



## General Purpose CMOS Analog Switches

### General Description

Maxim's DG381-DG390 and DG381A-DG390A CMOS dual and quad analog switches combine low power operation with fast switching times and superior DC and AC switch characteristics. On resistance is less than 50Ω and is essentially constant over the analog signal range. Device specifications are ideal for battery powered circuitry.

These switches are available in a variety of formats as outlined below in the Pin Configurations section. The switch control logic inputs are fully TTL and CMOS compatible. Also featured are "break-before-make" switching and low charge injection.

Maxim's DG381-DG390 and DG381A-DG390A families are electrically compatible and pin compatible with the original manufacturer's devices. All devices will operate with power supplies ranging from ±5V to ±18V. Single supply operation is implemented by connecting V<sup>-</sup> to GND.

### Applications

Portable Instruments  
Low Power Sample/Holds  
Power Supply Switching  
Programmable Gain Amplifiers  
SPDT and DPDT Functions  
Process Control and Telemetry

### Features

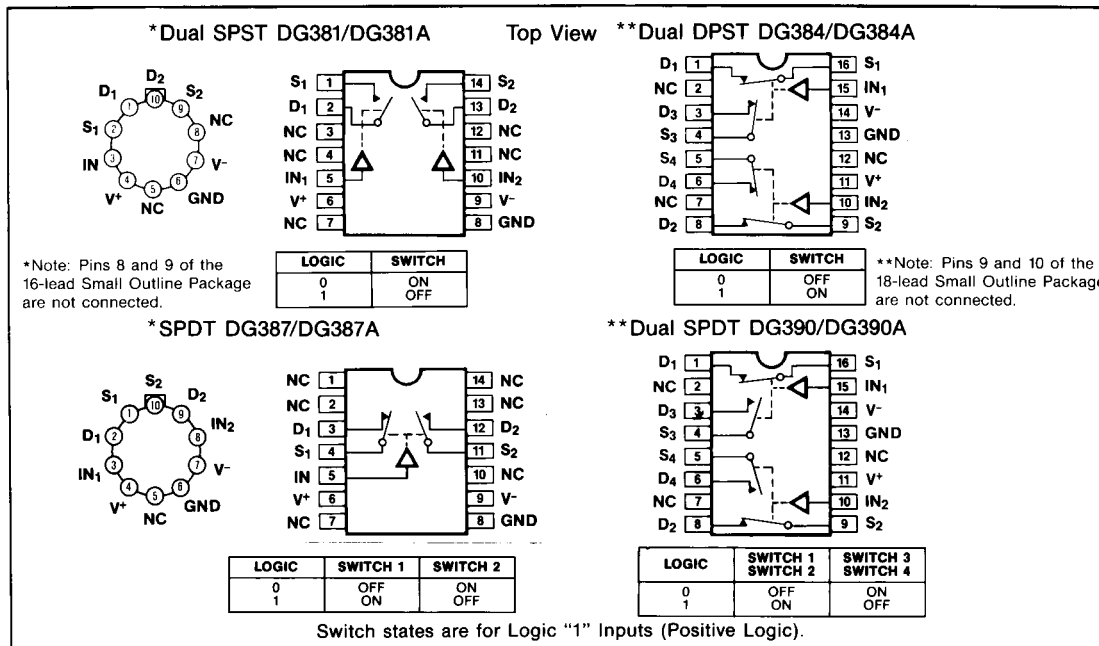
- ◆ Monolithic Low Power CMOS
- ◆ Latch-Up Proof Construction
- ◆ Fully Compatible 2nd Source
- ◆ Low On Resistance, <50Ω
- ◆ Fast Switching Time
- ◆ V<sup>+</sup> to V<sup>-</sup> Analog Signal Range
- ◆ Single Supply Capability

### Ordering Information

| PART     | TEMP. RANGE     | PACKAGE             |
|----------|-----------------|---------------------|
| DG381C/D | 0°C to +70°C    | Dice                |
| DG381CJ  | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG381CWE | 0°C to +70°C    | 16 Lead Wide SO     |
| DG381CK  | 0°C to +70°C    | 14 Lead CERDIP      |
| DG381BWE | -25°C to +85°C  | 16 Lead Wide SO     |
| DG381BK  | -25°C to +85°C  | 14 Lead CERDIP      |
| DG381BA  | -25°C to +85°C  | 10 Lead Metal Can   |
| DG381AK  | -55°C to +125°C | 14 Lead CERDIP      |
| DG381AA  | -55°C to +125°C | 10 Lead Metal Can   |

(Ordering Information is continued on last page.)

### Pin Configurations



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DG381(A)/DG384(A)/DG387(A)/DG390(A)

# General Purpose CMOS Analog Switches

## ABSOLUTE MAXIMUM RATINGS

|                                                                |                                                               |                                                 |                |
|----------------------------------------------------------------|---------------------------------------------------------------|-------------------------------------------------|----------------|
| Voltages Referenced to V <sup>-</sup>                          |                                                               | Operating Temperature (A Suffix) .....          | -55°C to 125°C |
| V <sup>+</sup> (DG381-DG390) .....                             | 36V                                                           | (B Suffix) .....                                | -25°C to 85°C  |
| V <sup>+</sup> (DG381A-DG390A) .....                           | 44V                                                           | (C Suffix) .....                                | 0°C to 70°C    |
| GND .....                                                      | 25V                                                           | Lead Temperature (Soldering 10 sec.) .....      | +300°C         |
| Digital Inputs, V <sub>S</sub> , V <sub>D</sub> (Note 1) ..... | -4V to (V <sup>+</sup> + 4V) or 30mA, whichever occurs first. | Power Dissipation*                              |                |
| Current, Any Terminal Except S or D .....                      | 30mA                                                          | Cerdip (K) (Derate 11mW/°C above 75°C) .....    | 825mW          |
| Continuous Current, S or D .....                               | 30mA                                                          | Plastic DIP (J) (Derate 6.5mW/°C above 25°C) .. | 470mW          |
| (Pulsed at 1msec, 10% duty cycle max) .....                    | 100mA                                                         | Metal Can (A) (Derate 6mW/°C above 75°C) ....   | 450mW          |
| Storage Temperature (A & B Suffix) .....                       | -65°C to 150°C                                                |                                                 |                |
| (C Suffix) .....                                               | -65°C to 125°C                                                |                                                 |                |

Stresses listed under "Absolute Maximum Ratings" may be applied (one at a time) to devices without resulting in permanent damage. These are stress ratings only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS (V<sup>+</sup> = +15V, V<sup>-</sup> = -15V, GND = 0V, T<sub>A</sub> = 25°C, unless otherwise indicated)

|        | PARAMETER                      | SYMBOL                                  | TEST CONDITIONS                                                     | DG381-DG390A<br>DG381A-DG390AA |          |     | DG381-DG390B/C<br>DG381A-DG390AB/C |          |     | UNITS |
|--------|--------------------------------|-----------------------------------------|---------------------------------------------------------------------|--------------------------------|----------|-----|------------------------------------|----------|-----|-------|
|        |                                |                                         |                                                                     | MIN                            | TYP      | MAX | MIN                                | TYP      | MAX |       |
|        |                                |                                         |                                                                     | (Note 2)                       | (Note 3) |     | (Note 2)                           | (Note 3) |     |       |
| SWITCH | Analog Signal Range            | V <sub>ANALOG</sub>                     | I <sub>S</sub> = 10mA, V <sub>in</sub> = 0.8V or 4.0V               | -15                            |          | 15  | -15                                |          | 15  | V     |
|        | Drain-Source ON Resistance     | r <sub>DS(on)</sub>                     | I <sub>S</sub> = -10mA, V <sub>D</sub> = 10V                        |                                | 30       | 50  |                                    | 30       | 50  | Ω     |
|        |                                |                                         | I <sub>S</sub> = 10mA, V <sub>D</sub> = -10V                        |                                | 30       | 50  |                                    | 30       | 50  |       |
|        | Source OFF Leakage Current     | I <sub>S(off)</sub>                     | V <sub>in</sub> = 0.8V or 4.0V                                      |                                | 0.1      | 1   |                                    | 0.1      | 5   | nA    |
|        |                                |                                         | V <sub>S</sub> = 14V, V <sub>D</sub> = -14V                         |                                |          |     |                                    |          |     |       |
|        | Drain OFF Leakage Current      | I <sub>D(off)</sub>                     | V <sub>S</sub> = -14V, V <sub>D</sub> = 14V                         | -1                             | -0.1     |     | -5                                 | -0.1     |     |       |
|        |                                |                                         | V <sub>S</sub> = -14V, V <sub>D</sub> = 14V                         |                                | 0.1      | 1   |                                    | 0.1      | 5   |       |
|        | Drain ON Leakage Current       | I <sub>D(on)</sub>                      | V <sub>D</sub> = 14V, V <sub>S</sub> = -14V                         | -1                             | -0.1     |     | -5                                 | -0.1     |     |       |
| INPUT  |                                |                                         | V <sub>D</sub> = V <sub>S</sub> = 14V                               |                                | 0.1      | 1   |                                    | 0.1      | 5   |       |
|        |                                |                                         | V <sub>D</sub> = V <sub>S</sub> = -14V                              | -2                             | -0.1     |     | -5                                 | -0.1     |     |       |
|        | Input Current/Voltage High     | I <sub>INH</sub>                        | V <sub>in</sub> = 5.0V                                              | -1                             | -0.001   |     | -1                                 | -0.001   |     | μA    |
|        |                                |                                         | V <sub>in</sub> = 15V                                               |                                | 0.001    | 1   |                                    | 0.001    | 1   |       |
|        | Input Current/Voltage Low      | I <sub>INL</sub>                        | V <sub>in</sub> = 0V                                                | -1                             | -0.001   |     | -1                                 | -0.001   |     |       |
|        | Turn-ON Time                   | t <sub>on</sub>                         | See Switching Time Test Circuit                                     |                                | 150      | 300 |                                    | 150      | 300 | ns    |
|        | Turn-OFF Time                  | t <sub>off</sub>                        |                                                                     |                                | 130      | 250 |                                    | 130      | 250 |       |
|        | Break-Before-Make Interval     | t <sub>on</sub> -t <sub>off</sub>       | See Break-Before-Make Time Test Circuit<br>DG387(A)/DG390(A) Only   |                                | 50       |     |                                    | 50       |     |       |
|        | Charge Injection               | Q                                       | C <sub>L</sub> = 10nF, R <sub>gen</sub> = 0Ω, V <sub>gen</sub> = 0V |                                | 12       |     |                                    | 12       |     | pC    |
|        | Source OFF Capacitance         | C <sub>S(off)</sub>                     | f = 1MHz,<br>V <sub>in</sub> = 0.8V or<br>V <sub>in</sub> = 4.0V    |                                | 14       |     |                                    | 14       |     | pF    |
|        | Drain OFF Capacitance          | C <sub>D(off)</sub>                     |                                                                     |                                | 14       |     |                                    | 14       |     |       |
|        | Channel ON Capacitance         | C <sub>D(on)</sub> + C <sub>S(on)</sub> |                                                                     |                                | 40       |     |                                    | 40       |     |       |
|        | Input Capacitance              | C <sub>in</sub>                         | f = 1MHz                                                            |                                | 6        |     |                                    | 6        |     |       |
|        |                                |                                         |                                                                     |                                | 7        |     |                                    | 7        |     |       |
|        | Off Isolation (Note 4)         |                                         | V <sub>in</sub> = 0V, R <sub>L</sub> = 1kΩ                          |                                | 62       |     |                                    | 62       |     | dB    |
|        | Crosstalk (Channel to Channel) |                                         | V <sub>S</sub> = 1 V <sub>RMS</sub> , f = 500kHz                    |                                | 74       |     |                                    | 74       |     |       |

(See Notes next page).

# General Purpose CMOS Analog Switches

## ELECTRICAL CHARACTERISTICS (Continued)

(V<sup>+</sup> = +15V, V<sup>-</sup> = -15V, GND = 0V, T<sub>A</sub> = 25°C, unless otherwise indicated)

|        | PARAMETER               | SYMBOL         | TEST CONDITIONS                                      | DG381-DG390A<br>DG381A-DG390AA |        |     | DG381-DG390B/C<br>DG381A-DG390AB/C |        |     | UNITS |
|--------|-------------------------|----------------|------------------------------------------------------|--------------------------------|--------|-----|------------------------------------|--------|-----|-------|
|        |                         |                |                                                      | MIN                            | TYP    | MAX | MIN                                | TYP    | MAX |       |
| SUPPLY | Positive Supply Current | I <sup>+</sup> | V <sub>in</sub> = 4V (One Input)<br>(All Others = 0) | 0.23                           | 0.5    |     | 0.23                               | 0.5    |     | mA    |
|        | Negative Supply Current | I <sup>-</sup> |                                                      | -10                            | -0.001 |     | -100                               | -0.001 |     |       |
|        | Positive Supply Current | I <sup>+</sup> | V <sub>in</sub> = 0.8V (All Inputs)                  | 0.001                          | 10     |     | 0.001                              | 100    |     | μA    |
|        | Negative Supply Current | I <sup>-</sup> |                                                      | -10                            | -0.001 |     | -100                               | -0.001 |     |       |

## ELECTRICAL CHARACTERISTICS (Over Temperature)

(V<sup>+</sup> = +15V, V<sup>-</sup> = -15V, GND = 0V, T<sub>A</sub> = Over Temperature Range, unless otherwise indicated)

|        | PARAMETER                  | SYMBOL              | TEST CONDITIONS                                       | DG381-DG390A<br>DG381A-DG390AA |     |     | DG381-DG390B/C<br>DG381A-DG390AB/C |     |     | UNITS |
|--------|----------------------------|---------------------|-------------------------------------------------------|--------------------------------|-----|-----|------------------------------------|-----|-----|-------|
|        |                            |                     |                                                       | MIN                            | TYP | MAX | MIN                                | TYP | MAX |       |
| SWITCH | Analog Signal Range        | V <sub>ANALOG</sub> | I <sub>S</sub> = 10mA, V <sub>in</sub> = 0.8V or 4.0V | -15                            |     | 15  | -15                                |     | 15  | V     |
|        | Drain-Source ON Resistance | r <sub>DS(on)</sub> | I <sub>S</sub> = -10mA, V <sub>D</sub> = 10V          |                                |     | 75  |                                    |     | 75  | Ω     |
|        |                            |                     | I <sub>S</sub> = 10mA, V <sub>D</sub> = -10V          |                                |     | 75  |                                    |     | 75  |       |
|        |                            |                     | V <sub>S</sub> = 14V, V <sub>D</sub> = -14V           |                                |     | 100 |                                    |     | 100 |       |
|        | Source OFF Leakage Current | I <sub>S(off)</sub> | V <sub>in</sub> = 0.8V or 4.0V                        | -100                           |     |     | -100                               |     |     | nA    |
|        | Drain OFF Leakage Current  | I <sub>D(off)</sub> | V <sub>S</sub> = -14V, V <sub>D</sub> = 14V           |                                |     | 100 |                                    |     | 100 |       |
|        |                            |                     | V <sub>S</sub> = 14V, V <sub>D</sub> = -14V           | -100                           |     |     | -100                               |     |     |       |
|        | Drain ON Leakage Current   | I <sub>D(on)</sub>  | V <sub>D</sub> = V <sub>S</sub> = 14V                 |                                |     | 100 |                                    |     | 100 |       |
|        |                            |                     | V <sub>D</sub> = V <sub>S</sub> = -14V                | -200                           |     |     | -200                               |     |     |       |
| INPUT  | Input Current/Voltage High | I <sub>INH</sub>    | V <sub>in</sub> = 5.0V                                | -1                             |     |     | -10                                |     |     | μA    |
|        |                            |                     | V <sub>in</sub> = 15V                                 |                                |     | 1   |                                    |     | 10  |       |
|        | Input Current/Voltage Low  | I <sub>INL</sub>    | V <sub>in</sub> = 0V                                  | -1                             |     |     | -10                                |     |     |       |
| SUPPLY | Positive Supply Current    | I <sup>+</sup>      | V <sub>in</sub> = 4V (One Input)<br>(All Others = 0)  |                                |     | 1   |                                    |     | 1.5 | mA    |
|        | Negative Supply Current    | I <sup>-</sup>      |                                                       | -100                           |     |     | -200                               |     |     |       |
|        | Positive Supply Current    | I <sup>+</sup>      | V <sub>in</sub> = 0.8V (All Inputs)                   |                                |     | 100 |                                    |     | 200 | μA    |
|        | Negative Supply Current    | I <sup>-</sup>      |                                                       | -100                           |     |     | -200                               |     |     |       |

**Note 1:** Signals on S<sub>x</sub>, D<sub>x</sub>, or IN<sub>x</sub> exceeding V<sup>+</sup> or V<sup>-</sup> will be clamped by internal diodes. Limit diode forward current to maximum current ratings.

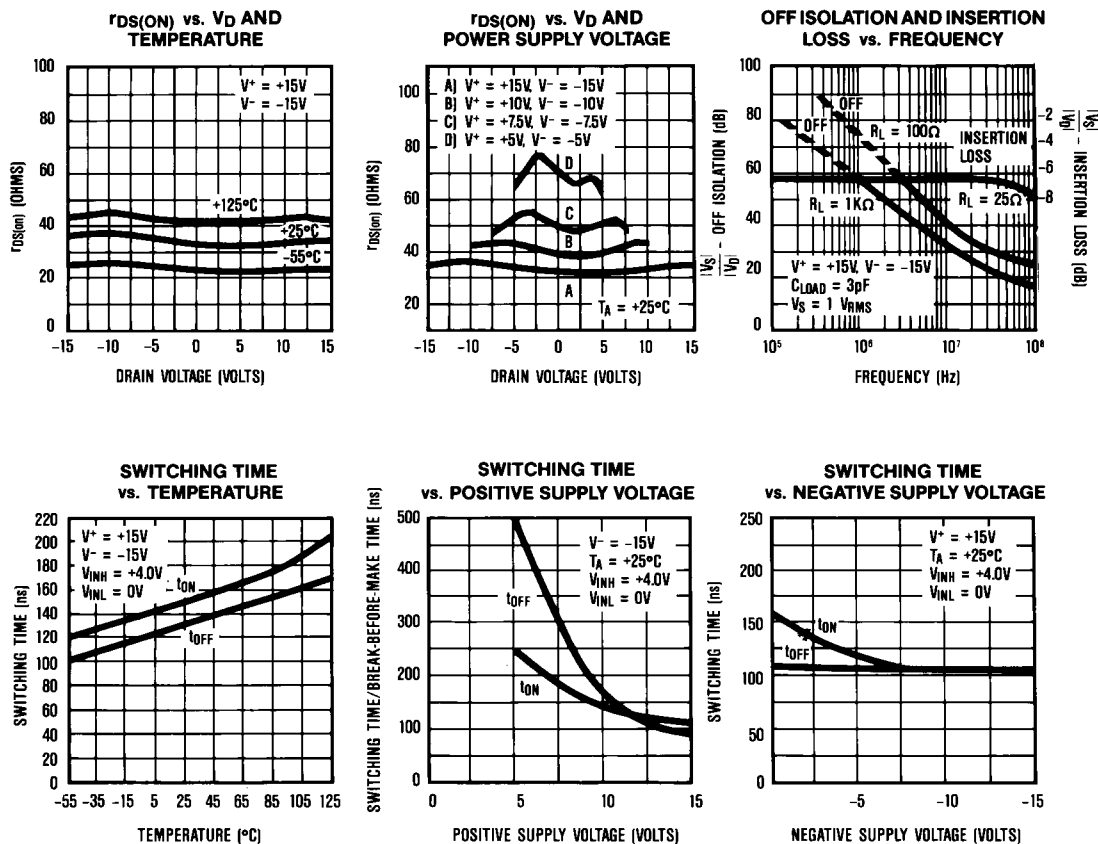
**Note 2:** The algebraic convention whereby the most negative value is a minimum, and the most positive value is a maximum is used in this data sheet.

**Note 3:** Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.

**Note 4:** OFF isolation = 20 log  $\frac{V_S}{V_D}$ , V<sub>S</sub> = input to OFF switch, V<sub>D</sub> = Output.

# General Purpose CMOS Analog Switches

## Typical Operating Characteristics



## Test Circuits

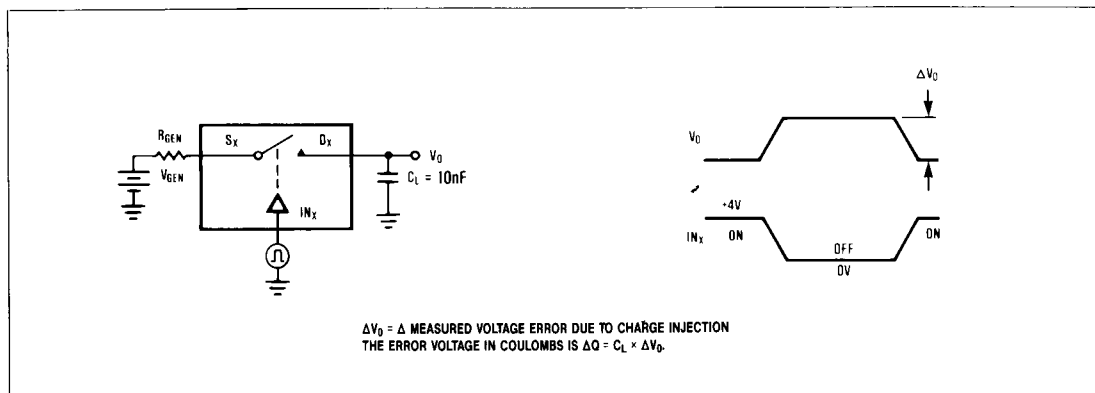


Figure 1. Charge Injection Test Circuit.

# General Purpose CMOS Analog Switches

## Test Circuits (Continued)

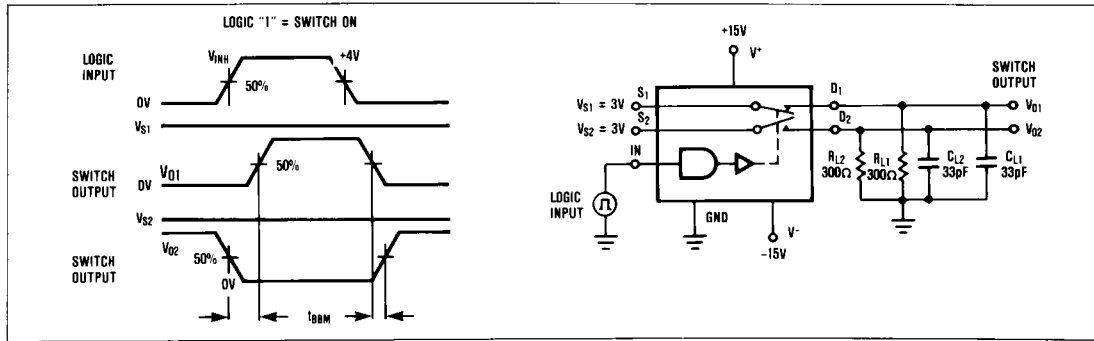


Figure 2. Break-Before-Make Time Test Circuit SPDT (DG387(A)/DG390(A)).

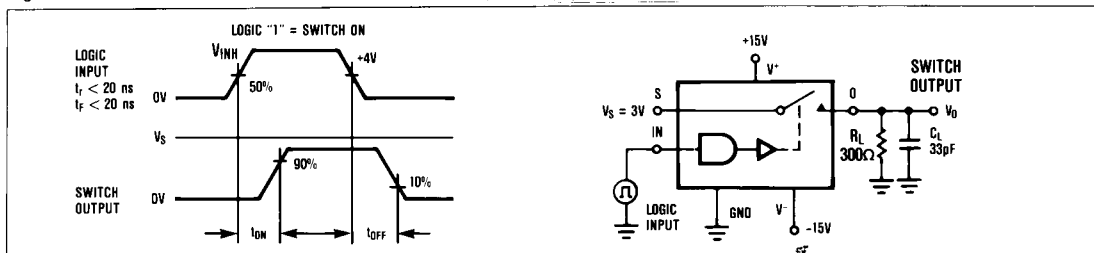


Figure 3. Switching Time Test Circuit.

## Application Information

All DG381 family switches will operate with  $\pm 5$  to  $\pm 15$ V power supplies. They can also be used with single ended power supplies ranging from +10V to +30V where the  $V^-$  terminal is connected to ground. In either case analog signals ranging from  $V^+$  to  $V^-$  can be switched.

The on resistance variation with analog signal and supply voltage is shown in the Typical Operating Characteristics graphs. The temperature coefficient of  $R_{ON}$  is typically 0.5%/°C. Typical on resistance matching from channel to channel is 10%. In addition, Table 1 outlines some typical parameters for single supply operation.

Table 1. Typical Single Supply Parameters

|                                     | $V^+$ SUPPLY VOLTAGE ( $V^- = 0V$ ) |            |            |            |
|-------------------------------------|-------------------------------------|------------|------------|------------|
|                                     | +10V                                | +15V       | +20V       | +30V       |
| Switching Time ( $R_L = 1k\Omega$ ) |                                     |            |            |            |
| $t_{ON}$                            | 190ns                               | 150ns      | 110ns      | 70ns       |
| $t_{OFF}$                           | 40ns                                | 40ns       | 40ns       | 40ns       |
| On Resistance                       |                                     |            |            |            |
| $V_{SIGNAL} = +1V$                  | 71Ω                                 | 51Ω        | 42Ω        | 31Ω        |
| $V_{SIGNAL} = V^+/2$                | 77Ω                                 | 54Ω        | 43Ω        | 30Ω        |
| $V_{SIGNAL} = V^+$                  | 84Ω                                 | 63Ω        | 54Ω        | 43Ω        |
| Input Logic Levels                  | 0.8V, 4.0V                          | 0.8V, 4.0V | 0.8V, 4.0V | 0.8V, 4.5V |

The charge injection test circuit is shown in Figure 1. Table 2 lists the typical injected charge for DG381 series switches with various input voltages.

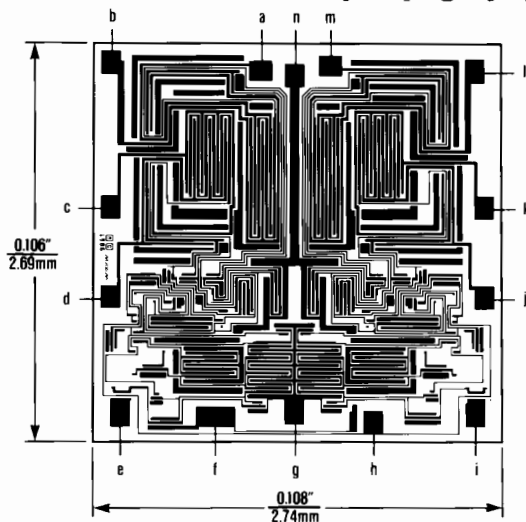
Table 2. Charge Injection ( $\pm 15V$  Supplies)

| ANALOG INPUT | INJECTED Q |
|--------------|------------|
| +10V         | 4pC        |
| +5V          | 8pC        |
| 0V           | 12pC       |
| -5V          | 8pC        |
| -10V         | 5pC        |

# General Purpose CMOS Analog Switches

## Chip Topography

## Ordering Information (continued)



| DIE PAD | DG381<br>DG381A | DG387<br>DG387A | DG384/390<br>DG384A/390A |
|---------|-----------------|-----------------|--------------------------|
| a       | N.C.            | N.C.            | S3                       |
| b       | D1              | D1              | D3                       |
| c       | D1              | S1              | D1                       |
| d       | S1              | IN1             | S1                       |
| e       | IN1             | IN1             | IN1                      |
| f       | V <sup>+</sup>  | V <sup>+</sup>  | V <sup>+</sup>           |
| g       | GND             | GND             | GND                      |
| h       | V <sup>-</sup>  | V <sup>-</sup>  | V <sup>-</sup>           |
| i       | IN2             | GND             | IN2                      |
| j       | S2              | V <sup>-</sup>  | S2                       |
| k       | D2              | S2              | D2                       |
| l       | D2              | D2              | D4                       |
| m       | N.C.            | N.C.            | S4                       |
| n       | V <sup>+</sup>  | V <sup>+</sup>  | V <sup>+</sup>           |

## Ordering Information (continued)

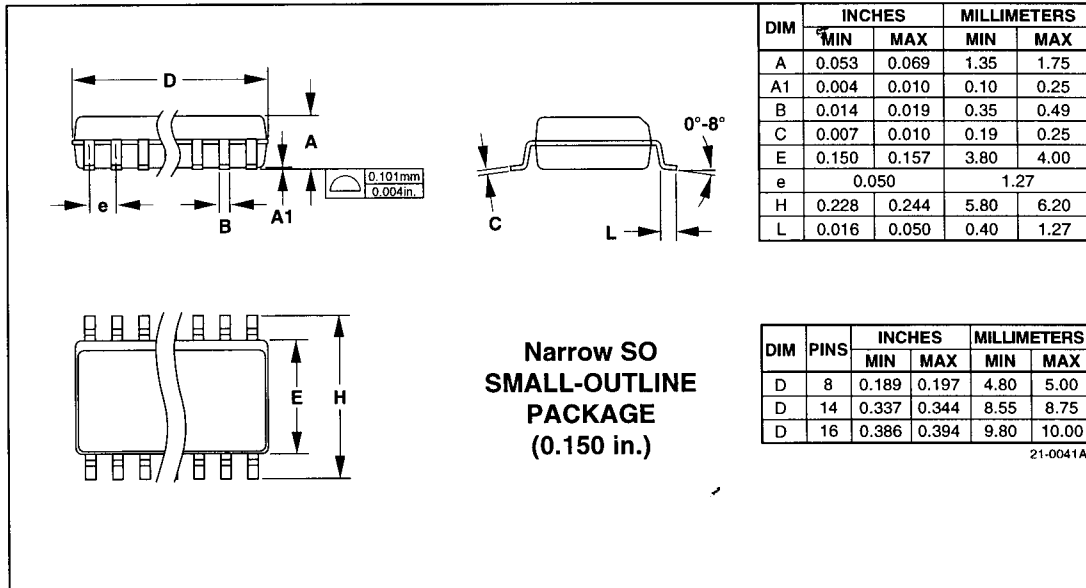
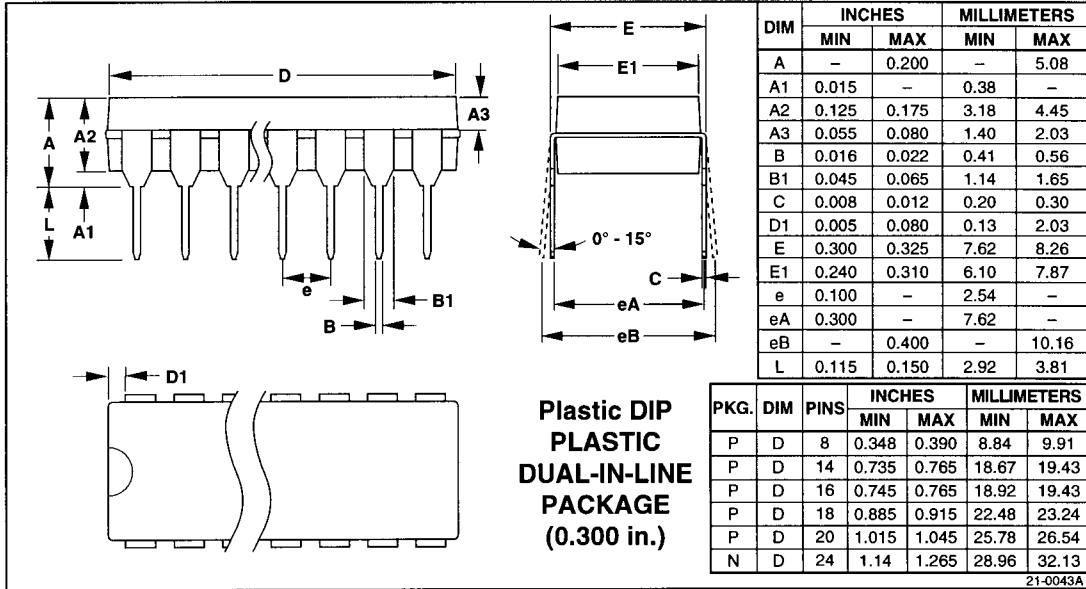
| PART      | TEMP. RANGE     | PACKAGE             |
|-----------|-----------------|---------------------|
| DG381AC/D | 0°C to +70°C    | Dice                |
| DG381ACJ  | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG381ACWE | 0°C to +70°C    | 16 Lead Wide SO     |
| DG381ACK  | 0°C to +70°C    | 14 Lead Cerdip      |
| DG381ABWE | -25°C to +85°C  | 16 Lead Wide SO     |
| DG381ABK  | -25°C to +85°C  | 14 Lead Cerdip      |
| DG381ABA  | -25°C to +85°C  | 10 Lead Metal Can   |
| DG384C/D  | 0°C to +70°C    | Dice                |
| DG384CJ   | 0°C to +70°C    | 16 Lead Plastic DIP |
| DG384CWE  | 0°C to +70°C    | 16 Lead Wide SO     |
| DG384CK   | 0°C to +70°C    | 16 Lead Cerdip      |
| DG384BWE  | -25°C to +85°C  | 16 Lead Wide SO     |
| DG384BK   | -25°C to +85°C  | 16 Lead Cerdip      |
| DG384AK   | -55°C to +125°C | 16 Lead Cerdip      |
| DG384AC/D | 0°C to +70°C    | Dice                |
| DG384ACJ  | 0°C to +70°C    | 16 Lead Plastic DIP |
| DG384ACWE | 0°C to +70°C    | 16 Lead Wide SO     |
| DG384ACK  | 0°C to +70°C    | 16 Lead Cerdip      |
| DG384ABWE | -25°C to +85°C  | 16 Lead Wide SO     |
| DG384ABK  | -25°C to +85°C  | 16 Lead Cerdip      |
| DG387C/D  | 0°C to +70°C    | Dice                |
| DG387CJ   | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG387CWE  | 0°C to +70°C    | 16 Lead Wide SO     |
| DG387CK   | 0°C to +70°C    | 14 Lead Cerdip      |
| DG387BWE  | -25°C to +85°C  | 16 Lead Wide SO     |

| PART      | TEMP. RANGE     | PACKAGE             |
|-----------|-----------------|---------------------|
| DG387BK   | -25°C to +85°C  | 14 Lead Cerdip      |
| DG387BA   | -25°C to +85°C  | 10 Lead Metal Can   |
| DG387AK   | -55°C to +125°C | 14 Lead Cerdip      |
| DG387AA   | -55°C to +125°C | 10 Lead Metal Can   |
| DG387AC/D | 0°C to +70°C    | Dice                |
| DG387ACJ  | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG387ACWE | 0°C to +70°C    | 16 Lead Wide SO     |
| DG387ACK  | 0°C to +70°C    | 14 Lead Cerdip      |
| DG387ABWE | -25°C to +85°C  | 16 Lead Wide SO     |
| DG387ABK  | -25°C to +85°C  | 14 Lead Cerdip      |
| DG387ABA  | -25°C to +85°C  | 10 Lead Metal Can   |
| DG390C/D  | 0°C to +70°C    | Dice                |
| DG390CJ   | 0°C to +70°C    | 16 Lead Plastic DIP |
| DG390CWE  | 0°C to +70°C    | 16 Lead Wide SO     |
| DG390CK   | 0°C to +70°C    | 16 Lead Cerdip      |
| DG390BWE  | -25°C to +85°C  | 16 Lead Wide SO     |
| DG390BK   | -25°C to +85°C  | 16 Lead Cerdip      |
| DG390AK   | -55°C to +125°C | 16 Lead Cerdip      |
| DG390AC/D | 0°C to +70°C    | Dice                |
| DG390ACJ  | 0°C to +70°C    | 16 Lead Plastic DIP |
| DG390ACWE | 0°C to +70°C    | 16 Lead Wide SO     |
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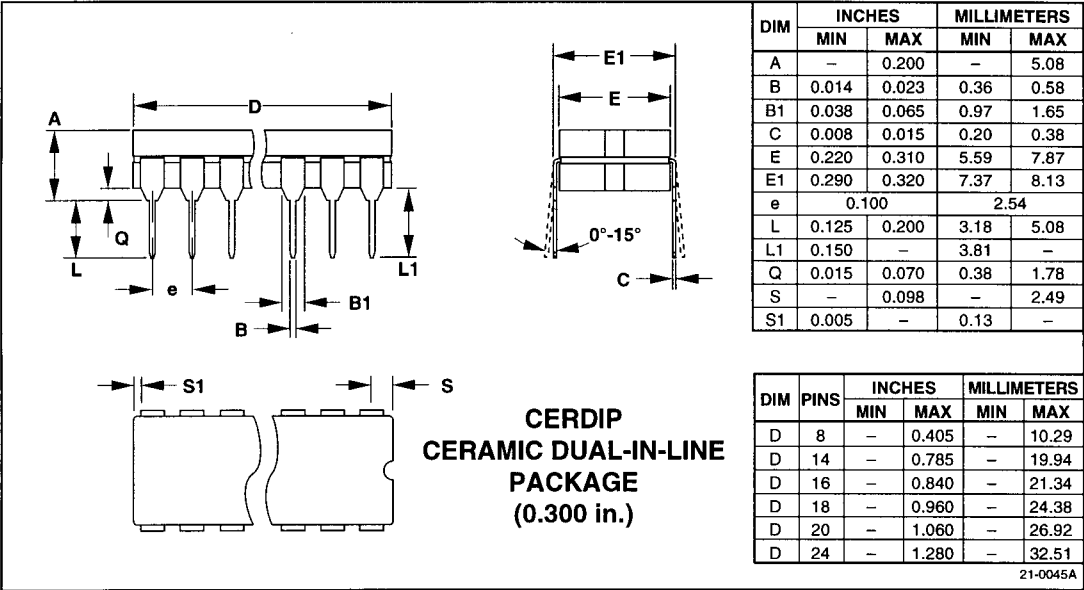
## Package Information

DG381(A)/DG384(A)/DG387(A)/DG390(A)



# General Purpose CMOS Analog Switches

## Package Information (continued)



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.

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