

# MAXIM

## CMOS Analog Switches

### General Description

Maxim's DG304-DG307 and DG304A-DG307A 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 compatible with CMOS logic. Also featured are "break-before-make" switching and low charge injection.

Maxim's DG304-DG307 and DG304A-DG307A 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

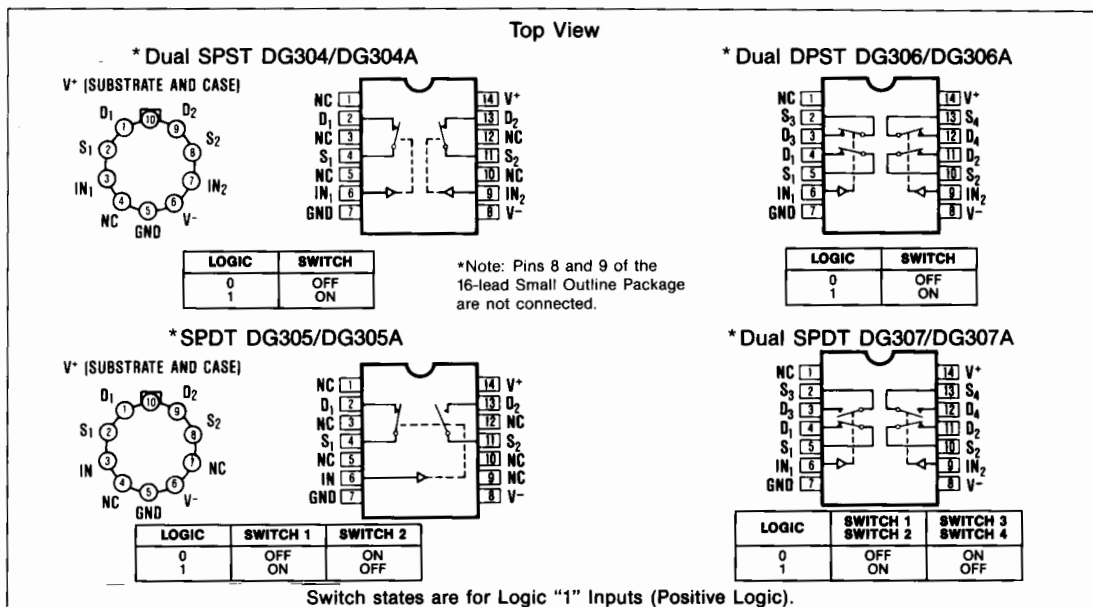
- ◆ Monolithic Low Power CMOS
- ◆ Latch-Up Proof Construction
- ◆ Fully Compatible 2nd Source
- ◆ Low On Resistance, <50Ω
- ◆ Fast Switching Time
- ◆ V<sup>+</sup> to V<sup>-</sup> Analog Signal Range
- ◆ Single Supply Capability

### Ordering Information

| PART     | TEMP. RANGE     | PACKAGE             |
|----------|-----------------|---------------------|
| DG304C/D | 0°C to +70°C    | Dice                |
| DG304CJ  | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG304CWE | 0°C to +70°C    | 16 Lead Wide SO     |
| DG304CK  | 0°C to +70°C    | 14 Lead CERDIP      |
| DG304BWE | -25°C to +85°C  | 16 Lead Wide SO     |
| DG304BK  | -25°C to +85°C  | 14 Lead CERDIP      |
| DG304BA  | -25°C to +85°C  | 10 Lead Metal Can   |
| DG304AK  | -55°C to +125°C | 14 Lead CERDIP      |
| DG304AA  | -55°C to +125°C | 10 Lead Metal Can   |

Ordering Information continued at end of data sheet.

### Pin Configurations



MAXIM

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DG304(A)/DG305(A)/DG306(A)/DG307(A)

# CMOS Analog Switches

## ABSOLUTE MAXIMUM RATINGS

|                                                          |                                                               |                                              |                |
|----------------------------------------------------------|---------------------------------------------------------------|----------------------------------------------|----------------|
| Voltages Referenced to V <sup>-</sup>                    |                                                               | Operating Temperature (A Suffix)             | -55°C to 125°C |
| V <sup>+</sup> (DG304-DG307)                             | 36V                                                           | (B Suffix)                                   | -25°C to 85°C  |
| V <sup>+</sup> (DG304A-DG307A)                           | 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                                                |                                              |                |

\* Device mounted with all leads soldered or welded to PC board.

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                                                     | DG304-DG307A<br>DG304A-DG307AA |          |     | DG304-DG307B/C<br>DG304A-DG307AB/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> = 3.5V or 11.0V              | -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> = 3.5V or V <sub>in</sub> = 11.0V                   |                                | 0.1      | 1   |                                    | 0.1      | 5   | nA    |
|         |                                |                                         | V <sub>S</sub> = 14V, V <sub>D</sub> = -14V                         |                                | 0.1      | 1   |                                    | 0.1      | 5   |       |
|         | 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   |       |
| INPUT   | Drain ON Leakage Current       | I <sub>D(on)</sub>                      | V <sub>D</sub> = V <sub>S</sub> = 14V                               | -1                             | -0.1     |     | -5                                 | -0.1     |     |       |
|         |                                |                                         | 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   |     |       |
| DYNAMIC | Turn-ON Time                   | t <sub>on</sub>                         | See Switching Time Test Circuit                                     |                                | 110      | 250 |                                    | 110      | 250 | ns    |
|         | Turn-OFF Time                  | t <sub>off</sub>                        |                                                                     |                                | 70       | 150 |                                    | 70       | 150 |       |
|         | Break-Before-Make Interval     | t <sub>on</sub> -t <sub>off</sub>       | See Break-Before-Make Time Test Circuit DG305(A)/DG307(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, V <sub>in</sub> = 3.5V or V <sub>in</sub> = 11.0V         |                                | 14       |     |                                    | 14       |     | pF    |
|         | Drain OFF Capacitance          | C <sub>D(off)</sub>                     | V <sub>S</sub> = 0V                                                 |                                | 14       |     |                                    | 14       |     |       |
|         | Channel-ON Capacitance         | C <sub>D(on)</sub> + C <sub>S(on)</sub> | V <sub>D</sub> = 0V                                                 |                                | 40       |     |                                    | 40       |     |       |
|         |                                |                                         | V <sub>S</sub> = V <sub>D</sub> = 0V                                |                                | 6        |     |                                    | 6        |     |       |
|         | Input Capacitance              | C <sub>in</sub>                         | f = 1MHz, V <sub>in</sub> = 0V                                      |                                | 7        |     |                                    | 7        |     |       |
|         |                                |                                         | V <sub>in</sub> = 15V                                               |                                | 62       |     |                                    | 62       |     |       |
|         | Off Isolation (Note 4)         |                                         | V <sub>in</sub> = 0V, R <sub>L</sub> = 1kΩ                          |                                | 74       |     |                                    | 74       |     | dB    |
|         | Crosstalk (Channel to Channel) |                                         | V <sub>S</sub> = 1 V <sub>RMS</sub> , f = 500kHz                    |                                |          |     |                                    |          |     |       |

(See Notes next page).

## 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                      | DG304-DG307A<br>DG304A-DG307AA |     |     | DG304-DG307B/C<br>DG304A-DG307AB/C |     |     | UNIT |
|--------|-------------------------|----------------|--------------------------------------|--------------------------------|-----|-----|------------------------------------|-----|-----|------|
|        |                         |                |                                      | MIN                            | TYP | MAX | MIN                                | TYP | MAX |      |
|        |                         |                |                                      | (Note 2) (Note 3)              |     |     | (Note 2) (Note 3)                  |     |     |      |
| SUPPLY | Positive Supply Current | I <sup>+</sup> | V <sub>in</sub> = 15.0V (All Inputs) | 0.001 10                       |     |     | 0.001 10                           |     |     | μA   |
|        | Negative Supply Current | I <sup>-</sup> |                                      | -10 -0.001                     |     |     | -10 -0.001                         |     |     |      |
|        | Positive Supply Current | I <sup>+</sup> | V <sub>in</sub> = 0V (All Inputs)    | 0.001 10                       |     |     | 0.001 10                           |     |     |      |
|        | Negative Supply Current | I <sup>-</sup> |                                      | -10 -0.001                     |     |     | -10 -0.001                         |     |     |      |

### ELECTRICAL CHARACTERISTICS (Over Temperature)

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

|        | PARAMETER                              | SYMBOL                                       | TEST CONDITIONS                                        |                                              | DG304-DG307A<br>DG304A-DG307AA |     |      | DG304-DG307B/C<br>DG304A-DG307AB/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> = 3.5V or 11.0V |                                              | -15                            |     | 15   | -15                                |     | 15  | V     |
|        | Drain-Source ON Resistance             | r <sub>DS(on)</sub>                          | V <sub>in</sub> = 3.5V or<br>V <sub>in</sub> = 11.0V   | 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                                 |     |     |       |
|        | Source OFF Leakage Current             | I <sub>S(off)</sub>                          |                                                        | V <sub>S</sub> = 14V, V <sub>D</sub> = -14V  |                                |     | 100  |                                    | 100 |     | nA    |
|        |                                        | V <sub>S</sub> = -14V, V <sub>D</sub> = 14V  |                                                        | -100                                         |                                |     | -100 |                                    |     |     |       |
|        | 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/<br>Voltage High         | I <sub>INH</sub>                             | V <sub>in</sub> = 5.0V                                 | -1                                           |                                |     | -10  |                                    |     | μA  |       |
|        |                                        | V <sub>in</sub> = 15V                        |                                                        |                                              | 1                              |     | 10   |                                    |     |     |       |
|        | Input Current/<br>Voltage Low          | I <sub>INL</sub>                             | V <sub>in</sub> = 0V                                   | -1                                           |                                |     | -10  |                                    |     |     |       |
| SUPPLY | Positive Supply Current                | I <sup>+</sup>                               | V <sub>in</sub> = 15.0V (All Inputs)                   | 100                                          |                                |     | 200  |                                    |     | μA  |       |
|        | Negative Supply Current                | I <sup>-</sup>                               |                                                        | -100                                         |                                |     | -200 |                                    |     |     |       |
|        | Positive Supply Current                | I <sup>+</sup>                               | V <sub>in</sub> = 0V (All Inputs)                      | 100                                          |                                |     | 200  |                                    |     |     |       |
|        | Negative Supply Current                | I <sup>-</sup>                               |                                                        | -100                                         |                                |     | -200 |                                    |     |     |       |

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

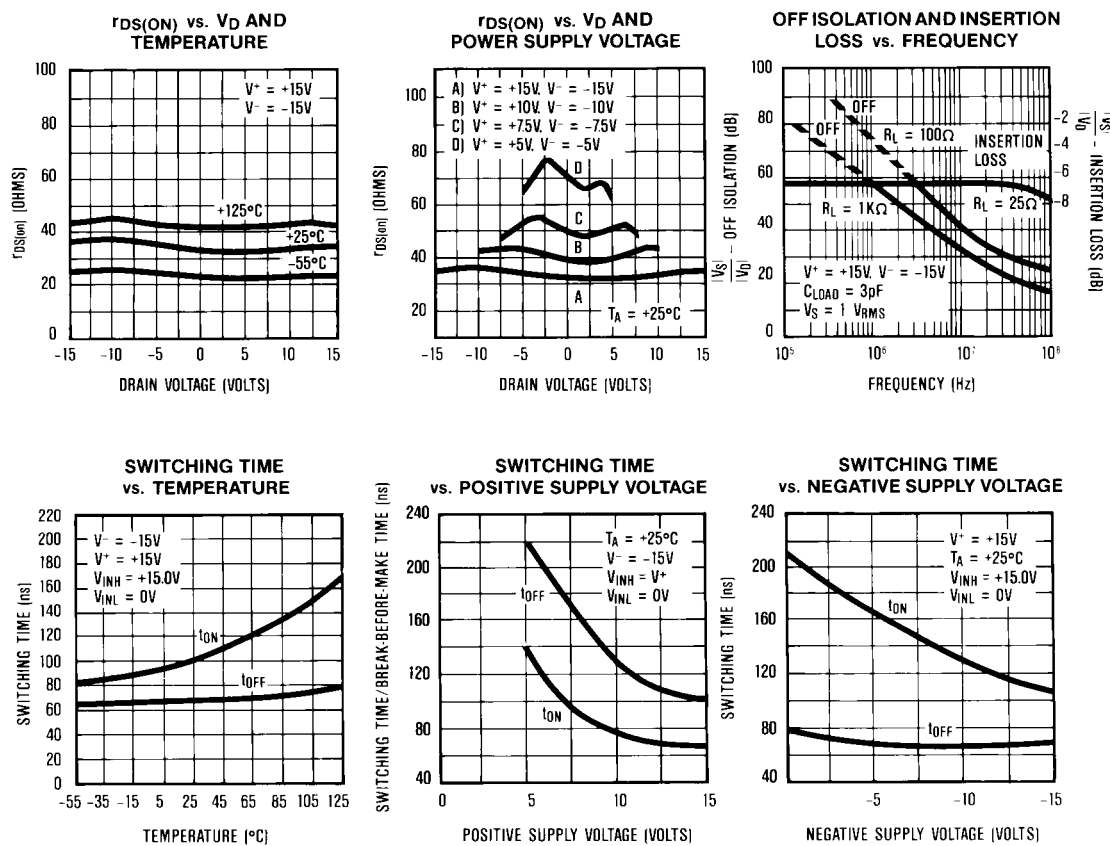
**Note 2:** The algebraic convention whereby the most negative value is a minimum, and the most positive value is a maximum is used in this data sheet.

**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.

# CMOS Analog Switches

## Typical Operating Characteristics



## Test Circuits

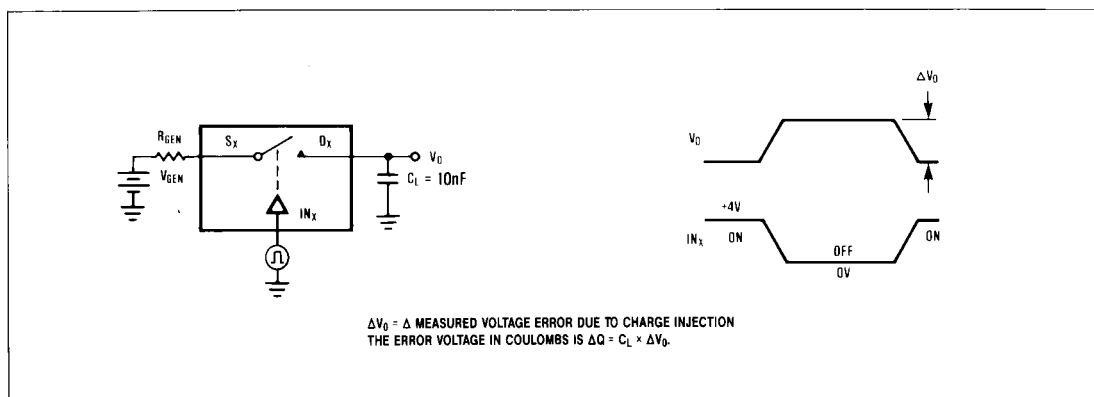


Figure 1. Charge Injection Test Circuit.

# CMOS Analog Switches

## Test Circuits (Continued)

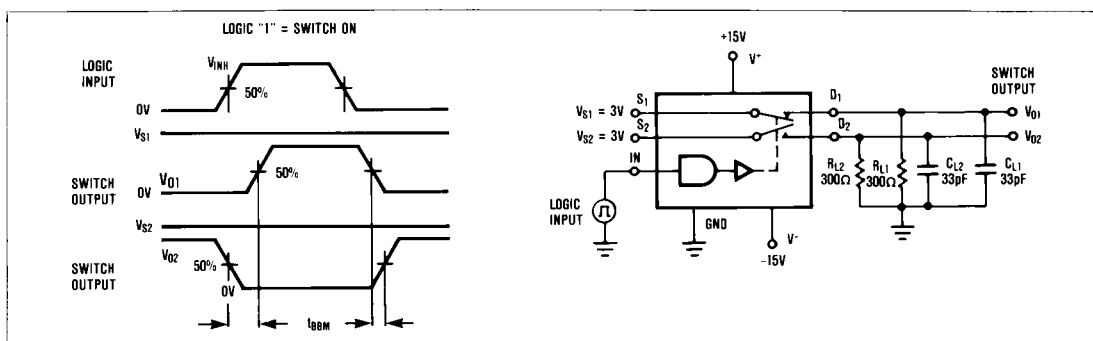


Figure 2. Break-Before-Make Time Test Circuit SPDT DG305(A), DG307(A).

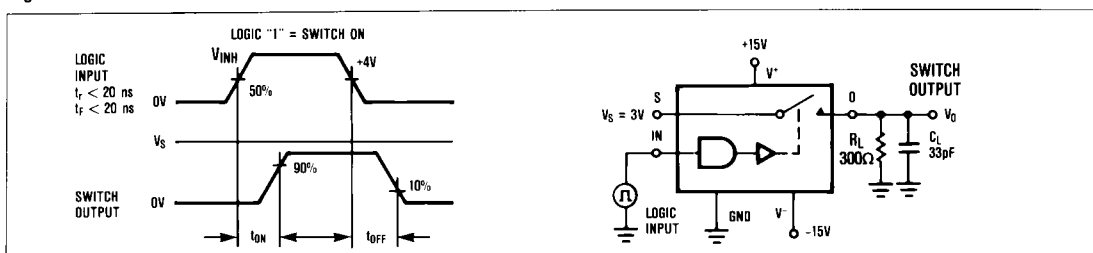


Figure 3. Switching Time Test Circuit.

## Application Information

All DG304 family switches will operate with  $\pm 15$  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 <sup>+</sup> SUPPLY VOLTAGE (V <sup>-</sup> = 0V) |             |             |             |
|-------------------------------------|-----------------------------------------------------|-------------|-------------|-------------|
|                                     | +10V                                                | +15V        | +20V        | +30V        |
| Switching Time ( $R_L = 1k\Omega$ ) |                                                     |             |             |             |
| $t_{ON}$                            | 220ns                                               | 180ns       | 165ns       | 110ns       |
| $t_{OFF}$                           | 60ns                                                | 40ns        | 30ns        | 20ns        |
| 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                  | 3.5V, 11.0V                                         | 3.5V, 11.0V | 3.5V, 12.5V | 3.5V, 22.0V |

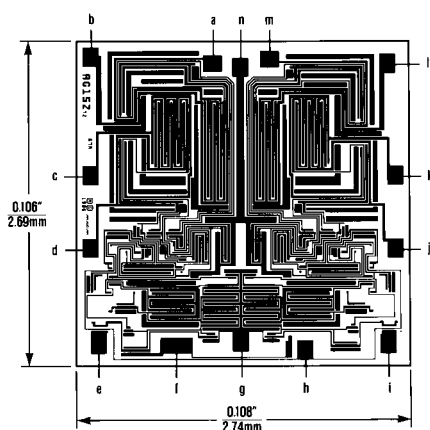
The charge injection test circuit is shown in Figure 1. Table 2 lists the typical injected charge for DG304 series switches with various input voltages.

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

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

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## Chip Topography



| DIE PAD | DG304<br>DG304A | DG305<br>DG305A | DG306/307<br>DG306A/307A |
|---------|-----------------|-----------------|--------------------------|
| 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)

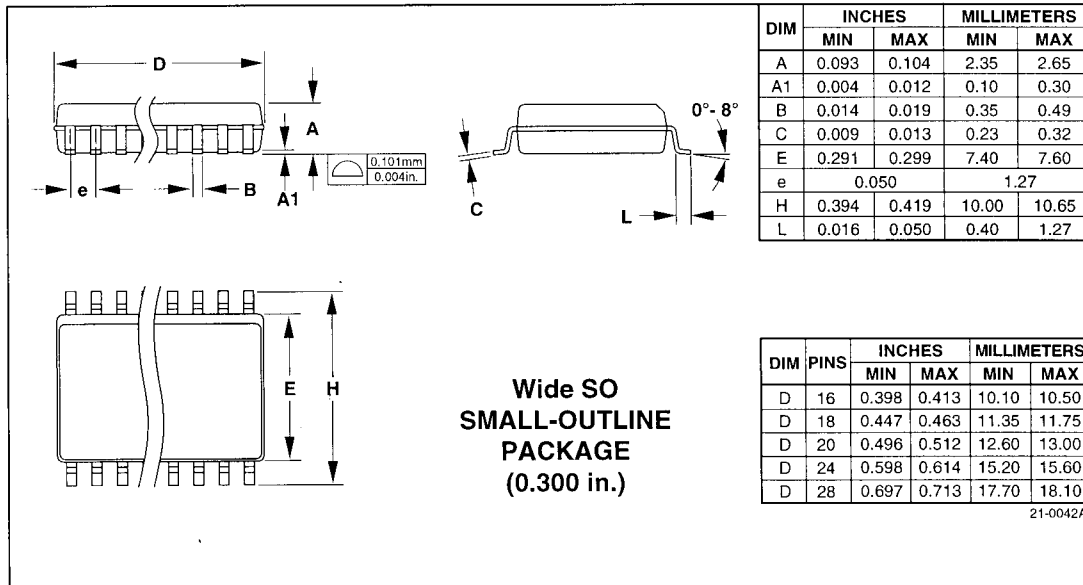
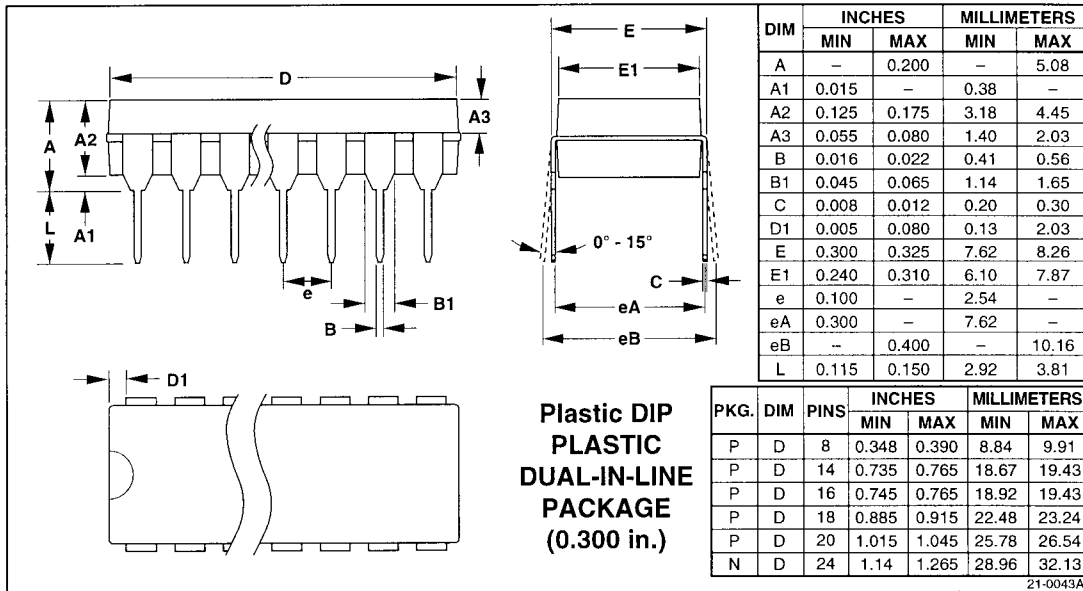
| PART      | TEMP. RANGE     | PACKAGE             |
|-----------|-----------------|---------------------|
| DG304AC/D | 0°C to +70°C    | Dice                |
| DG304ACJ  | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG304ACWE | 0°C to +70°C    | 16 Lead Wide SO     |
| DG304ACK  | 0°C to +70°C    | 14 Lead Cerdip      |
| DG304ABWE | -25°C to +85°C  | 16 Lead Wide SO     |
| DG304ABK  | -25°C to +85°C  | 14 Lead Cerdip      |
| DG304ABA  | -25°C to +85°C  | 10 Lead Metal Can   |
| DG305C/D  | 0°C to +70°C    | Dice                |
| DG305CJ   | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG305CWE  | 0°C to +70°C    | 16 Lead Wide SO     |
| DG305CK   | 0°C to +70°C    | 14 Lead Cerdip      |
| DG305BWE  | -25°C to +85°C  | 16 Lead Wide SO     |
| DG305BK   | -25°C to +85°C  | 14 Lead Cerdip      |
| DG305BA   | -25°C to +85°C  | 10 Lead Metal Can   |
| DG305AK   | -55°C to +125°C | 14 Lead Cerdip      |
| DG305AA   | -55°C to +125°C | 10 Lead Metal Can   |
| DG305AC/D | 0°C to +70°C    | Dice                |
| DG305ACJ  | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG305ACWE | 0°C to +70°C    | 16 Lead Wide SO     |
| DG305ACK  | 0°C to +70°C    | 14 Lead Cerdip      |
| DG305ABWE | -25°C to +85°C  | 16 Lead Wide SO     |
| DG305ABK  | -25°C to +85°C  | 14 Lead Cerdip      |
| DG305ABA  | -25°C to +85°C  | 10 Lead Metal Can   |

| PART      | TEMP. RANGE     | PACKAGE             |
|-----------|-----------------|---------------------|
| DG306C/D  | 0°C to +70°C    | Dice                |
| DG306CJ   | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG306CWE  | 0°C to +70°C    | 16 Lead Wide SO     |
| DG306CK   | 0°C to +70°C    | 14 Lead Cerdip      |
| DG306BWE  | -25°C to +85°C  | 16 Lead Wide SO     |
| DG306BK   | -25°C to +85°C  | 14 Lead Cerdip      |
| DG306AK   | -55°C to +125°C | 14 Lead Cerdip      |
| DG306AC/D | 0°C to +70°C    | Dice                |
| DG306ACJ  | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG306ACWE | 0°C to +70°C    | 16 Lead Wide SO     |
| DG306ACK  | 0°C to +70°C    | 14 Lead Cerdip      |
| DG306ABWE | -25°C to +85°C  | 16 Lead Wide SO     |
| DG306ABK  | -25°C to +85°C  | 14 Lead Cerdip      |
| DG307C/D  | 0°C to +70°C    | Dice                |
| DG307CJ   | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG307CWE  | 0°C to +70°C    | 16 Lead Wide SO     |
| DG307CK   | 0°C to +70°C    | 14 Lead Cerdip      |
| DG307BWE  | -25°C to +85°C  | 16 Lead Wide SO     |
| DG307BK   | -25°C to +85°C  | 14 Lead Cerdip      |
| DG307AK   | -55°C to +125°C | 14 Lead Cerdip      |
| DG307AC/D | 0°C to +70°C    | Dice                |
| DG307ACJ  | 0°C to +70°C    | 14 Lead Plastic DIP |
| DG307ACWE | 0°C to +70°C    | 16 Lead Wide SO     |
| DG307ACK  | 0°C to +70°C    | 14 Lead Cerdip      |
| DG307ABWE | -25°C to +85°C  | 16 Lead Wide SO     |
| DG307ABK  | -25°C to +85°C  | 14 Lead Cerdip      |

# CMOS Analog Switches

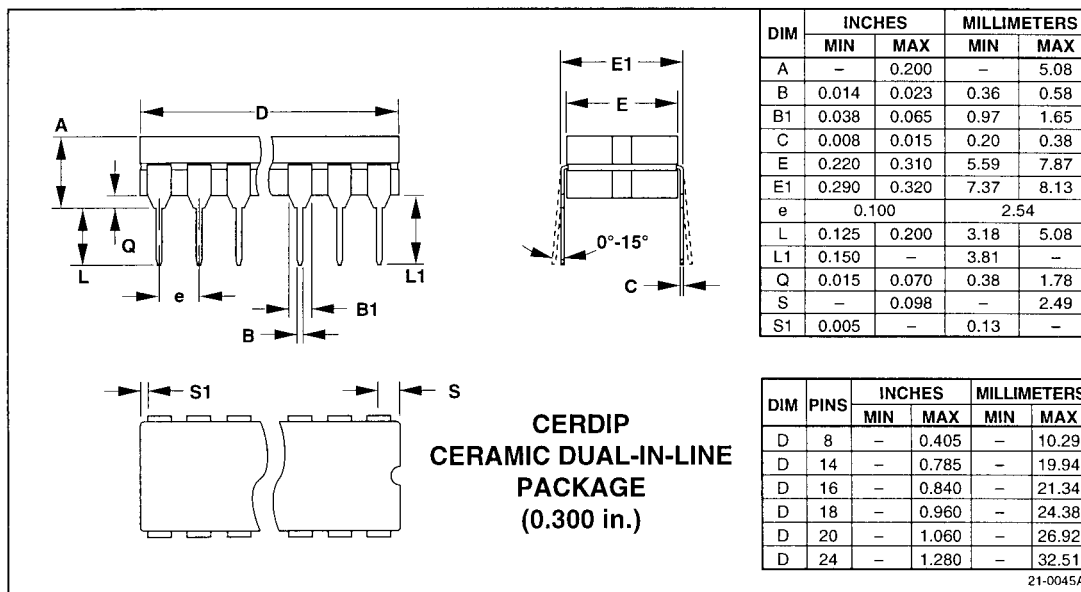
## Package Information

DG304(A)/DG305(A)/DG306(A)/DG307(A)



# CMOS Analog Switches

## Package Information (continued)



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