MAXIM

Ultra-Low Leakage Monolithic CMOS Analog Multiplexers

General Description

The MAX328/MAX329 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 of the multiplexers in portable applications.

Applications

Control Systems

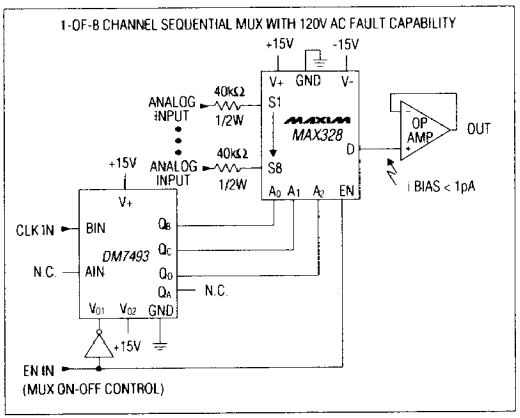
Data Logging Systems

Aircraft Heads-Up Displays

Data Acquisition Systems

Signal Routing

Typical Operating Circuit



Features

- ◆ **Ultra-Low "Off" and "On" Leakage: 1pA Typ**
- ◆ **Bi-Directional 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**
- ◆ **Latch-Up Proof Construction**

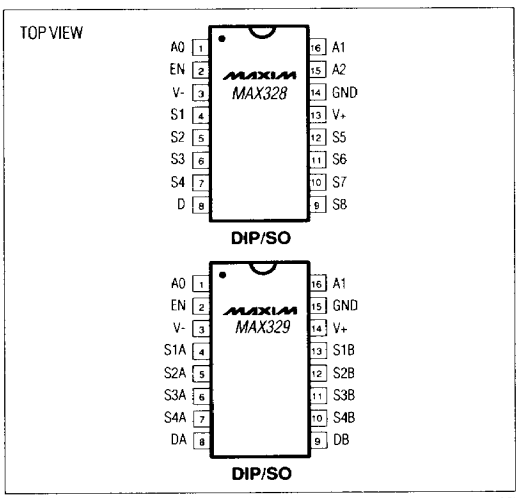
Ordering Information

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
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 availability. Substrate may be allowed to float or be tied to V+.*

Ordering information continued on page 7.

Pin Configurations



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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 10mA
Peak 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
Storage Temperature ..... -65°C to +150°C

Stresses listed under "Absolute Maximum Ratings" may be applied (one at a time) to devices without resulting in permanent damage. 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 peroids may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V+ = +15V, V- = -15V, GND = 0V, T_A = +25°C, 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		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		$\Delta r_{DS(on)}$	$\Delta r_{DS(on)} = \left(\frac{r_{DS(on)}\ \mathbf{Max} - r_{DS(on)}\ \mathbf{Min}}{r_{DS(on)}\ \mathbf{Ave}}\right)$ -10V ≤ V_S ≤ +10V			2			2		%
Source-Off Leakage Current (Note 5)		$I_{S(off)}$	V_S = 10V, V_D = -10V	V_{EN} = 0V		0.1	±10		1	±50	pA
			V_S = -10V, V_D = 10V			0.3	±10		0.3	±50	
Drain-Off Leakage Current (Note 5)	MAX328	$I_{D(off)}$	V_D = 10V, V_S = -10V	V_{EN} = 0V		0.3	±20		0.3	±50	pA
			V_D = -10V, V_S = 10V			1.0	±20		1.0	±50	
	MAX329		V_D = 10V, V_S = -10V			0.3	±10		0.3	±25	
			V_D = -10V, V_S = 10V			0.5	±10		0.5	±25	
Drain-On Leakage Current (Note 5)	MAX328	$I_{D(on)}$	$V_{S(all)}$ = V_D = 10V	Seq. Each Switch On V_{AL} = 0.8V V_{AH} = 2.4V		3.0	±50		3.0	±100	pA
			$V_{S(all)}$ = V_D = -10V			2.0	±50		2.0	±100	
	MAX329		$V_{S(all)}$ = V_D = 10V			1.5	±25		1.5	±50	
			$V_{S(all)}$ = V_D = -10V			1.0	±25		1.0	±50	

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ELECTRICAL CHARACTERISTICS (continued)

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

PARAMETER	SYMBOL	TEST CONDITIONS		LIMITS MAX328M MAX329M MIN	MAX328M MAX329M TYP	MAX328M MAX329M MAX	LIMITS MAX328C/E MAX329C/E MIN	MAX328C/E MAX329C/E TYP	MAX328C/E MAX329C/E MAX	UNITS
INPUT										
Address Input Current, Input Voltage High	I_{AH}	V_A = 2.4V			.001	±1		.001	±1	µA
		V_A = 15V			.001	±1		.001	±1	
Address Input Current, Input Voltage Low	I_{AL}	V_{EN} = 2.4V	All V_A = 0V		.001	±1		.001	±1	µA
		V_{EN} = 0V			.001	±1		.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 Time-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 = 7VRMS, 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	$Q_{(inj)}$	VA = +10V			2			2		pc
		VA = 0V			3			3		
		VA = -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	
Power-Supply Range For Continuous Operation (Note 6)	V_{OP}			±5		±18	±5		±18	V

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: Leakage parameters I_S(Off), I_D(Off), and I_D(On) are sample tested for M suffix devices at +25°C. The E and C suffix devices are guaranteed at +25°C, but not production tested.
Note 6: Electrical characteristics, such as On Resistance, will change when power supplies other than ±15V are used. Power-supply range is a design characteristic, not production tested.

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

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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						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		2.2	4		1.9	5	kΩ
			V_D = -10V, I_S = 100µA			1.5	4		1.2	5	
Source-Off Leakage Current (Note 7)		$I_{S(off)}$	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 7)	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 7)	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			.01	±1		.01	±1	µA
			V_A = 15V			.01	±1		.01	±1	
Address Input Current, Input Voltage Low		I_{AL}	V_{EN} = 2.4V	All V_A = 0V		.01	±1		.01	±1	µA
			V_{EN} = 0V			.01	±1		.01	±1	

Note 7: Leakage parameters are 100% tested at maximum rated operating temperature, i.e., +70°C, etc.

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TRUTH TABLE - MAX328

A_2	A_1	A_0	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

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" = $V_{AL} \leq 0.8V$, Logic "1" = $V_{AH} \geq 2.4V$

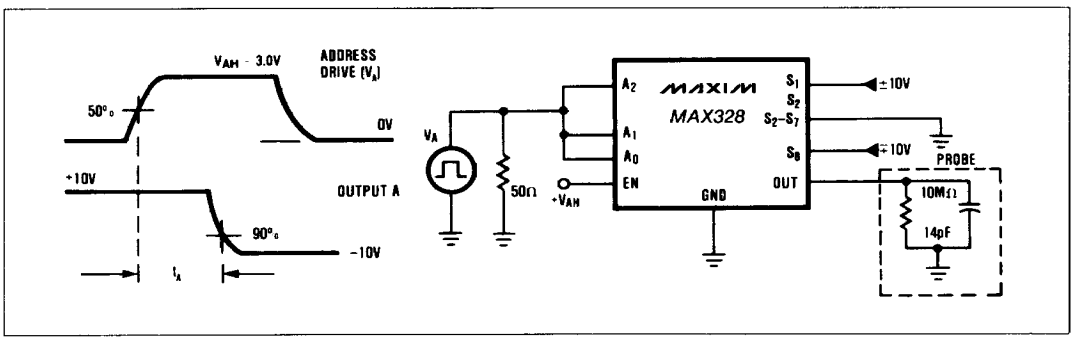

Figure 1. Access Time vs. Logic Level (High)

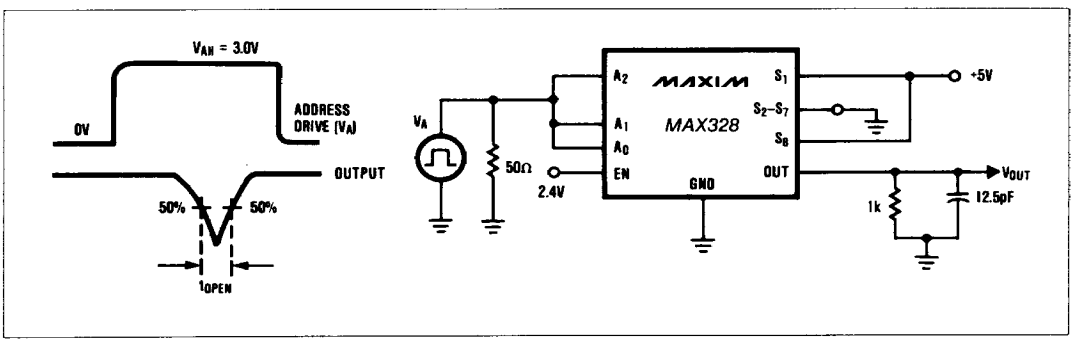

Figure 2. Break-Before-Make Delay (t_{OPEN})

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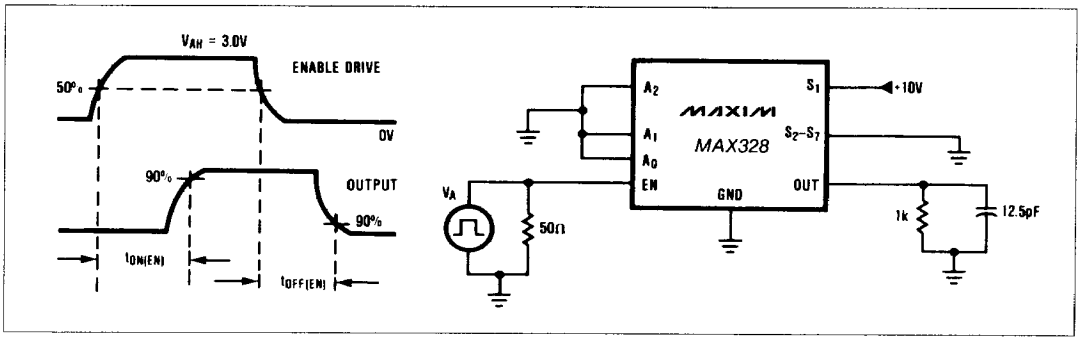
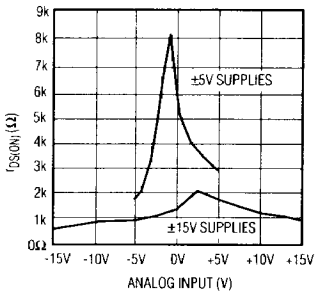


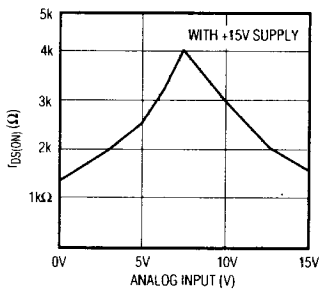
Figure 3. Enable Delay ($t_{ON(EN)}$, $t_{OFF(EN)}$)

Typical Operating Characteristics

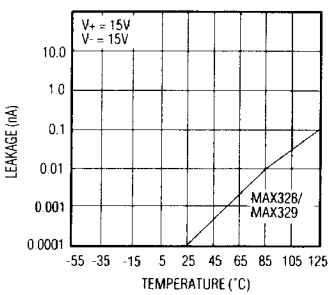
$r_{DS(ON)}$ VS ANALOG INPUT FOR DUAL SUPPLIES



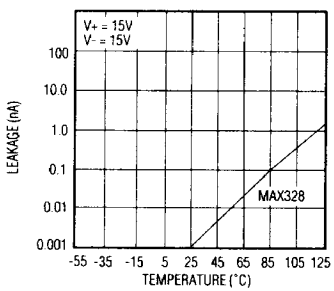
$r_{DS(ON)}$ VS ANALOG INPUT FOR SINGLE SUPPLY



$I_{S(OFF)}$ VS TEMPERATURE



$I_{D(ON)}$, $I_{D(OFF)}$ VS TEMPERATURE



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Application Notes

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 1/2W resistor is needed). The circuit withstands an indefinite fault to a 120V AC line with no damage to any component.

The guaranteed low leakage of the MAX328 is the key to this application. For the 10pA max I_S(off), the measurement error is 10pA X 39k = 0.39µV at room temperature. At 125°C, the leakages increase by a factor of 100; thus, 39µV is the high-temperature error. The commercial and industrial grades have a maximum leakage of 50pA of I_S(off) at room temperature. Therefore, 1.95µV is the room temperature error, and 195µV is the high-temperature (125°C) error.

Now, 17-bit accuracy decreases to 76µV for the least significant bit. Our 10pA model will meet this at 125°C, but not the 50pA model. Therefore, the 10pA model could be used in 16-bit systems over the military temperature range, but the 50pA model would be restricted to 100°C with adequate guardband.

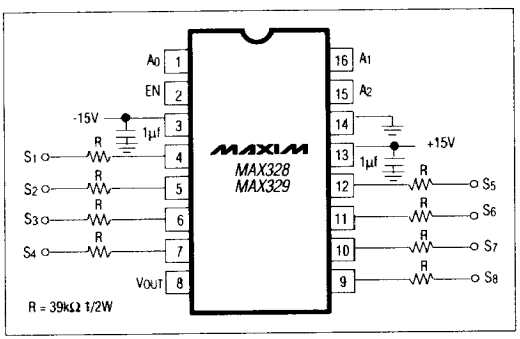


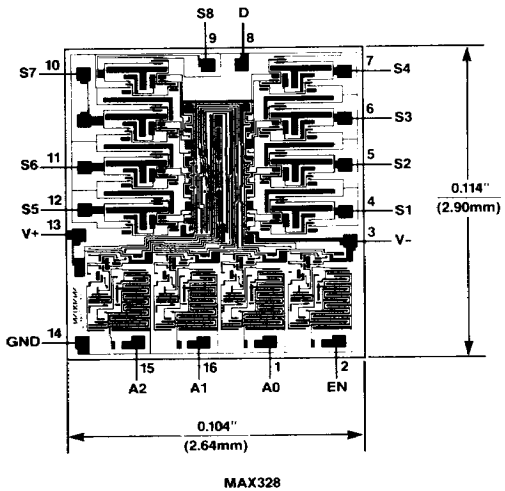
Figure 4. Fault-tolerant MUX (indefinitely withstands 120V AC fault voltages)

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
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 availability. Substrate may be allowed to float or be tied to V+.

Chip Topographies



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