

## MAX4684/MAX4685

## 0.5Ω/0.8Ω Low-Voltage, Dual SPDT Analog Switches in UCSP

### General Description

The MAX4684/MAX4685 low on-resistance ( $R_{ON}$ ), low-voltage, dual single-pole/double-throw (SPDT) analog switches operate from a single +1.8V to +5.5V supply. The MAX4684 features a 0.5Ω (max)  $R_{ON}$  for its NC switch and a 0.8Ω (max)  $R_{ON}$  for its NO switch at a +2.7V supply. The MAX4685 features a 0.8Ω max on-resistance for both NO and NC switches at a +2.7V supply.

Both parts feature break-before-make switching action (2ns) with  $t_{ON} = 50ns$  and  $t_{OFF} = 40ns$  at +3V. The digital logic inputs are 1.8V logic-compatible with a +2.7V to +3.3V supply.

The MAX4684/MAX4685 are packaged in the chip-scale package (UCSP)<sup>™</sup>, significantly reducing the required PC board area. The chip occupies only a 2.0mm x 1.50mm area. The 4 x 3 array of solder bumps are spaced with a 0.5mm bump pitch.

### Applications

- Speaker Headset Switching
- MP3 Players
- Power Routing
- Battery-Operated Equipment
- Relay Replacement
- Audio and Video Signal Routing
- Communications Circuits
- PCMCIA Cards
- Cellular Phones
- Modems

### Benefits and Features

- 12-Bump, 0.5mm-Pitch UCSP
- NC Switch  $R_{ON}$ 
  - 0.5Ω max (+2.7V Supply) (MAX4684)
  - 0.8Ω max (+2.7V Supply) (MAX4685)
- NO Switch  $R_{ON}$ 
  - 0.8Ω max (+2.7V Supply)
- $R_{ON}$  Match Between Channels
  - 0.06Ω (max)
- $R_{ON}$  Flatness Over Signal Range
  - 0.15Ω (max)
- +1.8V to +5.5V Single-Supply Operation
- Rail-to-Rail Signal Handling
- 1.8V Logic Compatibility
- Low Crosstalk: -68dB (100kHz)
- High Off-Isolation: -64dB (100kHz)
- THD: 0.03%
- 50nA (max) Supply Current
- Low Leakage Currents
  - 1nA (max) at  $T_A = +25^\circ C$

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**Ordering Information** appears at end of data sheet.

### Absolute Maximum Ratings

(All Voltages Referenced to GND)

|   |                      |
|---|----------------------|
| V+, IN_   | -0.3V to +6V         |
| COM_, NO_, NC_ (Note1)                                      | -0.3V to (V+ + 0.3V) |
| Continuous Current NO_, NC_, COM_                           | ±300mA               |
| Peak Current NO_, NC_, COM_ (pulsed at 1ms, 50% duty cycle) | ±400mA               |
| Peak Current NO_, NC_, COM_ (pulsed at 1ms, 10% duty cycle) | ±500mA               |

|   |                 |
|---|-----------------|
| Continuous Power Dissipation (T <sub>A</sub> = +70°C) |                 |
| 10-Pin TDFN (derate 18.5mW/°C above +70°C)            | 1482mW          |
| 12-Bump UCSP (derate 11.4mW/°C above +70°C)           | 909mW           |
| 10-Pin μMAX (derate 5.6mW/°C above +70°C)             | 444mW           |
| Operating Temperature Ranges                          | -40°C to +85°C  |
| Storage Temperature Range                             | -65°C to +150°C |
| Lead Temperature (soldering, 10s)                     | +300°C          |
| Bump Temperature (soldering) (Note 2)                 |                 |
| Infared (15s)   | +220°C          |
| Vapor Phase (60s)                                     | +215°C          |

**Note 1:** Signals on NO\_, NC\_, and COM\_ exceeding V+ or GND are clamped by internal diodes. 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/VPB 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.*

### Package Information

| PACKAGE TYPE | PACKAGE CODE | DOCUMENT NO.            |
|--------------|--------------|-------------------------|
| 12 UCSP      | B12-4        | <a href="#">21-0104</a> |
| 10 TDFN-EP   | T1033-1      | <a href="#">21-0137</a> |
| 10 μMAX      | U10-2        | <a href="#">21-0061</a> |

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.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.

### Electrical Characteristics—+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 +25°C.) (Notes 3, 9, 10)

| PARAMETER   | SYMBOL  | CONDITIONS  | T <sub>A</sub> | MIN   | TYP  | MAX  | UNITS |
|---|---|---|----------------|-------|------|------|-------|
| <b>ANALOG SWITCH</b>                              |   |   |                |       |      |      |       |
| Analog Signal Range                               | V <sub>NO_</sub> , V <sub>NC_</sub> , V <sub>COM_</sub> |   | E              | 0     |      | V+   | V     |
| NC_ On-Resistance (Note 4)                        | R <sub>ON(NC)</sub>                                     | V+ = 2.7V; I <sub>COM_</sub> = 100mA; V <sub>NC_</sub> = 0 to V+                  | MAX4684        | +25°C | 0.3  | 0.5  | Ω     |
|   |   |   |                | E     |      | 0.5  |       |
|   |   |   | MAX4685        | +25°C | 0.45 | 0.8  |       |
|   |   |   |                | E     |      | 0.8  |       |
| NO_ On-Resistance (Note 4)                        | R <sub>ON(NO)</sub>                                     | V+ = 2.7V; I <sub>COM_</sub> = 100mA; V <sub>NO_</sub> = 0 to V+                  |                | +25°C | 0.45 | 0.8  | Ω     |
|   |   |   |                | E     |      | 0.8  |       |
| On-Resistance Match Between Channels (Notes 4, 5) | ΔR <sub>ON</sub>  | V+ = 2.7V; I <sub>COM_</sub> = 100mA; V <sub>NO_</sub> or V <sub>NC_</sub> = 1.5V |                | +25°C |      | 0.06 | Ω     |
|   |   |   |                | E     |      | 0.06 |       |
| NC_ On-Resistance Flatness (Note 6)               | R <sub>FLAT (NC)</sub>                                  | V+ = 2.7V; I <sub>COM_</sub> = 100mA; V <sub>NC_</sub> = 0 to V+                  | MAX4684        | E     |      | 0.15 | Ω     |
|   |   |   | MAX4685        | E     |      | 0.35 |       |
| NO_ On-Resistance Flatness (Note 6)               | R <sub>FLAT (NO)</sub>                                  | V+ = 2.7V; I <sub>COM_</sub> = 100mA; V <sub>NO_</sub> = 0 to V+                  |                | E     |      | 0.35 | Ω     |

**Electrical Characteristics—+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 +25°C.)  
(Notes 3, 9, 10)

| PARAMETER   | SYMBOL   | CONDITIONS  | T <sub>A</sub>              | MIN  | TYP   | MAX   | UNITS |
|---|--|---|-----------------------------|------|-------|-------|-------|
| NO <sub>-</sub> or NC <sub>-</sub> Off-Leakage Current (Note 7) | I <sub>NO<sub>-</sub>(OFF)</sub> or I <sub>NC<sub>-</sub>(OFF)</sub> | V+ = 3.3V; V <sub>NO<sub>-</sub></sub> or V <sub>NC<sub>-</sub></sub> = 3V, 0.3V; V <sub>COM<sub>-</sub></sub> = 0.3V, 3V                                 | +25°C                       | -1   |       | 1     | nA    |
|   |  |   | E                           | -10  |       | 10    |       |
| COM <sub>-</sub> On-Leakage Current (Note 7)                    | I <sub>COM<sub>-</sub>(ON)</sub>                                     | V+ = 3.3V; V <sub>NO<sub>-</sub></sub> or V <sub>NC<sub>-</sub></sub> = 3V, 0.3V, or unconnected; V <sub>COM<sub>-</sub></sub> = 3V, 0.3V, or unconnected | +25°C                       | -2   |       | 2     | nA    |
|   |  |   | E                           | -20  |       | 20    |       |
| <b>DYNAMIC CHARACTERISTICS</b>                                  |  |   |                             |      |       |       |       |
| Turn-On Time  | t <sub>ON</sub>  | V+ = 2.7V, V <sub>NO<sub>-</sub></sub> or V <sub>NC<sub>-</sub></sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF; Figure 2                       | +25°C                       |      | 30    | 50    | ns    |
|   |  |   | E                           |      |       | 60    |       |
| Turn-Off Time   | t <sub>OFF</sub>   | V+ = 2.7V, V <sub>NO<sub>-</sub></sub> or V <sub>NC<sub>-</sub></sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF; Figure 2                       | +25°C                       |      | 25    | 30    | ns    |
|   |  |   | E                           |      |       | 40    |       |
| Break-Before-Make Delay   | t <sub>BBM</sub>   | V+ = 2.7V, V <sub>NO<sub>-</sub></sub> or V <sub>NC<sub>-</sub></sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF; Figure 3                       | E                           | 2    | 15    |       | ns    |
| Charge Injection  | Q  | COM <sub>-</sub> = 0; R <sub>S</sub> = 0; C <sub>L</sub> = 1nF; Figure 4  | +25°C                       |      | 200   |       | pC    |
| Off-Isolation (Note 8)  | V <sub>ISO</sub>   | C <sub>L</sub> = 5pF; R <sub>L</sub> = 50Ω; f = 100kHz; V <sub>COM<sub>-</sub></sub> = 1V <sub>RMS</sub> ; Figure 5                                       | +25°C                       |      | -64   |       | dB    |
| Crosstalk   | V <sub>CT</sub>  | C <sub>L</sub> = 5pF; R <sub>L</sub> = 50Ω; f = 100kHz; V <sub>COM<sub>-</sub></sub> = 1V <sub>RMS</sub> ; Figure 5                                       | +25°C                       |      | -68   |       | dB    |
| Total Harmonic Distortion                                       | THD  | R <sub>L</sub> = 600Ω, I <sub>N<sub>-</sub></sub> = 2Vp-p, f = 20Hz to 20kHz  | +25°C                       |      | 0.03  |       | %     |
| NC <sub>-</sub> Off-Capacitance                                 | C <sub>NC<sub>-</sub>(OFF)</sub>                                     | f = 1MHz; Figure 6  | +25°C                       |      | 84    |       | pF    |
| NO <sub>-</sub> Off-Capacitance                                 | C <sub>NO<sub>-</sub>(OFF)</sub>                                     | f = 1MHz; Figure 6  | +25°C                       |      | 37    |       | pF    |
| NC <sub>-</sub> On-Capacitance                                  | C <sub>NC<sub>-</sub>(ON)</sub>                                      | f = 1MHz; Figure 6  | +25°C                       |      | 190   |       | pF    |
| NO <sub>-</sub> On-Capacitance                                  | C <sub>NO<sub>-</sub>(ON)</sub>                                      | f = 1MHz; Figure 6  | +25°C                       |      | 150   |       | pF    |
| <b>DIGITAL I/O</b>  |  |   |                             |      |       |       |       |
| Input Logic High  | V <sub>IH</sub>  |   | E                           | 1.4  |       |       | V     |
| Input Logic Low   | V <sub>IL</sub>  |   | E                           |      |       | 0.5   | V     |
| IN <sub>-</sub> Input Leakage Current                           | I <sub>IN<sub>-</sub></sub>  | V <sub>IN<sub>-</sub></sub> = 0 or V+   | MAX4684/MAX4685<br>MAX4684A | E    | -1000 | +1000 | nA    |
|   |  |   |                             |      | -20   | +20   |       |
| <b>POWER SUPPLY</b>   |  |   |                             |      |       |       |       |
| Power-Supply Range  | V+   |   | E                           | 1.8  |       | 5.5   | V     |
| Supply Current (Note 4)   | I+   | V+ = 5.5V; V <sub>IN<sub>-</sub></sub> = 0 or V+  | +25°C                       | -50  | 0.04  | 50    | nA    |
|   |  |   | E                           | -200 |       | 200   |       |

**Note 3:** The algebraic convention used in this data sheet is where the most negative value is a minimum and the most positive value a maximum.

**Note 4:** Guaranteed by design.

**Note 5:**  $\Delta R_{ON} = R_{ON(MAX)} - R_{ON(MIN)}$ , between NC1 and NC2 or between NO1 and NO2.

**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:** Leakage parameters are 100% tested at T<sub>A</sub> = +85°C, and guaranteed by correlation over rated temperature range.

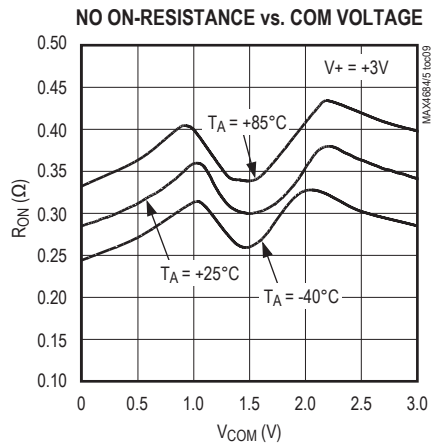
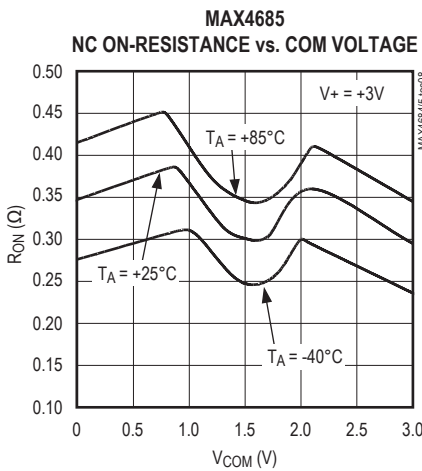
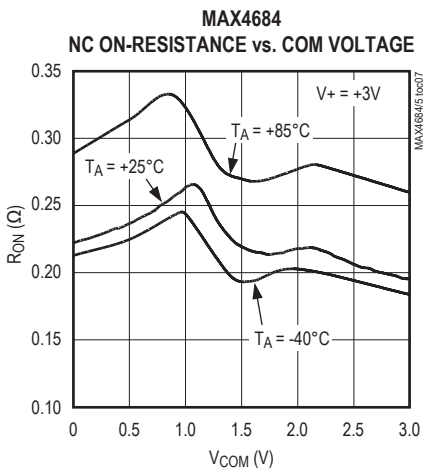
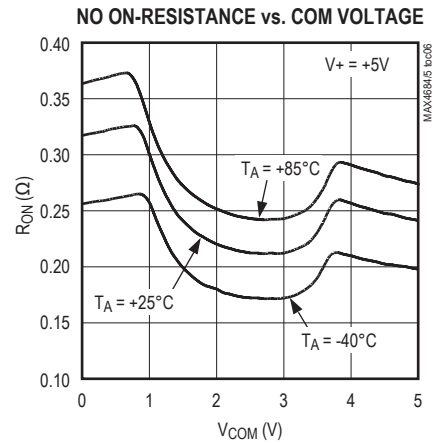
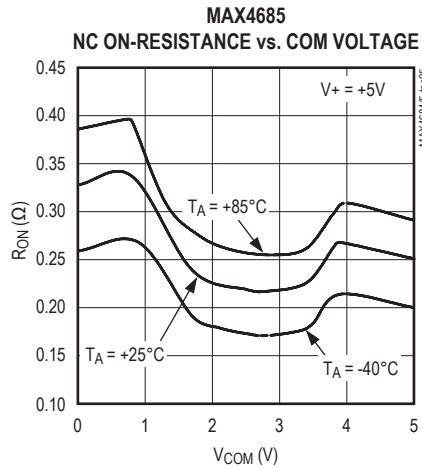
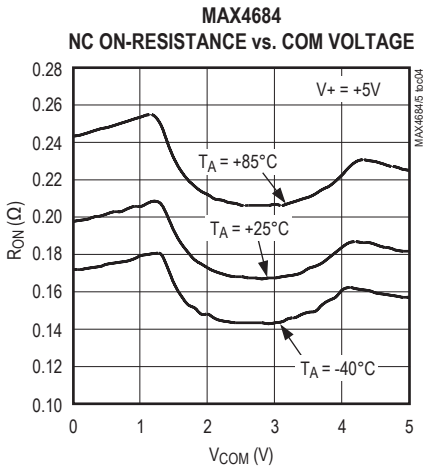
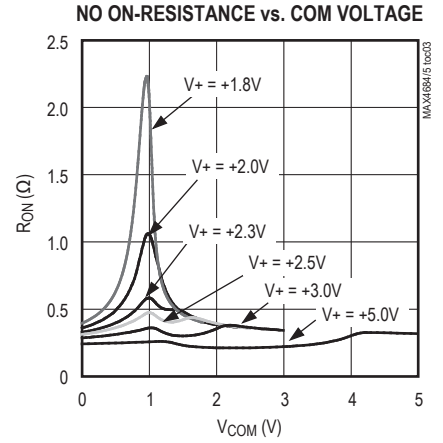
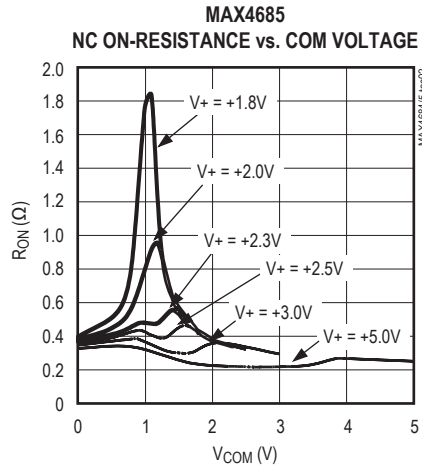
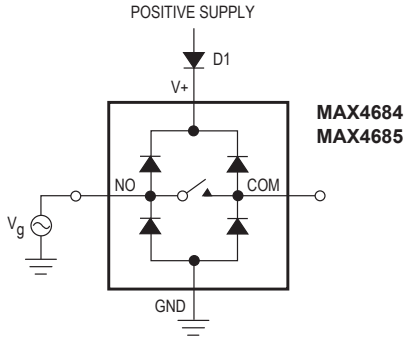
**Note 8:** Off-isolation = 20log<sub>10</sub> (V<sub>COM</sub> / V<sub>NO</sub>), V<sub>COM</sub> = output, V<sub>NO</sub> = input to off switch.

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

**Note 10:** -40°C specifications are guaranteed by design.

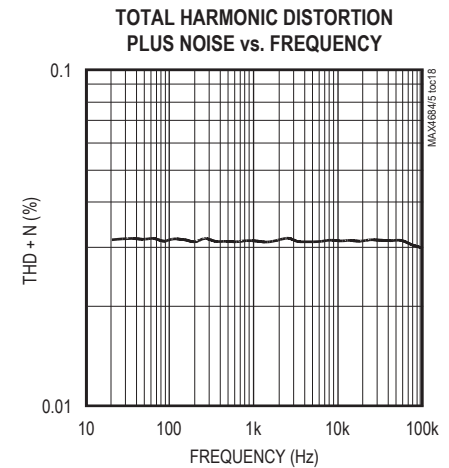
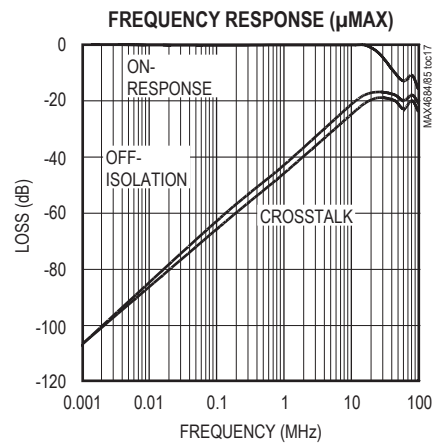
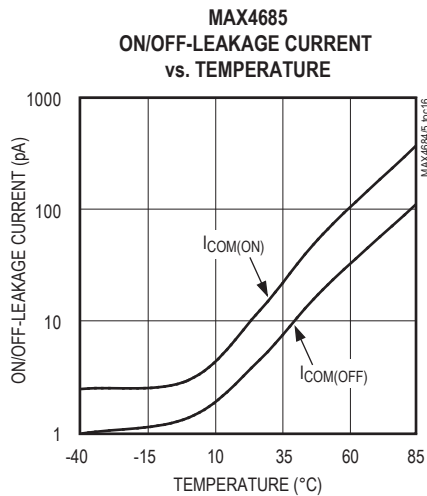
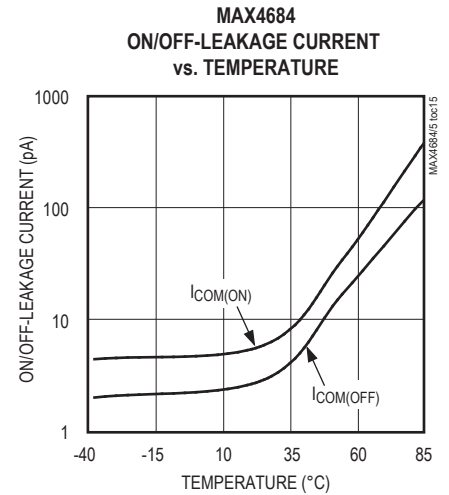
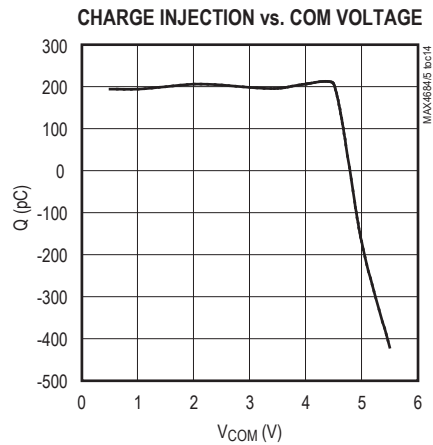
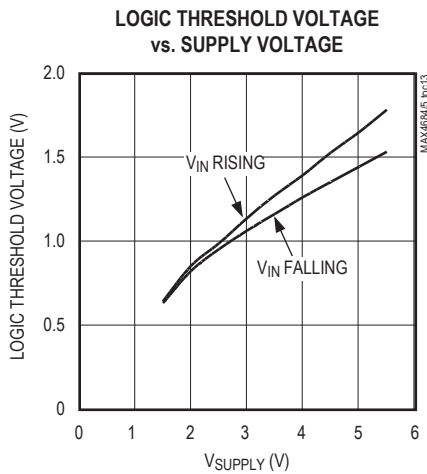
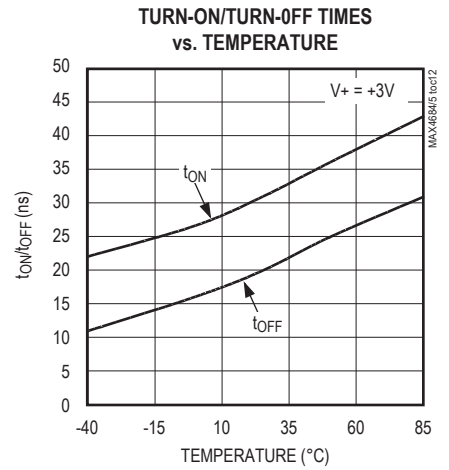
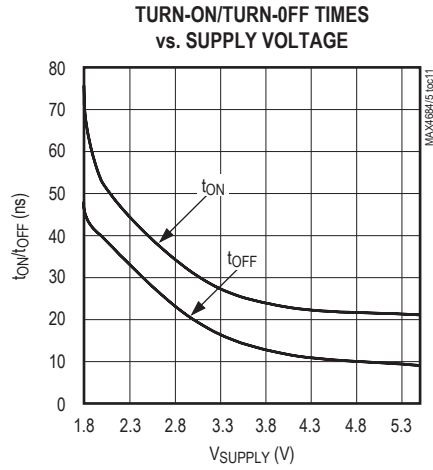
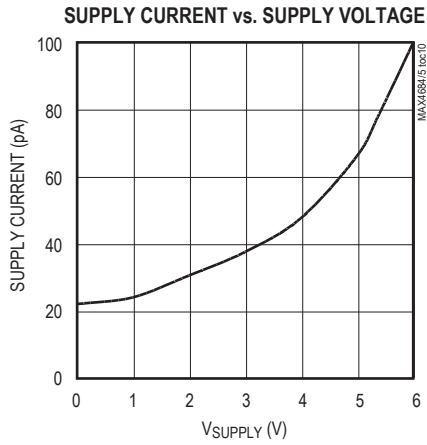
Typical Operating Characteristics

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

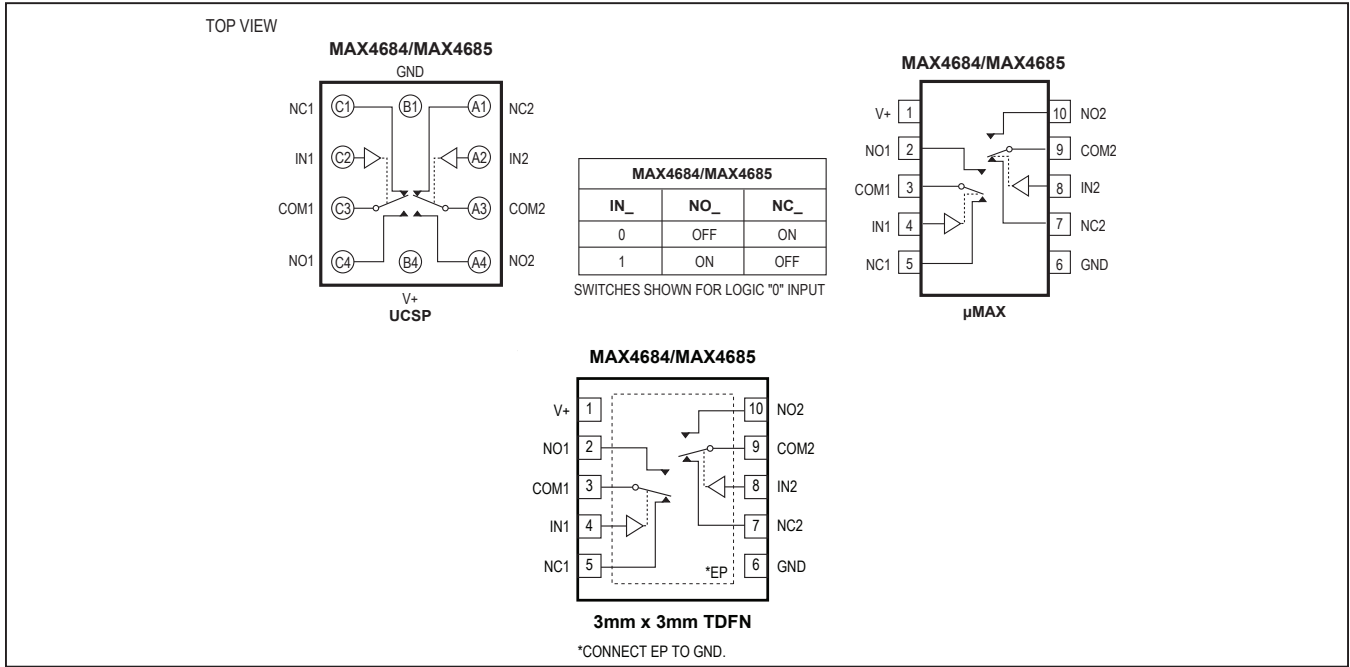


Typical Operating Characteristics (continued)

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



Pin Configurations/Functional Diagrams/Truth Table



Pin Description

| NAME | PIN    |           | FUNCTION  |
|------|--------|-----------|---|
|      | UCSP   | μMAX/TDFN |   |
| NC_  | A1, C1 | 5, 7      | Analog Switch—Normally Closed Terminal          |
| IN_  | A2, C2 | 4, 8      | Digital Control Input                           |
| COM_ | A3, C3 | 3, 9      | Analog Switch—Common Terminal                   |
| NO_  | A4, C4 | 2, 10     | Analog Switch—Normally Open Terminal            |
| V+   | B4     | 1         | Positive Supply Voltage Input                   |
| GND  | B1     | 6         | Ground  |
| EP   | —      | —         | Exposed Pad. Connect EP to GND (for TDFN only.) |

## Detailed Description

The MAX4684/MAX4685 are low on-resistance, low-voltage, dual SPDT analog switches that operate from a +1.8V to +5.5V supply. The devices are fully specified for nominal 3V applications. The MAX4684/MAX4685 have break-before-make switching and fast switching speeds ( $t_{ON} = 50\text{ns}$  max,  $t_{OFF} = 40\text{ns}$  max).

The MAX4684 offers asymmetrical normally closed (NC) and normally open (NO)  $R_{ON}$  for applications that require asymmetrical loads (examples include speaker headsets and internal speakers). The part features a  $0.5\Omega$  max  $R_{ON}$  for its NC switch and a  $0.8\Omega$  max  $R_{ON}$  for its NO switch at the 2.7V supply. The MAX4685 features a  $0.8\Omega$  max on-resistance for both NO and NC switches at the +2.7V supply.

## Applications Information

### Digital Control Inputs

The MAX4684/MAX4685 logic inputs accept up to +5.5V regardless of supply voltage. For example, with a +3.3V supply,  $IN_{-}$  may be driven low to GND and high to 5.5V. Driving  $IN_{-}$  rail-to-rail minimizes power consumption. Logic levels for a +1.8V supply are 0.5V (low) and 1.4V (high).

### Analog Signal Levels

Analog signals that range over the entire supply voltage ( $V_{+}$  to GND) are 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 either 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  $<20\text{mA}$ , add a small signal diode (D1) as shown in Figure 1. Adding a protection diode reduces the analog range to a diode drop (about 0.7V) below  $V_{+}$  (for D1).  $R_{ON}$  increases slightly at low

supply voltages. Maximum supply voltage ( $V_{+}$ ) must not exceed +6V. Protection diode D1 also protects against some overvoltage situations. No damage will result on Figure 1's circuit if the supply voltage is below the absolute maximum rating applied to an analog signal pin.

### UCSP Package Consideration

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

### UCSP Reliability

The chip-scale package (UCSP) represents a unique packaging form factor that may not perform equally to a packaged product through traditional mechanical reliability tests. 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 use of a UCSP package. Performance through Operating Life Test and Moisture Resistance remains uncompromised as it is primarily determined by the wafer-fabrication process.

Mechanical stress performance is a greater consideration for a UCSP package. UCSPs are attached through direct solder contact to the user's PC board, foregoing the inherent stress relief of a packaged product lead frame. Solder joint contact integrity must be considered. Information on Maxim's qualification plan, test data, and recommendations are detailed in the UCSP application note, which can be found on Maxim's website at [www.maximintegrated.com](http://www.maximintegrated.com).

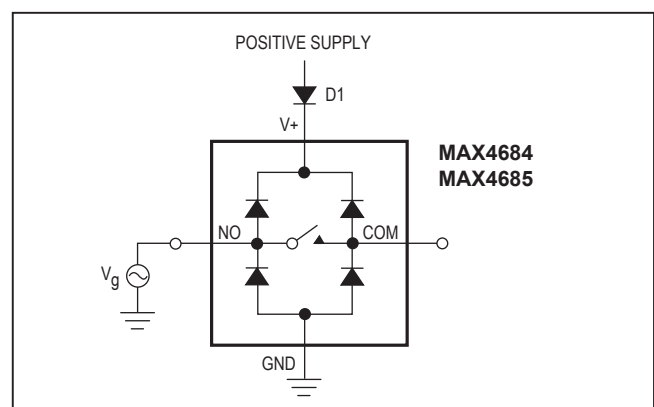


Figure 1. Overvoltage Protection Using Two External Blocking Diodes

Test Circuits/Timing Diagrams

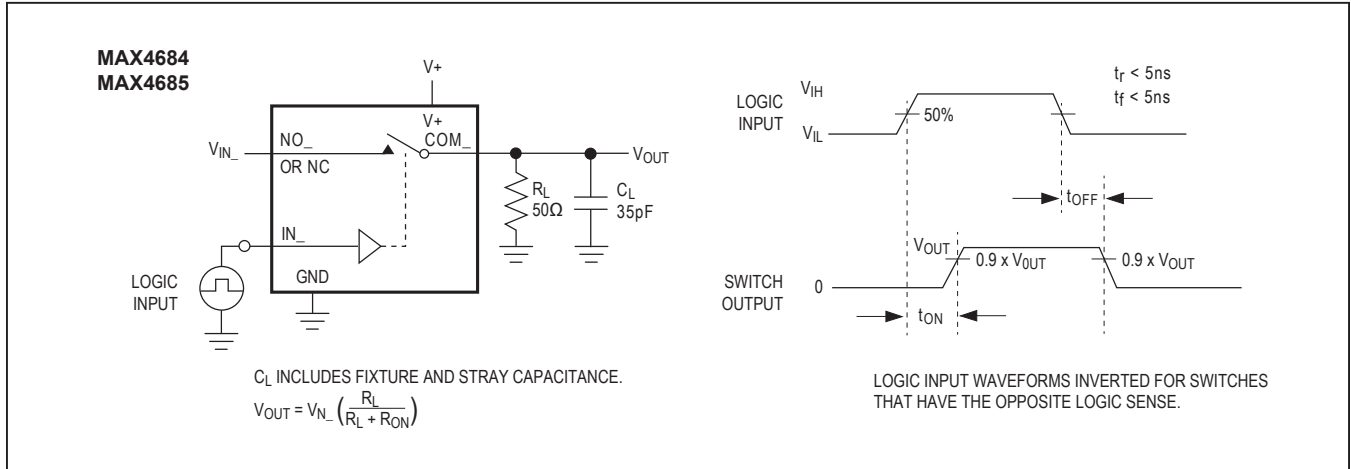


Figure 2. Switching Time

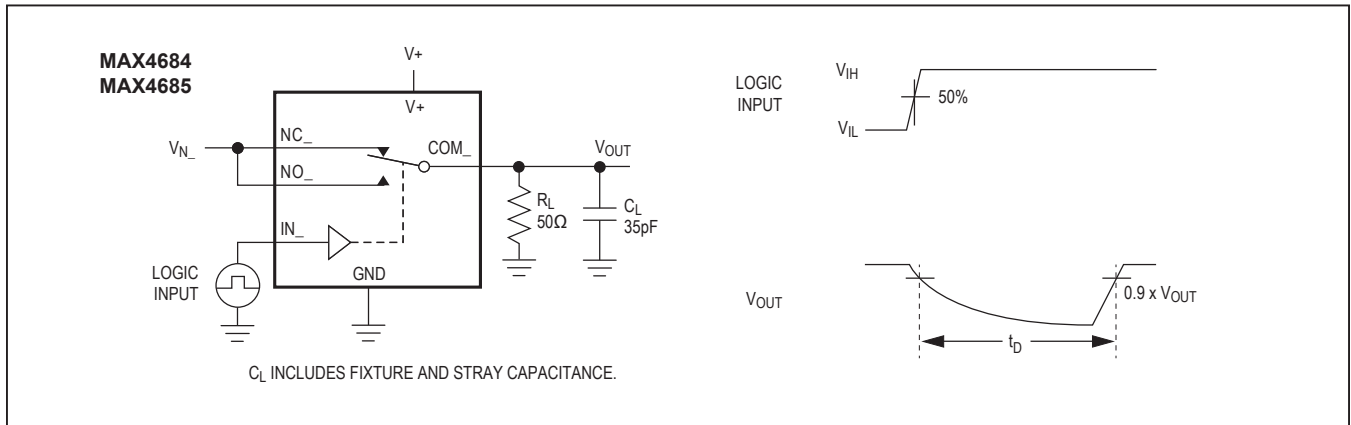


Figure 3. Break-Before-Make Interval

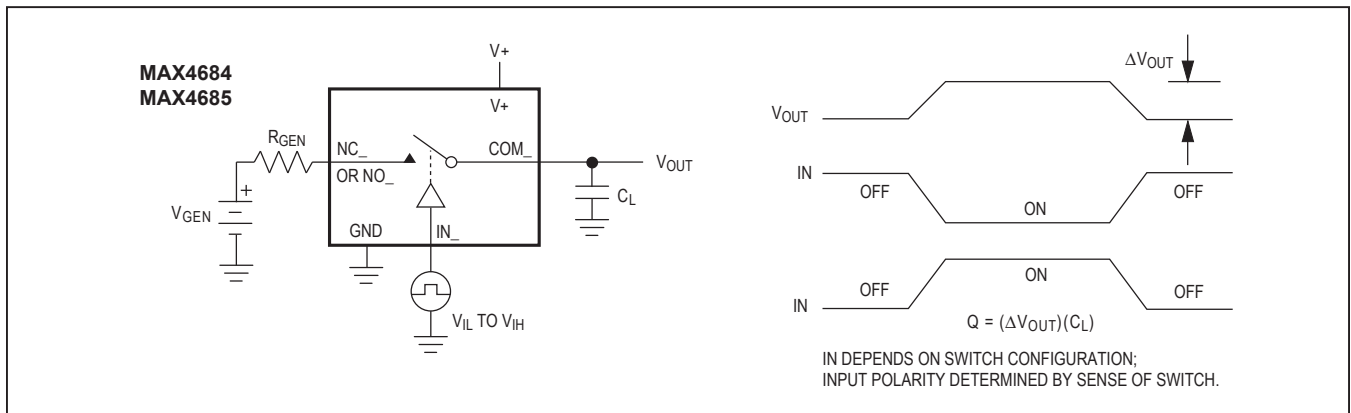


Figure 4. Charge Injection



Test Circuits/Timing Diagrams (continued)

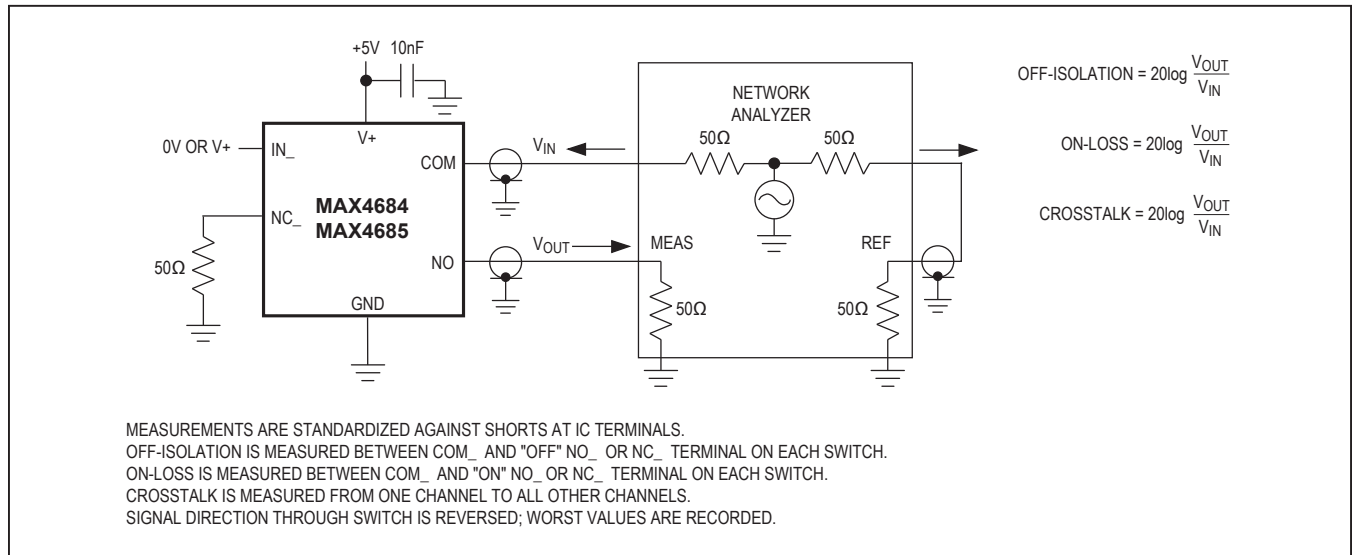


Figure 5. On-Loss, Off-Isolation, and Crosstalk

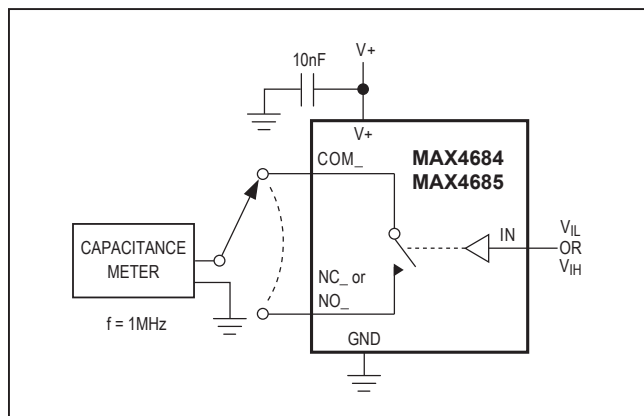


Figure 6. Channel Off/On-Capacitance

Ordering Information

| PART         | TEMP RANGE     | PIN/BUMP-PACKAGE | TOP MARK |
|--------------|----------------|------------------|----------|
| MAX4684EBC+T | -40°C to +85°C | 12 UCSP*         | AAF      |
| MAX4684ETB+T | -40°C to +85°C | 10 TDFN-EP**     | AAG      |
| MAX4684EUB+T | -40°C to +85°C | 10 μMAX®         | —        |
| MAX4684AEB+T | -40°C to +85°C | 12 UCSP*         | AEJ      |
| MAX4685EBC+T | -40°C to +85°C | 12 UCSP*         | AAG      |
| MAX4685ETB+T | -40°C to +85°C | 10 TDFN-EP**     | AAH      |
| MAX4685EUB+T | -40°C to +85°C | 10 μMAX          | —        |

+Denotes a lead(Pb)-free/RoHS-compliant package.

**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 Notice in the UCSP Reliability section of this data sheet for more information.

\*\*EP = Exposed Pad

T = Tape and reel.

Chip Information

PROCESS: BiCMOS

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION  | PAGES CHANGED |
|-----------------|---------------|--|---------------|
| 3               | 2/03          | Added TDFN packaging, noted parts are now UCSP qualified   | —             |
| 4               | 1/09          | Added lead-free packaging and exposed pad note   | 1, 2, 6–9     |
| 5               | 10/19         | Updated the <i>Electrical Characteristics</i> table and added MAX4684AEBC+T to the <i>Ordering Information</i> table | 3, 9          |

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