



## Precision, Quad, SPST Analog Switches

**MAX364/MAX365**

### General Description

The MAX364/MAX365 are precision, quad, single-pole single-throw (SPST) analog switches. The MAX364 has four normally closed (NC), and the MAX365 has four normally open (NO) switches. Both parts offer low-channel on resistance (less than  $85\Omega$ ), guaranteed to match within  $2\Omega$  between channels and to remain flat over the analog signal range ( $\Delta 9\Omega$  max). Both parts also offer low leakage (less than  $500\text{pA}$  at  $+25^\circ\text{C}$  and less than  $4\text{nA}$  at  $+85^\circ\text{C}$ ) and fast switching (turn-on time less than  $250\text{ns}$  and turn-off time less than  $170\text{ns}$ ).

The MAX364/MAX365 are fabricated with Maxim's new improved  $44\text{V}$  silicon-gate process. Design improvements guarantee extremely low charge injection ( $10\text{pC}$ ), low power consumption ( $35\mu\text{W}$ ), and electrostatic discharge (ESD) greater than  $2000\text{V}$ . The  $44\text{V}$  maximum breakdown voltage allows rail-to-rail analog signal handling 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     | Communication Systems    |
| Guidance and Control Systems | Battery-Operated Systems |
| Heads-Up Displays            | PBX, PABX                |
| Test Equipment               | Military Radios          |

### Features

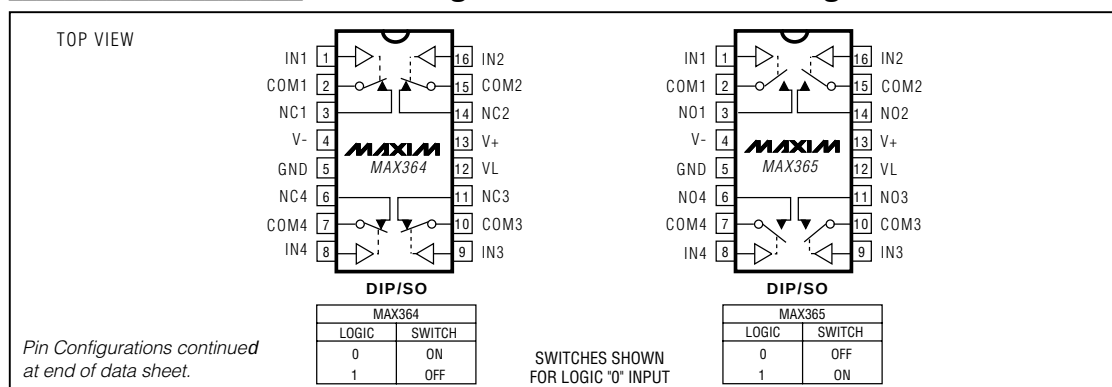
- ♦ Low On Resistance:  $< 45\Omega$  Typical ( $85\Omega$  Max)
- ♦ Guaranteed Matched On Resistance Between Channels:  $< 2\Omega$
- ♦ Guaranteed Flat On Resistance over Full Analog Signal Range:  $\Delta 9\Omega$  Max
- ♦ Guaranteed Charge Injection:  $< 10\text{pC}$
- ♦ Guaranteed Off-Channel Leakage:  $< 4\text{nA}$  at  $+85^\circ\text{C}$
- ♦ ESD Guaranteed  $> 2000\text{V}$  per Method 3015.7
- ♦ 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    |
|-----------|--------------------------------------------|----------------|
| MAX364CPE | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | 16 Plastic DIP |
| MAX364CSE | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | 16 Narrow SO   |
| MAX364C/D | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | Dice*          |
| MAX364EGE | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 QFN         |
| MAX364EPE | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 Plastic DIP |
| MAX364ESE | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 Narrow SO   |
| MAX365CPE | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | 16 Plastic DIP |
| MAX365CSE | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | 16 Narrow SO   |
| MAX365C/D | $0^\circ\text{C}$ to $+70^\circ\text{C}$   | Dice*          |
| MAX365EGE | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 QFN         |
| MAX365EPE | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 Plastic DIP |
| MAX365ESE | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ | 16 Narrow SO   |

\* Contact factory for dice specifications.

### Pin Configurations/Functional Diagrams/Truth Tables



Maxim Integrated Products 1

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

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### ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-

|                              |                                                            |
|------------------------------|------------------------------------------------------------|
| V+ .....                     | 44V                                                        |
| GND .....                    | 25V                                                        |
| VL .....                     | (GND - 0.3V) to (V+ + 0.3V)                                |
| IN_, COM_, NO_, or NC_ ..... | (V- - 2V) to (V+ + 2V) or 30mA<br>(whichever occurs first) |

Continuous Current (any terminal) .....30mA

Peak Current COM\_, NO\_, or NC\_

(pulsed at 1ms, 10% duty cycle max) .....100mA

ESD .....2000V

**Note 1:** All leads are soldered or welded to PC board.

Continuous Power Dissipation (T<sub>A</sub> = +70°C) (Note 1)

Plastic DIP (derate 10.53mW/°C above +70°C).....842mW

QFN (derate 19.2mW/°C above +70°C).....1538mW

Narrow SO (derate 8.70mW/°C above +70°C) .....696mW

Operating Temperature Ranges:

MAX36\_C\_ \_ .....0°C to +70°C

MAX36\_E\_ \_ .....-40°C to +85°C

Storage Temperature Range .....-65°C to +150°C

Lead Temperature (soldering, 10s) .....+300°C

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—Dual Supplies

(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 |
|--------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|-------|-----------------|------|-------|
| ANALOG                                           |                                                              |                                                                                                                               |                                                       |       |                 |      |       |
| Analog-Signal Range                              | V <sub>COM_</sub> ,<br>V <sub>NO_</sub> ,<br>V <sub>NC</sub> | (Note 3)                                                                                                                      |                                                       | -15   |                 | 15   | V     |
| On Resistance                                    | R <sub>ON</sub>                                              | COM_ to NO_ or NC,<br>I <sub>COM</sub> = -10mA,<br>V <sub>COM</sub> = 8.5V or -8.5V,<br>V+ = 13.5V, V- = -13.5V               | T <sub>A</sub> = +25°C                                | 50    |                 | 85   |       |
|                                                  |                                                              |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       |                 | 100  |       |
| On Resistance Match<br>Between Channels (Note 4) | R <sub>ON</sub>                                              | I <sub>COM</sub> = -10mA,<br>V <sub>COM</sub> = 10V or -10V,<br>V+ = 15V, V- = -15V                                           | T <sub>A</sub> = +25°C                                |       |                 | 2    |       |
|                                                  |                                                              |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       |                 | 4    |       |
| On Resistance Flatness (Note 4)                  | R <sub>ON</sub>                                              | I <sub>COM</sub> = -10mA,<br>V <sub>COM</sub> = 5V or -5V,<br>V+ = 15V, V- = -15V                                             | T <sub>A</sub> = +25°C                                |       |                 | 9    |       |
|                                                  |                                                              |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |       |                 | 15   |       |
| NC_ or NO_ Leakage Current                       | I <sub>NO_</sub> ,<br>I <sub>NC</sub>                        | NO_ or NC_ terminal,<br>V <sub>COM</sub> = ±15.5V,<br>V <sub>NO</sub> or V <sub>NC</sub> = ±15.5V,<br>V+ = 16.5V, V- = -16.5V | T <sub>A</sub> = +25°C                                | -0.50 | 0.01            | 0.50 | nA    |
|                                                  |                                                              |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -4    |                 | 4    |       |
| COM_ Off Leakage Current                         | I <sub>NO</sub> ,<br>I <sub>NC</sub>                         | COM_ terminal,<br>V <sub>NO</sub> or V <sub>NC</sub> = ±15.5V,<br>V <sub>COM</sub> = ±15.5V,<br>V+ = 16.5V, V- = -16.5V       | T <sub>A</sub> = +25°C                                | -0.50 | 0.01            | 0.50 | nA    |
|                                                  |                                                              |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -4    |                 | 4    |       |
| COM_, NC_ or NO_ On<br>Leakage Current           | I <sub>COM</sub> or<br>I <sub>NO</sub> , I <sub>NC</sub>     | COM_ to NC_ or NO_<br>V <sub>COM</sub> = ±15.5V,<br>V <sub>NO</sub> or V <sub>NC</sub> = ±15.5V,<br>V+ = 16.5V, V- = -16.5V   | T <sub>A</sub> = +25°C                                | -0.50 | 0.08            | 0.50 | nA    |
|                                                  |                                                              |                                                                                                                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -6    |                 | 6    |       |
| INPUT                                            |                                                              |                                                                                                                               |                                                       |       |                 |      |       |
| Input Current with<br>Input Voltage High         | I <sub>INH</sub>                                             | V <sub>IN_</sub> = 2.4V, all others = 0.8V                                                                                    |                                                       | -0.5  | -0.00001        | 0.5  | αA    |
| Input Current with<br>Input Voltage Low          | I <sub>INL</sub>                                             | V <sub>IN_</sub> = 0.8V, all others = 2.4V                                                                                    |                                                       | -0.5  | -0.00001        | 0.5  | αA    |

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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 |
|----------------------------|-----------|-----------------------------------------------------------------------|-------------------|------|-----------------|-------|-------|
| SUPPLY                     |           |                                                                       |                   |      |                 |       |       |
| Power-Supply Range         | V+, V-    |                                                                       |                   | ±4.5 |                 | ±20.0 | V     |
| Positive Supply Current    | I+        | All channels on or off,<br>VIN = 0V or 5V,<br>V+ = 16.5V, V- = -16.5V | TA = +25°C        | -1   | 0.001           | 1     | μA    |
|                            |           |                                                                       | TA = TMIN to TMAX | -5   |                 | 5     |       |
| Negative Supply Current    | I-        | All channels on or off,<br>VIN = 0V or 5V,<br>V+ = 16.5V, 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, V- = -16.5V | TA = +25°C        | -1   | 0.001           | 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, V- = -16.5V | TA = +25°C        | -1   | -0.0001         | 1     | μA    |
|                            |           |                                                                       | TA = TMIN to TMAX | -5   |                 | 5     |       |
| DYNAMIC                    |           |                                                                       |                   |      |                 |       |       |
| Turn-On Time               | tON       | VNO or VNC = ±10V, Figure 2                                           | TA = +25°C        |      | 150             | 250   | ns    |
| Turn-Off Time              | tOFF      | MAX364, VNO or VNC = ±10V, Figure 2                                   | TA = +25°C        |      | 90              | 120   | ns    |
|                            |           | MAX365, VNO or VNC = ±10V, Figure 2                                   | TA = +25°C        |      | 110             | 170   | ns    |
| Charge Injection           | Q         | CL = 1nF, VGEN = 0V, RGEN = 0Ω, Figure 3                              | TA = +25°C        |      | 5               | 10    | pC    |
| Off Isolation (Note 5)     | OIRR      | RL = 50Ω, CL = 5pF, f = 1MHz, Figure 4                                | TA = +25°C        |      | 60              |       | dB    |
| Crosstalk (Note 6)         |           | RL = 50Ω, CL = 5pF, f = 1MHz, Figure 5                                | TA = +25°C        |      | 100             |       | dB    |
| NC_ or NO_ Off Capacitance | C(OFF)    | f = 1MHz, Figure 6                                                    | TA = +25°C        |      | 4               |       | pF    |
| COM_ Off Capacitance       | CCOM(OFF) | f = 1MHz, Figure 6                                                    | TA = +25°C        |      | 4               |       | pF    |
| Channel-On Capacitance     | CCOM(ON)  | f = 1MHz, Figure 6                                                    | TA = +25°C        |      | 16              |       | 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 |
|-------------------------|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------|-----------------|------|-------|
| ANALOG                  |                                                               |                                                                                                                                           |                                                       |      |                 |      |       |
| Analog Signal Range     | V <sub>COM_</sub> ,<br>V <sub>NO_</sub> ,<br>V <sub>NC_</sub> | (Note 3)                                                                                                                                  |                                                       | 0    |                 | 12   | V     |
| On Resistance           | R <sub>ON</sub>                                               | COM_ to NO_ or NC_,<br>I <sub>NC</sub> or I <sub>NO</sub> = -10mA,<br>V <sub>L</sub> = 5.25V,<br>V <sub>COM</sub> = 3V, 8V,<br>V+ = 10.8V | T <sub>A</sub> = +25°C                                |      | 100             | 160  | Ω     |
|                         |                                                               |                                                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      |                 | 200  |       |
| SUPPLY                  |                                                               |                                                                                                                                           |                                                       |      |                 |      |       |
| Power-Supply Range      | V+, V-                                                        |                                                                                                                                           |                                                       | 10.8 |                 | 24.0 | V     |
| Power-Supply Current    | I+                                                            | All channels on or off,<br>V <sub>IN</sub> = 0V or 5V                                                                                     | T <sub>A</sub> = +25°C                                | -1   | 0.001           | 1    | μA    |
|                         |                                                               |                                                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | -5              | 5    |       |
| Negative Supply Current | I-                                                            | All channels on or off,<br>V <sub>IN</sub> = 0V or 5V                                                                                     | T <sub>A</sub> = +25°C                                | -1   | -0.0001         | 1    | μA    |
|                         |                                                               |                                                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | -5              | 5    |       |
| Logic Supply Current    | I <sub>L</sub>                                                | All channels on or off,<br>V <sub>IN</sub> = 0V or 5V                                                                                     | T <sub>A</sub> = +25°C                                | -1   | 0.001           | 1    | μA    |
|                         |                                                               |                                                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | -5              | 5    |       |
| Ground Current          | I <sub>GND</sub>                                              | All channels on or off,<br>V <sub>IN</sub> = 0V or 5V                                                                                     | T <sub>A</sub> = +25°C                                | -1   | -0.0001         | 1    | μA    |
|                         |                                                               |                                                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |      | -5              | 5    |       |
| DYNAMIC                 |                                                               |                                                                                                                                           |                                                       |      |                 |      |       |
| Turn-On Time            | t <sub>ON</sub>                                               | V <sub>NC</sub> or V <sub>NO</sub> = 8V, Figure 2                                                                                         | T <sub>A</sub> = +25°C                                |      | 300             | 400  | ns    |
| Turn-Off Time           | t <sub>OFF</sub>                                              | V <sub>NC</sub> or V <sub>NO</sub> = 8V, Figure 2                                                                                         | T <sub>A</sub> = +25°C                                |      | 60              | 200  | ns    |
| Charge Injection        | Q                                                             | C <sub>L</sub> = 1nF, V <sub>GEN</sub> = 0V,<br>R <sub>GEN</sub> = 0Ω, Figure 3                                                           | T <sub>A</sub> = +25°C                                |      | 5               | 10   | 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:** On resistance match between channels and flatness are guaranteed only with bipolar-supply operation.

**Note 5:** See Figure 2. Off Isolation =  $20 \log_{10} \left( \frac{V_{COM}}{V_{NC} \text{ or } V_{NO}} \right)$ , VCOM = output, VNO or VNC = input to off switch.

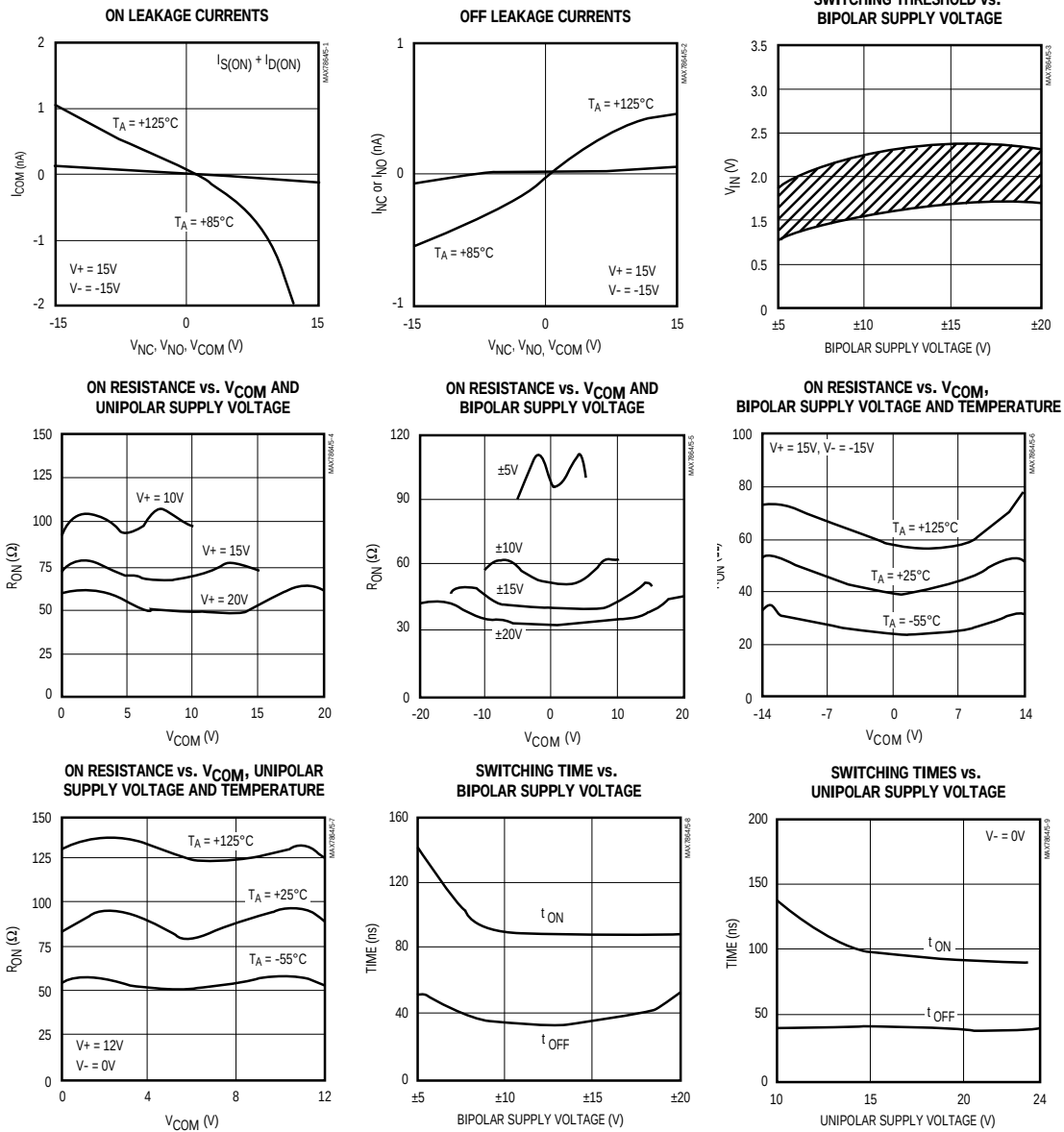
**Note 6:** Between any two switches. See Figure 5.

# Precision, Quad, SPST Analog Switches

## Typical Operating Characteristics

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

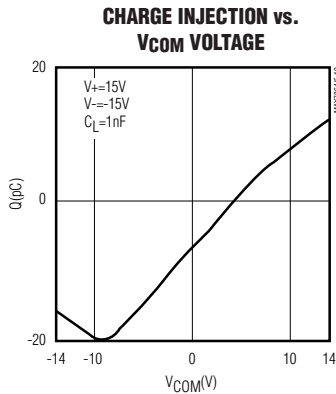
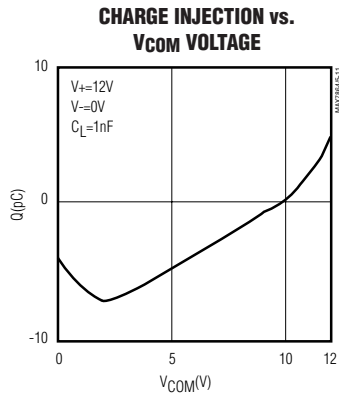
MAX364/MAX365



# Precision, Quad, SPST Analog Switches

## Typical Operating Characteristics

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



## Pin Description

| PIN          |              | NAME                     | FUNCTION                                                                               |
|--------------|--------------|--------------------------|----------------------------------------------------------------------------------------|
| DIP/SO       | QFN          |                          |                                                                                        |
| 1, 16, 9, 8  | 15, 14, 7, 6 | IN1–N4                   | Logic Control Input                                                                    |
| 2, 15, 10, 7 | 16, 13, 8, 5 | COM1–COM4                | Analog-Switch Common Terminal                                                          |
| 3, 14, 11, 6 | 1, 12, 9, 4  | NC1–NC4<br>or<br>NO1–NO4 | NC (normally closed, MAX364)<br>NO (normally closed, MAX365)<br>Analog-Switch Terminal |
| 4            | 2            | V-                       | Negative-Supply Voltage Input                                                          |
| 5            | 3            | GND                      | Ground                                                                                 |
| 12           | 10           | V <sub>L</sub>           | Logic-Supply Voltage Input                                                             |
| 13           | 11           | V+                       | Positive-Supply Voltage Input—Connected to Substrate                                   |

# Precision, Quad, SPST Analog Switches

## Applications Information

### Application Hints

1. Switches are open when power is off.
2. IN<sub>-</sub>, COM<sub>-</sub>, NO<sub>-</sub>, and NC<sub>-</sub> should not exceed V<sub>+</sub> or V<sub>-</sub>, even with the power off.
3. Switch leakage is from each analog switch terminal to V<sub>+</sub> or V<sub>-</sub>, not to the other switch terminal.

### Operation with Supply Voltages

#### Other than $\pm 15V$

The main limitation of supply voltages other than  $\pm 15V$  is reduction in the analog signal range. The MAX364/MAX365 switches operate with  $\pm 5V$  to  $\pm 20V$  bipolar supplies. The *Typical Operating Characteristics* graphs show typical on resistance for  $\pm 15V$ ,  $\pm 10V$ , and  $\pm 5V$  supplies. Switching times increase by a factor of two or more for  $\pm 5V$  operation. The MAX364/MAX365 operate from unipolar supplies of  $+10V$  to  $+24V$ . Both parts can be powered from a single  $+10V$  to  $+24V$  supply, as well as from unbalanced supplies, such as  $+24V$  and  $-5V$ . Connect V<sub>-</sub> to 0V when operating with a single supply. V<sub>L</sub> must be connected to  $+5V$  to be TTL compatible or to V<sub>+</sub> for CMOS logic input levels.

### 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 those listed 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, protect the devices from overvoltage by

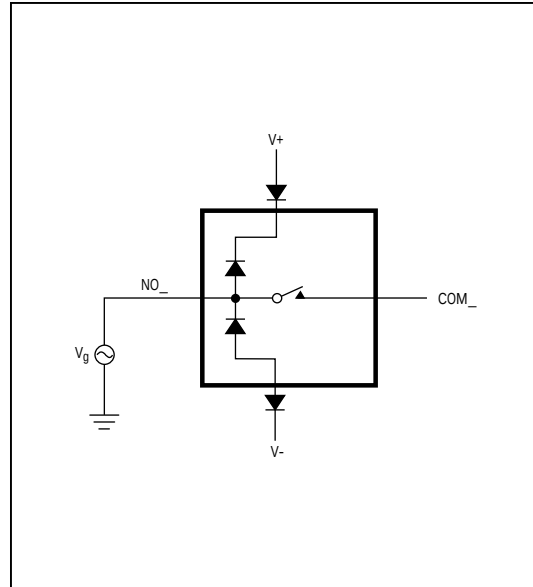


Figure 1. Overvoltage Protection Using Blocking Diodes

adding two small signal diodes in series with the supply pins (Figure 1). Adding the 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  $+44V$ .

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## Test Circuits/Timing Diagrams

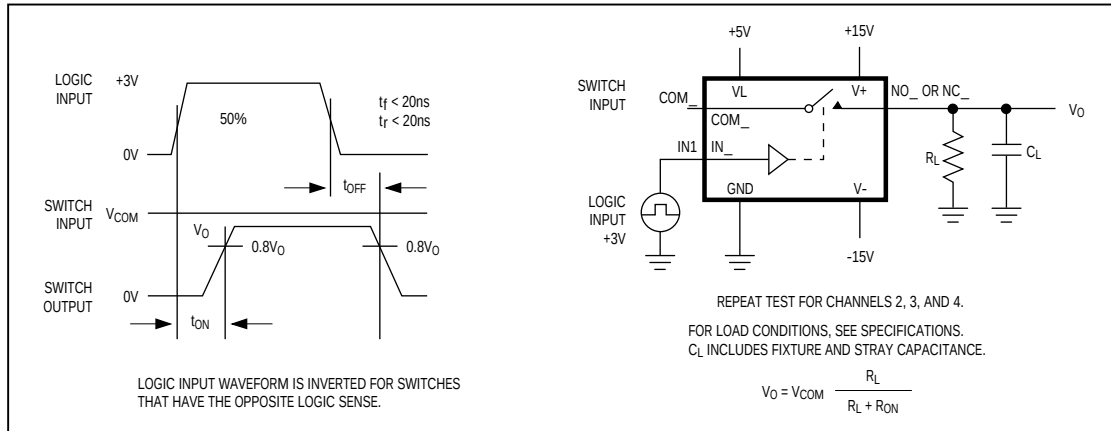


Figure 2. Switching-Time Test Circuit

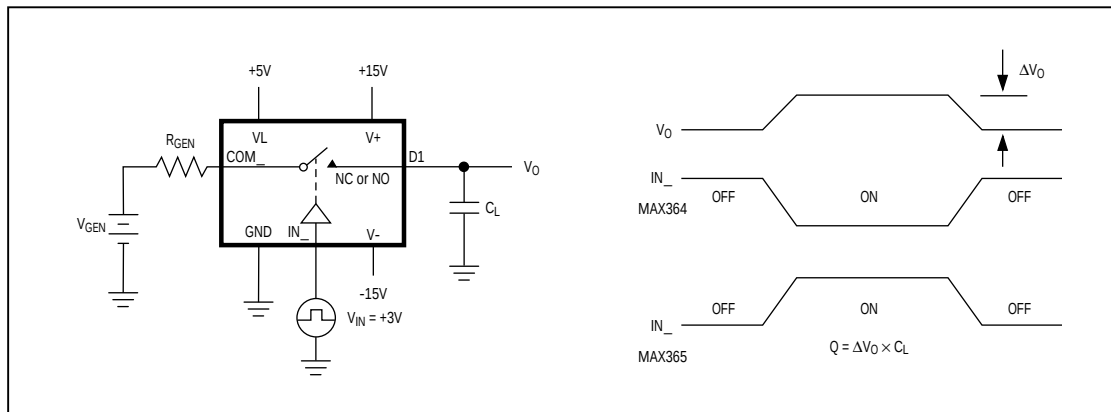


Figure 3. Charge-Injection Test Circuit

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## Test Circuits/Timing Diagrams (continued)

MAX364/MAX365

| FREQUENCY TESTED | SIGNAL GENERATOR      | ANALYZER          |
|------------------|-----------------------|-------------------|
| 100Hz to 13MHz   | AUTOMATIC SYNTHESIZER | SPECTRUM ANALYZER |

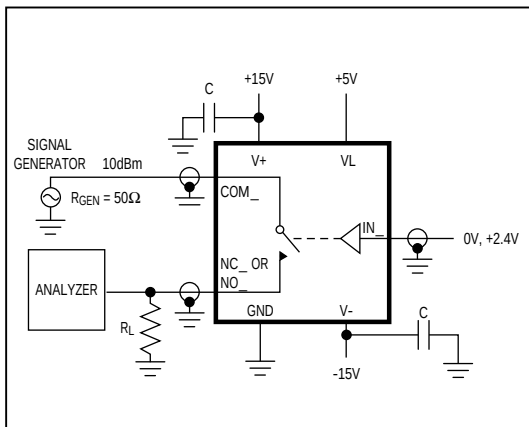


Figure 4. Off Isolation Test Circuit

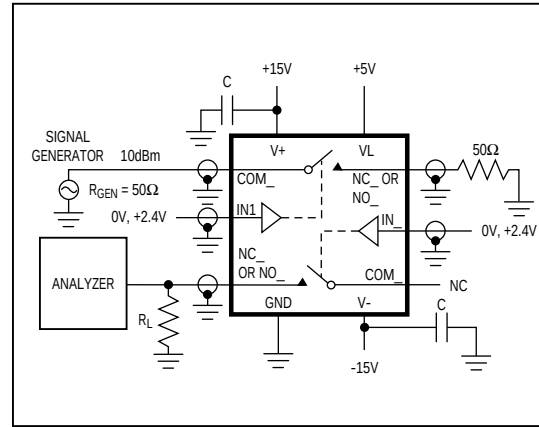


Figure 5. Crosstalk Test Circuit

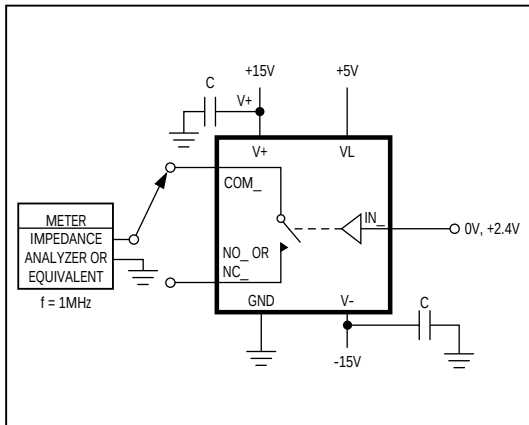


Figure 6. COM\_, NC\_, NO\_ Off Capacitance

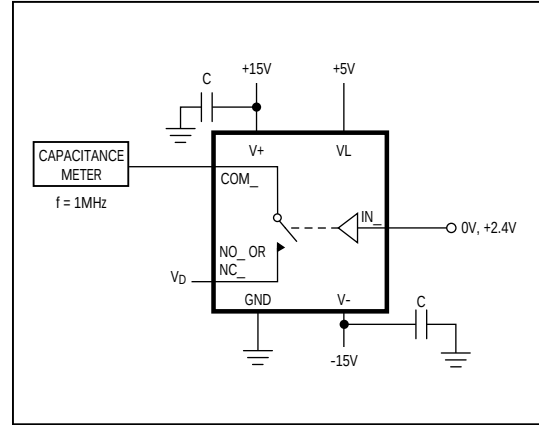
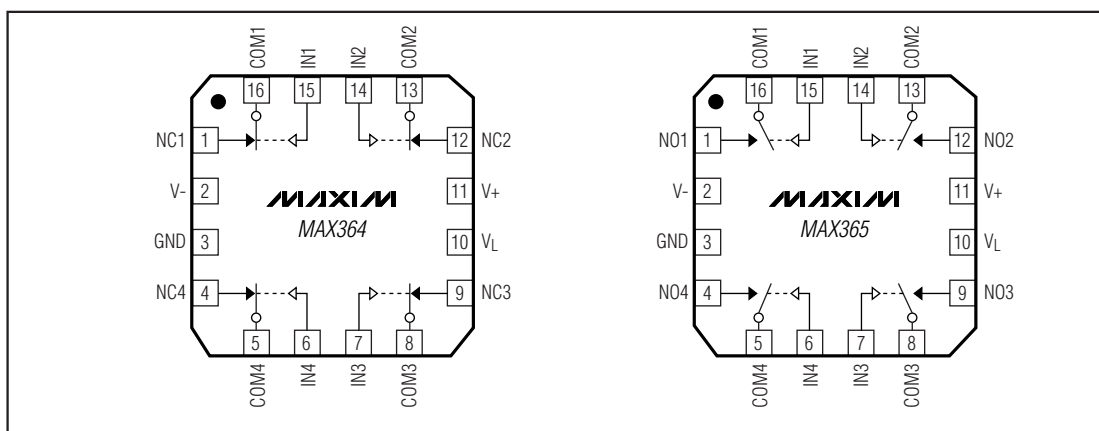


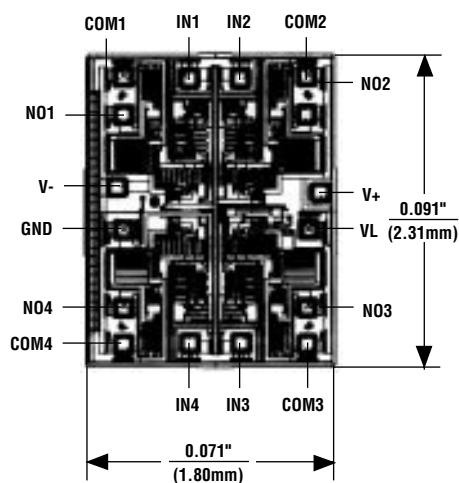
Figure 7. COM\_, NC\_, NO\_ On Capacitance

## Precision, Quad, SPST Analog Switches

### Pin Configurations/Functional Diagrams (continued)



### Chip Topography



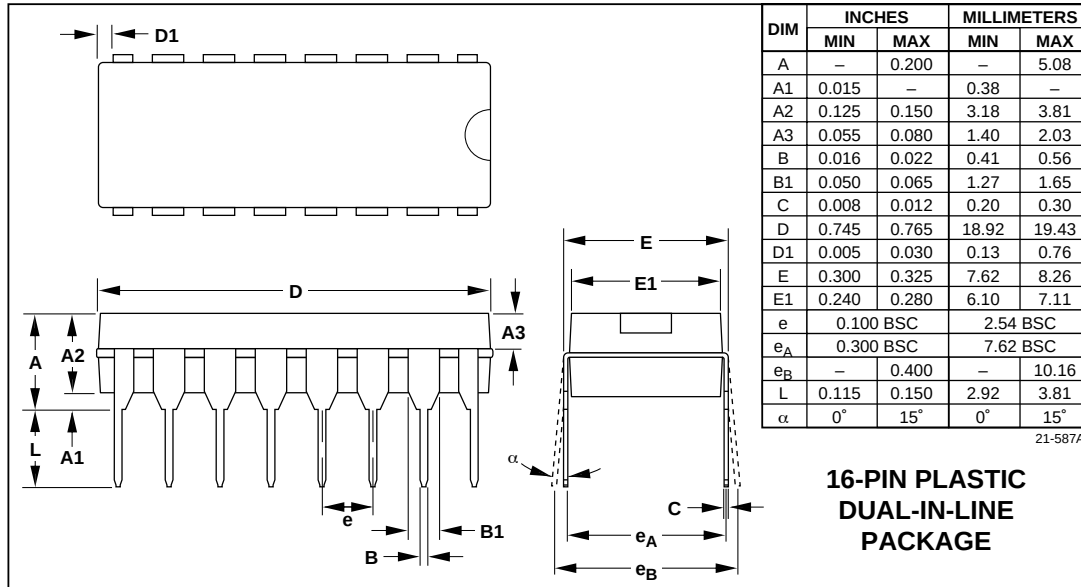
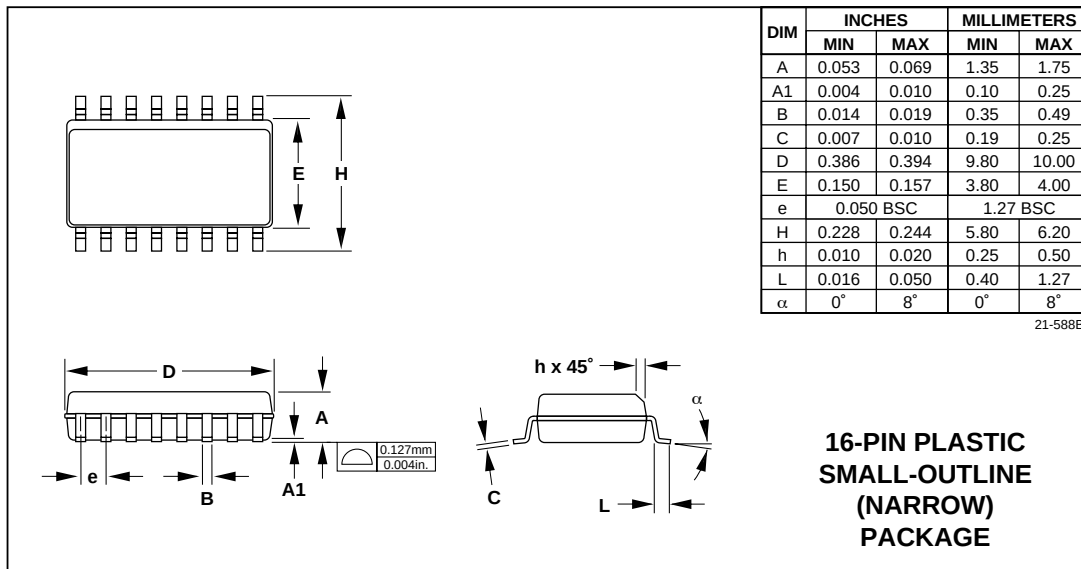
TRANSISTOR COUNT: 126;  
SUBSTRATE CONNECTED TO V<sub>+</sub>.

# Precision, Quad, SPST 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).)

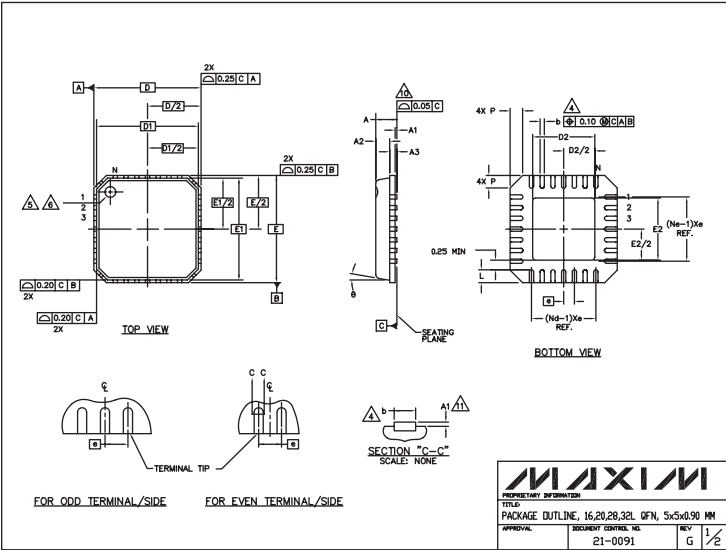
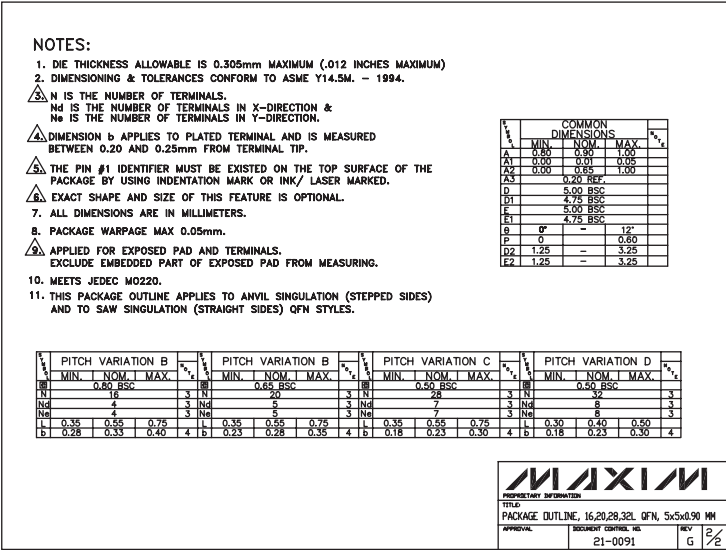
MAX364/MAX365



# Precision, Quad, SPST 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).)



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