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## MAX14689

## Ultra-Small, Low- $R_{ON}$ , Beyond-the-Rails™ DPDT Analog Switches

### General Description

The MAX14689 ultra-small, low-on-resistance ( $R_{ON}$ ) 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 on-resistance ( $0.25\Omega$ ) also makes the device ideal for low-distortion switching applications, such as audio or video.

The MAX14689 is fully specified to operate from a single +1.6V to +5.5V power supply. Because of the low supply current requirement,  $V_{CC}$  can be provided by a GPIO. When power is not applied, the switches go to a high-impedance mode and all analog signal ports can withstand signals from -5.5V to +5.5V. The switch is controlled with a single control bit, CB.

The MAX14689 is available in a 1.2mm x 1.2mm, 0.4mm pitch, 9-bump wafer-level package (WLP) and 10-pin, 2.5mm x 2.0mm TDFN package. It operates over the -40°C to +85°C extended temperature range.

### Applications

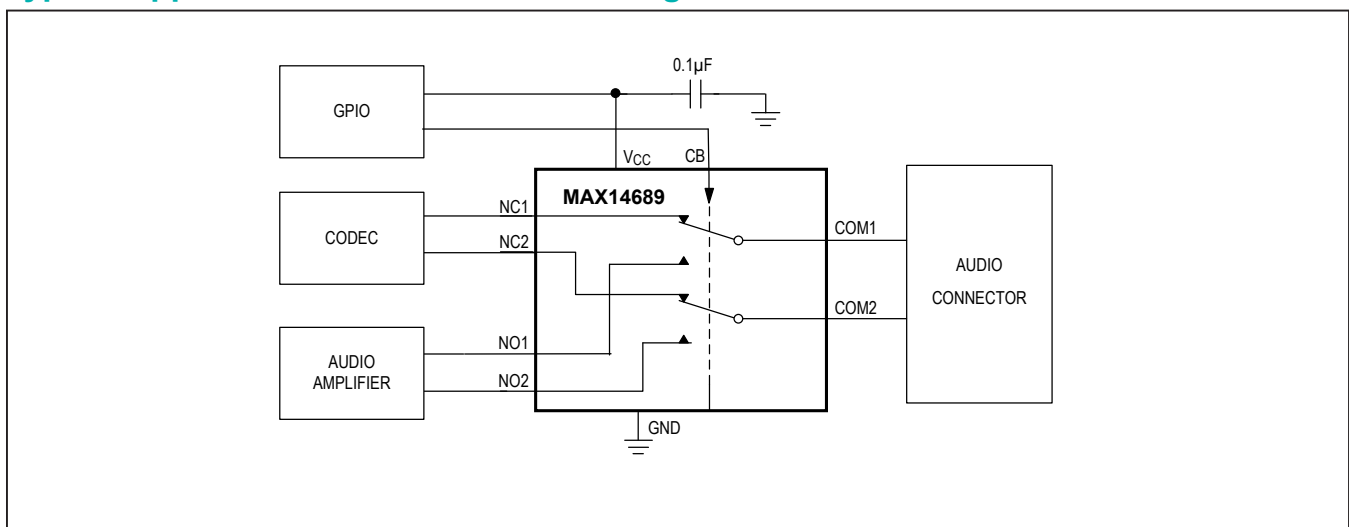
- Smartphones
- Tablets
- Portable Audio/Video Equipment
- Low-Distortion Signal Switches

### Benefits and Features

- Distortion-Free Beyond-the-Rails Signaling
  - Negative Voltage Audio and Video Signal Capable
  - -5.5V to +5.5V Analog Signal Range Independent from  $V_{CC}$
  - On-Resistance  $0.25\Omega$  (typ)
  - +1.6V to +5.5V Single-Supply Range
  - Total Harmonic Distortion Plus Noise 0.001% (typ)
  - On-Resistance Flatness  $0.001\Omega$  (typ)
- Low Supply Current  $40\mu\text{A}$  (typ) at 1.6V
  - Can be Powered by GPIO
  - High-Impedance Mode when  $V_{CC}$  Not Applied
- ESD Protection on  $\text{COM}_-$ 
  - $\pm 15\text{kV}$  Human Body Model
  - $\pm 10\text{kV}$  IEC 61000-4-2 Air Gap
  - $\pm 8\text{kV}$  IEC 61000-4-2 Contact
- ESD Protection on  $\text{NC}_-$  and  $\text{NO}_-$ 
  - $\pm 15\text{kV}$  Human Body Model
- Design Flexibility
  - Break-Before-Make Operation
  - 9-Bump WLP (1.2mm x 1.2mm) Package
  - 10-Pin TDFN (2.5mm x 2.0mm) Package
  - -40°C to +85°C Operating Temperature Range

*Ordering Information appears at end of data sheet.*

### Typical Application Circuit/Functional Diagram



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

### Absolute Maximum Ratings

(All voltages referenced to GND.)

$V_{CC}$ , 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 ( $T_A = +70^{\circ}C$ )	
9-Bump WLP (derate 12mW/°C above +70°C).....	963.8mW
10-Pin TDFN (derate 9.8mW/°C above +70°C).....	784mW
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 Information

<b>PACKAGE TYPE: 9 WLP</b>	
Package Code	W91J1+1
Outline Number	<a href="#">21-0459</a>
Land Pattern Number	<a href="#">Refer to Application Note 1891</a>
<b>THERMAL RESISTANCE, FOUR-LAYER BOARD</b>	
Junction to Ambient ( $\theta_{JA}$ )	83°C/W

<b>PACKAGE TYPE: 10 TDFN</b>	
Package Code	T102A2+2C
Outline Number	<a href="#">21-100013</a>
Land Pattern Number	<a href="#">90-100007</a>
<b>THERMAL RESISTANCE, FOUR-LAYER BOARD</b>	
Junction to Ambient ( $\theta_{JA}$ )	102°C/W
Junction to Case ( $\theta_{JC}$ )	2.9°C/W

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).

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.

## Electrical Characteristics

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

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT	
<b>POWER SUPPLY</b>							
Power-Supply Range	$V_{CC}$		1.6		5.5	V	
Power-Supply Rejection Ratio	PSRR	$R_{COM\_} = 32\Omega$ , $f = 20kHz$		80		dB	
Supply Current	$I_{CC}$	$V_{CC} = +1.6V$ , $V_{CB} = 0V$ or $V_{CC}$		40	65	$\mu A$	
		$V_{CC} = +4.2V$ , $V_{CB} = 0V$ or $V_{CC}$		70	125		
<b>ANALOG SWITCH</b>							
Analog Signal Range	$V_{NC\_}$ , $V_{NO\_}$ , $V_{COM\_}$		-5.5		+5.5	V	
On-Resistance	$R_{ON}$	$V_{COM\_} = 0V$ , $I_{COM\_} = 100mA$ (Note 3)	$V_{CC} = 2.5V$	0.25	0.45	$\Omega$	
			$V_{CC} = 1.8V$	0.325	0.55		
On-Resistance Match Between Channels	$\Delta R_{ON}$	$V_{CC} = 2.5V$ , $V_{NC\_} = 0V$ , $I_{COM\_} = 100mA$ , between same NC_ and NO_ channel (Note 4)		0.005	0.05	$\Omega$	
On-Resistance Flatness	$R_{FLAT}$	$V_{CC} = 2.5V$ , $I_{COM\_} = 100mA$ , $V_{COM\_} = -5.5V$ to $5.5V$ (Notes 5,6)		0.001	0.01	$\Omega$	
NC_ or NO_ Off-Leakage Current	$I_{NC\_ (OFF)}$ , $I_{NO\_ (OFF)}$	$V_{CC} = 2.5V$ , switch open, $V_{NO\_}$ or $V_{NC\_} = -5.5$ or $+5.5V$ $V_{COM\_} = +5.5V$ , $-5.5V$ , unconnected	-100		+100	nA	
COM_ Off-Leakage Current	$I_{COM\_ (OFF)}$	$V_{CC} = 0V$ $V_{COM\_} = -5.5V$ , $0V$ , $+5.5$ $V_{NO\_}$ or $V_{NC\_} = -5.5V$ , $+5.5V$ , unconnected	-100		+100	nA	
COM_ On Leakage-Current	$I_{COM\_ (ON)}$	$V_{CC} = 2.5V$ , switch closed, $V_{COM\_} = +5.5V$ , $-5.5V$ $V_{NO\_}$ or $V_{NC\_} = +5.5V$ , $-5.5V$ , unconnected	-100		+100	nA	
<b>DYNAMIC TIMING</b>							
Turn-Off Time	$t_{OFF}$	$V_{NO}$ or $V_{NC\_} = 0V$ , $R_L = 50\Omega$ , Figure 1 (Note 6)		5	30	$\mu s$	
Break-Before-Make Time	$t_{BBM}$	$R_L = 50\Omega$ . Time that both NC_/NO_ switches are open during transition, Figure 2 (Note 6)	$V_{CC} = 2.5V$	0	80	150	$\mu s$
			$V_{CC} = 1.8V$	0		250	
Turn-On Time	$t_{ON}$	$V_{NO}$ or $V_{NC\_} = 0V$ , Figure 1 (Note 6)	$V_{CC} = 2.5V$	85	200	$\mu s$	
			$V_{CC} = 1.8V$		250		

**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  $V_{CC} = +2.5V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
<b>AUDIO PERFORMANCE</b>						
Total Harmonic Distortion Plus Noise	THD+N	$f = 20\text{Hz}$ to $20\text{kHz}$ , $V_{COM\_} = 0.5V_{P-P}$ , $R_S = R_L = 50\Omega$ ; DC bias = $0V$		0.001		%
Off-Isolation	$V_{ISO}$	$R_S = R_L = 50\Omega$ ; $V_{COM\_} = 0.5V_{P-P}$ , $f = 100\text{kHz}$ , $V_{CC} = 0V$ , DC bias = $0.25V$ , Figure 3		-60		dB
Crosstalk	$V_{CT}$	$R_S = R_L = 50\Omega$ ; $V_{COM\_} = 0.5V_{P-P}$ , $f = 100\text{kHz}$ (Note 7), Figure 3		-100		dB
-3dB Bandwidth	BW	$R_S = R_L = 50\Omega$		110		MHz
NC_ or NO_ Off-Capacitance	$C_{NC\_}(OFF)$ $C_{NO\_}(OFF)$	$V_{NC\_} / V_{NO\_} = 0.5V_{P-P}$ , $f = 1\text{MHz}$		25		pF
COM_ On-Capacitance	$C_{COM\_}(ON)$	$V_{NC\_} / V_{NO\_} = 0.5V_{P-P}$ , $f = 1\text{MHz}$		50		pF
<b>DIGITAL I/O</b>						
Input Logic High Voltage	$V_{IH}$		1.4			V
Input Logic Low Voltage	$V_{IL}$				0.325	V
Input Leakage Current	$I_{IN}$	$V_{CB} = 0V$ or $V_{CC}$	-1		+1	$\mu A$
<b>THERMAL PROTECTION</b>						
Thermal Shutdown				+150		$^\circ C$
Thermal Shutdown Hysteresis				25		$^\circ C$
<b>ESD PROTECTION</b>						
COM_		Human Body Model		$\pm 15$		kV
		IEC 61000-4-2 Air-Gap		$\pm 10$		
		IEC 61000-4-2 Contact Discharge		$\pm 8$		
NC_, NO_		Human Body Model		$\pm 15$		kV
All Other Pins		Human Body Model		$\pm 2$		kV

**Note 1:** All specifications are 100% production tested at  $T_A = +25^\circ C$ , unless otherwise noted. Specifications over  $T_A = -40^\circ C$  to  $+85^\circ C$  are guaranteed by design.

**Note 2:** The same limits apply for  $V_{COM\_} = -5.5V$  to  $+5.5V$  and are guaranteed by design.

**Note 3:**  $\Delta R_{ON} = |R_{ON}(CH1) - R_{ON}(CH2)|$ .

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

**Note 5:** Guaranteed by design; not production tested.

**Note 6:** Between two switches.

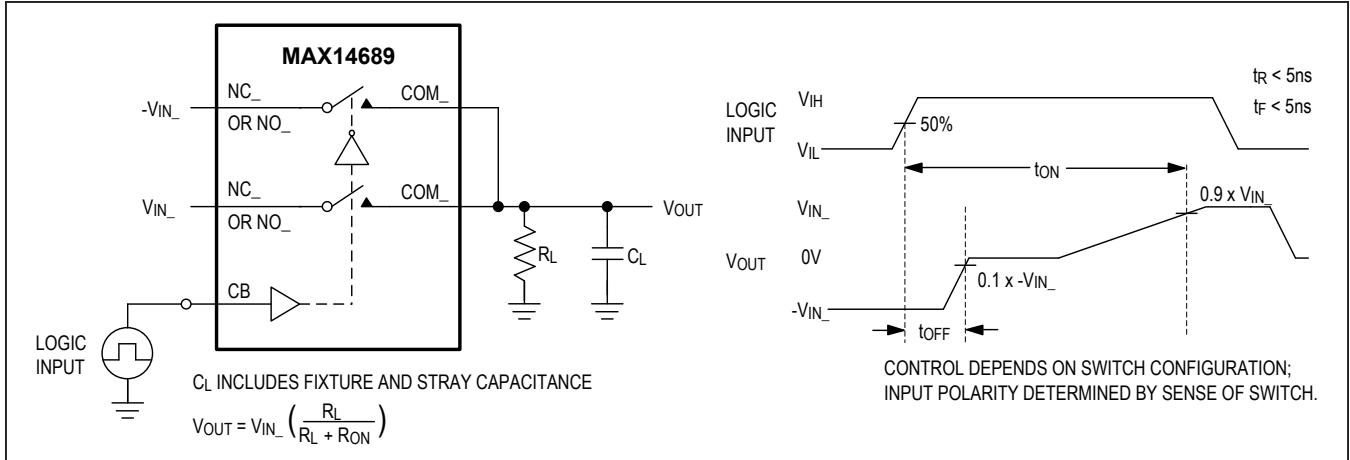


Figure 1. Switching Time

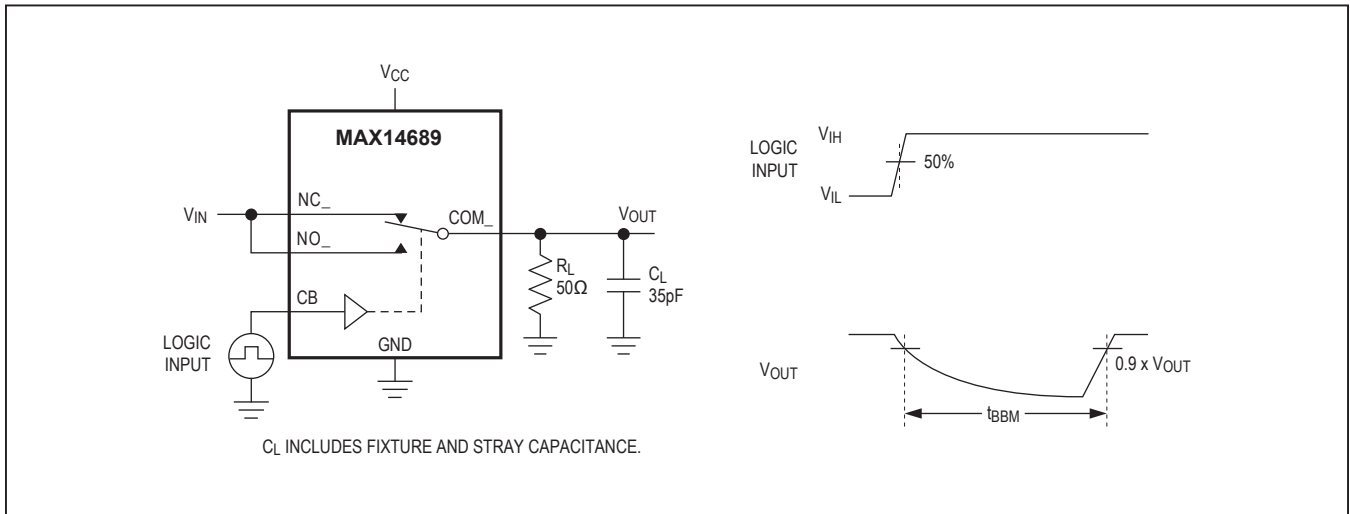


Figure 2. Break-Before-Make Interval

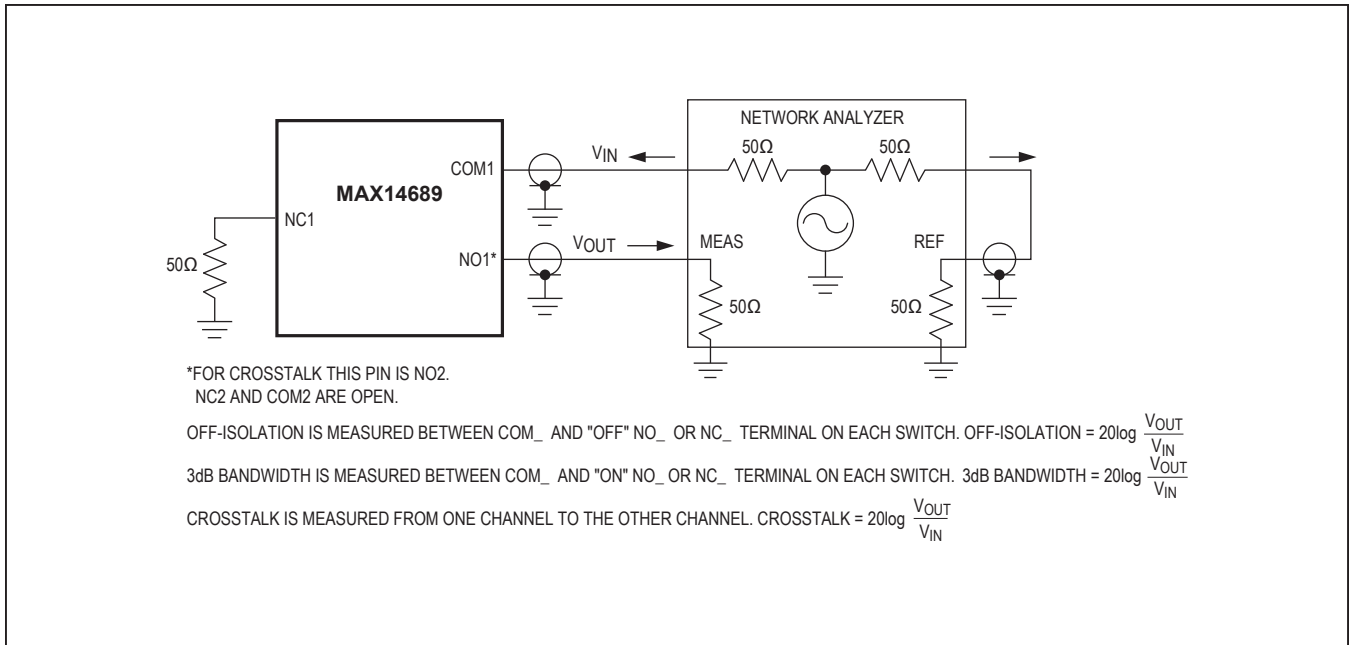
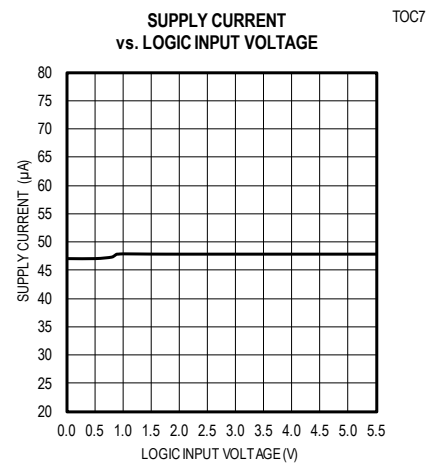
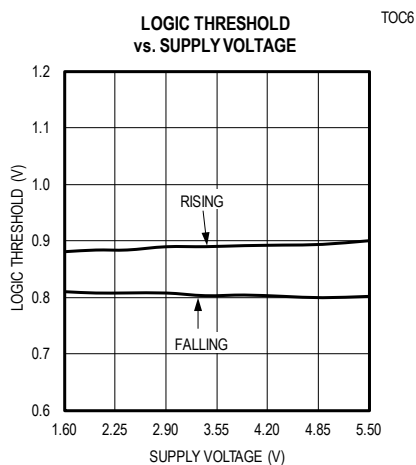
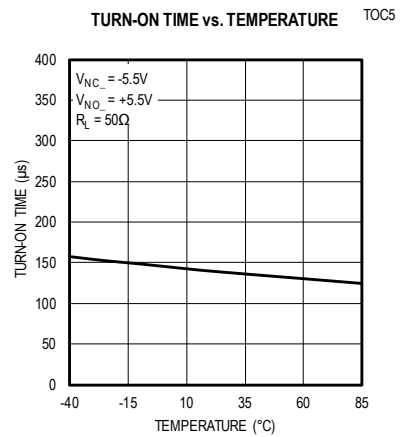
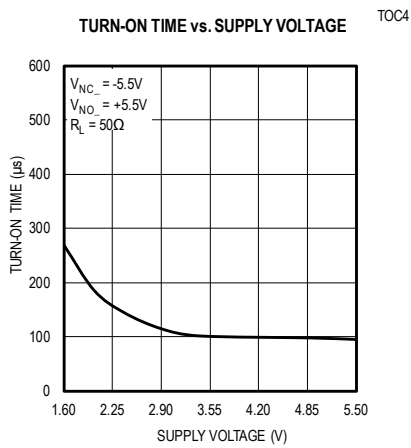
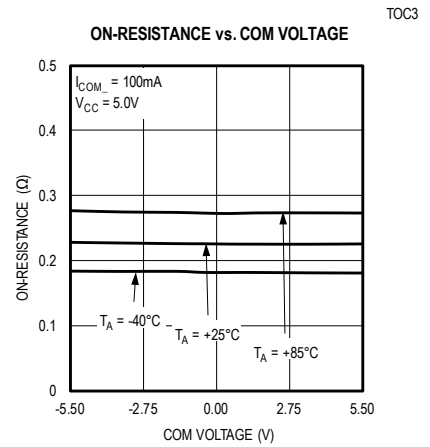
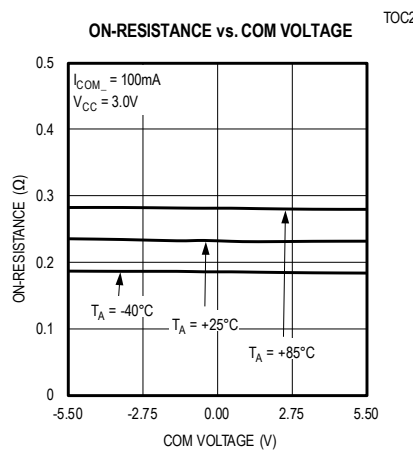
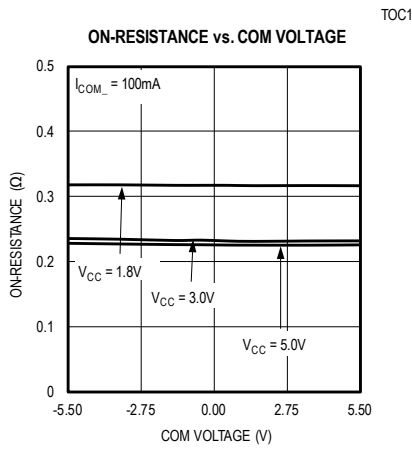


Figure 3. 3dB Bandwidth, Off-Isolation, and Crosstalk

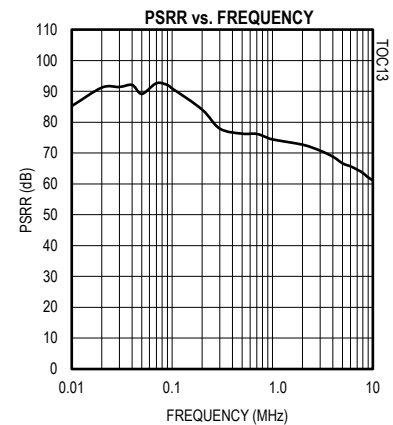
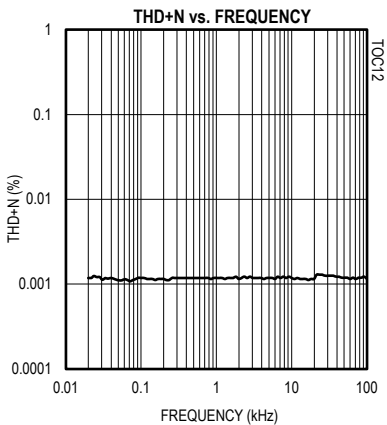
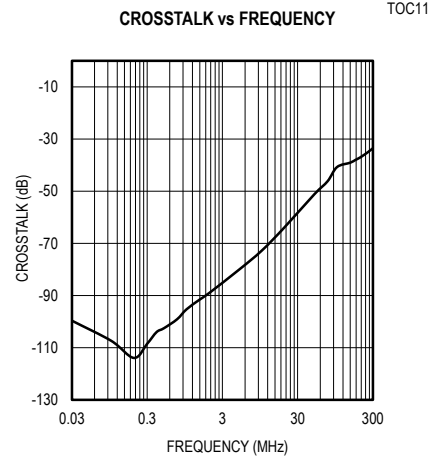
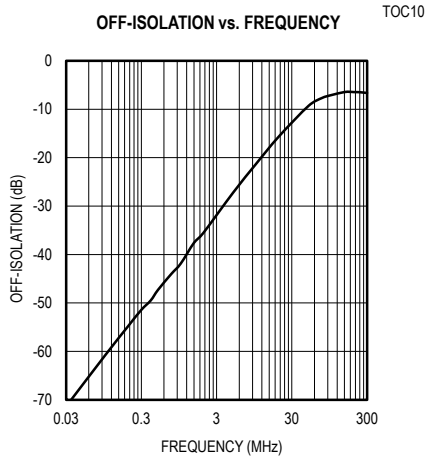
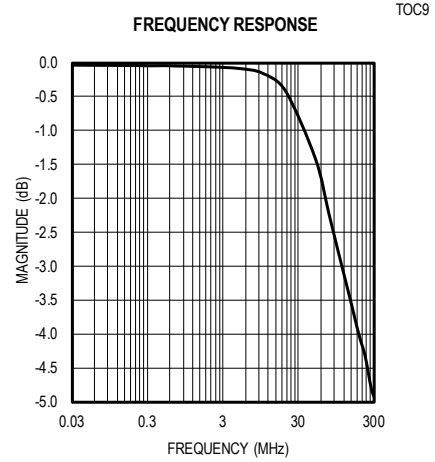
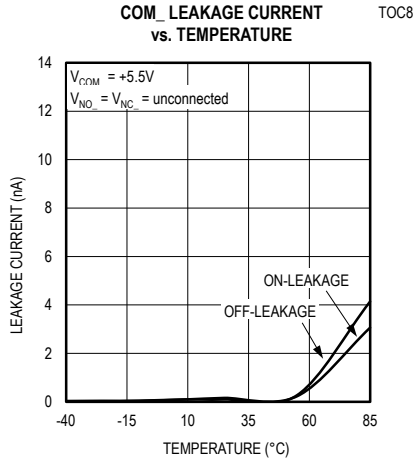
Typical Operating Characteristics

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



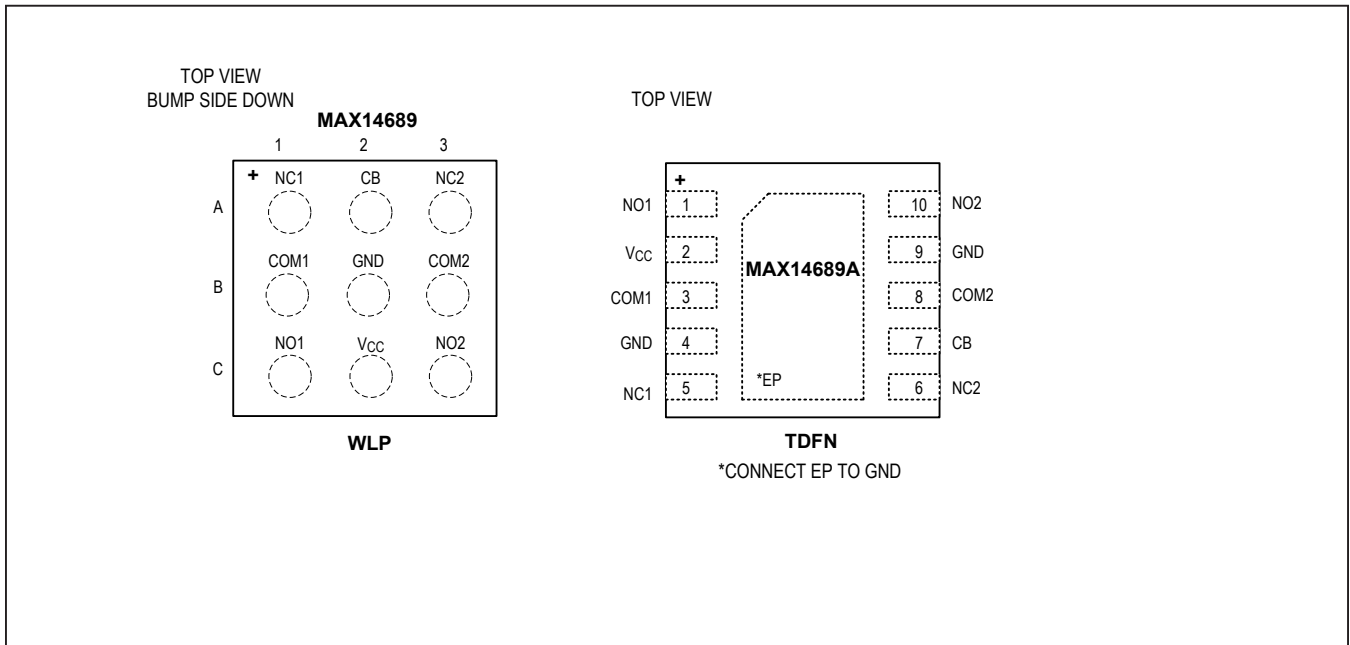
Typical Operating Characteristics (continued)

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





Pin Configuration



Pin Description

WLP BUMP	TDFN PIN	NAME	FUNCTION
A1	5	NC1	Normally Closed Terminal for Switch 1
A2	7	CB	Digital Control Input. Drive CB low to connect COM_ to NC_. Drive CB high to connect COM_ to NO_.
A3	6	NC2	Normally Closed Terminal for Switch 2
B1	3	COM1	Common Terminal for Switch 1
B2	4, 9	GND	Ground
B3	8	COM2	Common Terminal for Switch 2
C1	1	NO1	Normally Open Terminal for Switch 1
C2	2	V <sub>CC</sub>	Supply Voltage Input. Bypass V <sub>CC</sub> to GND with a 0.1μF capacitor as close to the device as possible.
C3	10	NO2	Normally Open Terminal for Switch 2
—	—	EP	Exposed Pad. Connect EP to ground. (TDFN only)

## Detailed Description

The MAX14689 is an ultra-small, low on-resistance, high ESD-protected DPDT switch that operates from a +1.6V to +5.5V supply, and is designed to pass analog signals such as AC-biased or DC-biased audio and video signals. These switches feature the low on-resistance ( $R_{ON}$ ) necessary for high-performance switching applications. The Beyond-the-Rails signal capability of the MAX14689 allows signals below ground and above  $V_{CC}$  to pass without distortion.

## Analog Signal Levels

The MAX14689 is bidirectional, allowing  $NO_*$ ,  $NC_*$ , and  $COM_*$  to be configured as either inputs or outputs. The topology of the switches allows the signal to drop below ground without the need of an external negative voltage supply. Note: The devices can also withstand analog signal levels of -5.5V to +5.5V when the device is not powered.

## Digital Control Input

The MAX14689 provides a single-bit control logic input, CB. CB controls the switch position, as shown in the *Typical Application Circuit/Functional Diagram*.

## 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.  $NO_*$  and  $NC_*$  are 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 4](#) shows the Human Body Model. [Figure 5](#) 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 6](#) shows the IEC 61000-4-2 model and [Figure 7](#) shows the current waveform for the  $\pm 8kV$ , IEC 61000-4-2, Level 4, ESD Contact-Discharge Method.

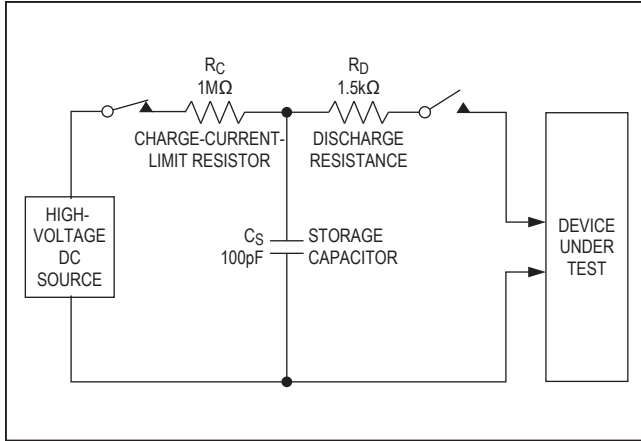


Figure 4. Human Body ESD Test Model

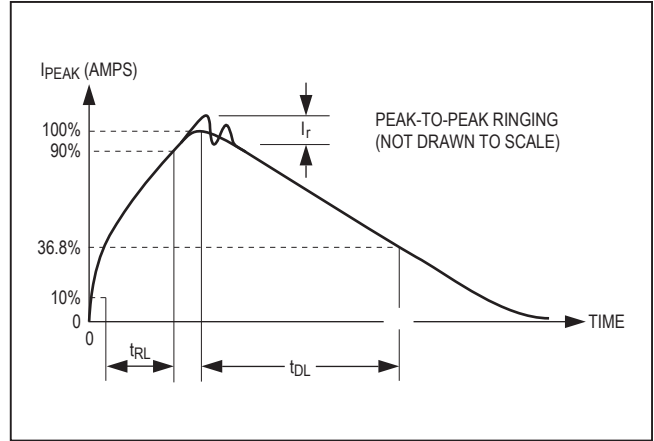


Figure 5. Human Body Current Waveform

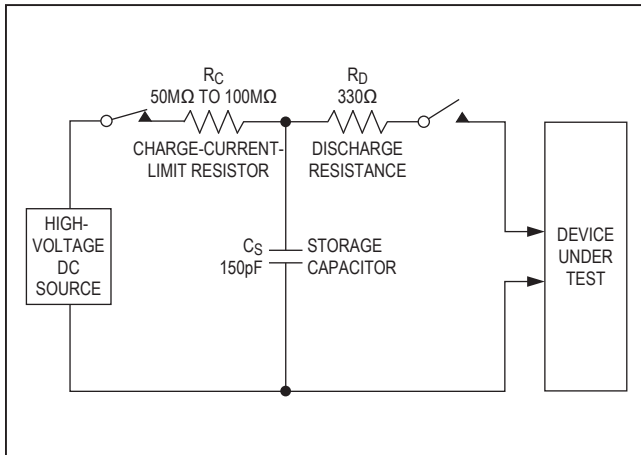


Figure 6. IEC 61000-4-2 ESD Test Model

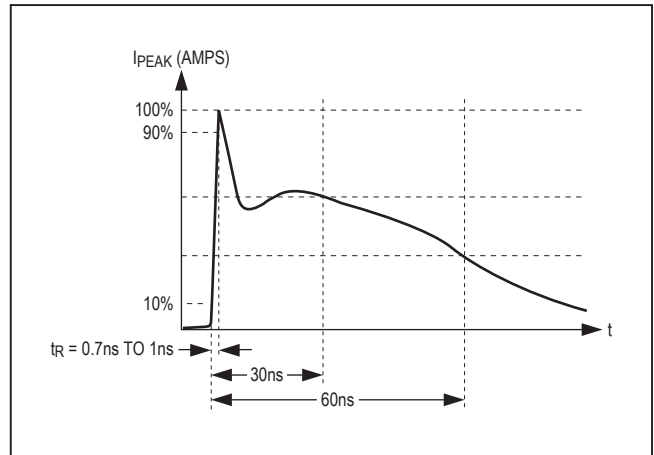


Figure 7. IEC 61000-4-2 ESD Generator Current Waveform

### Ordering Information

PART	PIN-PACKAGE	TOP MARK
MAX14689EWL+T	9 WLP	AKL
MAX14689AETB+T	10 TDFN-EP*	AAF

\*EP = Exposed pad  
 +Denotes lead(Pb)-free/RoHS-compliant package.  
 T = Tape and reel.

### Chip Information

PROCESS: BiCMOS

## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	9/13	Initial release	—
1	1/14	Added MAX14689EWL+ to <i>Ordering Information</i>	11
2	12/14	Corrected package code	11
3	5/18	Updated <i>General Description</i> and <i>Benefits and Features</i> sections, <i>Pin Configuration</i> diagram, <i>Pin Description</i> , <i>Ordering Information</i> , and <i>Package Information</i> tables	1, 2, 9, 11
4	9/18	Updated the <i>Typical Application Circuit</i> , <i>Electrical Characteristics</i> table, <i>Pin Configuration</i> , <i>Pin Description</i> table, and <i>Package Information</i> table; fixed a font rendering issue in TOC01–TOC05.	1–2, 7, 9,
5	6/20	Updated Figure 1	5

For pricing, delivery, and ordering information, please visit Maxim Integrated's online storefront at <https://www.maximintegrated.com/en/storefront/storefront.html>.

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