19-1656; Rev 0; 3/00

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 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**

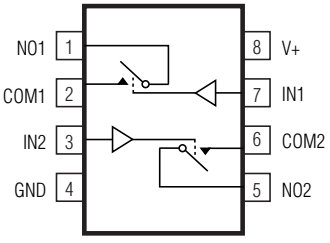
## Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE |
|---|---|---|
| **MAX4641**EUA | -40°C to +85°C | 8 µMAX |
| **MAX4642**EUA | -40°C to +85°C | 8 µMAX |
| **MAX4643**EUA | -40°C to +85°C | 8 µMAX |

## Pin Configurations/Functional Diagrams/Truth Tables

TOP VIEW

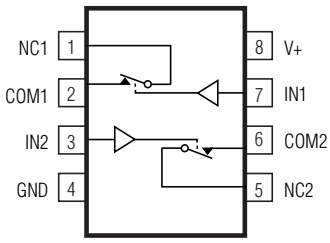
MAXIM *MAX4641*




µMAX

| MAX4641 | |
|---|---|
| IN_ | NO_ |
| 0 | OFF |
| 1 | ON |

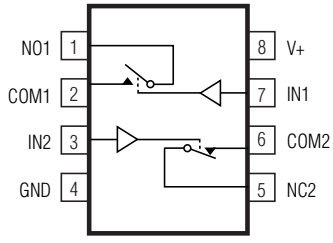
MAXIM *MAX4642*




µMAX

| MAX4642 | |
|---|---|
| IN_ | NC_ |
| 0 | ON |
| 1 | OFF |

MAXIM *MAX4643*




µMAX

| MAX4643 | | |
|---|---|---|
| IN_ | NO1 | NC2 |
| 0 | OFF | ON |
| 1 | ON | OFF |

# 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
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 (Note 2) | $\Delta R_{ON}$ | 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 (Note 2) | $\Delta R_{ON}$ | 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.

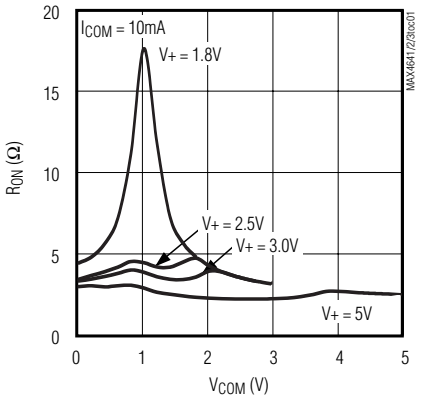
**Note 6:** Off-Isolation = $20\log_{10} (V_{O\_} / V_{I\_})$, where $V_O$ is $V_{COM\_}$ and $V_I$ is $V_{NC\_}$ or $V_{NO\_}$ from the network analyzer.

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

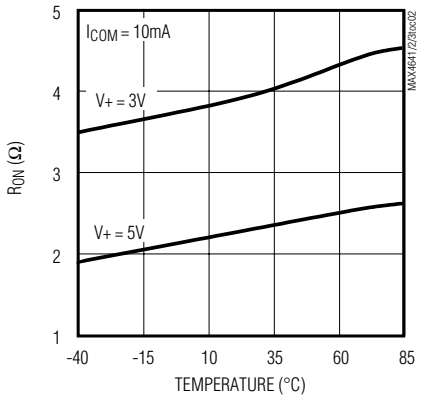
## Typical Operating Characteristics

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

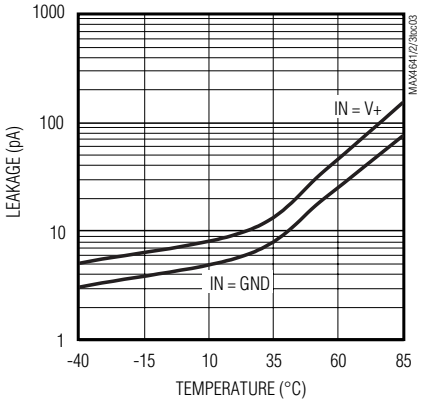
**ON-RESISTANCE vs. $V_{COM}$**



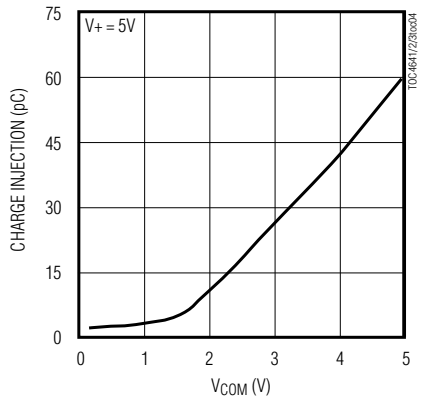

**ON-RESISTANCE vs. TEMPERATURE**



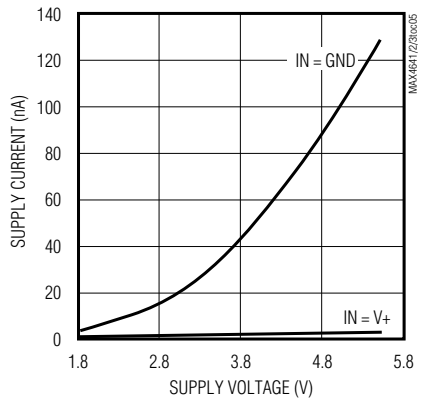

**ON-/OFF-LEAKAGE CURRENT vs. TEMPERATURE**



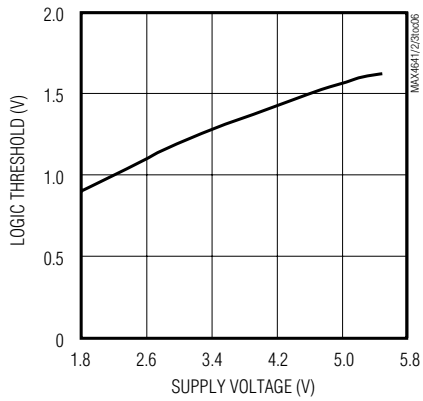

**CHARGE INJECTION vs. $V_{COM}$**



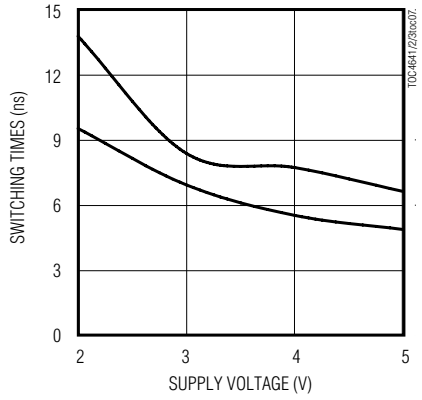

**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



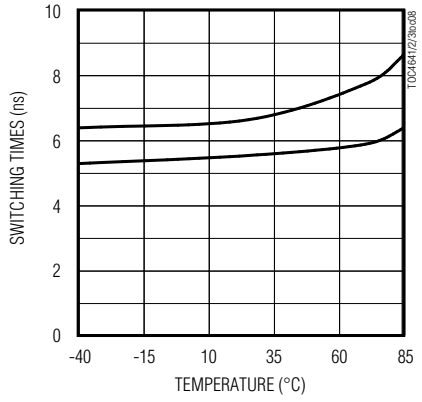

**LOGIC THRESHOLD vs. SUPPLY VOLTAGE**



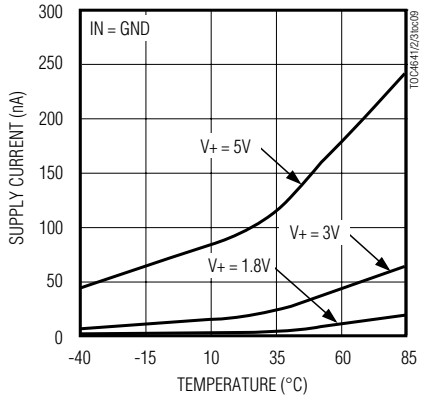

**SWITCHING TIMES vs. SUPPLY VOLTAGE**




**SWITCHING TIMES vs. TEMPERATURE**




**SUPPLY CURRENT vs. TEMPERATURE**

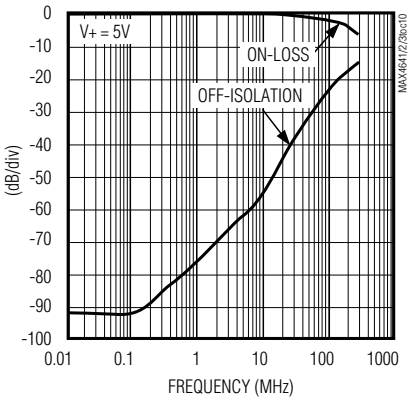


# High-Speed, Low-Voltage, 4Ω, Dual SPST CMOS Analog Switches

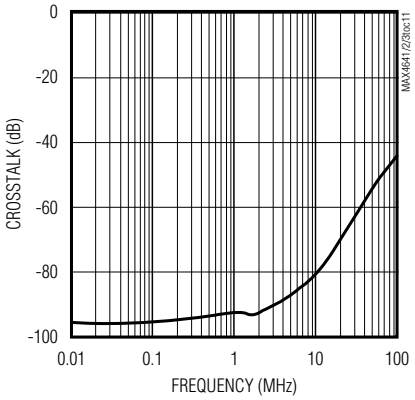
## Typical Operating Characteristics (continued)

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

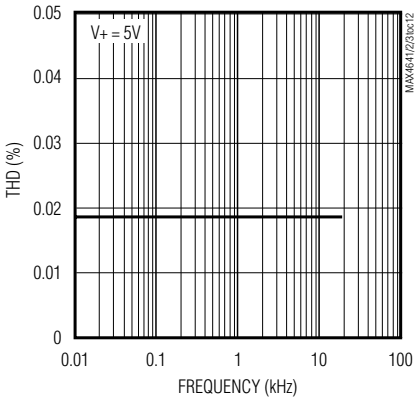
**FREQUENCY RESPONSE**




**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.*

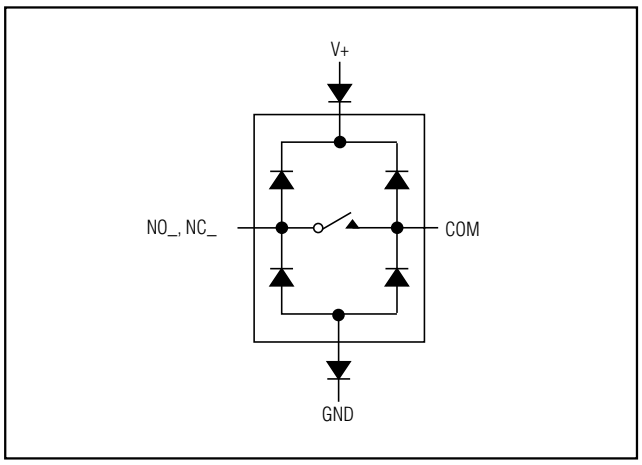



*Figure 1. Overvoltage Protection Using External Blocking Diodes*

## Applications Information

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

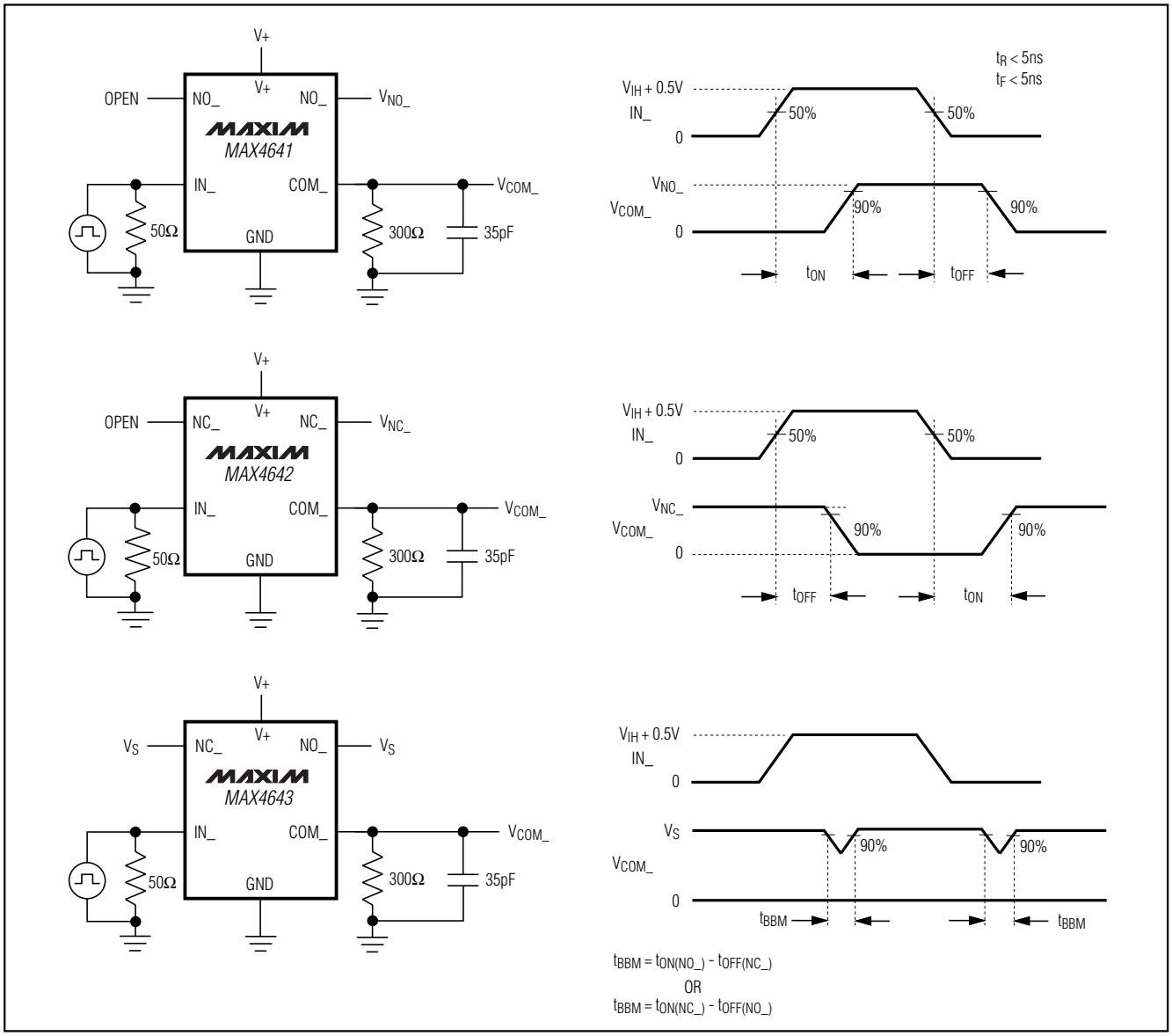



*Figure 2. Switching Times*

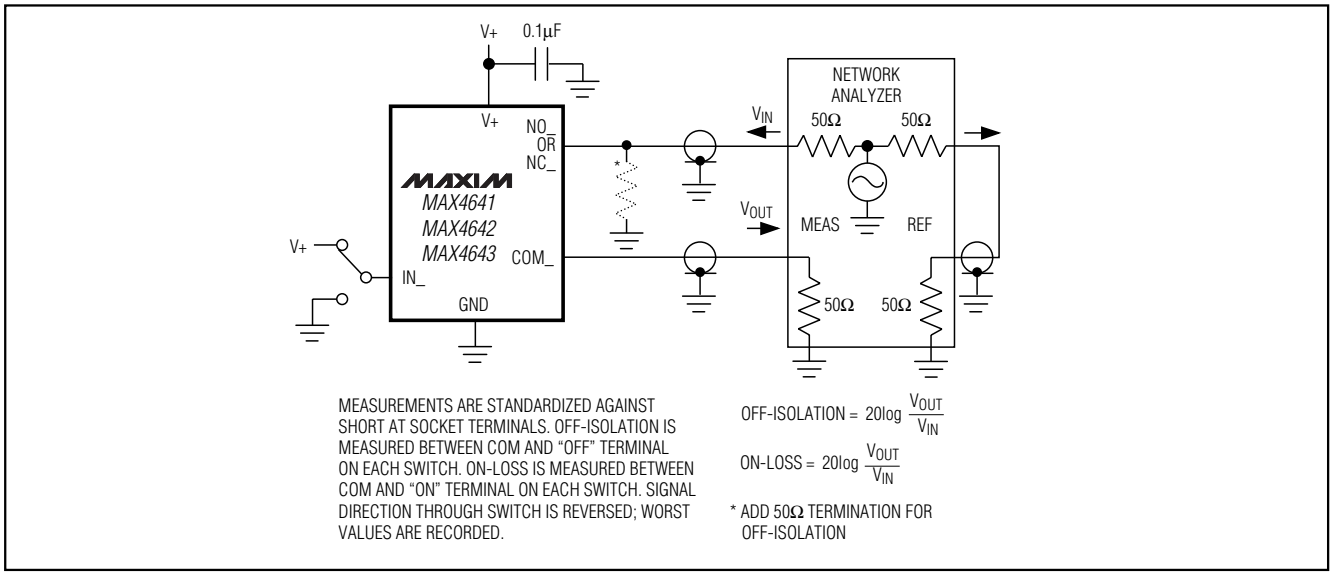



*Figure 3. Off-Isolation, On-Loss, and Crosstalk*

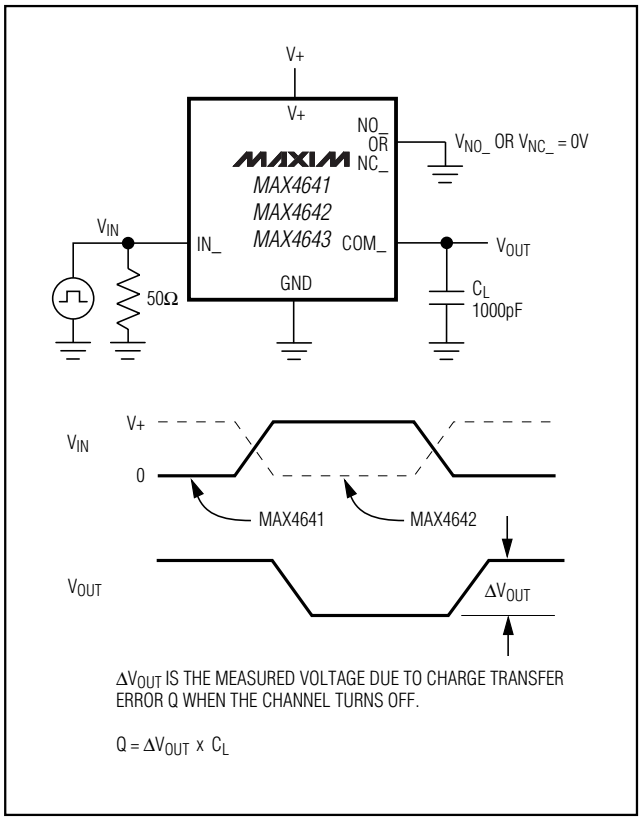



*Figure 4. Charge Injection*

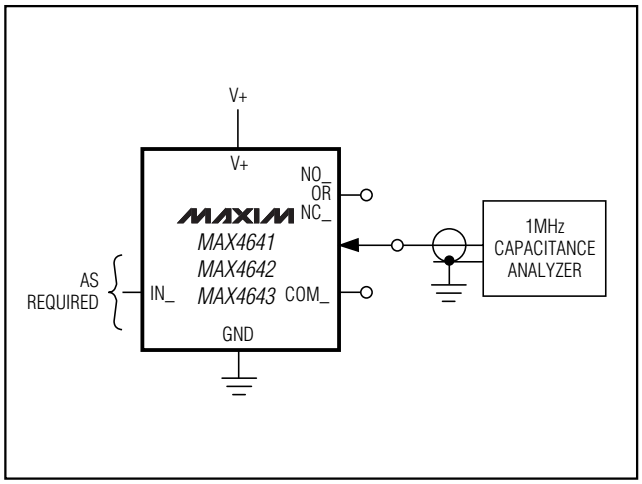



*Figure 5. NO_, NC_, and COM_ Capacitance*

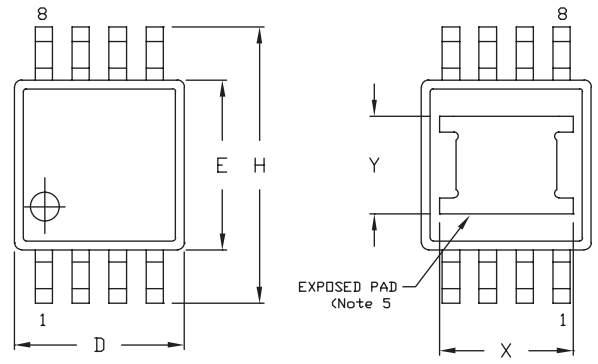
## Chip Information

TRANSISTOR COUNT: 105

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

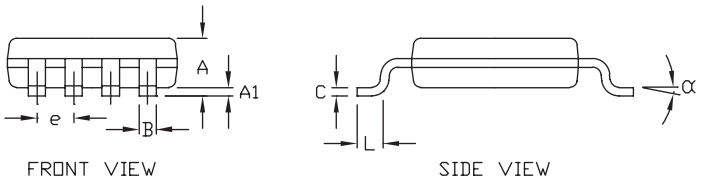
## Package Information

8LUMAXD.EPS




| | 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° |
| *X | 0.087 | 0.099 | 2.210 | 2.515 | | | | |
| *Y | 0.062 | 0.074 | 1.575 | 1.880 | | | | |

* EXPOSED PAD (Note 5)




NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15 MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187.
5. DIMENSIONS X & Y APPLY TO EXPOSED PAD (EP) VERSIONS ONLY. SEE INDIVIDUAL PRODUCT DATASHEET TO DETERMINE IF A PRODUCT USES EXPOSED PAD PACKAGE.
6. EXPOSED PAD FLUSH WITH BOTTOM OF PACKAGE WITHIN .002".

MAXIM
PROPRIETARY INFORMATION

TITLE:
PACKAGE OUTLINE, 8L uMAX WITH EP OPTION

| APPROVAL | DOCUMENT CONTROL NO. | REV | |
|---|---|---|---|
| | 21-0036 | H | 1/1 |

**NOTES**

**NOTES**