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[RS-485 Quick Guide](#) - Just the Essentials on a Single Piece of Paper

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RS422/485 Application Note

[Chapter 1: Overview](#)

Chapter 2: System Configuration

Network Topologies

Network configuration isn't defined in the RS-422 or RS-485 specification. In most cases the designer can use a configuration that best fits the physical requirements of the system.

Two Wire or Four Wire Systems

RS-422 systems require a dedicated pair of wires for each signal, a transmit pair, a receive pair and an additional pair for each handshake/control signal used (if required). The tristate capabilities of RS-485 allow a single pair of wires to share transmit and receive signals for half-duplex communications. This "two wire" configuration (note that an additional ground conductor should be used) reduces cabling cost. RS-485 devices may be internally or externally configured for two wire systems. Internally configured RS-485 devices simply provide A and B connections (sometimes labeled "-" and "+").

Devices configured for four wire communications bring out A and B connections for both the transmit and the receive pairs. The user can connect the transmit lines to the receive lines to create a two wire configuration. The latter type device provides the system designer with the most configuration flexibility. Note that the signal ground line should also be connected in the system. This connection is necessary to keep the V_{cm} common mode voltage at the receiver within a safe range. The interface circuit may operate without the signal ground connection, but may sacrifice reliability and noise immunity. Figures 2.1 and 2.2 illustrate connections of two and four wire systems.

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Recommended Reading

- RS-422/485 Application Note
- Industrial Bus Compatibility Chart
- Data Line Isolation Theory
- Tips for Using Port Powered Converters
- Basics of the RS-485 Standard
- System Design With Port Powered Converters

Glossary Terms

- Interface Converter
- Multidrop
- Optical Isolation
- RS-232
- RS-422
- RS-485



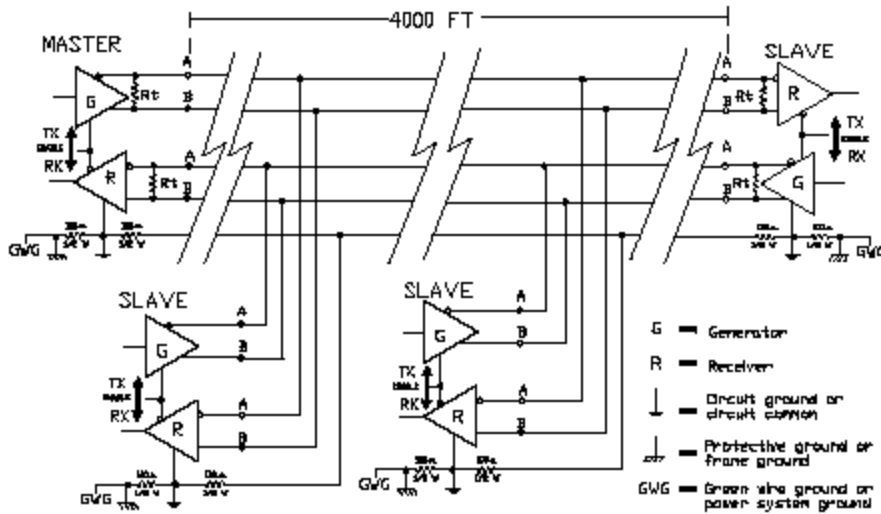


Figure 2.1 Typical RS-485 Four Wire Multidrop Configuration

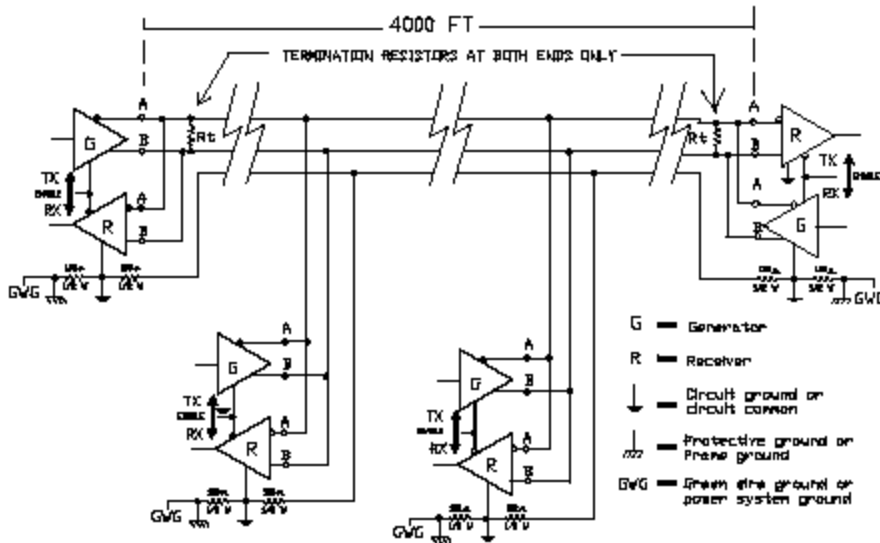


Figure 2.2 Typical RS-485 Two Wire Multidrop Configuration

Termination

Termination is used to match impedance of a node to the impedance of the transmission line being used. When impedance are mismatched, the transmitted signal is not completely absorbed by the load and a portion is reflected back into the transmission line. If the source, transmission line and load impedance are equal these reflections are eliminated. There are disadvantages of termination as well. Termination increases load on the drivers, increases installation complexity, changes biasing requirements and makes system modification more difficult.

The decision whether or not to use termination should be based on the cable length and data rate used by the system. A good rule of thumb is if the propagation delay of the data line is much less than one bit width, termination is not needed. This rule makes the assumption that reflections will damp out in several trips up and down the data line. Since the receiving

UART will sample the data in the middle of the bit, it is important that the signal level be solid at that point. For example, in a system with 2000 feet of data line the propagation delay can be calculated by multiplying the cable length by the propagation velocity of the cable. This value, typically 66 to 75% of the speed of light (c), is specified by the cable manufacturer.

For our example, a round trip covers 4000 feet of cable. Using a propagation velocity of $0.66 \times c$, one round trip is completed in approximately $6.2 \mu\text{s}$. If we assume the reflections will damp out in three "round trips" up and down the cable length, the signal will stabilize $18.6 \mu\text{s}$ after the leading edge of a bit. At 9600 baud one bit is $104 \mu\text{s}$ wide. Since the reflections are damped out much before the center of the bit, termination is not required.

There are several methods of terminating data lines. The method recommended by B&B is parallel termination. A resistor is added in parallel with the receiver's "A" and "B" lines in order to match the data line characteristic impedance specified by the cable manufacturer (120 ohms. is a common value). This value describes the intrinsic impedance of the transmission line and is not a function of the line length. A terminating resistor of less than 90 ohms should not be used. Termination resistors should be placed only at the extreme ends of the data line, and no more than two terminations should be placed in any system that does not use repeaters. This type of termination clearly adds heavy DC loading to a system and may overload port powered RS-232 to RS-485 converters. Another type of termination, AC coupled termination, adds a small capacitor in series with the termination resistor to eliminate the DC loading effect. Although this method eliminates DC loading, capacitor selection is highly dependent on the system properties. System designers interested in AC termination are encouraged to read National Semiconductors Application Note 903 ([note 2](#)) for further information. Figure 2.3 illustrates both parallel and AC termination on an RS-485 two-wire node. In four-wire systems, the termination is placed across the receiver of the node.

Note 2: Refer to Chapter 7 for Information on National Semiconductors Application Notes

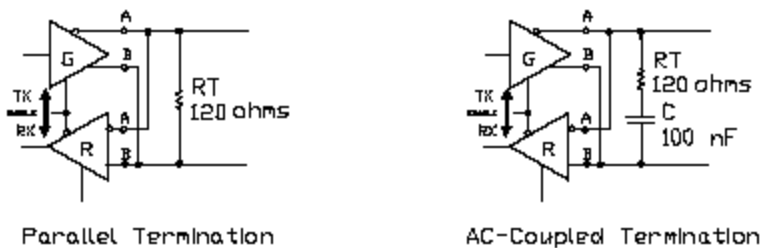


Figure 2.3 Parallel and AC Termination

Biasing an RS-485 Network

When an RS-485 network is in an idle state, all nodes are in listen (receive) mode. Under this condition there are no active drivers on the network. All drivers are tristated. Without anything driving the network, the state of the line is unknown. If the voltage level at the receiver's A and B inputs is less than $\pm 200\text{mV}$ the logic level at the output of the receivers will be the value of the last bit received. In order to maintain the proper idle voltage state, bias resistors must be applied to force the data lines to the idle condition. Bias resistors are nothing more than a pullup resistor on the data B line (typically to 5 volts) and a pulldown resistor (to ground) on the data A line. Figure 2.4

can be sensitive to over biasing.

Extending the Specification

Some systems require longer distances or higher numbers of nodes than supported by RS-422 or RS-485. Repeaters are commonly used to overcome these barriers. An RS-485 repeater such as B&B Electronics' 485OP can be placed in a system to divide the load into multiple segments. Each "refreshed" signal is capable of driving another 4000 feet of cable and an additional 31 RS-485 loads.

Another method of increasing the number of RS-485 nodes is to use low load type RS-485 receivers. These receivers use a higher input impedance to reduce the load on the RS-485 drivers to increase the total number of nodes. There are currently half and quarter load integrated circuit receivers available, extending the total allowable number of nodes to 64 and 128.

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[Appendix A: EIA Specification Summary](#)

[Appendix B: EIA Standard RS-423 Data Transmission](#)

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