LINEAR TECHNOLOGY
DESIGN NOTES

RS485 Transceivers Sustain ±60V Faults – Design Note 203

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Introduction

The LT®1785 and LT1791 RS485/RS422 transceivers with ±60V fault tolerance solve a real-world problem of field failures in typical RS485 interface circuits. Modems and other computer peripherals use point-to-point RS422 connections to support higher communication speeds with better noise immunity over greater distances than is possible with RS232 connections. Multipoint RS485 networks are used for LANs and industrial control networks. All of these applications are vulnerable to the unknown, sometimes hostile environment outside of the controlled, shielded environment of a typical electrical equipment chassis. Because the RS485 transceivers are directly in the line of fire, the transceiver chips are often socketed PDIP packages to allow easy field servicing of equipment. Field failures in standard transceiver circuits are caused by data-line voltages exceeding the absolute maximum ratings of the transceiver chips. Installation wiring faults, ground voltage faults and lightning-induced surge voltages are all common causes of overvoltage conditions.

Up to ±60V Faults

The electrical standards for RS422 and RS485 signaling reflect the need for tolerance of ground voltage drops in an extended network by requiring receivers to operate with input common mode voltages from –7V to 12V. The RS485 and RS422 transceivers commonly available from various vendors are all vulnerable to damage from fault voltages only slightly outside of the operating envelope. One vendor's RS485 transceivers have absolute maximum voltage ratings of –8V to 12.5V on the data I/O pins. Such narrow margins beyond the required –7V to 12V operating conditions makes such circuits very fragile in a real-world environment. In addition, external protection circuitry is ineffective at protecting these circuits without corrupting normal operating signal levels.

The LT1785 and LT1791, with ±60V absolute maximum ratings on the driver output and receiver input pins are inherently safe in most environments that will destroy other interface circuits. Standard pinouts in either PDIP or SO packages allow easy upgrades to existing RS422/RS485 networks. Whether the circuit is transmitting, receiving, in standby or powered off, any voltage within ±60V will be tolerated by the chip without damage. Data communication will be interrupted during the fault condition, but the circuit will live to talk another day. Figure 1 shows the I-V characteristics at the RS485 input/output pins.

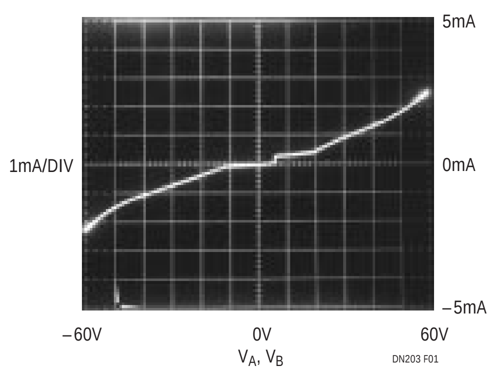

Figure 1. LT1785 Input Current vs V_{IN}

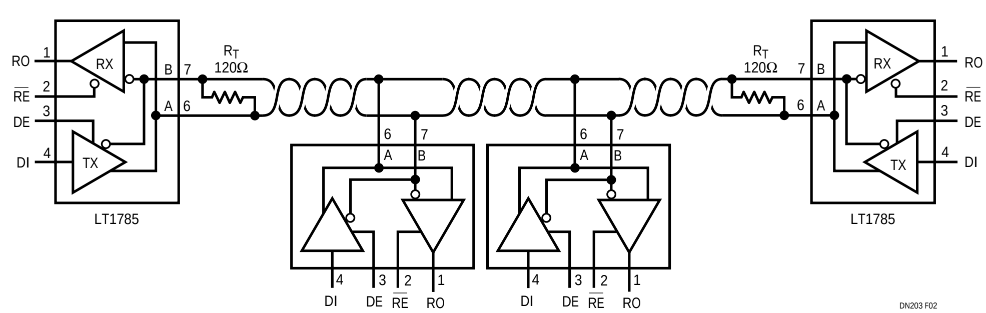

Figure 2. Half-Duplex RS485 Network Operation ±60V DC, ±15kV ESD Protected

128-Node Networks at 250kbaud

In addition to their unique fault tolerance capabilities, these transceivers feature high input impedance to support extended RS485 networks of up to 128 nodes (Figure 2). Controlled slew-rate outputs minimize EMI problems while supporting data rates up to 250kbaud (see Figure 3). Driver outputs are capable of working with inexpensive telephone cable with characteristic impedance as low as 72Ω with no loss of signal amplitude. "A" grade devices are available that ensure "fail safe" receiver outputs when inputs are open, shorted or no signal is present.

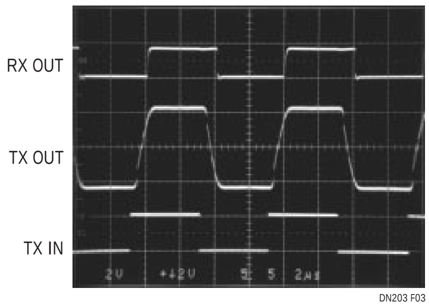

Figure 3. Normal Operation Waveforms at 250kbaud

Extending Protection Beyond ±60V

While ±60V fault tolerance forgives a great number of sins, higher voltage demons may still be lurking. ESD is one such demon, with voltage spikes into the thousands of volts. The LT1785 and LT1791 have on-chip protection to ±15kV air gap ESD transients for other high voltage faults, such as lightning-induced surge voltages or AC line shorts. For such high energy faults, external protection must be used to protect the circuits. Typical protection networks use voltage clamping and current limiting networks. In concept, such networks could be used with normal RS485 circuits to afford extended protection, but in practice, the addition of protection networks would interfere with normal operation of the data network. The voltage clamping Zeners or TransZorbs® are not available in tight voltage tolerances, and in addition, their internal impedances cause several volts of additional potential above their nominal breakdown voltage to appear at the protected device's pins. To protect a circuit with a –8V to 12.5V absolute maximum voltage rating would require the use of protection devices with voltage ratings much below the required common mode range of RS485 networks interfering with normal data transmission.

Figure 4 gives an example of the use of external clamping and limiting components to extend the LT1785's ±60V tolerance to the peak 120V AC line voltage. 36V TransZorbs are used to clamp the transceiver's line pins below the 60V capability of the transceiver. During a 120V AC line fault, peak surge currents of nearly 3A will flow through the 47Ω limiting resistors and the PolySwitch™ limiters. The peak current rating and series resistance of the TransZorbs must be considered when selecting the clamp device to ensure that the clamp limiter can withstand the surge and that the peak voltage will remain below the ±60V limitations of the LT1785. At 3A, even high current TransZorbs will exceed their nominal breakdown voltage by several volts, making this protection method ineffective with transceiver circuits with only 1V to 4V margin above their operating ranges. The PolySwitch limiters are thermally activated and increase in resistance by many orders of magnitude in about 10ms. After the PolySwitch transition, fault currents are only a few milliamperes. Carbon composite resistors must be used for limiting the initial surge current before the PolySwitch transition point. Metal film resistors do not have effective surge overload ratings and will fail before the PolySwitch transition drops the currents to sustainable levels.

TransZorb is a registered trademark of General Instruments, GSI.
PolySwitch is a trademark of Raychem Corporation.

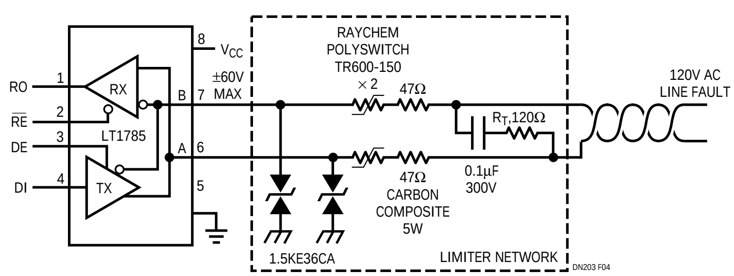

Figure 4. Limiter Network Clamps 120V AC Fault Voltage to Less Than ±60V

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