# MAX14759/MAX14761/MAX14763

# Above- and Below-the-Rails Low On-Resistance Analog Switches

## General Description

The MAX14759/MAX14761/MAX14763 analog switches are capable of passing bipolar signals that are beyond their supply rails. These devices operate from a single +3.0V to +5.5V supply and support signals in the -25V to +25V range.

The MAX14759 is a single-pole/single-throw (SPST) analog switch, while the MAX14761 is a dual-SPST analog switch. The MAX14763 is a single-pole/double-throw (SPDT) analog switch.

The MAX14759 features 1Ω (max) on-resistance with a ±200nA (max) on-leakage current. The MAX14761/MAX14763 feature 2Ω (max) on-resistance with a ±100nA (max) on-leakage current. The low on-resistance and high bandwidth allow use in digital- and analog-signal switching applications.

The MAX14759/MAX14763 are available in an 8-pin (3mm x 3mm) TDFN package. The MAX14761 is available in a 10-pin (3mm x 3mm) TDFN package. These devices are specified over the -40°C to +85°C extended temperature range.

***Ordering Information/Selector Guide* appears at end of data sheet.**

*For related parts and recommended products to use with this part, refer to www.maximintegrated.com/MAX14759.related.*

## Benefits and Features

- **Simplify Power-Supply Requirements**
  - **+3.0V to +5.5V Supply Range**
  - **-25V to +25V Signal Range**
- **High Performance**
  - **Low 1Ω (max) or 2Ω (max) On-Resistance**
  - **Low 2.4mΩ (typ) and 5.1mΩ (typ) $R_{ON}$ Flatness**
  - **500mA (max) Switch Current for MAX14759**
  - **Thermal Shutdown Protection**
  - **-40°C to +85°C Operating Temperature Range**
  - **High Bandwidth: 100MHz (typ) Insertion Loss**
  - **High-ESD Protection Up to 2kV**
- **Save Board Space**
  - **Small 8-Pin and 10-Pin TDFN Packages**

## Applications

Industrial Measurement Systems

Instrumentation Systems

RS-485 Termination Switching

CAN Bus Termination Switching

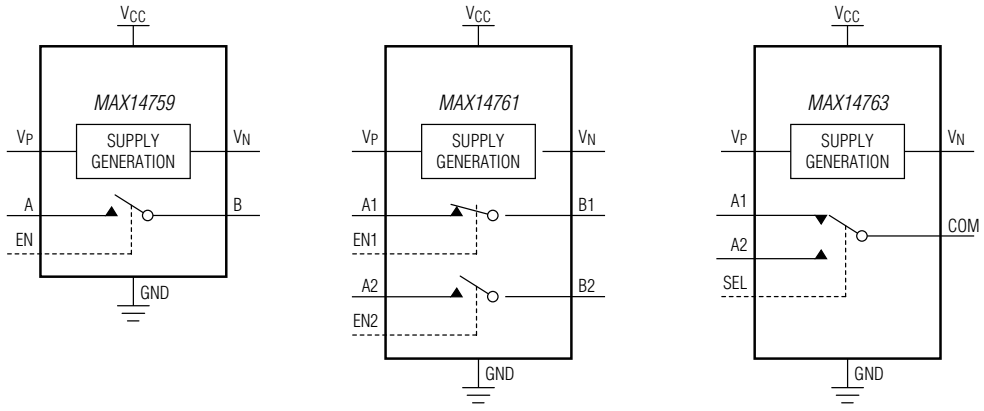
Opto-Relay Replacement

Medical Systems

ATE Systems

Audio Signal Routing and Switching

## Functional Diagrams/Truth Tables




| EN | A |
|---|---|
| 0 | OPEN |
| 1 | CLOSED |

| EN1 | A1 |
|---|---|
| 0 | CLOSED |
| 1 | OPEN |

| EN2 | A2 |
|---|---|
| 0 | OPEN |
| 1 | CLOSED |

| SEL | A1 | A2 |
|---|---|---|
| 0 | CLOSED | OPEN |
| 1 | OPEN | CLOSED |

**For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maximintegrated.com.**

*19-6051; Rev 1; 8/12*

## ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND, unless otherwise noted.)
$V_{CC}$ ..... -0.3V to +6V
EN, EN1, EN2, SEL ..... -0.3V to + ($V_{CC}$ + 0.3V)
A, B, A1, A2, B1, B2, COM ..... ($V_N$ - 0.3V) to Lesser of ($V_P$ + 0.3V) or ($V_N$ + 52V)
$V_P$ ..... -0.3V to Lesser of (+52V) or ($V_N$ + 70V)
$V_N$ ..... Greater of ($V_{CC}$ - 40V) or ($V_P$ - 70V) to +0.3V
$V_P$ to $V_N$ ..... -0.3V to +70V
Continuous Current Through Switch (MAX14759) ..... ±500mA
Continuous Current Through Switch
(MAX14761, MAX14763) ..... ±250mA
Continuous Power Dissipation ($T_A$ = +70°C)
8-Pin TDFN Package
(derate 24.4mW/°C above +70°C) ..... 1951.2mW
10-Pin TDFN Package
(derate 24.4mW/°C above +70°C) ..... 1951.2mW
Operating Temperature Range ..... -40°C to +85°C
Storage Temperature Range ..... -65°C to +160°C
Lead Temperature (soldering, 10s) ..... +300°C
Soldering Temperature (reflow) ..... +260°C

*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 THERMAL CHARACTERISTICS (Note 1)

8-Pin TDFN
Junction-to-Ambient Thermal Resistance ($\theta_{JA}$) ..... 48°C/W
Junction-to-Case Thermal Resistance ($\theta_{JC}$) ..... 8°C/W

10-Pin TDFN
Junction-to-Ambient Thermal Resistance ($\theta_{JA}$) ..... 41°C/W
Junction-to-Case Thermal Resistance ($\theta_{JC}$) ..... 9°C/W

**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

## ELECTRICAL CHARACTERISTICS

($V_{CC}$ = +3.0V to +5.5V, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $V_{CC}$ = 5V and $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **DC CHARACTERISTICS** | | | | | | | |
| Power Supply Range | $V_{CC}$ | | | 3.0 | | 5.5 | V |
| Continuous Current Through Switch | $I_{A_}$ | (MAX14759) | | -500 | | +500 | mA |
| | | (MAX14761/MAX14763) | | -250 | | +250 | |
| Supply Current | $I_{CC}$ | $V_{CC} \le 4.7V$ | $V_{EN_} = V_{CC}$ | | 4.1 | 10 | mA |
| | | | $V_{EN_} = V_{CC}/2$ | | 4.1 | 10 | |
| | | $V_{CC} > 4.7V$ | $V_{EN_} = V_{CC}$ | | 2.5 | 6 | |
| | | | $V_{EN_} = V_{CC}/2$ | | 2.5 | 6 | |
| Analog-Signal Range | $V_{COM}$, $V_{A_}$, $V_{B_}$ | Switch open or closed | | -25 | | +25 | V |
| On-Resistance | $R_{ON}$ | $I_B$ = ±500mA, $V_A$ = ±25V (MAX14759) | | | 0.6 | 1 | Ω |
| | | $I_{COM}$ or $I_{B_}$ = ±250mA, $V_{A_}$ = ±25V (MAX14761/MAX14763) | | | 1.2 | 2 | |
| On-Resistance Flatness | $\Delta R_{ON}$ | -25V < $V_A$ < +25V, $I_B$ = ±500mA (MAX14759) | | | 2.4 | | mΩ |
| | | -25V < $V_{A_}$ < +25V, $I_{B_}$ or $I_{COM}$ = ±250mA (MAX14761/MAX14763) | | | 5.1 | | |
| A, A1, A2 Off-Leakage Current | $I_{A_(OFF)}$ | $V_A$ = +25V, $V_B$ = 0V, Figure 1 (MAX14759) | | -250 | | +250 | nA |
| | | $V_{A_}$ = +25V, $V_{COM}$ or $V_{B_}$ = 0V, Figure 1 (MAX14761/MAX14763) | | -250 | | +250 | |
| COM, B, B1, B2 Off-Leakage Current | $I_{COM(OFF)}$, $I_{B_(OFF)}$ | $V_{COM}$ or $V_B$ = 15V, $V_{A_}$ = 0V, Figure 1 (MAX14759/MAX14763) | | -100 | | +100 | nA |
| | | $V_{B_}$ = 15V, $V_{A_}$ = 0V, Figure 1 (MAX14761) | | -100 | | +100 | |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = +3.0V to +5.5V, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $V_{CC}$ = 5V and $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| On-Leakage Current | $I_{ON}$ | $V_A$ = ±25V, B1, B2, or COM are unconnected, Figure 1 (MAX14759) | -200 | | +200 | nA |
| | | $V_A$ = ±25V, B1, B2, or COM are unconnected, Figure 1 (MAX14761) | -100 | | +100 | |
| | | $V_A$ = ±25V, B1, B2, or COM are unconnected, Figure 1 (MAX14763) | -250 | | +250 | |
| **DIGITAL LOGIC** | | | | | | |
| Input-Voltage Low | $V_{IL}$ | $V_{CC}$ = 3.0V | | | 0.7 | V |
| | | $V_{CC}$ = 3.6V | | | 0.7 | |
| | | $V_{CC}$ = 4.5V | | | 0.8 | |
| | | $V_{CC}$ = 5.5V | | | 0.8 | |
| Input-Voltage High | $V_{IH}$ | $V_{CC}$ = 3.0V | 1.7 | | | V |
| | | $V_{CC}$ = 3.6V | 1.9 | | | |
| | | $V_{CC}$ = 4.5V | 2.0 | | | |
| | | $V_{CC}$ = 5.5V | 2.1 | | | |
| Input Current | $I_L$ | | -1 | | +1 | µA |
| **AC CHARACTERISTICS** | | | | | | |
| Power-On Time | $t_{PWRON}$ | $C_{VP}$ = $C_{VN}$ = 100nF (Note 3) | | 50 | | ms |
| Enable Turn-On Time | $t_{ON}$ | $V_{A_}$ = ±10V, $R_L$ = 10kΩ, Figure 2 (MAX14759/MAX14761) | | 152 | 300 | µs |
| | | $V_{A_}$ = ±10V, $R_L$ = 10kΩ, Figure 2 (MAX14763) | | 1.12 | 1.8 | ms |
| Enable Turn-Off Time | $t_{OFF}$ | $V_{A_}$ = ±10V, $R_L$ = 10kΩ, Figure 2 | | 300 | 1000 | µs |
| Break-Before-Make Interval | $t_{BBM}$ | $V_{A_}$ = $1V_{RMS}$, $R_L$ = 10kΩ, Figure 3 (MAX14763) | | 740 | | µs |
| Off-Isolation | $V_{ISO}$ | $V_{A_}$ = $1V_{RMS}$, f = 100kHz, $R_L$ = 50Ω, $C_L$ = 15pF, Figure 4 | | -77 | | dB |
| Crosstalk | $V_{CT}$ | $R_S$ = $R_L$ = 50Ω, f = 100kHz, $V_{COM}$ = $1V_{RMS}$, Figure 5 (MAX14763) | | -83 | | dB |
| -3dB Bandwidth | BW | $R_S$ = 50Ω, $R_L$ = 50Ω , $V_{A_}$ = $1V_{P-P}$, Figure 6 | | 100 | | MHz |
| Total Harmonic Distortion Plus Noise | THD+N | $R_S$ = $R_L$ = 1kΩ, f = 20Hz to 20kHz | | 0.0012 | | % |
| Charge Injection | Q | $V_{A_}$ = GND, $C_L$ = 1nF, Figure 7 | | 1370 | | pC |
| Input Capacitance | $C_{IN}$ | At A, A1, A2, B, B1, B2, and COM pins | | 58 | | pF |
| **THERMAL PROTECTION** | | | | | | |
| Thermal Shutdown Temperature | $t_{HYST}$ | | | +154 | | °C |
| Shutdown Temperature Hysteresis | $t_{SHUT}$ | | | 24 | | °C |
| **ESD PROTECTION** | | | | | | |
| All Pins | | Human Body Model | | ±2 | | kV |

**Note 2:** All devices are 100% production tested at $T_A$ = +25°C. Specifications over operating temperature range are guaranteed by design.

**Note 3:** The power-on time is defined as the settling time for the charge pump's output to reach steady-state value within 1%.

### *Test Circuits/Timing Diagrams*

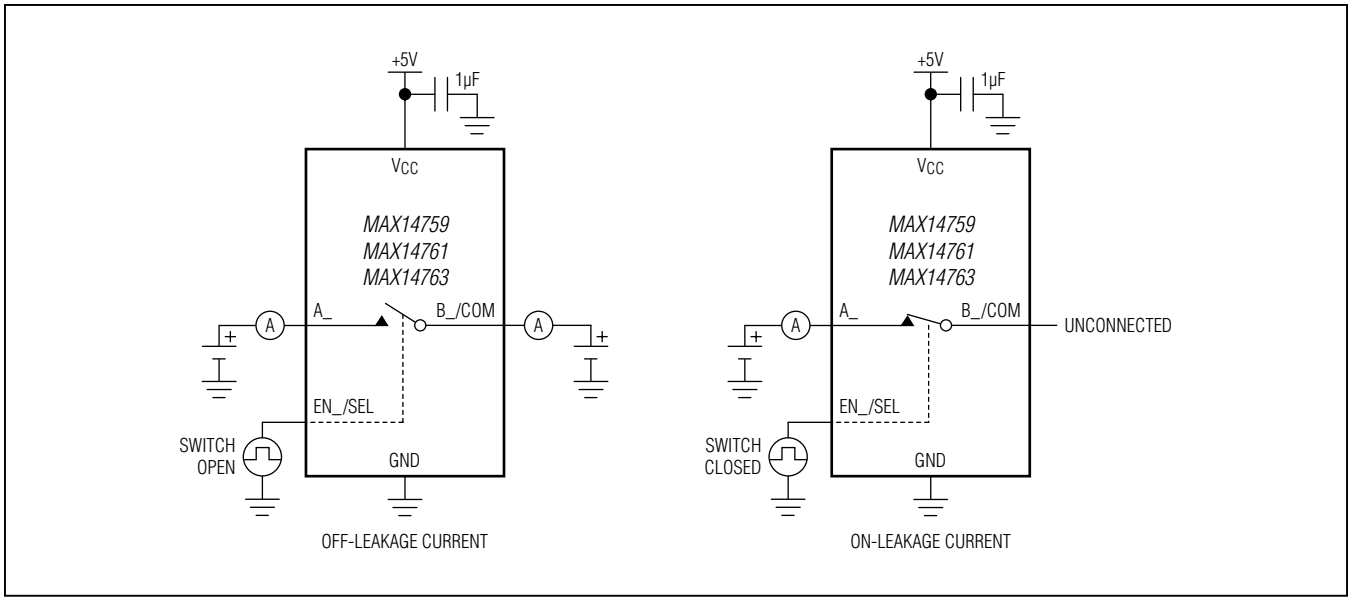



*Figure 1. Leakage Current Measurement*

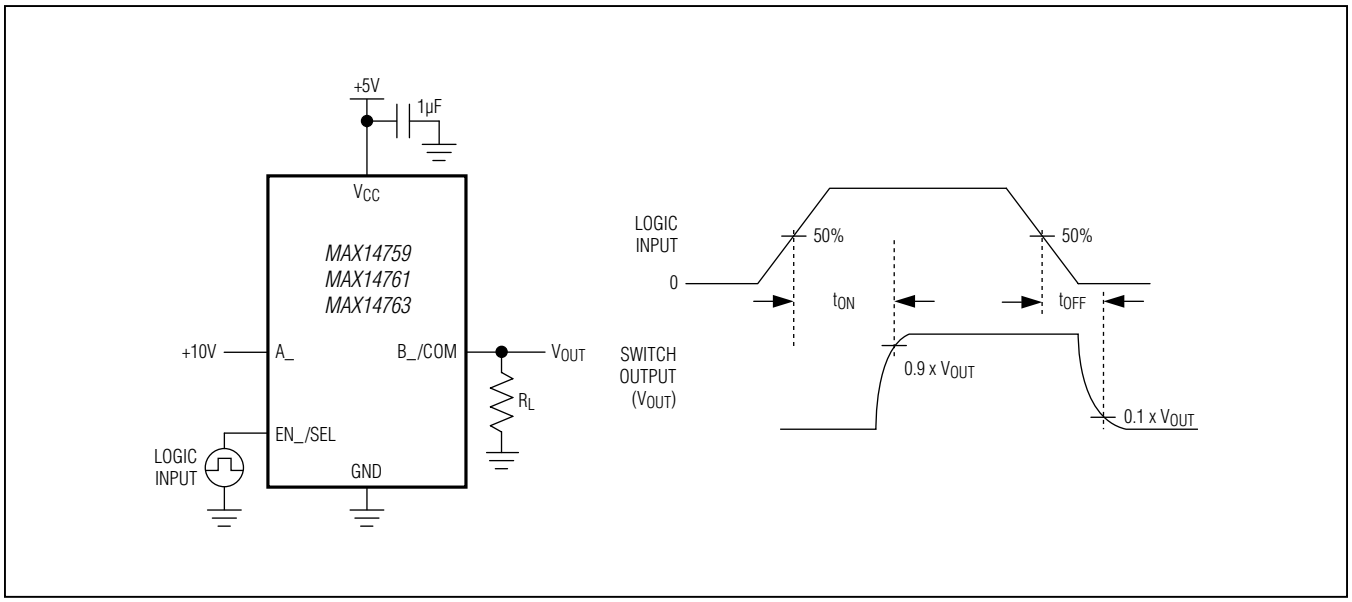



*Figure 2. Switching Time*

## *Test Circuits/Timing Diagrams (continued)*

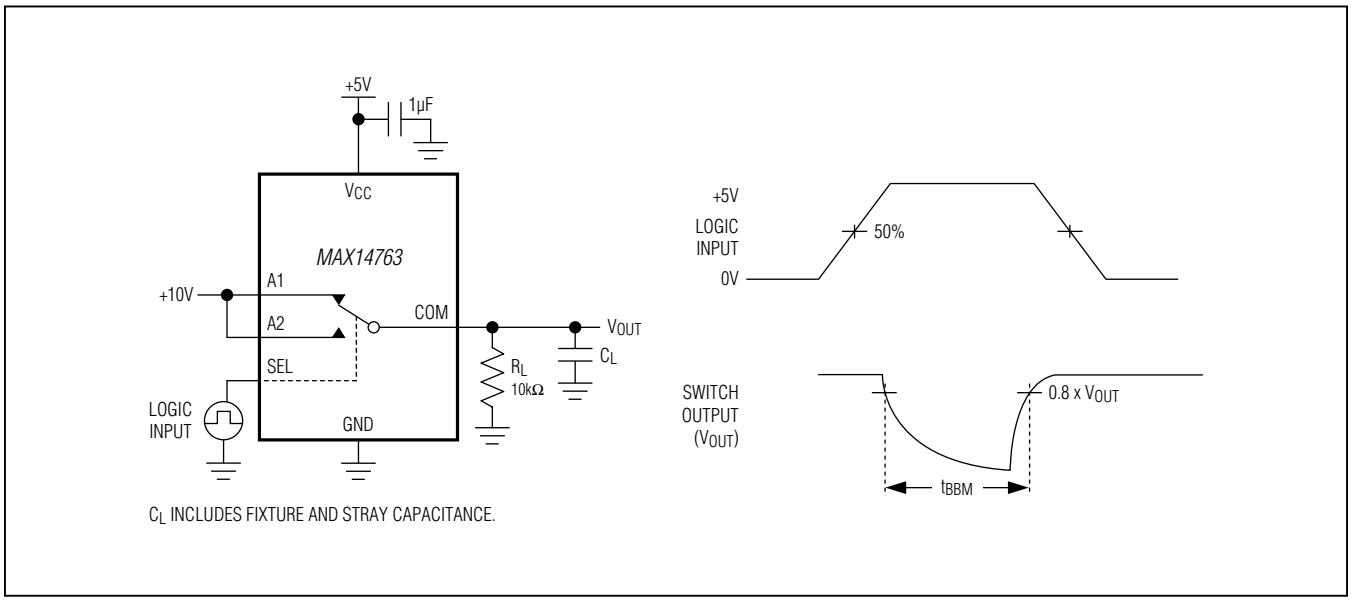



*Figure 3. Break-Before-Make*

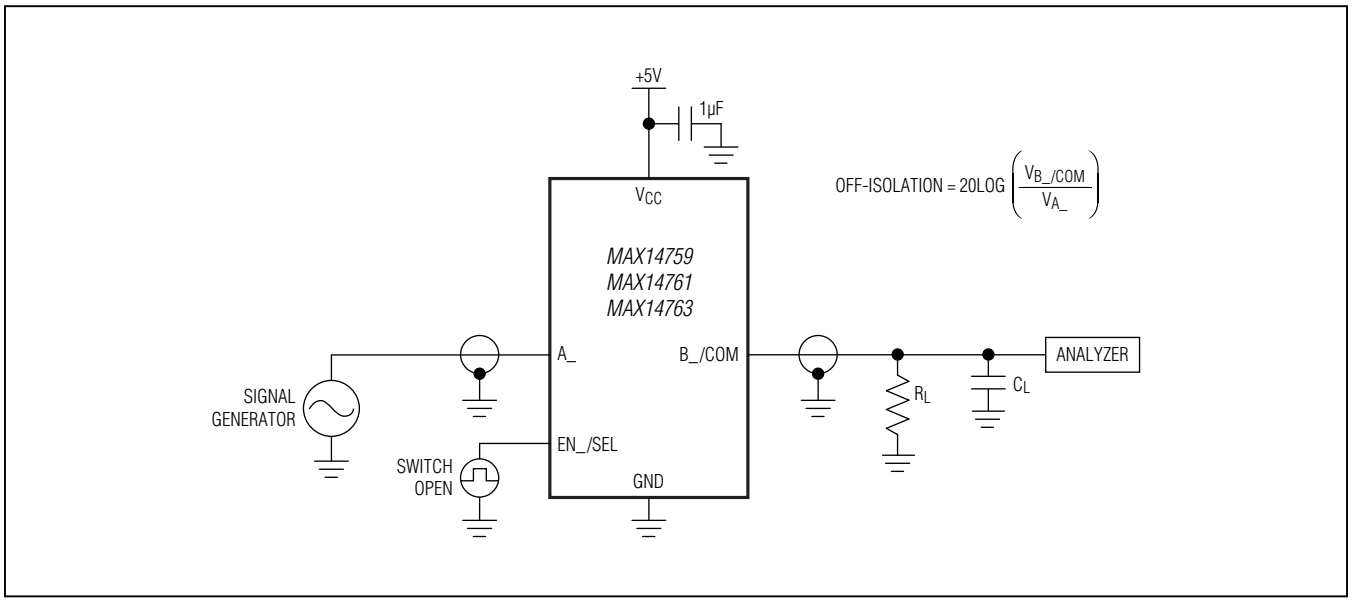



*Figure 4. Off-Isolation*

## *Test Circuits/Timing Diagrams (continued)*

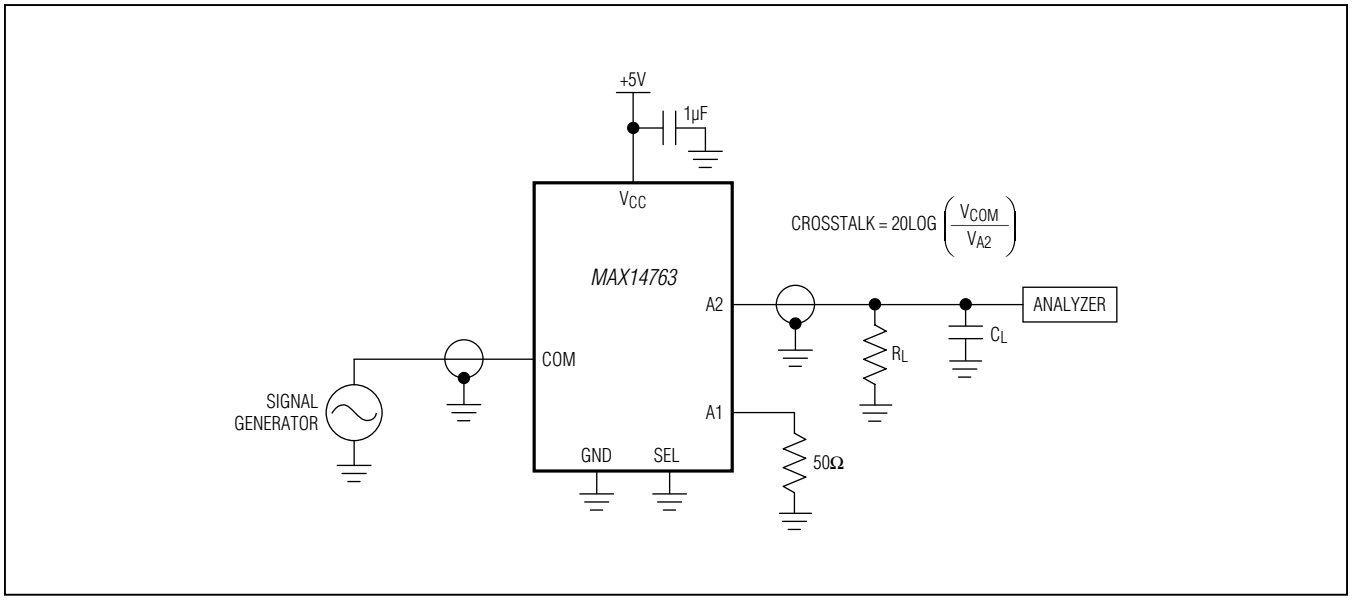



*Figure 5. Crosstalk*

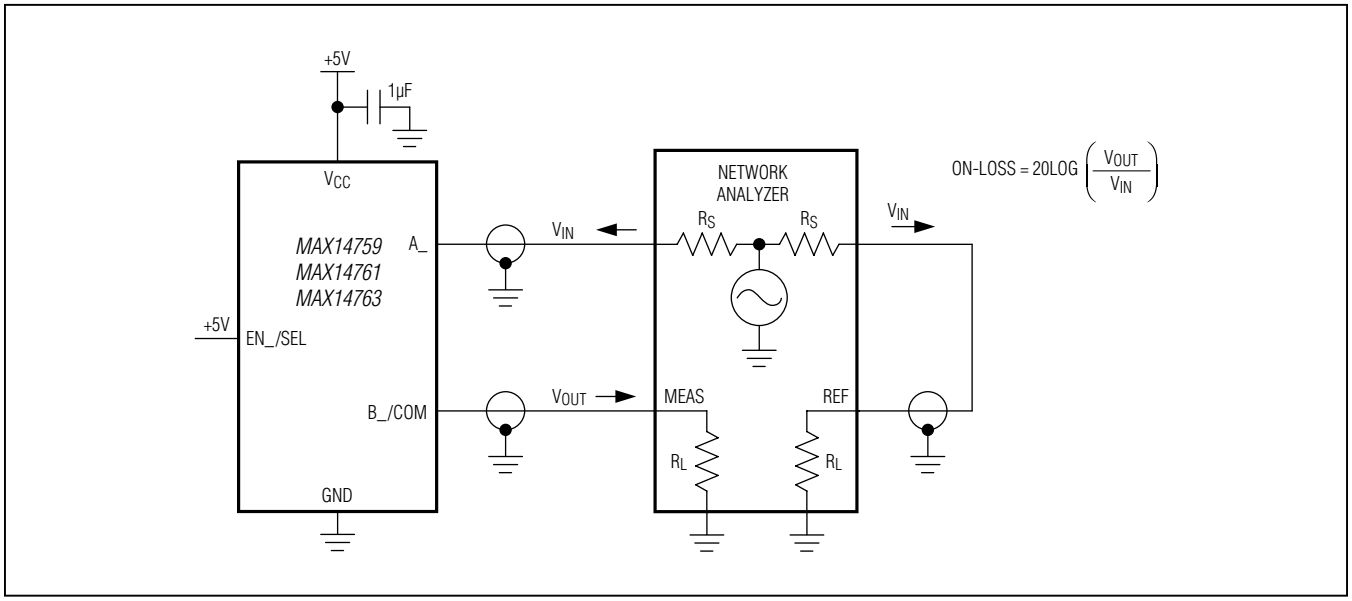



*Figure 6. Insertion Loss*

## Test Circuits/Timing Diagrams (continued)

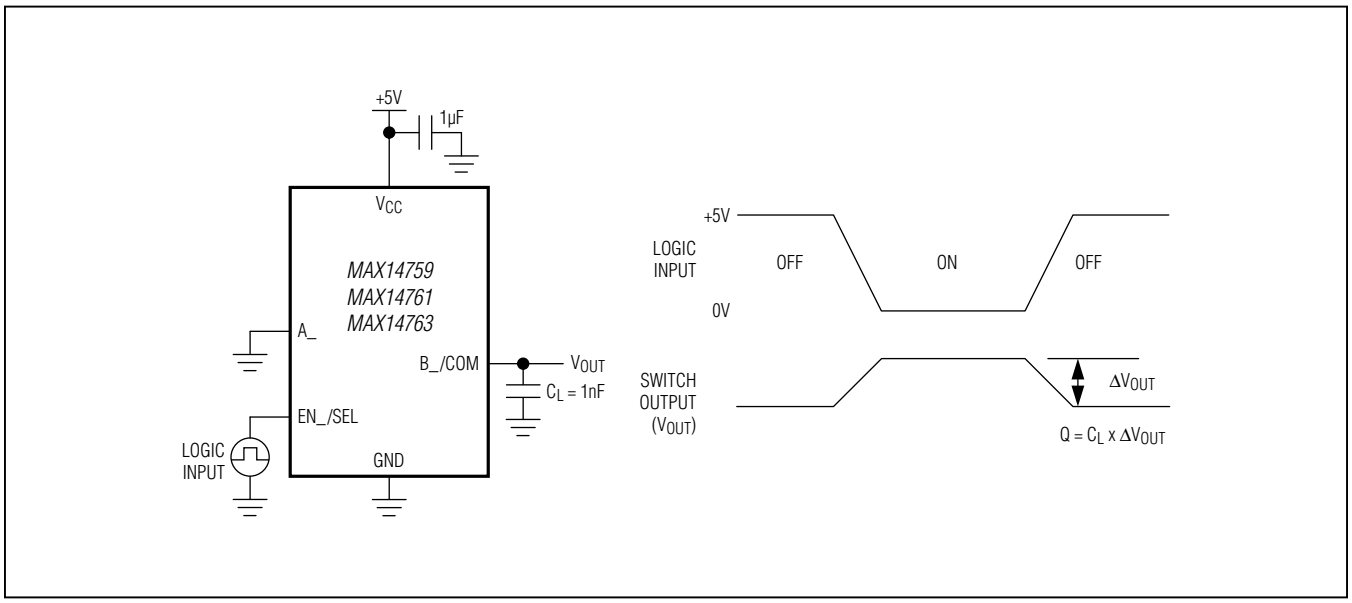
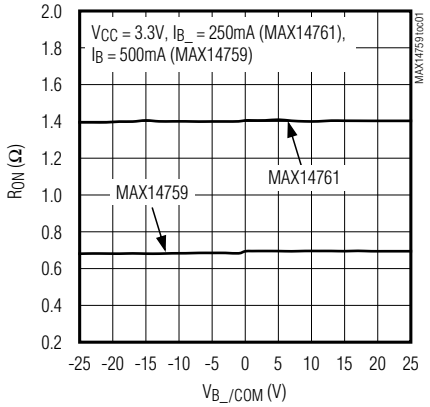



*Figure 7. Charge Injection*

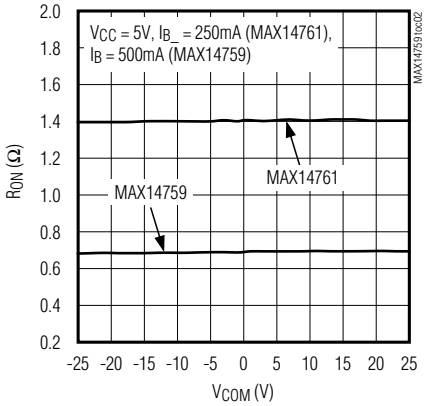
## Typical Operating Characteristics

($T_A$ = +25°C, unless otherwise noted.)

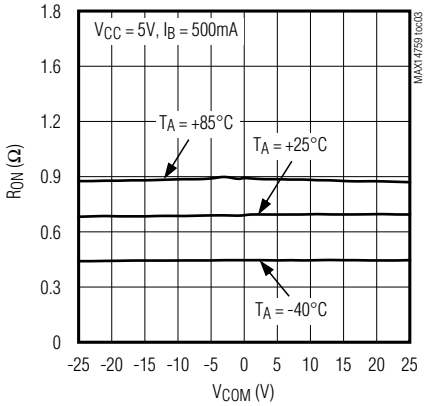
**ON-RESISTANCE vs. $V_{B_/COM}$**




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



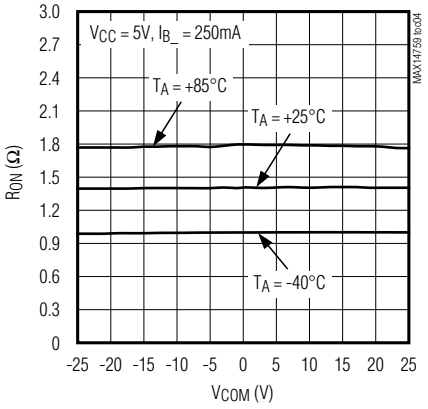

**ON-RESISTANCE vs. TEMPERATURE (MAX14759)**



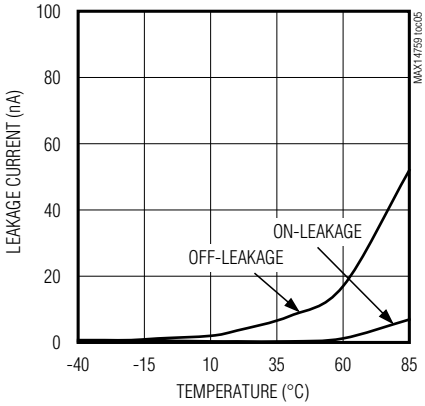
## *Typical Operating Characteristics (continued)*

($T_A$ = +25°C, unless otherwise noted.)

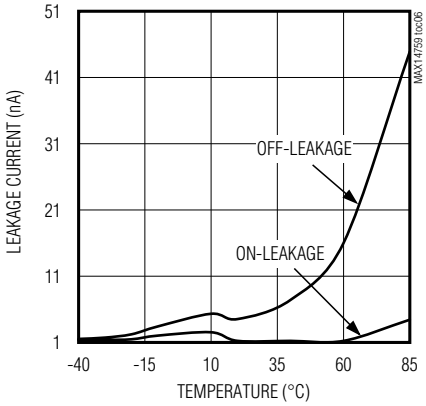
**ON-RESISTANCE vs. $V_{COM}$ (MAX14761)**



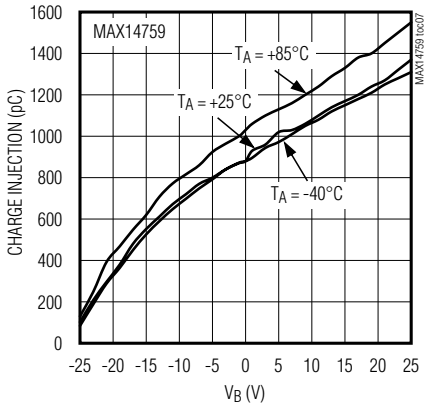

**LEAKAGE CURRENT vs. TEMPERATURE (MAX14759)**



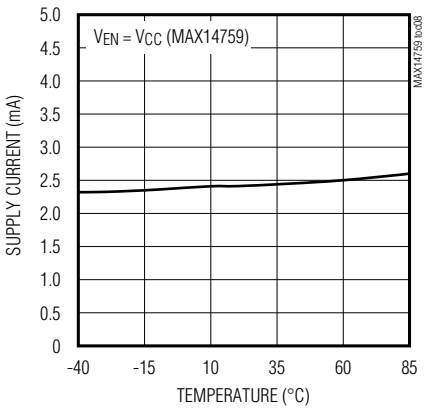

**LEAKAGE CURRENT vs. TEMPERATURE (MAX14761)**



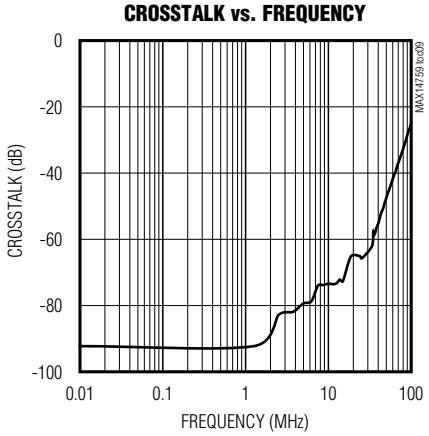

**CHARGE INJECTION vs. $V_B$**



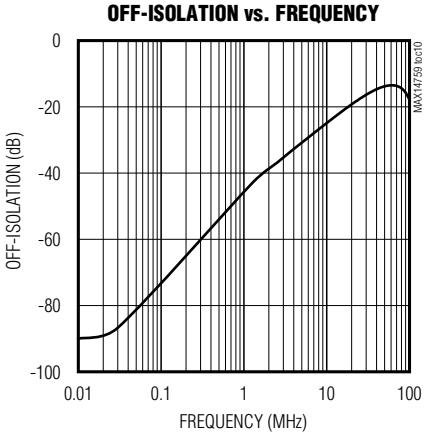

**SUPPLY CURRENT vs. TEMPERATURE**




**CROSSTALK vs. FREQUENCY**



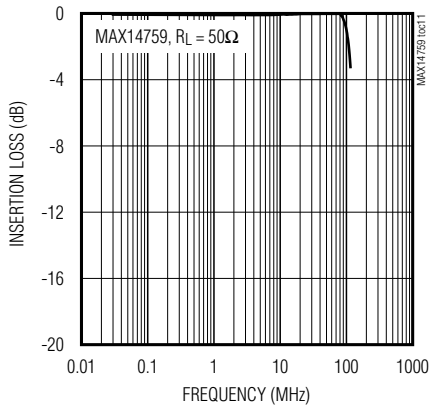

**OFF-ISOLATION vs. FREQUENCY**



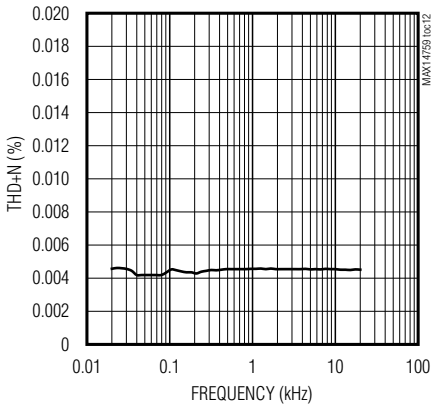
## *Typical Operating Characteristics (continued)*

($T_A$ = +25°C, unless otherwise noted.)

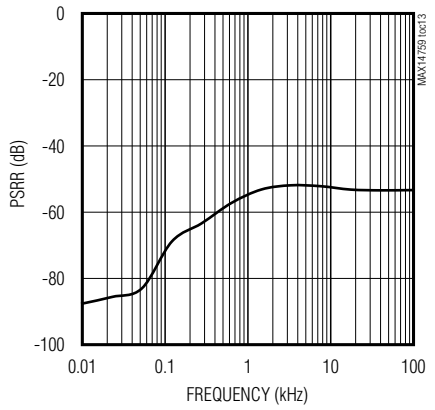
**INSERTION LOSS vs. FREQUENCY**



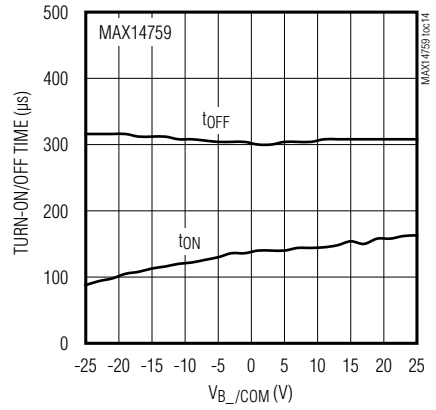

**THD+N vs. FREQUENCY**



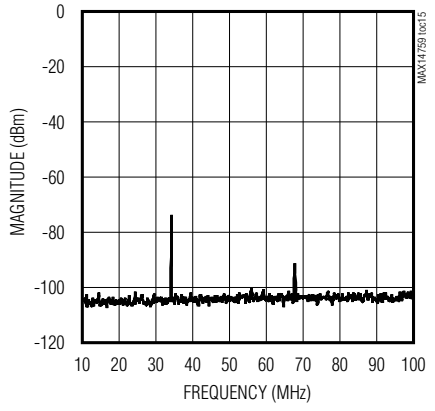

**PSRR vs. FREQUENCY**



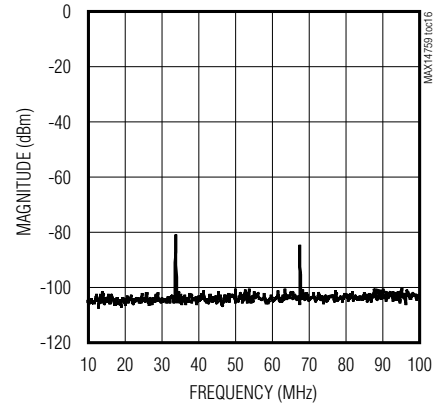

**TURN-ON/OFF TIME vs. $V_{B_/COM}$**



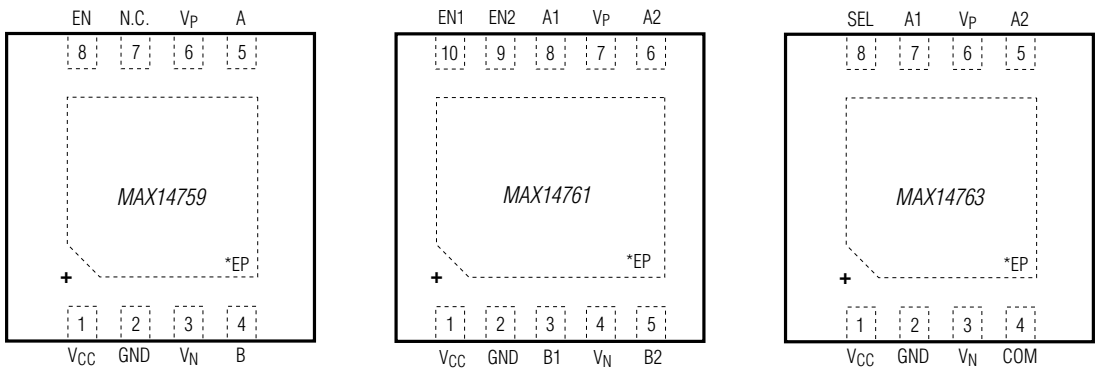

**MAX14761 CHARGE-PUMP NOISE (SWITCHES DISABLED)**




**MAX14761 CHARGE-PUMP NOISE (SWITCH ENABLED)**



## Pin Configurations




**TDFN**

*CONNECT EXPOSED PAD (EP) TO $V_N$.

## Pin Description

| PIN | | | NAME | FUNCTION |
|---|---|---|---|---|
| MAX14759 | MAX14761 | MAX14763 | | |
| 1 | 1 | 1 | $V_{CC}$ | Positive-Supply Voltage Input. Bypass $V_{CC}$ to GND with a 1µF ceramic capacitor placed as close as possible to the device. |
| 2 | 2 | 2 | GND | Ground |
| 3 | 4 | 3 | $V_N$ | Negative Voltage Output. Bypass $V_N$ to GND with a 0.1µF, 50V ceramic capacitor placed as close as possible to the device. |
| 4 | — | — | B | Analog Switch Common Terminal |
| — | — | 4 | COM | Analog Switch Common Terminal |
| 5 | — | — | A | Analog Switch Normally Open Terminal |
| 6 | 7 | 6 | $V_P$ | Positive Voltage Output. Bypass $V_P$ to GND with a 0.1µF, 50V ceramic capacitor placed as close as possible to the device. |
| 7 | — | — | N.C. | No Connection. Leave unconnected. |
| 8 | — | — | EN | Switch Control Input. Drive EN high to close the switch or drive EN low to open the switch. |
| — | 8 | 7 | A1 | Analog Switch 1 Normally Closed Terminal |

## Pin Description (continued)

| PIN | | | NAME | FUNCTION |
|---|---|---|---|---|
| MAX14759 | MAX14761 | MAX14763 | | |
| — | 3 | — | B1 | Analog Switch 1 Common Terminal |
| — | 6 | 5 | A2 | Analog Switch 2 Normally Open Terminal |
| — | 5 | — | B2 | Analog Switch 2 Common Terminal |
| — | 10 | — | EN1 | Switch 1 Control Input. Drive EN1 high to open switch 1 or drive EN1 low to close switch 1. |
| — | 9 | — | EN2 | Switch 2 Control Input. Drive EN2 high to close switch 2 or drive EN2 low to open switch 2. |
| — | — | 8 | SEL | Switch Control Input. Drive SEL low to connect the COM terminal to A1 or drive SEL high to connect the COM terminal to A2. |
| — | — | — | EP | Exposed Pad. Connect EP to $V_N$. EP is not intended as an electrical connection. |

## Detailed Description

The MAX14759/MAX14761/MAX14763 are analog switches capable of handling signals above and below their rails. These devices operate from a single +3.0V to +5.5V supply and support signals in the -25V to +25V range. The low on-resistance and high bandwidth allow for use in digital- and analog-signal switching applications.

### Integrated Bias Generation

The MAX14759/MAX14761/MAX14763 contain a total of three charge pumps to generate bias voltages for the internal switches: a 5V regulated charge pump, a positive high-voltage (+35V) charge pump, and a negative high-voltage (-27V) charge pump. When $V_{DD}$ is above 4.7V (typ), the 5V regulated charge pump is bypassed, and $V_{DD}$ provides the input for the high-voltage charge pumps, reducing overall supply current. An external 0.1µF capacitor is required for each high-voltage charge pump between $V_P$/$V_N$ and GND.

### Analog Signal Range

The devices switch signals in the range from -25V to +25V that are above and below their rails. The on-resistance for these devices exhibit a high degree of flatness of 2.4mΩ (MAX14759 typ) and 5.1mΩ (MAX14761/MAX14763 typ) over the whole input voltage range of -25V to +25V. The analog switches allow bidirectional current flow, so A, A1, A2, B, B1, B2, and COM can be used as either inputs or outputs.

### Bypass Capacitors

Bias stabilizing capacitors are required on the $V_P$ and $V_N$ pins. 1µF ceramic capacitors are suggested for effective operation. $V_P$ and $V_N$ are not intended as a power supply for other circuitry.

## Applications Information

### Nonpowered Condition

The MAX14759/MAX14761/MAX14763 can tolerate input voltages on the A, B, or COM pins in the ±25V range when it is not powered. When $V_{DD}$ = 0V, the DC input leakage current into the A, B, or COM pins is typically below 1µA. Some devices can have a larger leakage current up to the mA range due to technology spread.

With $V_{DD}$ not powered, internal diodes between the analog pins and the $V_P$ and $V_N$ charge up the external capacitors on $V_P$ and $V_N$ when positive and/or negative voltages are applied to these pins. This causes transient input current flow.

Large dv/dt on the inputs causes large capacitive charging currents, which have to be limited to 300mA to avoid destroying the internal diodes. Hence, the 100nF capacitors on $V_P$ and $V_N$, the dv/dt must be limited to 3V/µs. Once the capacitors reach their final voltage, the input current decays to the leakage current levels mentioned above.

### *Differential Termination Resistor Switch*

The MAX14759 can be used to switch a differential termination resistor in or out. In RS-485 and CAN applications, both ends of high-speed transmission lines require termination. Figures 8 and 9 show an application of RS-485 and CAN termination using two equal resistors. These switches support RS-485's high -7V to +12V common-mode range.

In RS-232/RS-485 multiprotocol applications, the MAX14759 can be used for switching in the line-terminating resistors for RS-485 usage, and can disable the termination resistor for RS-232 operation, as shown in Figure 10.

The MAX14761 is ideal for switching in fail-safe biasing resistors in RS-485 applications, as shown in Figures 11 and 12.

### *Audio Amplifier Switch*

The MAX14763 is used for selecting between audio amplifier sources to drive loudspeaker applications (Figures 13 and 14.)

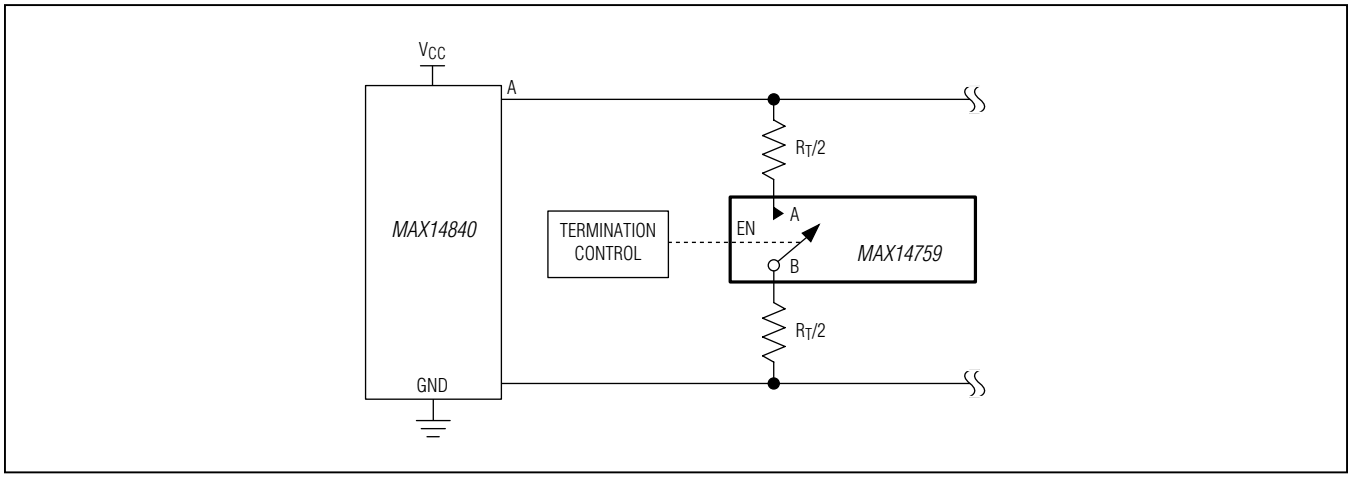



*Figure 8. RS-485 Termination Switch*

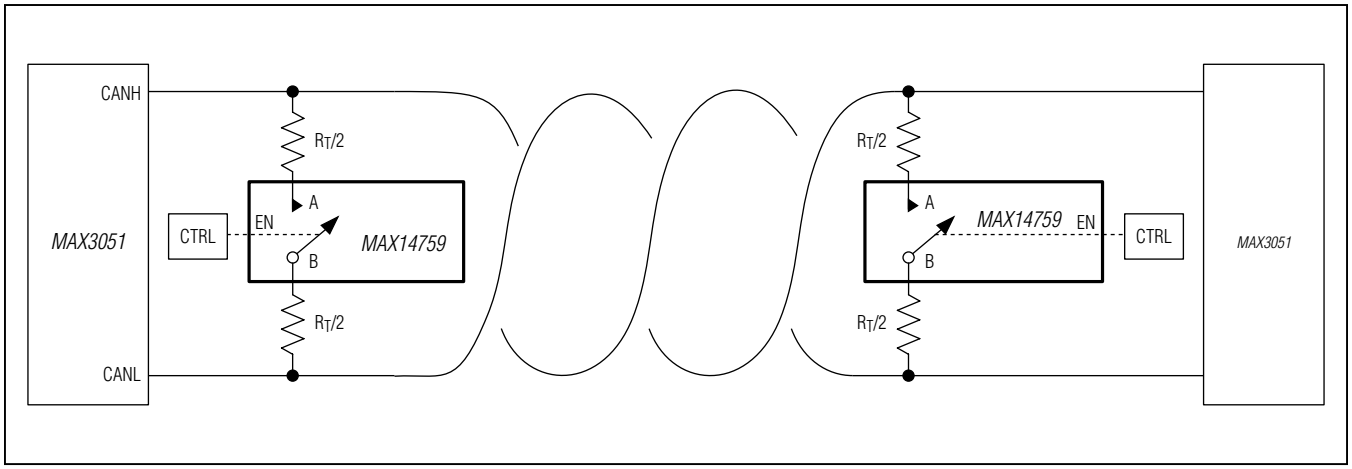



*Figure 9. CAN Termination Switch*

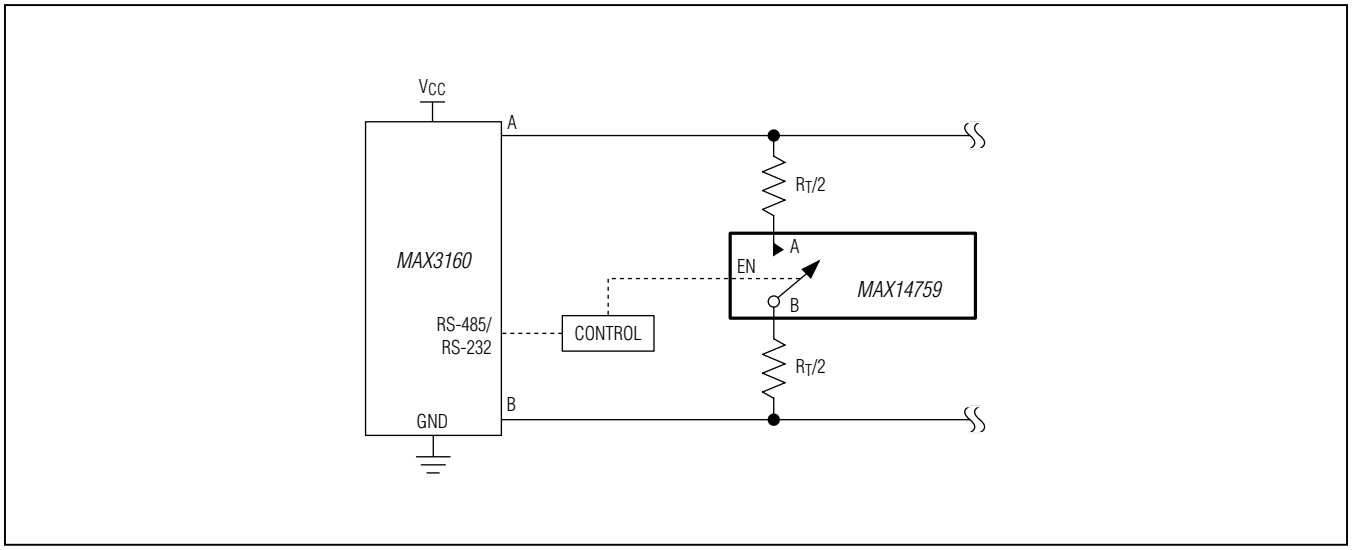



*Figure 10. Multiprotocol Termination Switch*

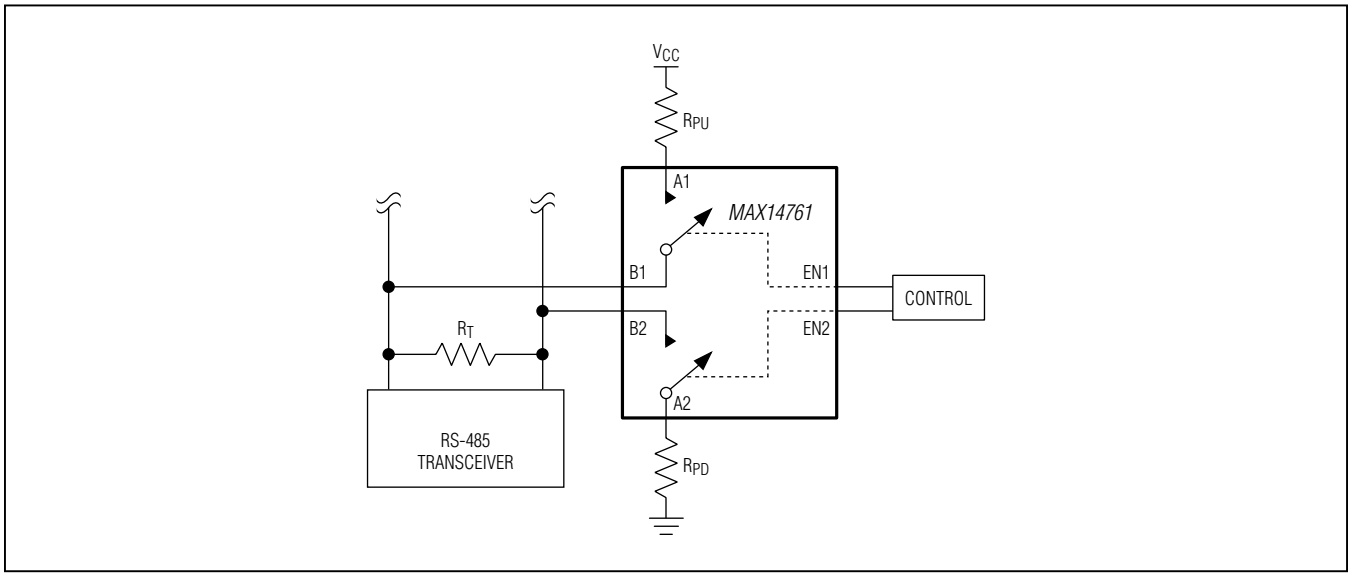



*Figure 11. Pullup and Pulldown Resistance Switch*

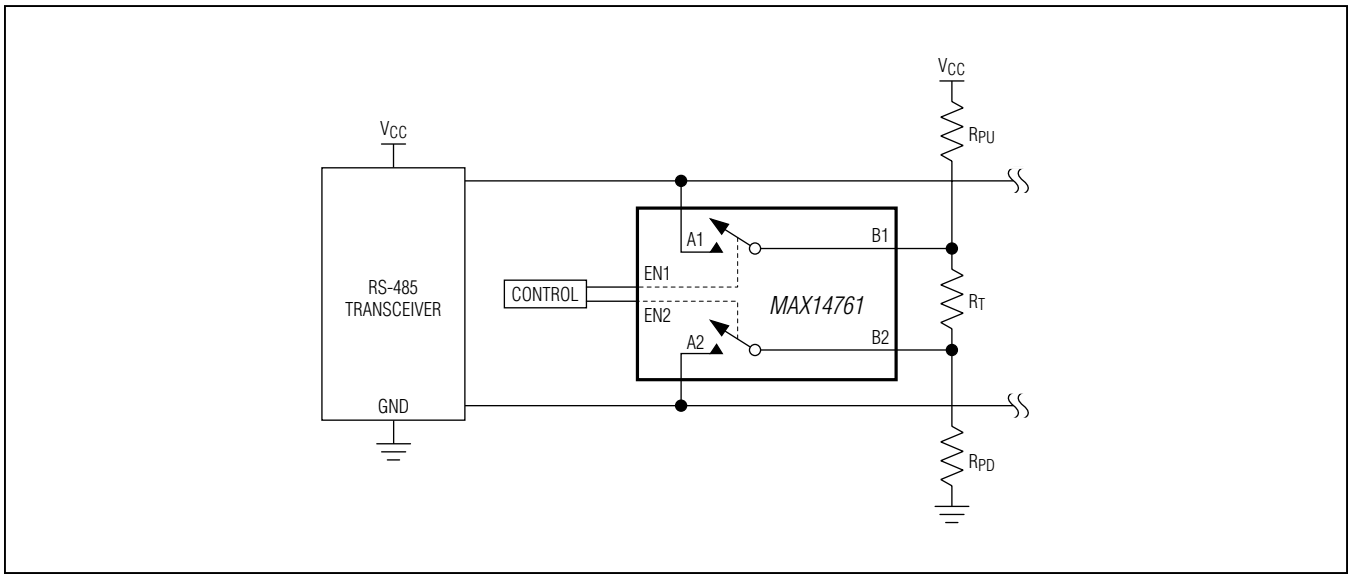



*Figure 12. Fail-Safe Biasing Network Switch*

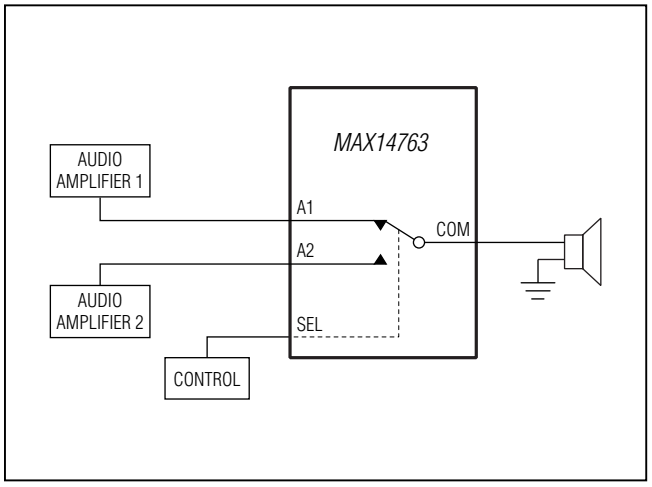



*Figure 13. Single-Ended Amplifier Switching*

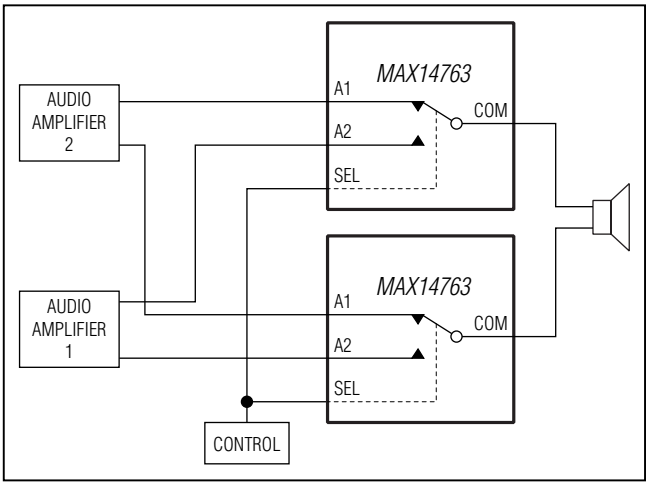



*Figure 14. Differential Amplifier Switching*

## Ordering Information/Selector Guide

| PART | TEMP RANGE | PIN-PACKAGE | FUNCTION | $R_{ON}$ (MAX) (Ω) |
|---|---|---|---|---|
| **MAX14759**ETA+ | -40°C to +85°C | 8 TDFN-EP* | 1 x SPST | 1 |
| **MAX14761**ETB+ | -40°C to +85°C | 10 TDFN-EP* | 2 x SPST | 2 |
| **MAX14763**ETA+ | -40°C to +85°C | 8 TDFN-EP* | 1 x SPDT | 2 |

*+Denotes a lead(Pb)-free/RoHS-compliant package.*
**EP = Exposed pad.*

## Chip Information

PROCESS: BiCMOS

## Package Information

For the latest package outline information and land patterns (footprints), go to **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.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO. | LAND PATTERN NO. |
|---|---|---|---|
| 8 TDFN | T833+2 | 21-0137 | 90-0059 |
| 10 TDFN | T1033+1 | 21-0137 | 90-0003 |

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 9/11 | Initial release | — |
| 1 | 8/12 | Updated *Electrical Characteristics* table, updated Figures 1–7, added Switch Enabled and Switch Disabled figures, updated *Pin Configuration* table, added *Integrated Bias Generation* and *Nonpowered Condition* sections | 3–7, 9–11 |

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