

19-0212; Rev 1; 4/94

# MAXIM

## Precision, Quad, SPST Analog Switches

### General Description

The MAX351/MAX352/MAX353 are precision, quad, single-pole single-throw (SPST) analog switches. The MAX351 has four normally closed (NC), and the MAX352 has four normally open (NO) switches. The MAX353 has two NO and two NC switches. All three parts offer low on resistance (less than  $35\Omega$ ), guaranteed to match within  $2\Omega$  between channels and to remain flat over the analog signal range ( $\Delta 3\Omega$  max). They also offer low leakage (less than  $250\text{pA}$  at  $+25^\circ\text{C}$  and less than  $6\text{nA}$  at  $+85^\circ\text{C}$ ) and fast switching (turn-on time less than  $175\text{ns}$  and turn-off time less than  $145\text{ns}$ ).

The MAX351/MAX352/MAX353 are fabricated with Maxim's new improved  $44\text{V}$  silicon-gate process. Design improvements guarantee extremely low charge injection ( $10\text{pC}$ ), low power consumption ( $35\mu\text{W}$ ), and electrostatic discharge (ESD) greater than  $2000\text{V}$ . The  $44\text{V}$  maximum breakdown voltage allows rail-to-rail analog signal handling.

These monolithic switches operate with a single positive supply ( $+10\text{V}$  to  $+30\text{V}$ ) or with split supplies ( $\pm 4.5\text{V}$  to  $\pm 20\text{V}$ ) while retaining CMOS-logic input compatibility and fast switching. CMOS inputs provide reduced input loading.

### Applications

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

### Features

- ♦ Low On Resistance  $< 22\Omega$  Typical ( $35\Omega$  Max)
- ♦ Guaranteed Matched On Resistance Between Channels  $< 2\Omega$
- ♦ Guaranteed Flat On Resistance Over Analog Signal Range  $\Delta 3\Omega$  Max
- ♦ Guaranteed Charge Injection  $< 10\text{pC}$
- ♦ Guaranteed Off-Channel Leakage  $< 6\text{nA}$  at  $+85^\circ\text{C}$
- ♦ ESD Guaranteed  $> 2000\text{V}$  per Method 3015.7
- ♦ Single-Supply Operation ( $+10\text{V}$  to  $+30\text{V}$ )  
Bipolar-Supply Operation ( $\pm 4.5\text{V}$  to  $\pm 20\text{V}$ )
- ♦ TTL-/CMOS-Logic Compatibility
- ♦ Rail-to-Rail Analog Signal Handling Capability

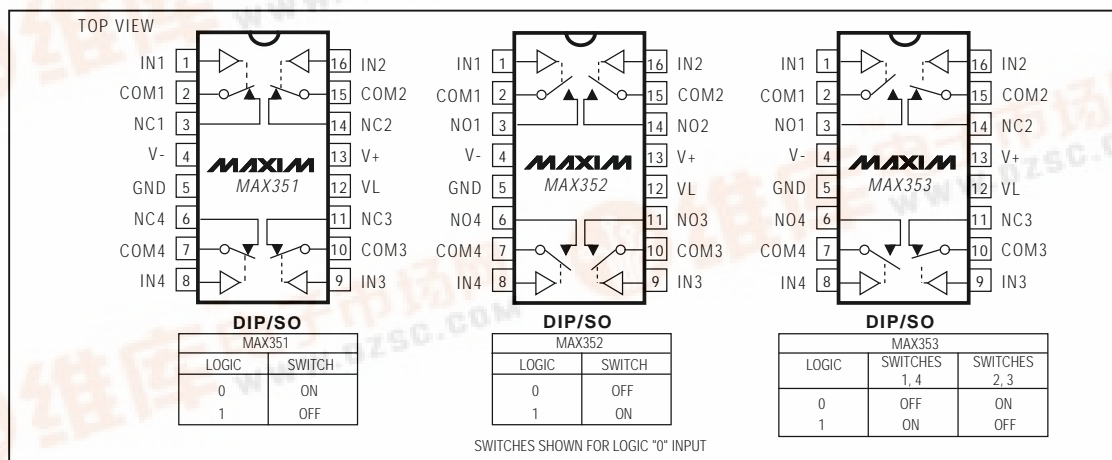
### Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX351CPE	$0^\circ\text{C}$ to $+70^\circ\text{C}$	16 Plastic DIP
MAX351CSE	$0^\circ\text{C}$ to $+70^\circ\text{C}$	16 Narrow SO
MAX351C/D	$0^\circ\text{C}$ to $+70^\circ\text{C}$	Dice*
MAX351EPE	$-40^\circ\text{C}$ to $+85^\circ\text{C}$	16 Plastic DIP
MAX351ESE	$-40^\circ\text{C}$ to $+85^\circ\text{C}$	16 Narrow SO
MAX351EJE	$-40^\circ\text{C}$ to $+85^\circ\text{C}$	16 CERDIP
MAX351MJE	$-55^\circ\text{C}$ to $+125^\circ\text{C}$	16 CERDIP

Ordering Information continued on last page.

\* Contact factory for availability and processing to MIL-STD-883.

### Pin Configurations/Functional Diagrams/Truth Tables



MAXIM

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

MAX351/MAX352/MAX353



## Precision, Quad, SPST Analog Switches

### ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-

V+	44V
GND	25V
VL	(GND - 0.3V) to (V+ + 0.3V)
Digital Inputs, VCOM, VNC, VNO (Note 1)	(V- - 2V) to (V+ + 2V)
	or 30mA (whichever occurs first)
Current (any terminal)	30mA
Peak Current COM <sub>-</sub> , NO <sub>-</sub> , NC <sub>-</sub>	
(pulsed at 1ms, 10% duty cycle max)	100mA
ESD per Method 3015.7	>2000V

Continuous Power Dissipation (T<sub>A</sub> = +70°C) (Note 2)

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:

MAX35_C_	0°C to +70°C
MAX35_E_	-40°C to +85°C
MAX35_MJE	-55°C to +125°C

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

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

**Note 1:** Signals on NC<sub>-</sub>, NO<sub>-</sub>, COM<sub>-</sub>, or IN<sub>-</sub> exceeding V+ or V- will be clamped by internal diodes. Limit forward diode current to maximum current rating.

**Note 2:** All leads are 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—Dual Supplies

(V+ = 15V, V- = -15V, VL = 5V, GND = 0V, V<sub>INH</sub> = 2.4V, V<sub>INL</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 3)	MAX	UNITS
SWITCH								
Analog Signal Range	V <sub>COM-</sub> , V <sub>NO-</sub> , V <sub>NC-</sub>	(Notes 1, 4)			V-		V+	V
On Resistance	R <sub>ON</sub>	I <sub>COM</sub> = -10mA, V <sub>NO-</sub> or V <sub>NC-</sub> = ±8.5V, V+ = 13.5V, V- = -13.5V	T <sub>A</sub> = +25°C	C, E	17	35	Ω	
				M	17	30		
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			45		
On Resistance Match Between Channels (Note 5)	R <sub>ON</sub>	I <sub>COM</sub> = -10mA, V <sub>NO-</sub> or V <sub>NC-</sub> = ±10V, V+ = 15V, V- = -15V	T <sub>A</sub> = +25°C		2		Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		4			
On Resistance Flatness (Note 5)	R <sub>ON</sub>	I <sub>COM</sub> = -10mA, V <sub>NO-</sub> or V <sub>NC-</sub> = ±5V, V+ = 15V, V- = -15V	T <sub>A</sub> = +25°C		3		Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		5			
Off Leakage Current (NO <sub>-</sub> or NC <sub>-</sub> )	I <sub>NO</sub> I <sub>NC</sub>	V <sub>COM</sub> = -15.5V, V <sub>NO-</sub> or V <sub>NC-</sub> = 15.5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C		-0.25	-0.10	0.25	nA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-6	6		
				M	-20	20		
COM <sub>-</sub> Off Leakage Current	I <sub>NC</sub> (OFF)	V <sub>COM</sub> = -15.5V, V <sub>NO-</sub> or V <sub>NC-</sub> = 15.5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C		-0.25	-0.10	0.25	nA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-6	6		
				M	-20	20		
COM <sub>-</sub> On Leakage Current	I <sub>COM</sub> (ON)	V <sub>COM</sub> = ±15.5V, V <sub>NO-</sub> or V <sub>NC-</sub> = ±15.5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C		-0.4	-0.1	0.4	nA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-10	10		
				M	-40	40		

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### ELECTRICAL CHARACTERISTICS—Dual Supplies (continued)

(V+ = 15V, V- = -15V, VL = 5V, GND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 3)	MAX	UNITS
INPUT							
Input Current with Input Voltage High	I <sub>INH</sub>	I <sub>N-</sub> = 2.4V, all others = 0.8V		-0.500	0.005	0.500	μA
Input Current with Input Voltage Low	I <sub>INL</sub>	I <sub>N-</sub> = 0.8V, all others = 2.4V		-0.500	0.005	0.500	μA
SUPPLY							
Power-Supply Range				±4.5		±20.0	V
Positive Supply Current	I <sub>+</sub>	All channels on or off, V <sub>IN</sub> = 0V or 5V, V <sub>+</sub> = 16.5V V <sub>-</sub> = -16.5V	T <sub>A</sub> = +25°C	-1	0.0001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Negative Supply Current	I <sub>-</sub>	All channels on or off, V <sub>IN</sub> = 0V or 5V, V <sub>+</sub> = 16.5V V <sub>-</sub> = -16.5V	T <sub>A</sub> = +25°C	-1	-0.0001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Logic Supply Current	I <sub>L</sub>	All channels on or off, V <sub>IN</sub> = 0V or 5V, V <sub>+</sub> = 16.5V V <sub>-</sub> = -16.5V	T <sub>A</sub> = +25°C	-1	0.0001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
Ground Current	I <sub>GND</sub>	All channels on or off, V <sub>IN</sub> = 0V or 5V, V <sub>+</sub> = 16.5V V <sub>-</sub> = -16.5V	T <sub>A</sub> = +25°C	-1	-0.0001	1	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5		5	
DYNAMIC							
Turn-On Time	t <sub>ON</sub>	Figure 2, V <sub>COM</sub> = ±10V	T <sub>A</sub> = +25°C		110	175	ns
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			220	
Turn-Off Time	t <sub>OFF</sub>	Figure 2, V <sub>COM</sub> = ±10V	T <sub>A</sub> = +25°C		100	145	ns
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			160	
Break-Before-Make Time Delay	t <sub>D</sub>	MAX353 only, Figure 3, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF	T <sub>A</sub> = +25°C		25		ns
Charge Injection	Q	C <sub>L</sub> = 1.0nF, V <sub>GEN</sub> = 0V, R <sub>GEN</sub> = 0Ω, Figure 4	T <sub>A</sub> = +25°C		5	10	pC
Off Isolation (Note 6)	OIRR	R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, f = 1MHz, Figure 5	T <sub>A</sub> = +25°C		68		dB
Crosstalk (Note 7)		R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, f = 1MHz, Figure 6	T <sub>A</sub> = +25°C		85		dB
NC or NO Capacitance	C <sub>(OFF)</sub>	f = 1MHz, Figure 7	T <sub>A</sub> = +25°C		9		pF
COM Off Capacitance	C <sub>(COM)</sub>	f = 1MHz, Figure 7	T <sub>A</sub> = +25°C		9		pF
On Capacitance	C <sub>(COM)</sub>	f = 1MHz, Figure 8	T <sub>A</sub> = +25°C		35		pF

MAX351/MAX352/MAX353

## Precision, Quad, SPST Analog Switches

### ELECTRICAL CHARACTERISTICS—Single Supply

(V+ = 12V, V- = 0V, VL = 5V, GND = 0V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 3)	MAX	UNITS
SWITCH							
Analog Signal Range	V <sub>COM_</sub> , V <sub>NO_</sub> , V <sub>NC</sub>	(Notes 1, 4)		0		V+	V
Channel On Resistance	R <sub>ON</sub>	I <sub>COM</sub> = -10mA, V <sub>NC_</sub> or V <sub>NO_</sub> = 3.8V, V+ = 10.8V	T <sub>A</sub> = +25°C	40	80		Ω
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		100		
SUPPLY							
Positive Supply Current	I+	V+ = 13.2V, all channels on or off, V <sub>IN</sub> = 0V or 5V	T <sub>A</sub> = +25°C	-1	0.0001	1	μA
			T <sub>A</sub> = T <sub>MAX</sub>	-5		5	
Negative Supply Current	I-	V+ = 13.2V, all channels on or off, V <sub>IN</sub> = 0V or 5V	T <sub>A</sub> = +25°C	-1	0.0001	1	μA
			T <sub>A</sub> = T <sub>MAX</sub>	-5		5	
Logic Supply Current	I <sub>L</sub>	V <sub>L</sub> = 5.25V, all channels on or off, V <sub>IN</sub> = 0V or 5V	T <sub>A</sub> = +25°C	-1	0.0001	1	μA
			T <sub>A</sub> = T <sub>MAX</sub>	-5		5	
Ground Current	I <sub>GND</sub>	V <sub>L</sub> = 5.25V, all channels on or off, V <sub>IN</sub> = 0V or 5V	T <sub>A</sub> = +25°C	-1	-0.0001	1	μA
			T <sub>A</sub> = T <sub>MAX</sub>	-5		5	
DYNAMIC							
Turn-On Time	t <sub>ON</sub>	Figure 2, V <sub>NO_</sub> or V <sub>NC_</sub> = 8V	T <sub>A</sub> = +25°C	175	250		ns
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		315		
Turn-Off Time	t <sub>OFF</sub>	Figure 2, V <sub>NO_</sub> or V <sub>NC_</sub> = 8V	T <sub>A</sub> = +25°C	95	125		ns
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		140		
Break-Before-Make Time Delay	t <sub>D</sub>	MAX353 only, Figure 3, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF	T <sub>A</sub> = +25°C	25			ns
Charge Injection	Q	Figure 8, C <sub>L</sub> = 1.0nF, V <sub>GEN</sub> = 0V, R <sub>GEN</sub> = 0V	T <sub>A</sub> = +25°C	5	10		pC

**Note 3:** 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 4:** Guaranteed by design.

**Note 5:**  $\Delta R_{ON} = R_{ON\ max} - R_{ON\ min}$ . On-resistance match between channels and flatness are guaranteed only with bipolar-supply operation.

**Note 6:** See Figure 5. Off Isolation =  $20 \log_{10} [V_{COM} / (V_{NC} \text{ or } V_{NO})]$ , VCOM = output, VNC or VNO = input to off switch.

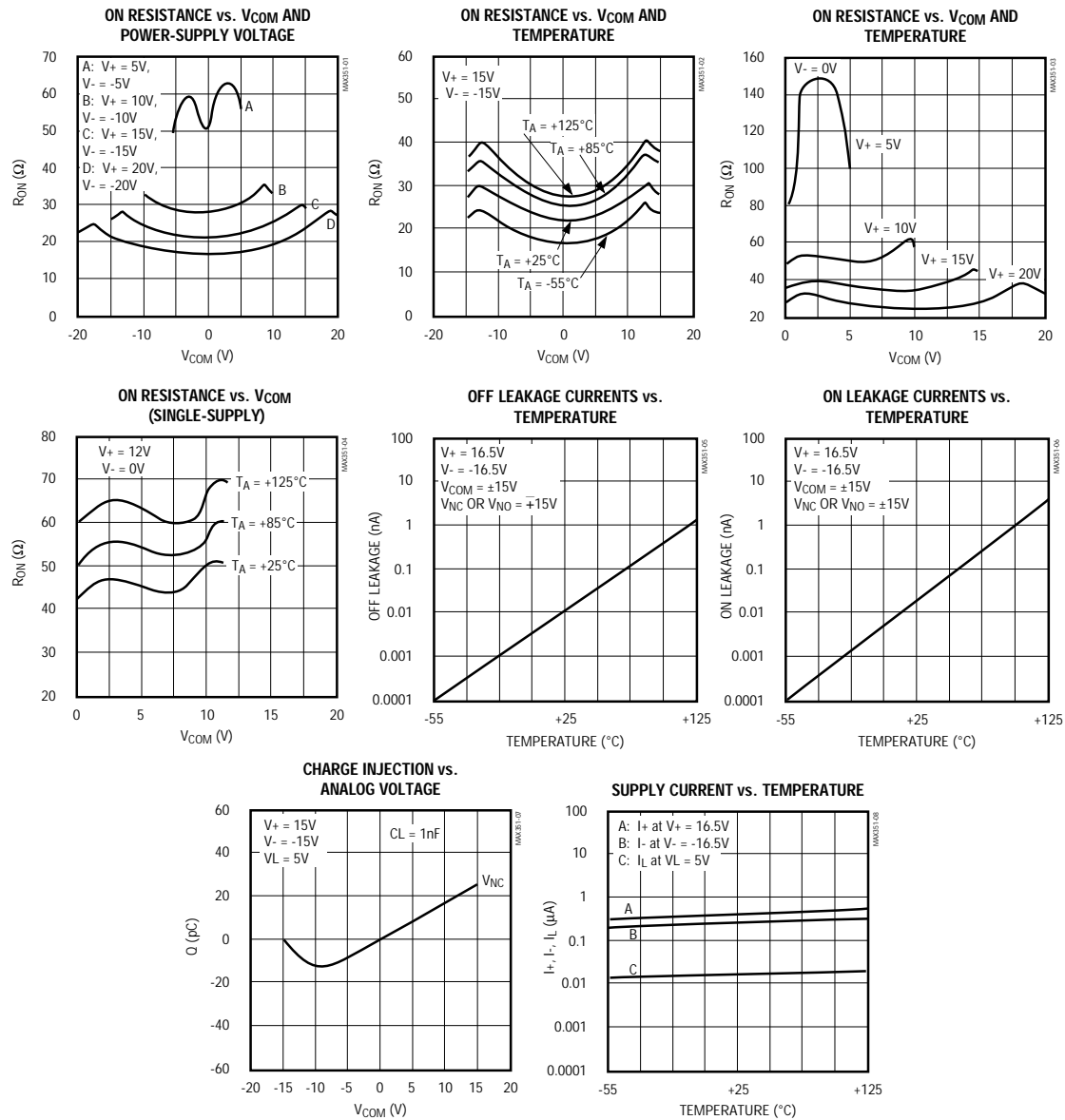
**Note 7:** Between any two switches. See Figure 6.

# Precision, Quad, SPST Analog Switches

## Typical Operating Characteristics

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

MAX3551/MAX3552/MAX3553



## Precision, Quad, SPST Analog Switches

### Pin Description

PIN	NAME	FUNCTION
1, 8, 9, 16	IN1-IN4	Inputs
2, 7, 10, 15	COM1-COM4	Analog Switch Common Terminal
3, 6, 11, 14	NO or NC	Switch Inputs
4	V-	Negative Supply-Voltage Input
5	GND	Ground
12	VL	Logic Supply Voltage
13	V+	Positive Supply-Voltage Input—connected to substrate

### Applications Information

**Operation with Supplies Other than  $\pm 15V$**   
The main limitation of supply voltages other than  $\pm 15V$  is reduced analog-signal range. The MAX351/MAX352/MAX353 operate with  $\pm 5V$  to  $\pm 20V$  bipolar supplies. The *Typical Operating Characteristics* graphs show typical on resistance ( $R_{ON}$ ) for  $\pm 15V$ ,  $\pm 10V$ , and  $\pm 5V$  supplies. (Switching times increase by a factor of two or more for operation at  $\pm 5V$ .) The MAX351/MAX352/MAX353 can operate from  $+10V$  to  $+30V$  unipolar supplies. Each device can also be powered from unbalanced supplies such as  $+24V$  and  $-5V$ . Connect V- to 0V when operating with a single supply. VL must be connected to  $+5V$  to be TTL compatible or to V+ for CMOS-logic input levels.

### 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+ first, followed by VL, V-, and logic inputs. If power-supply sequencing is not possible, add two small signal diodes in series with the supply pins for overvoltage protection (Figure 1). Adding diodes reduces the analog signal range to 1V below V+ and 1V below V-, but low switch resistance and low-leakage characteristics are unaffected. Device operation is unchanged, and the difference between V+ to V- should not exceed  $+44V$ .

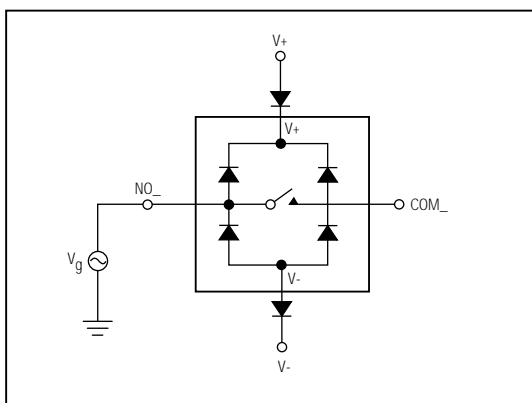


Figure 1. Overvoltage Protection Using External Blocking Diodes

# Precision, Quad, SPST Analog Switches

## Test Circuits/Timing Diagrams

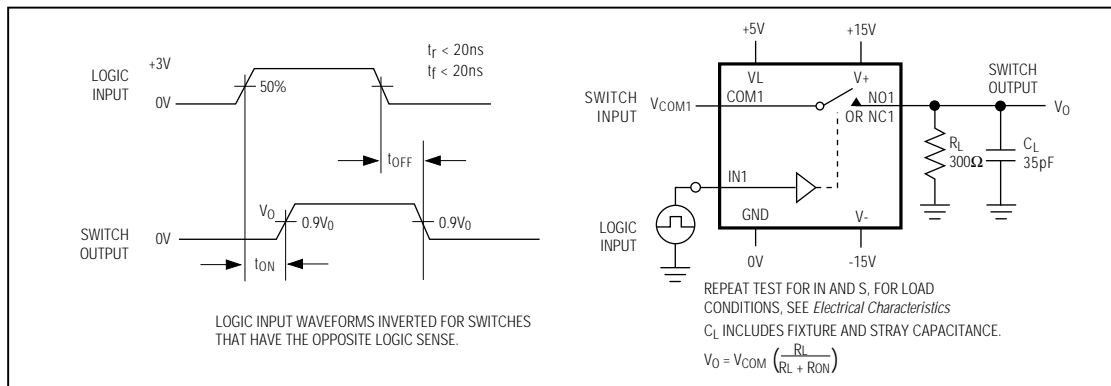


Figure 2. Switching-Time Test Circuit

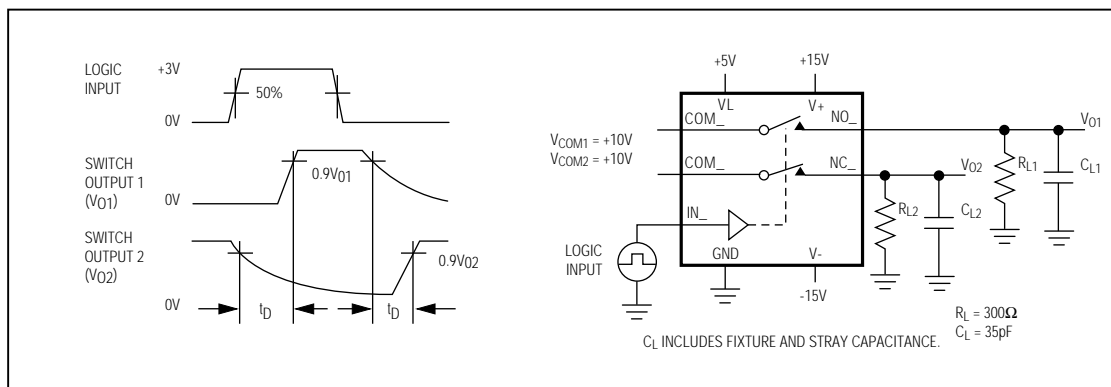


Figure 3. Break-Before-Make Test Circuit (MAX353 only)

MAX3551/MAX3552/MAX3553

# Precision, Quad, SPST Analog Switches

## Test Circuits/Timing Diagrams (continued)

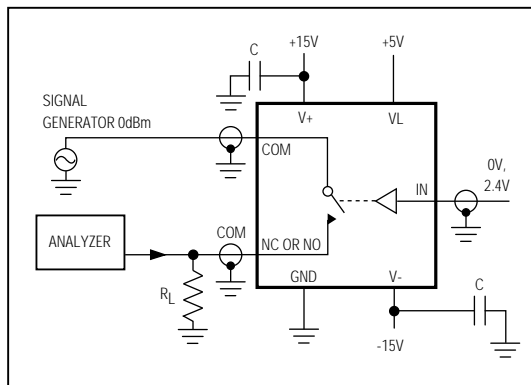
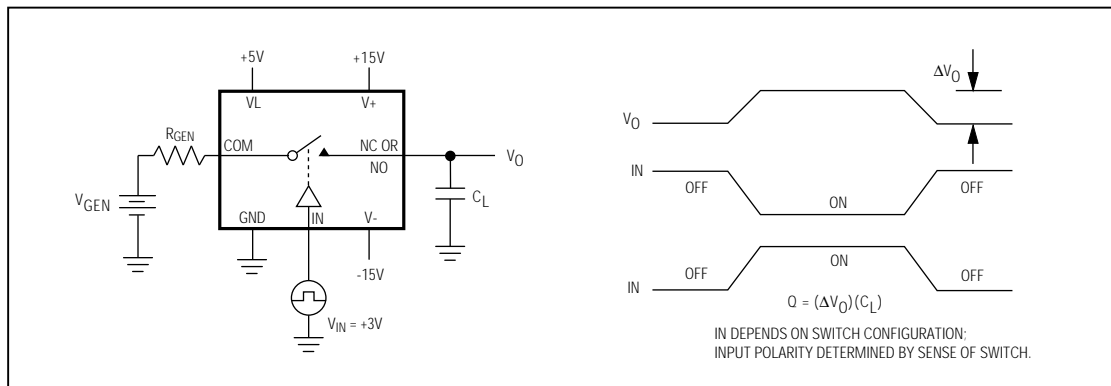


Figure 5. Off-Isolation Test Circuit

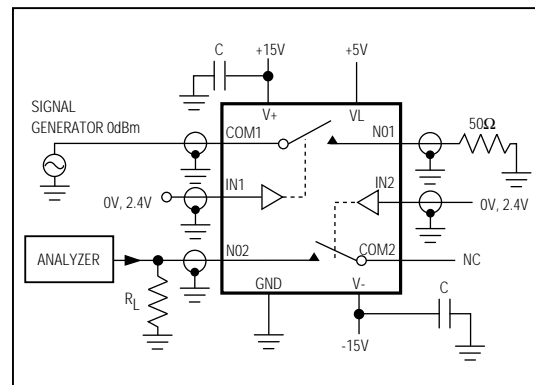


Figure 6. Crosstalk Test Circuit



## Precision, Quad, SPST Analog Switches

### Test Circuits/Timing Diagrams (continued)

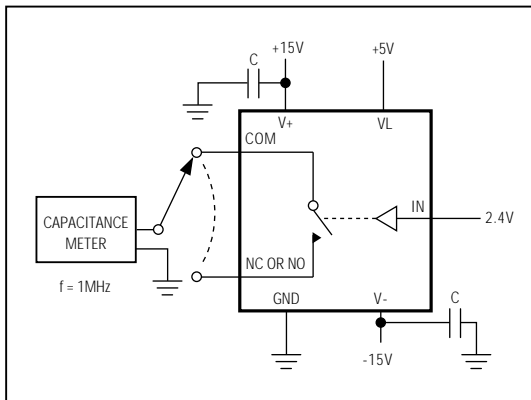


Figure 7. Channel-Off Capacitance

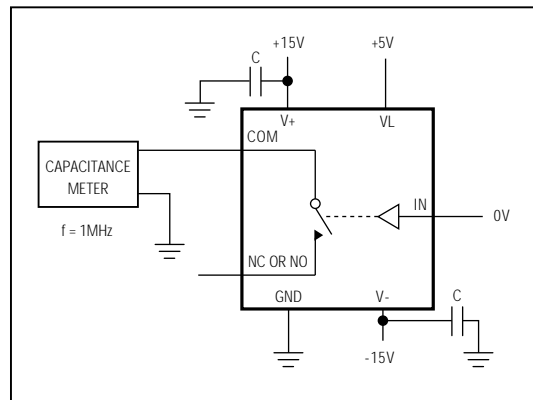


Figure 8. Channel-On Capacitance Test Circuit

MAX351/MAX352/MAX353

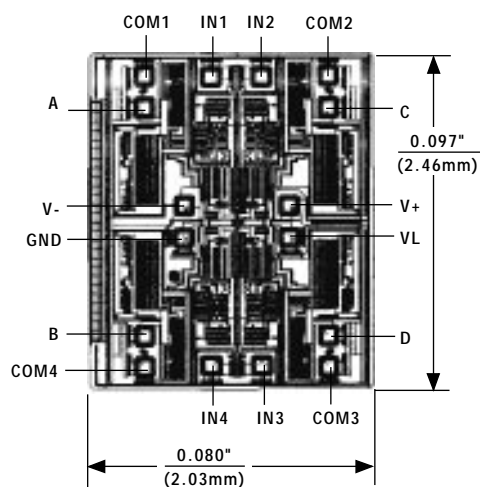
## Precision, Quad, SPST Analog Switches

### Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
<b>MAX352</b> CPE	0°C to +70°C	16 Plastic DIP
MAX352CSE	0°C to +70°C	16 Narrow SO
MAX352C/D	0°C to +70°C	Dice*
MAX352EPE	-40°C to +85°C	16 Plastic DIP
MAX352ESE	-40°C to +85°C	16 Narrow SO
MAX352EJE	-40°C to +85°C	16 CERDIP
MAX352MJE	-55°C to +125°C	16 CERDIP
<b>MAX353</b> CPE	0°C to +70°C	16 Plastic DIP
MAX353CSE	0°C to +70°C	16 Narrow SO
MAX353C/D	0°C to +70°C	Dice*
MAX353EPE	-40°C to +85°C	16 Plastic DIP
MAX353ESE	-40°C to +85°C	16 Narrow SO
MAX353EJE	-40°C to +85°C	16 CERDIP
MAX353MJE	-55°C to +125°C	16 CERDIP

\* Contact factory for dice specifications.

### Chip Topography



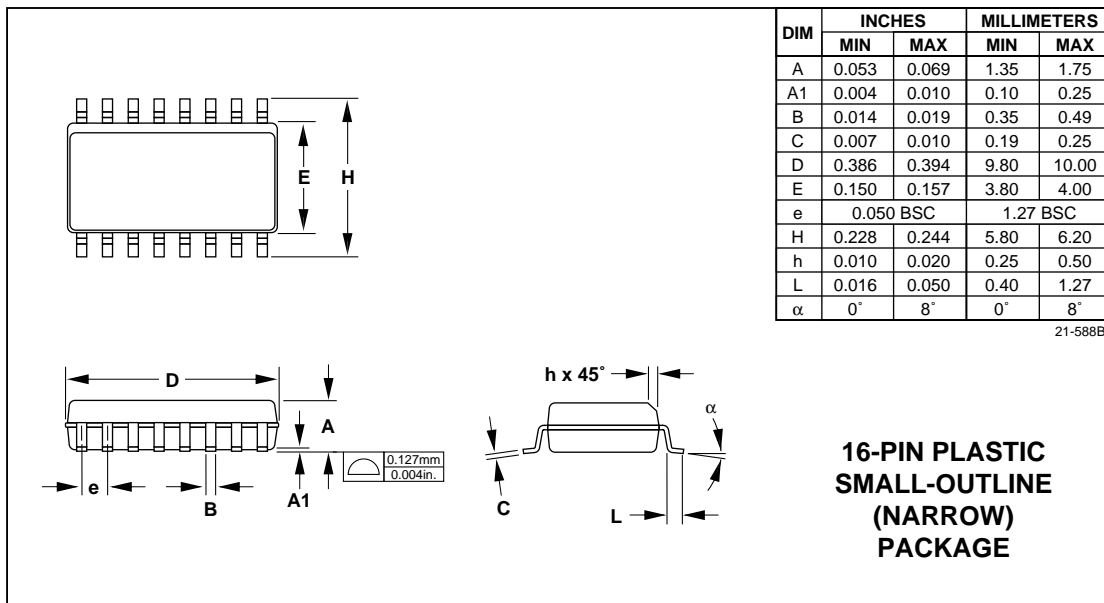
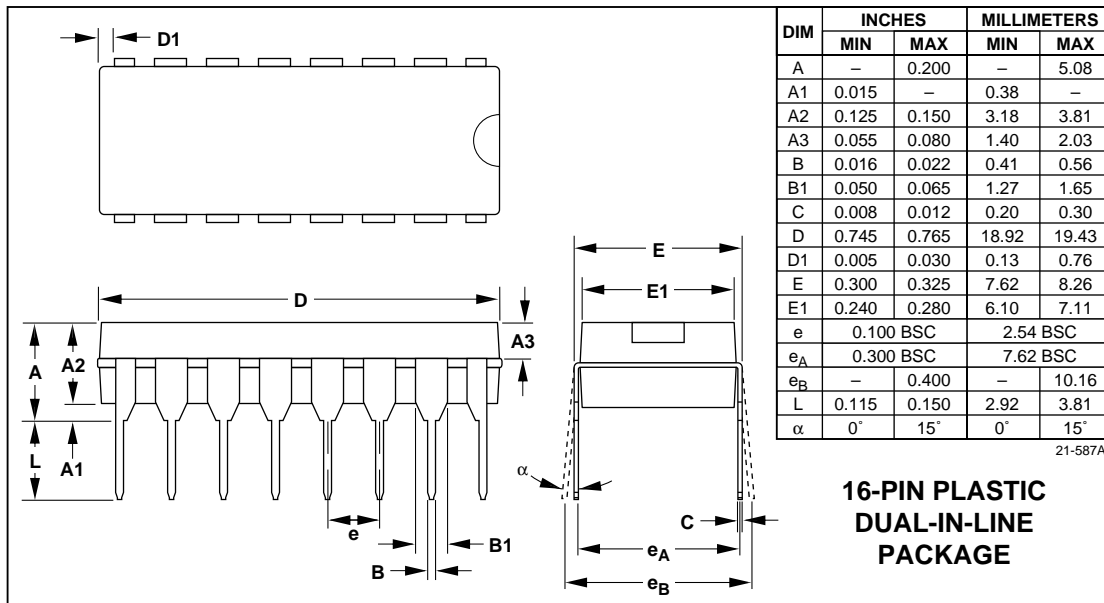
TRANSISTOR COUNT: 136;  
SUBSTRATE CONNECTED TO V+.

MAX351		MAX352		MAX353	
PIN	NAME	PIN	NAME	PIN	NAME
A	NC	A	NO	A	NO
B	NC	B	NO	B	NO
C	NC	C	NO	C	NC
D	NC	D	NO	D	NC

## Precision, Quad, SPST Analog Switches

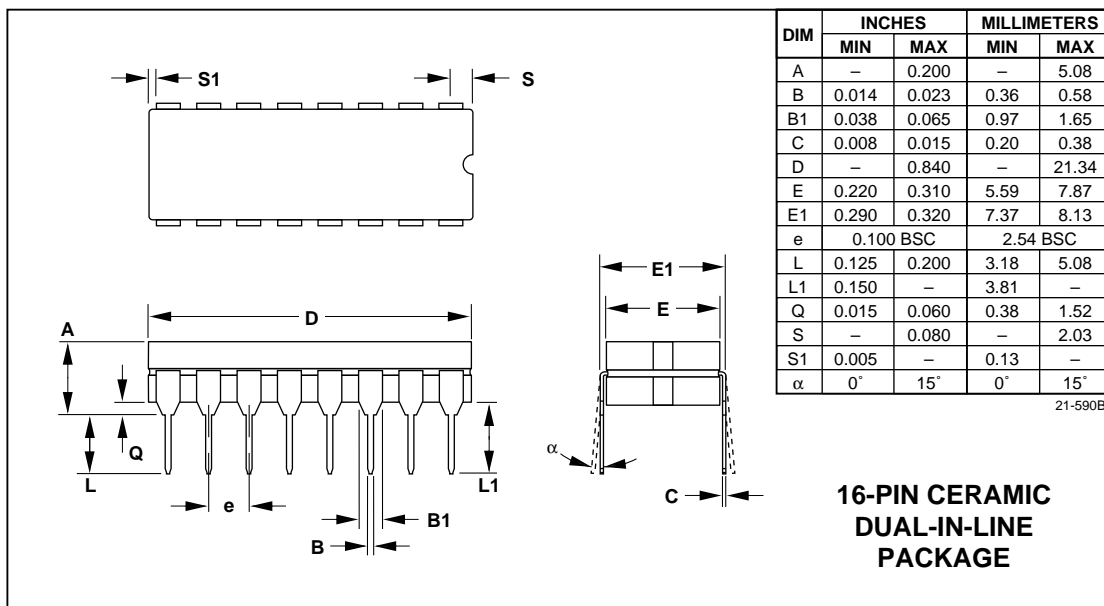
### Package Information

MAX351/MAX352/MAX353



# Precision, Quad, SPST Analog Switches

Package Information (continued)



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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