

19-0272; Rev 0; 8/94



## 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

### General Description

The MAX338/MAX339 are monolithic, CMOS analog multiplexers (muxes). The 8-channel MAX338 is designed to connect one of eight inputs to a common output by control of a 3-bit binary address. The dual, 4-channel MAX339 is designed to connect one of four inputs to a common output by control of a 2-bit binary address. Both devices can be used as either a mux or a demux. On-resistance is 400Ω max, and the devices conduct current equally well in both directions.

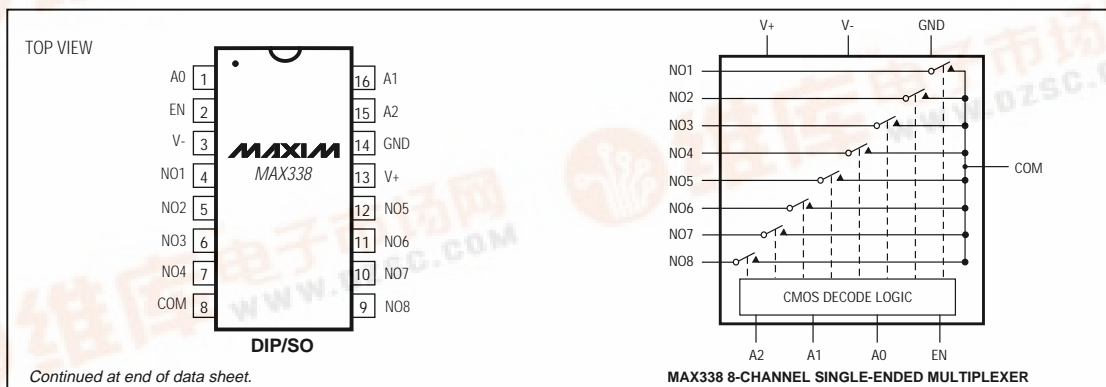
These muxes feature extremely low off leakages (less than 20pA at +25°C), and extremely low on-channel leakages (less than 50pA at +25°C). The new design offers guaranteed low charge injection (1.5pC typ) and electrostatic discharge (ESD) protection greater than 2000V, per method 3015.7. These improved muxes are pin-compatible upgrades for the industry-standard DG508A and DG509A. For similar Maxim devices with lower leakage and charge injection but higher on-resistance, see the MAX328 and MAX329.

The MAX338/MAX339 operate from a single +4.5V to +30V supply or from dual supplies of ±4.5V to ±20V. All control inputs (whether address or enable) are TTL compatible (+0.8V to +2.4V) over the full specified temperature range and over the ±4.5V to ±18V supply range. These parts are fabricated with Maxim's 44V silicon-gate process.

### Applications

Data-Acquisition Systems    Sample-and-Hold Circuits  
Test Equipment                Heads-Up Displays  
Military Radios                Communications Systems  
Guidance and Control Systems  
PBX, PABX

### Pin Configurations/Functional Diagrams/Truth Tables



### Features

- ♦ On-Resistance, <400Ω max
- ♦ Transition Time, <500ns
- ♦ On-Resistance Match, <10Ω
- ♦ NO-Off Leakage Current, <20pA at +25°C
- ♦ 1.5pC Charge Injection
- ♦ Single-Supply Operation (+4.5V to +30V)  
Bipolar-Supply Operation (±4.5V to ±20V)
- ♦ Plug-In Upgrade for Industry-Standard  
DG508A/DG509A
- ♦ Rail-to-Rail Signal Handling
- ♦ TTL/CMOS-Logic Compatible
- ♦ ESD Protection >2000V, per Method 3015.7

### Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX338CPE	0°C to +70°C	16 Plastic DIP
MAX338CSE	0°C to +70°C	16 Narrow SO
MAX338C/D	0°C to +70°C	Dice*
MAX338EPE	-40°C to +85°C	16 Plastic DIP
MAX338ESE	-40°C to +85°C	16 Narrow SO
MAX338EJE	-40°C to +85°C	16 CERDIP
MAX338MJE	-55°C to +125°C	16 CERDIP**

Ordering Information continued at end of data sheet.

\* Contact factory for dice specifications.

\*\* Contact factory for availability.



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Call toll free 1-800-998-8800 for free samples or literature.

MAX338/MAX339



## 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

### ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-

V+ .....-0.3V, 44V

GND .....-0.3V, 25V

Digital Inputs, NO, COM (Note 1).....(V- - 2V) to (V+ + 2V) or  
30mA (whichever occurs first)

Continuous Current (any terminal) .....30mA

Peak Current, NO or COM  
(pulsed at 1ms, 10% duty cycle max) .....100mA

Continuous Power Dissipation (TA = +70°C)

Plastic DIP (derate 10.53mW/°C above +70°C) .....842mW

Narrow SO (derate 8.70mW/°C above +70°C) .....696mW

CERDIP (derate 10.00mW/°C above +70°C) .....800mW

Operating Temperature Ranges

MAX33\_C\_\_ .....0°C to +70°C

MAX33\_E\_ .....-40°C to +85°C

MAX33\_MJE .....-55°C to +125°C

Storage Temperature Range .....-65°C to +150°C

Lead Temperature (soldering, 10sec) .....+300°C

**Note 1:** Signals on NO, COM, EN, A0, A1, or A2 exceeding V+ or V- are clamped by internal diodes. Limit forward current to maximum current ratings.

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

### ELECTRICAL CHARACTERISTICS—Dual Supplies

(V+ = +15V, V- = -15V, GND = 0V, VAH = +2.4V, VAL = +0.8V, TA = TMIN to TMAX, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS				MIN	TYP (Note 2)	MAX	UNITS
SWITCH									
Analog Signal Range	V <sub>NO</sub> , V <sub>COM</sub>	(Note 3)				-15		15	V
On-Resistance	R <sub>ON</sub>	I <sub>NO</sub> = 0.2mA, V <sub>COM</sub> = ±10V		T <sub>A</sub> = +25°C		220		400	Ω
				T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>				500	
On-Resistance Matching Between Channels	ΔR <sub>ON</sub>	I <sub>NO</sub> = 0.2mA, V <sub>COM</sub> = ±10V (Note 4)		T <sub>A</sub> = +25°C		4		10	Ω
				T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>				15	
NO-Off Leakage Current (Note 5)	I <sub>NO(OFF)</sub>	V <sub>COM</sub> = ∓10V, V <sub>NO</sub> = ±10V, V <sub>EN</sub> = 0V		T <sub>A</sub> = +25°C		-0.02	0.001	0.02	nA
				T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-1.25		1.25	
					M		-20		
COM-Off Leakage Current (Note 5)	I <sub>COM(OFF)</sub>	V <sub>NO</sub> = ±10V, V <sub>COM</sub> = ∓10V, V <sub>EN</sub> = 0V	MAX338	T <sub>A</sub> = +25°C		-0.05	0.005	0.05	nA
				T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-3.25		3.25	
					M		-40		
		V <sub>NO</sub> = ∓10V, V <sub>COM</sub> = ±10V, V <sub>EN</sub> = 0V	MAX339	T <sub>A</sub> = +25°C		-0.05	0.005	0.05	
				T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-1.65		1.65	
					M		-20		
COM-On Leakage Current (Note 5)	I <sub>COM(ON)</sub>	V <sub>COM</sub> = ±10V, V <sub>NO</sub> = ±10V, sequence each switch on	MAX338	T <sub>A</sub> = +25°C		-0.05	0.006	0.05	nA
				T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-3.25		3.25	
					M		-40		
			MAX339	T <sub>A</sub> = +25°C		-0.05	0.008	0.05	
				T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-1.65		1.65	
					M		-20		

## 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

### ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V<sub>+</sub> = +15V, V<sub>-</sub> = -15V, GND = 0V, V<sub>AH</sub> = +2.4V, V<sub>AL</sub> = +0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
INPUT							
Input Current with Input Voltage High	I <sub>AH</sub>	V <sub>A</sub> = 2.4V or 15V		-1.0	0.001	1.0	μA
Input Current with Input Voltage Low	I <sub>AL</sub>	V <sub>EN</sub> = 0V or 2.4V, V <sub>A</sub> = 0V		-1.0		1.0	μA
SUPPLY							
Power-Supply Range				±4.5		±20	V
Positive Supply Current	I <sub>+</sub>	V <sub>EN</sub> = V <sub>A</sub> = 0V	T <sub>A</sub> = +25°C		50	100	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			150	
		V <sub>EN</sub> = 2.4V, V <sub>A(ALL)</sub> = 2.4V	T <sub>A</sub> = +25°C		290	500	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			600	
Negative Supply Current	I <sub>-</sub>	V <sub>EN</sub> = 0V or 2.4V, V <sub>A(ALL)</sub> = 0V, 2.4V or 5V	T <sub>A</sub> = +25°C	-1		1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-10		10	
DYNAMIC							
Transition Time	t <sub>TRANS</sub>	Figure 2		T <sub>A</sub> = +25°C		200 500	ns
Break-Before-Make Interval	t <sub>OPEN</sub>	Figure 4		T <sub>A</sub> = +25°C		10 140	ns
Enable Turn-On Time	t <sub>ON(EN)</sub>	Figure 3	T <sub>A</sub> = +25°C			160 500	ns
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			750	
Enable Turn-Off Time	t <sub>OFF(EN)</sub>	Figure 3	T <sub>A</sub> = +25°C			100 500	ns
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			750	
Charge Injection (Note 3)	Q	C <sub>L</sub> = 100pF, V <sub>NO</sub> = 0V, R <sub>S</sub> = 0Ω, Figure 6		T <sub>A</sub> = +25°C		1.5 5	pC
Off Isolation (Note 6)	V <sub>ISO</sub>	V <sub>EN</sub> = 0V, R <sub>L</sub> = 1kΩ, f = 100kHz		T <sub>A</sub> = +25°C		-75	dB
Crosstalk Between Channels	V <sub>CT</sub>	V <sub>EN</sub> = 2.4V, f = 100kHz, V <sub>GEN</sub> = 1V <sub>p-p</sub> , R <sub>L</sub> = 1kΩ, Figure 7		T <sub>A</sub> = +25°C		-92	dB
Logic Input Capacitance	C <sub>IN</sub>	f = 1MHz		T <sub>A</sub> = +25°C		2	pF
NO-Off Capacitance	C <sub>NO(OFF)</sub>	f = 1MHz, V <sub>EN</sub> = V <sub>NO</sub> = 0V, Figure 8		T <sub>A</sub> = +25°C		3	pF
COM-Off Capacitance	C <sub>COM(OFF)</sub>	f = 1MHz, V <sub>EN</sub> = 0.8V, V <sub>COM</sub> = 0V, Figure 8	MAX338	T <sub>A</sub> = +25°C	11		pF
			MAX339		6		
COM-On Capacitance	C <sub>COM(ON)</sub>	f = 1MHz, V <sub>EN</sub> = 2.4V, V <sub>COM</sub> = 0V, Figure 8	MAX338	T <sub>A</sub> = +25°C	16		pF
			MAX339		9		

MAX338/MAX339

## 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

### ELECTRICAL CHARACTERISTICS—Single Supply

(V<sub>+</sub> = +12V, V<sub>-</sub> = 0V, GND = 0V, V<sub>AH</sub> = +2.4V, V<sub>AL</sub> = +0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
SWITCH							
Analog Signal Range	V <sub>NO</sub> , V <sub>COM</sub>	(Note 3)		0		12	V
On-Resistance	R <sub>ON</sub>	I <sub>NO</sub> = 0.2mA V <sub>COM</sub> = 3V or 10V	T <sub>A</sub> = +25°C		460	650	Ω
DYNAMIC							
Transition Time (Note 3)	t <sub>TRANS</sub>	V <sub>NO1</sub> = 8V, V <sub>NO8</sub> = 0V, V <sub>IN</sub> = 2.4V, Figure 1	T <sub>A</sub> = +25°C		210	500	ns
Enable Turn-On Time (Note 3)	t <sub>ON(EN)</sub>	V <sub>INH</sub> = 2.4V, V <sub>INL</sub> = 0V, V <sub>NO1</sub> = 5V, Figure 3	T <sub>A</sub> = +25°C		280	500	ns
Enable Turn-Off Time (Note 3)	t <sub>OFF(EN)</sub>	V <sub>INH</sub> = 2.4V, V <sub>INL</sub> = 0V, V <sub>NO1</sub> = 5V, Figure 3	T <sub>A</sub> = +25°C		110	500	ns
Charge Injection (Note 3)	Q	C <sub>L</sub> = 100pF, V <sub>NO</sub> = 0V, R <sub>S</sub> = 0Ω	T <sub>A</sub> = +25°C		1.8	5	pC

**Note 2:** The algebraic convention where the most negative value is a minimum and the most positive value a maximum is used in this data sheet.

**Note 3:** Guaranteed by design.

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

**Note 5:** Leakage parameters are 100% tested at the maximum rated hot temperature and guaranteed by correlation at +25°C.

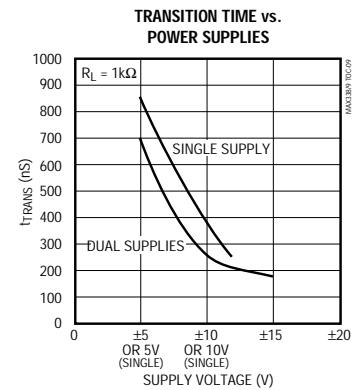
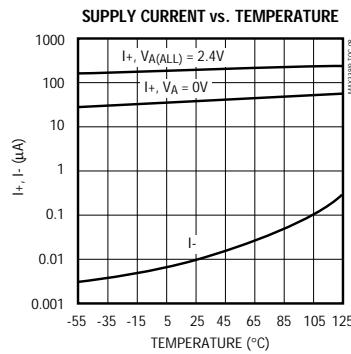
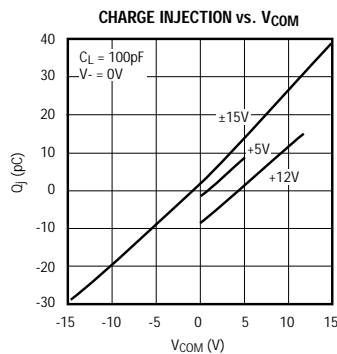
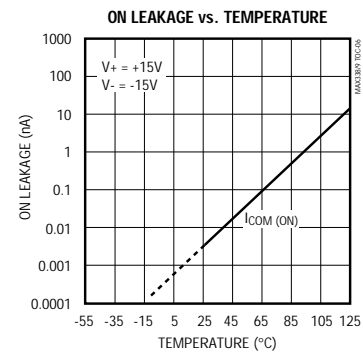
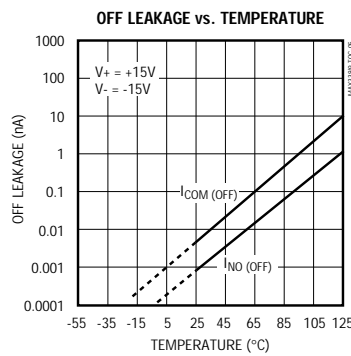
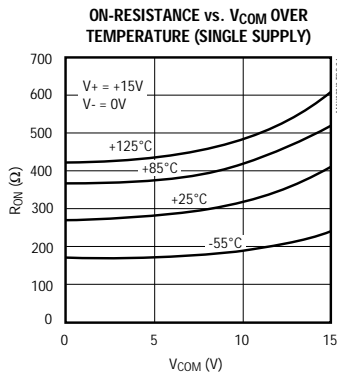
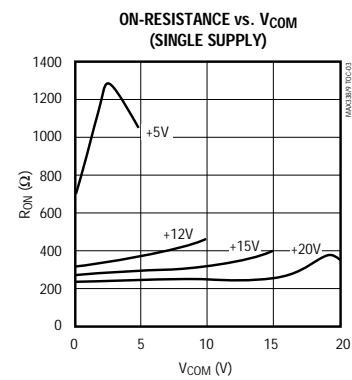
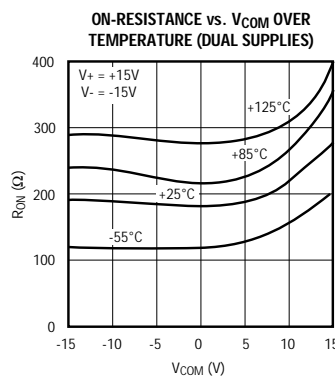
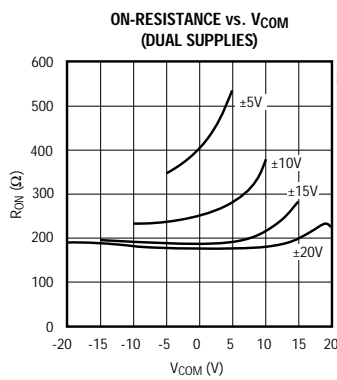
**Note 6:** Worst-case isolation is on channel 4 because of its proximity to the drain pin. Off isolation =  $20 \log V_{COM}/V_{NO}$ , where V<sub>COM</sub> = output and V<sub>NO</sub> = input to off switch.

# 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

## Typical Operating Characteristics

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

MAX338/MAX339



## 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

### Pin Description

PIN		NAME	FUNCTION
MAX338	MAX339		
1, 15, 16	—	A0, A2, A1	Address Inputs
—	1, 16	A0, A1	Address Inputs
2	2	EN	Enable Input
3	3	V-	Negative Supply Voltage Input
4–7	—	NO1–NO4	Analog Inputs—bidirectional
—	4–7	NO1A–NO4A	Analog Inputs—bidirectional
8	—	COM	Analog Output—bidirectional
—	8, 9	COMA, COMB	Analog Outputs—bidirectional
9–12	—	NO8–NO5	Analog Inputs—bidirectional
—	10–13	NO4B–NO1B	Analog Inputs—bidirectional
13	14	V+	Positive Supply Voltage Input
14	15	GND	Ground

### Applications Information

#### Operation with Supply Voltages Other than 15V

Using supply voltages less than  $\pm 15\text{V}$  will reduce the analog signal range. The MAX338/MAX339 switches operate with  $\pm 4.5\text{V}$  to  $\pm 20\text{V}$  bipolar supplies or with a  $+4.5\text{V}$  to  $+30\text{V}$  single supply. Connect  $V^-$  to GND when operating with a single supply. Both device types can also operate with unbalanced supplies such as  $+24\text{V}$  and  $-5\text{V}$ . The *Typical Operating Characteristics* graphs show typical on-resistance with 20V, 15V, 10V, and 5V supplies. (Switching times increase by a factor of two or more for operation at 5V.)

#### Overvoltage Protection

Proper power-supply sequencing is recommended for all CMOS devices. Do not exceed the absolute maximum ratings, because stresses beyond the listed ratings may cause permanent damage to the devices. Always sequence  $V^+$  on first, then  $V^-$ , followed by the logic inputs NO and COM. If power-supply sequencing is not possible, add two small signal diodes in series with supply pins for overvoltage protection (Figure 1). Adding diodes reduces the analog signal range to 1V below  $V^+$  and 1V above  $V^-$ , but does not affect the devices' low switch resistance and low leakage characteristics. Device operation is unchanged, and the difference between  $V^+$  and  $V^-$  should not exceed 44V.

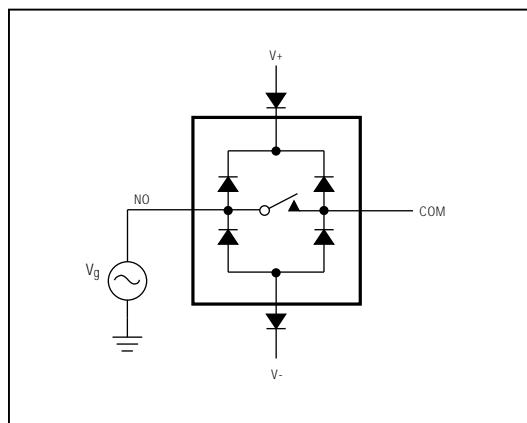


Figure 1. Overvoltage Protection Using External Blocking Diodes

## 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

Test Circuits/Timing Diagrams

MAX338/MAX339

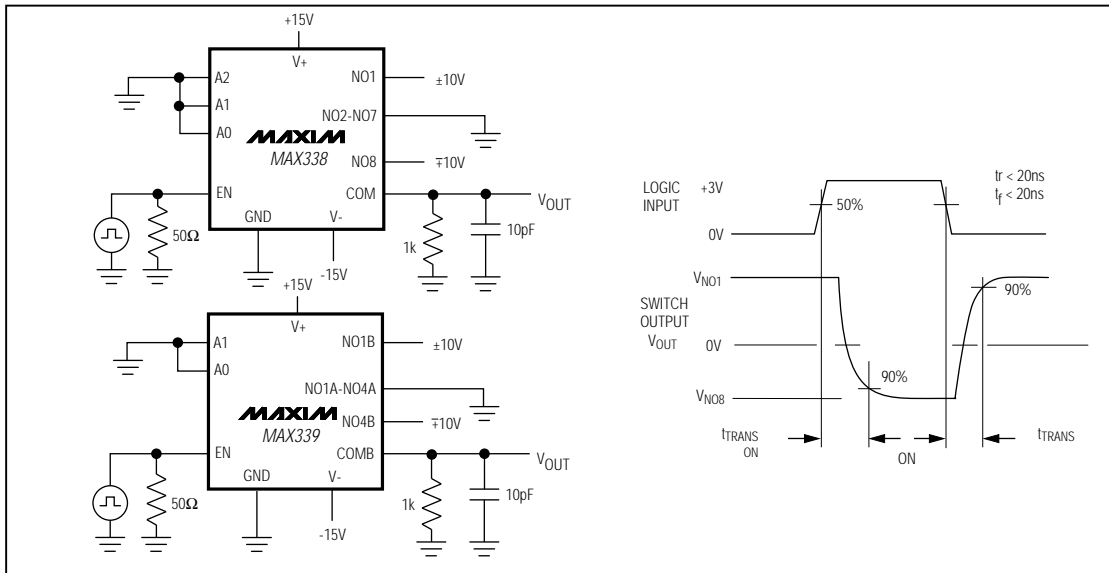


Figure 2. Transition Time

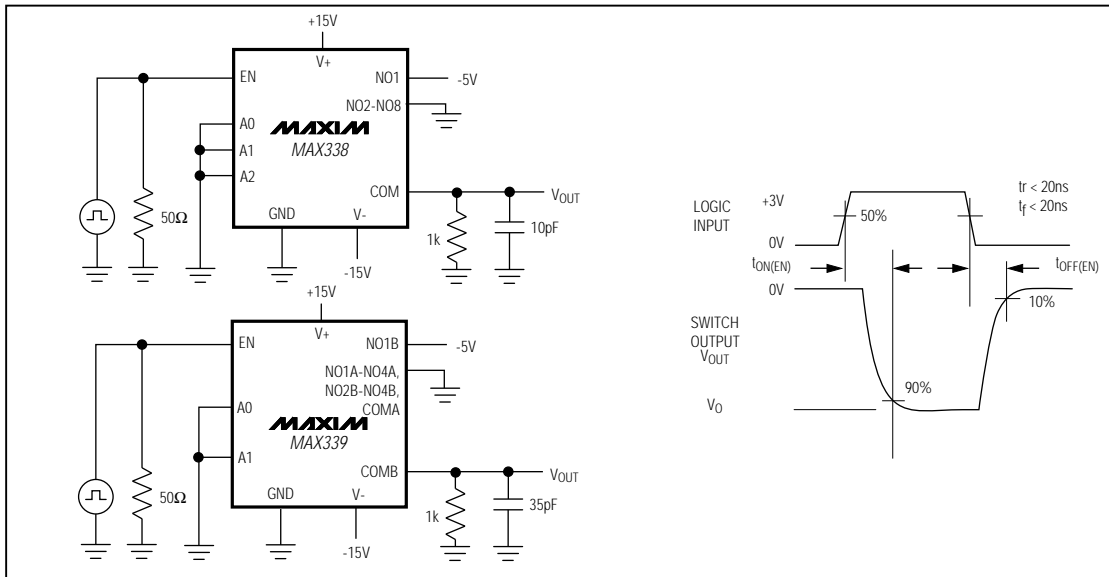


Figure 3. Enable Switching Time

## 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

Test Circuits/Timing Diagrams (continued)

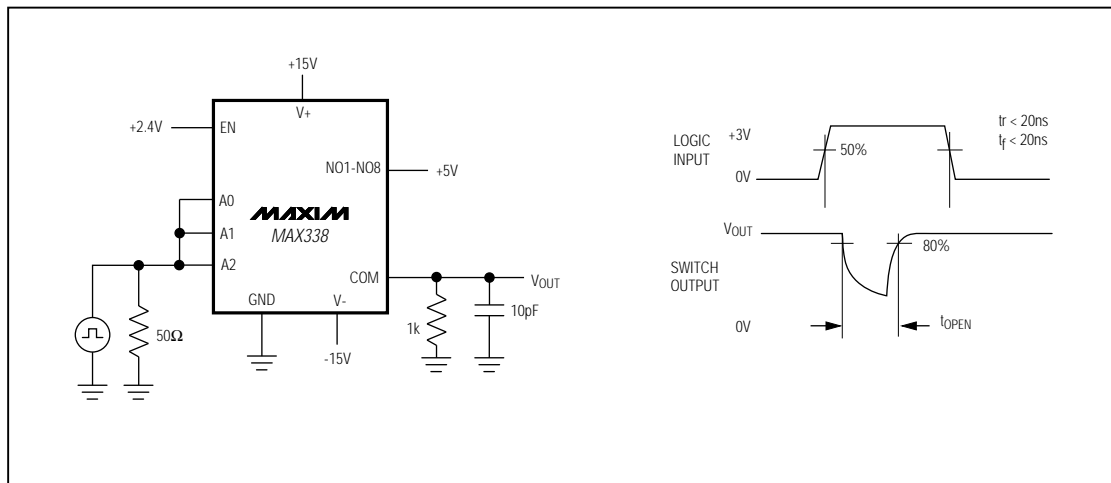


Figure 4. Break-Before-Make Interval

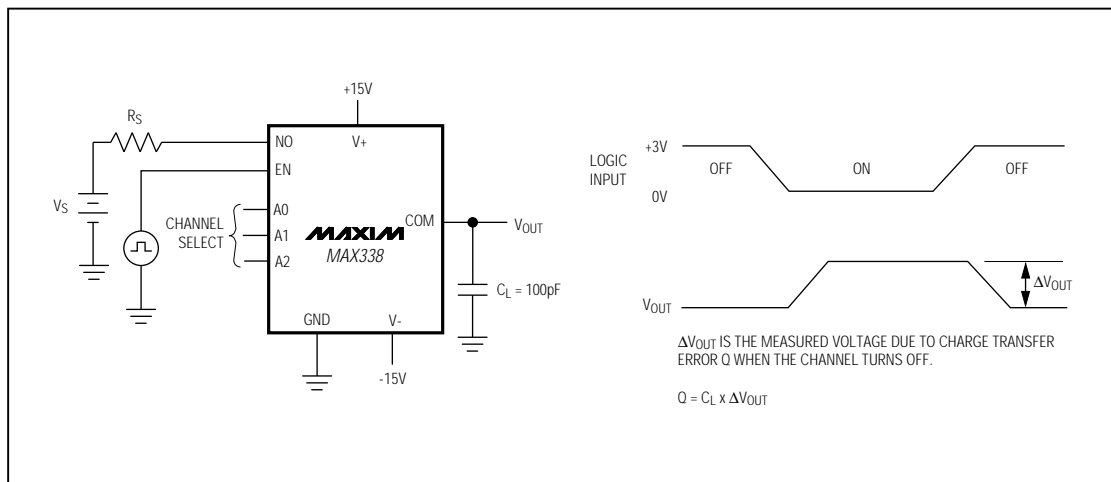


Figure 5. Charge Injection

## 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

Test Circuits/Timing Diagrams (continued)

MAX338/MAX339

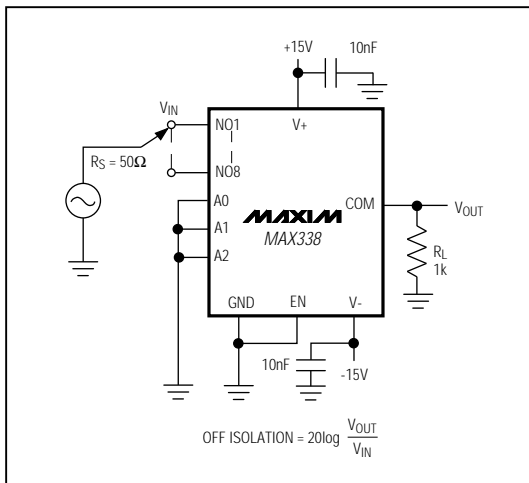


Figure 6. Off Isolation

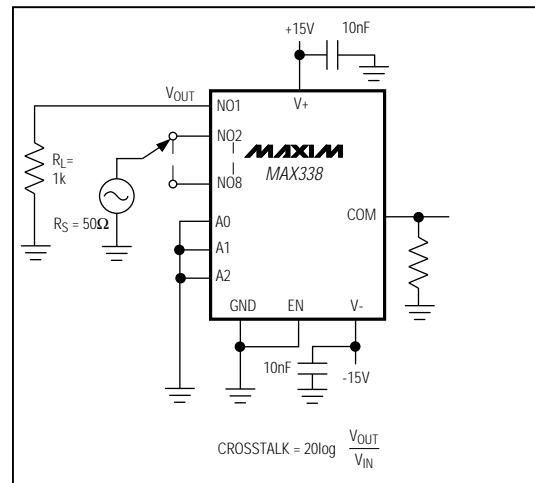


Figure 7. Crosstalk

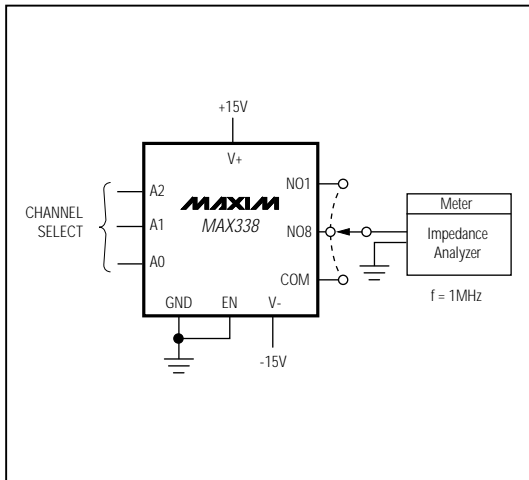
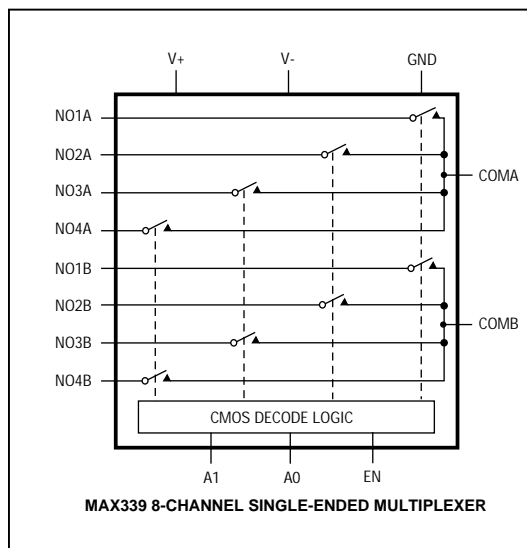
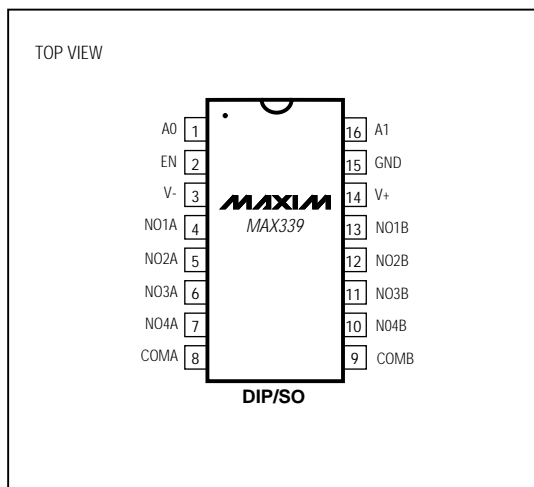


Figure 8. NO/COM Capacitance

# 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

\_\_\_\_\_Pin Configurations/Functional Diagrams/Truth Tables (continued)



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

MAX338

LOGIC "0"  $V_{AL} \leq 0.8V$ , LOGIC "1"  $V_{AH} \geq 2.4V$

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

MAX339

LOGIC "0"  $V_{AL} \leq 0.8V$ , LOGIC "1"  $V_{AH} \geq 2.4V$

## 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

### \_Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
<b>MAX339</b> CPE	0°C to +70°C	16 Plastic DIP
MAX339CSE	0°C to +70°C	16 Narrow SO
MAX339C/D	0°C to +70°C	Dice*
MAX339EPE	-40°C to +85°C	16 Plastic DIP
MAX339ESE	-40°C to +85°C	16 Narrow SO
MAX339EJE	-40°C to +85°C	16 CERDIP
MAX339MJE	-55°C to +125°C	16 CERDIP**

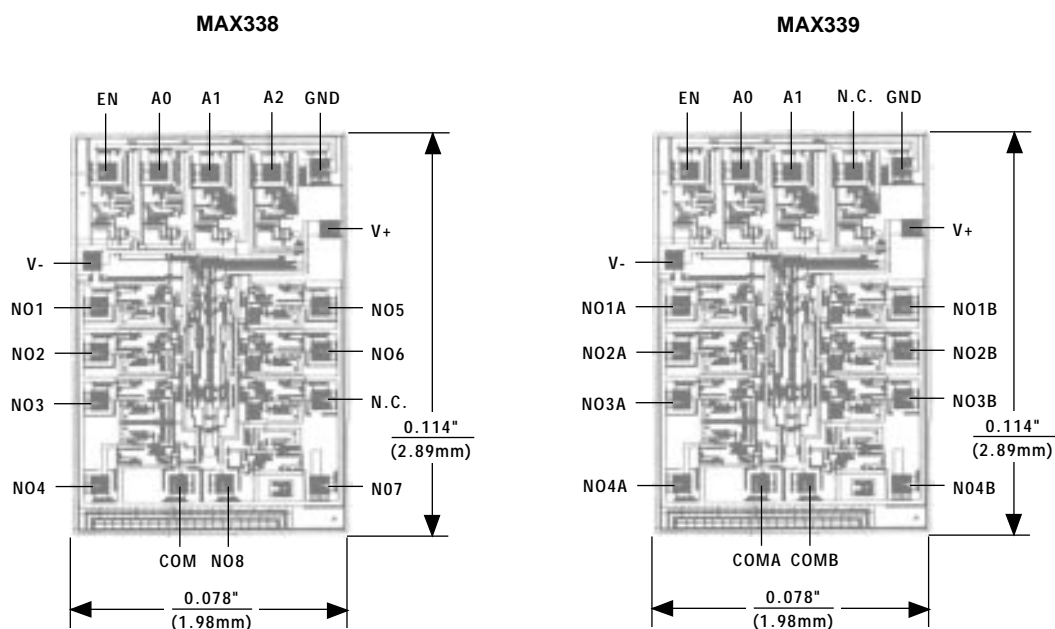
\* Contact factory for dice specifications.

\*\* Contact factory for availability.

MAX338/MAX339

# 8-Channel/Dual 4-Channel, Low-Leakage, CMOS Analog Multiplexers

Chip Topographies



N.C. = NO INTERNAL CONNECTION

TRANSISTOR COUNT: 224  
SUBSTRATE IS INTERNALLY CONNECTED TO V+

TRANSISTOR COUNT: 224  
SUBSTRATE IS INTERNALLY CONNECTED TO V+

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