

Isolated RS485 Transceiver Breaks Ground Loops

by Mitchell Lee

The RS485 interface is designed to handle a $-7V$ to $12V$ input signal range; however, in practical systems, ground potentials vary widely from node to node, often exceeding the specified range. This can result in an interruption of communications, or worse, destruction of a transceiver. Guarding against large ground-to-ground differentials calls for an isolated interface. A new surface mount device, the LTC1535 isolated RS485 transceivers, provides a one-chip solution for breaking ground loops.

Previously, isolation was achieved using at least three optoisolators and a separate isolated power supply. The LTC1535 replaces not only the optoisolators, but also the power supply, as it includes an on-chip DC/DC converter. Other features include selectable driver slew rate to reduce EMI and susceptibility to reflections, full-duplex pinout and fail-safe detection of open and shorted lines.

The LTC1535 consists of two separate dice assembled on a proprietary, isolated lead frame. The lead frame includes integral coupling capacitors that bridge the isolation barrier and exhibit $2,500V_{RMS}$ guaranteed stand-off. Data communication takes place via the coupling capacitors, while an on-chip, $400kHz$ push-pull switching regulator sends power to the isolated side through a small transformer. Total common-mode capacitance across the barrier amounts to less than $20pF$, with the transformer accounting for about $16pF$ of the total. Figure 1 shows the complete circuit for a fully isolated RS485 port.

The two halves of the LTC1535 communicate in a ping-pong fashion, first sending transmit data to the isolated side and then sending receive data back to the nonisolated side. The sampling nature of the internal communications link means that some jitter is introduced into the

data; this limits the useful baud rate to approximately $500k$ Bd. At $350k$ Bd, the jitter is guaranteed to be less than 10%. Figure 2 shows a double pulse propagating through the LTC1535. Waveform (A) is the transmitter data input and waveform (B) is the output of the receiver. The transmitter and receiver are looped back on the isolated side of the chip. The typical jitter is hardly visible. A negative-going double pulse is shown in Figure 3. The LTC1535 transceiver is unaffected by the DC average of the data waveform. Total round-trip propagation delay through the LTC1535 is approximately $1\mu s$ or roughly equivalent to 328 feet of cable.

Figure 4 shows the driver output waveform when loaded by 5000' of terminated cable, operating in the fast slew mode (SLEW pin pulled high). The effect of the SLEW pin on the driver output waveform is noticeable in Figure 5, where rise and fall times of approximately $1\mu s$ result.

Isolation can bring potentially dangerous voltages onto a circuit board and within easy reach of the end user.

For example, if the twisted pair is accidentally miswired or faults to $117V$ at some remote location, the floating section of each LTC1535 and its associated circuitry will also carry $117V$. An unwary user or installer could then come in contact with what is assumed to be a safe, low voltage circuit. Figure 6 shows how to detect and warn the user that a fault condition exists on the twisted pair or its shield. A small ($3.2mm$) glow lamp is connected between GND2 (the LTC1535's floating ground) and the equipment's safety "earth" ground. If a potential of more than $75VAC$ is present on the twisted pair or shield, B1 will light, indicating a wiring fault. Resistors R3 and R4 are used to ballast the current in B1. Two resistors are necessary because each resistor can only stand off $200V$, as well as for reasons of power dissipation. As shown, the circuit can withstand a direct fault to a $440V$, 3-phase system.

Other problems introduced by floating the twisted pair include the collection of static charge on the twisted pair, its shield and the

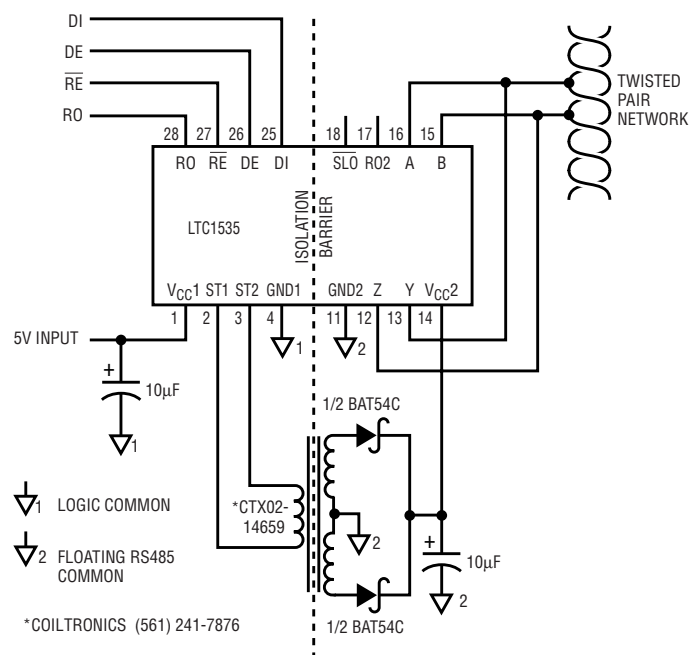


Figure 1. Fully isolated RS485 port

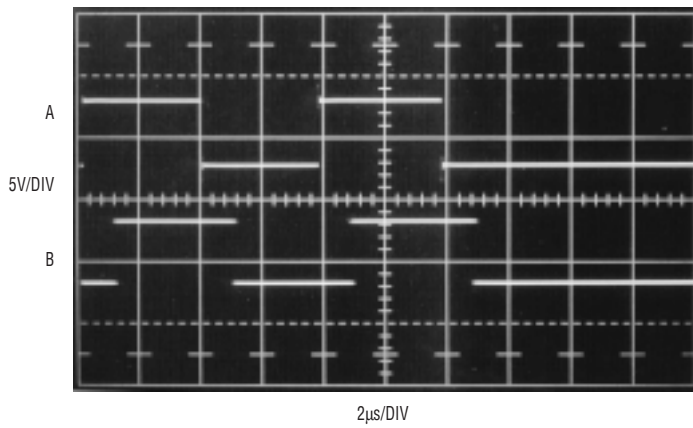


Figure 2. Positive-going double-pulse behavior: A = driver input, B = receiver output

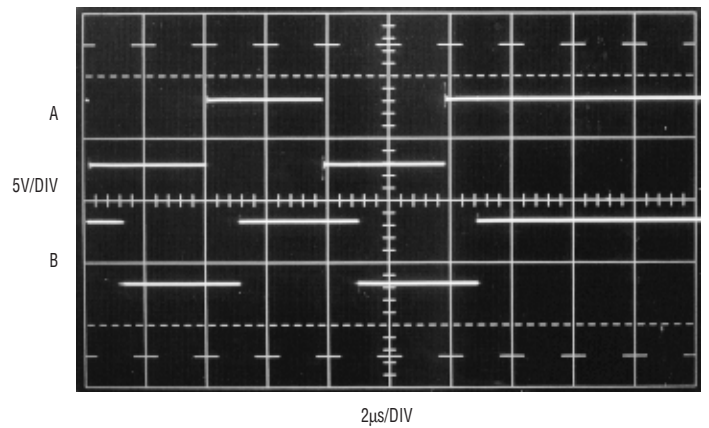


Figure 3. Negative-going double-pulse behavior: A = driver input, B = receiver output

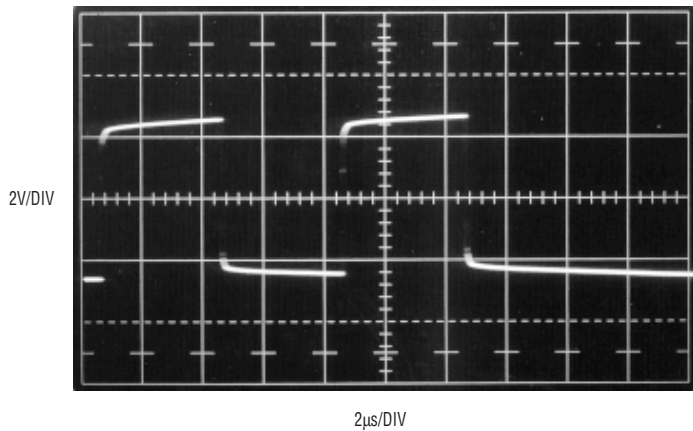


Figure 4. Driver in fast slew mode, loaded with 5000' of twice-terminated twisted pair

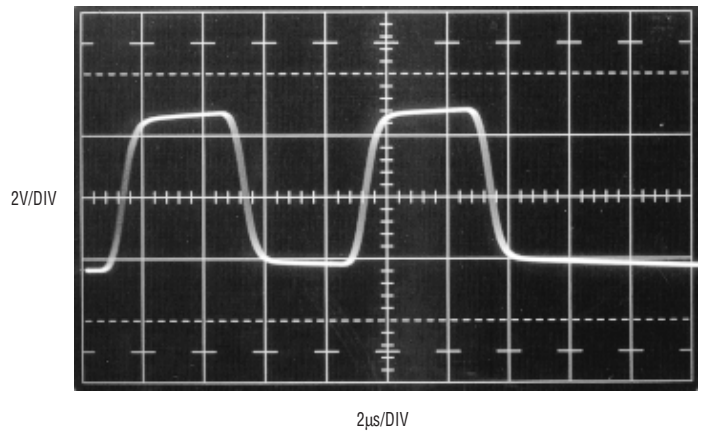


Figure 5. Driver in slow slew mode, loaded with 5000' of twice-terminated twisted pair

attached circuitry. R1 and R2 provide a path to shunt static charge safely to ground. Again, two resistors are necessary to withstand high voltage faults. Electrostatic spikes and transients can temporarily elevate the twisted pair to 10kV or more. C1 in Figure 6 absorbs this charge and limits the peak voltage that reaches the LTC1535 to a safe value. As an example, if a 1000pF source charged

to 10kV comes in contact with the cable, a single 10nF capacitor at C1 will reduce the peak voltage to just 1kV, decaying in less than 10ms through R1-R4 and B1. 1kV is well within the capabilities of the LTC1535.

Combining isolation, power and a fully-compliant RS485 transmitter and receiver, the LTC1535 provides a compact, cost-effective solution for isolated serial data communications.

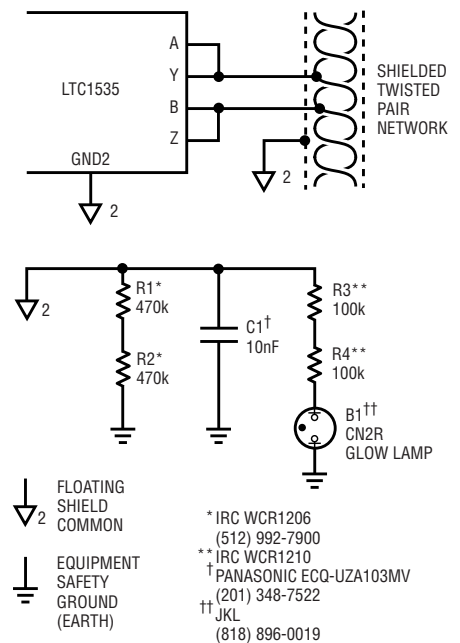


Figure 6. Detecting wiring faults

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