

Multiprotocol Transceivers Combine RS485 and RS232 in a Single Device to Simplify and Shrink Applications that Use Both Standards

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The RS232 and RS485¹ data transmission interface standards are in widespread use today despite their relatively advanced age—RS232 was introduced almost 50 years ago; RS485, 30 years ago. Such longevity for any standard is uncommon in today's rapidly changing electronics landscape, where consumer demand can force obsolescence in a handful of years.

Although the once ubiquitous RS232 port on personal computers has largely been replaced by USB, RS232 continues to proliferate in applications requiring rugged, short distance, point-to-point communication, such as in sensors, test equipment, device programming and diagnostics.

Likewise, RS485 thrives thanks to its high performance in harsh environments. Its differential signaling scheme and wide common mode tolerance provide excellent noise immunity, allowing high speed communication over relatively long distances. Perhaps equally important in the RS485 standard is the ability to network several devices on a single bus, thereby reducing wiring overhead. RS485 is specified as the physical layer for many Fieldbus networks including PROFIBUS and INTERBUS.

To simplify the design of RS485 and RS232 systems, the LTC2870 and LTC2871 multiprotocol transceivers combine both types of transceivers on a single device. Both support data rates as high as 20Mbps for the single RS485 transceiver and 500kbps for two RS232 transceivers.

These devices are designed to support a wide variety of applications with features that make them flexible and robust:

- They accept a wide range of input supply voltages from 3V to 5.5V, as well as a logic supply pin, allowing a digital interface down to 1.7V with no level translation needed.
- Integrated termination resistors are automatically engaged for compatibility with RS232 or RS485 operation.
- Half- and full-duplex control and loop-back functions provide system configurability and diagnostics capability.
- Robust performance allows continuous operation during ESD strikes of up to 26kV on the bus pins.
- Both devices are offered in small QFN and TSSOP packages, as shown in Figure 1.

The LTC2870 and LTC2871 differ in how their transceiver I/Os are pinned out, as well how they are controlled. The LTC2870 offers two RS232 transceivers that share I/O pins with an RS485 transceiver. It can operate in either RS232 mode or RS485 mode but not both at once. The LTC2871 provides additional flexibility by pinning the RS485 and RS232 transceivers out separately so that all transceivers

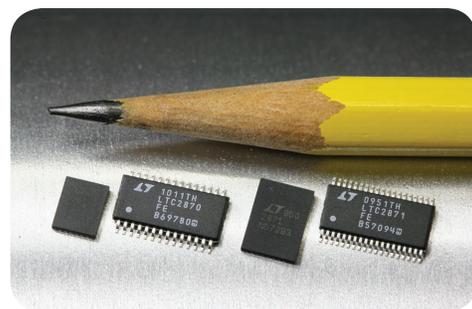


Figure 1. The LTC2870 and LTC2871 are offered in small QFN and TSSOP packages

can be operated concurrently as shown in Table 1. Figure 2 shows a simplified block diagram for each device.

APPLICATIONS

The LTC2870 and LTC2871 can be configured in a variety of ways. Application of these devices falls into three main categories:

- *Fixed interface:* The LTC2870 or the LTC2871 can be permanently configured as either an RS232 or RS485 interface. For instance, Figure 3 shows both modes of operation for the LTC2870. If two versions of a product are offered, one with each interface, a multiprotocol transceiver minimizes design differences, reducing inventory, and simplifying product qualification.
- *In situ configuration changes with a shared connector:* Some applications require the signaling interface to change between RS232 and RS485 during normal product usage. For example, a node in an alarm system might be networked with other nodes via an RS485 communication bus. However, the node can be configured for local RS232 access,

Table 1. Product selection guide

PART NUMBER	CONFIGURABLE TRANSCEIVER COMBINATIONS (RS485 + RS232)	PACKAGES
LTC2870	(0 + 0), (1 + 0), (0 + 2)	28-Lead QFN, 28-Lead TSSOP
LTC2871	(0 + 0), (1 + 0), (1 + 1), (1 + 2), (0 + 1), (0 + 2)	38-Lead QFN, 38-Lead TSSOP

allowing programming or diagnostics. Signaling pins are shared between the RS485 and the RS232 transceivers, with one transceiver active at any given time, as shown in Figure 4.

The LTC2870 changes modes between RS232 and RS485 via control of the 485/232 pin, which can be manipulated through processor control, manual jumper settings, or protocol-specific cables that connect the pin to V_L or ground. The LTC2871 can be

used in a similar way but with independent access to all signal pins.

- *Simultaneous operation.* Some applications require concurrent RS485 and RS232 communication. For example, in point-of-sale applications, a cash register may communicate with a server

Figure 2. Simplified block diagrams of the LTC2870 and the LTC2871

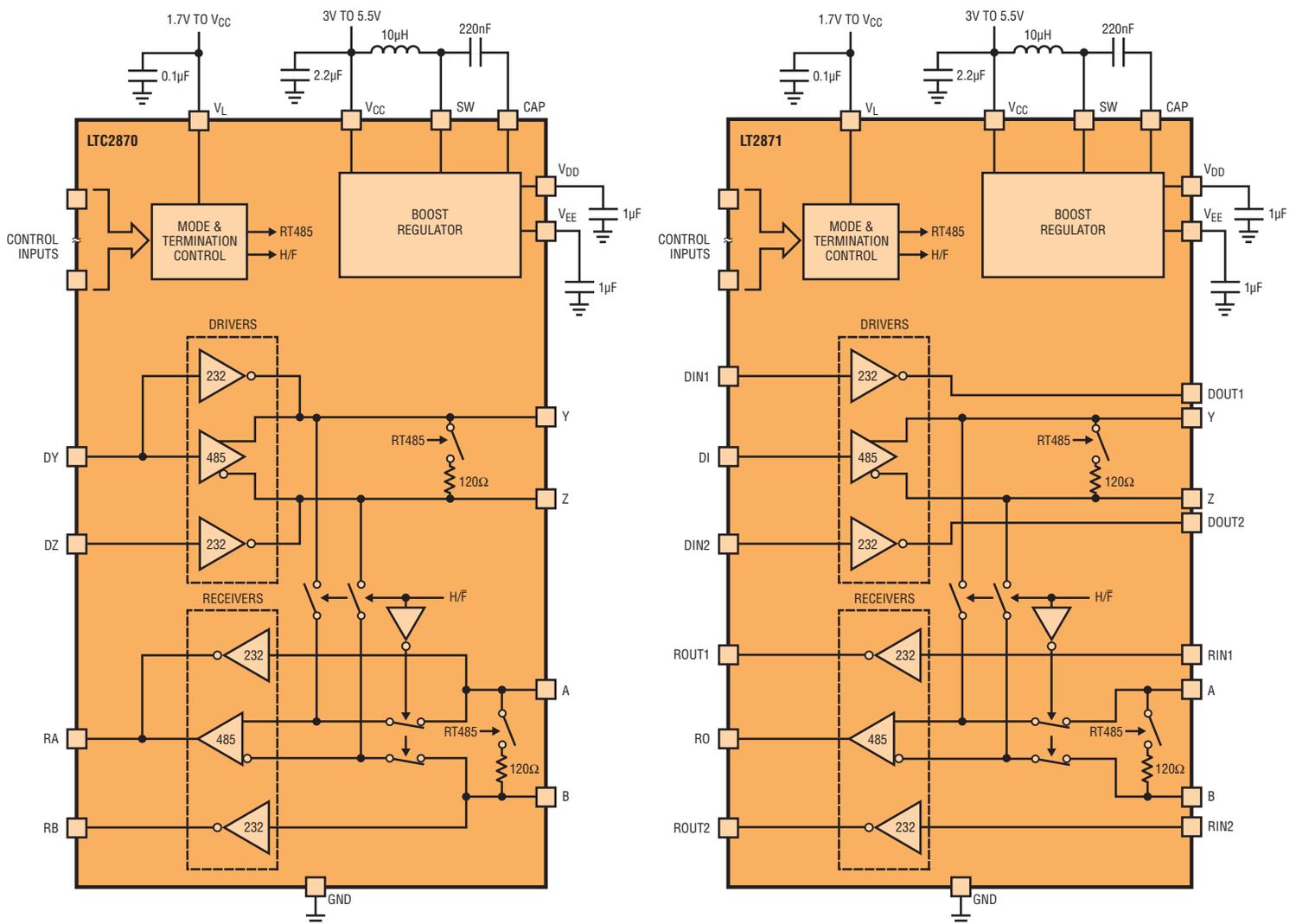
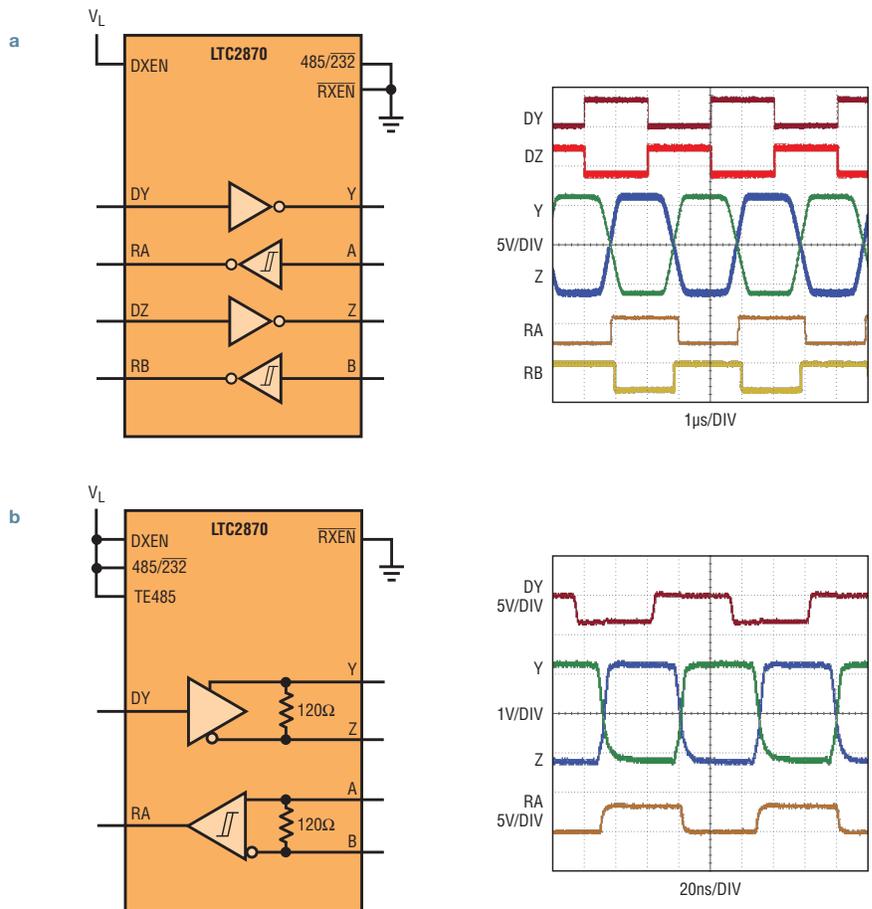


Figure 3. The LTC2870 configured for RS232 (a) or RS485 (b) communications. The RS485 configuration also shows the RS485 termination resistors optionally switched in with the TE485 pin tied high.



via RS485 but also accept input from an RS232-equipped keypad. The LTC2871, with completely independent RS232 and RS485 transceivers, enables separate terminals for each protocol with a single IC. Another example of simultaneous usage is translation between RS232 and RS485 protocols. Figure 5 shows the LTC2871 configured as an RS232 4000-foot “extension cord” implemented by converting to RS485 for the long cable run and converting back to RS232 at the ends.

THE WHOLE IS BETTER THAN THE SUM OF ITS PARTS

Using a multiprotocol device, such as the LTC2870 with shared RS485 and RS232 interface pins, offers a number of advantages over simply combining standalone RS485 and RS232 transceivers. First, by combining the function of both transceivers in one device, the overall footprint on a circuit board is reduced. Second, all of the interface pins on the RS232 can tolerate inputs to $\pm 15\text{V}$. Most RS485 devices can only tolerate -7 to 12V , so connecting such a device to RS232 pins would lower the shared pin rating.

Perhaps the biggest obstacle in combining individual RS485 and RS232 transceivers concerns the termination resistors used in each signaling standard. This situation is illustrated in Figure 6, where two different devices are connected to the same bus. The input resistance of the RS232 receivers is specified to be 5k (nominally), which acts as a termination resistor for an RS232 driver connected to it. On the other hand, the differential RS485 receiver can be terminated with 120Ω resistors across its

inputs if it is located at the end of the signaling bus, to reduce signal reflections. The challenge is in switching out the resistors that are not needed in the selected transceiver mode. For example, in RS485 mode, the 5k resistors should not be present and likewise, in RS232 mode, the 120Ω differential termination must not be present.

The LTC2870 and LTC2871 seamlessly switch between termination schemes as needed, using internal components.

Table 2. Termination control in the LTC2870. The LTC2870 and LTC2871 seamlessly switch between termination schemes as needed, using internal components. The RS485 120Ω termination resistor can be disabled in any mode by setting TE485 pin low, which is useful if the transceiver is not positioned at the end of the bus.

INPUTS			RESULTING TERMINATION		
485/232	TE485	R _{XEN}	120Ω: A TO B, Y TO Z	5k: A TO GND, B TO GND	MODE
1	0	X	No	No	RS485 Mode Without Termination
1	1	X	Yes	No	RS485 Mode With Termination
0	X	0	No	Yes	RS232 Mode, Receiver Enabled
0	X	1	No	No	RS232 Mode, Receiver Disabled

There is no need for external termination components or relays to control them. Furthermore, the RS485 120Ω termination resistor can be disabled in any mode by setting TE485 pin low, which is useful if the transceiver is not positioned at the end of the bus. Table 2 summarizes the termination control in the LTC2870.

The LTC2871 offers similar controls but since the RS232 and RS485 pins are not shared, all of the termination resistors can be engaged simultaneously if desired. Refer to the data sheet for details.

SOME SPECIFICS REGARDING THE RS485 TERMINATION RESISTOR

RS485 communicates differentially over a bus containing one or more pairs of twisted wires. If the transition time of the signal driven into the bus is significantly less than the round trip delay to the load and back, then the bus needs to be terminated differentially with a resistor whose characteristic impedance matches that of the bus. This termination should be placed at the receiver end of the bus or both ends of the bus, but not in between. The absence of termination or improper termination introduces reflections that can cause severe waveform distortion.²

When RS485 termination is enabled on the LTC2870 or LTC2871, the 120Ω differential resistors are connected across receiver inputs A and B and also across

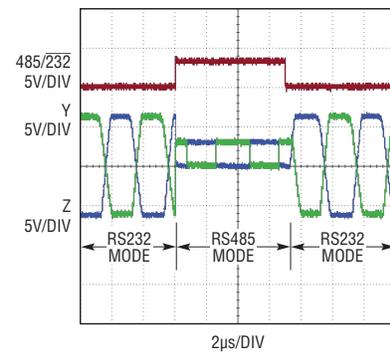
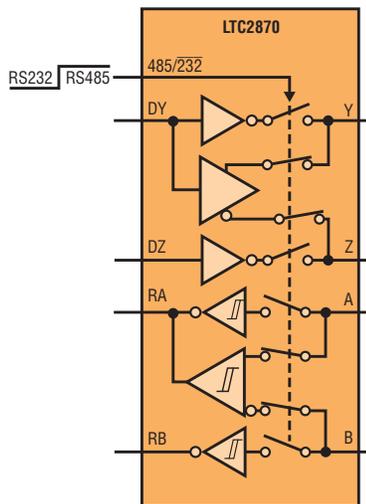


Figure 4. LTC2870 protocol switching, using the 485/232 pin. Oscilloscope traces show the driver outputs toggling data during mode changes.

driver outputs Y and Z. The driver termination is not strictly necessary for the case when this device is actively driving the bus, such as the master in Figure 7. However, the Y to Z termination is necessary in applications such as the slave at the far end of the bus in Figure 7, where another device is driving the bus.

The RS485 standard specifies cable with a characteristic impedance of 120Ω while RS422 specifies 100Ω cable. These cables generally contain one or more twisted pairs as well as ground shields or a ground wire (sometimes called a drain wire). As an alternative to shielded twisted pair, unshielded 100Ω Category 5 (CAT5) cabling is increasingly applied in RS485 and RS422 systems as an economic alternative.

The LTC2870 and LTC2871 perform equally well with 100Ω or 120Ω cable. Even when the internal termination resistor, nominally 120Ω, is used to terminate a 100Ω cable, the impedance mismatch has negligible impact on the resulting signal. For instance, the effect of using a 120Ω termination on each end of a 100Ω cable is to develop an overshoot of about 10% at the receiver end with a duration equal to

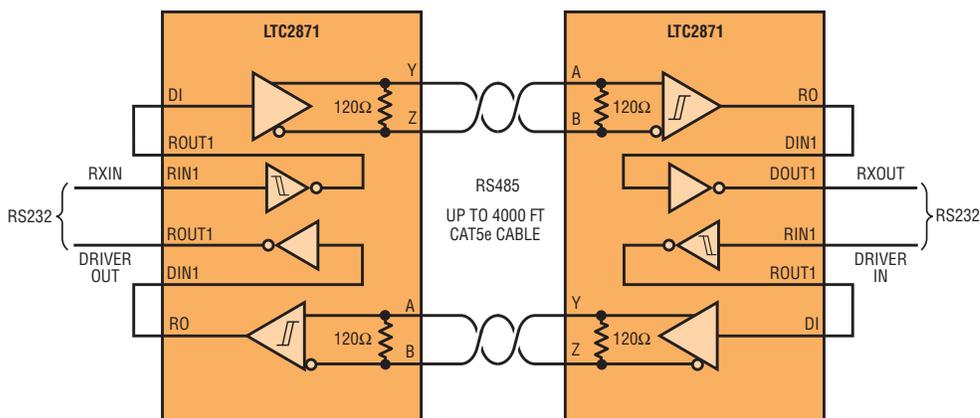


Figure 5. RS232 "Extension cord" using the LTC2871's simultaneous RS232 and RS485 communication mode

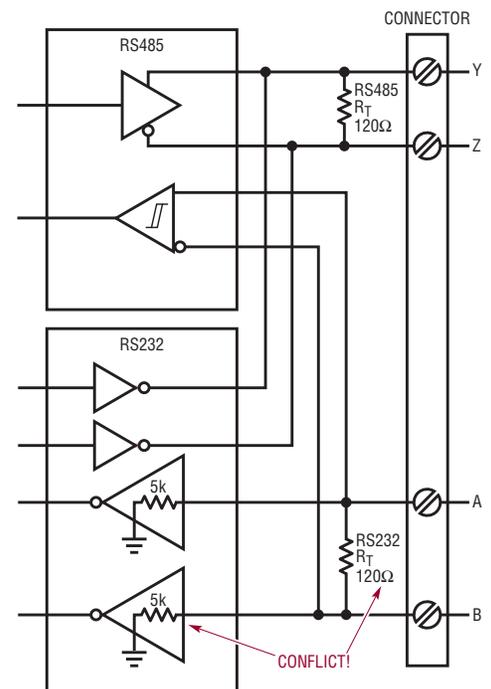
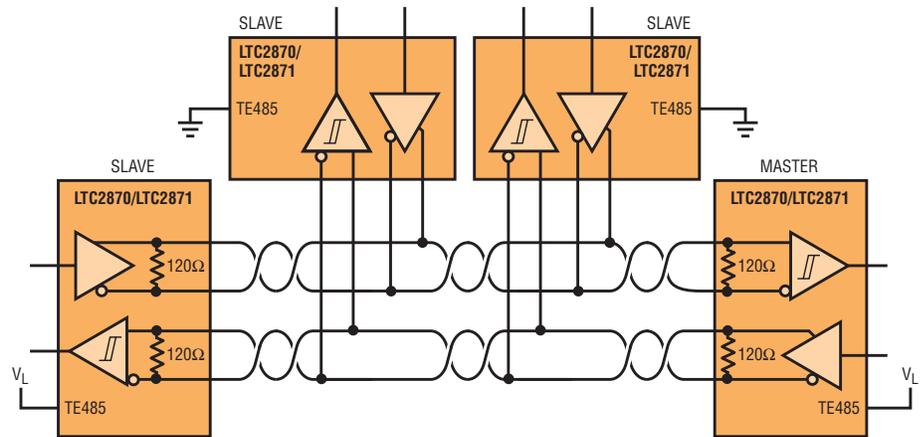


Figure 6. Termination resistors pose challenges when separate RS232 and RS485 transceivers are used in combination.

The only required external components are one 10 μ H inductor for the boost voltage and one 220nF cap for the voltage inversion, as well as the bypass caps on the generated V_{DD} and V_{EE} rails.

Figure 7. Full-duplex network with LTC2870/71 at each node



twice the one-way propagation delay in the cable. This small deviation from ideal is easily tolerated in most communications systems, and can improve performance, which is why the PROFIBUS standard specifies a similar termination mismatch.

Figure 8 shows the results of using the LTC2871 internal 120 Ω termination resistor to terminate 100 feet of CAT5e cable

compared to the same cable terminated with 100 Ω . Although the internal terminator is not a perfect match for the 100 Ω cable, there is almost no effect on the overall signal other than a slight amplitude increase at the beginning of the received signal, which can improve system performance via increased signal overdrive and noise margin. Normal

cable variation, stub reflections and discontinuities have a far greater impact on signal integrity. The figure also shows the devastating effect of leaving the cable unterminated at the receiving end, where reflections degrade the signal substantially.

INTERNAL RS232 SUPPLY ENOUGH TO DRIVE TWO TRANSCEIVERS

RS232 signals are driven on a single wire with respect to ground at levels that must exceed 5V and -5V. A DC/DC boost converter and capacitive inverter are integrated into the LTC2870 and LTC2871 to produce both positive and negative voltages used to support these drive levels while operating on a single 3V-5.5V supply. The only required external components are one 10 μ H inductor for the boost voltage and one 220nF cap for the voltage inversion, as well as the bypass caps on the generated V_{DD} and V_{EE} rails. Figure 9 shows the LTC2870 or LTC2871 configured in a typical application with all of the required external components.

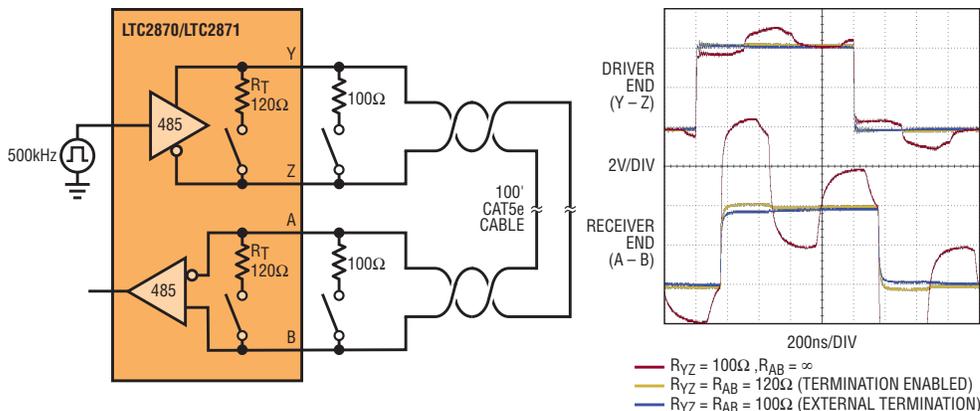


Figure 8. Driving signal on Cat5e cable with the LTC2871 and comparing effects of the termination resistance. Scope traces on the top show the differential signal at the driven end of the cable (Y - Z) and the bottom set of traces show the differential signal received after traversing the cable (A - B).

Predictable fault handling is important for robust system design. LTC2870 and LTC2871 receivers produce a high output, called a failsafe condition, in response to an idle bus, disconnected bus or shorted bus.

Two LTC2870 or LTC2871 devices can be powered simultaneously from the internal DC/DC converter of one device, reducing the number of external components. Figure 10 shows two LTC2870s, two LTC2871s or one of each sharing a single internal RS232 supply.

LOGIC SUPPLY PIN SUPPORTS 1.7V TO 5.5V SUPPLIES

A separate logic supply pin v_L allows the LTC2870 and LTC2871 to interface with any logic signals from 1.7V to 5.5V. All logic I/Os use v_L as their high supply. Optionally, v_L can be tied to v_{CC} . Figure 11 shows the LTC2870 or LTC2871 used with a low voltage microprocessor.

RS485 BALANCED RECEIVER AND FAILSAFE

Failsafe operation is a term used to describe how a receiver reacts to various conditions, most of which are faults. Predictable fault handling is important for robust system design. LTC2870 and LTC2871 receivers produce a high output, called a failsafe condition, in response to all of the following conditions:

- *Idle Bus.* All drivers on the bus are disabled with high impedance outputs. This condition is not actually a fault; it is a normal mode of operation in RS485. Some receivers cannot support this by themselves but require a resistor network to bias the differential signals on the bus in such a way that the receiver senses it as a high input. The LTC2870 and LTC2871 support this function without requiring a bus-biasing network, whether the bus is terminated or not.
- *Disconnected Bus.* This category of failsafe operation refers to the case where the receiver becomes disconnected from the bus. This is similar to the idle bus state but is truly a fault condition. Receivers that rely on bus biasing resistors to handle an idle bus condition do not respond properly to this type of fault.
- *Shorted Bus.* In this situation, the receiver inputs are shorted together. Some receivers provide failsafe operation for open, but not shorted, inputs. Again, bus-biasing resistors are not effective for shorted bus conditions.

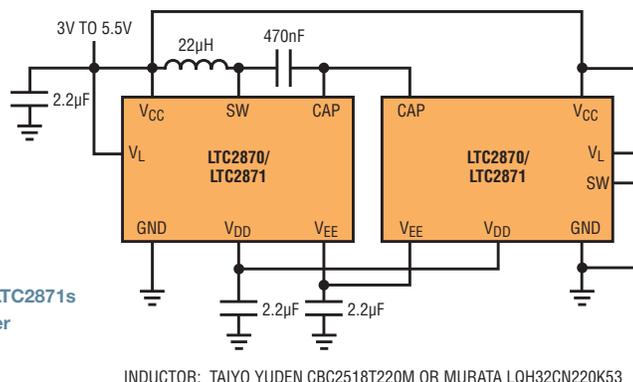


Figure 10. Running two LTC2870s or LTC2871s from a single, shared DC/DC converter

INDUCTOR: TAIYO YUDEN CBC2518T220M OR MURATA LQH32CN220K53

Many modern RS485 receivers meet failsafe requirements by introducing a negative offset into the differential threshold. In this way, whenever the bus is shorted or undriven, but terminated, the input to the receiver is zero, which is interpreted as a high level. The receiver in this case is unbalanced, since the threshold is not symmetric around zero volts—the average of a differential signal.

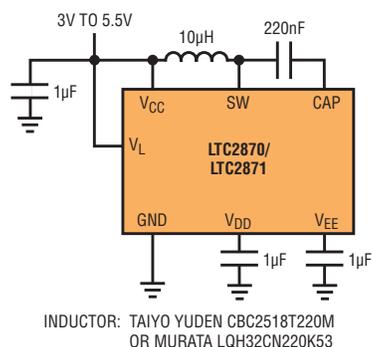


Figure 9. Typical supply connections with external components shown

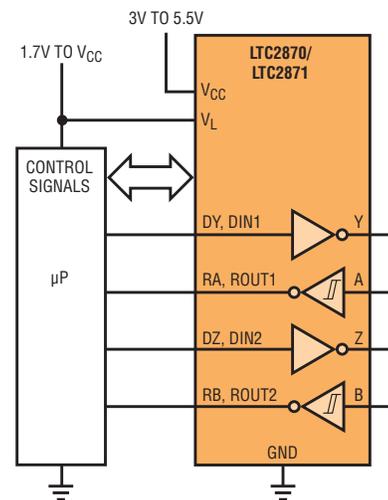


Figure 11. The v_L pin permits low voltage logic interface

100Ω unshielded Category 5 (CAT5) cabling is used with RS485 and RS422 systems as an economic alternative to specialized shielded twisted pair cabling. With this in mind, the LTC2870 and LTC2871 perform equally well with 100Ω cable or 120Ω cable. Even when the internal 120Ω termination resistor is used to terminate a 100Ω cable, the resulting signals are not degraded.

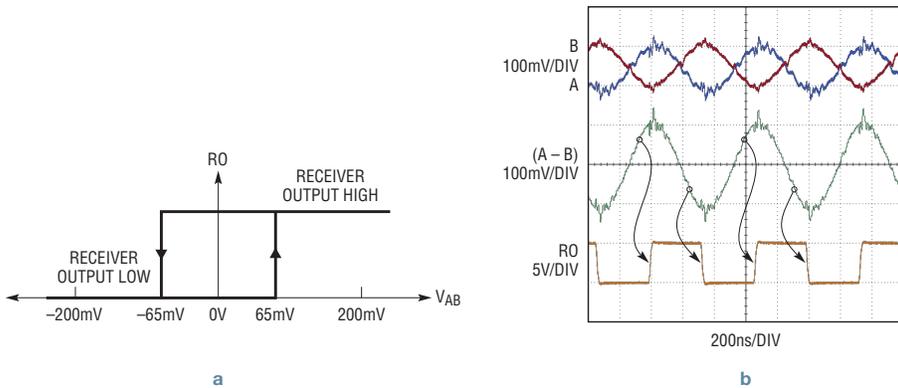


Figure 12. (a) RS485 receiver input threshold characteristics for fast moving signals. (b) Measured 3Mbps signal driven down 4000ft of CAT5e cable. Top Traces: receiver signals after transmission through cable; Middle Trace: math showing the differences of the top two signals; Bottom Trace: receiver output, exhibiting excellent duty cycle.

The unbalanced receiver can introduce severe signal pulse-width and duty-cycle distortion for weak signals that result from transmission over long cables.

The LTC2870 and LTC2871 use a balanced receiver with a rising threshold of 65mV and a falling threshold of -65mV for signals transitioning through that window in less than 2μs, as shown in Figure 12. If the differential signal lingers within this window for more than 2μs, the positive

threshold drops down to -40mV to support all modes of failsafe operation, as previously described. The balanced receiver architecture permits transmission over longer cables than an unbalanced receiver and offers the additional benefit of excellent noise immunity due to the wide effective differential input signal hysteresis of 130mV for typical communications

Figure 12 highlights the performance of the LTC2871 balanced receiver, where a signal is driven through 4000 feet of CAT5e cable at 3Mbps. Even though the differential signal peaks at just over ±100mV with slow edges, the output maintains nearly a perfect signal and the receiver introduces almost no duty cycle distortion.

DUPLEX AND LOOPBACK CONTROL
RS485 networks can be wired in a 2-wire, half-duplex configuration or a 4-wire, full-duplex configuration. In some systems the interface may need to support both. The LTC2870 and LTC2871 offer on-the-fly flexibility via the H/F pin. When the H/F control

is low, the device is in full-duplex mode, with the driver outputs on the Y and Z pins and the receiver inputs on the A and B pins. If the H/F pin is high, the RS485 transceiver enters half duplex mode where the receiver takes its inputs from the Y and Z pins. This works seamlessly with the termination control and has no effect on RS232 operation. Figure 13 shows the simplified block diagram illustrating this flexibility.

The LTC2870 and LTC2872 also feature a logic loopback feature that can be used for diagnostics and as a debug tool. The loopback mode works for both the RS232 and RS485 transceivers, and provides a logic path from the driver input pin to the corresponding receiver output pin. The driver and receiver are not engaged in the loop; just logic buffers are used. This allows diagnostic tests to be run

Figure 13. RS485 full- and half-duplex control in the LTC2870

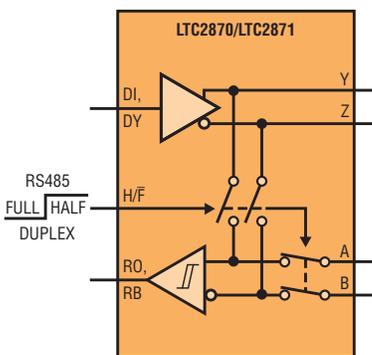
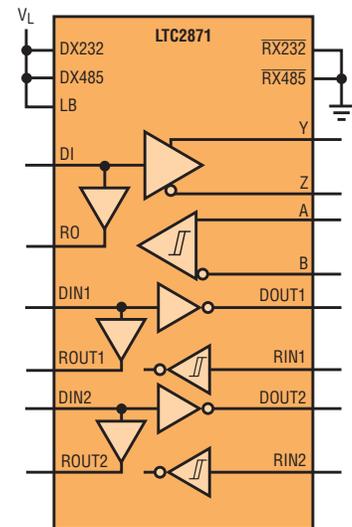
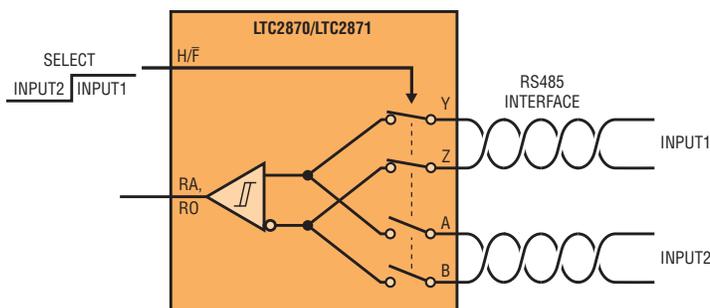


Figure 14. Logic loopback control in the LTC2871. Loopback works whether or not the drivers are enabled.



The LTC2870 and LTC2871 multiprotocol transceivers simplify the design of RS485 and RS232 systems by combining both types of transceivers on a single device. They support data rates as high as 20Mbps for the single RS485 transceiver and 500kbps for two RS232 transceivers.

Figure 15. RS485 receiver with multiplexed inputs.



without disturbing the bus. Optionally, the bus may be driven during loopback by simply enabling the appropriate driver. Figure 14 shows loopback operation.

MORE APPLICATIONS

The rich feature sets of the LTC2870 and LTC2871 make it possible to build applications that would otherwise be challenging to produce. For example,

Figure 15 shows an RS485 receiver with multiplexed inputs making use of the half- and full-duplex control.

Figure 16 shows how to combine two LTC2871 devices to make a triple RS232 transceiver with either a selectable line or logic interface. This application makes use of the $\overline{\text{CH2}}$ pin, which selectively disables the second RS232 transceiver.

When disabled, the driver and receiver outputs are not driven and the receiver input becomes high-z. This allows these pins to be connected to the same pins on another device whose $\overline{\text{CH2}}$ pin is driven with the complementary state of the first.

CONCLUSION

The LTC2870 and LTC2871 are flexible 3V to 5.5V multiprotocol transceivers that communicate using RS485 and RS232 signaling on either shared I/O pins (LTC2870) or separate I/O pins (LTC2871). Integrated selectable termination and duplex control allow easy configuration with minimal external components. ■

Notes

- 1 Formally, TIA/EIA-485 and TIA/EIA-232
- 2 "Rugged 3.3V RS485/RS422 Transceivers with Integrated Switchable Termination," by S. Tanghe, R. Schuler, *LT Magazine*, March 2007.

Figure 16. RS232 triple transceiver with selectable line interface (a), and logic interface (b)

