# XR33053

## ±60V Fault Tolerant 3.0V to 5.5V TIA-485/TIA-422 Transceiver

## Description

The XR33053 is a high performance TIA-485/TIA-422 device 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 receiver includes full fail-safe circuitry, guaranteeing a logic-high receiver output when the receiver inputs are open, shorted or undriven. The XR33053 receiver input impedance is at least 120kΩ (1/10 unit load), allowing more than 320 devices on the bus.

The driver is protected by short circuit detection as well as thermal shutdown and maintains high impedance in shutdown or when powered off.

The DE and $\overline{RE}$ pins include hot swap circuitry to prevent false transitions on the bus during powerup 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)
- 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 14-pin NSOIC package
- -40°C to 85°C ambient operating temperature range

**APPLICATIONS**

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

## Typical Application

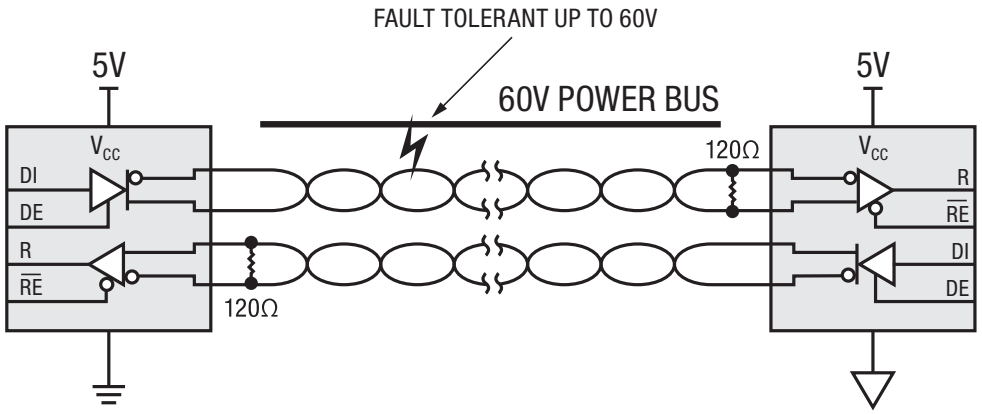



Figure 1. Typical Application

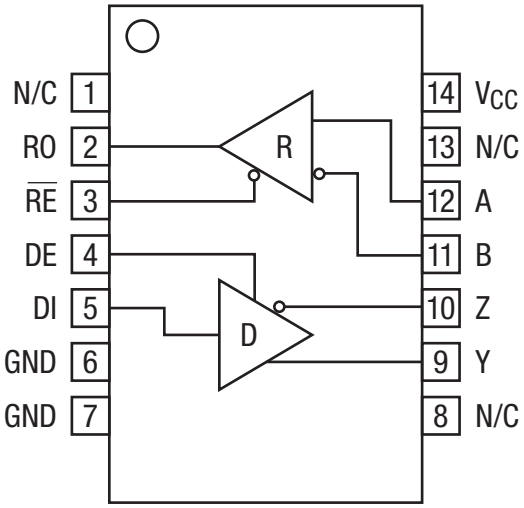
## Absolute Maximum Ratings

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections to the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability and cause permanent damage to the device.

| | |
|---|---|
| $V_{CC}$ | -0.3V to 7.0V |
| Input voltage at control and driver input (DE and DI) | -0.3V to 7.0V |
| Input voltage at control and driver input ($\overline{RE}$) | -0.3V to ($V_{CC}$ + 0.3V) |
| Receiver output voltage (RO) | -0.3V to ($V_{CC}$ + 0.3V) |
| Driver output voltage (A, B, Y and Z) | ±60V |
| Receiver input voltage (A and B, full duplex) | ±60V |
| Transient voltage pulse, through 100Ω (Figure 6) | ±100V |
| Driver output current | ±250mA |
| Storage temperature range | -65°C to 150°C |
| Lead temperature (soldering, 10s) | 300°C |
| Package power dissipation, 14-pin NSOIC $\theta_{JA}$ = 86°C/W | Maximum junction temperature = 150°C |

**CAUTION:**
ESD-sensitive (electrostatic discharge) device. Permanent damage may occur on unconnected devices subject to high energy electrostatic fields. Unused devices must be stored in conductive foam or shunts. Personnel should be properly grounded prior to handling this device. The protective foam should be discharged to the destination socket before devices are removed.

## Pin Configuration




## Pin Functions

| Full Duplex XR33053 Pin Number | Pin Name | Type | Pin Function |
|---|---|---|---|
| 2 | RO | Out | 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. |
| 3 | $\overline{RE}$ | In | 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. |
| 4 | DE | In | 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. |
| 5 | DI | In | 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. |
| 6, 7 | GND | Power | Ground. |
| 14 | $V_{CC}$ | Power | 3.0V to 5.5V power supply input, bypass to ground with 0.1µF capacitor. |
| 12 | A | In | Non-inverting receiver input. |
| 11 | B | In | Inverting receiver input. |
| 9 | Y | Out | Non-inverting driver output. |
| 10 | Z | Out | Inverting driver output. |
| 1, 8, 13 | N/C | - | Not connected. |

## Pin Functions

| Transmitting | | | | |
|---|---|---|---|---|
| Inputs | | | Outputs | |
| $\overline{RE}$ | DE | DI | Y | Z |
| X | 1 | 1 | 1 | 0 |
| X | 1 | 0 | 0 | 1 |
| 0 | 0 | X | High-Z | |
| 1 | 0 | X | High-Z (shutdown) | |

| Receiving | | | |
|---|---|---|---|
| Inputs | | | Output |
| $\overline{RE}$ | DE | $V_A$ - $V_B$ | RO |
| 0 | X | ≥ 200mV | 1 |
| 0 | X | ≤ -200mV | 0 |
| 0 | X | Open/shorted | 1 |
| 1 | 1 | X | High-Z |
| 1 | 0 | X | High-Z (shutdown) |

## 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°C.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Driver DC Characteristics | | | | | | |
| $V_{CC}$ | Supply voltage range | | 3.0 | | 5.5 | V |
| $V_{OD}$ | Differential driver output, 4.5V ≤ $V_{CC}$ ≤ 5.5V | $R_L$ = 100Ω (TIA-422), Figure 3 | 2 | | $V_{CC}$ | V |
| | | $R_L$ = 54Ω (TIA-485), Figure 3 | 1.5 | | $V_{CC}$ | V |
| | | -25V ≤ $V_{CM}$ ≤ 25V, Figure 4 | 1.5 | | $V_{CC}$ | V |
| | Differential driver output, 3.0V ≤ $V_{CC}$ ≤ 4.5V | $R_L$ = 100Ω (TIA-422), Figure 3 | 0.85 | | $V_{CC}$ | V |
| | | $R_L$ = 54Ω (TIA-485), Figure 3 | 0.65 | | $V_{CC}$ | V |
| $\Delta V_{OD}$ | Change in magnitude of differential output voltage, Note 1 | RL = 100Ω (TIA-422) or RL = 54Ω (TIA-485), Figure 3 | | | ±0.2 | V |
| $V_{CM}$ | Driver common-mode output voltage (steady state) | | 1 | | 3 | V |
| $\Delta V_{CM}$ | Change in magnitude of common-mode output voltage, Note 1 | | | | ±0.2 | V |
| $V_{IH}$ | Logic high input thresholds (DI, DE and $\overline{RE}$) | $V_{CC}$ = 3.3V | 2.0 | | | V |
| | | $V_{CC}$ = 5.0V | 2.4 | | | V |
| $V_{IL}$ | Logic low input thresholds (DI, DE and $\overline{RE}$) | Logic input low | | | 0.8 | V |
| $V_{HYS}$ | Input hysteresis (DI, DE and $\overline{RE}$) | | | 100 | | mV |
| $I_{IN}$ | Logic input current (DI, DE and $\overline{RE}$) | 0V ≤ $V_{IN}$ ≤ $V_{CC}$, After first transition, Note 2 | | | ±1 | µA |
| $I_{INHS}$ | Logic input current hot swap (DE and $\overline{RE}$) | Until first transition, Note 2 | | 100 | ±200 | µA |
| $I_{A, B}$ | Input current (A and B) | $V_{CC}$ = 0V or 5.5V, $V_{OUT}$ = 12V, DE = 0V | | | 100 | µA |
| | | $V_{CC}$ = 0V or 5.5V, $V_{OUT}$ = -7V, DE = 0V | -80 | | | µA |
| $I_{OL}$ | Output leakage (Y and Z) Full duplex, Note 2 | $V_{OUT}$ = 12V, DE = 0V, $V_{CC}$ = 0V or 5.5V | | | 100 | µA |
| | | $V_{OUT}$ = -7V, DE = 0V, $V_{CC}$ = 0V or 5.5V | -80 | | | µA |
| $I_{OSD}$ | Driver short-circuit output current | -60V ≤ $V_{OUT}$ ≤ 60V DI = 0V or $V_{CC}$, Figure 5 | | | ±250 | µA |

**NOTES:**

1. 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.
2. The hot swap feature disables the DE and $\overline{RE}$ inputs for the first 10µs after power is applied. Following this time period, these inputs are weakly pulled to their disabled state (low for DE, high for $\overline{RE}$) until the first transition, after which they become high impedance inputs.

## 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°C.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| | | Driver Thermal Characteristics | | | | |
| $T_{TS}$ | Thermal shutdown temperature | Junction temperature, Note 1 | | 175 | | °C |
| $T_{TSH}$ | Thermal shutdown hysteresis | Note 1 | | 15 | | °C |
| | | Receiver DC Characteristics | | | | |
| $V_{STH}$ | Receiver differential input signal threshold voltage ($V_A$ - $V_B$) | -25V ≤ $V_{OUT}$ ≤ 25V | | ±85 | ±200 | mV |
| $\Delta V_{STH}$ | Receiver differential input signal hysteresis | | | 170 | | mV |
| $V_{FSTH-}$ | Negative going receiver differential input fail-safe threshold voltage ($V_A$ - $V_B$) | -25V ≤ $V_{OUT}$ ≤ 25V | -200 | -125 | -40 | mV |
| $V_{FSTH+}$ | Positive going receiver differential input fail-safe threshold voltage ($V_A$ - $V_B$) | -25V ≤ $V_{OUT}$ ≤ 25V | | -100 | -10 | mV |
| $\Delta V_{FSTH}$ | Receiver differential input fail-safe hysteresis | | | 25 | | mV |
| $V_{OH}$ | Receiver output high voltage (RO) | $I_{OUT}$ = -4mA | $V_{CC}$ - 0.6 | | | V |
| $V_{OL}$ | Receiver output low voltage (RO) | $I_{OUT}$ = 4mA | | | 0.4 | V |
| $I_{OZR}$ | High-Z receiver output current | 0V ≤ $V_{OUT}$ ≤ $V_{CC}$ | | | ±1 | µA |
| $R_{IN}$ | RX input resistance | -25V ≤ $V_{CM}$ ≤ 25V | 120 | | | kΩ |
| | | -25V ≤ $V_{CM}$ ≤ 25V | 30 | | | kΩ |
| $I_{OSC}$ | RX output short-circuit current | 0V ≤ $V_{RO}$ ≤ $V_{CC}$ | | | 110 | mA |
| | | Supply Current | | | | |
| $I_{CC}$ | Supply current | No load, $\overline{RE}$ = 0V or $V_{CC}$, 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 | µA |
| | | ESD Protection | | | | |
| | ESD protection for A, B, Y, and Z | Human body model | | ±15 | | kV |
| | ESD protection for all other pins | Human body model | | ±4 | | kV |

**NOTE:**
1. This spec is guaranteed by design and bench characterization.

## Driver AC Characteristics - XR33053 (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°C.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $t_{DPLH}$ | Driver prop. delay (low to high) | $C_L$ = 50pF, $R_L$ = 54Ω, Figure 7 | | 150 | 500 | ns |
| $t_{DPHL}$ | Driver prop. delay (high to low) | | | 150 | 500 | ns |
| $\lvert t_{DPLH}-t_{DPHL}\rvert$ | 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, $R_L$ = 500Ω, Figure 8 | | 1000 | 2500 | ns |
| $t_{DZL}$ | Driver enable to output low | | | 1000 | 2500 | 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, $R_L$ = 500Ω, 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 - XR33053 (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°C.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $t_{RPLH}$ | Receiver prop. delay (low to high) | $C_L$ = 15pF, $V_{ID}$ = ±2V, $V_{ID}$ rise and fall times < 15ns, Figure 9 | | | 200 | ns |
| $t_{RPHL}$ | Receiver prop. delay (high to low) | | | | 200 | ns |
| $\lvert t_{RPLH}-t_{RPHL}\rvert$ | 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, $R_L$ = 1kΩ, 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, $R_L$ = 1kΩ, 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.

## Applications Information

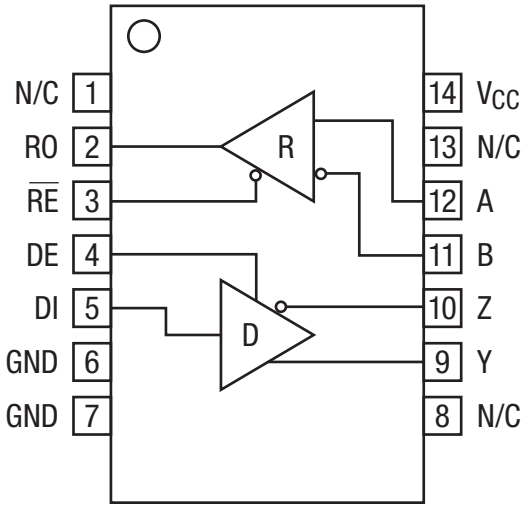



Figure 2. Full Duplex XR33053

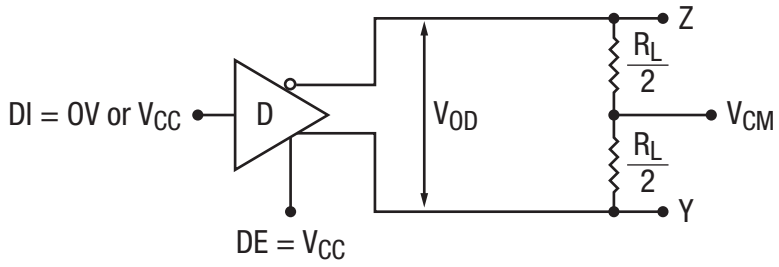



Figure 3. Differential Driver Output Voltage

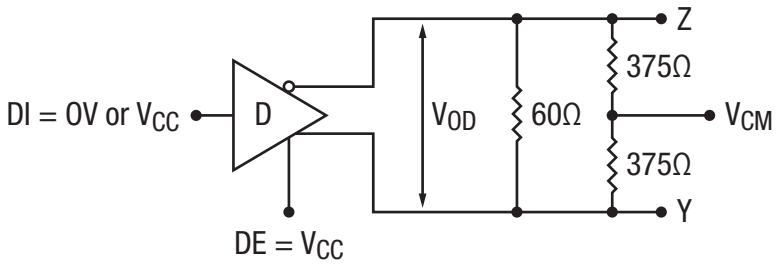



Figure 4. Differential Driver Output Voltage Over Common Mode

## Applications Information

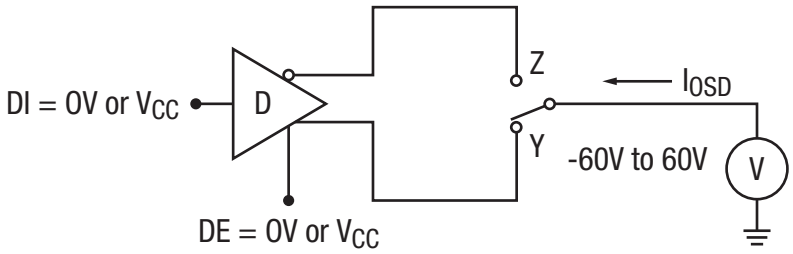



Figure 5. Driver Output Short Circuit Current

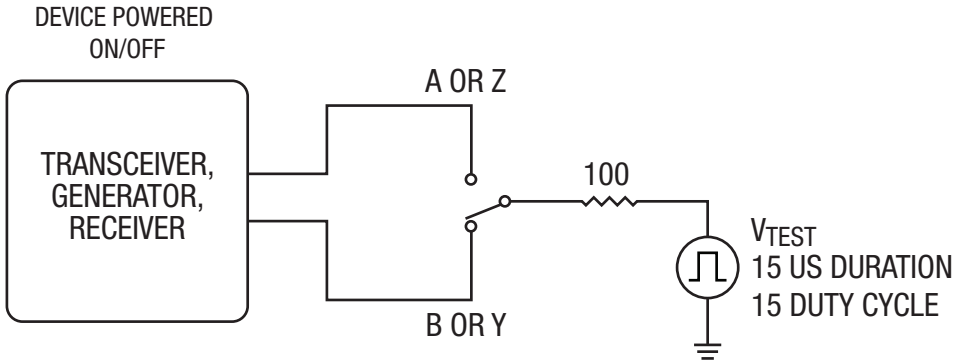



Figure 6. Transient Overvoltage Test Circuit

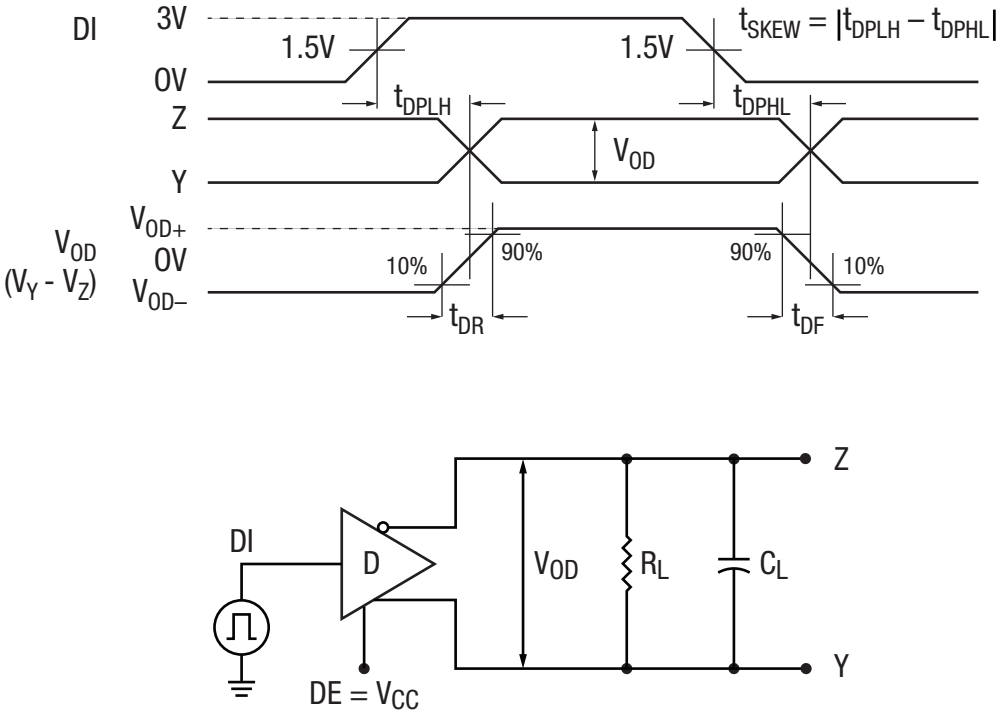



Figure 7. Driver Propagation Delay Test Circuit and Timing Diagram

## Applications Information

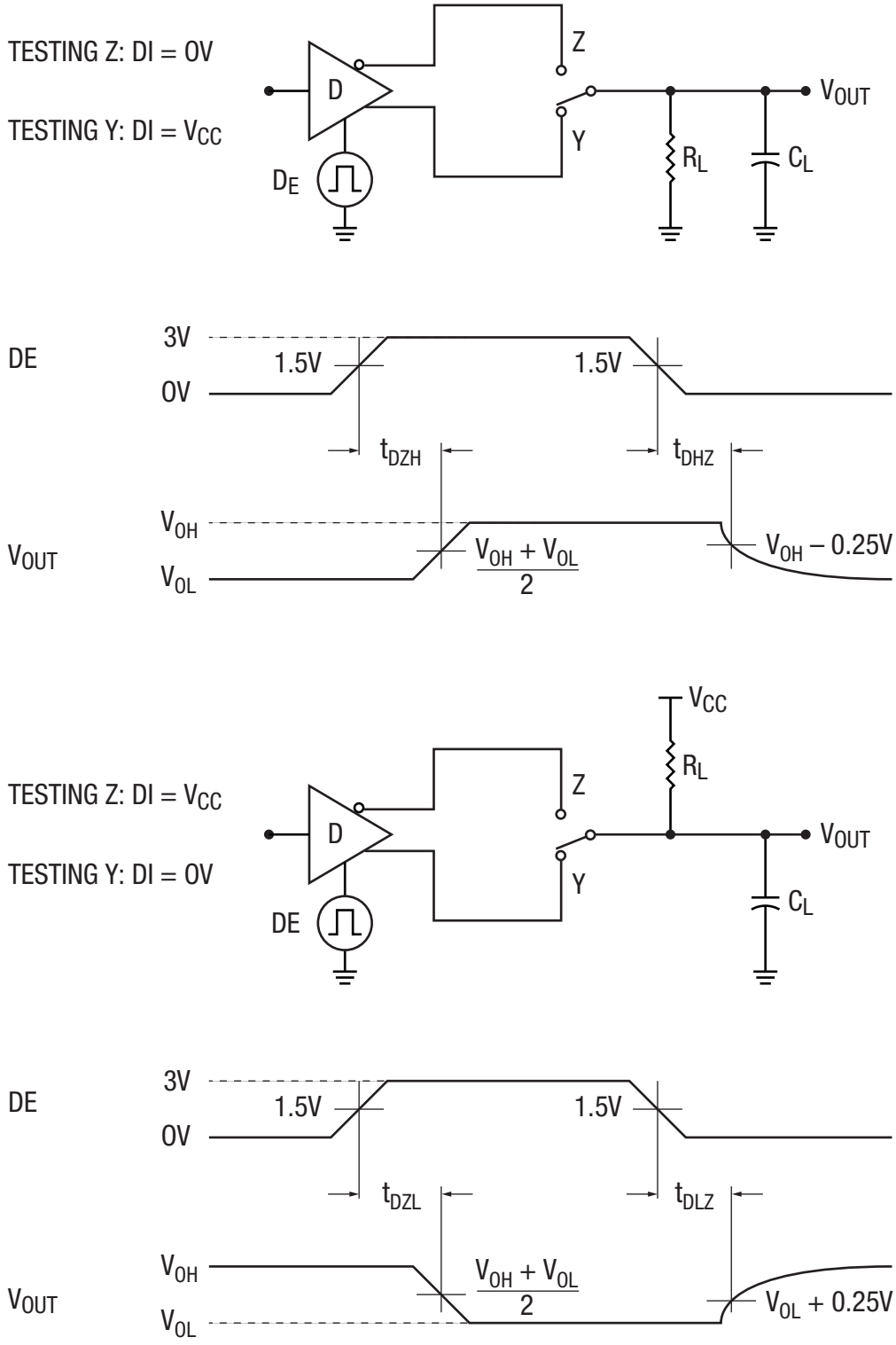



Figure 8. Driver Enable and Disable Timing Test Circuits and Timing Diagrams

## Applications Information

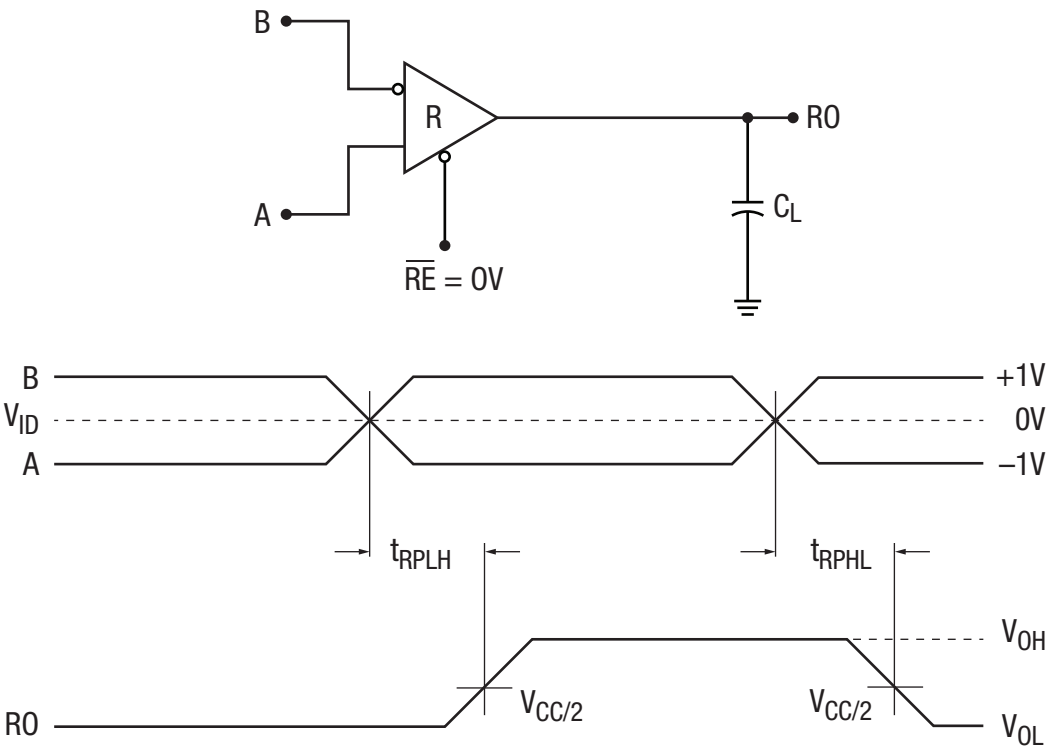



Figure 9. Receiver Propagation Delay Test Circuit and Timing Diagram

## Applications Information

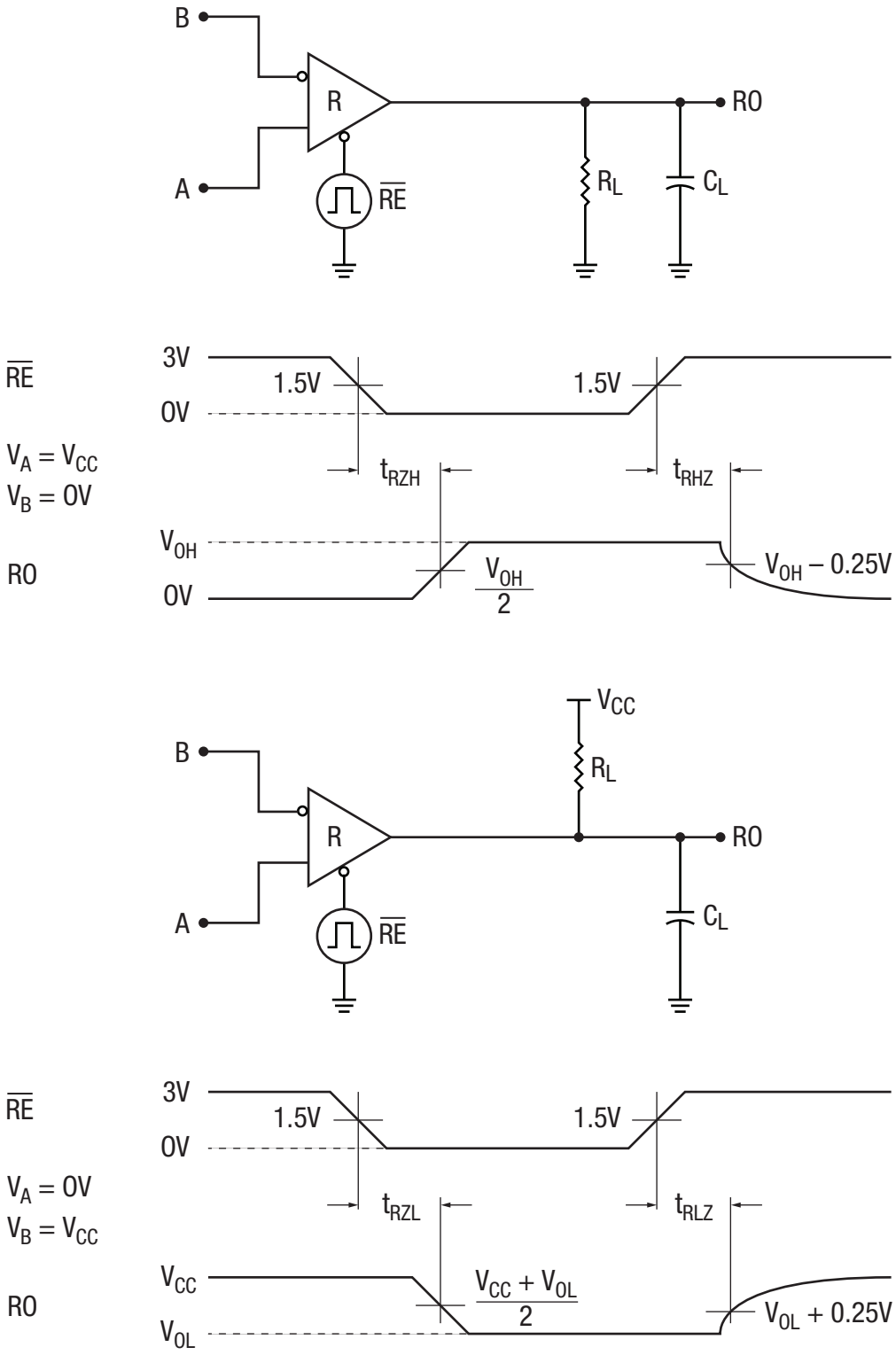



Figure 10. Receiver Enable and Disable Test Circuits and Timing Diagrams

## Applications Information

The XR33053 TIA-485/TIA-422 device is part of Exar's high performance serial interface product line. The analog bus pins can survive direct shorts up to ±60V and are protected against ESD events up to ±15kV.

### Enhanced Failsafe

Ordinary TIA-485 differential receivers will be in an indeterminate state whenever the data bus is not being actively driven. The enhanced failsafe feature of the XR33053 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 XR33053 interprets 0V differential as a logic high with a minimum 50mV noise margin while maintaining compliance with the TIA-485 standard of ±200mV. Although the XR33053 does not need failsafe biasing resistors, it can operate without issue if biasing is used.

### Receiver Input Filtering

XR33053 receiver incorporates internal filtering in addition to input hysteresis. This filtering enhances noise immunity by ignoring signals that do not meet a minimum pulse width of 30ns. Receiver propagation delay increases slightly due to this filtering.

### Hot Swap Capability

When $V_{CC}$ is first applied, the XR33053 holds the driver enable and receiver enable inactive for approximately 10µs. 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 XR33053 from driving any output signal until power has stabilized. After the initial 10µs, the driver and receiver enable pins are weakly pulled to their disabled states (low for DE, 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 TIA-485/TIA-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.

### ±15kV ESD Protection

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 XR33053 has extra protection against static electricity. Exar uses 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, the XR33053 keeps operating without latch-up or damage.

ESD protection can be tested in various ways. The transmitter outputs and receiver inputs of the XR33053 is characterized for protection to the following limits:

- ±15kV using the Human Body Model, TIA-485 bus pins
- ±4kV using the Human Body Model, all other pins

### ESD Test Conditions

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

### Maximum Number of Transceivers on the Bus

The standard TIA-485 receiver input impedance is 12kΩ (1 unit load). A standard driver can drive up to 32 unit loads. The XR33053 transceiver has a 1/10th unit load receiver input impedance of 120kΩ, allowing up to 320 transceivers to be connected in parallel on a communication line. Any combination of the XR33053's and other TIA-485 transceivers up to a total of 32 unit loads may be connected to the line.

### Low Power Shutdown Mode

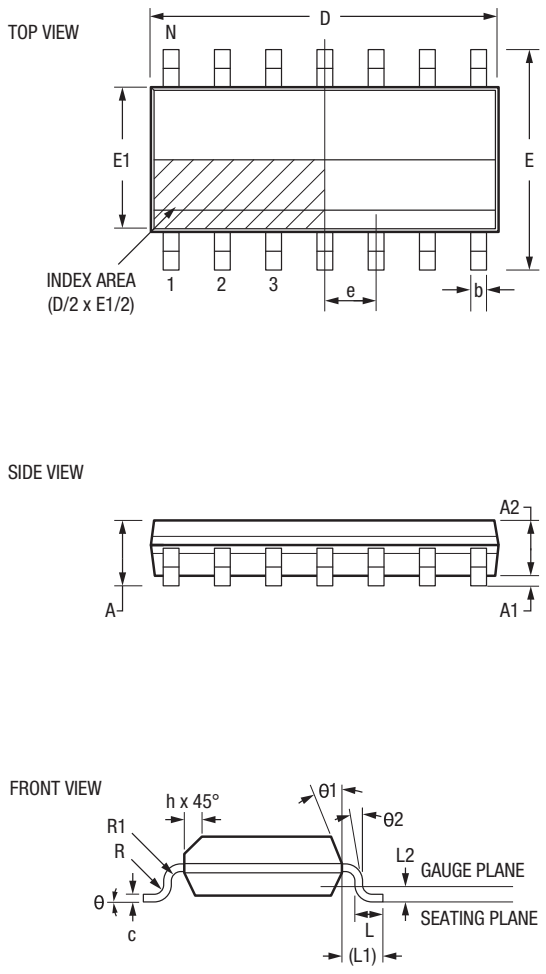
Low power shutdown mode is initiated by bringing both $\overline{RE}$ high and DE low simultaneously. While in shutdown devices draw less than 1µA of supply current. DE and $\overline{RE}$ may be tied together and driven by a single control signal. Devices are guaranteed not to enter shutdown if $\overline{RE}$ 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.

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 parts are 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 $t_{ZL}$).

| Part Number | Operation | Data Rate | Shutdown | Receiver/Driver Enable | Nodes On Bus | Package |
|---|---|---|---|---|---|---|
| XR33053 | Full duplex | 1Mbps | Yes | Yes/Yes | 320 | 14-pin NSOIC |

## Package Description

### 14-Pin NSOIC Package




| 14-Pin NSOIC (JEDEC MS-012) | | | | | | |
|---|---|---|---|---|---|---|
| Symbols | Dimension in mm (Control unit) | | | Dimension in inches (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 | - | - |
| θ | 0° | - | 8° | 0° | - | 8° |
| θ1 | 5° | - | 15° | 5° | - | 15° |
| θ2 | 0° | - | - | 0° | - | - |
| D | 8.65 BSC | | | 0.341 BSC | | |
| N | 14 | | | 14 | | |

## Order Information

| Part Number | Operation | Data Rate | Package | Environmental Rating | Operating Temperature Range |
|---|---|---|---|---|---|
| XR33053ID-F | Full duplex | 1Mbps | 14-pin SOIC | Green/RoHS | -40°C to 85°C |
| XR33053IDTR-F | | | | | |

www.exar.com

48760 Kato Road
Fremont, CA 94538
USA

Tel.: +1 (510) 668-7000
Fax: +1 (510) 668-7001
Email: support@exar.com