## Absolute Maximum Ratings

Supply Voltage ($V_{CC}$) ..... +7V
Control Input Voltage ($\overline{RE}$, DE) ..... -0.3V to +7V
Driver Input Voltage (DI) ..... -0.3V to +7V
Driver Output Voltage (A, B, Y, Z) ..... -7.5V to +12.5V
Receiver Input Voltage (A, B) ..... -7.5V to +12.5V
Receiver Output Voltage (RO) ..... -0.3V to ($V_{CC}$ + 0.3V)
Continuous Power Dissipation ($T_A$ = +70°C)
8-Pin SO (derate 5.88mW/°C above +70°C) ..... 471mW
8-Pin Plastic DIP (derate 9.09mW/°C above +70°C) .. 727mW
14-Pin SO (derate 8.33mW/°C above +70°C) ..... 667mW
14-Pin Plastic DIP (derate 10mW/°C above +70°C) ..... 800mW
Operating Temperature Ranges
MAX34_ _ EC_ _ ..... 0°C to +70°C
MAX34_ _ EE_ _ ..... -40°C to +85°C
Junction Temperature ..... +150°C
Storage Temperature Range ..... -65°C to +150°C
Lead Temperature (soldering, 10sec) ..... +300°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 Information

### TDFN-14

| PACKAGE CODE | S14+1 |
|---|---|
| Outline Number | 21-0041 |
| Land Pattern Number | 90-0112 |
| **Thermal Resistance, Single-Layer Board:** | |
| Junction to Ambient ($\theta_{JA}$) | 120°C/W |
| Junction to Case ($\theta_{JC}$) | 37°C/W |
| **Thermal Resistance, Four-Layer Board:** | |
| Junction to Ambient ($\theta_{JA}$) | 84°C/W |
| Junction to Case ($\theta_{JC}$) | 34°C/W |

*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 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.*



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## DC Electrical Characteristics

($V_{CC}$ = +3.3V ±0.3V, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Differential Driver Output | $V_{OD}$ | $R_L$ = 100Ω (RS-422), Figure 4 | | 2.0 | | | V |
| | | $R_L$ = 54Ω (RS-485), Figure 4 | | 1.5 | | | |
| | | $R_L$ = 60Ω (RS-485), $V_{CC}$ = 3.3V, Figure 5 | | 1.5 | | | |
| Change in Magnitude of Driver Differential Output Voltage for Complementary Output States (Note 1) | $\Delta V_{OD}$ | $R_L$ = 54Ω or 100Ω, Figure 4 | | | | 0.2 | V |
| Driver Common-Mode Output Voltage | $V_{OC}$ | $R_L$ = 54Ω or 100Ω, Figure 4 | | | | 3 | V |
| Change in Magnitude of Common-Mode Output Voltage (Note 1) | $\Delta V_{OC}$ | $R_L$ = 54Ω or 100Ω, Figure 4 | | | | 0.2 | V |
| Input High Voltage | $V_{IH}$ | DE, DI, $\overline{RE}$ | | 2.0 | | | V |
| Input Low Voltage | $V_{IL}$ | DE, DI, $\overline{RE}$ | | | | 0.8 | V |
| Logic Input Current | $I_{IN1}$ | DE, DI, $\overline{RE}$ | | | | ±2 | µA |
| Input Current (A, B) | $I_{IN2}$ | DE = 0V, $V_{CC}$ = 0V or 3.6V | $V_{IN}$ = 12V | | | 1.0 | mA |
| | | | $V_{IN}$ = -7V | | | -0.8 | |
| Output Leakage (Y, Z) | $I_O$ | DE = 0V, $\overline{RE}$ = 0V, $V_{CC}$ = 0V or 3.6V, MAX3491E | $V_{OUT}$ = 12V | | | 20 | µA |
| | | | $V_{OUT}$ = -7V | | | -20 | |
| Output Leakage (Y, Z) in Shutdown Mode | $I_O$ | DE = 0V, $\overline{RE}$ = $V_{CC}$, $V_{CC}$ = 0V or 3.6V, MAX3491E | $V_{OUT}$ = 12V | | | 1 | µA |
| | | | $V_{OUT}$ = -7V | | | -1 | |
| Receiver Differential Threshold Voltage | $V_{TH}$ | -7V ≤ $V_{CM}$ ≤ 12V | | -0.2 | | 0.2 | V |
| Receiver Input Hysteresis | $\Delta V_{TH}$ | $V_{CM}$ = 0V | | | 50 | | mV |
| Receiver Output High Voltage | $V_{OH}$ | $I_{OUT}$ = -1.5mA, $V_{ID}$ = 200mV, Figure 6 | | $V_{CC}$ - 0.4 | | | V |
| Receiver Output Low Voltage | $V_{OL}$ | $I_{OUT}$ = 2.5mA, $V_{ID}$ = 200mV, Figure 6 | | | | 0.4 | V |
| Three-State (High Impedance) Output Current at Receiver | $I_{OZR}$ | $V_{CC}$ = 3.6V, 0V ≤ $V_{OUT}$ ≤ $V_{CC}$ | | | | ±1 | µA |
| Receiver Input Resistance | $R_{IN}$ | -7V ≤ $V_{CM}$ ≤ 12V | | 12 | | | kΩ |
| Supply Voltage Range | $V_{CC}$ | | | 3.0 | | 3.6 | V |



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## DC Electrical Characteristics (continued)

($V_{CC}$ = +3.3V ±0.3V, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Supply Current | $I_{CC}$ | No load, DI = 0 or $V_{CC}$ | DE = $V_{CC}$, $\overline{RE}$ = 0 or $V_{CC}$ | | 1.1 | 2.2 | mA |
| | | | DE = 0V, $\overline{RE}$ = 0 | | 0.95 | 1.9 | |
| Supply Current in Shutdown Mode | $I_{SHDN}$ | DE = 0, $\overline{RE}$ = $V_{CC}$, DI = $V_{CC}$ or 0 | | | 0.002 | 1 | µA |
| Driver Short-Circuit Output Current | $I_{OSD}$ | $V_{OUT}$ = -7V | | | | -250 | mA |
| | | $V_{OUT}$ = 12V | | | | 250 | |
| Receiver Short-Circuit Output Current | $I_{OSR}$ | 0 ≤ $V_{RO}$ ≤ $V_{CC}$ | | ±8 | | ±60 | mA |
| ESD Protection for Y, Z, A, B | | IEC 1000-4-2 Air Discharge | | | ±15 | | kV |
| | | IEC 1000-4-2 Contact Discharge (MAX3483E, MAX3485E, MAX3486E, MAX3491E) | | | ±8 | | |
| | | IEC 1000-4-2 Contact Discharge (MAX3490E, MAX3488E)* | | | ±6 | | |
| | | Human Body Model | | | ±15 | | |

**MAX3488E and MAX3491E will be compliant to ±8kV per IEC 1000-4-2 Contact Discharge by September 1999.*

## Driver Switching Characteristics—MAX3485E/MAX3490E/MAX3491E

($V_{CC}$ = +3.3V, $T_A$ = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Maximum Data Rate | | | 12 | 15 | | Mbps |
| Driver Differential Output Delay | $t_{DD}$ | $R_L$ = 60Ω, Figure 7 | 1 | 22 | 35 | ns |
| Driver Differential Output Transition Time | $t_{TD}$ | $R_L$ = 60Ω, Figure 7 | 3 | 11 | 25 | ns |
| Driver Propagation Delay, Low-to-High Level | $t_{PLH}$ | $R_L$ = 27Ω, Figure 8 | 7 | 23 | 35 | ns |
| Driver Propagation Delay, High-to-Low Level | $t_{PHL}$ | $R_L$ = 27Ω, Figure 8 | 7 | 23 | 35 | ns |
| $\lvert t_{PLH} - t_{PHL} \rvert$ Driver Propagation Delay Skew (Note 2) | $t_{PDS}$ | $R_L$ = 27Ω, Figure 8 | | -1.4 | ±8 | ns |
| **DRIVER-OUTPUT ENABLE/DISABLE TIMES (MAX3485E/MAX3491E only)** | | | | | | |
| Driver-Output Enable Time to Low Level | $t_{PZL}$ | $R_L$ = 110Ω, Figure 10 | | 42 | 90 | ns |
| Driver-Output Enable Time to High Level | $t_{PZH}$ | $R_L$ = 110Ω, Figure 9 | | 42 | 90 | ns |
| Driver-Output Disable Time from High Level | $t_{PHZ}$ | $R_L$ = 110Ω, Figure 9 | | 35 | 80 | ns |
| Driver-Output Disable Time from Low Level | $t_{PLZ}$ | $R_L$ = 110Ω, Figure 10 | | 35 | 80 | ns |
| Driver-Output Enable Time from Shutdown to Low Level | $t_{PSL}$ | $R_L$ = 110Ω, Figure 10 | | 650 | 900 | ns |
| Driver-Output Enable Time from Shutdown to High Level | $t_{PSH}$ | $R_L$ = 110Ω, Figure 9 | | 650 | 900 | ns |



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## Driver Switching Characteristics—MAX3486E

($V_{CC}$ = +3.3V, $T_A$ = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Maximum Data Rate | | | 2.5 | | | Mbps |
| Driver Differential Output Delay | $t_{DD}$ | $R_L$ = 60Ω, Figure 7 | 20 | 42 | 70 | ns |
| Driver Differential Output Transition Time | $t_{TD}$ | $R_L$ = 60Ω, Figure 7 | 15 | 28 | 60 | ns |
| Driver Propagation Delay, Low-to-High Level | $t_{PLH}$ | $R_L$ = 27Ω, Figure 8 | 20 | 42 | 75 | ns |
| Driver Propagation Delay, High-to-Low Level | $t_{PHL}$ | $R_L$ = 27Ω, Figure 8 | 20 | 42 | 75 | ns |
| $\lvert t_{PLH} - t_{PHL} \rvert$ Driver Propagation Delay Skew (Note 2) | $t_{PDS}$ | $R_L$ = 27Ω, Figure 8 | | -6 | ±12 | ns |
| **DRIVER-OUTPUT ENABLE/DISABLE TIMES** | | | | | | |
| Driver Output Enable Time to Low Level | $t_{PZL}$ | $R_L$ = 110Ω, Figure 10 | | 52 | 100 | ns |
| Driver Output Enable Time to High Level | $t_{PZH}$ | $R_L$ = 110Ω, Figure 9 | | 52 | 100 | ns |
| Driver Output Disable Time from High Level | $t_{PHZ}$ | $R_L$ = 110Ω, Figure 9 | | 40 | 80 | ns |
| Driver Output Disable Time from Low Level | $t_{PLZ}$ | $R_L$ = 110Ω, Figure 10 | | 40 | 80 | ns |
| Driver Output Enable Time from Shutdown to Low Level | $t_{PSL}$ | $R_L$ = 110Ω, Figure 10 | | 700 | 1000 | ns |
| Driver Output Enable Time from Shutdown to High Level | $t_{PSH}$ | $R_L$ = 110Ω, Figure 9 | | 700 | 1000 | ns |

## Driver Switching Characteristics—MAX3483E/MAX3488E

($V_{CC}$ = +3.3V, $T_A$ = +25°C)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Maximum Data Rate | | | 250 | | | kbps |
| Driver Differential Output Delay | $t_{DD}$ | $R_L$ = 60Ω, Figure 7 | 600 | 900 | 1400 | ns |
| Driver Differential Output Transition Time | $t_{TD}$ | $R_L$ = 60Ω, Figure 7 | 400 | 740 | 1200 | ns |
| Driver Propagation Delay, Low-to-High Level | $t_{PLH}$ | $R_L$ = 27Ω, Figure 8 | 700 | 930 | 1500 | ns |
| Driver Propagation Delay, High-to-Low Level | $t_{PHL}$ | $R_L$ = 27Ω, Figure 8 | 700 | 930 | 1500 | ns |
| $\lvert t_{PLH} - t_{PHL} \rvert$ Driver Propagation Delay Skew (Note 2) | $t_{PDS}$ | $R_L$ = 27Ω, Figure 8 | | ±50 | | ns |
| **DRIVER-OUTPUT ENABLE/DISABLE TIMES (MAX3483E only)** | | | | | | |
| Driver-Output Enable Time to Low Level | $t_{PZL}$ | $R_L$ = 110Ω, Figure 10 | | 900 | 1300 | ns |
| Driver-Output Enable Time to High Level | $t_{PZH}$ | $R_L$ = 110Ω, Figure 9 | | 600 | 800 | ns |
| Driver-Output Disable Time from High Level | $t_{PHZ}$ | $R_L$ = 110Ω, Figure 9 | | 50 | 80 | ns |
| Driver-Output Disable Time from Low Level | $t_{PLZ}$ | $R_L$ = 110Ω, Figure 10 | | 50 | 80 | ns |
| Driver-Output Enable Time from Shutdown to Low Level | $t_{PSL}$ | $R_L$ = 110Ω, Figure 10 | | 1.9 | 2.7 | µs |
| Driver-Output Enable Time from Shutdown to High Level | $t_{PSH}$ | $R_L$ = 110Ω, Figure 9 | | 2.2 | 3.0 | µs |



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## Receiver Switching Characteristics

($V_{CC}$ = +3.3V, $T_A$ = +25°C)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Time to Shutdown | $t_{SHDN}$ | MAX3483E/MAX3485E/MAX3486E/MAX3491E only (Note 3) | 80 | 190 | 300 | ns |
| Receiver Propagation Delay, Low-to-High Level | $t_{RPLH}$ | $V_{ID}$ = 0 to 3.0, $C_L$ = 15pF, Figure 11 | 25 | 62 | 90 | ns |
| | | MAX3483E/MAX3488E | 25 | 75 | 120 | |
| Receiver Propagation Delay, High-to-Low Level | $t_{RPHL}$ | $V_{ID}$ = 0 to 3.0, $C_L$ = 15pF, Figure 11 | 25 | 62 | 90 | ns |
| | | MAX3483E/MAX3488E | 25 | 75 | 120 | |
| $\lvert t_{PLH} - t_{PHL} \rvert$ Receiver Propagation Delay Skew | $t_{RPDS}$ | $V_{ID}$ = 0 to 3.0, $C_L$ = 15pF, Figure 11 | | 6 | ±10 | ns |
| | | MAX3483E/MAX3488E | | 12 | ±20 | |
| Receiver Output Enable Time to Low Level | $t_{PRZL}$ | $C_L$ = 15pF, Figure 12, MAX3483E/85E/86E/91E only | | 25 | 50 | ns |
| Receiver Output Enable Time to High Level | $t_{PRZH}$ | $C_L$ = 15pF, Figure 12, MAX3483E/85E/86E/91E only | | 25 | 50 | ns |
| Receiver Output Disable Time from High Level | $t_{PRHZ}$ | $C_L$ = 15pF, Figure 12, MAX3483E/85E/86E/91E only | | 25 | 45 | ns |
| Receiver Output Disable Time from Low Level | $t_{PRLZ}$ | $C_L$ = 15pF, Figure 12, MAX3483E/85E/86E/91E only | | 25 | 45 | ns |
| Receiver Output Enable Time from Shutdown to Low Level | $t_{PRSL}$ | $C_L$ = 15pF, Figure 12, MAX3483E/85E/86E/91E only | | 720 | 1400 | ns |
| Receiver Output Enable Time from Shutdown to High Level | $t_{PRSH}$ | $C_L$ = 15pF, Figure 12, MAX3483E/85E/86E/91E only | | 720 | 1400 | ns |

**Note 1:** $\Delta V_{OD}$ and $\Delta V_{OC}$ are the changes in $V_{OD}$ and $V_{OC}$, respectively, when the DI input changes state.

**Note 2:** Measured on $\lvert t_{PLH}$ (Y) - $t_{PHL}$ (Y)$\rvert$ and $\lvert t_{PLH}$ (Z) - $t_{\overline{PHL}}$(Z)$\rvert$.

**Note 3:** The transceivers are put into shutdown by bringing $\overline{RE}$ high and DE low. If the inputs are in this state for less than 80ns, the parts are guaranteed not to enter shutdown. If the inputs are in this state for at least 300ns, the parts are guaranteed to have entered shutdown. See *Low-Power Shutdown Mode* section.



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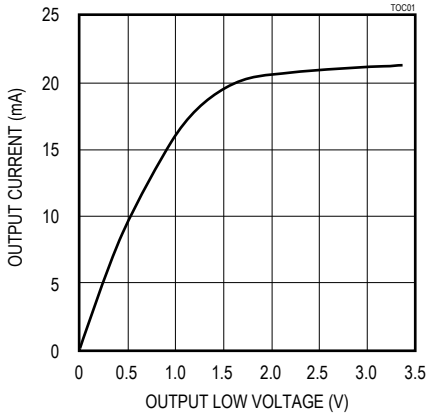
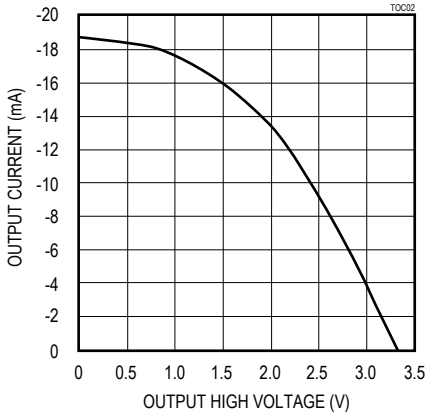
## Typical Operating Characteristics

($V_{CC}$ = +3.3V, $T_A$ = +25°C, unless otherwise noted.)

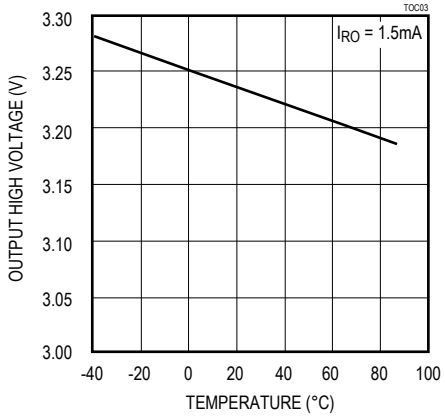
**OUTPUT CURRENT vs. RECEIVER OUTPUT LOW VOLTAGE**



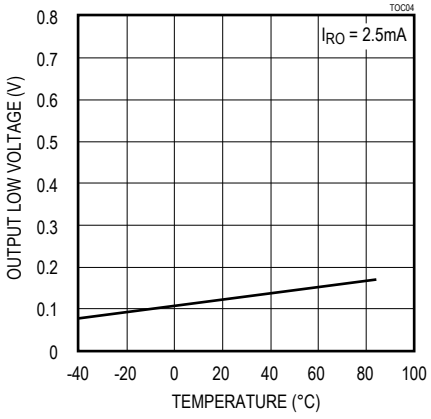

**OUTPUT CURRENT vs. RECEIVER OUTPUT HIGH VOLTAGE**



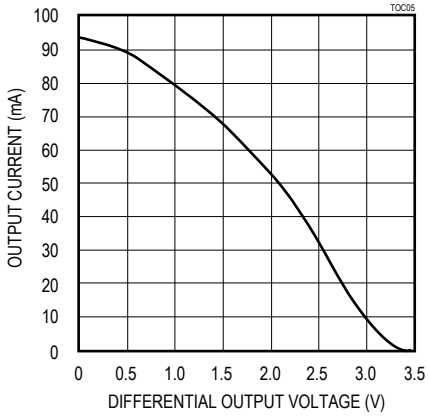

**RECEIVER OUTPUT HIGH VOLTAGE vs. TEMPERATURE**



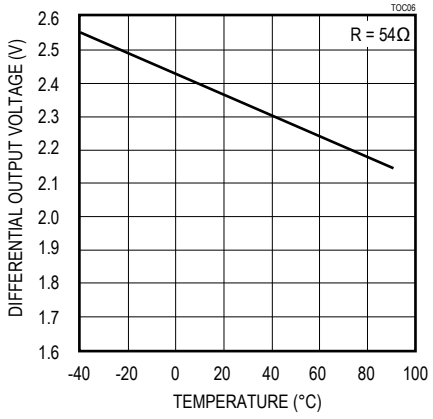

**RECEIVER OUTPUT LOW VOLTAGE vs. TEMPERATURE**



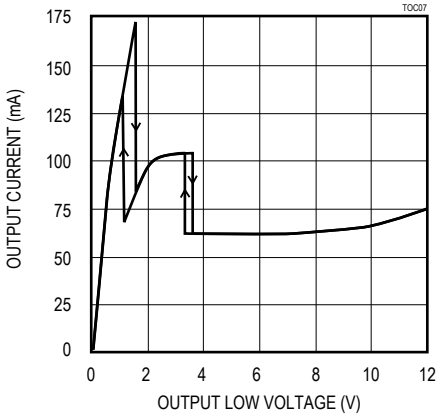

**DRIVER OUTPUT CURRENT vs. DIFFERENTIAL OUTPUT VOLTAGE**



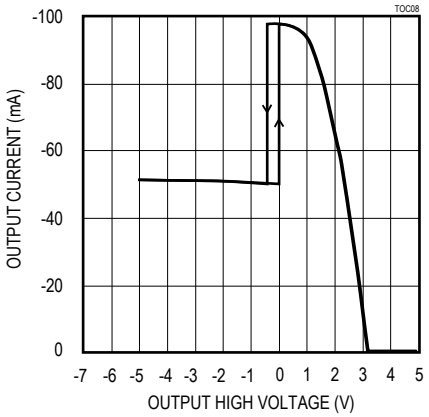

**DRIVER DIFFERENTIAL OUTPUT VOLTAGE vs.TEMPERATURE**




**OUTPUT CURRENT vs. DRIVER OUTPUT LOW VOLTAGE**




**OUTPUT CURRENT vs. DRIVER OUTPUT HIGH VOLTAGE**



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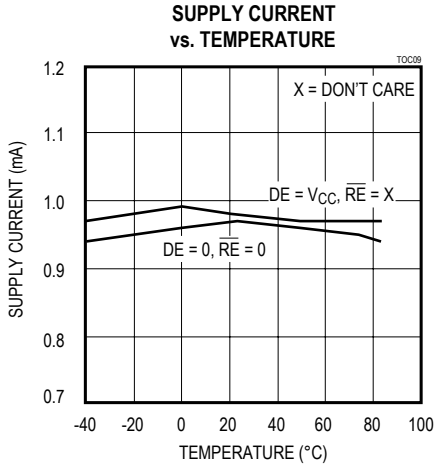
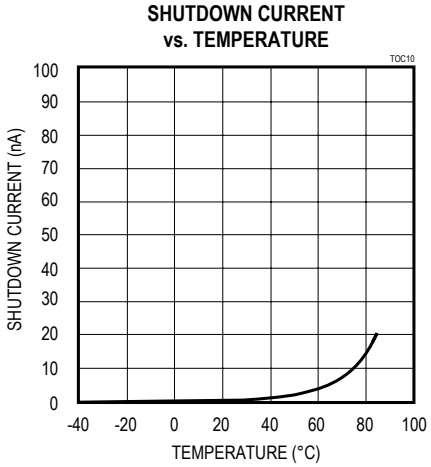
## Typical Operating Characteristics (continued)

($V_{CC}$ = +3.3V, $T_A$ = +25°C, unless otherwise noted.)




## Pin Description

| PIN | | | NAME | FUNCTION |
|---|---|---|---|---|
| MAX3483E MAX3485E MAX3486E | MAX3488E MAX3490E | MAX3491E | | |
| 1 | 2 | 2 | RO | Receiver Output. If A > B by 200mV, RO will be high; if A < B by 200mV, RO will be low. |
| 2 | — | 3 | $\overline{RE}$ | Receiver Output Enable. RO is enabled when $\overline{RE}$ is low; RO is high impedance when $\overline{RE}$ is high. If $\overline{RE}$ is high and DE is low, the device will enter a low-power shutdown mode. |
| 3 | — | 4 | DE | Driver Output Enable. The driver outputs are enabled by bringing DE high. They are high impedance when DE is low. If $\overline{RE}$ is high and DE is low, the device will enter a low-power shutdown mode. If the driver outputs are enabled, the parts function as line drivers. While they are high impedance, they function as line receivers if $\overline{RE}$ is low. |
| 4 | 3 | 5 | DI | Driver Input. A low on DI forces output Y low and output Z high. Similarly, a high on DI forces output Y high and output Z low. |
| 5 | 4 | 6, 7 | GND | Ground |
| — | 5 | 9 | Y | Noninverting Driver Output |
| — | 6 | 10 | Z | Inverting Driver Output |
| 6 | — | — | A | Noninverting Receiver Input and Noninverting Driver Output |
| — | 8 | 12 | A | Noninverting Receiver Input |
| 7 | — | — | B | Inverting Receiver Input and Inverting Driver Output |
| — | 7 | 11 | B | Inverting Receiver Input |
| 8 | 1 | 13, 14 | $V_{CC}$ | Positive Supply: 3.0V ≤ $V_{CC}$ ≤ 3.6V. Do not operate device with $V_{CC}$ > 3.6V |
| — | — | 1, 8 | N.C. | No Connection. Not internally connected. |



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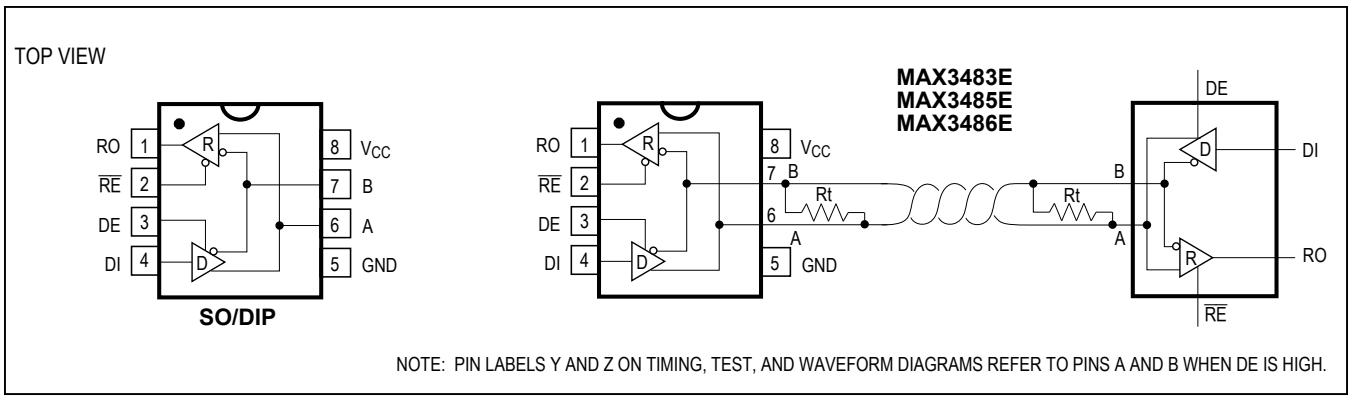


*Figure 1. MAX3483E/MAX3485E/MAX3486E Pin Configuration and Typical Operating Circuit*

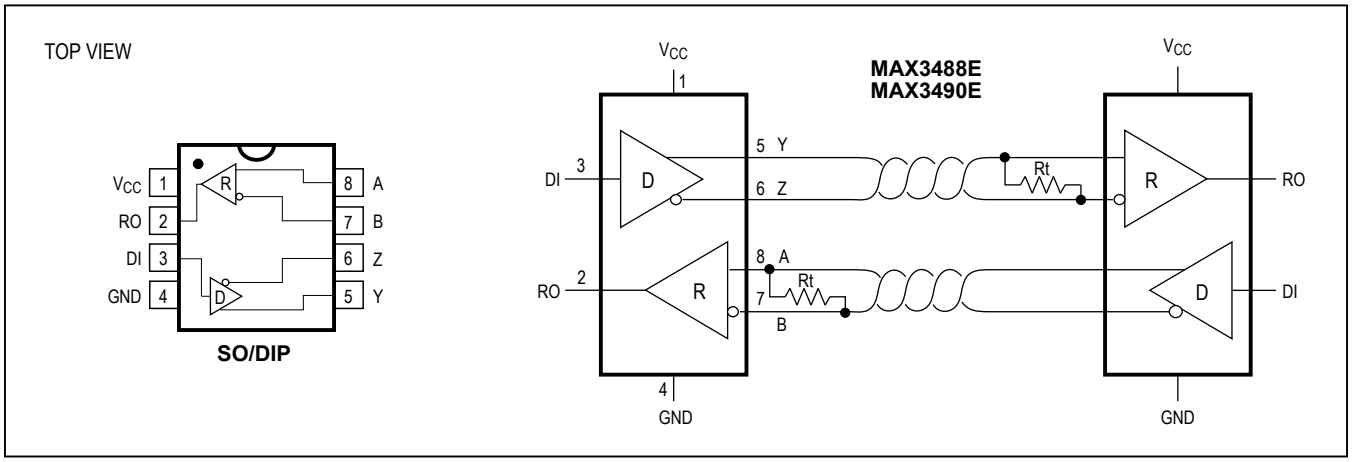


*Figure 2. MAX3488E/MAX3490E Pin Configuration and Typical Operating Circuit*

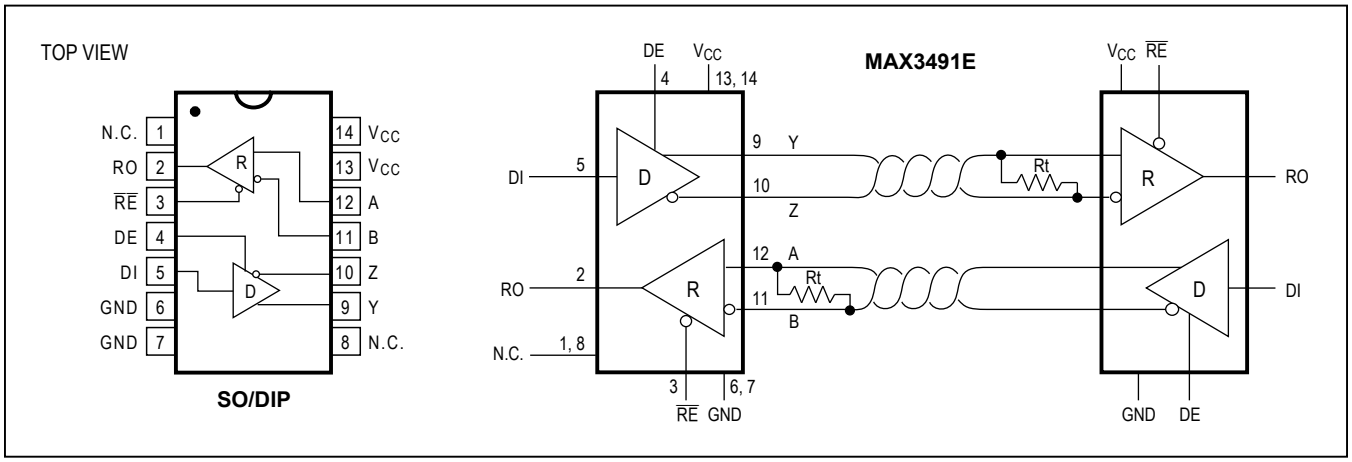


*Figure 3. MAX3491E Pin Configuration and Typical Operating Circuit*



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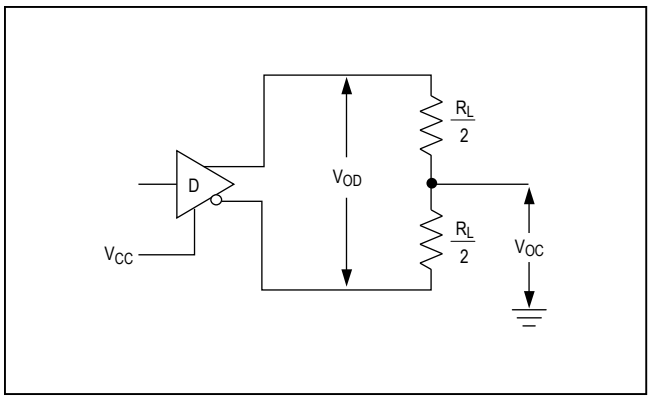


*Figure 4. Driver $V_{OD}$ and $V_{OC}$*

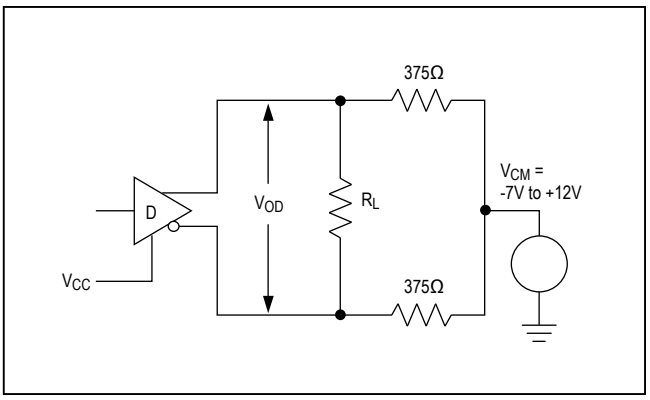


*Figure 5. Driver $V_{OD}$ with Varying Common-Mode Voltage*

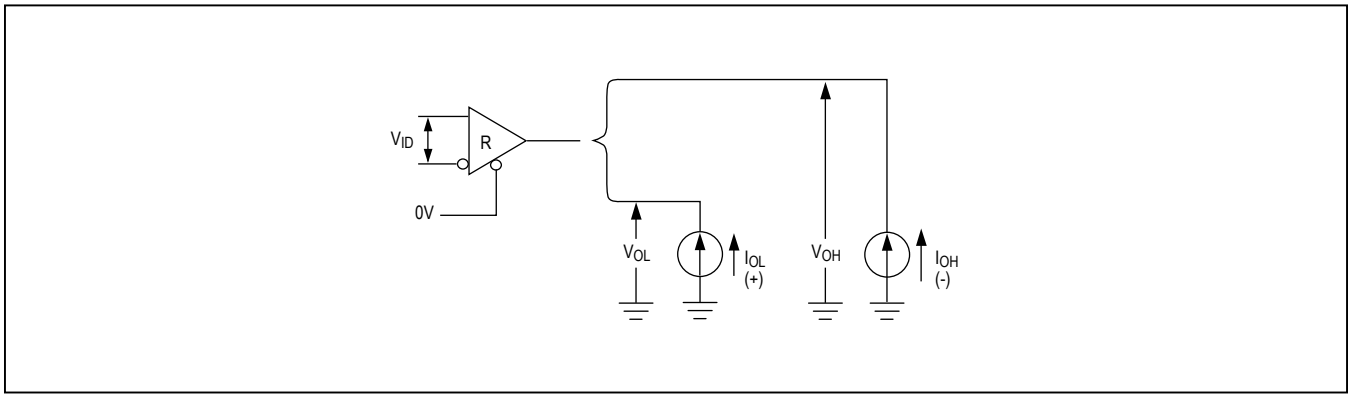


*Figure 6. Receiver $V_{OH}$ and $V_{OL}$*

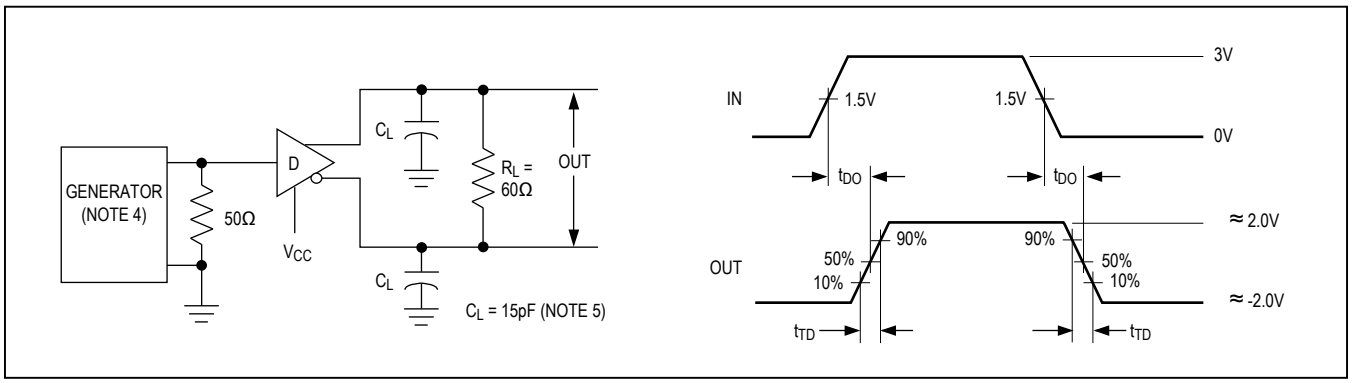


*Figure 7. Driver Differential Output Delay and Transition Times*



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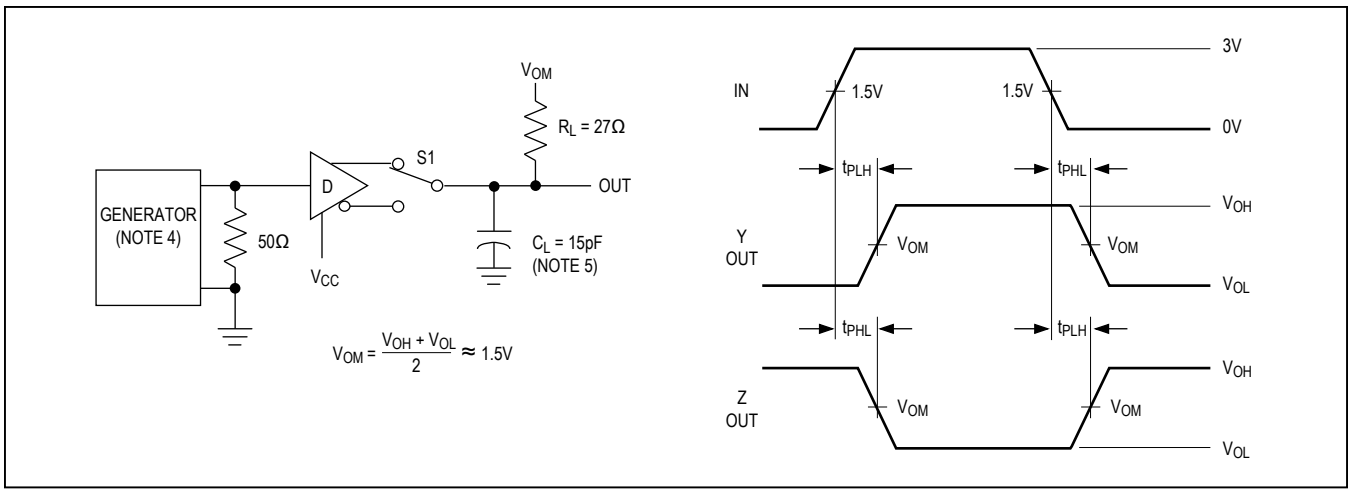


*Figure 8. Driver Propagation Times*

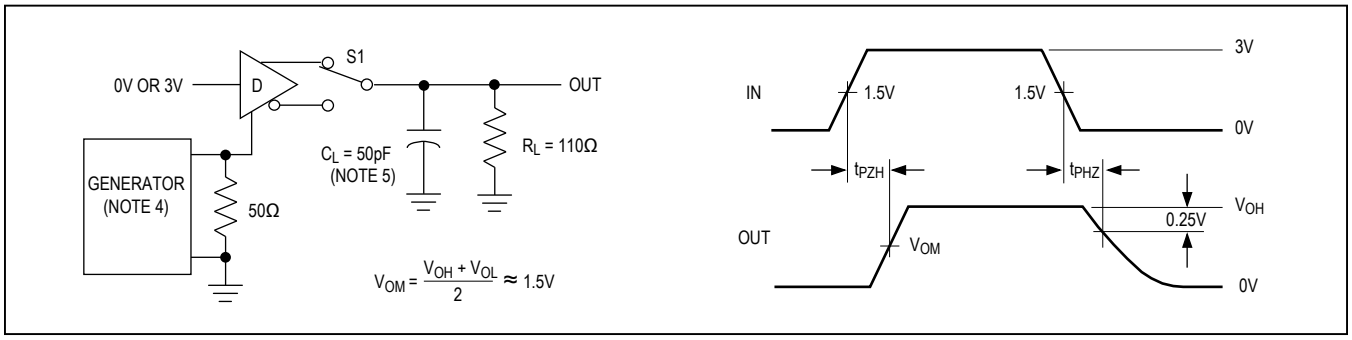


*Figure 9. Driver Enable and Disable Times ($t_{PZH}$, $t_{PSH}$, $t_{PHZ}$)*

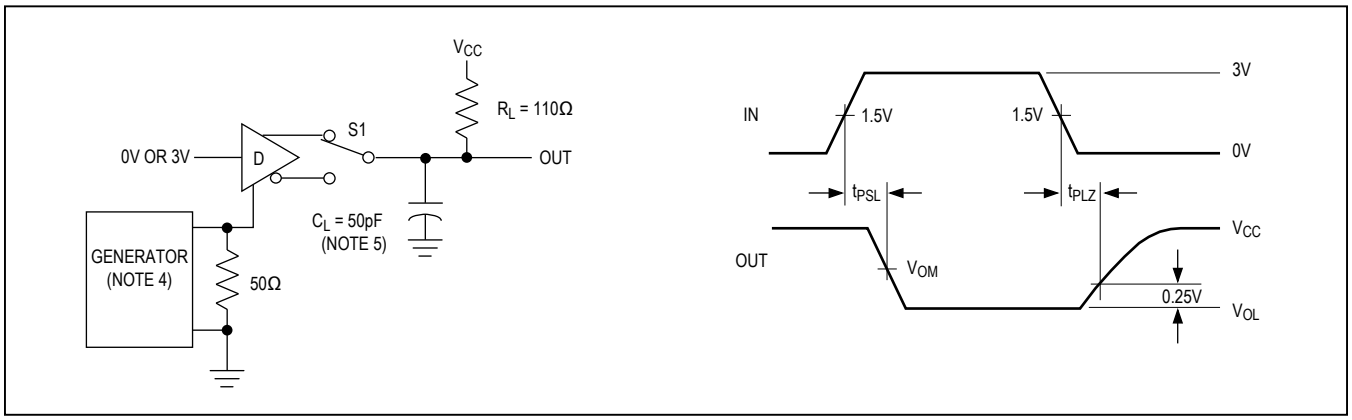


*Figure 10. Driver Enable and Disable Times ($t_{PZL}$, $t_{PSL}$, $t_{PLZ}$)*



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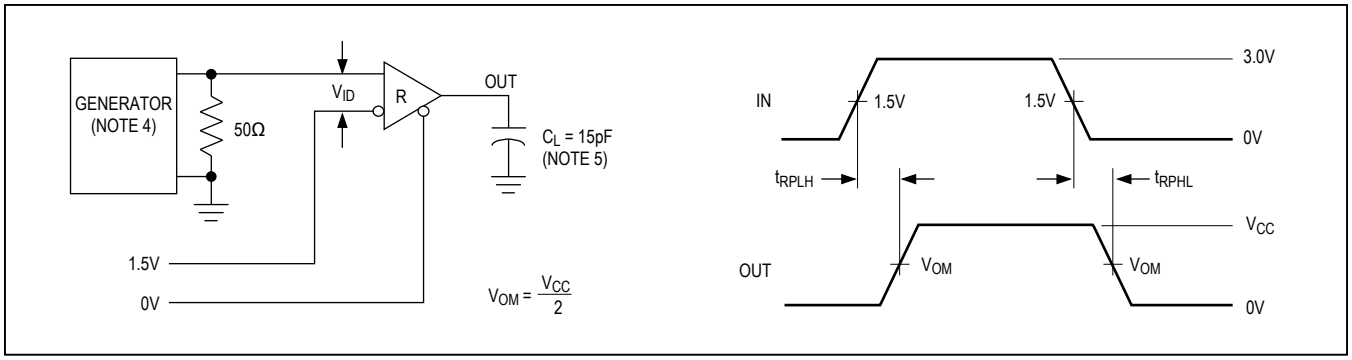


*Figure 11. Receiver Propagation Delay*

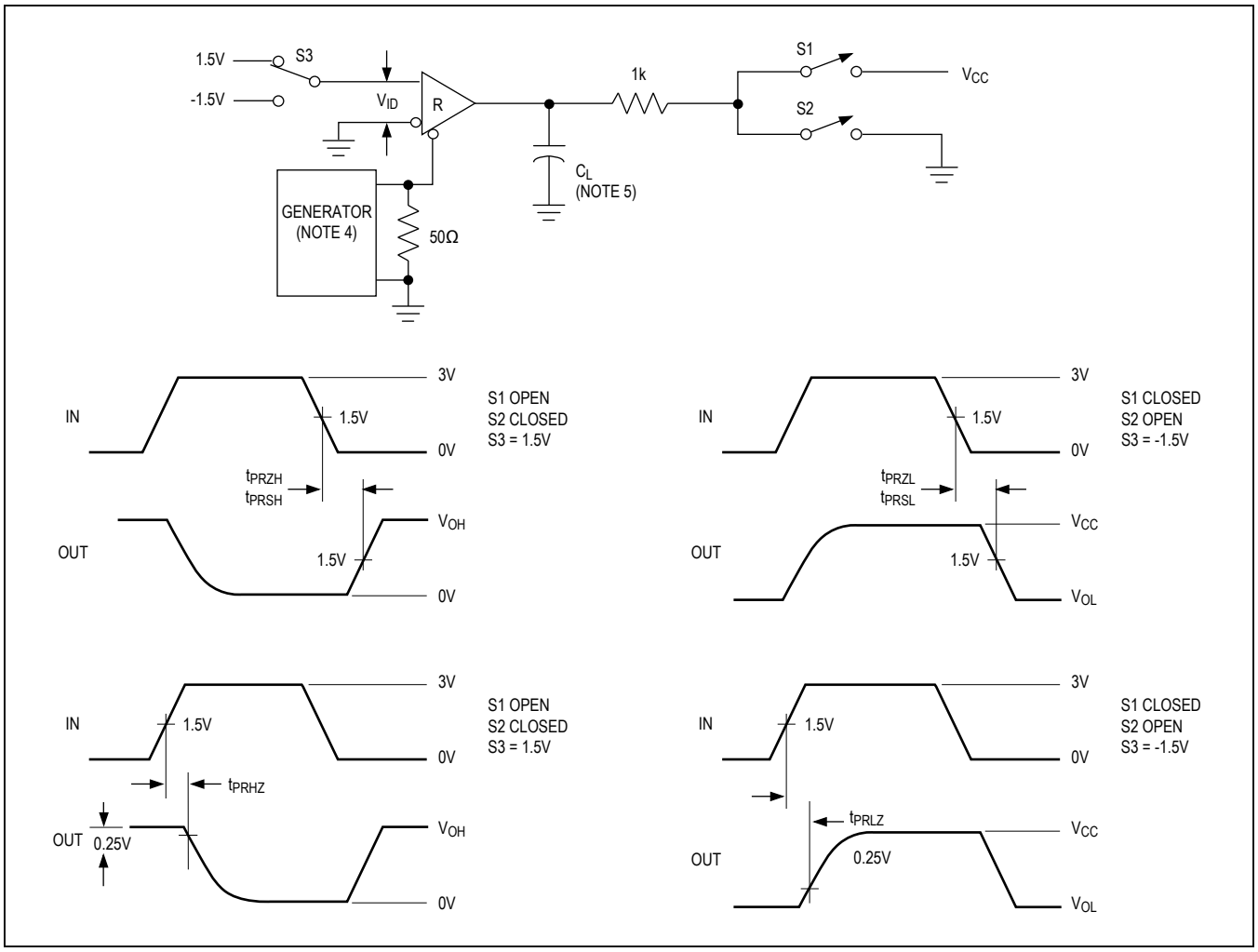


*Figure 12. Receiver Enable and Disable Times*

**Note 4:** The input pulse is supplied by a generator with the following characteristics: f = 250kHz, 50% duty cycle, $t_r$ ≤ 6.0ns, $Z_O$ = 50Ω.
**Note 5:** $C_L$ includes probe and stray capacitance.



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## Function Tables

### Devices with Receiver/Driver Enable (MAX3483E/MAX3485E/MAX3486E/MAX3491E)

#### Table 1. Transmitting

| INPUTS | | | OUTPUTS | | MODE |
|---|---|---|---|---|---|
| $\overline{RE}$ | DE | DI | B* | A* | |
| X | 1 | 1 | 0 | 1 | Normal |
| X | 1 | 0 | 1 | 0 | Normal |
| 0 | 0 | X | High-Z | High-Z | Normal |
| 1 | 0 | X | High-Z | High-Z | Shutdown |

** B and A outputs are Z and Y, respectively, for full-duplex part (MAX3491E).*
*X = Don't care; High-Z = High impedance*

#### Table 2. Receiving

| INPUTS | | | OUTPUTS | MODE |
|---|---|---|---|---|
| $\overline{RE}$ | DE | A, B | RO | |
| 0 | 0* | ≥ +0.2V | 1 | Normal |
| 0 | 0* | ≤ -0.2V | 0 | Normal |
| 0 | 0* | Inputs Open | 1 | Normal |
| 1 | 0 | X | High-Z | Shutdown |

** DE is a "don't care" (x) for the full-duplex part (MAX3491E).*
*X = Don't care; High-Z = High impedance*

### Devices without Receiver/Driver Enable (MAX3488E/MAX3490E)

#### Table 3. Transmitting

| INPUT | OUTPUTS | |
|---|---|---|
| DI | Z | Y |
| 1 | 0 | 1 |
| 0 | 1 | 0 |

#### Table 4. Receiving

| INPUTS | OUTPUT |
|---|---|
| A, B | RO |
| ≥ +0.2V | 1 |
| ≤ -0.2V | 0 |
| Inputs Open | 1 |

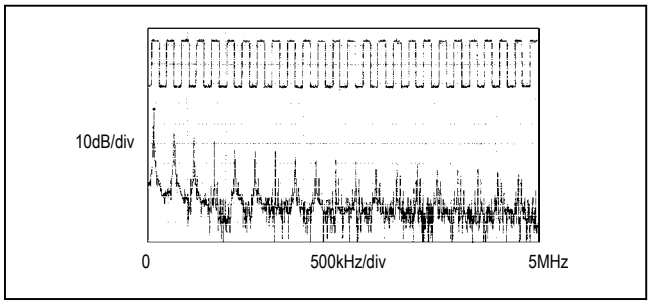


*Figure 13. Driver Output Waveform and FFT Plot of MAX3485E/ MAX3490E/MAX3491E Transmitting a 125kHz Signal*

## Applications Information

The MAX3483E/MAX3485E/MAX3486E/MAX3488E/ MAX3490E/MAX3491E are low-power transceivers for RS-485 and RS-422 communications. The MAX3483E and MAX3488E can transmit and receive at data rates up to 250kbps, the MAX3486E at up to 2.5Mbps, and the MAX3485E/MAX3490E/MAX3491E at up to 12Mbps. The MAX3488E/MAX3490E/MAX3491E are full-duplex transceivers, while the MAX3483E/MAX3485E/MAX3486E are half-duplex. Driver Enable (DE) and Receiver Enable ($\overline{RE}$) pins are included on the MAX3483E/MAX3485E/ MAX3486E/MAX3491E. When disabled, the driver and receiver outputs are high impedance.

### Reduced EMI and Reflections (MAX3483E/MAX3486E/MAX3488E)

The MAX3483E/MAX3488E are slew-rate limited, minimizing EMI and reducing reflections caused by improperly terminated cables. Figure 13 shows the driver output waveform of a MAX3485E/MAX3490E/MAX3491E transmitting a 125kHz signal, as well as the Fourier analysis of that waveform. High-frequency harmonics with large amplitudes are evident. Figure 14 shows the same information, but for the slew-rate-limited MAX3483E/ MAX3488E transmitting the same signal. The high-frequency harmonics have much lower amplitudes, and the potential for EMI is significantly reduced.

### Low-Power Shutdown Mode (MAX3483E/MAX3485E/MAX3486E/MAX3491E)

A low-power shutdown mode is initiated by bringing both $\overline{RE}$ high and DE low. The devices will not shut down unless both the driver and receiver are disabled (high impedance). In shutdown, the devices typically draw only 2nA of supply current.

For these devices, the $t_{PSH}$ and $t_{PSL}$ enable times assume the part was in the low-power shutdown mode; the $t_{PZH}$ and $t_{PZL}$ enable times assume the receiver or driver was disabled, but the part was not shut down.

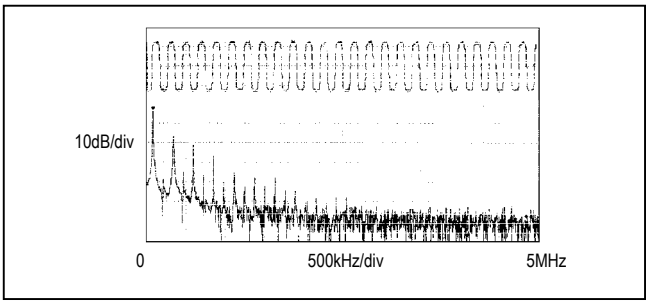


*Figure 14. Driver Output Waveform and FFT Plot of MAX3483E/ MAX3488E Transmitting a 125kHz Signal*



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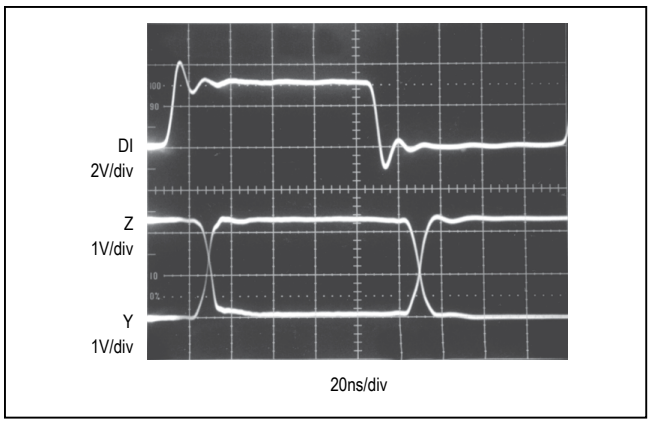


*Figure 15. MAX3485E/MAX3490E/MAX3491E Driver Propagation Delay*

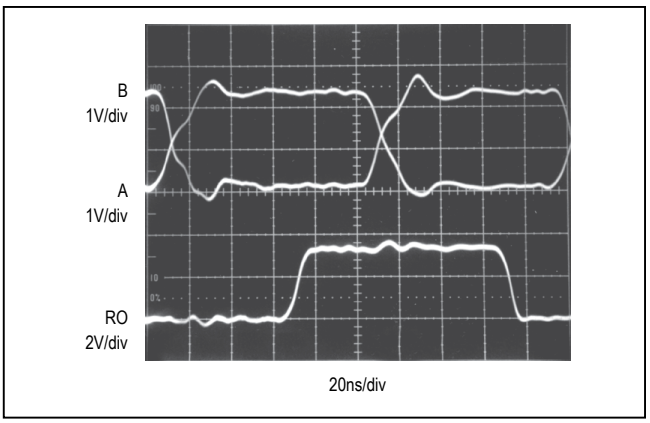


*Figure 16. MAX3485E/MAX3490E/MAX3491E Receiver Propagation Delay Driven by External RS-485 Device*

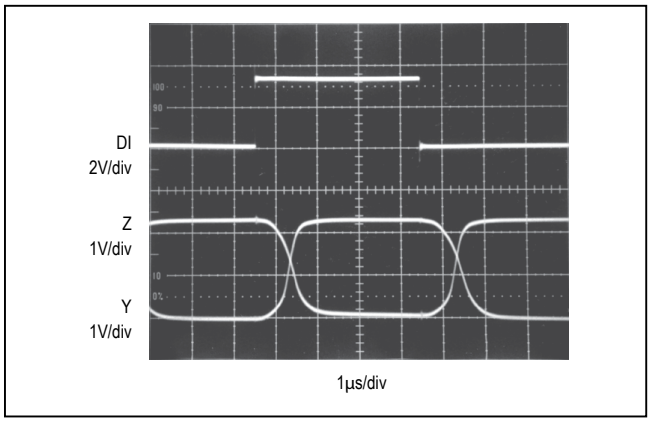


*Figure 17. MAX3483E/MAX3488E Driver Propagation Delay*

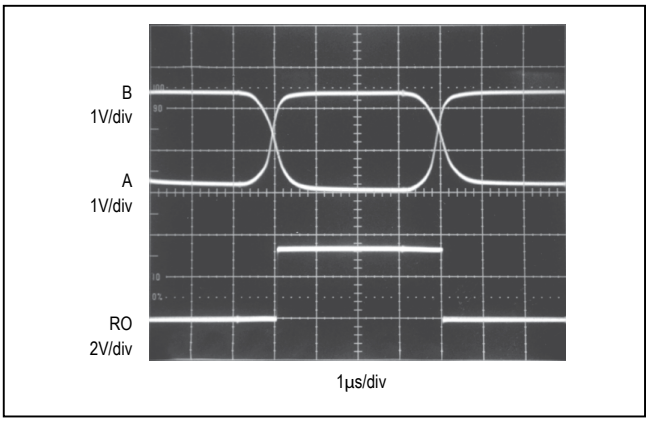


*Figure 18. MAX3483E/MAX3488E Receiver Propagation Delay*

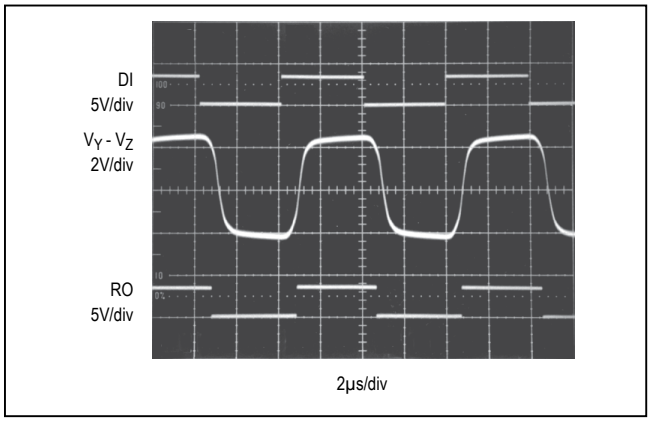


*Figure 19. MAX3483E/MAX3488E System Differential Voltage at 125kHz Driving 4000 Feet of Cable*

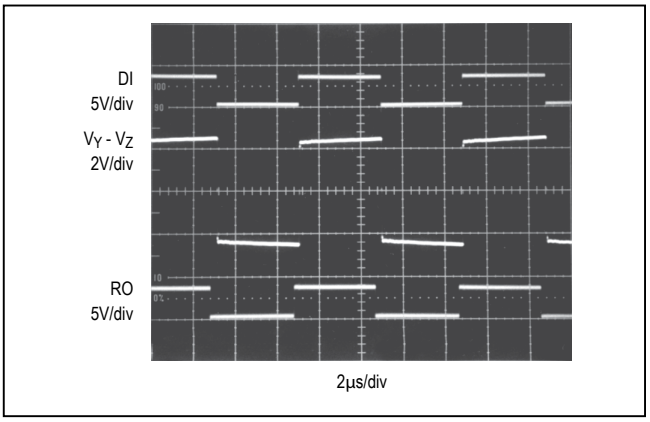


*Figure 20. MAX3485E/MAX3490E/MAX3491E System Differential Voltage at 125kHz Driving 4000 Feet of Cable*



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## Driver Output Protection

Excessive output current and power dissipation caused by faults or by bus contention are prevented by two mechanisms. A foldback current limit on the output stage provides immediate protection against short circuits over the whole common-mode voltage range (see *Typical Operating Characteristics*). In addition, a thermal shutdown circuit forces the driver outputs into a high-impedance state if the die temperature rises excessively.

## Propagation Delay

Figures 15–18 show the typical propagation delays. Skew time is simply the difference between the low-to-high and high-to-low propagation delay. Small driver/receiver skew times help maintain a symmetrical mark-space ratio (50% duty cycle).

The receiver skew time, $|t_{PRLH} - t_{PRHL}|$, is under 10ns 20ns for the MAX3483E/MAX3488E). The driver skew times are 8ns for the MAX3485E/MAX3490E/MAX3491E, 12ns for the MAX3486E, and typically under 50ns for the MAX3483E/MAX3488E.

## Line Length vs. Data Rate

The RS-485/RS-422 standard covers line lengths up to 4000 feet. For line lengths greater than 4000 feet, see Figure 21 for an example of a line repeater.

Figures 19 and 20 show the system differential voltage for parts driving 4000 feet of 26AWG twisted-pair wire at 125kHz into 120Ω loads.

For faster data rate transmission, please consult the factory.

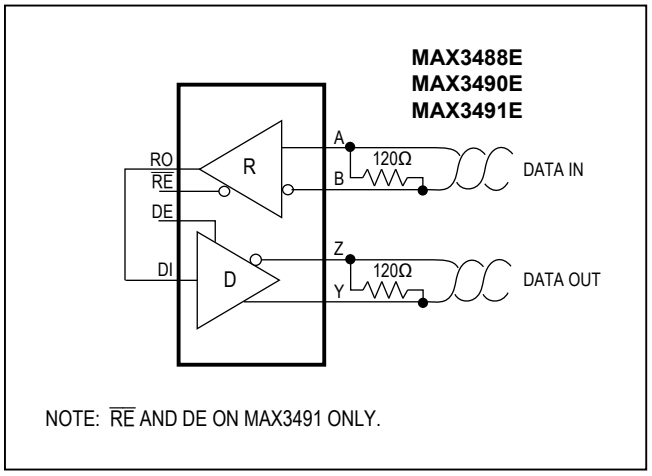


*Figure 21. Line Repeater for MAX3488E/MAX3490E/MAX3491E*

## ±15kV ESD Protection

As with all Maxim devices, ESD-protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. The driver outputs and receiver inputs of the MAX3483E family of devices have extra protection against static electricity. Maxim's engineers have developed state-of-the-art structures to protect these pins against ESD of ±15kV without damage. The ESD structures withstand high ESD in all states: normal operation, shutdown, and powered down. After an ESD event, Maxim's E versions keep working without latchup or damage.

ESD protection can be tested in various ways; the transmitter outputs and receiver inputs of this product family are characterized for protection to the following limits:

1) ±15kV using the Human Body Model
2) ±8kV using the Contact-Discharge method specified in IEC 1000-4-2
3) ±15kV using IEC 1000-4-2's Air-Gap method.

## 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

Figure 22a shows the Human Body Model and Figure 22b shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a 1.5kΩ resistor.

## IEC 1000-4-2

The IEC 1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX3483E family of devices helps you design equipment that meets Level 4 (the highest level) of IEC 1000-4-2, without the need for additional ESD-protection components.

The major difference between tests done using the Human Body Model and IEC 1000-4-2 is higher peak current in IEC 1000-4-2, because series resistance is lower in the IEC 1000-4-2 model. Hence, the ESD withstand voltage measured to IEC 1000-4-2 is generally lower than that measured using the Human Body Model. Figure 23a shows the IEC 1000-4-2 model, and Figure 23b shows the current waveform for the ±8kV IEC 1000-4-2, Level 4 ESD contact-discharge test. test.



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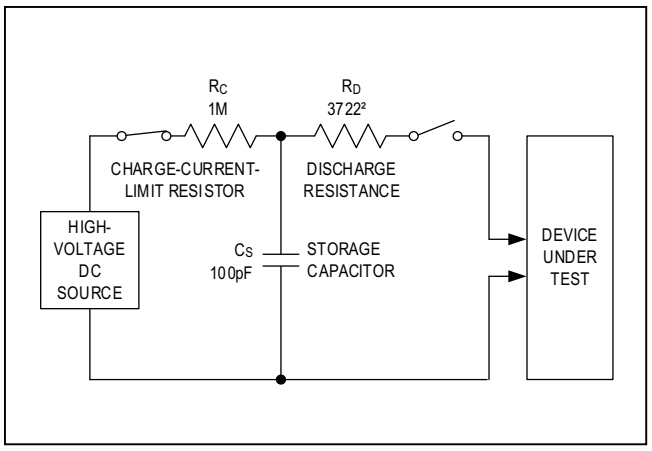


*Figure 22a. Human Body ESD Test Model*

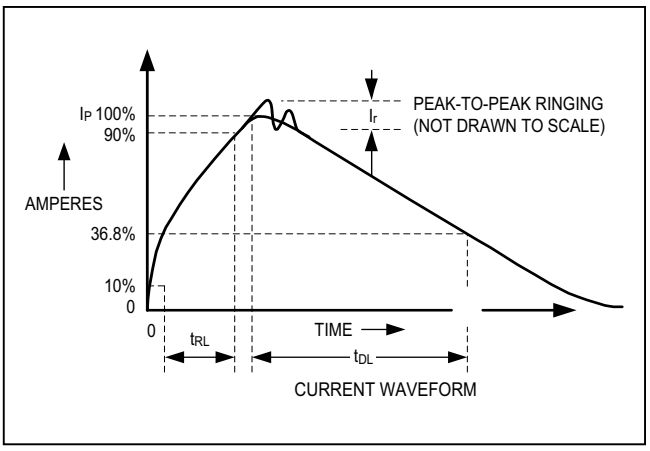


*Figure 22b. Human Body Current Waveform*

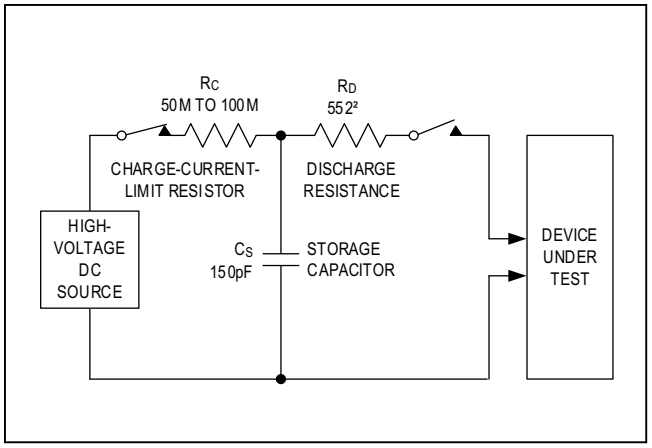


*Figure 23a. IEC 1000-4-2 ESD Test Model*

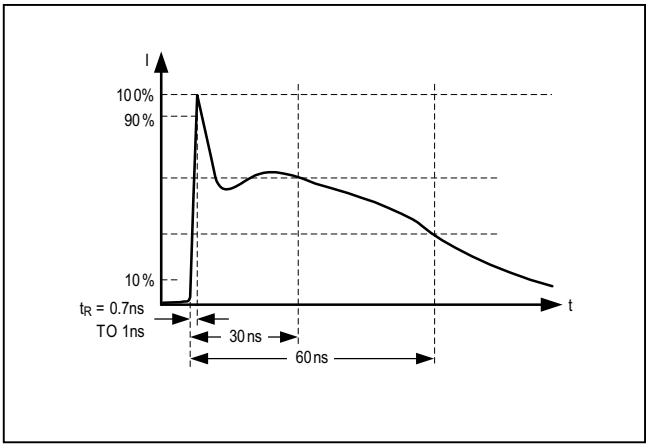


*Figure 23b. IEC 1000-4-2 ESD Generator Current Waveform*

The air-gap test involves approaching the device with a charged probe. The contact-discharge method connects the probe to the device before the probe is energized.

### Machine Model

The Machine Model for ESD tests all pins using a 200pF storage capacitor and zero discharge resistance. Its objective is to emulate the stress caused when I/O pins are contacted by handling equipment during test and assembly. Of course, all pins require this protection, not just RS-485 inputs and outputs.

## Typical Applications

The MAX3483E/MAX3485E/MAX3486E/MAX3488E/MAX3490E/MAX3491E transceivers are designed for bidirectional data communications on multipoint bus transmission lines. Figures 24 and 25 show typical network applications circuits. These parts can also be used as line repeaters, with cable lengths longer than 4000 feet, as shown in Figure 21.

To minimize reflections, the line should be terminated at both ends in its characteristic impedance, and stub lengths off the main line should be kept as short as possible. The slew-rate-limited MAX3483E/MAX3488E and the partially slew-rate-limited MAX3486E are more tolerant of imperfect termination.



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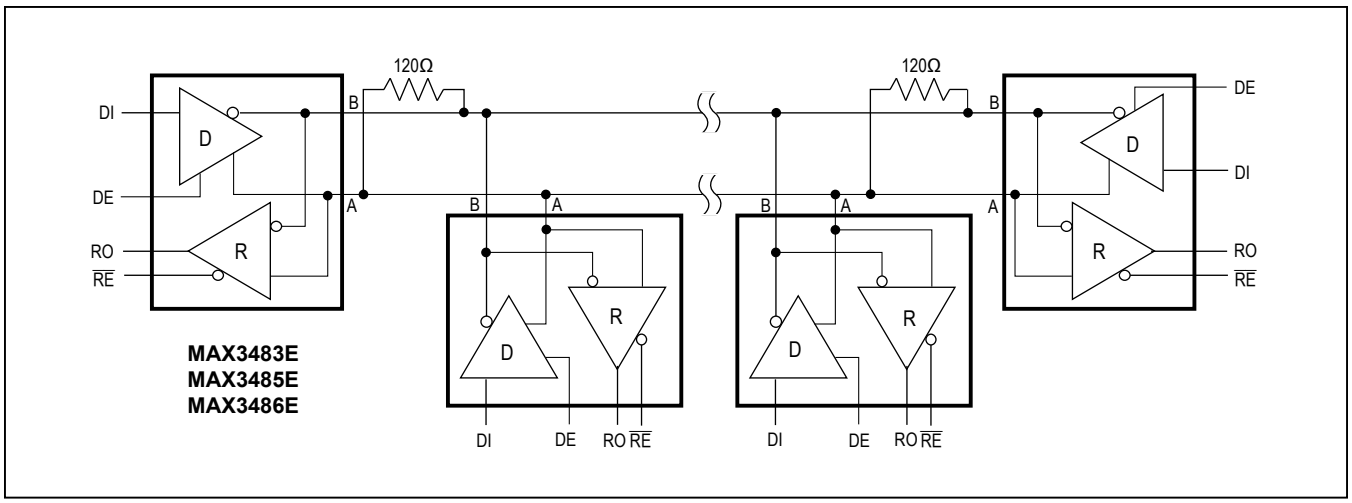


*Figure 24. MAX3483E/MAX3485E/MAX3486E Typical RS-485 Network*

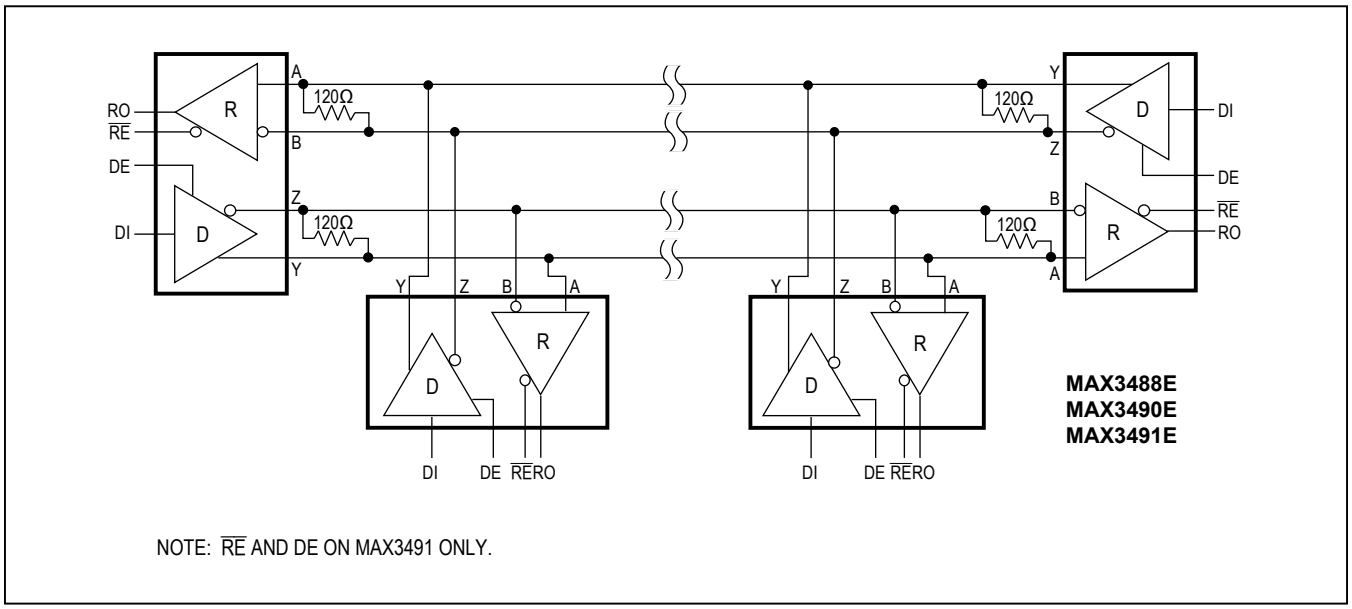


*Figure 25. MAX3488E/MAX3490E/MAX3491E Full-Duplex RS-485 Network*



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## Ordering Information (continued)

| PART | TEMP. RANGE | PIN-PACKAGE |
|---|---|---|
| **MAX3485E**CSA | 0°C to+70°C | 8 SO |
| MAX3485ECPA | 0°C to+70°C | 8 Plastic DIP |
| MAX3485EESA | -40°C to+85°C | 8 SO |
| MAX3485EEPA | -40°C to+85°C | 8 Plastic DIP |
| **MAX3486E**CSA | 0°C to +70°C | 8 SO |
| MAX3486ECPA | 0°C to +70°C | 8 Plastic DIP |
| MAX3486EESA | -40°C to +85°C | 8 SO |
| MAX3486EEPA | -40°C to +85°C | 8 Plastic DIP |
| **MAX3488E**CSA | 0°C to +70°C | 8 SO |
| MAX3488ECPA | 0°C to +70°C | 8 Plastic DIP |
| MAX3488EESA | -40°C to +85°C | 8 SO |
| MAX3488EEPA | -40°C to +85°C | 8 Plastic DIP |
| **MAX3490E**CSA | 0°C to +70°C | 8 SO |
| MAX3490ECPA | 0°C to +70°C | 8 Plastic DIP |
| MAX3490EESA | -40°C to +85°C | 8 SO |
| MAX3490EEPA | -40°C to +85°C | 8 Plastic DIP |
| **MAX3491E**CSD | 0°C to +70°C | 14 SO |
| MAX3491ECPD | 0°C to +70°C | 14 Plastic DIP |
| MAX3491EESD | -40°C to +85°C | 14 SO |
| MAX3491EEPD | -40°C to +85°C | 14 Plastic DIP |

## Chip Information

TRANSISTOR COUNT: 761



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## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 4/99 | Initial release | — |
| 1 | 5/19 | Updated *Absolute Maximum Ratings* and *Package Information* section | 2 |

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