

DT-E - Hands-on Data Communications, Networking and TCP/IP Troubleshooting



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Short Description

More and more people who work in plants need to understand how data from the field is transmitted to the control room and even to Manufacturing Execution Systems located in head offices situated considerable distances from the plant. It is a technological marvel and this manual helps you to understand the flow of information and the various techniques involved in it.

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First Chapter

Serial Data Communication

Serial Data Communication

Objectives

When you have completed studying this chapter, you will be able to:

- Explain the basics of serial communication
- Describe the specifications of RS-232 standard and its limitations.
- Describe the RS-422 interface standard
- Describe the specifications of RS-485 interface standard.

1.1 Asynchronous Serial Communication Basics

In serial communication data is sent and received one bit at a time, sequentially, over a communication channel. Most computers are typically equipped with serial ports (9 pin and 25 pin). Serial ports are used to communicate with terminals and peripheral devices. This port is also known as COM port (Communication Port). COM ports are controlled by UART (Universal Asynchronous Receiver Transmitter). Nearly all industrial and commercial communication between devices is serial, including high speed systems using USB or Local Area Networks such as Ethernet.

In parallel communication, 8 (or 16 or 32) bits are sent and received simultaneously over a bus comprising 8 (or 16 or 32) channels, one for each bit. This allows data to be transferred 8 (or 16 or 32) times faster than serial communication. But in a serial link, data transfer is done using a single channel over very long distances compared to a parallel link. Parallel communication is usually only used within a device, and is beyond the scope of this course.

1.1.1 Types of Connectors

Serial ports come in two sizes, 9 pin and 25 pin (Male and Female) connectors. These are known as D-Type plugs. Figure 1.1 shows the types of D-type plugs. Each pin of a serial port has specific function, hence different applications use different pins depending on the function required.

Figure 1.1

Types of connectors

1.1.2 Pins Description

Table 1.1

Pin description of 25 & 9 pin D-Type plug

Function	Pin Symbol	9 pin no.	25 pin no.
Receive Data (Serial data input)	RD	2	3
Transmit Data (Serial data output)	TD	3	2
Request to send (acknowledge to modem that UART is ready to exchange data)	RTS	7	4
Clear to send (Modem is ready to exchange data)	CTR	8	5
Data ready state (UART establishes a link)	DSR	6	6
Signal ground	SG	5	7
Data Carrier detect (This line is active when modem detects a carrier)	DCD	1	8
Data Terminal Ready	DTR	4	20
Ring Indicator (Becomes active when modem detects ringing signal from PSTN)	RI	9	22

1.1.3 DTE & DCE

Devices that use serial cables for their communication are split into two categories:

- DTE (Data Terminal Equipment) - for example, computers, printers and terminals are DTE
- DCE (Data Communication Equipment) - for example, modems.

1.1.4 Communication Methods

Serial communication can be achieved in two methods - Synchronous and

Asynchronous.

Synchronous method:

In this type of communication, the two devices initially synchronize themselves to each other, and then continually send characters to stay in sync. In other words, the receiver will know when to read the next bit coming from the sender, this can be achieved by sharing a clock between sender and receiver. Even when data is not really being sent, a constant flow of bits allows each device to know where the other is at any given time. That is, each character that is sent is either actual data or an idle character (fill character, so that, the data is always being transmitted). Synchronous communications allows faster data transfer rates than asynchronous methods, because additional bits to mark the beginning and end of each data byte are not required.

Asynchronous method:

Asynchronous means "no synchronization", therefore it does not require sending and receiving idle characters. However, the beginning and end of each byte of data must be identified by start and stop bits. The start bit indicates when the data byte is about to begin and the stop bit indicates when it ends. When the entire data word has been sent, the transmitter may add a Parity Bit that the transmitter generates. The Parity Bit may be used by the receiver to perform simple error checking. The requirement to send these additional bits causes asynchronous communication to be significantly slower than synchronous; however it has the advantage that the processor does not have to deal with the additional idle characters.

The standard serial communications hardware in the PC does not support synchronous operations.

An idle asynchronous line is identified with a value of '1' (also called a mark state). This value indicates that no data is currently being sent and hence with this value the devices are able to distinguish between an idle state and a disconnected line. When a character is about to be transmitted, a start bit is sent. A start bit has a value of '0' (also called a space state). Thus, when the line switches from a value of '1' to a value of '0', the receiver is alerted that a data character is about to be sent.

Figure 1.2

1.1.5 Handshaking

The procedure used to check the link between DTE and DCE before transmitting data is called handshaking. Data is transmitted and received on pins '2' (Tx) and '3' (Rx) respectively, on a DB-25 RS-232 interface.

- DTE would first request to send data to DCE (RTS).
- The DCE will indicate to DTE, that, it is ready and clear to send data (CTS).

Both RTS and CTS are used to control data flow between DTE and DCE. Also DSR, DTR and CD are also important in controlling data flow. Data Set Ready (DSR) is an indication from the DCE (e.g. modem), that it is 'ON'. Similarly, DTR (e.g. PC) indicates to the Data Set, that the DTE is 'ON'. Data Carrier Detect (CD) indicates that a good carrier is being received from the remote modem.

1.1.6 Baud Rate

Baud rate indicates the transmission speed in asynchronous communication. It represents the number of bits that are actually being sent over the serial link. The Baud count includes the overhead bits Start, Stop and Parity that are generated by the sending UART and removed by the receiving UART.

1.1.7 Type of Cables

Modem Cable:

A normal modem cable runs straight through with pin 1 to pin 1, pin 2 to pin 2 etc. The end connected to the terminal or PC has a female connector, and the end connected to the modem has a male connector. However, if the PC DTE uses a nine pin connector then and the DCE has a DB-25 connector then the connections in Table 1.2 must be applied.

Table 1.2

RS-232 Pinouts DB9 to DB25

Signal Description	9-pin DTE	25-pin DCE	Remarks
Carrier Detect (CD)	1	8	From Modem
Receive Data (RD)	2	3	From Modem
Transmit Data (TD)	3	2	From Terminal/Computer
Data Terminal Ready (DTR)	4	20	From Terminal/Computer
Signal Ground (SG)	5	7	From Modem
Data Set Ready (DSR)	6	6	From Modem
Request to Send (RTS)	7	4	From Terminal/Computer
Clear to Send (CTS)	8	5	From Modem
Ring Indicator (RI)	9	22	From Modem

Null Modem Cables:

To connect equipment where both are DCE, or both are DTE such as connecting two PC's, then use the cable with pin connections (25 to 25) shown below. This type of cable is called a Null Modem cable.

Table 1.3

Connecting 25 pin to 25 pin for Null Modem

Signal description	25-pin	25-pin	Signal description
Receive Data	3	2	Transmit Data
Transmit Data	2	3	Receive Data
Data Terminal Ready	20	6+8	Data Set Ready + Carrier Detect
System Ground	7	7	System Ground
Data Set Ready + Carrier Detect	6+8	20	Data Terminal Ready
Request to Send	4	5	Clear to Send
Clear to Send	5	4	Request to Send

Table 1.4

Connecting 9 pin to 9 pin for Null

modem

Signal description	9-pin	9-pin	Signal description
Receive Data	2	3	Transmit Data
Transmit Data	3	2	Receive Data
Data Terminal Ready	4	6+1	Data Set Ready + Carrier Detect
System Ground	5	5	System Ground
Data Set Ready + Carrier Detect	6+1	4	Data Terminal Ready
Request to Send	7	8	Clear to Send
Clear to Send	8	7	Request to Send

1.2 RS-232 Basics

The RS-232 (Recommended Standard-232) interface standard was issued 1969 by the engineering department of the Electronics Industry Association (EIA). Almost immediately, minor revisions were made and EIA-232C was issued. The prefix 'EIA' was superseded by 'EIA/TIA' in 1988, when the EIA merged with the Telecommunications Industry Association (TIA). Revision EIA/TIA-232E (1991) brought it into line with the international standards ITU V.24, ITU V.28 and ISO-2110. The TIA/EIA designation was later simplified to 'TIA' and the current standard is TIA-232-F. It should be emphasized that RS-232 and other related TIA standards define the electrical and mechanical details of the interface (Layer 1 of the OSI model) and do not define a protocol.

The RS-232 standard specifies the method of connection of two devices; a DTE and a DCE. A DTE device communicates with a DCE device. DCE equipment is now also called Data Circuit-terminating Equipment in EIA/TIA-232-E. A DCE device receives data from the DTE and retransmits it to another DCE device via a data communications channel such as a telephone link. A connection between the DTE and the DCE using DB-25 connectors is shown in Figure 1.3.

Figure 1.3

Connections between the DTE and the DCE using DB-25 connectors

1.2.1 Major Elements of RS-232

The RS-232 standard consists of three major parts, which define:

- Electrical signal characteristics
- Mechanical characteristics of the interface
- Functional description of the interchange circuits

Electrical signal characteristics:

RS-232 defines electrical signal characteristics such as the voltage levels and grounding characteristics of the interchange signals and associated circuitry for an unbalanced system.

The RS-232 transmitter is required to produce voltages in the range +/- 5V to +/- 25V as follows:

- Logic 1: -5V to -25V
- Logic 0: +5V to +25V
- Undefined logic level: +5 V to -5 V.

At the RS-232 receiver, the following voltage levels are defined:

- Logic 1: -3V to -25V
- Logic 0: +3V to +25V
- Undefined logic level: -3V to +3V.

The difference between the minimum send and receive levels allows for a voltage drop along the line.

The voltage levels associated with a microprocessor are typically 0V to +5V for Transistor-Transistor Logic (TTL). A line driver is required at the transmitting end to adjust the voltage to the correct level for the communications link. Similarly, a line receiver is required at the receiving end to translate the voltage on the communications link to the correct TTL voltages for interfacing to a microprocessor. Despite the bipolar input voltage, TTL compatible RS-232 receivers operate on a single +5V supply. Modern PC power supplies usually have a standard +12V output that could be used for the line driver.

The control or 'handshaking' lines have the same range of voltages as the

transmission of 'logic 0' and 'logic 1', except that they are of opposite polarity. This means that:

- A control line 'asserted' (made active) by the transmitting device has a voltage range of +5V to +25V. The receiving device connected to this control line allows a voltage range of +3V to +25V.
- A control line 'inhibited' (made inactive) by the transmitting device has a voltage range of -5V to -25V. The receiving device of this control line allows a voltage range of -3V to -25V.

Figure 1.4

Voltage levels for RS-232

At the receiving end, a line receiver is necessary for each data and control line to reduce the voltage level to the 0V and +5V logic levels required by the internal electronics.

Figure 1.5

RS-232 transmitters and receivers

The RS-232 standard defines 25 electrical connections. The electrical connections are divided into four groups:

- Data lines
- Control lines
- Timing lines
- Special secondary functions.

Data lines are used for the transfer of data. Data flow is designated from the perspective of the DTE interface. Control lines are used for interactive device control, commonly known as hardware handshaking. They regulate the way in which data flows across the interface.

There is a relationship between the permissible speed of data transmission and the length of the cable connecting the two devices on the RS-232 interface. As the speed of data transmission increases, the quality of the signal transition from

one voltage level to another, for example, from -25V to +25V becomes increasingly dependent on the capacitance and inductance of the cable.

The common data transmission rates used with RS-232 are 110, 300, 600, 1200, 2400, 4800, 9600 and 19200 bps. For short distances, however, transmission rates of up to 12 Mbps can be used. Based on field tests, Table 1.5 shows the practical relationship between selected baud rates and maximum allowable cable length, indicating that much longer cable lengths are possible at lower baud rates. Note that the achievable speed depends on the transmitter voltages, cable capacitance (as discussed above) as well as the noise environment.

Table 1.5

Demonstrated maximum cable lengths with RS-232 interface

Baud rate	Cable length (metres)
110	850
300	800
600	700
1200	500
2400	200
4800	100
9600	70
19200	50
115 K	20

Mechanical characteristics of the interface:

RS-232 defines the mechanical characteristics of the interface between the DTE and the DCE. It dictates that the interface must consist of a plug and socket and that the socket will normally be on the DCE.

The DB-25 connector (25 pin D-type) is closely associated with RS-232 and is the *de facto* standard with revision D. Revision E formally specifies a new connector in the 26-pin alternative connector (known as the ALT-A connector). This connector supports all 25 signals associated with RS-232. ALT-A is physically smaller than the DB-25 and satisfies the demand for a smaller connector suitable for modern computers. On most RS-232 compatible equipment the DB-9 connector (9 pin, D-type) is common.

Functional description of the interchange circuits:

RS-232 defines the function of the data, timing and control signals used at the interface of the DTE and DCE, and the pinouts are shown in Table 1.6. Only those used in the DB-9 interface are relevant to applications for data communications for instrumentation and control.

The circuit functions are defined with reference to the DTE as follows:

- Protective Ground (shield): The protective ground ensures that the DTE and DCE chassis are at equal potentials (remember that this protective ground could cause problems with circulating ground currents). The cable shield connects to this to provide electrostatic (high frequency) shielding.
- Transmitted Data (TxD): This line carries serial data from the DTE to the corresponding pin on the DCE. The line is held at a negative voltage by the DTE during periods of line idle
- Received Data (RxD) : This line carries serial data from the DCE to the corresponding pin on the DTE. The line is held at a negative voltage by the DCE during periods of line idle
- Request To Send (RTS): RTS is the 'request to send' hardware control line. This line is asserted (+V) when the DTE requests permission to send data. The DCE then asserts CTS for hardware data flow control
- Clear To Send (CTS): When a half-duplex modem is receiving, the DTE keeps RTS inhibited. When it is the DTE's turn to transmit, it advises the modem by asserting the RTS pin. When the modem asserts the CTS, it informs the DTE that it is now safe to send data
- DCE Ready: This is formerly called Data Set Ready (DSR). The DTE ready line is an indication from the DCE to the DTE that the modem is ready
- Signal Ground (common): This is the common return line for all the data transmit and receive signals and all other circuits in the interface. This connection between the two ends is always implemented
- Data Carrier Detect (DCD): This is also called the 'received line signal detector'. It is asserted by the modem when it receives a remote carrier and remains asserted for the duration of the connection
- DTE Ready: This is formerly referred to as Data Terminal Ready (DTR). DTE ready enables, but does not cause, the modem to switch onto the line. In originate mode, DTE ready must be asserted in order to auto-dial. In answer mode, DTE ready must be asserted to auto-answer
- Ring Indicator: This pin is asserted during a ring voltage on the line
- Data Signal Rate Selector (DSRS): When two data rates are possible, the higher is selected by asserting DSRS. However, this line is not used much these days.

Table 1.6*Common DB-9 and DB-25 pin assignments for RS-232 and TIA-530*

Pin no.	DB-9 connector DTE IBM pin assignment	DB-25 connector TIA-232 pin assignment	DB-25 connector TIA-530 pin assignment
1	Received line signal	Shield	Shield
2	Received data	Transmitted data	Transmitted data (A)
3	Transmitted data	Received data	Received data (A)
4	DTE ready	Request to send	Request to send (A)
5	Signal/Common ground	Clear to send	Clear to send (A)
6	DCE ready	DCE ready	DCE ready (A)
7	Request to send	Signal/Common ground	Signal/Common ground
8	Clear to send	Received line signal	Received line signal (A)
9	Ring indicator	+Voltage (testing)	Receiver signal
10		-Voltage (testing)	DCE element timing (B) Received line (B)
11		Unassigned	Transmitter signal
12		Sec received line signal	DTE element timing (B) Transmitter signal
13		detector/data signal	DCE element timing
14		Sec clear to send	Clear to send (B)
15		Sec transmitted data	Transmitted data (B)
16		Transmitter signal	Transmitter signal
17		DCE element timing	DCE element timing (A)
18		Sec received data	Received data (B)
19		Receiver signal	Receiver signal
20		DCE element timing	DCE element timing (A)
21		Local loopback	Local loopback
22		Sec request to send	Request to send (B)
23		DTE ready	DTE ready (A)
24		Remote loopback/signal	Remote loopback
		quality detector	
22		Ring indicator	DCE ready (B)
23		Data signal rate	DTE ready (B)
24		Transmit signal	Transmitter signal

1.2.2 Half-Duplex Operation of RS-232

The following description of one particular mode of operation of the RS-232 interface is based on half-duplex data interchange. The description encompasses the more generally used full-duplex operation.

Figure 1.5 shows the operation with the initiating user terminal, DTE, and its associated modem, DCE, on the left of the diagram and the remote computer and its modem on the right.

The following sequence of steps occurs when a user sends information over a telephone link to a remote modem and computer:

- The initiating user manually dials the number of the remote computer
- The receiving modem asserts the RI line in a pulsed ON/OFF fashion reflecting the ringing tone. The remote computer already has its DTR line asserted to indicate that it is ready to receive calls. Alternatively, the remote computer may assert the DTR line after a few rings. The remote computer then sets its RTS line to ON
- The receiving modem answers the phone and transmits a carrier signal to the initiating end. It asserts the DCE Ready line after a few seconds
- The initiating modem asserts the data carrier detect (DCD) line. The initiating terminal asserts its DTR line, if it is not already high. The modem responds by asserting its DTE Ready line.
- The receiving modem asserts its CTS line, which permits the transfer of data from the remote computer to the initiating side
- Data is transferred from the receiving DTE (TxD) to the receiving modem. The receiving remote computer then transmits a short message to indicate to the originating terminal that it can proceed with the data transfer. The originating modem transmits the data to the originating terminal
- The receiving terminal sets its RTS line to OFF. The receiving modem then sets its CTS line to OFF
- The receiving modem switches its carrier signal OFF.
- The originating terminal detects that the DCD signal has been switched OFF on the originating modem and switches its RTS line to the ON state. The originating modem indicates that transmission can proceed by setting its CTS line to ON
- Transmission of data proceeds from the originating terminal to the remote computer

- When the interchange is complete, both carriers are switched OFF and, in many cases; the DTR is set to OFF. This means that the CTS, RTS and DCE ready lines are set to OFF.

Full-duplex operation requires that transmission and reception must be able to occur simultaneously. In this case, there is no RTS/CTS interaction at either end. The RTS and CTS lines are left ON with a carrier to the remote computer.

1.2.3 Limitations

In spite of its popularity and extensive use, it should be remembered that RS-232 was originally developed for interfacing data terminals to modems. In the context of modern requirements, RS-232 has several weaknesses. Most have arisen as a result of the increased requirements for interfacing other devices such as PCs, digital instrumentation, digital variable speed drives, power system monitors and other peripheral devices in industrial plants.

The main limitations of RS-232 when used for the communications of instrumentation and control equipment in an industrial environment are:

- The point-to-point restriction, a severe limitation when several 'smart' instruments are used
- The distance limitation of 15 meters (50 feet) end-to-end, too short for most control systems
- The 20 Kbps rate, too slow for many applications
- The -3 to -25 V and $+3$ to $+25$ V signal levels, not directly compatible with modern standard power supplies.
- Most modern laptop computers do not have serial ports. In this case an external USB to serial interface could be used, but not all models work with all applications.

Consequently, a number of other interface standards have been developed to overcome these limitations. The RS-485 interface standards are increasingly being used for instrumentation and control systems.

Figure 1.6

1.3 RS-485/422 Basics

1.3.1 The RS-422 Interface Standard

The RS-422 standard introduced in the early '70s defines a balanced, or differential, data communications interface using two separate wires for each signal. This permits very high data rates and minimizes problems with varying ground potentials because the ground is not used as a voltage reference, as in RS-232 and RS-423. RS-422 is an improvement on RS-423 and allows:

- Data to be communicated at distances of up to 1200 m (4000 feet, similar to RS-423)
- Data rates of up to 10 Mbps (increase of 100 times)
- Only one line driver on a line
- Up to 10 line receivers to be driven by one line driver.

The differential voltages between the A and B lines are specified as:

- -2 V to -6V with respect to the B line for a binary 1 (MARK or OFF) state
- $+2\text{ V}$ to $+6\text{V}$ with respect to the B line for a binary 0 (SPACE or ON) state.

The specification refers to the lines as A and B, but there are also called A (–) and B (+), or TX+ and TX–.

The line driver for the RS-422 interface produces a 5V differential voltage on two wires. These voltage levels allows the transmitters and drivers to be supplied by the 5 V supply, common in today's computers. Figure 1.7 illustrates the connection of RS-422 devices.

Figure 1.7

The RS-422 balanced line driver connections

As the differential receiver is only sensitive to the difference between two signals on its inputs, common noise signals picked up in both wires will have little effect on the operation of the receiver. Differential receivers are therefore said to have

good Common Mode Rejection (CMR) characteristics.

The major feature of the RS-422 standard is the differential voltage signal, which allows an increase in speed and provides higher noise immunity. Each signal is transferred on one pair of wires and is the voltage difference between them. The penalty is that two wires are required for each signal, compared to one wire for RS-232 and RS-423. A common ground wire is preferred to aid noise rejection. Consequently, 3 wires are required for a half duplex, and 5 wires for a full duplex system.

The balanced line driver can also have an input signal called an *enable* signal. The purpose of this signal is to connect the driver to its output terminals, A and B. If the enable signal is off, one can consider the driver as disconnected from the transmission line or in a *high impedance* state.

The differential lines of the RS-422 are normally terminated with a resistor equal to the characteristic impedance (Z_0) of the line. This will prevent signal distortion due to reflections from the end of line. A typical value of ' Z_0 ' would be in the order of 120Ω, for a twisted pair line.

The RS-422 standard does not specify mechanical connections or assign pin numbers. It is common practice to use the pin assignment of RS-449 for a DB-37 connector (see Table 1.7).

1.3.2 The RS-485 Interface Standard

The RS-485 (TIA-485) is one of the most versatile of the TIA interface standards. It is an extension of RS-422 and allows the same distance and data speed, but increases the number of transmitters and receivers permitted on the line. RS-485 permits a 'multi-drop' network connection on 2 wires and allows reliable serial data communication for:

- Distances of up to 1200 m (4000 feet, same as RS-422)
- Data rates of up to 10 Mbps (same as RS-422)
- 32 line drivers on the same line
- 32 line receivers on the same line.

The maximum bit rate and maximum length can, however, not be achieved at the same time. For 24 AWG twisted pair cable the maximum data rate at 1200 m is approximately 90 kbps. The maximum cable length at 10 Mbps is less than 15m. Better performance will require a higher-grade cable and possibly the use of active (solid state) terminators in the place of the 120-ohm resistors.

The two conductors making up the bus are referred to as A and B in the specification. The A conductor is alternatively known as A⁻, Tx_A and Tx⁺. The B conductor, in similar fashion, is called B⁺, Tx_B and Tx⁻. In the MARK or OFF state (i.e. when the RS-232 Tx_D pin is LOW (e.g. -8V), the voltage on the A wire is more negative than that on the B wire.

The differential voltages on the A and B outputs of the driver (transmitter) are similar (although not identical) to those for RS-422, namely:

- -1.5V to -6V on the A terminal with respect to the B terminal for a binary 1 (MARK or OFF) state, and
- +1.5V to +6V on the A terminal with respect to the B terminal for a binary 0 (SPACE or ON state).

As with RS-422, the line driver for the RS-485 interface produces a $\pm 5V$ differential voltage on two wires. The major enhancement of RS-485 is that a line driver can operate in three states called tri-state operation:

- Logic 1
- Logic 0
- High-impedance.

RS-485 is necessary for systems where several instruments or controllers are connected on the same line. All transmitters remain in the high-impedance state when they are not actually transmitting data. This ensures that they do not interfere with any other transmitter. Special care must be taken with the software to ensure that only one transmitter on the network can become active at a time. In most cases a master terminal, such as a PC or computer, controls which transmitter will be active at a given time.

The 2-wire data transmission line does not require special termination if the signal transmission time from one end of the line to the other end (approximately 200 meters per microsecond) is significantly smaller than one quarter of the signal's rise time. This is typical with short lines or low bit rates. At high bit rates or in the case of long lines, proper termination becomes critical. The value of the terminating resistors (one at each end) should be equal to the characteristic impedance of the cable. This is typically 120 ohms for twisted pair wire.

Table 1.7

Common DB-9 pin assignments for RS-422 and RS-485 and DB-37 pin assignments specified according to RS-449

Figure 1.8 shows a typical 2-wire multi-drop network. Note that the transmission line is terminated at both ends of the line but not at drop points in the middle of the line. This configuration limits the system to full-duplex operation.

Figure 1.8

Typical 2-wire multi-drop network

A RS-485 network can also be connected in a 4-wire configuration as shown in Figure 1.9. In this configuration, full-duplex operation is possible.

Figure 1.9

4-wire network configuration

1.4 Summary

Serial communication is the process of sending data one bit at a time. RS-232, RS-485, RS-422 are the popular serial communications standards. Devices that use serial cables for their communication are 'DTE' (Data Terminal Equipment) and 'DCE' (Data Communication Equipment). DTE's are usually computers whereas DCE's are modems, printers and other devices. Most of the computers have RS-232 serial Com port.

RS 232, EIA RS-232, or simply RS-232 standard is used to communicate

between DTE - DCE, DTE - DTE or DCE - DCE.

RS-485 allows multiple devices to communicate with each other and most of the links are half duplex. A RS-485 network can be configured in two ways - '2-wire' or '4-wire'. 2-wire networks are on the half duplex link and 4-wire networks are on the full duplex link.

RS-422 is a standard similar to RS-232. The RS-422 standard allows for operation of up to 10 receivers from a single transmitter. On RS-422 interfaces, each signal line consists of two wires, and they are twisted to reduce noise. Such type of data transmission is called 'balanced transmission', as it is not referenced to ground.