

## RS-485 Interfaces

Despite its widespread use, RS-485 is not as well understood as it should be. However, if you invest a little time on familiarizing yourself with the bus and pay attention to 10 aspects of your application, you'll find that designing rock-solid implementations is easy.

Recommended Standard 485 (RS-485) has become the industry's workhorse interface for multipoint, differential data transmission. RS-485 is unique in allowing multiple nodes to communicate bidirectionally over a single twisted pair. No other standard combines this capability with equivalent noise rejection, data rate, cable length, and general robustness. For these reasons, a variety of applications use RS-485 for data transmission. The list includes automotive radios, hard-disk drives, LANs, cellular base stations, industrial programmable logic controllers (PLCs), and even slot machines. The standard's widespread acceptance also results from its generic approach, which deals only with the interface's electrical parameters. RS-485 does not specify a connector, cable, or protocol. Higher level standards, such as the ANSI's SCSI standards and the Society of Automotive Engineers' (SAE's) J1708 automotive-communication standard, govern these parameters and reference RS-485 for the electrical specifications.

Although RS-485 is extremely popular, many system designers must learn how to address its interface issues. You should review 10 areas before you design an RS-485 interface into a product. Understanding the issues during system design can lead to a trouble-free application and can reduce time to market.

RS-485 addresses a need beyond the scope of RS-422, which covers buses with a single driver and multiple receivers. RS-485 provides a low-cost, bidirectional, multipoint interface that supports high noise rejection, fast data rates, long cable, and a wide common mode range. The standard specifies the electrical characteristics of drivers and receivers for differential multipoint data transmission but does not specify the protocol, encoding, connector mechanical characteristics, or pinout. RS-485 networks include many systems that the general public uses daily. These applications appear wherever a need exists for simple, economical communication among multiple nodes. Examples are gas-station pumps, traffic and railroad signals, point-of-sale equipment, and aircraft passenger seats. The Electronic Industries Association (EIA) Technical Recommendation Committee, TR30, made RS-485 a standard in 1983. The Telecommunications Industry Association (TIA) is now responsible for revisions. RS-485 is currently being revised. After successful balloting, the revised standard will become "ANSI TIA/EIA-485-A."

The 10 considerations that you should review early in a system design are:

- Mode and nodes,
- Configurations,
- Interconnect media,
- Data rate vs cable length,
- Termination and stubs,
- Unique differential and RS-485 parameters,

## Mode and Nodes

- Grounding and shielding,
- Contention protection,
- Special-function transceivers, and
- Fail-safe biasing.

In its simplest form, RS-485 is a bidirectional half-duplex bus comprising a transceiver (driver and receiver) located at each end of a twisted-pair cable. Data can flow in either direction but can flow only in one direction at a time. A full-duplex bus, on the other hand, supports simultaneous data flow in both directions. RS-485 is mistakenly thought to be a full-duplex bus because it supports bidirectional data transfer. Simultaneous bidirectional transfers require not one but two data pairs, however.

RS-485 allows for connection of up to 32 unit loads (ULs) to the bus. The 32 ULs can include many devices but commonly comprise 32 transceivers. *Figure 1* illustrates a multipoint bus. In this application, three transceivers—two receivers and one driver—connect to the twisted pair. You must observe the 32-UL limitation, because the loads appear in parallel with each other and add to the load that the termination resistors present to the driver. Exceeding 32-UL loads excessively limits the drivers and attenuates the differential signal, thus reducing the differential noise margin.

RS-485 drivers are usually called "60 mA drivers." The name relates to the allowable loading. Developing 1.5V across the 60Ω termination load (120Ω at each end of the bus) requires 25 mA. The worst-case input current of a UL is 1 mA (at extreme common mode, explained later). *Figure 2* shows the loading curve of a full UL. The worst-case UL input resistance is 10.56 kΩ, although a frequently quoted incorrect value is 12 kΩ. Thus, 32 ULs require 32 mA drive capability. Adding this current to the 25 mA for the terminations yields 57 mA, which rounds up to an even 60 mA. A driver that cannot supply the full 60 mA violates the standard and reduces the bus's performance. The resulting problems include reduced noise margin, reduction in the number of unit loads or allowable cable length, and limited common-mode voltage tolerance.

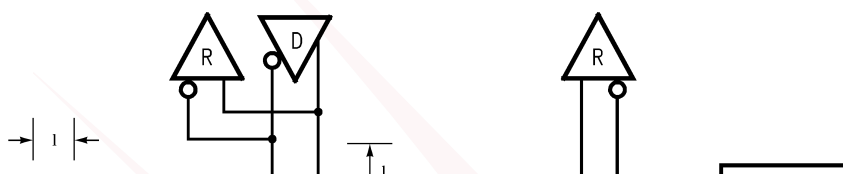
Designers frequently ask, "What is the maximum number of transceivers the bus allows?" The standard does not specify a maximum number of transceivers, but it does specify a maximum of 32 ULs. If a transceiver imposes one unit load, the maximum number of transceivers is also 32. You can now obtain transceivers with 1/2- and 1/4-UL ratings, which allow 64 and 128 transceivers. However, these fractional-UL devices, with their high-impedance input stages, typically operate much more slowly than do single-UL devices. The lower speed is acceptable for buses operating in the low hundreds of kilobits per second, but it may not be acceptable for a 10 Mbps bus.

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## Mode and Nodes (Continued)

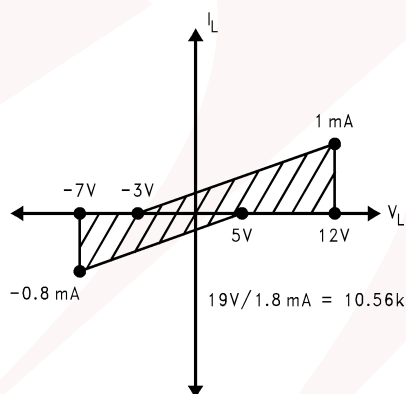
A solution exists for high-speed buses: You can use RS-485 repeaters to connect multiple buses end to end. In this setup, each bus must have no more than 32 loads. Directional

control of the repeaters is complex, but hardware can handle it (Reference 1). Therefore, a conservative estimate is that, without using special transceivers, a bus can include 32 transceivers.



An RS-485 bus supports two-way data transfer over a single pair of wires. A typical bus includes multiple nodes. Each transceiver includes a differential driver, D, and a differential receiver, R. The stub length is  $l$ . The bus is terminated only at the ends — not at each node.

FIGURE 1.



The loading of a transceiver must remain within the shading region to be one unit load.

FIGURE 2.