

### Description

The [XR33152](#), [XR33155](#), [XR33156](#) and [XR33158](#) (XR3315x) family of high performance RS-485/RS-422 devices are designed for improved performance in noisy industrial environments and increased tolerance to system faults.

The analog bus pins can withstand direct shorts up to ±60V and are protected against ESD events up to ±15kV HBM. An extended ±25V common mode operating range allows for more reliable operation in noisy environments.

The XR3315x receivers include full fail-safe circuitry, guaranteeing a logic high receiver output when the receiver inputs are open, shorted or undriven. The XR33152/55 receiver input impedance is at least 120kΩ (1/10 unit load), allowing more than 320 devices on the bus. The XR33156/58 receiver input impedance is at least 30kΩ (1/2.5 unit load), allowing more than 80 devices on the bus.

The drivers are protected by short circuit detection as well as thermal shutdown and maintain high impedance in shutdown or when powered off. The XR33152 driver is slew limited for reduced EMI and error-free communication over long or unterminated data cables.

The XR3315x family of high performance RS-485/RS-422 devices are designed for improved performance in noisy industrial environments and increased tolerance to system faults.

The devices with DE and  $\overline{RE}$  pins include hot swap circuitry to prevent false transitions on the bus during power up or live insertion and can enter a 1nA low current shutdown mode for extreme power savings.

### FEATURES

- 3.0V to 5.5V operation
- ±60V fault tolerance on analog bus pins
- Extended ±25V common mode operation
- Robust ESD protection:
  - ±15kV HBM (bus pins)
  - ±4kV HBM (non-bus pins)
- 1.65V to 5.5V logic Interface VL pin (full-duplex package option)
- Invert control to correct for reversed bus pins
- Enhanced receiver fail-safe protection for open, shorted or terminated but idle data lines
- Hot swap glitch protection on DE and  $\overline{RE}$  pins
- Driver short-circuit current limit and thermal shutdown for overload protection
- Reduced unit loads allows up to 320 devices on bus
- Industry standard 8-pin and 14-pin NSOIC packages
- -40°C to 85°C and -40°C to 105°C ambient operating temperature ranges

### APPLICATIONS

- Industrial control networks
- HVAC networks
- Building and process automation
- Remote utility meter reading
- Energy monitoring and control
- Long or unterminated transmission lines

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### Typical Application

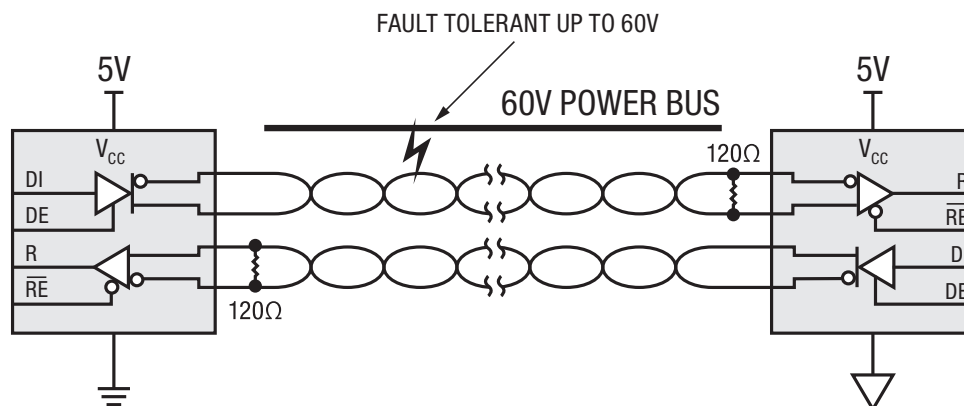


Figure 1. Typical Application

**Absolute Maximum Ratings**

Stresses beyond the limits listed below may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

|   |                              |
|---|------------------------------|
| $V_{CC}$ .....  | -0.3V to 7.0V                |
| $V_L$ .....   | $V_L \leq V_{CC}$            |
| Input voltage at control and driver input (DE, DI and INV)<br>XR33152/55/58.....                    | -0.3V to ( $V_{CC} + 0.3V$ ) |
| Receiver output voltage (RO)<br>XR33152/55/58.....  | -0.3V to ( $V_{CC} + 0.3V$ ) |
| Input voltage at control ( $\overline{RE}$ ) XR33156<br>.....                                       | -0.3V to ( $V_L + 0.3V$ )    |
| Input voltage at control and driver input<br>(DE, DI, $R_{INV}$ , $D_{INV}$ , and INV) XR33156..... | -0.3V to 7.0V                |
| Receiver output voltage (RO)<br>XR33156.....  | -0.3V to ( $V_L + 0.3V$ )    |
| Driver output voltage (Y, Z, A/Y and B/Z) .....   | $\pm 60V$                    |
| Receiver input voltage (A, B, A/Y and B/Z) .....  | $\pm 60V$                    |
| Transient voltage pulse, through 100 $\Omega$ (Figure 7) .....                                      | $\pm 100V$                   |
| Driver output current.....  | $\pm 250mA$                  |
| Storage temperature range .....   | -65°C to 150°C               |
| Lead temperature (soldering 10 seconds).....  | 300°C                        |
| Maximum junction temperature .....  | 150°C                        |

**ESD Ratings**

|   |            |
|---|------------|
| HBM - Human Body Model (A, B, Y and Z pins) ..... | $\pm 15kV$ |
| HBM - Human Body Model (all other pins).....      | $\pm 4kV$  |

**Operating Conditions**

|  |                |
|--|----------------|
| Supply voltage range.....                                      | 3.0V to 5.5V   |
| Operating temperature range .....                              | -40°C to 105°C |
| Package power dissipation,<br>8-pin NSOIC $\theta_{JA}$ .....  | 128.4°C/W      |
| Package power dissipation,<br>14-pin NSOIC $\theta_{JA}$ ..... | 86°C/W         |

## Electrical Characteristics

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5.0V$ ,  $T_A = 25^\circ C$ .

| Symbol                           | Parameter  | Conditions  | Min        | Typ | Max        | Units   |
|----------------------------------|--|---|------------|-----|------------|---------|
| <b>Driver DC Characteristics</b> |  |   |            |     |            |         |
| $V_{CC}$                         | Supply voltage range   |   | 3.0        |     | 5.5        | V       |
| $V_L$                            | I/O logic supply voltage range                                     | $V_L \leq V_{CC}$   | 1.65       |     | 5.5        | V       |
| $V_{OD}$                         | Differential driver output,<br>$4.5V \leq V_{CC} \leq 5.5V$        | $R_L = 100\Omega$ (RS-422), Figure 4  | 2          |     | $V_{CC}$   | V       |
|                                  |  | $R_L = 54\Omega$ (RS-485), Figure 4   | 1.5        |     | $V_{CC}$   | V       |
|                                  |  | $-25V \leq V_{CM} \leq 25V$ , Figure 5  | 1.5        |     | $V_{CC}$   | V       |
| $V_{OD}$                         | Differential driver output,<br>$3.0V \leq V_{CC} \leq 4.5V$        | $R_L = 100\Omega$ (RS-422), Figure 4  | 0.85       |     | $V_{CC}$   | V       |
|                                  |  | $R_L = 54\Omega$ (RS-485), Figure 4   | 0.65       |     | $V_{CC}$   | V       |
| $\Delta V_{OD}$                  | Change in magnitude of differential output voltage, Note 1         |   |            |     | $\pm 0.2$  | V       |
| $V_{CM}$                         | Driver common-mode output voltage (steady state)                   | $R_L = 100\Omega$ (RS-422) or<br>$R_L = 54\Omega$ (RS-485), Figure 4                      | 1          |     | 3          | V       |
| $\Delta V_{CM}$                  | Change in magnitude of common-mode output voltage, Note 1          |   |            |     | $\pm 0.2$  | V       |
| $V_{IH}$                         | Logic high input thresholds (DI, DE and INV)                       | $V_{CC} = 3.3V$ , for XR33152/55/58   | 2.0        |     |            | V       |
|                                  |  | $V_{CC} = 5.0V$ , for XR33152/55/58   | 2.4        |     |            | V       |
| $V_{IL}$                         | Logic low input thresholds (DI, DE and INV)                        | For XR33152/55/58   |            |     | 0.8        | V       |
| $V_{IH}$                         | Logic high input thresholds (DI, DE, RE, $D_{INV}$ and $R_{INV}$ ) | $V_L \leq V_{CC}$ , for XR33156   | $(2/3)V_L$ |     |            | V       |
| $V_{IL}$                         | Logic low input thresholds (DI, DE, RE, $D_{INV}$ and $R_{INV}$ )  | $V_L \leq V_{CC}$ , for XR33156   |            |     | $(1/3)V_L$ | V       |
| $V_{HYS}$                        | Input hysteresis (DI, DE, RE, $D_{INV}$ , $R_{INV}$ and INV)       |   |            | 100 |            | mV      |
| $I_{IN}$                         | Logic input current (DI, DE and $\overline{RE}$ )                  | $0V \leq V_{IN} \leq V_{CC}$ , for XR33152/55/58<br>After first transition, Note 2        |            |     | $\pm 1$    | $\mu A$ |
|                                  | Logic input current (INV)  | $V_{IN} = V_{CC} = 5.5V$ , for XR33152/55/58  | 25         | 33  | 55         | $\mu A$ |
|                                  | Logic input current (DI, DE and $\overline{RE}$ )                  | $0V \leq V_{IN} \leq V_L = V_{CC} = 5.5V$ , for XR33156<br>After first transition, Note 2 |            |     | $\pm 1$    | $\mu A$ |
|                                  | Logic input current ( $D_{INV}$ and $R_{INV}$ )                    | $V_{IN} = V_L = V_{CC} = 5.5V$ , for XR33156  | 25         | 33  | 55         | $\mu A$ |
| $I_{INHS}$                       | Logic input current hot swap (DE and $\overline{RE}$ )             | Until first transition, Note 2  |            | 100 | $\pm 200$  | $\mu A$ |
| $I_{A, B}$                       | Input current (A and B)  | $V_{CC} = 0V$ or $5.5V$ , $V_{OUT} = 12V$ ,<br>DE = $0V$ , for XR33152/55                 |            |     | 100        | $\mu A$ |
|                                  |  | $V_{CC} = 0V$ or $5.5V$ , $V_{OUT} = -7V$ ,<br>DE = $0V$ , for XR33152/55                 | -80        |     |            | $\mu A$ |
|                                  |  | $V_{OUT} = 12V$ , DE = $0V$ ,<br>$V_{CC} = 0V$ or $5.5V$ , for XR33156/58                 |            |     | 400        | $\mu A$ |
|                                  |  | $V_{OUT} = -7V$ , DE = $0V$ ,<br>$V_{CC} = 0V$ or $5.5V$ , for XR33156/58                 | -320       |     |            | $\mu A$ |

### NOTES:

- Change in magnitude of differential output voltage and change in magnitude of common mode output voltage are the changes in output voltage when DI input changes state.
- The hot swap feature disables the DE and  $\overline{RE}$  inputs for the first  $10\mu s$  after power is applied. Following this time period, these inputs are weakly pulled to their disabled state (low for DE, high for RE) until the first transition, after which they become high impedance inputs.

## Electrical Characteristics (Continued)

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5.0V$ ,  $T_A = 25^\circ C$ .

| Symbol                         | Parameter   | Conditions  | Min            | Typ      | Max       | Units      |
|--------------------------------|---|---|----------------|----------|-----------|------------|
| $I_{OL}$                       | Output leakage (Y and Z)<br>Full-duplex   | $V_{OUT} = 12V$ , $DE = 0V$ , $V_{CC} = 0V$ or $5.5V$   |                |          | 100       | $\mu A$    |
|                                |   | $V_{OUT} = -7V$ , $DE = 0V$ , $V_{CC} = 0V$ or $5.5V$   | -80            |          |           | $\mu A$    |
| $I_{OSD}$                      | Driver short-circuit output current   | $-60V \leq V_{OUT} \leq 60V$ , Figure 6   |                |          | $\pm 250$ | $mA$       |
| Driver Thermal Characteristics |   |   |                |          |           |            |
| $T_{TS}$                       | Thermal shutdown temperature  | Junction temperature, Note 1  |                | 175      |           | $^\circ C$ |
| $T_{TSH}$                      | Thermal shutdown hysteresis   | Note 1  |                | 15       |           | $^\circ C$ |
| Receiver DC Characteristics    |   |   |                |          |           |            |
| $V_{STH}$                      | Receiver differential input signal threshold voltage ( $V_A - V_B$ )                  | $-25V \leq V_{OUT} \leq 25V$  |                | $\pm 85$ | $\pm 200$ | $mV$       |
| $\Delta V_{STH}$               | Receiver differential input signal hysteresis   |   |                | 170      |           | $mV$       |
| $V_{FSTH-}$                    | Negative going receiver differential input failsafe threshold voltage ( $V_A - V_B$ ) | $-25V \leq V_{OUT} \leq 25V$  | -200           | -125     | -40       | $mV$       |
| $V_{FSTH+}$                    | Positive going receiver differential input failsafe threshold voltage ( $V_A - V_B$ ) | $-25V \leq V_{OUT} \leq 25V$  |                | -100     | -10       | $mV$       |
| $\Delta V_{FSTH}$              | Receiver differential input failsafe hysteresis                                       |   |                | 25       |           | $mV$       |
| $V_{OH}$                       | Receiver output high voltage (RO)   | $I_{OUT} = -4mA$ , for XR33152/55/58  | $V_{CC} - 0.6$ |          |           | $V$        |
| $V_{OL}$                       | Receiver output low voltage (RO)  | $I_{OUT} = 4mA$ , for XR33152/55/58   |                |          | 0.4       | $V$        |
| $V_{OH}$                       | Receiver output high voltage (RO)   | $3.0V \leq V_L \leq 5.5V$ , $I_{OUT} = -4mA$ ,<br>$1.6V \leq V_L \leq 3.0V$ , $I_{OUT} = -1mA$ ,<br>for XR33156 | $V_L - 0.6$    |          |           | $V$        |
| $V_{OL}$                       | Receiver output low voltage (RO)  | $3.0V \leq V_L \leq 5.5V$ , $I_{OUT} = 4mA$ ,<br>$1.6V \leq V_L \leq 3.0V$ , $I_{OUT} = 1mA$ ,<br>for XR33156   |                |          | 0.4       | $V$        |
| $I_{OZR}$                      | High-Z receiver output current  | $0V \leq V_{OUT} \leq V_{CC}$ , for XR33152/55/58<br>$0V \leq V_{OUT} \leq V_L$ , for XR33156                   |                |          | $\pm 1$   | $\mu A$    |
| $R_{IN}$                       | RX input resistance   | $-25V \leq V_{CM} \leq 25V$ , for XR33152/55  | 120            |          |           | $k\Omega$  |
|                                |   | $-25V \leq V_{CM} \leq 25V$ , for XR33156/58  | 30             |          |           | $k\Omega$  |
| $I_{OSC}$                      | RX output short-circuit current   | $0V \leq V_{RO} \leq V_{CC}$ , for XR33152/55/58  |                |          | 110       | $mA$       |
|                                | RX output short-circuit current   | $0V \leq V_{RO} \leq V_L$ , for XR33156   |                |          | 110       | $mA$       |
| Supply Current                 |   |   |                |          |           |            |
| $I_{CC}$                       | Supply current  | No load, $\overline{RE} = 0V$ or $V_{CC}$ ,<br>$DE = V_{CC}$ , $DI = 0V$ or $V_{CC}$                            |                |          | 4         | $mA$       |
| $I_{SHDN}$                     | Supply current in shutdown mode   | $\overline{RE} = V_{CC}$ , $DE = 0V$  |                | 0.001    | 1         | $\mu A$    |

## NOTES:

1. This spec is guaranteed by design and bench characterization.

**Electrical Characteristics (Continued)**

**Driver AC Characteristics - XR33152 (250kbps)**

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5.0V$ ,  $T_A = 25^{\circ}C$ .

| Symbol                | Parameter                                    | Conditions                                  | Min | Typ | Max  | Units |
|-----------------------|--|---|-----|-----|------|-------|
| $t_{DPLH}$            | Driver propagation delay (low to high)       | $C_L = 50pF$ , $R_L = 54\Omega$ , Figure 7  | 350 |     | 1500 | ns    |
| $t_{DPHL}$            | Driver propagation delay (high to low)       |   | 350 |     | 1600 | ns    |
| $ t_{DPLH}-t_{DPHL} $ | Differential driver output skew              |   |     | 20  | 200  | ns    |
| $t_{DR}$ , $t_{DF}$   | Driver differential output rise or fall time |   |     | 400 |      | 1500  |
|                       | Maximum data rate                            | $1/t_{UI}$ , duty cycle 40% to 60%          | 250 |     |      | kbps  |
| $t_{DZH}$             | Driver enable to output high                 | $C_L = 50pF$ , $R_L = 500\Omega$ , Figure 8 |     | 200 | 2500 | ns    |
| $t_{DZL}$             | Driver enable to output low                  |   |     | 200 | 2500 | ns    |
| $t_{DZH}$             | Driver disable from output high              |   |     |     | 250  | ns    |
| $t_{DLZ}$             | Driver disable from output low               |   |     |     | 250  | ns    |
| $t_{RZH}(SHDN)$       | Driver enable from shutdown to output high   | $C_L = 50pF$ , $R_L = 500\Omega$ , Figure 8 |     |     | 5500 | ns    |
| $t_{RZL}(SHDN)$       | Driver enable from shutdown to output low    |   |     |     | 5500 | ns    |
| $t_{SHDN}$            | Time to shutdown                             | Notes 1 and 2                               | 50  | 200 | 600  | ns    |

**Receiver AC Characteristics -XR33152 (250kbps)**

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5.0V$ ,  $T_A = 25^{\circ}C$ .

| Symbol                | Parameter                                    | Conditions   | Min | Typ | Max  | Units |
|-----------------------|--|--|-----|-----|------|-------|
| $t_{RPLH}$            | Receiver propagation delay (low to high)     | $C_L = 15pF$ , $V_{ID} = \pm 2V$ , $V_{ID}$ rise and fall times < 15ns, Figure 9 |     |     | 200  | ns    |
| $t_{RPHL}$            | Receiver propagation delay (high to low)     |  |     |     | 200  | ns    |
| $ t_{RPLH}-t_{RPHL} $ | Receiver propagation delay skew              |  |     |     | 30   | ns    |
|                       | Maximum data rate                            | $1/t_{UI}$ , duty cycle 40% to 60%   | 250 |     |      | kbps  |
| $t_{RZH}$             | Receiver enable to output high               | $C_L = 15pF$ , $R_L = 1k\Omega$ , Figure 10                                      |     |     | 50   | ns    |
| $t_{RZL}$             | Receiver enable to output low                |  |     |     | 50   | ns    |
| $t_{RHZ}$             | Receiver disable from output high            |  |     |     | 50   | ns    |
| $t_{RLZ}$             | Receiver disable from output low             |  |     |     | 50   | ns    |
| $t_{RZH}(SHDN)$       | Receiver enable from shutdown to output high | $C_L = 15pF$ , $R_L = 1k\Omega$ , Figure 10                                      |     |     | 3500 | ns    |
| $t_{RZL}(SHDN)$       | Receiver enable from shutdown to output low  |  |     |     | 3500 | ns    |
| $t_{SHDN}$            | Time to shutdown                             | Notes 1 and 2  | 50  | 200 | 600  | ns    |

**NOTES:**

1. The transceivers are put into shutdown by bringing  $\overline{RE}$  high and DE low simultaneously for at least 600ns. If the control inputs are in this state for less than 50ns, the device is guaranteed to not enter shutdown. If the enable inputs are held in this state for at least 600ns, the device is ensured to be in shutdown. Note that the receiver and driver enable times increase significantly when coming out of shutdown.
2. This spec is guaranteed by design and bench characterization.

**Electrical Characteristics (Continued)**

**Driver AC Characteristics - XR33155 (1Mbps)**

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5.0V$ ,  $T_A = 25^{\circ}C$ .

| Symbol                  | Parameter                                    | Conditions                                  | Min | Typ  | Max  | Units |    |
|-------------------------|--|---|-----|------|------|-------|----|
| $t_{DPLH}$              | Driver propagation delay (low to high)       | $C_L = 50pF$ , $R_L = 54\Omega$ , Figure 7  |     | 150  | 500  | ns    |    |
| $t_{DPHL}$              | Driver propagation delay (high to low)       |   |     | 150  | 500  | ns    |    |
| $ t_{DPLH} - t_{DPHL} $ | Differential driver output skew              |   |     |      | 5    | 50    | ns |
| $t_{DR}$ , $t_{DF}$     | Driver differential output rise or fall time |   |     | 100  | 200  | 300   | ns |
|                         | Maximum data rate                            | $1/t_{UI}$ , duty cycle 40% to 60%          | 1   |      |      | Mbps  |    |
| $t_{DZH}$               | Driver enable to output high                 | $C_L = 50pF$ , $R_L = 500\Omega$ , Figure 8 |     | 1000 | 2500 | ns    |    |
| $t_{DZL}$               | Driver enable to output low                  |   |     | 1000 | 2500 | ns    |    |
| $t_{DZH}$               | Driver disable from output high              |   |     |      | 250  | ns    |    |
| $t_{DLZ}$               | Driver disable from output low               |   |     |      | 250  | ns    |    |
| $t_{DZH(SHDN)}$         | Driver enable from shutdown to output high   | $C_L = 50pF$ , $R_L = 500\Omega$ , Figure 8 |     | 2500 | 4500 | ns    |    |
| $t_{DZL(SHDN)}$         | Driver enable from shutdown to output low    |   |     | 2500 | 4500 | ns    |    |
| $t_{SHDN}$              | Time to shutdown                             | Notes 1 and 2                               | 50  | 200  | 600  | ns    |    |

**Receiver AC Characteristics - XR33155 (1Mbps)**

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5.0V$ ,  $T_A = 25^{\circ}C$ .

| Symbol                  | Parameter                                    | Conditions   | Min | Typ | Max  | Units |
|-------------------------|--|--|-----|-----|------|-------|
| $t_{RPLH}$              | Receiver propagation delay (low to high)     | $C_L = 15pF$ , $V_{ID} = \pm 2V$ , $V_{ID}$ rise and fall times < 15ns, Figure 9 |     |     | 200  | ns    |
| $t_{RPHL}$              | Receiver propagation delay (high to low)     |  |     |     | 200  | ns    |
| $ t_{RPLH} - t_{RPHL} $ | Receiver propagation delay skew              |  |     |     | 30   | ns    |
|                         | Maximum data rate                            | $1/t_{UI}$ , duty cycle 40% to 60%   | 1   |     |      | Mbps  |
| $t_{RZH}$               | Receiver enable to output high               | $C_L = 15pF$ , $R_L = 1k\Omega$ , Figure 10                                      |     |     | 50   | ns    |
| $t_{RZL}$               | Receiver enable to output low                |  |     |     | 50   | ns    |
| $t_{RHZ}$               | Receiver disable from output high            |  |     |     | 50   | ns    |
| $t_{RLZ}$               | Receiver disable from output low             |  |     |     | 50   | ns    |
| $t_{RZH(SHDN)}$         | Receiver enable from shutdown to output high | $C_L = 15pF$ , $R_L = 1k\Omega$ , Figure 10                                      |     |     | 3500 | ns    |
| $t_{RZL(SHDN)}$         | Receiver enable from shutdown to output low  |  |     |     | 3500 | ns    |
| $t_{SHDN}$              | Time to shutdown                             | Notes 1 and 2  | 50  | 200 | 600  | ns    |

**NOTES:**

1. The transceivers are put into shutdown by bringing  $\overline{RE}$  high and DE low simultaneously for at least 600ns. If the control inputs are in this state for less than 50ns, the device is guaranteed to not enter shutdown. If the enable inputs are held in this state for at least 600ns, the device is ensured to be in shutdown. Note that the receiver and driver enable times increase significantly when coming out of shutdown.
2. This spec is guaranteed by design and bench characterization.

## Electrical Characteristics (Continued)

### Driver AC Characteristics - XR33156 and XR33158 (20Mbps)

Unless otherwise noted:  $V_{CC} = 3.0V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5.0V$ ,  $T_A = 25^\circ C$ .

| Symbol                  | Parameter                                    | Conditions                                     | Min | Typ | Max  | Units |
|-------------------------|--|--|-----|-----|------|-------|
| $t_{DPLH}$              | Driver prop. delay (low to high)             | $C_L = 50pF$ , $R_L = 54\Omega$ ,<br>Figure 7  |     |     | 25   | ns    |
| $t_{DPHL}$              | Driver prop. delay (high to low)             |  |     |     | 25   | ns    |
| $ t_{DPLH} - t_{DPHL} $ | Differential driver output skew              |  |     |     | 5    | ns    |
| $t_{DR}$ , $t_{DF}$     | Driver differential output rise or fall time |  |     |     | 15   | ns    |
|                         | Maximum data rate                            | $1/t_{UI}$ , duty cycle 40% to 60%             | 20  |     |      | Mbps  |
| $t_{DZH}$               | Driver enable to output high                 | $C_L = 50pF$ , $R_L = 500\Omega$ ,<br>Figure 8 |     |     | 60   | ns    |
| $t_{DZL}$               | Driver enable to output low                  |  |     |     | 60   | ns    |
| $t_{DHZ}$               | Driver disable from output high              |  |     |     | 250  | ns    |
| $t_{DLZ}$               | Driver disable from output low               |  |     |     | 250  | ns    |
| $t_{DZH(SHDN)}$         | Driver enable from shutdown to output high   | $C_L = 50pF$ , $R_L = 500\Omega$ ,<br>Figure 8 |     |     | 2200 | ns    |
| $t_{DZL(SHDN)}$         | Driver enable from shutdown to output low    |  |     |     | 2200 | ns    |
| $t_{SHDN}$              | Time to shutdown                             | Notes 1 and 2                                  | 50  | 200 | 600  | ns    |

### Receiver AC Characteristics - XR33156 and XR33158 (20Mbps)

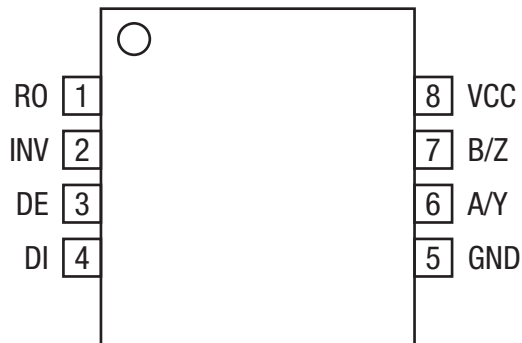
Unless otherwise noted:  $V_{CC} = 3.0V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5.0V$ ,  $T_A = 25^\circ C$ .

| Symbol                  | Parameter                                    | Conditions   | Min | Typ | Max  | Units |
|-------------------------|--|--|-----|-----|------|-------|
| $t_{RPLH}$              | Receiver prop. delay (low to high)           | $C_L = 15pF$ , $V_{ID} = \pm 2V$ ,<br>$V_{ID}$ rise and fall times < 15ns,<br>Figure 9 |     |     | 60   | ns    |
| $t_{RPHL}$              | Receiver prop. delay (high to low)           |  |     |     | 60   | ns    |
| $ t_{RPLH} - t_{RPHL} $ | Receiver propagation delay skew              |  |     |     | 5    | ns    |
|                         | Maximum data rate                            | $1/t_{UI}$ , duty cycle 40% to 60%   | 20  |     |      | Mbps  |
| $t_{RZH}$               | Receiver enable to output high               | $C_L = 15pF$ , $R_L = 1k\Omega$ ,<br>Figure 10, for XR33156                            |     |     | 50   | ns    |
| $t_{RZL}$               | Receiver enable to output low                |  |     |     | 50   | ns    |
| $t_{RHZ}$               | Receiver disable from output high            |  |     |     | 50   | ns    |
| $t_{RLZ}$               | Receiver disable from output low             |  |     |     | 50   | ns    |
| $t_{RZH(SHDN)}$         | Receiver enable from shutdown to output high | $C_L = 15pF$ , $R_L = 1k\Omega$ ,<br>Figure 10, for XR33156                            |     |     | 2200 | ns    |
| $t_{RZL(SHDN)}$         | Receiver enable from shutdown to output low  |  |     |     | 2200 | ns    |
| $t_{SHDN}$              | Time to shutdown                             | Notes 1 and 2, for XR33156   | 50  | 200 | 600  | ns    |

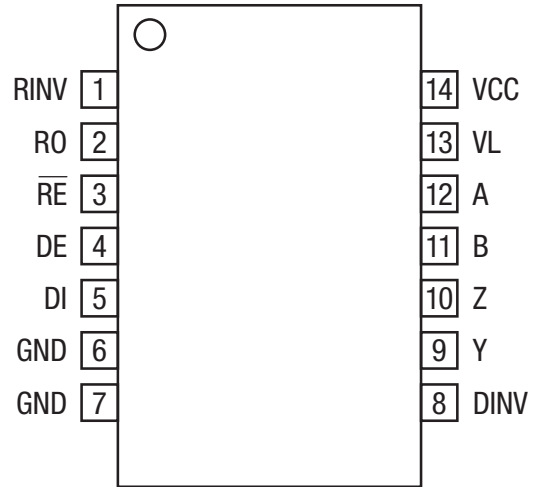
#### NOTES:

- The transceivers are put into shutdown by bringing  $\overline{RE}$  high and DE low simultaneously for at least 600ns. If the control inputs are in this state for less than 50ns, the device is guaranteed to not enter shutdown. If the enable inputs are held in this state for at least 600ns, the device is ensured to be in shutdown. Note that the receiver and driver enable times increase significantly when coming out of shutdown.
- This spec is guaranteed by design and bench characterization.

Pin Configurations



XR33152, XR33155 and XR33158 Half-duplex



XR33156 Full-duplex

Pin Functions

| Pin Number                                   |                        | Pin Name        | Type | Description   |
|--|------------------------|-----------------|------|---|
| Half-duplex<br>XR33152<br>XR33155<br>XR33158 | Full-duplex<br>XR33156 |                 |      |   |
| -  | 1                      | RINV            | I    | Receiver invert control (active high). When enabled, the polarity of the receiver bus pins (A & B) is reversed: A = inverting and B = non-inverting. When disabled, the receiver bus pins (A & B) operate normally: A = non-inverting and B = inverting. The R <sub>INV</sub> pin has a 150kΩ pull-down resistor. |
| 1  | 2                      | RO              | O    | Receiver output, when $\overline{RE}$ is low and if (A-B) ≥ 200mV, RO is high. If (A-B) ≤ -200mV, RO is low. If inputs are left floating, shorted together or terminated and undriven for more than 2μs the output is high.   |
| 2  | -                      | INV             | I    | Driver and receiver invert control (active high). When enabled, the polarity of the driver input and receiver input bus pins is inverted. When disabled, the driver input and receiver inputs operate normally: A = non-inverting and B = inverting. The INV pin has a 150kΩ pull-down resistor.                  |
| -  | 3                      | $\overline{RE}$ | I    | Receiver output enable (hot swap). When $\overline{RE}$ is low, RO is enabled. When $\overline{RE}$ is high, RO is high impedance. $\overline{RE}$ should be high and DE should be low to enter shutdown mode.  |
| 3  | 4                      | DE              | I    | Driver output enable (hot swap). When DE is high, outputs are enabled. When DE is low, outputs are high impedance. DE should be low and $\overline{RE}$ should be high to enter shutdown mode.  |
| 4  | 5                      | DI              | I    | Driver input. With DE high, a low level on DI forces non-inverting output low and inverting output high. Similarly, a high level on DI forces non-inverting output high and inverting output low.   |
| 5  | 6, 7                   | GND             | PWR  | Ground.   |
| 6  | -                      | A/Y             | I/O  | Non-inverting receiver input and non-Inverting driver output.   |
| 7  | -                      | B/Z             | I/O  | Inverting receiver input and Inverting driver output.   |

**NOTE:**  
Type: I = Input, O = Output, I/O = Input/Output, PWR = Power.



## Pin Functions (Continued)

| Pin Number                                   |                        | Pin Name | Type | Description   |
|--|------------------------|----------|------|---|
| Half-duplex<br>XR33152<br>XR33155<br>XR33158 | Full-duplex<br>XR33156 |          |      |   |
| 8  | 14                     | VCC      | PWR  | 3.0V to 5.5V power supply input bypass to ground with 0.1 $\mu$ F capacitor.  |
| -  | 12                     | A        | I    | Non inverting receiver input.   |
| -  | 11                     | B        | I    | Inverting receiver input.   |
| -  | 9                      | Y        | O    | Non-inverting driver output.  |
| -  | 10                     | Z        | O    | Inverting driver output.  |
| -  | 8                      | DINV     | I    | Driver invert control (active high). When enabled, the polarity of the driver input pin is inverted causing the driver output (Y & Z) polarities to be inverted. When disabled, the driver bus pins (Y & Z) operate normally: Y = non-inverting and Z = inverting. The D <sub>INV</sub> pin has a 150k $\Omega$ pull-down resistor. |
| -  | 13                     | VL       | PWR  | Logic interface power supply.   |

**NOTE:**

Type: I = Input, O = Output, I/O = Input/Output, PWR = Power.

**Pin Functions (Continued)**

XR33156 (Full-duplex - 14 Pins)

| Transmitting     |                 |    |    |                   |   |
|------------------|-----------------|----|----|-------------------|---|
| Inputs           |                 |    |    | Outputs           |   |
| D <sub>INV</sub> | $\overline{RE}$ | DE | DI | Y                 | Z |
| 0                | X               | 1  | 1  | 1                 | 0 |
| 0                | X               | 1  | 0  | 0                 | 1 |
| 1                | X               | 1  | 1  | 0                 | 1 |
| 1                | X               | 1  | 0  | 1                 | 0 |
| X                | 0               | 0  | X  | High-Z            |   |
| X                | 1               | 0  | X  | High-Z (shutdown) |   |

XR33156 (Full-duplex - 14 Pins)

| Receiving        |                 |    |                                 |                   |
|------------------|-----------------|----|---------------------------------|-------------------|
| Inputs           |                 |    |                                 | Output            |
| R <sub>INV</sub> | $\overline{RE}$ | DE | V <sub>A</sub> - V <sub>B</sub> | RO                |
| 0                | 0               | X  | $\geq 200\text{mV}$             | 1                 |
| 0                | 0               | X  | $\leq -200\text{mV}$            | 0                 |
| 0                | 0               | X  | Open/shorted                    | 1                 |
| 1                | 0               | X  | $\geq 200\text{mV}$             | 0                 |
| 1                | 0               | X  | $\leq -200\text{mV}$            | 1                 |
| 1                | 0               | X  | Open/shorted                    | 1                 |
| X                | 1               | 1  | X                               | High-Z            |
| X                | 1               | 0  | X                               | High-Z (shutdown) |

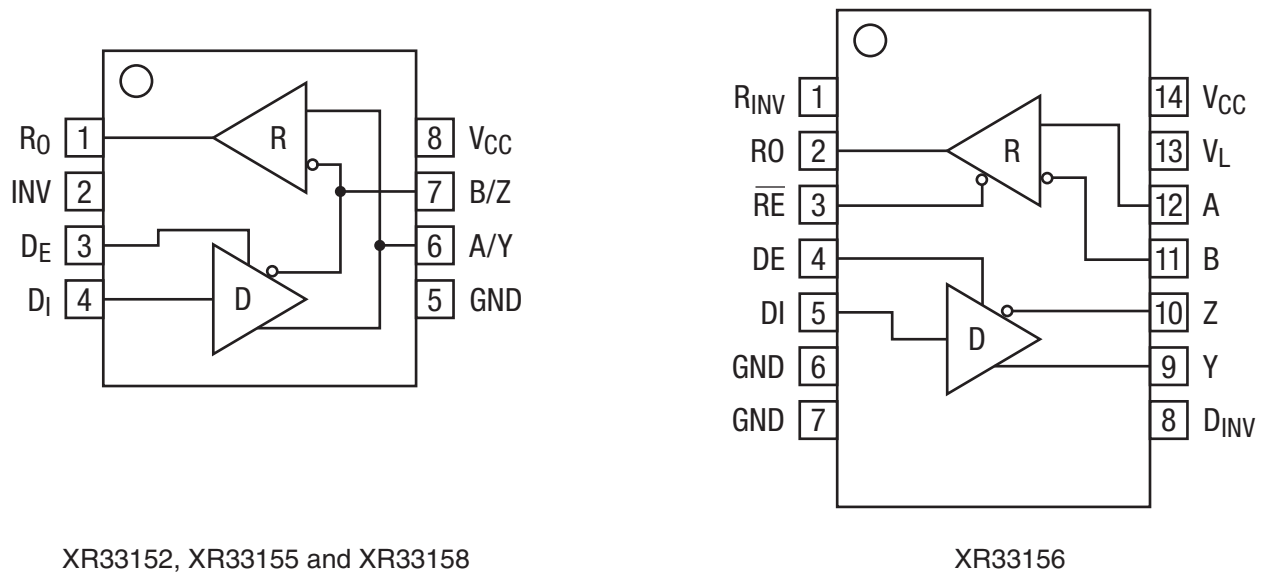
XR33152, XR33155 and XR33158 (Half-duplex - 8 Pins)

| Transmitting |    |    |         |     |
|--------------|----|----|---------|-----|
| Inputs       |    |    | Outputs |     |
| INV          | DE | DI | A/Y     | B/Z |
| 0            | 1  | 1  | 1       | 0   |
| 0            | 1  | 0  | 0       | 1   |
| 1            | 1  | 1  | 0       | 1   |
| 1            | 1  | 0  | 1       | 0   |
| X            | 0  | X  | High-Z  |     |

XR33152, XR33155 and XR33158 (Half-duplex - 8 Pins)

| Receiving |    |                                 |        |
|-----------|----|---------------------------------|--------|
| Inputs    |    |                                 | Output |
| INV       | DE | V <sub>A</sub> - V <sub>B</sub> | RO     |
| 0         | 0  | $\geq 200\text{mV}$             | 1      |
| 0         | 0  | $\leq -200\text{mV}$            | 0      |
| 1         | 0  | Open/shorted                    | 1      |
| 1         | 0  | $\geq +200\text{mV}$            | 0      |
| 1         | 0  | $\leq -200\text{mV}$            | 1      |
| 1         | 0  | Open/shorted                    | 1      |

**Applications Information**



XR33152, XR33155 and XR33158

XR33156

Figure 2. XR33152, XR33155 and XR33158 Half-duplex and XR33156 Full-duplex

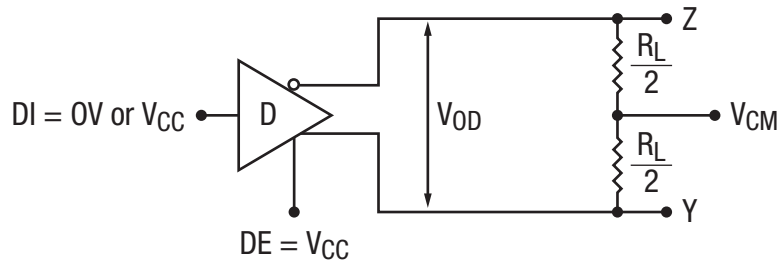


Figure 3. Differential Driver Output Voltage

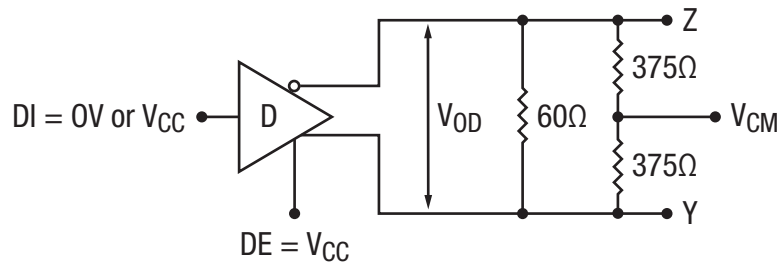


Figure 4. Differential Driver Output Voltage Over Common Mode

Applications Information (Continued)

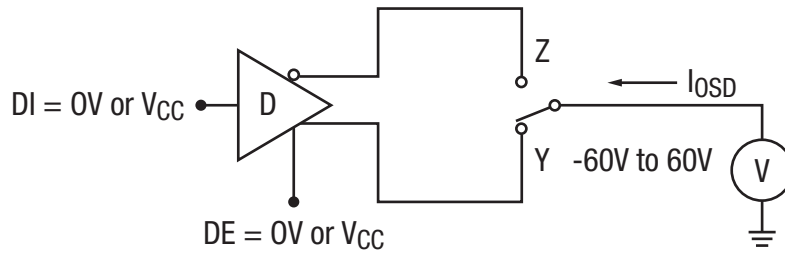


Figure 5. Driver Output Short Circuit Current

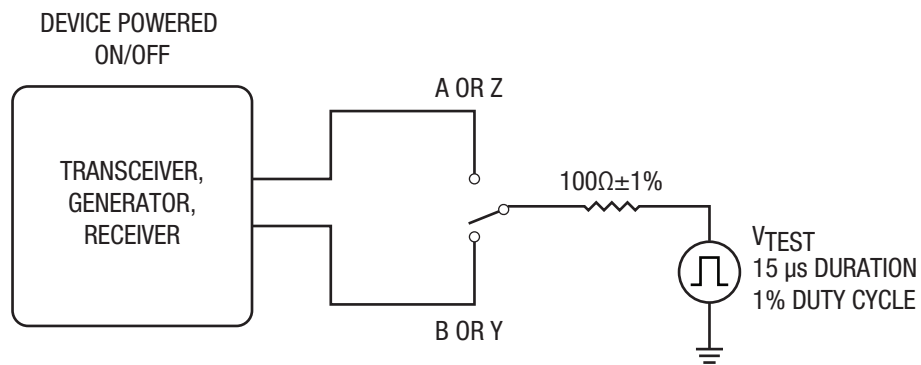


Figure 6. Transient Overvoltage Test Circuit

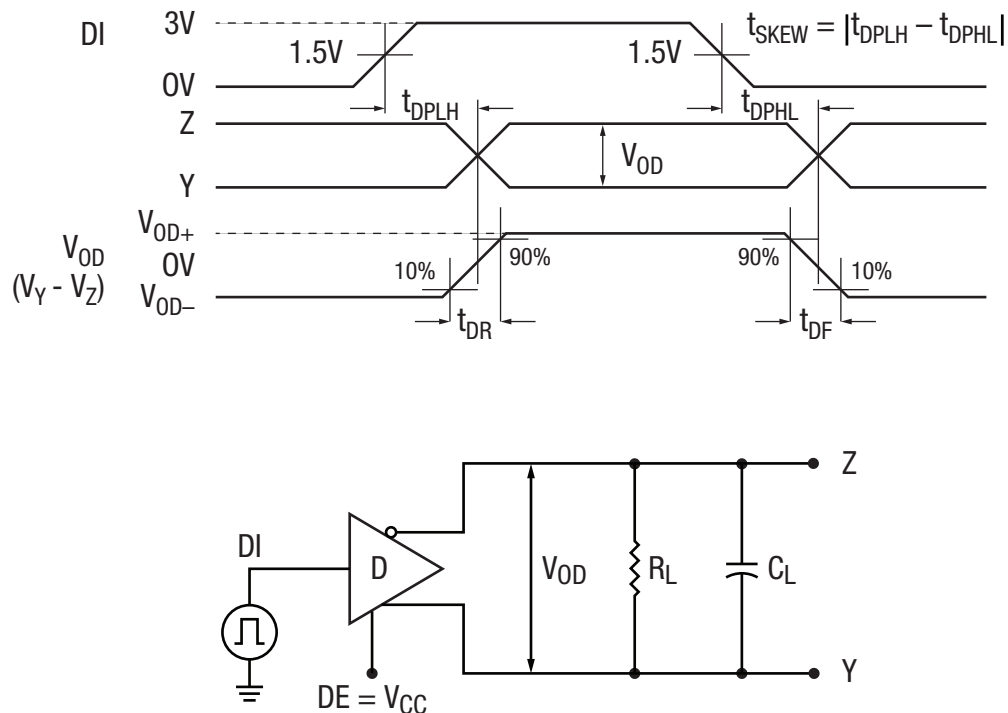


Figure 7. Driver Propagation Delay Test Circuit and Timing Diagram

Applications Information (Continued)

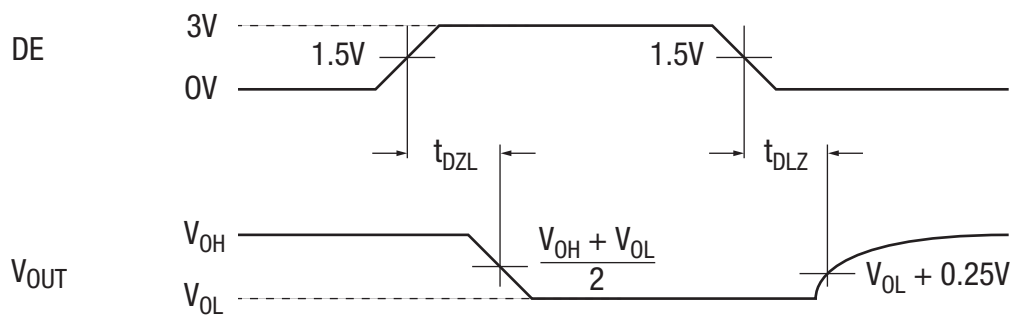
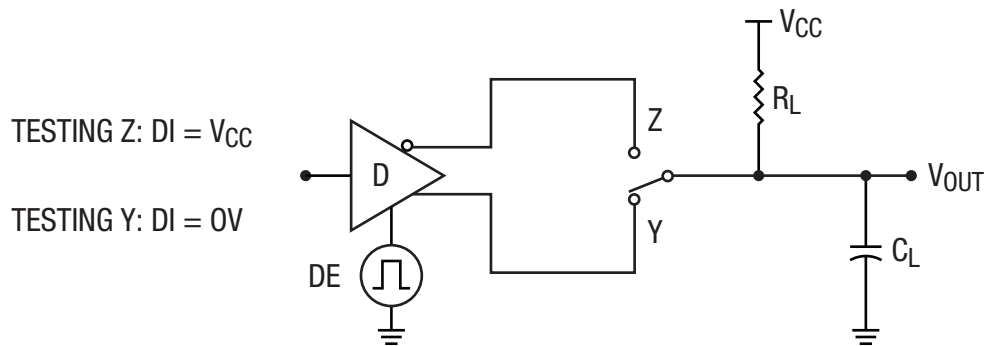
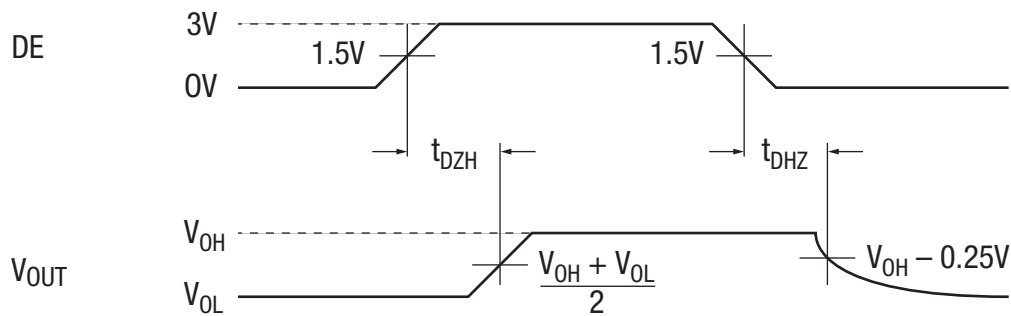
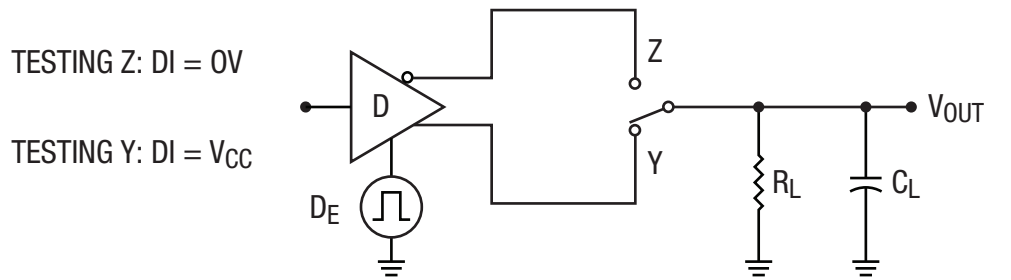


Figure 8. Driver Enable and Disable Timing Test Circuits and Timing Diagrams

Applications Information (Continued)

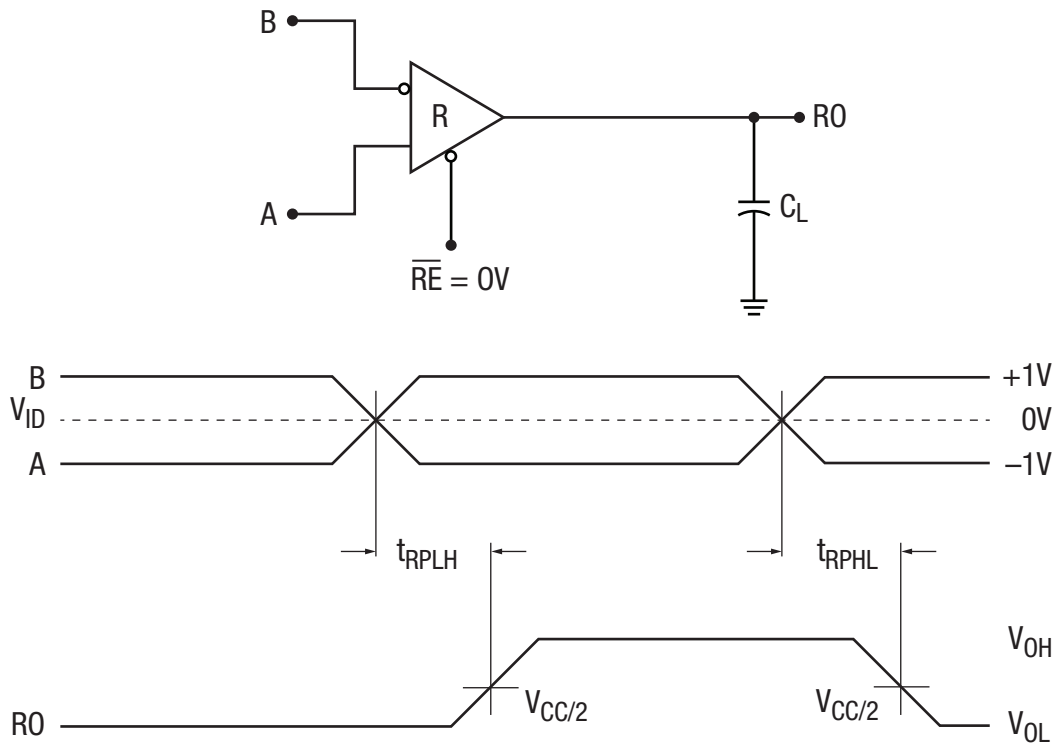


Figure 9. Receiver Propagation Delay Test Circuit and Timing Diagram

Applications Information (Continued)

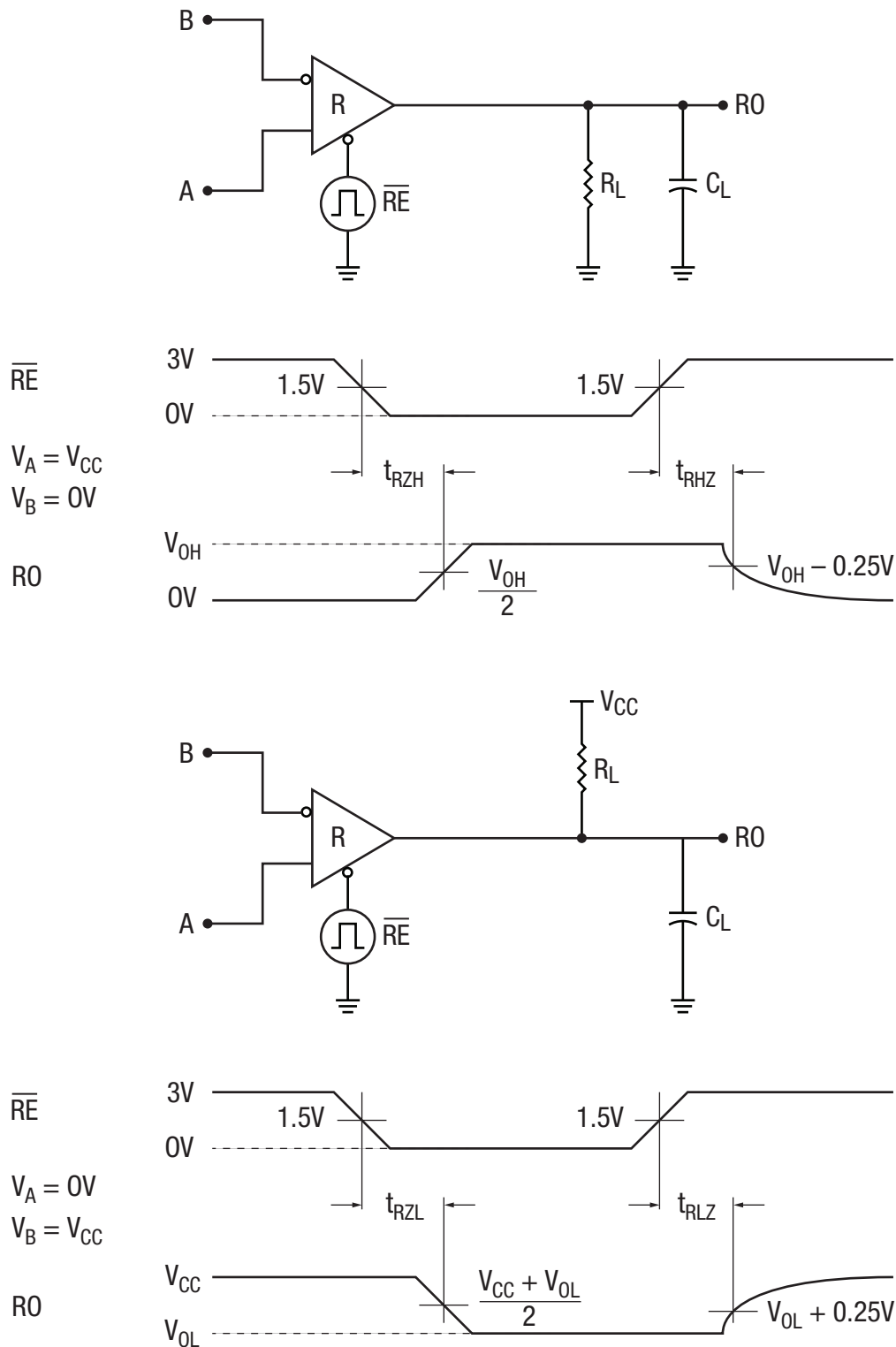


Figure 10. Receiver Enable and Disable Test Circuits and Timing Diagrams

## Applications Information (Continued)

The XR3315x RS-485/RS-422 devices are part of MaxLinear's high performance serial interface product line. The analog bus pins can survive direct shorts up to  $\pm 60V$  and are protected against ESD events up to  $\pm 15kV$ .

### Enhanced Failsafe

Ordinary RS-485 differential receivers will be in an indeterminate state whenever the data bus is not being actively driven. The enhanced failsafe feature of the XR3315x family guarantees a logic-high receiver output when the receiver inputs are open, shorted or when they are connected to a terminated transmission line with all drivers disabled. In a terminated bus with all transmitters disabled, the receivers' differential input voltage is pulled to 0V by the termination. The XR3315x family interprets 0V differential as a logic high with a minimum 50mV noise margin while maintaining compliance with the RS-485 standard of  $\pm 200mV$ . Although the XR3315x family does not need failsafe biasing resistors, it can operate without issue if biasing is used.

### Hot Swap Capability

When  $V_{CC}$  is first applied the XR3315x family holds the driver enable and receiver enable inactive for approximately 10 $\mu s$ . During power ramp-up, other system ICs may drive unpredictable values or tristated lines may be influenced by stray capacitance. The hot swap feature prevents the XR3315x family from driving any output signal until power has stabilized. After the initial 10 $\mu s$ , the driver and receiver enable pins are weakly pulled to their disabled states (low for DE and high for  $\overline{RE}$ ) until the first transition. After the first transition, the DE and  $\overline{RE}$  pins operate as high impedance inputs.

If circuit boards are inserted into an energized backplane (commonly called "live insertion" or "hot swap") power may suddenly be applied to all circuits. Without the hot swap capability, this situation could improperly enable the transceiver's driver or receiver, driving invalid data onto shared buses and possibly causing driver contention or device damage.

### Driver Output Protection

Two mechanisms prevent excessive output current and power dissipation caused by faults or by bus contention. First, a driver current limit on the output stage provides immediate protection against short circuits over the whole common-mode voltage range. Second, a thermal shutdown circuit forces the driver outputs into a high impedance state if junction temperature becomes excessive.

### Line Length

The RS-485/RS-422 standard covers line lengths up to 4000ft. Maximum achievable line length is a function of signal attenuation and noise. Termination prevents signal reflections by eliminating the impedance mismatches on a transmission line. Line termination is generally used if rise and fall times are shorter than the round trip signal propagation time. Higher output drivers may allow longer cables to be used.

### $\pm 15kV$ HBM ESD Protection (Unpowered Part)

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 XR3315x family have extra protection against static electricity. MaxLinear uses state-of-the-art structures to protect these pins against ESD damage:

- $\pm 15kV$  HBM for bus pins to GND
- $\pm 4kV$  HBM for all other pins

### ESD Test Conditions

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

### Maximum Number of Transceivers on the Bus

The standard RS-485 receiver input impedance is 12k $\Omega$  (1 unit load). A standard driver can drive up to 32 unit loads. The XR33152 transceiver has a 1/10th unit load receiver input impedance of 120k $\Omega$ , allowing up to 320 transceivers to be connected in parallel on a communication line. The XR33156/58 transceivers have a 1/2.5 unit load receiver input impedance of 30k $\Omega$ , allowing up to 80 transceivers to be connected in parallel on a communication line. Any combination of these devices and other RS-485 transceivers up to a total of 32 unit loads may be connected to the line.

### Low Power Shutdown Mode

The XR33156 has a low-power shutdown mode that is initiated by bringing both  $\overline{RE}$  high and DE low simultaneously. While in shutdown the XR33156 draws less than 1 $\mu A$  of supply current. DE and  $\overline{RE}$  may be tied together and driven by a single control signal. Devices are guaranteed not to enter shutdown if  $\overline{RE}$  is high and DE is low for less than 50ns. If the inputs are in this state for at least 600ns, the parts will enter shutdown.

XR33156 enable times,  $t_{ZH}$  and  $t_{ZL}$ , apply when the part is not in low power shutdown state. Enable times,  $t_{ZH(SHDN)}$  and  $t_{ZL(SHDN)}$  apply when the part is shutdown. The driver and receiver take longer to become enabled from low power shutdown  $t_{ZH(SHDN)}$  and  $t_{ZL(SHDN)}$  than from driver or receiver disable mode ( $t_{ZH}$  and  $t_{ZL}$ ).



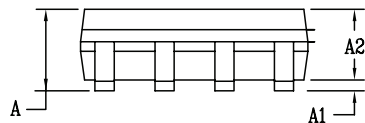
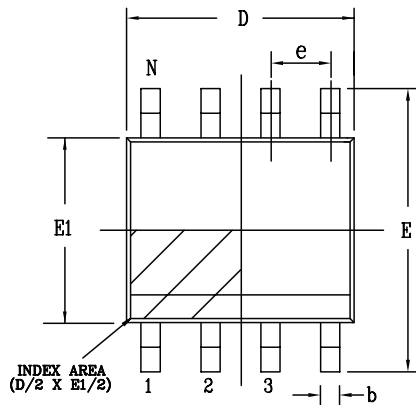
**Applications Information (Continued)****Product Selector Guide**

| Part Number | Operation   | Data Rate | Shutdown | Receiver/Driver Enable | Nodes On Bus | Footprint |
|-------------|-------------|-----------|----------|------------------------|--------------|-----------|
| XR33152     | Half-duplex | 250kbps   | No       | No/Yes                 | 320          | 8-NSOIC   |
| XR33155     | Half-duplex | 1Mbps     |          |                        |              |           |
| XR33156     | Full-duplex | 20Mbps    | Yes      | Yes/Yes                | 80           | 14-NSOIC  |
| XR33158     | Half-duplex |           | No       | No/Yes                 | 80           | 8-NSOIC   |

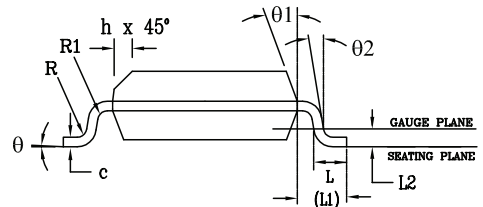
Mechanical Dimensions

NSOIC-8

Top View



Side View



Front View

| PACKAGE OUTLINE NSOIC .150" BODY<br>JEDEC MS-012 VARIATIONAA |   |     |      |   |     |       |
|--|---|-----|------|---|-----|-------|
| SYMBOLS  | COMMON DIMENSIONS IN MM<br>(Control Unit) |     |      | COMMON DIMENSIONS IN INCH<br>(Reference Unit) |     |       |
|  | MIN                                       | NOM | MAX  | MIN   | NOM | MAX   |
| A  | 1.35                                      | —   | 1.75 | 0.053   | —   | 0.069 |
| A1   | 0.10                                      | —   | 0.25 | 0.004   | —   | 0.010 |
| A2   | 1.25                                      | —   | 1.65 | 0.049   | —   | 0.065 |
| b  | 0.31                                      | —   | 0.51 | 0.012   | —   | 0.020 |
| c  | 0.17                                      | —   | 0.25 | 0.007   | —   | 0.010 |
| E  | 6.00 BSC                                  |     |      | 0.236 BSC                                     |     |       |
| E1   | 3.90 BSC                                  |     |      | 0.154 BSC                                     |     |       |
| e  | 1.27 BSC                                  |     |      | 0.050 BSC                                     |     |       |
| h  | 0.25                                      | —   | 0.50 | 0.010   | —   | 0.020 |
| L  | 0.40                                      | —   | 1.27 | 0.016   | —   | 0.050 |
| L1   | 1.04 REF                                  |     |      | 0.041 REF                                     |     |       |
| L2   | 0.25 BSC                                  |     |      | 0.010 BSC                                     |     |       |
| R  | 0.07                                      | —   | —    | 0.003   | —   | —     |
| R1   | 0.07                                      | —   | —    | 0.003   | —   | —     |
| q  | 0°  | —   | 8°   | 0°  | —   | 8°    |
| q1   | 5°  | —   | 15°  | 5°  | —   | 15°   |
| q2   | 0°  | —   | —    | 0°  | —   | —     |
| D  | 4.90 BSC                                  |     |      | 0.193 BSC                                     |     |       |
| N  | 8   |     |      |   |     |       |

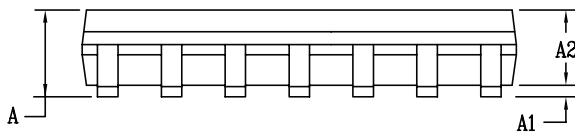
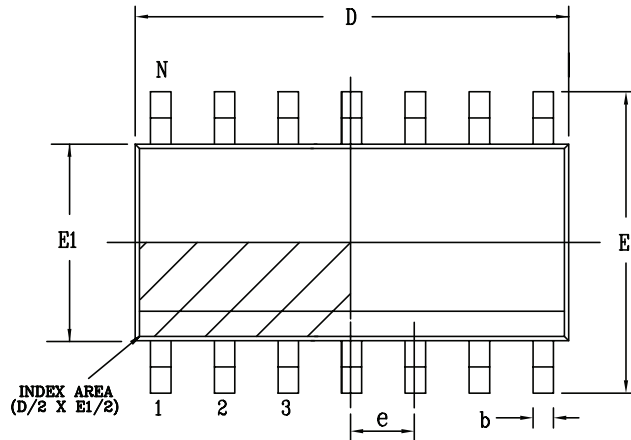
Drawing No: POD-00000108

Revision: A

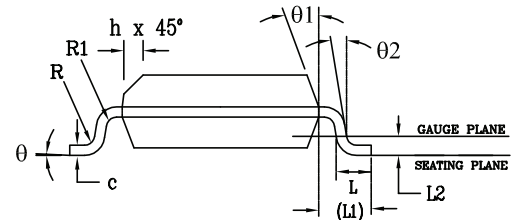
Mechanical Dimensions

NSOIC-14

Top View



Side View



Front View

| PACKAGE OUTLINE NSOIC .150" BODY<br>JEDEC MS-012 VARIATION AB |   |     |      |   |     |       |
|---|---|-----|------|---|-----|-------|
| SYMBOLS   | COMMON DIMENSIONS IN MM<br>(Control Unit) |     |      | COMMON DIMENSIONS IN INCH<br>(Reference Unit) |     |       |
|   | MIN                                       | NOM | MAX  | MIN   | NOM | MAX   |
| A   | 1.35                                      | —   | 1.75 | 0.053   | —   | 0.069 |
| A1  | 0.10                                      | —   | 0.25 | 0.004   | —   | 0.010 |
| A2  | 1.25                                      | —   | 1.65 | 0.049   | —   | 0.065 |
| b   | 0.31                                      | —   | 0.51 | 0.012   | —   | 0.020 |
| c   | 0.17                                      | —   | 0.25 | 0.007   | —   | 0.010 |
| E   | 6.00 BSC                                  |     |      | 0.236 BSC                                     |     |       |
| E1  | 3.90 BSC                                  |     |      | 0.154 BSC                                     |     |       |
| e   | 1.27 BSC                                  |     |      | 0.050 BSC                                     |     |       |
| h   | 0.25                                      | —   | 0.50 | 0.010   | —   | 0.020 |
| L   | 0.40                                      | —   | 1.27 | 0.016   | —   | 0.050 |
| L1  | 1.04 REF                                  |     |      | 0.041 REF                                     |     |       |
| L2  | 0.25 BSC                                  |     |      | 0.010 BSC                                     |     |       |
| R   | 0.07                                      | —   | —    | 0.003   | —   | —     |
| R1  | 0.07                                      | —   | —    | 0.003   | —   | —     |
| q   | 0°  | —   | 8°   | 0°  | —   | 8°    |
| q1  | 5°  | —   | 15°  | 5°  | —   | 15°   |
| q2  | 0°  | —   | —    | 0°  | —   | —     |
| D   | 8.65 BSC                                  |     |      | 0.341 BSC                                     |     |       |
| N   | 14  |     |      |   |     |       |

Drawing No: POD-0000109

Revision: A

Ordering Information<sup>(1)</sup>

| Part Number  | Operation         | Data Rate | Operating Temperature Range | Lead-Free          | Package    | Packaging Method |      |
|--|-------------------|-----------|-----------------------------|--------------------|------------|------------------|------|
| XR33152ID-F  | Half-duplex       | 250kbps   | -40°C to 85°C               | Yes <sup>(2)</sup> | 8-pin SOIC | Tube             |      |
| XR33152IDTR-F  |                   |           | Tape and Reel               |                    |            |                  |      |
| XR33152HD-F  |                   |           | -40°C to 105°C              |                    |            | Tube             |      |
| XR33152HDTR-F  |                   |           | Tape and Reel               |                    |            |                  |      |
| XR33155ID-F  | Half-duplex       | 1Mbps     | -40°C to 85°C               |                    | 8-pin SOIC | Tube             |      |
| XR33155IDTR-F  |                   |           | Tape and Reel               |                    |            |                  |      |
| XR33155HD-F  |                   |           | -40°C to 105°C              |                    |            | Tube             |      |
| XR33155HDTR-F  |                   |           | Tape and Reel               |                    |            |                  |      |
| XR33156ID-F  | Full-duplex       | 20Mbps    | -40°C to 85°C               |                    |            | 14-pin SOIC      | Tube |
| XR33156IDTR-F  |                   |           | Tape and Reel               |                    |            |                  |      |
| XR33156HD-F  |                   |           | -40°C to 105°C              |                    |            |                  | Tube |
| XR33156HDTR-F  |                   |           | Tape and Reel               |                    |            |                  |      |
| XR33158ID-F  | Half-duplex       | 20Mbps    | -40°C to 85°C               |                    | 8-pin SOIC |                  | Tube |
| XR33158IDTR-F  |                   |           | Tape and Reel               |                    |            |                  |      |
| XR33158HD-F  |                   |           | -40°C to 105°C              |                    |            |                  | Tube |
| XR33158HDTR-F  |                   |           | Tape and Reel               |                    |            |                  |      |
| XR33152IDEVB<br>XR33152HDEVB<br>XR33155IDEVB<br>XR33155HDEVB<br>XR33156IDEVB<br>XR33156HDEVB<br>XR33158IDEVB<br>XR33158HDEVB | Evaluation Boards |           |                             |                    |            |                  |      |

NOTE:

1. Refer to [www.exar.com/XR33152](http://www.exar.com/XR33152), [www.exar.com/XR33155](http://www.exar.com/XR33155), [www.exar.com/XR33156](http://www.exar.com/XR33156), [www.exar.com/XR33158](http://www.exar.com/XR33158) for most up-to-date Ordering Information.
2. Visit [www.exar.com](http://www.exar.com) for additional information on Environmental Rating.

## Revision History

| Revision | Date      | Description  |
|----------|-----------|--|
| 1A       | Jan 2016  | Initial Release  |
| 2A       | July 2016 | Add XR33155, -40°C to 105°C parts, and Revision History.   |
| 2B       | Jan 2017  | Corrected XR33158 max temperature typo   |
| 2C       | Feb 2018  | Updated to MaxLinear logo. Updated format and Ordering Information. Moved ESD ratings to page 2. |



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