



±15kV ESD-Protected, Low-Voltage, Dual, SPST, CMOS Analog Switches

General Description

The MAX4575/MAX4576/MAX4577 are low-voltage, high electrostatic discharge (ESD)-protected, dual single-pole/single-throw (SPST) analog switches. The normally closed (NO) and normally open (NC) pins are protected against ±15kV ESD without latchup or damage. Each switch can handle Rail-to-Rail® analog signals. Off-leakage current is 0.5nA at +25°C. These analog switches are suitable for low-distortion audio applications and are the preferred solution over mechanical relays in automated test equipment or applications where current switching is required. They have low power requirements (0.5µW), require less board space, and are more reliable than mechanical relays. Each device is controlled by TTL/CMOS input voltage levels and is bilateral.

These switches feature guaranteed operation from a single supply of +2V to +12V, making them ideal for use in battery-powered applications. On-resistance is 70Ω (max), matched between switches to 0.5Ω (typ) and flat (2Ω typ) over the specified signal range.

The MAX4575 has two NO switches, the MAX4576 has two NC switches, and the MAX4577 has one NO and one NC switch. These devices are available in 8-pin µMAX and SO packages.

Applications

Battery-Powered Systems
Audio and Video Signal Routing
Low-Voltage Data-Acquisition Systems
Sample-and-Hold Circuits
Communications Circuits
Relay Replacement

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX4575 EUA	-40°C to +85°C	8 µMAX
MAX4575ESA	-40°C to +85°C	8 SO
MAX4576 EUA	-40°C to +85°C	8 µMAX
MAX4576ESA	-40°C to +85°C	8 SO
MAX4577 EUA	-40°C to +85°C	8 µMAX
MAX4577ESA	-40°C to +85°C	8 SO

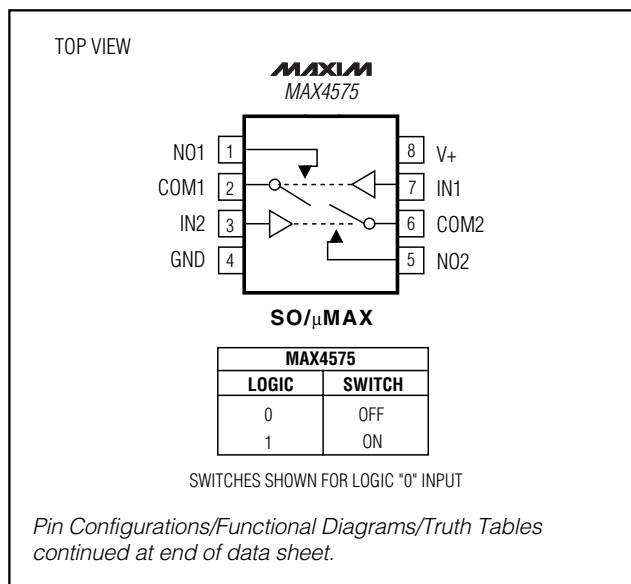
Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.

Features

- ◆ ESD-Protected NO/NC Pins
 - ±15kV (Human Body Model)
 - ±15kV (IEC 1000-4-2 Air-Gap Discharge)
 - ±8kV (IEC 1000-4-2 Contact Discharge)
- ◆ Pin Compatible with MAX4541/MAX4542/MAX4543
- ◆ Guaranteed On-Resistance
 - 70Ω (max) at +5V
 - 150Ω (max) at +3V
- ◆ On-Resistance Flatness
 - 2Ω (typ) at +5V
 - 6Ω (typ) at +3V
- ◆ On-Resistance Matching
 - 0.5Ω (typ) at +5V
 - 0.6Ω (typ) at +3V
- ◆ Guaranteed 0.5nA Leakage Current at T_A = +25°C
- ◆ +2V to +12V Single-Supply Voltage
- ◆ TTL/CMOS-Logic Compatible
- ◆ Low Distortion: 0.015%
- ◆ -3dB Bandwidth >300MHz
- ◆ Rail-to-Rail Signal Range

Pin Configurations/

Functional Diagrams/Truth Tables



$\pm 15\text{kV}$ ESD-Protected, Low-Voltage, Dual, SPST, CMOS Analog Switches

ABSOLUTE MAXIMUM RATINGS

V+ to GND -0.3V to +13V
 IN_, COM_, NO_, NC_ to GND (Note 1) -0.3V to (V+ + 0.3V)
 Continuous Current (NO_, NC_, COM) $\pm 10\text{mA}$
 Peak Current (NO_, NC_, COM; pulsed at 1ms 10% duty cycle) $\pm 30\text{mA}$
 ESD Protection per Method IEC 1000-4-2 (NO_, NC_)
 Air-Gap Discharge $\pm 15\text{kV}$
 Contact Discharge $\pm 8\text{kV}$
 ESD Protection per Method 3015.7
 NO_, NC_ $\pm 15\text{kV}$
 V+, GND, IN_, COM_ $\pm 2.5\text{kV}$

Continuous Power Dissipation ($T_A = +70^\circ\text{C}$)
 8-Pin μMAX (derate $4.1\text{mW}/^\circ\text{C}$ above $+70^\circ\text{C}$) 330mW
 8-Pin SO (derate $8\text{mW}/^\circ\text{C}$ above $+70^\circ\text{C}$) 640mW
 Operating Temperature Range
 MAX457_E_A -40°C to $+85^\circ\text{C}$
 Storage Temperature Range -65°C to $+150^\circ\text{C}$
 Maximum Die Temperature $+150^\circ\text{C}$
 Lead Temperature (soldering, 10s) $+300^\circ\text{C}$

Note 1: Signals on NO_, NC_, COM_, or IN_ exceeding V+ or GND 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—SINGLE +5V SUPPLY

(V+ = +4.5V to +5.5V, $V_{IH} = 2.4\text{V}$, $V_{IL} = 0.8\text{V}$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise specified. Typical values are at V+ = +5V, $T_A = +25^\circ\text{C}$.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Input Voltage Range	$V_{COM_}$, $V_{NO_}$, $V_{NC_}$			0		V+	V
On-Resistance	R_{ON}	$V+ = +4.5V$, $I_{COM_} = 1mA$, $V_{NO_}$ or $V_{NC_} = 3.5V$	$T_A = +25^{\circ}C$	45		70	Ω
			$T_A = T_{MIN}$ to T_{MAX}			75	
On-Resistance Match Between Channels (Note 3)	ΔR_{ON}	$V+ = +4.5V$, $I_{COM_} = 1mA$, $V_{NO_}$ or $V_{NC_} = 3.5V$	$T_A = +25^{\circ}C$	0.5		2	Ω
			$T_A = T_{MIN}$ to T_{MAX}			3	
On-Resistance Flatness (Note 4)	$R_{FLAT(ON)}$	$V+ = +4.5V$, $I_{COM_} = 1mA$, $V_{NO_}$ or $V_{NC_} = 1V$, 2.25V, 3.5V	$T_A = +25^{\circ}C$	2		4	Ω
			$T_A = T_{MIN}$ to T_{MAX}			5	
Off-Leakage Current ($NO_$ or $NC_$) (Note 5)	$I_{NO_}$, $I_{NC_}$	$V+ = 5.5V$ $V_{COM_} = 1V$, 4.5V $V_{NO_}$ or $V_{NC_} = 4.5V$, 1V	$T_A = +25^{\circ}C$	-0.5	0.01	0.5	nA
			$T_A = T_{MIN}$ to T_{MAX}	-5		5	
COM_ Off-Leakage Current (Note 5)	$I_{COM_ (OFF)}$	$V+ = 5.5V$ $V_{COM_} = 1V$, 4.5V $V_{NO_}$ or $V_{NC_} = 4.5V$, 1V	$T_A = +25^{\circ}C$	-0.5	0.01	0.5	nA
			$T_A = T_{MIN}$ to T_{MAX}	-5		5	
COM_ On-Leakage Current (Note 5)	$I_{COM_ (ON)}$	$V+ = 5.5V$ $V_{COM_} = 1V$, 4.5V $V_{NO_}$ or $V_{NC_} = 1V$, 4.5V or floating	$T_A = +25^{\circ}C$	-1	0.02	1	nA
			$T_A = T_{MIN}$ to T_{MAX}	-10		10	

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ELECTRICAL CHARACTERISTICS—SINGLE +5V SUPPLY (continued)

(V+ = +4.5V to +5.5V, V_{IH} = 2.4V, V_{IL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at V+ = +5V, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
LOGIC INPUT						
IN_ Input High	V _{IH}		2.4			V
IN_ Input Low	V _{IL}				0.8	V
Logic Input Leakage	I _{IN}	V _{IN} = 0 or V+	-1		1	μA
SWITCH DYNAMIC						
Turn-On Time	t _{ON}	V _{COML} = 3V, R _L = 300Ω, C _L = 35pF, Figure 1	T _A = +25°C		90	150
			T _A = T _{MIN} to T _{MAX}			180
Turn-Off Time	t _{OFF}	V _{COML} = 3V, R _L = 300Ω, C _L = 35pF, Figure 1	T _A = +25°C		50	80
			T _A = T _{MIN} to T _{MAX}			100
Break-Before-Make (MAX4577 only)		V _{COML} = 3V, R _L = 300Ω, C _L = 35pF	T _A = +25°C		5	45
			T _A = T _{MIN} to T _{MAX}		4	
On-Channel Bandwidth -3dB	BW	Signal = 0dBm, R _{IN} = R _{OUT} = 50Ω, C _L = 5pF, Figure 2		300		MHz
Charge Injection	Q	V _{GEN} = 2V, C _L = 1.0nF, R _{GEN} = 0, Figure 3		4		pC
NO_ or NC_ Off-Capacitance	C _{OFF}	V _{NO_} = V _{NC_} = GND, f = 1MHz, Figure 4		20		pF
COM_ Off-Capacitance	C _{COM(OFF)}	V _{COML} = GND, f = 1MHz, Figure 4		12		pF
COM_ On-Capacitance	C _{COM(ON)}	V _{COML} = V _{NO_} , V _{NC_} = GND, f = 1MHz,		20		pF
Off-Isolation (Note 7)	V _{ISO}	R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 2		-75		dB
		R _L = 50Ω, C _L = 5pF, f = 10MHz, Figure 2		-45		
Crosstalk (Note 8)	V _{CT}	R _L = 50Ω, C _L = 5pF, f = 1MHz, Figure 6		-90		dB
		R _L = 50Ω, C _L = 5pF, f = 10MHz, Figure 6		-70		
Total Harmonic Distortion	THD	R _L = 600Ω, f = 20Hz to 20kHz		0.015		%
ESD SCR Holding Current	I _H			110		mA
ESD SCR Holding Voltage	V _H			3		V
POWER SUPPLY						
Power-Supply Range	V+		2		12	V
Positive Supply Current	I+	V+ = 5.5V, V _{IN} = 0 or V+	T _A = +25°C		1	μA
			T _A = T _{MIN} to T _{MAX}		10	

MAX4575/MAX4576/MAX4577

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ELECTRICAL CHARACTERISTICS—SINGLE +3V SUPPLY

($V_+ = +2.7\text{V}$ to $+3.6\text{V}$, $V_{IH} = 2.0\text{V}$, $V_{IL} = 0.6\text{V}$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise specified. Typical values are at $T_A = +25^\circ\text{C}$.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Input Voltage Range	V _{COM_} , V _{NO_} , V _{NC_}			0		V+	V
On-Resistance	R _{ON}	V+ = 2.7V; I _{COM_} = 1mA; V _{NO_} or V _{NC_} = 1.5V	T _A = +25°C	70		120	Ω
			T _A = T _{MIN} to T _{MAX}			150	
On-Resistance Match Between Channels (Notes 3, 8)	ΔR _{ON}	V+ = 2.7V; I _{COM_} = 1mA; V _{NO_} or V _{NC_} = 1.5V	T _A = +25°C	0.6		3	Ω
			T _A = T _{MIN} to T _{MAX}			4	
On-Resistance Flatness (Notes 4, 8)	R _{FLAT(ON)}	V+ = 2.7V; I _{COM_} = 1mA; V _{NO_} or V _{NC_} = 0.5V, 1.5V, 2.2V	T _A = +25°C	6		12	Ω
			T _A = T _{MIN} to T _{MAX}			15	
LOGIC INPUT							
IN_ Input High	V _{IH}			2.0			V
IN_ Input Low	V _{IL}					0.6	V
Logic Input Leakage Current	I _{IN}	V _{IN} = 0 or V+		-1		1	μA
SWITCH DYNAMIC CHARACTERISTICS							
Turn-On Time	t _{ON}	V _{COM_} = 1.5V, R _L = 300Ω, C _L = 35pF, Figure 1	T _A = +25°C	150		250	ns
			T _A = T _{MIN} to T _{MAX}			300	
Turn-Off Time	t _{OFF}	V _{COM_} = 1.5V, R _L = 300Ω, C _L = 35pF, Figure 1	T _A = +25°C	60		100	ns
			T _A = T _{MIN} to T _{MAX}			150	
Break-Before-Make (MAX4577 only)		V _{COM_} = 1.5V, R _L = 300Ω, C _L = 35pF	T _A = +25°C	5			ns
			T _A = T _{MIN} to T _{MAX}	4			
Charge Injection	Q	V _{GEN} = 1.5V, C _L = 1.0nF, R _{GEN} = 0, Figure 3		5			pC
ESD SCR Holding Current	I _H			110			mA
ESD SCR Holding Voltage	V _H			3			V
POWER SUPPLY							
Power-Supply Range	V+			2		12	V
Positive Supply Current	I+	V+ = 3.6V, V _{IN} = 0 or V+	T _A = +25°C			1	μA
			T _A = T _{MIN} to T _{MAX}			10	

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

Note 3: $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$.

Note 4: Flatness is defined as the difference between the maximum and the minimum values of on-resistance as measured over the specified analog signal ranges.

Note 5: Leakage parameters are 100% tested at $T_A(MAX)$, and guaranteed by correlation at $+25^\circ\text{C}$.

Note 6: Off-Isolation = $20\log_{10}(V_{COM} / V_{NO})$, V_{COM} = output, V_{NO} = input to off switch.

Note 7: Between any two switches.

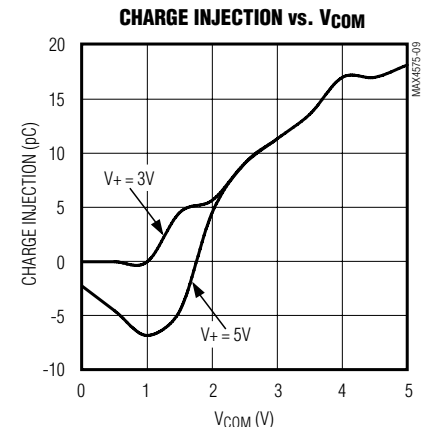
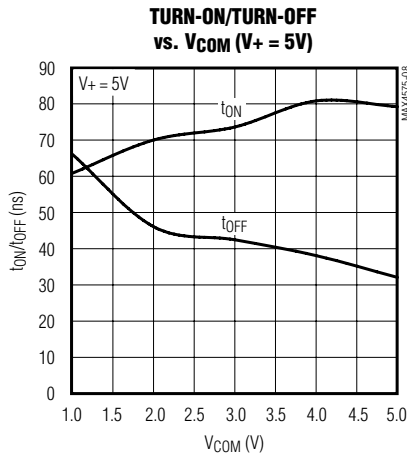
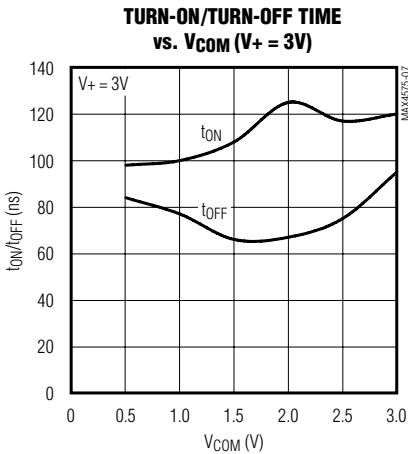
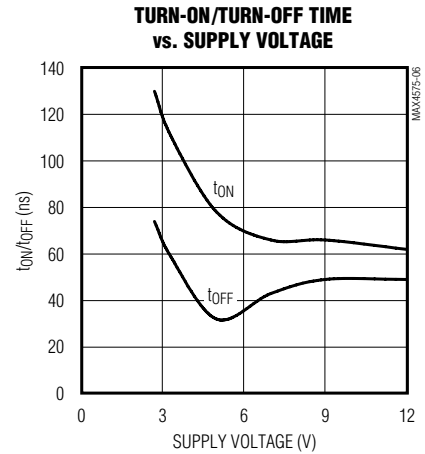
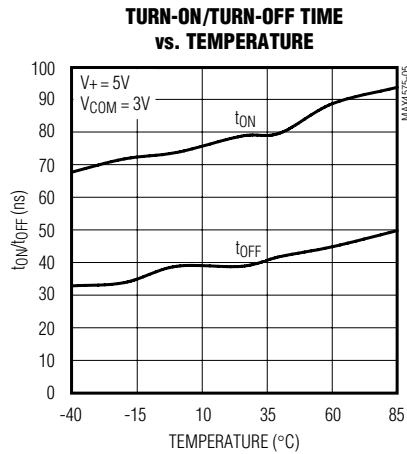
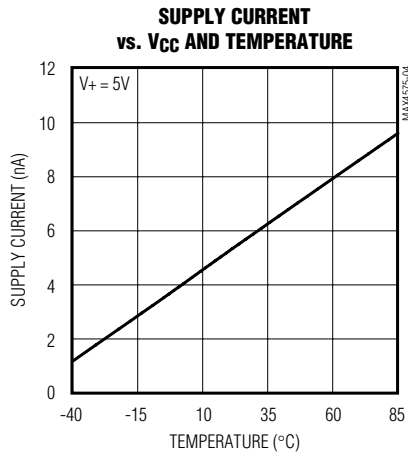
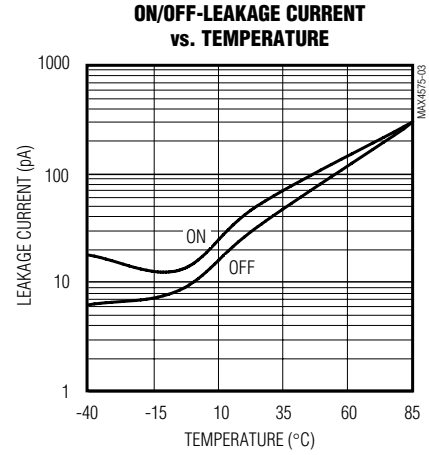
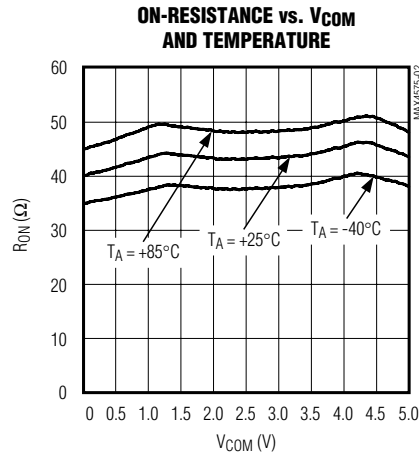
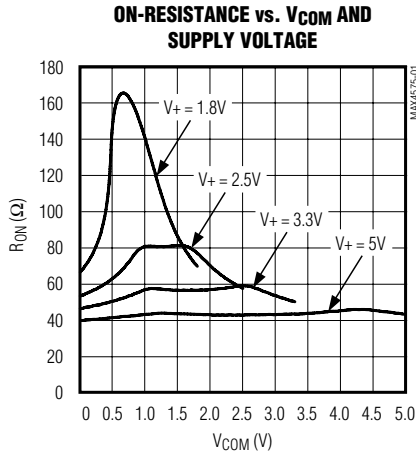
Note 8: Guaranteed by design.

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Typical Operating Characteristics

($V_+ = 5V$, $T_A = +25^\circ\text{C}$, unless otherwise specified.)

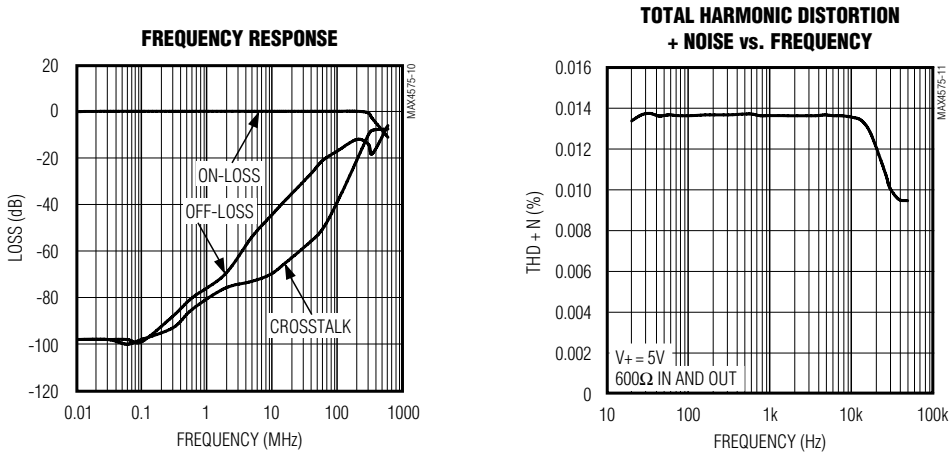
MAX4575/MAX4576/MAX4577



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Typical Operating Characteristics (continued)

(V+ = 5V, TA = +25°C, unless otherwise specified.)



Pin Description

PIN			NAME	FUNCTION
MAX4575	MAX4576	MAX4577		
1	—	1	NO1	Analog Switch 1—Normally Open
—	1	—	NC1	Analog Switch 1—Normally Closed
2	2	2	COM1	Analog Switch 1—Common
3	3	3	IN2	Digital Control Input 2
4	4	4	GND	Ground
5	—	—	NO2	Analog Switch 2—Normally Open
—	5	5	NC2	Analog Switch 2—Normally Closed
6	6	6	COM2	Analog Switch 2—Common
7	7	7	IN1	Digital Control Input 1
8	8	8	V+	Positive Supply Voltage Input

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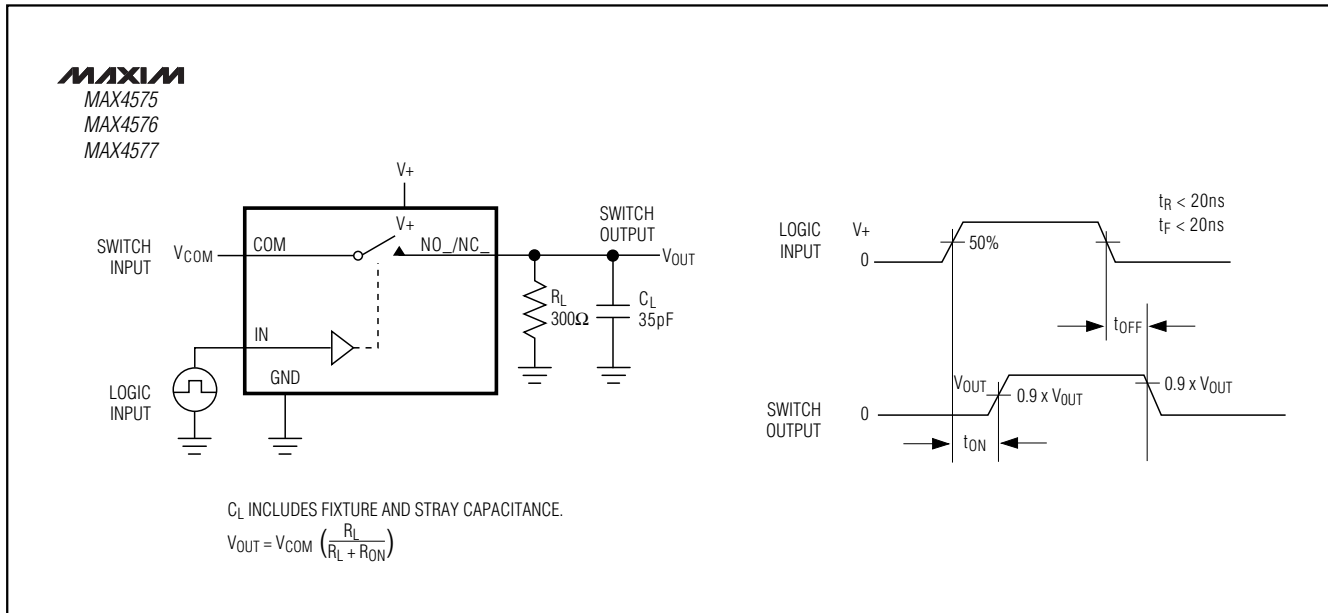


Figure 1. Switching Time

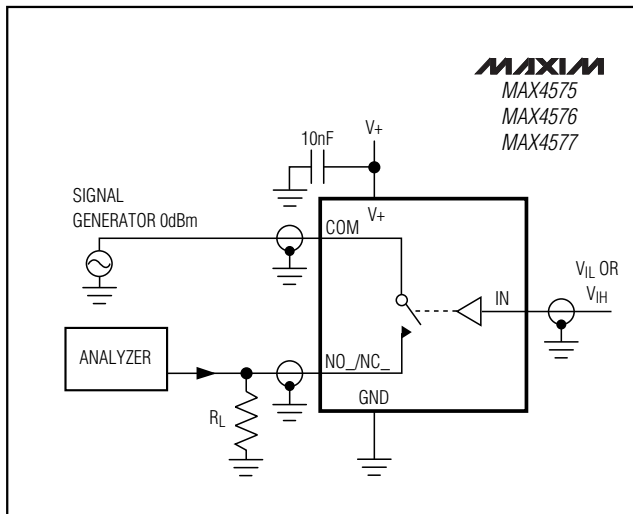


Figure 2. Off-Isolation/On-Channel Bandwidth

Detailed Description

The MAX4575/MAX4576/MAX4577 are dual SPST CMOS analog switches with circuitry providing ±15kV ESD protection on the NO and NC pins. The CMOS switch construction provides rail-to-rail signal handling while consuming virtually no power. Each of the two

switches is independently controlled by a TTL/CMOS-level-compatible digital input.

Applications Information

Do not exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the device.

Proper power-supply sequencing is recommended for all CMOS devices. Always sequence V₊ on first, followed by the logic inputs, NO/NC, or COM.

Operating Considerations for High-Voltage Supply

The MAX4575/MAX4576/MAX4577 are capable of +12V single-supply operation with some precautions. The absolute maximum rating for V₊ is +13V (referenced to GND). When operating near this region, bypass V₊ with a minimum 0.1μF capacitor to ground as close to the IC as possible.

±15kV ESD Protection

The MAX4575/MAX4576/MAX4577 are ±15kV ESD protected (according to IEC 1000-4-2) at the NC/NO terminals. To accomplish this, bidirectional SCRs are included on-chip between these terminals. When the voltages at these terminals go Beyond-the-Rail™, the corresponding SCRs turns on in a few nanoseconds

Beyond-the-Rail is a trademark of Maxim Integrated Products.

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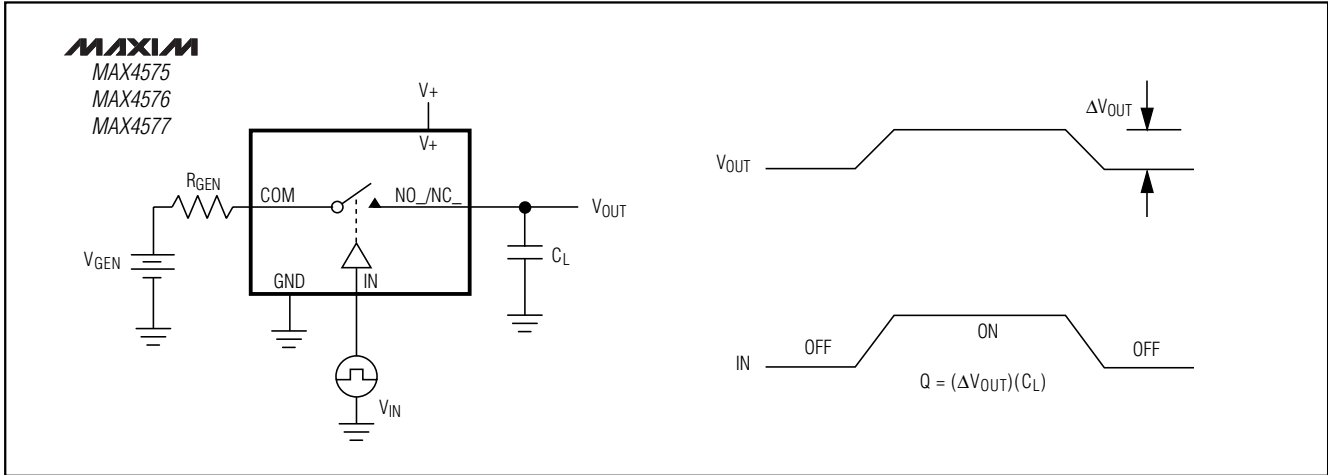


Figure 3. Charge Injection

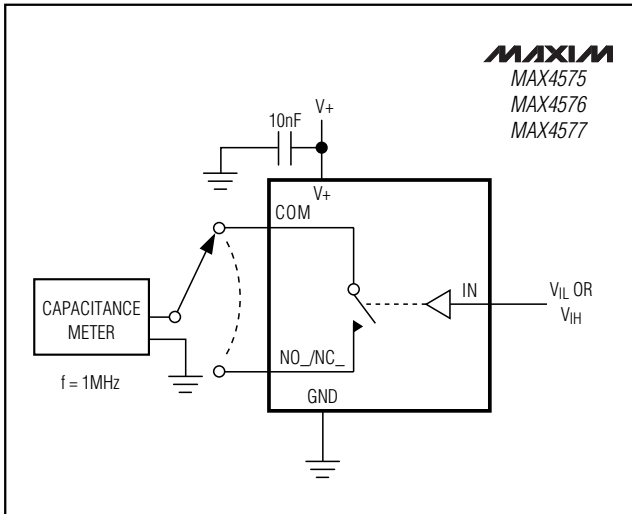


Figure 4. Channel Off/On-Capacitance

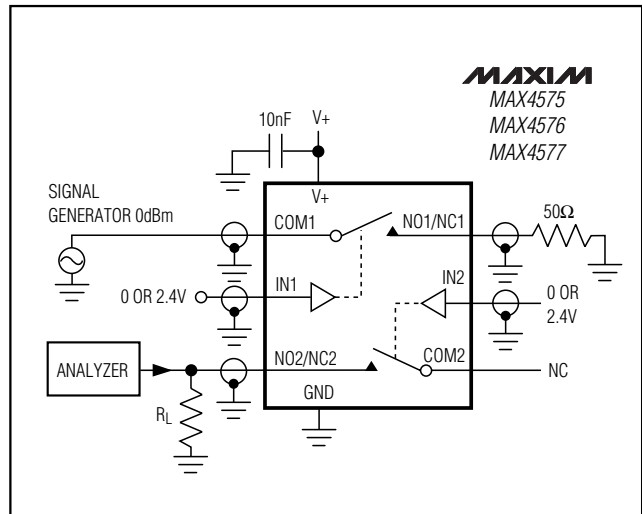


Figure 5. Crosstalk

and bypass the surge safely to ground. This method is superior to using diode clamps to the supplies because, unless the supplies are very carefully decoupled through low-ESR capacitors, the ESD current through the diode clamp could cause a significant spike in the supplies. This may damage or compromise the reliability of any other chip powered by those same supplies.

There are diodes from NC/NO to the supplies in addition to the SCRs. There is a resistance in series with each of these diodes to limit the current into the supplies during an ESD strike. The diodes protect these

terminals from overvoltages that are not a result of ESD strikes. These diodes also protect the device from improper power-supply sequencing.

Once the SCR turns on because of an ESD strike, it continues to be on until the current through it falls below its "holding current." The holding current is typically 110mA in the positive direction (current flowing into the NC/NO terminal) at room temperature (see SCR Holding Current vs. Temperature in the *Typical Operating Characteristics*). Design the system so that any sources connected to NC/NO are current limited to a value below the holding current to ensure the SCR

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turns off when the ESD event is finished and normal operation may be resumed. Also, keep in mind that the holding current varies significantly with temperature. The worst case is at $+85^{\circ}\text{C}$ when the holding currents drop to 70mA. Since this is a typical number to guarantee turn-off of the SCRs under all conditions, the sources connected to these terminals should be current limited to not more than half this value. When the SCR is latched, the voltage across it is about 3V, depending on the polarity of the pin current. The supply voltages do not affect the holding current appreciably. The sources connected to the COM side of the switches do not need to be current limited since the switches turn off internally when the corresponding SCR(s) latches.

Even though most of the ESD current flows to GND through the SCRs, a small portion of it goes into $V+$. Therefore, it is a good idea to bypass the $V+$ with 0.1 μF capacitors directly to the ground plane.

ESD protection can be tested in various ways. Transmitter outputs and receiver inputs are characterized for protection to the following:

- $\pm 15\text{kV}$ using the Human Body Model
- $\pm 8\text{kV}$ using the Contact Discharge method specified in IEC 1000-4-2 (formerly IEC 801-2)
- $\pm 15\text{kV}$ using the Air-Gap Discharge method specified in IEC 1000-4-2 (formerly IEC 801-2).

ESD Test Conditions

Contact Maxim Integrated Products for a reliability report that documents test setup, methodology, and results.

Human Body Model

Figure 6 shows the Human Body Model and Figure 7 shows the waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which can be discharged into the test device through a 1.5k Ω resistor.

IEC 1000-4-2

The IEC 1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX4575/MAX4576/MAX4577 enable the design of equipment that meets Level 4 (the highest level) of IEC 1000-4-2, without additional ESD protection components.

The major difference between tests done using the Human Body Model and IEC 1000-4-2 is higher peak current in IEC 1000-4-2. Because series resistance is lower in the IEC 1000-4-2 ESD test model (Figure 8), the ESD withstand voltage measured to this standard is generally lower than that measured using the Human Body Model. Figure 9 shows the current waveform for the $\pm 8\text{kV}$ IEC 1000-4-2 Level 4 ESD Contact Discharge test.

The Air-Gap test involves approaching the device with a charged probe. The Contact Discharge method connects the probe to the device before the probe is energized.

Chip Information

TRANSISTOR COUNT: 78

PROCESS: CMOS

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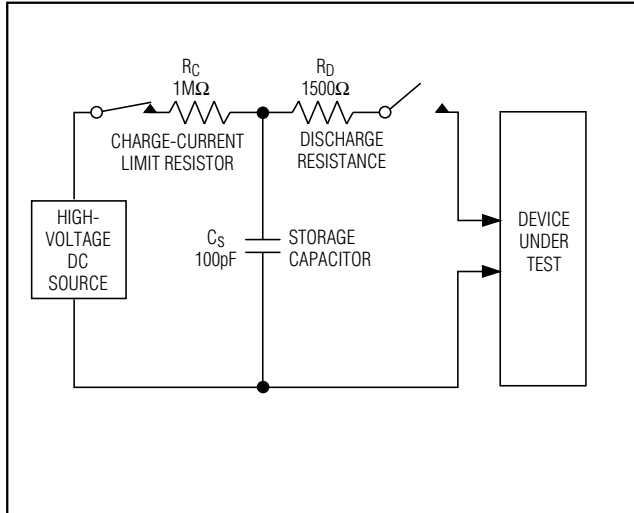


Figure 6. Human Body ESD Test Model

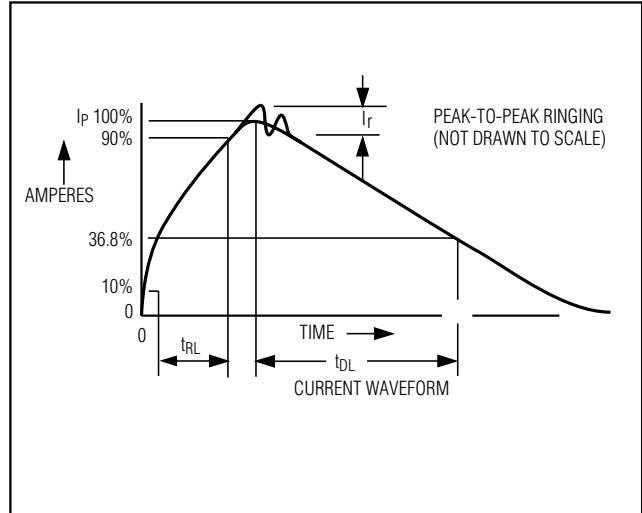


Figure 7. Human Body Model Current Waveform

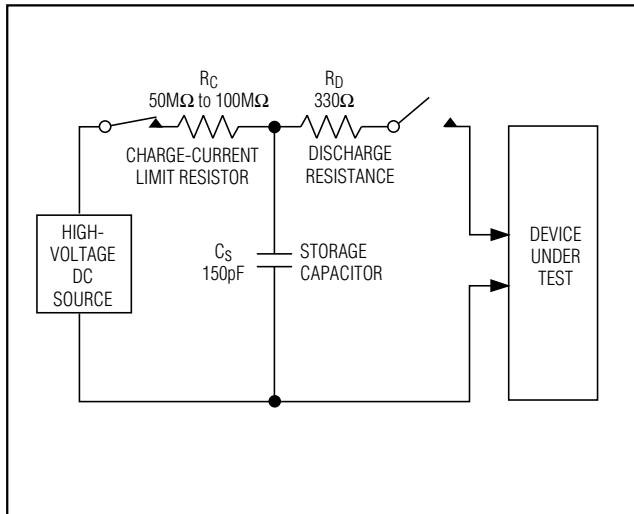


Figure 8. IEC 1000-4-2 ESD Test Model

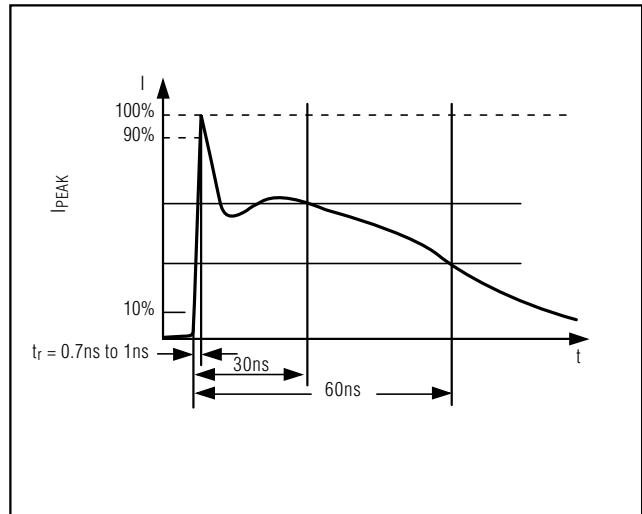
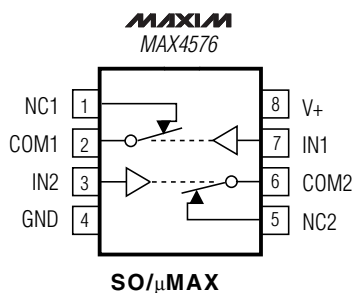


Figure 9. IEC 1000-4-2 ESD Generator Current Waveform

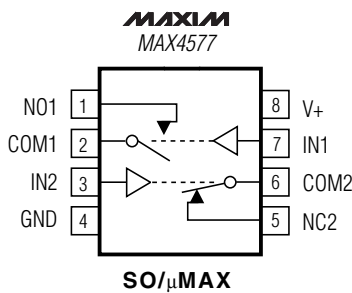
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Pin Configurations/Functional Diagrams/Truth Tables (continued)

TOP VIEW



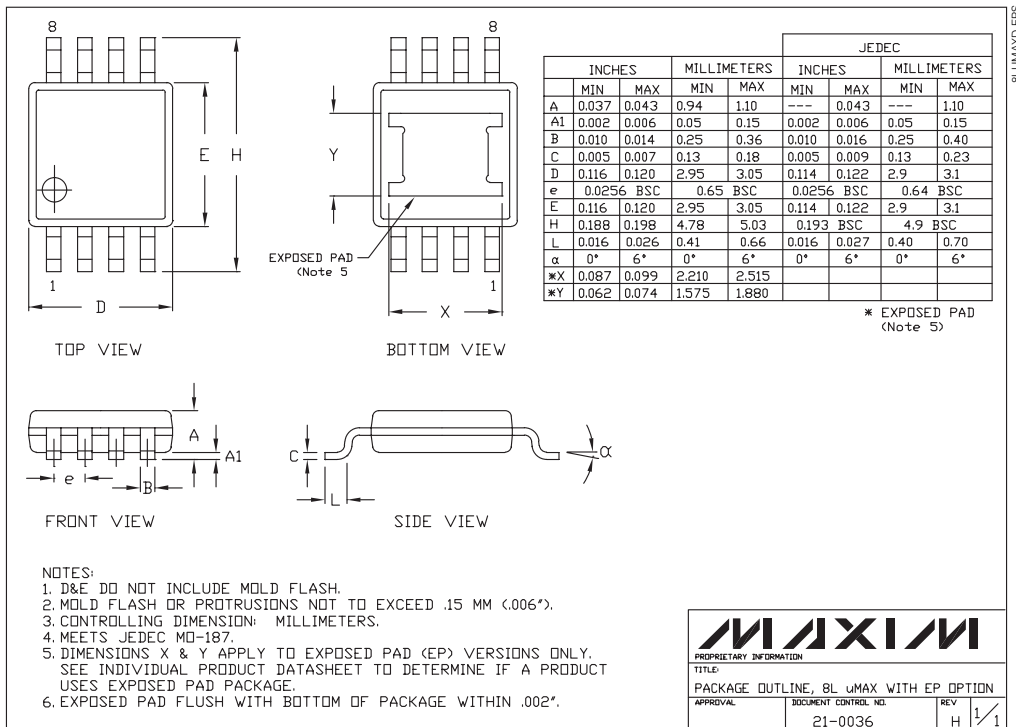
MAX4576	
LOGIC	SWITCH
0	ON
1	OFF



MAX4577		
LOGIC	SWITCH 1	SWITCH 2
0	OFF	ON
1	ON	OFF

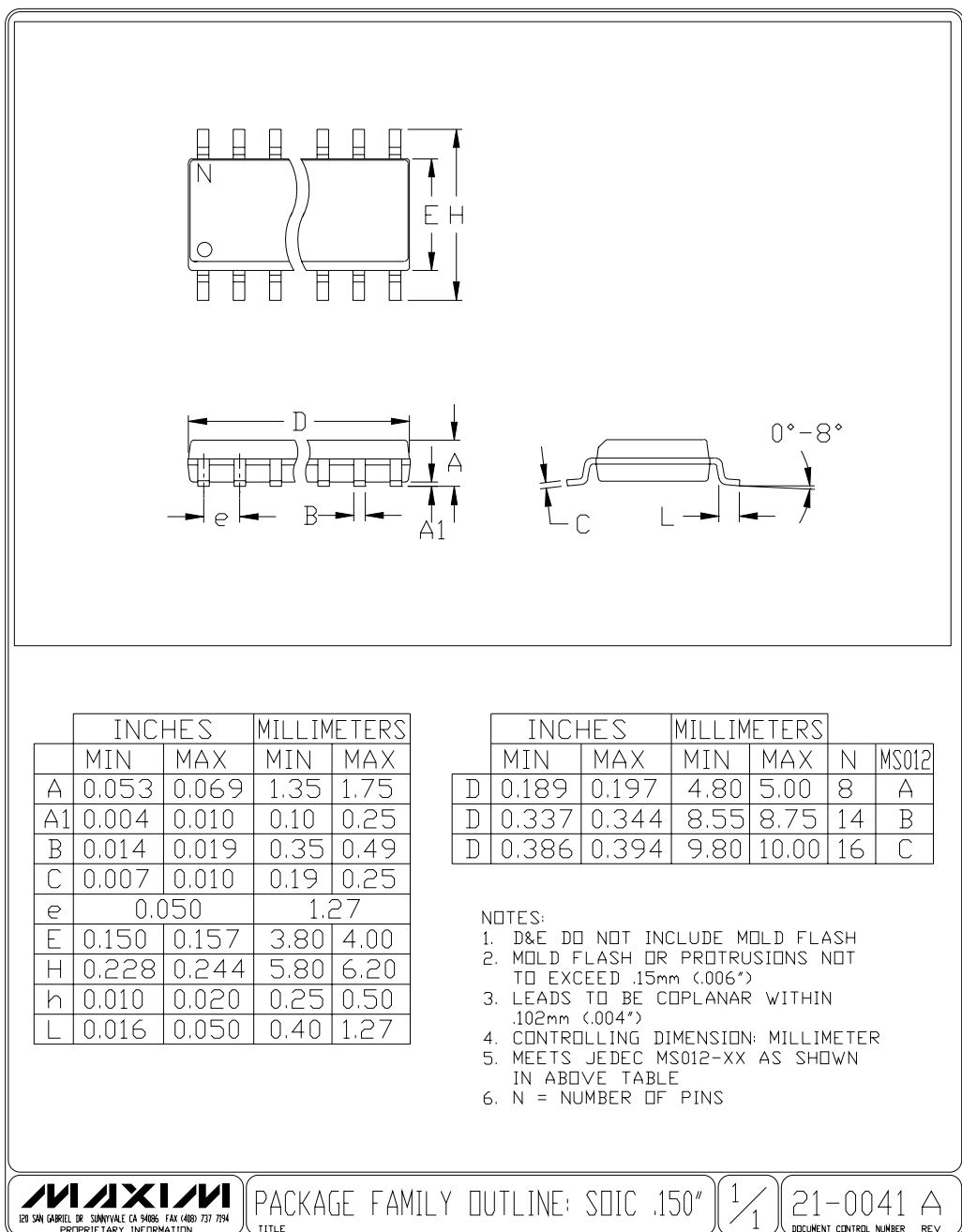
SWITCHES SHOWN FOR LOGIC "0" INPUT

Package Information



±15kV ESD-Protected, Low-Voltage, Dual, SPST, CMOS Analog Switches

Package Information (continued)



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