



# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## General Description

The MAX4534 (single 4-to-1) and MAX4535 (dual 2-to-1) fault-protected multiplexers operate with  $\pm 4.5\text{V}$  to  $\pm 20\text{V}$  dual supplies or a  $+9\text{V}$  to  $+36\text{V}$  single supply. These multiplexers feature fault-protected inputs, rail-to-rail signal-handling capability, and overvoltage clamping at  $150\text{mV}$  beyond the rails. Both parts feature  $\pm 40\text{V}$  overvoltage protection with supplies off and  $\pm 25\text{V}$  protection with supplies on. On-resistance is  $400\Omega$  max and is matched between channels to  $10\Omega$  max. All digital inputs have TTL logic thresholds, ensuring TTL/CMOS-logic compatibility when using a single  $+12\text{V}$  or dual  $\pm 15\text{V}$  supplies.

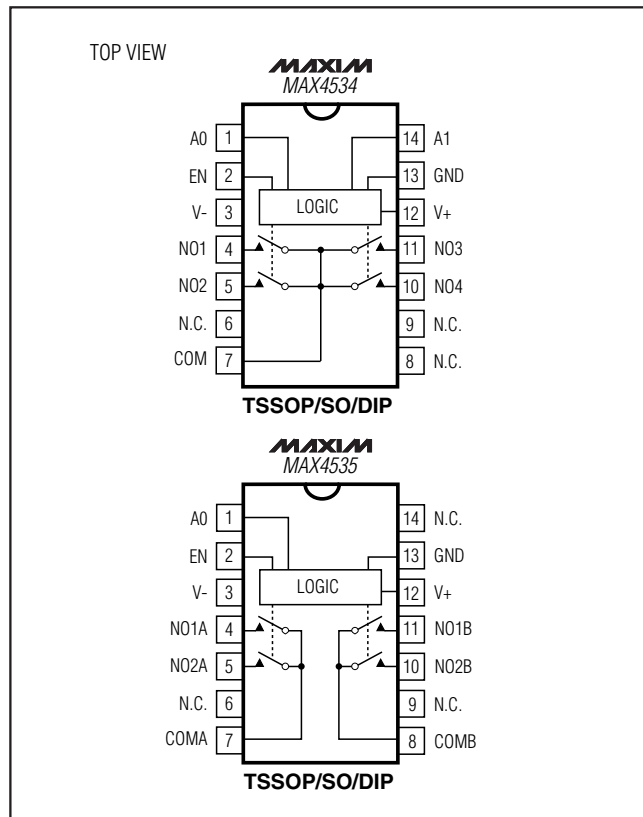
## Applications

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

## Features

- ◆  $\pm 40\text{V}$  Fault Protection with Power Off
- ◆  $\pm 25\text{V}$  Fault Protection with  $\pm 15\text{V}$  Supplies
- ◆ No Power-Supply Sequencing Required
- ◆ All Channels Off with Power Off
- ◆ Rail-to-Rail Signal Handling
- ◆ Output Clamped to Appropriate Supply Voltage During Fault Condition
- ◆  $1.0\text{k}\Omega$  typ Output Clamp Resistance During Overvoltage
- ◆  $400\Omega$  max On-Resistance
- ◆  $20\text{ns}$  typ 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

## Pin Configurations



## Ordering Information

| PART       | TEMP RANGE                                     | PIN-PACKAGE    |
|------------|------------------------------------------------|----------------|
| MAX4534CUD | $0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$   | 14 TSSOP       |
| MAX4534CSD | $0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$   | 14 Narrow SO   |
| MAX4534CPD | $0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$   | 14 Plastic DIP |
| MAX4534EUD | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 14 TSSOP       |
| MAX4534ESD | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 14 Narrow SO   |
| MAX4534EPD | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 14 Plastic DIP |
| MAX4535CUD | $0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$   | 14 TSSOP       |
| MAX4535CSD | $0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$   | 14 Narrow SO   |
| MAX4535CPD | $0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$   | 14 Plastic SO  |
| MAX4535EUD | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 14 TSSOP       |
| MAX4535ESD | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 14 Narrow SO   |
| MAX4535EPD | $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ | 14 Plastic DIP |



# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to GND)

|                                                                   |                                                         |
|-------------------------------------------------------------------|---------------------------------------------------------|
| V+                                                                | .....-0.3V to +44V                                      |
| V-                                                                | .....-44V to +0.3V                                      |
| V+ to V-                                                          | .....-0.3V to +44V                                      |
| COM <sub>-</sub> , A <sub>-</sub> , EN (Note 1)                   | .....(V <sub>-</sub> - 0.3V) to (V <sub>+</sub> + 0.3V) |
| NO <sub>-</sub> (Note 2)                                          | .....(V <sub>+</sub> - 40V) to (V <sub>-</sub> + 40V)   |
| NO <sub>-</sub> to COM <sub>-</sub> (Note 2)                      | .....-40V to +40V                                       |
| NO <sub>-</sub> Overvoltage with Switch Power On (Note 2)         | ...-36V to +36V                                         |
| NO <sub>-</sub> Overvoltage with Switch Power Off (Note 2)        | ...-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)

|                                                 |                      |
|-------------------------------------------------|----------------------|
| 14-Pin TSSOP (derate 6.3mW/°C above +70°C)      | .....500mW           |
| 14-Pin Narrow SO (derate 8mW/°C above +70°C)    | .....640mW           |
| 14-Pin Plastic DIP (derate 10mW/°C above +70°C) | .....800mW           |
| Operating Temperature Ranges                    |                      |
| MAX453_C_D                                      | .....0°C to +70°C    |
| MAX453_E_D                                      | .....-40°C to +85°C  |
| Storage Temperature Range                       | .....-65°C to +150°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<sub>+</sub> or V<sub>-</sub> are clamped by internal diodes. Limit forward diode current to maximum current rating.

**Note 2:** NO<sub>-</sub> pins are fault-protected. Signals on NO<sub>-</sub> exceeding -25V to +25V may damage the device during power-on conditions. When the power is off the maximum voltage range is -40V to +40V.

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

## ELECTRICAL CHARACTERISTICS—Dual Supplies

(V<sub>+</sub> = +15V, V<sub>-</sub> = -15V, V<sub>A\_H</sub> = V<sub>ENH</sub> = 2.4V, V<sub>A\_L</sub> = V<sub>ENL</sub> = 0.8V, 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 3)

| PARAMETER                                     | SYMBOL                 | CONDITIONS                                                          |         | T <sub>A</sub> | MIN  | TYP  | MAX | UNITS |
|-----------------------------------------------|------------------------|---------------------------------------------------------------------|---------|----------------|------|------|-----|-------|
| ANALOG SWITCH                                 |                        |                                                                     |         |                |      |      |     |       |
| Fault-Free Analog Signal Range                | V <sub>NO_</sub>       | Applies with power on or off                                        |         |                | V-   |      | V+  | V     |
| On-Resistance                                 | R <sub>ON</sub>        | V <sub>COM_</sub> = ±10V, I <sub>NO_</sub> = 1mA                    |         | +25°C          |      | 275  | 400 | Ω     |
|                                               |                        |                                                                     |         | C, E           |      |      | 500 |       |
| On-Resistance Match Between Channels (Note 4) | ΔR <sub>ON</sub>       | V <sub>COM_</sub> = ±10V, I <sub>NO_</sub> = 1mA                    |         | +25°C          |      | 2    | 10  | Ω     |
|                                               |                        |                                                                     |         | C, E           |      |      | 15  |       |
| NO_ Off-Leakage Current (Note 5)              | I <sub>NO_(OFF)</sub>  | V <sub>NO_</sub> = ±10V, V <sub>COM_</sub> = ∓10V                   |         | +25°C          | -0.5 | 0.01 | 0.5 | nA    |
|                                               |                        |                                                                     |         | C, E           | -5   |      | 5   |       |
| COM_ Off-Leakage Current (Note 5)             | I <sub>COM_(OFF)</sub> | V <sub>COM_</sub> = ±10V, V <sub>NO_</sub> = ∓10V                   | MAX4534 | +25°C          | -2   | 0.05 | 2   | nA    |
|                                               |                        |                                                                     |         | C, E           | -60  |      | 60  |       |
|                                               |                        |                                                                     | MAX4535 | +25°C          | -1   | 0.05 | 1   |       |
|                                               |                        |                                                                     |         | C, E           | -30  |      | 30  |       |
| COM_ On-Leakage Current (Note 5)              | I <sub>COM_(ON)</sub>  | V <sub>COM_</sub> = ±10V, V <sub>NO_</sub> = floating               | MAX4534 | +25°C          | -2   | 0.1  | 2   | nA    |
|                                               |                        |                                                                     |         | C, E           | -80  |      | 80  |       |
|                                               |                        |                                                                     | MAX4535 | +25°C          | -1   | 0.1  | 1   |       |
|                                               |                        |                                                                     |         | C, E           | -40  |      | 40  |       |
| FAULT PROTECTION                              |                        |                                                                     |         |                |      |      |     |       |
| Fault-Protected Analog Signal Range (Note 6)  | V <sub>NO_</sub>       | Applies with power on                                               |         |                | -25  |      | +25 | V     |
|                                               |                        | Applies with power off                                              |         |                | -40  |      | +40 |       |
| COM_ Output Leakage Current, Supplies On      | I <sub>COM_</sub>      | V <sub>NO_</sub> = ±25V, V <sub>EN</sub> = 0, V <sub>COM_</sub> = 0 |         | +25°C          | -20  |      | 20  | nA    |
|                                               |                        |                                                                     |         | C, E           | -1   |      | 1   | μA    |

# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +15V, V- = -15V, V<sub>A\_H</sub> = V<sub>ENH</sub> = 2.4V, V<sub>A\_L</sub> = V<sub>ENL</sub> = 0.8V, 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 3)

| PARAMETER                                    | SYMBOL                              | CONDITIONS                                                                      | T <sub>A</sub> | MIN      | TYP      | MAX | UNITS |
|----------------------------------------------|-------------------------------------|---------------------------------------------------------------------------------|----------------|----------|----------|-----|-------|
| NO_ 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          | -20      |          | 20  | nA    |
|                                              |                                     |                                                                                 | C, E           | -200     |          | 200 |       |
| NO_ Input Leakage Current, Supplies Off      | I <sub>NO_</sub>                    | V <sub>NO_</sub> = ±40V, V <sub>COM_</sub> = 0, V+ = 0, V- = 0                  | +25°C          | -20      |          | 20  | nA    |
|                                              |                                     |                                                                                 | C, E           | -5       |          | 5   | μA    |
| COM_ On Clamp Output Current, Supplies On    | I <sub>COM_</sub>                   | V <sub>NO_</sub> = +25V V <sub>COM_</sub> = 0                                   | +25°C          | 7        | 10       | 13  | mA    |
|                                              |                                     | V <sub>NO_</sub> = -25V V <sub>COM_</sub> = 0                                   |                | -13      | -11      | -7  |       |
| COM_ On Clamp Output Resistance, Supplies On | R <sub>COM_</sub>                   | V <sub>NO_</sub> = ±25V                                                         | +25°C          | 0.1      | 1.0      | 2.5 | kΩ    |
|                                              |                                     |                                                                                 | C, E           | 0.08     |          | 3   |       |
| ± Fault Response Time                        |                                     | R <sub>L</sub> = 10kΩ, V <sub>NO_</sub> = ±25V                                  |                |          | 20       |     | ns    |
| ± Fault Recovery Time                        |                                     | R <sub>L</sub> = 10kΩ, V <sub>NO_</sub> = ±25V                                  |                |          | 2.5      |     | μs    |
| Fault Trip Threshold                         |                                     | R <sub>L</sub> = 1kΩ                                                            |                | V- - 400 | V+ + 400 |     | mV    |
| <b>LOGIC INPUT</b>                           |                                     |                                                                                 |                |          |          |     |       |
| Input Logic Voltage High                     | V <sub>A_H</sub> , V <sub>ENH</sub> |                                                                                 |                | 2.4      |          |     | V     |
| Input Logic Voltage Low                      | V <sub>A_L</sub> , V <sub>ENL</sub> |                                                                                 |                |          |          | 0.8 | V     |
| Input Logic Current                          | I <sub>A_</sub> , I <sub>EN</sub>   | V <sub>A_</sub> = V <sub>EN</sub> = 0.8V or 2.4V                                |                | -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, Figure 3                         | +25°C          |          | 135      | 275 | ns    |
|                                              |                                     |                                                                                 | C, E           |          |          | 400 |       |
| Enable Turn-Off Time                         | t <sub>OFF</sub>                    | V <sub>NO_</sub> = ±10V, R <sub>L</sub> = 1kΩ, Figure 3                         | +25°C          |          | 60       | 200 | ns    |
|                                              |                                     |                                                                                 | C, E           |          |          | 250 |       |
| Transition Time                              | t <sub>TRANS</sub>                  | Figure 2                                                                        | +25°C          |          | 130      | 350 | ns    |
|                                              |                                     |                                                                                 | C, E           |          |          | 500 |       |
| Break-Before-Make Time Delay                 | t <sub>BBM</sub>                    | V <sub>NO_</sub> = ±10V, R <sub>L</sub> = 1kΩ, Figure 4                         |                | 10       | 60       |     | ns    |
| Charge Injection (Note 7)                    | Q                                   | C <sub>L</sub> = 1nF, V <sub>NO_</sub> = 0, R <sub>S</sub> = 0, Figure 5        |                |          | 1        | 10  | pC    |
| Off-Isolation (Note 8)                       | V <sub>ISO</sub>                    | R <sub>L</sub> = 50Ω, V <sub>NO_</sub> = 1V <sub>RMS</sub> , f = 1MHz, Figure 6 |                |          | -62      |     | dB    |
| Channel-to-Channel Crosstalk (Note 9)        | V <sub>CT</sub>                     | R <sub>L</sub> = 50Ω, V <sub>NO_</sub> = 1V <sub>RMS</sub> , f = 1MHz, Figure 7 |                |          | -53      |     | dB    |
| NO_ Off-Capacitance                          | C <sub>NO_(OFF)</sub>               | f = 1MHz, Figure 8                                                              |                |          | 5        |     | pF    |
| COM_ Off-Capacitance                         | C <sub>COM_(OFF)</sub>              | f = 1MHz, Figure 8                                                              | MAX4534        |          | 6.5      |     | pF    |
|                                              |                                     |                                                                                 | MAX4535        |          | 4        |     |       |
| COM_ On-Capacitance                          | C <sub>COM_(ON)</sub>               | f = 1MHz, Figure 8                                                              | MAX4534        |          | 13.5     |     | pF    |
|                                              |                                     |                                                                                 | MAX4535        |          | 10.5     |     |       |

**MAX4534/MAX4535**

# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = +15V, V- = -15V, V<sub>A\_H</sub> = V<sub>ENH</sub> = 2.4V, V<sub>A\_L</sub> = V<sub>ENL</sub> = 0.8V, 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 3)

| PARAMETER           | SYMBOL           | CONDITIONS                                            | T <sub>A</sub> | MIN  | TYP  | MAX | UNITS |
|---------------------|------------------|-------------------------------------------------------|----------------|------|------|-----|-------|
| <b>POWER SUPPLY</b> |                  |                                                       |                |      |      |     |       |
| Power-Supply Range  | V+, V-           |                                                       |                | ±4.5 |      | ±20 | V     |
| V+ Supply Current   | I+               | All V <sub>A_</sub> = V <sub>EN</sub> = 0 or 5V       | +25°C          |      | 225  | 400 | μA    |
|                     |                  |                                                       | C, E           |      |      | 600 |       |
|                     |                  | All V <sub>A_</sub> = V <sub>EN</sub> = 0 or 15V      | +25°C          |      | 125  | 200 |       |
|                     |                  |                                                       | C, E           |      |      | 300 |       |
| V- Supply Current   | I-               | All V <sub>A_</sub> = V <sub>EN</sub> = 0, 5V, or 15V | +25°C          |      | 125  | 200 | μA    |
|                     |                  |                                                       | C, E           |      |      | 300 |       |
| GND Supply Current  | I <sub>GND</sub> | All V <sub>A_</sub> = V <sub>EN</sub> = 0 or 15V      | +25°C          |      | 0.01 | 1   | μA    |
|                     |                  |                                                       | C, E           |      |      | 10  |       |
|                     |                  | All V <sub>A_</sub> = V <sub>EN</sub> = 5V            | +25°C          |      | 100  | 200 |       |
|                     |                  |                                                       | C, E           |      |      | 300 |       |

## ELECTRICAL CHARACTERISTICS—Single +12V Supply

(V+ = +12V, V- = 0, V<sub>A\_H</sub> = V<sub>ENH</sub> = 2.4V, V<sub>A\_L</sub> = V<sub>ENL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MIN</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 3)

| PARAMETER                                     | SYMBOL                 | CONDITIONS                                                              | T <sub>A</sub> | MIN   | TYP  | MAX  | UNITS |
|-----------------------------------------------|------------------------|-------------------------------------------------------------------------|----------------|-------|------|------|-------|
| Fault-Free Analog Signal Range                | V <sub>NO_</sub>       | Applies with power on or off                                            |                | 0     |      | V+   | V     |
| On-Resistance                                 | R <sub>ON</sub>        | V <sub>COM_</sub> = 10V, I <sub>NO_</sub> = 500μA                       | +25°C          |       | 650  | 950  | Ω     |
|                                               |                        |                                                                         | C, E           |       |      | 1100 |       |
| On-Resistance Match Between Channels (Note 5) | ΔR <sub>ON</sub>       | V <sub>COM_</sub> = 10V, I <sub>NO_</sub> = 500μA                       | +25°C          |       | 10   | 25   | Ω     |
|                                               |                        |                                                                         | C, E           |       |      | 40   |       |
| NO_ Off-Leakage Current (Notes 5, 10)         | I <sub>NO_(OFF)</sub>  | V <sub>COM_</sub> = 10V, 1V;<br>V <sub>NO_</sub> = 1V, 10V              | +25°C          | -0.5  | 0.01 | 0.5  | nA    |
|                                               |                        |                                                                         | C, E           | -10   |      | 10   |       |
| COM_ Off-Leakage Current (Notes 5, 10)        | I <sub>COM_(OFF)</sub> | V <sub>COM_</sub> = 10V, 1V;<br>V <sub>NO_</sub> = 1V, 10V              | MAX4534        | +25°C | -2   | 2    | nA    |
|                                               |                        |                                                                         | C, E           |       | -60  | 60   |       |
|                                               |                        | MAX4535                                                                 | +25°C          | -1    |      | 1    |       |
|                                               |                        |                                                                         | C, E           |       | -30  | 30   |       |
| COM_ On-Leakage Current (Notes 5, 10)         | I <sub>COM_(ON)</sub>  | V <sub>COM_</sub> = 10V, 1V;<br>V <sub>NO_</sub> = 10V, 1V, or floating | MAX4534        | +25°C | -2   | 2    | nA    |
|                                               |                        |                                                                         | C, E           |       | -80  | 80   |       |
|                                               |                        | MAX4535                                                                 | +25°C          | -1    |      | 1    |       |
|                                               |                        |                                                                         | C, E           |       | -40  | 40   |       |

# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

**MAX4534/MAX4535**

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

(V<sub>+</sub> = +12V, V<sub>-</sub> = 0, V<sub>A\_H</sub> = V<sub>ENH</sub> = 2.4V, V<sub>A\_L</sub> = V<sub>ENL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MIN</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 3)

| PARAMETER                                    | SYMBOL                              | CONDITIONS                                                                      | T <sub>A</sub> | MIN                  | TYP | MAX                  | UNITS |
|----------------------------------------------|-------------------------------------|---------------------------------------------------------------------------------|----------------|----------------------|-----|----------------------|-------|
| <b>FAULT PROTECTION</b>                      |                                     |                                                                                 |                |                      |     |                      |       |
| Fault-Protected Analog Signal Range (Note 6) | V <sub>NO_</sub>                    | Applies with all power on                                                       | +25°C          | -25                  |     | 25                   | V     |
|                                              |                                     | Applies with all power off                                                      |                | -40                  |     | 40                   |       |
| COM_ Output Leakage Current, Supply On       | I <sub>COM_</sub>                   | V <sub>NO_</sub> = ±25V, V <sub>COM_</sub> = 0                                  | +25°C          | -20                  |     | 20                   | nA    |
|                                              |                                     |                                                                                 | C, E           | -1                   |     | 1                    | μA    |
| NO_ Input Leakage Current, Supply On         | I <sub>NO_</sub>                    | V <sub>NO_</sub> = ±25V, V <sub>COM_</sub> = 0,                                 | +25°C          | -20                  |     | 20                   | nA    |
|                                              |                                     |                                                                                 | C, E           | -5                   |     | 5                    | μA    |
| NO_ Input Leakage Current, Supply Off        | I <sub>NO_</sub>                    | V <sub>NO_</sub> = ±40V, V <sub>+</sub> = 0                                     | +25°C          | -20                  | 0.1 | 20                   | nA    |
|                                              |                                     |                                                                                 | C, E           | -5                   |     | 5                    | μA    |
| COM_ ON Output Current, Supply On            | I <sub>COM_</sub>                   | V <sub>NO_</sub> = 25V                                                          | +25°C          | 2                    | 3   | 5                    | nA    |
| COM_ ON Output Resistance, Supply On         | R <sub>COM_</sub>                   | V <sub>NO_</sub> = 25V                                                          | +25°C          |                      | 2.4 | 6                    | kΩ    |
| Fault Trip Threshold                         |                                     | R <sub>L</sub> = 1kΩ                                                            |                | V <sub>-</sub> - 400 |     | V <sub>+</sub> + 400 | mV    |
| <b>LOGIC INPUT</b>                           |                                     |                                                                                 |                |                      |     |                      |       |
| Input Logic Voltage High                     | V <sub>A_H</sub> , V <sub>ENH</sub> |                                                                                 |                | 2.4                  |     |                      | V     |
| <b>ANALOG SWITCH</b>                         |                                     |                                                                                 |                |                      |     |                      |       |
| Input Logic voltage Low                      | V <sub>A_L</sub> , V <sub>ENL</sub> |                                                                                 |                |                      |     | 0.8                  | V     |
| Input Logic Current                          | I <sub>A_</sub> , I <sub>EN</sub>   | V <sub>A_</sub> = V <sub>EN</sub> = 0.8V or 2.4V                                |                | -1                   |     | 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, Figure 3                         | +25°C          |                      | 220 | 500                  | ns    |
|                                              |                                     |                                                                                 | C, E           |                      |     | 700                  |       |
| Enable Turn-Off Time                         | t <sub>OFF</sub>                    | V <sub>COM_</sub> = 10V, R <sub>L</sub> = 2kΩ, Figure 3                         | +25°C          |                      | 100 | 250                  | ns    |
|                                              |                                     |                                                                                 | C, E           |                      |     | 350                  |       |
| Break-Before-Make Time Delay                 | t <sub>BBM</sub>                    | V <sub>COM_</sub> = 10V, R <sub>L</sub> = 2kΩ, Figure 4                         | +25°C          | 50                   | 100 |                      | ns    |
| Charge Injection (Note 7)                    | Q                                   | C <sub>L</sub> = 1nF, V <sub>NO_</sub> = 0, R <sub>S</sub> = 0, Figure 5        | +25°C          |                      | 2   | 10                   | pC    |
| Off-Isolation (Note 8)                       | V <sub>ISO</sub>                    | R <sub>L</sub> = 50Ω, V <sub>NO_</sub> = 1V <sub>RMS</sub> , f = 1MHz, Figure 6 |                |                      | -62 |                      | dB    |
| Channel-to-Channel Crosstalk (Note 9)        | V <sub>CT</sub>                     | R <sub>L</sub> = 50Ω, V <sub>NO_</sub> = 1V <sub>RMS</sub> , f = 1MHz, Figure 7 |                |                      | -65 |                      | dB    |

# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

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

( $V_+ = +12V$ ,  $V_- = 0$ ,  $V_{A\_H} = V_{ENH} = 2.4V$ ,  $V_{A\_L} = V_{ENL} = 0.8V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .) (Note 3)

| PARAMETER            | SYMBOL | CONDITIONS                          | $T_A$         | MIN | TYP | MAX | UNITS   |
|----------------------|--------|-------------------------------------|---------------|-----|-----|-----|---------|
| <b>POWER SUPPLY</b>  |        |                                     |               |     |     |     |         |
| Power-Supply Range   | $V_+$  |                                     |               | 9   |     | 36  | V       |
| $V_+$ Supply Current | $I_+$  | All $V_{A\_} = V_{EN} = 0$ or $12V$ | $+25^\circ C$ |     | 75  | 150 | $\mu A$ |
|                      |        |                                     | C, E          |     |     | 250 |         |
|                      |        | All $V_{A\_} = V_{EN} = 5V$         | $+25^\circ C$ |     | 150 | 275 |         |
|                      |        |                                     | C, E          |     |     | 375 |         |

**Note 3:** Algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

**Note 4:**  $\Delta R_{ON} = R_{ON}(MAX) - R_{ON}(MIN)$ .

**Note 5:** Leakage parameters are 100% tested at maximum-rated hot temperature and guaranteed by correlation at  $T_A = 25^\circ C$ .

**Note 6:**  $NO_+$  pins are fault protected, and  $COM_+$  pins are not fault protected. The max input voltage, on  $NO_+$  pins, depends upon the  $COM_+$  load configuration. Generally, the max input voltage is  $\pm 25V$ , with  $\pm 15V$  supplies, and a load referred to ground. For more detailed information, see the *NO\_+ Input Voltage* section.

**Note 7:** Guaranteed by design.

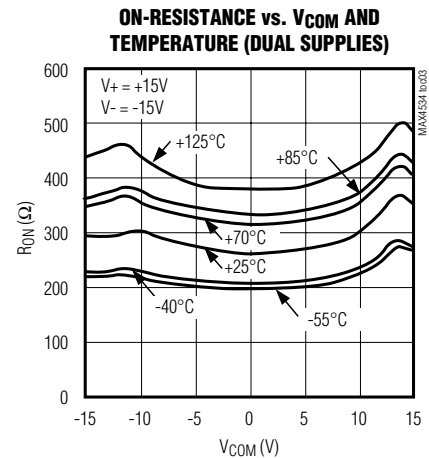
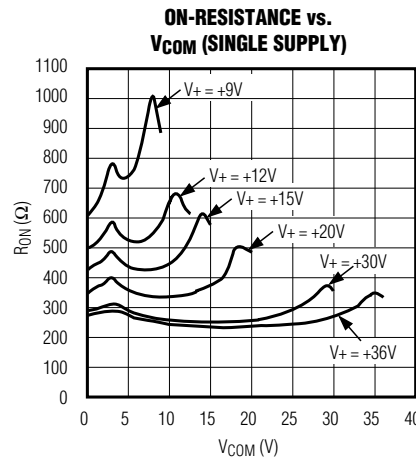
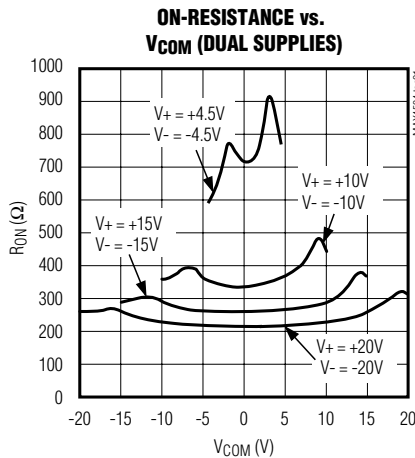
**Note 8:** Off-isolation =  $20 \log_{10} (V_{COM_+} / V_{NO_+})$ ,  $V_{COM_+}$  = output,  $V_{NO_+}$  = input to off switch.

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

**Note 10:** Leakage testing for single-supply operation is guaranteed by testing with dual supplies.

## Typical Operating Characteristics

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



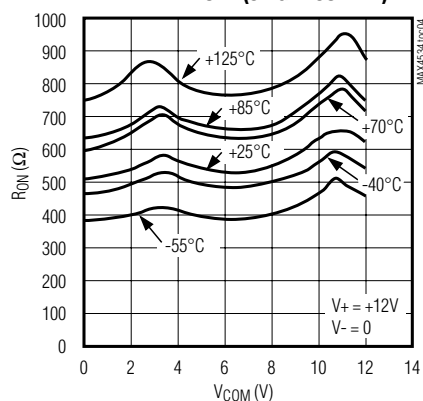
# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## Typical Operating Characteristics (continued)

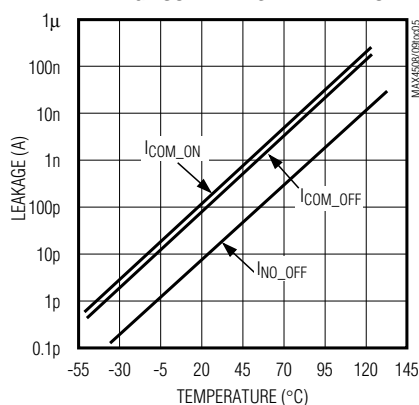
( $V_+ = +15V$ ,  $V_- = -15V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX4534/MAX4535

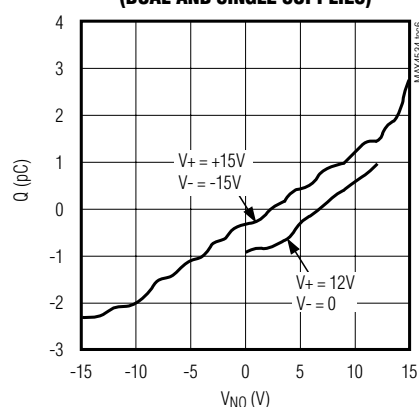
**ON-RESISTANCE vs.  $V_{COM}$  AND TEMPERATURE (SINGLE SUPPLY)**



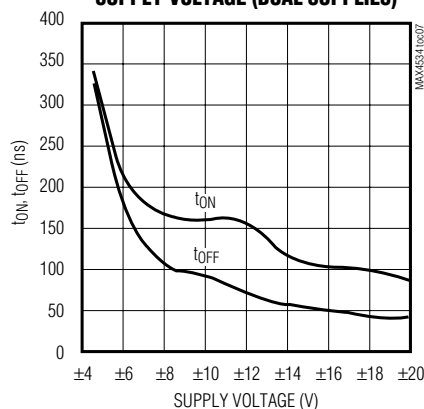
**LEAKAGE CURRENT vs. TEMPERATURE**



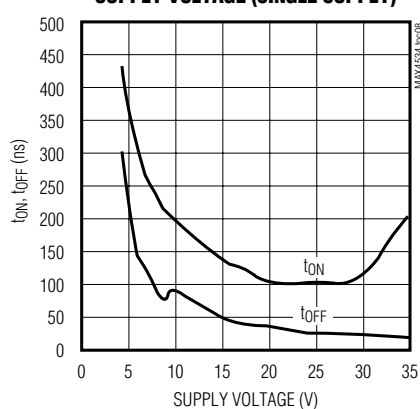
**CHARGE INJECTION vs.  $V_{NO}$  (DUAL AND SINGLE SUPPLIES)**



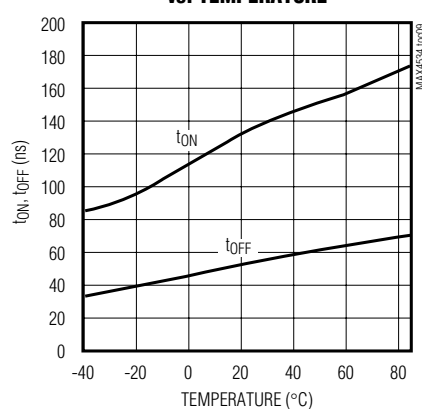
**ENABLE ON/OFF-TIMES vs. SUPPLY VOLTAGE (DUAL SUPPLIES)**



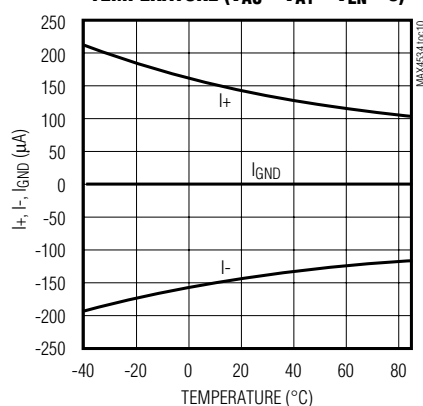
**ENABLE ON/OFF-TIMES vs. SUPPLY VOLTAGE (SINGLE SUPPLY)**



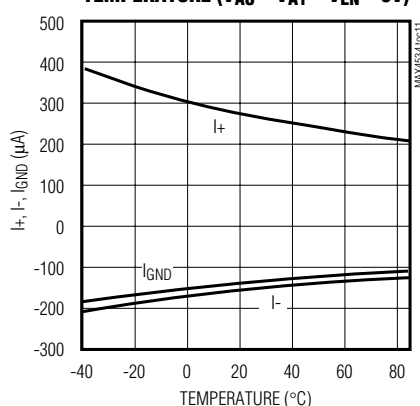
**ENABLE ON/OFF-TIMES vs. TEMPERATURE**



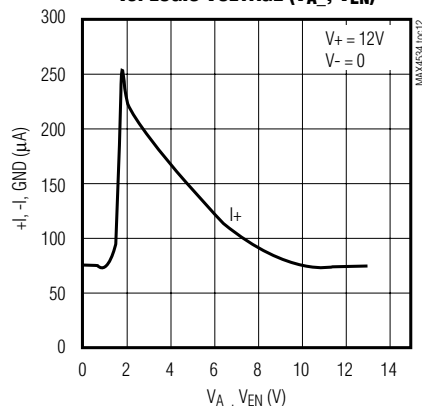
**POWER-SUPPLY CURRENT vs. TEMPERATURE ( $V_{A0} = V_{A1} = V_{EN} = 0$ )**



**POWER-SUPPLY CURRENT vs. TEMPERATURE ( $V_{A0} = V_{A1} = V_{EN} = 5V$ )**



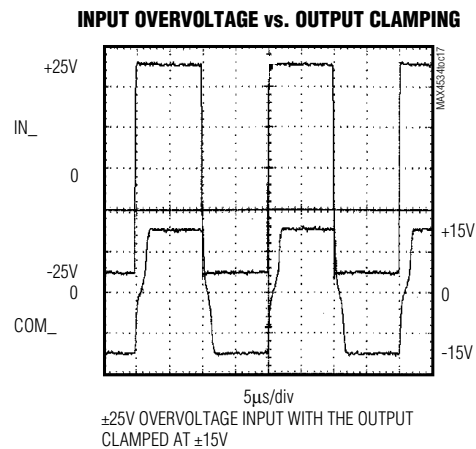
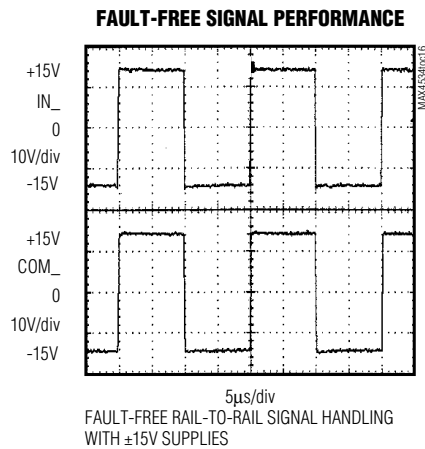
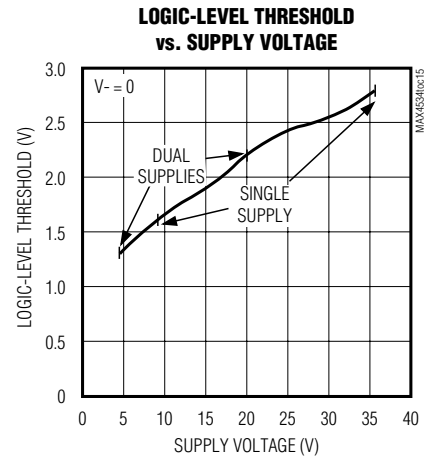
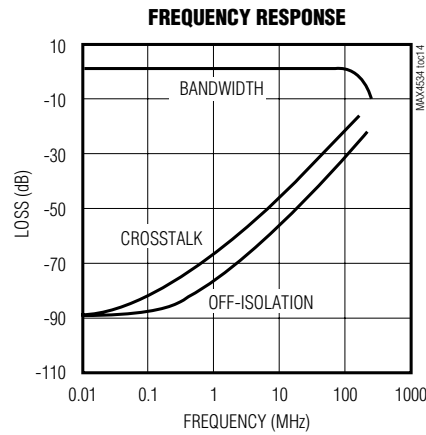
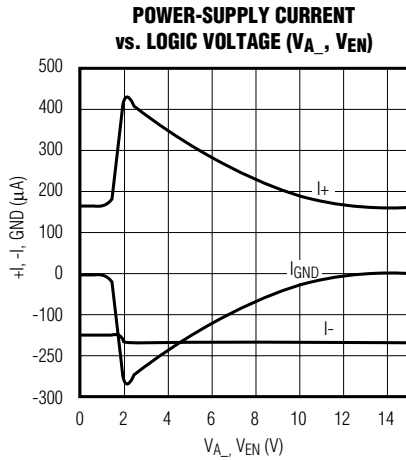
**POWER-SUPPLY CURRENT vs. LOGIC VOLTAGE ( $V_A$ ,  $V_{EN}$ )**



# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## Typical Operating Characteristics (continued)

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





# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## Pin Descriptions

### MAX4534 (Single 4-to-1 Mux)

| PIN     | NAME | FUNCTION                          |
|---------|------|-----------------------------------|
| 1       | A0   | Address Bit 0                     |
| 2       | EN   | Enable Input                      |
| 3       | V-   | Negative Supply Voltage           |
| 4       | NO1  | Channel Input 1 (fault protected) |
| 5       | NO2  | Channel Input 2 (fault protected) |
| 6, 8, 9 | N.C. | No connection                     |
| 7       | COM  | Analog Output                     |
| 10      | NO4  | Channel Input 4 (fault protected) |
| 11      | NO3  | Channel Input 3 (fault protected) |
| 12      | V+   | Positive Supply Voltage           |
| 13      | GND  | Ground                            |
| 14      | A1   | Address Bit 1                     |

### MAX4535 (Dual 2-to-1 Mux)

| PIN      | NAME | FUNCTION                           |
|----------|------|------------------------------------|
| 1        | A0   | Address Bit 0                      |
| 2        | EN   | Enable Input                       |
| 3        | V-   | Negative Supply Voltage            |
| 4        | NO1A | Channel Input 1A (fault protected) |
| 5        | NO2A | Channel Input 2A (fault protected) |
| 6, 9, 14 | N.C. | No connection                      |
| 7        | COMA | Mux Output A                       |
| 8        | COMB | Mux Output B                       |
| 10       | NO2B | Channel Input 2B (fault protected) |
| 11       | NO1B | Channel Input 1B (fault protected) |
| 12       | V+   | Positive Supply Voltage            |
| 13       | GND  | Ground                             |

## Truth Tables

### MAX4534 (Single 4-to-1 Mux)

| A1 | A0 | EN | ON SWITCH |
|----|----|----|-----------|
| X  | X  | 0  | None      |
| 0  | 0  | 1  | NO1       |
| 0  | 1  | 1  | NO2       |
| 1  | 0  | 1  | NO3       |
| 1  | 1  | 1  | NO4       |

X = Don't care; logic 0:  $V_{AL} \leq +0.8$ ; logic 1:  $V_{AH} \geq +2.4V$

### MAX4535 (Dual 2-to-1 Mux)

| A0 | EN | COMA | COMB |
|----|----|------|------|
| X  | 0  | None | None |
| 0  | 1  | NO1A | NO1B |
| 1  | 1  | NO2A | NO2B |

X = Don't care; logic 0:  $V_{AL} \leq +0.8$ ; logic 1:  $V_{AH} \geq +2.4V$

## Detailed Description

The MAX4534/MAX4535 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 on VNO\_ 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.

When the NO\_ voltage goes beyond supply rails (fault condition), the NO\_ 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\_ terminals are a virtual open circuit. The fault can be up to  $\pm 40V$ , with  $V_+ = V_- = 0$ . If the switch is on, the COM\_ output current is furnished from the V+ or V- pin by "booster" FETs connected to each supply pin. These FETs can source or sink up to 10mA.

The COM\_ pins are not fault-protected. If a voltage source is connected to any COM\_ 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.

# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

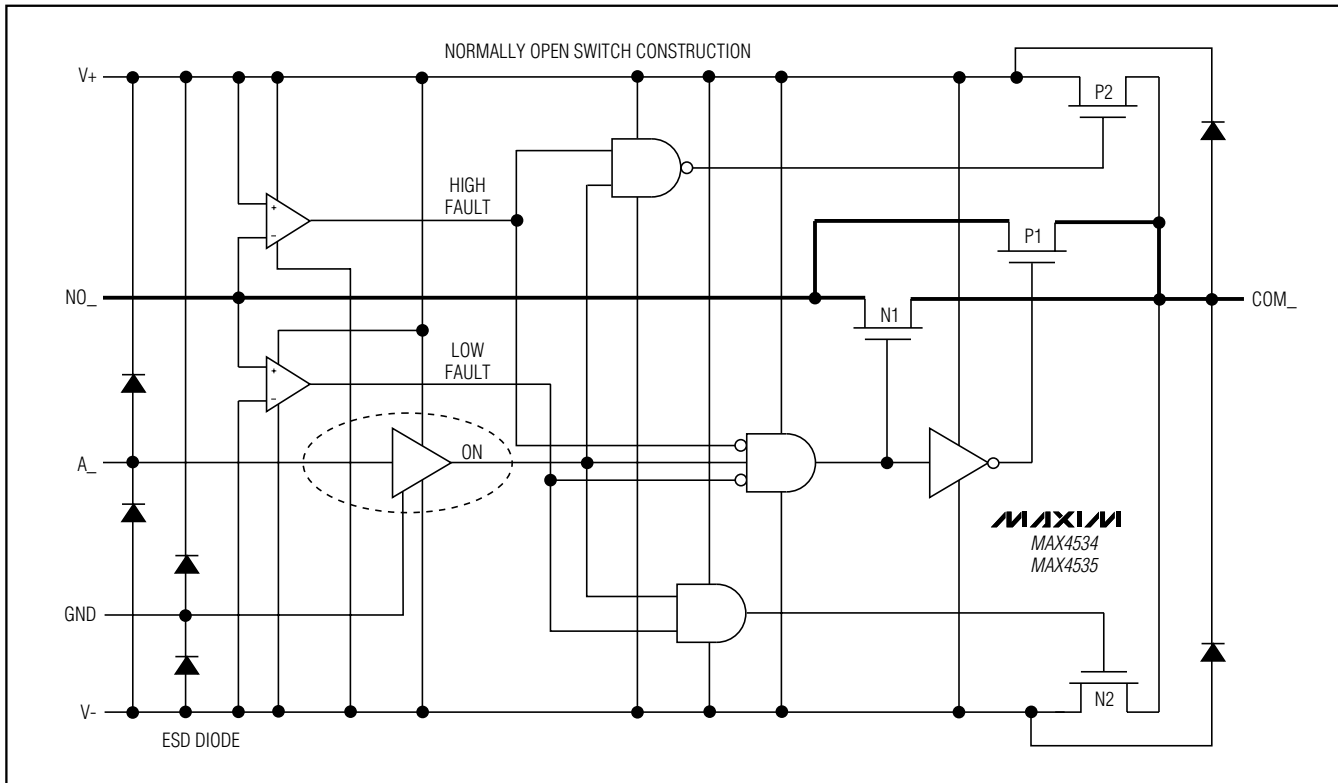


Figure 1. Functional Diagram

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

The maximum allowable input voltage for safe operation depends on whether supplies are on or off and on the load configuration at the COM output. If COM is referred to a voltage other than ground, but within the supplies, VNO<sub>-</sub> may range higher or lower than the supplies, provided the absolute value of VNO<sub>-</sub> - VCOM<sub>-</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  $\pm 15\text{V}$  and COM is referenced to ground through a load, the maximum NO<sub>-</sub> voltage is  $\pm 36\text{V}$ . If the supplies are off and the COM output is referenced to ground, the maximum NO<sub>-</sub> voltage is  $\pm 40\text{V}$ .

## 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 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>.

# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## 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. 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.

## Non-Fault-Protected Pins

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 30mA absolute maximum current rating is never exceeded, both in normal and fault conditions.

The GND, COM<sub>-</sub>, EN, and A<sub>-</sub> pins do not have fault protection. Reverse ESD protection diodes are internally connected between GND, COM<sub>-</sub>, A<sub>-</sub>, EN, and both V<sub>+</sub> and V<sub>-</sub>. If a signal on GND, COM<sub>-</sub>, EN, 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.

**Caution: Exceeding these limits can damage the IC.**

## Logic-Level Thresholds

The logic-level thresholds are CMOS and TTL compatible with V<sub>+</sub> = 4.5V to 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 channel MOSFETs. This drive signal is the only connection between the power supplies and the analog signals. GND, A<sub>-</sub>, EN, 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 300μA (typ) to 180μA.

### Power Supplies

The MAX4534/MAX4535 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 MAX4534/MAX4535 operate from single supplies between +9V and +36V when V<sub>-</sub> is connected to GND.

# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## Test Circuits/Timing Diagrams

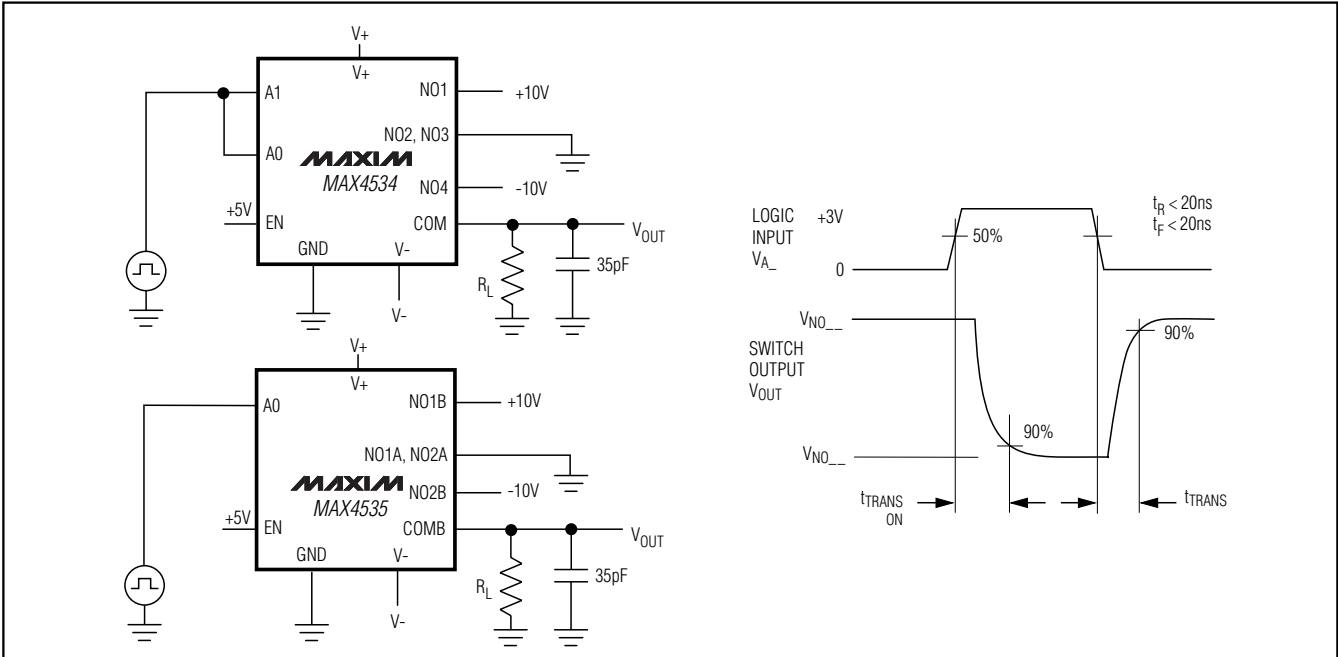


Figure 2. Address Transition Time

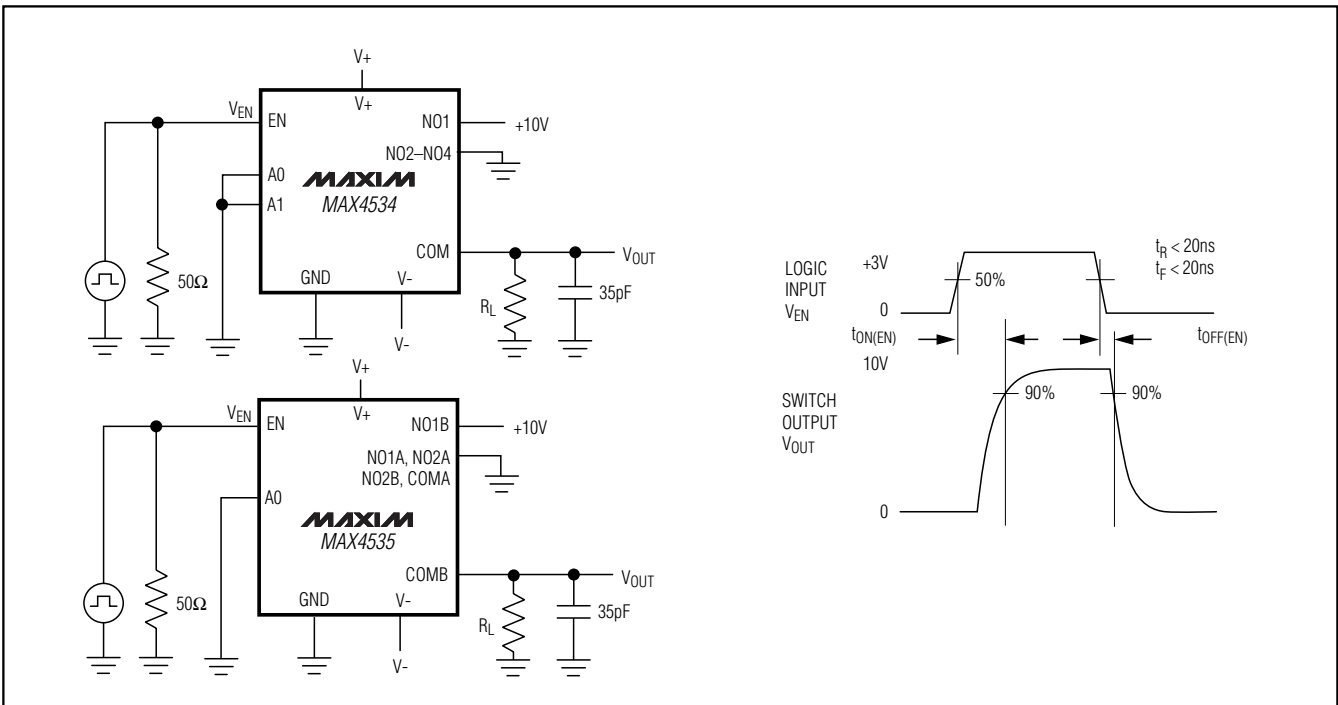


Figure 3. Enable Switching Time

# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## Test Circuits/Timing Diagrams (continued)

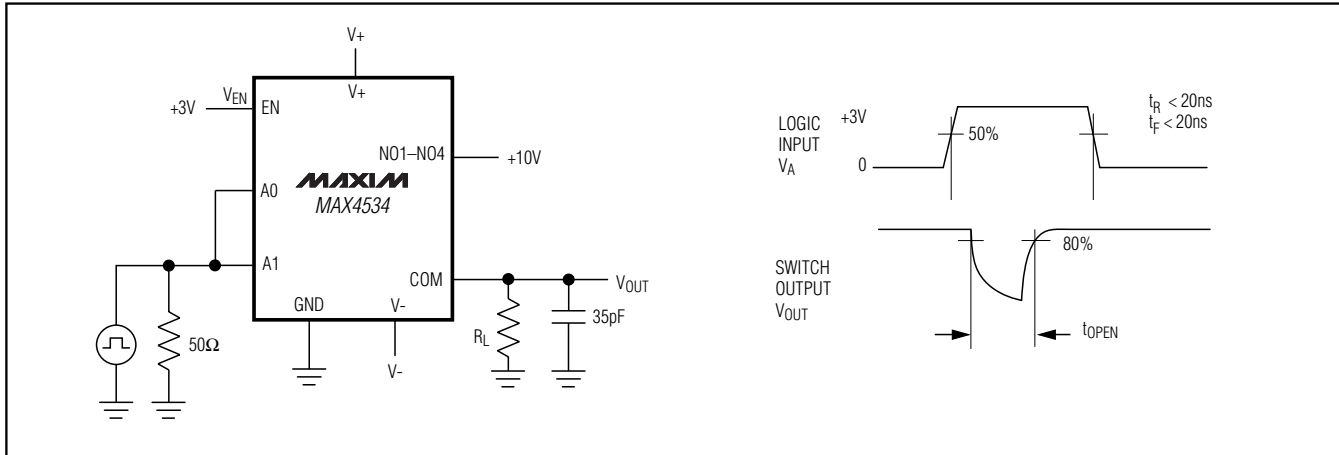


Figure 4. MAX4534 Break-Before-Make Interval

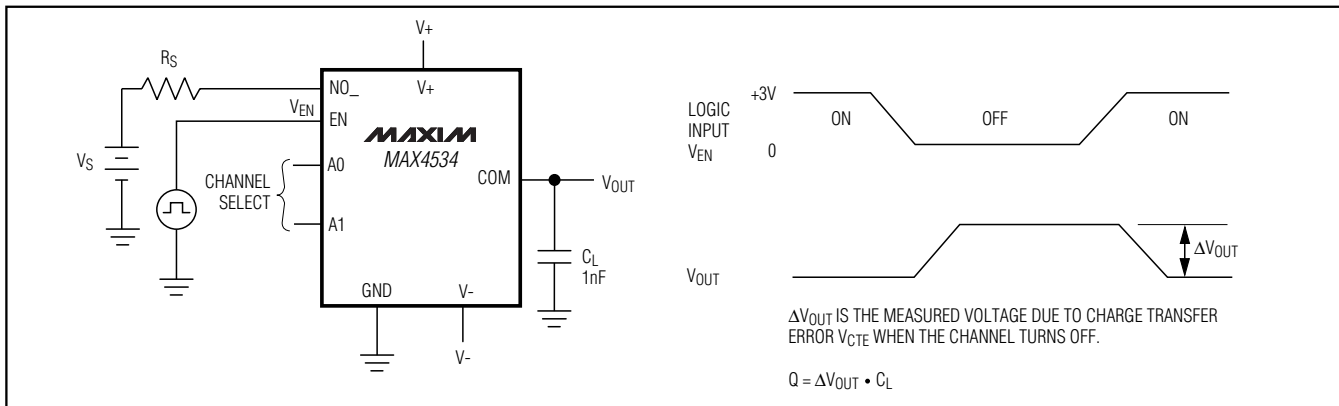


Figure 5. Charge Injection

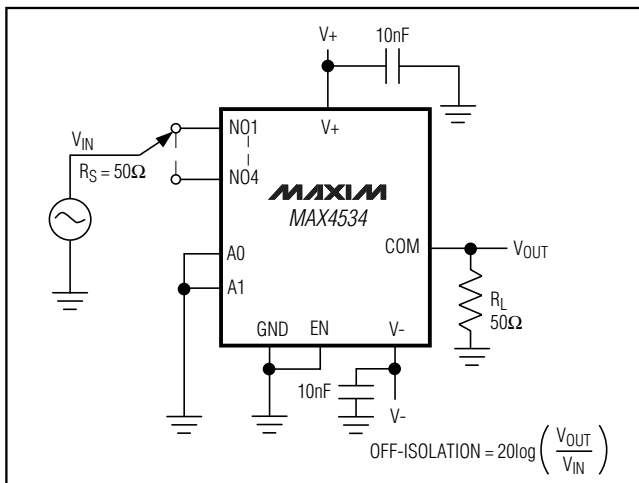


Figure 6. Off-Isolation

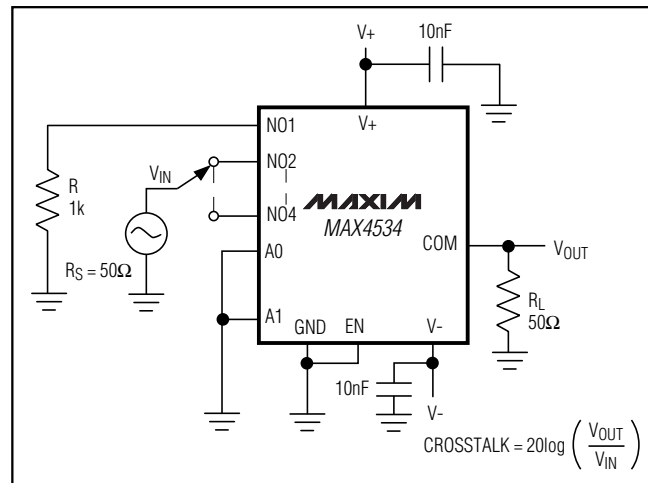


Figure 7. Crosstalk

# Fault-Protected, High-Voltage, Single 4-to-1/Dual 2-to-1 Multiplexers

## Test Circuits/Timing Diagrams (continued)

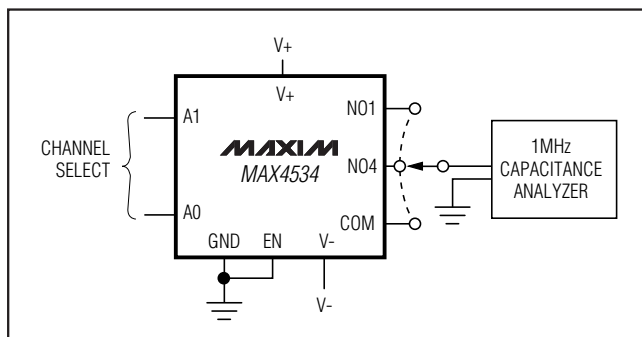


Figure 8. NO\_, COM\_ Capacitance

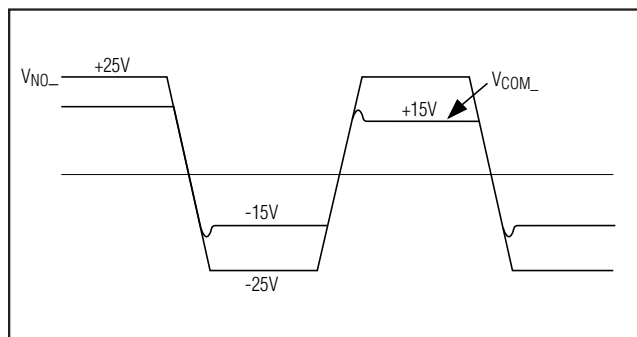


Figure 9. Transient Behavior of Fault Condition

## Chip Information

TRANSISTOR COUNT: 265

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