## 1. DESCRIPTION

The XLX487 are low-power transceivers for RS-485 and RS-422 communications in harsh environments. Each driver output and receiver input is protected against ±15kV electro-static discharge (ESD) shocks, without latchup. These parts contain one driver and one receiver. The XLX487 feature reduced slew-rate drivers that minimize EMI and reduce reflections caused by improperly terminated cables, thus allowing error-free data transmission up to 250kbps.

The transceivers draw as little as 120µA supply current when unloaded or when fully loaded with disabled drivers .

Drivers are short-circuit current limited, and are protected against excessive power dissipation by thermal shutdown circuitry that places their outputs into a high-impedance state. The receiver input has a fail-safe feature that guarantees a logic-high output if the input is open circuit.

The XLX487 feature quarter-unit-load receiver input impedance, allowing up to 128 transceivers on the bus. The XLX487 are designed for half-duplex applications.

## 2. APPLICATIONS

- Low-Power RS-485 Transceivers
- Low-Power RS-422 Transceivers
- Level Translators
- Transceivers for EMI-Sensitive Applications
- Industrial-Control Local Area Networks

## 3. ABSOLUTE MAXIMUM RATINGS

Supply Voltage (VCC)..........................................................12V

Control Input Voltage ($\overline{RE}$ , DE)..................-0.5V to (VCC + 0.5V)

Driver Input Voltage (DI)............................-0.5V to (VCC + 0.5V)

Driver Output Voltage (Y, Z; A, B) .........................-8V to +12.5V

Receiver Input Voltage (A, B)................................-8V to +12.5V

Receiver Output Voltage (RO)...................-0.5V to (VCC + 0.5V)

Continuous Power Dissipation (TA = +70°C)

8-Pin Plastic DIP (derate 9.09mW/°C above +70°C) ....727mW

8-Pin SO (derate 5.88mW/°C above +70°C)................471mW

Operating Temperature Ranges ..........................-40°C to +85°C

Storage Temperature Range ............................-65°C to +160°C

Lead Temperature (soldering, 10sec) ............................+300°C

NOTE: 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.

## 4. DC ELECTRICAL CHARACTERISTICS

($V_{CC}$ = 5V ±5%, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted.) (Notes 1, 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Differential Driver Output (no load) | VOD1 | | | | | 5 | V |
| Differential Driver Output (with load) | VOD2 | R = 50Ω (RS-422) | | 2 | | | V |
| | | R = 27Ω (RS-485), Figure 8 | | 1.5 | | 5 | |
| Change in Magnitude of Driver Differential Output Voltage for Complementary Output States | ΔVOD | R = 27Ω or 50Ω, Figure 8 | | | | 0.2 | V |
| Driver Common-Mode Output Voltage | VOC | R = 27Ω or 50Ω, Figure 8 | | | | 3 | V |
| Change in Magnitude of Driver Common-Mode Output Voltage for Complementary Output States | ΔVOD | R = 27Ω or 50Ω, Figure 8 | | | | 0.2 | V |
| Input High Voltage | VIH | DE, DI, $\overline{RE}$ | | 20 | | | V |
| Input Low Voltage | VIL | DE, DI, $\overline{RE}$ | | | | 0.8 | V |
| Input Current | IIN1 | DE, DI, $\overline{RE}$ | | | | ±2 | µA |
| Input Current (A, B) | IIN2 | DE = 0V, $V_{CC}$ = 0V or 5.25V | $V_{IN}$ = 12V | | | 0.25 | mA |
| | | | $V_{IN}$ = -7V | | | -0.2 | |
| Receiver Differential Threshold Voltage | VTH | -7V ≤ VCM ≤ 12V | | -0.2 | | 0.2 | V |
| Receiver Input Hysteresis | ΔVTH | VCM = 0V | | | 70 | | mV |
| Receiver Output High Voltage | VOH | IO = -4mA, VID = 200mV | | 3.5 | | | V |
| Receiver Output Low Voltage | VOL | IO = 4mA, VID = -200mV | | | | 0.4 | V |
| Three-State (high impedance) Output Current at Receiver | IOZR | 0.4V ≤ VO ≤ 2.4V | | | | ±1 | µA |
| Receiver Input Resistance | RIN | -7V ≤ VCM ≤ 12V | | 48 | | | kΩ |

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| No-Load Supply Current (Note 3) | ICC | RE = 0V or $V_{CC}$ | DE = VCC | | 250 | 00 | μA |
| | | | DE = 0V | | 120 | 250 | |
| Supply Current in Shutdown | ISHDN | DE = 0V, RE = VCC | | | 0.5 | 10 | μA |
| Driver Short-Circuit Current, $V_O$ = High | IOSD1 | -7V ≤ $V_O$ ≤12V (Note 4) | | 35 | | 250 | mA |
| Driver Short-Circuit Current, $V_O$ = Low | IOSD2 | -7V ≤ $V_O$ ≤12V (Note 4) | | 35 | | 250 | mA |
| Receiver Short-Circuit Current | IOSR | 0V ≤ VO ≤ VCC | | 7 | | 95 | mA |
| ESD Protection | | A, B, Y andZ pins, tested using Human Body Model | | | ±15 | | kV |

## 5. SWITCHING CHARACTERISTICS

($V_{CC}$ = 5V ±5%, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted.) (Notes 1, 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Driver Input to Output | tPLH | Figures 8 and 10, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | 250 | 800 | 2000 | ns |
| | tPHL | | 250 | 800 | 2000 | |
| Driver Output Skew to Output | tSKEW | Figures 8 and 10, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | | 20 | 800 | ns |
| Driver Enable to Output High | tZH | Figures 9 and 11, $C_L$ = 100pF, S2 closed | 250 | | 2000 | ns |
| Driver Enable to Output Low | tZL | Figures 9 and 11, $C_L$ = 100pF, S1 closed | 250 | | 2000 | ns |
| Driver Disable Time from Low | tLZ | Figures 9 and 11, $C_L$ = 15pF, S1 closed | 300 | | 3000 | ns |
| Driver Disable Time from High | tHZ | Figures 9 and 11, $C_L$ = 15pF, S2 closed | 300 | | 3000 | ns |
| Receiver Input to Output | tPLH | Figures 8 and 12, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | 250 | | 2000 | ns |
| | tPHL | | 250 | | 2000 | |
| I $t_{PLH}$ - $t_{PHL}$ I Differential Receiver Skew | tSKD | Figures 8 and 12, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | | 100 | | ns |
| Receiver Enable to Output Low | tZL | Figures 7 and 13, $C_{RL}$ = 15pF, S1 closed | | 25 | 50 | ns |
| Receiver Enable to Output High | tZH | Figures 7 and 13, $C_{RL}$ = 15pF, S2 closed | | 25 | 50 | ns |
| Receiver Disable Time from Low | tLZ | Figures 7 and 13, $C_{RL}$ = 15pF, S1 closed | | 25 | 50 | ns |
| Receiver Disable Time from High | tHZ | Figures 7 and 13, $C_{RL}$ = 15pF, S2 closed | | 25 | 50 | ns |
| Maximum Data Rate | fMAX | $t_{PLH}$, $t_{PHL}$ < 50% of data period | 250 | | | kbps |
| Time to Shutdown | tSHDN | (Note 5) | 50 | 200 | 600 | ns |
| Driver Enable from Shutdown to Output High | tZH(SHDN) | Figures 9 and 11, $C_L$ = 100pF, S2 closed | | | 2000 | ns |
| Driver Enable from Shutdown to Output Low | tZL(SHDN) | Figures 9 and 11, $C_L$ = 100pF, S1 closed | | | 2000 | ns |
| Receiver Enable from Shutdown to Output High | tZH(SHDN) | Figures 7 and 13, $C_L$ = 15pF, S2 closed | | | 2500 | ns |
| Receiver Enable from Shutdown to Output Low | tZL(SHDN) | Figures 7 and 13, $C_L$ = 15pF, S1 closed | | | 2500 | ns |

**Note 1:** All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

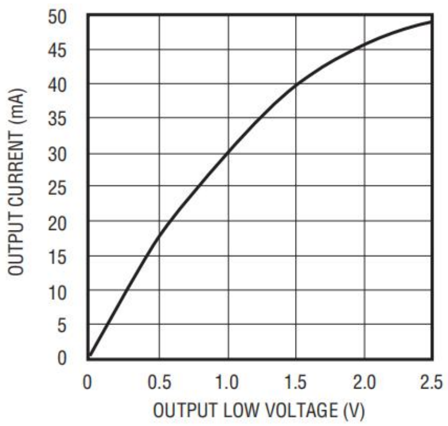
**Note 2:** All typical specifications are given for VCC = 5V and TA = +25°C.

**Note 3:** Supply current specification is valid for loaded transmitters when DE = 0V.

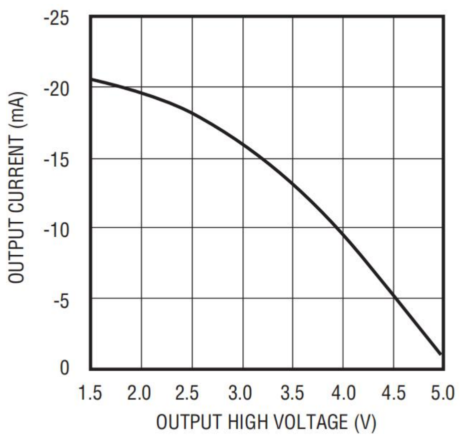
**Note 4:** Applies to peak current. See Typical Operating Characteristics.

**Note 5:** The XLX487 are put into shutdown by bringing RE high and DE low. If the inputs are in this state for less than 50ns, the parts are guaranteed not to enter shutdown. If the inputs are in this state for at least 600ns, the parts are guaranteed to have entered shutdown. See Low-Power Shutdown Mode section.

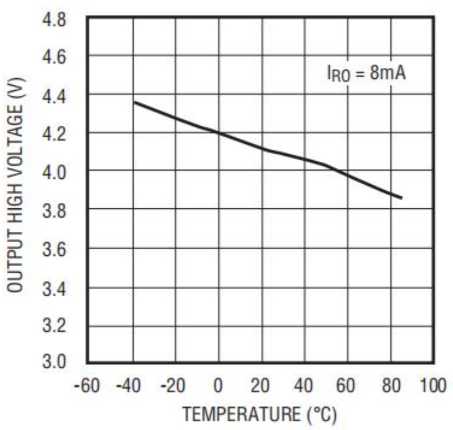
## 6. TYPICAL OPERATING CHARACTERISTICS



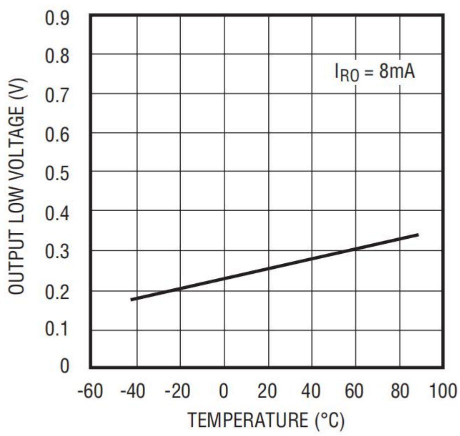

**OUTPUT CURRENT vs. RECEIVER OUTPUT LOW VOLTAGE**



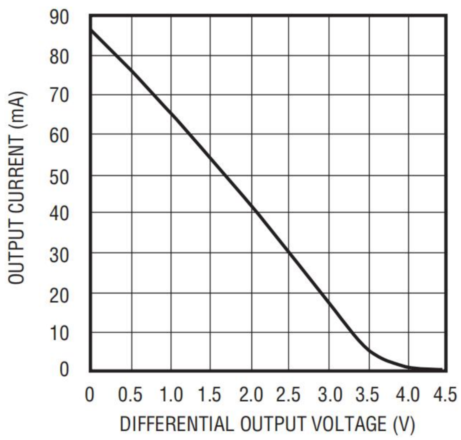

**OUTPUT CURRENT vs. RECEIVER OUTPUT HIGH VOLTAGE**



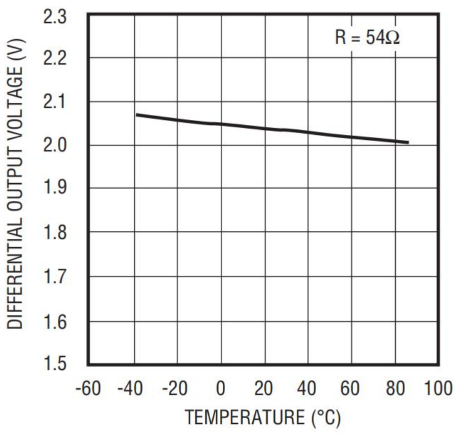

**RECEIVER OUTPUT HIGH VOLTAGE vs. TEMPERATURE**



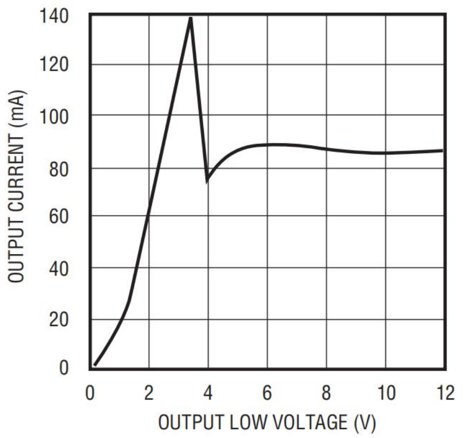

**RECEIVER OUTPUT LOW VOLTAGE vs. TEMPERATURE**



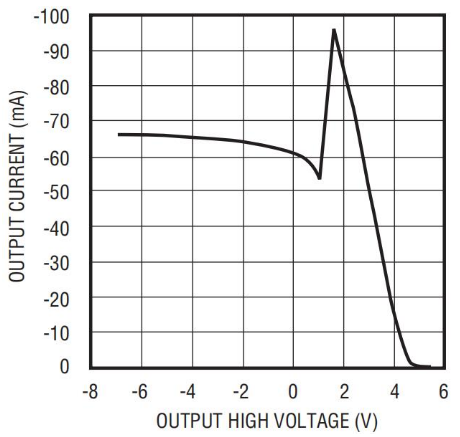

**DRIVER OUTPUT CURRENT vs. DIFFERENTIAL OUTPUT VOLTAGE**




**DRIVER DIFFERENTIAL OUTPUT VOLTAGE vs. TEMPERATURE**




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

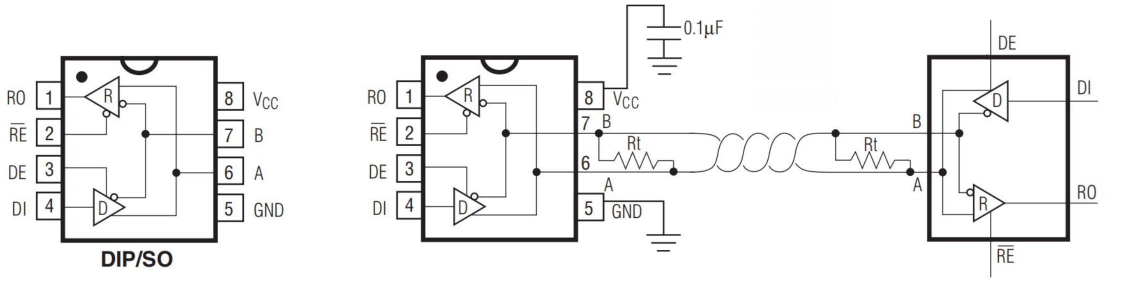



**OUTPUT CURRENT vs. DRIVER OUTPUT HIGH VOLTAGE**

## 7. PIN DESCRIPTION

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | RO | Receiver Output: If A > B by 200mV, RO will be high; If A < B by 200mV, RO will be low. |
| 2 | $\overline{RE}$ | Receiver Output Enable. RO is enabled when $\overline{RE}$ is low; RO is high impedance when RE is high. |
| 3 | DE | Driver Output Enable. The driver outputs, Y and Z, are enabled by bringing DE high. They are high imped-ance when DE is low. 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 | DI | Driver Input. A low on DI forces output Y low and out- put Z high. Similarly, a high on DI forces output Y high and output Z low. |
| 5 | GND | Ground |
| 6 | A | Noninverting Receiver Input and Noninverting Driver Output |
| 7 | B | Inverting Receiver Input and Inverting Driver Output |
| 8 | VCC | Positive Supply: 4.75V ≤ VCC ≤ 5.25V |

**TOP VIEW**




NOTE: PIN LABELS Y AND Z ON TIMING, TEST, AND WAVEFORM DIAGRAMS REFER TO PINS A AND B WHEN DE IS HIGH. TYPICAL OPERATING CIRCUIT SHOWN WITH DIP/SO PACKAGE.

**Figure 1. Pin Configuration and Typical Operating Circuit**

## 8. FUNCTION TABLES

**Table 1. Transmitting**

| INPUTS | | | OUTPUTS | |
|---|---|---|---|---|
| $\overline{RE}$ | DE | DI | Z | Y |
| X | 1 | 1 | 0 | 1 |
| X | 1 | 0 | 1 | 0 |
| 0 | 0 | X | High-Z | High-Z |
| 1 | 0 | X | High-Z* | High-Z* |

X = Don't care
High-Z = High impedance
*Shutdown mode

**Table 2. Receiving**

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

X = Don't care
High-Z = High impedance
*Shutdown mode

## 9. APPLICATIONS INFORMATION

The XLX487 are low-power transceivers for RS-485 and RS-422 communications. Provide extra protection against ESD. The eliminate the need for transient suppres sor diodes and the associated high capacitance loading.

The XLX487 are specified for data rates up to 250kbps. The XLX487 are half-duplex. In addition, driver enable (DE) and receiver-enable (RE) pins are included on the XLX487. When disabled, the driver and receiver outputs are high impedance.

### 9.1. ±15kV ESD Protection

ESD-protection structures are incorporated on all pins to protect against electro static discharges encountered during handling and assembly. The driver outputs and receiver inputs have extra protection against static electricity. 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, XLX487 keep working without latchup.

ESD protection can be tested in various ways; the transmitter outputs and receiver inputs of this product family are characterized for protection to ±15kV using the Human Body Model.

Other ESD test methodologies include IEC10004-2 con tact discharge and IEC1000-4-2 air-gap discharge (for merly IEC801-2).

### 9.2. Human Body Model

Figure 2 shows the Human Body Model, and Figure 3 shows the current waveform it generates when dis charged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of inter est, which is then discharged into the test device through a 1.5kΩ resistor.

### 9.3. IEC1000-4-2

The IEC1000-4-2 standard covers ESD testing and per formance of finished equipment; it does not specifically refer to integrated circuits (Figure 4).

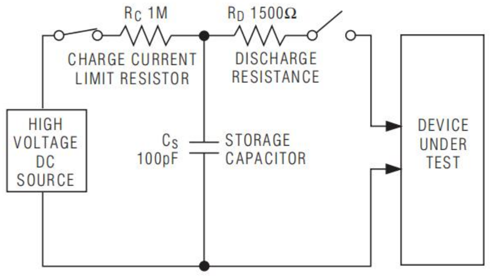



**Figure 2. Human Body ESD Test Model**

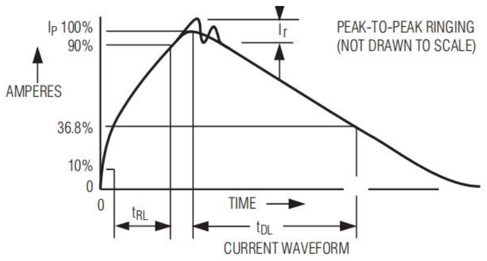



**Figure 3. Human Body Model Current Waveform**

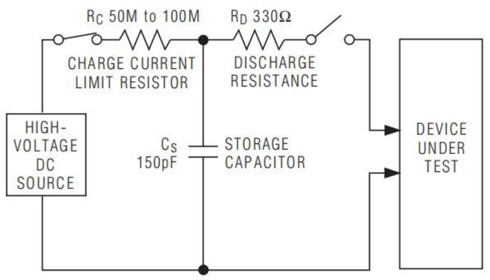



**Figure 4. IEC1000-4-2 ESD Test Model**

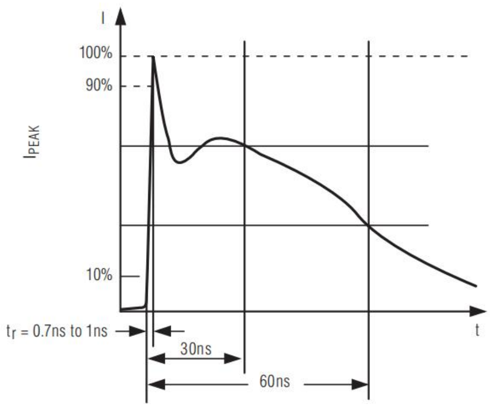



**Figure 5. IEC1000-4-2 ESD Generator Current**

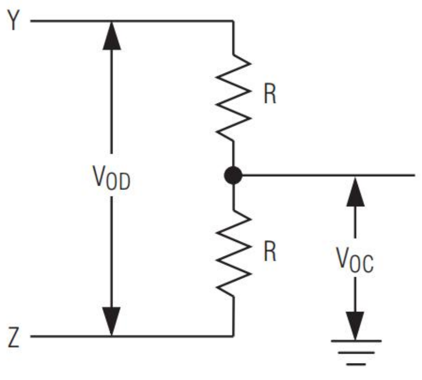



**Figure 6. Driver DC Test Load**

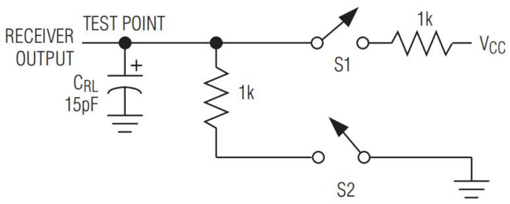



**Figure 7. Receiver Timing Test Load**

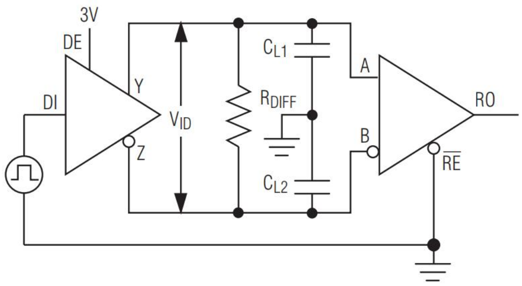



**Figure 8. Driver/Receiver Timing Test Circuit**

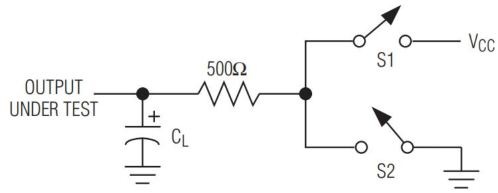



**Figure 9. Driver Timing Test Load**

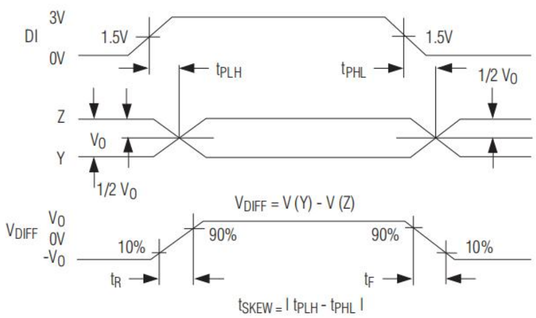



**Figure 10. Driver Propagation Delays**

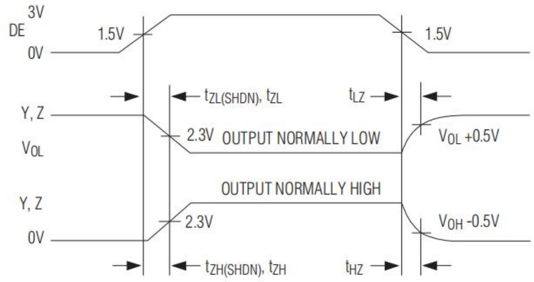



**Figure 11. Driver Enable and Disable Times**

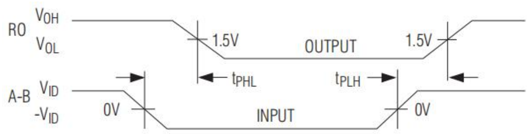



**Figure 12. Receiver Propagation Delays**

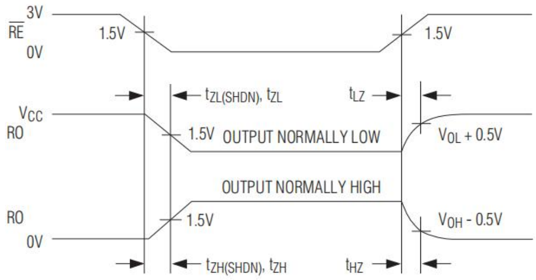



**Figure 13. Receiver Enable and Disable Times**

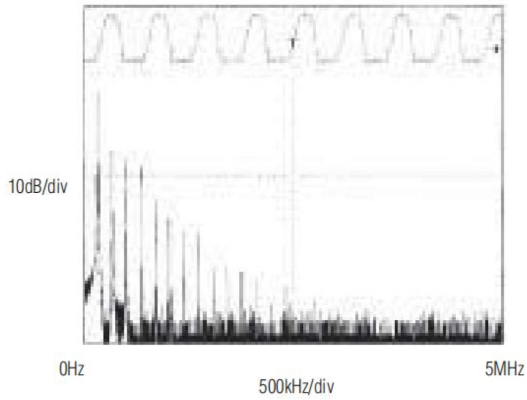



**Figure 14. Driver Output Waveform and FFT Plot of Transmitting a 150kHz Signa**

The major difference between tests done using the Human Body Model and IEC1000-4-2 is higher peak current in IEC1000-4-2, because series resistance is lower in the IEC1000-4-2 model. Hence, the ESD with stand voltage measured to IEC1000-4-2 is generally lower than that measured using the Human Body Model. Figure 5 shows the current waveform for the 8kV IEC1000-4-2 ESD contact-discharge test.

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 resis tance. Its objective is to emulate the stress caused by contact that occurs with handling and assembly during manufacturing. Of course, all pins require this protec tion during manufacturing—not just inputs and outputs. Therefore, after PC board assembly, the Machine Model is less relevant to I/O ports.

## Reduced EMI and Reflections:

The XLX487 are slew-rate limited, minimizing EMI and reducing reflections caused by improperly terminated cables. High frequency harmonics with large amplitudes are evident. Figure 14 shows the same information displayed for a XLX487 transmit ting under the same conditions. Figure 14’s high-fre quency harmonics have much lower amplitudes, and the potential for EMI is significantly reduced.

## Low-Power Shutdown Mode:

A low-power shutdown mode is initiated by bringing both RE high and DE low. The devices will not shut down unless both the driver and receiver are disabled. In shutdown, the devices typically draw only 0.5µA of supply current.

$\overline{RE}$ and DE may be driven simultaneously; the parts are guaranteed not to enter shutdown if RE is high and DE is low for less than 50ns. If the inputs are in this state for at least 600ns, the parts are guaranteed to enter shutdown.

For the XLX487, the tZH and tZL enable times assume the part was not in the low-power shutdown state. The tZH(SHDN) and tZL(SHDN) enable times assume the parts were shut down (see Electrical Characteristics).

It takes the drivers and receivers longer to become enabled from the low-power shutdown state (tZH(SHDN), tZL(SHDN)) than from the operating mode (tZH, tZL). (The parts are in operating mode if the RE, DE inputs equal a logical 0,1 or 1,1 or 0, 0.)

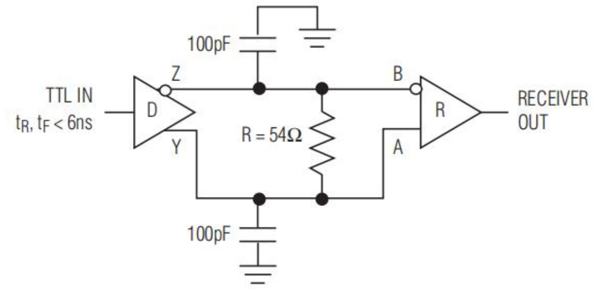



**Figure 15. Receiver Propagation Delay Test Circuit**

## 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 shut down circuit forces the driver outputs into a high-imped ance state if the die temperature rises excessively.

## Propagation Delay:

Many digital encoding schemes depend on the differ ence between the driver and receiver propagationdelay times. Typical propagation delays are shown in Figures 16-17 using Figure 15's test circuit.

The difference in receiver delay times, tPLH - tPHL, is and is typically less than 100ns for the XLX487.

The driver skew times are typically and are typically 100ns (800ns max) for the XLX487.

## Typical Applications:

The XLX487 is designed for bidirectional data communications on multipoint bus transmission lines. Figures 18 show typical net work application circuits. These parts can also be used as line repeaters, with cable lengths longer than 4000 feet.

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 possi ble. The slew-rate-limited XL487 is more tolerant of imperfect termination. Bypass the VCC pin with 0.1μF.

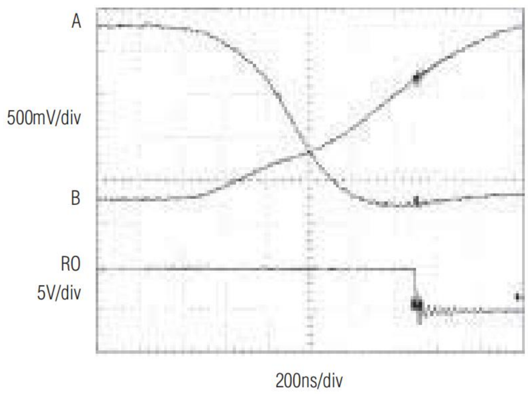



Figure 16. Receiver tPHL

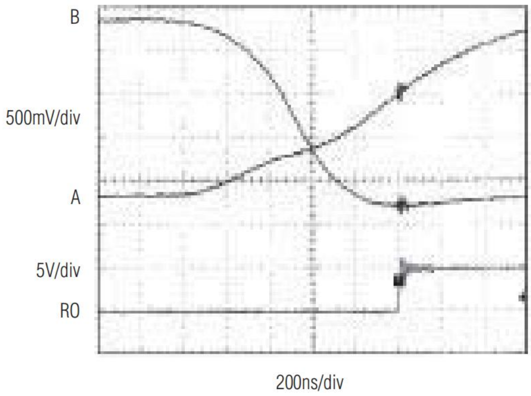



Figure 17. Receiver tPLH

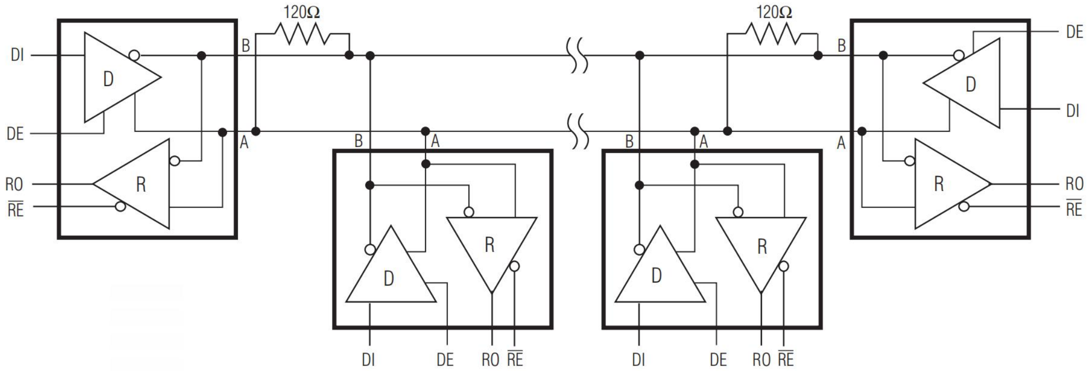



Figure 18. Typical Half-Duplex RS-485 Network

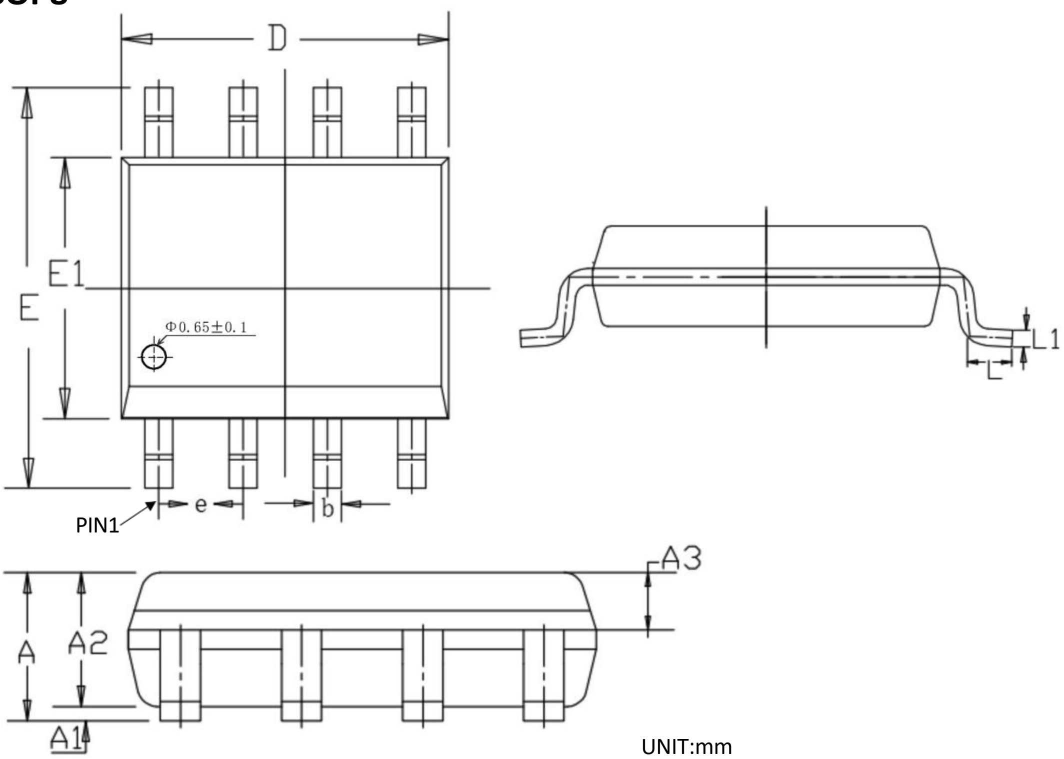
## 10. ORDERING INFORMATION

**Ordering Information**

| Part Number | Device Making | Package type | Body size (mm) | Temperate (°C) | MSL | Transpo Rt | Package Quantit |
|---|---|---|---|---|---|---|---|
| XLX487CSA | XLX487C | SOP-8 | 4.90*3.90 | -40 to +85 | MSL3 | T&R | 2500 |
| XLX487EPA | XLX487E | DIP-8 | 9.25*6.38 | -40 to +85 | MSL3 | Tube 50 | 2000 |

## 11. DIMENSIONAL DRAWINGS

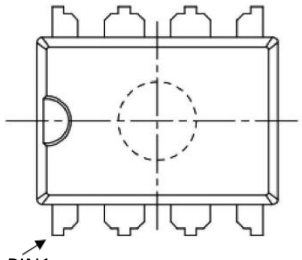
**SOP8**

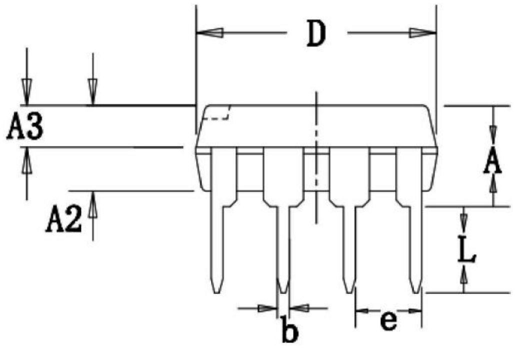


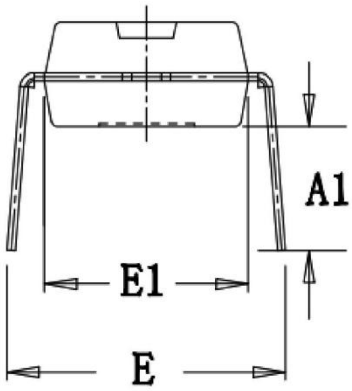

UNIT:mm

| | MIN | NOM | MAX |
|---|---|---|---|
| A | 1.450 | 1.550 | 1.650 |
| A1 | 0.100 | 0.150 | 0.200 |
| A2 | 1.300 | 1.400 | 1.500 |
| A3 | 0.600 | 0.650 | 0.700 |
| b | 0.380 | – | 0.510 |
| e | 1.240 | 1.270 | 1.300 |
| D | 4.800 | 4.900 | 5.000 |
| E | 5.800 | 6.000 | 6.200 |
| E1 | 3.800 | 3.900 | 4.000 |
| L | 0.450 | 0.600 | 0.750 |
| L1 | – | 0.25BSC | – |

## DIP8




UNIT:mm

| | MIN | NOM | MAX |
|---|---|---|---|
| A | 3.600 | 3.800 | 4.000 |
| A1 | 3.786 | 3.886 | 3.986 |
| A2 | 3.200 | 3.300 | 3.400 |
| A3 | 1.550 | 1.600 | 1.650 |
| b | 0.440 | – | 0.490 |
| e | 2.510 | 2.540 | 2.570 |
| D | 9.150 | 9.250 | 9.350 |
| E | 7.800 | 8.500 | 9.200 |
| E1 | 6.280 | 6.380 | 6.480 |
| L | 3.000 | – | – |