

# MAX14784E/MAX14786E/ MAX14787E/MAX14789E

## Full-Duplex, $\pm 35\text{kV}$ ESD-Protected, RS-485 Transceivers for High-Speed Communication

### General Description

The MAX14784E/MAX14786E/MAX14787E/MAX14789E full-duplex RS-485 transceivers are designed for robust communication in harsh industrial environments. All devices feature  $\pm 35\text{kV}$  ESD protection on the RS-485 pins and operate from a 3V to 5.5V supply with a 4mA no-load supply current (max).

The MAX14784E/MAX14787E are optimized for communication over very long cables or short unterminated cables.

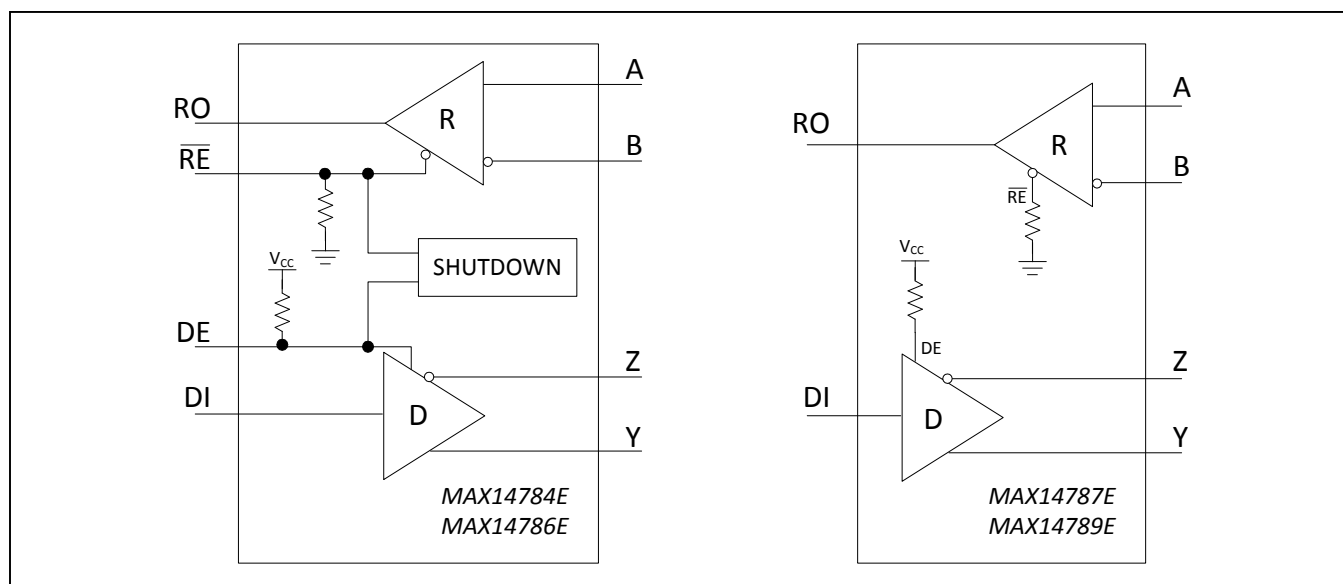
The MAX14784E/MAX14786E are available in a 14-pin SO package and operate over the  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  temperature range. The MAX14786E is also available in a 14-pin TSSOP package.

The MAX14787E/MAX14789E are optimized for space-constrained applications and are available in an 8-pin SO package, operating over the  $-40^{\circ}\text{C}$  to  $+105^{\circ}\text{C}$  temperature range.

### Applications

- Motion Controllers
- Encoder Interfaces
- HVAC Control Systems
- Utility Meters

### Functional Diagram



### Benefits and Features

- Flexibility
  - Use in Full-Duplex or Half-Duplex Applications
  - Wide 3.0V to 5.5V Supply Voltage Range
  - Available with 500kbps and 25Mbps Speed Options
  - Available in 8-Pin and 14-Pin SO and TSSOP Packages
- Optimized for Performance in Harsh Industrial Environments
  - $\pm 35\text{kV}$  ESD (HBM) Protection on RS-485 I/O Ports
  - Extended Operating Temperature Range
  - Slew-Rate Limited Outputs (MAX14784E/MAX14787E)
  - Integrated Receiver Deglitch Filter Increases Noise Immunity (MAX14784E/MAX14787E/)
  - Short-Circuit Protected Outputs
  - True Fail-Safe Receiver
  - Thermal Shutdown
- 1/4-Unit Load Allows up to 128 Transceivers on the Bus

*Ordering Information* appears at end of data sheet.

# MAX14784E/MAX14786E/ MAX14787E/MAX14789E

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### Absolute Maximum Ratings

(All voltages referenced to GND.)

|                                                                    |                              |
|--------------------------------------------------------------------|------------------------------|
| $V_{CC}$                                                           | -0.3V to +6.0V               |
| $\overline{RE}$ , RO                                               | -0.3V to ( $V_{CC} + 0.3$ )V |
| DE, DI                                                             | -0.3V to +6.0V               |
| A, B, Y, Z                                                         | -8.0V to +13.0V              |
| Short-Circuit Duration                                             | Continuous                   |
| Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )         |                              |
| 8 SO (derate 7.6mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ )   | 606mW                        |
| 14 SO (derate 11.9mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) | 952mW                        |
| TSSOP (derate 10mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ )   | 796mW                        |

Operating Temperature Range

|                                   |                                               |
|-----------------------------------|-----------------------------------------------|
| 8 SO                              | -40 $^\circ\text{C}$ to +105 $^\circ\text{C}$ |
| 14 SO                             | -40 $^\circ\text{C}$ to +125 $^\circ\text{C}$ |
| TSSOP                             | -40 $^\circ\text{C}$ to +125 $^\circ\text{C}$ |
| Junction Temperature              | +150 $^\circ\text{C}$                         |
| Storage Temperature Range         | -65 $^\circ\text{C}$ to +150 $^\circ\text{C}$ |
| Lead Temperature (soldering, 10s) | +300 $^\circ\text{C}$                         |
| Soldering Temperature (reflow)    | +260 $^\circ\text{C}$                         |

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)

Junction-to-Case Thermal Resistance ( $\theta_{JC}$ )

|       |                              |
|-------|------------------------------|
| 8 SO  | 38 $^\circ\text{C}/\text{W}$ |
| 14 SO | 34 $^\circ\text{C}/\text{W}$ |
| TSSOP | 30 $^\circ\text{C}/\text{W}$ |

Junction-to-Ambient Thermal Resistance ( $\theta_{JA}$ )

|       |                               |
|-------|-------------------------------|
| 8 SO  | 132 $^\circ\text{C}/\text{W}$ |
| 14 SO | 84 $^\circ\text{C}/\text{W}$  |
| TSSOP | 30 $^\circ\text{C}/\text{W}$  |

**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](http://www.maximintegrated.com/thermal-tutorial).

### Electrical Characteristics

( $V_{CC} = 3.0\text{V}$  to  $5.5\text{V}$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = 5\text{V}$ , and  $T_A = +25^\circ\text{C}$ .) (Notes 2, 3)

| PARAMETER                                                 | SYMBOL          | CONDITIONS                                            | MIN | TYP        | MAX | UNITS         |
|-----------------------------------------------------------|-----------------|-------------------------------------------------------|-----|------------|-----|---------------|
| <b>POWER SUPPLY</b>                                       |                 |                                                       |     |            |     |               |
| Supply Voltage                                            | $V_{CC}$        |                                                       | 3.0 |            | 5.5 | V             |
| Supply Current                                            | $I_{CC}$        | DE = high, $\overline{RE}$ = low, no load             |     | 1.9        | 4   | mA            |
| Shutdown Supply Current                                   | $I_{SHDN}$      | DE = low, $\overline{RE}$ = high                      |     | 5          | 10  | $\mu\text{A}$ |
| <b>DRIVER</b>                                             |                 |                                                       |     |            |     |               |
| Differential Driver Output                                | $V_{OD}$        | $R_L = 54\Omega$ , $V_{CC} = 4.5\text{V}$ , Figure 1  | 2.1 |            |     | V             |
|                                                           |                 | $R_L = 100\Omega$ , $V_{CC} = 3.0\text{V}$ , Figure 1 | 2.0 |            |     |               |
|                                                           |                 | $R_L = 54\Omega$ , $V_{CC} = 3.0\text{V}$ , Figure 1  | 1.5 |            |     |               |
| Change in Magnitude of Differential Driver Output Voltage | $\Delta V_{OD}$ | $R_L = 100\Omega$ or $54\Omega$ , Figure 1 (Note 4)   |     |            | 0.2 | V             |
| Driver Common-Mode Output Voltage                         | $V_{OC}$        | $R_L = 100\Omega$ or $54\Omega$ , Figure 1 (Note 4)   |     | $V_{CC}/2$ | 3   | V             |
| Change in Magnitude of Driver Common-Mode Output Voltage  | $\Delta V_{OC}$ | $R_L = 100\Omega$ or $54\Omega$ , Figure 1 (Note 4)   |     |            | 0.2 | V             |
| Single-Ended Driver Output Voltage High                   | $V_{OH}$        | Y and Z outputs, $I_{YZ} = -20\text{mA}$              | 2.2 |            |     | V             |
| Single-Ended Driver Output Voltage Low                    | $V_{OL}$        | Y and Z outputs, $I_{YZ} = +20\text{mA}$              |     |            | 0.8 | V             |
| Differential Driver Output Capacitance                    | $C_{OD}$        | DE = $\overline{RE}$ = high, $f = 4\text{MHz}$        |     | 12         |     | pF            |

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Full-Duplex,  $\pm 35\text{kV}$  ESD-Protected,  
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Electrical Characteristics (continued)

( $V_{CC} = 3.0\text{V}$  to  $5.5\text{V}$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = 5\text{V}$ , and  $T_A = +25^\circ\text{C}$ .) (Notes 2, 3)

| PARAMETER                                                      | SYMBOL             | CONDITIONS                                                                                         |                        | MIN                   | TYP  | MAX  | UNITS |
|----------------------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------|------------------------|-----------------------|------|------|-------|
| Peak Driver Short-Circuit Output Current                       | I <sub>OSD</sub>   | 0V ≤ V <sub>OUT</sub> ≤ +12V, output low                                                           |                        | +40                   |      | +250 | mA    |
|                                                                |                    | -7V ≤ V <sub>OUT</sub> ≤ V <sub>CC</sub> , output high                                             |                        | -250                  |      | -40  |       |
| RECEIVER                                                       |                    |                                                                                                    |                        |                       |      |      |       |
| Input Current (A and B)                                        | I <sub>A,B</sub>   | DE = low, V <sub>CC</sub> = 0V or 3.6V                                                             | V <sub>IN</sub> = +12V | +250                  |      |      | μA    |
|                                                                |                    |                                                                                                    | V <sub>IN</sub> = -7V  | -200                  |      |      |       |
| Differential Input Capacitance                                 | C <sub>A,B</sub>   | Measured between A and B, DE = low, f = 2MHz                                                       |                        | 12                    |      |      | pF    |
| Receiver Differential Threshold Voltage                        | V <sub>TH</sub>    | -7V ≤ V <sub>OUT</sub> ≤ +12V                                                                      |                        | -200                  | -120 | -10  | mV    |
| Receiver Input Hysteresis                                      | ΔV <sub>TH</sub>   | V <sub>CM</sub> = 0V                                                                               |                        | 20                    |      |      | mV    |
| Receiver Input Resistance                                      | R <sub>IN</sub>    | -7V ≤ V <sub>CM</sub> ≤ +12V                                                                       |                        | 48                    |      |      | kΩ    |
| LOGIC INTERFACE (DI, DE, $\overline{\text{RE}}$ , RO)          |                    |                                                                                                    |                        |                       |      |      |       |
| Input High Voltage                                             | V <sub>IH</sub>    | DE, DI, $\overline{\text{RE}}$                                                                     |                        | 2.0                   |      |      | V     |
| Input Low Voltage                                              | V <sub>IL</sub>    | DE, DI, $\overline{\text{RE}}$                                                                     |                        | 0.8                   |      |      | V     |
| Input Current                                                  | I <sub>IN</sub>    | DI                                                                                                 |                        | -2                    | +2   |      | μA    |
| $\overline{\text{RE}}$ Pulldown and DE Pullup Input Resistance | R <sub>IN</sub>    |                                                                                                    |                        | 1                     |      |      | MΩ    |
| Receiver Output High Voltage                                   | V <sub>OH</sub>    | $\overline{\text{RE}}$ = low, I <sub>OUT</sub> = -1mA, (V <sub>A</sub> - V <sub>B</sub> ) > 200mV  |                        | V <sub>CC</sub> - 1.5 |      |      | V     |
| Receiver Output Low Voltage                                    | V <sub>OL</sub>    | $\overline{\text{RE}}$ = low, I <sub>OUT</sub> = +1mA, (V <sub>A</sub> - V <sub>B</sub> ) < -200mV |                        | 0.4                   |      |      | V     |
| Receiver Output Three-State Current                            | I <sub>OZR</sub>   | $\overline{\text{RE}}$ = high, 0V ≤ V <sub>RO</sub> ≤ V <sub>CC</sub>                              |                        | -1                    | +1   |      | μA    |
| Receiver Output Short-Circuit Current                          | I <sub>OSR</sub>   | $\overline{\text{RE}}$ = low, 0V ≤ V <sub>RO</sub> ≤ V <sub>CC</sub>                               |                        | -95                   | +95  |      | mA    |
| PROTECTION                                                     |                    |                                                                                                    |                        |                       |      |      |       |
| Thermal Shutdown Threshold                                     | T <sub>SHDN</sub>  | Temperature rising                                                                                 |                        | +160                  |      |      | °C    |
| Thermal Shutdown Hysteresis                                    | ΔT <sub>SHDN</sub> |                                                                                                    |                        | 10                    |      |      | °C    |
| ESD Protection (A, B, Y and Z Pins)                            |                    | IEC 61000-4-2 Air Gap Discharge to GND                                                             |                        | ±18                   |      |      | kV    |
|                                                                |                    | IEC 61000-4-2 Contact Discharge to GND                                                             |                        | ±8                    |      |      |       |
|                                                                |                    | Human Body Model                                                                                   |                        | ±35                   |      |      |       |
| ESD Protection (All Other Pins)                                |                    | Human Body Model                                                                                   |                        | ±2                    |      |      | kV    |

MAX14784E/MAX14786E/  
MAX14787E/MAX14789E

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Switching Characteristics (MAX14784E/MAX14787E)

( $V_{CC} = 3.0\text{V}$  to  $5.5\text{V}$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = 5\text{V}$ , and  $T_A = +25^\circ\text{C}$ .) (Notes 2, 5)

| PARAMETER                                                  | SYMBOL              | CONDITIONS                                                        | MIN | TYP | MAX  | UNITS         |
|------------------------------------------------------------|---------------------|-------------------------------------------------------------------|-----|-----|------|---------------|
| <b>DRIVER</b>                                              |                     |                                                                   |     |     |      |               |
| Driver Propagation Delay                                   | $t_{DPLH}$          | $R_L = 54\Omega$ , $C_L = 50\text{pF}$ , Figures 2, 3             |     |     | 1000 | ns            |
|                                                            | $t_{DPHL}$          |                                                                   |     |     | 1000 |               |
| Differential Driver Output Skew<br>$ t_{DPLH} - t_{DPHL} $ | $t_{DSKEW}$         | $R_L = 54\Omega$ , $C_L = 50\text{pF}$ , Figures 2, 3<br>(Note 6) |     |     | 140  | ns            |
| Driver Differential Output Rise<br>or Fall Time            | $t_{HL}$ , $t_{LH}$ | $R_L = 54\Omega$ , $C_L = 50\text{pF}$ , Figures 2, 3             |     |     | 900  | ns            |
| Maximum Data Rate                                          | $DR_{MAX}$          | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            | 500 |     |      | kbps          |
| Driver Enable to Output High                               | $t_{DZH}$           | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            |     |     | 2500 | ns            |
| Driver Enable to Output Low                                | $t_{DZL}$           | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            |     |     | 2500 | ns            |
| Driver Disable Time from Low                               | $t_{DLZ}$           | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            |     |     | 100  | ns            |
| Driver Disable Time from High                              | $t_{DHZ}$           | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            |     |     | 100  | ns            |
| Driver Enable from Shutdown<br>to Output High              | $t_{DZH}(SHDN)$     | $R_L = 110\Omega$ , $C_L = 15\text{pF}$ , Figures 4, 5            |     |     | 100  | $\mu\text{s}$ |
| Driver Enable from Shutdown<br>to Output Low               | $t_{DZL}(SHDN)$     | $R_L = 110\Omega$ , $C_L = 15\text{pF}$ , Figures 4, 5            |     |     | 100  | $\mu\text{s}$ |
| Time to Shutdown                                           | $t_{SHDN}$          | (Note 7)                                                          | 50  |     | 800  | ns            |
| <b>RECEIVER</b>                                            |                     |                                                                   |     |     |      |               |
| Receiver Propagation Delay                                 | $t_{RPLH}$          | $C_L = 15\text{pF}$ , Figures 6, 7                                |     |     | 200  | ns            |
|                                                            | $t_{RPHL}$          |                                                                   |     |     | 200  |               |
| Receiver Output Skew<br>$ t_{RPLH} - t_{RPHL} $            | $t_{RSKEW}$         | $C_L = 15\text{pF}$ , Figures 6, 7 (Note 6)                       |     |     | 30   | ns            |
| Maximum Data Rate                                          | $DR_{MAX}$          |                                                                   | 500 |     |      | kbps          |
| Receiver Enable to Output<br>High                          | $t_{RZH}$           | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 30   | ns            |
| Receiver Enable to Output Low                              | $t_{RZL}$           | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 30   | ns            |
| Receiver Disable Time from<br>Low                          | $t_{RLZ}$           | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 30   | ns            |
| Receiver Disable Time from<br>High                         | $t_{RHZ}$           | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 30   | ns            |
| Receiver Enable from<br>Shutdown to Output High            | $t_{RZH}(SHDN)$     | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 100  | $\mu\text{s}$ |
| Receiver Enable from<br>Shutdown to Output Low             | $t_{RZL}(SHDN)$     | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 100  | $\mu\text{s}$ |
| Time to Shutdown                                           | $t_{SHDN}$          | (Note 7)                                                          | 50  |     | 800  | ns            |

MAX14784E/MAX14786E/  
MAX14787E/MAX14789E

Full-Duplex,  $\pm 35\text{kV}$  ESD-Protected,  
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High-Speed Communication

Switching Characteristics (MAX14786E/MAX14789E)

( $V_{CC} = 3.0\text{V}$  to  $5.5\text{V}$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = 5\text{V}$ , and  $T_A = +25^\circ\text{C}$ .) (Notes 2, 5)

| PARAMETER                                                  | SYMBOL              | CONDITIONS                                                        | MIN | TYP | MAX | UNITS         |
|------------------------------------------------------------|---------------------|-------------------------------------------------------------------|-----|-----|-----|---------------|
| <b>DRIVER</b>                                              |                     |                                                                   |     |     |     |               |
| Driver Propagation Delay                                   | $t_{DPLH}$          | $R_L = 54\Omega$ , $C_L = 50\text{pF}$ , Figures 2, 3             |     |     | 25  | ns            |
|                                                            | $t_{DPLH}$          |                                                                   |     |     | 25  |               |
| Differential Driver Output Skew<br>$ t_{DPLH} - t_{DPLH} $ | $t_{DSKEW}$         | $R_L = 54\Omega$ , $C_L = 50\text{pF}$ , Figures 2, 3<br>(Note 6) |     |     | 3   | ns            |
| Driver Differential Output Rise<br>or Fall Time            | $t_{HL}$ , $t_{LH}$ | $R_L = 54\Omega$ , $C_L = 50\text{pF}$ , Figures 2, 3             |     |     | 10  | ns            |
| Maximum Data Rate                                          | $DR_{MAX}$          | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            | 25  |     |     | Mbps          |
| Driver Enable to Output High                               | $t_{DZH}$           | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            |     |     | 40  | ns            |
| Driver Enable to Output Low                                | $t_{DZL}$           | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            |     |     | 40  | ns            |
| Driver Disable Time from Low                               | $t_{DLZ}$           | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            |     |     | 40  | ns            |
| Driver Disable Time from High                              | $t_{DHZ}$           | $R_L = 110\Omega$ , $C_L = 50\text{pF}$ , Figures 4, 5            |     |     | 40  | ns            |
| Driver Enable from Shutdown<br>to Output High              | $t_{DZH}(SHDN)$     | $R_L = 110\Omega$ , $C_L = 15\text{pF}$ , Figures 4, 5            |     |     | 100 | $\mu\text{s}$ |
| Driver Enable from Shutdown<br>to Output Low               | $t_{DZL}(SHDN)$     | $R_L = 110\Omega$ , $C_L = 15\text{pF}$ , Figures 4, 5            |     |     | 100 | $\mu\text{s}$ |
| Time to Shutdown                                           | $t_{SHDN}$          | (Note 7)                                                          | 50  |     | 800 | ns            |
| <b>RECEIVER</b>                                            |                     |                                                                   |     |     |     |               |
| Receiver Propagation Delay                                 | $t_{RPLH}$          | $C_L = 15\text{pF}$ , Figures 6, 7                                |     |     | 25  | ns            |
|                                                            | $t_{RPHL}$          |                                                                   |     |     | 25  |               |
| Receiver Output Skew<br>$ t_{RPLH} - t_{RPHL} $            | $t_{RSKEW}$         | $C_L = 15\text{pF}$ , Figures 6, 7 (Note 6)                       |     |     | 3   | ns            |
| Maximum Data Rate                                          | $DR_{MAX}$          |                                                                   | 25  |     |     | Mbps          |
| Receiver Enable to Output<br>High                          | $t_{RZH}$           | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 30  | ns            |
| Receiver Enable to Output Low                              | $t_{RZL}$           | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 30  | ns            |
| Receiver Disable Time from<br>Low                          | $t_{RLZ}$           | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 30  | ns            |
| Receiver Disable Time from<br>High                         | $t_{RHZ}$           | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 30  | ns            |
| Receiver Enable from<br>Shutdown to Output High            | $t_{RZH}(SHDN)$     | $R_L = 1\text{k}\Omega$ , $C_L = 15\text{pF}$ , Figure 8          |     |     | 100 | $\mu\text{s}$ |

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( $V_{CC} = 3.0V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = 5V$ , and  $T_A = +25^{\circ}C$ .) (Notes 2, 5)

**Note 2:** All devices 100% production tested at  $T_A = +25^{\circ}\text{C}$ . Specifications over temperature are guaranteed by design.

**Note 3:** All currents into the device are positive; all currents out of the device are negative. All voltages are referenced to ground, unless otherwise noted.

**Note 4:**  $\Delta V_{OD}$  and  $\Delta V_{OC}$  are the changes in  $V_{OD}$  and  $V_{OC}$ , respectively, when the DI input changes state.

**Note 5:** Capacitive load includes test fixture.

**Note 6:** Not production tested. Guaranteed by design.

**Note 7:** Shutdown is enabled by bringing  $\overline{\text{RE}}$  high and DE low. If the enabled inputs are in this state for less than 50ns, the device is guaranteed to not enter shutdown. If the enable inputs are in this state for at least 800ns, the device is guaranteed to have entered shutdown.

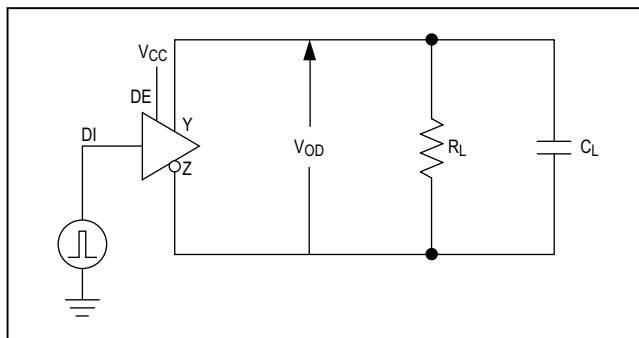


Figure 2. Driver Timing Test Circuit



MAX14784E/MAX14786E/  
MAX14787E/MAX14789E

Full-Duplex,  $\pm 35\text{kV}$  ESD-Protected,  
RS-485 Transceivers for  
High-Speed Communication

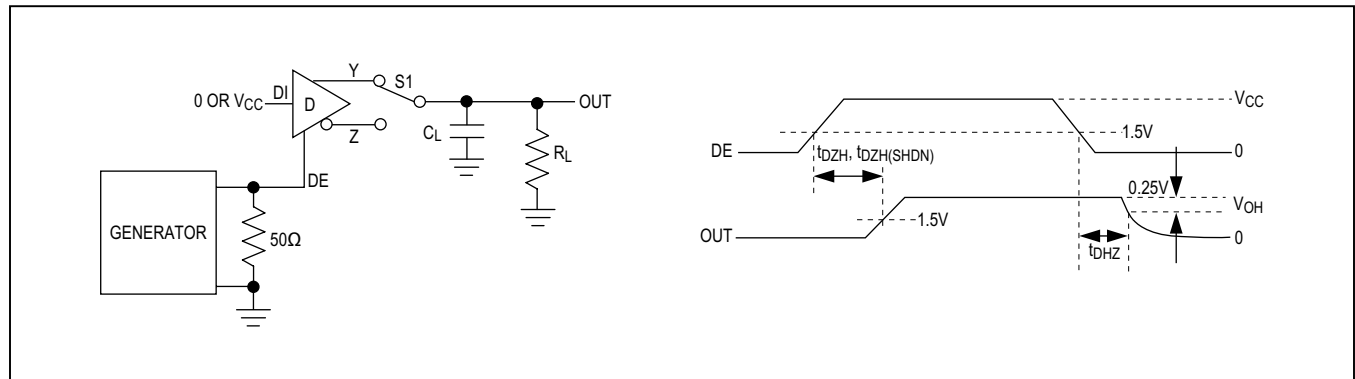


Figure 4. Driver Enable and Disable Times ( $t_{DZH}$ ,  $t_{DHL}$ ,  $t_{DZH(SHDN)}$ ,  $t_{DHL(SHDN)}$ )

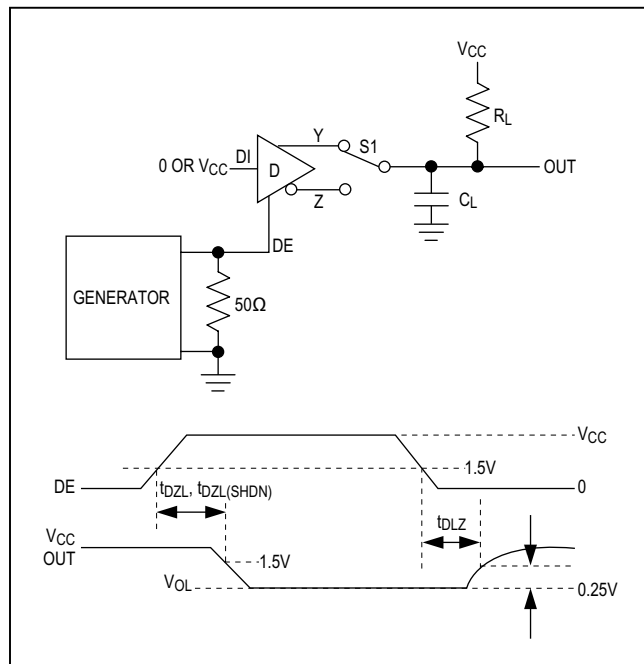


Figure 5. Driver Enable and Disable Times ( $t_{DZL}$ ,  $t_{DLZ}$ ,  $t_{DZL(SHDN)}$ ,  $t_{DLZ(SHDN)}$ )

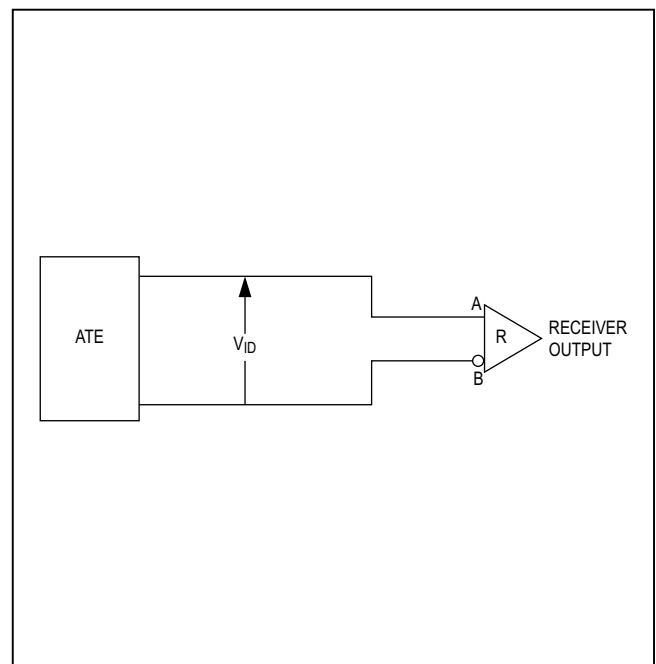


Figure 6. Receiver Propagation Delay Test Circuit

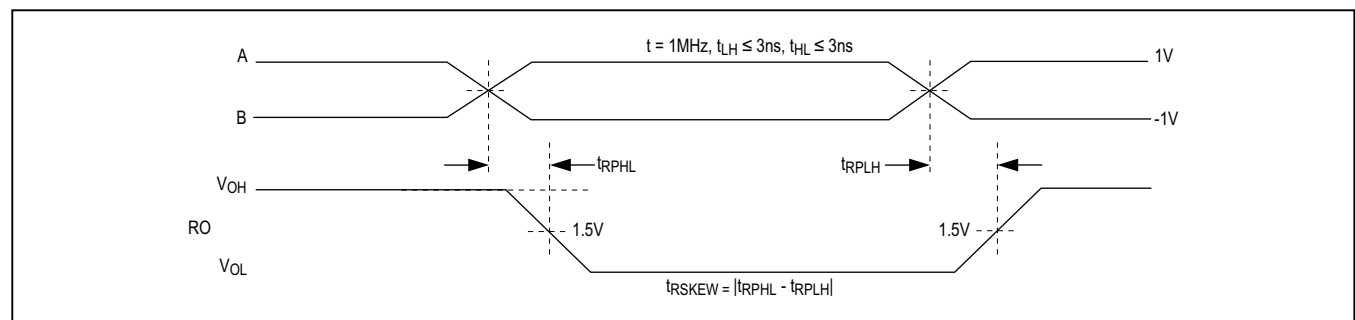


Figure 7. Receiver Propagation Delays

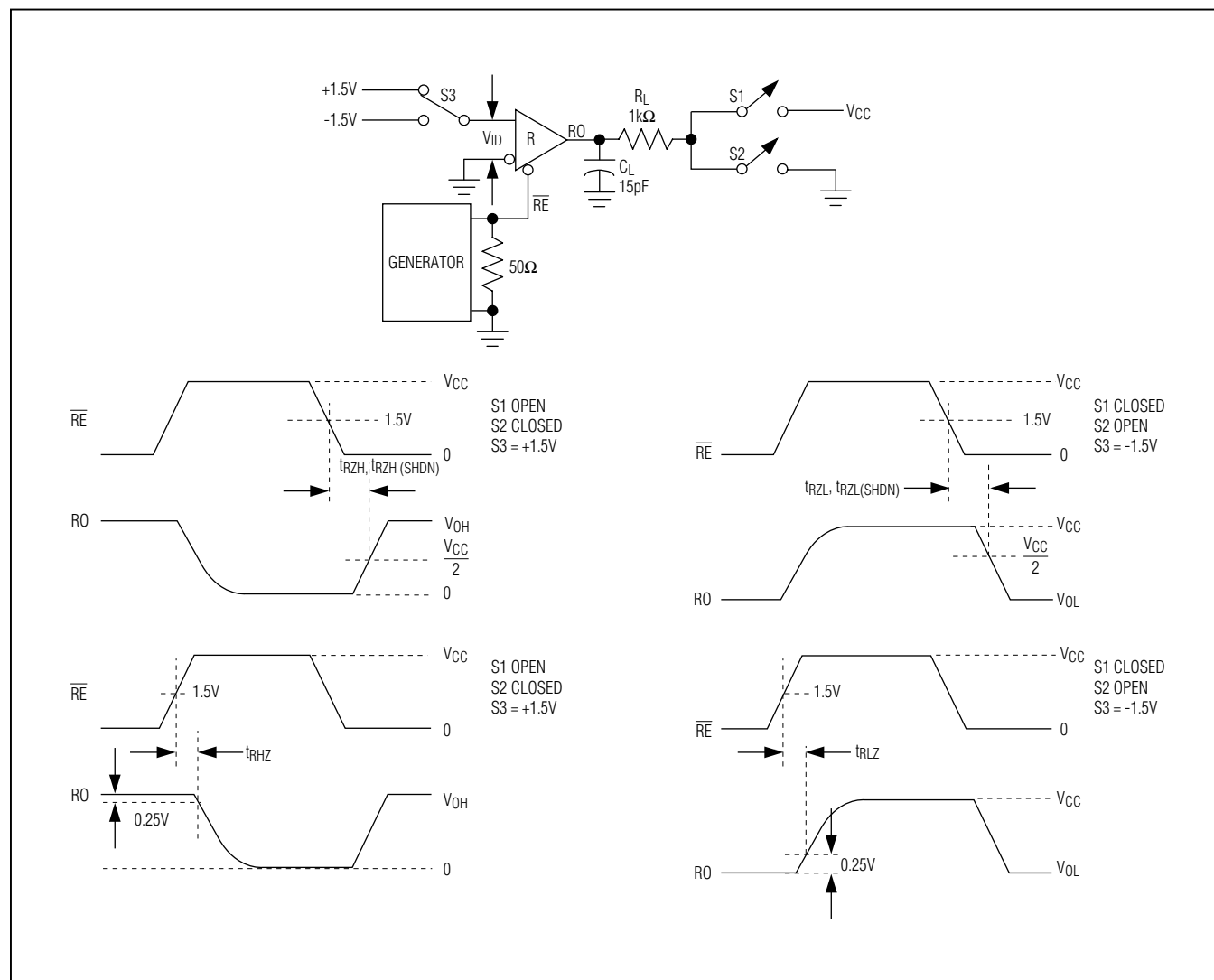


Figure 8. Receiver Enable and Disable Times

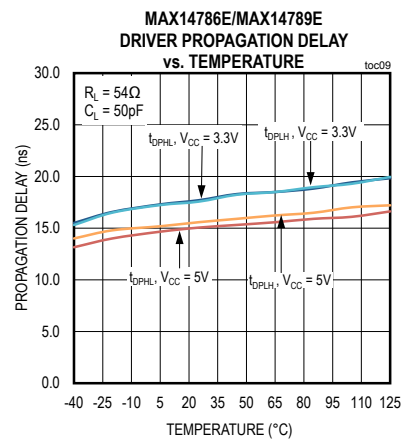
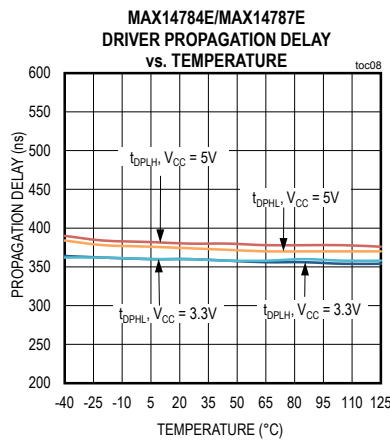
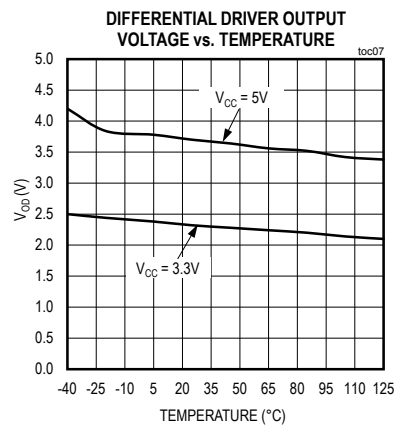
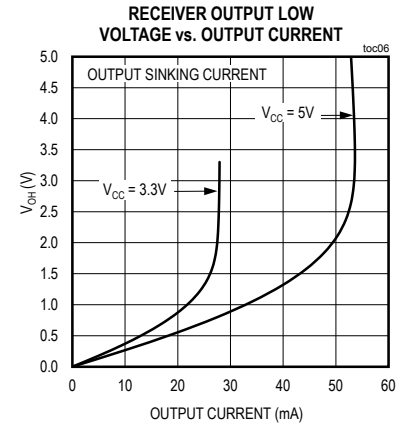
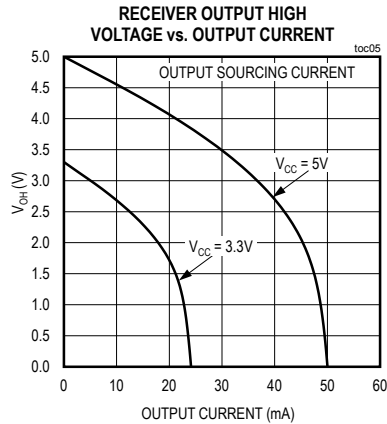
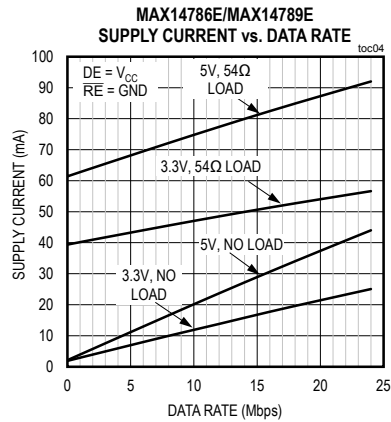
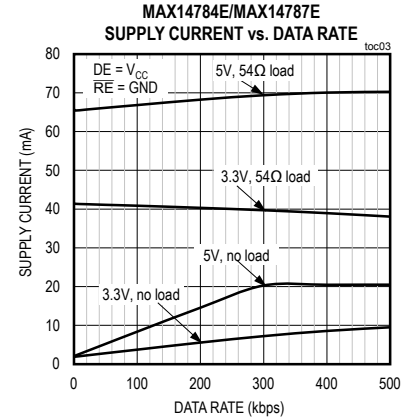
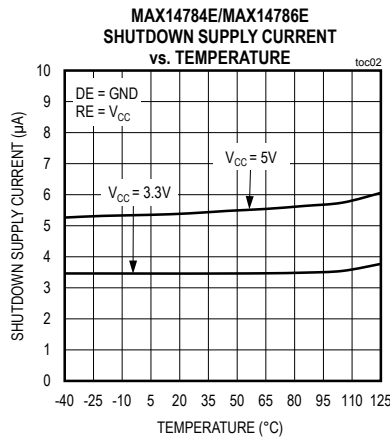
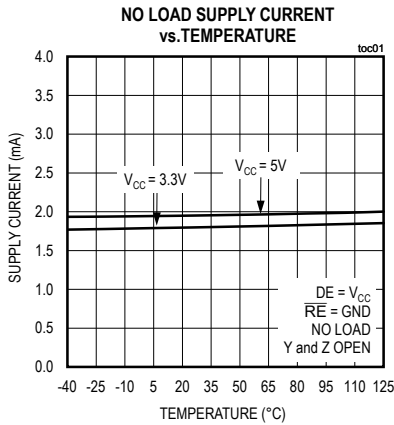


# MAX14784E/MAX14786E/ MAX14787E/MAX14789E

Full-Duplex,  $\pm 35\text{kV}$  ESD-Protected,  
RS-485 Transceivers for  
High-Speed Communication

## Typical Operating Characteristics

( $V_{CC} = 5\text{V}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

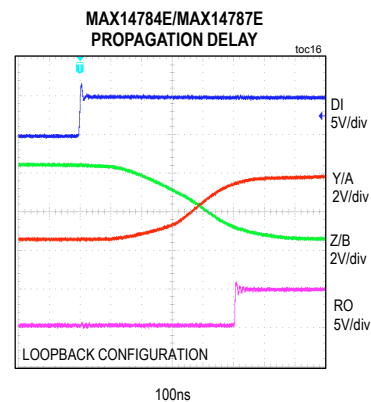
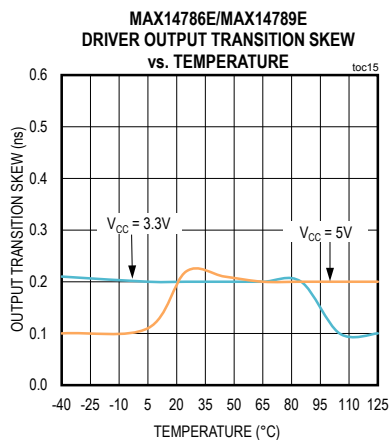
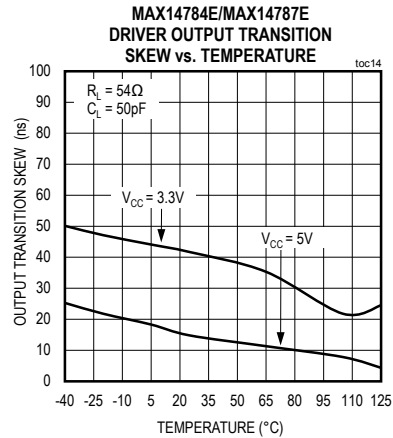
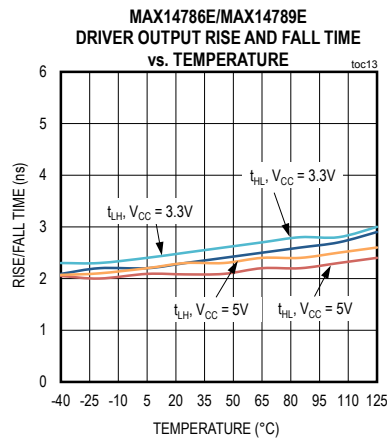
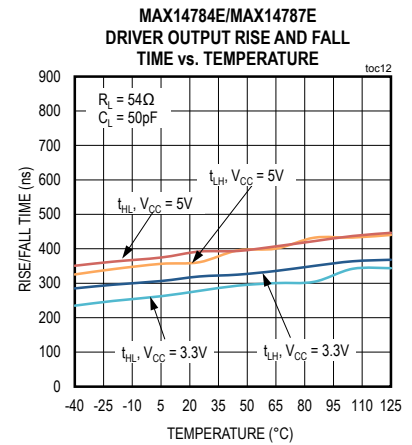
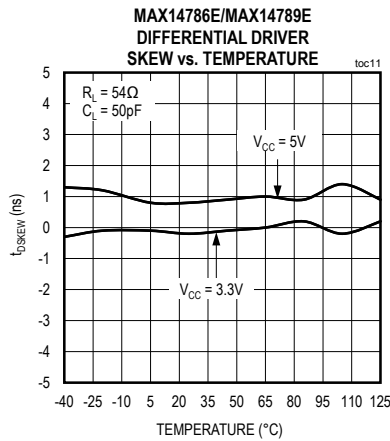
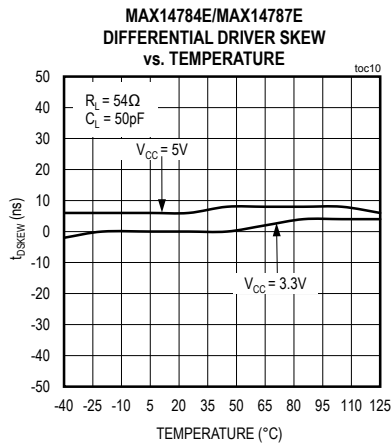


# MAX14784E/MAX14786E/ MAX14787E/MAX14789E

Full-Duplex,  $\pm 35\text{kV}$  ESD-Protected,  
RS-485 Transceivers for  
High-Speed Communication

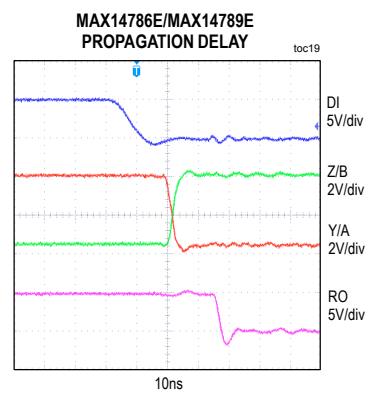
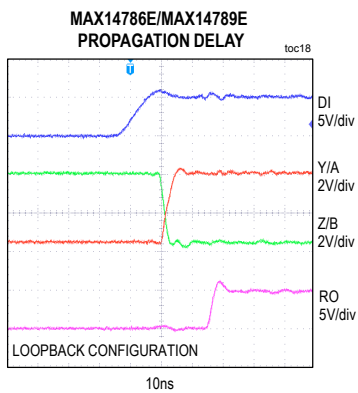
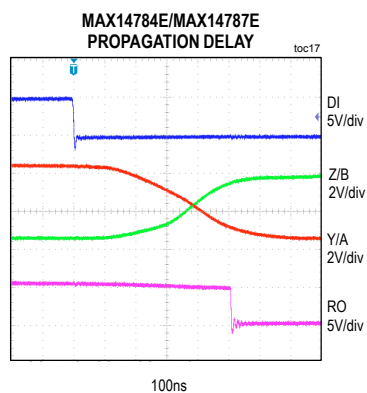
## Typical Operating Characteristics (continued)

( $V_{CC} = 5\text{V}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



### Typical Operating Characteristics (continued)

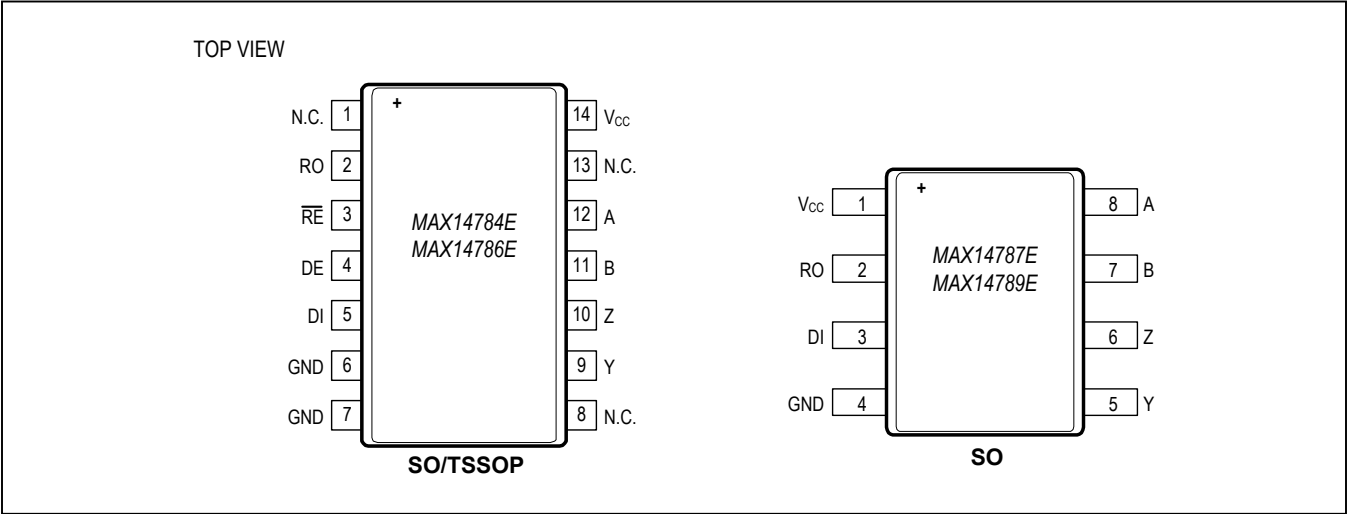
( $V_{CC} = 5\text{V}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



MAX14784E/MAX14786E/  
MAX14787E/MAX14789E

Full-Duplex,  $\pm 35\text{kV}$  ESD-Protected,  
RS-485 Transceivers for  
High-Speed Communication

Pin Configurations



Pin Description

| PIN                    |                        | NAME                   | FUNCTION                                                                                                                                                                                                                                                                                                                                                                                 |
|------------------------|------------------------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MAX14784E<br>MAX14786E | MAX14787E<br>MAX14789E |                        |                                                                                                                                                                                                                                                                                                                                                                                          |
| 1, 8, 13               | —                      | N.C.                   | No Connection. Not internally connected.                                                                                                                                                                                                                                                                                                                                                 |
| 2                      | 2                      | RO                     | Receiver Output. Drive $\overline{\text{RE}}$ low to enable RO. RO is always active on the MAX14787E and the MAX14789E. See the <i>Function Tables</i> section.                                                                                                                                                                                                                          |
| 3                      | —                      | $\overline{\text{RE}}$ | Receiver Enable. Drive $\overline{\text{RE}}$ low, or leave unconnected, to enable RO. RO is high impedance when $\overline{\text{RE}}$ is high. Drive $\overline{\text{RE}}$ high and DE low to enter low-power shutdown mode. $\overline{\text{RE}}$ has a weak pulldown to GND.                                                                                                       |
| 4                      | —                      | DE                     | Driver Enable. Drive DE high, or leave unconnected, to enable the driver outputs. The driver outputs are high impedance when DE is low. Drive $\overline{\text{RE}}$ high and DE low to enter low-power shutdown mode (MAX14784E and MAX14786E only).                                                                                                                                    |
| 5                      | 3                      | DI                     | Driver Input. Drive DE high on the MAX14784E and MAX14786E to enable the driver outputs. Driver outputs are always active on the MAX14787E and the MAX14789E. A low on DI forces the noninverting output, Y, low and the inverting output, Z, high. Similarly, a high on DI forces the noninverting output, Y, high and the inverting output, Z, low. DE has a weak pullup to $V_{CC}$ . |
| 6, 7                   | 4                      | GND                    | Ground                                                                                                                                                                                                                                                                                                                                                                                   |
| 9                      | 5                      | Y                      | Noninverting Driver Output                                                                                                                                                                                                                                                                                                                                                               |
| 10                     | 6                      | Z                      | Inverting Driver Output                                                                                                                                                                                                                                                                                                                                                                  |
| 11                     | 7                      | B                      | Inverting Receiver Input                                                                                                                                                                                                                                                                                                                                                                 |
| 12                     | 8                      | A                      | Noninverting Receiver Input                                                                                                                                                                                                                                                                                                                                                              |
| 14                     | 1                      | $V_{CC}$               | Positive Supply. Bypass $V_{CC}$ to GND with a 0.1 $\mu\text{F}$ capacitor as close as possible to the IC.                                                                                                                                                                                                                                                                               |

## Function Tables

| TRANSMITTING             |               |    |                |   |
|--------------------------|---------------|----|----------------|---|
| INPUTS                   |               |    | OUTPUTS        |   |
| $\overline{\text{RE}}^*$ | $\text{DE}^*$ | DI | Y              | Z |
| X                        | 1             | 1  | 1              | 0 |
| X                        | 1             | 0  | 0              | 1 |
| 0                        | 0             | X  | High-Impedance |   |
| 1                        | 0             | X  | Shutdown       |   |

| RECEIVING                |               |                      |                |
|--------------------------|---------------|----------------------|----------------|
| INPUTS                   |               |                      | OUTPUT         |
| $\overline{\text{RE}}^*$ | $\text{DE}^*$ | $V_A - V_B$          | RO             |
| 0                        | X             | $\geq -10\text{mV}$  | 1              |
| 0                        | X             | $\leq -200\text{mV}$ | 0              |
| 0                        | X             | Open/shorted         | 1              |
| 1                        | 1             | X                    | High-Impedance |
| 1                        | 0             | X                    | Shutdown       |

\* $\overline{\text{RE}}$  and  $\text{DE}$  on the MAX14787E and MAX14789E are internal. The driver outputs and receiver are always active in these devices.

## Detailed Description

The MAX14784E/MAX14786E/MAX14787E/MAX14789E are  $\pm 35\text{kV}$  ESD protected RS-485 transceivers intended for high-speed, full-duplex communication. These devices operate from a +3.0V to +5.5V supply and feature true fail-safe circuitry, guaranteeing a logic high on the receiver output when inputs are open or shorted.

The MAX14784E and MAX14787E feature a slew-rate limited driver that minimizes EMI and reduces reflections caused by improperly-terminated cables, allowing error-free data transmission at data rates up to 500kbps. The MAX14784E/MAX14787E feature an added deglitch filter on the receiver signal path for enhanced noise immunity when differential signals have very slow rise and fall times. Driver outputs are short-circuit current-limited, with thermal shutdown circuitry that protects drivers against excessive power dissipation.

The MAX14784E/MAX14786E/MAX14787E/MAX14789E transceivers draw 4mA (max) of supply current when unloaded, or when fully-loaded with the drivers disabled. The MAX14784E and MAX14786E draw less than 10 $\mu\text{A}$  (max) of supply current in low-power shutdown mode.

### True Fail-Safe

The MAX14784E/MAX14786E/MAX14787E/MAX14789E guarantee a logic-high receiver output when either the receiver inputs are shorted or open, or when they are connected to a terminated transmission line with all drivers disabled. If the differential receiver input voltage ( $V_A - V_B$ ) is greater than or equal to -10mV, RO is logic-high.

### Receiver Input Deglitch Filter (MAX14784E/MAX14787E Only)

The MAX14784E/MAX14787E include integrated circuitry to filter received data. This input deglitch filter reduces false triggers that can occur when data is passed over long cables. To minimize impact on the bus, the integrated filter is not connected to the receiver inputs. Instead, data is filtered after the differential receiver input but before reaching RO.

### Driver Single-Ended Operation

The Y and Z outputs can either be used in the standard differential operating mode, or can be used as single-ended outputs. Since the Y and Z driver outputs swing rail-to-rail, they can individually be used as standard TTL logic outputs.

## MAX14784E/MAX14786E/ MAX14787E/MAX14789E

## Full-Duplex, $\pm 35\text{kV}$ ESD-Protected, RS-485 Transceivers for High-Speed Communication

### Half-Duplex Operation

The MAX14784E/MAX14786E are full-duplex transceivers with driver and receiver enable/disable functionality. To use these devices in a half-duplex configuration, connect the Y output to the A input and connect the Z output to the B input.

### Driver Output Protection

Two mechanisms prevent excessive output current and power dissipation caused by faults or by bus contention. The first, a current limit on the output stage, provides immediate protection against short-circuits over the whole common-mode voltage range. The second, a thermal shutdown circuit, force the driver outputs into a high-impedance state if the die temperature exceeds  $+160^{\circ}\text{C}$  (typ).

### Low-Power Shutdown Mode (MAX14784E/ MAX14786E Only)

Low-power shutdown mode is initiated by bringing both  $\overline{\text{RE}}$  high and DE low. In shutdown, the devices draw only  $10\mu\text{A}$  (max) of supply current.  $\overline{\text{RE}}$  and DE can be driven simultaneously; the devices are guaranteed not to enter shutdown if  $\overline{\text{RE}}$  is high and DE is low for less than 50ns. If the inputs are in this state for at least 800ns, the devices are guaranteed to enter shutdown.

### $\pm 35\text{kV}$ ESD Protection

ESD protection structures are incorporated on all pins to protect against electrostatic discharge encountered during handling and assembly. The driver outputs and receiver inputs of the MAX14784E/MAX14786E/MAX14787E/MAX14789E have extra protection against static electricity. The ESD structures withstand high ESD in all states: normal operation, shutdown, and powered down. After an ESD event, the devices keep working without latchup or damage.

ESD protection can be tested in various ways. The transmitter outputs and receiver inputs of the MAX14784E/MAX14786E/MAX14787E/MAX14789E are characterized for protection to the following limits:

- $\pm 35\text{kV}$  HBM
- $\pm 18\text{kV}$  using the Air-Gap Discharge method specified in IEC 61000-4-2
- $\pm 8\text{kV}$  using the Contact Discharge method specified in the IEC 61000-4-2

### ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test setup, test methodology, and test results.

### Human Body Model (HBM)

Figure 9 shows the HBM test model, while Figure 10 shows the current waveform it generates when discharged in a low-impedance state. This model consists of a  $100\text{pF}$  capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a  $1.5\text{k}\Omega$  resistor.

### IEC 61000-4-2

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment. However, it does not specifically refer to integrated circuits. The MAX14784E/MAX14786E/MAX14787E/MAX14789E help facilitate designing equipment to meet the IEC 61000-4-2 specification without the need for additional ESD protection components.

The major difference between tests performed using the HBM and IEC 61000-4-2 is higher peak current in IEC 61000-4-2 due to lower series resistance in the IEC 61000-4-2 model. Hence, the ESD withstand voltage measured to IEC 61000-4-2 is generally lower than that measured using the HBM.

Figure 11 shows the IEC 61000-4-2 model, while Figure 12 shows the current waveform for IEC 61000-4-2 ESD Contact Discharge Test.

# MAX14784E/MAX14786E/ MAX14787E/MAX14789E

## Full-Duplex, $\pm 35\text{kV}$ ESD-Protected, RS-485 Transceivers for High-Speed Communication

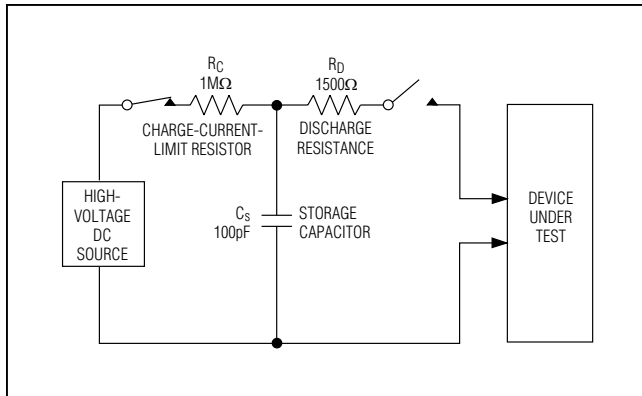


Figure 9. Human Body ESD Test Model

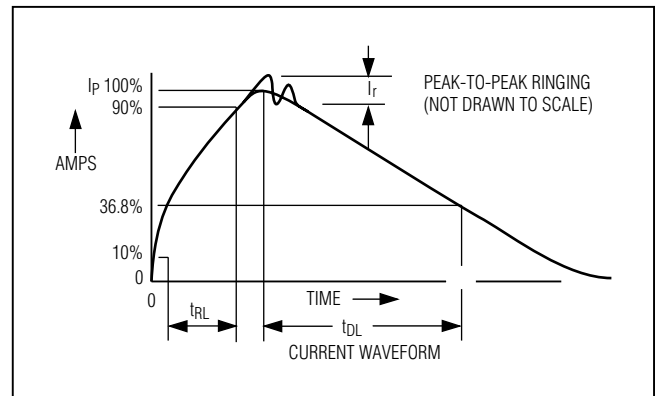


Figure 10. Human Body Current Waveform

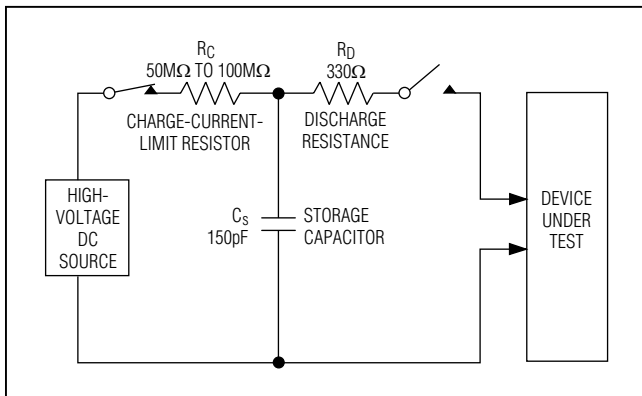


Figure 11. IEC 61000-4-2 ESD Test Model

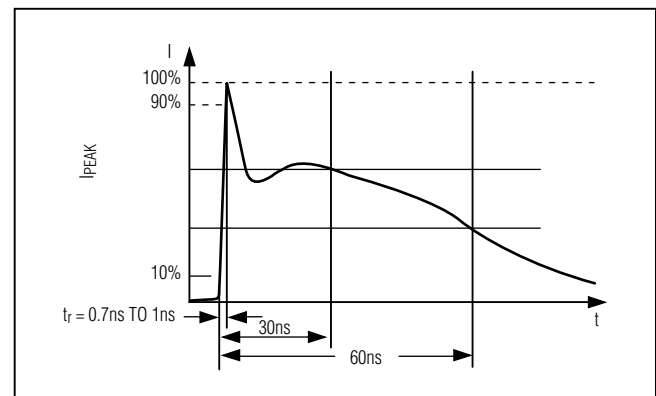
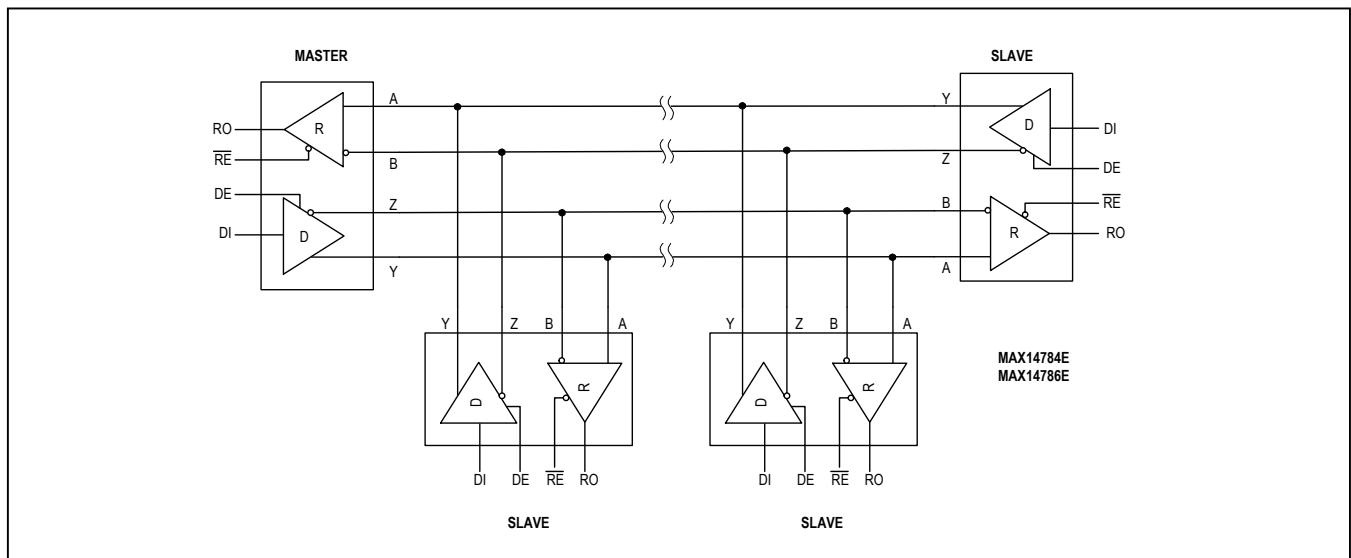


Figure 12. IEC 61000-4-2 ESD Generator Current Waveform

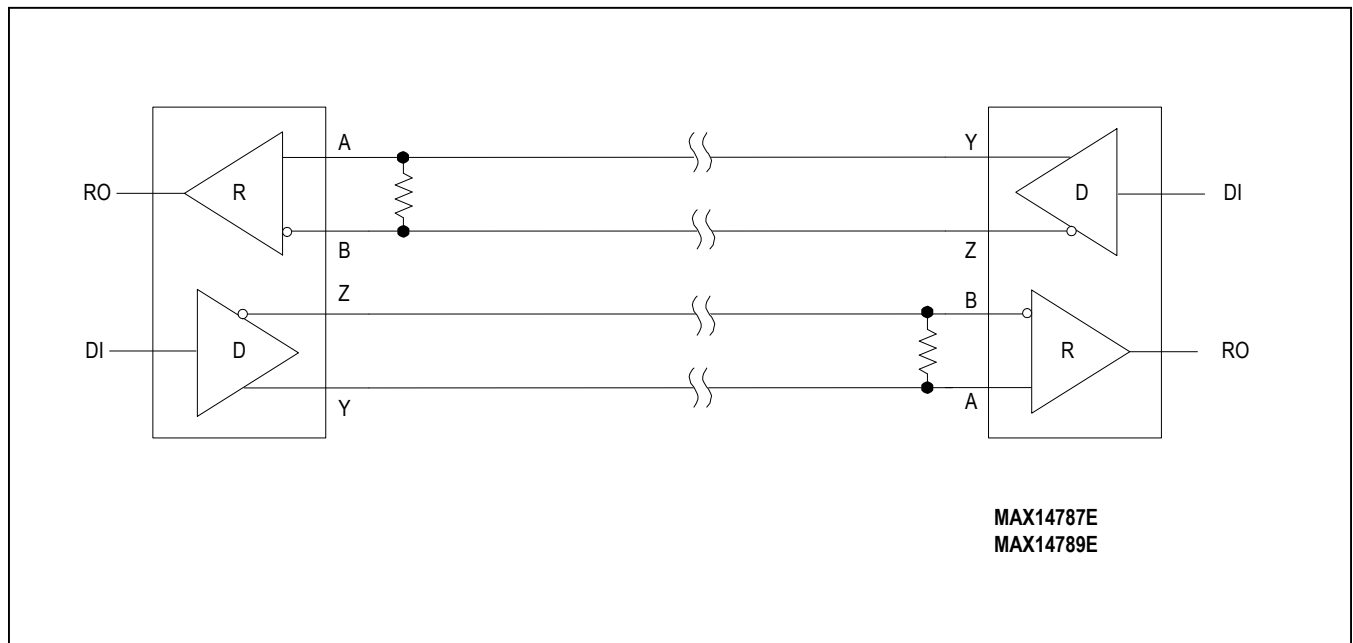
## Typical Application Circuit



MAX14784E/MAX14786E/  
MAX14787E/MAX14789E

# Full-Duplex, $\pm 35\text{kV}$ ESD-Protected, RS-485 Transceivers for High-Speed Communication

## Typical Application Circuit (continued)



## Ordering Information/Selector Guide

| PART                 | DATA RATE (MAX) | DRIVER SLEW-RATE LIMITED | DEGLITCHED RECEIVER SIGNAL | DRIVER/RECEIVER ENABLE | TEMP RANGE      | PIN-PACKAGE |
|----------------------|-----------------|--------------------------|----------------------------|------------------------|-----------------|-------------|
| <b>MAX14784EASD+</b> | 500kbps         | Yes                      | Yes                        | Yes                    | -40°C to +125°C | 14 SO       |
| <b>MAX14786EASD+</b> | 25Mbps          | No                       | No                         | Yes                    | -40°C to +125°C | 14 SO       |
| MAX14786EAUD+        | 25Mbps          | No                       | No                         | Yes                    | -40°C to +125°C | 14 TSSOP    |
| <b>MAX14787EGSA+</b> | 500kbps         | Yes                      | Yes                        | No                     | -40°C to +105°C | 8 SO        |
| <b>MAX14789EGSA+</b> | 25Mbps          | No                       | No                         | No                     | -40°C to +105°C | 8 SO        |

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

## Chip Information

PROCESS: BiCMOS

## Package Information

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.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.        |
|--------------|--------------|-------------------------|-------------------------|
| 8 SO         | S8+4         | <a href="#">21-0041</a> | <a href="#">90-0096</a> |
| 14 SO        | S14+1        | <a href="#">21-0041</a> | <a href="#">90-0112</a> |
| 14 TSSOP     | U14+1        | <a href="#">21-0066</a> | <a href="#">90-0113</a> |



MAX14784E/MAX14786E/  
MAX14787E/MAX14789E

Full-Duplex,  $\pm 35\text{kV}$  ESD-Protected,  
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High-Speed Communication

## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION                                                                  | PAGES<br>CHANGED |
|--------------------|------------------|------------------------------------------------------------------------------|------------------|
| 0                  | 12/13            | Initial release                                                              | —                |
| 1                  | 6/14             | Removed future product asterisk from MAX14789E                               | 1                |
| 2                  | 1/15             | Updated <i>General Description</i> and <i>Benefits and Features</i> sections | 1                |

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at [www.maximintegrated.com](http://www.maximintegrated.com).

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- Комплексную поставку.
- Работу по проектам и поставку образцов.
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