



# Precision, Dual, High-Speed Analog Switches

MAX301/MAX303/MAX305

## General Description

The MAX301/MAX303/MAX305 are precision, dual, high-speed analog switches. The single-pole single-throw (SPST) MAX301 and double-pole single-throw (DPST) MAX305 dual switches are normally open (NO). The single-pole double-throw (SPDT) MAX303 has two NO and two normally closed (NC) poles. All three parts offer low on resistance (less than 35Ω), guaranteed to match to within 2Ω between channels and to remain flat over the full analog signal range (Δ3Ω max). They also offer low leakage (less than 250pA at +25°C and less than 6nA at +85°C) and fast switching (turn-on time less than 150ns and turn-off time less than 100ns).

The MAX301/MAX303/MAX305 are fabricated with Maxim's new improved silicon-gate process for high system accuracy. Design improvements guarantee extremely low charge injection (15pC) and low power consumption (35μW). A 44V maximum breakdown voltage allows rail-to-rail analog signal capability.

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

## Applications

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

## Features

- ◆ Low On Resistance <22Ω Typical (35Ω Max)
- ◆ Guaranteed Matched On Resistance Between Channels <2Ω
- ◆ Guaranteed Flat On Resistance over Full Analog Signal Range Δ3Ω Max
- ◆ Guaranteed Charge Injection <15pC
- ◆ Guaranteed Off-Channel Leakage <6nA at +85°C
- ◆ Single-Supply Operation (+10V to +30V)  
 Bipolar-Supply Operation (±4.5V to ±20V)
- ◆ TTL-/CMOS-Logic Compatible
- ◆ Rail-to-Rail Analog Signal Handling Capability

## Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX301CPE	0°C to +70°C	16 Plastic DIP
MAX301CSE	0°C to +70°C	16 Narrow SO
MAX301CJE	0°C to +70°C	16 CERDIP
MAX301C/D	0°C to +70°C	Dice*
MAX301EPE	-40°C to +85°C	16 Plastic DIP
MAX301ESE	-40°C to +85°C	16 Narrow SO
MAX301EJE	-40°C to +85°C	16 CERDIP
MAX301MJE	-55°C to +125°C	16 CERDIP
MAX301MLP	-55°C to +125°C	20 LCC**

Ordering Information continued on last page.

\* Contact factory for dice specifications.

\*\* Contact factory for package availability.

## Pin Configurations/Block Diagrams/Truth Tables

TOP VIEW

**DIP/SO**

MAX301	
LOGIC	SWITCH
0	OFF
1	ON

*LCC packages on last page.*

**DIP/SO**

MAX303		
LOGIC	SWITCHES 1, 2	SWITCHES 3, 4
0	OFF	ON
1	ON	OFF

SWITCHES SHOWN FOR LOGIC "0" INPUT

**DIP/SO**

MAX305	
LOGIC	SWITCH
0	OFF
1	ON



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## ABSOLUTE MAXIMUM RATINGS

Voltage Referenced to V-

V+ .....	.44V
GND .....	.25V
V <sub>L</sub> .....	(GND-0.3V) to (V+) +0.3V
NO <sub>-</sub> , NC <sub>-</sub> , IN <sub>-</sub> , COM <sub>-</sub> .....	(V- - 2V) to (V+ + 2V) or 30mA, .....whichever occurs first
Continuous Current, COM <sub>-</sub> , NO <sub>-</sub> , NC <sub>-</sub> .....	30mA
Peak Current, COM <sub>-</sub> , NO <sub>-</sub> , NC <sub>-</sub> (pulsed at 1ms, 10% duty cycle max) .....	100mA

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

16-Pin Plastic DIP (derate 10.53mW/°C above +70°C) .....	842mW
16-Pin Narrow SO (derate 8.70mW/°C above +70°C) .....	696mW
16-Pin CERDIP (derate 10.00mW/°C above +70°C) .....	800mW
20-Pin LCC (derate 9.09mW/°C above +70°C) .....	727mW

Operating Temperature Ranges:

MAX30_C_ .....	0°C to +70°C
MAX30_E_ .....	-40°C to +85°C
MAX30_M_ .....	-55°C to +125°C

Storage Temperature Range .....

Lead Temperature (soldering, 10sec) .....	+300°C
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**Note 1:** Signals on NO<sub>-</sub>, NC<sub>-</sub>, or COM<sub>-</sub> beyond V+ or V- are clamped by internal diodes. Limit forward current to maximum current rating. 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, V<sub>L</sub> = +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	TEMP. RANGE	MIN	TYP (Note 2)	MAX	UNITS	
<b>SWITCH</b>								
Analog-Signal Range	V <sub>ANA</sub>	(Note 3)		V-		V+	V	
On Resistance	R <sub>ON</sub>	I <sub>(NC or NO)</sub> = -10mA, V <sub>COM-</sub> = ±10V V <sub>INH</sub> = 2.4V, V <sub>INL</sub> = 0.8V	T <sub>A</sub> = +25°C	C, E	20	35	Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	M	20	30		
				C, E				55
			M			45		
On Resistance Match Between Channels (Note 4)	R <sub>ON</sub>	I <sub>(NC or NO)</sub> = -10mA, V <sub>COM-</sub> = ±10V V+ = 15V, V- = -15V	T <sub>A</sub> = +25°C	C, E, M	0.5	2	Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E, M				3
On Resistance Flatness (Note 4)	R <sub>ON</sub>	I <sub>S</sub> = -10mA V <sub>COM-</sub> = ±5V V+ = 15V, V- = -15V	T <sub>A</sub> = +25°C	C, E, M		3	Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E, M				5
NC or NO Off Leakage Current	NC <sub>-(OFF)</sub> or NO <sub>-(OFF)</sub>	V <sub>COM-</sub> = ±15.5V, V <sub>NC-</sub> or V <sub>NO-</sub> = ±15.5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C	C, E	-0.50	-0.01	0.50	nA
				M	-0.25	-0.01	0.25	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-6		6	
				M	-20		20	
COM Off Leakage Current	COM <sub>OFF</sub>	V <sub>COM-</sub> = ±15.5V, V <sub>NC-</sub> or V <sub>NO-</sub> = ±15.5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C	C, E	-0.50	-0.01	0.50	nA
				M	-0.25	-0.01	0.25	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-6		6	
				M	-20		20	
COM On Leakage Current	COM <sub>ON</sub>	V <sub>COM-</sub> = ±15.5V, V <sub>NC-</sub> or V <sub>NO-</sub> = ±15.5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C	C, E	-1.0	-0.04	1.0	nA
				M	-0.4	-0.04	0.4	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	C, E	-20		20	
				M	-40.0		40.0	

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## ELECTRICAL CHARACTERISTICS (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 2)	MAX	UNITS	
<b>INPUT</b>							
Input Current with Input Voltage High	I <sub>INH</sub>	V <sub>INL</sub> = 2.4V, all others = 0.8V	-1.000	0.005	1.000	μA	
Input Current with Input Voltage Low	I <sub>INH</sub>	V <sub>INL</sub> = 0.8V, all others = 2.4V	-1.000	0.005	1.000	μA	
<b>SUPPLY</b>							
Power-Supply Range			±4.5		±20	V	
Positive Supply Current	I+	All channels on or off, V <sub>IN</sub> = 0V or 5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C	-1.00	0.01	1.00	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5.00		5.00	
Negative Supply Current	I-	All channels on or off, V <sub>IN</sub> = 0V or 5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C	-1.00	-0.01	1.00	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5.00		5.00	
Logic Supply Current	I <sub>L</sub>	All channels on or off, V <sub>IN</sub> = 0V or 5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C	-1.00	0.01	1.00	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5.00		5.00	
Ground Current	I <sub>GND</sub>	All channels on or off, V <sub>IN</sub> = 0V or 5V, V+ = 16.5V, V- = -16.5V	T <sub>A</sub> = +25°C	-1.00	-0.01	1.00	μA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	-5.00		5.00	
<b>DYNAMIC</b>							
Turn-On Time	t <sub>ON</sub>	Figure 1			100 150	ns	
Turn-Off Time	t <sub>OFF</sub>	Figure 1			60 100	ns	
Break-Before-Make Time Delay (Note 3)	t <sub>D</sub>	MAX303 only, Figure 2			10 20	ns	
Charge Injection (Note 3)	Q	C <sub>L</sub> = 10nF, V <sub>GEN</sub> = 0V, R <sub>GEN</sub> = 0Ω, Figure 3			10 15	pC	
Off Isolation (Note 5)	OIRR	R <sub>L</sub> = 100Ω, C <sub>L</sub> = 5pF, f = 1MHz, Figure 4			72	dB	
Crosstalk (Note 6)		R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, f = 1MHz, Figure 5			90	dB	
Off Capacitance	C <sub>OFF</sub>	f = 1MHz, Figure 6			12	pF	
COM Off Capacitance	C <sub>COM(OFF)</sub>	f = 1MHz, Figure 6			12	pF	
Channel-On Capacitance	C <sub>COM(ON)</sub>	f = 1MHz, Figure 7			39	pF	

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

**Note 3:** Guaranteed by design.

**Note 4:**  $\Delta R_{ON} = \Delta R_{ONMAX} - \Delta R_{ONMIN}$ . On resistance match between channels and flatness are guaranteed only with specified voltages.

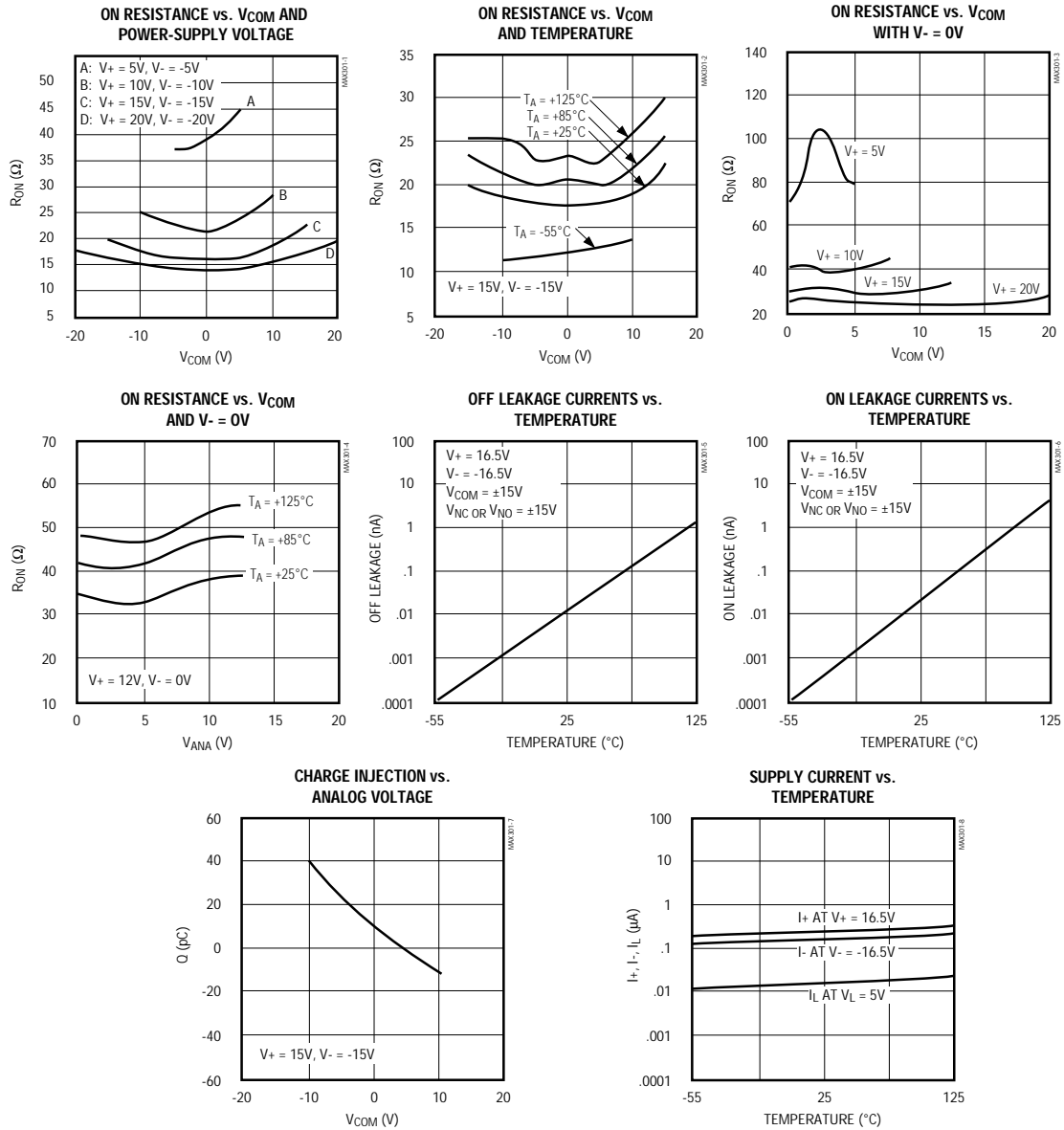
**Note 5:** See Figure 4. Off isolation =  $20 \log_{10} V_{COM}/V_{NC}$  or  $V_{NO}$ . V<sub>COM</sub> = output, V<sub>NC</sub> or V<sub>NO</sub> = input to off switch.

**Note 6:** Between any two switches. See Figure 5.

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## Typical Operating Characteristics

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



# Precision, Dual, High-Speed Analog Switches

MAX301/MAX303/MAX305

## Pin Descriptions

MAX301 PIN		NAME	FUNCTION
DIP/SO	LCC		
1, 8	2, 10	COM1, COM2	Drain (Analog Signal)
2-7	1, 3-9, 11, 16	N.C.	Not internally connected
9, 16	5, 7, 12, 20	NC1, NC2	Source (Analog Signal)
10, 15	13, 19	IN2, IN1	Digital Logic Inputs
11	14	V+	Positive Supply-Voltage Input—connected to substrate
12	15	V <sub>L</sub>	Logic Supply-Voltage Input
13	17	GND	Ground
14	18	V-	Negative Supply Voltage Input
MAX303 PIN		NAME	FUNCTION
DIP/SO	LCC		
1, 8, 3, 6	2, 4, 8, 10	COM <sub>-</sub>	Drain (Analog Signal)
2-7	1, 3, 6, 9, 11, 16	N.C.	Not internally connected
11	14	V+	Positive Supply-Voltage Input—connected to substrate
12	15	V <sub>L</sub>	Logic Supply-Voltage Input
13	17	GND	Ground
14	18	V-	Negative Supply Voltage Input
15, 10	19, 13	IN1, IN2	Digital Logic Inputs
16, 9, 5, 4	5, 7, 12, 20	NC <sub>-</sub> , NO <sub>-</sub>	Source (Analog Signal)
MAX305 PIN		NAME	FUNCTION
DIP/SO	LCC		
1, 8, 3, 6	2, 4, 8, 10	COM <sub>-</sub>	Drain (Analog Signal)
2-7	1, 3, 6, 9, 11, 16	N.C.	Not internally connected
11	14	V+	Positive Supply-Voltage Input—connected to substrate
12	15	V <sub>L</sub>	Logic Supply-Voltage Input
13	17	GND	Ground
14	18	V-	Negative Supply Voltage Input
15, 10	19, 13	IN1, IN2	Digital Logic Inputs
16, 9, 5, 4	5, 7, 12, 20	NO <sub>-</sub>	Source (Analog Signal)

## Applications Information

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

The MAX301/MAX303/MAX305 switches operate with ±4.5V to ±20V bipolar supplies and a +10V to +30V single supply. In either case, analog signals ranging from V<sub>+</sub> to V<sub>-</sub> can be switched. The *Typical Operating Characteristics* graphs show the typical on-resistance variation with analog signal and supply voltage. The usual on-resistance temperature coefficient is 0.5%/°C (typ).

### Logic Inputs

The MAX301/MAX303/MAX305 operate with a single positive supply or with bipolar supplies. The devices maintain TTL compatibility with supplies anywhere in the ±4.5V to ±20V range as long as V<sub>L</sub> = +5V. If V<sub>L</sub> is connected to V<sub>+</sub> or another supply at voltages other than +5V, the devices will operate at CMOS-logic level inputs.

### Overvoltage Protection

Proper power-supply sequencing is recommended for all CMOS devices. It is important not to exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the devices. Always sequence V<sub>+</sub> on first, followed by V<sub>L</sub>, V<sub>-</sub>, 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<sub>+</sub> and 1V below V<sub>-</sub>, but low switch resistance and low leakage characteristics are unaffected. Device operation is unchanged, and the difference between V<sub>+</sub> to V<sub>-</sub> should not exceed +44V.

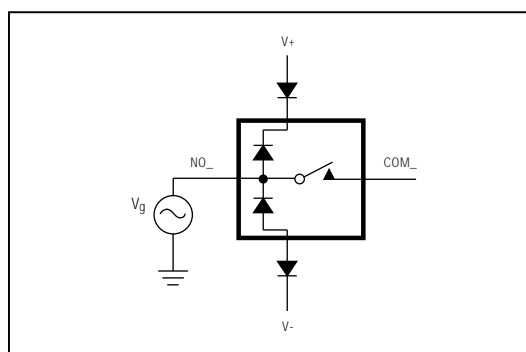


Figure 1. Overvoltage Protection Using Blocking Diodes

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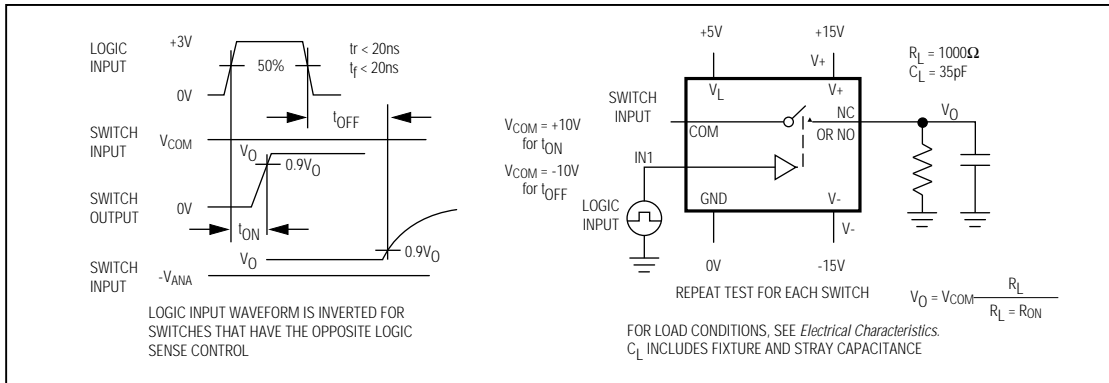


Figure 2. Switching-Time Test Circuit

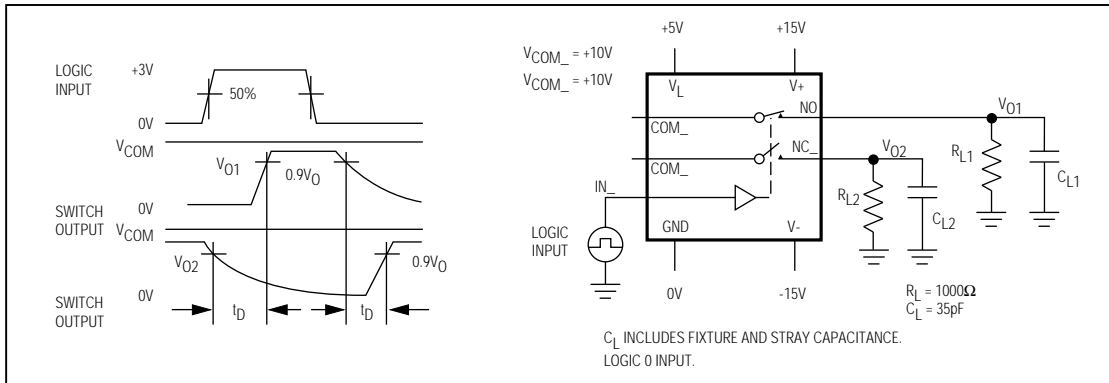


Figure 3. Break-Before-Make Test Circuit

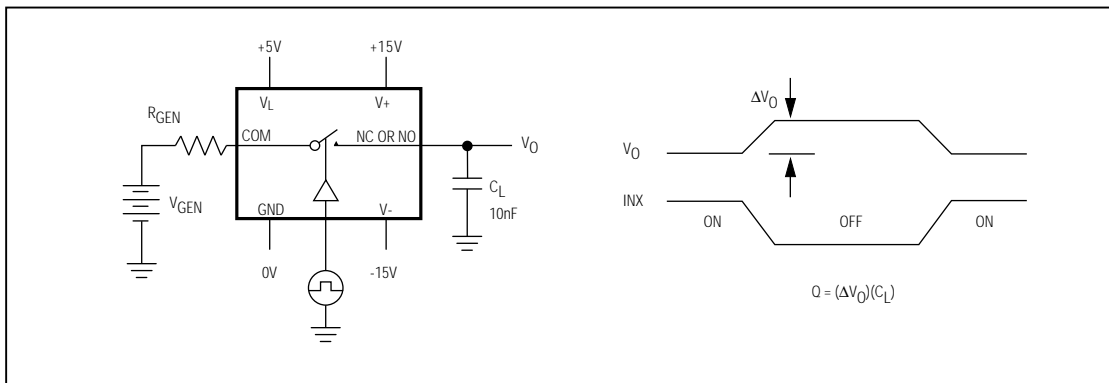


Figure 4. Charge-Injection Test Circuit

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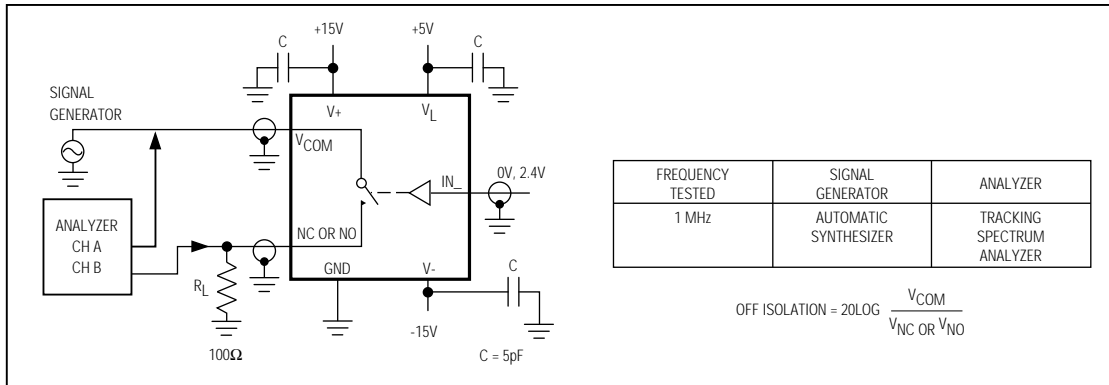


Figure 5. Off Isolation

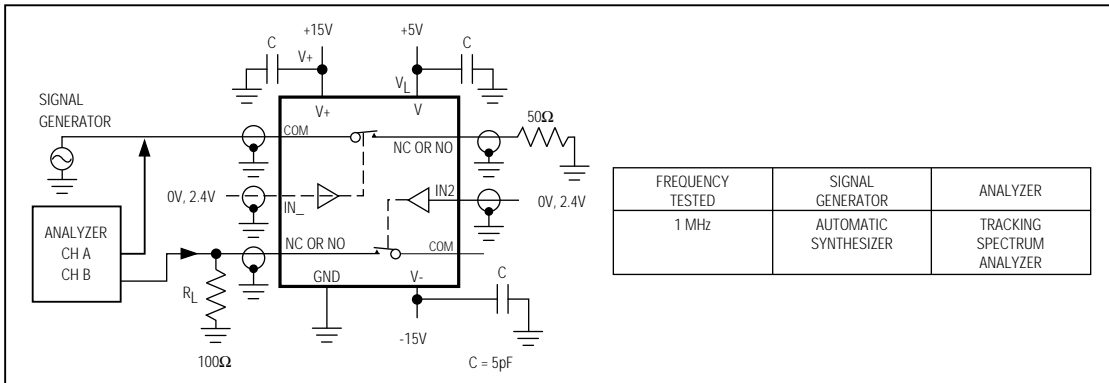


Figure 6. Crosstalk Test Circuit

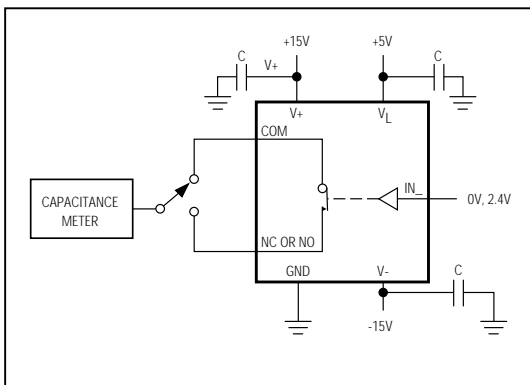


Figure 7. Channel-Off Capacitance

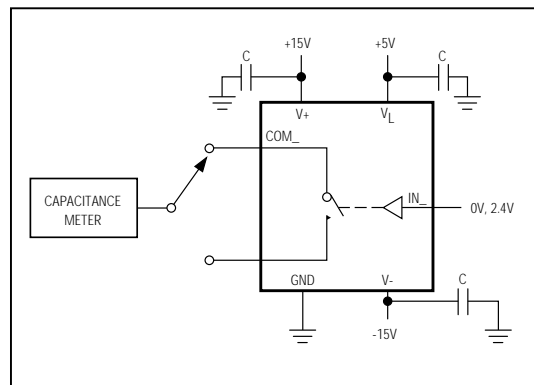


Figure 8. Channel-On Capacitance

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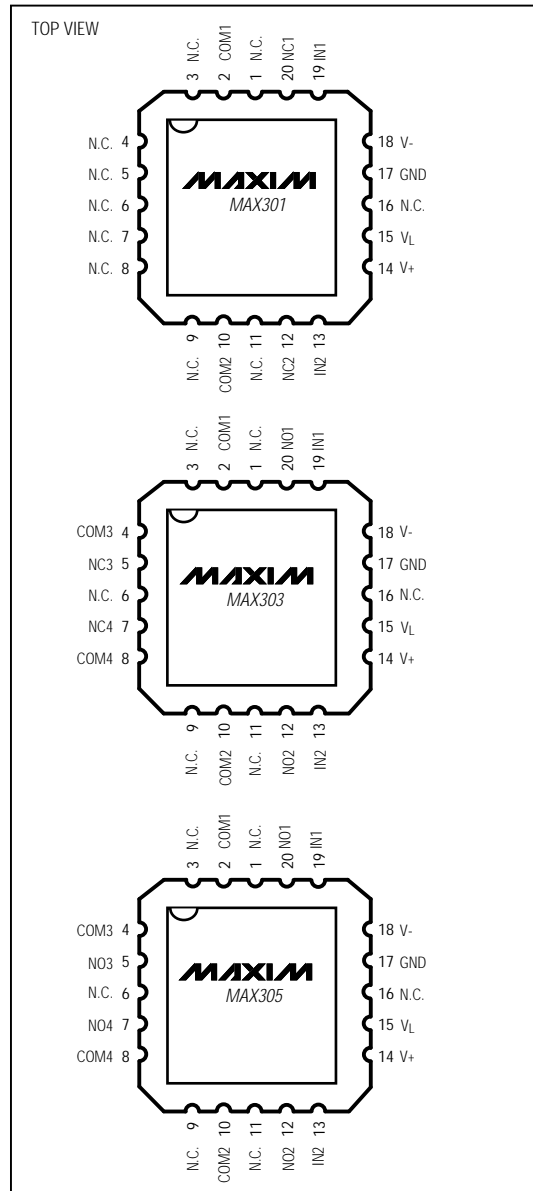
## Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
<b>MAX303</b> CPE	0°C to +70°C	16 Plastic DIP
MAX303CSE	0°C to +70°C	16 Narrow SO
MAX303CJE	0°C to +70°C	16 CERDIP
MAX303C/D	0°C to +70°C	Dice*
MAX303EPE	-40°C to +85°C	16 Plastic DIP
MAX303ESE	-40°C to +85°C	16 Narrow SO
MAX303EJE	-40°C to +85°C	16 CERDIP
MAX303MJE	-55°C to +125°C	16 CERDIP
MAX303MLP	-55°C to +125°C	20 LCC**
<b>MAX305</b> CPE	0°C to +70°C	16 Plastic DIP
MAX305CSE	0°C to +70°C	16 Narrow SO
MAX305CJE	0°C to +70°C	16 CERDIP
MAX305C/D	0°C to +70°C	Dice*
MAX305EPE	-40°C to +85°C	16 Plastic DIP
MAX305ESE	-40°C to +85°C	16 Narrow SO
MAX305EJE	-40°C to +85°C	16 CERDIP
MAX305MJE	-55°C to +125°C	16 CERDIP
MAX305MLP	-55°C to +125°C	20 LCC**

\* Dice are tested at  $T_A = +25^\circ\text{C}$  only.

\*\* Contact factory for availability.

## Pin Configuration (continued)



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