19-1714; Rev 1; 7/12

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

General Description

The MAX4561/MAX4568/MAX4569 are low-voltage, ESD-protected analog switches. The normally open (NO) and normally closed (NC) inputs are protected against ±15kV electrostatic discharge (ESD) without latchup or damage, and the COM input is protected against 2.5kV ESD.

These switches operate from a single +1.8V to +12V supply. The 70Ω at 5V (120Ω at 3V) on-resistance is matched between channels to 2Ω max, and is flat (4Ω max) over the specified signal range. The switches can handle Rail-to-Rail® analog signals. Off-leakage current is only 0.5nA at +25°C and 5nA at +85°C. The digital input has +0.8V to +2.4V logic thresholds, ensuring TTL/CMOS-logic compatibility when using a single +5V supply. The MAX4561 is a single-pole/double-throw (SPDT) switch. The MAX4568 NO and MAX4569 NC are single-pole/single-throw (SPST) switches.

The MAX4561 is available in a 6-pin SOT23 package, and the MAX4568/MAX4569 are available in 5-pin SOT23 packages.

Applications

High-ESD Environments

Battery-Powered Systems

Audio and Video Signal Routing

Low-Voltage Data-Acquisition Systems

Sample-and-Hold Circuits

Communications Circuits

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

Features

- **ESD-Protected NO, NC**
  - **±15kV—Human Body Model**
  - **±15kV—IEC 1000-4-2, Air-Gap Discharge**
  - **±8kV—IEC 1000-4-2, Contact Discharge**
- **Guaranteed On-Resistance**
  - **70Ω +5V Supply**
  - **120Ω with Single +3V Supply**
- **On-Resistance Match Between Channels (2Ω max)**
- **Low On-Resistance Flatness: 4Ω max**
- **Guaranteed Low Leakage Currents**
  - **0.5nA Off-Leakage (at T_A = +25°C)**
  - **0.5nA On-Leakage (at T_A = +25°C)**
- **Guaranteed Break-Before-Make at 5ns (MAX4561 only)**
- **Rail-to-Rail Signal Handling Capability**
- **TTL/CMOS-Logic Compatible with +5V Supplies**
- **Industry Standard Pin-Outs**
  - **MAX4561 Pin Compatible with MAX4544**
  - **MAX4568/MAX4569 Pin Compatible with MAX4514/MAX4515**

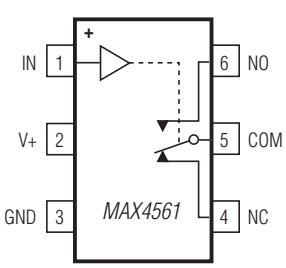
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	SOT TOP MARK
MAX4561EUT+T	-40°C to +85°C	6 SOT23	AAIE
MAX4568EUK+T	-40°C to +85°C	5 SOT23	ADOE
MAX4569EUK+T	-40°C to +85°C	5 SOT23	ADOF

+Denotes a lead(Pb)-free/RoHS-compliant package.
T = Tape and reel.

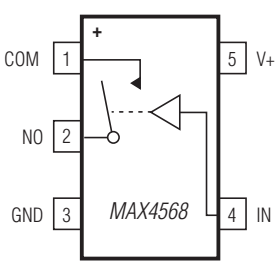
Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW



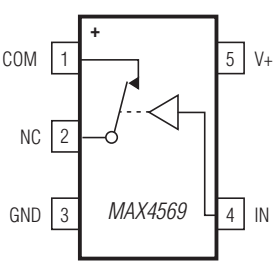
SOT23

LOGIC	NO	NC
0	OFF	ON
1	ON	OFF



SOT23

LOGIC	SWITCH
0	OFF
1	ON



SOT23

LOGIC	SWITCH
0	ON
1	OFF

SWITCHES SHOWN FOR LOGIC "0" INPUT.

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

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

ABSOLUTE MAXIMUM RATINGS

V+ to GND .....-0.3 to +13V
IN, COM, NO, NC to GND (Note 1) .....-0.3V to (V+ + 0.3V)
Continuous Current (any terminal).....±10mA
Peak Current
(NO, NC, COM; pulsed at 1ms 10% duty cycle).....±30mA
ESD Protection per Method IEC 1000-4-2 (NO, NC)
Air-Gap Discharge .....±15kV
Contact Discharge .....±8kV
ESD Protection per Method 3015.7
V+, GND, IN, COM.....±2.5kV
NO, NC.....±15kV
Continuous Power Dissipation (T_A = +70°C)
5-Pin SOT23 (derate 3.1mW/C above +70°C 247mW
6-Pin SOT23 (derate 8.7mW/°C above +70°C).....696mW
Operating Temperature Range .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C
Soldering Temperature (reflow) .....+260°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} = +2.4V, V_{IL} = +0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at T_A = +25°C.) (Notes 2, 3)

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} = 1V, 3.5V	T_A = +25°C		45	70	Ω
			T_A = T_{MIN} to T_{MAX}			75	
On-Resistance Match Between Channels (Note 4)	ΔR_{ON}	V+ = 4.5V, I_{COM} = 1mA; V_{NO} or V_{NC} = 1V, 3.5V	T_A = +25°C		0.5	2	Ω
			T_A = T_{MIN} to T_{MAX}			3	
On-Resistance Flatness (Note 5)	$R_{FLAT(ON)}$	V+ = 4.5V, I_{COM} = 1mA; V_{NO} or V_{NC} = 1V, 2.25V, 3.5V	T_A = +25°C		2	4	Ω
			T_A = T_{MIN} to T_{MAX}			5	
Off-Leakage Current (NO or NC)	$I_{NO(OFF)}$, $I_{NC(OFF)}$	V+ = 5.5V, V_{COM} = 1V, 4.5V; V_{NO} or V_{NC} = 4.5V, 1V	T_A = +25°C	-0.5	0.01	0.5	nA
			T_A = T_{MIN} to T_{MAX}	-5		5	
COM Off-Leakage Current (MAX4568/MAX4569 only)	$I_{COM(OFF)}$	V+ = 5.5V, V_{COM} = 1V, 4.5V; V_{NO} or V_{NC} = 4.5V, 1V	T_A = +25°C	-0.5	0.01	0.5	nA
			T_A = T_{MIN} to T_{MAX}	-5		5	
COM On-Leakage Current	$I_{COM(ON)}$	V+ = 5.5V, V_{COM} = 1V, 4.5V; V_{NO} or V_{NC} = 1V, 4.5V or unconnected	T_A = +25°C	-1		1	nA
			T_A = T_{MIN} to T_{MAX}	-10		10	
LOGIC INPUT							
Input Logic High	V_{IH}			2.4			V
Input Logic Low	V_{IL}					0.8	V
Input Leakage Current	I_{IN}	V_{IN} = 0 or V+		-1		1	µA

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 T_A = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS			MIN	TYP	MAX	UNITS
SWITCH DYNAMIC CHARACTERISTICS								
Turn-On Time	t_{ON}	V_{NO}, V_{NC} = 3V, R_L = 300Ω, C_L = 35pF; Figure 1	T_A = +25°C			90	150	ns
			T_A = T_{MIN} to T_{MAX}				180	
Turn-Off Time	t_{OFF}	V_{NO}, V_{NC} = 3V, R_L = 300Ω, C_L = 35pF, Figure 1	T_A = +25°C			40	80	ns
			T_A = T_{MIN} to T_{MAX}				100	
Break-Before-Make Delay (MAX4561 only)	t_{BBM}	V_{NO}, V_{NC} = 3V, R_L = 300Ω, C_L = 35pF, Figure 2			5	50		ns
Charge Injection	Q	V_{GEN} = 2V, C_L = 1.0nF, R_{GEN} = 0; Figure 3	T_A = +25°C	MAX4561		17		pC
				MAX4568/9		6		
NO or NC Off Capacitance	C_{OFF}	V_{NO} = V_{NC} = GND, f = 1MHz, Figure 4	T_A = +25°C			20		pF
COM Off-Capacitance (MAX4568/MAX4569 only)	C_{COM}	V_{COM} = GND, f = 1MHz, Figure 4	T_A = +25°C			12		pF
COM On-Capacitance	C_{COM}	V_{COM} = V_{NO}, V_{NC} = GND, f = 1MHz, Figure 4	T_A = +25°C	MAX4561		31		pF
				MAX4568/9		20		
Off-Isolation (Note 6)	V_{ISO}	V_{NO} = V_{NC} = $1V_{RMS}$, R_L = 50Ω; C_L = 5pF, f = 1MHz; Figure 5	T_A = +25°C			-75		dB
Total Harmonic Distortion	THD	R_L = 600Ω, 5Vp-p, f = 20Hz to 20kHz	T_A = +25°C			0.01		%
ESD SCR Holding Current	I_H		T_A = +25°C			110		mA
			T_A = +85°C			70		
POWER SUPPLY								
Power-Supply Range	V+				1.8		12	V
Positive Supply Current	I+	V+ = 5.5V, V_{IN} = 0 or V+	T_A = +25°C			0.05	1	µA
			T_A = T_{MIN} to T_{MAX}				10	

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

ELECTRICAL CHARACTERISTICS—Single +3V Supply

(V+ = +2.7V to +3.6V, V_{IH} = +2.0V, V_{IL} = +0.6V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified. Typical values are at T_A = +25°C.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
On-Resistance	R_{ON}	I_{COM} = 1mA, V_{NO} or V_{NC} = 1.5V, V+ = 2.7V	T_A = +25°C		75	120	Ω
			T_A = T_{MIN} to T_{MAX}			150	
LOGIC INPUT							
Input Logic High	V_{IH}			2.0			V
Input Logic Low	V_{IL}					0.6	V
SWITCH DYNAMIC CHARACTERISTICS							
Turn-On Time	t_{ON}	V_{NO} or V_{NC} = 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_{NO} or V_{NC} = 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 Delay (MAX4561 only)	T_{BBM}	V_{NO} or V_{NC} = 3V, R_L = 300Ω, C_L = 35pF, Figure 2	T_A = +25°C	1.5	80		ns

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: Parameters are 100% tested at +25°C and guaranteed by correlation at the full rated temperature.

Note 4: $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$.

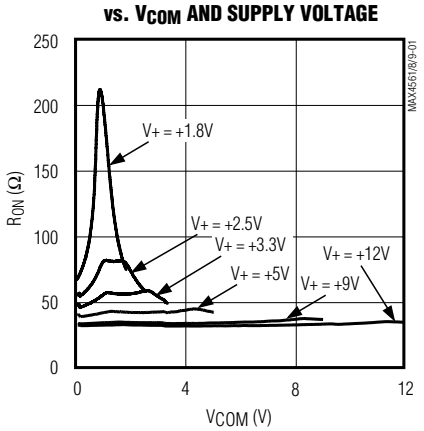
Note 5: Flatness is defined as the difference between the maximum and the minimum value of on-resistance as measured over the specified analog signal ranges.

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

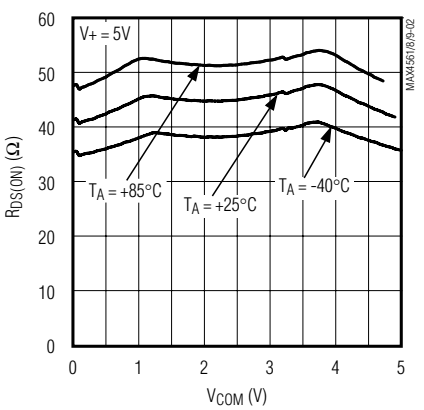
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

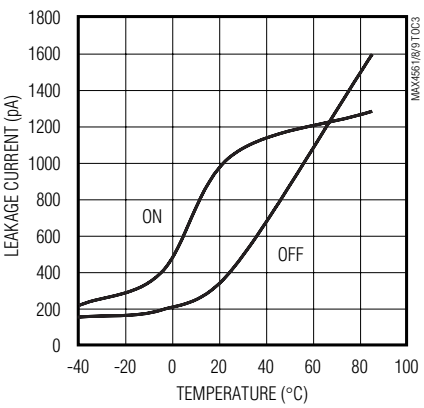
ON-RESISTANCE vs. V_{COM} AND SUPPLY VOLTAGE



ON-RESISTANCE vs. TEMPERATURE



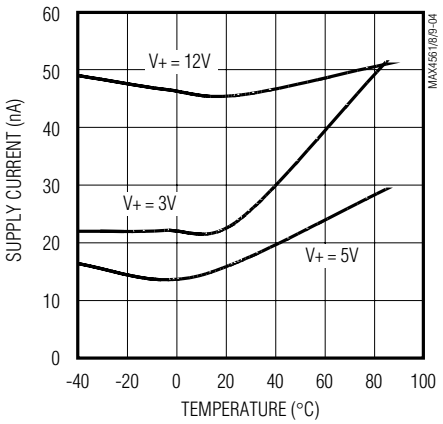
LEAKAGE CURRENT vs. TEMPERATURE



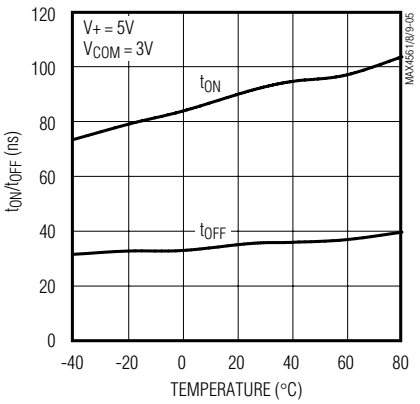
Typical Operating Characteristics (continued)

(T_A = +25°C, unless otherwise noted.)

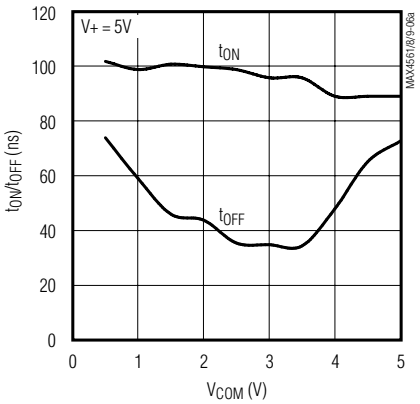
SUPPLY CURRENT vs. TEMPERATURE AND SUPPLY VOLTAGE



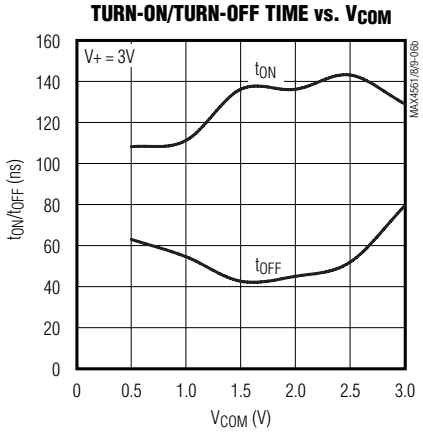
TURN-ON/TURN-OFF TIME vs. TEMPERATURE



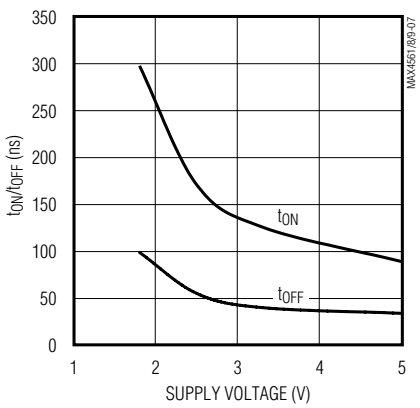
TURN-ON/TURN-OFF TIME vs. V_{COM}



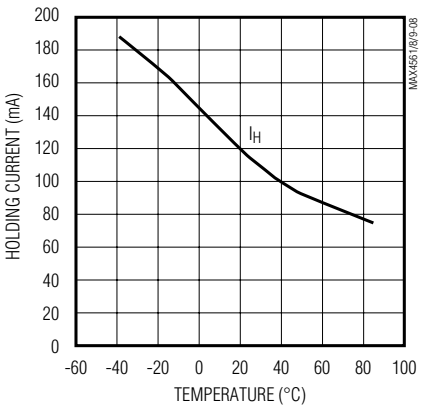
TURN-ON/TURN-OFF TIME vs. V_{COM}



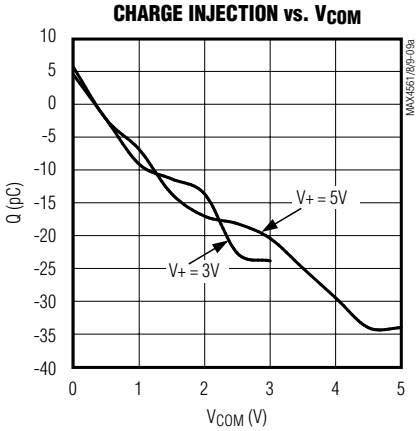
TURN-ON/TURN-OFF TIME vs. SUPPLY VOLTAGE



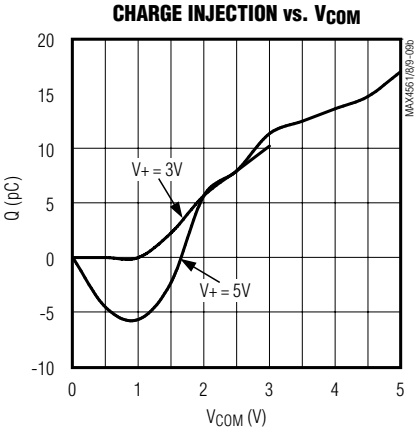
SCR HOLDING CURRENT vs. TEMPERATURE



MAX4561 CHARGE INJECTION vs. V_{COM}



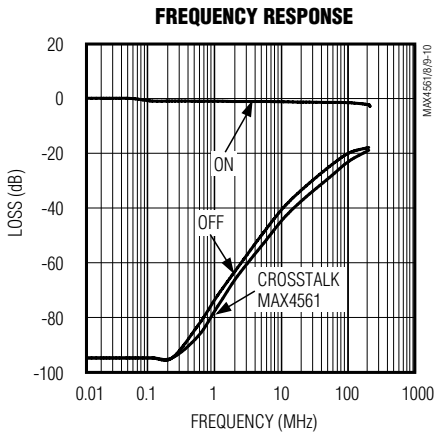
MAX4568/MAX4569 CHARGE INJECTION vs. V_{COM}

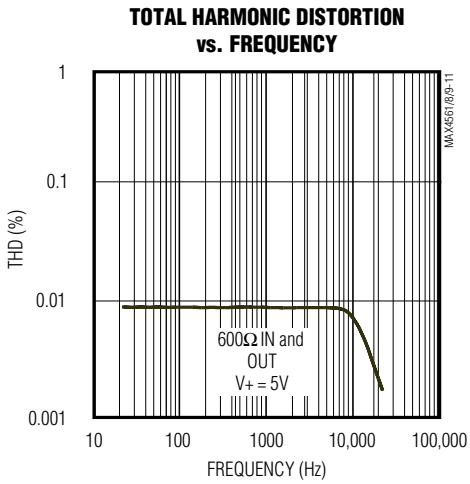


±15kV ESD-Protected, Low-Voltage, SPDT/SPST, CMOS Analog Switches

Typical Operating Characteristics (continued)

(T_A = +25°C, unless otherwise noted.)





Pin Description

PIN			NAME	FUNCTION
MAX4561	MAX4568	MAX4569		
1	4	4	IN	Logic Control Input
2	5	5	V+	Positive Supply Voltage
3	3	3	GND	Ground
4	–	2	NC	Analog Switch Normally Closed Terminal
5	1	1	COM	Analog Switch Common Terminal
6	2	–	NO	Analog Switch Normally Open Terminal

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 MAX4561/MAX4568/MAX4569 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 0.1µF min capacitor to ground as close to the device as possible.

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

±15kV ESD Protection

The MAX4561/MAX4568/MAX4569 are ±15kV ESD-protected at the NC/NO terminals in accordance with IEC1000-4-2. To accomplish this, bidirectional SCRs are included on-chip between these terminals. When the voltages at these terminals go Beyond-the-Rails™, the corresponding SCR turns on in a few nanoseconds and bypasses 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. A resistance in series with each of these diodes limits 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 remains 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 turns off when the ESD event is finished and normal operation resumes. Also, remember that the holding current varies significantly with temperature. The worst case is at +85°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 no more than half this value. When the SCR is latched, the voltage across it is approximately 3V. The supply voltages do not affect the holding current appreciably. The sources connected to the COM side of the switches need not be current limited since the switches turn off internally when the corresponding SCR(s) latch.

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 0.1µF capacitors directly to the ground plane.

ESD protection can be tested in various ways. Inputs are characterized for protection to the following:

- ±15kV using the Human Body Model
- ±8kV using the Contact Discharge method specified in IEC 1000-4-2 (formerly IEC 801-2)
- ±15kV 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 1.5kΩ 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 MAX4561 enables 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 ±8kV 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

PROCESS: CMOS

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

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

Test Circuits/Timing Diagrams

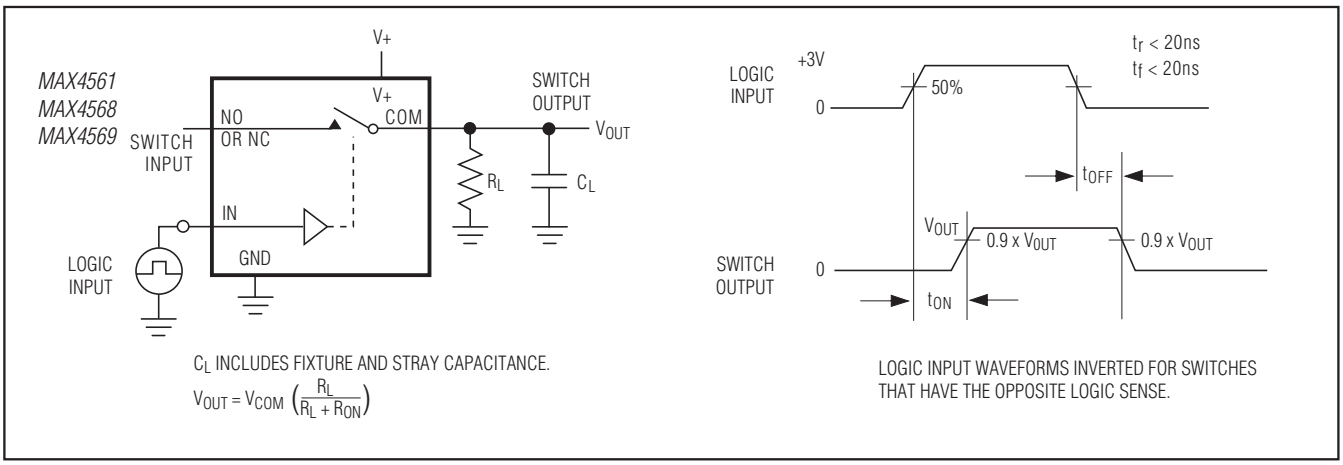


Figure 1. Switching Time

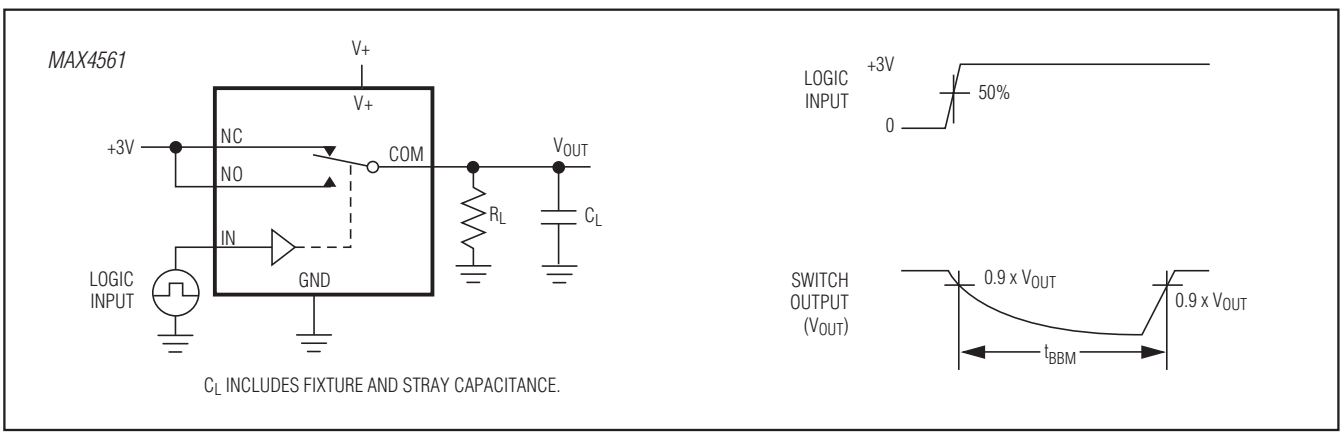


Figure 2. Break-Before-Make Interval

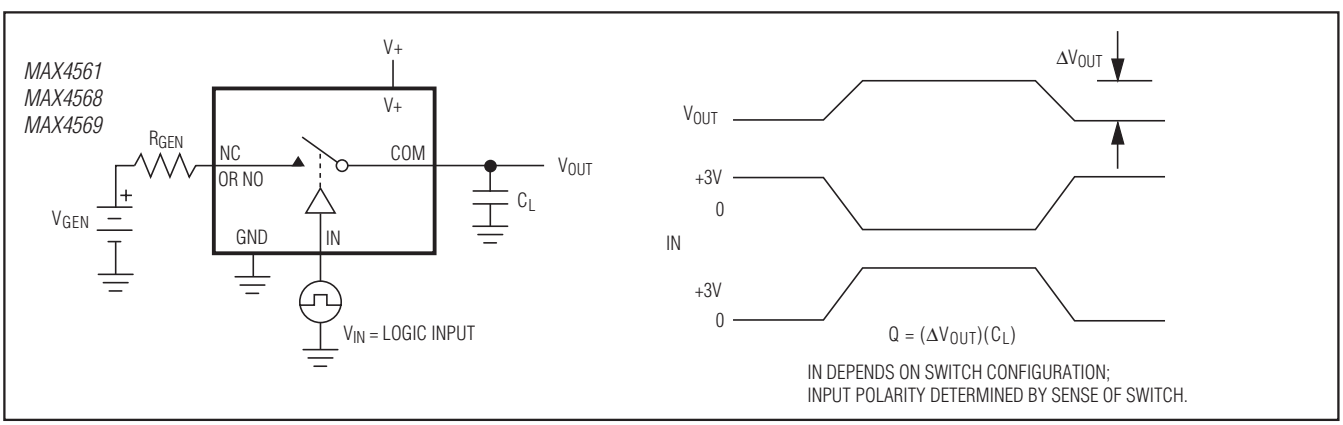


Figure 3. Charge Injection

Test Circuits/Timing Diagrams (continued)

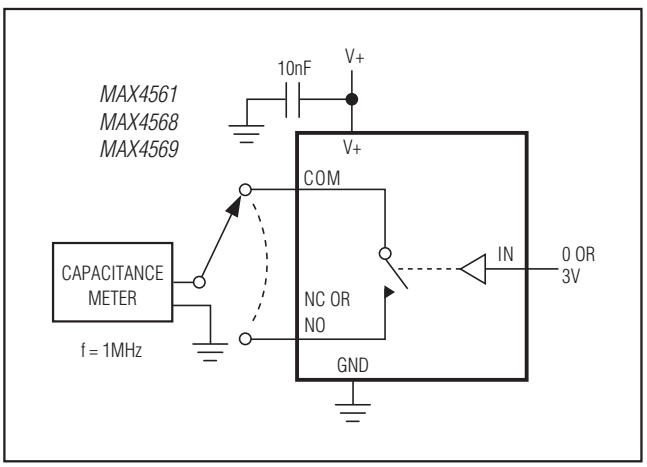


Figure 4. Channel On/Off-Capacitance

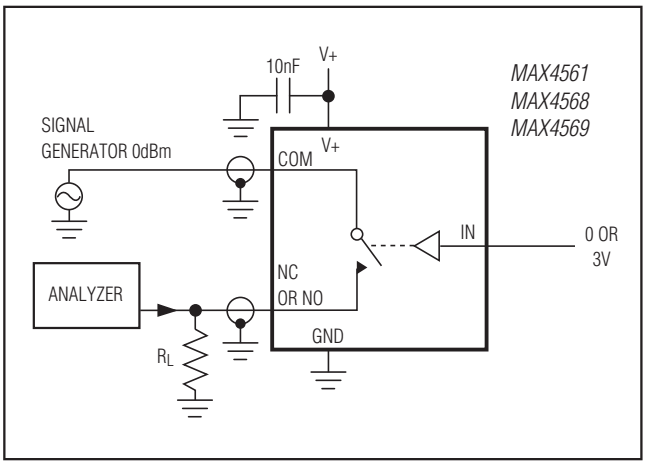


Figure 5. Off-Isolation/On-Channel

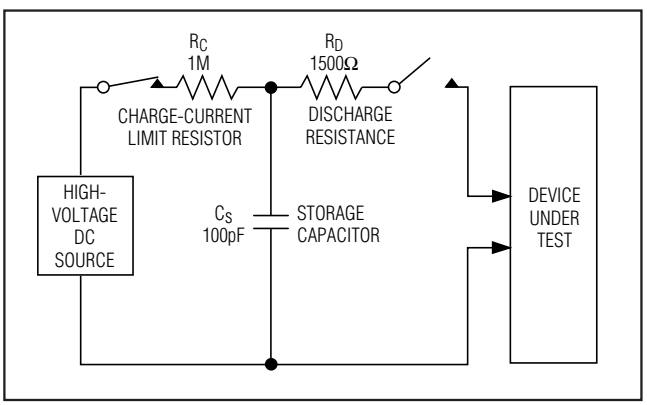


Figure 6. Human Body ESD Test Model

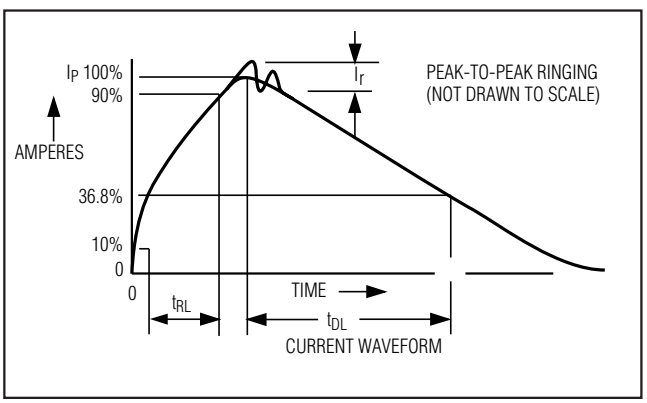


Figure 7. Human Body Model Current Waveform

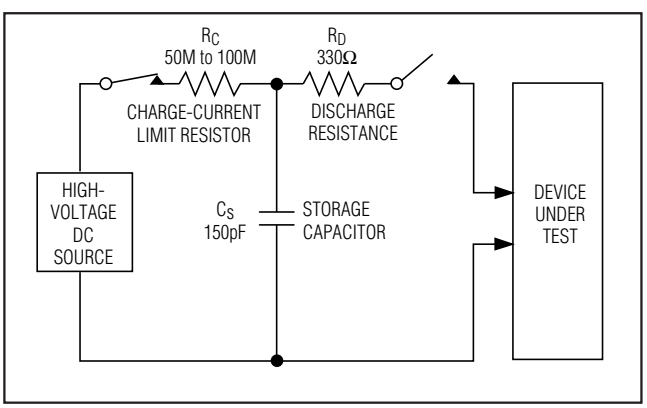


Figure 8. IEC 1000-4-2 ESD Test Model

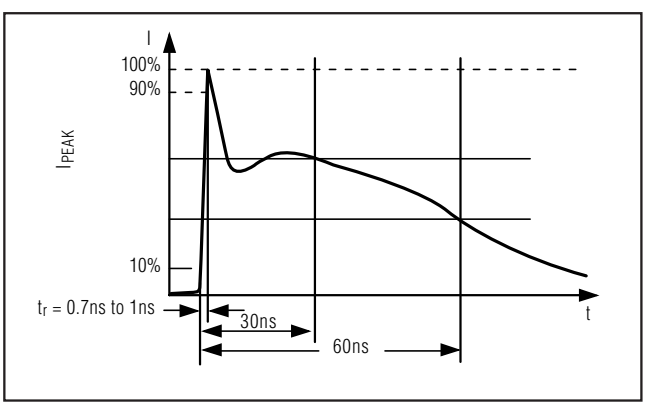


Figure 9. IED 1000-4-2 ESD Generator Current Waveform

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

Package Information

For the latest package outline information and land patterns (footprints), go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
5 SOT23	U5+2	21-0057	90-0174
6 SOT23	U6SN+1	21-0058	90-0175

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	4/00	Initial release	—
1	7/12	Added RoHS packaging option to data sheet	1, 2, 10

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