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Reference guide for a RS-485 network installation 1.2

2012-05-08

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1. Introduction

This guide contains RS-485 network installation recommendations. RS-485 network installation can be tricky. In case of doubt use the services of specialist network.

2. Cabling rules

2.1. Maximal cable length

The maximum length of a network is based on its communication speed and the number of devices. Longer the segment becomes longer, slower the speed will be. Using the cable and proper installation, the maximum recommended length of a RS-485 network will be about 1200 m (4000 feet). See the curve below.

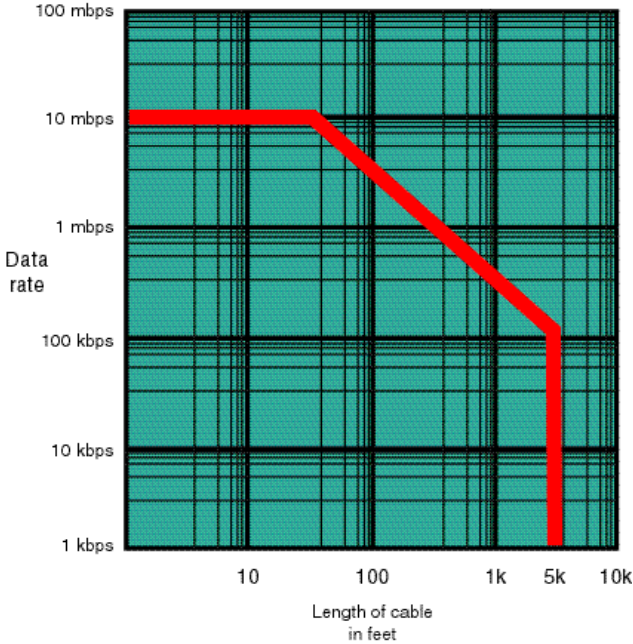


Fig. 1 – Speed vs network length

(Source: The Art and Science of RS-485 - circuitcellar.com)

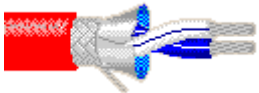


Some network cable models identify the cable length on the jacket (sheath). It is recommended to note the lengths of cable on the plan which could be useful information when problems occur.

2.2. *Cable type*

Cristal Controls recommend the use of EIA RS-485 cable 22-24 AWG twisted and balanced, with an impedance of 100-130 ohms, a capacitance below 100 pF per meter (30 pF per foot), with a braided shield . Compared to the shielding sheet, the braided shield offers better protection against electromagnetic interference, especially for high frequencies.

The table below shows a few suggested cables meeting these specifications.

Recommended Cables

Look	Manufacturer	Model		AWG
		1 pair	2 pairs	
	Belden	9841	9842	24
	Belden	82841	82842	24
	Belden	89841	89842	24
	Belden	3105A	3107A	22
	Belden	3106A (1 paire + 1)		22
	Cerco Cable	8250	8251	24
	Alpha Wire	6412	6413	24
	General Cable	C0841A	C0842A	24
	General Cable	C4841A	C4842A	24

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3. Network characteristic

The RS-485 network may have to 32 unit loads. When more than 32 controllers are needed on the same RS-485 network, routers or repeaters need to be added as recommended.

The network requires two 120- Ω termination resistors connected in parallel with or behind the last device at each end of the network segment. The termination resistors reduce signal reflections which may cause misinterpretation of logic levels by receivers.

One end network also requires two bias resistors of 604- Ω . The bias resistors are forcing a neutral state on the network and avoid false start bits when no device is on RS-485 transmission.

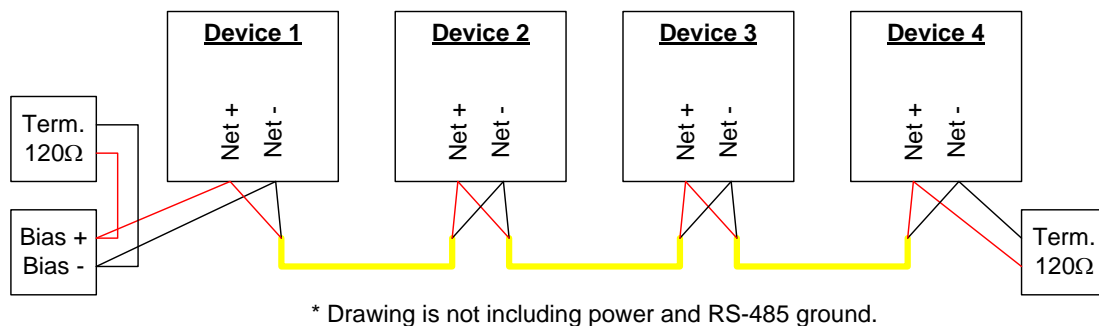


Fig. 2 - RS-485 Polarization and end of line resistor

The polarity of a RS-485 network is important. We must connect the positive network and the negative network with corresponding terminals on the other components.

On some components, it is possible to activate a termination resistor or bias resistors by installing jumpers. Refer to the documentation of those products to enable them. If the

products you use do not offer the on board possibility, external components can be added for the same result.

3.1. *Network third wire*

A RS-485 network also requires the presence of a third wire to make the communication channels with the same reference, so the communication remains stable at all times. Without the third wire, potential differences can occur between components, which can cause loss of communication or even damage the circuits of communication.

On all Cristal Controls products, the RS-485 circuit is not isolated from other electronic components of the device. So the supply terminal N24 is the reference power for communication.

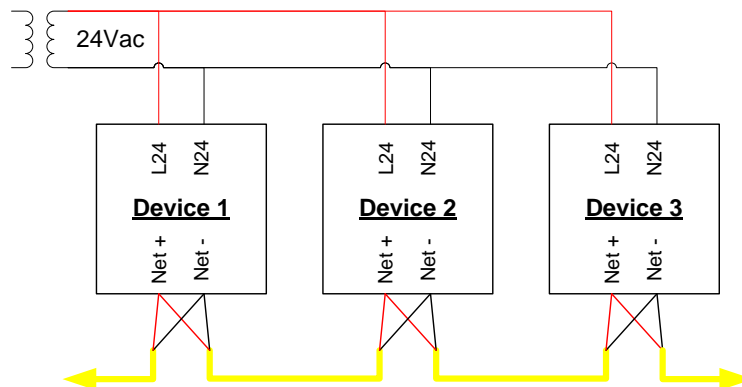


Fig. 3 - RS-485 with a common supply

A third wire must be used for devices with multiple power sources in order to have the same reference.

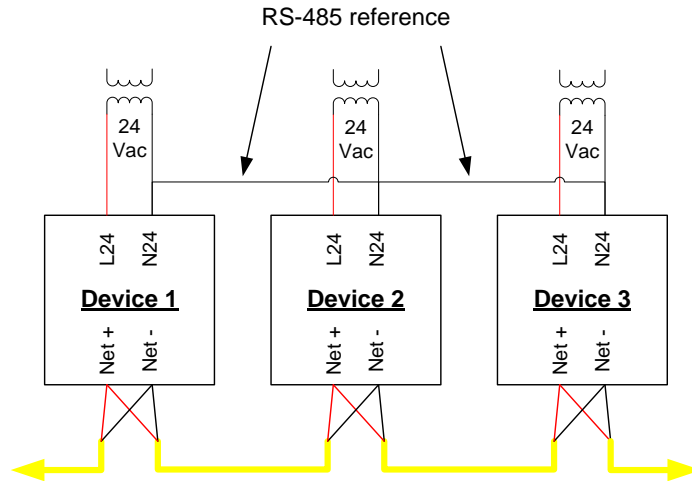


Fig. 4 - RS-485 with multiple N supply

On a network with isolated communication circuit, a third wire must be used to have a common communication reference.

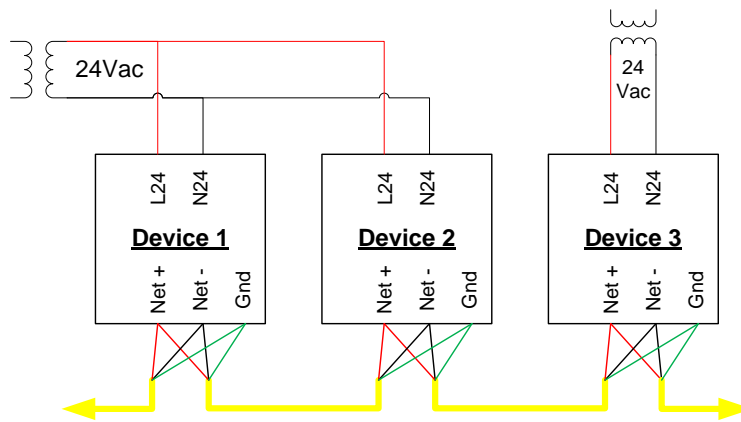


Fig. 5 - RS-485 network with isolated communication

Although the RS-485 communication may seem to communicate well with only 2 wires, it is risky not to properly install the third wire. Once the products are installed, potential differences can be created over time and make communication ineffective or intermittent. Costs related to network diagnosis or addition of the third wire will be much higher than initially providing the third wire at the time of installation.

TIPS: Installed a 4-conductor wire, use a pair for communication and the other pair to connect your references. Connect the unused conductors to ground earth at both ends to prevent them from becoming a disruptive antenna.

3.2. *Wire Stripping and Metal Shield*

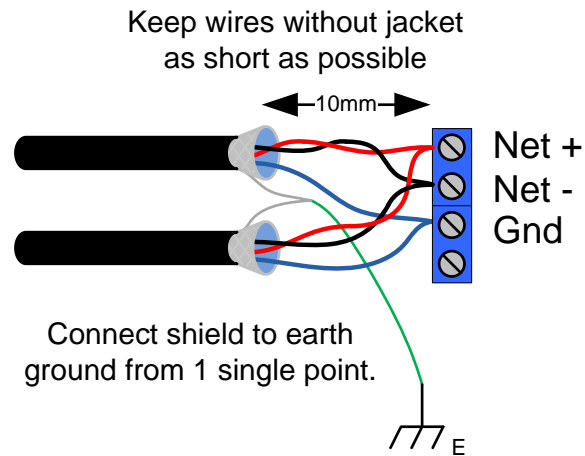


Fig. 6 – Stripping and Shield

Keep as much as possible minimal (10mm or ½ inch) stripping at terminal connections, at the connector level we shall not see any wire copper.

Connect together all the related wire to metal shielding and make the ground connection at one place on the network.

Attention and care at the connections level can make the difference between an impeccable and an unreliable up to a non-functional network.

4. Network Installation and testing

Here is some know Rs 485 network problems.

- Reversed polarity.
- Weak connections and the surface contact between the conductors is too small
- Wires are no longer twisted or protected by their shield on a long length.
- Wires are short circuited between them or with the ground
- Excessive electrical noise due to the proximity of power cables or noisy equipment.
- Design of RS-485 network is not balance.
- The signals are reflected due to end of line misconfigurations.
- The network is deployed in a star or with long legs in the shape of "T".

Most of these problems can be avoided by carefully, pre design the network before installation.

Here are several tests that can be done in case of problems after installing the network wire and power supply. As early these tests are done easier the problems will be identified and corrected. Most tests cannot be done once the equipment is installed and powered.

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4.1. Recommended installation

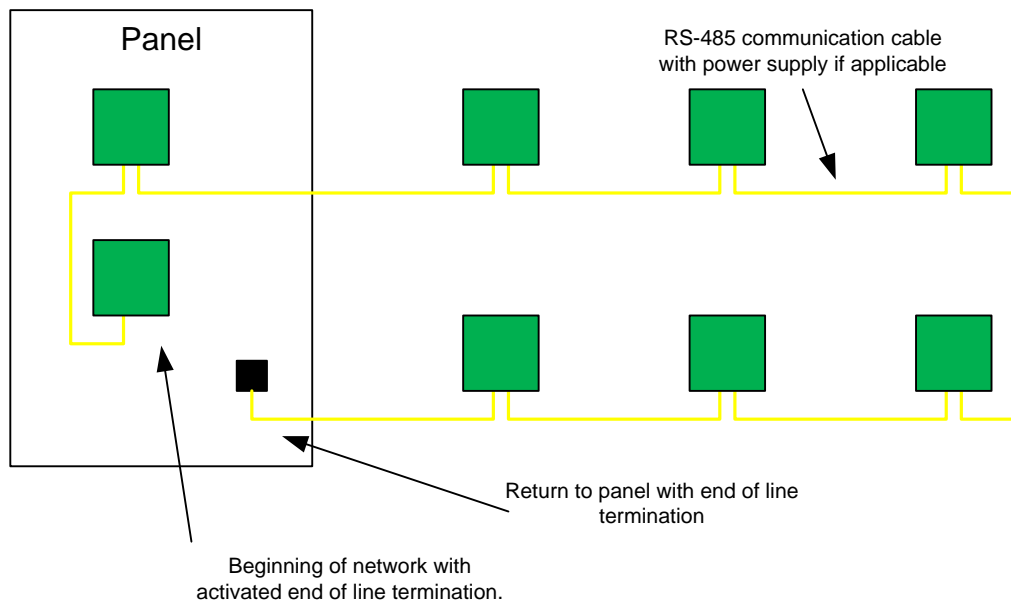


Fig. 7 – Recommended network

All RS-485 devices shall be on the same recommended 32 devices network. Ideally power shall follow the same path than the network if both are coming from the same point. We suggest returning network and power to the starting point. The extra length use to go back to the starting point will be use to test the network (see 4.5 end to end testing)

If you are using mark cable you will know the exact length of your network. Finally, a defective network can be very easy to repair with this extra wire. Look at the following picture.

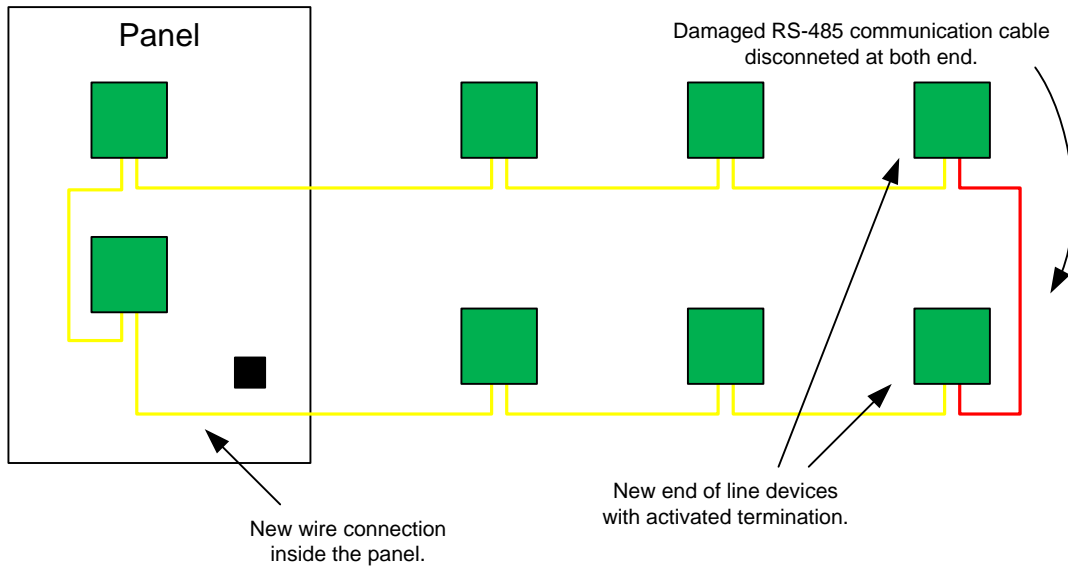


Fig. 8 - Network reorganized

It is desirable to keep the cables for the data signals separated from power cables. Data cable should always be kept at a distance of 5x the radius of a power cable so it will not be influenced by it. A cable with a strong current that is set to ON or OFF can induce a type of disturbance called "common mode noise".

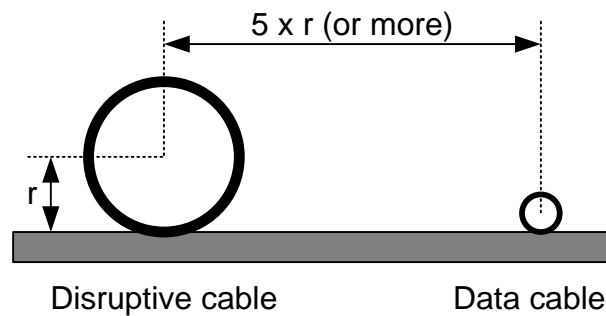
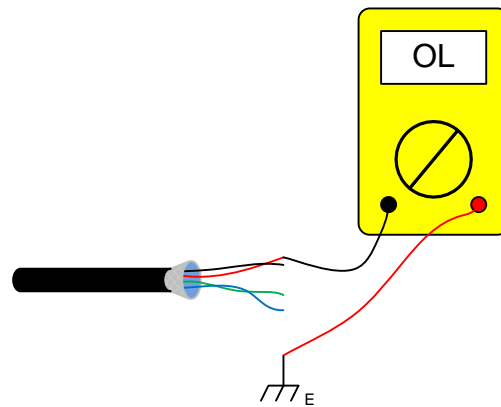


Fig. 9 - Length between cables

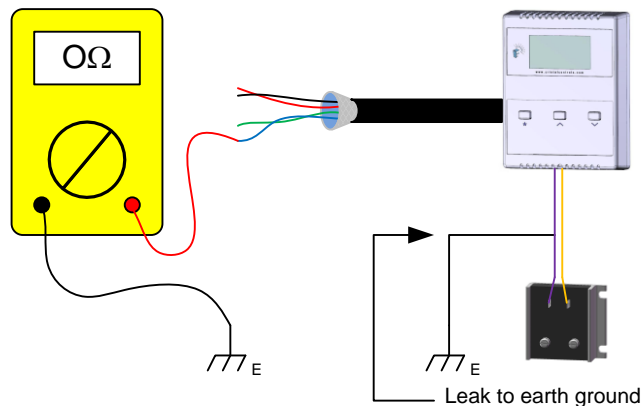
4.2. Test with grounding

A test shall be run between each conductor of you cable and the building earth ground.

If a resistance value is read, all wire connections should be inspected to repair the short circuit fault.



Be aware of devices that are connected. It may occur that when testing supply or network conductor, you may read a short circuit through the devices. In some cases your also are testing equipments connected to them. So we suggest testing the cables at the installation to reduce the time needed for investigation.



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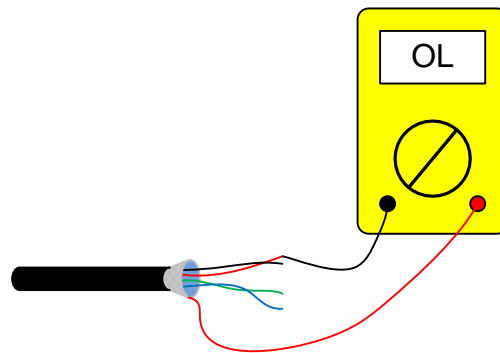
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4.3. *Test with metal shield*

A test between each conductors of the cable and the metal shield shall be done in order to make sure there is no conduction.

If a resistance value is detected, all wire connections shall be inspected and the short circuit fault fixed.

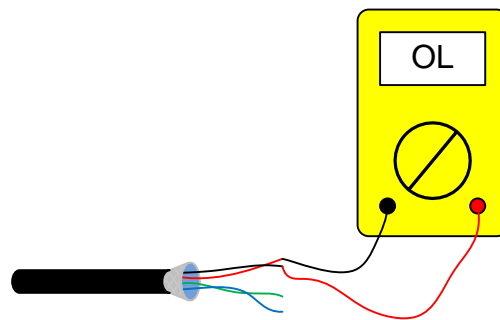


4.4. *Test between wires*

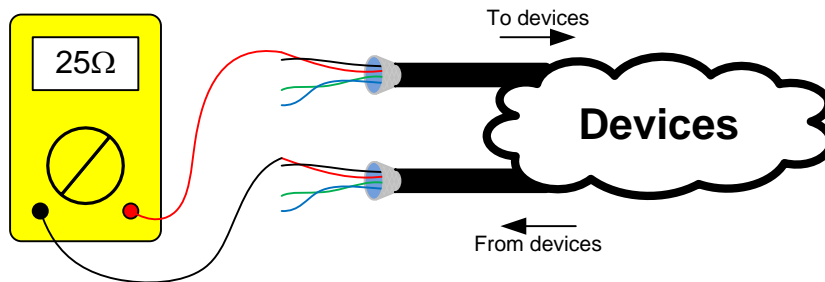
A test between each pair shall be done to check conduction between them.

On a 4 conductors cable there is 6 possible test scenarios.

If a resistance value is detected, all wire connections shall be inspected and the short circuit fault fixed.



4.5. End to end test



When your network does a loop from starting to end point (from to the same panel) make your end to end test at the panel level. You shall be reading of 15 to 30Ω base on the network length and type of cable used. Repeat this test for each conductor and shield.

If you read a higher value all network connections shall be inspected and fix where there is a weak contact.

If you read an open circuit, the cable needs to be tested in smaller sections in order to identify the weak section or connection.

If a cable section cannot be fixed, you can reconfigure the network. You must discard the defective wire part. Now, you can join your two separate networks both present in your electrical panel. Finally, reconfigure your terminating resistor properly. (Refer to Fig. 8 - Network reorganized)

4.6. Visual inspection

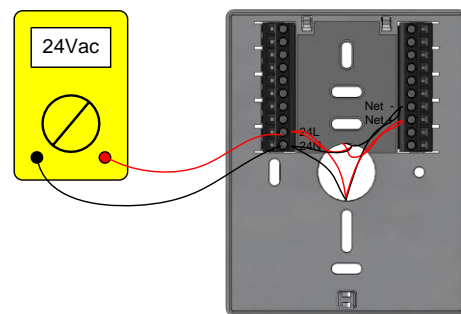
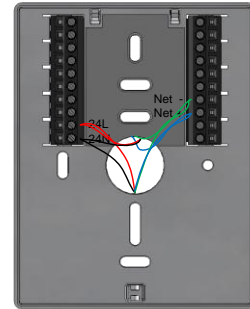
A visual inspection is suggested prior to powering the network. Check all color code and make sure they all match from connections points to connections points.

This step will prevent damage devices on the network and prevent devices operating failures.

If your 2 pairs of wires have the same color, proceed with a multimeter test to validate the 2 pairs were not mixed.

Example: if you have Thermostats terminals on the network you can test all terminals before installing the thermostats on their base. This can be done with any type of equipments.

Tips: Short circuit one of the pairs and check if the short circuit is on the proper terminals pair.



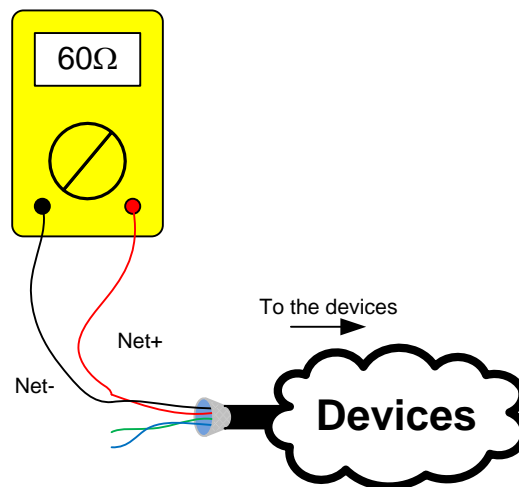
4.7. Network terminations test

Once all devices are connected (AT THIS POINT WITHOUT POWER), verify the resistance between the 2 network conductors , you shall read around 60Ω .

A different reading may indicate that you have more or less than 2 terminating resistors installed.

Example: 1 terminating resistor = 120Ω

3 terminating resistor = 40Ω .



5. References

1. Standard TIA-485A
2. TSB-89-A - Application Guidelines for TIA/EIA-485-A
3. BACnet ASHRAE Manual (ANSI/ASHRAE Standard 135-2008), Section 9.2, ISSN 1041-2336
4. [Practical Industrial Data Communications, Best Practice Techniques – IDC Technologies – 2005, ISBN 978-0-7506-6395-3 \(En ligne\)](#)
5. [Guide réseau MODBUS – Schneider Electric – Merlin Guerin – 2000](#)
6. [Maxim APPLICATION NOTE 3884 - How Far and How Fast Can You Go with RS-485?](#)
7. [Designing RS-485 Circuits - circuitcellar.com - Jan Axelson – June 1999](#)
8. [The Art and Science of RS-485 - circuitcellar.com - Bob Perrin - July 1999](#)
9. [RS-485 Bus - interfacebus.com](#)
10. [RS485 Cables – Why you need 3 wires for 2 \(two\) wire RS485 – Chipkin.com](#)

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