19-1006; Rev 2; 9/01

MAXIM

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 40kΩ resistor to each input makes the MAX328/MAX329 an excellent fault-tolerant multiplexer. Low leakage (less than 1pA at +25°C) and 2.5kΩ 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 40kΩ).

The MAX328/MAX329 work equally well with a single supply of 10V to 30V or dual supplies of ±5V to ±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 ±15V supplies) allows use in portable applications.

Applications

Control Systems

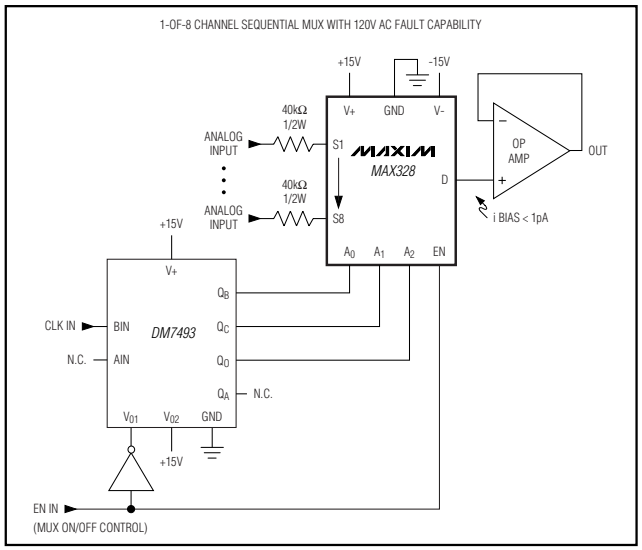
Data Logging Systems

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 1.5µs**
- ♦ **Pin Compatible with DG508/DG509 and MAX358/MAX359**
- ♦ **Latchup Proof Construction**

Ordering Information

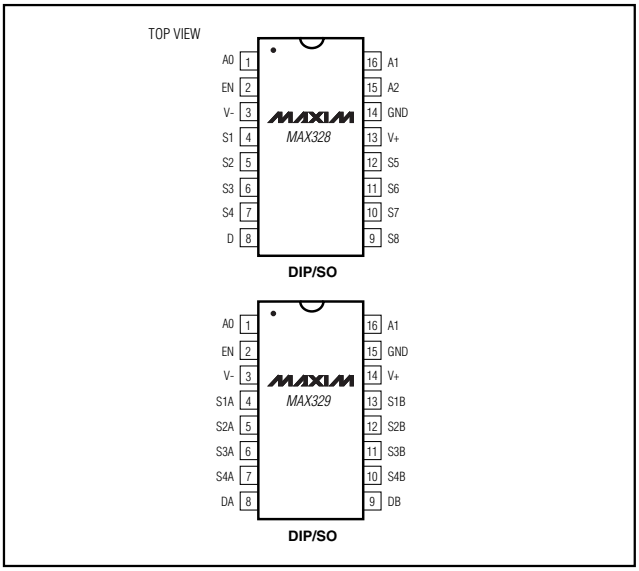
PART	TEMP RANGE	PIN-PACKAGE
MAX328CPE	0°C to +70°C	16 Plastic DIP
MAX328CWE	0°C to +70°C	16 Wide SO
MAX328CJE	0°C to +70°C	16 CERDIP
MAX328C/D	0°C to +70°C	Dice*
MAX328EGE	-40°C to +85°C	16 QFN
MAX328EPE	-40°C to +85°C	16 Plastic DIP
MAX328EWE	-40°C to +85°C	16 Wide SO
MAX328EJE	-40°C to +85°C	16 CERDIP**
MAX328MJE	-55°C to +125°C	16 CERDIP**

**Contact factory for dice specifications.*

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

Ordering Information and Pin Configurations continued at end of data sheet.

Pin Configurations



Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

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)
16-Pin CERDIP (Note 2) 900mW
16-Pin Plastic DIP (Note 3).....470mW
16-Pin Wide SO (Note 4).....750mW
16-Pin QFN (Note 5) 1538mw
Storage Temperature.....-65°C to +150°C

Note 1: All leads soldered or welded to PC board.
Note 2: Derate 12mW/°C above +75°C.
Note 3: Derate 6.3mW/°C above +75°C.
Note 4: Derate 10mW/°C above +75°C.
Note 5: Derate 19.2mW/°C above +75°C.

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, GND = 0V, T_A = +25°C, unless otherwise noted.)

PARAMETER		SYMBOL	TEST CONDITIONS		LIMITS						UNITS
					MAX328M MAX329M			MAX328C/E MAX329C/E			
					MIN	TYP	MAX	MIN	TYP	MAX	
SWITCH											
Analog Signal Range		V_{ANALOG}			±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		$\Delta R_{DS(ON)}$	$R_{DS(on)} = \left(\frac{R_{DS(ON)}\ \textbf{Max} - R_{DS(ON)}\ \textbf{Min}}{R_{DS(ON)}\ \textbf{Ave}}\right)$			2			2		%
Source Off-Leakage Current (Note 6)		$I_{S(OFF)}$	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 6)	MAX328	$I_{D(OFF)}$	V_D = 10V, V_S = -10V	V_{EN} = 0V		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 6)	MAX328	$I_{D(ON)}$	V_S (all) = V_D = 10V	Seq. each switch on, V_{AL} = 0.8V, V_{AH} = 2.4V		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	

ELECTRICAL CHARACTERISTICS (continued)

(V+ = +15V, V- = -15V, GND = 0V, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITIONS		LIMITS						UNITS
				MAX328M MAX329M			MAX328C/E MAX329C/E			
				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 V_A = 0V		0.001	±1		0.001	±1	µA
		V_{EN} = 0V			0.001	±1		0.001	±1	
DYNAMIC										
Switching Time of Multiplexer	$t_{TRANSITION}$	See Figure 1				1.0			1.5	µs
Break-Before-Make Interval	t_{OPEN}	See Figure 2			0.2			0.2		µs
Enable Turn-On Time	$t_{ON(EN)}$	See Figure 3				1.0			1.5	µs
Enable Turn-Off Time	$t_{OFF(EN)}$	See 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 MAX328	$C_{D(OFF)}$	V_D = 0V	V_{EN} = 0V, f = 1MHz		8.0			8.0		pF
Drain Off-Capacitance MAX329					4.0			4.0		
Charge Injection (Note 8)	$Q_{(INJ)}$	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

Note 6: 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 7: Electrical characteristics, such as On-Resistance, change when power supplies other than ±15V are used. Power-supply range is a design characteristic, not production tested.

Note 8: Guaranteed by design.

Typical values are for DESIGN AID ONLY, not guaranteed or subject to production testing.

Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

ELECTRICAL CHARACTERISTICS (Over Temperature)

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

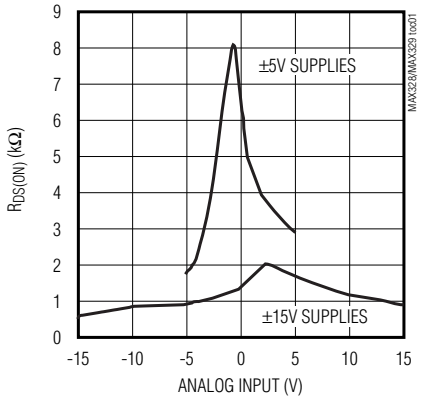
PARAMETER		SYMBOL	TEST CONDITIONS		LIMITS MAX328M MAX329M MIN	TYP	MAX	LIMITS MAX328C/E MAX329C/E MIN	TYP	MAX	UNITS
SWITCH											
Analog Signal Range		V_{ANALOG}			±15			±15			V
Drain-Source On-Resistance		$R_{DS(ON)}$	V_D = 10V, I_S = 100µA	Seq. each switch on, V_{AL} = 0.8V, V_{AH} = 2.4V		2.2	4		1.9	5	kΩ
			V_D = -10V, I_S = 100µA			1.5	4		1.2	5	
Source Off-Leakage Current (Note 9)		$I_{S(OFF)}$	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 9)	MAX328	$I_{D(OFF)}$	V_D = 10V, V_S = -10V	V_{EN} = 0V			±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 9)	MAX328	$I_{D(ON)}$	V_S (all) = V_D = 10V	Seq. each switch on, V_{AL} = 0.8V, V_{AH} = 2.4V			±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		0.01	±1	

Note 9: Leakage parameters are 100% tested at maximum rated operating temperature, i.e., +70°C, etc.

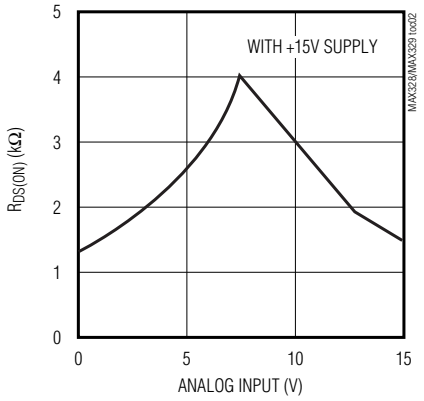
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

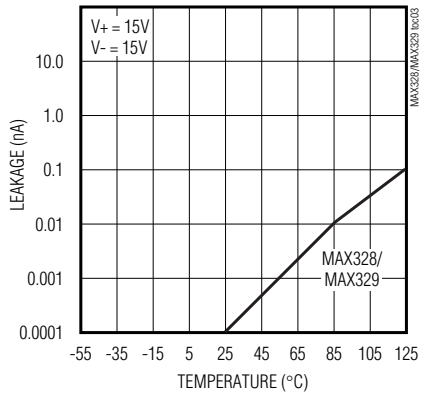
$R_{DS(ON)}$ vs. ANALOG INPUT FOR DUAL SUPPLIES



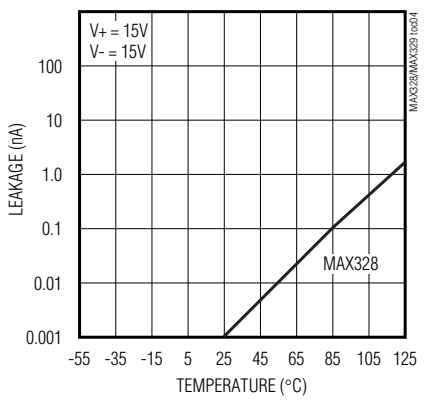
$R_{DS(ON)}$ vs. ANALOG INPUT FOR SINGLE SUPPLY



$I_{S(OFF)}$ vs. TEMPERATURE



$I_{D(ON)}$, $I_{D(OFF)}$ vs. TEMPERATURE



Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

Pin Description

PIN				NAME	FUNCTION
MAX328		MAX329			
DIP/SO	QFN	DIP/SO	QFN		
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

Truth Table—MAX328

A_2	A_1	A_0	EN	ON SWITCH
X	X	X	0	None
0	0	0	0	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

A_1	A_0	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” = $V_{AL} \le 0.8V$, Logic “1” = $V_{AH} \ge 2.4V$

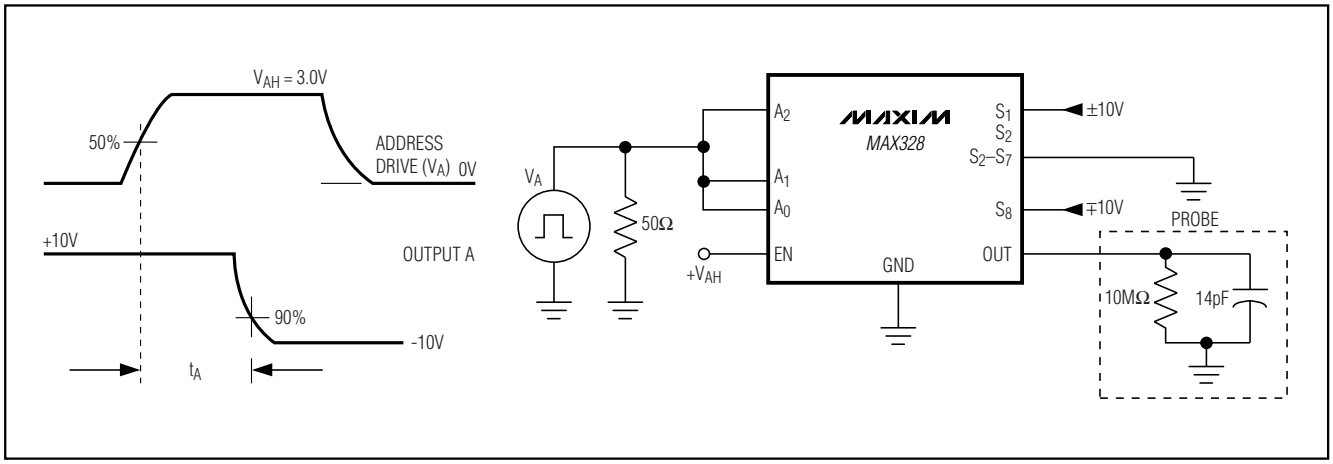


Figure 1. Access Time vs. Logic Level (High)

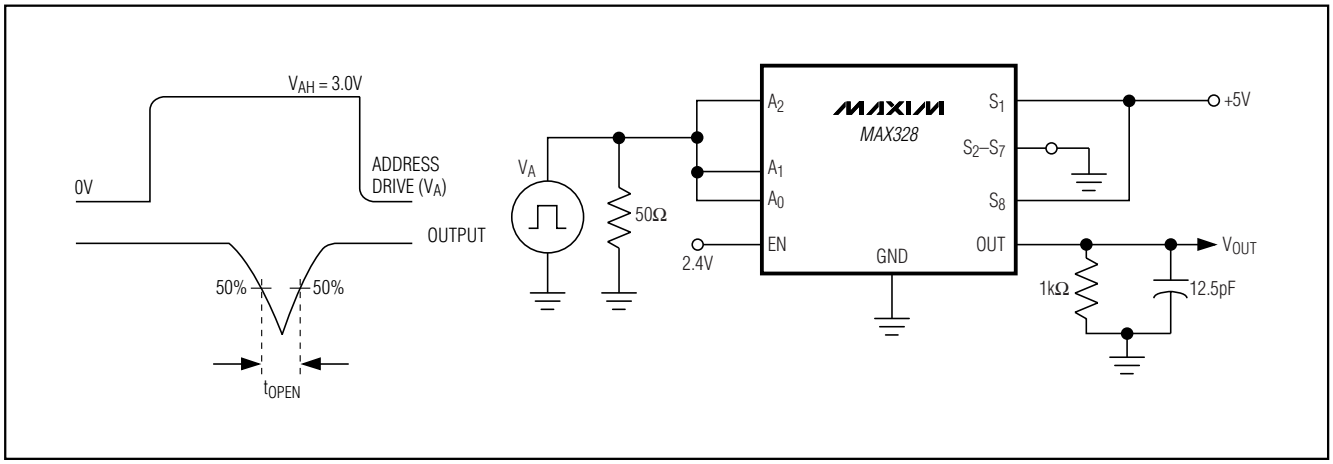


Figure 2. Break-Before-Make Delay (t_{OPEN})

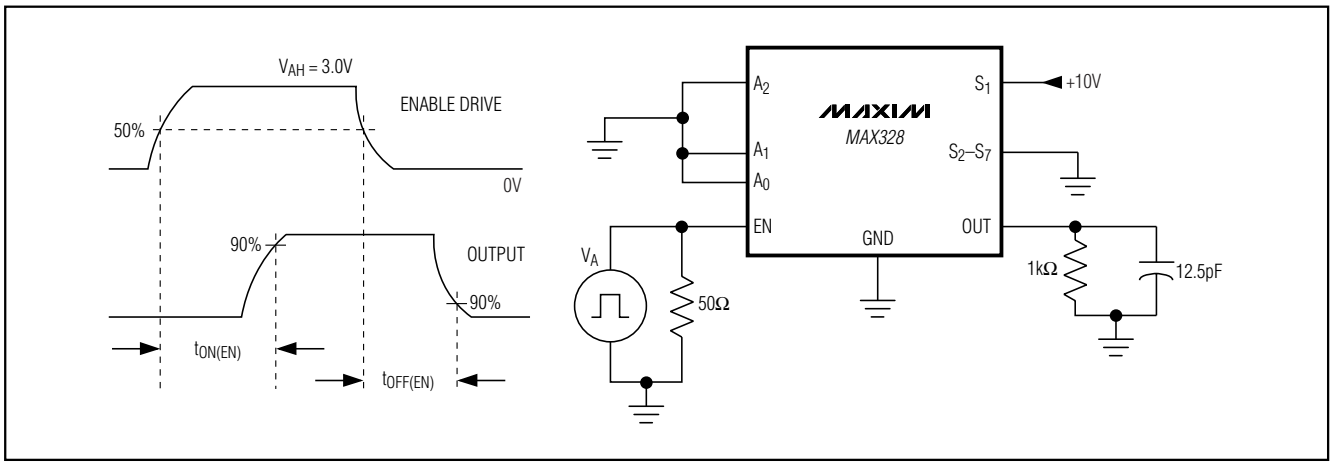


Figure 3. Enable Delay ($t_{ON(EN)}$, $t_{OFF(EN)}$)

Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

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 ±15.7V (±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 39kΩ or higher to limit the power dissipation in the resistor when a 120V AC fault occurs (i.e., power dissipation is $(120\text{-}16)^2/39k\Omega$ or 0.28W. This is why a 1/2/W 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) x 39kΩ or 0.39µV at room temperature and 39µV at +125°C. Therefore, for 10V signals, the MAX328/MAX329 allows 17-bit resolution (38µV = 1LSB) over the full temperature range.

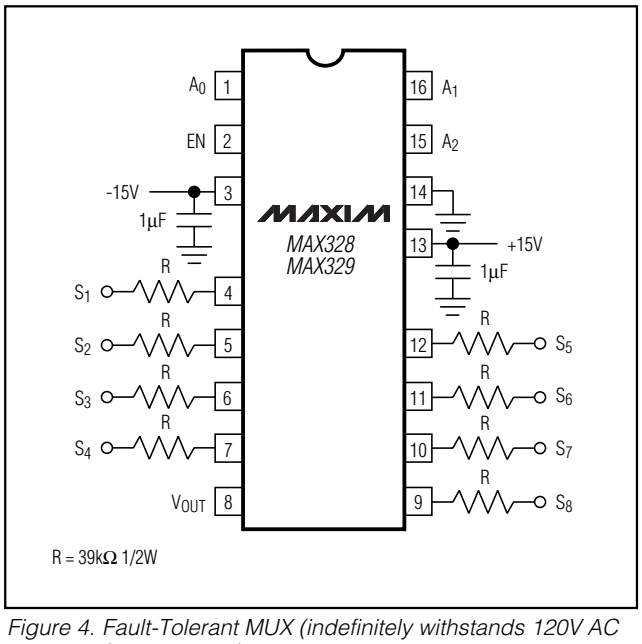
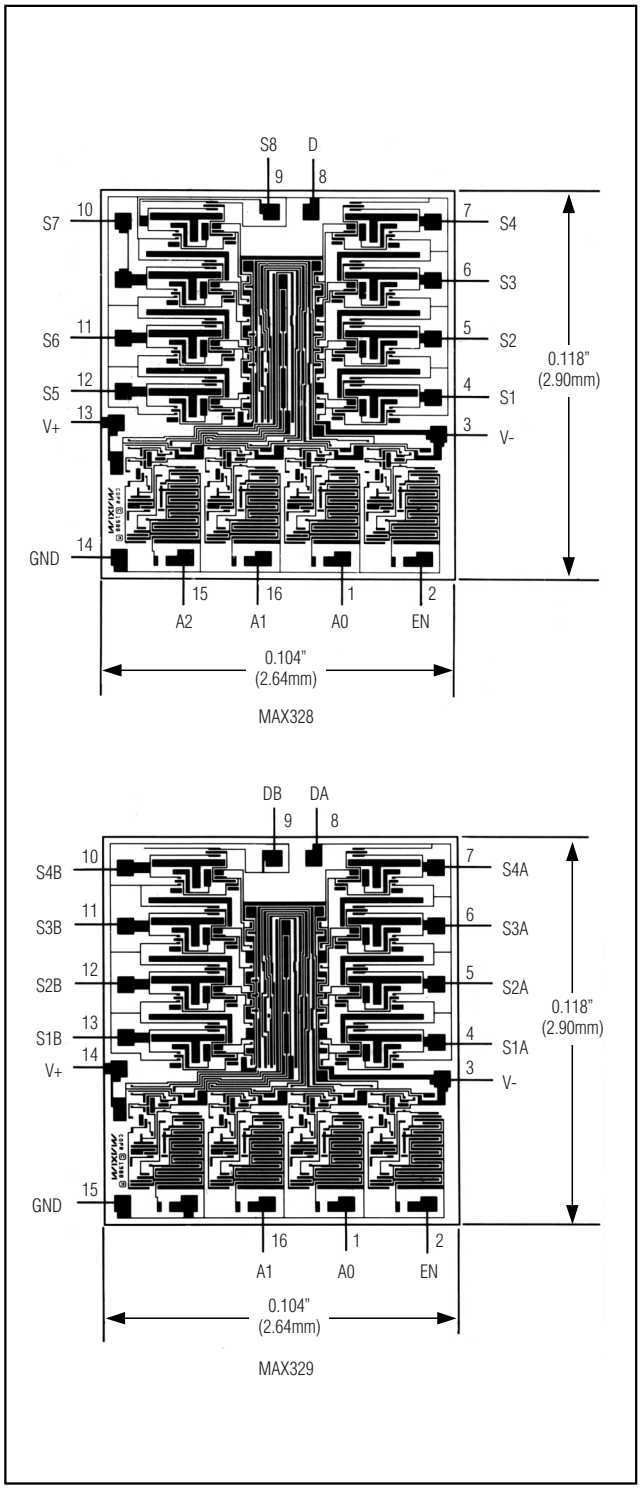


Figure 4. Fault-Tolerant MUX (indefinitely withstands 120V AC fault voltages)

Chip Topographies



Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

Ordering Information (continued)

PART	TEMP RANGE	PIN-PACKAGE
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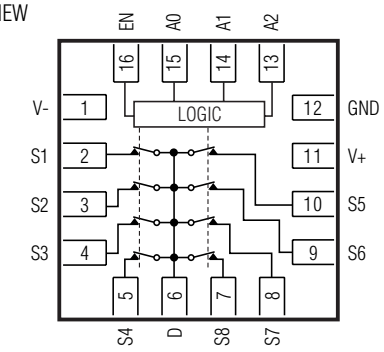
MAX329CWE	0°C to +70°C	16 Wide SO
MAX329CJE	0°C to +70°C	16 CERDIP
MAX329C/D	0°C to +70°C	Dice*
MAX329EGE	-40°C to +85°C	16 QFN
MAX329EPE	-40°C to +85°C	16 Plastic DIP
MAX329EWE	-40°C to +85°C	16 Wide SO
MAX329EJE	-40°C to +85°C	16 CERDIP**
MAX329MJE	-55°C to +125°C	16 CERDIP**

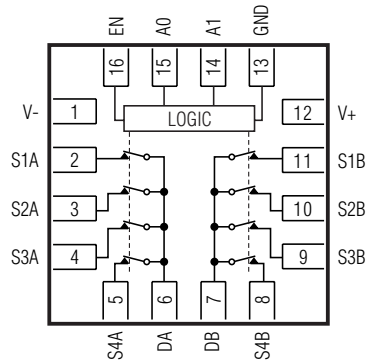
**Contact factory for dice specifications.*
***Contact factory for availability. Substrate may be allowed to float or be connected to V+.*

Pin Configurations (continued)

TOP VIEW



MAXIM
MAX328



MAXIM
MAX329

Package Information

For the latest package outline information, go to **www.maxim-ic.com/packages**.