Technical Brief
AN236 Rev D

Serial Communications RS232, RS485, RS422

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Summary

Electronic communications is all about interlinking circuits (processors or other integrated circuits) to create a symbiotic system. For those individual circuits to swap information, they must share a common standard communication protocol. Many communication protocols have been designed to achieve data exchange.

The most common serial communication protocols are RS232, RS485, RS422, USB, and Ethernet. But because USB and Ethernet require powerful interfaces with complex protocols, many efficient devices utilized RS232, RS485, and RS422 which is what this note is all about.

Protocol Comparison Chart

	RS-232	RS-422	RS-485
Cable	Single ended	Single ended multi-drop	Multi-drop
Number of Devices	1 transmitter 1 receiver	1 transmitter 10 receivers	32 transmitters 32 receivers
Communication Mode	Full duplex	Full duplex, Half duplex	Full duplex, Half duplex
Maximum Distance	50 feet at 19.2 kbps	4000 feet at 100 kbps	4000 feet at 100 kbps
Max Data Rate (50 feet)	1 mbps	10 mbps	10 mbps
Digital 1 / Digital 0	-V / +V	+V / -V	+V / -V

Serial Protocols

The RS232, RS485, RS422 serial protocols only relate to the hardware interface, not the software protocols used to make the devices communicate. There are many protocols that

exist in the market place so one cannot assume interoperability between different manufacturers of "RS232" ports.

To define Instruments that supports a mixture of industry standard and proprietary serial protocols:

Modbus RTU

This protocol is used in industrial applications and most SCADA PLC's have drivers for Modbus RTU. The Modbus protocol is well published and every manufacturer determines its own addressing scheme. The manufacturer must supply the addressing scheme, register type, and Modbus commands that is supports.

ASCII protocol

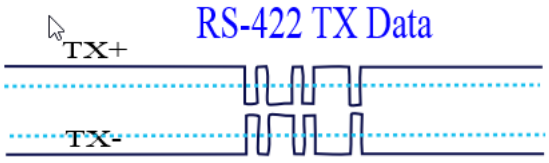
ASCII is popular because it is easier than Modbus to write your own driver in a PLC or a PC. Most every manufacturer's protocols are not usually compatible.

The Advantages of RS485 and RS422 vs RS232

RS485 and RS422 use differentiation. Two wires are required for each signal. The figure below shows a single RS485 / RS422 signal being transmitted. To transmit a logic 1, line B is high and line A is low. To transmit a logic 0, line B is low and line A is high. The advantage of this arrangement is that signals can be transmitted faster and over greater distances than is possible with a single wire.

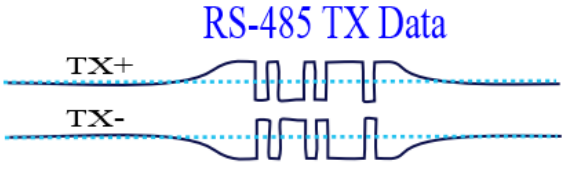
Here are the main differences between RS422 and RS485. The main difference between RS-422 and RS-485 is the types of communications allowed.

RS422 allows only one-way (simplex) communications between one driver, and as many as ten receiving devices. To control devices and need no feedback from them, RS-422 multi-drop network will work well. The output data driver from the master is always enabled. Full Duplex communication.



RS422 (One Master and up to 10 Slaves)
1 Driver up to 10 Receivers

RS485 was designed to address the multi-drop limitation of RS422, allowing up to 32 devices to communicate. In RS485 each driver can be switched off allowing multiple units to send data. The Output data drivers from the masters are disabled unless data is coming out of a master.



RS485 (Many Masters and Many Slaves)
Up to 32 Driver/Receiver Pairs

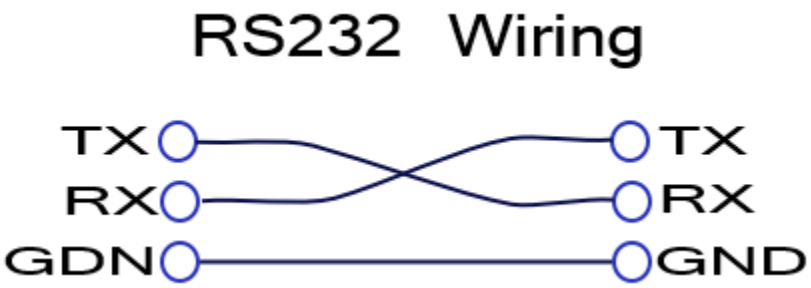
RS-422 and RS-485 transceivers are sometimes confused with each other. One type is assumed to be a full-duplex version of the other. The electrical differences in their common-mode ranges and receiver input resistance make these suitable for different applications. RS-485 meets most all the RS-422 specifications, RS-485 drivers can be used in RS-422 applications. RS-422 drivers cannot be used with RS-485. The output voltage for RS-485

drivers is -7V to +12V, but the range for RS-422 drivers is only ±3V. The minimum input resistance of the receiver is 4kΩ for RS-422 and 12kΩ for RS-485.

4-Wire RS-485 networks are the same as RS-422 Multi-Drop Networking. An RS-422 device is used as the master and an RS485 device is used as a slave in a 4-Wire RS-485 bus. RS422 and RS485 have different electrical standards, and most manufacturers' use ICs that provide both RS422 and RS485 interfaces. RS-422 Multi-Drop and 4-Wire RS485 can be considered equal.

RS-232

An RS232 serial bus consists of just two communication wires - one for sending data and another for receiving. As such, serial devices should have two serial pins: the receiver, RX, and the transmitter, TX. Because the communication data is based upon the voltage on the wires, relative to the ground level, a ground connection must be made between devices that communicate with RS-232. Here is an RS232 wiring diagram:

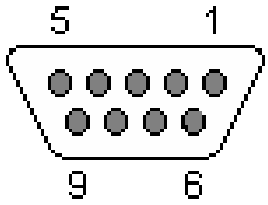


A digital 1 voltage is: -5V to -15V

A digital 0 voltage is: +5V to +15V

RS232 data is sent serially, each bit is sent one after the next because there is only one data line in each direction. This mode of data transmission also requires that the receiver knows when the actual data bits are arriving so that it can synchronize itself to the incoming data. To achieve this a logic 0 is sent as a synchronization start bit.

The RS-232 is usually a 9-pin serial I/O connector. On radio modems, it is a female 9-pin D-subminiature connector having the following pins configuration. It is pinned out so that it may be plugged directly into a computer or PC's 9-pin COM port.



Front-view of DB-9 connector on modem (female) The pins are:

Pin	*Name*	*Dir*	*Function*	*Level / Specification*
1	CD	out	Carrier detect	If enabled, indicates presence of carrier. Logical 0 (+ voltage on RS-232) means carrier is present.
2	RxD	out	Receive data	Data out of the modem.

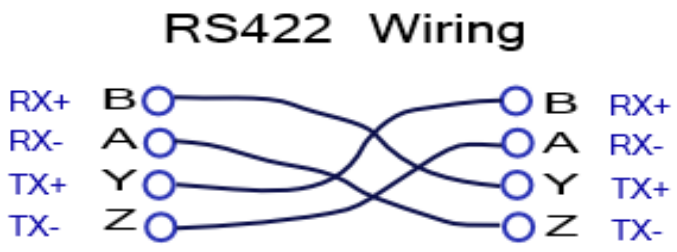
3	TxD	in	Transmit data	Data into the modem.
4	DTR	in	Data terminal ready	Normally ignored by the *M7* modem. May control the power-state of the modem in low-power mode if this feature is enabled.
5	GND		Ground connection	Signal and power ground
6	DSR	out	Data Set Ready	Normally is set to 0 when modem is powered on and running. Modem sets to a 1 when in low-power mode or in command mode.
7	RTS	in	Request to send	Used to stop/start the flow of data coming out of the modem TxD pin. 0 = OK to send, 1 = don't send. Leave disconnected if not used.
8	CTS	out	Clear to send	Used to stop the flow of data going into the RxD pin from the device connected to the *M7*. 0 = OK to send, 1 = don't send. If the *M7* cannot accept more data, it will negate this signal (set to a 1).
9	Power	In/out	DC power (Ring signal)	User may supply the DC power to the modem on this pin. Some products use this as a Ring Indicator Output. Some use this as DC power out, or Input.

RS422 *(Single Driver Communications)*

RS422 is designed to be tolerant of noise and forgiving of long cable runs. It is typically used between one transmitter receiver pair to one other transmitter receiver pair. Each output can drive up to 10 receivers. It achieves this by using a differential current drive output which has high immunity to noise. The noise immunity enables RS422 systems to operate over very long connections, much better than RS232, US, and Ethernet.

Each signal uses two wires to pass the data. The differential voltage on the A and B wires represent the digital value. If B>A the value is 1. If A>B then value is 0.

Input Signal	A B	Output Signal
0	1 0	0
1	0 1	1



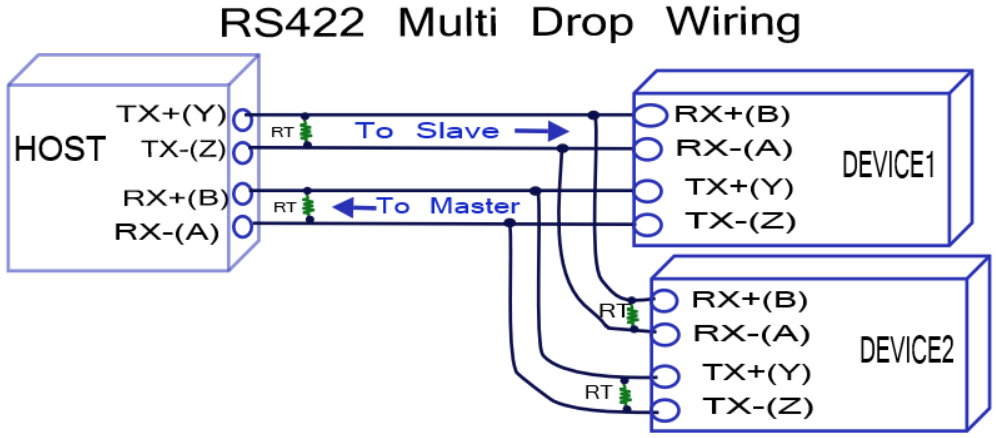
RS422A Standard Specifications

- 1 Driver, up to 10 Receivers

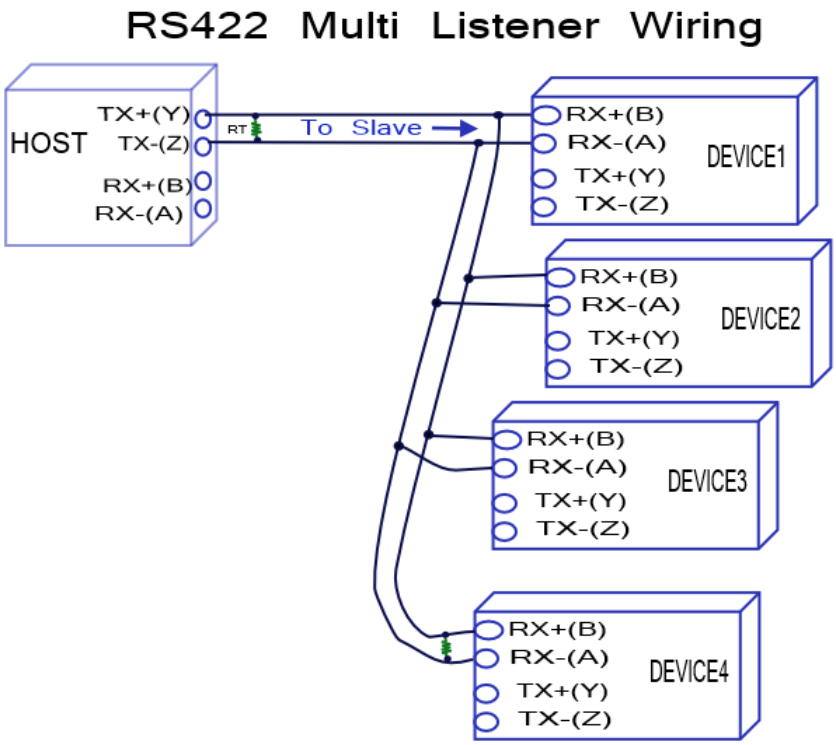
Line Length for Max Data Rate:

- 40 Feet = 12m 10 Mbits/sec
- 400 Feet = 122m 1 Mbits/sec
- 4000 Feet = 1219m 100 Kbits/sec

RS422 networks are often used in a half-duplex mode similar to RS485. The RS-422 products that can do multi-drop communications, are actually RS-485 4-wire systems.



A multi-drop wiring has many desirable advantages, RS422 devices cannot be used to construct a truly multi-point network. A true multi-point network consists of multiple drivers and receivers connected on a single bus, where any node can transmit or receive data. To use 2 wires to send data to multiple devise, TX outputs can be sent to multiple listeners.

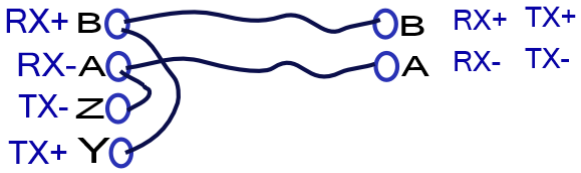


RS485*(Multiple Driver Communications)*

RS485 is similar to RS422 upon which it is based. The main difference is that up to 32 transmitter receiver pairs may be present on the RS485 lines at one time. RS-485 is generally a 2-wire half duplex system.

Sime RS485 products have 4-wire outputs that get connected together to create the RS485 two-wire interface. AN RS485 4-wire full duplex system is very similar to RS-422 interface, and the RX pins are connected to the TX pins to create the two-wire RS485 interface.

4-Port RS485 Wiring



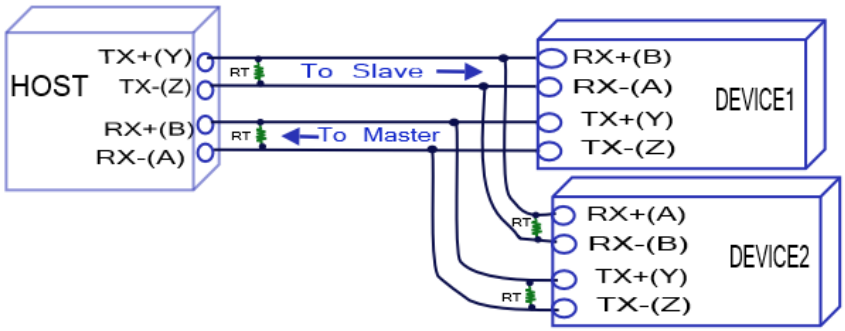
RS485 is still popular. It is similar to the RS422 upon which it is based. The RS485 port has been used for many years. RS485 has many advantages over both RS232 and USB when it comes to applications in noisy industrial environments. RS422 devices can be used on an RS485 bus network if they are only used as recipients.

The Primary features of RS-485 are:

- Balanced interface
- Tri-state outputs
- Multipoint operation from a single 5-V supply
- –7-V to +12-V bus common-mode range
- Up to 32 unit loads

The main difference between RS422 and RS485 is that up to 32 transmitter receiver pairs may be present on the line at one time on RS485. A 120 Ohm resistor must be used to terminate the main line. The full-duplex implementation requires two signal pairs, (four wires).

RS485 Full Duplex Wiring



RS485A Standard

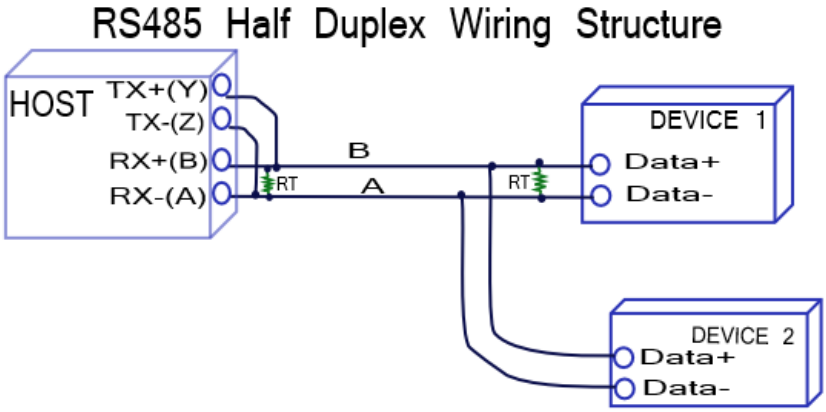
- Up to 32 Driver/Receiver Pairs

Line Length Max Data Rate

- 40 Feet = 12m 10 Mbits/sec
- 400 Feet = 122m 1 Mbits/sec
- 4000 Feet = 1219m 100 kbits/sec

Traditional RS485 devises use two wires.

In half-duplex, only one signal pair (A, B) is used. When instruments are described as having an RS485 interface this tells you nothing for sure about the signals being transmitted. Usually though only the Transmit Data (TX) and Receive Data (RX) of a normal serial port are converted to RS485 or RS422. The other signals of the serial port are not used. Three arrangements are commonplace: Write only, 4-wire (full duplex) and 2-wire (half duplex). The "2-wire" RS-485 connection is shown below.



RS485 half-duplex can use just two wires to communicate with up to 32 device, one at a time. Each device has the ability to turn off its output drivers, so only the one device that is linking to the host outputs a signal on its TX lines. Terminating Resistors (RT) are connected across the ends of the A B wires. Cable trunk is commonly terminated with 120 ohm resistors. Because you are sending and receiving on the same two wires, you need to enable and disable the transmitter at the correct time so that you may perform proper communications. In half-duplex RS-485 network, the master transceiver tri-states the bus after transmitting a message to the slave devices.

Tri-State Control

RS-485 systems have the ability to multi-drop network nodes. To do so, the outputs of all of the RS-485 drivers that are not currently transmitting are effectively disconnected from the transmission line. This is called tri-state because the output is in three states, 0, 1, or open circuit. To facilitate multiple master drivers on the line, the RS-485 line driver circuits in the devices that do output data have an “enable” circuit that enables/disables their output driver.

Termination Resistors

Termination resistors should be placed on both ends of the twisted pair of wires. The impedance value should be the same value of the characteristic impedance of the twisted pair and should be placed at the far ends of the cable. For cables that are 2000 feet or less, a termination resistor is not needed at baud rates of 9600bps or less.

If a termination resister is required, a 120Ω or greater should be used. No more than 2 termination resistors should be used, one at each end of the RS485 transmission line.

The A B wires should always be looped around together. Looping the wires helps reduce noise, and when electrical, magnetic, and RF noise couples onto the A B cable, by looping the cable, the noise goes equally onto both A and B wires, so the differential data has no differential noise.

DB9 Pin Outs

DB9 connectors can be used for RS232, RS485, and RS422. Typical pin outs connections for DB9 male DCE mode connectors on modems and hosts are:

	1	2	3	4	5	6	7	8	9
RS232 DTE	CD	RXD	TXD	DTR	GND	DSR	RTS	CTS	RI
RS232 DCE Radio Modems	CD	TXD	RXD	DSR	GND	DTR	CTS	RTS	RI
RS485	-	Zout-	B-	A+	GND	-	Yout+	-	-
RS422		B-	TX+B	DTR+	GND	RX+B	TX-A		

TXD: Data coming out of the radio modem.
RXD: Data going into the radio modem.
B-: Inverting RS-422 data input line
A+: Non-inverting RS-422 data input line
Zout: Inverted data output pin

Yout: No-inverted data output
GND: Ground common connection.

The Pin-out of a DB9 straight cable for RS-232 between two devices is shown here. The DTE is typically a computer or controller. The DCE is a computer modem. Raveon modems are configured as DCE.

DTE Device	DB9		DB9	DCE Device
1 Carrier Detect (CD)	CD		CD	1 Carrier Detect (CD)
2 Receive Data (RXD)	RXD		RXD	2 Receive Data (RXD)
3 Transmit Data (TXD)	TXD		TXD	3 Transmit Data (TXD)
4 Data terminal Ready	DTR		DTR	4 Data terminal Ready
5 Ground, Common	GND		GND	5 Ground, Common
6 Data Set ready	DSR		DSR	6 Data Set ready
7 Request To Send	RTS		RTS	7 Request To Send
8 Clear To Send	CTS		CTS	8 Clear To Send
9 Ring indicator	RI		RI	9 Ring indicator
Shield to connector	GND		GND	Shield to connector

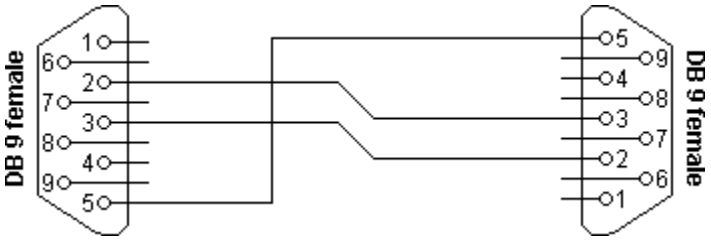
RS232 Null Modem Cables

Null modem cables without handshaking

Sometimes, a “Null Modem” cable may be required to connect the M7 modem to another device. The specific connections are very dependent upon the type of hardware and handshaking used, but the following sections should help in configuring a null-modem cable.

How to use the handshaking lines in a null modem configuration? The simplest way is to don't use them at all. In that situation, only the data lines and signal ground are cross connected in the null modem communication cable. All other pins have no connection. An example of such a null modem cable without handshaking can be seen in the figure below.

Simple null modem without handshaking



(DB-9 Female shown. Same wiring for male-to-male cable)

Connector 1	Connector 2	Function
2	3	Rx ← Tx
3	2	Tx → Rx
5	5	Signal ground

Compatibility issues

There is a problem, if either of the two devices checks the **DSR** or **CD** inputs. These signals normally define the ability of the other side to communicate. As they are not connected, their signal level will never go high. This might cause a problem.

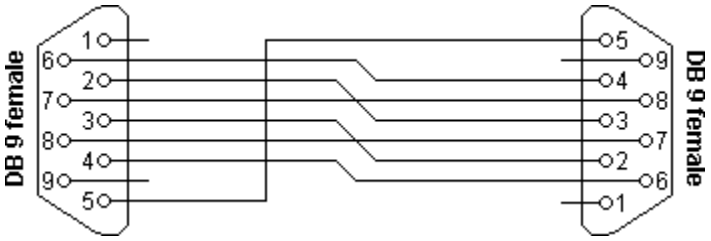
The same holds for the **RTS**/**CTS** handshaking sequence. If the software on both sides is well structured, the **RTS** output is set high and then a waiting cycle is started until a ready signal is received on the **CTS** line. This causes the software to hang because no physical connection is present to either **CTS** line to make this possible. The only type of communication which is allowed on such a null modem line is data-only traffic on the cross connected **Rx**/**Tx** lines.

RS232 Null Modem Cable with full handshaking

Caution: Most null modem cables are designed for host-to-host communication and will not work for device-to-device communication! See the section on compatibility issues for more details.

In this null modem cable, seven wires are present. The cable is shown in the following figure.

Null modem with full handshaking



(DB-9 Female shown. Same wiring for male-to-male cable)

Connector 1	Connector 2	Function
2	3	Rx ← Tx
3	2	Tx → Rx
4	6	DTR → DSR
5	5	Signal ground
6	4	DSR ← DTR
7	8	RTS → CTS
8	7	CTS ← RTS

NMEA Serial Communications

NMEA is a marine electronics protocol created for serial data communications on marine vessels that is still widely in use today. Since its inception in 1987 there have been many protocol updates. NMEA 0183 was the first marine electronics protocol.

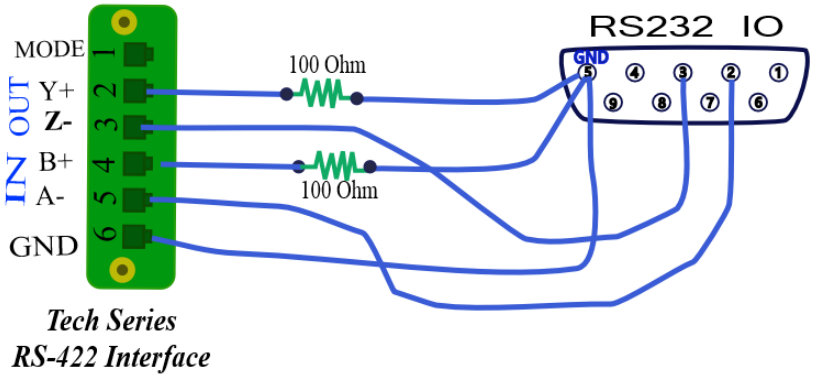
NMEA 0183 v1.5 is a *'single ended'* method for connecting devices together, which is known as RS232.

NMEA 0183 v2.0 uses a RS422 differential connections. V2.0 method uses two lines for sending data (*'A'* or *'+'* and a *'B'* or *'-'* and there is also a 'Ground' connection.

NMEA 2000 is a multilane superhighway where entire digital conversations are sped along in two directions simultaneously. Each onboard device can chatter away with up to 50 other devices. It has a high data rate up to 250k bits/second where NMEA 0183 was 4800 bits/second. NMEA 2000 products is not electrically compatible with NMEA 0183 products. NMEA 2000 is CAN Bus type communications, not serial data as described in this document.

Trying to communicat with RS232 to an RS-422

Raveon's Tech Series RS-422 interface is shown below, and wiring it to an RS-232 serial port, with two resistors to help be safe connections, will work on some systems. In general, RS-232 should not connect to RS-422 interfaces.



Tech Series
RS-422 Interface

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