



# Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

DG406/DG407

## General Description

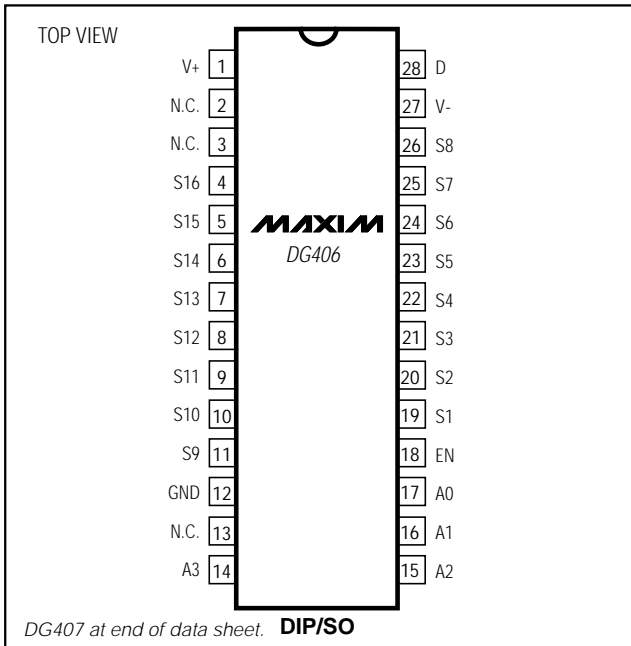
Maxim's redesigned DG406 and DG407 CMOS analog multiplexers now feature guaranteed matching between channels (8Ω max) and flatness over the specified signal range (9Ω max). These low on-resistance muxes (100Ω max) conduct equally well in either direction and feature guaranteed low charge injection (15pC max). In addition, these new muxes offer low input off-leakage current over temperature—less than 5nA at +85°C.

The DG406 is a 1 of 16 multiplexer/demultiplexer and the DG407 is a dual 8-channel multiplexer/demultiplexer. Both muxes operate with a +4.5V to +30V single supply and with ±4.5V to ±20V dual supplies. ESD protection is guaranteed to be greater than 2000V per Method 3015.7 of MIL-STD 883. These improved muxes are pin-compatible plug-in upgrades for the industry standard DG406 and DG407.

## Applications

- Sample-and-Hold Circuits
- Test Equipment
- Guidance and Control Systems
- Communications Systems
- Data-Acquisition Systems
- Audio Signal Routing

## Pin Configurations



## Features

- ◆ Pin-Compatible Plug-In Upgrade for Industry Standard DG406/DG407
- ◆ Guaranteed Matching Between Channels, 8Ω Max
- ◆ Guaranteed On-Resistance Flatness, 9Ω Max
- ◆ Guaranteed Low Charge Injection, 15pC Max
- ◆ Low On-Resistance 100Ω Max
- ◆ Input Leakage, 5nA Max at +85°C
- ◆ Low Power Consumption, 1.25mW Max
- ◆ Rail-to-Rail Signal Handling
- ◆ Digital Input Controls TTL/CMOS Compatible
- ◆ ESD Protection >2000V per Method 3015.7

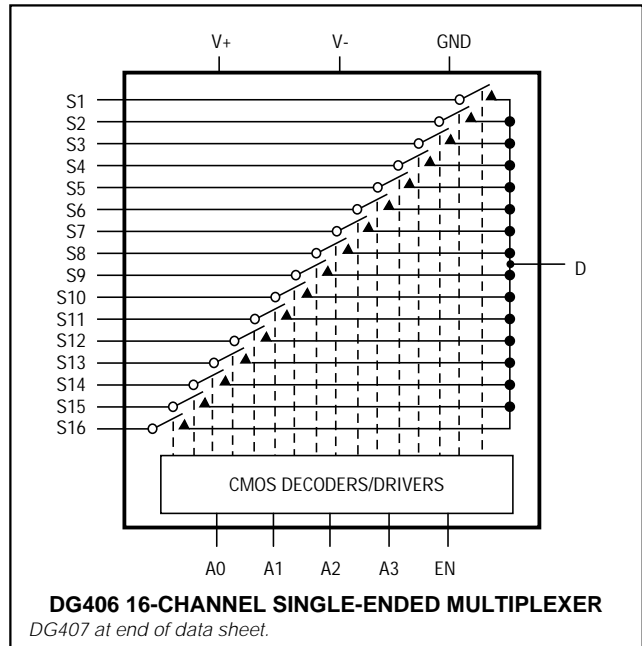
## Ordering Information

| PART     | TEMP. RANGE     | PIN-PACKAGE    |
|----------|-----------------|----------------|
| DG406CJ  | 0°C to +70°C    | 28 Plastic DIP |
| DG406CWI | 0°C to +70°C    | 28 Wide SO     |
| DG406C/D | 0°C to +70°C    | Dice*          |
| DG406DJ  | -40°C to +85°C  | 28 Plastic DIP |
| DG406DWI | -40°C to +85°C  | 28 Wide SO     |
| DG406DN  | -40°C to +85°C  | 28 PLCC        |
| DG406AK  | -55°C to +125°C | 28 CERDIP      |

Ordering Information continued at end of data sheet.

\* Contact factory for dice specifications.

## Functional Diagrams



# Improved, 16-Channel/Dual 8-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 or D (pulsed at 1ms, 10% duty cycle max) | 100mA   |
| Continuous Power Dissipation (TA = +70°C)                |   |
| Plastic DIP (derate 9.09mW/°C above +70°C)               | 727mW   |

|   |                 |
|---|-----------------|
| Wide SO (derate 12.50mW/°C above +70°C) | 1000mW          |
| PLCC (derate 10.53mW/°C above +70°C)    | 842mW           |
| CERDIP (derate 16.67mW/°C above +70°C)  | 1333mW          |
| Operating Temperature Ranges            |                 |
| DG406/DG407C_                           | 0°C to +70°C    |
| DG406/DG407D_                           | -40°C to +85°C  |
| DG406/DG407AK                           | -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>, A0, A1, A2, A3, or EN exceeding V+ or V- 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+ = 15V, V- = -15V, GND = 0V, VAH = +2.4V, VAL = +0.8V, TA = TMIN to TMAX, unless otherwise noted.)

| PARAMETER                               | SYMBOL          | CONDITIONS                                    |                   | MIN               | TYP (Note 2) | MAX  | UNITS |    |
|---|-----------------|---|-------------------|-------------------|--------------|------|-------|----|
| <b>SWITCH</b>                           |                 |   |                   |                   |              |      |       |    |
| Analog Signal Range                     | VANALOG         | (Note 3)                                      |                   | -15               |              | 15   | V     |    |
| Drain-Source On-Resistance              | rDS(ON)         | IS = -1.0mA, VD = ±10V                        | TA = +25°C        | 60                |              | 100  | Ω     |    |
|   |                 |   | TA = TMIN to TMAX |                   |              | 125  |       |    |
| On-Resistance Matching Between Channels | ΔrDS(ON)        | IS = -1.0mA, VD = ±10V (Note 4)               | TA = +25°C        | 1.5               |              | 8    | Ω     |    |
|   |                 |   | TA = TMIN to TMAX |                   |              | 10   |       |    |
| On-Resistance Flatness                  | rFLAT           | IS = -1.0mA, VD = ±5V or 0V                   | TA = +25°C        | 1.8               |              | 9    | Ω     |    |
|   |                 |   | TA = TMIN to TMAX |                   |              | 12   |       |    |
| Source-Off Leakage Current (Note 5)     | IS(OFF)         | VD = ∓10V, VS = ±10V, VEN = 0V                | TA = +25°C        | -0.5              | 0.01         | 0.5  | nA    |    |
|   |                 |   | TA = TMIN to TMAX | C, D              | -5           |      |       | 5  |
|   |                 |   |                   | A                 | -50          |      |       | 50 |
| Drain-Off Leakage Current (Note 5)      | ID(OFF)         | VD = ±10V, VS = ∓10V, VEN = 0V                | DG406             | TA = +25°C        | -1           | 0.02 | 1     | nA |
|   |                 |   |                   | TA = TMIN to TMAX | C, D         | -40  |       |    |
|   |                 |   | A                 |                   | -200         |      | 200   |    |
|   |                 | DG407   | TA = +25°C        | -1                | 0.02         | 1    |       |    |
|   |                 |   | TA = TMIN to TMAX | C, D              | -20          |      | 20    |    |
|   |                 |   |                   | A                 | -100         |      | 100   |    |
| Drain-On Leakage Current (Note 5)       | ID(ON) + IS(ON) | VD = ±10V, VS = ±10V, sequence each switch on | DG406             | TA = +25°C        | -1           | 0.02 | 1     | nA |
|   |                 |   |                   | TA = TMIN to TMAX | C, D         | -40  |       |    |
|   |                 |   | A                 |                   | -200         |      | 200   |    |
|   |                 | DG407   | TA = +25°C        | -1                | 0.02         | 1    |       |    |
|   |                 |   | TA = TMIN to TMAX | C, D              | -20          |      | 20    |    |
|   |                 |   |                   | A                 | -100         |      | 100   |    |

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## 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 |
|---------------------------------------|---|--|---|------------------------|-----------------|-----|-------|
| <b>INPUT</b>                          |   |  |   |                        |                 |     |       |
| 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,<br>V <sub>A</sub> = 0V   |   | -1.0                   |                 | 1.0 | μA    |
| <b>SUPPLY</b>                         |   |  |   |                        |                 |     |       |
| Power-Supply Range                    |   |  |   | ±4.5                   |                 | ±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,<br>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> |                        |                 | 1   |       |
| Negative Supply Current               | I <sub>-</sub>                                | V <sub>EN</sub> = 2.4V,<br>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 |       |
| <b>DYNAMIC</b>                        |   |  |   |                        |                 |     |       |
| Transition Time                       | t <sub>TRANS</sub>                            | Figure 2   | T <sub>A</sub> = +25°C                                |                        | 110             | 300 | ns    |
|                                       |   |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |                        |                 | 400 |       |
| 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                                |                        | 130             | 200 | ns    |
|                                       |   |  | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |                        |                 | 400 |       |
| Enable Turn-Off Time                  | t <sub>OFF(EN)</sub>                          | Figure 3   | T <sub>A</sub> = +25°C                                |                        | 55              | 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,<br>V <sub>S</sub> = 0V,<br>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,<br>R <sub>L</sub> = 1kΩ,<br>f = 100kHz, Figure 6   | T <sub>A</sub> = +25°C                                |                        | -69             |     | dB    |
| Crosstalk Between Channels            | V <sub>CT</sub>                               | V <sub>EN</sub> = 2.4V,<br>f = 100kHz,<br>V <sub>GEN</sub> = 1V <sub>P-P</sub> ,<br>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,<br>V <sub>EN</sub> = V <sub>S</sub> = 0V,<br>Figure 8  | T <sub>A</sub> = +25°C                                |                        | 8               |     | pF    |
| Drain-Off Capacitance                 | C <sub>D(OFF)</sub>                           | f = 1MHz,<br>V <sub>EN</sub> = 0.8V,<br>V <sub>D</sub> = 0V,<br>Figure 8   | DG406   | T <sub>A</sub> = +25°C | 130             |     | pF    |
|                                       |   |  | DG407   |                        | 65              |     |       |
| Drain-Source On Capacitance           | C <sub>D(ON)</sub><br>+<br>C <sub>S(ON)</sub> | f = 1MHz,<br>V <sub>EN</sub> = 2.4V,<br>V <sub>D</sub> = 0V,<br>Figure 8   | DG406   | T <sub>A</sub> = +25°C | 140             |     | pF    |
|                                       |   |  | DG407   |                        | 70              |     |       |

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## 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 |
|----------------------------------|----------------------|---|-----|-----------------|-----|-------|
| <b>SWITCH</b>                    |                      |   |     |                 |     |       |
| 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<br>T <sub>A</sub> = +25°C                               |     | 120             | 175 | Ω     |
| <b>DYNAMIC</b>                   |                      |   |     |                 |     |       |
| Transition Time<br>(Note 3)      | t <sub>TRANS</sub>   | V <sub>S1</sub> = 8V,<br>V <sub>S16</sub> = 0V,<br>V <sub>A</sub> = 0V,<br>Figure 2<br>T <sub>A</sub> = +25°C |     | 130             | 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<br>T <sub>A</sub> = +25°C                          |     | 105             | 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<br>T <sub>A</sub> = +25°C                          |     | 80              | 300 | ns    |
| Charge Injection<br>(Note 3)     | Q                    | C <sub>L</sub> = 1.0nF,<br>V <sub>S1</sub> = 0V,<br>R <sub>S</sub> = 0Ω<br>T <sub>A</sub> = +25°C             |     | 2               | 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:** ΔR<sub>ON</sub> = R<sub>ON(MAX)</sub> - R<sub>ON(MIN)</sub>. 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.

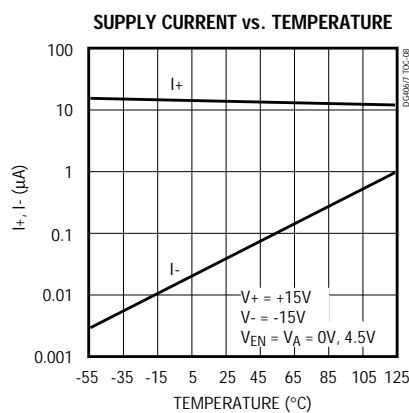
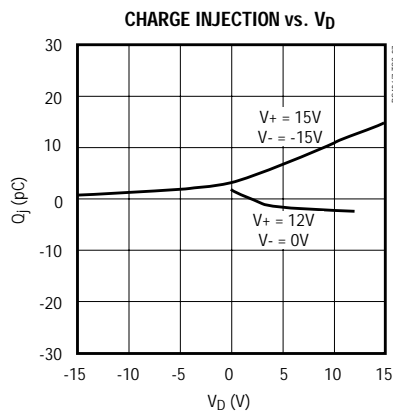
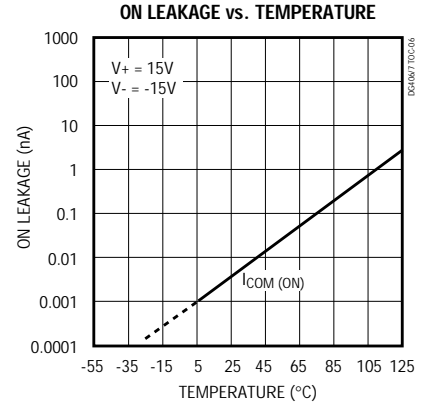
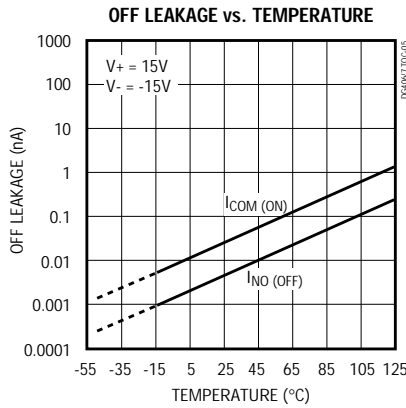
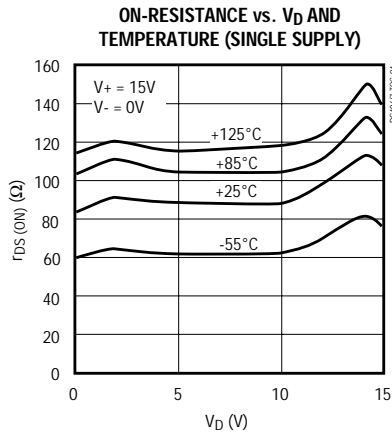
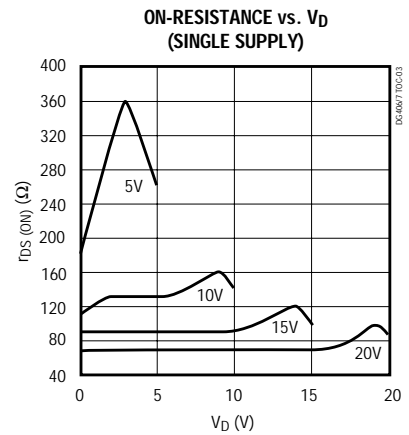
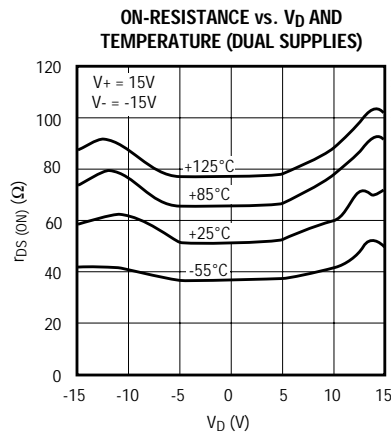
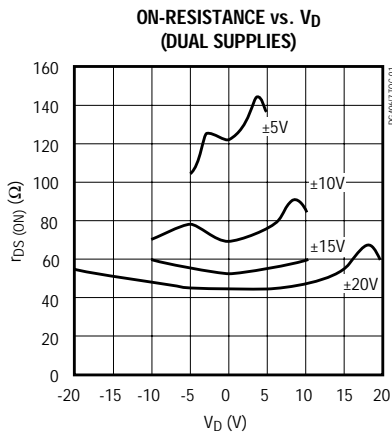
**Note 6:** Off isolation = 20log V<sub>D</sub>/V<sub>S</sub>, where V<sub>D</sub> = output and V<sub>S</sub> = input to off switch.

# Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

## Typical Operating Characteristics

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

DG406/DG407



# Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

## Pin Descriptions

| DG406 PIN | NAME   | FUNCTION                      |
|-----------|--------|-------------------------------|
| 1         | V+     | Positive Supply Voltage Input |
| 2, 3, 13  | N.C.   | No Internal Connections       |
| 4-11      | S16-S9 | Bidirectional Analog Inputs   |
| 12        | GND    | Ground                        |
| 14-17     | A3-A0  | Address Inputs                |
| 18        | EN     | Enable Inputs                 |
| 19-26     | S1-S8  | Bidirectional Analog Inputs   |
| 27        | V-     | Negative Supply Voltage Input |
| 28        | D      | Bidirectional Output          |

| DG407 PIN  | NAME       | FUNCTION                      |
|------------|------------|-------------------------------|
| 1          | V+         | Positive Supply Voltage Input |
| 2          | DB         | Bidirectional Output B        |
| 3, 13, 14  | N.C.       | No Internal Connection        |
| 4-11       | S8B-S1B    | Bidirectional Analog Inputs   |
| 12         | GND        | Ground                        |
| 15, 16, 17 | A2, A1, A0 | Address Inputs                |
| 18         | EN         | Enable Input                  |
| 19-26      | S1A-S8A    | Bidirectional Analog Inputs   |
| 27         | V-         | Negative Supply Voltage Input |
| 28         | DA         | Bidirectional Output A        |

## Applications Information

### Operation with Supply Voltages Other than $\pm 15V$

Using supply voltages other than  $\pm 15V$  reduces the analog signal range. The DG406/DG407 switches operate with  $\pm 4.5V$  to  $\pm 20V$  bipolar supplies or with a  $+4.5V$  to  $+30V$  single supply; connect V- to GND when operating with a single supply. Also, both device types can operate with unbalanced supplies such as  $+24V$  and  $-5V$ . 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 and analog signals. 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 above V+ and 1V below V-, but low switch resistance and low leakage characteristics are unaffected. Device operation is unchanged, and the difference between V+ and V- should not exceed +44V.

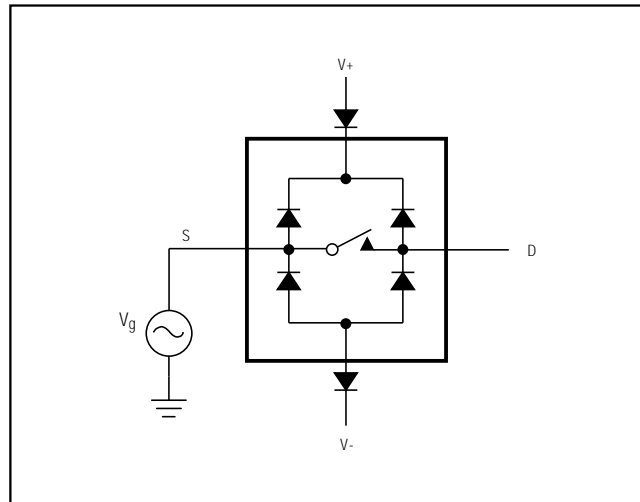


Figure 1. Overvoltage Protection Using External Blocking Diodes

# Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

## Test Circuits/Timing Diagrams

DG406/DG407

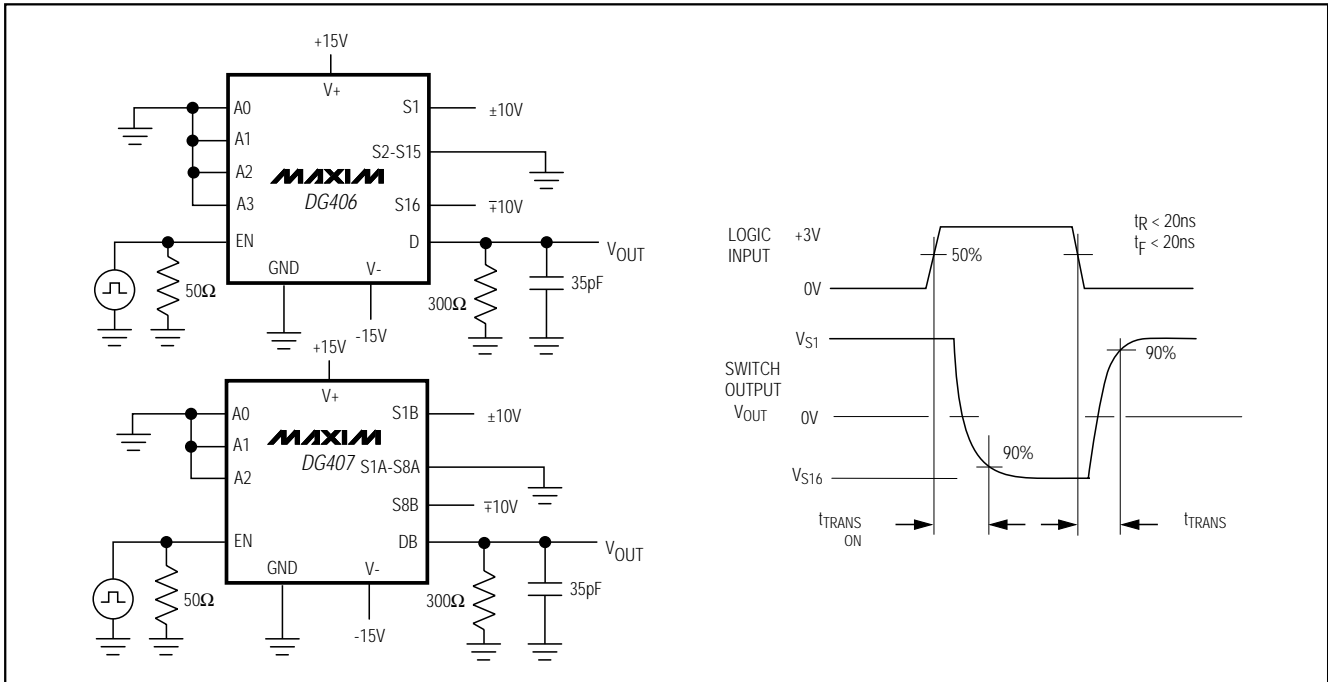


Figure 2. Transition Time

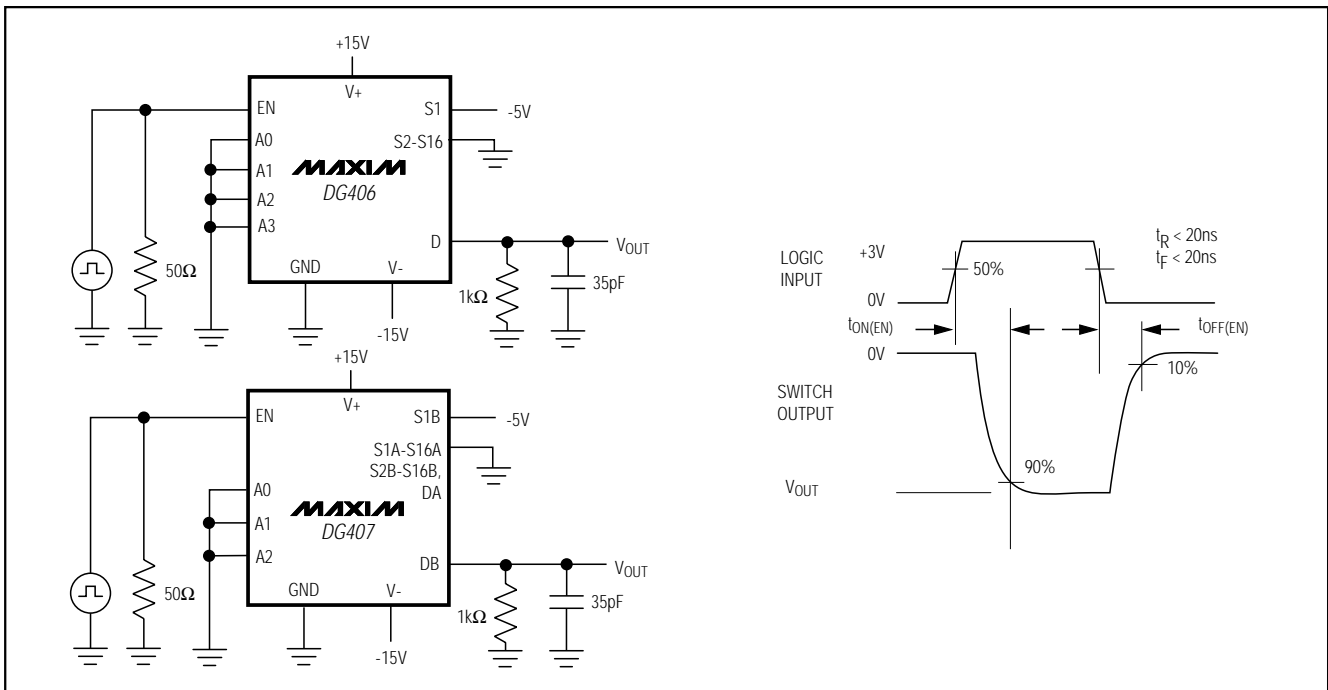


Figure 3. Enable Switching Time

# Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

Test Circuits/Timing Diagrams (continued)

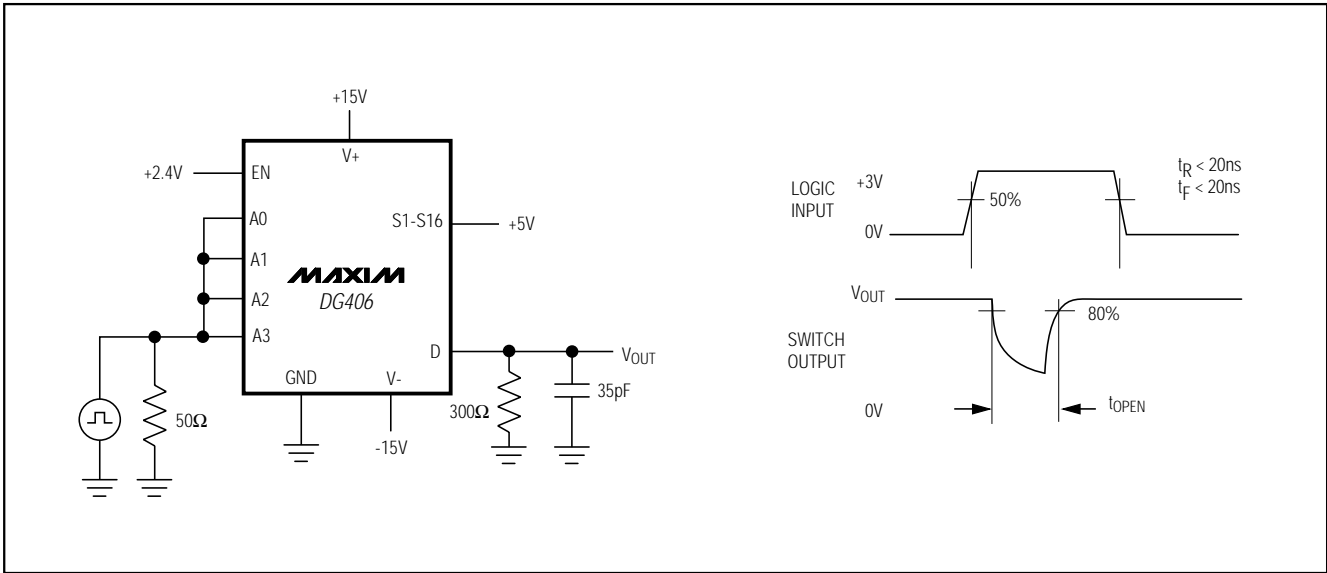


Figure 4. Break-Before-Make Interval

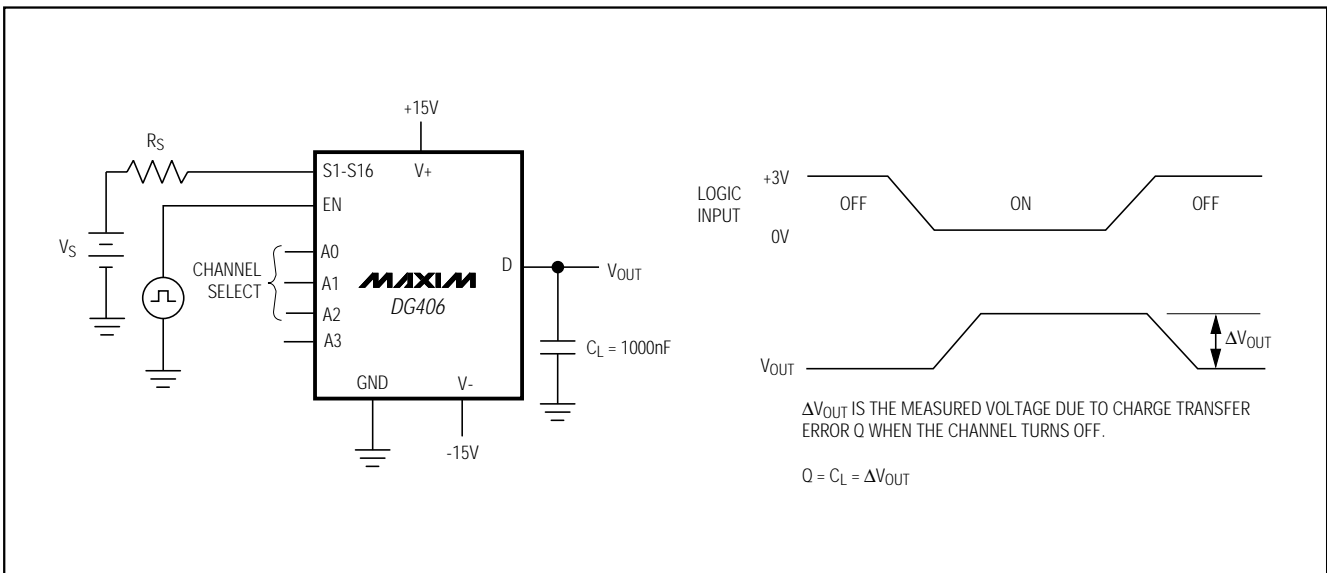


Figure 5. Charge Injection



# Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

Test Circuits/Timing Diagrams (continued)

DG406/DG407

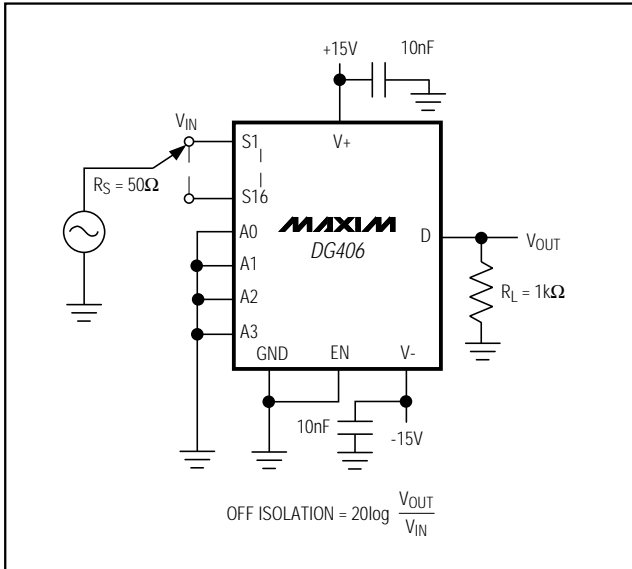


Figure 6. Off Isolation

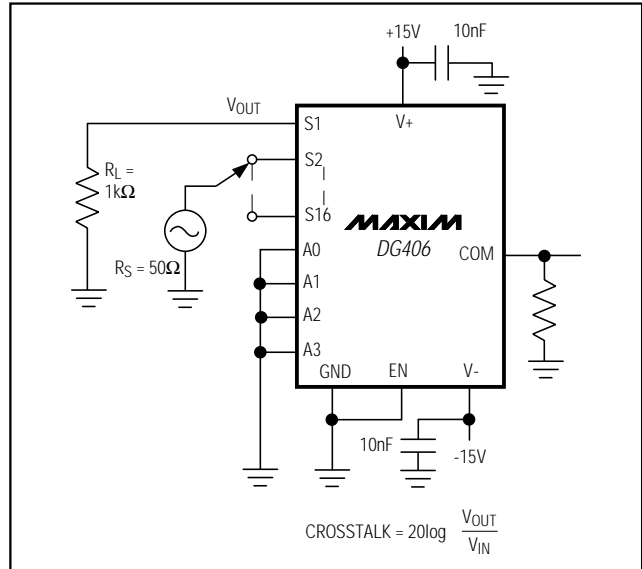


Figure 7. Crosstalk

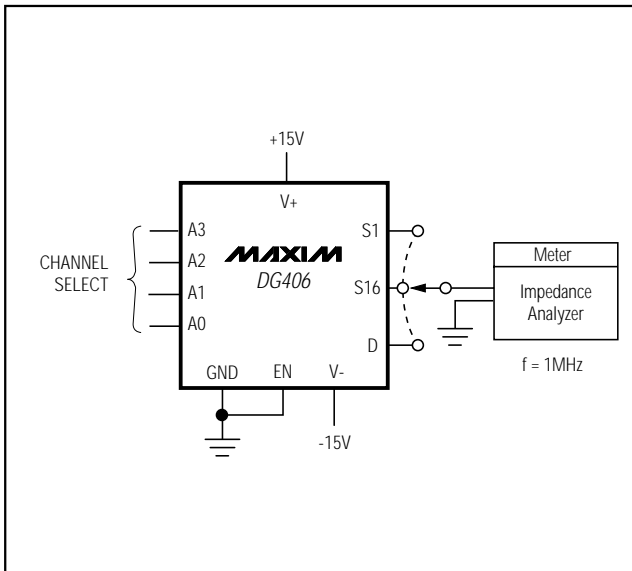
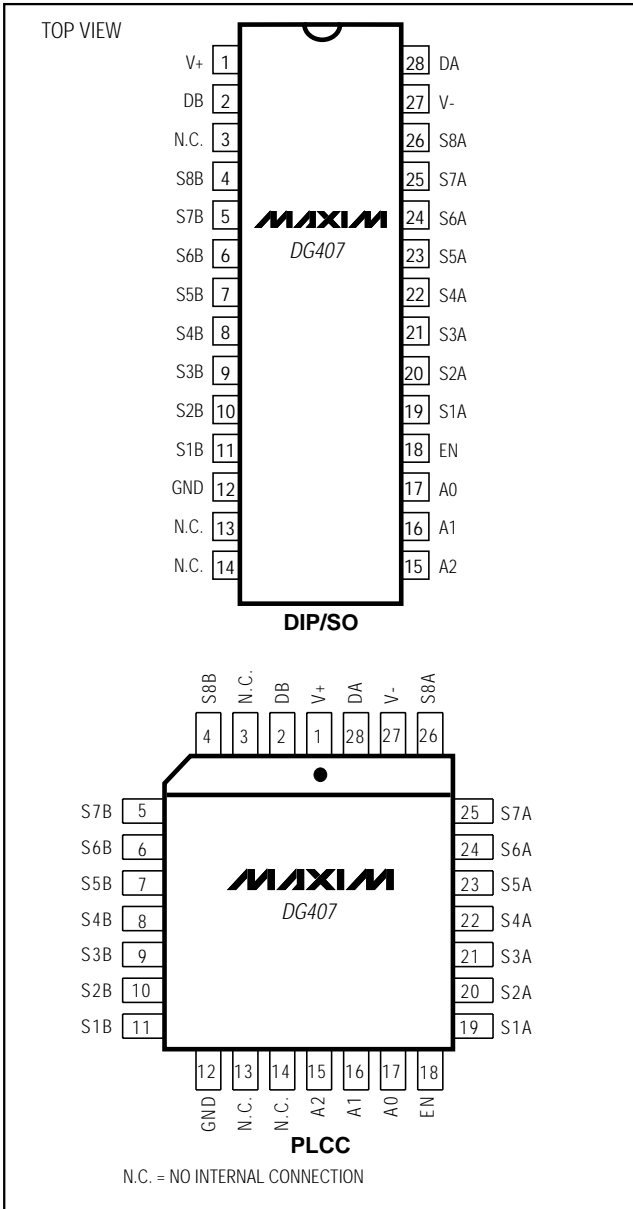


Figure 8. Source/Drain Capacitance

# Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

\_\_\_\_\_ Pin Configurations/Functional Diagrams/Truth Tables (continued)



| A3 | A2 | A1 | A0 | EN | ON Switch |
|----|----|----|----|----|-----------|
| X  | X  | X  | X  | 0  | None      |
| 0  | 0  | 0  | 0  | 1  | 1         |
| 0  | 0  | 0  | 1  | 1  | 2         |
| 0  | 0  | 1  | 0  | 1  | 3         |
| 0  | 0  | 1  | 1  | 1  | 4         |
| 0  | 1  | 0  | 0  | 1  | 5         |
| 0  | 1  | 0  | 1  | 1  | 6         |
| 0  | 1  | 1  | 0  | 1  | 7         |
| 0  | 1  | 1  | 1  | 1  | 8         |
| 1  | 0  | 0  | 0  | 1  | 9         |
| 1  | 0  | 0  | 1  | 1  | 10        |
| 1  | 0  | 1  | 0  | 1  | 11        |
| 1  | 0  | 1  | 1  | 1  | 12        |
| 1  | 1  | 0  | 0  | 1  | 13        |
| 1  | 1  | 0  | 1  | 1  | 14        |
| 1  | 1  | 1  | 0  | 1  | 15        |
| 1  | 1  | 1  | 1  | 1  | 16        |

DG406

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

| 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         |

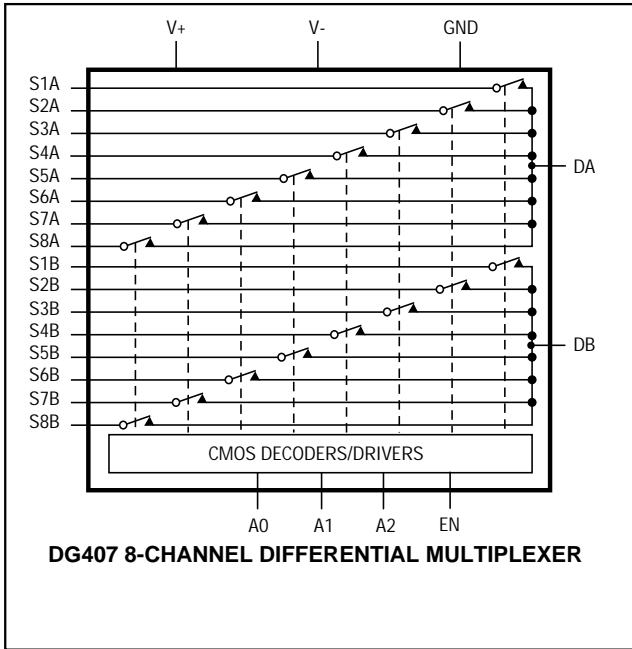
DG407

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

# Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

DG406/DG407

## \_Functional Diagrams (continued)



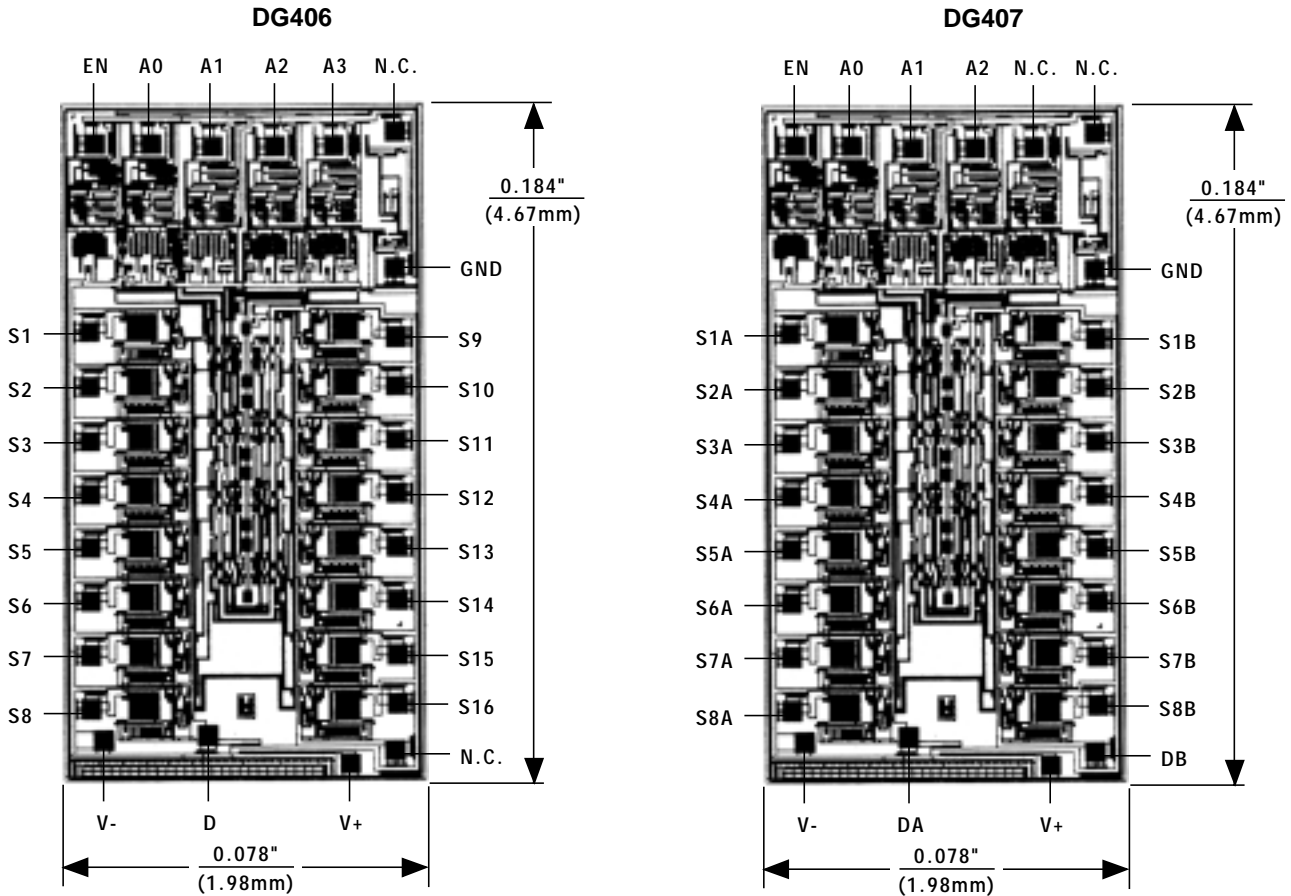
## \_Ordering Information (continued)

| PART           | TEMP. RANGE     | PIN-PACKAGE    |
|----------------|-----------------|----------------|
| <b>DG407CJ</b> | 0°C to +70°C    | 28 Plastic DIP |
| DG407CWI       | 0°C to +70°C    | 28 Wide SO     |
| DG407C/D       | 0°C to +70°C    | Dice*          |
| DG407DJ        | -40°C to +85°C  | 28 Plastic DIP |
| DG407DWI       | -40°C to +85°C  | 28 Wide SO     |
| DG407DN        | -40°C to +85°C  | 28 PLCC        |
| DG407AK        | -55°C to +125°C | 28 CERDIP      |

\* Contact factory for dice specifications.

# Improved, 16-Channel/Dual 8-Channel, CMOS Analog Multiplexers

Chip Topographies



N.C. = NO INTERNAL CONNECTION

TRANSISTOR COUNT: 269  
 SUBSTRATE IS INTERNALLY CONNECTED TO V+

TRANSISTOR COUNT: 269  
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