



# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

MAX4508/MAX4509

## General Description

The MAX4508/MAX4509 are 8-to-1 and dual 4-to-1 fault-protected multiplexers that are pin compatible with the industry-standard DG508/DG509. The MAX4508/MAX4509 operate with dual supplies of  $\pm 4.5V$  to  $\pm 20V$  or a single supply of  $+9V$  to  $+36V$ . These multiplexers feature fault-protected inputs, rail-to-rail signal handling capability, and overvoltage clamping at  $150mV$  beyond the rails.

Both parts offer  $\pm 40V$  overvoltage protection with supplies off and  $\pm 25V$  protection with supplies on. On-resistance is  $400\Omega$  max and is matched between channels to  $15\Omega$  max. All digital inputs have TTL logic thresholds, ensuring both TTL and CMOS logic compatibility when using a single  $+12V$  supply or dual  $\pm 15V$  supplies.

## Applications

- Data-Acquisition Systems
- Industrial and Process Control
- Avionics
- Signal Routing
- Redundant/Backup Systems

Functional Diagrams/Truth Tables appear at end of data sheet.

## Features

- ◆  $\pm 40V$  Fault Protection with Power Off
- ◆  $\pm 25V$  Fault Protection with  $\pm 15V$  Supplies
- ◆ Rail-to-Rail Signal Handling
- ◆ No Power-Supply Sequencing Required
- ◆ All Channels Off with Power Off
- ◆ Output Clamped to Appropriate Supply Voltage During Fault Condition
- ◆  $1k\Omega$  Output Clamp Resistance During Overvoltage
- ◆  $400\Omega$  max On-Resistance
- ◆  $20ns$  Fault-Response Time
- ◆  $\pm 4.5V$  to  $\pm 20V$  Dual Supplies
- ◆  $+9V$  to  $+36V$  Single Supply
- ◆ TTL/CMOS-Compatible Logic Inputs

## Ordering Information

| PART        | TEMP RANGE                       | PIN-PACKAGE    | PKG CODE |
|-------------|----------------------------------|----------------|----------|
| MAX4508CSE+ | $0^{\circ}C$ to $+70^{\circ}C$   | 16 Narrow SO   | S16-8    |
| MAX4508CPE+ | $0^{\circ}C$ to $+70^{\circ}C$   | 16 Plastic DIP | P16-4    |
| MAX4508C/D  | $0^{\circ}C$ to $+70^{\circ}C$   | Dice*          | —        |
| MAX4508ESE+ | $-40^{\circ}C$ to $+85^{\circ}C$ | 16 Narrow SO   | S16-8    |
| MAX4508EPE+ | $-40^{\circ}C$ to $+85^{\circ}C$ | 16 Plastic DIP | P16-4    |
| MAX4508MJE  | $-40^{\circ}C$ to $+85^{\circ}C$ | 16 CERDIP**    | J16-3    |

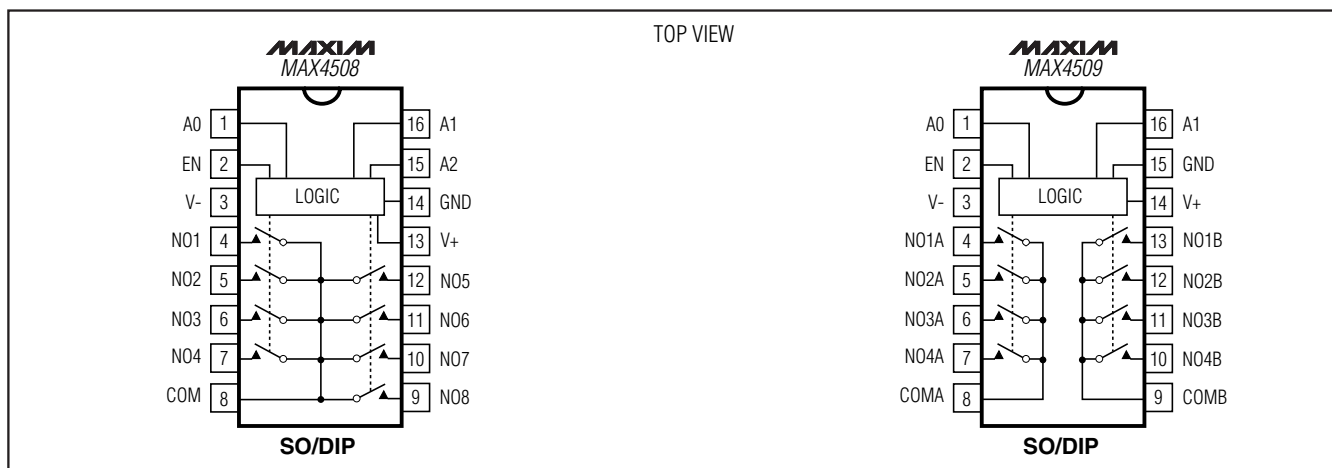
Ordering Information continued at end of data sheet.

\*Contact factory for dice specifications.

\*\*Contact factory for availability.

+Denotes a lead-free package.

## Pin Configurations/Functional Diagrams



# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## ABSOLUTE MAXIMUM RATINGS

(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 <sub>-</sub> , A <sub>-</sub> (Note 1)                         | ..... (V+ + 0.3V) to (V- - 0.3V) |
| NO <sub>-</sub>  | .....(V+ - 40V) to (V- + 40V)    |
| NO <sub>-</sub> to COM <sub>-</sub>                                | .....-36V to +36V                |
| NO <sub>-</sub> Overvoltage with Switch Power On                   | .....-30V to +30V                |
| NO <sub>-</sub> Overvoltage 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-Pin PDIP (derate 10.53mW/°C above +70°C)     | .....842mW           |
| 16-Pin CERDIP (derate 10.00mW/°C above +70°C)   | .....800mW           |
| Operating Temperature Ranges                    |                      |
| MAX4508C <sub>-</sub> E/MAX4509C <sub>-</sub> E | .....0°C to +70°C    |
| MAX4508E <sub>-</sub> E/MAX4509E <sub>-</sub> E | .....-40°C to +85°C  |
| MAX4508MJE/MAX4509MJE                           | .....-55°C to +125°C |
| Storage Temperature Range                       | .....-65°C to +160°C |
| Lead Temperature (soldering, 10s)               | .....+300°C          |

**Note 1:** COM<sub>-</sub>, EN, and A<sub>-</sub> pins are not fault protected. Signals on COM<sub>-</sub>, EN, or A<sub>-</sub> 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 (Notes 3, 4)   | V <sub>NO-</sub>       | V+ = +15V, V- = -15V, V <sub>NO-</sub> = ±15V                 | C, E, M        | 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     |      |    |
|   |                        |   | C, E           |       |      | 500   |       |      |    |
|   |                        |   | M              |       |      | 700   |       |      |    |
| On-Resistance Match Between Channels (Note 5) | ΔR <sub>ON</sub>       | V <sub>COM-</sub> = ±10V, I <sub>NO-</sub> = 0.2mA            | +25°C          |       |      | 15    | Ω     |      |    |
|   |                        |   | C, E           |       |      | 20    |       |      |    |
|   |                        |   | M              |       |      | 25    |       |      |    |
| NO <sub>-</sub> Off-Leakage Current (Note 6)  | I <sub>NO-(OFF)</sub>  | V <sub>NO-</sub> = ±10V, V <sub>COM-</sub> = ∓10V             | +25°C          | -0.5  |      | +0.5  | nA    |      |    |
|   |                        |   | C, E           |       | -5   | +5    |       |      |    |
|   |                        |   | M              |       | -50  | +50   |       |      |    |
| COM <sub>-</sub> Off-Leakage Current (Note 6) | I <sub>COM-(OFF)</sub> | V <sub>COM-</sub> = ±10V, V <sub>NO-</sub> = ∓10V             | MAX4508        | +25°C |      |       | nA    |      |    |
|   |                        |   |                | C, E  |      | -2    |       | +2   |    |
|   |                        |   | MAX4509        | C, E  |      | -20   |       | +75  |    |
|   |                        |   |                | M     |      | -200  |       | +200 |    |
|   |                        |   | MAX4508        | C, E  |      | +25°C |       | -1   | +1 |
|   |                        |   |                | M     |      | -100  |       | +75  |    |
| COM <sub>-</sub> On-Leakage Current (Note 6)  | I <sub>COM-(ON)</sub>  | V <sub>COM-</sub> = ±10V, V <sub>NO-</sub> = ±10V or floating | MAX4508        | C, E  |      | -100  | +75   |      |    |
|   |                        |   |                | M     |      | -300  | +300  |      |    |
|   |                        |   | MAX4509        | C, E  |      | +25°C | -1    | +1   |    |
|   |                        |   |                | M     |      | -15   | +75   |      |    |
|   |                        |   | M              |       | -150 | +150  |       |      |    |

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

MAX4508/MAX4509

## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +15V, V- = -15V, VA\_H = +2.4V, VA\_L = +0.8V, VEN = +2.4V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.) (Note 2)

| PARAMETER  | SYMBOL     | CONDITIONS  | TA      | MIN         | TYP  | MAX | UNITS |    |    |
|--|------------|---|---------|-------------|------|-----|-------|----|----|
| <b>FAULT PROTECTION</b>                          |            |   |         |             |      |     |       |    |    |
| Fault-Protected Analog Signal Range (Notes 3, 4) | VNO_       | Applies with power on, Figure 9                       | +25°C   | -25         |      | +25 | V     |    |    |
|  |            | Applies with power off                                |         | -40         |      | +40 |       |    |    |
| COM_ Output Leakage Current, Supplies On         | ICOM_      | VNO_ = ±25V, VEN = 0                                  | +25°C   | -20         |      | +20 | nA    |    |    |
|  |            |   |         | C, E        | -1   |     | +1    | μA |    |
|  |            |   |         | M           | -100 |     | +100  | μA |    |
| NO_ Input Leakage Current, Supplies On           | INO_       | VNO_ = ±25V, VCOM_ = ±10V, VEN = 0                    | +25°C   | -20         |      | +20 | nA    |    |    |
|  |            |   |         | C, E        | -200 |     | +200  | μA |    |
|  |            |   |         | M           | -50  |     | +50   | μA |    |
| NO_ Input Leakage Current, Supplies Off          | INO_       | VNO_ = ±40V, VCOM = 0, V+ = 0, V- = 0                 | +25°C   | -20         |      | +20 | nA    |    |    |
|  |            |   |         | C, E        | -5   |     | +5    | μA |    |
|  |            |   |         | M           | -100 |     | +100  | μA |    |
| COM_ On Clamp Output Current, Supplies On        | ICOM_      | VCOM = 0  | +25°C   | VNO_ = +25V |      | 7   | 10    | 13 | mA |
|  |            |   |         | VNO_ = -25V |      | -13 | -11   | -7 |    |
| COM_ On Clamp Output Resistance, Supplies On     | RCOM_      | VNO_ = ±25V   | +25°C   | 100         | 1.0  | 2.5 | kΩ    |    |    |
| ± Fault Output Clamp Turn-On Delay (Note 4)      |            | RL = 10kΩ, VNO_ = ±25V                                | +25°C   |             | 20   |     | ns    |    |    |
| ± Fault Recovery Time (Note 4)                   |            | RL = 10kΩ, VNO_ = ±25V                                | +25°C   |             | 2.5  |     | μs    |    |    |
| <b>LOGIC INPUT</b>                               |            |   |         |             |      |     |       |    |    |
| A_ Input Logic Threshold High                    | VA_H       |   | C, E, M | 2.4         |      |     | V     |    |    |
| A_ Input Logic Threshold Low                     | VA_L       |   | C, E, M |             |      | 0.8 | V     |    |    |
| A_ Input Current Logic High or Low               | IA_H, IA_L | VA_ = 0.8V or 2.4V                                    | C, E, M | -1          |      | +1  | μA    |    |    |
| <b>SWITCH DYNAMIC CHARACTERISTICS</b>            |            |   |         |             |      |     |       |    |    |
| Enable Turn-On Time                              | tON        | VNO_ = ±10V, RL = 1kΩ, Figures 2 and 3                | +25°C   | 160         |      | 275 | ns    |    |    |
|  |            |   |         | C, E        |      | 400 |       |    |    |
|  |            |   |         | M           |      | 600 |       |    |    |
| Transition Time                                  | tTRANS     | Figure 2  | +25°C   | 170         |      | 350 | ns    |    |    |
|  |            |   |         | C, E, M     |      | 500 |       |    |    |
| Enable Turn-Off Time                             | tOFF       | VNO_ = ±10V, RL = 1kΩ, Figures 2 and 3                | +25°C   | 120         |      | 200 | ns    |    |    |
|  |            |   |         | C, E        |      | 250 |       |    |    |
|  |            |   |         | M           |      | 400 |       |    |    |
| Break-Before-Make Time Delay (Note 4)            | tBBM       | VNO_ = ±10V, RL = 1kΩ, Figure 4                       | C, E, M | 10          | 80   |     | ns    |    |    |
| Charge Injection (Note 4)                        | Q          | CL = 1.0nF, VNO_ = 0, RS = 0, Figure 5                | +25°C   |             | 2    | 10  | pC    |    |    |
| Off-Isolation (Note 7)                           | VISO       | RL = 75Ω, CL = 15pF, VNO_ = 1VRMS, f = 1MHz, Figure 6 | +25°C   |             | -70  |     | dB    |    |    |

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +15V, V- = -15V, VA\_H = +2.4V, VA\_L = +0.8V, VEN = +2.4V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.) (Note 2)

| PARAMETER                             | SYMBOL     | CONDITIONS  | TA      | MIN     | TYP | MAX | UNITS |
|---------------------------------------|------------|---|---------|---------|-----|-----|-------|
| Channel-to-Channel Crosstalk (Note 8) | VCT        | RL = 75Ω, CL = 15pF, VNO_ = 1VRMS, f = 1MHz, Figure 7 | +25°C   |         | -62 |     | dB    |
| NO_ Off-Capacitance                   | CN_(OFF)   | f = 1MHz, Figure 8                                    | +25°C   |         | 10  |     | pF    |
| COM_ Off-Capacitance                  | CCOM_(OFF) | f = 1MHz, Figure 8                                    | +25°C   |         | 19  |     | pF    |
|                                       |            |   |         |         | 14  |     |       |
| COM_ On-Capacitance                   | CCOM_(ON)  | f = 1MHz, Figure 8                                    | +25°C   |         | 28  |     | pF    |
|                                       |            |   |         |         | 22  |     |       |
| <b>POWER SUPPLY</b>                   |            |   |         |         |     |     |       |
| Power-Supply Range                    | V+, V-     |   | C, E, M | ±4.5    |     | ±20 | V     |
| V+ Supply Current                     | I+         | All VA_ = 0 or 5V, VNO_ = 0, VEN = 5V                 | +25°C   |         | 370 | 500 | μA    |
|                                       |            |   |         | C, E    |     | 750 |       |
|                                       |            |   |         | M       |     | 850 |       |
| V- Supply Current                     | I-         | All VA_ = 0 or 5V, VNO_ = 0, VEN = 5V                 | +25°C   |         | 200 | 300 | μA    |
|                                       |            |   |         | C, E    |     | 400 |       |
|                                       |            |   |         | M       |     | 500 |       |
| GND Supply Current                    | IGND       | All VA_ = 0 or 5V, VNO_ = 0, VEN = 5V                 | +25°C   |         | 200 | 300 | μA    |
|                                       |            |   |         | C, E, M |     | 500 |       |

## ELECTRICAL CHARACTERISTICS—Single +12V Supply

(V+ = +12V, V- = 0, VA\_H = +2.4V, VA\_L = +0.8V, VEN = +2.4V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.) (Note 2)

| PARAMETER                                     | SYMBOL    | CONDITIONS                      | TA      | MIN  | TYP  | MAX  | UNITS |    |
|---|-----------|---------------------------------|---------|------|------|------|-------|----|
| <b>ANALOG SWITCH</b>                          |           |                                 |         |      |      |      |       |    |
| Fault-Free Analog Signal Range (Note 3)       | VNO_      | V+ = 12V, V- = 0, VNO_ = 12V    | C, E, M | 0    |      | V+   | V     |    |
| On-Resistance                                 | RON       | VCOM_ = +10V, INO_ = 200μA      | +25°C   |      | 650  | 950  | Ω     |    |
|   |           |                                 |         | C, E |      | 1100 |       |    |
|   |           |                                 |         | M    |      | 1300 |       |    |
| On-Resistance Match Between Channels (Note 5) | ΔRON      | VCOM_ = 10V, INO_ = 200μA       | +25°C   |      | 10   | 35   | Ω     |    |
|   |           |                                 |         | C, E |      | 50   |       |    |
|   |           |                                 |         | M    |      | 75   |       |    |
| NO_ Off-Leakage Current (Notes 6, 9)          | INO_(OFF) | VCOM_ = 10V, 1V; VNO_ = 1V, 10V | +25°C   |      | -0.5 | 0.01 | +0.5  | nA |
|   |           |                                 |         | C, E |      | -10  | +10   |    |
|   |           |                                 |         | M    |      | -200 | +200  |    |

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

**MAX4508/MAX4509**

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

(V+ = +12V, V- = 0, VA\_H = +2.4V, VA\_L = +0.8V, VEN = +2.4V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.) (Note 2)

| PARAMETER   | SYMBOL         | CONDITIONS   | TA      | MIN   | TYP  | MAX  | UNITS |    |
|---|----------------|--|---------|-------|------|------|-------|----|
| COM_ Off-Leakage Current<br>(Note 6)                    | ICOM_(OFF)     | VCOM_ = 10V, 1V;<br>VNO_ = 1V, 10V                 | MAX4508 | +25°C | -2   |      | +2    | nA |
|   |                |  |         | C, E  | -20  |      | +75   |    |
|   |                |  |         | M     | -200 |      | +200  |    |
|   |                |  | MAX4509 | +25°C | -1   |      | +1    |    |
|   |                |  |         | C, E  | -10  |      | +75   |    |
|   |                |  |         | M     | -100 |      | +100  |    |
| COM_ On-Leakage Current<br>(Note 6)                     | ICOM_(ON)      | VCOM_ = 10V, 1V;<br>VNO_ = 10V, 1V, or<br>floating | MAX4508 | +25°C | -2   |      | +2    | nA |
|   |                |  |         | C, E  | -100 |      | +75   |    |
|   |                |  |         | M     | -300 |      | +300  |    |
|   |                |  | MAX4509 | +25°C | -1   |      | +1    |    |
|   |                |  |         | C, E  | -15  |      | +75   |    |
|   |                |  |         | M     | -150 |      | +150  |    |
| <b>FAULT PROTECTION</b>                                 |                |  |         |       |      |      |       |    |
| Fault-Protected Analog Signal<br>Range (Notes 3, 10)    | VNO_           | Applies with all power on                          | +25°C   | -25   |      | +25  | V     |    |
|   |                | Applies with all power off                         |         | -40   |      | +40  |       |    |
| COM_ Output Leakage Current,<br>Supply On (Notes 3, 10) | ICOM_          | VNO_ = ±25V, V+ = 12V                              | +25°C   | -20   |      | +20  | nA    |    |
|   |                |  | C, E    | -1    |      | +1   | µA    |    |
|   |                |  | M       | -100  |      | +100 |       |    |
| NO_ Input Leakage Current,<br>Supply On (Notes 3, 10)   | INO_           | VNO_ = ±25V, VCOM_ = 0,<br>V+ = 12V                | +25°C   | -20   |      | +20  | nA    |    |
|   |                |  | C, E    | -5    |      | +5   | µA    |    |
|   |                |  | M       | -100  |      | +100 |       |    |
| NO_ Input Leakage Current,<br>Supply Off (Notes 3, 10)  | INO_           | VNO_ = ±40V, V+ = 0, V- = 0                        | +25°C   | -20   | 0.1  | +20  | nA    |    |
|   |                |  | C, E    | -5    |      | +5   | µA    |    |
|   |                |  | M       | -100  |      | +100 |       |    |
| COM_ ON Output Current,<br>Supply On                    | ICOM_          | VNO_ = 25V, V+ = 12V                               | +25°C   | 2     | 3    | 5    | mA    |    |
| COM_ ON Output Resistance,<br>Supply On                 | RCOM_          | VNO_ = 25V, V+ = 12V                               | +25°C   |       | 2.4  | 6    | kΩ    |    |
| <b>LOGIC INPUT</b>                                      |                |  |         |       |      |      |       |    |
| A_ Input Logic Threshold High                           | VIN_H          |  | C, E, M |       | 1.8  | 2.4  | V     |    |
| A_ Input Logic Threshold Low                            | VIN_L          |  | C, E, M | 0.8   | 1.8  |      | V     |    |
| A_ Input Current Logic<br>High or Low                   | IINH_<br>IINL_ | VIN_ = 0.8V or 2.4V                                | C, E, M | -1    | 0.03 | +1   | µA    |    |

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

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

(V+ = +12V, V- = 0, VA\_H = +2.4V, VA\_L = +0.8V, VEN = +2.4V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.) (Note 2)

| PARAMETER                                | SYMBOL     | CONDITIONS   | TA      | MIN | TYP | MAX | UNITS |
|--|------------|--|---------|-----|-----|-----|-------|
| <b>SWITCH DYNAMIC CHARACTERISTICS</b>    |            |  |         |     |     |     |       |
| Enable Turn-On Time                      | tON        | VCOM_ = 10V, RL = 2kΩ,<br>Figure 3                       | +25°C   |     | 220 | 500 | ns    |
|  |            |  | C, E, M |     |     | 700 |       |
| Enable Turn-Off Time                     | tOFF       | VCOM_ = 10V, RL = 2kΩ,<br>Figure 3                       | +25°C   |     | 100 | 250 | ns    |
|  |            |  | C, E, M |     |     | 350 |       |
| Break-Before-Make Time Delay<br>(Note 4) | tBBM       | VCOM_ = 10V, RL = 2kΩ,<br>Figure 4                       | +25°C   | 50  | 100 |     | ns    |
| Charge Injection<br>(Note 4)             | Q          | CL = 1.0nF, VNO_ = 0, RS = 0,<br>Figure 5                | +25°C   |     | 2   | 10  | pC    |
| NO_ Off-Capacitance                      | CNO_(OFF)  | VNO_ = 0, f = 1MHz, Figure 8                             | +25°C   |     | 10  |     | pF    |
| COM_ Off-Capacitance                     | CCOM_(OFF) | VCOM_ = 0, f = 1MHz, Figure 8                            | +25°C   |     | 19  |     | pF    |
| COM_ On-Capacitance                      | CCOM_(ON)  | VCOM_ = VNO_ = 0, f = 1MHz,<br>Figure 8                  | +25°C   |     | 28  |     | pF    |
| Off-Isolation<br>(Note 7)                | VISO       | RL = 75Ω, CL = 15pF,<br>VNO_ = 1VRMS, f = 1MHz, Figure 6 | +25°C   |     | -70 |     | dB    |
| Channel-to-Channel Crosstalk<br>(Note 8) | VCT        | RL = 75Ω, CL = 15pF,<br>VNO_ = 1VRMS, f = 1MHz, Figure 7 | +25°C   |     | -62 |     | dB    |
| <b>POWER SUPPLY</b>                      |            |  |         |     |     |     |       |
| Power-Supply Range                       | V+         |  | C, E, M | 9   |     | 36  | V     |
| V+ Supply Current                        | I+         | All VA_ = 0 or 5V,<br>VNO_ = 0, VEN = 5V                 | +25°C   |     | 200 | 300 | μA    |
|  |            |  | C, E, M |     |     | 675 |       |
|  |            | All VA_ = 0 or V+,<br>VNO_ = 0, VEN = 0 or V+            | +25°C   |     | 100 | 250 |       |
|  |            |  | C, E, M |     |     | 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 ±36V with ±15V supplies and a load referred to ground. For more detailed information see the *NO\_ Input Voltage* section.

**Note 4:** Guaranteed by design.

**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 TA = +25°C.

**Note 7:** Off-Isolation =  $20\log_{10}(V_{COM\_} / V_{NO\_})$ , where VCOM\_ = output and VNO\_ = input to off switch.

**Note 8:** Between any two analog inputs.

**Note 9:** Leakage testing for single-supply operation is guaranteed by testing with dual supplies.

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

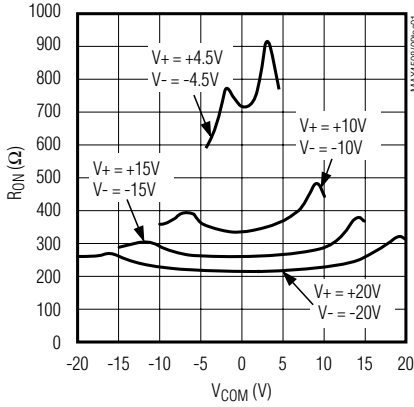
# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## Typical Operating Characteristics

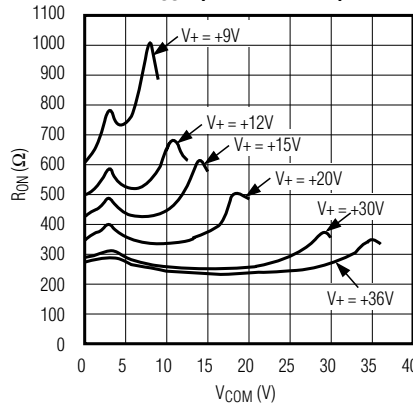
( $V_+ = +15V$ ,  $V_- = -15V$ ,  $V_{EN} = +2.4V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX4508/MAX4509

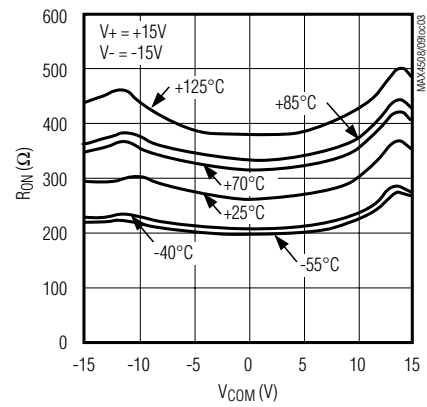
**ON-RESISTANCE vs.  $V_{COM}$  (DUAL SUPPLIES)**



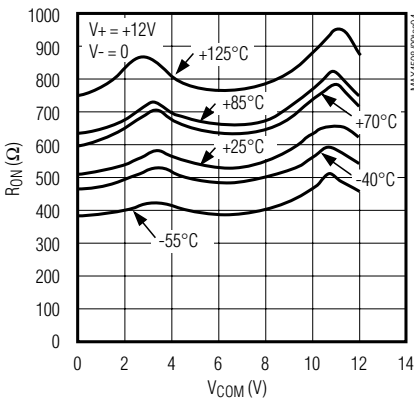
**ON-RESISTANCE vs.  $V_{COM}$  (SINGLE SUPPLY)**



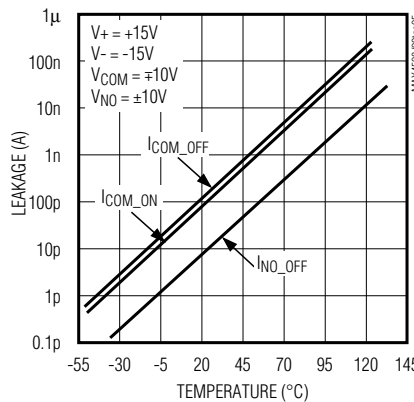
**ON-RESISTANCE vs.  $V_{COM}$  AND TEMPERATURE (DUAL SUPPLIES)**



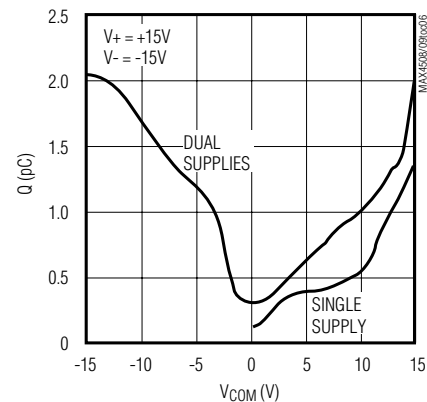
**ON-RESISTANCE vs.  $V_{COM}$  AND TEMPERATURE (SINGLE SUPPLY)**



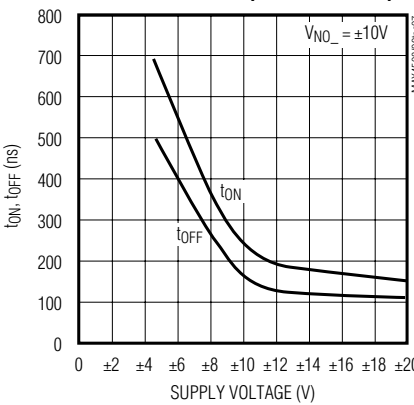
**LEAKAGE CURRENT vs. TEMPERATURE**



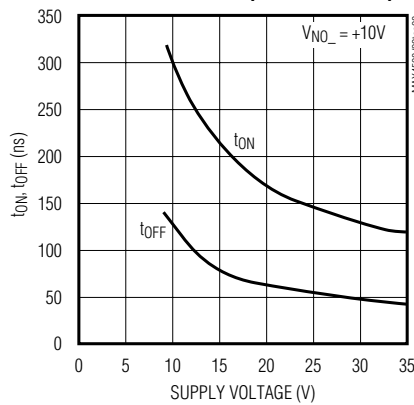
**CHARGE INJECTION vs.  $V_{COM}$**



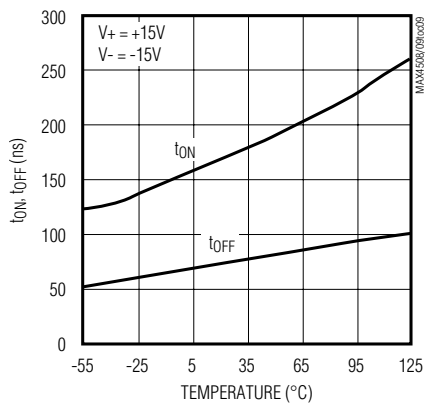
**ENABLE ON AND OFF TIMES vs. SUPPLY VOLTAGE (DUAL SUPPLIES)**



**ENABLE ON AND OFF TIMES vs. SUPPLY VOLTAGE (SINGLE SUPPLY)**



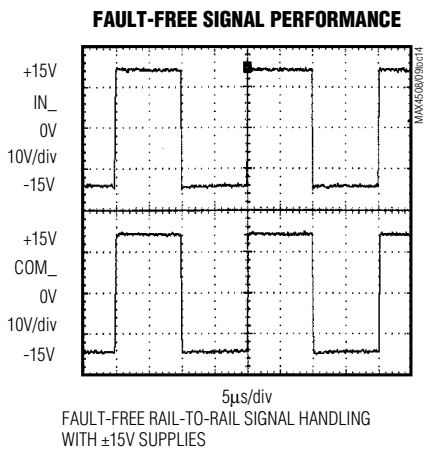
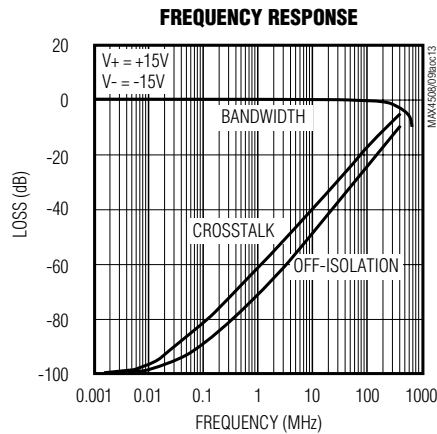
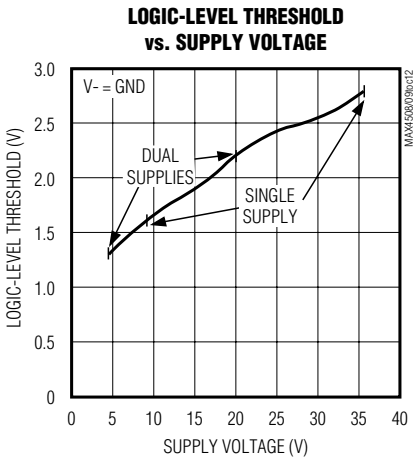
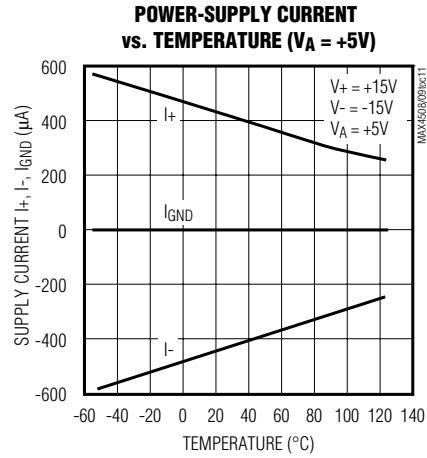
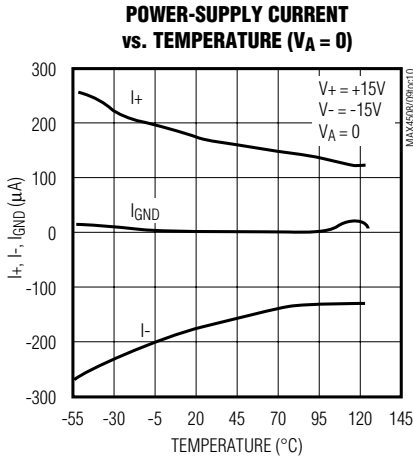
**ENABLE ON AND OFF TIMES vs. TEMPERATURE**



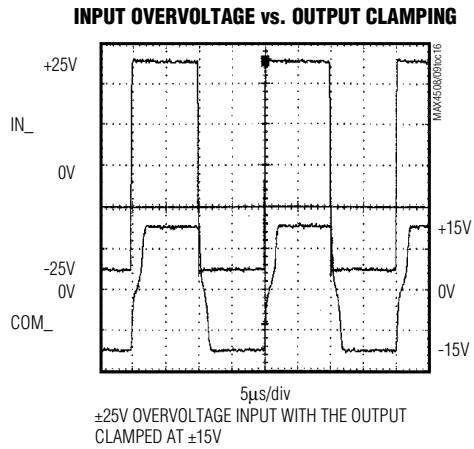
# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## Typical Operating Characteristics (continued)

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



FAULT-FREE RAIL-TO-RAIL SIGNAL HANDLING WITH  $\pm 15V$  SUPPLIES



$\pm 25V$  OVERVOLTAGE INPUT WITH THE OUTPUT CLAMPED AT  $\pm 15V$



# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## Pin Descriptions

MAX4508/MAX4509

### MAX4508 (Single 8-to-1 Mux)

| PIN | NAME | FUNCTION                |
|-----|------|-------------------------|
| 1   | A0   | Address Bit 0           |
| 2   | EN   | Mux Enable              |
| 3   | V-   | Negative Supply Voltage |
| 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 |
| 14  | GND  | Ground                  |
| 15  | A2   | Address Bit 2           |
| 16  | A1   | Address Bit 1           |

### MAX4509 (Dual 4-to-1 Mux)

| PIN | NAME | FUNCTION                |
|-----|------|-------------------------|
| 1   | A0   | Address Bit 0           |
| 2   | EN   | Mux Enable              |
| 3   | V-   | Negative Supply Voltage |
| 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 |
| 15  | GND  | Ground                  |
| 16  | A1   | Address Bit 1           |

## Truth Tables

### MAX4508 (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       |

### MAX4509 (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 |

## Detailed Description

Traditional fault-protected multiplexers are constructed with three series FET switches. This produces good off protection, but limits the switches input voltage range to as much as 3V below the supply rails, reducing its usable dynamic range. As the voltage on one side of the switch approaches within about 3V of either supply rail (a fault condition), the switch impedance increases, limiting the output signal range to approximately 3V less than the appropriate polarity supply voltage.

The MAX4508/MAX4509 differ considerably from traditional fault-protected multiplexers, offering several advantages. First, they are constructed with two parallel FETs, allowing very low resistance when the switch is on. Second, they allow signals on the NO\_ pins that are within or beyond the supply rails to be passed through the switch to the COM terminal. This allows rail-to-rail signal operation. Third, when a signal  $V_{NO\_}$  exceeds the supply rails (i.e., a fault condition), the voltage on COM\_ is limited to the supply rails. Operation is identical for both fault polarities.

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

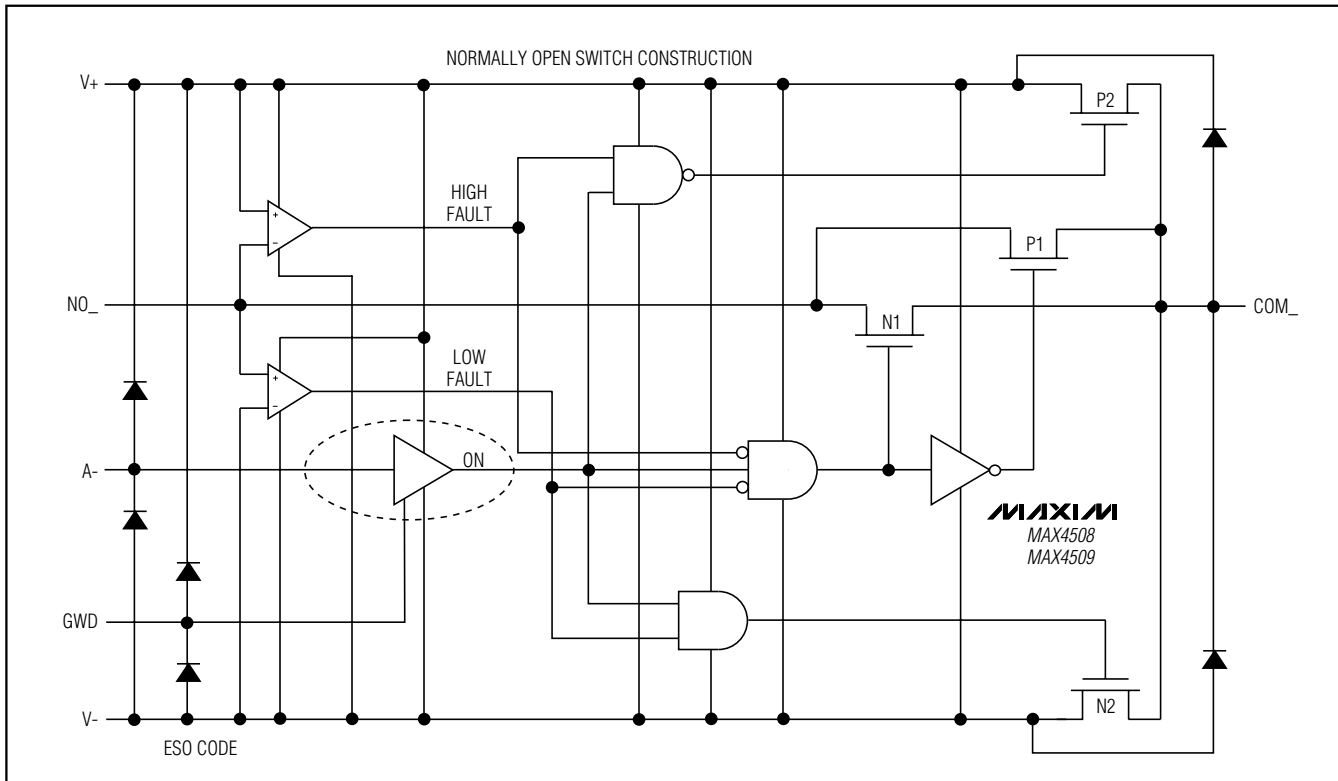


Figure 1. Functional Diagram

When the NO<sub>-</sub> voltage goes beyond supply rails (fault condition), the NO<sub>-</sub> input becomes high impedance regardless of the switch state or load resistance. When power is removed, and the fault protection is still in effect, the NO<sub>-</sub> terminals are a virtual open circuit. The fault can be up to ±40V, with V<sub>+</sub> = V<sub>-</sub> = 0. If the switch is on, the COM<sub>-</sub> output current is furnished from the V<sub>+</sub> or V<sub>-</sub> pin by “booster” FETs connected to each supply pin. These FETs can source or sink up to 10mA.

The COM<sub>-</sub> pins are not fault protected. If a voltage source is connected to any COM<sub>-</sub> pin, it should be limited to the supply voltages. Exceeding the supply voltage will cause high currents to flow through the ESD protection diodes, damaging the device (see *Absolute Maximum Ratings*).

Figure 1 shows the internal construction, with the analog signal paths shown in bold. A single normally open (NO) switch is shown. The analog switch is formed by the parallel combination of N-channel FET N1 and P-channel FET P1, which are driven on and off simultaneously, according to the input fault condition and the logic level state.

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

The maximum allowable input voltage for safe operation depends on whether supplies are on or off and the load configuration at the COM output. If COM is referred to a voltage other than ground, but within the supplies, V<sub>NO<sub>-</sub></sub> may range higher or lower than the supplies provided the absolute value of |V<sub>NO<sub>-</sub></sub> - V<sub>COM</sub>| is less than 40V. For example, if the load is referred to +10V at COM<sub>-</sub>, then the NO<sub>-</sub> voltage range can be from +50V to -30V. As another example, if the load is connected to -10V at COM<sub>-</sub>, the NO<sub>-</sub> voltage range is limited to -50V to +30V.

If the supplies are ±15V and COM is referenced to ground through a load, the maximum NO<sub>-</sub> voltage is ±25V. If the supplies are off and the COM output is referenced to ground, the maximum NO<sub>-</sub> voltage is ±40V.

## Normal Operation

Two comparators continuously compare the voltage on the NO<sub>-</sub> pin with V<sub>+</sub> and V<sub>-</sub> supply voltages. When the signal on NO<sub>-</sub> is between V<sub>+</sub> and V<sub>-</sub>, the multiplexer behaves normally, with FETs N1 and P1 turning on and off in response to A<sub>-</sub> signals (Figure 1). The parallel

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

MAX4508/MAX4509

combination of N1 and P1 forms a low-value resistor between NO<sub>-</sub> and COM<sub>-</sub> so that signals pass equally well in either direction.

## Positive Fault Condition

When the signal on NO<sub>-</sub> exceeds V<sub>+</sub> by about 150mV, the positive fault comparator output goes high, turning off FETs N1 and P1 (Figure 1). This makes the NO<sub>-</sub> pin high impedance, regardless of the switch state. If the switch state is “off,” all FETs turn off, and both NO<sub>-</sub> and COM<sub>-</sub> are high impedance. If the switch state is “on,” FET P2 turns on, clamping COM<sub>-</sub> to V<sub>+</sub>.

## Negative Fault Condition

When the signal on NO<sub>-</sub> goes about 150mV below V<sub>-</sub>, the negative fault comparator output goes high, turning off FETs N1 and P1 (Figure 1). This makes the NO<sub>-</sub> pin high impedance, regardless of the switch state. If the switch state is “off,” all FETs turn off, and both NO<sub>-</sub> and COM<sub>-</sub> are high impedance. If the switch state is “on,” FET N2 turns on, clamping COM<sub>-</sub> to V<sub>-</sub>.

## Transient Fault Condition

When a fast rising or falling transient on NO<sub>-</sub> exceeds V<sub>+</sub> or V<sub>-</sub>, the output (COM<sub>-</sub>) follows the input (NO<sub>-</sub>) to the supply rail with only a few nanoseconds delay. This delay is due to the switch on-resistance and circuit capacitance to ground. When the input transient returns to within the supply rails, however, there is a longer output recovery time. For positive faults, the recovery time is typically 2.5μs (see *Typical Operating Characteristics*). For negative faults, the recovery time is typically 1.3μs. These values depend on the COM<sub>-</sub> output resistance and capacitance. The delays do not depend on the fault amplitude. Higher COM<sub>-</sub> output resistance and capacitance increase the recovery times.

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

FETs N2 and P2 can source about ±10mA from V<sub>+</sub> or V<sub>-</sub> to the COM<sub>-</sub> pin in the fault condition (Figure 1). Ensure that if the COM<sub>-</sub> pin is connected to a low-impedance load, the absolute maximum current rating of 30mA is never exceeded, either in normal or fault conditions.

The GND, COM<sub>-</sub>, and A<sub>-</sub> pins do not have fault protection. Reverse ESD protection diodes are internally con-

nected between GND, COM<sub>-</sub>, A<sub>-</sub>, and both V<sub>+</sub> and V<sub>-</sub>. If a signal on GND, COM<sub>-</sub>, or A<sub>-</sub> exceeds V<sub>+</sub> or V<sub>-</sub> by more than 300mV, one of these diodes will conduct. During normal operation, these reverse-biased ESD diodes leak a few nanoamps of current to V<sub>+</sub> and V<sub>-</sub>.

## Fault Protection Voltage and Power Off

The maximum fault voltage on the NO<sub>-</sub> pins is ±40V from ground when the power is off. With ±15V supply voltages, the highest voltage on NO<sub>-</sub> can be V<sub>-</sub> + 40V, and the lowest voltage on NO<sub>-</sub> can be V<sub>+</sub> - 40V. Exceeding these limits can damage the chip.

## Logic Level Thresholds

The logic level thresholds are CMOS and TTL compatible with V<sub>+</sub> = 13.5V to V<sub>+</sub> = 16.5V.

## Applications Information

### Ground

There is no connection between the analog signal paths and GND. The analog signal paths consist of an N-channel and a P-channel MOSFET with their sources and drains paralleled and their gates driven out of phase to V<sub>+</sub> and V<sub>-</sub> by the logic-level translators.

V<sub>+</sub> and GND power the internal logic and logic level translators and set the input logic thresholds. The logic-level translators convert the logic levels to switched V<sub>+</sub> and V<sub>-</sub> signals to drive the gates of the multiplexers. This drive signal is the only connection between the power supplies and the analog signals. GND, A<sub>-</sub>, and COM<sub>-</sub> have ESD protection diodes to V<sub>+</sub> and V<sub>-</sub>.

### Supply Current Reduction

When the logic signals are driven rail-to-rail from 0 to +15V or -15V to +15V, the current consumption will be reduced from 370μA (typ) to 200μA.

### Power Supplies

The MAX4508/MAX4509 operate with bipolar supplies between ±4.5V and ±20V. The V<sub>+</sub> and V<sub>-</sub> supplies need not be symmetrical, but their sum cannot exceed the 44V absolute maximum rating.

The MAX4508/MAX4509 operate from single supplies between +9V and +36V when V<sub>-</sub> is connected to GND.

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## Test Circuits/Timing Diagrams

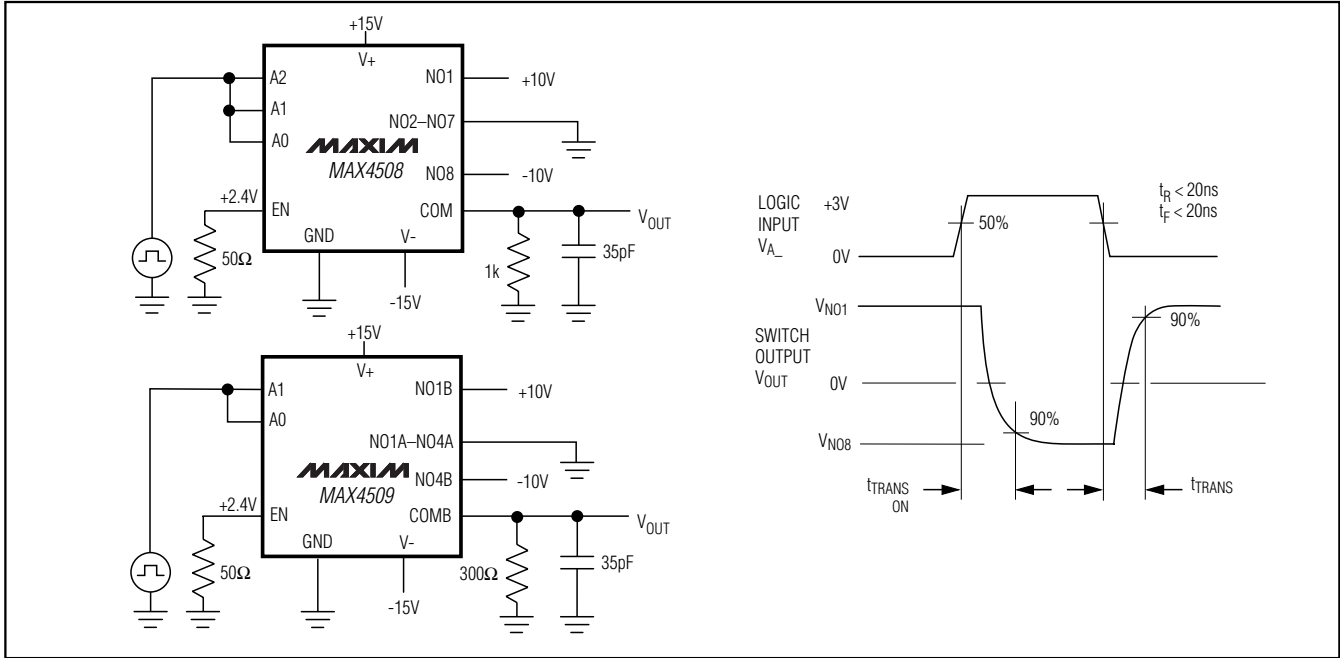


Figure 2. Address Transition Time

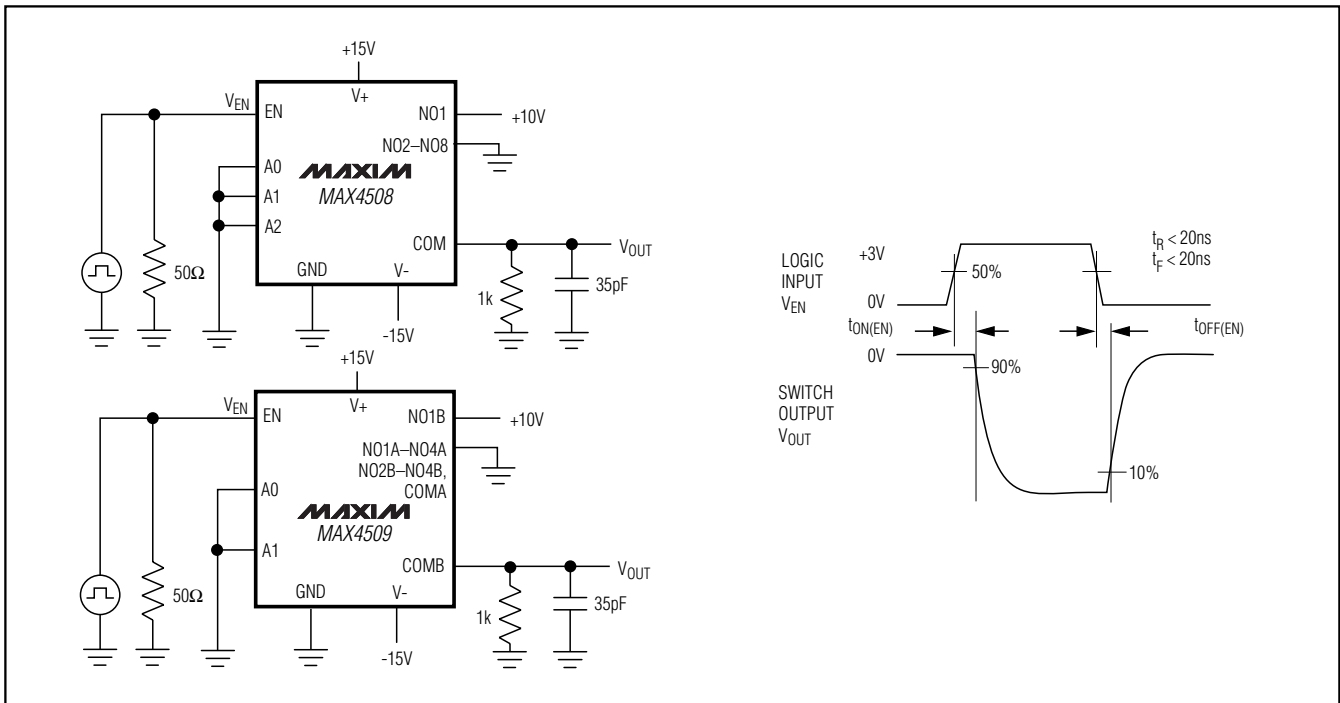


Figure 3. Enable Switching Time

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## Test Circuits/Timing Diagrams (continued)

MAX4508/MAX4509

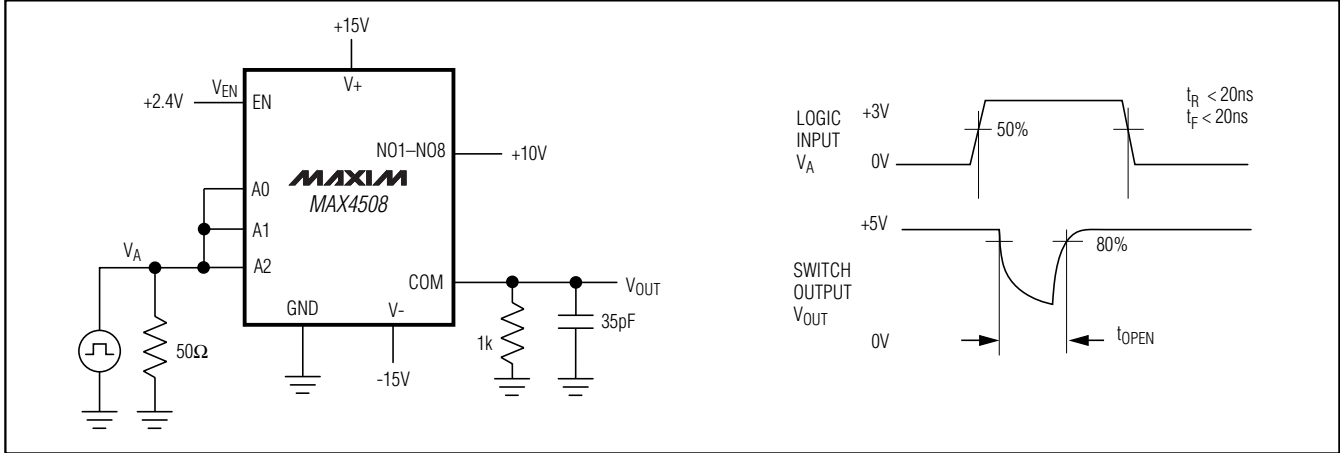


Figure 4. MAX4508 Break-Before-Make Interval

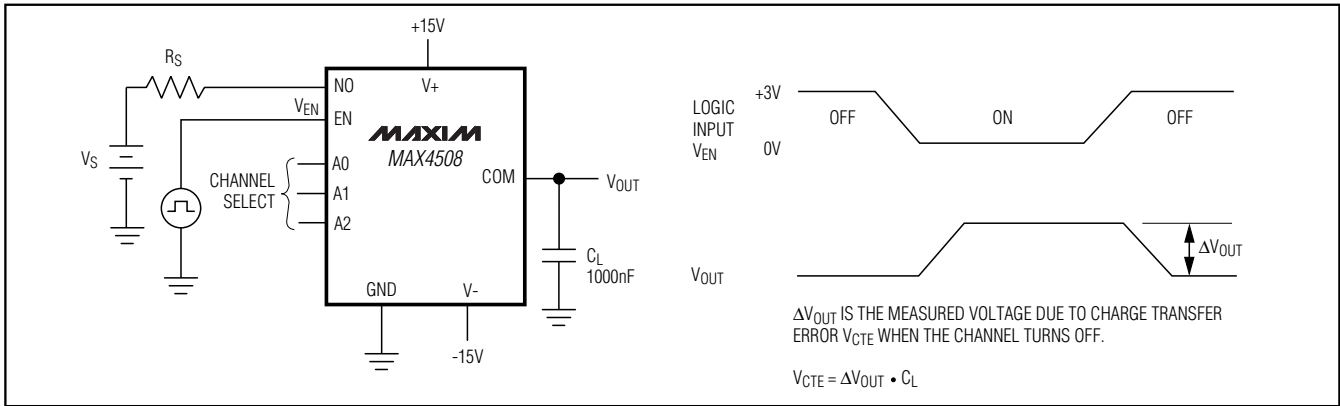


Figure 5. Charge Injection

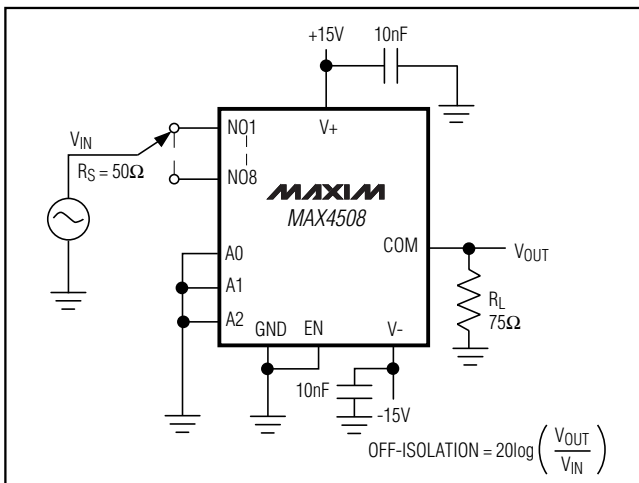


Figure 6. Off-Isolation

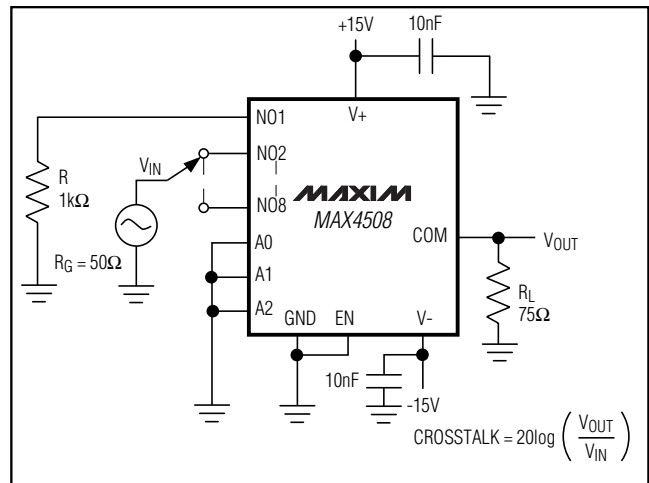


Figure 7. Crosstalk

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## Test Circuits/Timing Diagrams (continued)

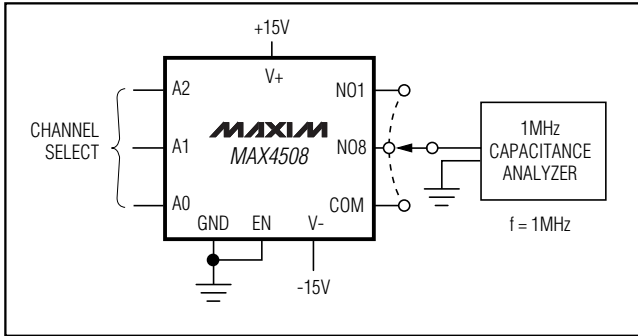


Figure 8. NO<sub>1</sub>, COM<sub>1</sub> Capacitance

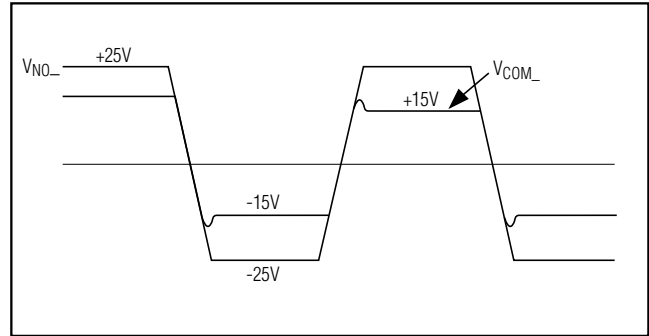


Figure 9. Transient Behavior of Fault Condition

## Functional Diagrams/Truth Tables

| MAX4508 |    |    |    |           |
|---------|----|----|----|-----------|
| 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<sub>AL</sub> ≤ +0.8V, LOGIC "1" V<sub>AH</sub> ≥ +2.4V

| MAX4509 |    |    |           |
|---------|----|----|-----------|
| 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<sub>AL</sub> ≤ +0.8V, LOGIC "1" V<sub>AH</sub> ≥ +2.4V

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## Ordering Information (continued)

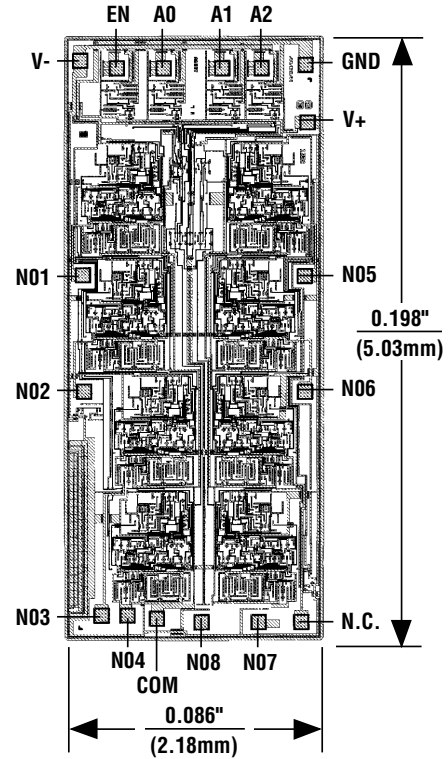
| PART        | TEMP RANGE     | PIN-PACKAGE    | PKG CODE |
|-------------|----------------|----------------|----------|
| MAX4509CSE+ | 0°C to +70°C   | 16 Narrow SO   | S16-8    |
| MAX4509CPE+ | 0°C to +70°C   | 16 Plastic DIP | P16-4    |
| MAX4509C/D  | 0°C to +70°C   | Dice*          | —        |
| MAX4509ESE+ | -40°C to +85°C | 16 Narrow SO   | S16-8    |
| MAX4509EPE+ | -40°C to +85°C | 16 Plastic DIP | P16-4    |
| MAX4509MJE  | -40°C to +85°C | 16 CERDIP**    | J16-3    |

\*Contact factory for dice specifications.

\*\*Contact factory for availability.

+Denotes a lead-free package.

## Chip Topography



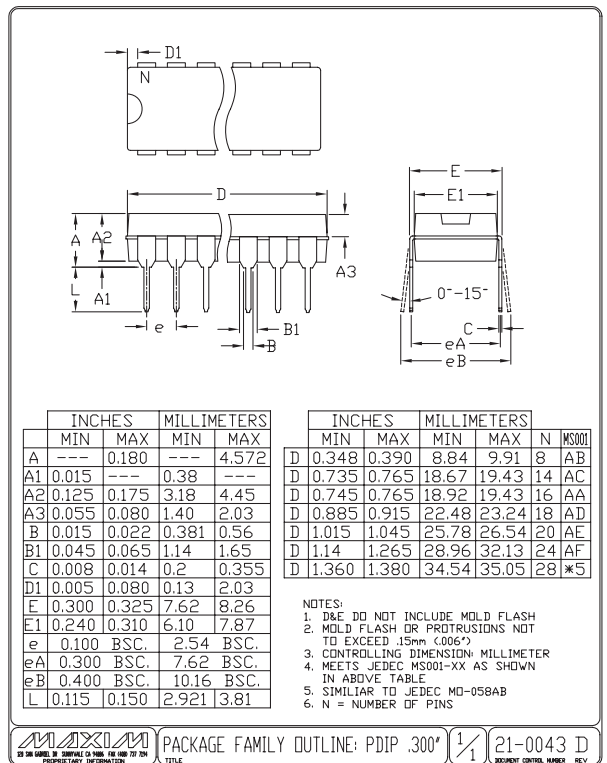
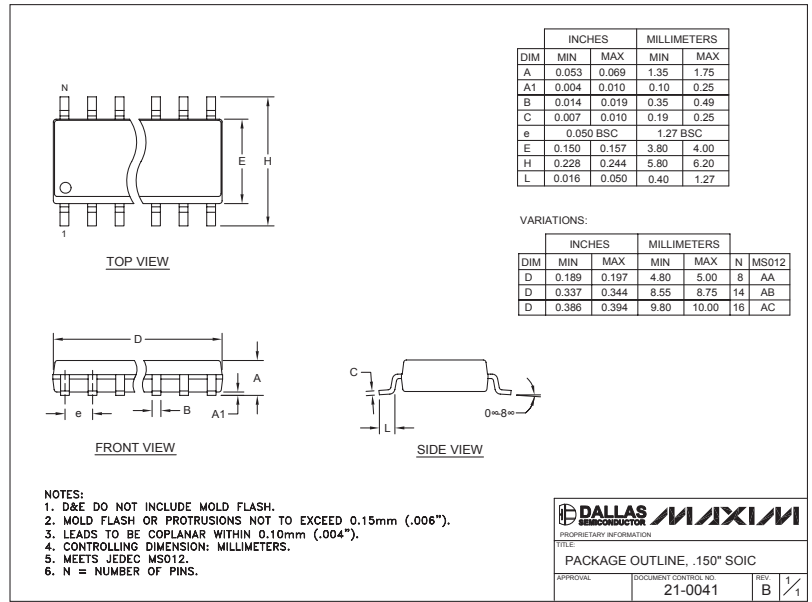
**MAX4508/MAX4509**

SUBSTRATE IS INTERNALLY CONNECTED TO V+

# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



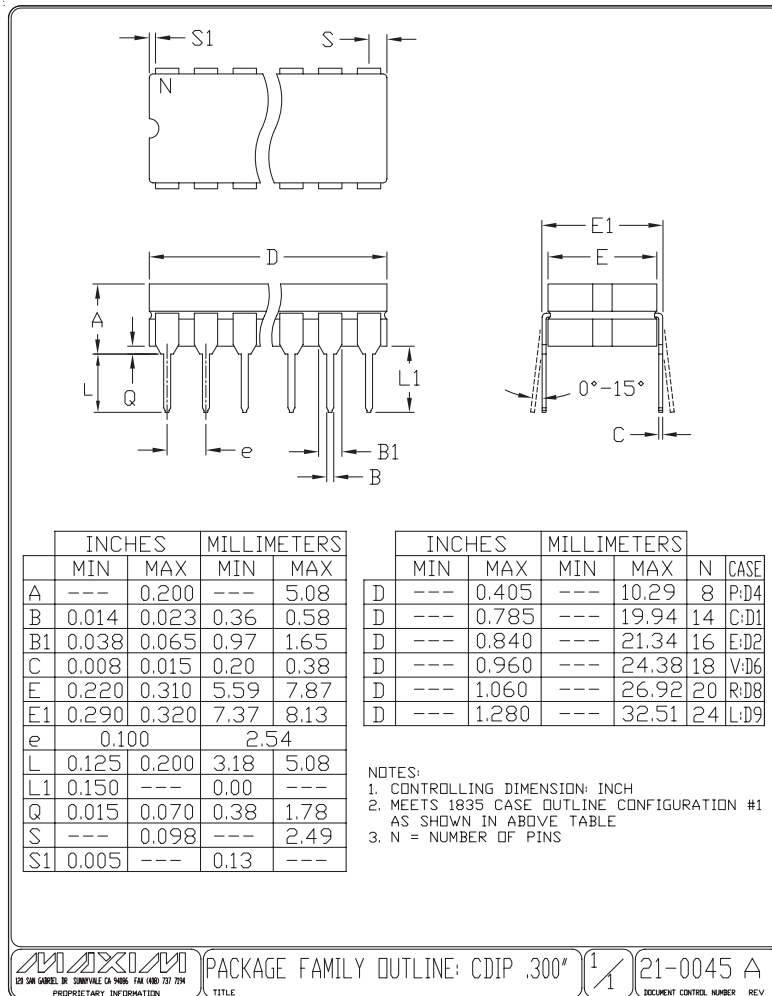


# Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

**MAX4508/MAX4509**



# **Fault-Protected, High-Voltage Single 8-to-1/ Dual 4-to-1 Multiplexers with Output Clamps**

## **Revision History**

| <b>REVISION NUMBER</b> | <b>REVISION DATE</b> | <b>DESCRIPTION</b>                         | <b>PAGES CHANGED</b> |
|------------------------|----------------------|--|----------------------|
| 5                      | 10/07                | EC table changes and stylistic corrections | 2-5                  |

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