



# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## General Description

The MAX4708/MAX4709 8-to-1 and dual 4-to-1 fault-protected multiplexers are pin compatible with the industry-standard DG508/DG509. The MAX4708/MAX4709 are similar to the MAX4508/MAX4509, but these devices do not have clamp diodes to the supply rails on the switch outputs. These multiplexers feature fault-protected inputs, rail-to-rail signal-handling capability, and do not require power-supply sequencing.

Both devices offer  $\pm 40\text{V}$  overvoltage protection with the supplies off,  $\pm 36\text{V}$  protection with the supplies on, and feature  $400\Omega$  (max) on-resistance with  $15\Omega$  (max) matching between channels. The MAX4708/MAX4709 operate with dual supplies of  $\pm 4.5\text{V}$  to  $\pm 20\text{V}$  or a single supply of  $+9\text{V}$  to  $+36\text{V}$ . All digital inputs have TTL logic-compatible thresholds, ensuring both TTL and CMOS logic compatibility when using a single  $+12\text{V}$  supply or dual  $\pm 15\text{V}$  supplies.

For low-voltage applications requiring fault protection, refer to the MAX4711/MAX4712/MAX4713 data sheet.

## Applications

Data-Acquisition Systems  
Industrial and Process Control  
Avionics  
Signal Routing  
Redundancy/Backup Systems  
ATE Systems  
Hot Swap

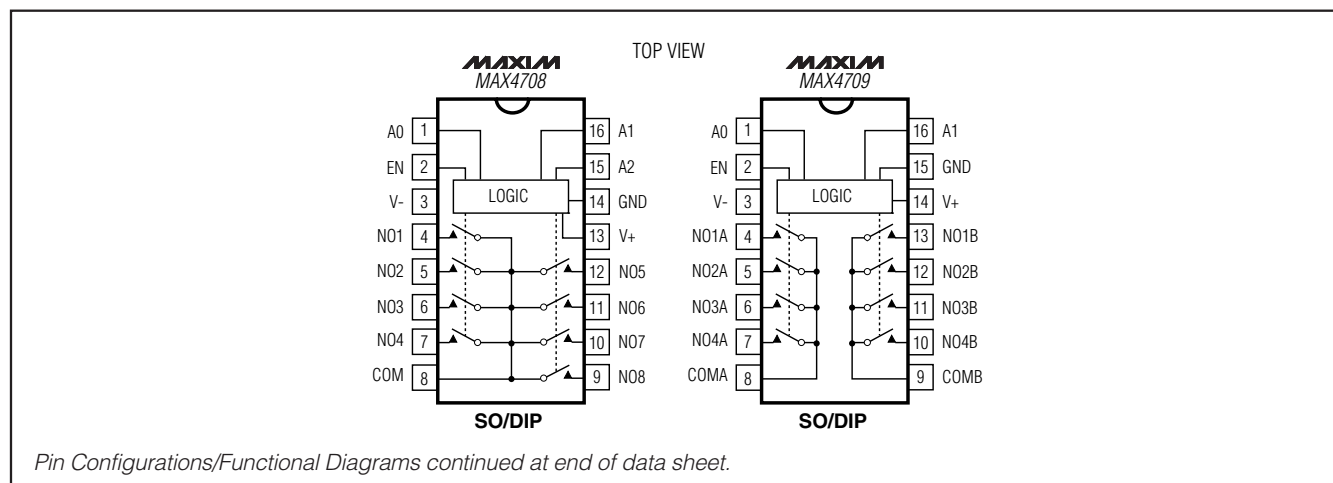
## Features

- ◆ No Power-Supply Sequencing Required
- ◆ All Channels Off with Power Off
- ◆ Rail-to-Rail Signal Handling
- ◆  $400\Omega$  (max) On-Resistance
- ◆  $\pm 40\text{V}$  Fault Protection with Power Off
- ◆  $\pm 25\text{V}$  Fault Protection with  $\pm 15\text{V}$  Supplies
- ◆ 100ns Fault-Response Time
- ◆  $\pm 4.5\text{V}$  to  $\pm 20\text{V}$  Dual Supplies
- ◆  $+9\text{V}$  to  $+36\text{V}$  Single Supply
- ◆ TTL/CMOS-Compatible Logic Inputs

## Ordering Information

| PART       | TEMP RANGE                                     | PIN-PACKAGE    |
|------------|--|----------------|
| MAX4708ESE | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 16 Narrow SO   |
| MAX4708EWE | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 16 Wide SO     |
| MAX4708EPE | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 16 Plastic DIP |
| MAX4709ESE | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 16 Narrow SO   |
| MAX4709EWE | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 16 Wide SO     |
| MAX4709EPE | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 16 Plastic DIP |

## Pin Configurations/Functional Diagrams



# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## ABSOLUTE MAXIMUM RATINGS

(All Voltages Referenced to GND)

|  |                            |
|--|----------------------------|
| V+ .....   | -0.3V to +44.0V            |
| V- .....   | -44.0V to +0.3V            |
| V+ to V-.....  | -0.3V to +44.0V            |
| COM_, A_, EN (Note 1).....   | (V+ + 0.3V) to (V- - 0.3V) |
| NO_.....   | (V+ - 40V) to (V- + 40V)   |
| NO_ to COM_ .....  | -36V to +36V               |
| NO_ Voltage with Switch Power On .....                                 | -30V to +30V               |
| NO_ Voltage with Switch Power Off .....                                | -40V to +40V               |
| Continuous Current into any Terminal.....                              | ±30mA                      |
| Peak Current into any Terminal<br>(pulsed at 1ms, 10% duty cycle)..... | ±100mA                     |

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

|  |                 |
|--|-----------------|
| 16 Narrow SO (derate 8.70mW/°C above +70°C) .....    | 696mW           |
| 16 Plastic DIP (derate 10.53mW/°C above +70°C) ..... | 842mW           |
| 16 Wide SO (derate 9.52mW/°C above +70°C).....       | 762mW           |
| Operating Temperature Range                          |                 |
| MAX4708E_E/MAX4709E_E .....                          | -40°C to +85°C  |
| Junction Temperature .....                           | +150°C          |
| Storage Temperature Range .....                      | -65°C to +160°C |
| Lead Temperature (soldering, 10s) .....              | +300°C          |

**Note 1:** COM\_, EN, and A\_ pins are not fault protected. Signals on COM\_, EN, or A\_ exceeding V+ or V- are clamped by internal diodes. Limit forward-diode current to maximum current rating.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS—Dual Supplies

(V+ = +15V, V- = -15V, V<sub>A\_H</sub> = +2.4V, V<sub>A\_L</sub> = +0.8V, V<sub>EN</sub> = +2.4V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                            | SYMBOL                 | CONDITIONS  | T <sub>A</sub> | MIN   | TYP | MAX  | UNITS |    |
|--------------------------------------|------------------------|---|----------------|-------|-----|------|-------|----|
| <b>ANALOG SWITCH</b>                 |                        |   |                |       |     |      |       |    |
| Fault-Free Analog Signal Range       | V <sub>NO_</sub>       | (Notes 3, 4)  | E              | V-    |     | V+   | V     |    |
| On-Resistance                        | R <sub>ON</sub>        | V <sub>COM_</sub> = ±10V, I <sub>NO_</sub> = 0.2mA                      | +25°C          |       | 300 | 400  | Ω     |    |
|                                      |                        |   | E              |       |     | 500  |       |    |
| On-Resistance Match Between Channels | ΔR <sub>ON</sub>       | V <sub>COM_</sub> = ±10V, I <sub>NO_</sub> = 0.2mA (Note 5)             | +25°C          |       |     | 15   | Ω     |    |
|                                      |                        |   | E              |       |     | 20   |       |    |
| NO_ Off-Leakage Current              | I <sub>NO_(OFF)</sub>  | V <sub>COM_</sub> = ±10V, V <sub>NO_</sub> = ±10V (Note 6)              | +25°C          | -0.5  |     | +0.5 | nA    |    |
|                                      |                        |   | E              | -5    |     | +5   |       |    |
| COM_ Off-Leakage Current             | I <sub>COM_(OFF)</sub> | V <sub>COM_</sub> = ±10V, V <sub>NO_</sub> = ±10V (Note 6)              | MAX4708        | +25°C | -2  |      | +2    | nA |
|                                      |                        |   |                | E     | -20 |      | +20   |    |
|                                      |                        |   | MAX4709        | +25°C | -1  |      | +1    |    |
|                                      |                        |   |                | E     | -10 |      | +10   |    |
| COM_ On-Leakage Current              | I <sub>COM_(ON)</sub>  | V <sub>COM_</sub> = ±10V, V <sub>NO_</sub> = ±10V, or floating (Note 6) | MAX4708        | +25°C | -2  |      | +2    | nA |
|                                      |                        |   |                | E     | -25 |      | +25   |    |
|                                      |                        |   | MAX4709        | +25°C | -1  |      | +1    |    |
|                                      |                        |   |                | E     | -15 |      | +15   |    |

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

MAX4708/MAX4709

## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V<sub>+</sub> = +15V, V<sub>-</sub> = -15V, V<sub>A\_H</sub> = +2.4V, V<sub>A\_L</sub> = +0.8V, V<sub>EN</sub> = +2.4V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER  | SYMBOL             | CONDITIONS  | T <sub>A</sub> | MIN                     | TYP | MAX                     | UNITS |
|--|--------------------|---|----------------|-------------------------|-----|-------------------------|-------|
| <b>FAULT PROTECTION</b>                              |                    |   |                |                         |     |                         |       |
| Fault-Protected Analog Signal Range (Notes 3, 4)     | V <sub>NO_</sub>   | Power on  | +25°C          | -25                     |     | +25                     | V     |
|  |                    | Power off   |                | -40                     |     | +40                     |       |
| COM <sub>-</sub> Output Leakage Current, Supplies On | I <sub>COM_</sub>  | V <sub>NO_</sub> = ±25V, V <sub>EN</sub> = 0  | +25°C          | -1                      |     | +1                      | μA    |
|  |                    |   | E              | -10                     |     | +10                     |       |
| NO <sub>-</sub> Input Leakage Current, Supplies On   | I <sub>NO_</sub>   | V <sub>NO_</sub> = ±25V, V <sub>COM_</sub> = ±10V, V <sub>EN</sub> = 0  | +25°C          | -1                      |     | +1                      | μA    |
|  |                    |   | E              | -10                     |     | +10                     |       |
| NO <sub>-</sub> Input Leakage Current, Supplies Off  | I <sub>NO_</sub>   | V <sub>NO_</sub> = ±40V, V <sub>COM_</sub> = 0, V <sub>+</sub> = 0, V <sub>-</sub> = 0                          | +25°C          | -1                      |     | +1                      | μA    |
|  |                    |   | E              | -10                     |     | +10                     |       |
| Fault-Trip Threshold                                 |                    |   | E              | V <sub>-</sub><br>- 0.4 |     | V <sub>+</sub><br>+ 0.4 | V     |
| ±Fault Output Turn-Off Delay                         |                    | R <sub>L</sub> = 10kΩ, V <sub>NO_</sub> = ±25V  | +25°C          |                         | 100 |                         | ns    |
| ±Fault Recovery Time                                 |                    | R <sub>L</sub> = 10kΩ, V <sub>NO_</sub> = ±25V  | +25°C          |                         | 1.5 |                         | μs    |
| <b>LOGIC INPUT (V<sub>EN</sub>, V<sub>A_</sub>)</b>  |                    |   |                |                         |     |                         |       |
| Logic Threshold High                                 | V <sub>IH</sub>    |   | E              | 2.4                     |     |                         | V     |
| Logic Threshold Low                                  | V <sub>IL</sub>    |   | E              |                         |     | 0.8                     | V     |
| Input Leakage Current                                | I <sub>IN</sub>    | V <sub>A_</sub> = 0.8V or 2.4V  | E              | -1                      |     | +1                      | μA    |
| <b>SWITCH DYNAMIC CHARACTERISTICS</b>                |                    |   |                |                         |     |                         |       |
| Enable Turn-On Time                                  | t <sub>ON</sub>    | V <sub>NO_</sub> = ±10V, R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 35pF, Figure 3 (Note 7)                         | +25°C          |                         | 160 | 275                     | ns    |
|  |                    |   | E              |                         |     | 400                     |       |
| Enable Turn-Off Time                                 | t <sub>OFF</sub>   | V <sub>NO_</sub> = ±10V, R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 35pF, Figure 3 (Note 7)                         | +25°C          |                         | 120 | 200                     | ns    |
|  |                    |   | E              |                         |     | 250                     |       |
| Transition Time                                      | t <sub>TRANS</sub> | R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 35pF, Figure 2 (Note 7)  | +25°C          |                         | 170 | 350                     | ns    |
|  |                    |   | E              |                         |     | 500                     |       |
| Settling Time  | t <sub>SETT</sub>  | V <sub>NO_</sub> = 5V, R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 35pF  | E              | 0.1%                    | 1   |                         | μs    |
|  |                    |   |                | 0.01%                   | 2.5 |                         |       |
| Break-Before-Make Time Delay                         | t <sub>BBM</sub>   | V <sub>NO_</sub> = ±10V, R <sub>L</sub> = 1kΩ, Figure 4 (Note 4)  | E              | 10                      | 80  |                         | ns    |
| Charge Injection                                     | Q                  | V <sub>NO_</sub> = 0, R <sub>S</sub> = 0, C <sub>L</sub> = 1.0nF, Figure 5                                      | +25°C          |                         | 0   |                         | pC    |
| Off-Isolation  | V <sub>ISO</sub>   | f = 1MHz, V <sub>NO_</sub> = 1V <sub>RMS</sub> , R <sub>L</sub> = 75Ω, C <sub>L</sub> = 15pF, Figure 6 (Note 8) | +25°C          |                         | -70 |                         | dB    |

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +15V, V- = -15V, V<sub>AH</sub> = +2.4V, V<sub>AL</sub> = +0.8V, V<sub>EN</sub> = +2.4V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                    | SYMBOL                 | CONDITIONS  | T <sub>A</sub> | MIN   | TYP | MAX   | UNITS |
|------------------------------|------------------------|---|----------------|-------|-----|-------|-------|
| Channel-to-Channel Crosstalk | V <sub>CT</sub>        | f = 1MHz, V <sub>NO-</sub> = 1V <sub>RMS</sub> , R <sub>L</sub> = 75Ω, C <sub>L</sub> = 15pF, Figure 7 (Note 9) | +25°C          |       | -62 |       | dB    |
| NO_ Off-Capacitance          | C <sub>NO_(OFF)</sub>  | f = 1MHz, Figure 8  | +25°C          |       | 10  |       | pF    |
| COM_ Off-Capacitance         | C <sub>COM_(OFF)</sub> | f = 1MHz, Figure 8  | MAX4708        | +25°C |     | 19    | pF    |
|                              |                        |   | MAX4709        |       |     | 14    |       |
| COM_ On-Capacitance          | C <sub>COM_(ON)</sub>  | f = 1MHz, Figure 8  | MAX4708        | +25°C |     | 28    | pF    |
|                              |                        |   | MAX4709        |       |     | 22    |       |
| <b>POWER SUPPLY</b>          |                        |   |                |       |     |       |       |
| Power-Supply Range           | V+, V-                 |   | E              | ±4.5  |     | ±20.0 | V     |
| V+ Supply Current            | I+                     | All V <sub>A-</sub> = 0 or 5V, V <sub>NO-</sub> = 0, V <sub>EN</sub> = 5V                                       | +25°C          |       | 370 | 525   | μA    |
|                              |                        |   | E              |       |     | 750   |       |
| V- Supply Current            | I-                     | All V <sub>A-</sub> = 0 or 5V, V <sub>NO-</sub> = 0, V <sub>EN</sub> = 5V                                       | +25°C          |       | 200 | 300   | μA    |
|                              |                        |   | E              |       |     | 400   |       |
| GND Supply Current           | I <sub>GND</sub>       | All V <sub>A-</sub> = 0 or 5V, V <sub>NO-</sub> = 0, V <sub>EN</sub> = 5V                                       | +25°C          |       | 200 | 300   | μA    |
|                              |                        |   | E              |       |     | 500   |       |

## ELECTRICAL CHARACTERISTICS—Single +12V Supply

(V+ = +12V, V- = 0, V<sub>AH</sub> = +2.4V, V<sub>AL</sub> = +0.8V, V<sub>EN</sub> = +2.4V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                            | SYMBOL                 | CONDITIONS  | T <sub>A</sub> | MIN   | TYP  | MAX  | UNITS |    |
|--------------------------------------|------------------------|---|----------------|-------|------|------|-------|----|
| <b>ANALOG SWITCH</b>                 |                        |   |                |       |      |      |       |    |
| Fault-Free Analog Signal Range       | V <sub>NO-</sub>       | Power on or off (Note 3)  | E              | -0.3  |      | V+   | V     |    |
| On-Resistance                        | R <sub>ON</sub>        | V <sub>COM-</sub> = 10V, I <sub>NO-</sub> = 0.2mA                     | +25°C          |       | 630  | 950  | Ω     |    |
|                                      |                        |   | E              |       |      | 1100 |       |    |
| On-Resistance Match Between Channels | ΔR <sub>ON</sub>       | V <sub>COM-</sub> = 10V, I <sub>NO-</sub> = 0.2mA (Note 5)            | +25°C          |       | 10   | 35   | Ω     |    |
|                                      |                        |   | C, E           |       |      | 50   |       |    |
| NO_ Off-Leakage Current              | I <sub>NO_(OFF)</sub>  | V <sub>COM-</sub> = 10V, 1V, V <sub>NO-</sub> = 1V, 10V (Notes 6, 10) | +25°C          | -0.5  | 0.01 | +0.5 | nA    |    |
|                                      |                        |   | E              | -10   |      | +10  |       |    |
| COM_ Off-Leakage Current             | I <sub>COM_(OFF)</sub> | V <sub>COM-</sub> = 10V, 1V, V <sub>NO-</sub> = 1V, 10V (Notes 6, 10) | MAX4708        | +25°C | -2   |      | +2    | nA |
|                                      |                        |   |                | E     | -20  |      | +20   |    |
|                                      |                        |   | MAX4709        | +25°C | -1   |      | +1    |    |
|                                      |                        |   |                | E     | -10  |      | +10   |    |

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

**MAX4708/MAX4709**

## ELECTRICAL CHARACTERISTICS—Single +12V Supply (continued)

(V<sub>+</sub> = +12V, V<sub>-</sub> = 0, V<sub>A\_H</sub> = +2.4V, V<sub>A\_L</sub> = +0.8V, V<sub>EN</sub> = +2.4V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER   | SYMBOL                 | CONDITIONS   | T <sub>A</sub> | MIN   | TYP  | MAX | UNITS |    |
|---|------------------------|--|----------------|-------|------|-----|-------|----|
| COM_ On-Leakage Current                             | I <sub>COM_(ON)</sub>  | V <sub>COM_</sub> = 10V, 1V;<br>V <sub>NO_</sub> = 10V, 1V, or<br>floating (Notes 6, 10) | MAX4708        | +25°C | -2   |     | +2    | nA |
|   |                        |  |                | E     | -25  |     | +25   |    |
|   |                        |  | MAX4709        | +25°C | -1   |     | +1    |    |
|   |                        |  |                | E     | -15  |     | +15   |    |
| <b>FAULT PROTECTION</b>                             |                        |  |                |       |      |     |       |    |
| Fault-Protected Analog Signal Range (Notes 3, 10)   | V <sub>NO_</sub>       | Power on   | E              | -36   |      | +36 | V     |    |
|   |                        | Power off  |                | -40   |      | +40 |       |    |
| COM_ Output Leakage Current, Supplies On            | I <sub>COM_</sub>      | V <sub>NO_</sub> = ±36V, V <sub>+</sub> = 12V (Notes 3, 10)                              | +25°C          | -1    |      | +1  | μA    |    |
|   |                        |  | E              | -10   |      | +10 |       |    |
| NO_ Input Leakage Current, Supplies On              | I <sub>NO_</sub>       | V <sub>NO_</sub> = ±36V, V <sub>COM_</sub> = 0, V <sub>+</sub> = 12V (Notes 3, 10)       | +25°C          | -1    |      | +1  | μA    |    |
|   |                        |  | E              | -10   |      | +10 |       |    |
| NO_ Input Leakage Current, Supply Off               | I <sub>NO_</sub>       | V <sub>NO_</sub> = ±40V, V <sub>+</sub> = 0, V <sub>-</sub> = 0 (Notes 3, 10)            | +25°C          | -1    |      | +1  | μA    |    |
|   |                        |  | E              | -10   |      | +10 |       |    |
| <b>LOGIC INPUT (V<sub>EN</sub>, V<sub>A_</sub>)</b> |                        |  |                |       |      |     |       |    |
| Logic Threshold High                                | V <sub>IH</sub>        |  | E              | 2.4   |      |     | V     |    |
| Logic Threshold Low                                 | V <sub>IL</sub>        |  | E              |       |      | 0.8 | V     |    |
| Input Leakage Current                               | I <sub>IN</sub>        | V <sub>A_</sub> = 0.8V or 2.4V   | E              | -1    | 0.03 | +1  | μA    |    |
| <b>SWITCH-DYNAMIC CHARACTERISTICS</b>               |                        |  |                |       |      |     |       |    |
| Enable Turn-On Time                                 | t <sub>ON</sub>        | V <sub>COM_</sub> = 10V, R <sub>L</sub> = 2kΩ, C <sub>L</sub> = 35pF, Figure 3 (Note 7)  | +25°C          |       | 240  | 500 | ns    |    |
|   |                        |  | E              |       |      | 700 |       |    |
| Enable Turn-Off Time                                | t <sub>OFF</sub>       | V <sub>COM_</sub> = 10V, R <sub>L</sub> = 2kΩ, C <sub>L</sub> = 35pF, Figure 3 (Note 7)  | +25°C          |       | 100  | 250 | ns    |    |
|   |                        |  | E              |       |      | 350 |       |    |
| Transition Time                                     | t <sub>TRANS</sub>     | R <sub>L</sub> = 2kΩ, C <sub>L</sub> = 35pF, Figure 2 (Note 7)                           | +25°C          |       | 180  | 400 | ns    |    |
|   |                        |  | E              |       |      | 600 |       |    |
| Settling Time                                       | t <sub>SETT</sub>      | V <sub>NO_</sub> = 5V, R <sub>L</sub> = 1kΩ, C <sub>L</sub> = 35pF                       | E              | 0.1%  | 1    |     | μs    |    |
|   |                        |  |                | 0.01% | 2.5  |     |       |    |
| Break-Before-Make Time Delay                        | t <sub>BBM</sub>       | V <sub>COM_</sub> = 10V, R <sub>L</sub> = 2kΩ, Figure 4 (Note 4)                         | +25°C          | 50    | 100  |     | ns    |    |
| Charge Injection                                    | Q                      | V <sub>NO_</sub> = 0, R <sub>S</sub> = 0, C <sub>L</sub> = 1.0 nF, Figure 5              | +25°C          |       | 2    |     | pC    |    |
| NO_ Off-Capacitance                                 | C <sub>NO_(OFF)</sub>  | f = 1MHz, V <sub>NO_</sub> = 0, Figure 8   | +25°C          |       | 5    |     | pF    |    |
| COM_ Off-Capacitance                                | C <sub>COM_(OFF)</sub> | f = 1MHz, V <sub>NO_</sub> = 0, Figure 8   | +25°C          |       | 5    |     | pF    |    |
| COM_ On-Capacitance                                 | C <sub>COM_(ON)</sub>  | f = 1MHz, V <sub>COM_</sub> = V <sub>NO_</sub> = 0, Figure 8                             | +25°C          |       | 28   |     | pF    |    |

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## ELECTRICAL CHARACTERISTICS—Single +12V Supply (continued)

( $V_+ = +12V$ ,  $V_- = 0$ ,  $V_{A\_H} = +2.4V$ ,  $V_{A\_L} = +0.8V$ ,  $V_{EN} = +2.4V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .) (Note 2)

| PARAMETER                    | SYMBOL    | CONDITIONS   | $T_A$         | MIN | TYP | MAX | UNITS   |
|------------------------------|-----------|--|---------------|-----|-----|-----|---------|
| Off-Isolation                | $V_{ISO}$ | $f = 1MHz$ , $V_{NO\_} = 1V_{RMS}$ , $R_L = 75\Omega$ , $C_L = 15pF$ , Figure 6 (Note 8) | $+25^\circ C$ |     | -70 |     | dB      |
| Channel-to-Channel Crosstalk | $V_{CT}$  | $f = 1MHz$ , $V_{NO\_} = 1V_{RMS}$ , $R_L = 75\Omega$ , $C_L = 15pF$ , Figure 7 (Note 9) | $+25^\circ C$ |     | -62 |     | dB      |
| <b>POWER SUPPLY</b>          |           |  |               |     |     |     |         |
| Power-Supply Range           | $V_+$     |  | E             | 9   |     | 36  | V       |
| V+ Supply Current            | I+        | All $V_{A\_} = V_{EN} = 5V$ , $V_{NO\_} = 0$   | $+25^\circ C$ |     | 180 | 300 | $\mu A$ |
|                              |           |  | E             |     |     | 450 |         |
|                              |           | All $V_{A\_} = 0$ or $V_+$ , $V_{NO\_} = 0$ , $V_{EN} = 0$ or $V_+$                      | $+25^\circ C$ |     | 112 | 250 |         |
|                              |           |  | E             |     |     | 375 |         |

**Note 2:** The algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

**Note 3:**  $NO\_$  pins are fault protected and  $COM\_$  pins are not fault protected. The max input voltage on  $NO\_$  pins depends on the  $COM\_$  load configuration. Generally, the max input voltage is  $\pm 36V$  with  $\pm 15V$  supplies and a load referred to ground. For more detailed information, see the *NO\_ Input Voltage* section.

**Note 4:** Guaranteed by design and not production tested.

**Note 5:**  $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$ .

**Note 6:** Leakage parameters are 100% tested at the maximum rated hot temperature and guaranteed by correlation at  $T_A = +25^\circ C$ .

**Note 7:** Dynamic testing is 100% functionally tested on the ATE system and correlated with the initial design characterization per Figures 2 and 3.

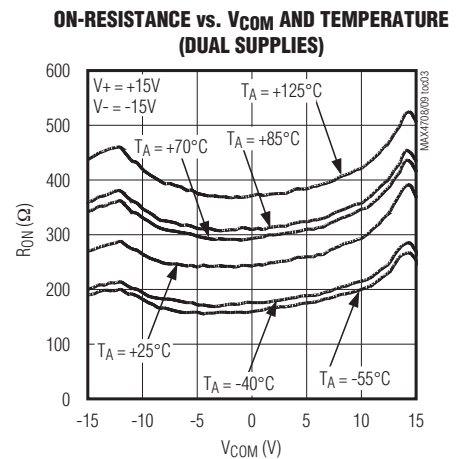
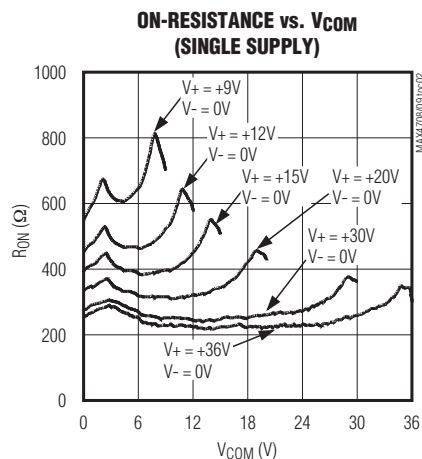
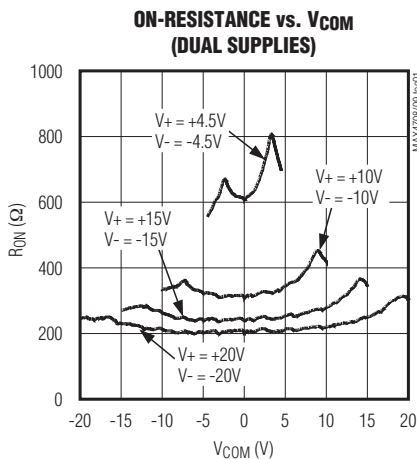
**Note 8:** Off-Isolation =  $20 \times \log_{10}(V_{COM\_} / V_{NO\_})$ , where  $V_{COM\_}$  = output and  $V_{NO\_}$  = input to open switch.

**Note 9:** Between any two analog inputs.

**Note 10:** Guaranteed by testing with dual supplies.

## Typical Operating Characteristics

( $V_+ = +15V$ ,  $V_- = -15V$ ,  $V_{EN} = +2.4V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



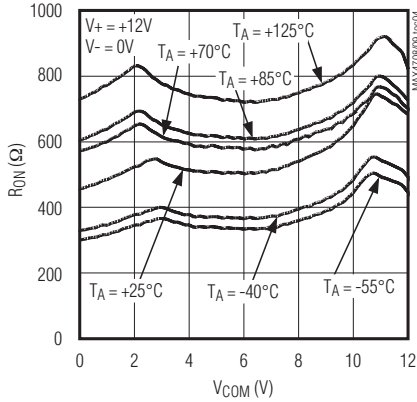
# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

MAX4708/MAX4709

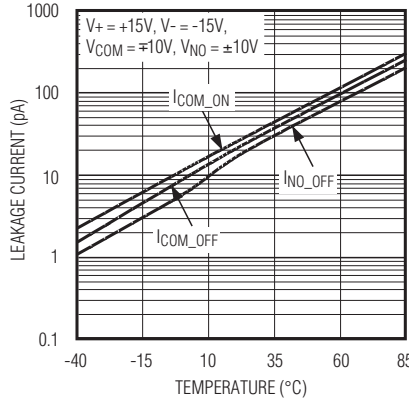
## Typical Operating Characteristics (continued)

( $V_+ = +15V$ ,  $V_- = -15V$ ,  $V_{EN} = +2.4V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

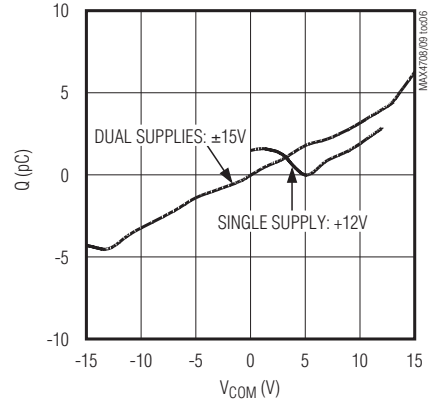
**ON-RESISTANCE vs.  $V_{COM}$  AND TEMPERATURE (SINGLE SUPPLY)**



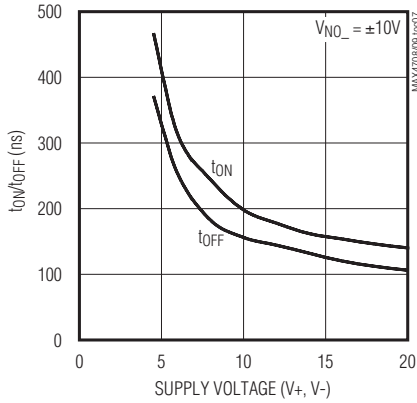
**LEAKAGE CURRENT vs. TEMPERATURE**



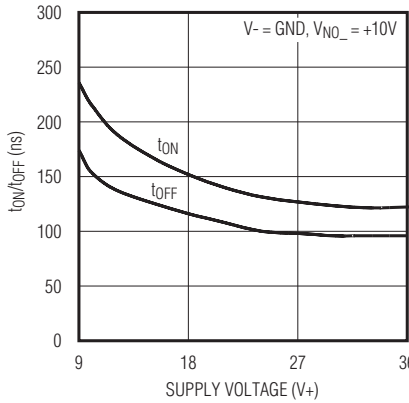
**CHARGE INJECTION vs.  $V_{COM}$**



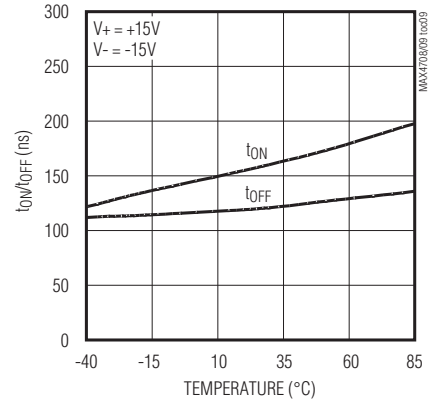
**ENABLE TURN-ON/OFF TIMES vs. SUPPLY VOLTAGE (DUAL SUPPLIES)**



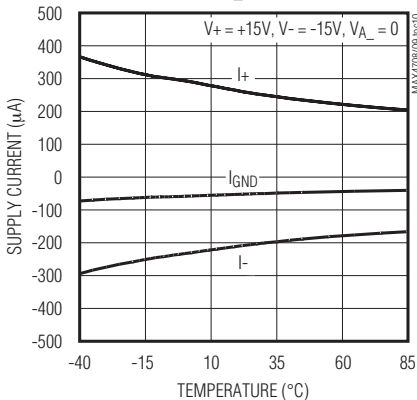
**ENABLE TURN-ON/OFF TIMES vs. SUPPLY VOLTAGE (SINGLE SUPPLY)**



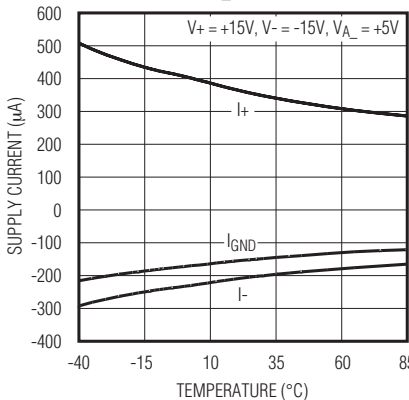
**ENABLE ON/OFF TIMES vs. TEMPERATURE**



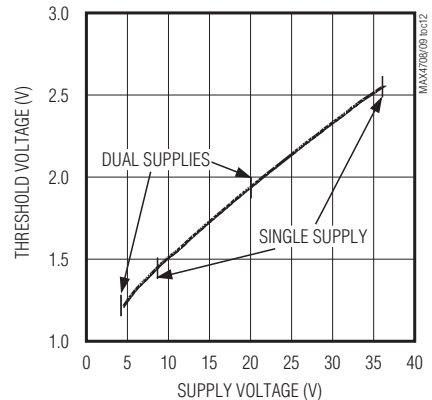
**SUPPLY CURRENT vs. TEMPERATURE ( $V_A = 0$ )**



**SUPPLY CURRENT vs. TEMPERATURE ( $V_A = +5V$ )**



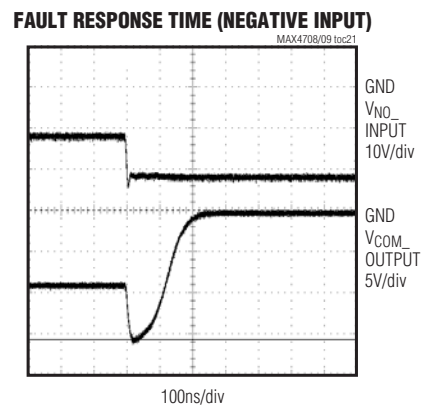
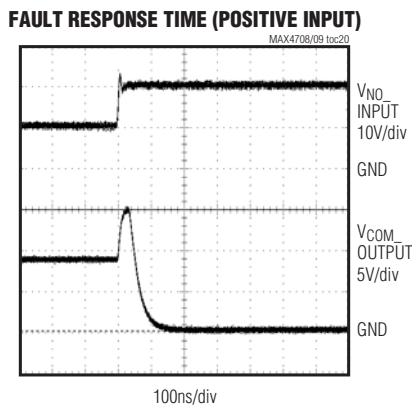
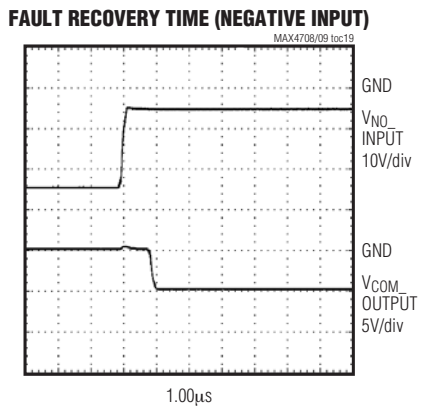
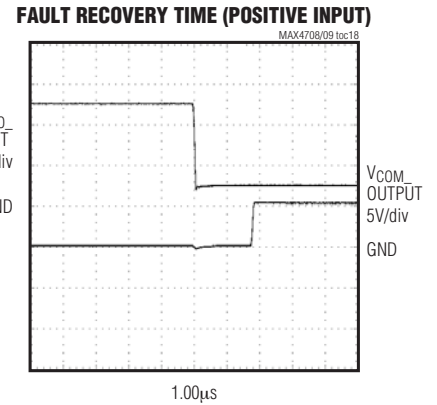
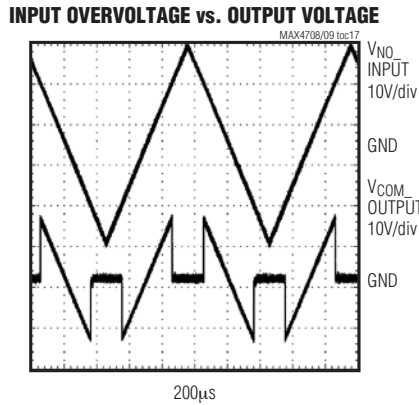
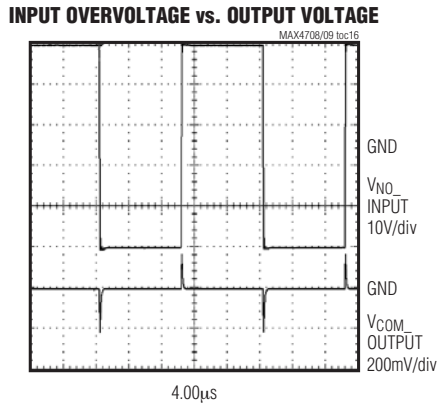
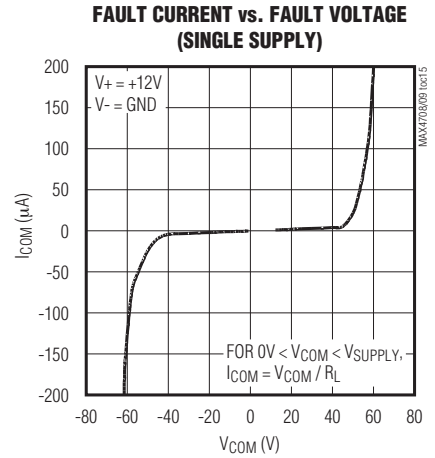
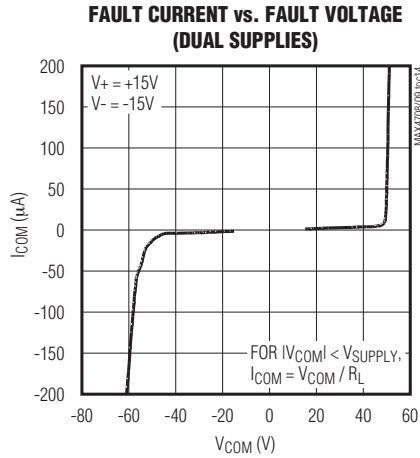
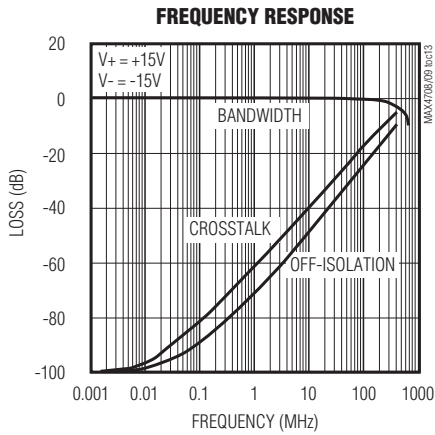
**LOGIC-LEVEL THRESHOLD VOLTAGE vs. SUPPLY VOLTAGE**



# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## Typical Operating Characteristics (continued)

(V+ = +15V, V- = -15V, VEN = +2.4V, TA = +25°C, unless otherwise noted.)





# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## Pin Descriptions

### MAX4708 (Single 8-to-1 Mux)

| PIN | NAME | FUNCTION   |
|-----|------|--|
| 1   | A0   | Address Bit 0  |
| 2   | EN   | Mux Enable   |
| 3   | V-   | Negative Supply Voltage. Bypass to GND with a 0.1 $\mu$ F capacitor. |
| 4   | NO1  | Channel Input 1  |
| 5   | NO2  | Channel Input 2  |
| 6   | NO3  | Channel Input 3  |
| 7   | NO4  | Channel Input 4  |
| 8   | COM  | Analog Output  |
| 9   | NO8  | Channel Input 8  |
| 10  | NO7  | Channel Input 7  |
| 11  | NO6  | Channel Input 6  |
| 12  | NO5  | Channel Input 5  |
| 13  | V+   | Positive Supply Voltage. Bypass to GND with a 0.1 $\mu$ F capacitor. |
| 14  | GND  | Ground   |
| 15  | A2   | Address Bit 2  |
| 16  | A1   | Address Bit 1  |

### MAX4709 (Dual 4-to-1 Mux)

| PIN | NAME | FUNCTION   |
|-----|------|--|
| 1   | A0   | Address Bit 0  |
| 2   | EN   | Mux Enable   |
| 3   | V-   | Negative Supply Voltage. Bypass to GND with a 0.1 $\mu$ F capacitor. |
| 4   | NO1A | Channel Input 1A   |
| 5   | NO2A | Channel Input 2A   |
| 6   | NO3A | Channel Input 3A   |
| 7   | NO4A | Channel Input 4A   |
| 8   | COMA | Mux Output A   |
| 9   | COMB | Mux Output B   |
| 10  | NO4B | Channel Input 4B   |
| 11  | NO3B | Channel Input 3B   |
| 12  | NO2B | Channel Input 2B   |
| 13  | NO1B | Channel Input 1B   |
| 14  | V+   | Positive Supply Voltage. Bypass to GND with a 0.1 $\mu$ F capacitor. |
| 15  | GND  | Ground   |
| 16  | A1   | Address Bit 1  |

MAX4708/MAX4709

## Truth Tables

### MAX4708 (Single 8-to-1 Mux)

| A2 | A1 | A0 | EN | ON SWITCH |
|----|----|----|----|-----------|
| X  | X  | X  | 0  | None      |
| 0  | 0  | 0  | 1  | NO1       |
| 0  | 0  | 1  | 1  | NO2       |
| 0  | 1  | 0  | 1  | NO3       |
| 0  | 1  | 1  | 1  | NO4       |
| 1  | 0  | 0  | 1  | NO5       |
| 1  | 0  | 1  | 1  | NO6       |
| 1  | 1  | 0  | 1  | NO7       |
| 1  | 1  | 1  | 1  | NO8       |

X = Don't care.

### MAX4709 (Dual 4-to-1 Mux)

| A1 | A0 | EN | COMA | COMB |
|----|----|----|------|------|
| X  | X  | 0  | None | None |
| 0  | 0  | 1  | NO1A | NO1B |
| 0  | 1  | 1  | NO2A | NO2B |
| 1  | 0  | 1  | NO3A | NO3B |
| 1  | 1  | 1  | NO4A | NO4B |

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## Detailed Description

Several unique features differentiate the MAX4708/MAX4709 from traditional fault-protected multiplexers. First, instead of the three series FETs utilized in older designs, the MAX4708/MAX4709 design employs two parallel FETs for lower on-resistance and improved flatness. Second, older devices limited the range of signal amplitudes the switch could pass by as much as 3V below the supply rails. The MAX4708/MAX4709 feature rail-to-rail signal handling that allows the devices to transmit signals with amplitudes at or slightly beyond the supply rails. Finally, in former designs (MAX4508/MAX4509), when a fault occurred, the devices clamped and held the output voltage at the appropriate supply rail until the fault was removed. Instead, the MAX4708/MAX4709 now disconnect COM<sub>o</sub> from NO<sub>o</sub> during a fault condition, making COM<sub>o</sub> a high-impedance output as long as the fault is present. Operation is identical for both positive and negative fault polarities.

When the NO<sub>o</sub> voltage ranges beyond supply rails (fault condition), the NO<sub>o</sub> input becomes high impedance, regardless of the switch state or load resistance. If power is removed, and the fault voltage is still present, the NO<sub>o</sub> terminals remain high impedance. The fault voltage can be up to ±40V, with V<sub>+</sub> = V<sub>-</sub> = 0.

The COM<sub>o</sub> pins are not fault protected. Limit any voltage sources connected to COM<sub>o</sub> to the supply rails.

Figure 1 shows the internal construction of a single normally open (NO) switch, with the analog signal paths shown in bold. The parallel combination of N-channel FET N1 and P-channel FET P1 form the analog switch. During normal operation, these FETs are driven on and off simultaneously according to the control voltages on A<sub>o</sub>. During a fault condition, both FETs turn off.

### NO<sub>o</sub> Input Voltage

The maximum allowable input voltage for safe operation depends on whether supplies are on or off, and the load configuration on COM<sub>o</sub>. If COM<sub>o</sub> is referred to a voltage other than ground, but within the supplies, V<sub>NO<sub>o</sub></sub> can range higher or lower than the supplies, provided the absolute value of |V<sub>NO<sub>o</sub></sub> - V<sub>COM<sub>o</sub></sub>| is less than 40V.

For example, with V<sub>+</sub> = V<sub>-</sub> = 0, if the load is referred to +10V at COM<sub>o</sub>, then the NO<sub>o</sub> voltage range can be from +50V to -30V. If the supplies are ±15V and COM<sub>o</sub> is referenced to ground through a load, the maximum NO<sub>o</sub> voltage is ±36V. If the supplies are off and the COM output is referenced to ground, the maximum NO<sub>o</sub> voltage is ±40V.

### Normal Operation

Two comparators continuously compare the voltage on NO<sub>o</sub> with V<sub>+</sub> and V<sub>-</sub> supply voltages. When the signal

on NO<sub>o</sub> ranges between V<sub>+</sub> and V<sub>-</sub>, the multiplexer operates normally, with FETs N1 and P1 turning on and off in response to the control signals on A<sub>o</sub> (Figure 1). When the switch state is on, the parallel combination of N1 and P1 forms a low-value resistor between NO<sub>o</sub> and COM<sub>o</sub> so that signals pass equally well in either direction. When the switch state is off, both NO<sub>o</sub> and COM<sub>o</sub> are high-impedance inputs.

### Fault Conditions

A fault condition occurs when the voltage at any NO<sub>o</sub> input exceeds the supply rail. At this point, the output of one of the two fault comparators goes high, effectively turning OFF both FETs N1 and P1. With the two FETs in the OFF position, both the switch input (NO<sub>o</sub>) and the output (COM<sub>o</sub>) go into a high-impedance state. They remain high impedance regardless of the state of the control voltages in A<sub>o</sub> and EN, until the fault is removed. The input voltage must not exceed the absolute maximum rating at any moment (see the *Absolute Maximum Ratings* section).

A fault condition on the selected channel drives COM<sub>o</sub> to a high-impedance state. However, the fault condition does not affect the performance of other channels. Therefore, while the selected channel is in fault condition, selecting another channel or operating under normal condition, drives COM<sub>o</sub> out of high impedance.

### Transient Fault Condition

When a fast rising or falling transient on NO<sub>o</sub> exceeds V<sub>+</sub> or V<sub>-</sub>, there is a 100ns delay before the fault protection turns on (see the *Typical Operating Characteristics*, Fault Response Time). COM<sub>o</sub> follows NO<sub>o</sub> until the fault protection turns on. This delay is due to the switch on-resistance and circuit capacitance to ground. When the input transient returns to within the supply rails, there is a longer output recovery time (see the *Typical Operating Characteristics*, Fault Response Times). These values depend on the COM<sub>o</sub> output resistance and capacitance. Higher COM<sub>o</sub> output resistance and capacitance increase the recovery times. The delays do not depend on the fault amplitude.

### COM and A<sub>o</sub>

The GND, COM<sub>o</sub>, and A<sub>o</sub> pins are not fault protected. ESD-protection diodes internally connect A<sub>o</sub> to both V<sub>+</sub> and V<sub>-</sub>. If a signal on GND, COM<sub>o</sub>, or A<sub>o</sub> exceeds V<sub>+</sub> or V<sub>-</sub> by more than 300mV, excessive current can flow to or from the supplies, possibly damaging the device.

### Logic-Level Thresholds

The logic-level thresholds are CMOS and TTL compatible with V<sub>+</sub> = +15V and V<sub>-</sub> = -15V. Logic levels change as V<sub>+</sub> increases (see the *Typical Operating Characteristics*, Logic-Level Threshold Voltage vs. Supply Voltage.)

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

MAX4708/MAX4709

## Applications Information

### Ground

V+ and GND power the internal logic and logic-level translators. The logic-level translators convert the logic-level inputs to V+ and V- to drive the gates of the internal FETs. In this design, there is no galvanic connection inside the MAX4708/MAX4709 between the analog signal paths and GND. ESD-protection diodes connect A<sub>-</sub> to V+ and V-.

### Supply Current Reduction

Driving the logic signals rail-to-rail from 0 to +15V or -15V to +15V reduces the current consumption from 370μA (typ) to 200μA (typ) (see the *Electrical Characteristics* table, Power Supplies).

### Power Supplies

The MAX4708/MAX4709 operate with bipolar supplies between ±4.5V and ±20V. The V+ and V- supplies need not be symmetrical, but V+ - V- cannot exceed the 44V absolute maximum rating.

The MAX4708/MAX4709 operate from single supplies between +9V and +36V when V- is connected to GND.

## Chip Information

PROCESS: CMOS

SUBSTRATE INTERNALLY CONNECTED TO V+

## 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 Narrow SO   | —            | <a href="#">21-0041</a> |
| 16 Wide SO     | —            | <a href="#">21-0042</a> |
| 16 Plastic DIP | —            | <a href="#">21-0043</a> |

## Pin Configurations/Functional Diagrams (continued)

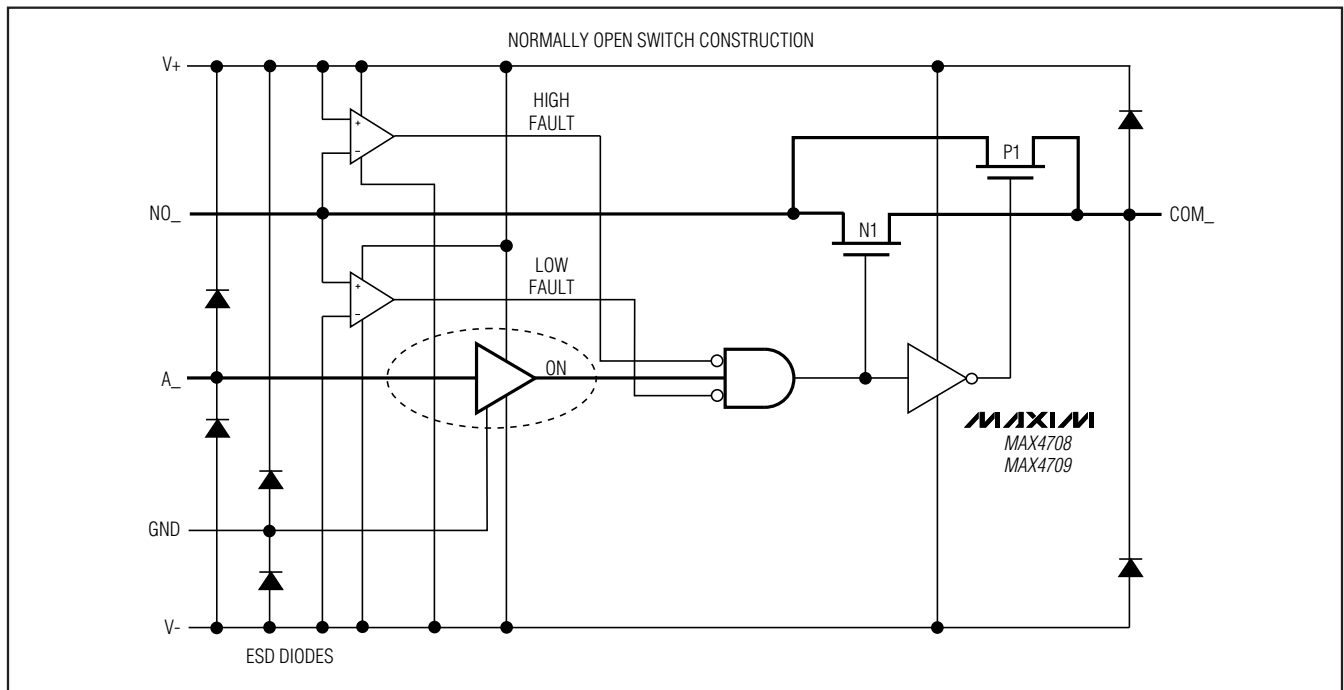


Figure 1. Functional Diagram

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## Test Circuits/Timing Diagrams

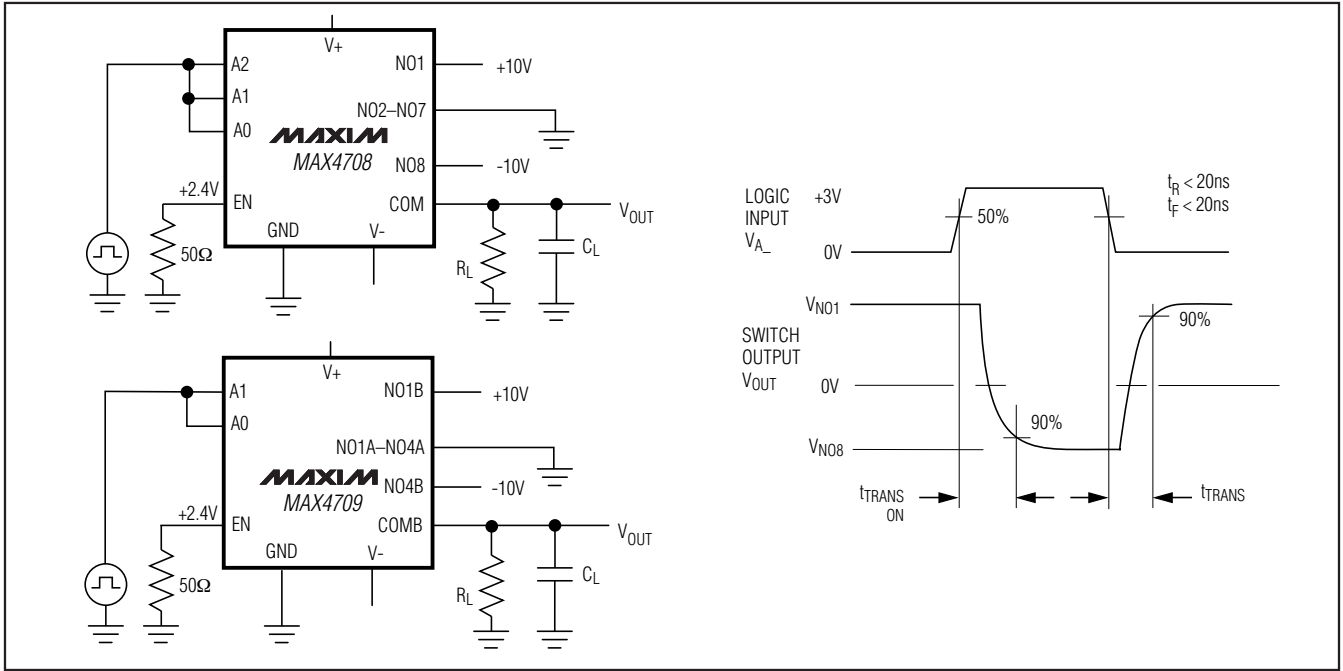


Figure 2. Address Transition Time

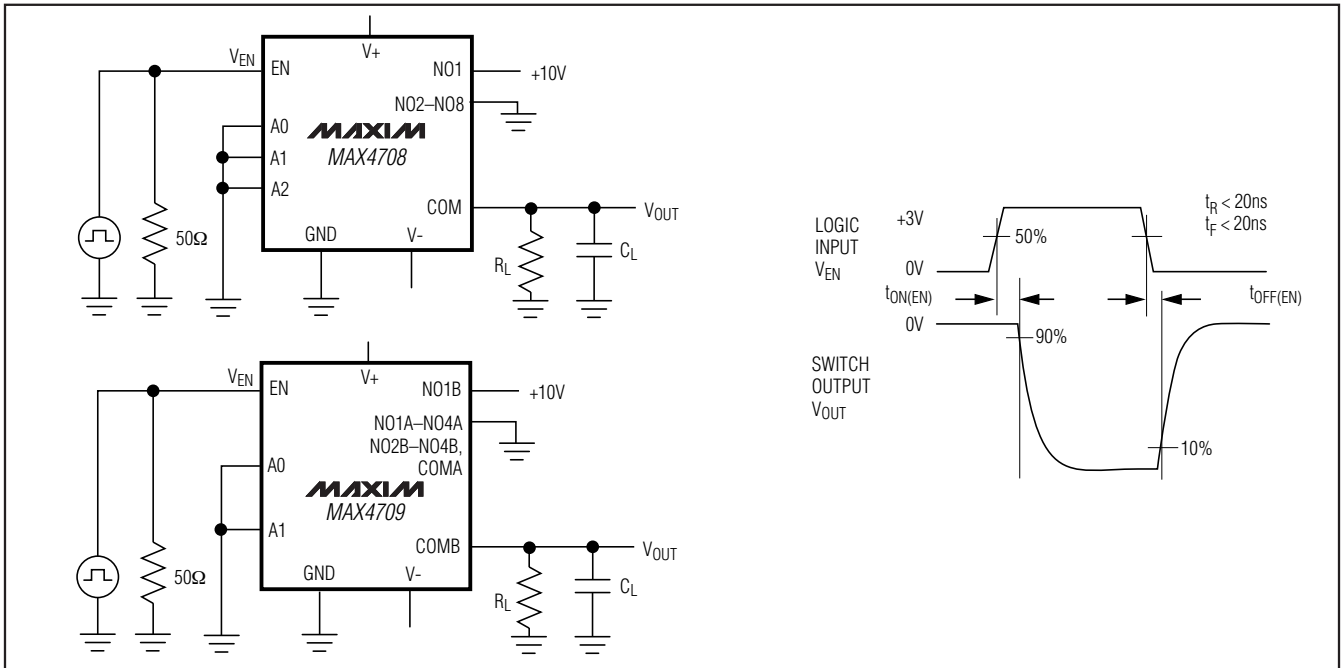


Figure 3. Enable Switching Time

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## Test Circuits/Timing Diagrams (continued)

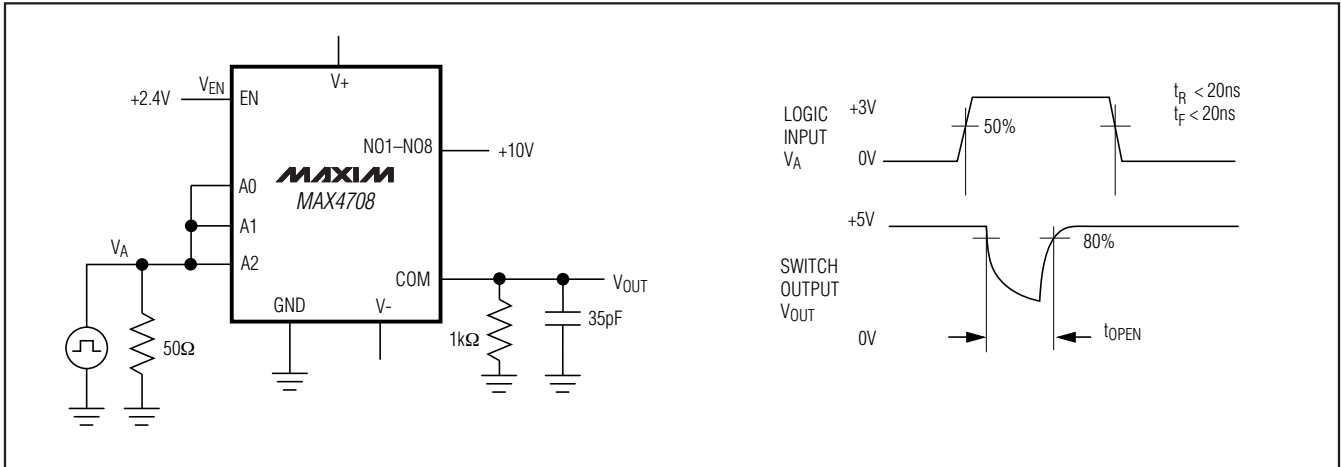


Figure 4. Break-Before-Make Interval

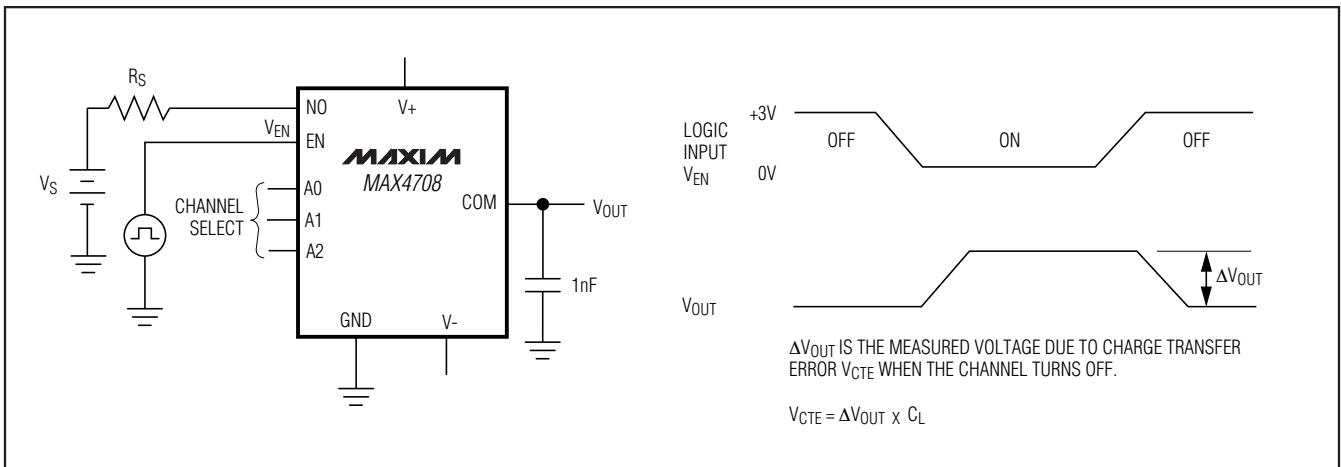


Figure 5. Charge Injection

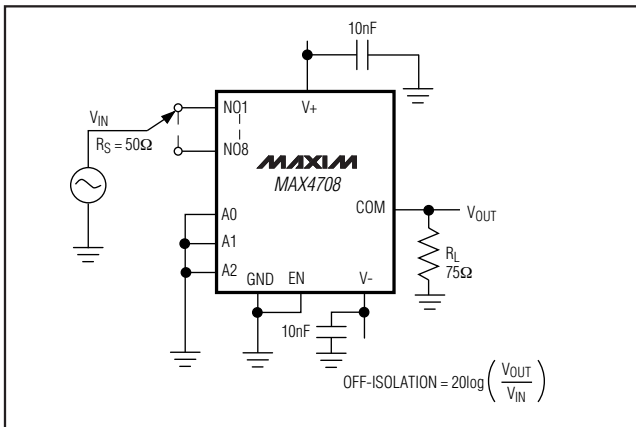


Figure 6. Off-Isolation

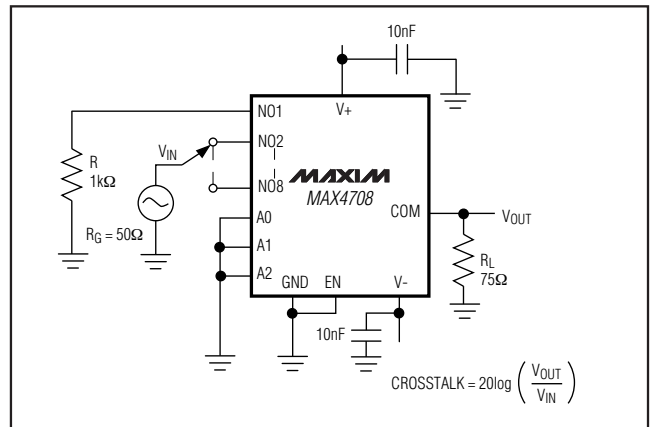


Figure 7. Crosstalk

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## Test Circuits/Timing Diagrams (continued)

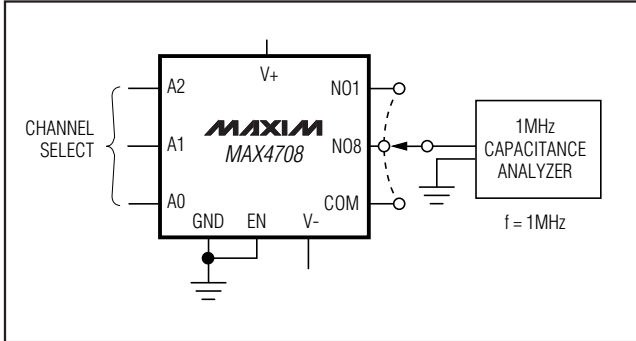


Figure 8. NO\_, COM\_ Capacitance

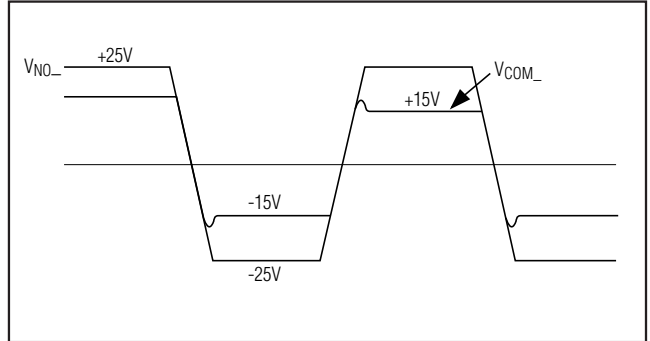


Figure 9. Transient Behavior of Fault Condition

## Functional Diagrams/Truth Tables

| MAX4708 |    |    |    |           |
|---------|----|----|----|-----------|
| 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         |

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

| MAX4709 |    |    |           |
|---------|----|----|-----------|
| 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         |

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

# Fault-Protected, Single 8-to-1/ Dual 4-to-1 Multiplexers

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION  | PAGES CHANGED |
|-----------------|---------------|--|---------------|
| 0               | 9/02          | Initial release  | —             |
| 1               | 12/08         | Added chip process and packaging information; changed fault conditions information | 10, 11        |

MAX4708/MAX4709

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### Наши контакты:

**Телефон:** +7 812 627 14 35

**Электронная почта:** [sales@st-electron.ru](mailto:sales@st-electron.ru)

**Адрес:** 198099, Санкт-Петербург,  
Промышленная ул, дом № 19, литера Н,  
помещение 100-Н Офис 331