

# MAX14589E/MAX14594E

## High-Density, ±5V Capable DPDT Analog Switches

### General Description

The MAX14589E/MAX14594E high-density, double-pole/double-throw (DPDT) analog switches feature Beyond-the-Rails™ capability that allows signals from -5.5V to +5.5V to pass without distortion even when the power supply is below the signal range. The low  $R_{ON}$  resistance (0.2Ω) makes the devices ideal for low-distortion switching, such as audio.

The MAX14594E has internal shunt switches that discharge the audio amplifier AC-coupling capacitance at the normally open (NO1 and NO2) terminals. This feature reduces click-and-pop sounds that occur when switching audio signals between precharged points.

The switches are fully specified to operate from a single +1.6V to +5.5V power supply. Because of the low supply current requirement,  $V_{CCEN}$  can be provided by a GPIO. When the power is not applied, switches go to a high-impedance mode and all analog signal ports can withstand signals from -5.5V to +5.5V. The devices control the switches with a control bit, CB.

The MAX14589E/MAX14594E are available in a 1.2mm x 1.2mm, 0.4mm pitch, 9-bump wafer-level package (WLP), and operate over the -40°C to +85°C extended temperature range.

### Applications

Smartphones  
Tablets  
Portable Audio/Video Equipment  
Portable Navigation Devices

### Benefits and Features

- ◆ **Distortion-Free Beyond-the-Rails Signaling**
  - ◇ Negative Audio and Video Signal Capable
  - ◇ -5.5V to +5.5V Analog Signal Range Independent from  $V_{CCEN}$
  - ◇ On-Resistance 0.2Ω (typ)
  - ◇ +1.6V to +5.5V Single-Supply Range
  - ◇ Click-and-Pop Suppression
- ◆ **Smooth Switch Transition**
  - ◇ Break-Before-Make Operation
- ◆ **Low Supply Current 30μA (typ) at 1.6V**
  - ◇ Can be Powered by a GPIO
  - ◇ High-Impedance Mode When  $V_{CCEN}$  Not Applied
- ◆ **ESD Protection on COM<sub>1</sub>**
  - ◇ ±15kV Human Body Model
  - ◇ ±10kV IEC 61000-4-2 Air Gap
  - ◇ ±8kV IEC 61000-4-2 Contact
- ◆ **ESD Protection on NC<sub>1</sub> and NO<sub>1</sub>**
  - ◇ ±15kV Human Body Model
- ◆ **Small Board Space**
  - ◇ 9-Bump WLP (1.2mm x 1.2mm) Package
- ◆ **-40°C to +85°C Operating Temperature Range**

*Ordering Information/Selector Guide appears at end of data sheet.*

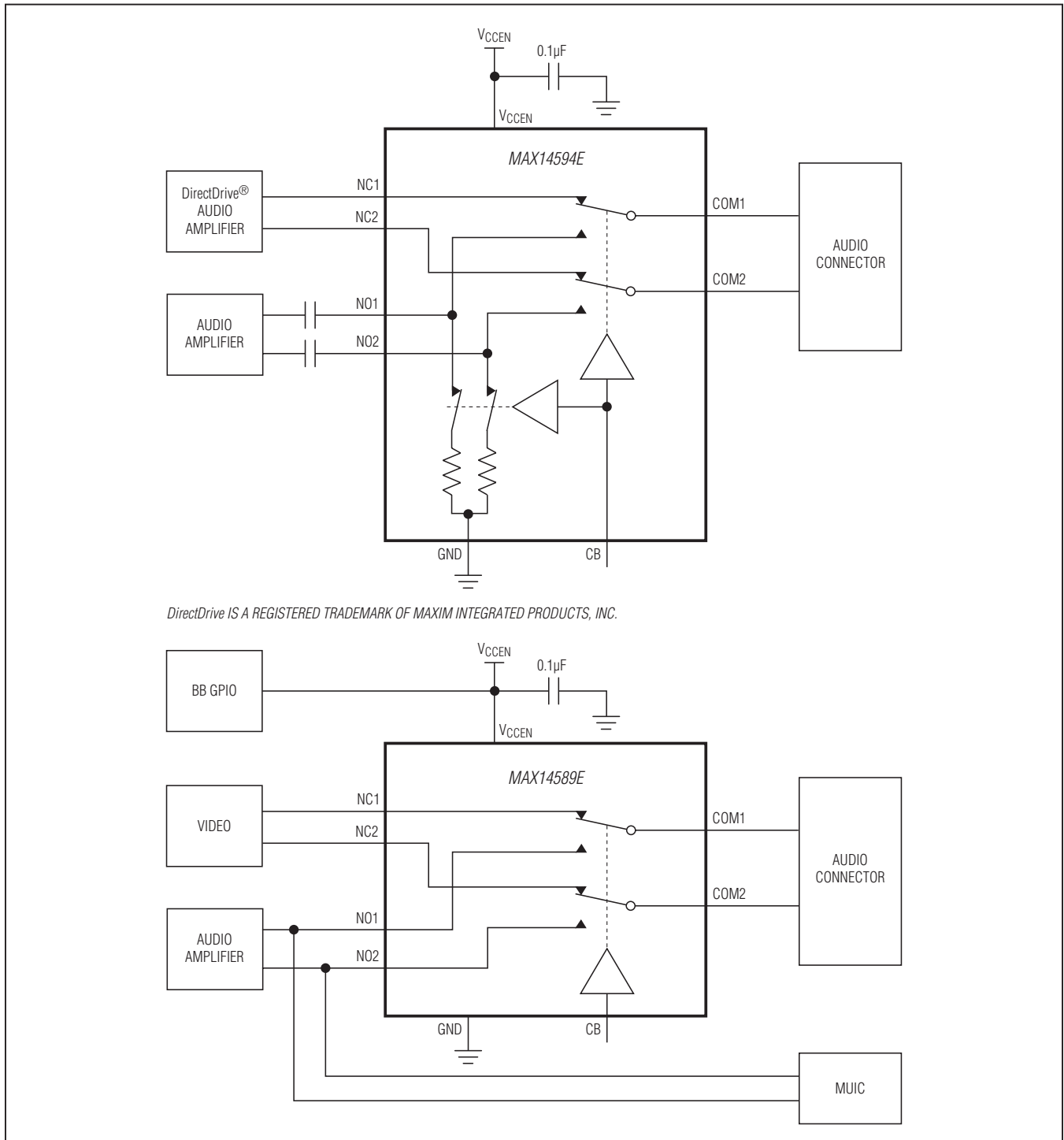
*For related parts and recommended products to use with this part, refer to [www.maximintegrated.com/MAX14589E.related](http://www.maximintegrated.com/MAX14589E.related).*

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

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### Typical Application Circuits/Functional Diagrams



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### ABSOLUTE MAXIMUM RATINGS

(All Voltages Referenced to GND.)

V <sub>CCEN</sub> , CB	-0.3V to +6V
NC <sub>-</sub> , NO <sub>-</sub> , COM <sub>-</sub>	-6V to +6V
Continuous Current NC <sub>-</sub> , NO <sub>-</sub> , COM <sub>-</sub>	±500mA
Peak Current NC <sub>-</sub> , NO <sub>-</sub> , COM <sub>-</sub> (50% duty cycle)	±850mA

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

WLP (derate 12mW/°C above +70°C)	963.8mW
Operating Temperature Range	-40°C to +85°C
Junction Temperature	+150°C
Storage Temperature Range	-65°C to +150°C
Soldering Temperature (reflow)	+260°C

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.

### PACKAGE THERMAL CHARACTERISTICS (Note 1)

WLP

Junction-to-Ambient Thermal Resistance (θ<sub>JA</sub>) .....83°C/W

**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maximintegrated.com/thermal-tutorial](http://www.maximintegrated.com/thermal-tutorial).

### ELECTRICAL CHARACTERISTICS

(V<sub>CCEN</sub> = +1.6V to +5.5V, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V<sub>CCEN</sub> = +2.5V and T<sub>A</sub> = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>POWER SUPPLY</b>						
Power-Supply Range	V <sub>CCEN</sub>		1.6		5.5	V
PSRR		R <sub>COM-</sub> = 32Ω, f = 20kHz		80		dB
V <sub>CCEN</sub> Supply Current	I <sub>CC</sub>	V <sub>CCEN</sub> = +1.60V, V <sub>CB</sub> = 0V or V <sub>CCEN</sub>		30	50	μA
		V <sub>CCEN</sub> = +4.2V, V <sub>CB</sub> = 0V or V <sub>CCEN</sub>		35	60	
<b>ANALOG SWITCH</b>						
Analog Signal Range (Note 3)	V <sub>NC-</sub> , V <sub>NO-</sub> , V <sub>COM-</sub>	V <sub>CCEN</sub> > 1.6V	-5.5		+5.5	V
		V <sub>CCEN</sub> < 1.6V, R <sub>S</sub> = 50Ω	-5.5		+5.5	
On-Resistance	R <sub>ON</sub>	V <sub>COM-</sub> = 0V, I <sub>COM-</sub> = 100mA (Note 4)	V <sub>CCEN</sub> = 2.5V	0.2	0.38	Ω
			V <sub>CCEN</sub> = 1.8V	0.25	0.43	
On-Resistance Match Between Channels	ΔR <sub>ON(NC)</sub>	V <sub>CCEN</sub> = 2.5V, V <sub>NC-</sub> = 0V, I <sub>COM-</sub> = 100mA, between same NC <sub>-</sub> and NO <sub>-</sub> channel (Note 5)		0.005	0.05	Ω
On-Resistance Flatness	R <sub>FLAT(ON)</sub>	V <sub>CCEN</sub> = 2.5V, I <sub>COM-</sub> = 100mA, V <sub>COM-</sub> = -5.5V to +5.5V (Notes 6, 7)		0.001	0.01	Ω
Shunt Switch Resistance	R <sub>SHUNT</sub>	I <sub>COM-</sub> = 1mA, MAX14594E		500	1000	Ω
NC <sub>-</sub> or NO <sub>-</sub> Off-Leakage Current	I <sub>NC-(OFF)</sub> , I <sub>NO-(OFF)</sub>	V <sub>CCEN</sub> = 2.5V; open switch; V <sub>NO-</sub> or V <sub>NC-</sub> = -5.5V, +5.5V; V <sub>COM-</sub> = +5.5V, -5.5V, unconnected	-400		+400	nA
		V <sub>CCEN</sub> = 0V; V <sub>NO-</sub> or V <sub>NC-</sub> = 0V, +5.5V; V <sub>COM-</sub> = +5.5V, 0V, unconnected	-400		+400	
COM <sub>-</sub> Off-Leakage Current	I <sub>COM-(OFF)</sub>	V <sub>CCEN</sub> = 0V; V <sub>COM-</sub> = +5.5V, 0V; V <sub>NO-</sub> or V <sub>NC-</sub> = 0V, +5.5V, unconnected	-400		+400	nA

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### ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +1.6V$  to  $+5.5V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted. Typical values are at  $V_{CC} = +2.5V$  and  $T_A = +25^{\circ}C$ .) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
COM_ On-Leakage Current	$I_{COM\_}(ON)$	$V_{CCEN} = 2.5V$ ; switch closed; $V_{COM\_} = +5.5V, -5.5V$ ; $V_{NO\_}$ or $V_{NC\_} = +5.5V, -5.5V$ , unconnected	-400		+400	nA
<b>DYNAMIC TIMING</b>						
Turn-On Time	$t_{ON}$	$V_{NO\_}$ or $V_{NC\_} = 0V$ , $R_L = 50\Omega$ , Figure 1a (Note 6)		5	10	ms
Turn-Off Time	$t_{OFF}$	$V_{NO\_}$ or $V_{NC\_} = 0V$ , $R_L = 50\Omega$ , Figure 1a (Note 6)		1	2.25	ms
Break-Before-Make Time	$t_{BBM}$	$R_L = 50\Omega$ , $V_{CCEN} = 3.3V$ , time for both $NC\_/NO\_$ switches are open during transition, Figure 1b (Note 6)	0	5	10	ms
<b>AUDIO PERFORMANCE</b>						
Total Harmonic Distortion Plus Noise	THD+N	$f = 20Hz$ to $20kHz$ , $V_{COM\_} = 0.5V_{P-P}$ , $R_S = R_L = 50\Omega$ , DC bias = $0V$		0.001		%
Off-Isolation	$V_{ISO}$	$R_S = R_L = 50\Omega$ , $V_{COM\_} = 0.5V_{P-P}$ , $f = 100kHz$ , $V_{CCEN} = 0V$ , DC bias = $0.25V$ , Figure 2		-60		dB
Crosstalk	$V_{CT}$	$R_S = R_L = 50\Omega$ , $V_{COM\_} = 0.5V_{P-P}$ , $f = 100kHz$ , Figure 2 (Note 8)		-80		dB
-3dB Bandwidth (Note 9)	BW	$R_S = R_L = 50\Omega$ , $V_{NO\_}/NC_$ , $V_{COM\_} < 2V_{P-P}$		200		MHz
NC_ or NO_ Off-Capacitance	$C_{NC\_}(OFF)$ $C_{NO\_}(OFF)$	$V_{NC\_}/NO_ = 0.5V_{P-P}$ , $f = 1MHz$		25		pF
COM_ On-Capacitance	$C_{COM\_}(ON)$	$V_{NC\_}/NO_ = 0.5V_{P-P}$ , $f = 1MHz$		50		pF
<b>DIGITAL I/O (CB)</b>						
Input Logic-High Voltage	$V_{IH}$		1.4			V
Input Logic-Low Voltage	$V_{IL}$				0.4	V
Input Leakage Current	$I_{IN}$	$V_{CB} = 0V$ or $V_{CCEN}$	-1		+1	$\mu A$
<b>ESD PROTECTION</b>						
COM1, COM2		Human Body Model		±15		kV
		IEC 61000-4-2 Air-Gap Discharge		±10		
		IEC 61000-4-2 Contact Discharge		±8		
NO_, NC_		Human Body Model		±15		kV
All Other Pins		Human Body Model		±2		kV

**Note 2:** All specifications are 100% production tested at  $T_A = +25^{\circ}C$ , unless otherwise noted. Specifications are over  $-40^{\circ}C$  to  $+85^{\circ}C$  and are guaranteed by design.

**Note 3:** Full analog voltage range supported for signal frequencies less than 50kHz applied to all signal pins.

**Note 4:** The same limits apply for  $V_{COM\_} = -5.5V$  to  $+5.5V$  and are guaranteed by design.

**Note 5:**  $\Delta R_{ON(MAX)} = |R_{ON(CH1)} - R_{ON(CH2)}|$ .

**Note 6:** Guaranteed by design; not production tested.

**Note 7:** Flatness is defined as the difference between the maximum and minimum value of on-resistance, as measured over specified analog signal ranges.

**Note 8:** Between two switches.

**Note 9:** Full bandwidth supported for signal amplitudes less than 2V peak to peak applied to all signal pins.

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### Timing Diagrams

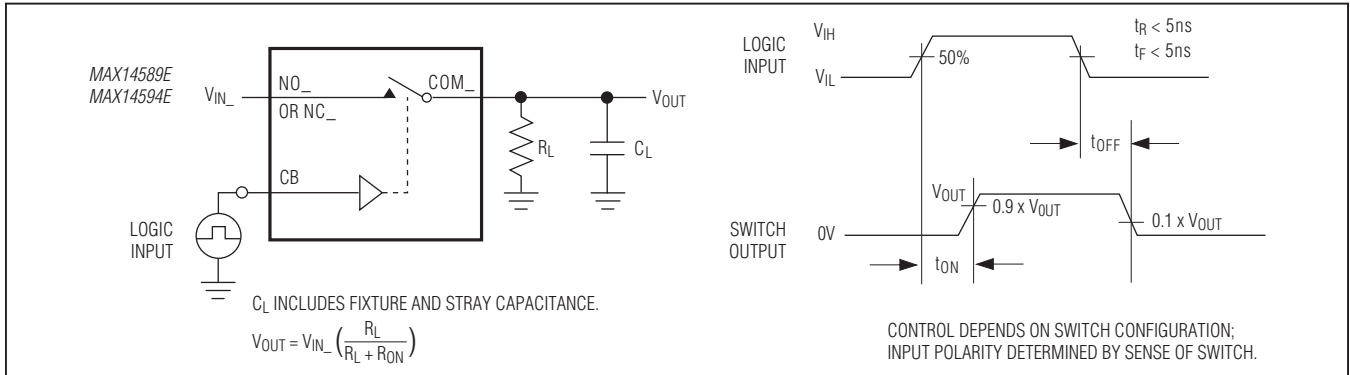


Figure 1a. Switching Time

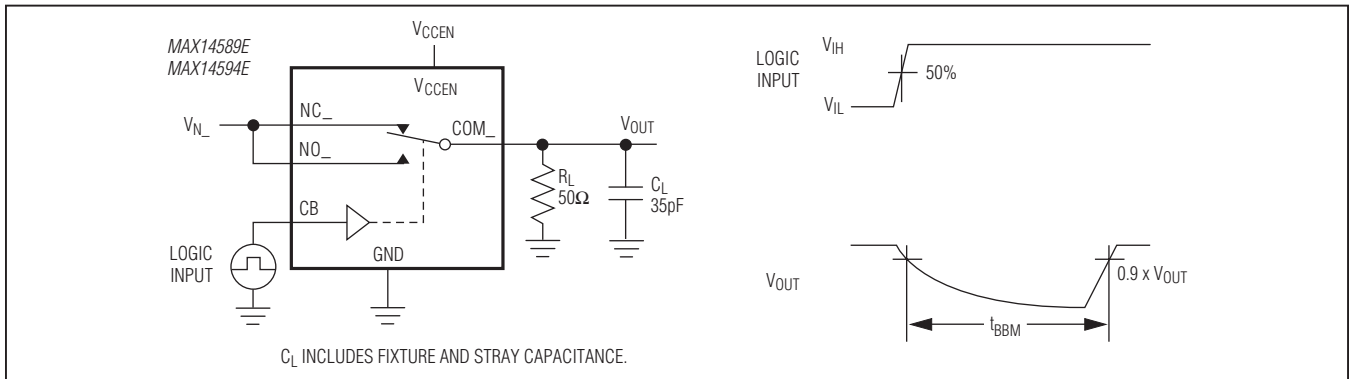


Figure 1b. Break-Before-Make Interval

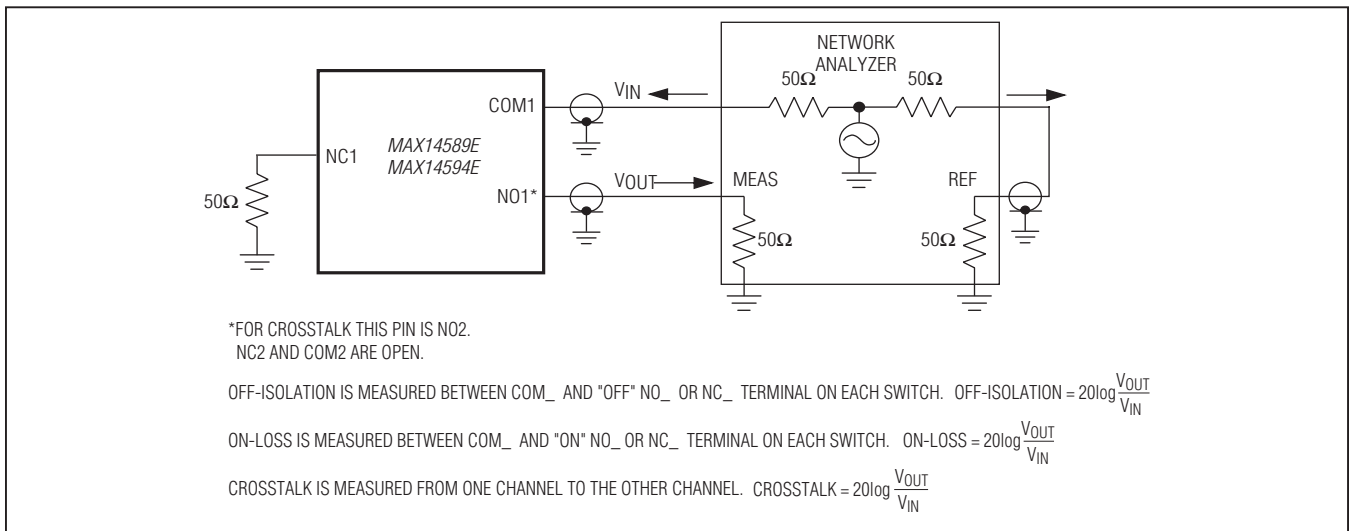


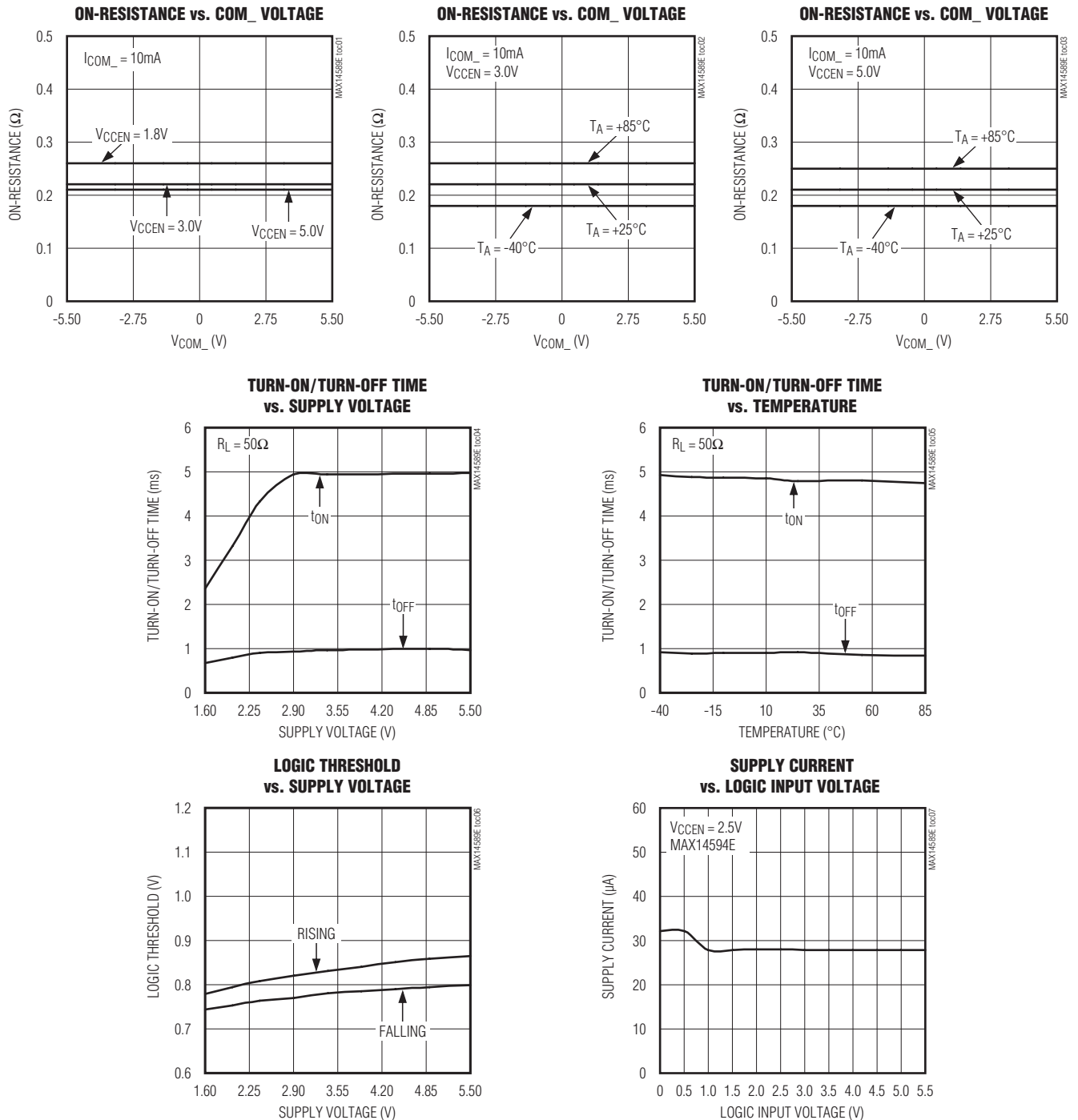
Figure 2. On-Loss, Off-Isolation, and Crosstalk

# MAX14589E/MAX14594E

## High-Density, $\pm 5V$ Capable DPDT Analog Switches

### Typical Operating Characteristics

( $V_{CCEN} = +2.5V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

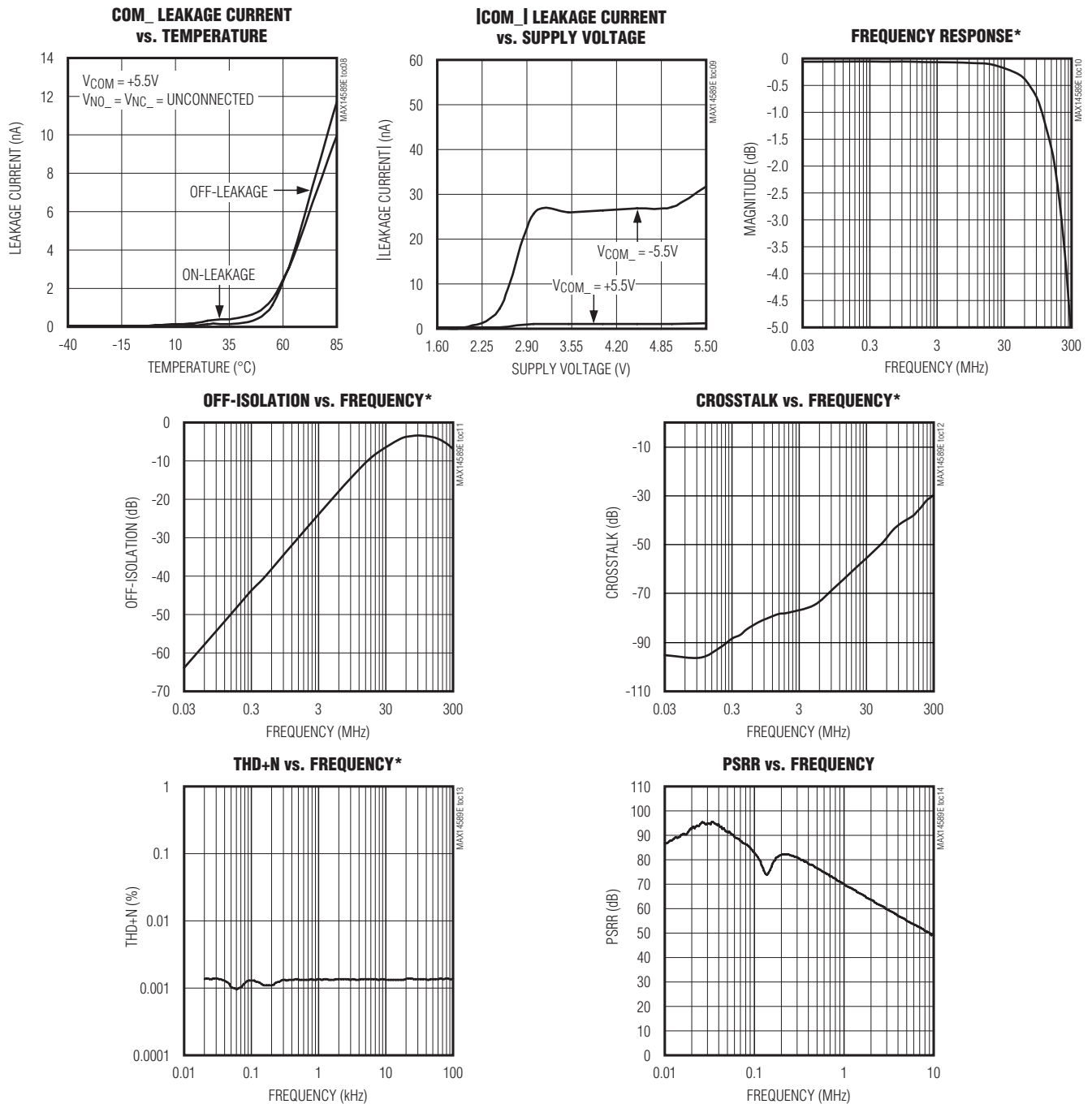


# MAX14589E/MAX14594E

## High-Density, $\pm 5V$ Capable DPDT Analog Switches

### Typical Operating Characteristics (continued)

( $V_{CCEN} = +2.5V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

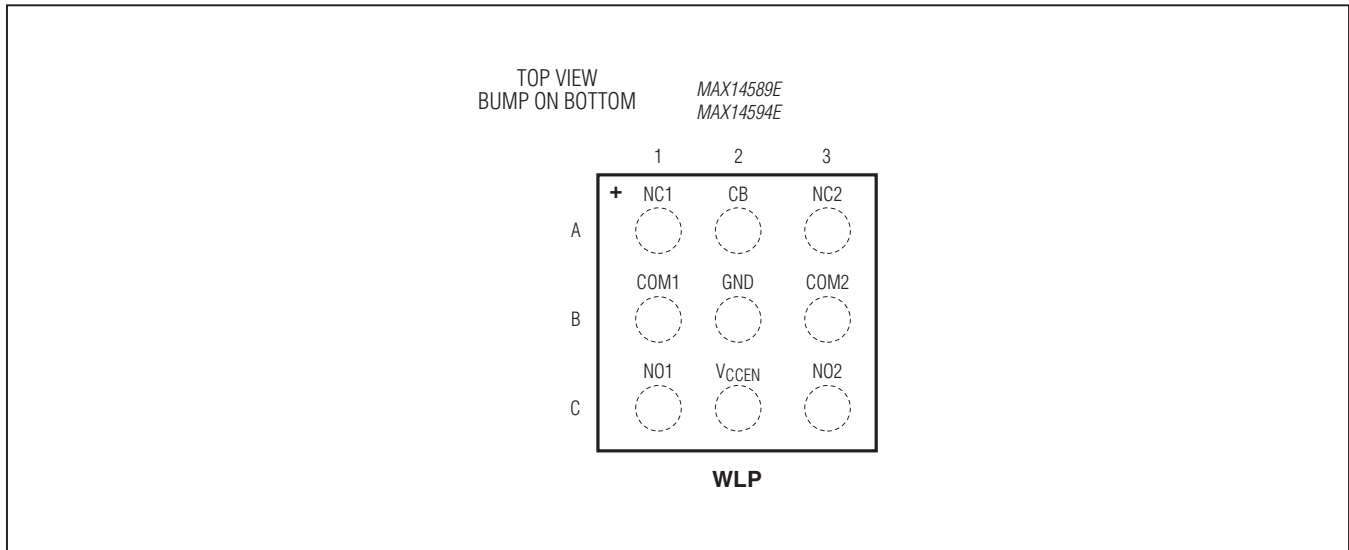


**\*Note:** Signals with frequencies greater than 50kHz are supported for amplitudes up to  $2V_{p-p}$ . Full analog voltage range supported for signal frequencies less than 50kHz applied to any signal pin.

# MAX14589E/MAX14594E

## High-Density, $\pm 5V$ Capable DPDT Analog Switches

### Bump Configuration



### Bump Description

BUMP	NAME	FUNCTION
A1	NC1	Normally Closed Terminal for Switch 1
A2	CB	Digital Control Input. Drive CB low to connect COM_ to NC_. Drive CB high to connect COM_ to NO_.
A3	NC2	Normally Closed Terminal for Switch 2
B1	COM1	Common Terminal for Switch 1
B2	GND	Ground
B3	COM2	Common Terminal for Switch 2
C1	NO1	Normally Open Terminal for Switch 1
C2	VCCEN	Positive Supply Voltage Input. Bypass VCCEN to GND with a 0.1 $\mu$ F capacitor as close as possible to the device.
C3	NO2	Normally Open Terminal for Switch 2



# MAX14589E/MAX14594E

## High-Density, $\pm 5V$ Capable DPDT Analog Switches

### Detailed Description

The MAX14589E/MAX14594E are low on-resistance and high ESD-protected DPDT switches that operate from a +1.6V to +5.5V supply and are designed to multiplex AC-coupled analog signals. These switches feature the low on-resistance ( $R_{ON}$ ) necessary for high-performance switching applications. The Beyond-the-Rails signal capability of the analog channel allows signals below ground and above  $V_{CCEN}$  to pass through without distortion.

### Analog Signal Levels

The devices are bidirectional, allowing NO<sub>-</sub>, NC<sub>-</sub>, and COM<sub>-</sub> to be configured as either inputs or outputs. The topology of the internal switches allows the signal to drop below ground without the need of an external negative voltage supply. **Note:** The devices can withstand analog signal levels of -5.5V to +5.5V when the device is not powered.

### Digital Control Input

The devices provide a single-bit control logic input, CB. CB controls the switch position, as shown in the [Typical Application Circuits/Functional Diagrams](#).

### Click-and-Pop Suppression (MAX14594E Only)

The 500 $\Omega$  shunt resistors automatically discharge any capacitance at both NO<sub>-</sub> terminals when they are not connected to COM<sub>-</sub>. This reduces audio click-and-pop

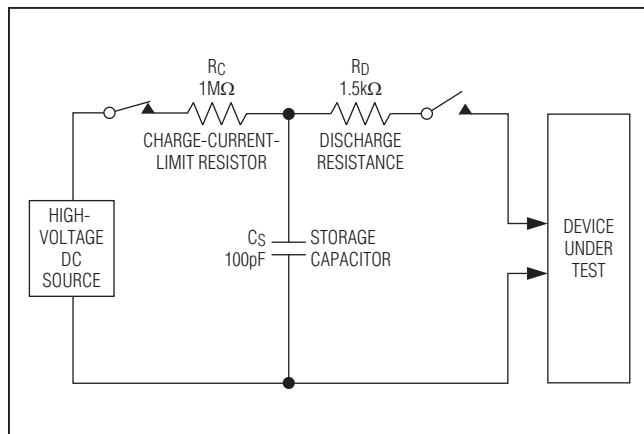


Figure 3. Human Body ESD Test Model

sounds that might occur when switching between capacitively coupled audio sources.

The shunt resistors are controlled by CB. When CB is low, NC<sub>-</sub> is connected to COM<sub>-</sub> and NO<sub>-</sub> is connected to the shunt resistors. When CB is high, NO<sub>-</sub> is connected to COM<sub>-</sub> and the shunt resistors are unconnected.

### Applications Information

#### Extended ESD Protection

ESD-protection structures are incorporated on all pins to protect against electrostatic discharges up to  $\pm 2kV$  (HBM) encountered during handling and assembly. COM1 and COM2 are further protected against ESD up to  $\pm 15kV$  (HBM),  $\pm 10kV$  (Air-Gap Discharge), and  $\pm 8kV$  (Contact Discharge) without damage. NO<sub>-</sub> and NC<sub>-</sub> are further protected against ESD up to  $\pm 15kV$  (HBM) without damage. The ESD structures withstand high ESD both in normal operation and when the device is powered down. After an ESD event, the devices continue to function without latchup.

#### ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test methodology and test results.

#### Human Body Model

Figure 3 shows the Human Body Model. Figure 4 shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest that is then discharged into the device through a 1.5k $\Omega$  resistor.

#### IEC 61000-4-2

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment. It does not specifically refer to integrated circuits. The major difference between tests done using the HBM and IEC 61000-4-2 is higher peak current in IEC 61000-4-2, because series resistance is lower in the IEC 61000-4-2 model. Hence, the ESD withstand voltage measured to IEC 61000-4-2 is generally lower than that measured using the HBM. Figure 4 shows the IEC 61000-4-2 model and Figure 5 shows the current waveform for the  $\pm 8kV$ , IEC 61000-4-2, Level 4, ESD Contact-Discharge Method.

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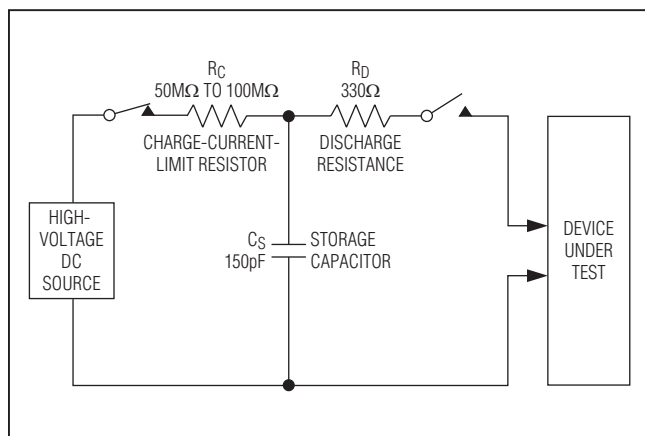


Figure 4. IEC 61000-4-2 ESD Test Model

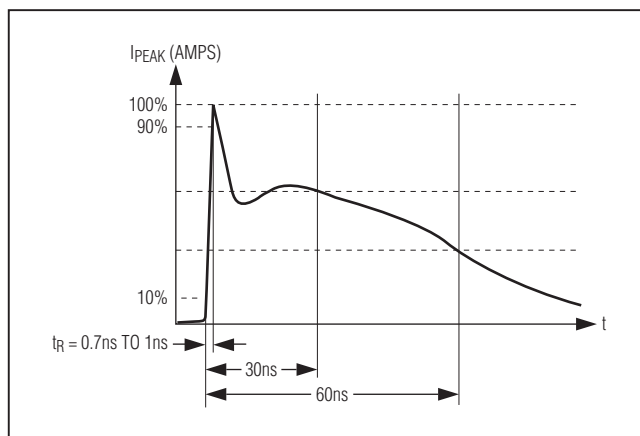


Figure 5. IEC 61000-4-2 ESD Generator Current Waveform

### Chip Information

PROCESS: BiCMOS

### Ordering Information/ Selector Guide

PART	PIN-PACKAGE	TOP MARK	SHUNT RESISTOR
MAX14589EWL+T	9 WLP	AJA	No
MAX14594EWL+T	9 WLP	AJB	Yes

**Note:** All devices are specified over the  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range.

+Denotes a lead(Pb)-free/RoHS-compliant package.

T = Tape and reel.

### Package Information

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.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.
9 WLP	W91B1+7	<a href="#">21-0459</a>	Refer to <a href="#">Application Note 1891</a>

# MAX14589E/MAX14594E

## High-Density, $\pm 5V$ Capable DPDT Analog Switches

### Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	6/12	Initial release	—
1	1/13	Updated <i>Electrical Characteristics</i> table, added note to TOCs	4, 7



Maxim Integrated cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim Integrated product. No circuit patent licenses are implied. Maxim Integrated reserves the right to change the circuitry and specifications without notice at any time. The parametric values (min and max limits) shown in the *Electrical Characteristics* table are guaranteed. Other parametric values quoted in this data sheet are provided for guidance.

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