19-1656; Rev 1; 2/02

MAXIM

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 (R_{ON}), 0.6Ω R_{ON} matching between channels, and 1Ω R_{ON} 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 R_{ON}**
  - **4Ω max (+5V supply)**
  - **8Ω max (+3V supply)**
- **+1.8V Operation**
  - **R_{ON} 30Ω typ Over Temperature**
  - **t_{ON} 18ns typ, t_{OFF} 12ns typ**
- **Guaranteed R_{ON} Flatness: 1Ω (+5V supply)**
- **Guaranteed R_{ON} 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**

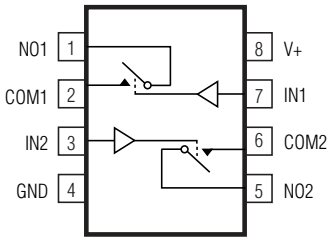
Ordering Information

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

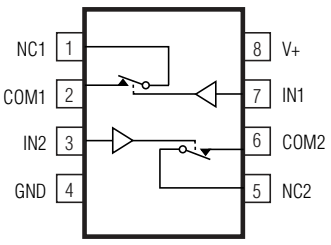
MAXIM *MAX4641*



µMAX

MAX4641	
IN_	**NO_**
0	OFF
1	ON

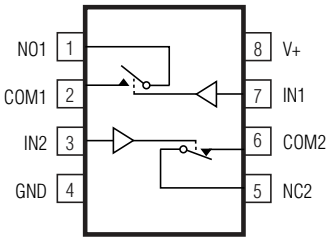
MAXIM *MAX4642*



µMAX

MAX4642	
IN_	**NC_**
0	ON
1	OFF

MAXIM *MAX4643*



µMAX

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_A = +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_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	$V_{COM\_}$, $V_{NO\_}$, $V_{NC\_}$			0		V+	V
On-Resistance	R_{ON}	V+ = 4.5V, $I_{COM\_}$ = 10mA, $V_{NO\_}$ or $V_{NC\_}$ = 0 to V+	T_A = +25°C		2.5	4	Ω
			T_A = T_{MIN} to T_{MAX}			5	
On-Resistance Match Between Channels (Notes 2, 8)	ΔR_{ON}	V+ = 4.5V, $I_{COM\_}$ = 10mA, $V_{NO\_}$ or $V_{NC\_}$ = 0 to V+	T_A = +25°C		0.2	0.6	Ω
			T_A = T_{MIN} to T_{MAX}			0.8	
On-Resistance Flatness (Note 3)	R_{FLAT}	V+ = 4.5V, $I_{COM\_}$ = 10mA, $V_{NO\_}$ or $V_{NC\_}$ = 0 to V+	T_A = +25°C		0.85	1	Ω
			T_A = T_{MIN} to T_{MAX}			1.5	
NO_, NC_ Off-Leakage Current (Note 4)	$I_{NO\_(OFF)}$, $I_{NC\_(OFF)}$	V+ = 5.5V, $V_{COM\_}$ = 1V or 4.5V, $V_{NO\_}$ or $V_{NC\_}$ = 4.5V or 1V	T_A = +25°C	-0.25	0.01	0.25	nA
			T_A = T_{MIN} to T_{MAX}	-0.35		0.35	
COM_ Off-Leakage Current (Note 4)	$I_{COM\_(OFF)}$	V+ = 5.5V, $V_{COM\_}$ = 1V or 4.5V, $V_{NO\_}$ or $V_{NC\_}$ = 4.5V or 1V	T_A = +25°C	-0.25	0.01	0.25	nA
			T_A = T_{MIN} to T_{MAX}	-0.35		0.35	
COM_ On-Leakage Current (Notes 4, 5)	$I_{COM\_(ON)}$	V+ = 5.5V, $V_{COM\_}$ = 1V or 4.5V	T_A = +25°C	-0.25	0.01	0.25	nA
			T_A = T_{MIN} to T_{MAX}	-0.35		0.35	
DIGITAL INPUTS							
IN_ Input Logic High	V_{IH}			2.4			V
IN_ Input Logic Low	V_{IL}					0.8	V
IN_ Input Current	I_{IN}	$V_{IN\_}$ = 0.8V or 2.4V		-0.1	0.005	0.1	µA

ELECTRICAL CHARACTERISTICS—Single +5V Supply (continued)

(V+ = +4.5V to +5.5V, V_{INH} = 2.4V, V_{INL} = 0.8V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DYNAMIC							
Turn-On Time (Note 4)	t_{ON}	R_L = 300Ω, C_L = 35pF, $V_{NO\_}$ = $V_{NC\_}$ = 3V, Figure 2	T_A = +25°C		9	15	ns
			T_A = T_{MIN} to T_{MAX}			18	
Turn-Off Time (Note 4)	t_{OFF}	R_L = 300Ω, C_L = 35pF, $V_{NO\_}$ = $V_{NC\_}$ = 3V, Figure 2	T_A = +25°C		5	8	ns
			T_A = T_{MIN} to T_{MAX}			10	
Break-Before-Make (Note 4) (MAX4643 only)	t_{BBM}	R_L = 300Ω, C_L = 35pF, $V_{NO\_}$ = $V_{NC\_}$ = 3V, Figure 2	T_A = +25°C		7		ns
			T_A = T_{MIN} to T_{MAX}	1			
Charge Injection	Q	V_{GEN} = 0, R_{GEN} = 0, C_L = 1nF, Figure 4			2		pC
NO_, NC_ Off-Capacitance	$C_{NO\_ (OFF)}$, $C_{NC\_ (OFF)}$	NO_ or NC_ = GND, f = 1MHz, Figure 5			7		pF
COM_ Off-Capacitance	$C_{COM\_ (OFF)}$	f = 1MHz, Figure 5			7		pF
Switch On-Capacitance	$C_{(ON)}$	f = 1MHz, Figure 5			18		pF
Off-Isolation (Note 6)	V_{ISO}	C_L = 5pF, R_L = 50Ω, Figure 3	f = 10MHz		-56		dB
			f = 1MHz		-80		
Crosstalk (Note 7)	V_{CT}	C_L = 5pF, R_L = 50Ω, Figure 3	f = 10MHz		-77		dB
			f = 1MHz		-97		
Total Harmonic Distortion	THD	R_L = 600Ω, 0.5Vp-p, f = 20Hz to 20kHz			0.018		%
SUPPLY							
Positive Supply Current	I+	V+ = 5.5V, $V_{IN\_}$ = 0 or V+			0.001	1.0	µA

ELECTRICAL CHARACTERISTICS—Single +3V Supply

(V+ = +2.7V to +3.3V, V_{INH} = 2.0V, V_{INL} = 0.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
ANALOG SWITCH							
Analog Signal Range	$V_{COM\_}$, $V_{NO\_}$, $V_{NC\_}$			0		V+	V
On-Resistance	R_{ON}	V+ = 2.7V, $I_{COM\_}$ = 10mA, $V_{NO\_}$ or $V_{NC\_}$ = 0 to V+	T_A = +25°C		6	8	Ω
			T_A = T_{MIN} to T_{MAX}			9	
On-Resistance Match Between Channels (Notes 2, 8)	ΔR_{ON}	V+ = 2.7V, $I_{COM\_}$ = 10mA, $V_{NO\_}$ or $V_{NC\_}$ = 0 to V+	T_A = +25°C		0.2	0.6	Ω
			T_A = T_{MIN} to T_{MAX}			0.8	
On-Resistance Flatness (Note 3)	R_{FLAT}	V+ = 2.7V, $I_{COM\_}$ = 10mA, $V_{NO\_}$ or $V_{NC\_}$ = 0 to V+	T_A = +25°C		1.5	3.0	Ω
			T_A = T_{MIN} to T_{MAX}			3.5	

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

ELECTRICAL CHARACTERISTICS—Single +3V Supply (continued)

(V+ = +2.7V to +3.3V, V_{INH} = 2.0V, V_{INL} = 0.4V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DIGITAL INPUTS							
IN_ Input Logic High	V_{IH}			2.0			V
IN_ Input Logic Low	V_{IL}					0.4	V
IN_ Input Current	I_{IN}	$V_{IN\_}$ = 0.4V or 2.0V		-0.1	0.005	0.1	µA
DYNAMIC							
Turn-On Time (Note 4)	t_{ON}	R_L = 300Ω, C_L = 35pF, $V_{NO\_}$ = $V_{NC\_}$ = 2V, Figure 2	T_A = +25°C		14	20	ns
			T_A = T_{MIN} to T_{MAX}			22	
Turn-Off Time (Note 4)	t_{OFF}	R_L = 300Ω, C_L = 35pF, $V_{NO\_}$ = $V_{NC\_}$ = 2V, Figure 2	T_A = +25°C		6	10	ns
			T_A = T_{MIN} to T_{MAX}			11	
Break-Before-Make (Note 4) (MAX4643 only)	t_{BBM}	R_L = 300Ω, C_L = 35pF, $V_{NO\_}$ = $V_{NC\_}$ = 2V, Figure 2	T_A = +25°C		7		ns
			T_A = T_{MIN} to T_{MAX}	1			
Charge Injection	Q	V_{GEN} = 0, R_{GEN} = 0, C_L = 1nF, Figure 4			2		pC
NO_, NC_ Off-Capacitance	$C_{NO\_(OFF)}$, $C_{NC\_(OFF)}$	NO_ or NC_ = GND, f = 1MHz, Figure 5			7		pF
COM_ Off-Capacitance	$C_{COM\_(OFF)}$	f =1MHz, Figure 5			7		pF
Switch On-Capacitance	$C_{(ON)}$	f =1MHz, Figure 5			18		pF
Off-Isolation (Note 6)	V_{ISO}	C_L = 5pF, R_L = 50Ω, Figure 3	f = 10MHz		-56		dB
			f = 1MHz		-80		
Crosstalk (Note 7)	V_{CT}	C_L = 5pF, R_L = 50Ω, Figure 3	f = 10MHz		-77		dB
			f = 1MHz		-97		
SUPPLY							
Positive Supply Current	I+	V+ = 3.3V, $V_{IN\_}$ = 0 or V+			0.001	1.0	µA

Note 2: $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$.

Note 3: R_{ON} 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 = $20\log_{10} (V_{O\_} / V_{I\_})$, where V_O is $V_{COM\_}$ and V_I is $V_{NC\_}$ or $V_{NO\_}$ from the network analyzer.

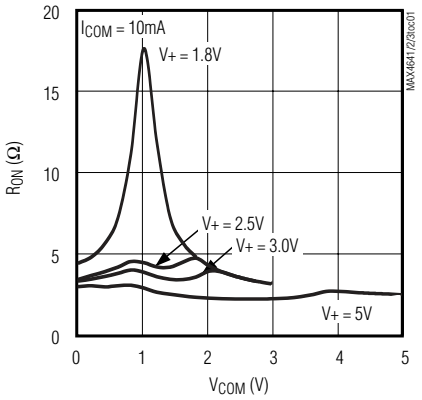
Note 7: Crosstalk is measured between the two switches.

Note 8: R_{ON} and ΔR_{ON} matching specifications for QFN-packaged parts are guaranteed by design.

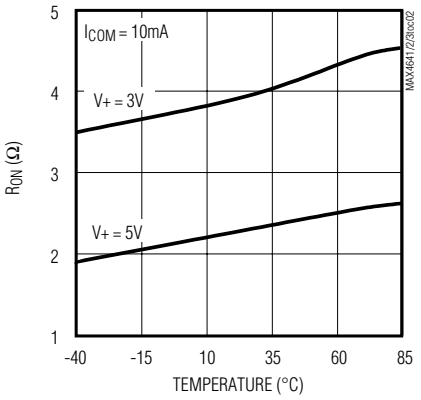
Typical Operating Characteristics

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

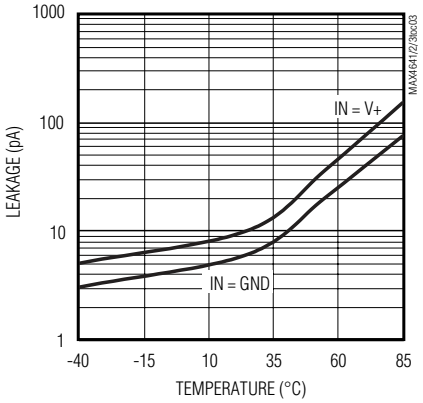
ON-RESISTANCE vs. V_{COM}



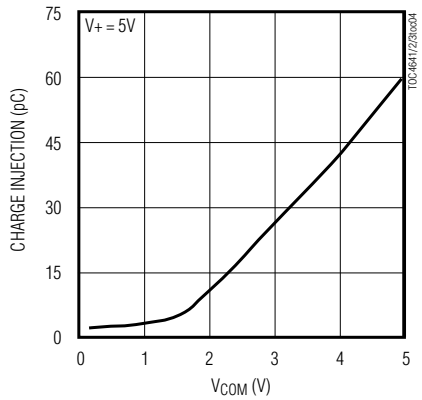
ON-RESISTANCE vs. TEMPERATURE



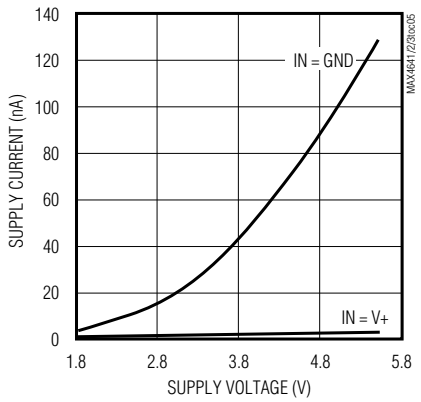
ON-/OFF-LEAKAGE CURRENT vs. TEMPERATURE



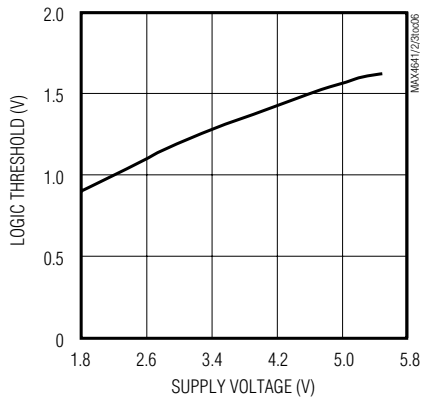
CHARGE INJECTION vs. V_{COM}



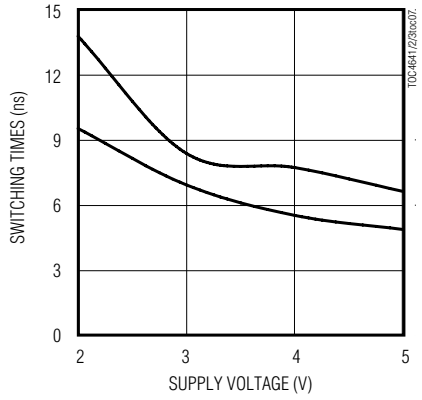
SUPPLY CURRENT vs. SUPPLY VOLTAGE



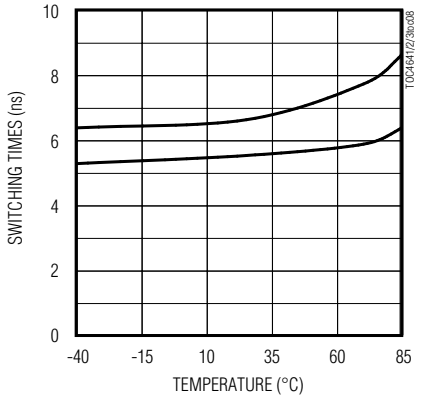
LOGIC THRESHOLD vs. SUPPLY VOLTAGE



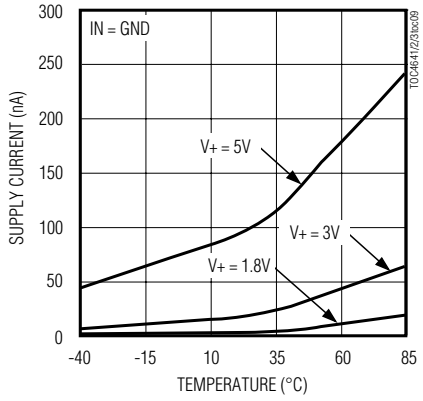
SWITCHING TIMES vs. SUPPLY VOLTAGE



SWITCHING TIMES vs. TEMPERATURE



SUPPLY CURRENT vs. TEMPERATURE

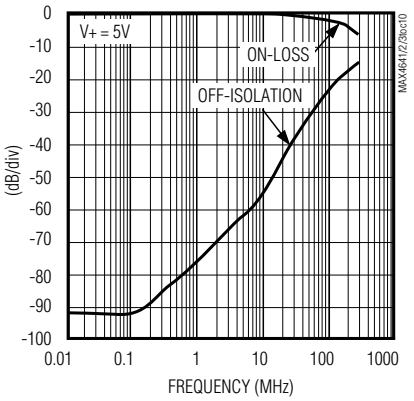


High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

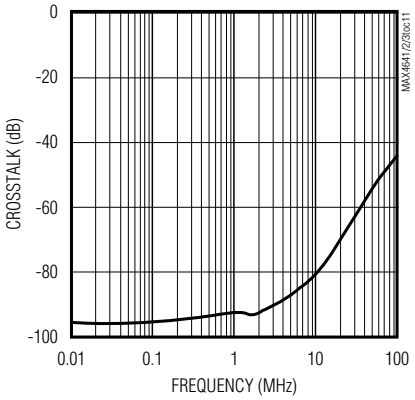
Typical Operating Characteristics (continued)

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

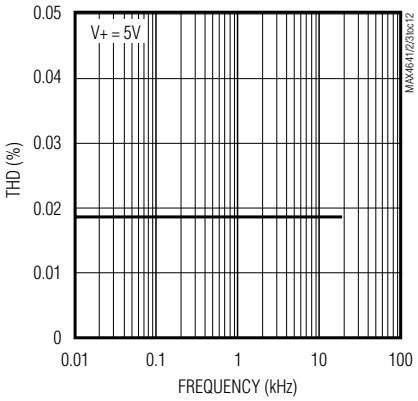
FREQUENCY RESPONSE



CROSSTALK vs. FREQUENCY



TOTAL HARMONIC DISTORTION vs. FREQUENCY



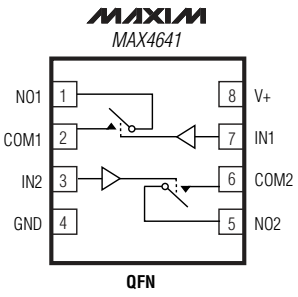
Pin Description

PIN			NAME	FUNCTION
MAX4641	MAX4642	MAX4643		
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.

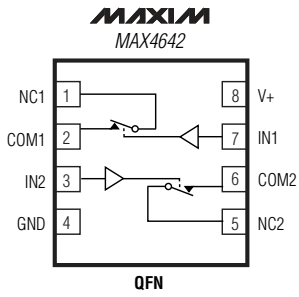
Note: NO_, NC_, and COM_ pins are identical and interchangeable. Signals can be passed through either side of these bidirectional switches. However, the typical off-capacitances differ, as shown in the *Electrical Characteristics.*

Pin Configurations/Functional Diagrams/Truth Tables (continued)

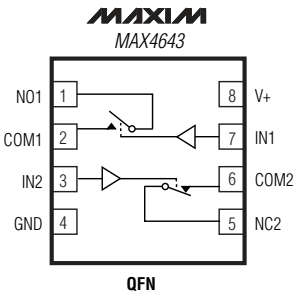
TOP VIEW



MAX4641	
IN_	NO_
0	OFF
1	ON



MAX4642	
IN_	NC_
0	ON
1	OFF



MAX4643		
IN_	NO1	NC2
0	OFF	ON
1	ON	OFF

Applications Information

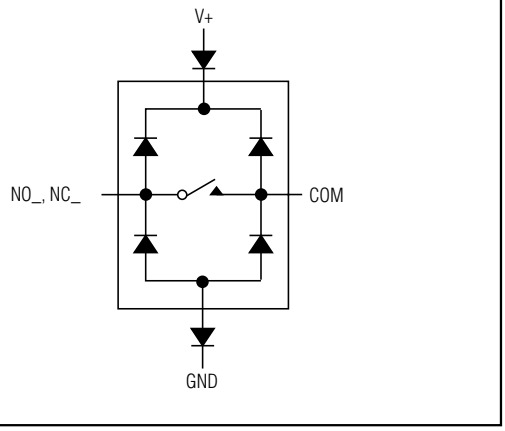


Figure 1. Overvoltage Protection Using External Blocking Diodes

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

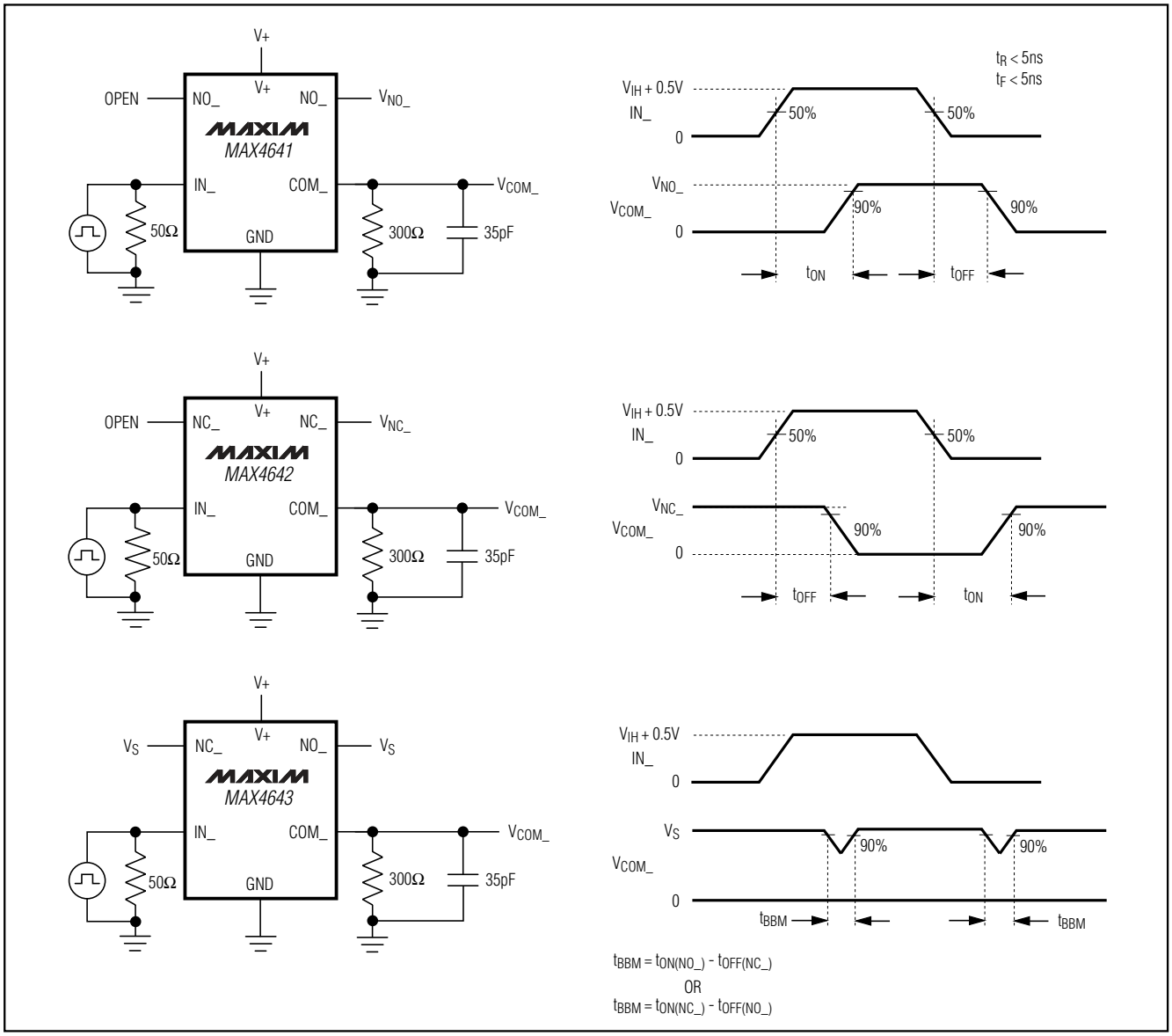


Figure 2. Switching Times

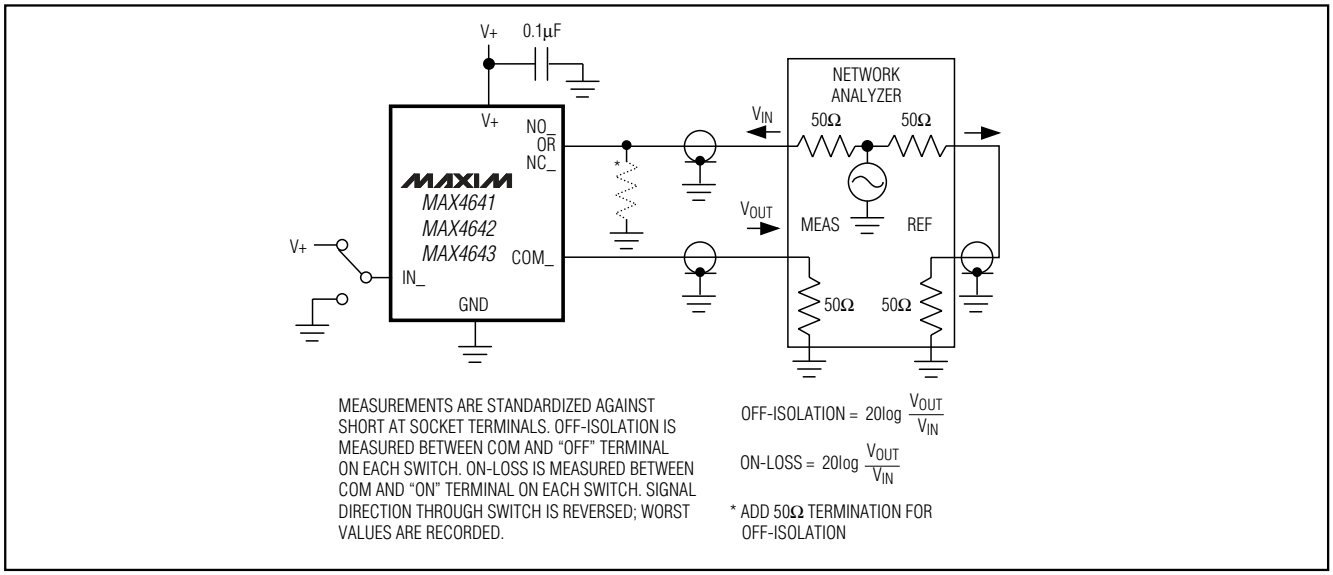


Figure 3. Off-Isolation, On-Loss, and Crosstalk

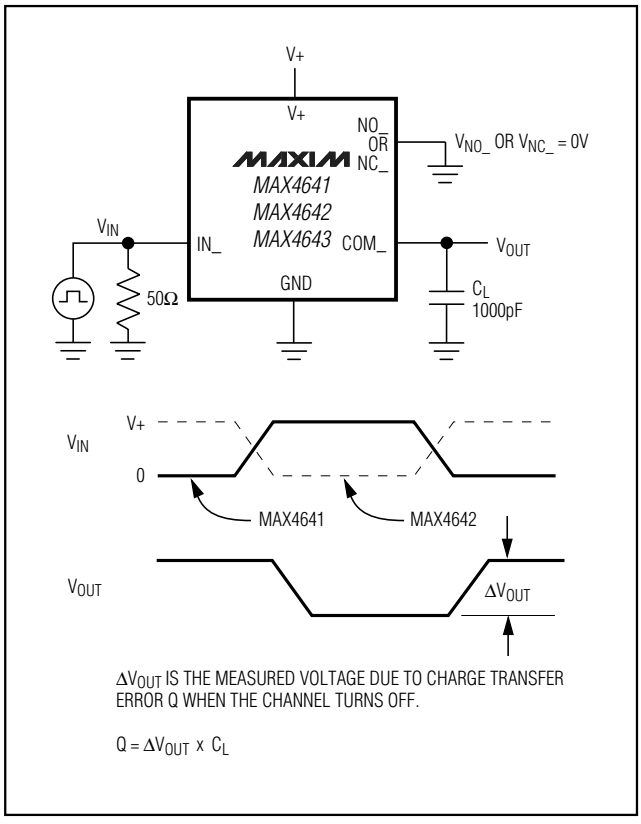


Figure 4. Charge Injection

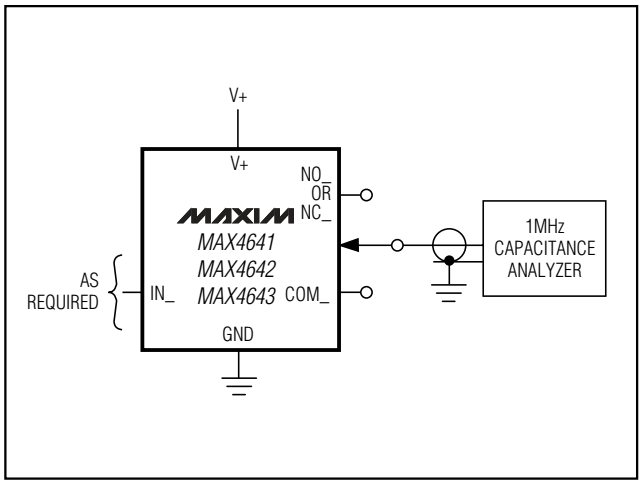


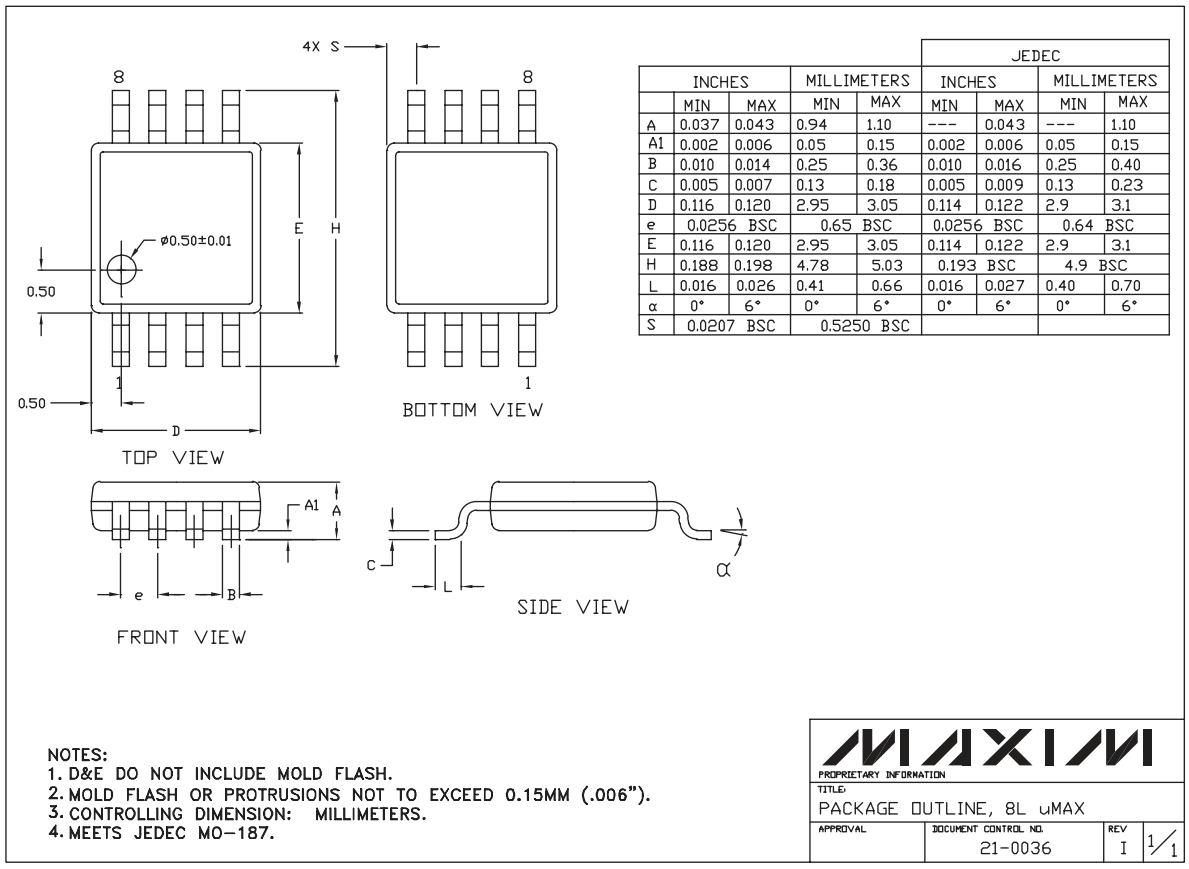
Figure 5. NO_, NC_, and COM_ Capacitance

Chip Information

TRANSISTOR COUNT: 105

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

Package Information



	INCHES		MILLIMETERS		JEDEC INCHES		JEDEC MILLIMETERS	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
A	0.037	0.043	0.94	1.10	---	0.043	---	1.10
A1	0.002	0.006	0.05	0.15	0.002	0.006	0.05	0.15
B	0.010	0.014	0.25	0.36	0.010	0.016	0.25	0.40
C	0.005	0.007	0.13	0.18	0.005	0.009	0.13	0.23
D	0.116	0.120	2.95	3.05	0.114	0.122	2.9	3.1
e	0.0256 BSC		0.65 BSC		0.0256 BSC		0.64 BSC	
E	0.116	0.120	2.95	3.05	0.114	0.122	2.9	3.1
H	0.188	0.198	4.78	5.03	0.193 BSC		4.9 BSC	
L	0.016	0.026	0.41	0.66	0.016	0.027	0.40	0.70
α	0°	6°	0°	6°	0°	6°	0°	6°
S	0.0207 BSC		0.5250 BSC					

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187.

MAXIM
PROPRIETARY INFORMATION
TITLE: PACKAGE OUTLINE, 8L uMAX
APPROVAL | DOCUMENT CONTROL NO. 21-0036 | REV I | 1/1