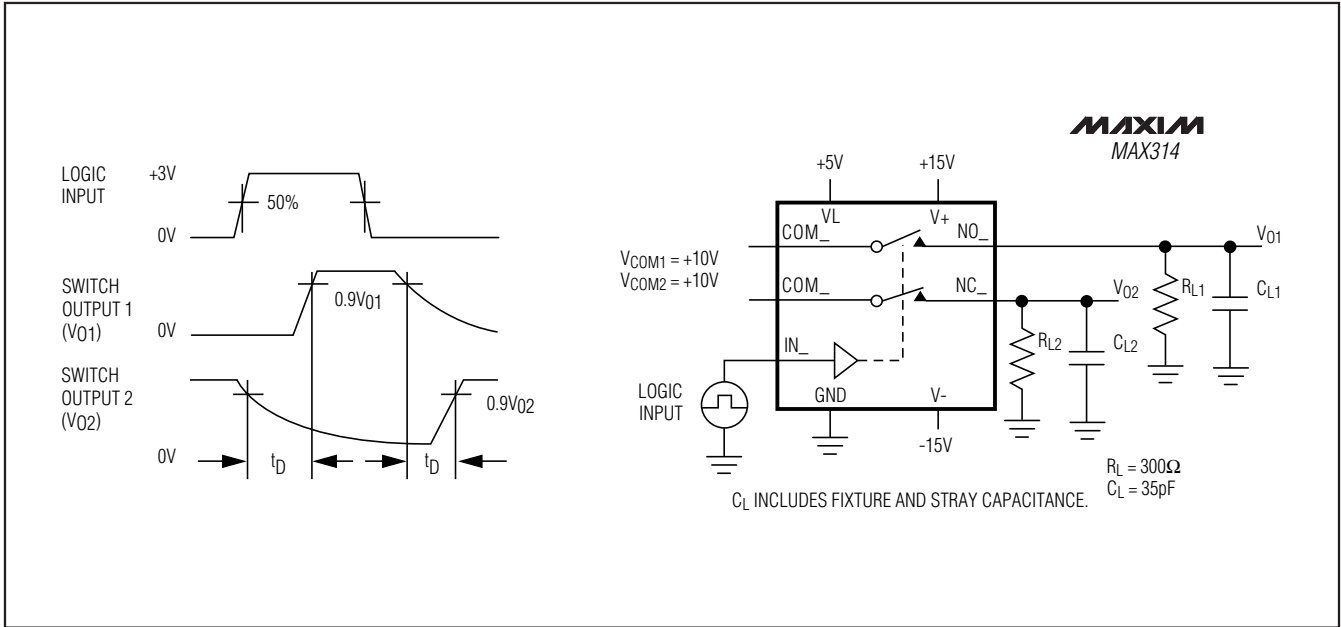


Figure 3. Break-Before-Make Test Circuit (MAX314 only)

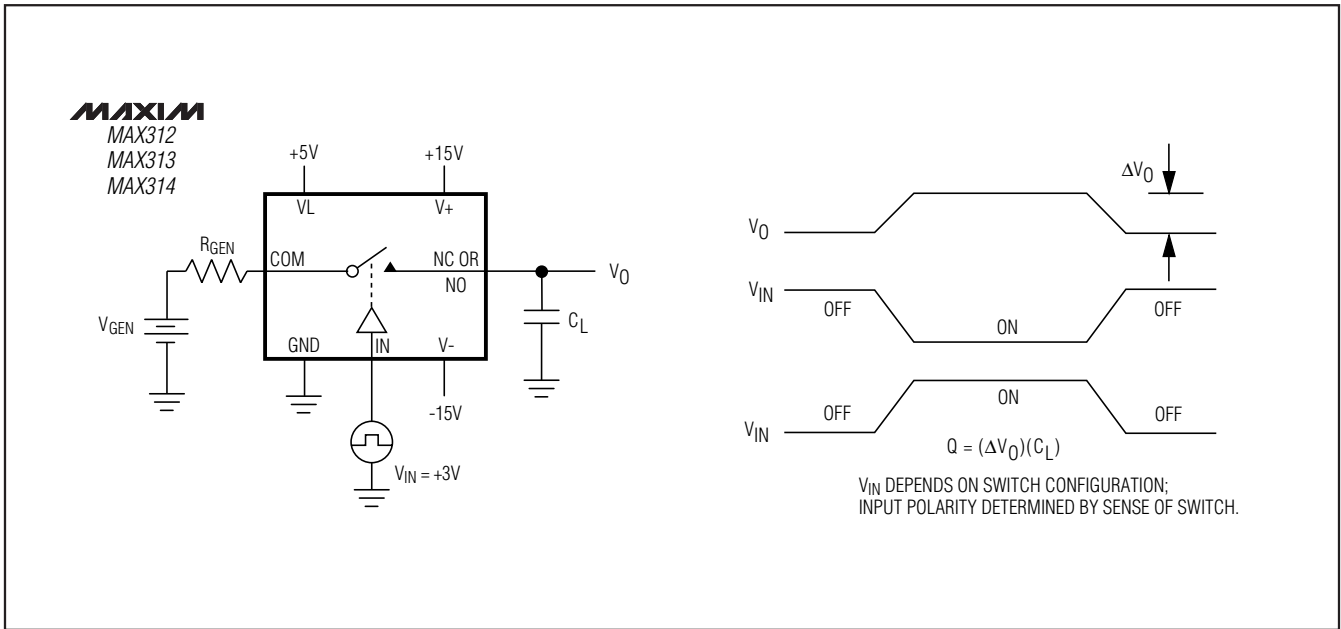


Figure 4. Charge Injection Test Circuit



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Figure 5. Off-Isolation Test Circuit



Figure 6. Crosstalk Test Circuit



Figure 7. Channel-Off Capacitance Test Circuit



Figure 8. Channel-On Capacitance Test Circuit

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## Ordering Information (continued)

| PART      | TEMP. RANGE     | PIN-PACKAGE    |
|-----------|-----------------|----------------|
| MAX313CPE | 0°C to +70°C    | 16 Plastic DIP |
| MAX313CSE | 0°C to +70°C    | 16 Narrow SO   |
| MAX313CUE | 0°C to +70°C    | 16 TSSOP       |
| MAX313C/D | 0°C to +70°C    | Dice*          |
| MAX313EPE | -40°C to +85°C  | 16 Plastic DIP |
| MAX313ESE | -40°C to +85°C  | 16 Narrow SO   |
| MAX313EUE | -40°C to +85°C  | 16 TSSOP       |
| MAX313MJE | -55°C to +125°C | 16 CERDIP**    |
| MAX314CPE | 0°C to +70°C    | 16 Plastic DIP |
| MAX314CSE | 0°C to +70°C    | 16 Narrow SO   |
| MAX314CUE | 0°C to +70°C    | 16 TSSOP       |
| MAX314C/D | 0°C to +70°C    | Dice*          |
| MAX314EPE | -40°C to +85°C  | 16 Plastic DIP |
| MAX314ESE | -40°C to +85°C  | 16 Narrow SO   |
| MAX314EUE | -40°C to +85°C  | 16 TSSOP       |
| MAX314MJE | -55°C to +125°C | 16 CERDIP**    |

\* Contact factory for dice specifications.

\*\*Contact factory for availability.

## Chip Topography



| MAX312 |      | MAX313 |      | MAX314 |      |
|--------|------|--------|------|--------|------|
| PIN    | NAME | PIN    | NAME | PIN    | NAME |
| A      | NC1  | A      | NO1  | A      | NO1  |
| B      | NC4  | B      | NO4  | B      | NO4  |
| C      | NC3  | C      | NO3  | C      | NC3  |
| D      | NC2  | D      | NO2  | D      | NC2  |

TRANSISTOR COUNT: 100

SUBSTRATE CONNECTED TO V+

# 10Ω, Quad, 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).)



TSSOP4.40mm.EPS

MAX312/MAX313/MAX314



PDIP .300"

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## 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).)



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