



# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

## General Description

The MAX4641/MAX4642/MAX4643 are monolithic, dual, single-pole/single-throw (SPST) switches that can operate from a single supply ranging from +1.8V to +5.5V. The MAX4641/MAX4642/MAX4643 provide low 4Ω on-resistance (RON), 0.6Ω RON matching between channels, and 1Ω RON flatness over the entire analog signal range. These devices offer fast switching times of less than 20ns while consuming less than 0.01μW of quiescent power.

The MAX4641 has two normally open (NO) switches, and the MAX4642 has two normally closed (NC) switches. The MAX4643 has one NO switch and one NC switch. All three devices have low 0.35nA leakage currents over the entire temperature range. The MAX4641/MAX4642/MAX4643 are available in small 8-pin μMAX and 8-pin QFN packages.

## Applications

Battery-Operated Equipment  
 Audio and Video Signal Routing  
 Low-Voltage Data-Acquisition Systems  
 Sample-and-Hold Circuits  
 Communications Circuits

*Rail-to-Rail is a trademark of Nippon Motorola, Ltd.*

## Features

- ◆ +1.8V to +5.5V Single-Supply Operation
- ◆ Rail-to-Rail™ Analog Signal Range
- ◆ Guaranteed RON
  - 4Ω max (+5V supply)
  - 8Ω max (+3V supply)
- ◆ +1.8V Operation
  - RON 30Ω typ Over Temperature
  - tON 18ns typ, tOFF 12ns typ
- ◆ Guaranteed RON Flatness: 1Ω (+5V supply)
- ◆ Guaranteed RON Match Between Channels
  - 0.6Ω (+5V supply)
- ◆ Low Leakage (<0.35nA) Over Entire Temperature Range
- ◆ Excellent AC Characteristics
  - Low Crosstalk: -97dB at 1MHz
  - High Off-Isolation: -80dB at 1MHz
  - 0.018% Total Harmonic Distortion
- ◆ Low Power Consumption: < 0.01μW

## Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX4641EUA	-40°C to +85°C	8 μMAX
MAX4641EGA	-40°C to +85°C	8 QFN 3 x 3
MAX4642EUA	-40°C to +85°C	8 μMAX
MAX4642EGA	-40°C to +85°C	8 QFN 3 x 3
MAX4643EUA	-40°C to +85°C	8 μMAX
MAX4643EGA	-40°C to +85°C	8 QFN 3 x 3

## Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW

MAX4641

IN_	NO_
0	OFF
1	ON

MAX4642

IN_	NC_
0	ON
1	OFF

MAX4643

IN_	NO1	NC2
0	OFF	ON
1	ON	OFF

*Pin Configurations continued at end of data sheet.*



# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

## ABSOLUTE MAXIMUM RATINGS

(All Voltages Referenced to GND)

V+	-0.3V to +6V
IN_, COM_, NO_, NC_ (Note 1)	-0.3V to (V+ + 0.3V)
Continuous Current (any terminal)	±20mA
Continuous Current (NO_, NC_, COM_)	±50mA
Peak Current (NO_, NC_, COM_, pulsed at 1ms, 10% duty cycle)	±100mA

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

8-Pin μMAX (derate 4.5mW/°C above +70°C)	362mW
8-Pin QFN (derate 24.4mW/°C above +70°C)	1951mW
Operating Temperature Range	-40°C to +85°C
Junction Temperature	+150°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C

**Note 1:** Signals on NO\_, NC\_, COM\_, or IN\_ 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 +5V Supply

(V+ = +4.5V to +5.5V, V<sub>INH</sub> = 2.4V, V<sub>INL</sub> = 0.8V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	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> = 10mA, V <sub>NO_</sub> or V <sub>NC_</sub> = 0 to V+	T <sub>A</sub> = +25°C	2.5	4	Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		5		
On-Resistance Match Between Channels (Notes 2, 8)	ΔR <sub>ON</sub>	V+ = 4.5V, I <sub>COM_</sub> = 10mA, V <sub>NO_</sub> or V <sub>NC_</sub> = 0 to V+	T <sub>A</sub> = +25°C	0.2	0.6	Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		0.8		
On-Resistance Flatness (Note 3)	R <sub>FLAT</sub>	V+ = 4.5V, I <sub>COM_</sub> = 10mA, V <sub>NO_</sub> or V <sub>NC_</sub> = 0 to V+	T <sub>A</sub> = +25°C	0.85	1	Ω	
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		1.5		
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 or 4.5V, V <sub>NO_</sub> or V <sub>NC_</sub> = 4.5V or 1V	T <sub>A</sub> = +25°C	-0.25	0.01	0.25	nA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		-0.35	0.35	
COM_ Off-Leakage Current (Note 4)	I <sub>COM_(OFF)</sub>	V+ = 5.5V, V <sub>COM_</sub> = 1V or 4.5V, V <sub>NO_</sub> or V <sub>NC_</sub> = 4.5V or 1V	T <sub>A</sub> = +25°C	-0.25	0.01	0.25	nA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		-0.35	0.35	
COM_ On-Leakage Current (Notes 4, 5)	I <sub>COM_(ON)</sub>	V+ = 5.5V, V <sub>COM_</sub> = 1V or 4.5V	T <sub>A</sub> = +25°C	-0.25	0.01	0.25	nA
			T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>		-0.35	0.35	
<b>DIGITAL INPUTS</b>							
IN_ Input Logic High	V <sub>IH</sub>		2.4			V	
IN_ Input Logic Low	V <sub>IL</sub>				0.8	V	
IN_ Input Current	I <sub>IN</sub>	V <sub>IN_</sub> = 0.8V or 2.4V	-0.1	0.005	0.1	μA	

# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

MAX4641/MAX4642/MAX4643

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

(V+ = +4.5V to +5.5V, VINH = 2.4V, VINL = 0.8V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>DYNAMIC</b>						
Turn-On Time (Note 4)	tON	RL = 300Ω, CL = 35pF, VNO_ = VNC_ = 3V, Figure 2	TA = +25°C	9	15	ns
			TA = TMIN to TMAX		18	
Turn-Off Time (Note 4)	tOFF	RL = 300Ω, CL = 35pF, VNO_ = VNC_ = 3V, Figure 2	TA = +25°C	5	8	ns
			TA = TMIN to TMAX		10	
Break-Before-Make (Note 4) (MAX4643 only)	tBBM	RL = 300Ω, CL = 35pF, VNO_ = VNC_ = 3V, Figure 2	TA = +25°C	7		ns
			TA = TMIN to TMAX	1		
Charge Injection	Q	VGEN = 0, RGEN = 0, CL = 1nF, Figure 4		2		pC
NO_, NC_ Off-Capacitance	CNO_ (OFF), CNC_ (OFF)	NO_ or NC_ = GND, f = 1MHz, Figure 5		7		pF
COM_ Off-Capacitance	CCOM_ (OFF)	f = 1MHz, Figure 5		7		pF
Switch On-Capacitance	C(ON)	f = 1MHz, Figure 5		18		pF
Off-Isolation (Note 6)	VISO	CL = 5pF, RL = 50Ω, Figure 3	f = 10MHz	-56		dB
			f = 1MHz	-80		
Crosstalk (Note 7)	VCT	CL = 5pF, RL = 50Ω, Figure 3	f = 10MHz	-77		dB
			f = 1MHz	-97		
Total Harmonic Distortion	THD	RL = 600Ω, 0.5Vp-p, f = 20Hz to 20kHz		0.018		%
<b>SUPPLY</b>						
Positive Supply Current	I+	V+ = 5.5V, VIN_ = 0 or V+		0.001	1.0	μA

## ELECTRICAL CHARACTERISTICS—Single +3V Supply

(V+ = +2.7V to +3.3V, VINH = 2.0V, VINL = 0.4V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>ANALOG SWITCH</b>						
Analog Signal Range	VCOM_, VNO_, VNC_		0		V+	V
On-Resistance	RON	V+ = 2.7V, ICOM_ = 10mA, VNO_ or VNC_ = 0 to V+	TA = +25°C	6	8	Ω
			TA = TMIN to TMAX		9	
On-Resistance Match Between Channels (Notes 2, 8)	ΔRON	V+ = 2.7V, ICOM_ = 10mA, VNO_ or VNC_ = 0 to V+	TA = +25°C	0.2	0.6	Ω
			TA = TMIN to TMAX		0.8	
On-Resistance Flatness (Note 3)	RFLAT	V+ = 2.7V, ICOM_ = 10mA, VNO_ or VNC_ = 0 to V+	TA = +25°C	1.5	3.0	Ω
			TA = TMIN to TMAX		3.5	

# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

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

(V+ = +2.7V to +3.3V, VINH = 2.0V, VINL = 0.4V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
<b>DIGITAL INPUTS</b>							
IN_ Input Logic High	V <sub>IH</sub>			2.0			V
IN_ Input Logic Low	V <sub>IL</sub>					0.4	V
IN_ Input Current	I <sub>IN</sub>	V <sub>IN_</sub> = 0.4V or 2.0V		-0.1	0.005	0.1	μA
<b>DYNAMIC</b>							
Turn-On Time (Note 4)	t <sub>ON</sub>	R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, V <sub>NO_</sub> = V <sub>NC_</sub> = 2V, Figure 2	TA = +25°C	14	20		ns
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>			22	
Turn-Off Time (Note 4)	t <sub>OFF</sub>	R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, V <sub>NO_</sub> = V <sub>NC_</sub> = 2V, Figure 2	TA = +25°C	6	10		ns
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>			11	
Break-Before-Make (Note 4) (MAX4643 only)	t <sub>BBM</sub>	R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, V <sub>NO_</sub> = V <sub>NC_</sub> = 2V, Figure 2	TA = +25°C	7			ns
			TA = T <sub>MIN</sub> to T <sub>MAX</sub>	1			
Charge Injection	Q	V <sub>GEN</sub> = 0, R <sub>GEN</sub> = 0, C <sub>L</sub> = 1nF, Figure 4			2		pC
NO_, NC_ Off-Capacitance	C <sub>NO_(OFF)</sub> , C <sub>NC_(OFF)</sub>	NO_ or NC_ = GND, f = 1MHz, Figure 5			7		pF
COM_ Off-Capacitance	C <sub>COM_(OFF)</sub>	f = 1MHz, Figure 5			7		pF
Switch On-Capacitance	C <sub>(ON)</sub>	f = 1MHz, Figure 5			18		pF
Off-Isolation (Note 6)	V <sub>ISO</sub>	C <sub>L</sub> = 5pF, R <sub>L</sub> = 50Ω, Figure 3	f = 10MHz	-56			dB
			f = 1MHz	-80			
Crosstalk (Note 7)	V <sub>CT</sub>	C <sub>L</sub> = 5pF, R <sub>L</sub> = 50Ω, Figure 3	f = 10MHz	-77			dB
			f = 1MHz	-97			
<b>SUPPLY</b>							
Positive Supply Current	I <sub>+</sub>	V <sub>+</sub> = 3.3V, V <sub>IN_</sub> = 0 or V <sub>+</sub>			0.001	1.0	μA

**Note 2:** ΔRON = RON(MAX) - RON(MIN).

**Note 3:** RON Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal range.

**Note 4:** Guaranteed by design.

**Note 5:** On-Leakage performed with voltage applied to COM\_, with NO\_ and NC\_ left floating.

**Note 6:** Off-Isolation = 20log<sub>10</sub>(V<sub>O\_</sub> / V<sub>I\_</sub>), where V<sub>O\_</sub> is V<sub>COM\_</sub> and V<sub>I\_</sub> is V<sub>NC\_</sub> or V<sub>NO\_</sub> from the network analyzer.

**Note 7:** Crosstalk is measured between the two switches.

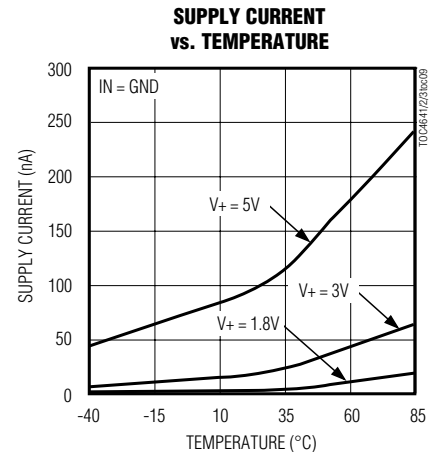
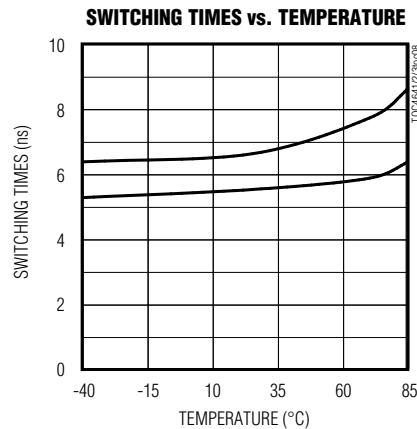
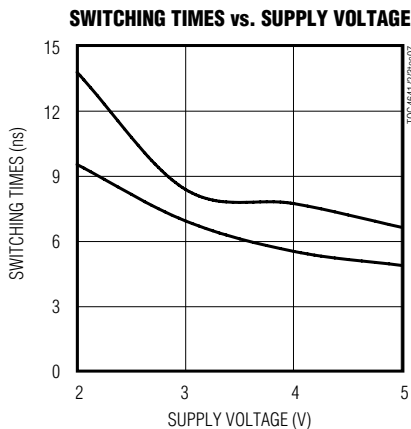
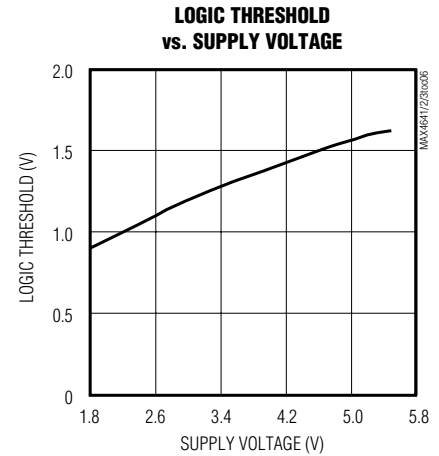
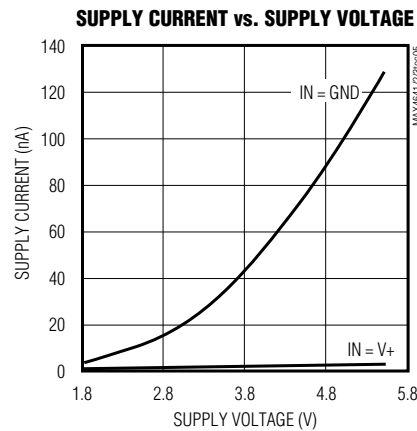
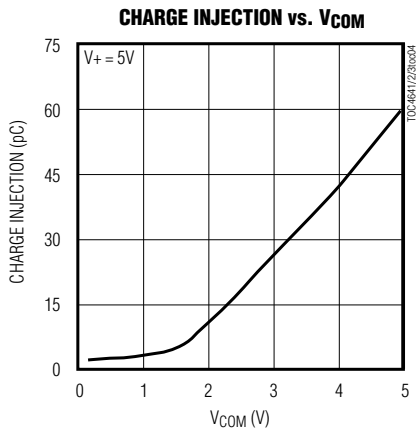
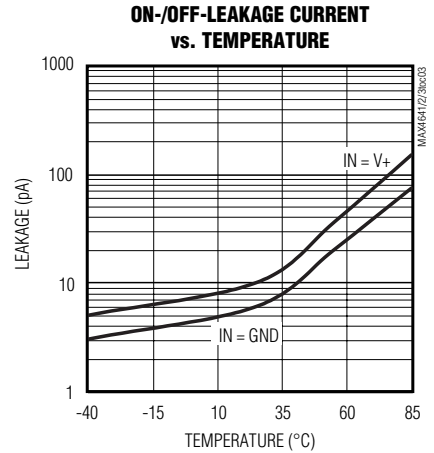
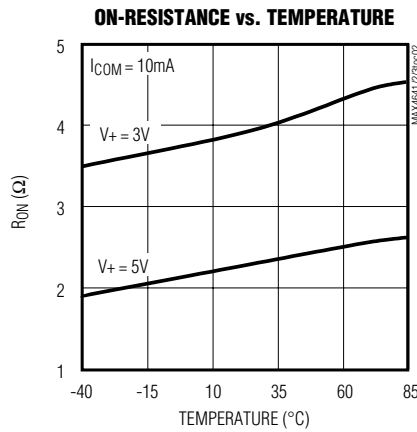
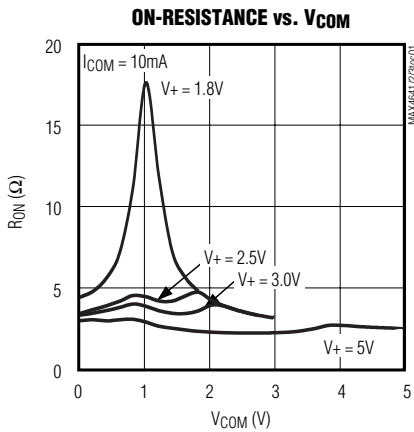
**Note 8:** RON and ΔRON matching specifications for QFN-packaged parts are guaranteed by design.

# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

## Typical Operating Characteristics

( $V_+ = +5V$  or  $+3V$ ,  $V_{INH} = V_+$ ,  $V_{INL} = GND$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

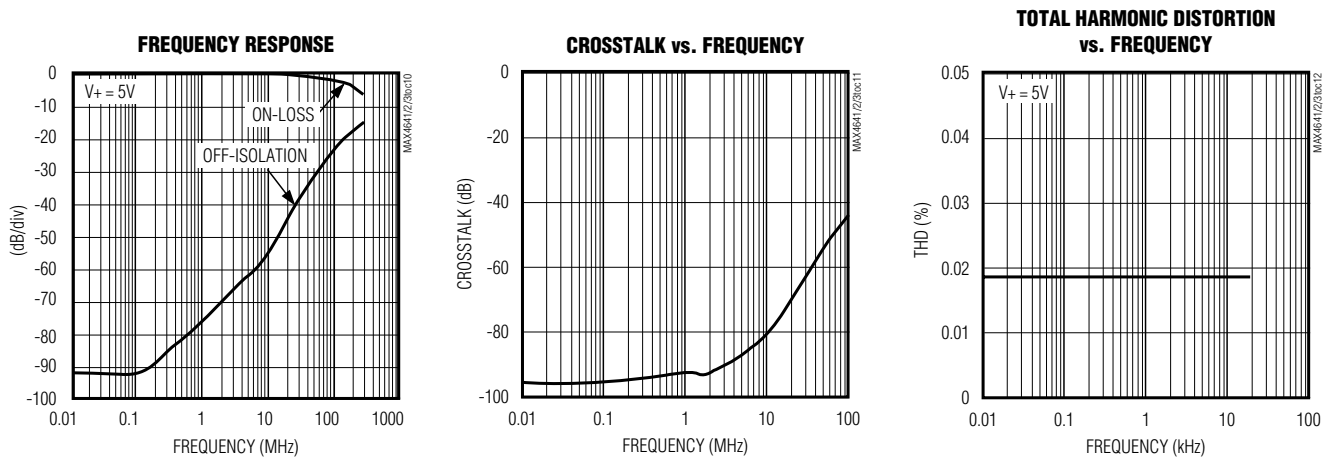
MAX4641/MAX4642/MAX4643



# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

## Typical Operating Characteristics (continued)

(V+ = +5V or +3V, VINH = V+, VINL = GND, TA = +25°C, unless otherwise noted.)



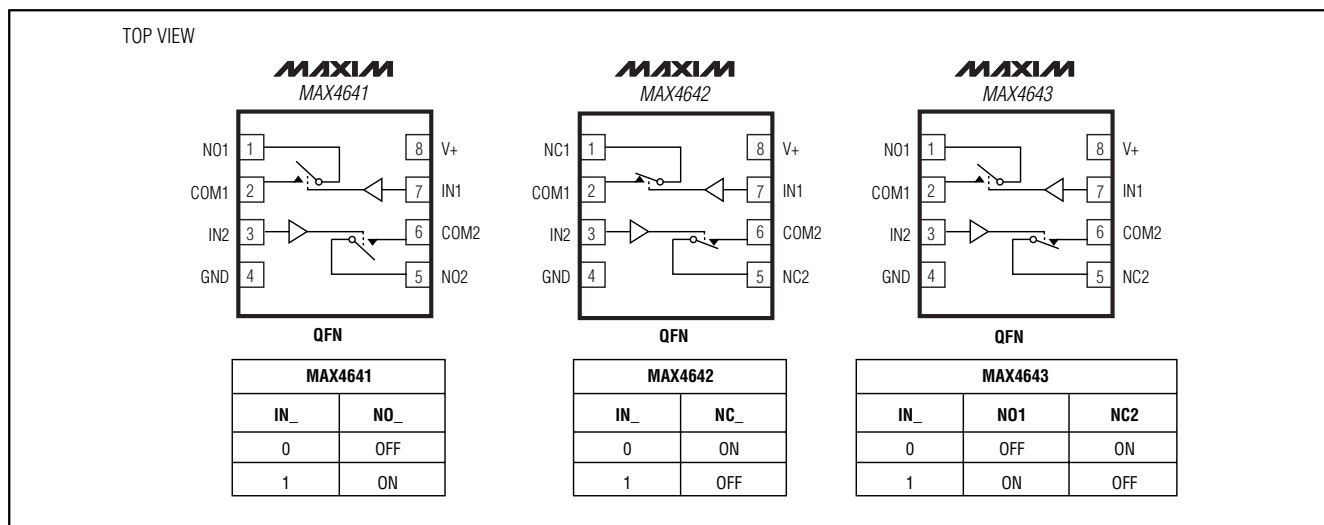
## Pin Description

PIN			NAME	FUNCTION
<b>MAX4641</b>	<b>MAX4642</b>	<b>MAX4643</b>		
1, 5	–	–	NO1, NO2	Analog Switch Normally Open Terminals
–	1, 5	–	NC1, NC2	Analog Switch Normally Closed Terminals
–	–	1	NO1	Analog Switch Normally Open Terminal
–	–	5	NC2	Analog Switch Normally Closed Terminal
2, 6	2, 6	2, 6	COM1, COM2	Analog Switch Common Terminals
3, 7	3, 7	3, 7	IN2, IN1	Logic-Controlled Inputs
4	4	4	GND	Ground
8	8	8	V+	Positive Supply Input. Bypass with a 0.1μF capacitor to GND.

**Note:** NO\_, NC\_, and COM\_ pins are identical and interchangeable. Signals can be passed through either side of these bidirectional switches. However, the typical off-capacitances differ, as shown in the *Electrical Characteristics*.

# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

## Pin Configurations/Functional Diagrams/Truth Tables (continued)



## Applications Information

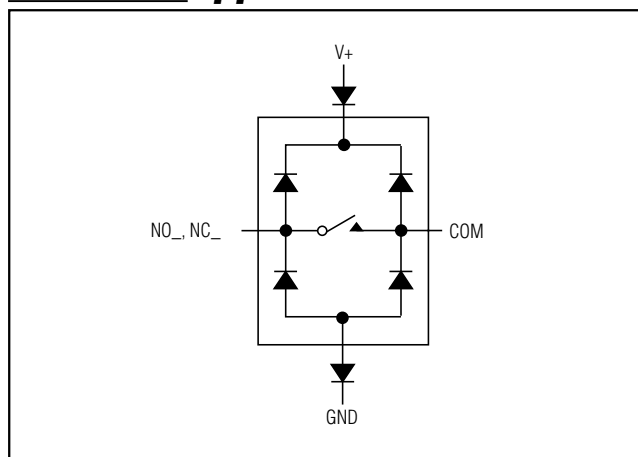


Figure 1. Overvoltage Protection Using External Blocking Diodes

The MAX4641/MAX4642/MAX4643 operate from a single supply ranging from +1.8V to +5.5V. The devices are guaranteed to be functional over that supply range, but TTL/CMOS compatibility is only valid for operation using a +5V supply. All voltage levels are referenced to GND. Positive and negative DC analog inputs or AC signals can be accommodated by shifting V+ and GND.

ESD-protection diodes are internally connected between each analog-signal pin and both V+ and GND. One of these diodes conducts if any analog signal

exceeds V+ or GND (Figure 1). Virtually all of the analog leakage current comes from the ESD diodes to V+ or GND. Although the ESD diodes on a given signal pin are identical, and therefore fairly well balanced, they are reverse biased differently. Each is biased by either V+ or GND and the analog signal. This means their leakages will vary as the signal varies. The difference in the two diode leakages to the V+ and GND pins constitutes the analog-signal-path leakage current. All analog leakage current flows between each pin and one of the supply terminals, not to the other switch terminal. This is why both sides of a given switch can show leakage currents of the same or opposite polarity.

There is no normal current path between the analog-signal paths and V+ or GND. V+ and GND also power the internal logic and logic-level translators. The logic-level translators convert the logic level into switched V+ and GND signals to drive the analog signal gates.

# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

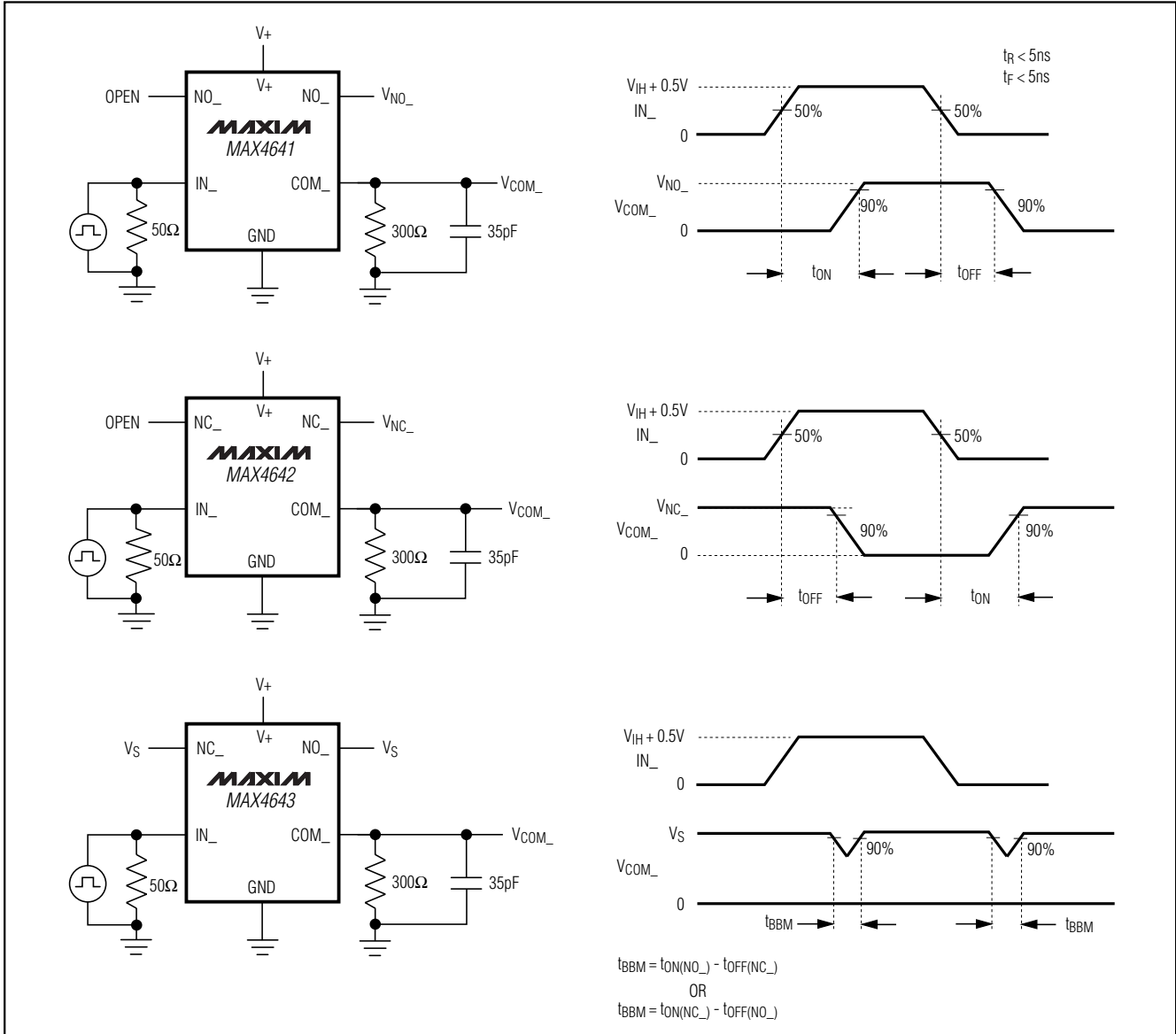


Figure 2. Switching Times



# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

MAX4641/MAX4642/MAX4643

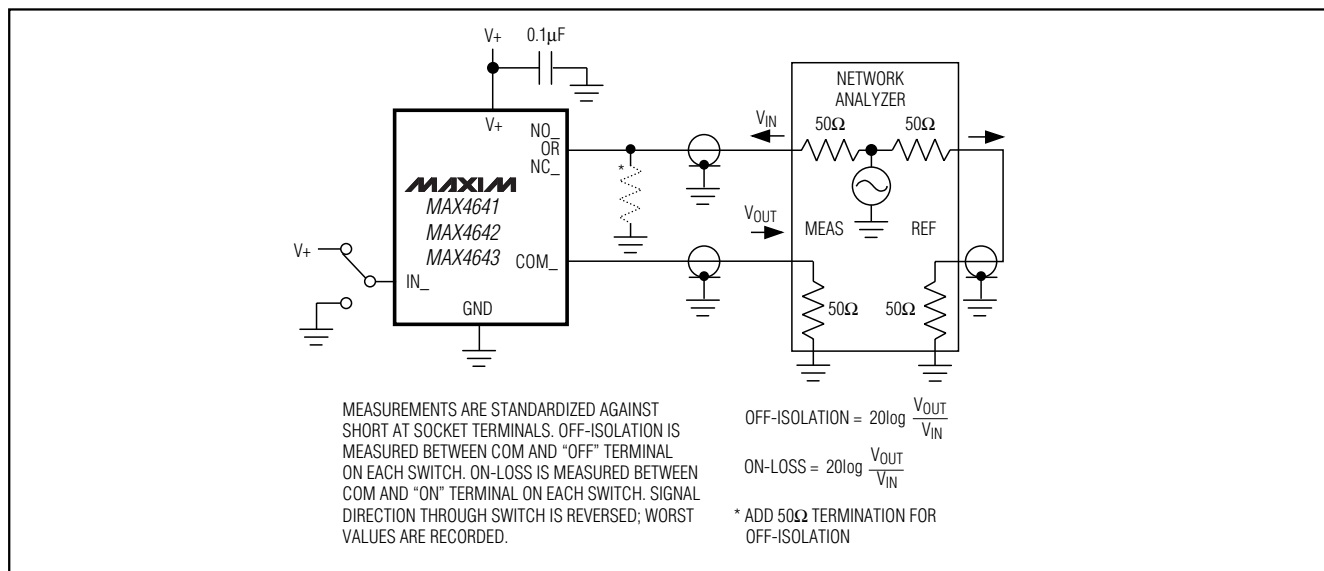


Figure 3. Off-Isolation, On-Loss, and Crosstalk

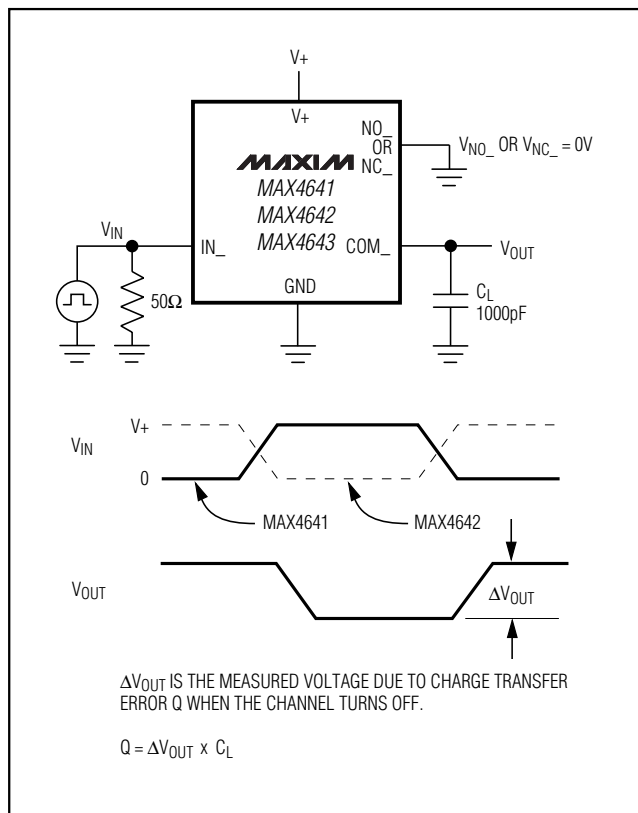


Figure 4. Charge Injection

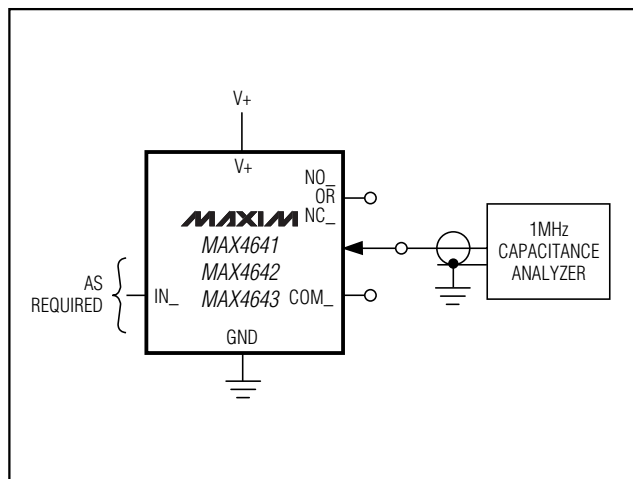


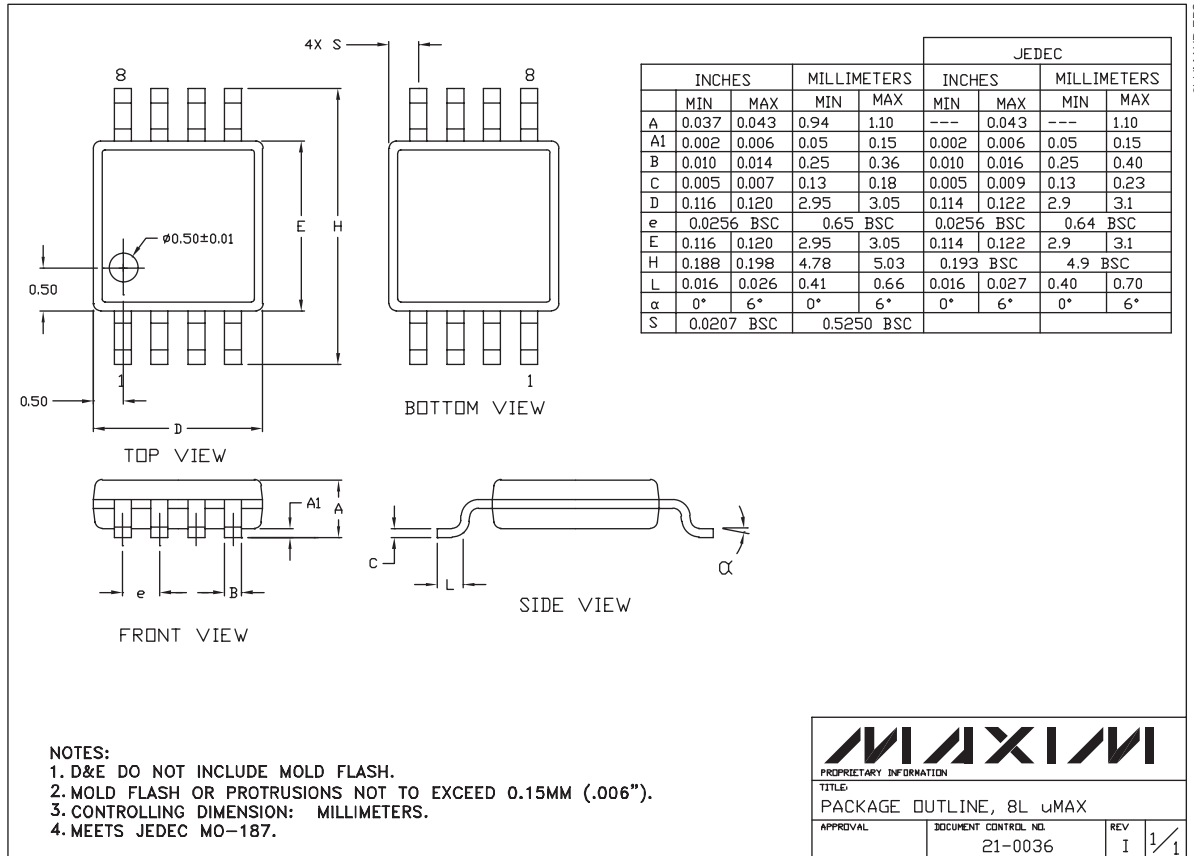
Figure 5. NO<sub>1</sub>, NC<sub>1</sub>, and COM<sub>1</sub> Capacitance

## Chip Information

TRANSISTOR COUNT: 105

# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

## Package Information



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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