3.1 RS-232

This specification is designed to allow half-duplex communication, i.e. one master device to transmit data to one slave receiver. These devices operate at speeds of up to 20K bits/second over short distances. The standard recommends a maximum cable length of 15 meters.

(Note: Master=Driver=Transmitter, Slave=Receiver)

RS-232 devices may be classified as:

- Data Terminal Equipment (DTE) E.g. PC, Terminal, Micro-controller
- Data Communications Equipment (DCE) E.g. Modem, Printer

The signals are unidirectional, so the output from the DTE is the input to the DCE, and vice-versa.

Some RS-232 devices can transmit/receive data rates of up to 1Mbps, but the distances are even shorter up to 1.5 meters). Full-duplex communication can be achieved by establishing two independent channels (i.e. 4-wires). Both communicating devices share a common power and ground. The data signals are determined by voltage levels. When data is transmitted positive voltages are used. When data is not transmitted a negative voltage is applied.

Table 2: RS-232 Line length vs max data rate

Line Length	Max Data Rate
15m	20 kbits/sec
120m	1 Mbits/sec
1200m	1 kbits/sec

Full speed communication can be maintained over longer distances (up to about 300m) by using low-capacitance cables

3.1.1 Applications

Connection of PCs, terminals and micro-controllers to equipment such as modems and printers. Modern computers use USB or Wi-Fi to connect to modems.

3.1.2 Standards

The current version of the standard is: ANSI/TIA-232-F (October 2002) F Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange. (The Telecommunications Industry Association (TIA), 2014) (The Telecommunications Industry Association (TIA), 2014)

The European CCITT Standard V.24/V.28 is essentially the same as the above American standard.

3.2 RS-422

(RS-485 is based on RS-422. A brief description of RS-422 will be given to provide context for the discussion on the RS-485 specification to follow.)

This specification is designed to allow serial communication over a two wire, (plus ground), balanced system. Depending upon the system requirements the communication can be high speed or over long distances. (One is inversely proportional to the other. See Table 3) RS-422 specifies half-duplex communication with enhanced operation over RS-232. The usual configuration is a 1:1 (point-to-point) Master-Slave arrangement. One Master can, however, transmit to up to ten slaves (multi-drop).

Table 3: RS-422 Line length vs max data rate

Line Length	Max Data Rate
12m	10 Mbits/sec
120m	1 Mbits/sec
1200m	100 kbits/sec

(Brainboxes Limited, 2014)

(Note: Balanced=Differential)

Traditionally, balanced means the signal on one wire is the same magnitude as the signal on the second wire but opposite in sign (e.g. +5V and -5V). EIA-485 is usually +5V and 0V When the signal on wire #1 is high the signal on wire #2 is low, and vice-versa. Figure 1 shows this graphically.

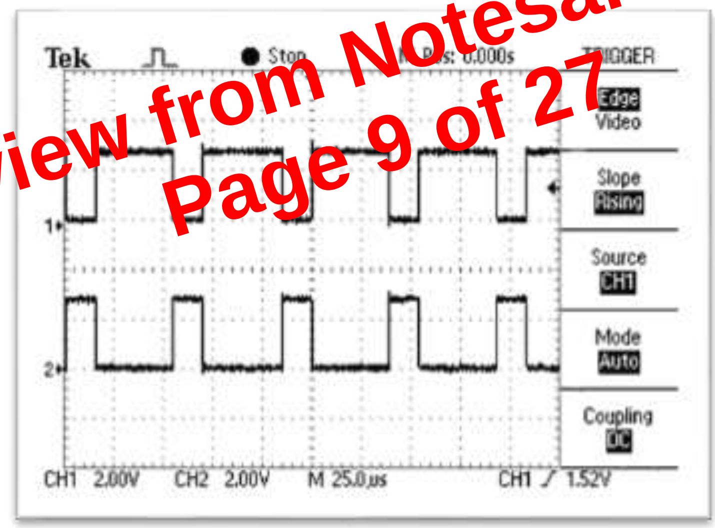

Figure 1: The signals on a balanced 2-wire system

The potential difference between the wires should ≥ 0.2 volts for valid operation. Any voltages between $+12V$ and $-7V$ volts is a valid level. (Maxim Integrated, 2001)

Table 10: Advantage / disadvantages of a Star Topology

Advantages	Disadvantages
Easy to set up.	If the central node fails **all** communication is lost.
Each node has an independent communication line. If one develops a fault the others remain unaffected.	Lots of cable required. As all the cables approach the central node the density of cables increases greatly. For an office network serving a hundred or more PCs the back of the patch cabinet is horrendous.
In theory a Wi-Fi router can serve 255 devices. (Much less if speed is to be maintained.) This does reduce the cable count and is easy to setup.	Fault finding at the central node is difficult when there are lots of cables, particularly if someone hasn't labelled them properly!
Efficient use of bandwidth. At most three devices and two links are required to pass data packets from one node to another.	Wi-Fi doesn't provide independent communication channels as the router broadcasts to every node. Every node receives all traffic. (They disregard what isn't addressed to them.)
Disconnecting one end of the cable is all that is required to isolate one device from the others.	All the data packets pass through the hub so it needs to be fast and efficient to ensure it does not form a bottle-neck in the data throughput.
If the hub is connected to the internet then the internet connection can be shared with all the nodes on the network.	
By putting a firewall on the hub all the nodes are protected.	
As all network traffic passes through the hub, monitoring the content is easy.	

8.2 Bus Topology

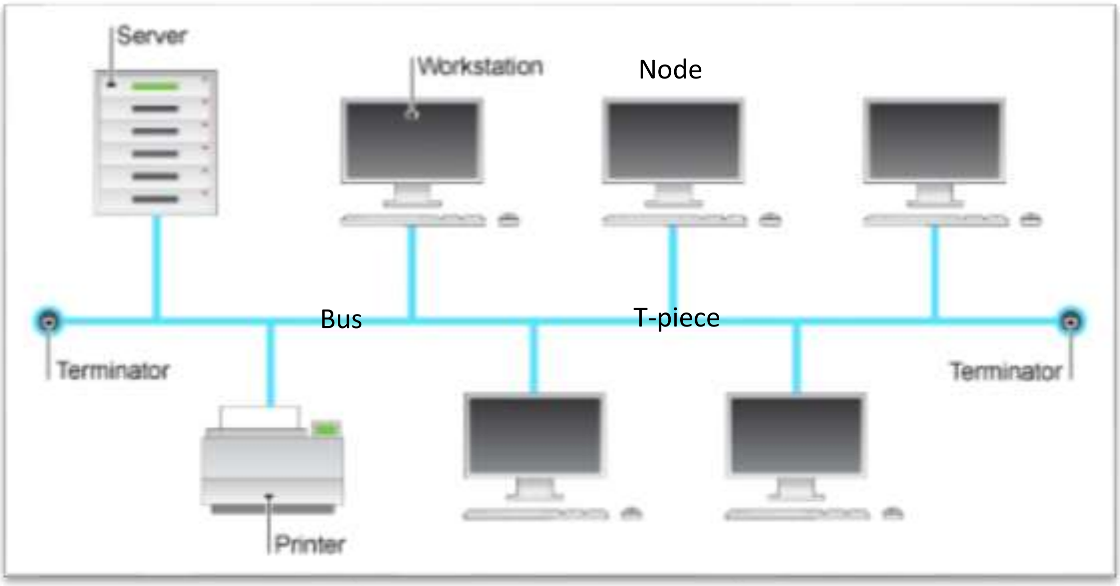

Figure 11: A typical bus topology. (BBC - GCSE Bitesize, 2014)

This configuration consists of a number nodes connected to a central cable (bus) as shown in Figure 11. Each node is usually connected to the bus via a t-piece. Coaxial cable is usually used in bus networks. A terminator is required at each end of the bus to prevent signal 'bounce' (a.k.a. 'reflection') where the signal bounces back across the bus.

A bus network uses multi-drop transmission. This allows only one device to transmit at a time. A distributed access protocol determines which station is to transmit. Data frames contain a source and destination addresses. Each node monitors the bus and it only copy frames that are addressed to itself.

A node checks for an empty data slot i.e. the absence of other traffic) before transmitting its' data on the bus. This is called Carrier sense multiple access (CSMA). It also handles collisions that occur when two nodes put data on the bus at the same time.

A message from a source node is broadcast to the whole network via the bus cable. All nodes on the bus check the recipient address of the message. The appropriate node then reads the message. The other nodes disregard the rest of the message.

The bus topology is passive. The nodes check for a message but they are not responsible for moving the signal along.

(Note: Bus=Cable=Backbone)