# EXAMPLE APPLICATIONS: RS-485 FOUR-WIRE

## 1. FOUR-WIRE RS-485 MULTI-DROP NETWORK

This document is designed to give you some practical examples of designing an RS-485 4-wire network. If is not intended to be a complete tutorial on RS-485.

Section 2 shows an example 4-wire network with an unrealistic variety of node connections. In real-life, software limitations will usually allow only one type of device on an RS-485 network. Therefore, all slaves would likely use the same hardware configuration.

Section 3 discusses grounding in more detail, and Section 4 discuses cable selection.

## 2. BASIC FOUR-WIRE MULTI-DROP NETWORK

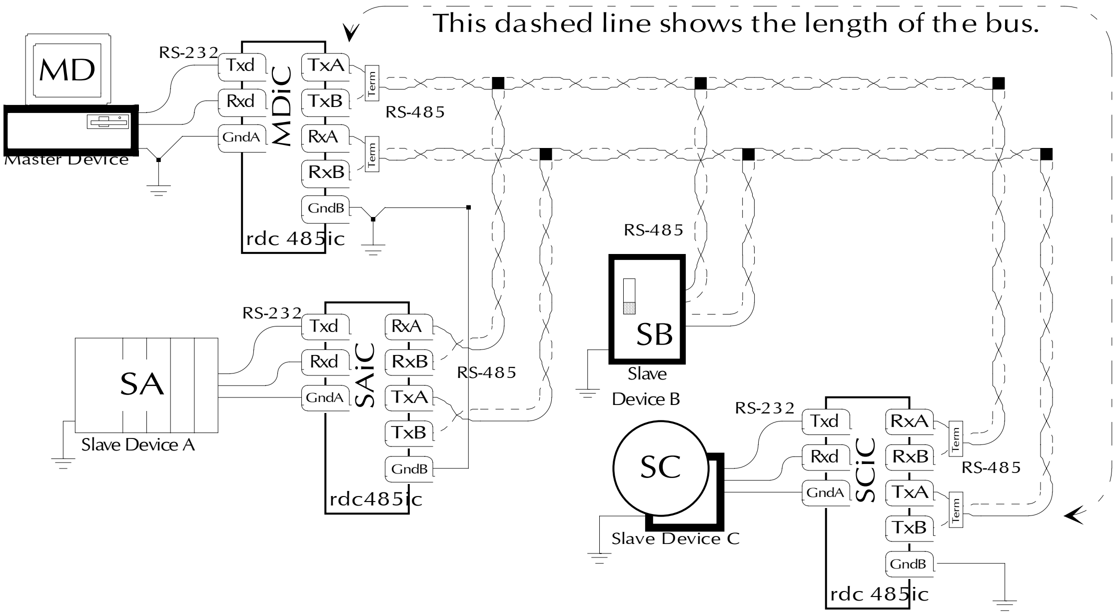


*Figure 1: Example 4-wire RS-485 Network*

Figure 1 shows a basic four device, 4-wire RS-485 network with 1 Master Device (MD) and

3 Slave Devices – SA, SB, and SC. It also includes 3 galvanically isolated RS-232 to RS-485 converters – MDiC, SAiC, and SCiC. Slave Device SB connects directly to RS-485.

### v The 4-wire RS-485 Bus

The RS-485 bus runs from MDiC to SCiC. Notice the 120ohm termination resister installed at all four ends. The ISO-8482 standard (ISO version of RS-485) defines limitations for RS-485 multipoint buses. The overall bus length is limited to 500m at a speed of 1Mbps. MD and SC define the ends of the bus. SA and SB are connected to the bus by *stubs*. Stubs are limited to 15m. Any surge protection on the bus should clamp beyond ±25vdc. Current limiting fuses should be 250mA.

Standards by nature are conservative. While ISO says only 500m, RS-485 product vendors claims distances from 1km up to 13km. One reason for discrepancy is the effect of speed (baud rate or bps) on the maximum bus length. Slower data speeds allow longer workable bus lengths. The most common RS-485 claim is 1000m at 9600 bps. Longer distances can be covered if you are willing to lower baud rates if problems develop on site.

### v Master Device (MD)

Master Device (MD) is a standard office-grade PC with an RS-232 port. It connects to the RS-485 bus by an isolated RS-232 to RS-485 converter (MDiC). Since this is the master device, the transmit direction can be fixed. This forces the RS-485 Tx wire pair into a known state at all times. Notice that the master's transmit pair (Tx) is connected to all slave's receive (Rx) inputs. The slaves have this pair fixed to receive always.

The master's receive pair (Rx) is connected to all slave's transmit pair. All slave devices will normally be ignoring this pair. Since no device is transmitting, the Rx pair will be "floating" idle – and floating wires are bad. They are very susceptible to noise, which will cause false communication interrupts on the master. Therefore, to pull the Rx pair into a known idle state bias resisters in MDiC are used. When idle, the voltage on wire RxA is greater than the voltage on RxB (RxA > RxB). Example voltages vary, but may be RxA = 2.6v and RxB = 2.2v.

MD is grounded per office equipment standards. Its RS-232 signal ground is tied directly to both the chassis ground and the internal digital ground -- a very good reason to galvanically isolate MD from an industrial plant! But don't be fooled by the term "industrial grade" – most industrial PCs follow the same design.

The rdc485ic is an RS-232 to RS-485 converter with 2Kv galvanic isolation. It can be configured to support both 2 or 4-wire RS-485.

### v Slave Device A (SA)

Slave Device (SA) also has an RS-232 port and uses an isolated RS-232 to RS-485 converter (SAiC) to connect to the RS-485 bus. The rdc485ic is an RS-232 to RS-485 converter with 2Kv galvanic isolation. It can be configured to support both 2 or 4-wire RS-485.

### v Slave Device B (SB)

Slave Device (SB) also has a direct RS-485 port without galvanic isolation. SB provides no ground terminal – therefore none is connected. SB assumes that the RS-485 ground is referenced to its own signal ground ± 7 vdc. If this is not known, install a galvanic isolator.

### v Slave Device C (SC)

Slave Device (SD) has an RS-232 port and connects to the RS-485 bus through SCiC. Since SCiC is technically the end of the bus, it also has bus terminating resisters installed.

SCiC is not grounded to the other RS-485 network devices. It's floating ground is tied to the local signal ground, so that SCiC also assumes that the RS-485 bus ground is referenced to its own signal ground ± 7 vdc. If this is not known, then connect SCiC's ground to the bus ground from MDiC and SAiC.

## 3. RS-485 GROUNDING

Data communication systems involve connecting multiple "systems" together and careful thought must be given to grounding. It is a common misconception that RS-485 requires only "two or four wires". ***This is never true.*** RS-485 always requires at least three or five conductors: 2 or 4 signal wires and 1 signal return path. The EIA/RS-485 standard states:

> *"Proper operation of the generator and receiver circuits requires the presence of a signal return path between the circuit grounds of the equipment at each end of the interconnection. The circuit reference may be established by a third conductor connecting the common leads of devices, **or** it may be established by connections in each using equipment to an earth reference."*

Looking at figure 1, you will see that MDiC and SAiC follow the "fifth conductor" rule, while SB and SCiC follow the "earth reference" rule. MDiC also has an earth reference connection to ensure that all RS-485 signals are referenced to earth to support SB and SCiC.

## 4. Cabling for 4-wire RS-485

If you chose the earth reference grounding rule, then a two twisted pair cable is required.

If you chose the fifth conductor grounding rule, then 4-wire RS-485 would then require one of the following: 1) 3-pair cable using 1 pair for ground, 2) 2-pair cable with a separate, external ground wire, or 3) 2-pair cable, with the signal reference run down the shield drain wire. While the first two schemes are understandable, the third suggestion will upset some people. Yet some reputable RS-485 vendors do actually suggest using the shield drain wire. Why? Even without a shield, RS-485 is quite robust. The small current involved in a floating data communication signal reference will have little impact on the effectiveness of the shield. Of course, this option *should not be used* if both devices at each end of the cable are locally grounded.

Just for reference, here are example cables specs from Beldon:

| Beldon P/N | Pairs | AWG | mm | Shield/drain wire | Imp | Cap | |
|---|---|---|---|---|---|---|---|
| 9842 | 2 | 24 | 0.6 | Yes, 24AWG | 120ohm | 42pf/m | |
| 9843 | 3 | 24 | 0.6 | Yes, 24AWG | 120ohm | 42pf/m | |
| 8132 | 2 | 28 | 0.4 | Yes, 28AWG | 120ohm | 36pf/m | |
| 8133 | 3 | 28 | 0.4 | Yes, 28AWG | 120ohm | 36pf/m | |