

# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

## ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-

V+ .....-0.3V, 44V

GND .....-0.3V, 25V

Digital Inputs, S, D (Note 1).....(V- - 2V) to (V+ + 2V) or  
30mA, (whichever occurs first)

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

Peak Current, S, D

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

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

TSSOP (derate 9.4mW/°C above +70°C) .....755mW

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

Operating Temperature Ranges

DG408/DG409C\_ .....0°C to +70°C

DG408/DG409D,E\_ .....-40°C to +85°C

DG408/DG409AK .....-55°C to +125°C

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

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

**Note 1:** Signals on S<sub>-</sub>, D<sub>-</sub>, EN, A0, A1, or A2 exceeding V<sub>+</sub> or V<sub>-</sub> are clamped by internal diodes. Limit forward current to maximum current ratings.

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<sub>+</sub> = 15V, V<sub>-</sub> = -15V, GND = 0V, V<sub>AH</sub> = +2.4V, V<sub>AL</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 |    |
|--------------------------------------------|----------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|------|-----------------|------|-------|----|
| SWITCH                                     |                      |                                                                                   |                                                          |                                                          |      |                 |      |       |    |
| Analog Signal Range                        | V <sub>ANALOG</sub>  | (Note 3)                                                                          |                                                          |                                                          | -15  |                 | 15   | V     |    |
| Drain-Source<br>On-Resistance              | r <sub>DS(ON)</sub>  | I <sub>S</sub> = -1.0mA,<br>V <sub>D</sub> = ±10V                                 | T <sub>A</sub> = +25°C                                   |                                                          | 60   |                 | 100  | Ω     |    |
|                                            |                      |                                                                                   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>    |                                                          |      |                 | 125  |       |    |
| On-Resistance Matching<br>Between Channels | Δr <sub>DS(ON)</sub> | I <sub>S</sub> = -1.0mA,<br>V <sub>D</sub> = ±10V (Note 4)                        | T <sub>A</sub> = +25°C                                   |                                                          | 1.5  |                 | 8    | Ω     |    |
|                                            |                      |                                                                                   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>    |                                                          |      |                 | 10   |       |    |
| On-Resistance Flatness                     | r <sub>FLAT</sub>    | I <sub>S</sub> = -1.0mA,<br>V <sub>D</sub> = ±5V or 0V                            | T <sub>A</sub> = +25°C                                   |                                                          | 1.8  |                 | 9    | Ω     |    |
|                                            |                      |                                                                                   | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>    |                                                          |      |                 | 12   |       |    |
| Source-Off Leakage Current<br>(Note 5)     | I <sub>S(OFF)</sub>  | V <sub>D</sub> = +10V,<br>V <sub>S</sub> = ±10V,<br>V <sub>EN</sub> = 0V          | T <sub>A</sub> = +25°C                                   |                                                          | -0.5 | 0.01            | 0.5  | nA    |    |
|                                            |                      |                                                                                   | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, D                                                     | -5   |                 | 5    |       |    |
|                                            |                      |                                                                                   |                                                          | A                                                        | -50  |                 | 50   |       |    |
| Drain-Off Leakage Current<br>(Note 5)      | I <sub>D(OFF)</sub>  | V <sub>D</sub> = ±10V,<br>V <sub>S</sub> = +10V,<br>V <sub>EN</sub> = 0V          | DG408                                                    | T <sub>A</sub> = +25°C                                   |      | -1              | 0.02 | 1     | nA |
|                                            |                      |                                                                                   |                                                          | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, D | -10             |      | 10    |    |
|                                            |                      |                                                                                   |                                                          |                                                          | A    | -100            |      | 100   |    |
|                                            |                      | V <sub>D</sub> = +10V,<br>V <sub>S</sub> = ±10V,<br>V <sub>EN</sub> = 0V          | DG409                                                    | T <sub>A</sub> = +25°C                                   |      | -1              | 0.02 | 1     |    |
|                                            |                      |                                                                                   |                                                          | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, D | -5              |      | 5     |    |
|                                            |                      |                                                                                   |                                                          |                                                          | A    | -50             |      | 50    |    |
| Drain-On Leakage Current<br>(Note 5)       | I <sub>D(ON)</sub>   | V <sub>D</sub> = ±10V,<br>V <sub>S</sub> = ±10V,<br>sequence<br>each switch<br>on | DG408                                                    | T <sub>A</sub> = +25°C                                   |      | -1              | 0.02 | 1     | nA |
|                                            |                      |                                                                                   |                                                          | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, D | -20             |      | 20    |    |
|                                            |                      |                                                                                   |                                                          |                                                          | A    | -100            |      | 100   |    |
|                                            |                      |                                                                                   | DG409                                                    | T <sub>A</sub> = +25°C                                   |      | -1              | 0.02 | 1     |    |
|                                            |                      |                                                                                   |                                                          | T <sub>A</sub> = T <sub>MIN</sub><br>to T <sub>MAX</sub> | C, D | -10             |      | 10    |    |
|                                            |                      |                                                                                   |                                                          |                                                          | A    | -50             |      | 50    |    |

# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

DG408/DG409

## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V<sub>+</sub> = 15V, V<sub>-</sub> = -15V, GND = 0V, V<sub>AH</sub> = +2.4V, V<sub>AL</sub> = +0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

| PARAMETER                             | SYMBOL                                  | CONDITIONS                                                                                                |                                                       | MIN                    | TYP<br>(Note 2) | MAX | UNITS |
|---------------------------------------|-----------------------------------------|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------------------------|-----------------|-----|-------|
| INPUT                                 |                                         |                                                                                                           |                                                       |                        |                 |     |       |
| Input Current with Input Voltage High | I <sub>AH</sub>                         | V <sub>A</sub> = 2.4V or 15V                                                                              |                                                       | -1.0                   |                 | 1.0 | μA    |
| Input Current with Input Voltage Low  | I <sub>AL</sub>                         | V <sub>EN</sub> = 0V or 2.4V, V <sub>A</sub> = 0V                                                         |                                                       | -1.0                   |                 | 1.0 | μA    |
| SUPPLY                                |                                         |                                                                                                           |                                                       |                        |                 |     |       |
| Power-Supply Range                    |                                         |                                                                                                           |                                                       | ±5                     |                 | ±20 | V     |
| Positive Supply Current               | I <sub>+</sub>                          | V <sub>EN</sub> = V <sub>A</sub> = 0V or 4.5V                                                             | T <sub>A</sub> = +25°C                                |                        | 16              | 30  | μA    |
|                                       |                                         |                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |                        |                 | 75  |       |
|                                       |                                         | V <sub>EN</sub> = 2.4V, V <sub>A(ALL)</sub> = 0V or 2.4V                                                  | T <sub>A</sub> = +25°C                                |                        | 0.075           | 0.5 | mA    |
|                                       |                                         |                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |                        |                 | 2   |       |
| Negative Supply Current               | I <sub>-</sub>                          | V <sub>EN</sub> = 2.4V, V <sub>A(ALL)</sub> = 0V or 2.4V                                                  | T <sub>A</sub> = +25°C                                | -1                     |                 | 1   | μA    |
|                                       |                                         |                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> | -10                    |                 | 10  |       |
| DYNAMIC                               |                                         |                                                                                                           |                                                       |                        |                 |     |       |
| Transition Time                       | t <sub>TRANS</sub>                      | Figure 2                                                                                                  | T <sub>A</sub> = +25°C                                |                        | 85              | 175 | ns    |
|                                       |                                         |                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |                        |                 | 250 |       |
| Break-Before-Make Interval            | t <sub>OPEN</sub>                       | Figure 4                                                                                                  | T <sub>A</sub> = +25°C                                | 10                     | 40              |     | ns    |
| Enable Turn-On Time                   | t <sub>ON(EN)</sub>                     | Figure 3                                                                                                  | T <sub>A</sub> = +25°C                                |                        | 85              | 150 | ns    |
|                                       |                                         |                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |                        |                 | 225 |       |
| Enable Turn-Off Time                  | t <sub>OFF(EN)</sub>                    | Figure 3                                                                                                  | T <sub>A</sub> = +25°C                                |                        |                 | 150 | ns    |
|                                       |                                         |                                                                                                           | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |                        |                 | 300 |       |
| Charge Injection (Note 3)             | Q                                       | C <sub>L</sub> = 1.0nF, V <sub>S</sub> = 0V, R <sub>S</sub> = 0Ω, Figure 5                                | T <sub>A</sub> = +25°C                                |                        | 2               | 15  | pC    |
| Off Isolation (Note 6)                | V <sub>ISO</sub>                        | V <sub>EN</sub> = 0V, R <sub>L</sub> = 1kΩ, f = 100kHz, Figure 6                                          | T <sub>A</sub> = +25°C                                |                        | -75             |     | dB    |
| Crosstalk Between Input Channels      | V <sub>CT</sub>                         | V <sub>EN</sub> = 2.4V, f = 100kHz, V <sub>GEN</sub> = 1V <sub>P-P</sub> , R <sub>L</sub> = 1kΩ, Figure 7 | T <sub>A</sub> = +25°C                                |                        | -92             |     | dB    |
| Logic Input Capacitance               | C <sub>IN</sub>                         | f = 1MHz                                                                                                  | T <sub>A</sub> = +25°C                                |                        | 8               |     | pF    |
| Source-Off Capacitance                | C <sub>S(OFF)</sub>                     | f = 1MHz, V <sub>EN</sub> = V <sub>S</sub> = 0V, Figure 8                                                 | T <sub>A</sub> = +25°C                                |                        | 3               |     | pF    |
| Drain-Off Capacitance                 | C <sub>D(OFF)</sub>                     | f = 1MHz, V <sub>EN</sub> = 0.8V V <sub>D</sub> = 0V, Figure 8                                            | DG408                                                 | T <sub>A</sub> = +25°C | 26              |     | pF    |
|                                       |                                         |                                                                                                           |                                                       |                        | DG409           | 14  |       |
| Drain-On Capacitance                  | C <sub>D(ON)</sub> + C <sub>S(ON)</sub> | f = 1MHz, V <sub>EN</sub> = 2.4V V <sub>D</sub> = 0V, Figure 8                                            | DG408                                                 | T <sub>A</sub> = +25°C | 37              |     | pF    |
|                                       |                                         |                                                                                                           |                                                       |                        | DG409           | 25  |       |

# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

## ELECTRICAL CHARACTERISTICS—Single Supply

(V<sub>+</sub> = 12V, V<sub>-</sub> = 0V, GND = 0V, V<sub>AH</sub> = +2.4V, V<sub>AL</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 |
|----------------------------------|----------------------|------------------------------------------------------------------------------------|------------------------|-----|-----------------|-----|-------|
| SWITCH                           |                      |                                                                                    |                        |     |                 |     |       |
| Analog Signal Range              | V <sub>ANALOG</sub>  | (Note 3)                                                                           |                        | 0   |                 | 12  | V     |
| Drain-Source On-Resistance       | r <sub>DS(ON)</sub>  | I <sub>S</sub> = -1.0mA<br>V <sub>D</sub> = 3V or 10V                              | T <sub>A</sub> = +25°C |     | 120             | 175 | Ω     |
| DYNAMIC                          |                      |                                                                                    |                        |     |                 |     |       |
| Transition Time<br>(Note 3)      | t <sub>TRANS</sub>   | V <sub>S1</sub> = 8V,<br>V <sub>S8</sub> = 0V,<br>V <sub>A</sub> = 0V,<br>Figure 2 | T <sub>A</sub> = +25°C |     | 115             | 450 | ns    |
| Enable Turn-On Time<br>(Note 3)  | t <sub>ON(EN)</sub>  | V <sub>AL</sub> = 0V,<br>V <sub>S1</sub> = 5V,<br>Figure 3                         | T <sub>A</sub> = +25°C |     | 100             | 600 | ns    |
| Enable Turn-Off Time<br>(Note 3) | t <sub>OFF(EN)</sub> | V <sub>AL</sub> = 0V,<br>V <sub>S1</sub> = 5V,<br>Figure 3                         | T <sub>A</sub> = +25°C |     | 75              | 300 | ns    |
| Charge Injection                 | Q                    | C <sub>L</sub> = 1.0nF,<br>V <sub>S</sub> = 0V,<br>R <sub>S</sub> = 0Ω             | T <sub>A</sub> = +25°C |     | 2               |     | 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:** ΔRON = RON(MAX) - RON(MIN). On-resistance match between channels and flatness are guaranteed only with specified voltages. Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured at the extremes of the specified analog signal range.

**Note 5:** Leakage parameters are 100% tested at the maximum rated hot temperature and guaranteed by correlation at +25°C.

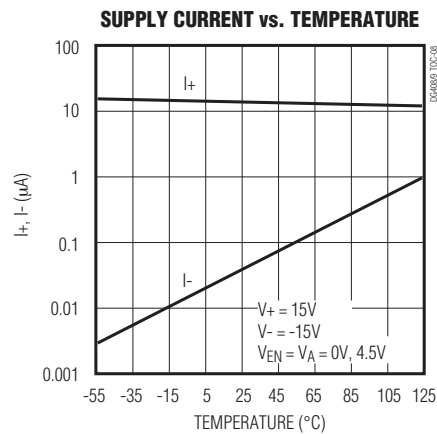
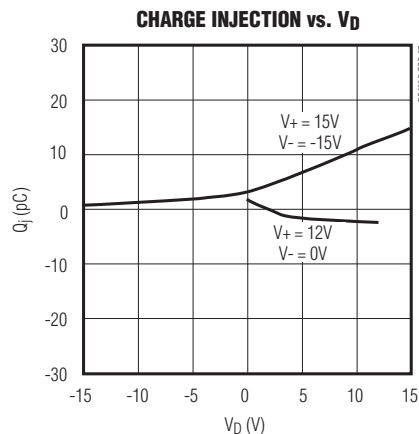
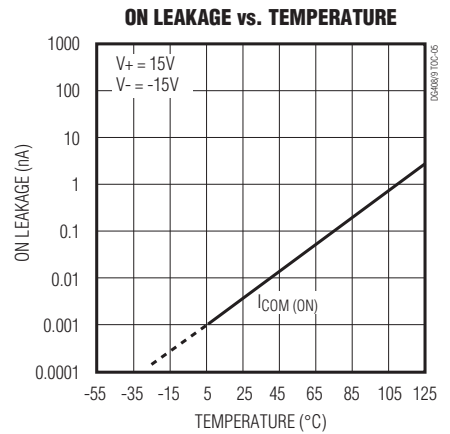
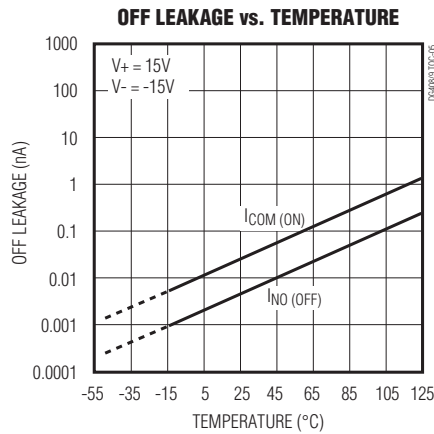
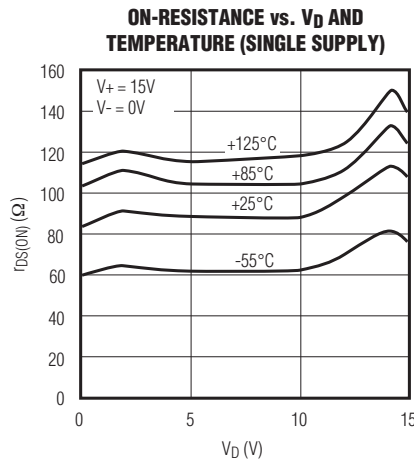
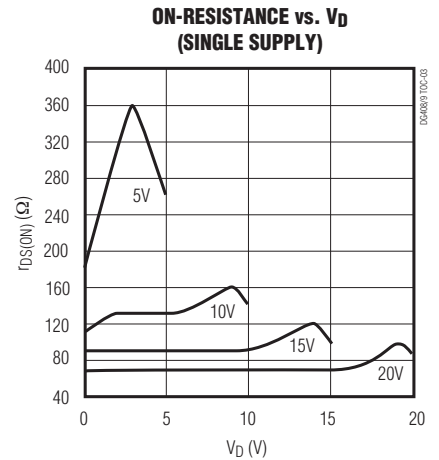
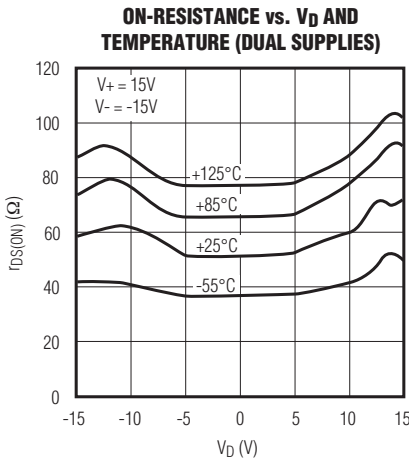
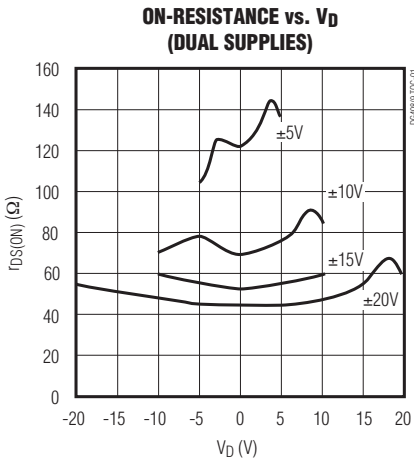
**Note 6:** Off isolation = 20log V<sub>D</sub>/V<sub>S</sub>, where V<sub>D</sub> = output and V<sub>S</sub> = input to off switch.

# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

## Typical Operating Characteristics

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

DG408/DG409



# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

## Pin Description

| PIN       |       | NAME       | FUNCTION                      |
|-----------|-------|------------|-------------------------------|
| DG408     | DG409 |            |                               |
| 1, 15, 16 | —     | A0, A2, A1 | Address Inputs                |
| —         | 1, 16 | A0, A1     | Address Inputs                |
| 2         | 2     | EN         | Enable Input                  |
| 3         | 3     | V-         | Negative Supply Voltage Input |
| 4–7       | —     | S1–S4      | Bidirectional Analog Inputs   |
| —         | 4–7   | S1A–S4A    | Bidirectional Analog Inputs   |
| 8         | —     | D          | Bidirectional Analog Output   |
| —         | 8, 9  | DA, DB     | Bidirectional Analog Outputs  |
| 9–12      | —     | S8–S5      | Bidirectional Analog Inputs   |
| —         | 10–13 | S4B–S1B    | Bidirectional Analog Inputs   |
| 13        | 14    | V+         | Positive Supply Voltage Input |
| 14        | 15    | GND        | Ground                        |

## Applications Information

### Operation with Supply Voltages Other than 15V

Using supply voltages less than  $\pm 15\text{V}$  reduces the analog signal range. The DG408/DG409 switches operate with  $\pm 5\text{V}$  to  $\pm 20\text{V}$  bipolar supplies or with a  $+5\text{V}$  to  $+40\text{V}$  single supply. Connect V- to GND when operating with a single supply. Both device types can also operate with unbalanced supplies, such as  $+24\text{V}$  and  $-5\text{V}$ . The *Typical Operating Characteristics* graphs show typical on-resistance with 20V, 15V, 10V, and 5V supplies. (Switching times increase by a factor of two or more for operation at 5V.)

### Overvoltage Protection

Proper power-supply sequencing is recommended for all CMOS devices. Do not exceed the absolute maximum ratings, because stresses beyond the listed ratings may cause permanent damage to the devices. Always sequence V+ on first, then V-, followed by the logic inputs, S or D. If power-supply sequencing is not possible, add two small signal diodes in series with supply pins for overvoltage protection (Figure 1). Adding diodes reduces the analog signal range to 1V below V+ and 1V above V-, but does not affect the devices' low switch resistance and low leakage characteristics. Device operation is unchanged, and the difference between V+ and V- should not exceed  $+44\text{V}$ .

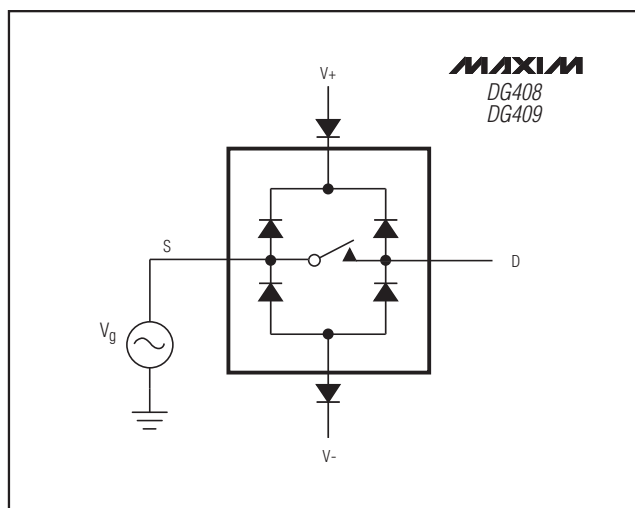


Figure 1. Overvoltage Protection Using External Blocking Diodes

# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

## Test Circuits/Timing Diagrams

DG408/DG409

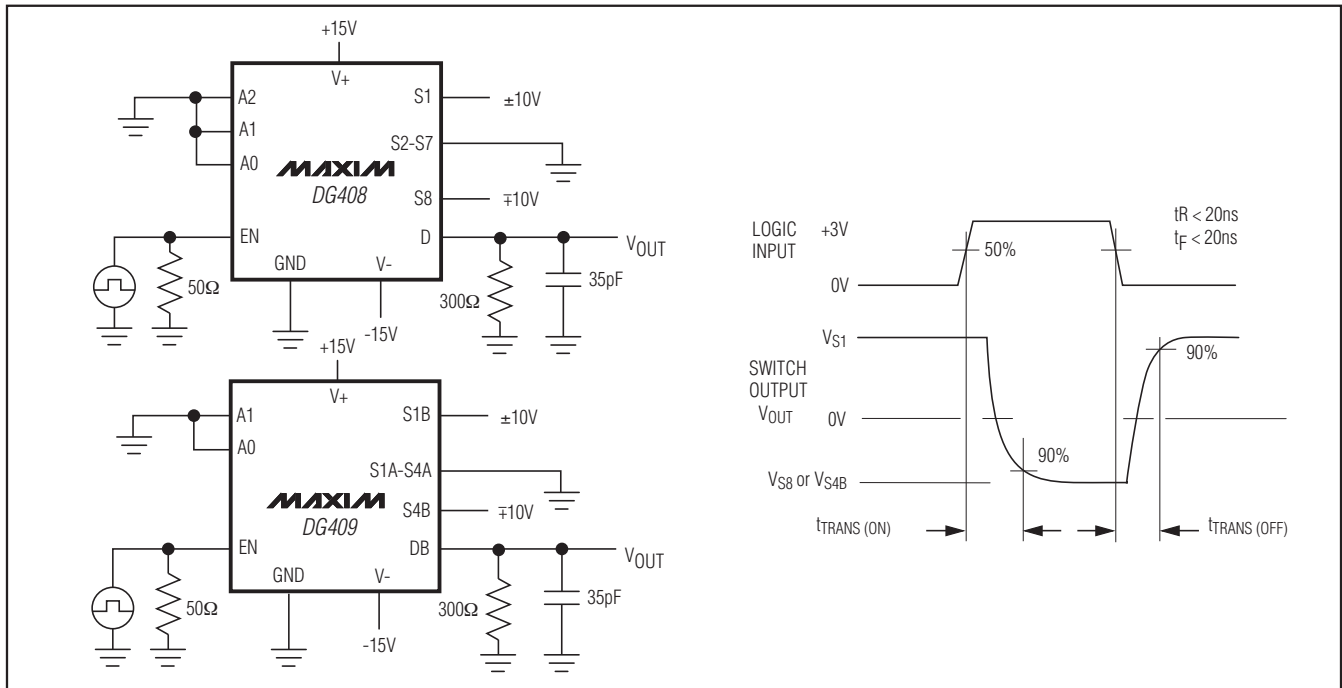


Figure 2. Transition Time

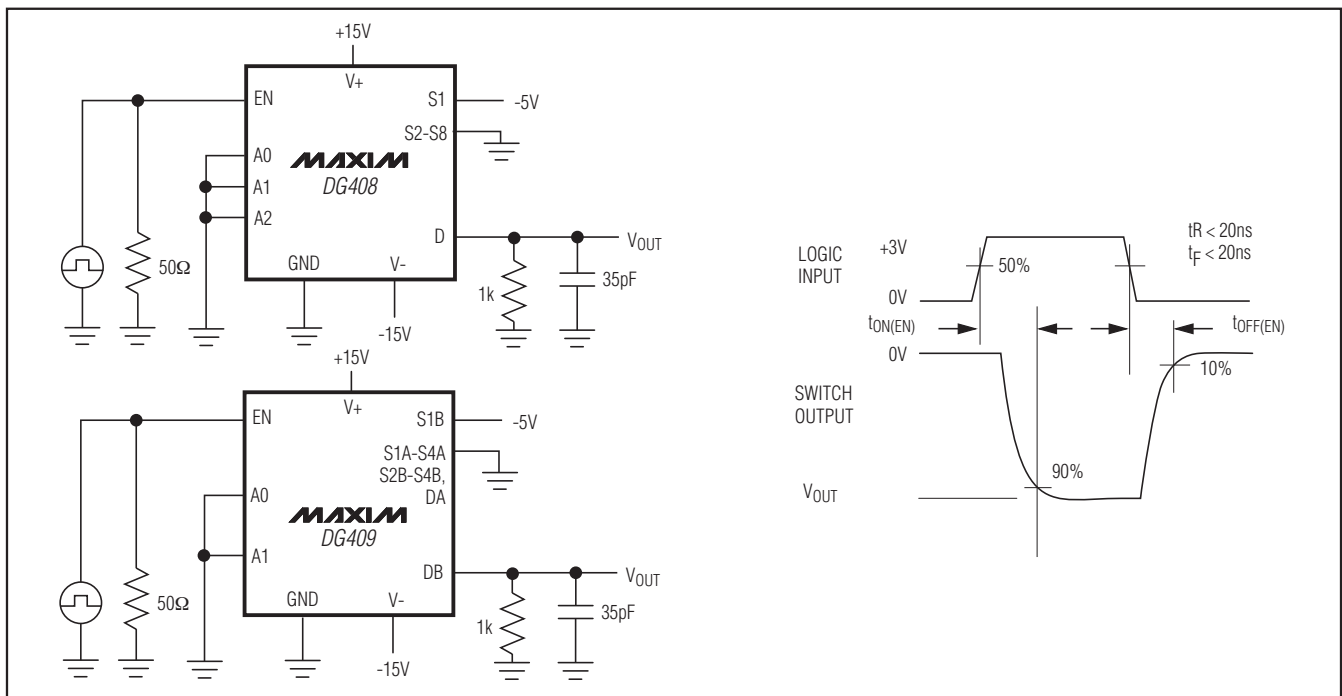


Figure 3. Enable Switching Time

# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

## Test Circuits/Timing Diagrams (continued)

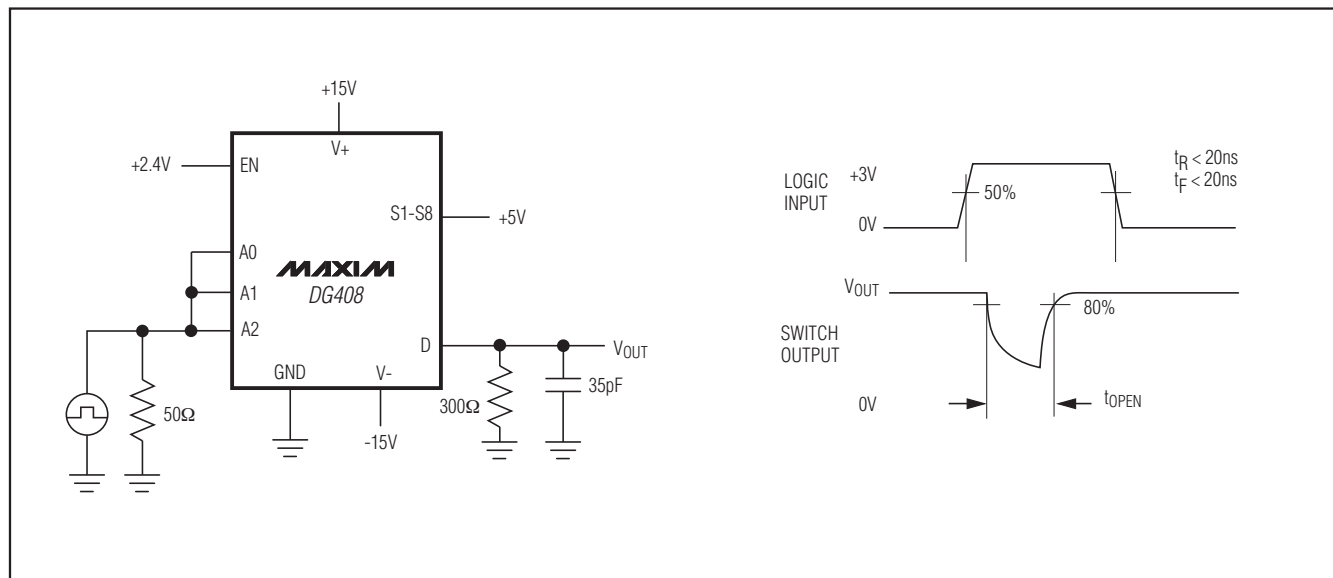


Figure 4. Break-Before-Make Interval

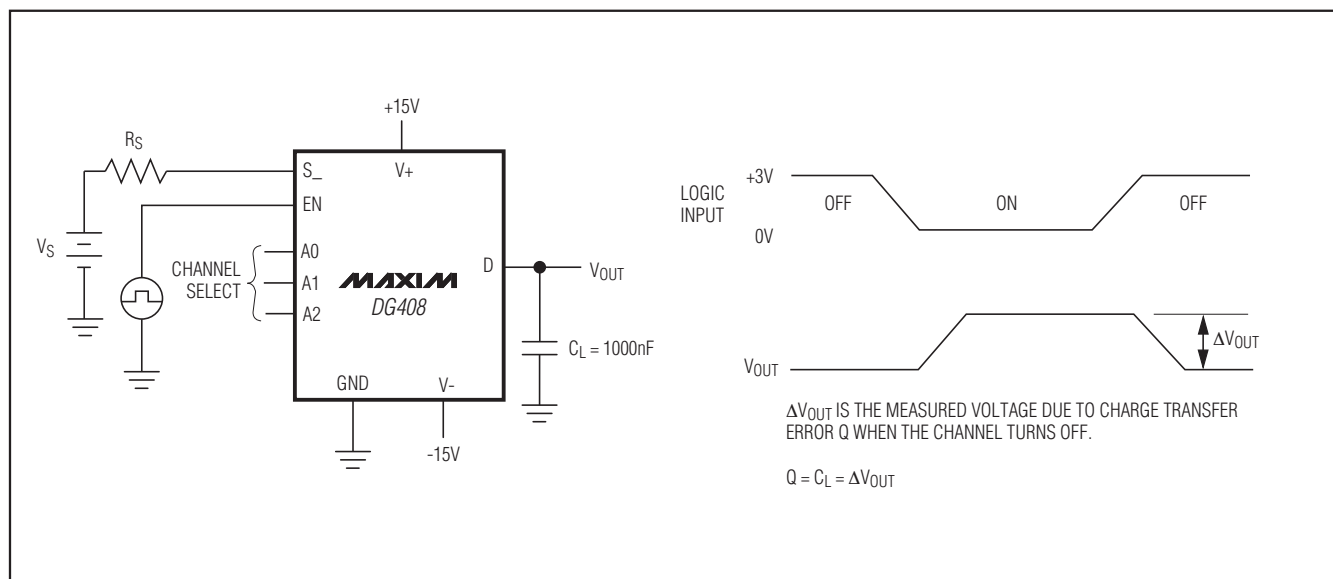
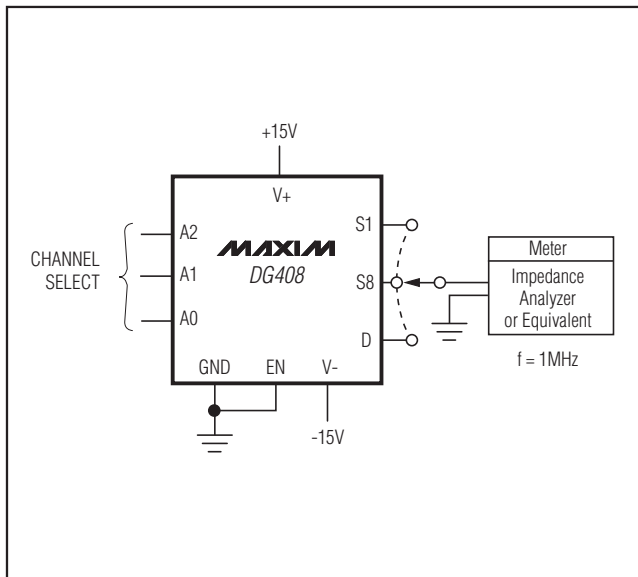
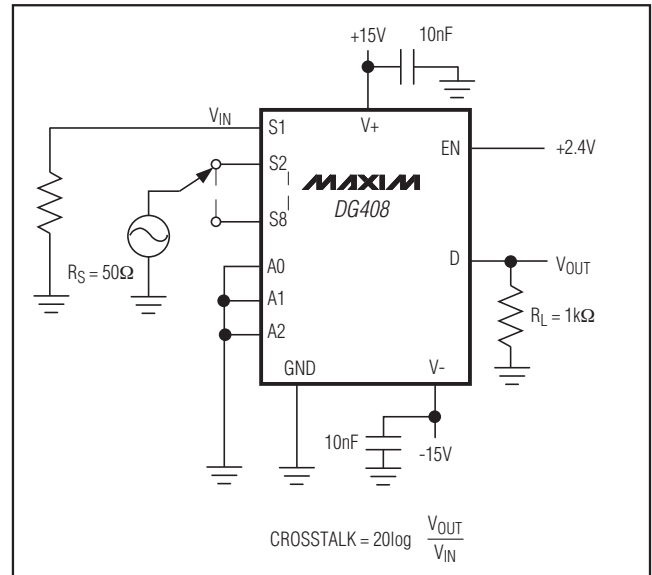
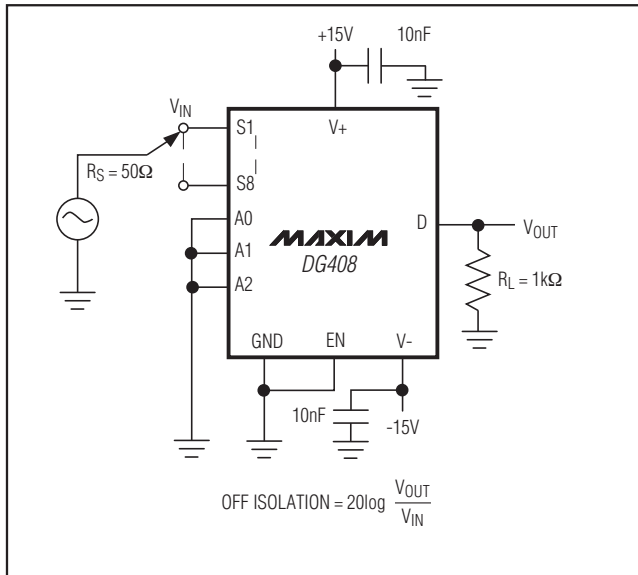


Figure 5. Charge Injection

# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

## Test Circuits/Timing Diagrams (continued)

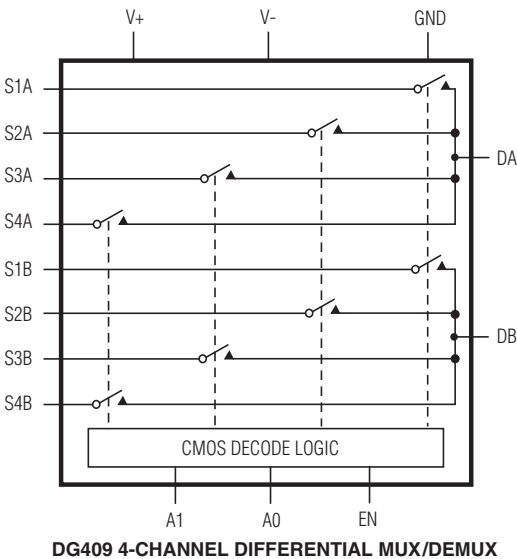
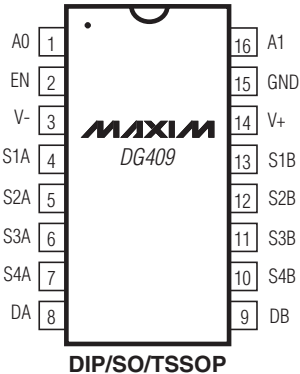
DG408/DG409



# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

## Pin Configurations/Functional Diagrams/Truth Tables (continued)

TOP VIEW



| A2 | A1 | A0 | EN | ON SWITCH |
|----|----|----|----|-----------|
| X  | X  | X  | 0  | None      |
| 0  | 0  | 0  | 1  | 1         |
| 0  | 0  | 1  | 1  | 2         |
| 0  | 1  | 0  | 1  | 3         |
| 0  | 1  | 1  | 1  | 4         |
| 1  | 0  | 0  | 1  | 5         |
| 1  | 0  | 1  | 1  | 6         |
| 1  | 1  | 0  | 1  | 7         |
| 1  | 1  | 1  | 1  | 8         |

DG408

LOGIC "0"  $V_{AL} \leq 0.8V$ , LOGIC "1"  $V_{AH} \geq 2.4V$

| A1 | A0 | EN | ON SWITCH |
|----|----|----|-----------|
| X  | X  | 0  | None      |
| 0  | 0  | 1  | 1         |
| 0  | 1  | 1  | 2         |
| 1  | 0  | 1  | 3         |
| 1  | 1  | 1  | 4         |

DG409

LOGIC "0"  $V_{AL} \leq 0.8V$ , LOGIC "1"  $V_{AH} \geq 2.4V$

# Improved, 8-Channel/Dual 4-Channel, CMOS Analog Multiplexers

DG408/DG409

## Ordering Information (continued)

| PART            | TEMP RANGE      | PIN-PACKAGE    |
|-----------------|-----------------|----------------|
| DG408DK         | -40°C to +85°C  | 16 Cerdip      |
| DG408AK         | -55°C to +125°C | 16 Cerdip**    |
| DG408MY/PR      | -55°C to +125°C | 16 SO***       |
| DG408MY/PR-T    | -55°C to +125°C | 16 SO***       |
| <b>DG409CUE</b> | 0°C to +70°C    | 16 TSSOP       |
| DG409CJ         | 0°C to +70°C    | 16 Plastic DIP |
| DG409CY         | 0°C to +70°C    | 16 Narrow SO   |
| DG409C/D        | 0°C to +70°C    | Dice*          |
| DG409EUE        | -40°C to +85°C  | 16 TSSOP       |
| DG409DJ         | -40°C to +85°C  | 16 Plastic DIP |
| DG409DK         | -40°C to +85°C  | 16 Cerdip      |
| DG409AK         | -55°C to +125°C | 12 Cerdip**    |
| DG409MY/PR      | -55°C to +125°C | 16 SO***       |
| DG409MY/PR-T    | -55°C to +125°C | 16 SO***       |

\*Contact factory for dice specifications.

\*\*Contact factory for availability and processing to MIL-STD-883.

## Package Information

For the latest package outline information and land patterns, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).

| PACKAGE TYPE   | PACKAGE CODE | DOCUMENT NO.            |
|----------------|--------------|-------------------------|
| 16 TSSOP       | U16-1        | <a href="#">21-0066</a> |
| 16 Plastic DIP | P16-2        | <a href="#">21-0043</a> |
| 16 Narrow SO   | S16-5        | <a href="#">21-0041</a> |
| 16 SO          | S16-5        | <a href="#">21-0041</a> |
| 16 Cerdip      | J16-3        | <a href="#">21-0590</a> |

# Improved, 8-Channel/Dual 4-Channel, High-Performance, CMOS Analog Multiplexers

## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION                                   | PAGES<br>CHANGED |
|--------------------|------------------|-----------------------------------------------|------------------|
| 3                  | 8/02             | Changed operating voltage and TSSOP packaging | —                |
| 4                  | 9/08             | Added rugged plastic information              | 1, 11            |

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.

12 **Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600**

© 2008 Maxim Integrated Products

**MAXIM** is a registered trademark of Maxim Integrated Products, Inc.