



# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

MAX4695

## General Description

The MAX4695 is a low-voltage, dual single-pole/double-throw (SPDT) analog switch that operates from a single +1.8V to +5.5V supply. The MAX4695 features break-before-make switching action with a  $t_{ON} = 30ns$  and  $t_{OFF} = 18ns$  at +3V.

When powered from a +2.7V supply, the device has a 60Ω (max) on-resistance ( $R_{ON}$ ), with 3Ω (max)  $R_{ON}$  matching and 10Ω (max)  $R_{ON}$  flatness. The digital logic inputs are 1.8V-logic compatible from a +2.7V to +3.3V supply. The MAX4695 is available in both a space-saving 3mm x 3mm 12-pin TQFN package and a 10-pin  $\mu$ MAX® package.

## Applications

- MP3 Players
- Battery-Operated Equipment
- Relay Replacement
- Audio and Video Signal Routing
- Low-Voltage Data-Acquisition Systems
- Communications Circuits
- PCMCIA Cards
- Cellular Phones
- Modems

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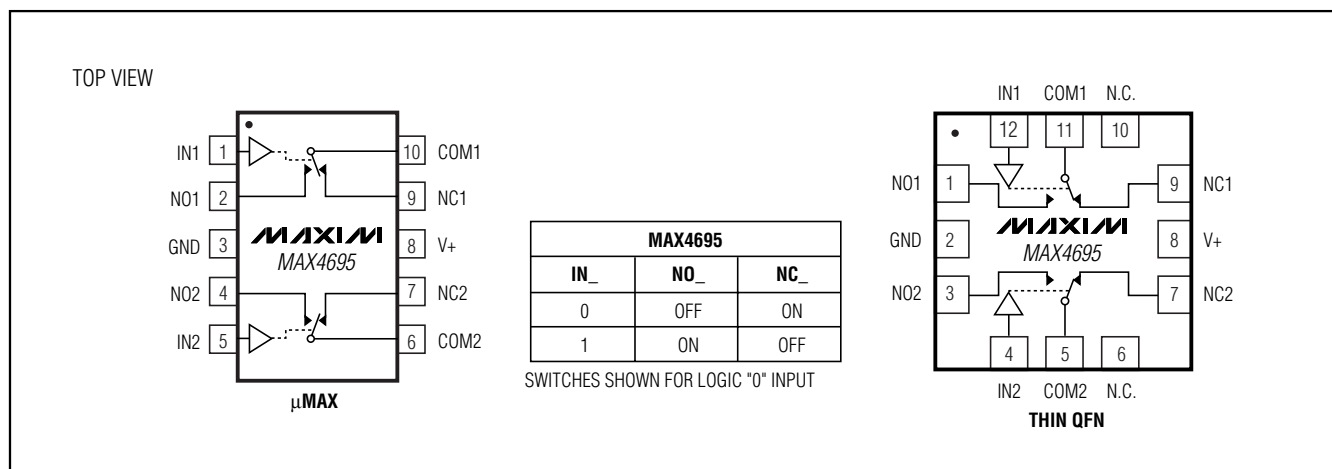
## Features

- ◆ 3mm x 3mm 12-Pin Thin QFN Package
- ◆ **Guaranteed On-Resistance:**  
60Ω (max) (+2.7V supply)  
25Ω (typ) (+5V supply)
- ◆ **Guaranteed Match Between Channels:** 3Ω (max)
- ◆ **Guaranteed Flatness Over Signal Range:**  
10Ω (max)
- ◆ **Guaranteed Low Leakage Currents:**  
100pA (max) at +25°C
- ◆ **Switching Time:**  $t_{ON} = 30ns$ ,  $t_{OFF} = 18ns$
- ◆ +1.8V to +5.5V Single-Supply Operation
- ◆ Rail-to-Rail Signal Handling
- ◆ -3dB Bandwidth: >300MHz
- ◆ **Low Crosstalk:** -82dB (1MHz)
- ◆ **High Off-Isolation:** -75dB (1MHz)
- ◆ **Low 4pC Charge Injection**
- ◆ **THD: 0.03%**
- ◆ +1.8V CMOS-Logic Compatible

## Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX4695ETC	-40°C to 85°C	12 TQFN
MAX4695EUB	-40°C to 85°C	10 $\mu$ MAX

## Pin Configurations



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## ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to GND)

V+	-0.3V to +6V
All Other Pins (Note 1)	-0.3V to (V+ + 0.3V)
Continuous Current COM <sub>-</sub> , NO <sub>-</sub> , NC <sub>-</sub>	±20mA
Peak Current COM <sub>-</sub> , NO <sub>-</sub> , NC <sub>-</sub> (pulsed at 1ms, 10% duty cycle)	±40mA
ESD per Method 3015.7	±2kV

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

10-Pin μMAX (derate 4.7mW/°C above +70°C)	330mW
12-Pin Thin QFN (derate 16.7mW/°C above +70°C)	1333.3mW
Operating Temperature Range	-40°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C

**Note 1:** Signals on IN<sub>-</sub>, COM<sub>-</sub>, NO<sub>-</sub>, and NC<sub>-</sub> exceeding V+ or GND 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—Single +3V Supply

(V+ = +2.7V to +3.3V, V<sub>IH</sub> = +1.4V, V<sub>IL</sub> = +0.5V, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V+ = +3V and T<sub>A</sub> = +25°C.) (Notes 2, 9)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
<b>ANALOG SWITCH</b>							
Analog Signal Range	V <sub>COM-</sub> , V <sub>NO-</sub> , V <sub>NC-</sub>			0		V+	V
On-Resistance	R <sub>ON</sub>	V+ = +2.7V, I <sub>COM-</sub> = 1mA, V <sub>NO-</sub> or V <sub>NC-</sub> = +1.4V	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		40 60	70	Ω
On-Resistance Match Between Channels (Note 3)	ΔR <sub>ON</sub>	V+ = +2.7V, I <sub>COM-</sub> = 1mA, V <sub>NO-</sub> or V <sub>NC-</sub> = +1.4V	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		0.5	3	Ω
On-Resistance Flatness (Note 4)	R <sub>FLAT (ON)</sub>	V+ = +2.7V, I <sub>COM-</sub> = 1mA, V <sub>NO-</sub> or V <sub>NC-</sub> = +1V, +1.4V, +1.8V	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		6	10	Ω
NO <sub>-</sub> , NC <sub>-</sub> Off-Leakage Current (Note 5)	I <sub>NO-(OFF)</sub> , I <sub>NC-(OFF)</sub>	V+ = +3.3V, V <sub>COM-</sub> = +0.3V, +3V V <sub>NO-</sub> or V <sub>NC-</sub> = +3V, +0.3V	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>	-0.1 -1	±0.01	+0.1 +1	nA
COM <sub>-</sub> On-Leakage Current (Note 5)	I <sub>COM-(ON)</sub>	V+ = +3.3V, V <sub>COM-</sub> = +0.3V, +3V V <sub>NO-</sub> or V <sub>NC-</sub> = +0.3V, +3V, or floating	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>	-0.2 -2	±0.01	+0.2 +2	nA
<b>DYNAMIC</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>NO</sub> or V <sub>NC-</sub> = +1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		24	30	ns
Turn-Off Time	t <sub>OFF</sub>	V <sub>NO</sub> or V <sub>NC-</sub> = +1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		12	18	ns
Break-Before-Make Time (Note 6)	t <sub>BBM</sub>	V <sub>NO</sub> or V <sub>NC-</sub> = +1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 3	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		12		ns
Charge Injection	Q	V <sub>GEN</sub> = 0, R <sub>GEN</sub> = 0, C <sub>L</sub> = 1.0nF, Figure 4			4		pC
On-Channel -3dB Bandwidth	BW	Signal = 0dBm, 50Ω in and out, Figure 5			300		MHz
Off-Isolation (Note 7)	V <sub>ISO</sub>	f = 1MHz, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, Figure 5			-75		dB

# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

MAX4695

## ELECTRICAL CHARACTERISTICS—Single +3V Supply (continued)

(V+ = +2.7V to +3.3V, V<sub>IH</sub> = +1.4V, V<sub>IL</sub> = +0.5V, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V+ = +3V and T<sub>A</sub> = +25°C.) (Notes 2, 9)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
Crosstalk (Note 8)	V <sub>CT</sub>	f = 1MHz, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, Figure 5			-82		dB
Total Harmonic Distortion	THD	f = 20Hz to 20kHz, 2Vp-p, R <sub>L</sub> = 600Ω			0.03		%
NO <sub>-</sub> , NC <sub>-</sub> Off-Capacitance	C <sub>NO_(OFF)</sub> , C <sub>NC_(OFF)</sub>	f = 1MHz, V <sub>NO_-</sub> or V <sub>NC_-</sub> = GND, Figure 6			7		pF
COM <sub>-</sub> On-Capacitance	C <sub>COM_(ON)</sub>	f = 1MHz, V <sub>NO_-</sub> or V <sub>NC_-</sub> = GND, Figure 6			19		pF
<b>DIGITAL I/O</b>							
Input Logic High	V <sub>IH</sub>			1.4			V
Input Logic Low	V <sub>IL</sub>					0.5	V
Input Leakage Current	I <sub>IH</sub> , I <sub>IL</sub>	V <sub>IN</sub> = 0 or V+		-1		+1	μA
<b>SUPPLY</b>							
Power-Supply Range	V+			1.8		5.5	V
Power-Supply Current	I+	V+ = +5.5V, V <sub>IN</sub> = 0 or V+				1	μA

## ELECTRICAL CHARACTERISTICS—Single +5V Supply

(V+ = +4.5V to +5.5V, V<sub>IH</sub> = +2.0V, V<sub>IL</sub> = +0.8V, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V+ = +5V and T<sub>A</sub> = +25°C.) (Notes 2, 9)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
<b>ANALOG SWITCH</b>							
Analog Signal Range	V <sub>COM_-</sub> , V <sub>NO_-</sub> , V <sub>NC_-</sub>			0		V+	V
On-Resistance	R <sub>ON</sub>	V+ = +4.5V, I <sub>COM_-</sub> = 1mA, V <sub>NO_-</sub> or V <sub>NC_-</sub> = +3.5V	+25°C		25	35	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			40	
On-Resistance Match Between Channels (Note 3)	ΔR <sub>ON</sub>	V+ = +4.5V, I <sub>COM_-</sub> = 1mA, V <sub>NO_-</sub> or V <sub>NC_-</sub> = +3.5V	+25°C		0.5	2	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			3	
On-Resistance Flatness (Note 4)	R <sub>FLAT (ON)</sub>	V+ = +4.5V, I <sub>COM_-</sub> = 1mA, V <sub>NO_-</sub> or V <sub>NC_-</sub> = +1V, +2.5V, +3.5V	+25°C		4	8	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			10	
NO <sub>-</sub> , NC <sub>-</sub> Off-Leakage Current (Note 5)	I <sub>NO_(OFF)</sub> , I <sub>NC_(OFF)</sub>	V+ = +5.5V, V <sub>COM_-</sub> = +1V, +4.5V, V <sub>NO_-</sub> or V <sub>NC_-</sub> = +4.5V, +1V	+25°C	-0.1	±0.01	+0.1	nA
			T <sub>MIN</sub> to T <sub>MAX</sub>	-1		+1	
COM <sub>-</sub> On-Leakage Current (Note 5)	I <sub>COM_(ON)</sub>	V+ = +5.5V, V <sub>COM_-</sub> = +1V, +4.5V, V <sub>NO_-</sub> or V <sub>NC_-</sub> = +1V, +4.5V, or floating	+25°C	-0.2	±0.01	+0.2	nA
			T <sub>MIN</sub> to T <sub>MAX</sub>	-2		+2	
<b>DYNAMIC</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>NO_-</sub> , V <sub>NC_-</sub> = +3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C		17	25	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			30	
Turn-Off Time	t <sub>OFF</sub>	V <sub>NO_-</sub> , V <sub>NC_-</sub> = +3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C		8	15	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			20	

# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

## ELECTRICAL CHARACTERISTICS—Single +5V Supply (continued)

(V+ = +4.5V to +5.5V, V<sub>IH</sub> = +2.0V, V<sub>IL</sub> = +0.8V, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V+ = +5V and T<sub>A</sub> = +25°C.) (Notes 2, 9)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
Break-Before-Make Time (Note 6)	t <sub>BBM</sub>	V <sub>NO_</sub> , V <sub>NC_</sub> = +3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 3	+25°C	9			ns
			T <sub>MIN</sub> to T <sub>MAX</sub>	2			
Charge Injection	Q	V <sub>GEN</sub> = 0, R <sub>GEN</sub> = 0, C <sub>L</sub> = 1.0nF, Figure 4		8			pC
On-Channel -3dB Bandwidth	BW	Signal = 0dBm, 50Ω in and out, Figure 5		300			MHz
Off-Isolation (Note 7)	V <sub>ISO</sub>	f = 1MHz, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, Figure 5		-75			dB
Crosstalk (Note 8)	V <sub>CT</sub>	f = 1MHz, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, Figure 5		-82			dB
Total Harmonic Distortion	THD	f = 20Hz to 20kHz, 2Vp-p, R <sub>L</sub> = 600Ω		0.02			%
<b>DIGITAL I/O</b>							
Input Logic High	V <sub>IH</sub>			2.0			V
Input Logic Low	V <sub>IL</sub>					0.8	V
Input Leakage Current	I <sub>IH</sub> , I <sub>IL</sub>	V <sub>IN_</sub> = 0 or V+		-1	+1		μA
<b>SUPPLY</b>							
Power-Supply Range	V+			1.8		5.5	V
Positive Supply Current	I+	V+ = +5.5V, V <sub>IN</sub> = 0 or V+				1	μA

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

**Note 3:** ΔRON = RON(MAX) - RON(MIN).

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

**Note 5:** Leakage currents are 100% tested at T<sub>A</sub> = +85°C. Limits across the full temperature range are guaranteed by correlation.

**Note 6:** Guaranteed by design.

**Note 7:** Off-Isolation = 20log<sub>10</sub>(V<sub>COM\_</sub> / V<sub>NO\_</sub>), V<sub>COM\_</sub> = output, V<sub>NO\_</sub> = input to off switch.

**Note 8:** Between any two switches.

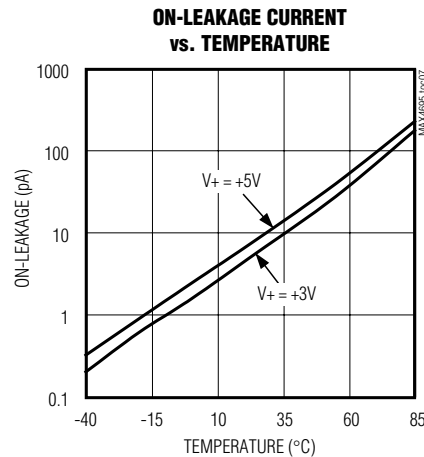
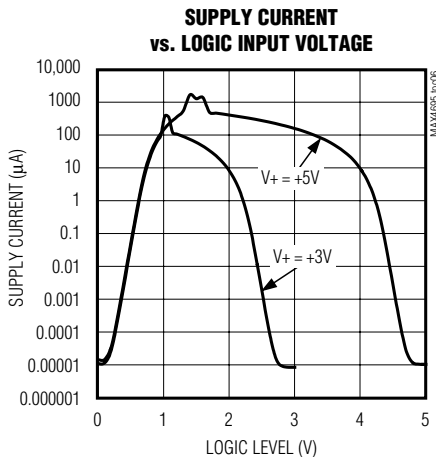
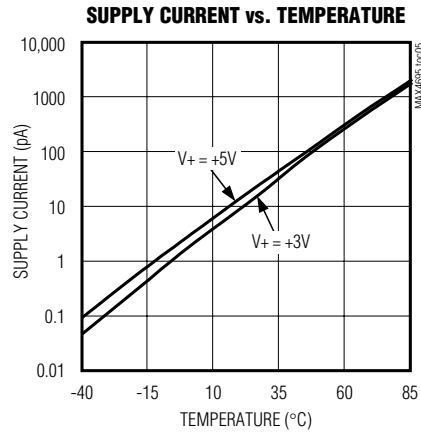
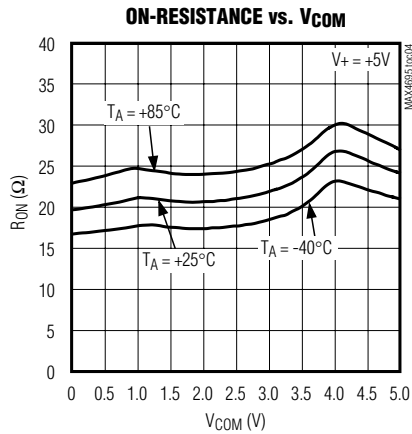
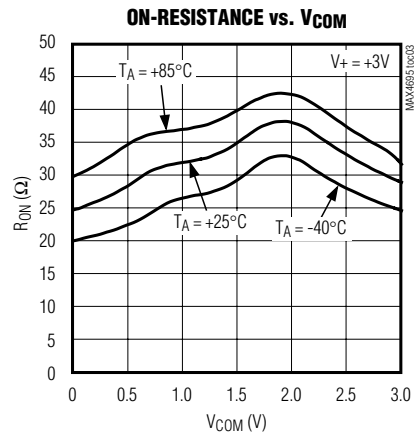
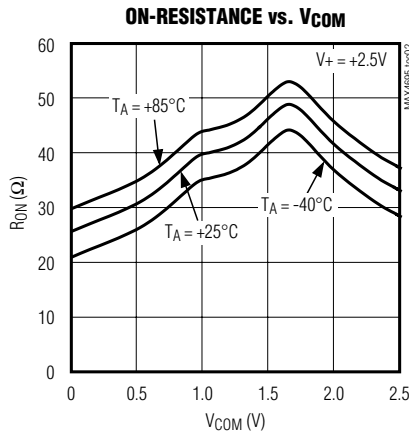
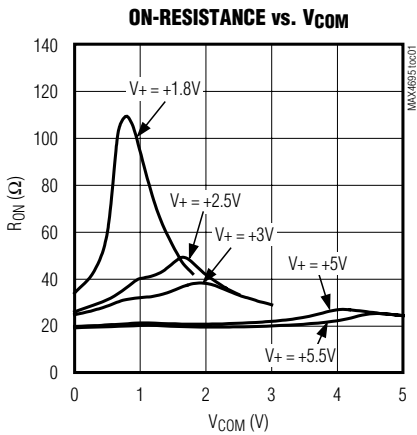
**Note 9:** -40°C specifications are guaranteed by design.

# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

## Typical Operating Characteristics

( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

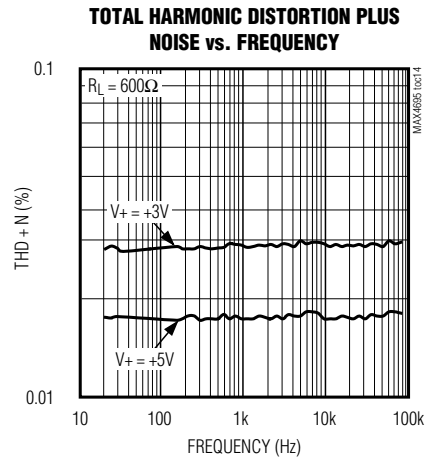
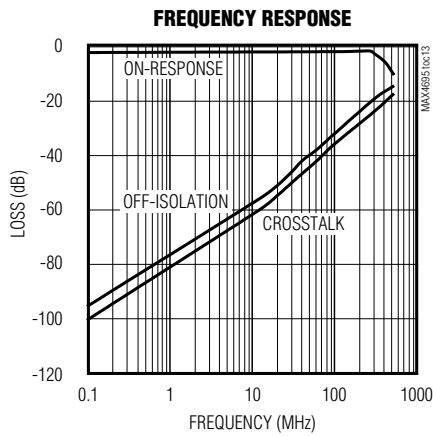
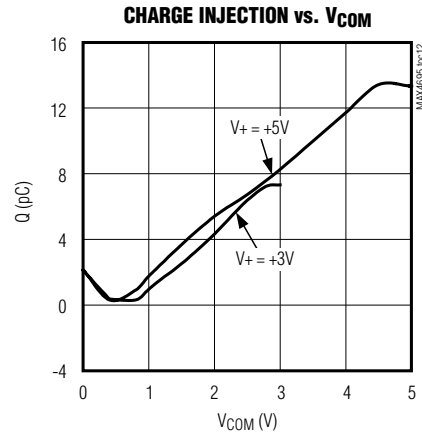
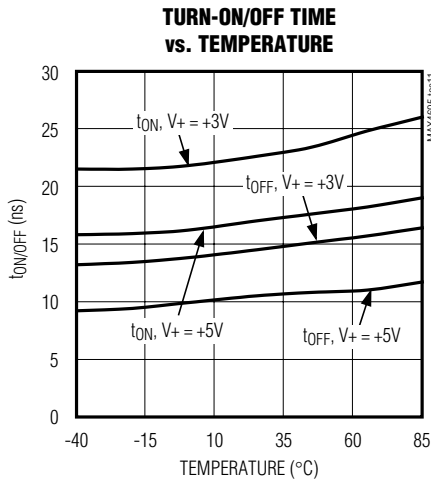
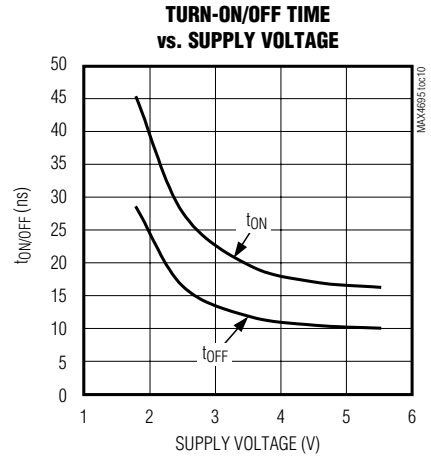
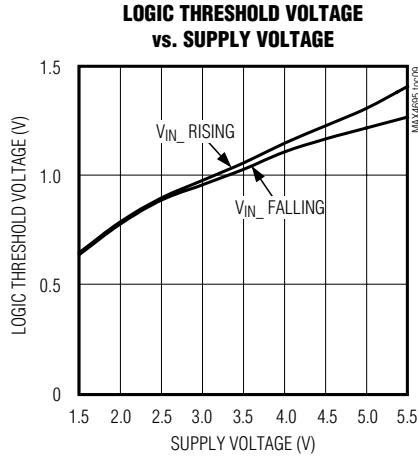
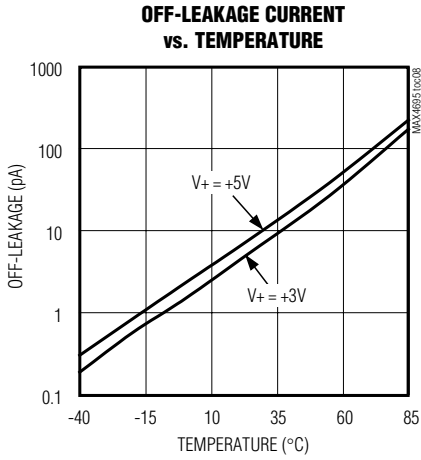
MAX4695



# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

## Typical Operating Characteristics (continued)

( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

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## Pin Description

PIN		NAME	FUNCTION
μMAX	TQFN		
1	12	IN1	Digital Control Input Switch 1
2	1	NO1	Analog Switch 1—Normally Open Terminal
3	2	GND	Ground
4	3	NO2	Analog Switch 2—Normally Open Terminal
5	4	IN2	Digital Control Input Switch 2
6	5	COM2	Analog Switch 2—Common Terminal
—	6, 10	N.C.	No Connection. Not internally connected.
7	7	NC2	Analog Switch 2—Normally Closed Terminal
8	8	V+	Positive Supply Voltage Input
9	9	NC1	Analog Switch 1—Normally Closed Terminal
10	11	COM1	Analog Common Switch 1

## Detailed Description

The MAX4695 is a low-voltage, dual single-pole/double-throw (SPDT) analog switch that operates from a single +1.8V to +5.5V supply. When powered from a +2.7V supply, the device has a 60Ω (max) on-resistance ( $R_{ON}$ ), with 3Ω (max)  $R_{ON}$  matching and 10Ω (max)  $R_{ON}$  flatness. The digital logic inputs are 1.8V-logic compatible from a +2.7V to +3.3V supply.

## Applications Information

### Digital Control Inputs

The MAX4695 logic inputs are 1.8V CMOS logic compatible for 3V operation and TTL compatible for 5V operation of V+. Driving IN\_ rail-to-rail minimizes power consumption.

### Analog Signal Levels

Analog signals that range over the entire supply voltage (V+ to GND) are passed with very little change in on-resistance (see *Typical Operating Characteristics*). The switches are bidirectional, so the NO\_, NC\_, and COM\_ pins can be either inputs or outputs.

### Power-Supply Sequencing and Overvoltage Protection

**Caution: Do not exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to devices.**

Proper power-supply sequencing is recommended for all CMOS devices. Always apply V+ before applying analog signals, especially if the analog signal is not current limited. If this sequencing is not possible, and if the analog inputs are not current limited to <20mA, add

a small signal diode (D1) as shown in Figure 1. If the analog signal can dip below GND, add D2. Adding protection diodes reduces the analog range to a diode drop (about 0.7V) below V+ (for D1), and a diode drop above ground (for D2). On-resistance increases slightly at low supply voltages. Maximum supply voltage (V+) must not exceed +6V.

Adding protection diode D2 causes the logic threshold to be shifted relative to GND. TTL compatibility is not guaranteed when D2 is added.

Protection diodes D1 and D2 also protect against some overvoltage situations. In the circuit in Figure 1, if the supply voltage is below the absolute maximum rating, and if a fault voltage up to the absolute maximum rating is applied to an analog signal pin, no damage will result.

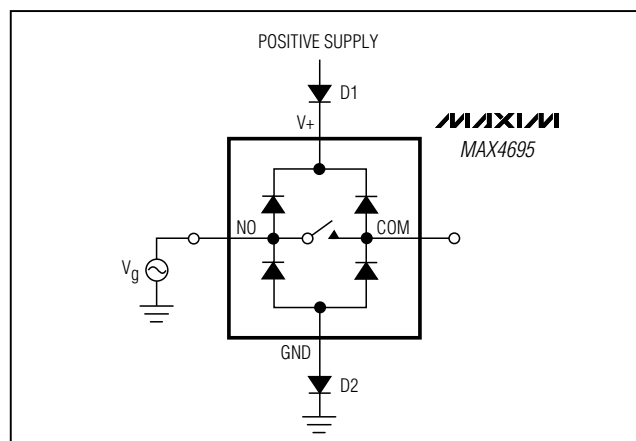


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

## Test Circuits/Timing Diagrams

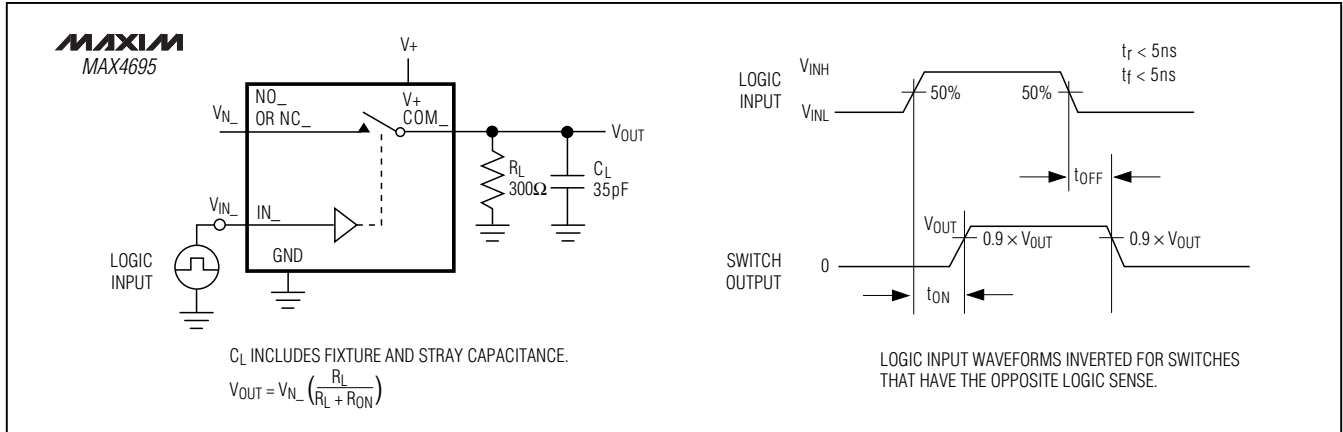


Figure 2. Switching Time

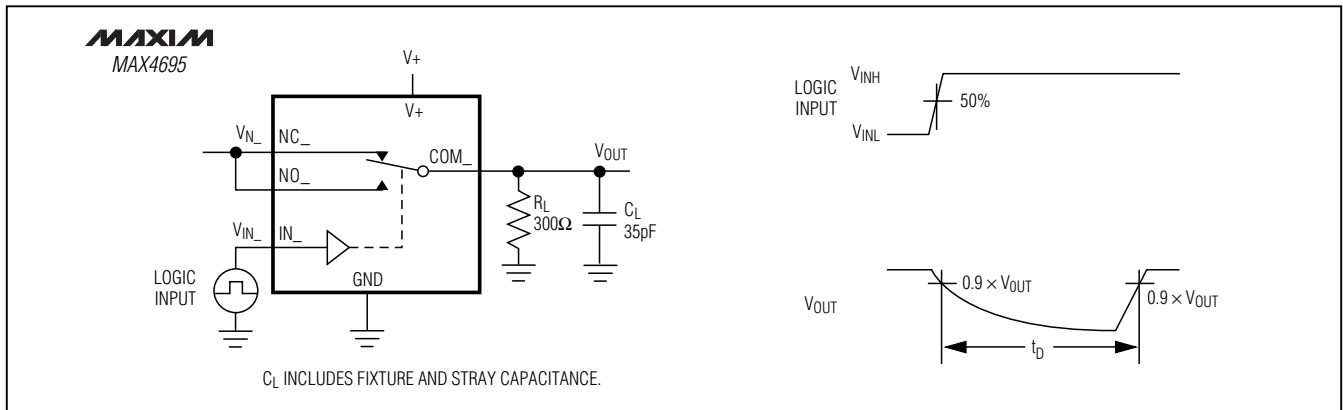


Figure 3. Break-Before-Make Interval

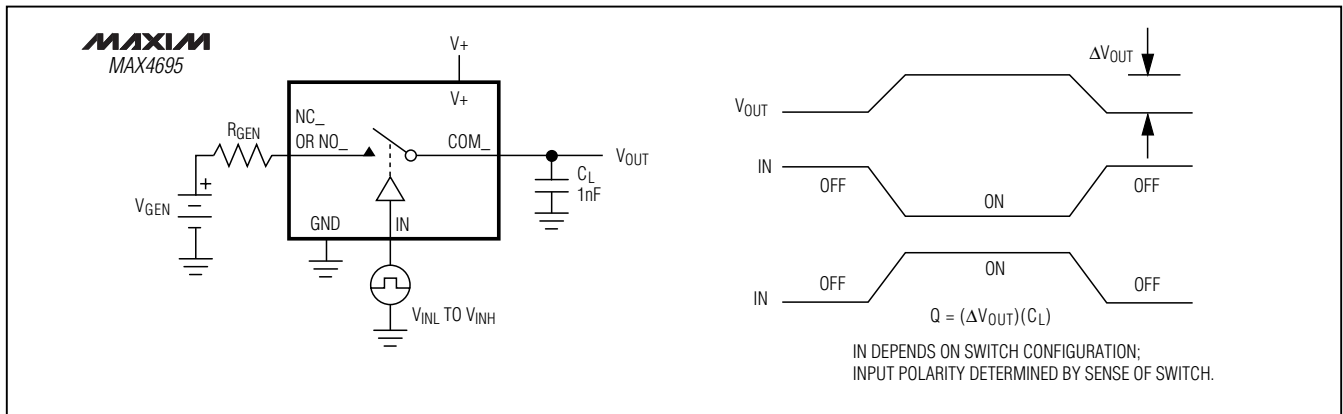


Figure 4. Charge Injection



# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

## Test Circuits/Timing Diagrams (continued)

MAX4695

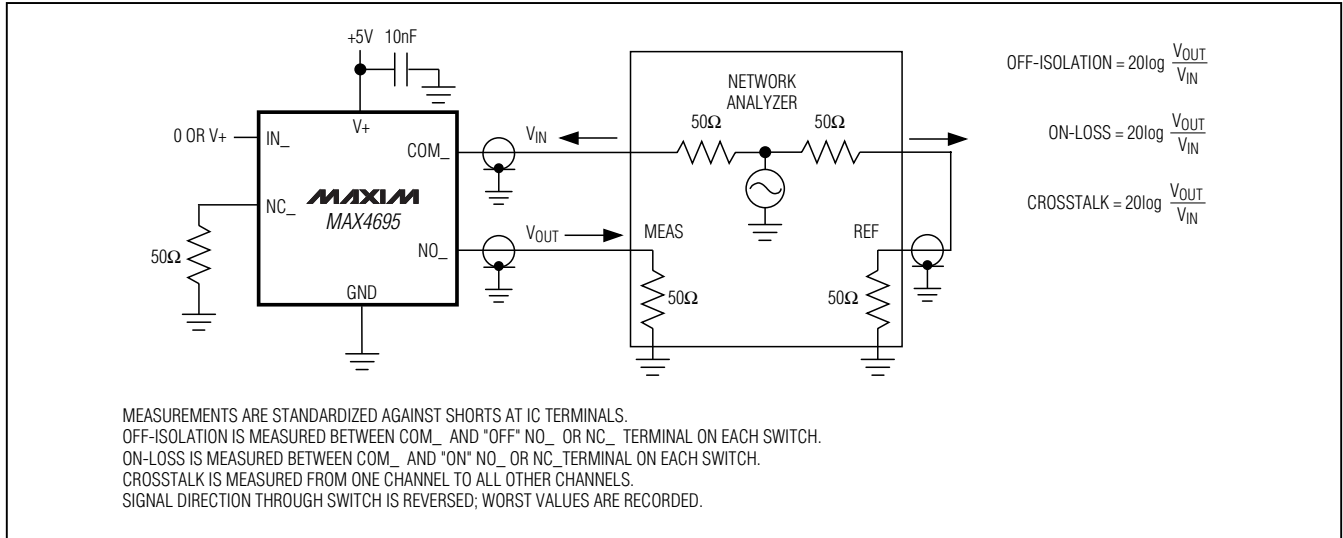


Figure 5. Off-Isolation/On-Channel Bandwidth, Crosstalk

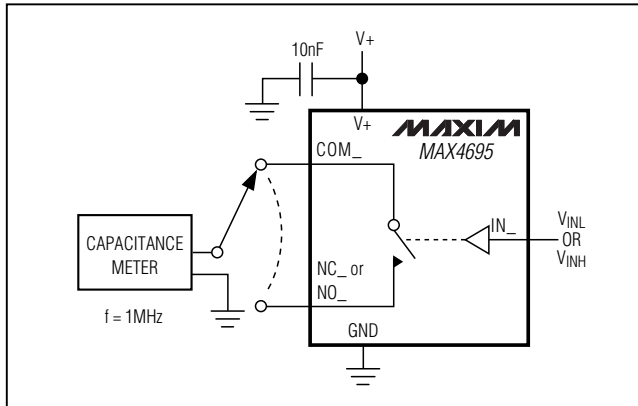


Figure 6. Channel Off/On-Capacitance

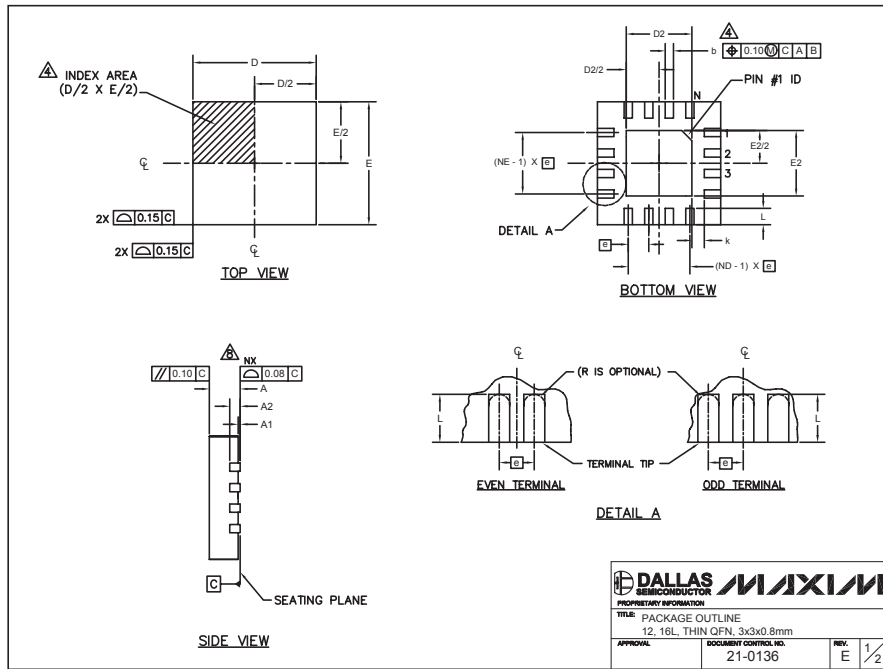
## Chip Information

TRANSISTOR COUNT: 130

# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



12x16L QFN THIN EPS

PKG	12L 3x3			16L 3x3		
REF.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80
b	0.20	0.25	0.30	0.20	0.25	0.30
D	2.90	3.00	3.10	2.90	3.00	3.10
E	2.90	3.00	3.10	2.90	3.00	3.10
e	0.50 BSC.					
L	0.45	0.55	0.65	0.30	0.40	0.50
N	12			16		
ND	3			4		
NE	3			4		
A1	0	0.02	0.05	0	0.02	0.05
A2	0.20 REF			0.20 REF		
k	0.25	-	-	0.25	-	-

PKG CODES	D2			E2			PIN ID	JEDEC	DOWN BONDS ALLOWED
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.			
T1233-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	NO
T1233-3	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	YES
T1633-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	NO
T1633-2	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	YES
T1633F-3	0.65	0.80	0.95	0.65	0.80	0.95	0.225 x 45°	WEED-2	N/A
T1633-4	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	NO

NOTES:

- DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
- ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
- N IS THE TOTAL NUMBER OF TERMINALS.
- THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
- DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.20 mm AND 0.25 mm FROM TERMINAL TIP.
- ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
- DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
- COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
- DRAWING CONFORMS TO JEDEC MO220 REVISION C.

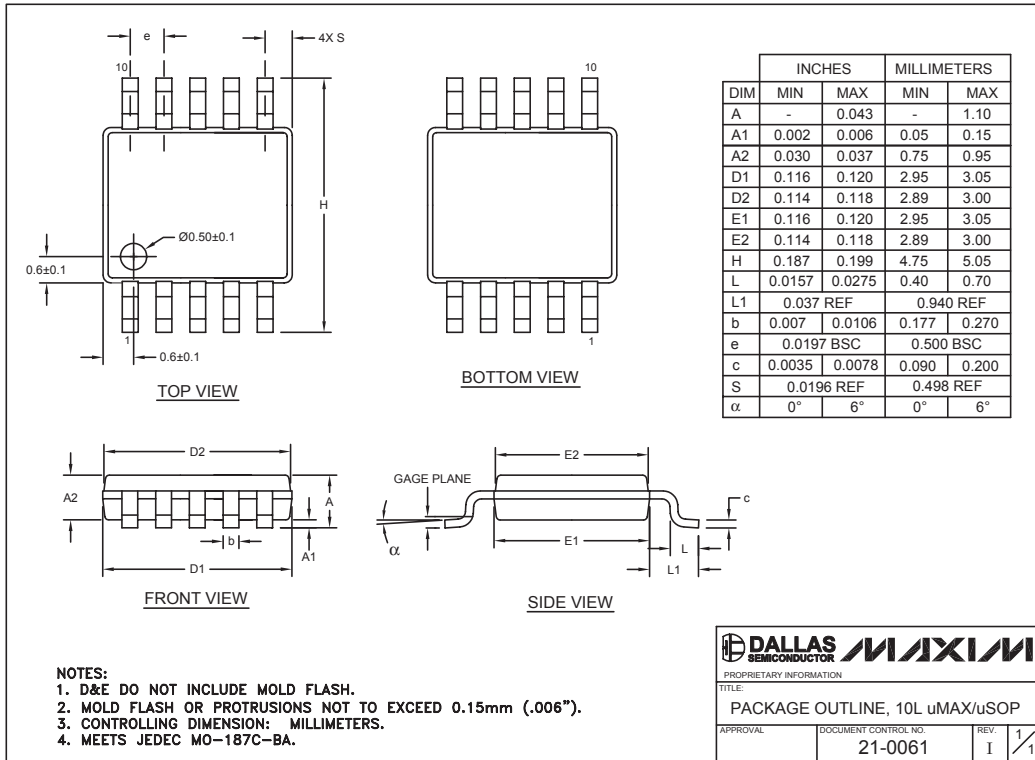
APPROVAL	DOCUMENT CONTROL NO.	REV.
	21-0136	E 2/2

# Low-Voltage, 60Ω Dual SPDT Analog Switch in Thin QFN

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

**MAX4695**



10LUMAX EFS

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- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

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