



Precision, Quad, SPDT, CMOS Analog Switch

General Description

The MAX333A is a precision, quad, single-pole double-throw (SPDT) analog switch. The four independent switches operate with bipolar supplies ranging from $\pm 4.5\text{V}$ to $\pm 20\text{V}$, or with a single-ended supply between $+10\text{V}$ and $+30\text{V}$. The MAX333A offers low on resistance (less than 35Ω), guaranteed to match within 2Ω between channels and to remain flat over the analog signal range ($\Delta 3\Omega$ max). It also offers break-before-make switching (10ns typical), with turn-off times less than 145ns and turn-on times less than 175ns. The MAX333A is ideal for portable operation since quiescent current runs less than $50\mu\text{A}$ with all inputs high or low.

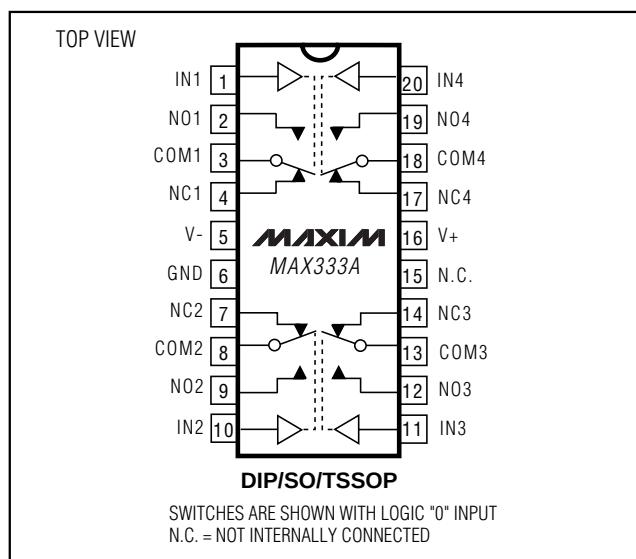
This monolithic, quad switch is fabricated with Maxim's new improved silicon-gate process. Design improvements guarantee extremely low charge injection (10pC), low power consumption (3.75mW), and electrostatic discharge (ESD) greater than 2000V.

Logic inputs are TTL and CMOS compatible and guaranteed over a $+0.8\text{V}$ to $+2.4\text{V}$ range—regardless of supply voltage. Logic inputs and switched analog signals can range anywhere between the supply voltages without damage.

Applications

Test Equipment
Communications Systems
PBX, PABX
Heads-Up Displays
Portable Instruments

Pin Configuration



Features

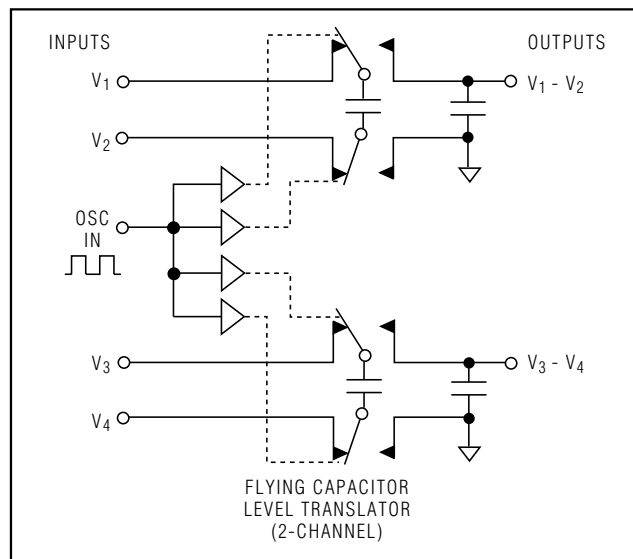
- ◆ Upgraded Replacement for a DG211/DG212 Pair or Two DG403s
- ◆ Low On Resistance $< 17\Omega$ Typical (35Ω Max)
- ◆ Guaranteed Matched On Resistance Between Channels $< 2\Omega$
- ◆ Guaranteed Flat On Resistance over Analog Signal Range $\Delta 3\Omega$ Max
- ◆ Guaranteed Charge Injection $< 10\text{pC}$
- ◆ 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
MAX333ACPP	0°C to $+70^\circ\text{C}$	20 Plastic DIP
MAX333ACWP	0°C to $+70^\circ\text{C}$	20 Wide SO
MAX333ACUP	0°C to $+70^\circ\text{C}$	20 TSSOP
MAX333AC/D	0°C to $+70^\circ\text{C}$	Dice*
MAX333AEPP	-40°C to $+85^\circ\text{C}$	20 Plastic DIP
MAX333AEWP	-40°C to $+85^\circ\text{C}$	20 Wide SO
MAX333AEUP	-40°C to $+85^\circ\text{C}$	20 TSSOP
MAX333AMJP	-55°C to $+125^\circ\text{C}$	20 CERDIP

* Contact factory for dice specifications.

Typical Operating Circuit



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ABSOLUTE MAXIMUM RATINGS

V+ to V-	44V
VIN, VCOM, VNO, VNC	V- to V+
(VNO - VNC)	32V
V+ to Ground	30V
V- to Ground	30V
Current, Any Terminal Except VCOM, VNO, or VNC	30mA
Continuous Current, VCOM, VNO, or VNC	20mA
Peak Current, VCOM, VNO, or VNC (Pulsed at 1ms, 10% duty cycle max)	70mA
ESD	2000V

Continuous Power Dissipation (TA = +70°C) (Note 1)

Plastic DIP (derate above +70°C by 11.11mW/°C)889mW

SO (derate above +70°C by 10.00mW/°C)800mW

CERDIP (derate above +70°C by 11.11mW/°C)889mW

TSSOP (derate above +70°C by 7mW/°C)559mW

Operating Temperature Ranges:

MAX333AC

MAX333AE

MAX333AMJP

Storage Temperature Range

Lead Temperature (soldering, 10sec)

Note 1: Device mounted with all leads soldered 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

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

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Notes 2, 3)	MAX	UNITS	
POWER REQUIREMENTS								
Positive Supply Current	I+	VIN = 0V/5V,V+ = 16.5V, V- = -16.5V			0.05	0.25	mA	
Supply Voltage Range	V+/V-	Dual supply, V+ = V-			±4.5V	±20	V	
	V+	Single supply, V- = GND			10	30		
Negative Supply Current	I-	VIN = 0V/5V,V+ = 16.5V, V- = -16.5V			0.01	1	µA	
LOGIC INPUT								
Input Voltage Low	VIL				V-	0.8	V	
Input Voltage High	VIH				2.4	V+	V	
Input Current	IIN	VIN = V-, V+			-1.0	0.0001	1.0	µA
SWITCH								
Analog Signal Range	VCOM, VNO, VNC				V-	V+	V	
On Circuit Resistance	RON	VCOM = +10V, I(NC or NO) = 1mA; VCOM = -10V, I(NC or NO) = 1mA		M	20	35	Ω	
				C, E		45		
On Resistance Match Between Channels (Note 4)	RON	I(NC or NO) = -10mA, VD = 10V or -10V, V+ =15V, V- = -15V		TA = +25°C		2	Ω	
				TA = TMIN to TMAX		4		
On Resistance Flatness (Note 4)	RON	I(NC or NO) = -10mA, VD = 5V or -5V, V+ =15V, V- = -15V		TA = +25°C		3	Ω	
				TA = TMIN to TMAX		5		
On Circuit Leakage Current	ICOM	VCOM = ±15.5V, VNC or VNO = ±15.5V, V+ = 16.5V, V- = -16.5V		M	-0.75	0.75	nA	
				C, E	-1.00	0.20		1.00
Off Circuit Leakage Current	INC or INO	VCOM = ±15.5V VNC or VNO = ±15.5V, V+ = 16.5V, V- = -16.5V		M	-0.25	0.01	nA	
				C, E	-0.50	0.02		0.05
DYNAMIC								
Turn-Off Time	tOFF	Figure 1				145	ns	
Turn-On Time	ton					175	ns	
Break-Before-Make Time	tOPEN				10		ns	
Off Capacitance	COFF				5		pF	
On Capacitance	CON				5		pF	
Charge Injection	Q	CL = 10nF, VGEN = 0V, RGEN = 0Ω, Figure 6		TA = +25°C		2	10	pC
Off Isolation	OIRR	f = 1MHz, RL = 75Ω, VCOM = 2.3VRMS			72		dB	
Crosstalk	CCRR				78		dB	

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ELECTRICAL CHARACTERISTICS—DUAL SUPPLIES (continued)

(GND = 0V, V+ = +15V, V- = -15V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP (Notes 2, 3)	MAX	UNITS
LOGIC INPUT						
Input Voltage Low	V _{IL}		V-		0.8	V
Input Voltage High	V _{IH}		2.4		V+	V
Input Current	I _{IN}	V _{IN} = V-, V+	-1.0	0.0001	1.0	μA
SWITCH						
Analog Signal Range	V _{COM}		V-		V+	V
On Circuit Resistance	R _{ON}	V _{COM} = 10V, I _(NC or NO) = 1mA; V _{COM} = -10V, I _(NC or NO) = 1mA	C, E		45	Ω
			M		45	
On Circuit Leakage Current	I _{COM}	V _{COM} = ±15V, V _{NC} or V _{NO} = -15V, V+ = 16.5V, V- = -16.5V	C, E		10	nA
			M		60	
On Circuit Leakage Current	I _{NC} or I _{NO}	V _{COM} = ±15V, V _{NC} or V _{NO} = -15V, V+ = 16.5V, V- = -16.5V	C, E		6	nA
			M			

ELECTRICAL CHARACTERISTICS—Single Supply

(GND = 0V, V+ = +12V, V- = 0V, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP (Notes 2, 3)	MAX	UNITS
SUPPLY						
Supply Voltage Range	V+	Single supply, V- = GND	10		30	V
Positive Supply Current	I+				0.25	mA
INPUT						
Input Voltage Low	V _{INLO}		0		0.8	V
Input Voltage High	V _{INHI}		2.4		V+	V
Input Current	I _{IN}	V _{IN} = V+, 0V			1	μA
SWITCH						
Analog Signal Range	V _{COM} , V _{NO} , V _{NC}		V-		V+	V
On Circuit Resistance	r _{ON}	V _{COM} = 10V, I _(NC or NO) = 1mA, V _{COM} = 1V, I _(NC or NO) = 1mA		35	75	Ω
On Circuit Leakage Current	I _{COM}	V _{COM} = 11V, V _{NC} or V _{NO} = 0V V _{COM} = 1V, V _{NC} or V _{NO} = V+			0.75	nA
Off Circuit Leakage Current	I _{NC} or I _{NO}	V _{COM} = 11V V _{NC} or V _{NO} = 1V			0.25	nA
DYNAMIC						
Turn-Off Time	t _{OFF}	Figure 1		45		ns
Turn-On Time	t _{ON}			90		ns
Break-Before-Make Time	t _{OPEN}		5	10		ns
Off Isolation	OIRR	f = 1MHz, R _L = 75Ω, V _{COM} = 2.3V _{RMS}		70		dB
Crosstalk	CCRR			72		dB

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

Note 3: Typical values are for design aid only, not guaranteed or subject to production testing.

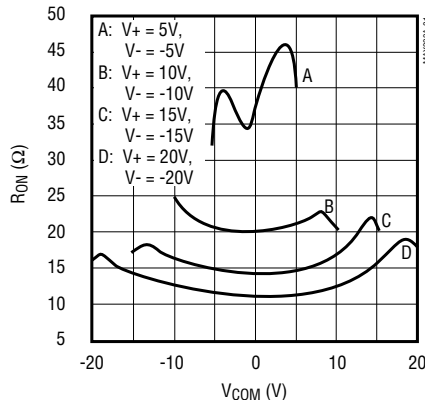
Note 4: On resistance match between channels and flatness are guaranteed only with bipolar-supply operation.

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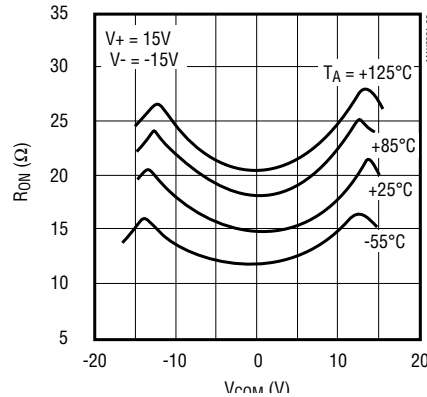
Typical Operating Characteristics

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

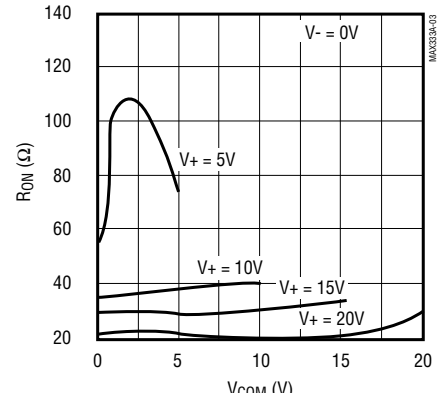
**ON RESISTANCE
vs. V_{COM} AND POWER SUPPLY VOLTAGE**



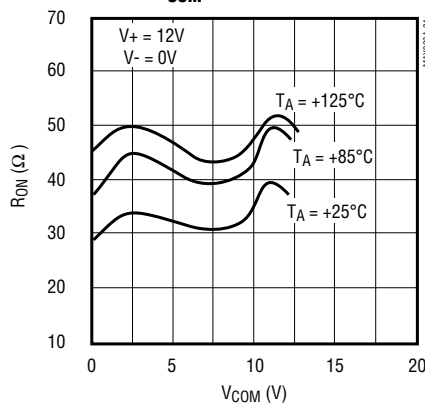
**ON RESISTANCE
vs. V_{COM} AND TEMPERATURE**



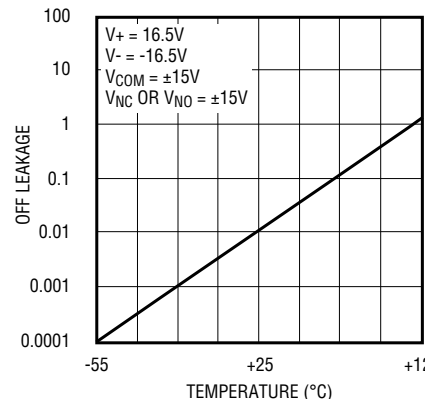
**ON RESISTANCE
vs. V_{COM} AND TEMPERATURE**



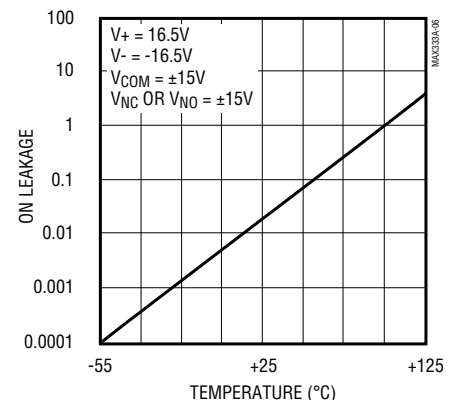
**ON RESISTANCE
vs. V_{COM} AND SINGLE SUPPLY**



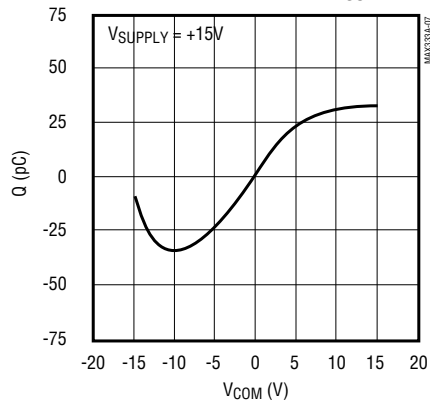
**OFF LEAKAGE CURRENTS
vs. TEMPERATURE**



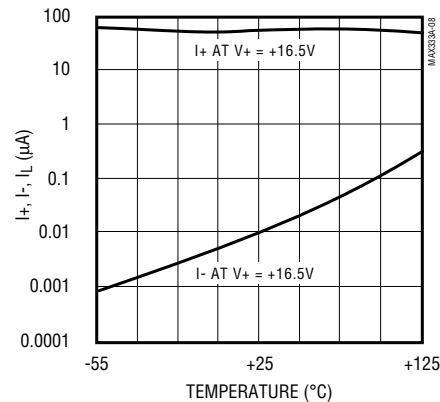
**ON LEAKAGE CURRENTS
vs. TEMPERATURE**



CHARGE INJECTION vs. V_{COM}



SUPPLY CURRENT vs. TEMPERATURE



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Pin Description

PIN	NAME	FUNCTION
1, 10, 11, 20	IN1-IN4	Logic-Level Inputs
2, 9, 12, 19	NO1-NO4	Normally Open Switches
3, 8, 13, 18	COM1-COM4	Common Switch Poles
4, 7, 14, 17	NC1-NC4	Normally Closed Switches
5	V-	Negative Power Supply
6	GND	Ground
15	N.C.	Not Internally Connected
16	V+	Positive Power Supply

Applications Information

Operation with Supply Voltages Other than $\pm 15V$

The main limitation of supply voltages other than $\pm 15V$ is a reduction in the analog signal range. The MAX333A operates with $\pm 5V$ to $\pm 20V$ bipolar supplies. The *Typical Operating Characteristics* and graphs show typical on resistance for $\pm 15V$, $\pm 10V$, $\pm 5V$ supplies. Switching times increase by a factor of two or more for $\pm 5V$ operation. The MAX333A can operate from $+10V$ to $+24V$ unipolar supplies. It can be powered from a single $+10V$ to $+24V$ supply, as well as from unbalanced supplies such as $+24V$ and $-5V$. Connect V- to $0V$ when operating with a single supply.

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+ on 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 (Figure 1). Adding the diodes reduces the analog signal range to 1V below V+ and 1V below V-, but low switch resistance and low leakage characteristics are unaffected.

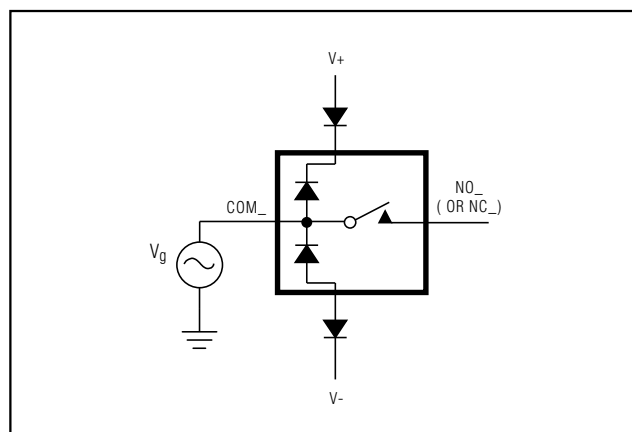


Figure 1. Overvoltage Protection Using Blocking Diodes

Test Circuits/Timing Diagrams

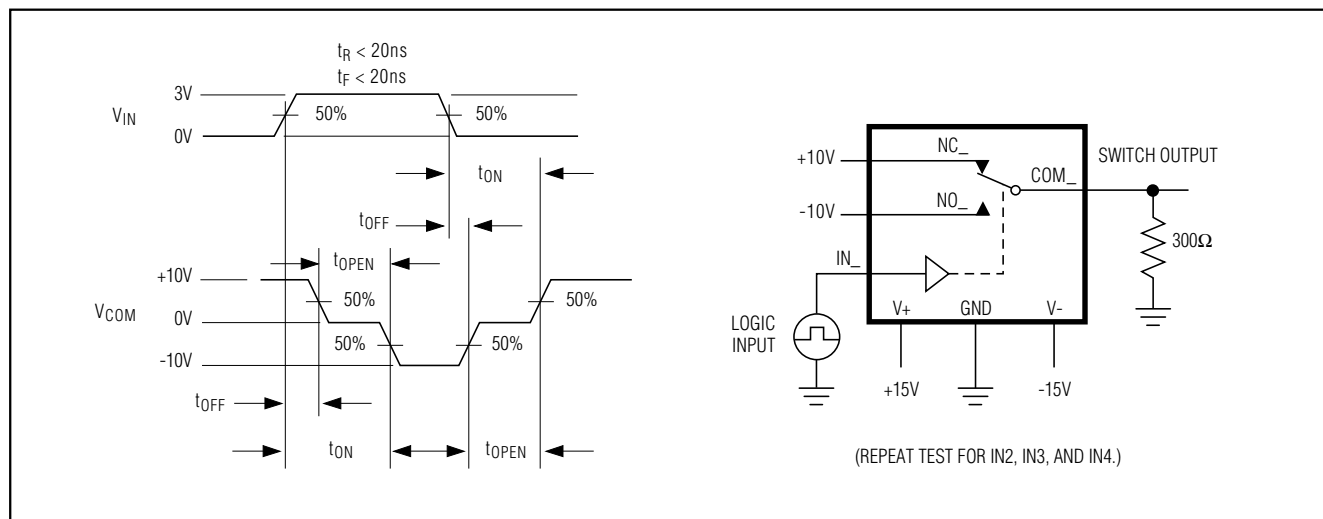


Figure 2. Switching-Time Test Circuit

MAX333A

The diagram shows a circuit for a capacitance meter. A central op-amp is configured with its non-inverting input (IN-) connected to ground (0V, 2.4V). The inverting input (IN+) is connected to a switch. The switch has three terminals: COM_ (common), NO (normally open), and NC (normally closed). The COM_ terminal is connected to a capacitance meter. The NO terminal is connected to a +15V supply through a capacitor C. The NC terminal is connected to ground. The op-amp's output (V-) is connected to ground through a capacitor C. The op-amp's power supply (V+) is connected to +15V through a capacitor C. The op-amp's ground (GND) is connected to ground.

The diagram shows an operational amplifier (op-amp) configured for capacitance measurement. The op-amp is represented by a central square block with several pins and internal components:

- COM_**: The non-inverting input (pin 3) is connected to ground.
- NO_ OR NC_**: The output (pin 6) is connected to the non-inverting input (pin 3) through a switch.
- IN_**: The inverting input (pin 2) is connected to a switch that is controlled by a **CAPACITANCE METER**.
- V+**: The positive supply pin (pin 4) is connected to a **+15V** source through a capacitor **C**.
- V-**: The negative supply pin (pin 5) is connected to a **-15V** source through a capacitor **C**.
- Output**: The op-amp's output (pin 1) is connected to a load consisting of a resistor and a capacitor, with a voltage of **0V, 2.4V** indicated across it.

The figure consists of two parts: a timing diagram on the left and a circuit schematic on the right.

Timing Diagram:

- LOGIC INPUT:** A square wave signal switching between +3V and 0V. The 50% transition point is marked.
- SWITCH OUTPUT:** A signal that switches between 0V and V_{COM} . The output voltage is labeled V_{O1} at the rising edge and $0.9V_O$ at the falling edge. The delay time t_D is indicated from the input transition to the output transition.
- SWITCH OUTPUT:** A signal that switches between 0V and V_{COM} . The output voltage is labeled V_{O2} at the rising edge and $0.9V_O$ at the falling edge. The delay time t_D is indicated from the input transition to the output transition.

Circuit Schematic:

- The circuit uses a 74VHC14 inverter.
- Power Supply:** +15V connected to V_+ and -15V connected to V_- .
- Logic Input:** A square wave signal connected to the IN pin.
- COM Pin:** Connected to V_{COM} .
- NC Pin:** Connected to the output of the inverter (NO pin).
- Output Load:** A load resistor R_{L1} and a load capacitor C_{L1} are connected to the output.
- Internal Node:** The output of the inverter is connected to a node labeled V_{O2} , which is also connected to a resistor R_{L2} and a capacitor C_{L2} .
- Grounding:** The GND pin is connected to ground.

Parameters:
 $R_L = 1000\Omega$
 $C_L = 35\text{pF}$

Notes:
 C_L INCLUDES FIXTURE AND STRAY CAPACITANCE.
 LOGIC 0 INPUT.

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Test Circuits/Timing Diagrams (continued)

MAX333A

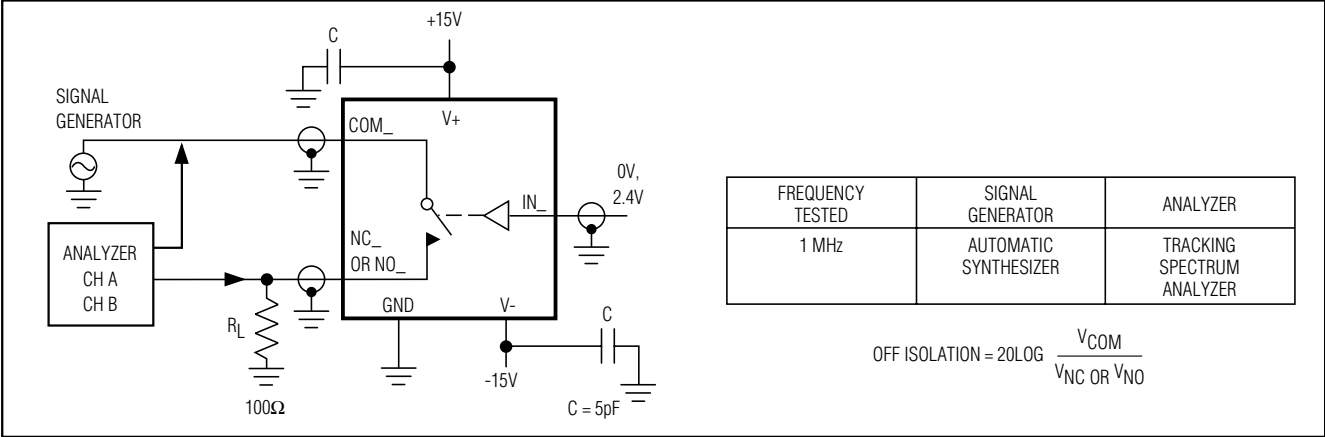


Figure 7. Off-Isolation

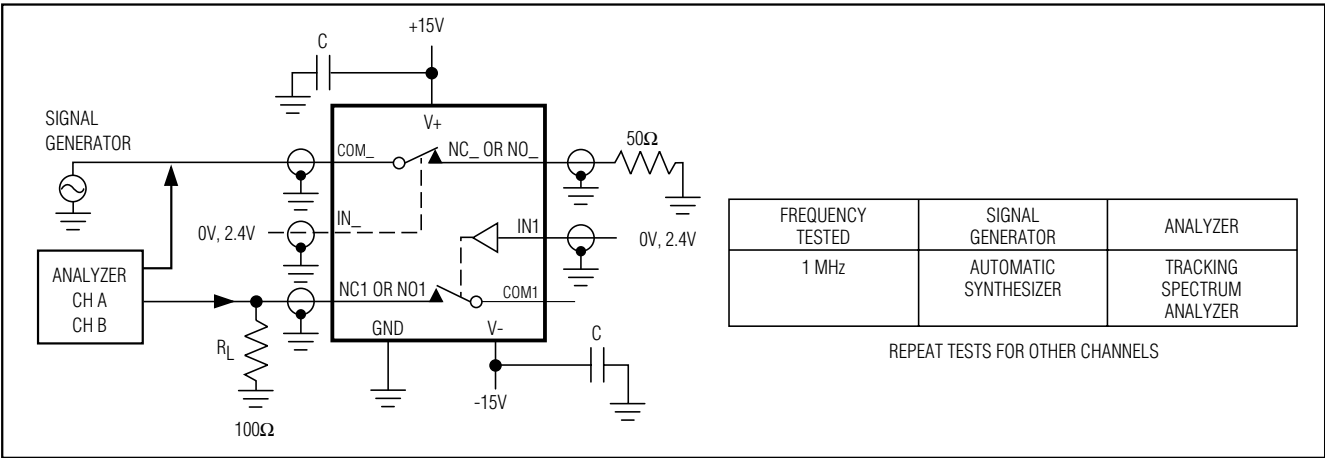
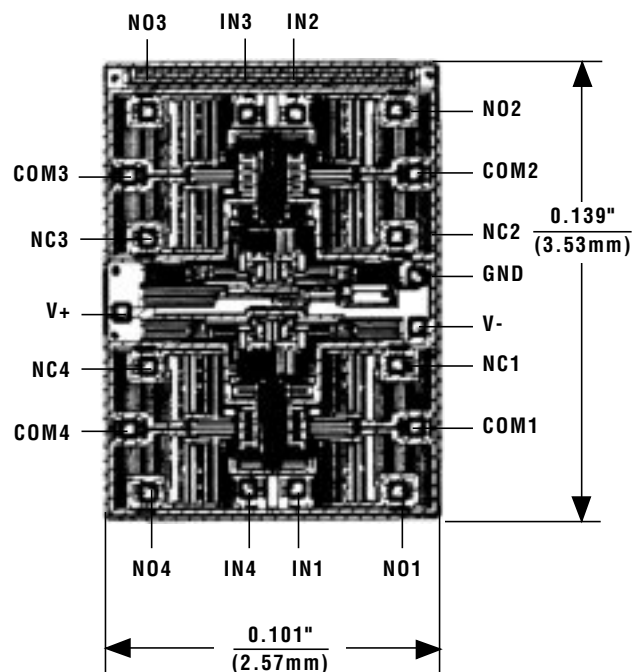


Figure 8. Crosstalk

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MAX333A

Chip Topography



TRANSISTOR COUNT: 145;
SUBSTRATE CONNECTED TO V+.

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