Application Bulletin AB-6

Making RS-485 Systems Work

Although RS-485 is in widespread use, many designers still encounter minor "teething" problems in the final set-up from a lack of attention to the interface requirements of terminations, cables, connections and layout. By addressing a few simple points many of the obstacles to a trouble-free installation can be avoided. Figure 1 shows a basic RS-485 configuration:

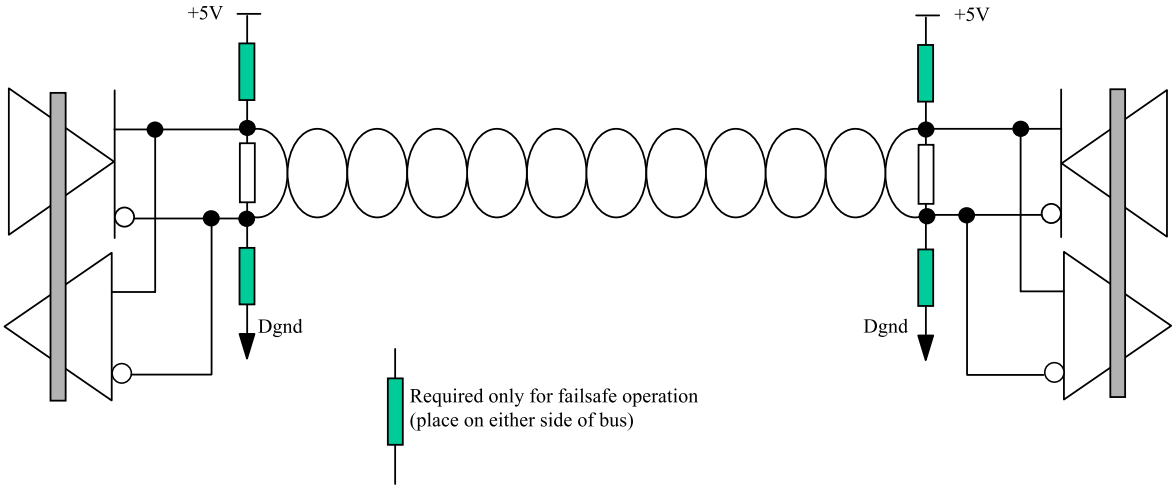
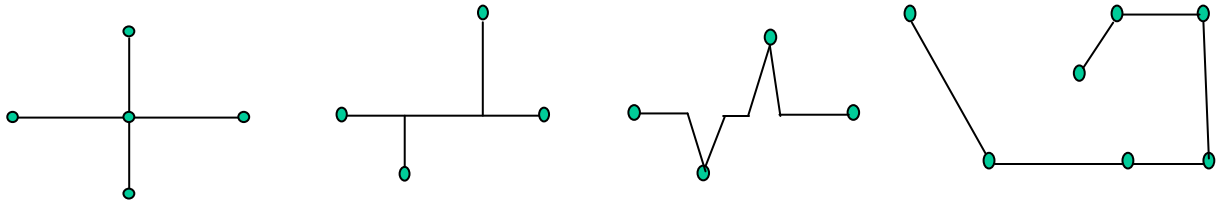


Figure 1. Simple Isolated RS-485 System

RS-485 is a bidirectional half-duplex transmission system, *i.e.* data can be transmitted in both directions but only in one direction at a time. The RS-485 Standard requires the system to allow up to 32 unit loads to be connected to the bus. Some available transceivers, such as the NVE IL3685P, have fractional loading to allow more nodes on the bus. Such transceivers are designed to avoid the problems of traditional fractional load transceivers such as limited speed and reduced input differentials.

Bus Layout:

RS-485 allows multiple transceivers (up to 32 Unit Loads) to be connected to the bus.



A. B. C. D.

Figure 2. Bus Configurations

Configurations C and D are examples of ideal configurations where the nodes are in a continuous line, although not necessarily straight. Configurations A and B have long spurs that can cause reflections. Short spurs from the bus to intermediate nodes are generally necessary, however (see Figure 3).

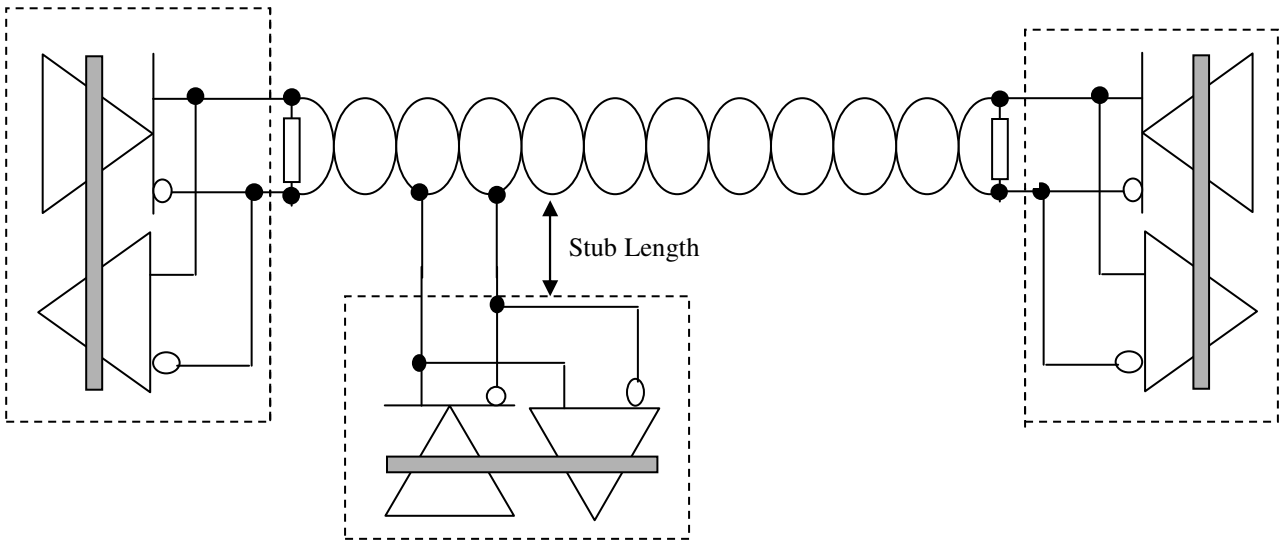


Figure 3. RS-485 Bus with Intermediate Unit

The stub length is defined as the distance between the transceiver chip output and the bus lines, including connectors and PCB traces. To minimize reflections and maintain signal integrity, stub lengths should be less than one-sixth of the electrical signal length. Electrical signal length is defined as:

$$\text{Elec. Length} = t_r / \text{prop delay}$$

Most standard transceivers have a signal rise time of approximately 10 ns. This gives an electrical signal length in a cable with 78% propagation velocity as follows:

$$\text{Elec. Length} = 10^{-8} \times 3\text{x}10^{8} \times 0.78 = 2.34 \text{ m}$$

One sixth of the electrical length is 390 mm (15"), so each stub-length in this example should be less than 390 mm.

Cabling:

Use twisted-pair cable. It may be unshielded if the cable run is short (less than 10 m) and the data rate is low (less than 100 Kbps). Otherwise, use screened cable with the shield tied to earth ground at one end only. Do not tie the shield to digital ground. The other end of the shield may be tied to earth ground via an R-C network. This prevents DC ground loops through the shield. Using shielded cable minimizes EMI emissions and external noise coupling into the bus.

Data Rate:

An important principle is that the longer the cable, the slower the data rate. The RS-485 bus can transmit over 1200 m and up to 10 Mbps, but not both at the same time. The transceiver and cable characteristics combine to act like a filter to give the general response shown in figure 4. Other parameters such as acceptable amounts of jitter will affect the final cable length versus data rate design tradeoff. Less jitter means better signal quality but shorter cable lengths or slower data rates.

Figure 4 shows data rate versus cable length with a generally accepted 30% jitter constraint:

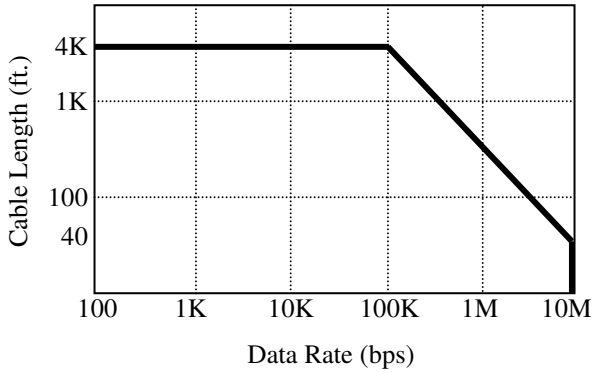
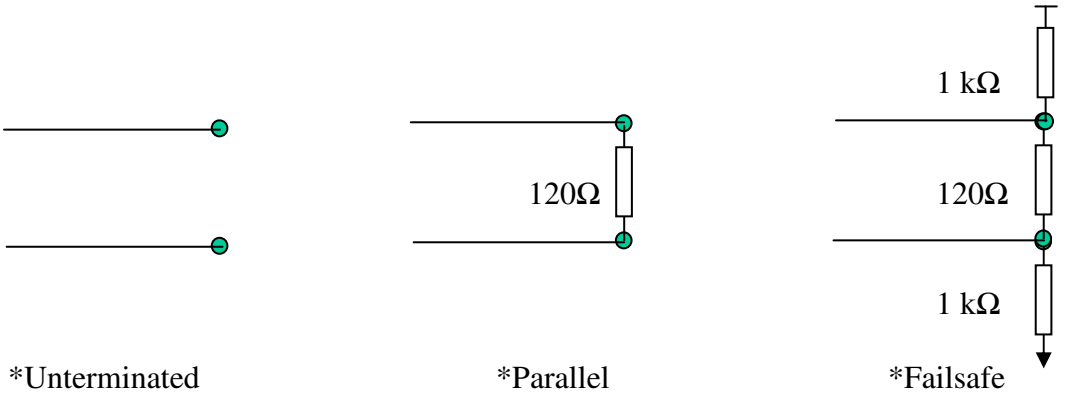


Figure 4. Cable Length Versus Data Rate

Terminations:

Transmission lines are usually terminated to avoid reflections that can cause data errors. Both ends of the bus should be terminated (not each node).



- Unterminated lines are only suitable for low data rates and short cables, otherwise line reflections cause problems.

- Parallel termination on both ends of the bus prevents reflections, providing excellent signal quality and allowing high data rates.

- The failsafe configuration bias provides for more than 200 mV across the conductor pair with no active drivers. This ensures the bus will be in a known state with no active drivers.

Isolation:

Many RS-485 networks require isolation for safety, noise reduction, or ground loop elimination. Optocoupler isolation is often slow, unreliable, and carries a high component count. NVE offers a full line of isolated RS-485 transceivers, including the legacy IL485, the very high speed IL3585, the PROFIBUS-compliant IL3685, the IL3685P fractional-load / 3.3V version, the passive-input IL3185 / IL3285 / IL3485, the IL4685 with an integrated DC-DC convertor, and ultra-miniature QSOP versions. All provide single-chip RS-485 isolation.