



Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

General Description

The MAX328/MA329 are monolithic CMOS analog multiplexers. The MAX328 is a single-ended, 1-of-8 device, and the MAX329 is a differential, 2-of-8 device.

Designed to provide the lowest possible on- and off-leakages, these multiplexers switch signals from high source impedance, providing the mux operates into a high-input-impedance op amp or A/D converter. The MAX328/MAX329 are pin-for-pin replacements for the popular DG508/DG509 in these applications.

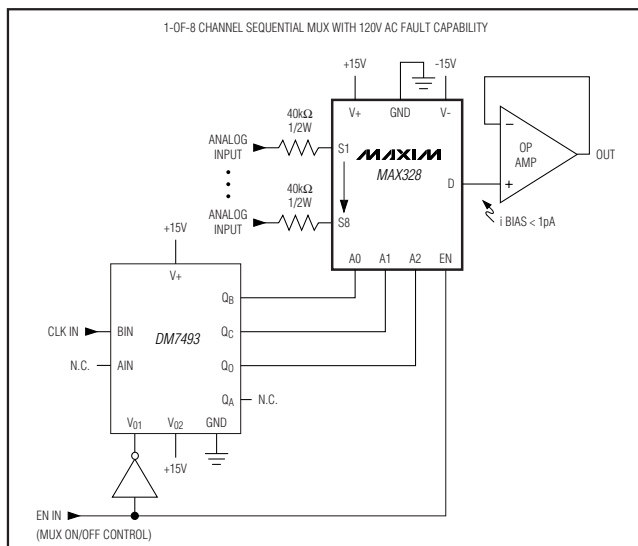
Adding an external 40k Ω resistor to each input makes the MAX328/MAX329 an excellent fault-tolerant multiplexer. Low leakage (less than 1pA at +25°C) and 2.5k Ω on-resistance allow the circuit to sustain 110V AC faults indefinitely while maintaining an error of less than 40nV for normal signals (i.e., 1pA times 40k Ω).

The MAX328/MAX329 work equally well with a single supply of 10V to 30V or dual supplies of $\pm 5V$ to $\pm 18V$. They also perform well with unbalanced combinations of supply voltage, such as +12V and -5V or +5V and -15V. Low power dissipation (1.9mW with $\pm 15V$ supplies) allows use in portable applications.

Applications

Control Systems
Data Logging Systems
Aircraft Heads-Up Displays
Data-Acquisition Systems
Signal Routing

Typical Operating Circuit



Features

- ◆ Ultra-Low Off- and On-Leakage: 1pA Typ
- ◆ Bidirectional Operation (Use as Mux or Demux)
- ◆ TTL and CMOS Logic Compatibility
- ◆ Analog-Signal Range Includes Power-Supply Rails
- ◆ Switching Speeds Less Than 1.5 μ s
- ◆ Pin Compatible with DG508/DG509 and MAX358/MAX359
- ◆ Latchup Proof Construction

Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|------------|-----------------|----------------|
| MAX328CPE+ | 0°C to +70°C | 16 Plastic DIP |
| MAX328CWE+ | 0°C to +70°C | 16 Wide SO |
| MAX328CJE | 0°C to +70°C | 16 CERDIP |
| MAX328C/D | 0°C to +70°C | Dice* |
| MAX328ETE+ | -40°C to +85°C | 16 TQFN-EP** |
| MAX328EPE+ | -40°C to +85°C | 16 Plastic DIP |
| MAX328EWE+ | -40°C to +85°C | 16 Wide SO |
| MAX328EJE | -40°C to +85°C | 16 CERDIP*** |
| MAX328MJE | -55°C to +125°C | 16 CERDIP*** |

+Denotes a lead(Pb)-free/RoHS-compliant package.

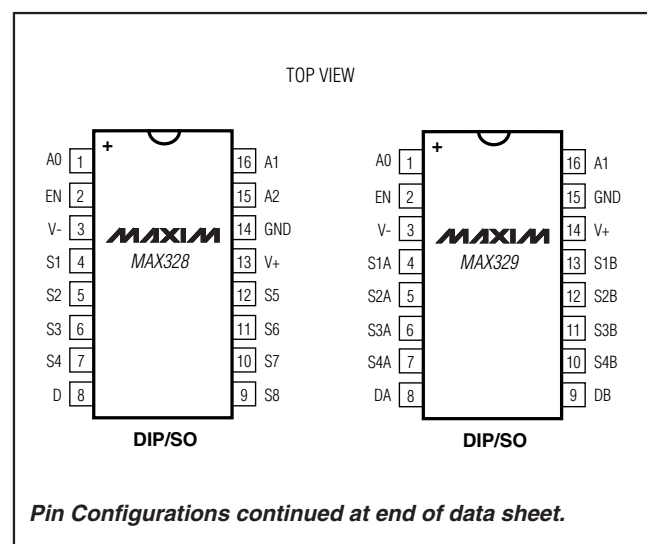
*Contact factory for dice specifications.

**EP = Exposed pad.

***Contact factory for availability. Substrate may be allowed to be unconnected or be connected to V+.

Ordering Information continued at end of data sheet.

Pin Configurations



Pin Configurations continued at end of data sheet.



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ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-

| | |
|---|------------------|
| V+ | +44V |
| GND | +25V |
| Digital Inputs (Note 1), V _S , V _D | -2V to (V+ + 2V) |
| Current (Any Terminal, Except S or D) | 30mA |
| Continuous Current, S or D (pulsed at 1ms, 10% duty cycle max) | 40mA |
| Operating Temperature Range | |
| MAX328/329 C | 0°C to +70°C |
| MAX328/329 E | -40°C to +85°C |
| MAX328/329 M | -55°C to +125°C |

Power Dissipation (Package) (Note 1)

| | |
|---|-----------------|
| CERDIP (derate 10mW/°C above +70°C) | 800mW |
| PDIP (derate 10.5mW/°C above +70°C) | 842.1mW |
| Wide SO (derate 14.3mW/°C above +70°C) | 1142.9mW |
| TQFN (derate 33.3mW/°C above +70°C) | 2666.7mW |
| Storage Temperature | -65°C to +150°C |
| Lead Temperature (soldering, 10s) | +300°C |
| Soldering Temperature (reflow) | |
| Lead(Pb)-free packages (PDIP, TQFN, Wide SO) | +260°C |
| Packages containing lead(Pb) (CERDIP, PDIP, Wide SO) .. | +240°C |
| Packages containing lead(Pb) (TQFN) | +260°C |

Note 1: All leads soldered or welded to PC board.

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

(V₊ = 15V, V₋ = -15V, V_{GND} = 0V, T_A = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MAX328M MAX329M | | | MAX328C/E MAX329C/E | | | UNITS |
|--|--|---|---|--|-----|------------------------|-----|-----|-------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SWITCH | | | | | | | | | |
| Analog Signal Range | V _{ANALOG} | | -15 | | +15 | -15 | | +15 | V |
| Drain-Source On-Resistance | R _{DS(ON)} | V _D = 10V, I _S = 100μA | Seq. each switch on, V _{AL} = 0.8V, V _{AH} = 2.4V | | 1.5 | 2.5 | 1.5 | 3.5 | kΩ |
| | | V _D = -10V, I _S = 100μA | 1.0 | 2.5 | 1.0 | 3.5 | | | |
| Greatest Change in Drain-Source On-Resistance Between Channels | ΔR _{DS(ON)} | $R_{DS(ON)} = \frac{R_{DS(ON) \text{ Max}} - R_{DS(ON) \text{ Min}}}{R_{DS(ON) \text{ Ave}}}$ | | | 2 | | | 2 | % |
| Source Off-Leakage Current (Note 3) | I _{S(OFF)} | V _S = 10V, V _D = -10V | V _{EN} = 0V | | 0.1 | ±10 | 0.1 | ±10 | pA |
| | | V _S = -10V, V _D = 10V | 0.3 | ±10 | 0.3 | ±10 | | | |
| Drain Off-Leakage Current (Note 3) | MAX328 | I _{D(OFF)} | V _{EN} = 0V | V _D = 10V, V _S = -10V | 0.3 | ±10 | 0.3 | ±10 | pA |
| | | | | V _D = -10V, V _S = 10V | 1.0 | ±10 | 1.0 | ±10 | |
| | MAX329 | | | V _D = 10V, V _S = -10V | 0.3 | ±10 | 0.3 | ±10 | |
| | V _D = -10V, V _S = 10V | | | 0.5 | ±10 | 0.5 | ±10 | | |
| Drain On-Leakage Current (Note 3) | MAX328 | I _{D(ON)} | Seq. each switch on, V _{AL} = 0.8V, V _{AH} = 2.4V | V _S (all) = V _D = 10V | 3.0 | ±10 | 3.0 | ±10 | pA |
| | | | | V _S (all) = V _D = -10V | 2.0 | ±10 | 2.0 | ±10 | |
| | MAX329 | | | V _S (all) = V _D = 10V | 1.5 | ±10 | 1.5 | ±10 | |
| | V _S (all) = V _D = -10V | | | 1.0 | ±10 | 1.0 | ±10 | | |

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MAX328/MAX329

ELECTRICAL CHARACTERISTICS (continued)

(V₊ = 15V, V₋ = -15V, V_{GND} = 0V, T_A = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MAX328M MAX329M | | | MAX328C/E MAX329C/E | | | UNITS |
|--|-------------------------|---|-----------------------------------|--------------------|------|-----|------------------------|------|-----|-------|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| INPUT | | | | | | | | | | |
| Address Input Current, Input Voltage High | I _{AH} | V _A = 2.4V | | 0.001 | ±1 | | 0.001 | ±1 | μA | |
| | | V _A = 15V | | 0.001 | ±1 | | 0.001 | ±1 | | |
| Address Input Current, Input Voltage Low | I _{AL} | V _{EN} = 2.4V | All | 0.001 | ±1 | | 0.001 | ±1 | μA | |
| | | V _{EN} = 0V | V _A = 0V | 0.001 | ±1 | | 0.001 | ±1 | | |
| DYNAMIC | | | | | | | | | | |
| Switching Time of Multiplexer | t _{TRANSITION} | Figure 1 | | | 1.0 | | 1.5 | | μs | |
| Break-Before-Make Interval | t _{OPEN} | Figure 2 | | | 0.2 | | 0.2 | | μs | |
| Enable Turn-On Time | t _{ON(EN)} | Figure 3 | | | 1.0 | | 1.5 | | μs | |
| Enable Turn-Off Time | t _{OFF(EN)} | Figure 3 | | | 0.7 | | 1.0 | | μs | |
| Off-Isolation | OIRR | V _{EN} = 0V, R _L = 1kΩ, C _L = 15pF, V _S = 7V _{RMS} , f = 500kHz | | | 84 | | 84 | | dB | |
| Source Off-Capacitance | C _{S(OFF)} | V _S = 0V | V _{EN} = 0V, f = 1MHz | | 1.8 | | 1.8 | | pF | |
| Drain Off- Capacitance | C _{D(OFF)} | V _D = 0V | V _{EN} = 0V, f = 1MHz | | 8.0 | | 8.0 | | pF | |
| | | | | | 4.0 | | 4.0 | | | |
| Charge Injection (Note 4) | Q _(INJ) | V _A = 10V | | | 1 | | 1 | | pC | |
| | | V _A = 0V | | | 2 | 5 | 2 | 5 | | |
| | | V _A = -10V | | | 4 | | 4 | | | |
| SUPPLY | | | | | | | | | | |
| Positive Supply Current | I ₊ | V _{EN} = 2.4V | V _A = 0V/5V | 4.5 | 200 | | 4.5 | 200 | μA | |
| Negative Supply Current | I ₋ | V _{EN} = 2.4V | V _A = 0V/5V | 1 | -100 | | 1 | -100 | μA | |
| Power-Supply Range for Continuous Operation (Note 7) | V _{OP} | | | ±5 | ±18 | | ±5 | ±18 | V | |

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ELECTRICAL CHARACTERISTICS (Overtemperature)

($V_+ = 15V$, $V_- = -15V$, $V_{GND} = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | TEST CONDITIONS | MAX328M MAX329M | | | MAX328C/E MAX329C/E | | | UNITS |
|---|--------------|------------------------------------|--|----------------------------|----------|------------------------|----------|---------|------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SWITCH | | | | | | | | | |
| Analogue-Signal Range | V_{ANALOG} | | -15 | +15 | -15 | +15 | | | V |
| Drain-Source On-Resistance | $R_{DS(ON)}$ | $V_D = 10V$, $I_S = 100\mu A$ | Seq. each switch on, $V_{AL} = 0.8V$, $V_{AH} = 2.4V$ | | 2.2 | 4 | 1.9 | 5 | k Ω |
| | | $V_D = -10V$, $I_S = 100\mu A$ | | | 1.5 | 4 | 1.2 | 5 | |
| Source Off-Leakage Current (Note 6) | $I_{S(OFF)}$ | $V_S = 10V$, $V_D = -10V$ | $V_{EN} = 0V$ | | ± 5 | | ± 5 | | nA |
| | | $V_S = -10V$, $V_D = 10V$ | | | ± 5 | | ± 5 | | |
| Drain Off-Leakage Current (Note 6) | MAX328 | $I_{D(OFF)}$ | $V_{EN} = 0V$ | $V_D = 10V$, $V_S = -10V$ | ± 20 | | ± 20 | | nA |
| | | | | $V_D = -10V$, $V_S = 10V$ | ± 20 | | ± 20 | | |
| | MAX329 | | | $V_D = 10V$, $V_S = -10V$ | ± 10 | | ± 10 | | |
| | | | | $V_D = -10V$, $V_S = 10V$ | ± 10 | | ± 10 | | |
| Drain On-Leakage Current (Note 6) | MAX328 | $I_{D(ON)}$ | Seq. each switch on, $V_{AL} = 0.8V$, $V_{AH} = 2.4V$ | V_S (all) = $V_D = 10V$ | ± 20 | | ± 20 | | nA |
| | | | | V_S (all) = $V_D = -10V$ | ± 20 | | ± 20 | | |
| | MAX329 | | | V_S (all) = $V_D = 10V$ | ± 10 | | ± 10 | | |
| | | | | V_S (all) = $V_D = -10V$ | ± 10 | | ± 10 | | |
| INPUT | | | | | | | | | |
| Address Input Current, Input Voltage High | I_{AH} | $V_A = 2.4V$ | | | 0.01 | ± 1 | 0.01 | ± 1 | μA |
| | | $V_A = 15V$ | | | 0.01 | ± 1 | 0.01 | ± 1 | |
| Address Input Current, Input Voltage Low | I_{AL} | $V_{EN} = 2.4V$ | All $V_A = 0V$ | | 0.01 | ± 1 | 0.01 | ± 1 | μA |
| | | $V_{EN} = 0V$ | | | | | 0.01 | ± 1 | |

Note 2: Typical values are for design aid only; not guaranteed or subject to production testing.

Note 3: All leakage parameters are 100% tested at maximum rated operating temperature, i.e., +70°C, +85°C, +125°C, and guaranteed by correlation at +25°C.

Note 4: Guaranteed by design.

Note 5: Electrical characteristics, such as On-Resistance, change when power supplies other than $\pm 15V$ are used. Power-supply range is a design characteristic, not production tested.

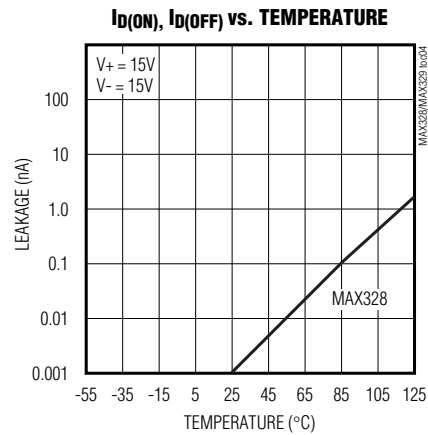
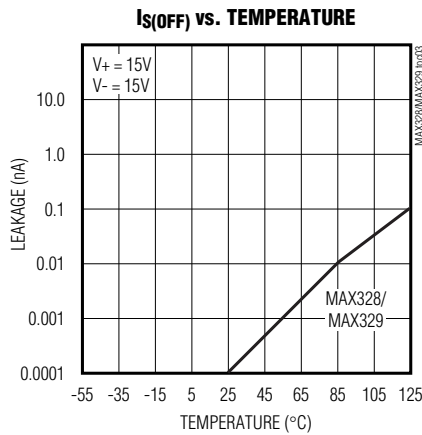
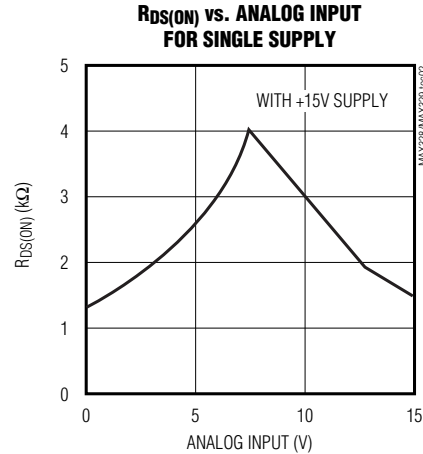
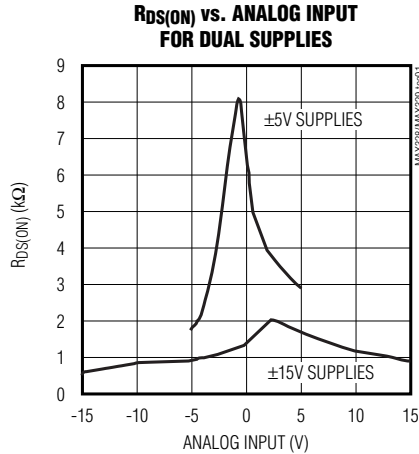
Note 6: Leakage parameters are 100% tested at maximum rated operating temperature, i.e., +70°C, etc.

Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

Typical Operating Characteristics

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

MAX328/MAX329



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Pin Description

| PIN | | | | NAME | FUNCTION |
|-----------|------------|--------|---------|------------|---|
| MAX328 | | MAX329 | | | |
| DIP/SO | TQFN-EP | DIP/SO | TQFN-EP | | |
| 1, 15, 16 | 15, 14, 13 | — | — | A0, A2, A1 | Address Input |
| — | — | 1, 16 | 15, 14 | A0, A1 | Address Input |
| 2 | 16 | 2 | 16 | EN | Enable |
| 3 | 1 | 3 | 1 | V- | Negative-Supply Voltage Input |
| 4–7 | 2–5 | — | — | S1–S4 | Analog Inputs—Bidirectional |
| — | — | 4–7 | 2–5 | S1A–S4A | Analog Inputs—Bidirectional |
| 8 | 6 | — | — | D | Analog Outputs—Bidirectional |
| — | — | 8, 9 | 6, 7 | DA, DB | Analog Outputs—Bidirectional |
| 9–12 | 7–10 | — | — | S8–S5 | Analog Inputs—Bidirectional |
| — | — | 10–13 | 8–11 | S4B–S1B | Analog Inputs—Bidirectional |
| 13 | 11 | 14 | 12 | V+ | Positive-Supply Voltage Input |
| 14 | 12 | 15 | 13 | GND | Ground |
| — | — | — | — | EP | Exposed pad. Connect EP to V+. (TQFN only). |

Truth Table—MAX328

| 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 |

Truth Table—MAX329

| 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 |

Note: Logic “0” = $V_{AL} \leq 0.8V$, Logic “1” = $V_{AH} \geq 2.4V$

Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

MAX328/MAX329

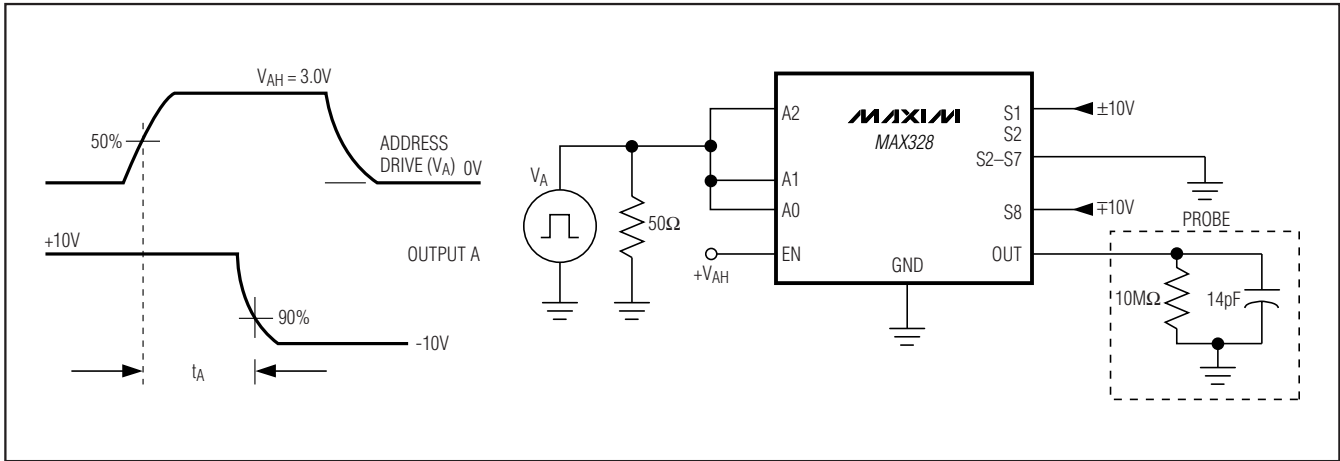


Figure 1. Access Time vs. Logic Level (High)

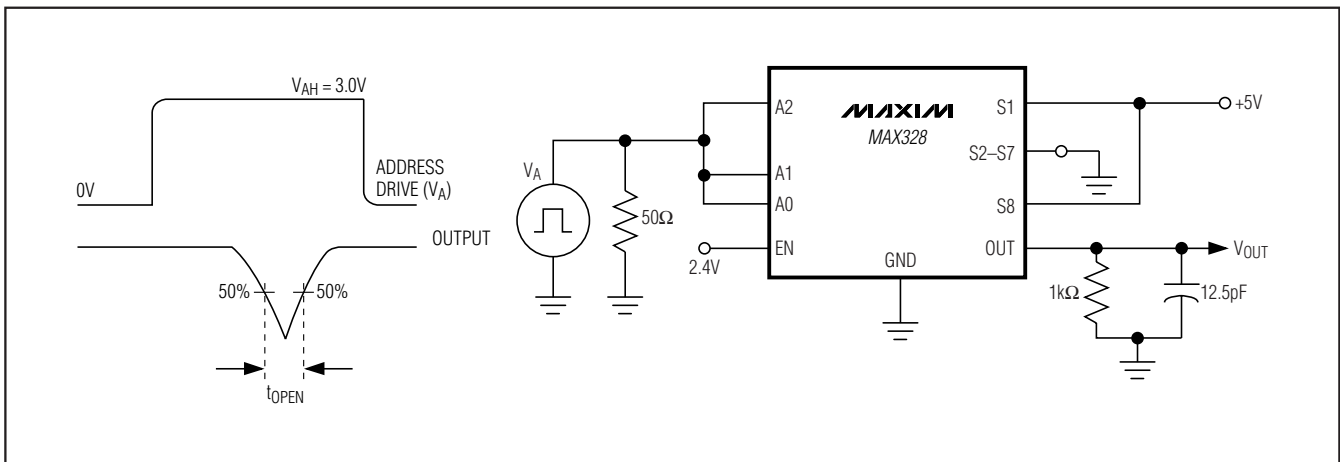


Figure 2. Break-Before-Make Delay (t_{OPEN})

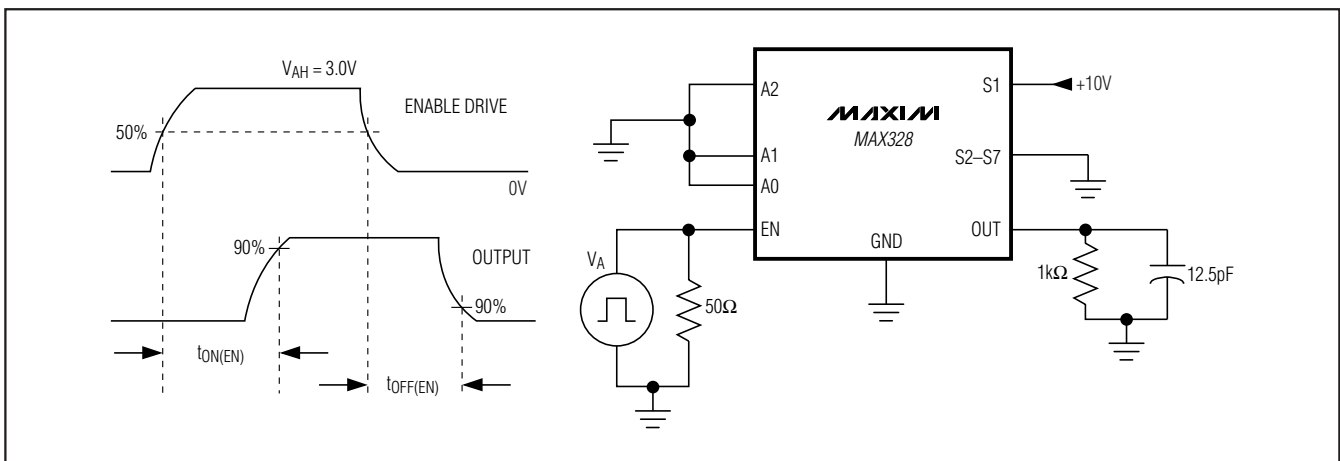


Figure 3. Enable Delay ($t_{ON(EN)}$, $t_{OFF(EN)}$)

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Applications Information

Figure 4 is a typical circuit for converting the MAX328/MAX329 into a fault-tolerant mux. In this application, the internal diodes limit the voltage at the MAX328 input to $\pm 15.7V$ ($\pm 15V$ supplies). No external diodes need to be added with the MAX328/MAX329, unlike conventional multiplexers requiring external diodes.

The resistors, R, need to be $39k\Omega$ or higher to limit the power dissipation in the resistor when a 120V AC fault occurs (i.e., power dissipation is $(120-16)^2/39k\Omega$ or 0.28W. This is why a 1/2W resistor is needed). The circuit withstands an indefinite fault to a 120V AC line with no damage to any component.

In addition to allowing fault-protection, the guaranteed low leakage of the MAX328/MAX329 also reduces signal errors. The circuit in Figure 4 produces an error voltage of $10pA$ (max leakage) $\times 39k\Omega$ or $0.39\mu V$ at room temperature and $39\mu V$ at $+125^\circ C$. Therefore, for 10V signals, the MAX328/MAX329 allows 17-bit resolution ($38\mu V = 1LSB$) over the full temperature range.

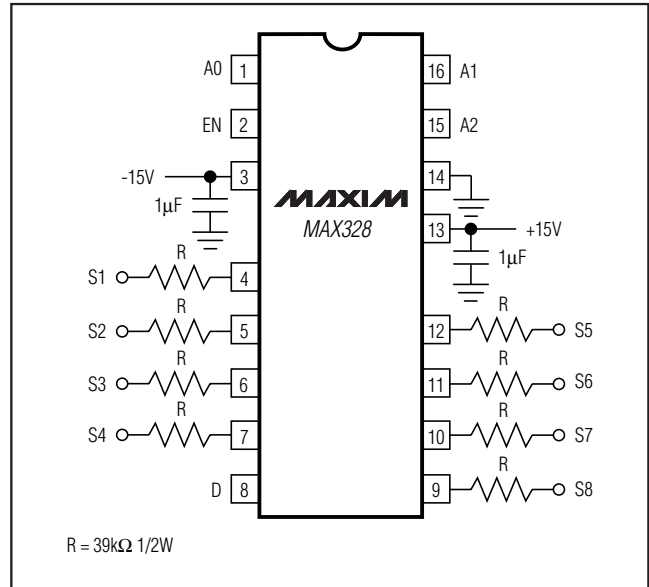
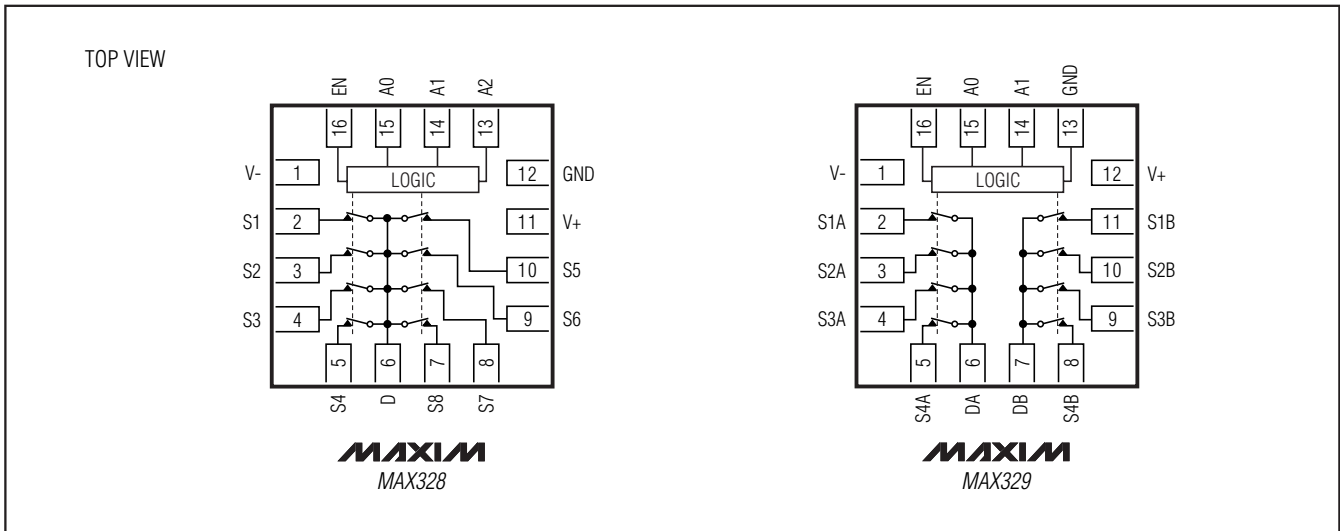


Figure 4. Fault-Tolerant Mux (indefinitely withstands 120V AC fault voltages)

Functional Diagrams



Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

MAX328/MAX329

Ordering Information (continued)

| PART | TEMP RANGE | PIN-PACKAGE |
|------------|-----------------|----------------|
| MAX329CPE+ | 0°C to +70°C | 16 Plastic DIP |
| MAX329CWE+ | 0°C to +70°C | 16 Wide SO |
| MAX329CJE | 0°C to +70°C | 16 CERDIP |
| MAX329C/D | 0°C to +70°C | Dice* |
| MAX329ETE+ | -40°C to +85°C | 16 TQFN-EP** |
| MAX329EPE+ | -40°C to +85°C | 16 Plastic DIP |
| MAX329EWE+ | -40°C to +85°C | 16 Wide SO |
| MAX329EJE | -40°C to +85°C | 16 CERDIP*** |
| MAX329MJE | -55°C to +125°C | 16 CERDIP*** |

+ Denotes a lead(Pb)-free/RoHS-compliant package.

* Contact factory for dice specifications.

** EP = Exposed pad.

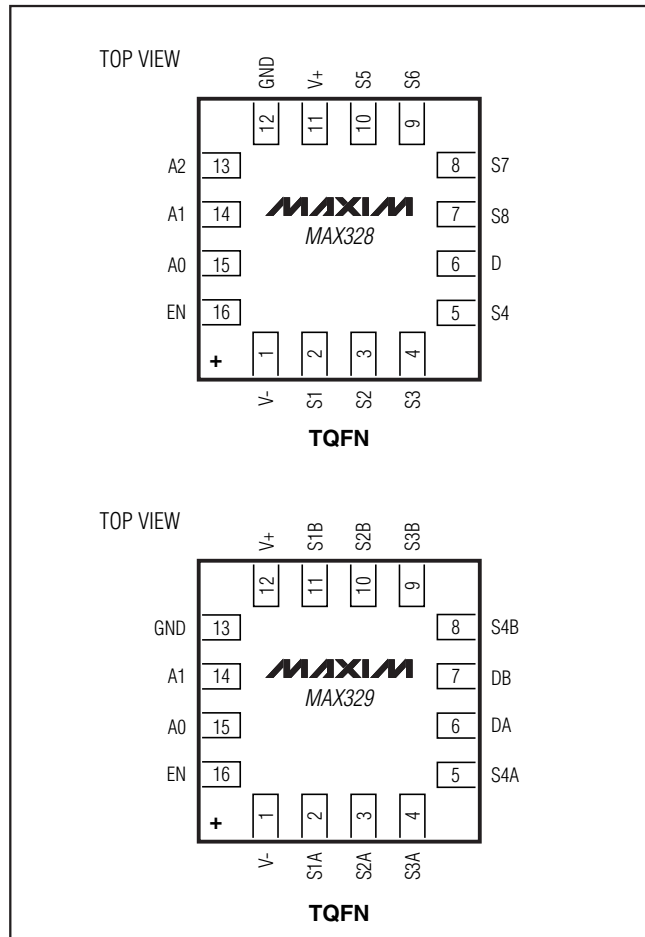
*** Contact factory for availability. Substrate may be allowed to be unconnected or be connected to V+.

Package Information

For the latest package outline information and land patterns (footprints), go to www.maxim-ic.com/packages. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO. | LAND PATTERN NO. |
|--------------|--------------|-------------------------|-------------------------|
| 16 CERDIP | J16+3 | 21-0045 | — |
| 16 PDIP | P16+2 | 21-0043 | — |
| 16 TQFN-EP | T1655+3 | 21-0140 | 90-0073 |
| 16 Wide SO | W16+2 | 21-0042 | 90-0107 |

Pin Configurations (continued)



Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|-----------------|---------------|---|---------------|
| 3 | 2/11 | Updated the <i>Ordering Information</i> table to reflect lead-free parts and corrected part numbers and package types | 1, 9 |

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