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# Example Applications: RS-485 Networking

## 1. BRIEF OVERVIEW OF EIA/RS-485

RS-485 is the most common, open standard for multi-drop industrial data communications today. Isolated RS-485 repeaters can be used to:

1) Extend the over-all distance.
2) Increase the RS-485 device count.
3) Increase the robustness.
4) Convert to a star or tree topology (wiring layout).

EC Data Technologies Pte Ltd has developed the world's most effective isolated RS-485 repeaters which gives you all this and greatly reduces your system down-time. EIA/RS-485 is called a "balanced differential" signal. It uses twisted wire pairs to transmit data by a differential voltage signal. **The two wires in a pair are not a loop,** both are '+' signals sourcing current to a third "virtual" ground conductor. (Read the summary for the serial communication standard for details).

RS-485 gains the noise immunity from the nature of electrical noise on a wire pair. A noise spike picked up by one wire will induce an equal noise on the other wire. Since an RS-485 receiver is just comparing the relative voltage polarity (which is more positive) even during the noise spike the transmitted relationship will hold true.

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

Figure 1 shows a basic three device, 2-wire RS-485 network. It consists of 1 Master device (Host) and 2 Slave Devices (PLC#1 & PLC#2). It also includes 3 galvanically isolated RS-232 to RS-485 converters (ECD485ic). Since generally RS-485 networks include only devices from 1 vendor, this example is not very realistic, but it shows the various configurations possible.

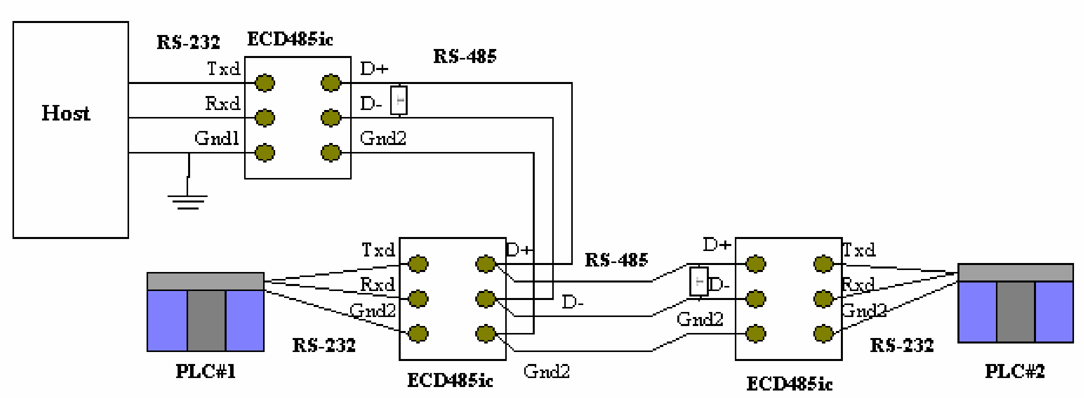


Fig.1. 2-wire RS-485 Network

## • THE 2-WIRE RS-485 BUS

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The RS-485 bus runs from ECD485ic(Host end) to ECD485ic(PLC#2 end). Notice the 120ohm termination resister installed at each end. 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. Host and PLC#2 define the ends of the bus. PLC#1 is connected to the bus by *stub*. Stub is 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 the 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. Longer distances can be covered if you are willing to lower baud rates if problems develop on site.

• MASTER DEVICE (Host)
Host 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 (ECD485ic). The RS-485 bus direction control is automatic, so host will *receive* from the bus until it has something to transmit. All slave devices will also be receiving from the bus. Since no device is transmitting, the bus will be "floating" -- and floating wires are bad. They are very susceptible to noise, which may cause false communication interrupts on devices. Therefore, to pull the bus into a known state bias resisters in ECD485ic are used. When idle, the voltage on wire D+ is greater than the voltage on D- (D+ > D-). Voltages vary, but maybe D+ = 2.6v and D- = 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 optically isolate Host from an industrial plant! But don't be fooled by the term "industrial grade" -- most industrial PCs follow the same design. The ECD485ic is an isolated RS-232 to RS-485 2-wire converter with 2.5Kv galvanic isolation. An ECD485ic can be configured to support both 2 or 4-wire RS-485. RS-485 direction control is automatic.

• SLAVE DEVICE A (PLC#1)
PLC#1 also has an RS-232 port and uses an isolated RS-232 to RS-485 converter (ECD485ic) to connect to the RS-485 bus. Like host end, it has automatic direction control. The ECD485ic is an isolated RS-232 to RS-485 2-wire converter with 2.5Kv galvanic isolation. The ECD485ic can be configured to support both 2 or 4-wire RS-485.

• SLAVE DEVICE (PLC#2)
PLC #2 has an RS-232 port and connects to the RS-485 bus much like host. Since ECD485ic is technically the end of the bus, it also has a bus terminating resister installed. You could enable the ECD485ic bias resisters to act as a back-up to those in Host end (if ECD485ic at the host end is powered off) the bus is still pulled to a known idle state. ECD485ic is not grounded to the other RS-485 network devices. It's floating ground is tied to the local signal ground, so that device also assumes that the RS-485 bus ground is referenced to its own signal ground ± 7 Vdc. If this is not known, then connect ECD485ic's ground to the bus ground from others.

**• CONTROL OF 2-WIRE HALF-DUPLEX TRANSMISSION**

Here is an example of an RS-485 two-wire network in action. Since RS-485 is half-duplex, data can only be transmitted in one direction at a time. Devices must be explicitly *receiving from* OR *transmitting to* the network at any one time, but never both. This change from transmit to receive mode must be activated electronically. The most robust method is to use a direct signal from the device to control the mode. This is often called a Ready To Send (RTS) control signal. Unfortunately, the device's control software must also be programmed to activate and deactivate RTS when appropriate -- many commercial developers plan for full-duplex RS-232 and overlook this. However, if you find yourself without an RTS signal all is not lost. RS-485 converters with automatic duplex control are available.

These detect a start-bit condition on the asynchronous transmit line from the device and automatically switch from receive to transmit mode.

3. **BASIC FOUR-WIRE MULTI-DROP NETWORK**

Figure 2 shows a basic three device, 4-wire RS-485 network. It consists of 1 Master device (Host) and 2 Slave Devices (PLC#1 & PLC#2). It also includes 3 galvanically isolated RS-232 to RS-485 converters (ECD485ic #1,#2,and #3). Since generally RS-485 networks include only devices from 1 vendor, this example is not very realistic, but it shows the various configurations possible.

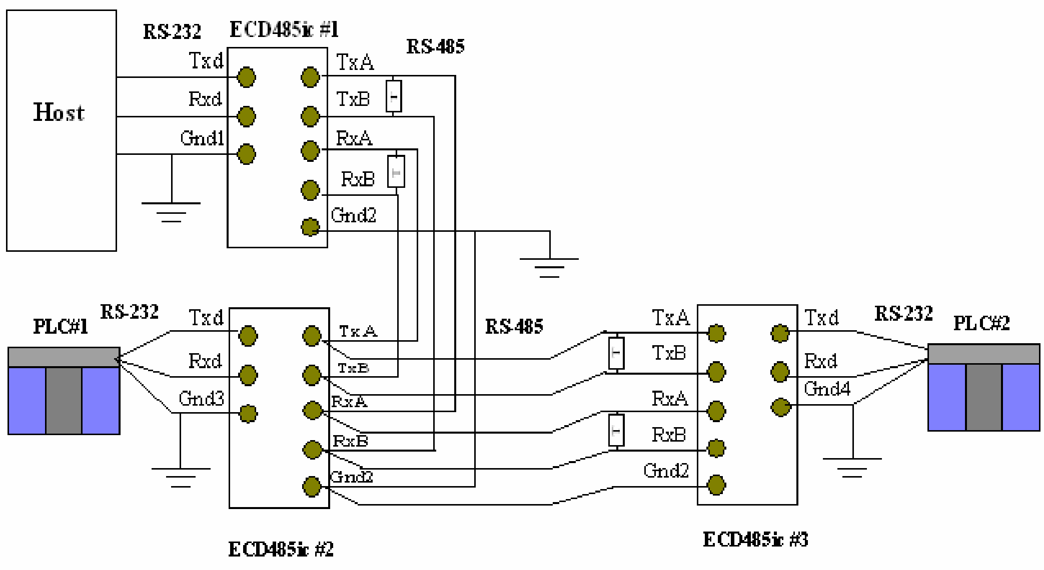


Fig.2. 4-wire RS-485 Network

**• THE 4-WIRE RS-485 BUS**

The RS-485 bus runs from ECD485ic #1(Host end) to ECD485ic #3(PLC#2 end). Notice the 120ohm termination resister installed at each end. The ISO-8482 standard (ISO version of RS-485) defines limitations for RS-485 multipoint buses. The overall bus

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length is limited to 500m at a speed of 1Mbps. Host and PLC#2 define the ends of the bus. PLC#1 is connected to the bus by *stub*. Stub is 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 the 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. Longer distances can be covered if you are willing to lower baud rates if problems develop on site.

• MASTER DEVICE (Host)
Host 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 (ECD485ic #1). Since this is a master device, the RS-485 bus direction can be fixed. This force 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 bus will be "floating" -- and floating wires are bad. They are very susceptible to noise, which may cause false communication interrupts on devices. Therefore, to pull the bus into a known state bias resisters in ECD485ic #1 are used. When idle, the voltage on wire RxA is greater than the voltage on RxB (RxA> RxB). Voltages vary, but maybe RxA = 2.6v and RxB = 2.2v.

Host 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 optically isolate Host from an industrial plant! But don't be fooled by the term "industrial grade" -- most industrial PCs follow the same design. The ECD485ic #1 is an isolated RS-232 to RS-485 4-wire converter with 2.5Kv galvanic isolation. An ECD485ic can be configured to support both 2 or 4-wire RS-485.

• SLAVE DEVICE A (PLC#1)
PLC#1 also has an RS-232 port and uses an isolated RS-232 to RS-485 converter (ECD485ic #2) to connect to the RS-485 bus. The ECD485ic is an isolated RS-232 to RS-485 2-wire converter with 2.5Kv galvanic isolation. The ECD485ic can be configured to support both 2 or 4-wire RS-485.

• SLAVE DEVICE B (PLC#2)
PLC #2 has an RS-232 port and connects to the RS-485 bus much like host. Since ECD485ic #3 is technically the end of the bus, it also has a bus terminating resister installed. You could enable the ECD485ic bias resisters to act as a back-up to those in Host end (if ECD485ic #1 is powered off) the bus is still pulled to a known idle state. ECD485ic is not grounded to the other RS-485 network devices. It's floating ground is tied to the local signal ground, so that device also assumes that the RS-485 bus ground is

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referenced to its own signal ground ± 7 vdc. If this is not known, then connect ECD485ic's ground to the bus ground from others.

**• RS-485 GROUNDING**

Data communication systems involve connecting multiple "systems" together and therefore careful thought must be given to grounding. It is a common misconception that RS-485 requires only "two wires". **This is never true.** RS-485 always requires at least three conductors: 2 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."

**• CABLING FOR RS-485**

**For 2-wire RS-485**

If you chose the earth reference grounding rule, then a single twisted pair cable is required. If you chose the third conductor grounding rule, then 2-wire RS-485 would then require one of the following:

1) 2-pair cable using 1 pair for ground,
2) 1-pair cable with a separate, external ground wire, or
3) 1-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.

**For 4-wire RS-485**

If you chose the earth reference grounding rule, then a single twisted pair cable is required.If you chose the third conductor grounding rule, then 4-wire RS-485 would then require one of the following:

4) 3-pair cable using 1 pair for ground,
5) 2-pair cable with a separate, external ground wire, or
6) 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 Belden**:

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| Belden P/N | Pairs | AWG | Mm | Shield/drain wire | Imp | Cap |
|---|---|---|---|---|---|---|
| 9841 | 1 | 24 | 0.6 | Yes, 24AWG | 120 ohm | 42pF/m |
| 9842 | 2 | 24 | 0.6 | Yes, 24AWG | 120 ohm | 42pF/m |
| 9843 | 3 | 24 | 0.6 | Yes, 24AWG | 120 ohm | 42pF/m |
| 8132 | 2 | 28 | 0.4 | Yes, 28AWG | 120 ohm | 36pF/m |
| 8133 | 3 | 28 | 0.4 | Yes, 28AWG | 120 ohm | 36pF/m |