



# 35Ω, Low-Voltage, SPST/SPDT Analog Switches in UCSP Package

MAX4696/MAX4697/MAX4698

## General Description

The MAX4696/MAX4697/MAX4698 low on-resistance ( $R_{ON}$ ), low-voltage analog switches operate from a single +2.0V to +5.5V supply. The MAX4696/MAX4697 are single-pole/single-throw (SPST) analog switches, and the MAX4698 is a single-pole/double-throw (SPDT) analog switch. The MAX4696 is a normally open (NO) switch, and the MAX4697 is a normally closed (NC) switch.

When powered from a 2.7V supply, these devices feature 35Ω (max)  $R_{ON}$ , with 2Ω (max)  $R_{ON}$  matching and 13Ω (max) flatness. The MAX4696/MAX4697/MAX4698 offer fast switching speeds ( $t_{ON} = 80ns$  max,  $t_{OFF} = 25ns$  max). The MAX4698 offers a break-before-make function.

The digital logic inputs are 1.8V logic compatible from a +2.7V to +3.3V supply and are TTL/CMOS compatible from a +4.5V to +5.5V supply. The MAX4696/MAX4697/MAX4698 are packaged in the chip-scale package (UCSP™), significantly reducing the required PC board area. The device occupies only a 1.50mm × 1.02mm area. The 3 × 2 array of solder bumps are spaced with a 0.5mm bump pitch.

## Applications

- MP3 Players
- Battery-Operated Equipment
- Relay Replacement
- Audio and Video Signal Routing
- Communications Circuits
- PCMCIA Cards
- Cellular Phones
- Hard Drives
- Modems

Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.  
UCSP is a trademark of Maxim Integrated Products, Inc.

## Features

- ◆ 6-Bump, 0.5mm Pitch, UCSP (Package pending full qualification—expected completion date 6/30/01. See UCSP Reliability section for more details.)
- ◆  $R_{ON}$   
35Ω max (+3V Supply)  
20Ω max (+5V Supply)
- ◆ 2Ω max  $R_{ON}$  Match Between Channels
- ◆ 13Ω max  $R_{ON}$  Flatness Over Signal Range
- ◆ Low Leakage Currents Over Temperature  
1nA (max) at  $T_A = +25^\circ C$
- ◆ Fast Switching:  $t_{ON} = 80ns$ ,  $t_{OFF} = 25ns$
- ◆ Guaranteed Break-Before-Make (MAX4698)
- ◆ +2.0V to +5.5V Single-Supply Operation
- ◆ Rail-to-Rail® Signal Handling
- ◆ Low Crosstalk: -75dB (100kHz)
- ◆ High Off-Isolation: -75dB (100kHz)
- ◆ 1.8V CMOS Logic Compatible
- ◆ -3dB Bandwidth: >200MHz

## Ordering Information

PART	TEMP. RANGE	PIN/BUMP-PACKAGE	TOP MARK
MAX4696EBT	-40°C to +85°C	6 UCSP*	AAL
MAX4697EBT	-40°C to +85°C	6 UCSP*	AAM
MAX4698EBT	-40°C to +85°C	6 UCSP*	AAN

\*Note: Requires special solder temperature profile described in the Absolute Maximum Ratings section.

\*UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and environment. Refer to the UCSP Reliability section of this data sheet for more information.

## Pin Configurations/Functional Diagrams/Truth Table

TOP VIEW

MAXIM  
MAX4696

MAXIM  
MAX4697

MAXIM  
MAX4698

IN	NO	NC
0	OFF	ON
1	ON	OFF

SWITCHES SHOWN FOR LOGIC "0"



# 35Ω, Low-Voltage, SPST/SPDT Analog Switches in UCSP Package

## ABSOLUTE MAXIMUM RATINGS

All Voltages Referenced to GND

V+, IN	-0.3V to +6V
COM, NO, NC (Note 1)	-0.3V to (V+ + 0.3V)
Continuous Current COM, NO, NC	±20mA
Peak Current COM, NO, NC (pulsed at 1ms, 10% duty cycle)	±40mA

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

3 × 2 UCSP (derate 10.1mW/°C at +70°C)	808mW
Operating Temperature Range	-40°C to +85°C
Storage Temperature Range	-65°C to +150°C
Bump Temperature (soldering) (Note 2)	
Infrared (15s)	+220°C
Vapor Phase (60s)	+215°C

**Note 1:** Signals on NO, NC, and COM exceeding V+ are clamped by an internal diode. Limit forward-diode current to maximum current rating.

**Note 2:** This device is constructed using a unique set of packaging techniques that impose a limit on the thermal profile the device can be exposed to during board level solder attach and rework. This limit permits only the use of the solder profiles recommended in the industry standard specification, JEDEC 020A, paragraph 7.6, Table 3 for IR/VPR and convection reflow. Preheating is required. Hand or wave soldering is not allowed.

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> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at +3V and T<sub>A</sub> = +25°C.) (Notes 3, 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>		T <sub>MIN</sub> to T <sub>MAX</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> = 1.5V	+25°C		30	35	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			40	
On-Resistance Match Between Channels (MAX4698 only) (Note 5)	ΔR <sub>ON</sub>	V+ = +2.7V, I <sub>COM</sub> = 1mA, V <sub>NO</sub> or V <sub>NC</sub> = 1.5V	+25°C		1	2	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			3	
On-Resistance Flatness (Note 6)	R <sub>FLAT(ON)</sub>	V+ = +2.7V, I <sub>COM</sub> = 1mA, V <sub>NO</sub> or V <sub>NC</sub> = 1V, 1.5V, 2V	+25°C		10	13	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			15	
NO, NC Off-Leakage Current (Note 4)	I <sub>NO(OFF)</sub> , I <sub>NC(OFF)</sub>	V+ = +3.6V; V <sub>COM</sub> = 0.3V, 3.3V; V <sub>NO</sub> or V <sub>NC</sub> = 3.3V, 0.3V	+25°C	-0.5	±0.01	0.5	nA
			T <sub>MIN</sub> to T <sub>MAX</sub>	-1		1	
COM Off-Leakage Current (Note 4) (MAX4696, MAX4697 only)	I <sub>COM(OFF)</sub>	V+ = +3.6V; V <sub>COM</sub> = 0.3V, 3.3V; V <sub>NO</sub> or V <sub>NC</sub> = 0.3V, 3.3V	+25°C	-0.5	±0.01	0.5	nA
			T <sub>MIN</sub> to T <sub>MAX</sub>	-1		1	
COM On-Leakage Current (Note 4)	I <sub>COM(ON)</sub>	V+ = +3.6V; V <sub>COM</sub> = 0.3V, 3.3V; V <sub>NO</sub> or V <sub>NC</sub> = 0.3V, 3.3V, or floating	+25°C	-0.5	±0.01	0.5	nA
			T <sub>MIN</sub> to T <sub>MAX</sub>	-2		2	
<b>DYNAMIC CHARACTERISTICS</b>							
Turn-On Time (Note 4)	t <sub>ON</sub>	V+ = +2.7V; V <sub>NO</sub> , V <sub>NC</sub> = 1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 1	+25°C		50	80	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			110	

# 35Ω, Low-Voltage, SPST/SPDT Analog Switches in UCSP Package

**MAX4696/MAX4697/MAX4698**

## 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> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at +3V and T<sub>A</sub> = +25°C.) (Notes 3, 9)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
Turn-Off Time (Note 4)	t <sub>OFF</sub>	V+ = +2.7V; V <sub>NO</sub> , V <sub>NC</sub> = 1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 1	+25°C		20	25	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			40	
Break-Before-Make Time (MAX4698 only) (Note 4)	t <sub>BBM</sub>	V+ = +3.3V; V <sub>NO</sub> , V <sub>NC</sub> = 1.5V, Figure 2	+25°C		15		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 3	+25°C		8		pC
On-Channel -3dB Bandwidth	BW	Signal = 0dBm, 50Ω in and out, Figure 4	+25°C		200		MHz
Off-Isolation (Note 7)	V <sub>ISO</sub>	f = 100kHz, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, Figure 4	+25°C		-75		dB
Crosstalk (MAX4698 only) (Note 8)	V <sub>CT</sub>	f = 100kHz, R <sub>L</sub> = 50Ω, C <sub>L</sub> = 5pF, Figure 4	+25°C		-75		dB
Total Harmonic Distortion	THD	f = 20Hz to 20kHz, 2Vp-p, R <sub>L</sub> = 600Ω	+25°C		0.014		%
NO, NC Off-Capacitance	C <sub>NO(OFF)</sub> , C <sub>NC(OFF)</sub>	f = 1MHz, Figure 5	+25°C		15		pF
COM Off-Capacitance	C <sub>COM(OFF)</sub>	f = 1MHz, Figure 5	+25°C		15		pF
Switch On-Capacitance	C <sub>(ON)</sub>	f = 1MHz, Figure 6	+25°C		30		pF
<b>DIGITAL I/O</b>							
Input Logic High	V <sub>IH</sub>		T <sub>MIN</sub> to T <sub>MAX</sub>	1.4			V
Input Logic Low	V <sub>IL</sub>		T <sub>MIN</sub> to T <sub>MAX</sub>			0.5	V
Input Leakage Current	I <sub>IN</sub>	V <sub>IN</sub> = 0 or V+	T <sub>MIN</sub> to T <sub>MAX</sub>	-1		1	μA
<b>POWER SUPPLY</b>							
Power-Supply Range	V+		T <sub>MIN</sub> to T <sub>MAX</sub>	2.0		5.5	V
Supply Current	I+	V+ = +3.3V, V <sub>IN</sub> = 0 or V+	T <sub>MIN</sub> to T <sub>MAX</sub>			1	μA

## ELECTRICAL CHARACTERISTICS—Single +5V Supply

(V+ = +4.5V to +5.5V, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at +5V and T<sub>A</sub> = +25°C.) (Notes 3, 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> = 1V, 3.5V	+25°C		15	20	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			25	
On-Resistance Match (MAX4698 only) (Note 5)	ΔR <sub>ON</sub>	V+ = 4.5V, I <sub>COM</sub> = 1mA, V <sub>NO</sub> or V <sub>NC</sub> = 1V, 3.5V	+25°C		1	3	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>			4	

# 35Ω, Low-Voltage, SPST/SPDT Analog Switches in UCSP Package

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

(V+ = +4.5V to +5.5V, V<sub>IH</sub> = +2.4V, V<sub>IL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at +5V and T<sub>A</sub> = 25°C.) (Notes 3,9)

PARAMETER	SYMBOL	CONDITIONS	T <sub>A</sub>	MIN	TYP	MAX	UNITS
On-Resistance Flatness (Note 6)	R <sub>FLAT(ON)</sub>	V+ = +4.5V, I <sub>COM</sub> = 1mA, V <sub>NO</sub> or V <sub>NC</sub> = 1V, 2.25V, 3.5V	+25°C	3	4	5	Ω
			T <sub>MIN</sub> to T <sub>MAX</sub>				
NO, NC Off-Leakage Current (Note 4)	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	-0.5	±0.01	0.5	nA
			T <sub>MIN</sub> to T <sub>MAX</sub>	-1		1	
COM Off-Leakage Current (MAX4696, MAX4697 only) (Note 4)	I <sub>COM(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	-0.5	±0.01	0.5	nA
			T <sub>MIN</sub> to T <sub>MAX</sub>	-1		1	
COM On-Leakage Current (Note 4)	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	-0.5	±0.01	0.5	nA
			T <sub>MIN</sub> to T <sub>MAX</sub>	-2		2	
Turn-On Time (Note 4)	t <sub>ON</sub>	V+ = +5.5V, V <sub>NO</sub> , V <sub>NC</sub> = 3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 1	+25°C		30	40	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			50	
Turn-Off Time (Note 4)	t <sub>OFF</sub>	V+ = +5.5V, V <sub>NO</sub> , V <sub>NC</sub> = 3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 1	+25°C		15	20	ns
			T <sub>MIN</sub> to T <sub>MAX</sub>			25	
Break-Before-Make Time (MAX4698 only) (Note 4)	t <sub>BBM</sub>	V+ = +5.5V, V <sub>NO</sub> , V <sub>NC</sub> = 3V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, Figure 2	+25°C		9		ns
			T <sub>MIN</sub> to T <sub>MAX</sub>	2			
<b>DIGITAL I/O</b>							
Input Logic High	V <sub>IH</sub>			2.4			V
Input Logic Low	V <sub>IL</sub>					0.8	V
Input Leakage Current	I <sub>IN</sub>	V <sub>IN</sub> = 0 or V+		-1		1	μA
<b>SUPPLY</b>							
Power-Supply Range	V+			2.0		5.5	V
Supply Current	I+	V+ = +5.5V, V <sub>IN</sub> = 0 or V+				1	μA

**Note 3:** 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 4:** Guaranteed by design.

**Note 5:** ΔR<sub>ON</sub> = R<sub>ON(MAX)</sub> - R<sub>ON(MIN)</sub>, between switches.

**Note 6:** Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal ranges.

**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.

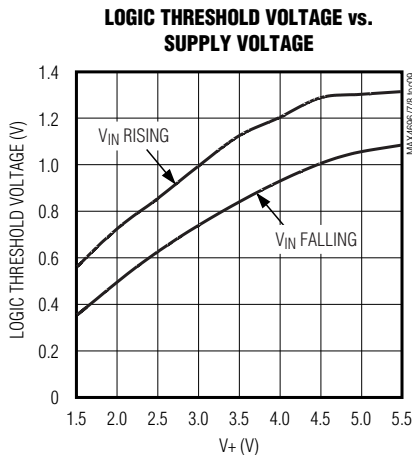
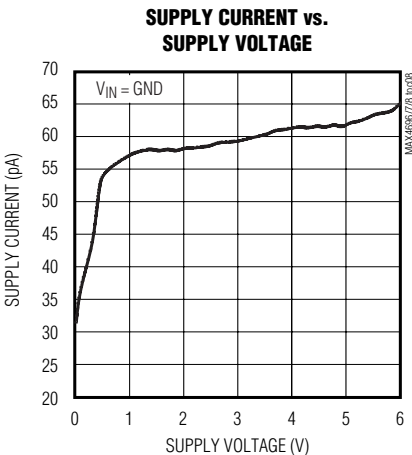
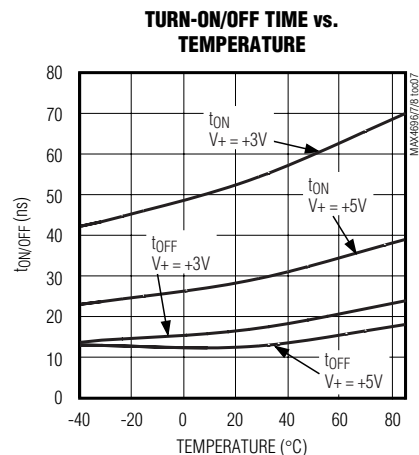
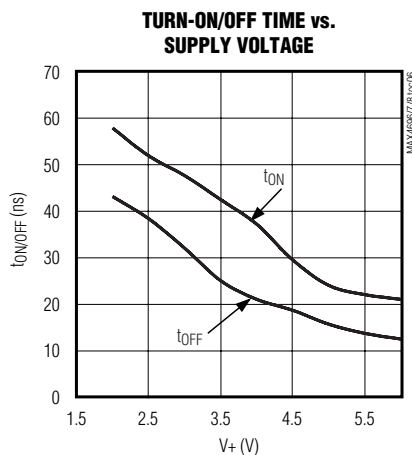
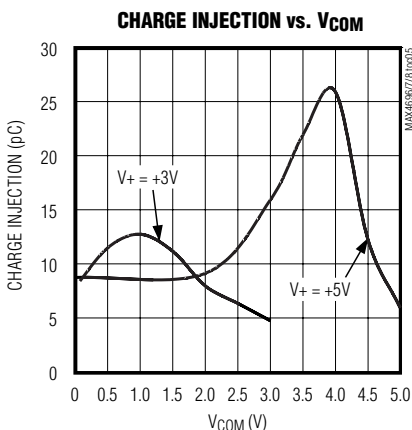
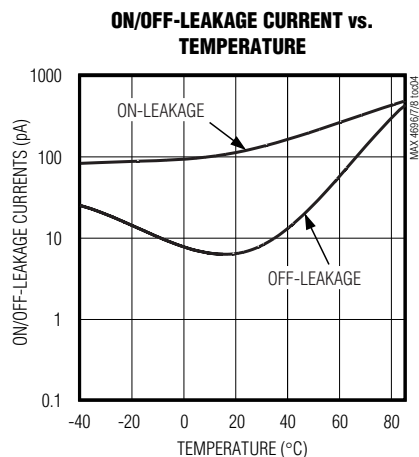
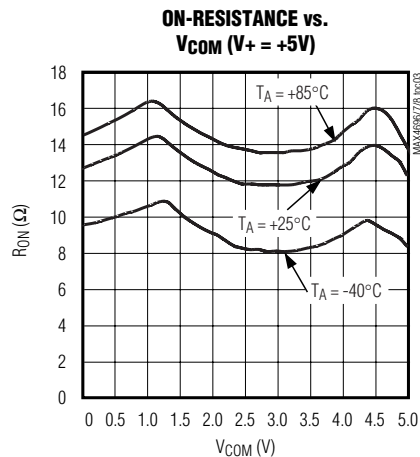
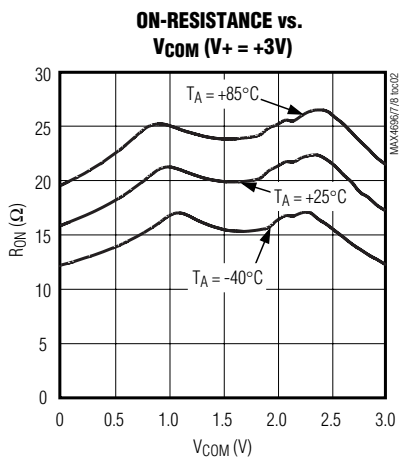
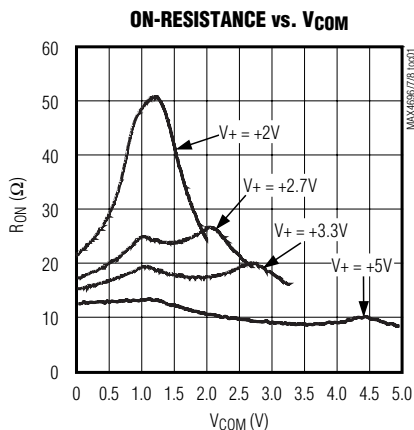
**Note 8:** Between switches.

**Note 9:** UCSP parts are 100% tested at +25°C only, and guaranteed by correlation at the full-rated temperature.

# 35Ω, Low-Voltage, SPST/SPDT Analog Switches in UCSP Package

## Typical Operating Characteristics

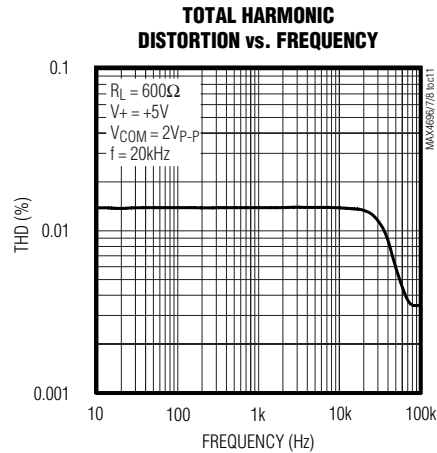
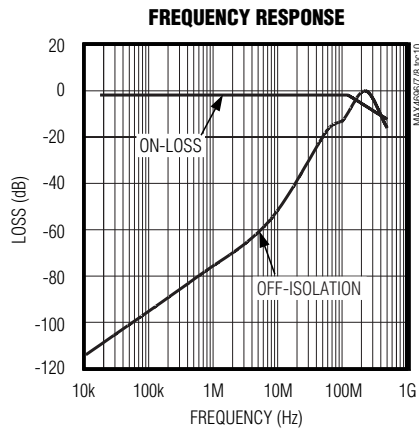
( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



# 35Ω, Low-Voltage, SPST/SPDT Analog Switches in UCSP Package

## Typical Operating Characteristics (continued)

(T<sub>A</sub> = +25°C, unless otherwise noted.)



## Pin/Bump Description

PIN/BUMP			NAME	FUNCTION
MAX4696	MAX4697	MAX4698		
B1	B1	B1	V+	Positive Supply Voltage Input
B2	B2	B2	IN	Digital Control Input
B3	B3	B3	GND	Ground
—	A1	A3	NC	Analog Switch, Normally Closed Terminal
A2, A3	A2, A3	A2	COM	Analog Switch, Common Terminal
A1	—	A1	NO	Analog Switch, Normally Open Terminal

## Applications Information

### Logic Inputs

Where the MAX4696/MAX4697/MAX4698 have a +3.3V supply, IN may be driven low to GND and driven high to 5.5V. Driving IN rail-to-rail minimizes power consumption. Logic inputs accept up to +5.5V regardless of supply voltage.

### Analog Signal Levels

Analog signals that range over the entire supply voltage (GND to V+) are passed with very little change in R<sub>ON</sub> (see *Typical Operating Characteristics*). The switches are bidirectional, so the NO, NC, and COM terminals are both 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 6. Adding a protection diode reduces the analog range to a diode drop (about 0.7V) below V+ (for D1). R<sub>ON</sub> increases slightly at low supply voltages. Maximum supply voltage (V+) must not exceed +6V. Protection diode D1 also protects against some overvoltage situations. No

# 35Ω, Low-Voltage, SPST/SPDT Analog Switches in UCSP Package

MAX4696/MAX4697/MAX4698

damage will result on the circuit in Figure 6 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 terminal.

## UCSP Package Consideration

For general UCSP package information and PC layout considerations, please refer to the Maxim Application Note "Wafer-Level Ultra-Chip-Scale Packages".

## UCSP Reliability

The chip-scale package (UCSP) represents a unique package that greatly reduces board space compared to other packages. UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and usage environment. The user should closely review these areas when considering a UCSP. Performance through

Operating Life Test and Moisture Resistance is equal to conventional package technology as it is primarily determined by the wafer-fabrication process. However, this form factor may not perform equally to a packaged product through traditional mechanical reliability tests.

Mechanical stress performance is a greater consideration for a UCSP. UCSP solder joint contact integrity must be considered since the package is attached through direct solder contact to the user's PC board. Testing done to characterize the UCSP reliability performance shows that it is capable of performing reliably through environmental stresses. Results of environmental stress tests and additional usage data and recommendations are detailed in the UCSP application note, which can be found on Maxim's website, at [www.maxim-ic.com](http://www.maxim-ic.com).

## Test Circuits/Timing Diagrams

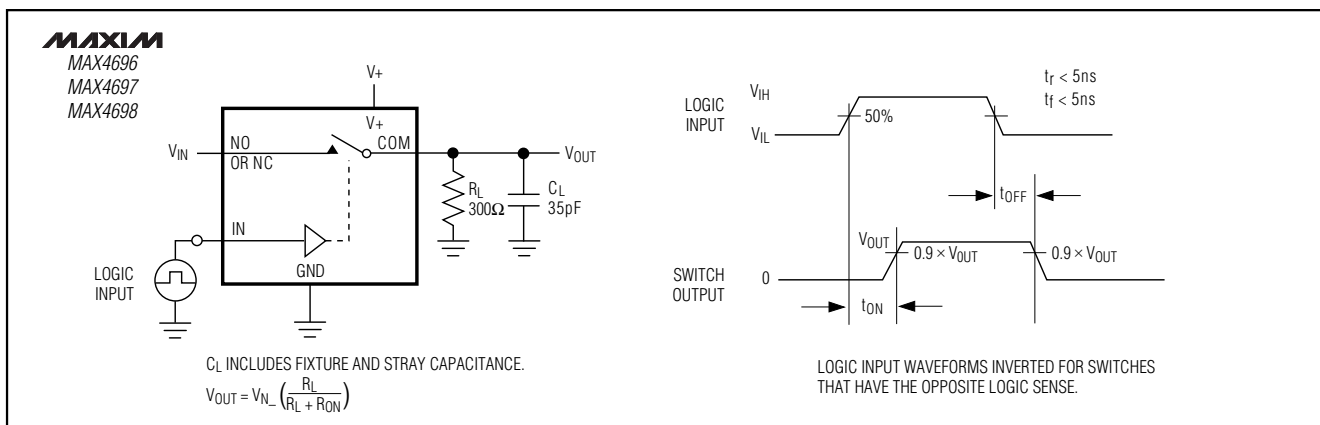


Figure 1. Switching Time

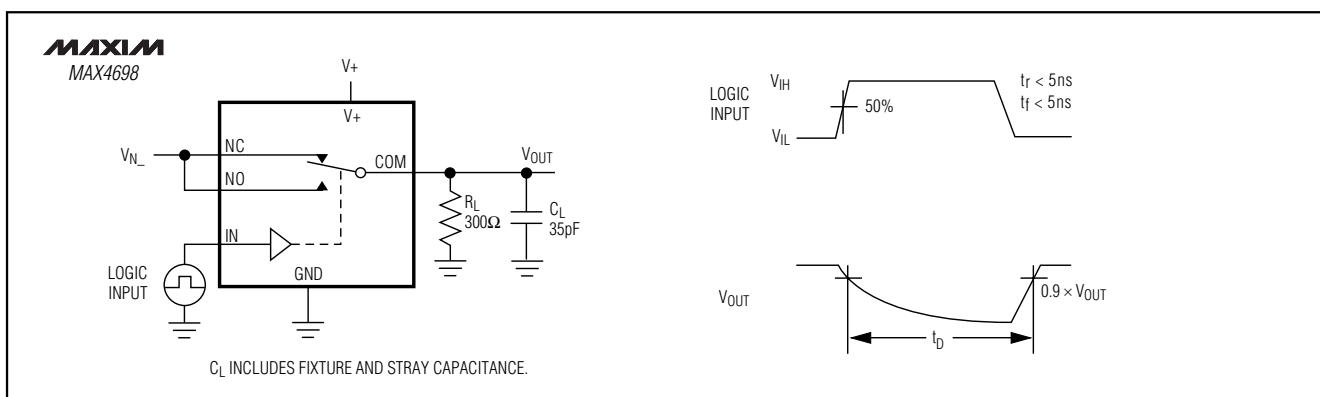


Figure 2. Break-Before-Make Interval (MAX4698 only)

# 35Ω, Low-Voltage, SPST/SPDT Analog Switches in UCSP Package

## Test Circuits/Timing Diagrams (continued)

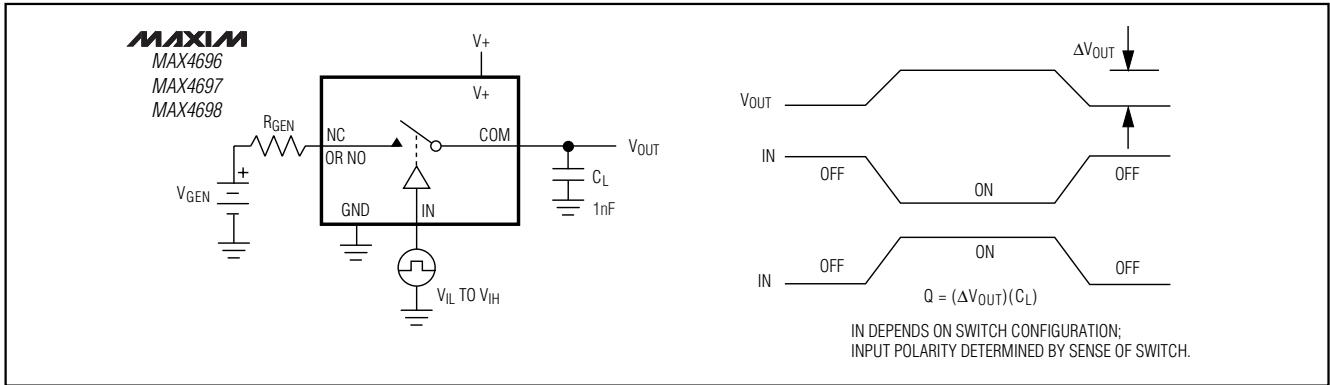


Figure 3. Charge Injection

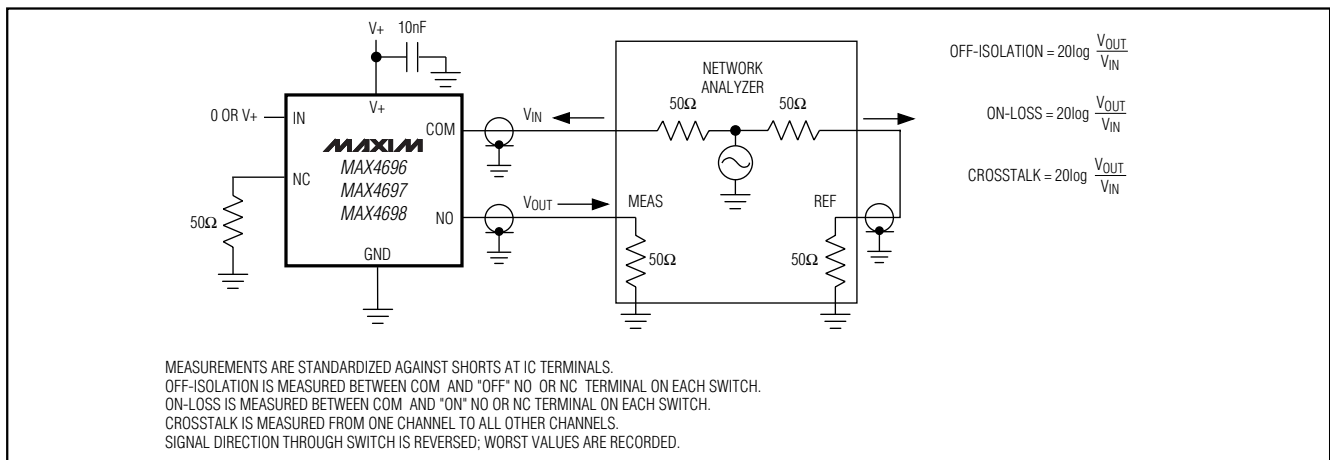


Figure 4. Off-Isolation/On-Channel Bandwidth, Crosstalk

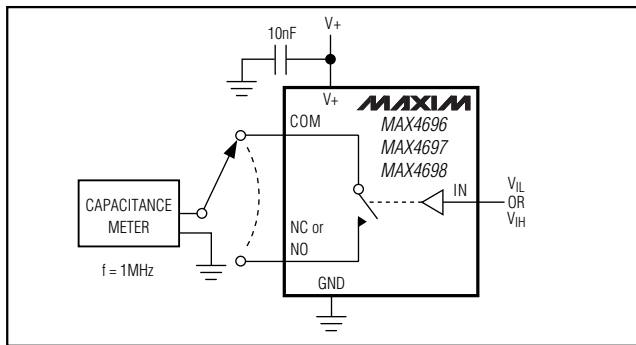


Figure 5. Channel Off/On-Capacitance

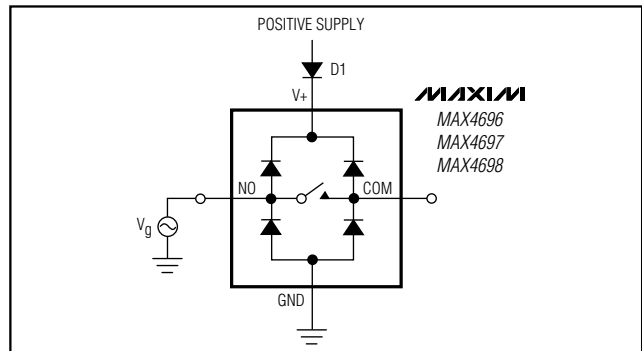


Figure 6. Overtoltage Protection Using External Blocking Diodes

## Chip Information

TRANSISTOR COUNT: 50

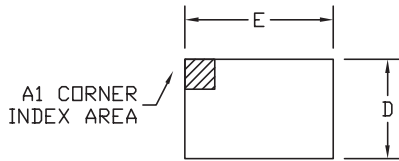


# 35Ω, Low-Voltage, SPST/SPDT Analog Switches in UCSP Package

MAX4696/MAX4697/MAX4698

## Package Information

6L UCSP.EPS.EPS

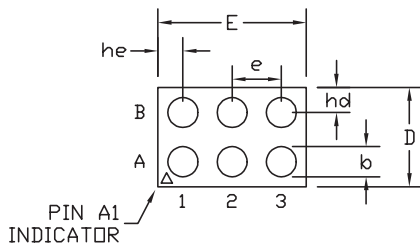


TOP VIEW

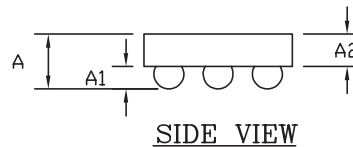
SYMBOL	DIMENSIONS
A	0.60±0.05
D	1.02±0.05
E	1.52±0.05
e	0.50 BASIC
b	∅ 0.35 BASIC
A1	0.27±0.04
A2	0.33 Ref.
hd	0.26 Ref.
he	0.26 Ref.

SOLDER BALL DEPOPULATION	
PKG. CODE	DEPOPULATED BALL
B6-1	NONE
B6-2	B2

- NOTES:  
 1. ALL DIMENSIONS ARE IN MILLIMETERS.  
 2. MEETS JEDEC M0195.



BOTTOM VIEW



SIDE VIEW

<b>MAXIM</b>		
<small>PROPRIETARY INFORMATION</small>		
<small>TITLE</small>		
PACKAGE OUTLINE, 3x2 UCSP		
<small>APPROVAL</small>	<small>DOCUMENT CONTROL NO.</small>	<small>REV.</small>
	21-0097	C 1/1

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