(TIA-EIA)RS-422 and -485

Notebook:	Standards		
Created:	1/21/2019 9:13 AM	**Updated:**	4/14/2020 5:22 PM
Author:	mark_a_davis@comcast.net		
URL:	https://en.wikipedia.org/wiki/RS-422		

https://en.wikipedia.org/wiki/RS-422
https://en.wikipedia.org/wiki/RS-485

http://app.ic.maximintegrated.com/e/er?utm_campaign=FY19_Q3_2019_JAN_CPG-SCPwr_AMER_AnalogNL_EN_A&utm_medium=email&utm_source=Eloqua&s=248385305&lid=7443&elqTrackId=C1C8585B0017B338F02F44F0A0EF4916&elq=b302cbc92f7e4b359
C:\dropbox\work\Standards\RS-485-Still-The-Most-Robust-Communication.pdf

https://www.electronicdesign.com/communications/implement-idle-bus-failsafe-multipoint-networks
C:\dropbox\work\Standards\RS-485-Still-The-Most-Robust-Communication.pdf

Differential/balanced signal encoding:

The 2 wires in for RS-422 and RS-485 links carry the same signal (0 to a positive voltage, usually around 5VDC), but one is inverted.

For example, if VCC is the max positive voltage for each wire, then when one wire is at the +VCC, the other is at 0 (relative to a ground/reference on the transmitter). This means that, although the voltage range for each wire separately varies only by VCC, the range of the voltage DIFFERENCE between the 2 wires is twice as much (since it goes from -VCC to +VCC).

The differential approach to encoding information also means that it is much less susceptible to common-mode noise, especially when using twisted pairs, as the noise tends to affect both wires the same. This means that, even if some EMI causes the voltage on both wires to jump by 1 volt, the difference between the 2 is not affected.

Ground/Common return path:

The big question seems to be if/when a "common return path" is needed or should be included. According to the Wiki page on RS-485, it is optional in the original standard, but the newer ANSI/TIA/EIA-485-A standard REQUIRES it for proper operation. Looking through tutorials on web, the opinions on which is the "right" approach is not at all consistent: Some say NEVER include a ground connection, others say make sure you DO include one.

My best guess is that, if you have connections and each device that is truly a reference for the voltage on the signal wires, and that reference is isolated to the communications interfaces on the devices, then by all means include it. Otherwise, it seems that it could cause as many problems as it solves.

Fail-safe Biasing:

The whole question of a ground/common return path connection may make more sense when fail-safe biasing (pull up/down) resistors are needed (pull-up to VCC for the normal signal, and down to ground/common for the inverted signal) to ensure that the lines are in the idle (MARK, logic 1) state when there is no transmitter enabled on the line. Without a common reference for the current path through the bias resistors, I would think that other current paths could result in different voltage differentials at different nodes. The fact that use of a return path was optional (and not common?) in the original version of the RS-485 standard but is required in the newer version of the standard and the (still) widely differing opinions found on the web about using/not using one means it is not at all obvious what constitutes best practice (or if there even IS a "best" way that is generally independent of how the devices are made).

The main thing to keep in mind regarding fail-safe biasing: The resulting voltage across the transmission lines when there is no active transmitter needs to be > 200mV to insure noise is not treated as actual data. And when calculating the appropriate resistor values, keep in mind that, for a line that is properly terminated at both ends, the resistance ACROSS the lines is determined by the 2 termination resistors in parallel (50 ohms for 100 ohm resistors, 60 ohms for 120 ohm resistors). Also note that, if the resistors are in the device itself, this changes when one end is physically disconnected. In such cases, it may make sense to "split" the biasing resistors across the 2 end devices so that one can be disconnected without changing the signal level. For example: if VCC = 5V and 120 ohm termination resistors and 1K pull up/down resistors are used at both ends, then you will get a signal level voltage of 283 mV when either or both devices are connected (and all transmitters are disabled).

Of course, if the devices at both ends are disconnected, then any other nodes on the bus will still have the problem of "floating" signal wires when no transmitter is enabled. The best practice would probably be to have the bias and termination resistors in the connectors for the devices at the end of the transmission lines, although the problem with that is that you have to have a separate power source for the biasing resistors to work. Without that, the voltages on the signal lines would both approach 0 (especially with the pull-down resistors), which could be interpreted as either a 1 or a 0 (depending on the previous state of the lines and the magnitude of any non common-mode noise).

All of which is why the star configuration for Ethernet networks is so popular (where all connections are point-to-point over twisted pairs, requiring hubs or switches with just one device physically connected to each port). In this day and age, it seems like doing the same for RS-422 and RS-485 would make things so much simpler and more reliable. But of course it would also increase the cost.

Another question I haven't seen addressed is just HOW devices are connected to the transmission line. Based on my limited experience with Ethernet back when a shared coax line was used, you could not simply use a "T" connection off the coax of any significant length without causing reflections in the signal. I assume the same applies to twisted pair RS-422 and RS-485 connections (?)

TIA/EIA / RS-422:

https://en.wikipedia.org/wiki/RS-422

RS-422	
Standard	TIA/EIA-422
Physical Media	Twisted Pair
Network Topology	Point-to-point, Multi-dropped

Maximum Devices	10 (1 driver & 10 receivers)
Maximum Distance	1500 metres (4,900 ft)
Mode of Operation	Differential
Maximum Binary Rate	100 kbit/s – 10 Mbit/s
Voltage Levels	−6V to +6V (maximum differential Voltage)
Mark (1)	Negative Voltages
Space (0)	Positive voltages
Available Signals	Tx+, Tx-, Rx+, Rx- (Full Duplex)
Connector types	Not specified

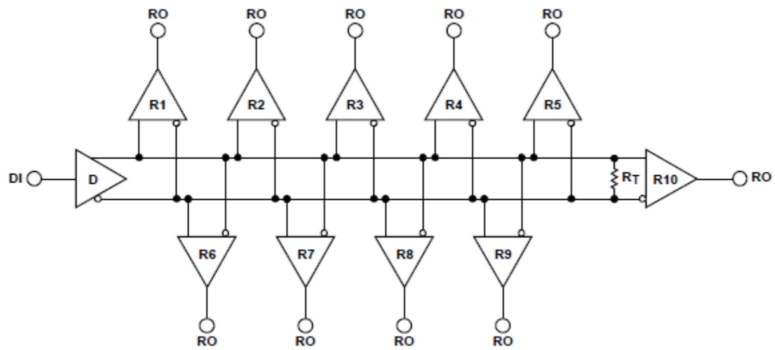


Figure 2. Typical RS-422 Interface Circuit

NOTE that the RS-422 standard defines the signaling standard for 1 pair of wires and specifies that there is just one "driver" node, with up to 10 receivers (with a maximum load defined for each receiver). It does NOT cover things like proper termination. It IS, however, generally assumed that the driver keeps the state of the wires in a valid state even when NOT transmitting, and so bias resistors should not be needed anywhere on the line to insure this is so. But for practical reasons, such as insuring the line is not susceptible to noise should the driver be disconnected from the lines, bias resistors might sometimes be need to avoid treating noise as real data.

NOTE that the standard says nothing about how to properly terminate a transmission line to avoid reflections, etc.

TIA/EIA / RS-485:

https://en.wikipedia.org/wiki/RS-485

TIA-485-A (Revision of EIA-485)	
Standard	ANSI/TIA/EIA-485-A-1998 Approved: March 3, 1998 Reaffirmed: March 28, 2003
Physical media	Balanced interconnecting cable
Network topology	Point-to-point, multi-dropped, multi-point
Maximum devices	At least 32 unit loads
Maximum distance	Not specified
Mode of operation	Different receiver levels: binary 1 (OFF): (Voa–Vob < −200 mV) binary 0 (ON): (Voa–Vob > +200 mV)
Available signals	A, B, C
Connector types	Not specified

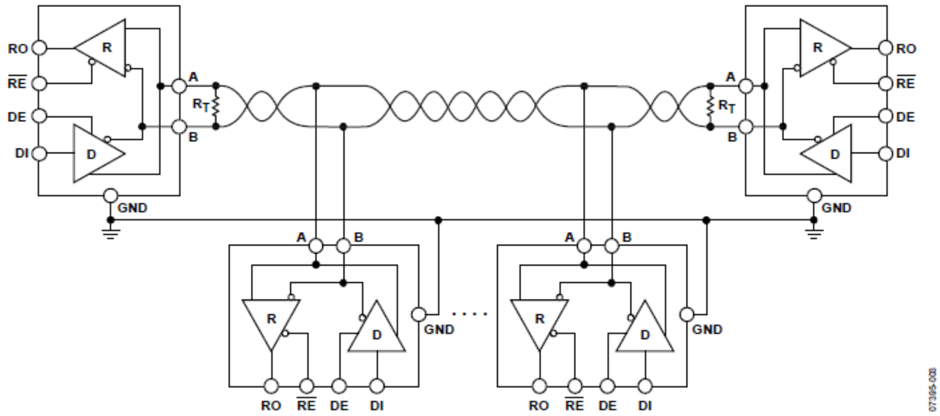


Figure 3. Half-Duplex RS-485 Bus Configuration

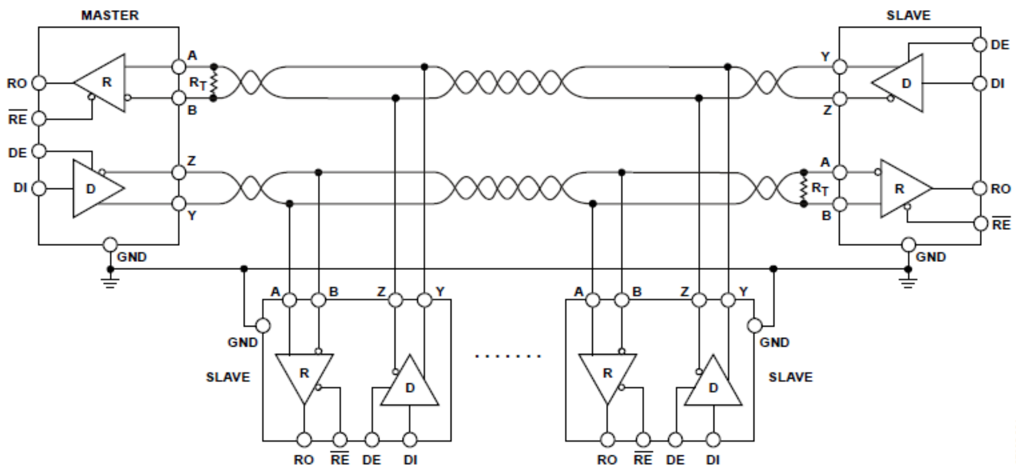
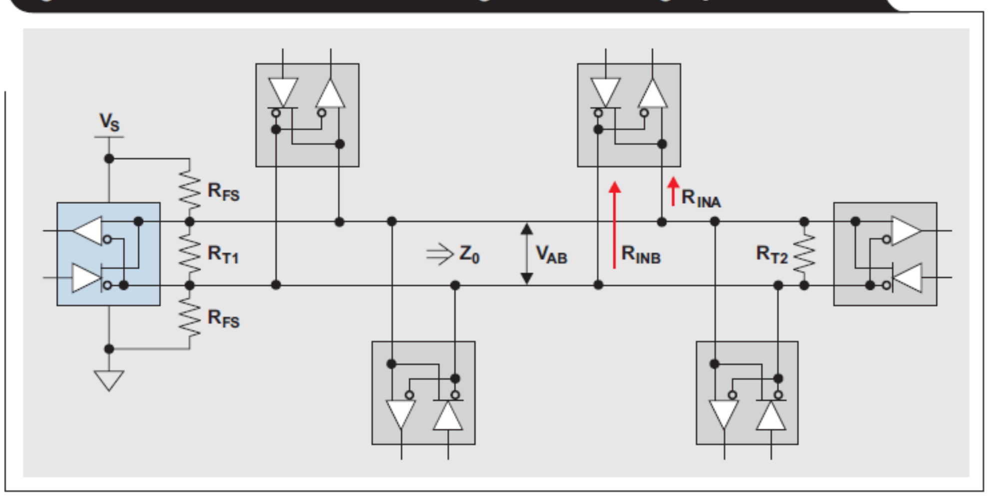


Figure 4. Full Duplex RS-485 Bus Configuration

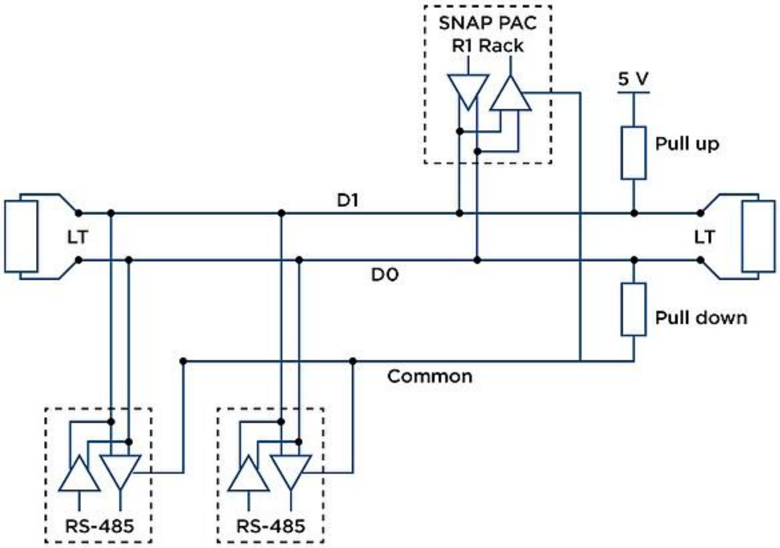
The signal-level characteristics for RS-485 is very similar to RS-422. The chief difference is that RS-485 supports true multi-drop configurations, where ANY device on the line can send data (as long as the times they do so don't overlap). For this to work, the driver for each node must be disconnected from the transmission lines when not actively transmitting. But this means the line is not forced to be in a valid state by any driver. So the lines need to be biased so that, when no node is transmitting, noise will not result in a sufficiently large voltage difference that it gets interpreted as data.

Figure 2. RS-485 bus with failsafe-biasing network for legacy transceivers



RS-485 - To Terminate, Bias, or Both?

https://blog.opto22.com/optoblog/rs-485-to-terminate-bias-or-both

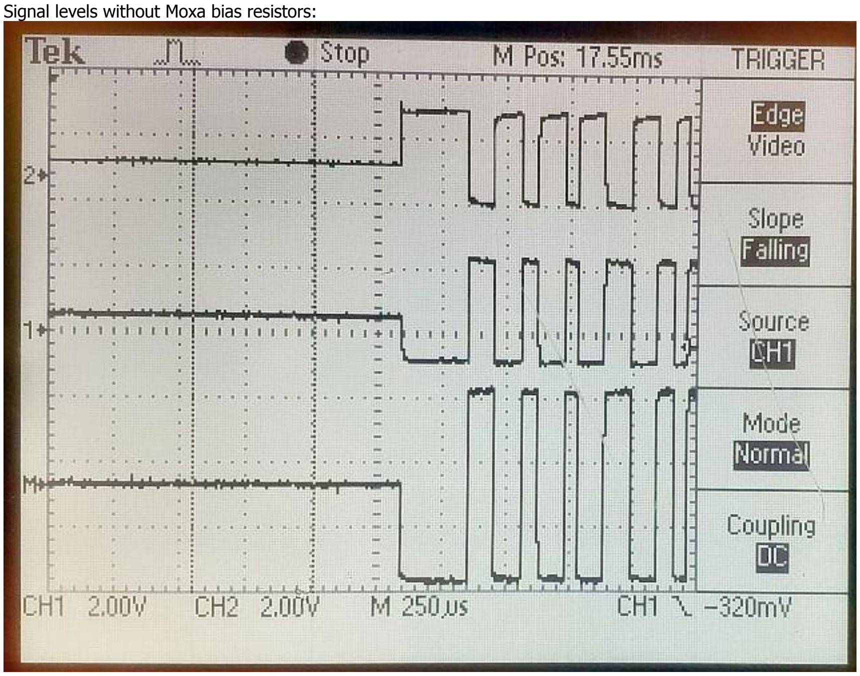


Comparison before/after enable the smaller Moxa pull up/down (bias) resistors for RS-485/RS-422:

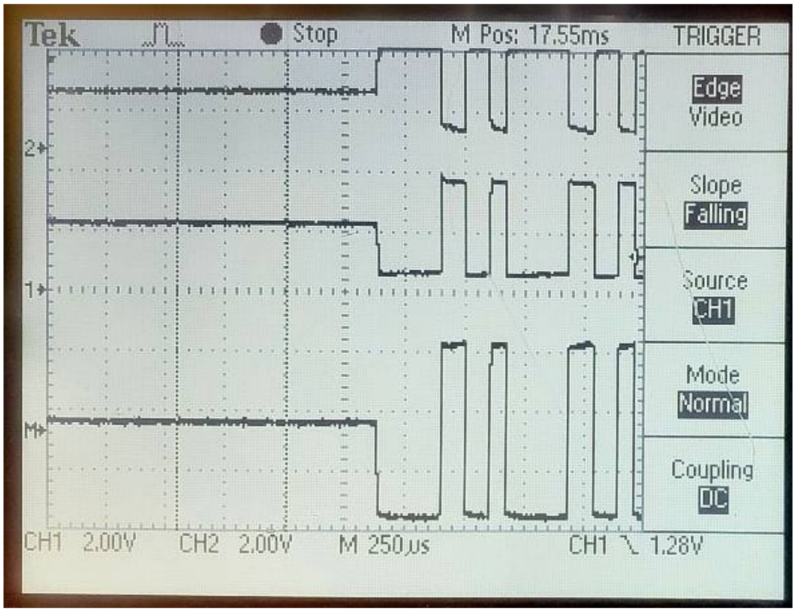
IN the following plots, the 1 and 2 plots are the differential pair the data is transmitted on. The M plot it difference between signal 1 and signal 2 (i.e. V1 - V2).

Notice that, without the smaller bias resistors on the Moxa enabled, the resulting difference (M) is very close to 0 when no data is being transmitted. But when the Moxa bias (pull up/pull down) resistors are enabled, the difference is large enough to satisfy the > 200mV requirement to ensure the receiver does not interpret it as actual data. Without the proper biasing, the result can be spurious chars between the real data bits or (what was happening to us) false characters at the end of a message.

Signal levels without Moxa bias resistors:



With Moxa bias resistors:


Tek
Stop
M Pos: 17.55ms
TRIGGER
Edge
Video
Slope
Falling
Source
CH1
Mode
Normal
Coupling
DC
CH1 2.00V
CH2 2.00V
M 250 µs
CH1 1.28V