

# Low-Voltage, Dual DPDT/Quad SPDT Analog Switches in QFN

## ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to GND)

V+	-0.3V to +6V
V <sub>L</sub> , IN <sub>-</sub> , COM <sub>-</sub> , NO <sub>-</sub> , NC <sub>-</sub> (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

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

TSSOP (derate 9.4mW/°C above +70°C)	754.7mW
16-Pin TQFN (derate 20.8mW/°C above +70°C)	1666.7mW
16-Pin Thin QFN (derate 25mW/°C above +70°C)	2000mW
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 IN<sub>-</sub>, COM<sub>-</sub>, NO<sub>-</sub>, and NC<sub>-</sub> exceeding 0 or V+ 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>GND</sub> = 0V, V<sub>IH</sub> = +1.4V, V<sub>IL</sub> = +0.5V, (V<sub>L</sub> = +1.5V, V<sub>IH</sub> = +1.0V, V<sub>IL</sub> = +0.4V for MAX4702 only), T<sub>A</sub> = -40°C to +85°C. Typical values are at V+ = +3V and T<sub>A</sub> = +25°C, unless otherwise noted.) (Notes 2, 3)

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> = 10mA; V <sub>NO-</sub> or V <sub>NC-</sub> = +1.5V	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		60 75	75 85	Ω
On-Resistance Match Between Channels (Note 4)	ΔR <sub>ON</sub>	V+ = +2.7V, I <sub>COM-</sub> = 10mA; V <sub>NO-</sub> or V <sub>NC-</sub> = +1.5V	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		2	4 5	Ω
On-Resistance Flatness (Note 5)	R <sub>FLAT</sub> (ON)	V+ = +2.7V, I <sub>COM-</sub> = 10mA; V <sub>NO-</sub> or V <sub>NC-</sub> = +1V, +1.5V, +2V	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		8	12 14	Ω
NO <sub>-</sub> , NC <sub>-</sub> Off-Leakage Current (Note 6)	I <sub>NO-(OFF)</sub> , I <sub>NC-(OFF)</sub>	V+ = +3.3V, V <sub>COM-</sub> = +1V, +3V; V <sub>NO-</sub> or V <sub>NC-</sub> = +3V, +1V	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>	-0.5 -1		+0.5 1	nA
COM <sub>-</sub> On-Leakage Current (Note 6)	I <sub>COM-</sub> (ON)	V+ = +3.3V, V <sub>COM-</sub> = +1V, +3V; V <sub>NO-</sub> or V <sub>NC-</sub> = +1V, +3V, or unconnected	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>	-0.5 -1		+0.5 1	nA
<b>DYNAMIC</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>NO-</sub> or V <sub>NC-</sub> = +2V; R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		27	35 45	ns
Turn-Off Time	t <sub>OFF</sub>	V <sub>NO-</sub> or V <sub>NC-</sub> = +2V; R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		15	20 25	ns
Break-Before-Make (Note 6)	t <sub>BBM</sub>	V <sub>NO-</sub> or V <sub>NC-</sub> = +2V; R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C T <sub>MIN</sub> to T <sub>MAX</sub>		15	1	ns
On-Channel -3dB Bandwidth	BW	Signal = 0dBm, 50Ω in and out, Figure 5			250		MHz
Off-Isolation (Note 7)	V <sub>ISO</sub>	f = 1MHz, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, Figure 5	+25°C		-76		dB

# Low-Voltage, Dual DPDT/Quad SPDT Analog Switches in QFN

MAX4699/MAX4701/MAX4702

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

(V+ = +2.7V to +3.3V, V<sub>GND</sub> = 0V, V<sub>IH</sub> = +1.4V, V<sub>IL</sub> = +0.5V, (V<sub>L</sub> = +1.5V, V<sub>IH</sub> = +1.0V, V<sub>IL</sub> = +0.4V for MAX4702 only), T<sub>A</sub> = -40°C to +85°C. Typical values are at V+ = +3V and T<sub>A</sub> = +25°C, unless otherwise noted.) (Notes 2, 3)

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	+25°C		-79		dB
Charge Injection	Q	V <sub>GEN</sub> = 0V, R <sub>GEN</sub> = 0Ω, C <sub>L</sub> = 1.0nF, Figure 4	+25°C		0.5		pC
NO <sub>-</sub> , NC <sub>-</sub> , Off-Capacitance	C <sub>NO_(OFF)</sub> , C <sub>NC_(OFF)</sub>	f = 1MHz, V <sub>NO_-</sub> , V <sub>NC_-</sub> = GND, Figure 6	+25°C		8		pF
Switch On-Capacitance	C <sub>(ON)</sub>	f = 1MHz, Figure 6	+25°C		20		pF
Total Harmonic Distortion	THD	f = 20Hz to 20kHz, 2.5V <sub>p-p</sub> , R <sub>L</sub> = 600Ω	+25°C		0.02		%
<b>DIGITAL I/O</b>							
Input Logic High	V <sub>IH</sub>	MAX4699/MAX4701		1.4			V
		MAX4702 (V <sub>L</sub> = +1.5V)		1.0			
Input Logic Low	V <sub>IL</sub>	MAX4699/MAX4701				0.8	V
		MAX4702 (V <sub>L</sub> = +1.5V)		0.4			
Input Leakage Current	I <sub>IH</sub> , I <sub>IL</sub>	V <sub>IN</sub> = 0 to V+		-1		1	μA
<b>SUPPLY</b>							
Power-Supply Range	V+			1.8		5.5	V
Logic Power-Supply Input	V <sub>L</sub>			1.5		V+	V
Positive Supply Current	I+	V+ = +3.3V, V <sub>IN</sub> = 0 or V+	T <sub>MIN</sub> to T <sub>MAX</sub>	-1		1	μA

## ELECTRICAL CHARACTERISTICS—Single +5V Supply

(V+ = +5V ±10%, V<sub>GND</sub> = 0V, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = +0.8V, (V<sub>L</sub> = +1.5V, V<sub>IH</sub> = +1.0V, V<sub>IL</sub> = +0.4V for MAX4702 only), T<sub>A</sub> = -40°C to +85°C. Typical values are at V+ = +5V and T<sub>A</sub> = +25°C, unless otherwise noted.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
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> = 10mA; V <sub>NO_-</sub> or V <sub>NC_-</sub> = +3.5V	+25°C		30	40	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			50	
On-Resistance Match Between Channels (Note 4)	ΔR <sub>ON</sub>	V+ = +4.5V, I <sub>COM_-</sub> = 10mA; V <sub>NO_-</sub> or V <sub>NC_-</sub> = +3.5V	+25°C		1	3	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			5	
On-Resistance Flatness (Note 5)	R <sub>FLAT (ON)</sub>	V+ = +4.5V, I <sub>COM_-</sub> = 10mA; V <sub>NO_-</sub> or V <sub>NC_-</sub> = +2.0V, +2.25V, +3.5V	+25°C		5	8	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			10	
<b>DYNAMIC</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>NO_-</sub> or V <sub>NC_-</sub> = +3V; R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C		15	18	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			20	

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

( $V_+ = +5V \pm 10\%$ ,  $V_{GND} = 0V$ ,  $V_{IH} = +2.4V$ ,  $V_{IL} = +0.8V$ , ( $V_L = +1.5V$ ,  $V_{IH} = +1.0V$ ,  $V_{IL} = +0.4V$  for MAX4702 only),  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ . Typical values are at  $V_+ = +5V$  and  $T_A = +25^\circ\text{C}$ , unless otherwise noted.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	$T_A$	MIN	TYP	MAX	UNITS
Turn-Off Time	$t_{OFF}$	$V_{NO\_}$ or $V_{NC\_} = +3V$ ; $R_L = 300\Omega$ , $C_L = 35\text{pF}$ , Figure 2	$+25^\circ\text{C}$		7	12	ns
			$T_{MIN}$ to $T_{MAX}$			15	
Break-Before-Make (Note 6)	$t_{BBM}$	$V_{NO\_}$ or $V_{NC\_} = +3V$ ; $R_L = 300\Omega$ , $C_L = 35\text{pF}$ , Figure 2	$+25^\circ\text{C}$		10		ns
			$T_{MIN}$ to $T_{MAX}$		2		
Charge Injection	Q	$V_{GEN} = 0V$ , $R_{GEN} = 0\Omega$ , $C_L = 1.0\text{nF}$ , Figure 4	$+25^\circ\text{C}$		0.5		pC
<b>DIGITAL I/O</b>							
Input Logic High	$V_{IH}$	MAX4699/MAX4701		2.4			V
		MAX4702 ( $V_L = +1.5V$ )		1.0			
Input Logic Low	$V_{IL}$	MAX4699/MAX4701				0.8	V
		MAX4702 ( $V_L = +1.5V$ )				0.4	
Logic Input Current	$I_{IH}$ , $I_{IL}$	$V_{IN} = 0$ to $V_+$		-1		1	$\mu\text{A}$

**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:**  $-40^\circ\text{C}$  specifications are guaranteed by design.

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

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

**Note 6:** Guaranteed by design.

**Note 7:** Off-Isolation =  $20\log_{10}(V_{COM\_} / V_{NO_})$ ,  $V_{COM\_}$  = output,  $V_{NO_}$  = input to off switch.

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

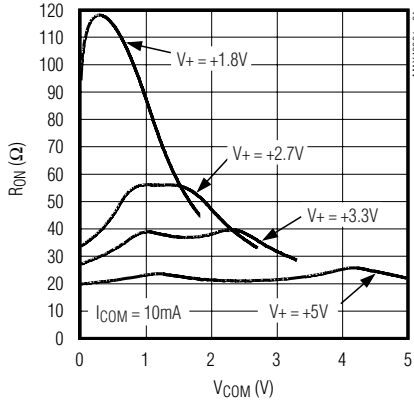
# Low-Voltage, Dual DPDT/Quad SPDT Analog Switches in QFN

## Typical Operating Characteristics

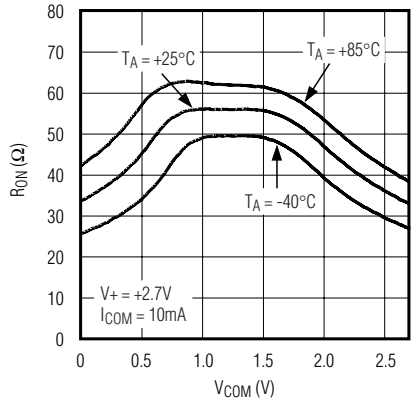
( $T_A = +25^\circ\text{C}$ , unless otherwise noted.  $V_L = +1.5\text{V}$  for MAX4702 only.)

MAX4699/MAX4701/MAX4702

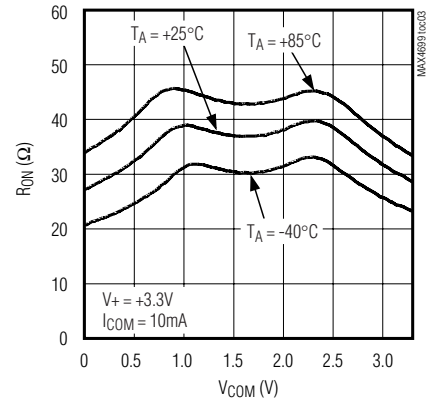
**ON-RESISTANCE vs. COM VOLTAGE OVER SUPPLY VOLTAGE**



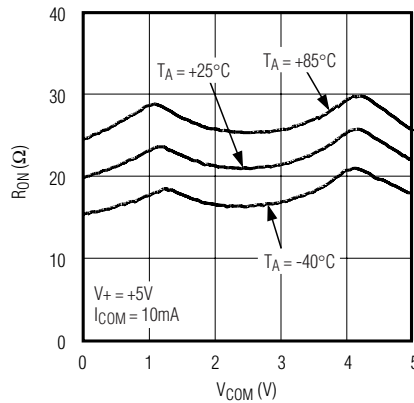
**ON-RESISTANCE vs. COM VOLTAGE OVER TEMPERATURE ( $V_+ = +2.7\text{V}$ )**



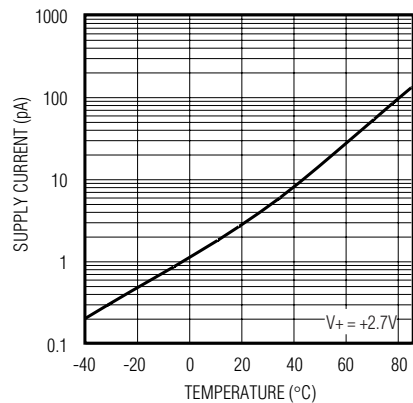
**ON-RESISTANCE vs. COM VOLTAGE OVER TEMPERATURE ( $V_+ = +3.3\text{V}$ )**



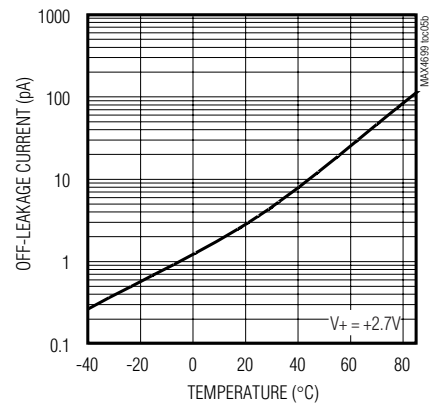
**ON-RESISTANCE vs. COM VOLTAGE OVER TEMPERATURE ( $V_+ = +5\text{V}$ )**



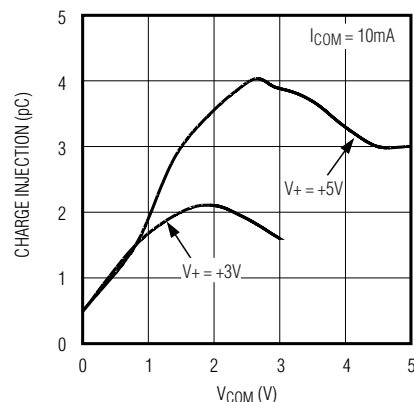
**ON-LEAKAGE CURRENT vs. TEMPERATURE**



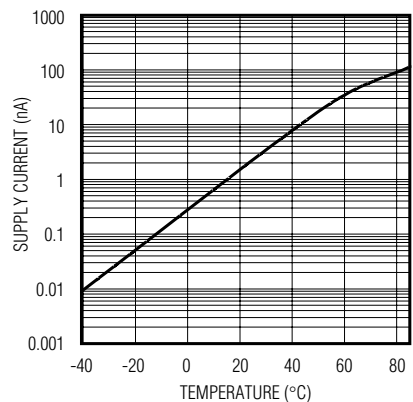
**OFF-LEAKAGE CURRENT vs. TEMPERATURE**



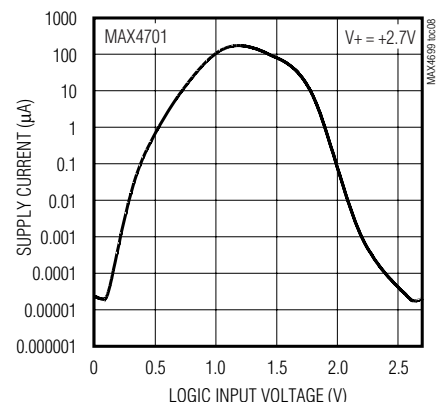
**CHARGE INJECTION vs. COM VOLTAGE OVER SUPPLY VOLTAGE**



**SUPPLY CURRENT vs. TEMPERATURE**



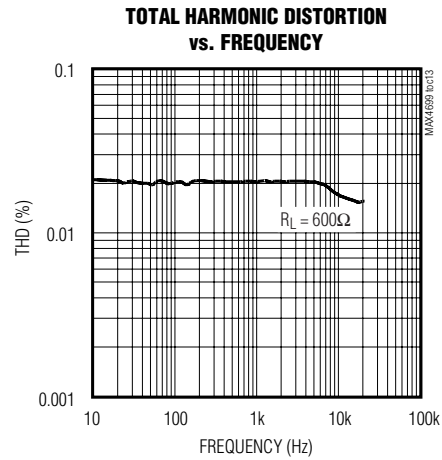
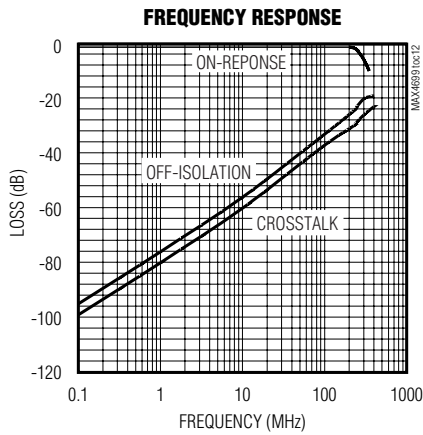
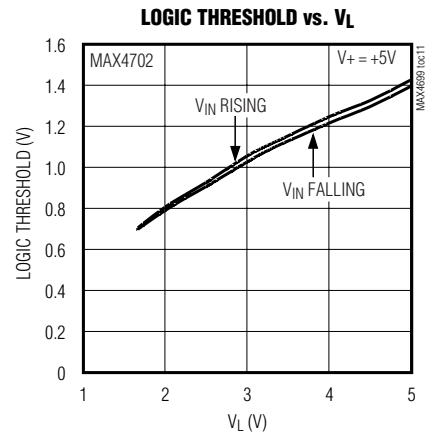
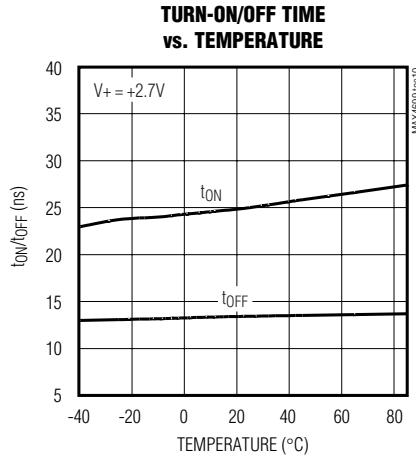
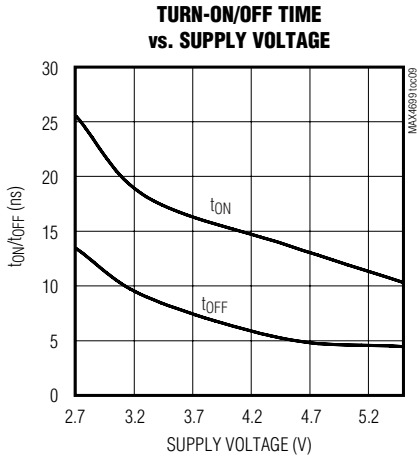
**SUPPLY CURRENT vs. LOGIC INPUT VOLTAGE**



# Low-Voltage, Dual DPDT/Quad SPDT Analog Switches in QFN

## Typical Operating Characteristics (continued)

( $T_A = +25^\circ\text{C}$ , unless otherwise noted.  $V_L = +1.5\text{V}$  for MAX4702 only.)



# Low-Voltage, Dual DPDT/Quad SPDT Analog Switches in QFN

## Pin Description

TQFN-EP PIN		TSSOP PIN		NAME	FUNCTION
MAX4699/ MAX4701	MAX4702	MAX4701	MAX4702		
1	1	3	3	NC1	Analog Switch 1—Normally Closed Terminal
—	2	—	4	IN	Digital Control Input Switch 1, 2, 3, and 4
2	—	4	—	IN1, IN2	Digital Control Input Switch 1 and 2
3	3	5	5	NO2	Analog Switch 2—Normally Open Terminal
4	4	6	6	COM2	Analog Switch 2—Common Terminal
5	5	7	7	NC2	Analog Switch 2—Normally Closed Terminal
6	6	8	8	GND	Ground
7	7	9	9	NO3	Analog Switch 3—Normally Open Terminal
8	8	10	10	COM3	Analog Switch 3—Common Terminal
9	9	11	11	NC3	Analog Switch 3—Normally Closed Terminal
—	10	—	12	V <sub>L</sub>	Logic Power-Supply Input
10	—	12	—	IN3, IN4	Digital Control Input Switch 3 and 4
11	11	13	13	NO4	Analog Switch 4—Normally Open Terminal
12	12	14	14	COM4	Analog Switch 4—Common Terminal
13	13	15	15	NC4	Analog Switch 4—Normally Closed Terminal
14	14	16	16	V+	Positive Supply Voltage Input
15	15	1	1	NO1	Analog Switch 1—Normally Open Terminal
16	16	2	2	COM1	Analog Switch 1—Common Terminal
—	—	—	—	EP	Exposed Pad (TQFN Only). Connect EP to GND.

MAX4699/MAX4701/MAX4702

## Detailed Description

The MAX4699/MAX4701 are low-voltage CMOS analog switches that operate from a single +1.8V to +5.5V power supply. The MAX4702 requires an additional logic supply that allows for setting lower logic thresholds. The MAX4699/MAX4701 are double-pole/double-throw (DPDT) devices. The MAX4702 is a quad single-pole/double-throw (SPDT) device. These devices feature a break-before-make switching, fast switching speeds (with V<sub>+</sub> = 5V: t<sub>ON</sub> = 18ns max, t<sub>OFF</sub> = 9ns max and with V<sub>+</sub> = 3V: t<sub>ON</sub> = 35ns, t<sub>OFF</sub> = 20) and rail-to-rail signal handling. A logic input on the MAX4702 allows for logic thresholds as low as 1.0V.

## Applications Information

### Analog Signal Levels

Analog signals that range over the entire supply voltage (V<sub>+</sub> to GND) can be 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 used as either inputs or outputs.

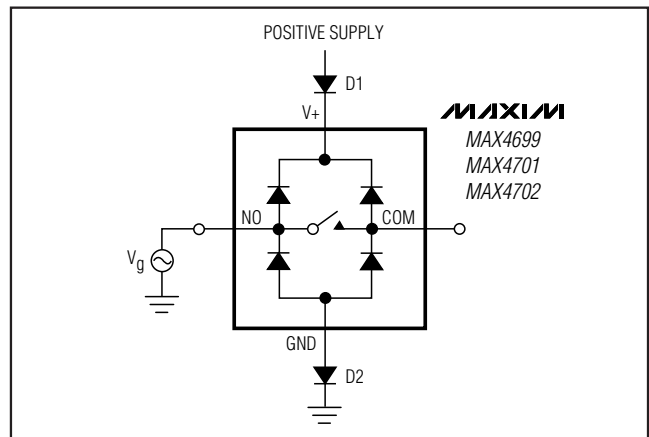


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

# Low-Voltage, Dual DPDT/Quad SPDT Analog Switches in QFN

## 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 the 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. With Figure 1's circuit, 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.

## V<sub>L</sub> Logic Input (MAX4702)

The MAX4702 features a V<sub>L</sub> logic input that allows for lower logic input thresholds down to 1.0V min for V<sub>IH</sub> in the quad SPDT configuration. Power-up V<sub>L</sub> after V+ has been powered with a minimum of 1.5V to ensure proper operation of the device.

## Test Circuits/Timing Diagrams

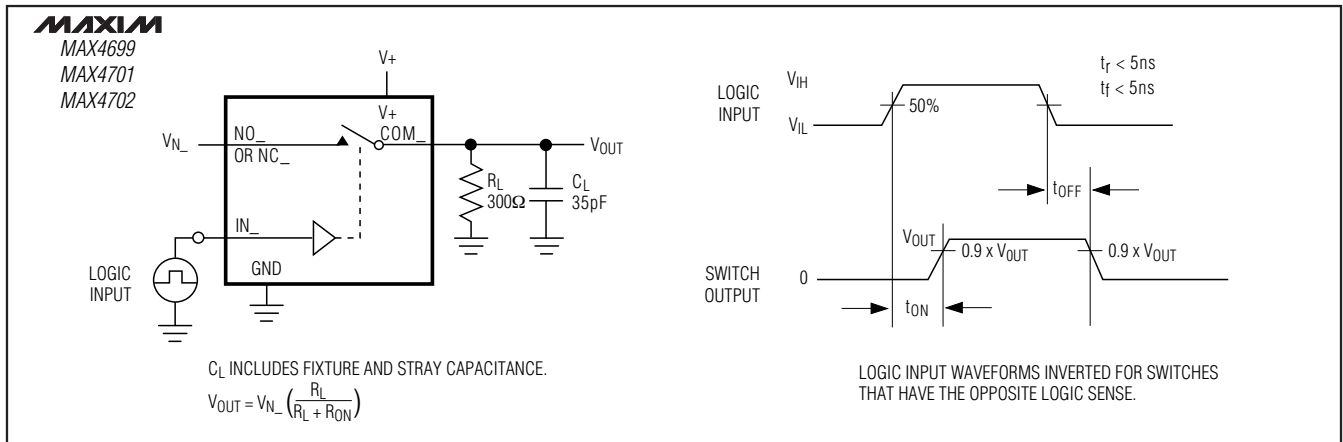


Figure 2. Switching Time

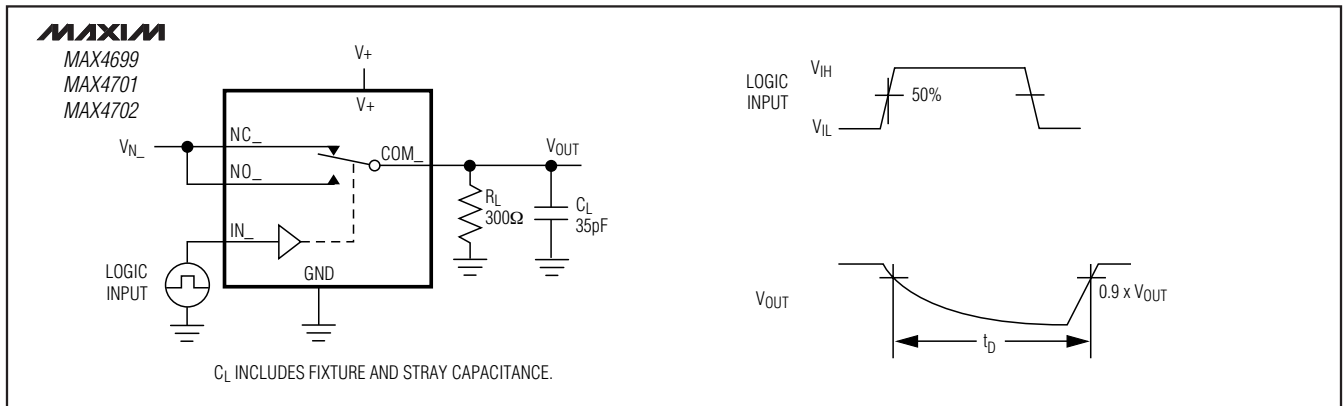


Figure 3. Break-Before-Make Interval

# Low-Voltage, Dual DPDT/Quad SPDT Analog Switches in QFN

## Test Circuits/Timing Diagrams (continued)

MAX4699/MAX4701/MAX4702

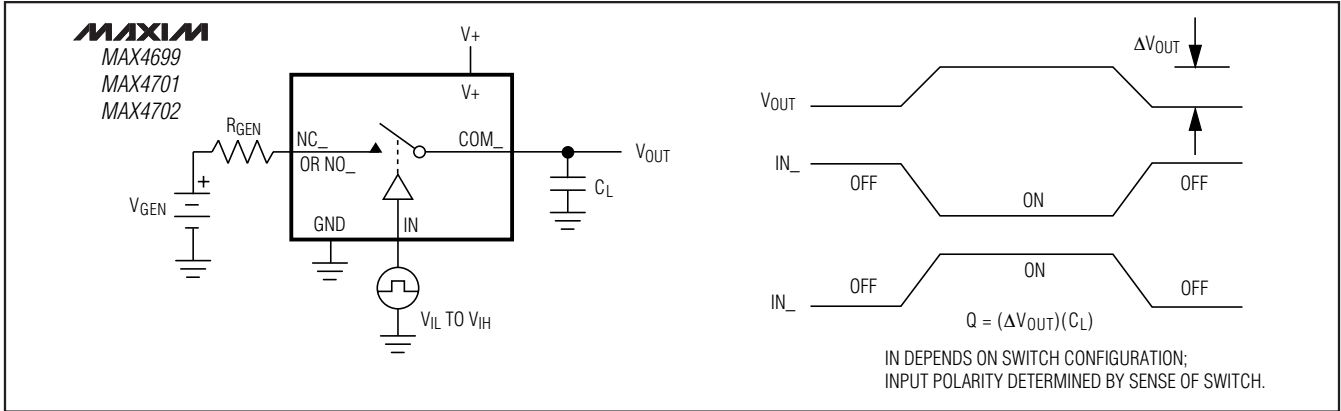


Figure 4. Charge Injection

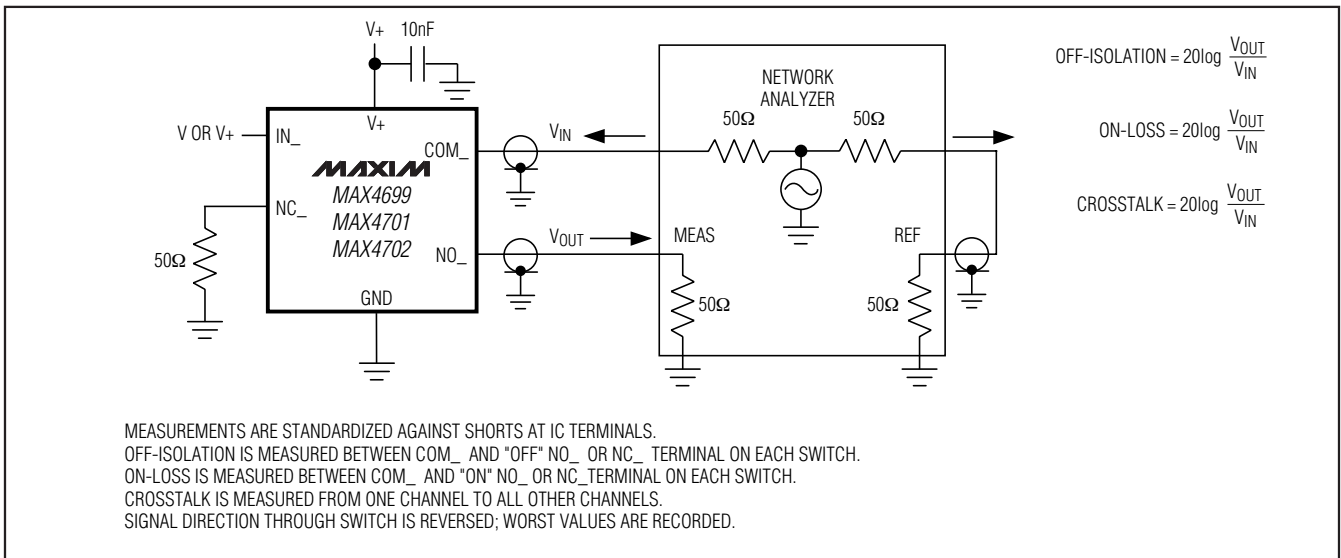


Figure 5. On-Loss, Off-Isolation, and Crosstalk

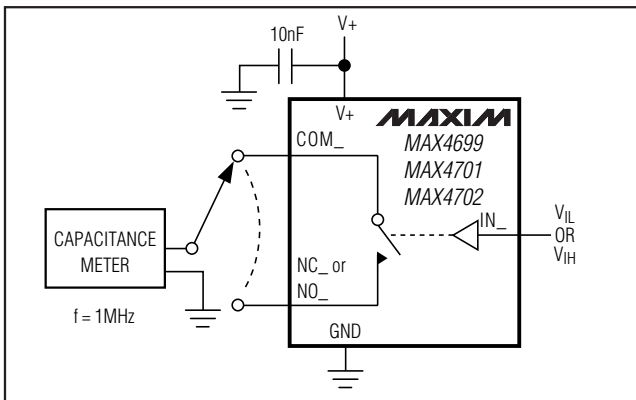


Figure 6. Channel Off/On-Capacitance

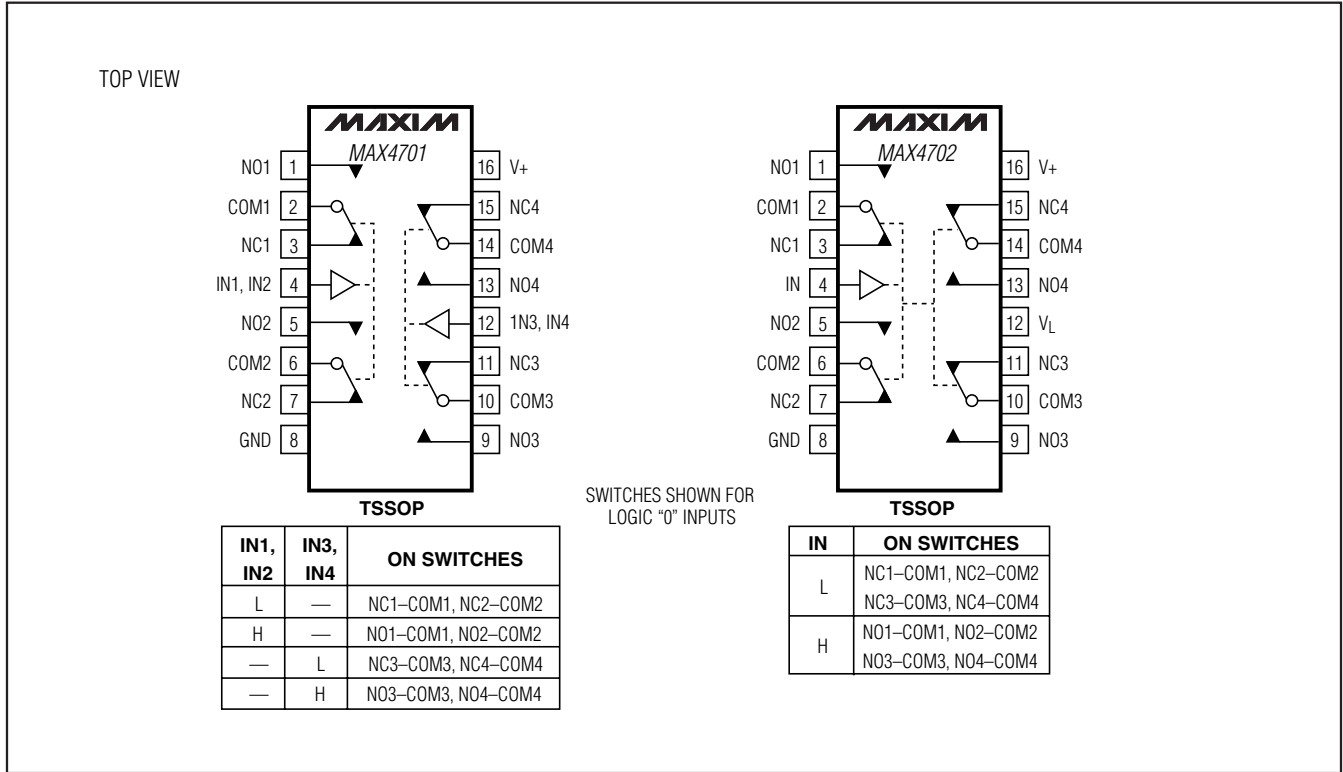
## Chip Information

SUBSTRATE CONNECTED TO GND



# Low-Voltage, Dual DPDT/Quad SPDT Analog Switches in QFN

## Pin Configurations (continued)



## Package Information

For the latest package outline information and land patterns (footprints), go to [www.maxim-ic.com/packages](http://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.
16 TQFN-EP (4mm x 4mm)	T1644+4	<a href="#">21-0139</a>	<a href="#">90-0070</a>
16 TQFN-EP (3mm x 3mm)	T1633+4	<a href="#">21-0136</a>	<a href="#">90-0031</a>
16 TSSOP	U16+2	<a href="#">21-0066</a>	<a href="#">90-0117</a>

# Low-Voltage, Dual DPDT/Quad SPDT Analog Switches in QFN

## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
2	10/09	Added "Exposed pad" reference to the <i>Ordering Information</i> table, <i>Pin Configurations</i> , and <i>Pin Description</i> table.	1, 7
3	4/11	Corrected part numbers in <i>Ordering Information</i> ; updated <i>Absolute Maximum Ratings</i> .	1, 2

MAX4699/MAX4701/MAX4702

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