

MAXIM

Low-Voltage, SPST, CMOS Analog Switches

General Description

The MAX4501/MAX4502 are single-pole/single-throw (SPST), low-voltage, single-supply, CMOS analog switches. The MAX4501 is normally open (NO). The MAX4502 is normally closed (NC).

These CMOS switches can operate continuously with a single supply between +2V and +12V. Each switch can handle rail-to-rail analog signals. The off-leakage current is only 1.0nA at +25°C or 10nA at +85°C.

The digital input has 0.8V and 2.4V logic thresholds, ensuring TTL/CMOS-logic compatibility when using a single +5V supply.

Applications

Battery-Operated Equipment
 Audio and Video Signal Routing
 Low-Voltage Data-Acquisition Systems
 Communications Circuits
 PCMCIA Cards
 Cellular Phones
 Modems

Features

- ◆ Available in SOT23-5 Package
- ◆ +2V to +12V Single-Supply Operation
- ◆ Guaranteed On-Resistance: 250Ω at +5V
- ◆ Guaranteed Low Off-Leakage Current:
 - 1nA at +25°C
 - 10nA at +85°C
- ◆ Guaranteed Low On-Leakage Current:
 - 2nA at +25°C
 - 20nA at +85°C
- ◆ Low Charge Injection: 10pC
- ◆ Fast Switching Speed: $t_{ON} = 75ns$, $t_{OFF} = 50ns$
- ◆ TTL/CMOS-Logic Compatible with +5V Supply

Ordering Information

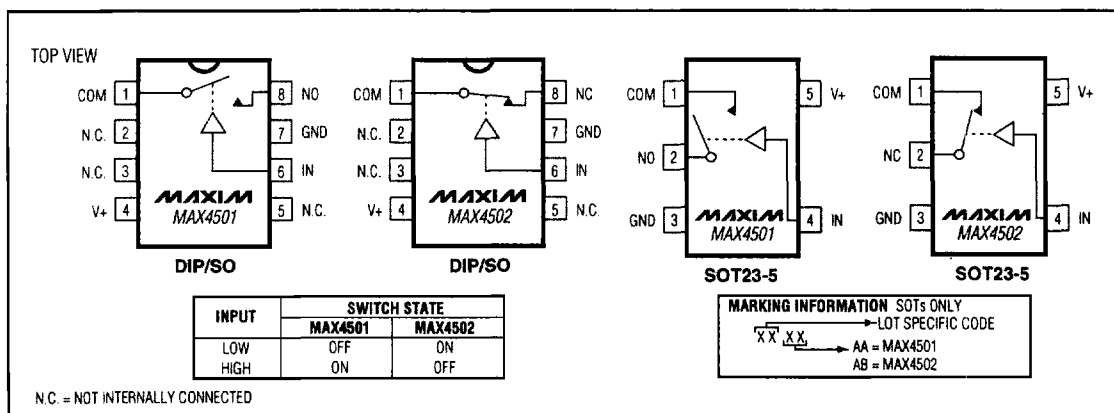
PART	TEMP. RANGE	PIN-PACKAGE
MAX4501CPA	0°C to +70°C	8 Plastic DIP
MAX4501CSA	0°C to +70°C	8 SO
MAX4501CUK	0°C to +70°C	5 SOT23-5
MAX4501C/D	0°C to +70°C	Dice*
MAX4501EPA	-40°C to +85°C	8 Plastic DIP
MAX4501ESA	-40°C to +85°C	8 SO
MAX4501EUK	-40°C to +85°C	5 SOT23-5
MAX4501MJA	-55°C to +125°C	8 CERDIP**

Ordering information continued at end of data sheet.

* Contact factory for dice specifications.

** Contact factory for availability.

Pin Configurations/Functional Diagrams/Truth Table


MAX4501/MAX4502
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ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to GND)

V+	-0.3V, +13V	SOT23-5 (derate 7.1mW/°C above +70°C).....	571mW
Voltage into Any Terminal (Note 1).....	-0.3V to (V+ + 0.3V) or ±10mA (whichever occurs first)	CERDIP (derate 8.00mW/°C above +70°C).....	640mW
Continuous Current into Any Terminal.....	±10mA	Operating Temperature Ranges	
Peak Current, NO_ or COM_		MAX4501C_/MAX4502C_	0°C to +70°C
(pulsed at 1ms, 10% duty cycle).....	±20mA	MAX4501E_/MAX4502E_	-40°C to +85°C
ESD per Method 3015.7	>2000V	MAX4501MJA/MAX4502MJA	-55°C to +125°C
Continuous Power Dissipation (TA = +70°C)		Storage Temperature Range	-65°C to +150°C
Plastic DIP (derate 9.09mW/°C above +70°C)	727mW	Lead Temperature (soldering, 10sec).....	+300°C
SO (derate 5.88mW/°C above +70°C).....	471mW		

Note 1: Voltages exceeding V+ or GND on any signal terminal are clamped by internal diodes. Limit forward-diode 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—+5V Supply

(V+ = +4.5V to +5.5V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP (Note 2)	MAX	UNITS		
ANALOG SWITCH								
Analog Signal Range	VCOM, VNO, VNC		0		V+	V		
COM to NO or NC On-Resistance	RON	VCOM = 3.5V, ICOM = 1mA	TA = +25°C		90	250	Ω	
			TA = TMIN to TMAX			350		
NO or NC Off-Leakage Current (Note 3)	INO(OFF), INC(OFF)	V+ = 5.5V, VCOM = 1V, VNO or VNC = 4.5V	TA = +25°C		-1	0.01	1	nA
			TA = TMIN to TMAX	C, E	-10	10		
				M	-100	100		
COM Off-Leakage Current (Note 3)	ICOM(OFF)	V+ = 5.5V, VCOM = 1V, VNO or VNC = 4.5V	TA = +25°C		-1	0.01	1	nA
			TA = TMIN to TMAX	C, E	-10	10		
				M	-100	100		
COM On-Leakage Current (Note 3)	ICOM(ON)	V+ = 5.5V, VCOM = 1V, VNO or VNC = 4.5V	TA = +25°C		-2	0.01	2	nA
			TA = TMIN to TMAX	C, E	-20	20		
				M	-200	200		
DIGITAL I/O								
Input Logic High	VIH		2.4		V+	V		
Input Logic Low	VIL		0		0.8	V		
Input Current Logic High or Low	IiH, IiL	VIN = V+, 0V	-1	0.03	1	μA		
SWITCH DYNAMIC CHARACTERISTICS								
Turn-On Time	tON	VNO = VNC = 1.5V, VIN = 3V, RL = 1kΩ Figure 1	TA = +25°C		16	75	ns	
			TA = TMIN to TMAX			150		
Turn-Off Time	tOFF	VNO = VNC = 1.5V, VIN = 3V, RL = 1kΩ Figure 1	TA = +25°C		10	50	ns	
			TA = TMIN to TMAX			150		

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ELECTRICAL CHARACTERISTICS—+5V Supply (continued)

(V+ = +4.5V to +5.5V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP (Note 2)	MAX	UNITS
SWITCH DYNAMIC CHARACTERISTICS (continued)						
Charge Injection (Note 4)	Q	CL = 1nF, VNO = 0V, RS = 0Ω, TA = +25°C, Figure 2		1	10	pC
Off Isolation	VISO	RL = 50Ω, CL = 15pF, VNO = 1VRMS, f = 100kHz, TA = +25°C, Figure 3		< -100		dB
NO or NC Off Capacitance	CNO(OFF), CNC(OFF)	f = 1MHz, Figure 4		3		pF
COM Off Capacitance	CCOM(OFF)	f = 1MHz, Figure 4		3		pF
COM On Capacitance	CCOM(ON)	f = 1MHz, Figure 4		8		pF
POWER SUPPLY						
V+ Supply Current	I+	VIN = 0V or V+	TA = +25°C	-1	1	μA
			TA = TMIN to TMAX	-10	10	

ELECTRICAL CHARACTERISTICS—+12V Supply

(V+ = +11.4V to +12.6V, VINH = 5.0V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP (Note 2)	MAX	UNITS	
ANALOG SWITCH							
Analog Signal Range	VCOM, VNO, VNC		0		V+	V	
COM to NO or NC On-Resistance	RON	VCOM = 10V, ICOM = 1mA	TA = +25°C	40	160	Ω	
			TA = TMIN to TMAX		200		
NO or NC Off-Leakage Current (Note 3)	INO(OFF), INC(OFF)	VCOM = 10V, VNO or VNC = 1V	TA = +25°C	-5	5	nA	
			TA = TMIN to TMAX	C, E	-50		50
				M	-500		500
COM Off-Leakage Current (Note 3)	ICOM(OFF)	VCOM = 10V, VNO or VNC = 1V	TA = +25°C	-5	5	nA	
			TA = TMIN to TMAX	C, E	-50		50
				M	-500		500
COM On-Leakage Current (Note 3)	ICOM(ON)	VCOM = 10V	TA = +25°C	-10	10	nA	
			TA = TMIN to TMAX	C, E	-100		100
				M	-1000		1000
DIGITAL I/O							
Input Logic High	VINH		5.0		V+	V	
Input Logic Low	VINL		0		0.8	V	
Input Current Logic High or Low	IINH, IINL	VIN = V+, 0V	-1	0.03	1	μA	
POWER SUPPLY							
V+ Supply Current	I+	IN = 0V or V+	TA = +25°C	-1	1	μA	
			TA = TMIN to TMAX	-10	10		

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ELECTRICAL CHARACTERISTICS—+3V Supply

($V_+ = +3.0V$ to $+3.6V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP (Note 2)	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	V_{COM} , V_{NO} , V_{NC}			0		V_+	V
COM to NO or NC On-Resistance	R_{ON}	$V_{COM} = 1.5V$, $I_{NO} = 0.1mA$	$T_A = +25^\circ C$	175	600		Ω
			$T_A = T_{MIN}$ to T_{MAX}		800		
DIGITAL I/O							
Input Logic High	V_{INH}			2.4		V_+	V
Input Logic Low	V_{INL}			0		0.8	V
Input Current Logic High or Low	I_{INH} , I_{INL}	$V_{IN} = V_+, 0V$		-1.00	0.03	1.00	μA
SWITCH DYNAMIC CHARACTERISTICS							
Turn-On-Time (Note 4)	t_{ON}	$V_{NO} = V_{NC} = 1.5V$, $V_{IN} = 3V$, $R_L = 1k\Omega$ Figure 1	$T_A = +25^\circ C$	45	300		ns
			$T_A = T_{MIN}$ to T_{MAX}			500	
Turn-Off-Time (Note 4)	t_{OFF}	$V_{NO} = V_{NC} = 1.5V$, $V_{IN} = 3V$, $R_L = 1k\Omega$ Figure 1	$T_A = +25^\circ C$	10	125		ns
			$T_A = T_{MIN}$ to T_{MAX}			175	
Charge Injection (Note 4)	Q	$C_L = 1nF$, $T_A = +25^\circ C$, Figure 2		0.5		10	μC
POWER SUPPLY							
V_+ Supply Current	I_+	$I_N = 0V$ or V_+	$T_A = +25^\circ C$	-1		1	μA
			$T_A = T_{MIN}$ to T_{MAX}	-10		10	

Note 2: The algebraic convention is used in this data sheet; the most negative value is shown in the minimum column.

Note 3: Leakage parameters are 100% tested at maximum-rated hot operating temperature, and are guaranteed by correlation at $+25^\circ C$.

Note 4: Guaranteed, not production tested.

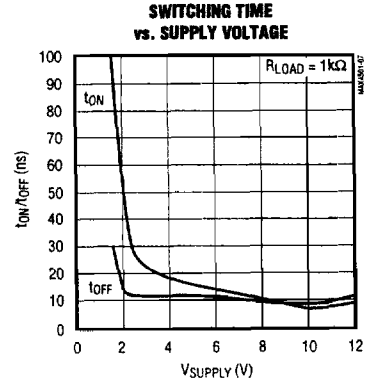
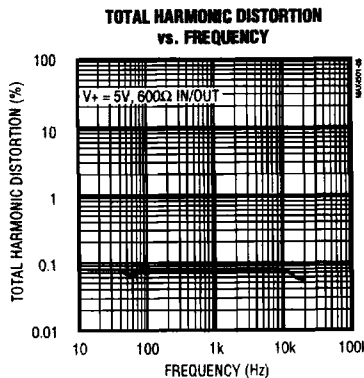
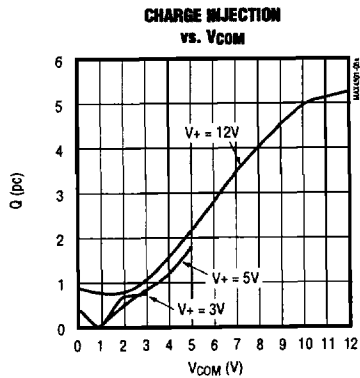
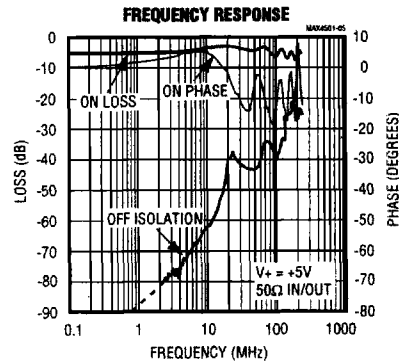
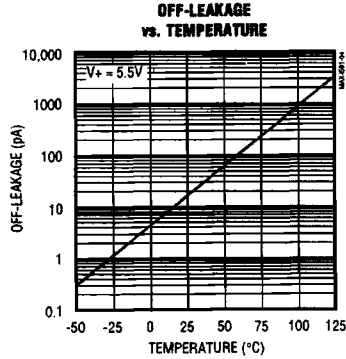
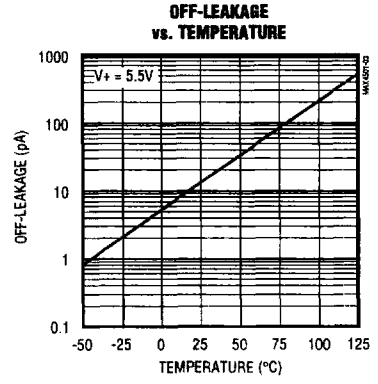
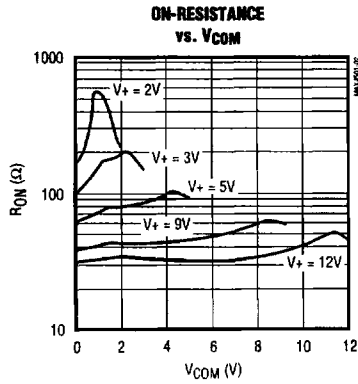
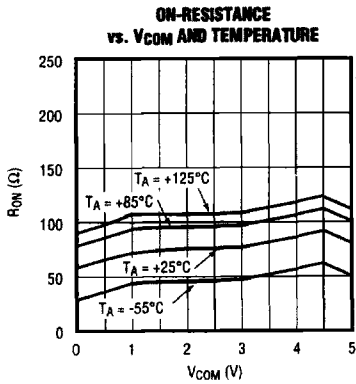
Note 5: SOT packaged parts are 100% tested at $+25^\circ C$. Limits at maximum and minimum rated temperature are guaranteed by design and correlation limits at $+25^\circ C$.

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Typical Operating Characteristics

($V_+ = 5V$, $GND = 0V$, $T_A = +25^\circ C$, unless otherwise noted.)

MAX4501/MAX4502



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Pin Description

PIN				NAME	FUNCTION
MAX4501		MAX4502			
DIP/SO	SOT23-5	DIP/SO	SOT23-5		
1	1	1	1	COM	Analog Switch Common Terminal
2, 3, 5	—	2, 3, 5	—	N.C.	No Connect (not internally connected)
4	5	4	5	V+	Positive Supply-Voltage Input (analog and digital)
6	4	6	4	IN	Digital Control Input
7	3	7	3	GND	Ground
8	2	—	—	NO	Analog Switch (normally open)
—	—	8	2	NC	Analog Switch (normally closed)

Note: NO, NC, and COM pins are identical and interchangeable. Any may be considered as an input or an output; signals pass equally well in both directions.

Applications Information

Power-Supply Considerations

The MAX4501/MAX4502 are constructed like most CMOS analog switches, except they have only two supply pins: V+ and GND. V+ and GND drive the internal CMOS switches and set the analog voltage limits of the switch. Reverse ESD-protection diodes are internally connected between each analog-signal pin and both V+ and GND. One of these diodes conducts if any analog signal exceeds V+ or GND. During normal operation, these and other reverse-biased ESD diodes leak, forming the only current drawn from V+ or GND.

Virtually all the analog leakage current comes from the ESD diodes. Although the ESD diodes on a given signal pin are identical and therefore fairly well balanced, they are reverse biased differently. Each is biased by either V+ or GND and the analog signal. This means their leakages will vary as the signal varies. The *difference* in the two diode leakages to the V+ and GND pins constitutes the analog-signal-path leakage current. All analog leakage current flows between each pin and one of the supply terminals, not to the other switch terminal. This is why both sides of a given switch can show leakage currents of the same or opposite polarity.

There is no connection between the analog-signal paths and V+ or GND.

V+ and GND also power the internal logic and logic-level translators, and set both the input and output logic limits. The logic-level translators convert the logic levels to switched V+ and GND signals to drive the analog

signal gates. This drive signal is the only connection between the logic supplies (and signals) and the analog supplies. COM, NO, and NC pins have ESD-protection diodes to V+ and GND.

The logic-level thresholds are CMOS/TTL-compatible when V+ is +5V. As V+ is raised, the threshold increases slightly. When V+ reaches +12V, the logic-level threshold is about 3V—above the TTL guaranteed high-level minimum of 2.8V, but still compatible with CMOS outputs.

Do not connect the MAX4501/MAX4502's V+ to +3V and then connect the logic-level pins to TTL logic-level signals. TTL levels can exceed +3V and violate the absolute maximum ratings, damaging the part and/or external circuits.

High-Frequency Performance

In 50Ω systems, signal response is reasonably flat up to 250MHz (see *Typical Operating Characteristics*). Above 20MHz, the on response has several minor peaks which are highly layout dependent. The problem is not in turning the switch on; it's in turning it off. The off-state switch acts like a capacitor and passes higher frequencies with less attenuation. At 10MHz, off isolation is about -60dB in 50Ω systems, decreasing approximately 20dB per decade as frequency increases. Higher circuit impedances also cause off isolation to decrease. Adjacent channel attenuation is about 3dB above that of a bare IC socket, and is due entirely to capacitive coupling.

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Test Circuits/Timing Diagrams

MAX4501/MAX4502

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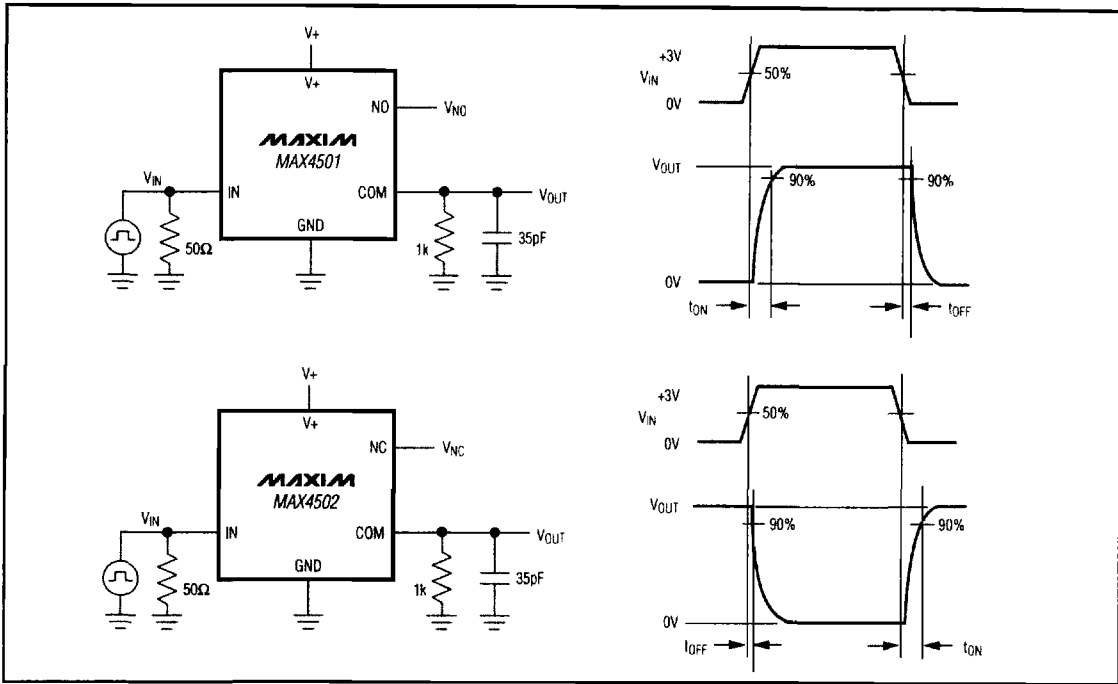


Figure 1. Switching Times

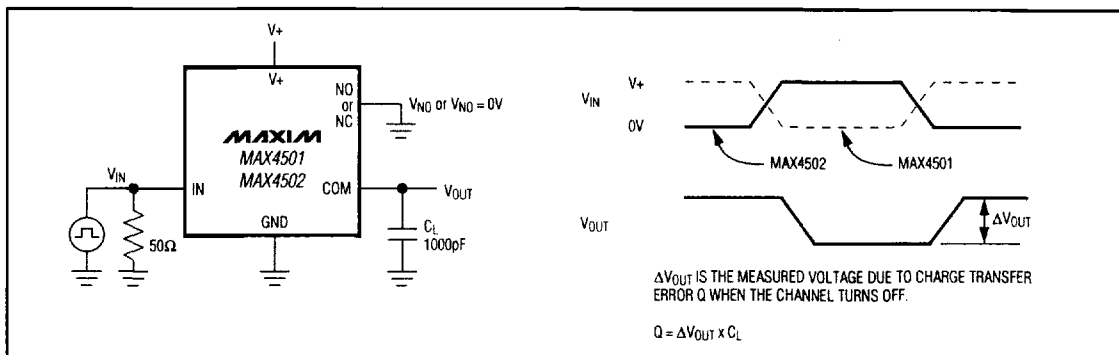


Figure 2. Charge Injection

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Test Circuits/Timing Diagrams (continued)

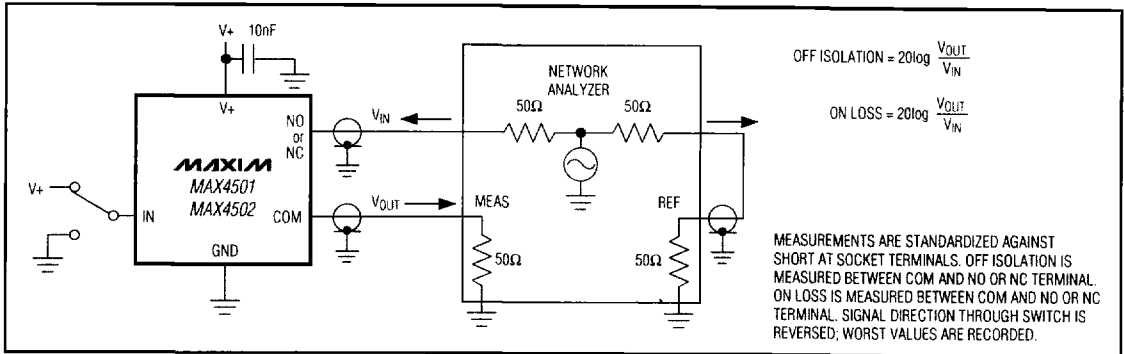


Figure 3. Off Isolation and On Loss

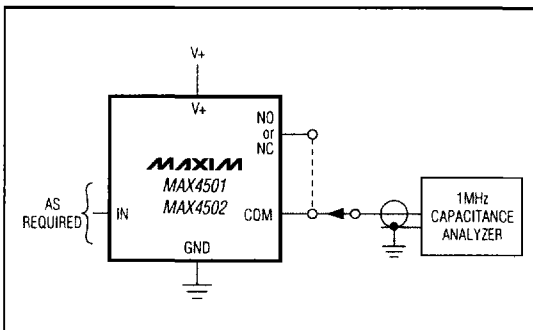
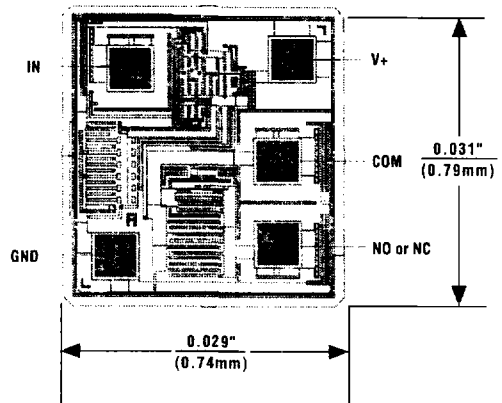


Figure 4. NO, NC, and COM Capacitance

Chip Topography



TRANSISTOR COUNT: 17
SUBSTRATE CONNECTED TO V+

Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX4502CPA	0°C to +70°C	8 Plastic DIP
MAX4502CSA	0°C to +70°C	8 SO
MAX4502CUK	0°C to +70°C	5 SOT23-5
MAX4502C/D	0°C to +70°C	Dice*
MAX4502EPA	-40°C to +85°C	8 Plastic DIP
MAX4502ESA	-40°C to +85°C	8 SO
MAX4502EUK	-40°C to +85°C	5 SOT23-5
MAX4502MJA	-55°C to +125°C	8 CERDIP**

* Contact factory for dice specifications.

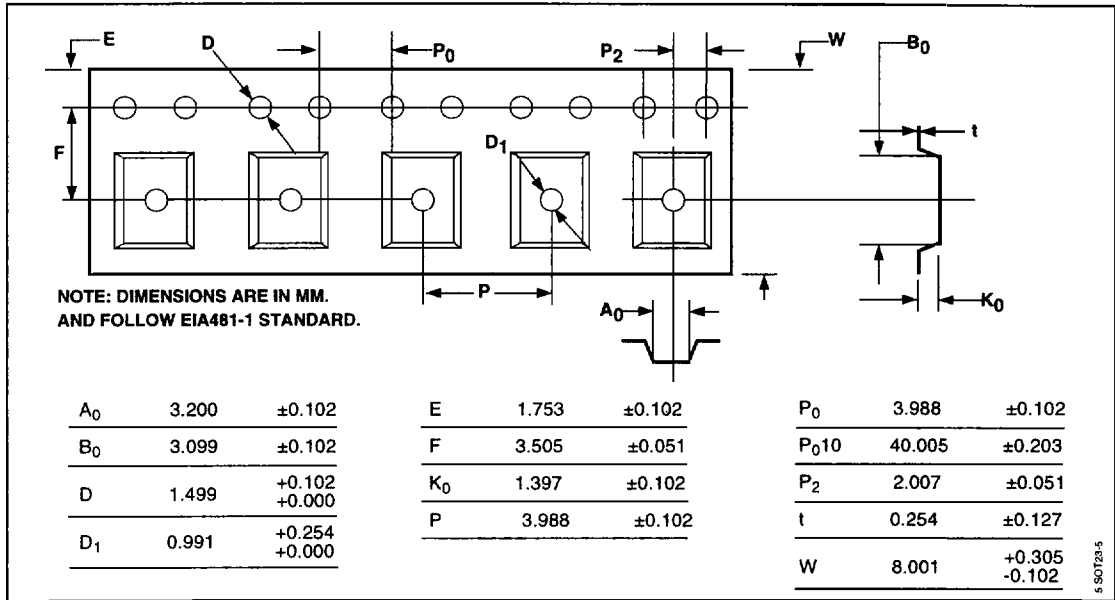
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Tape-and-Reel Information

MAX4501/MAX4502

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