

## MAX338/MAX339

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

### 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
MAX338CEE+	0°C to +70°C	16 QSOP
MAX338CPE+	0°C to +70°C	16 PDIP
MAX338CSE+	0°C to +70°C	16 Narrow SO
MAX338C/D	0°C to +70°C	Dice*
MAX338EEE+	-40°C to +85°C	16 QSOP
MAX338ETE+	-40°C to +85°C	16 TQFN-EP** (5mm x 5mm)

**Ordering Information continued at end of data sheet.**

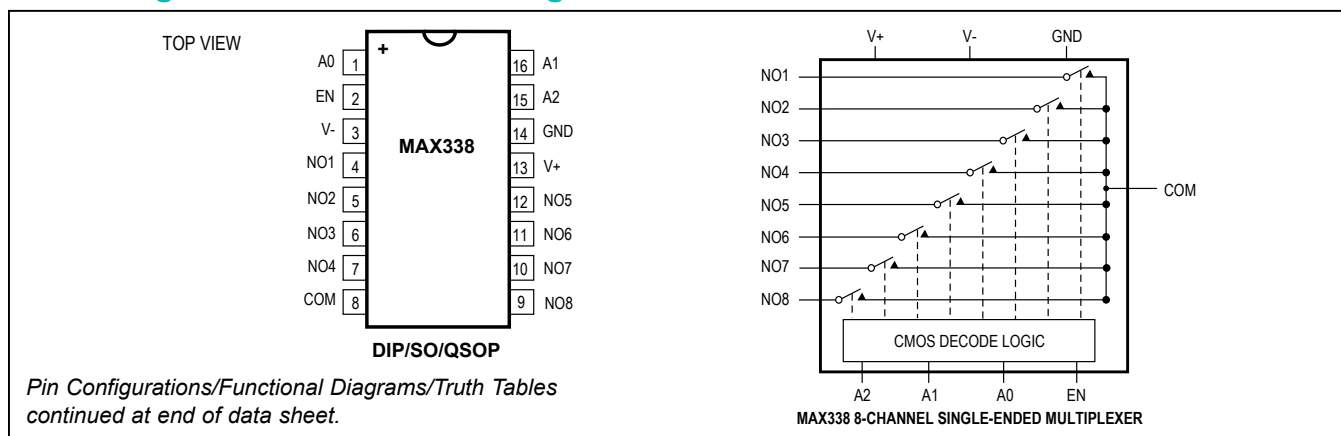
\*Contact factory for dice specifications.

\*\*EP = Exposed Pad

\*\*\*Contact factory for availability.

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

### Pin Configurations/Functional Diagrams/Truth Tables



**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 (T <sub>A</sub> = +70°C)	
Plastic DIP (derate 10.53mW/°C above +70°C).....	842mW
Narrow SO (derate 8.70mW/°C above +70°C) .....	696mW
16 QSOP (derate 8.3mW/°C above +70°C).....	666.7mW

16-Pin TQFN (derate 20.8mW/°C above +70°C) ...	1666.7mW
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, MSE.....	-55°C to +125°C
Storage Temperature Range.....	-65°C to +150°C
Lead Temperature (soldering, 10sec) .....	+300°C
Soldering Temperature (reflow)	
Lead(Pb)-free packages.....	+260°C
Packages containing lead(Pb).....	+240°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, V<sub>GND</sub> = 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		
<b>SWITCH</b>									
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	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	40		
		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	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	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	20		

**Electrical Characteristics—Dual Supplies (continued)**(V+ = +15V, V- = -15V, V<sub>GND</sub> = 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
<b>INPUT</b>							
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
<b>SUPPLY</b>							
Power-Supply Range				±4.5		±20	V
Positive Supply Current	I+	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-	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	
<b>DYNAMIC</b>							
Transition Time	t <sub>TRANS</sub>	Figure 2	T <sub>A</sub> = +25°C/ T <sub>A</sub> = -55°C		200	500	ns
			T <sub>A</sub> = +125°C				650
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>				
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>				
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		

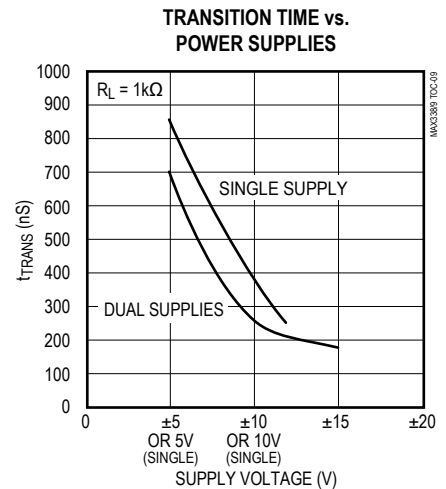
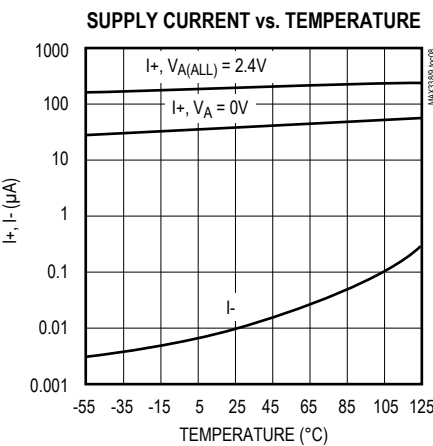
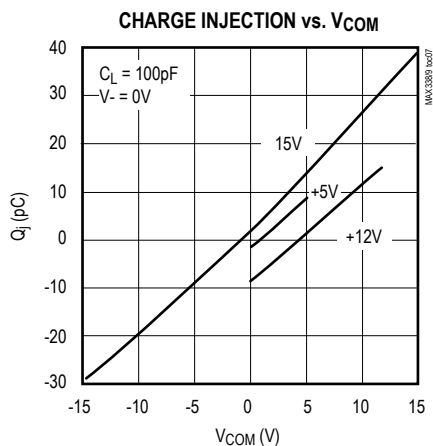
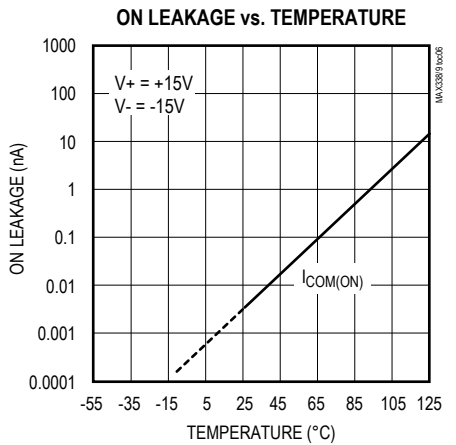
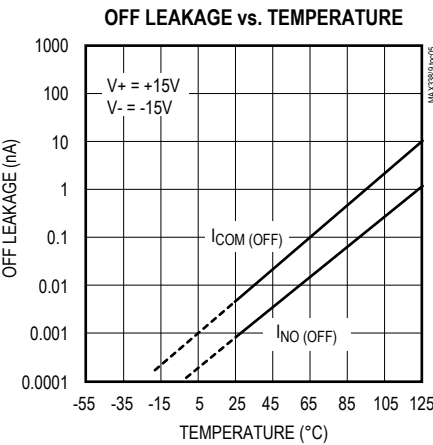
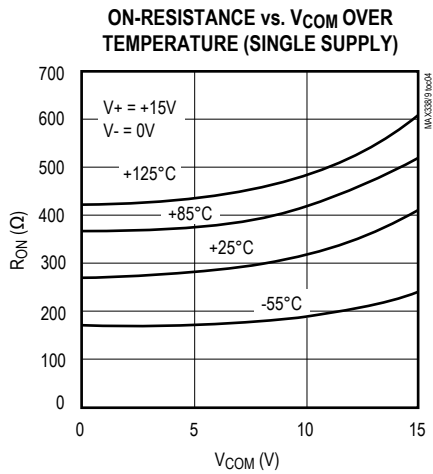
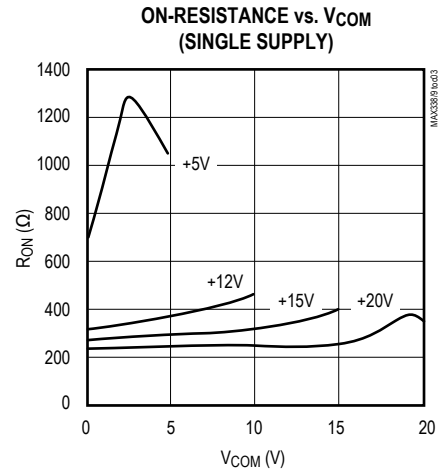
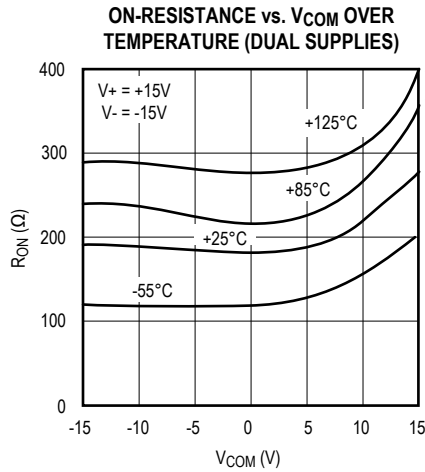
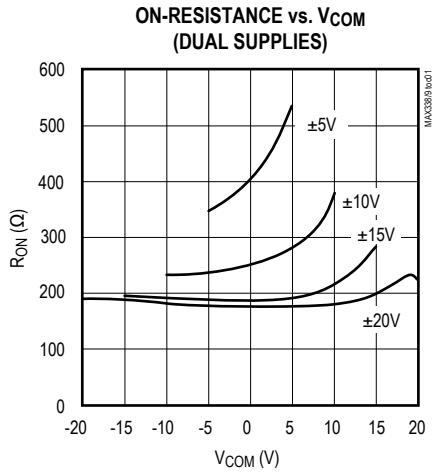
**Electrical Characteristics—Single Supply**(V+ = +12V, V- = 0V, V<sub>GND</sub> = 0V, V<sub>AH</sub> = +2.4V, V<sub>AL</sub> = +0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
<b>SWITCH</b>							
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
<b>DYNAMIC</b>							
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/ T <sub>A</sub> = -55°C		210	500	ns
						800	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	ns

**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:** ΔR<sub>ON</sub> = R<sub>ON(MAX)</sub> - R<sub>ON(MIN)</sub>.**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 = 20log V<sub>COM</sub>/V<sub>NO</sub>, where V<sub>COM</sub> = output and V<sub>NO</sub> = input to off switch.

Typical Operating Characteristics

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



Pin Description

PIN				NAME	FUNCTION
MAX338		MAX339			
DIP/SO/QSOP	TQFN-EP	DIP/SO/QSOP	TQFN-EP		
1, 15, 16,	15, 14, 13	—	—	A0, A2, A1	Address Inputs
—	—	1, 16	15, 14	A0, A1	Address Inputs
2	16	2	16	EN	Enable
3	1	3	1	V-	Negative-Supply Voltage Input
4–7	2–5	—	—	NO1–NO14	Analog Inputs—Bidirectional
—	—	4–7	2–5	NO1A–NO4A	Analog Inputs—Bidirectional
8	6	—	—	COM	Analog Output—Bidirectional
—	—	8, 9	6, 7	COMA, COMB	Analog Outputs—Bidirectional
9–12	7–10	—	—	NO8–NO5	Analog Inputs—Bidirectional
—	—	10–13	8–11	NO4B–NO1B	Analog Inputs—Bidirectional
13	11	14	12	V+	Positive-Supply Voltage Input
14	12	15	13	GND	Ground
—	—	—	—	Exposed Pad	Exposed Pad (TQFN only). Connect EP to V+.

Applications Information

Operation with Supply Voltages Other than 15V

Using supply voltages less than ±15V will reduce the analog signal range. The MAX338/MAX339 switches operate with ±4.5V to ±20V bipolar supplies or with a +4.5V to +30V single supply. Connect V- to GND when operating with a single supply. Both device types can also operate with unbalanced supplies such as +24V and -5V. 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.

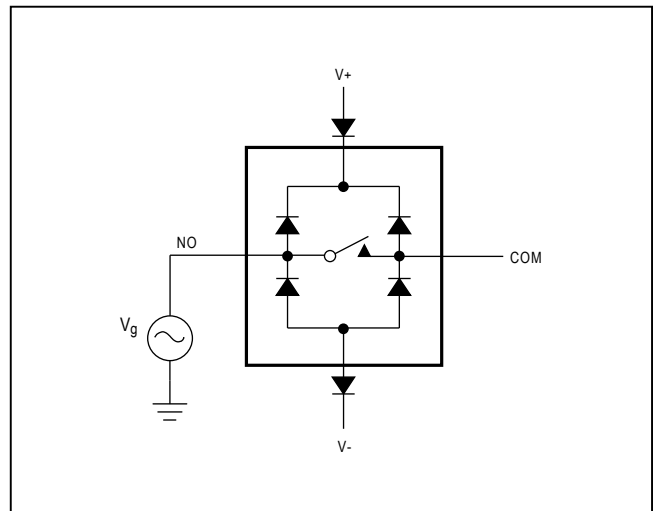


Figure 1. Overvoltage Protection Using External Blocking Diodes

Test Circuits/Timing Diagrams

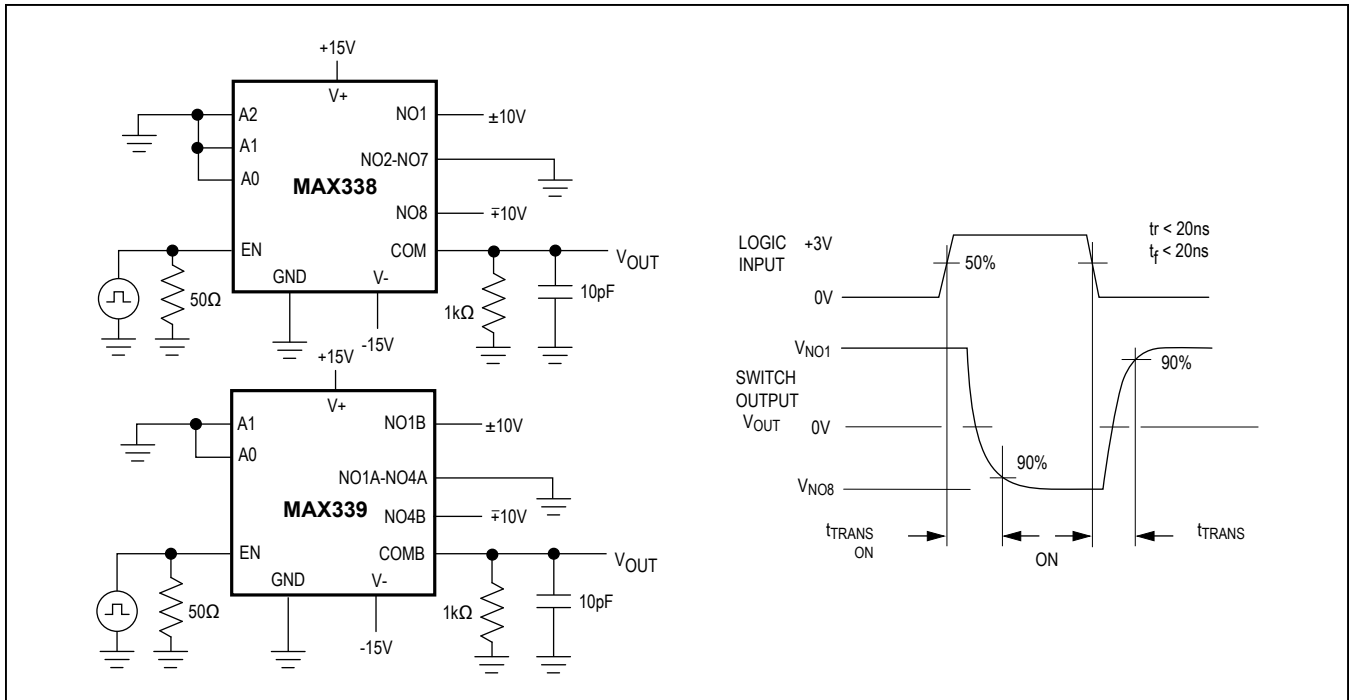


Figure 2. Transition Time

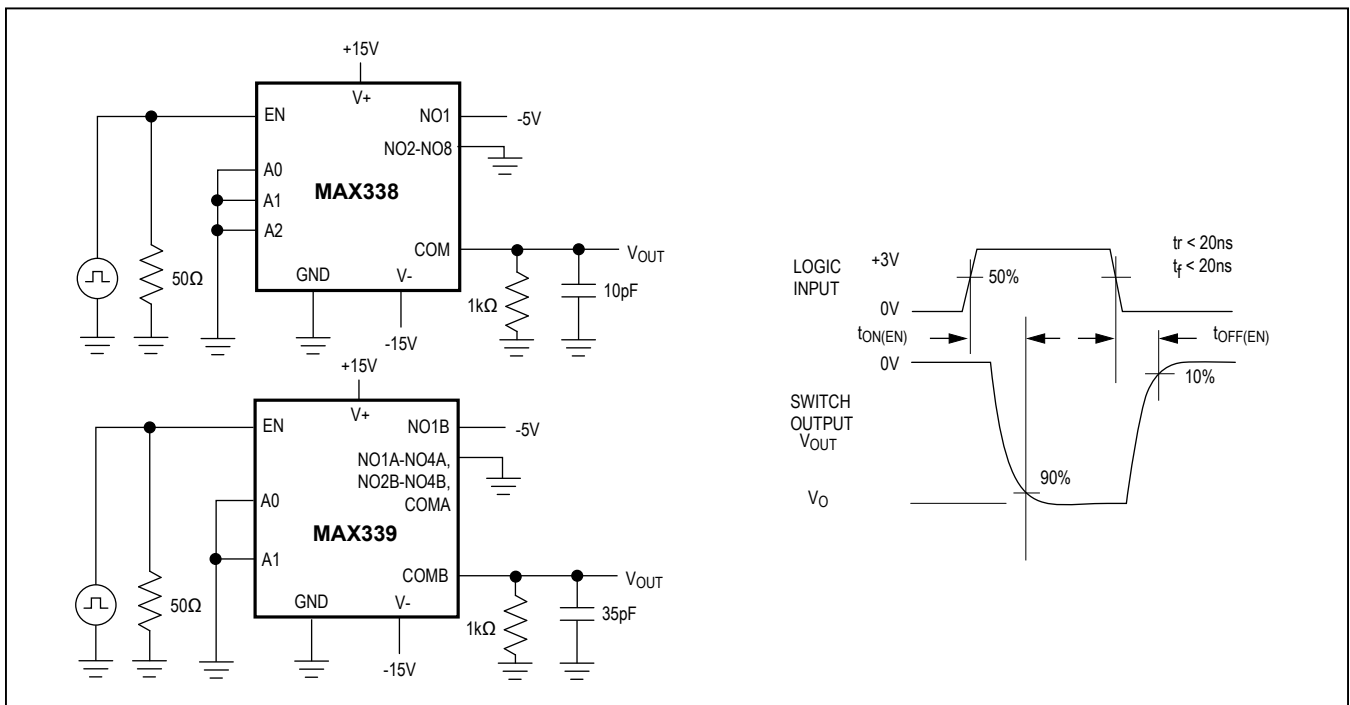


Figure 3. Enable Switching Time

Test Circuits/Timing Diagrams (continued)

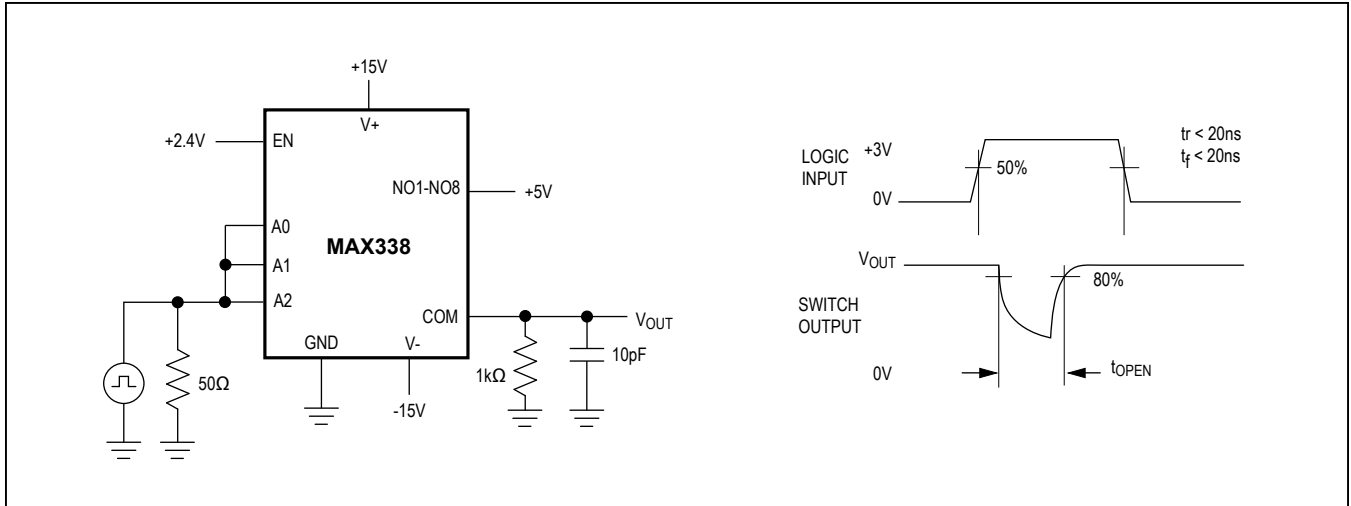


Figure 4. Break-Before-Make Interval

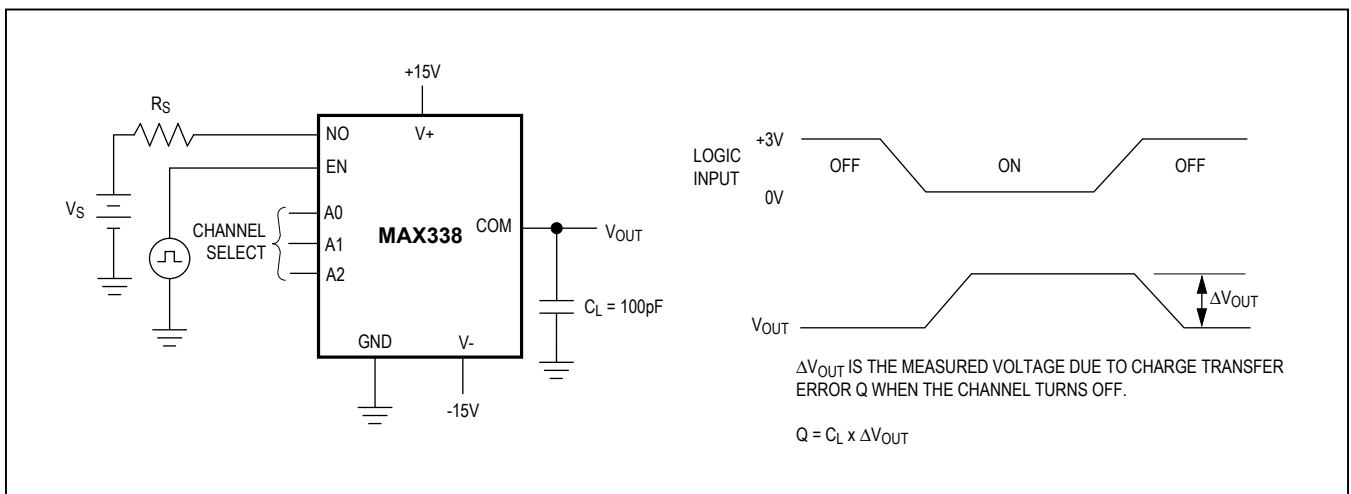


Figure 5. Charge Injection



Test Circuits/Timing Diagrams (continued)

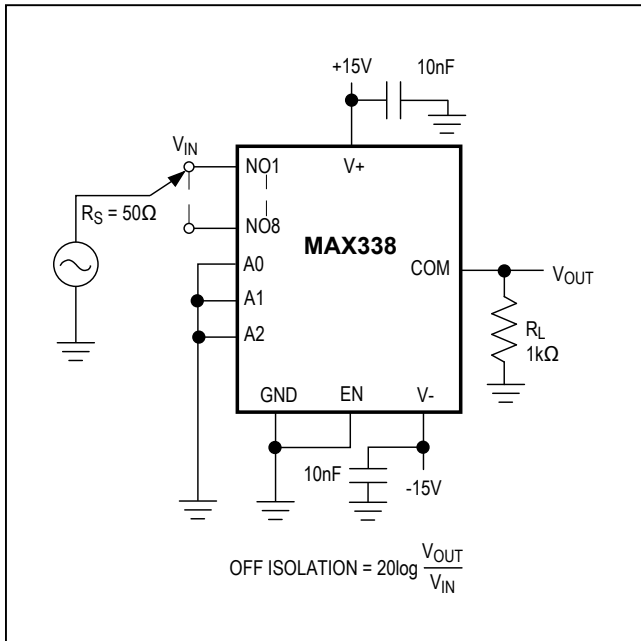


Figure 6. Off-Isolation

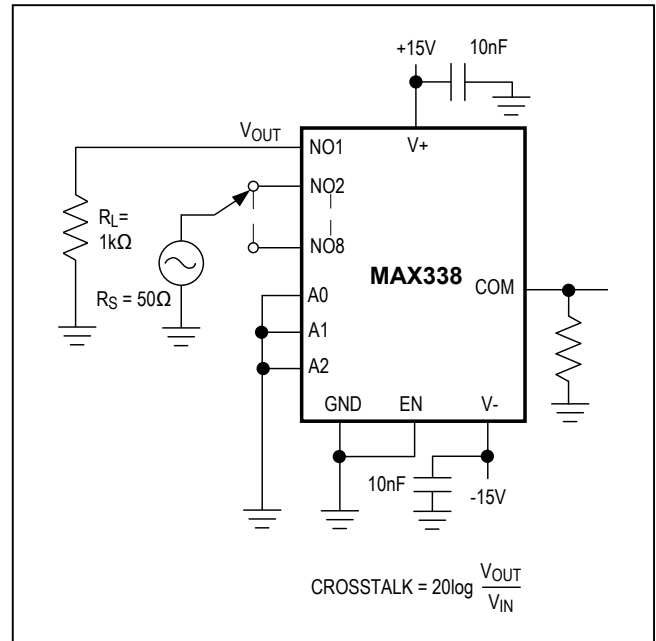


Figure 7. Crosstalk

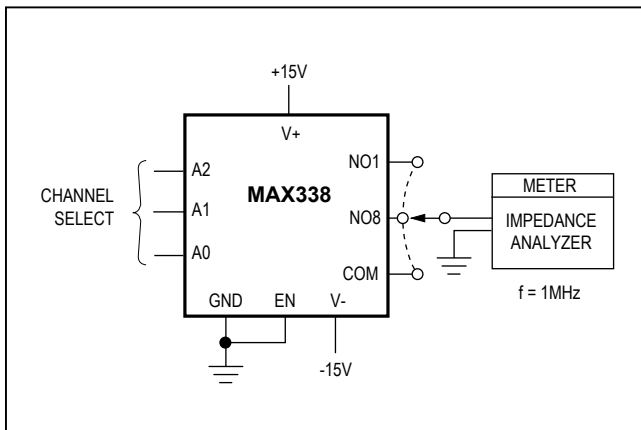
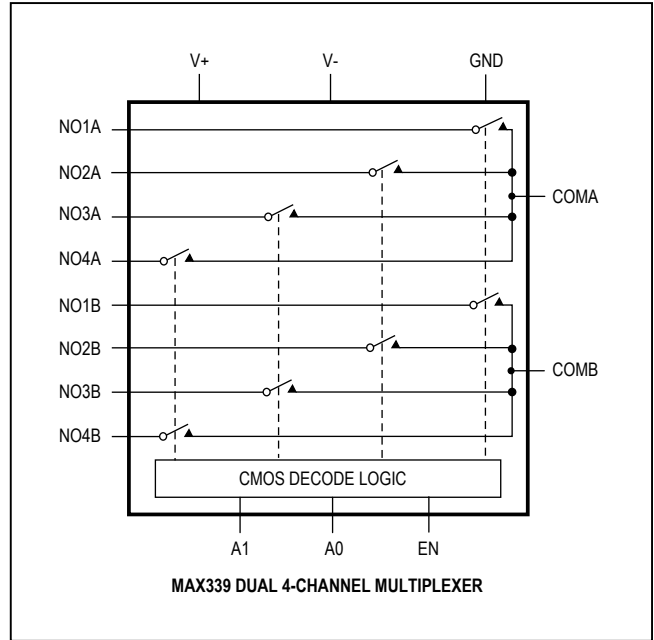
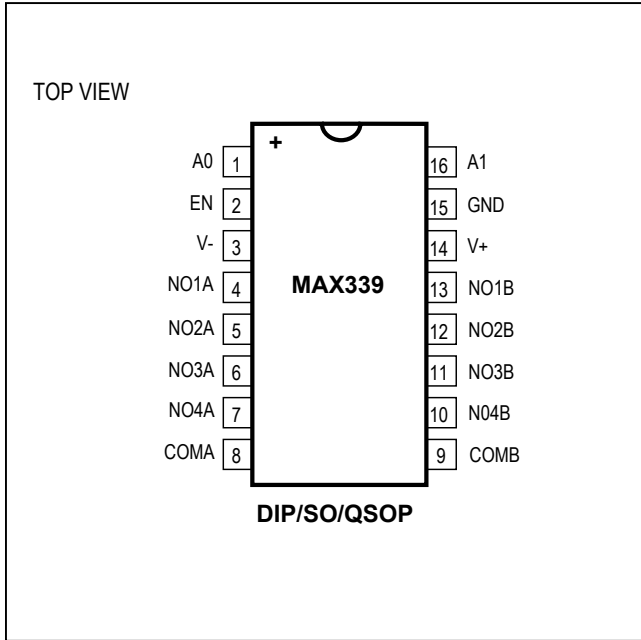


Figure 8. NO/COM Capacitance

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**

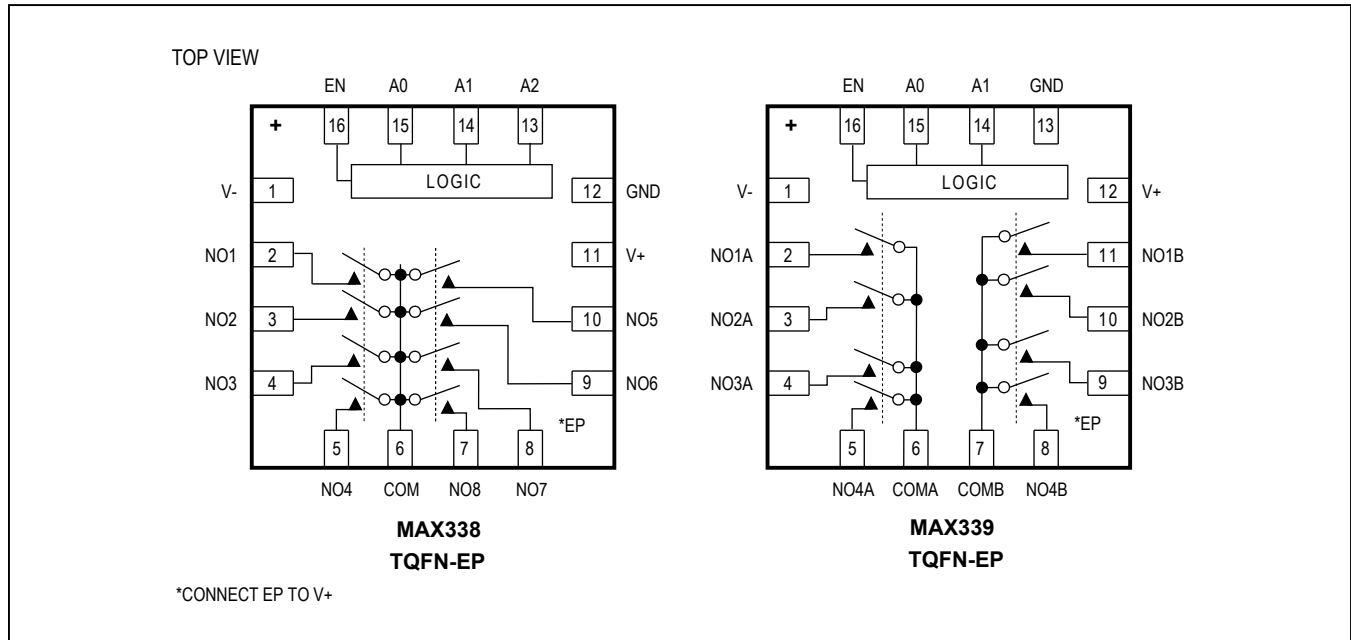
**LOGIC "0"  $V_{AL} \geq 0.8V$ , LOGIC "1"  $V_{AH} \geq 2.4V$**

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

Pin Configurations/Functional Diagrams/Truth Tables (continued)



Ordering Information (continued)

PART	TEMP RANGE	PIN-PACKAGE
MAX338EPE+	-40°C to +85°C	16 PDIP
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***
MAX338MSE/PR3+	-55°C to +125°C	16 Narrow SO
<b>MAX339CEE+</b>	0°C to +70°C	16 QSOP
MAX339CPE+	0°C to +70°C	16 PDIP
MAX339CSE+	0°C to +70°C	16 Narrow SO
MAX339C/D	0°C to +70°C	Dice*

PART	TEMP RANGE	PIN-PACKAGE
MAX339EEE+	-40°C to +85°C	16 QSOP
MAX339ETE+	-40°C to +85°C	16 TQFN-EP** (5mm x 5mm)
MAX339EPE+	-40°C to +85°C	16 PDIP
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***
MAX339MSE/PR3+	-55°C to +125°C	16 Narrow SO

\*Contact factory for dice specifications.

\*\*EP = Exposed Pad

\*\*\*Contact factory for availability.

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

## Package Information

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.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 PDIP	P16+1	<a href="#">21-0043</a>	—
16 Narrow SO	S16+1	<a href="#">21-0041</a>	<a href="#">90-0097</a>
16 QSOP	E16+5	<a href="#">21-0055</a>	<a href="#">90-0167</a>
16 TQFN-EP	T1655+3	<a href="#">21-0140</a>	<a href="#">90-0073</a>
16 CDIP	J16+4	<a href="#">21-0045</a>	—

## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
4	4/12	Added the MAX338CEE+ / MAX338EEE+ / MAX338MSE /PR3 / MAX339CEE+ / MAX339EEE+ part and packaging information	1, 2, 6, 10, 11
5	10/17	Updated <i>Ordering Information</i> table	11
6	5/19	Updated <i>Electrical Characteristics</i> table	3, 4

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