Mechatronics
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Lecture - 34
Input, Output, and Communication Systems

I welcome you all to today's NPTEL Online Certification Course lecture on Mechatronics. Today I am going to talk about the Input, Output systems, and Communication Systems. So, here I am going to talk about the two aspects. As I said, a communication system means how the devices communicate through each other. And the input-output means the connection of these input and output devices through to the microcontrollers or microprocessors.

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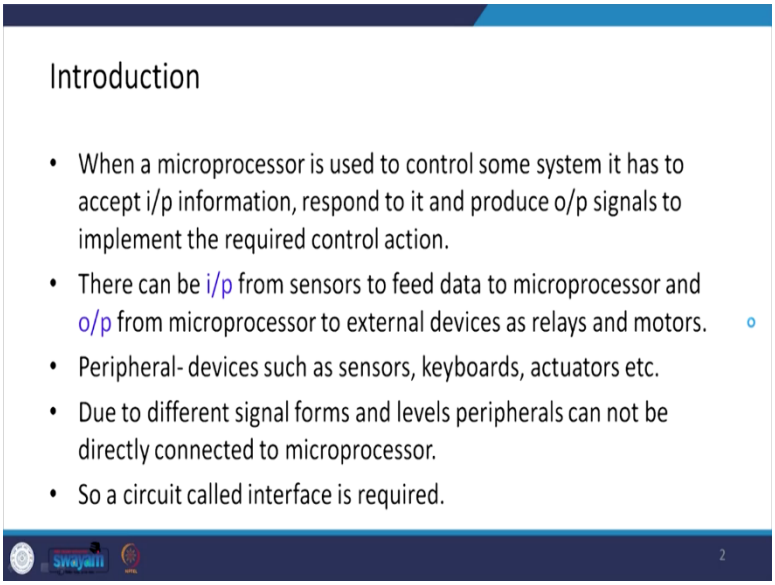

When a microprocessor is used to control some system, it has to accept the input information, respond to it, and produce an output signal to implement the required control action. This is ideally what happens. So, there could be input from sensors to feed data to microprocessor and output from microprocessor to external devices such as relays, motors, and so on.

Now, peripherals such as sensors, keyboard, actuator, etcetera, are what we call we mean by the peripherals. Now, due to different signal forms and levels, peripherals cannot be directly connected to the microprocessor. So, a circuit called an interface is required.

Now, while connecting, we need to address the input and output. So, microprocessors have special input instructions and output instructions. Microprocessors use parallel ports to input or output bytes of data.

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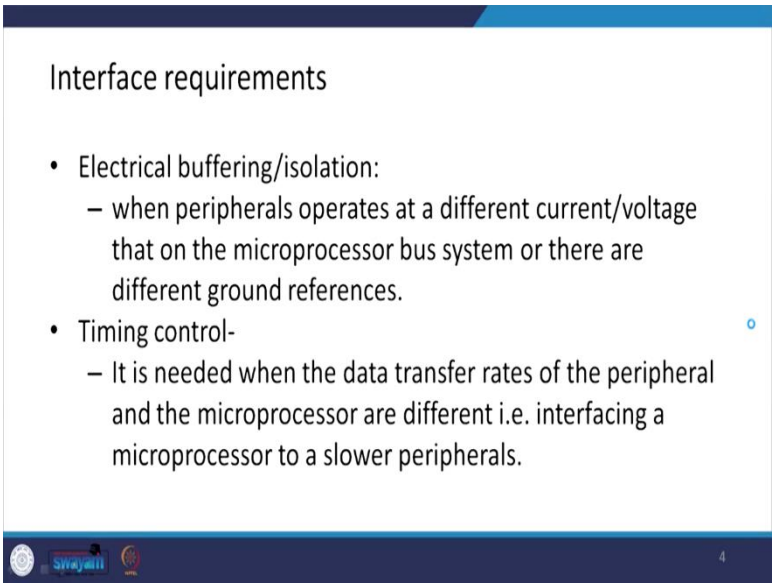

Now, what could be the interface requirements? As I said, we cannot connect the peripheral devices directly to a microprocessor or microcontroller, so it has to be done with the help of a certain interface. So, what could be these interface requirements? So, the first requirement could be electrically buffering and isolation. When peripherals operate at a different current or voltage than on the microprocessor bus system or there are different ground references, then we require electrical buffering or isolation. Next is for the timing control. It is needed when the data transfer rates of the peripheral and the microprocessor are different, so that is interfacing a microprocessor to a slower peripheral.

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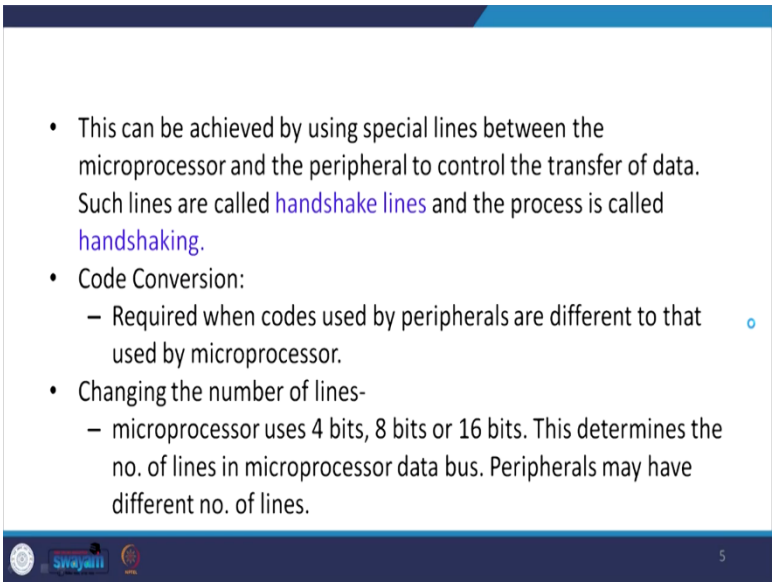

This can be achieved by using special lines between the microprocessor and the peripherals to control the transfer of data. Such lines are called handshake lines, and the process is called the handshake.

Next is the code conversion. This is required when the codes used by the peripherals are different from those used by the microprocessor.

We could also have the requirement of changing the number of lines. So, the microprocessor uses 4 bits or 8 bits, or 16 bits. So, this determines the number of lines in the microprocessor data bus. Peripherals may have a different number of lines. So, we may require to change the number of lines.

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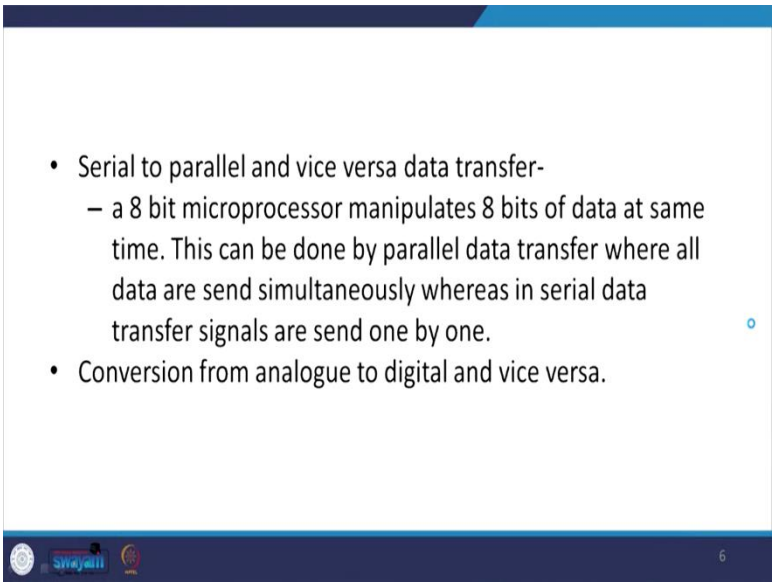

Serial to parallel and vice versa data transfer, an 8-bit microprocessor manipulates 8 bits of data at the same time. Now, this can be done by parallel data transfer where all the data are sent simultaneously, whereas, in serial data transfer, signals are sent one by one, and we may have the conversion from analog to digital or digital to analog. We have already seen these devices in my earlier lectures.

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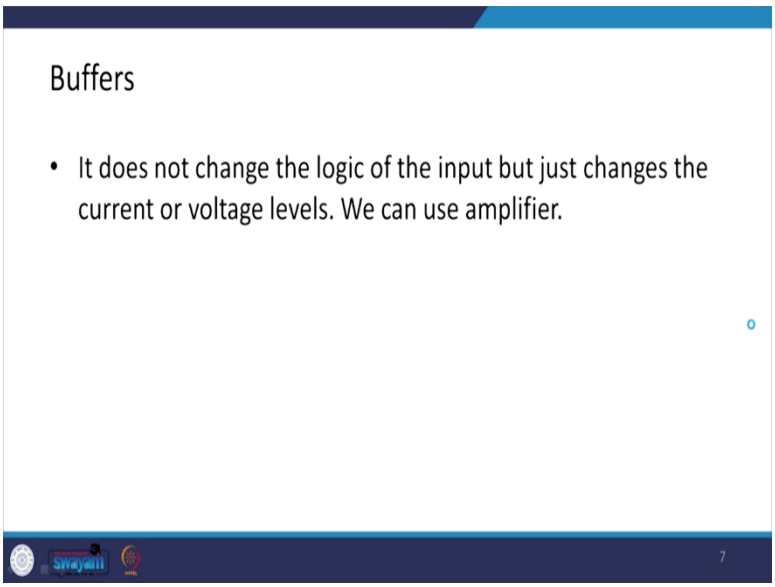

The buffers do not change the logic of the input but just change the current or voltage levels, and we can use an amplifier for this.

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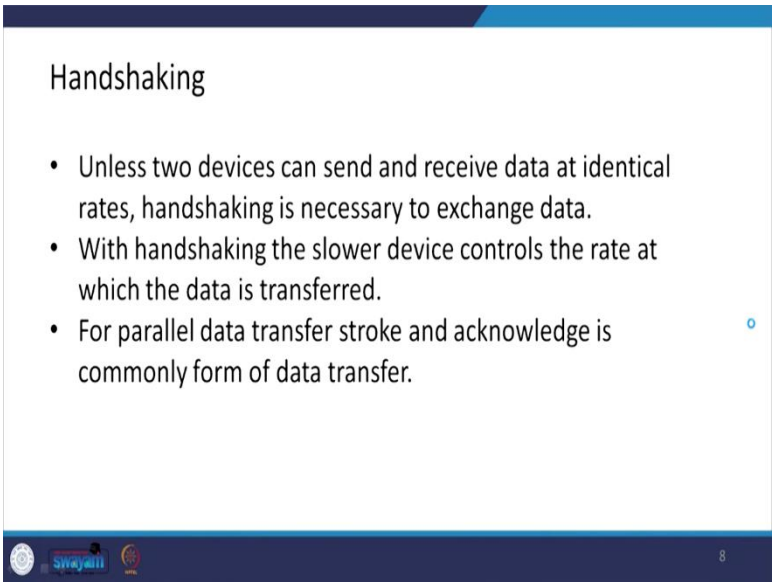

Handshaking, as I said, unless two devices can send and receive data at identical rates, handshaking is necessary to exchange data. With handshaking, the slower device controls the rate at which the data is to be transferred, and for parallel data transfer, stroke and acknowledge is common form of data transfer.

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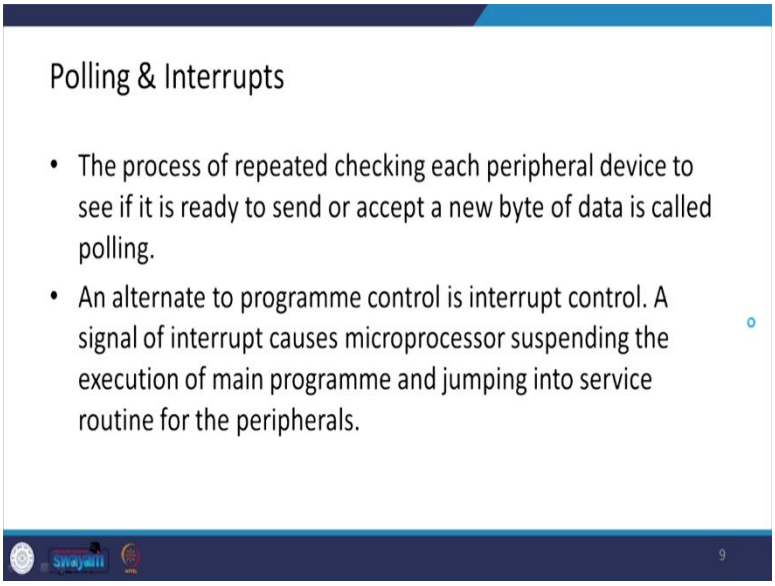

Polling and interrupts, the process of repeated checking is a peripheral device to see if it is ready to send or accept a new byte is called polling, and an alternate to program control is

the interrupt controller, and here, a signal of interrupt causes microprocessor is suspending the execution of the main program and jumping into the service routine for the peripherals.

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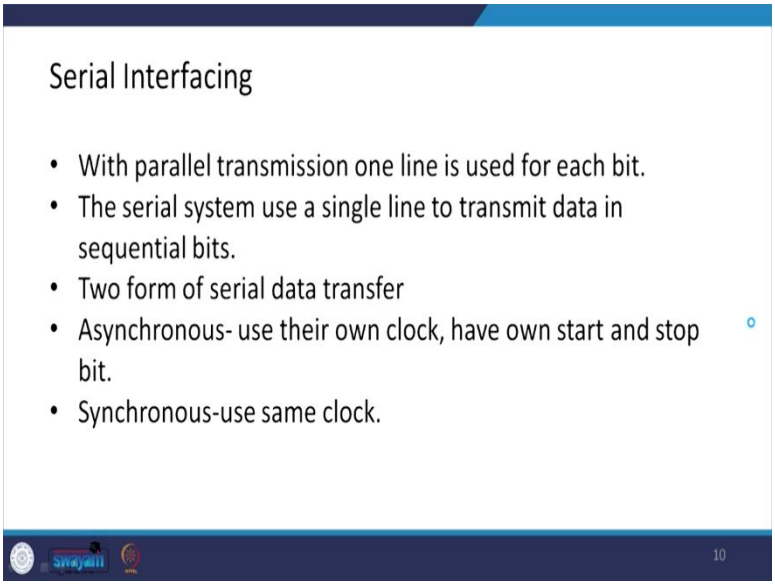

In serial interfacing, with the parallel transmission, one line is used for each bit, and in the serial interface system, they use a single line to transmit data in sequential bits. So, the two forms of serial data transfer are there, asynchronous and synchronous. So, the asynchronous one uses their own clock has its own start and stop bit whereas, the synchronous one, as the name indicates, use the same clock.

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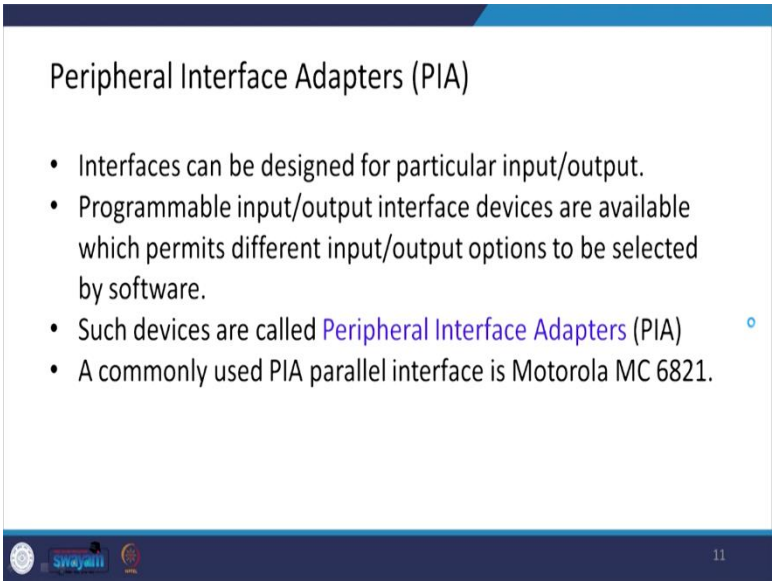

Peripheral interface adapters are, in short, they are also called PIA. So, interfaces can be designed for a particular input, output. Programmable input-output interface devices are available, which permits different input, output options to be selected by the software. Such devices are called PIA's, and a commonly used PIA parallel interface is Motorola MC 6821.

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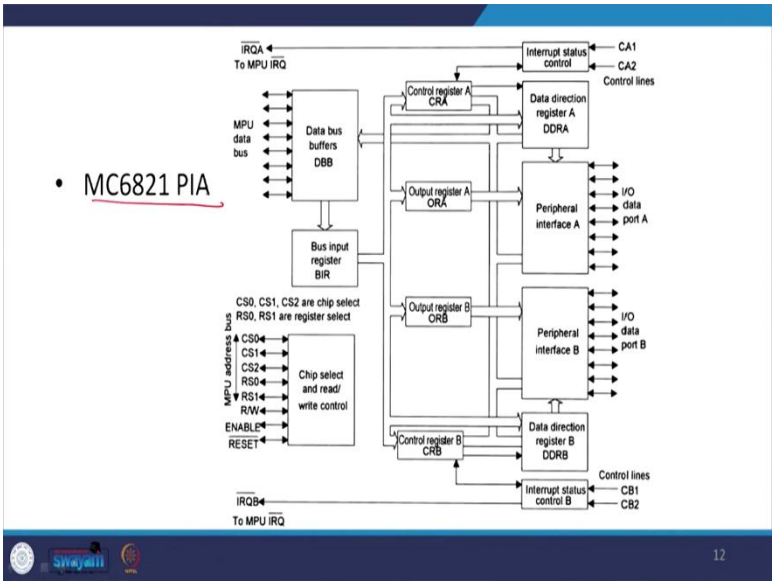

This is the schematic of the MC 6821 PIA, where you can see that there is various type of register; output register, output register B, A, control register are there, chip select read and write control, bus input register, data bus buffer is there. And here, you have input-output data port A input-output data port B. This is peripheral interface A, and this is peripheral interface B. It has the control lines here CA1, CA2 as well as CB1 and CB2. Here, they have the interrupt status control, interrupt status control over here.

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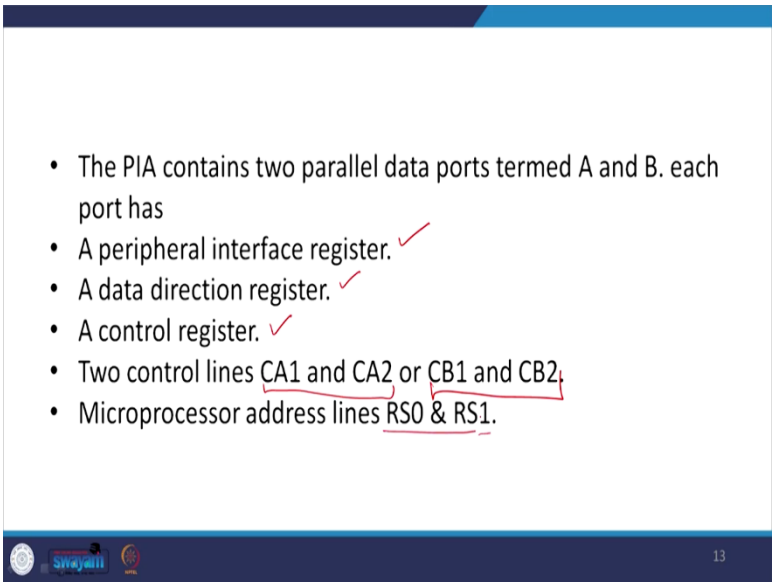

The PIA contains two parallel data ports termed A and B, and each port has a peripheral interface register, a data direction register, and a control register, and the two control lines; CA1 and CA2 and CB1 and CB2, are there. There are microprocessor address lines RS0 and RS1.

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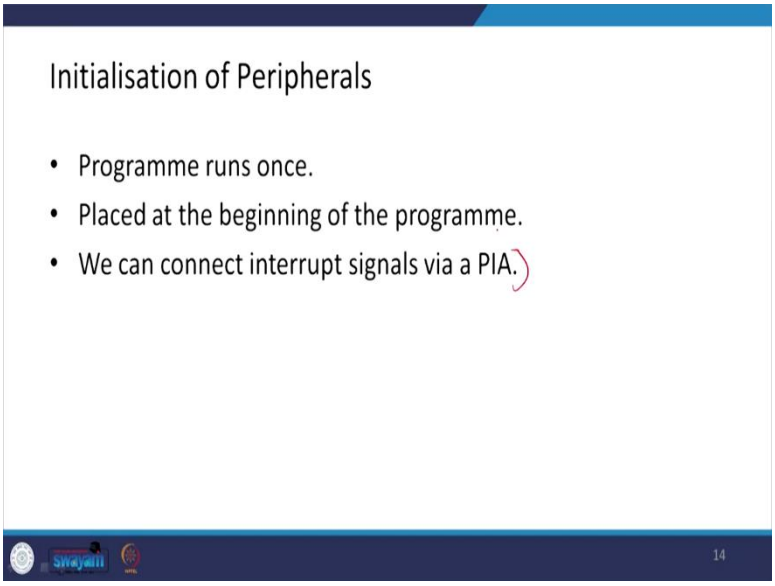

Initialization of peripherals. So, the program runs once, placed at the beginning of the program, and we can connect interrupt signal via the PIA. Now, let us look at the communication systems.

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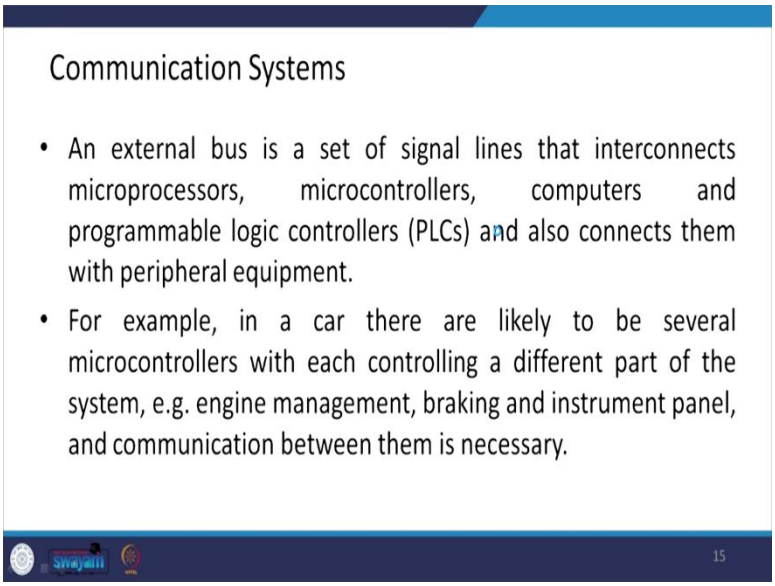

For those who are interested in further reading, you can refer to Mechatronics by Bolton. So, I have just given a very brief idea about these input-output devices as well as the communication systems. You can have the for the reading from that particular textbook.

Now, coming to the communication system, as I said, the devices have to communicate. So, an external bus is a set of signal lines that interconnects microprocessor, microcontroller computer, and PLCs and also connect them with the peripheral equipment. For example, in a car, there are likely to be several microcontrollers, each controlling a different part of the system, engine management system, braking system, instrument panel, communication between them is necessary.

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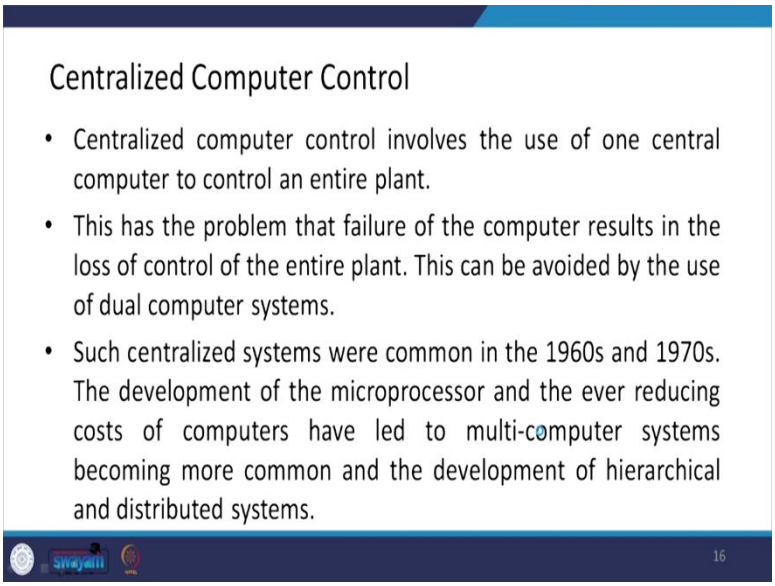

Centralized computer control involves the use of one central computer to control an entire plant. This has the problem that the failure of the computer results in the loss of control of the entire plant, and this can be avoided by the use of dual computer systems. Such centralized systems were common in the 1960s and ’70s, and the development of the microprocessor and the ever-reducing cost of the computer have led to the multi-computer system becoming more common and the development of hierarchical and the distributed system becoming more common these days. Now, let us look at the hierarchical system.

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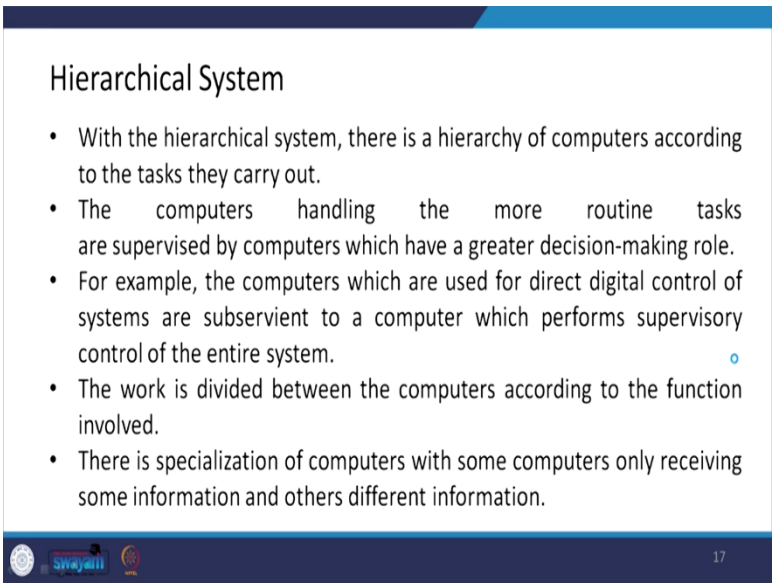

With the hierarchical system, there is a hierarchy of computers according to the task they carry out. The computer handling the more routine tasks are supervised by computers of which have a greater decision-making role. For example, the computer which is used for direct digital control of systems is subservient to a computer that performs supervisory control of the entire system, and the work is divided between the computers according to the function involved. There is a specialization of computers with some computers only receiving some information and the other the different information. Now, let us look at the distributed system.

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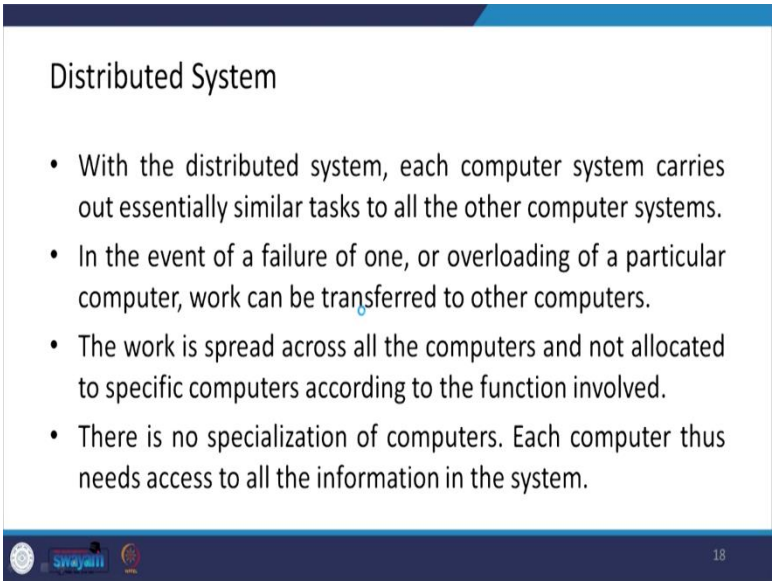

With the distributed system, each computer system carries out essentially similar tasks to all the other computer systems, and in the event of failure of one or overloading of a particular computer, what can be transferred to the other computers. The work is spread across all the computers and not allocated to specific computers according to the functions involved. There is no specialization of computers over here. Each computer thus needs access to all the information of the system.

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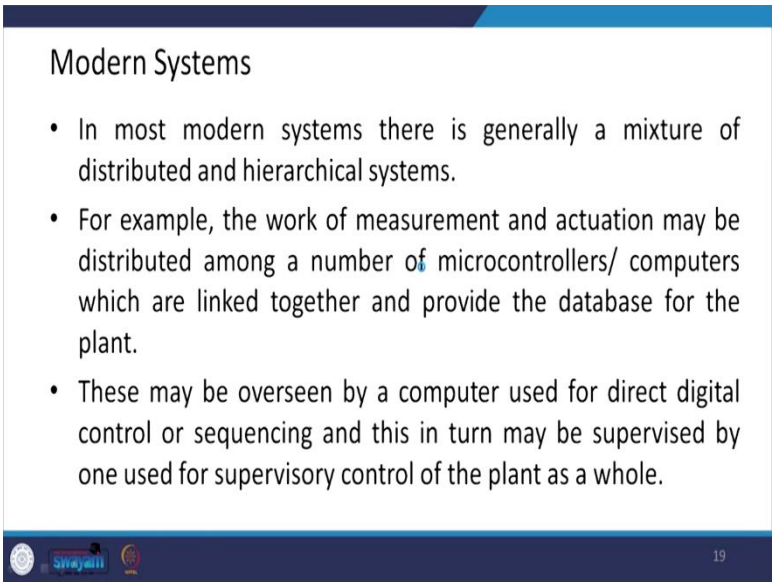

The modern systems, there is generally a mixture of distributed and hierarchical systems. For example, the work of measurement and actuation may be distributed among a number of microcontrollers computers which are linked together and provide the database for the plant. These may be overseen by a computer used for direct digital control or sequencing, and this, in turn, may be supervised by one used for supervisory control of the plant as a whole.

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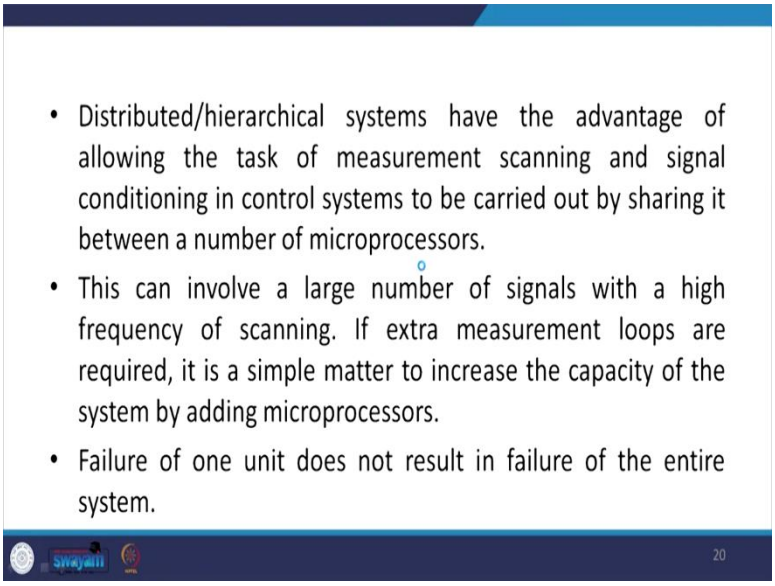

Now, these distributed or hierarchical systems have the advantage of allowing the task of measurement scanning and the signal conditioning in the control system to be carried out by sharing it between the number of microprocessors. This can involve a large number of signals with a high frequency of scanning. If extra measurement loops are required, it is a simple matter to increase the capacity of the system by adding a microprocessor. Failure of one unit does not result in the failure of the entire system.

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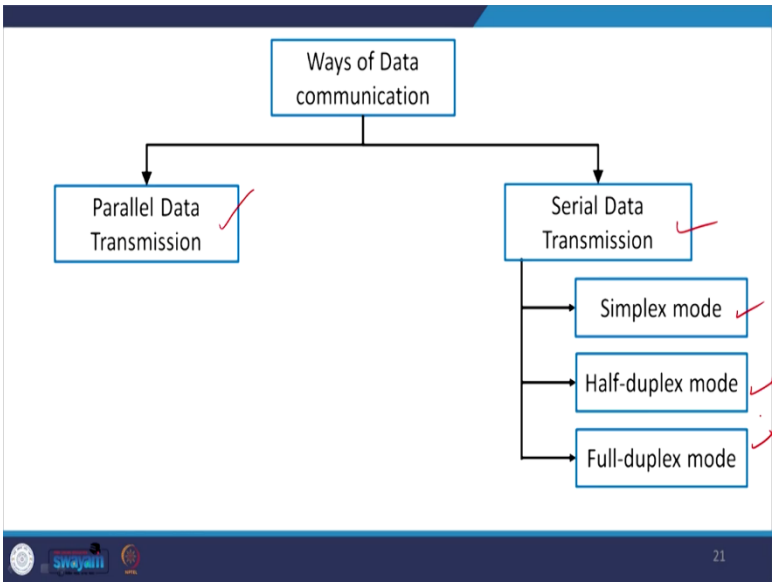

Here, If we look at the ways of communication, there are essentially two ways, as I discussed earlier, the parallel data transmission and the serial data transmission. Parallel data transmission, as I said, you have the parallel lines, and in the case of the serial data transmission, we could have the simplex mode or half-duplex mode or the full-duplex mode. I will be discussing all these ways.

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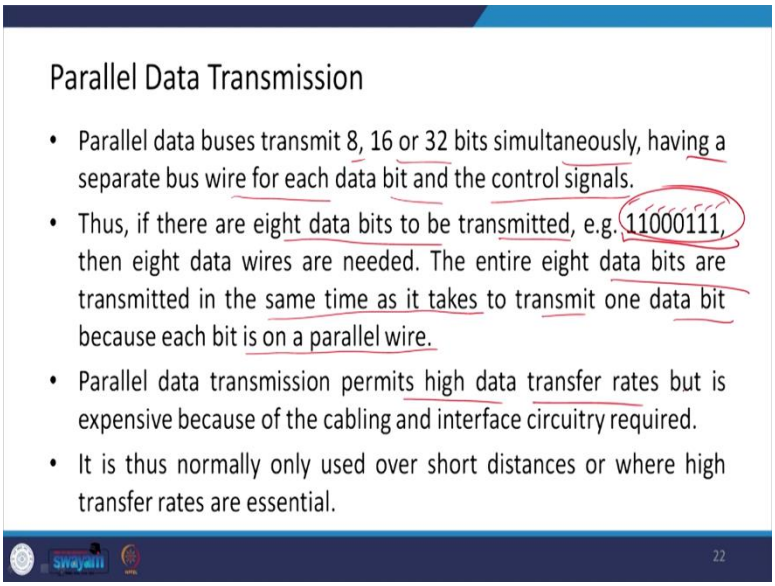

So, first of all, let us look at the parallel data transmission. So, the parallel data transmission, in this case, 8, 16, or 32 bits, can be transmitted simultaneously, and they have a separate bus for each data bit and the control signal. Suppose, if eight data bit to be transmitted, this is just, for example, so, you have one, two, three, four, five, six, seven, eight, this eight-bit data is to be transmitted then, eight wires are needed, one wire for each bit and the entire eight-bit data are transmitted in the at the same time as it takes to transmit one data bit because each bit is on a parallel wire. Parallel data transmission permits a high data transfer rate because you can transmit each data simultaneously, and it is expensive because of the cabling and interface circuit requirements. It is only used over short distances or where high transfer rates are required.

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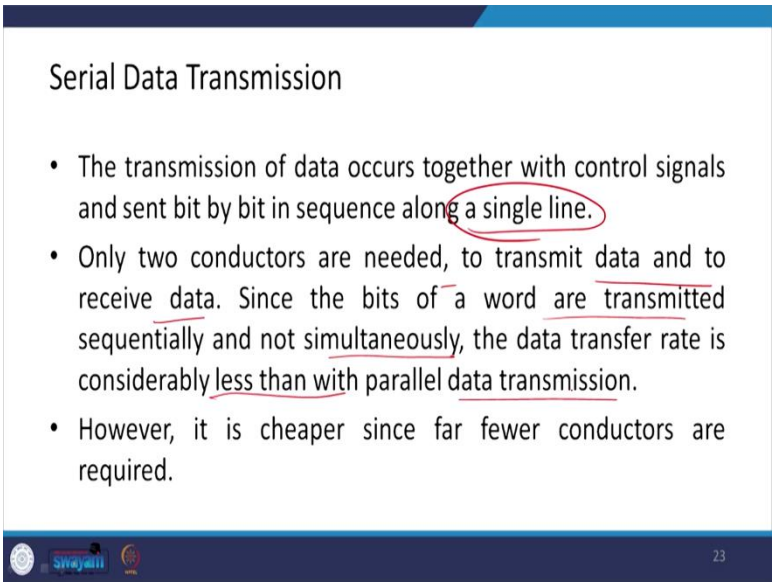

Next, let us look at the serial data transmission. So, as the name indicates, the transmission of data occurs together with the control signal and is sent bit by bit in sequence through a single line. So, this is the feature of the serial data transmission, and everything has to be transmitted through a single line, and only two conductors are needed to transmit data and to receive data. Since the bits of words are transmitted sequentially and not simultaneously, the data transfer rate is considerably less than with the parallel data transmission. It is quite obvious. However, it is cheaper since far few conductors are required.

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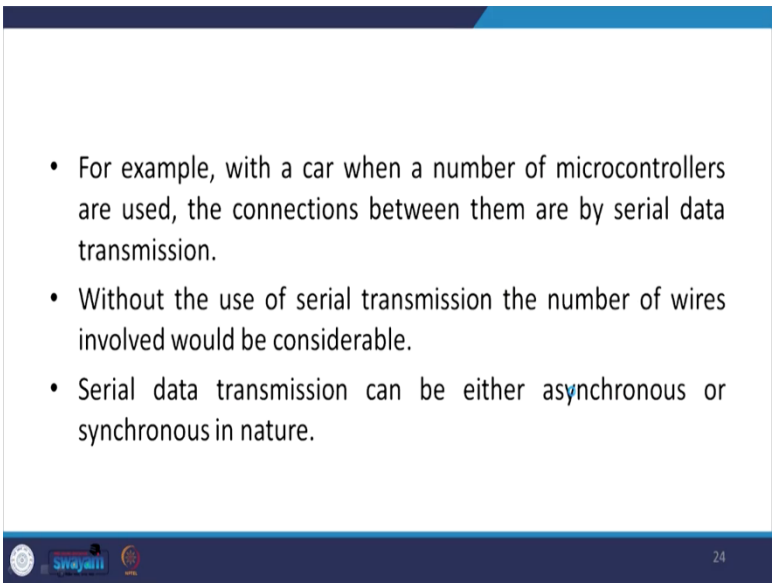

For example, with a car, when a number of microcontrollers are used, the connection between them or by serial data transmission. Without the use of serial transmission, the number of wires involved would be considerable, and the serial data transmission can be either asynchronous, or it could be synchronous in nature. That is, they could have different clocks, or they could have the same clock.

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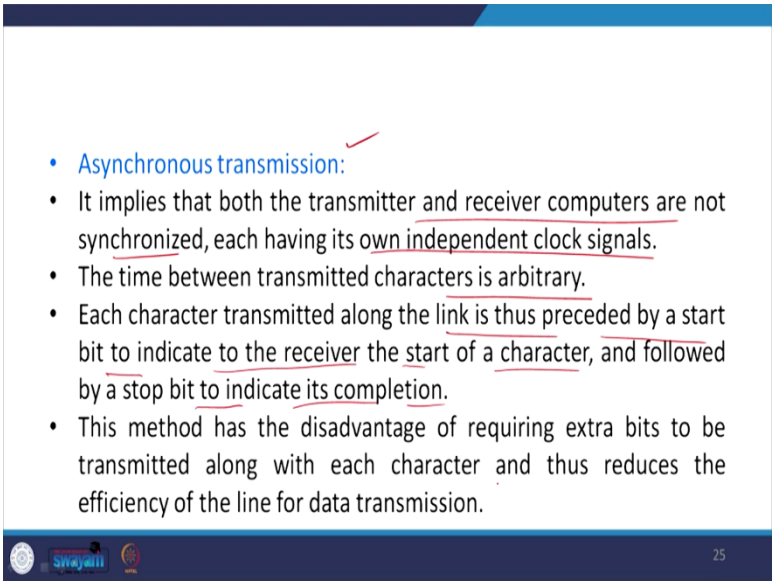

Asynchronous transmission implies that both the transmitter and receiver computers are not synchronized, each having its own independent clock signals, and the time between the transmitted characters is arbitrary. Each character transmitted along the link is thus preceded by a start bit to indicate to the receiver the start of a character and followed by a stop bit to indicate its completion. This method has the disadvantage of requiring an extra bit to be transmitted along with each character and thus reduces the efficiency of the line for the data transmission.

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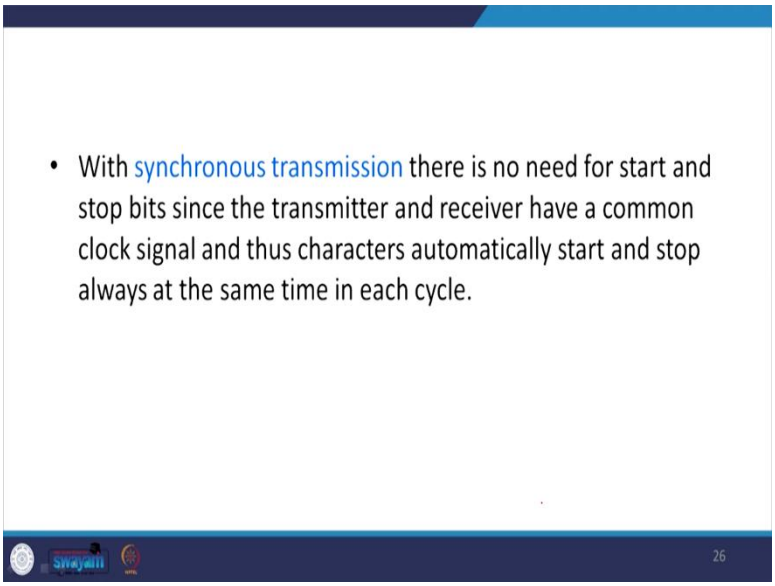

With synchronous transmission, there is no need for a start and stop bit since the transmitter and receiver have a common clock signal, and thus characters automatically start and always stop at the same time in each cycle. Now, let us look at the rate of data transmission.

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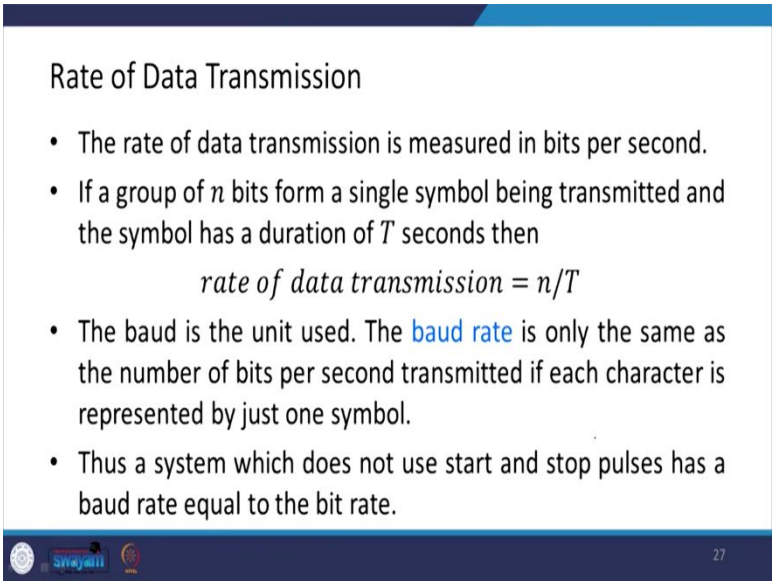

The rate of data transmission is measured in bits per second. If a group of n bits forms a single symbol being transmitted and the symbol has a duration of T second, then the

The rate of data transmission = n/T,

and the baud rate is the unit used. The baud rate is only the same as the number of bits per second transmitted if each character is represented by just one symbol. Thus, a system that does not use start and stop pulse has a baud rate equal to the bit rate.

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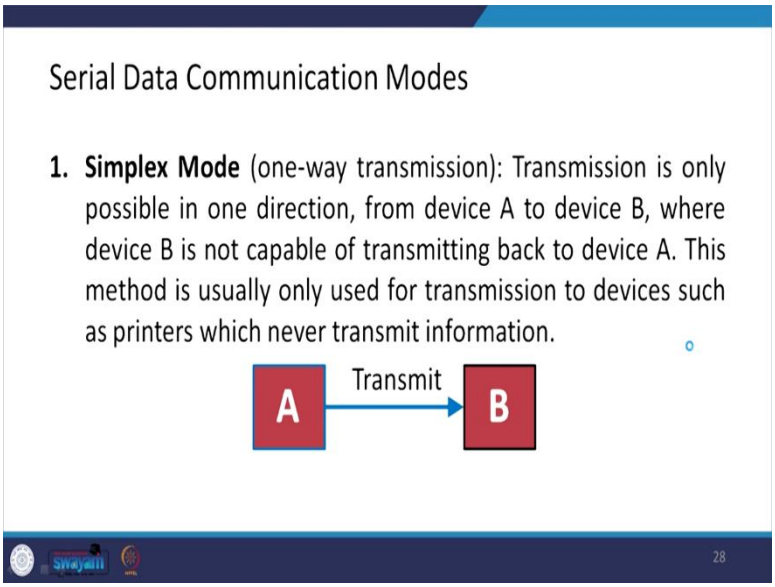

Now, let us look at the serial data communication mode, the three modes which I have talked to you about, the simplex mode. It is the only one-way transmission from A to B. So, the transmission is only possible in one direction from device A to device B, where device B is not capable of transmitting back to device A. This method is usually used for transmission to devices such as printers which never transmit the information.

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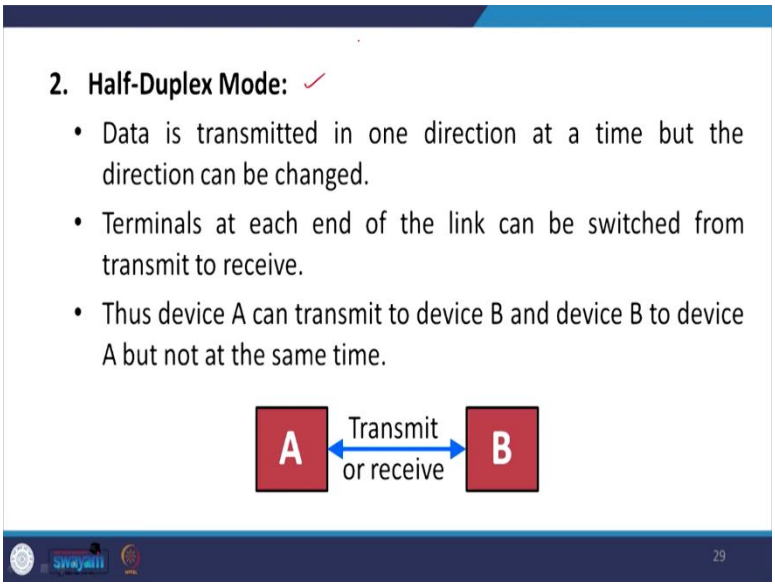

Then, we have the half-duplex mode. So, here, the data is transmitted in one direction at a time, but the direction can be changed, and the terminals at each end of the link can be switched from transmit to receive. Device A can transmit to devise B and receive device B to device A, but not at the same time. So, it can do either transmit or receive. Both cannot be done simultaneously in the case of half-duplex mode.

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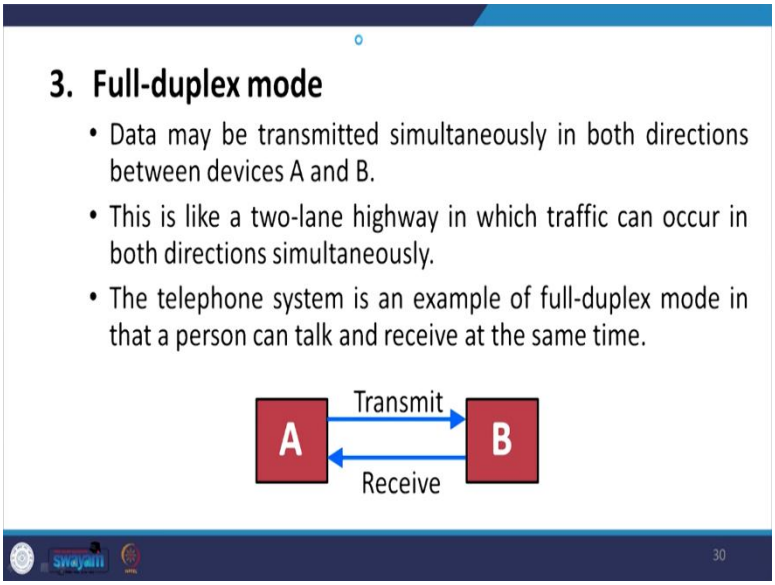

In the case of full-duplex mode, data may be transmitted simultaneously in both directions between A and B. So, here in the full-duplex mode, it could be either A to B, or we can

also have B to A. So, this is like the two-lane highway in which the traffic can occur in both directions simultaneously, and the telephone system is an example of the full-duplex mode in that a person can talk as well as receive at the same time.

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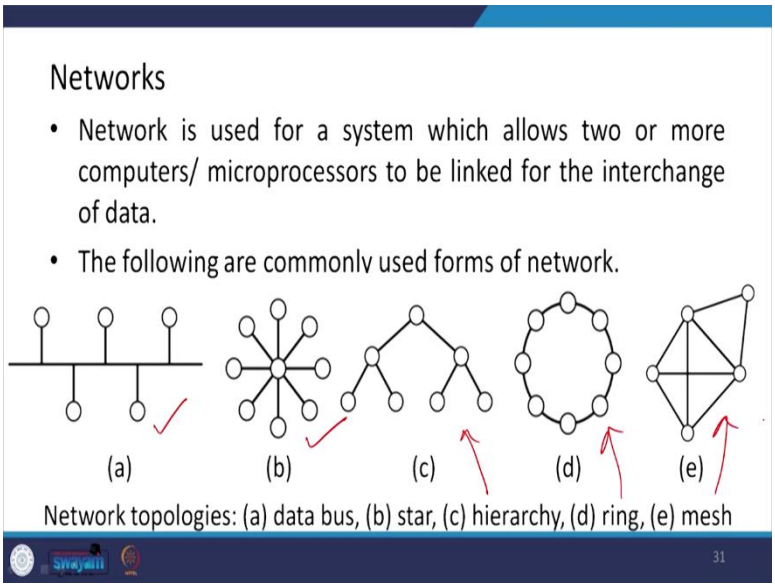

Now, let us look at the networks. The network is used for a system that allows two or more computers or microprocessors to be linked for the interchange of data. So, these are some of the common forms of the network. I will be talking details about is this is the data bus, this is the star configuration, this is hierarchical, this is the ring, and this is the mesh.

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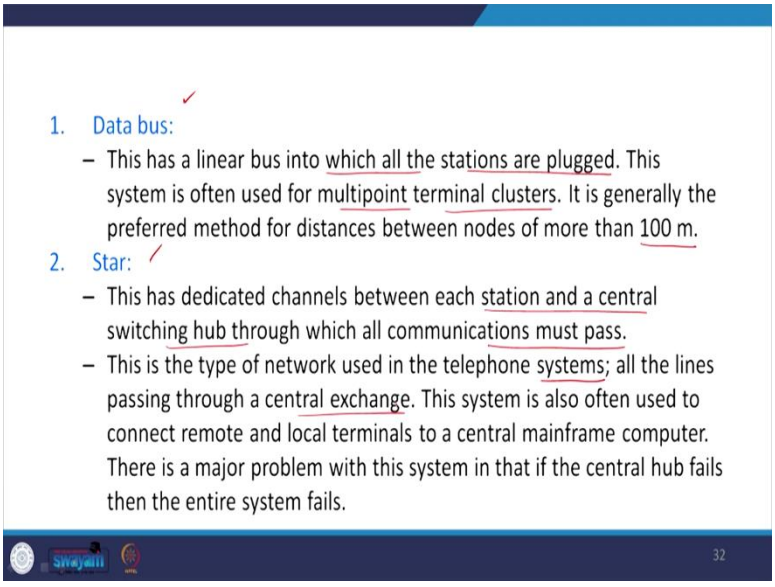

In the case of the data bus, this has a linear bus into which all the stations are plugged, and this system is often used for multipoint terminal clusters, and it is generally the preferred method for the distance between nodes of more than 100 meters.

Then, the star configuration this is has a dedicated channel between each station and the central switching hub through which all communication must pass. This is the type of network used in the telephone system; all the lines pass through the central exchange. The system is also often used to connect remote and local terminals to a central mainframe computer. There is a major problem with this system that if the central hub fails, the entire system fails in this case of the star form of network.

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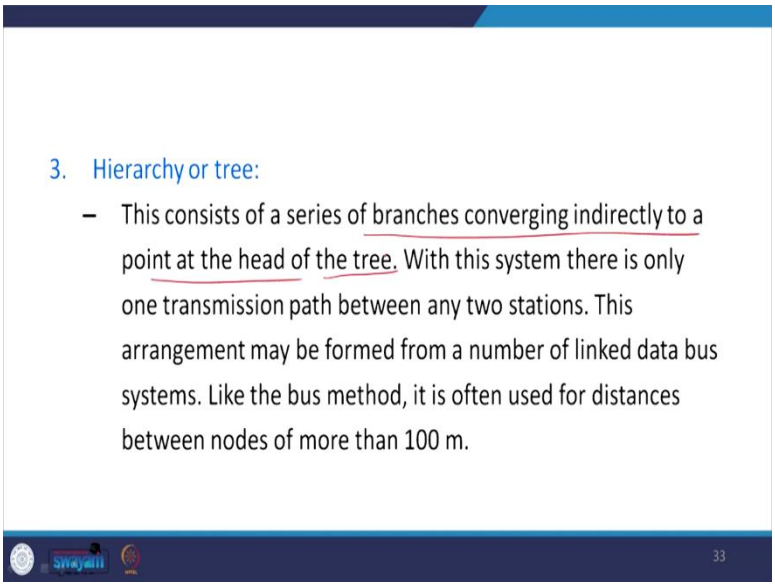

Then, next is the hierarchy or the tree network. This consists of a series of branches converging directly to a point at the head of the tree. With this system, there is only one transmission path between any two stations, and this arrangement may be formed from a number of link data bus systems. Like the bus method, it is often used for distances between more than 100 meters.

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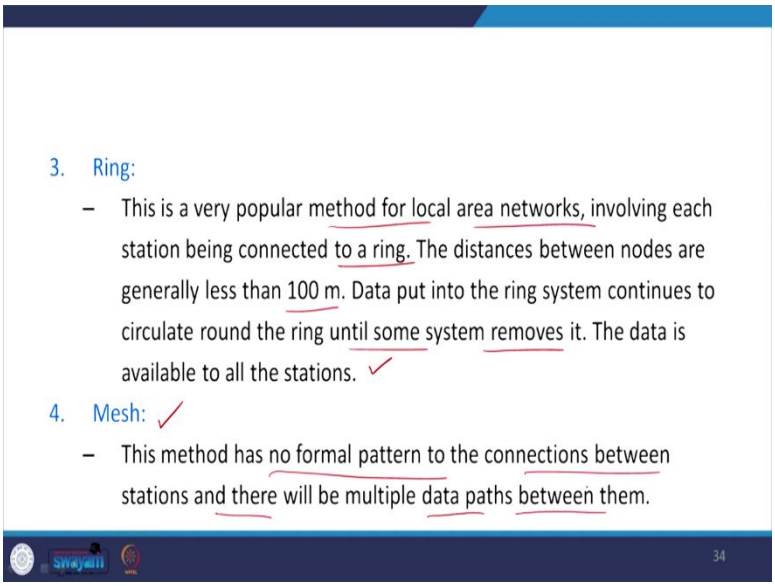

The ring system, ring form, is a very popular method for the local area network or the LAN, involving each station being connected to a ring. The distance between nodes is generally less than 100 meters, and data input into the ring system continues to circulate around the ring until some system removes it. The data is available to all the stations, and next is the mesh form. This form has no formal pattern to the connection between the stations, and there will be multiple data paths between them.

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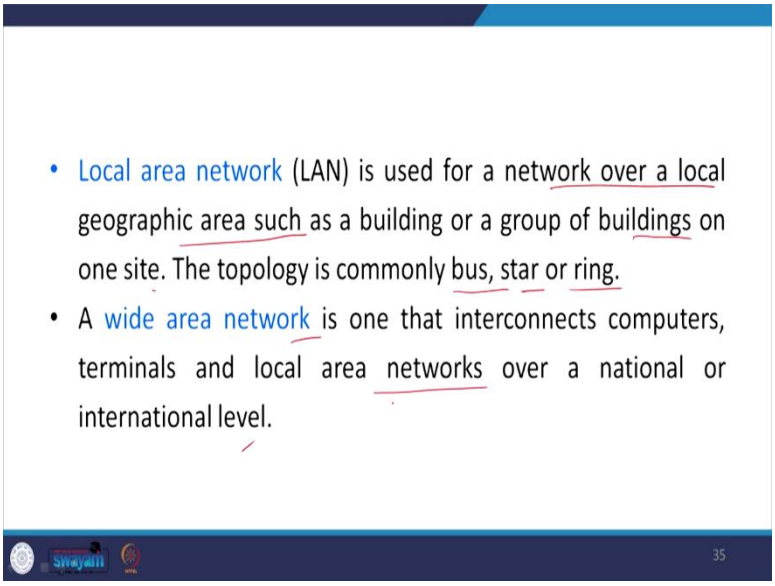

The local area network or the LAN is used for a network over a local geographic area, such as a building or group of building on one site. The topology commonly used is a bus, star, or the ring one, and the wide-area network is one that interconnects computer terminal and local area network over a national or the international level.

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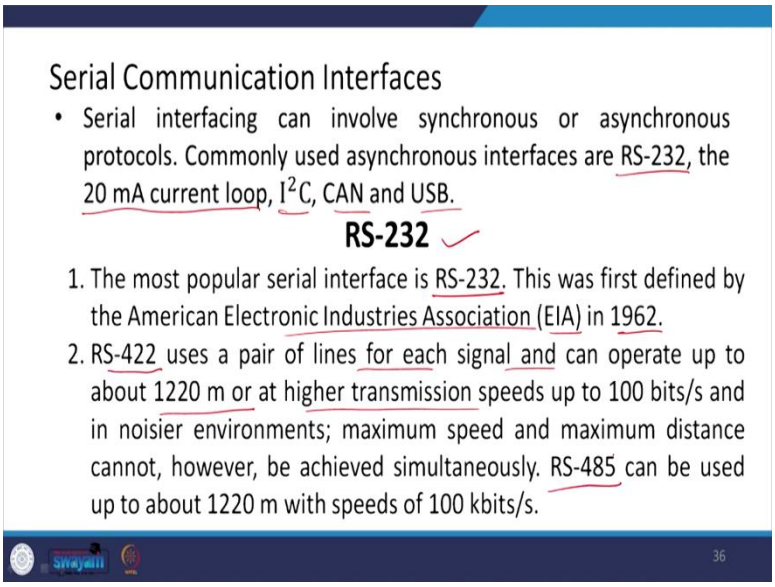

Now, let us look at the serial communication interfaces. So, serial interfacing can involve synchronous or asynchronous protocols. Commonly used asynchronous interfaces are RS-232, the 20-milliamp current loop, I square C, CAN, and the USB. Let us look at first the RS-232. The most popular serial interface is RS-232. This was first defined by the American Electronic Industries Association EIA in 1962. The RS-422, similar to RS-232, uses a pair of the line for each signal and can operate up to about 1220 meters or higher transmission speeds up to 100 bits per second and in noisier, noisy environments, maximum speed and maximum distance cannot be achieved simultaneously, similar is the case with RS-485.

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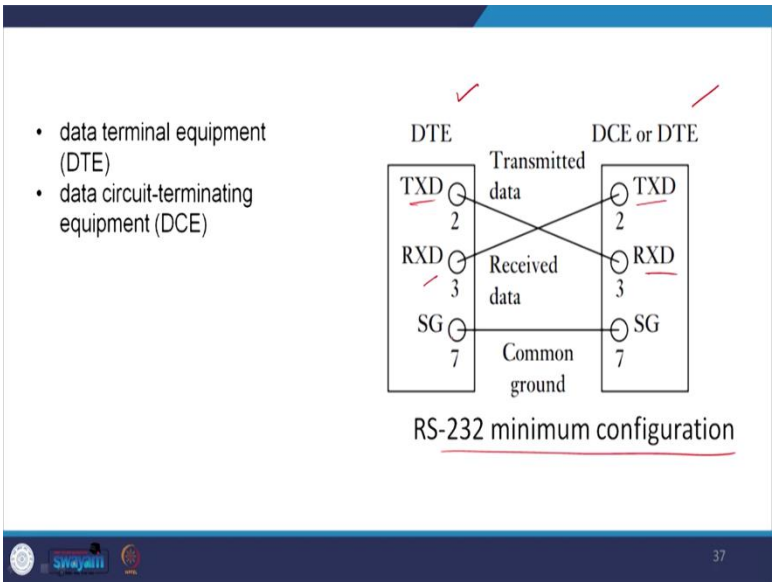

So, this is what the RS-232 minimum configuration looks like. We have the data terminal equipment over here and data circuit terminating equipment here. So, we could have the transmitted data from 2 and 3 could have, 3 have the receive data so. Similarly, we have two transmitted data, and 3 have the received data, and the 7 port is the common ground.

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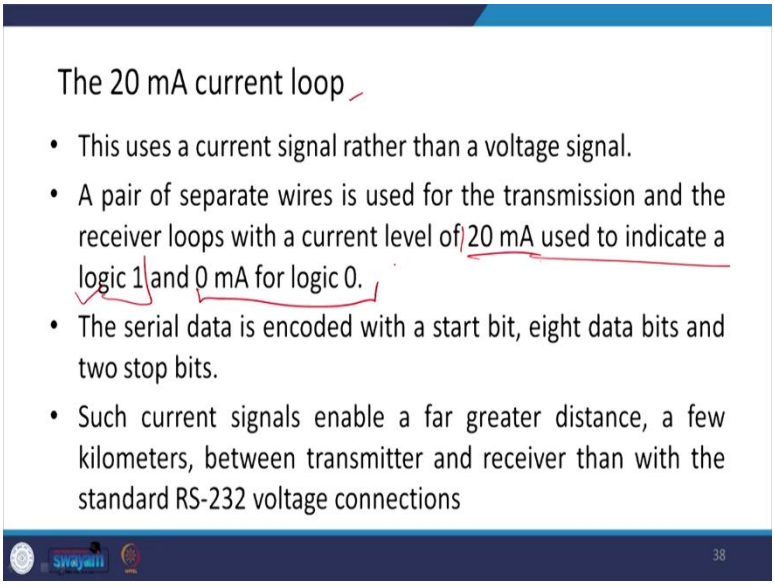

Next, let us look at the 20-milliamp current loop. This uses a current signal rather than a voltage signal. A pair of separate wires are used for the transmission, and the receiver loops with the current level of 20 milliamps are used to indicate a logic 1 and 0 milliamp

for logic 0. So, 20-milliamp for logic 1 and 0 milliamp for logic 0. The serial data is encoded with a start bit, eight-bit, and two stop bits. Such current signals enable a far greater distance, a few kilometers, between transmitter and receiver than with the standard RS-232 voltage connections.

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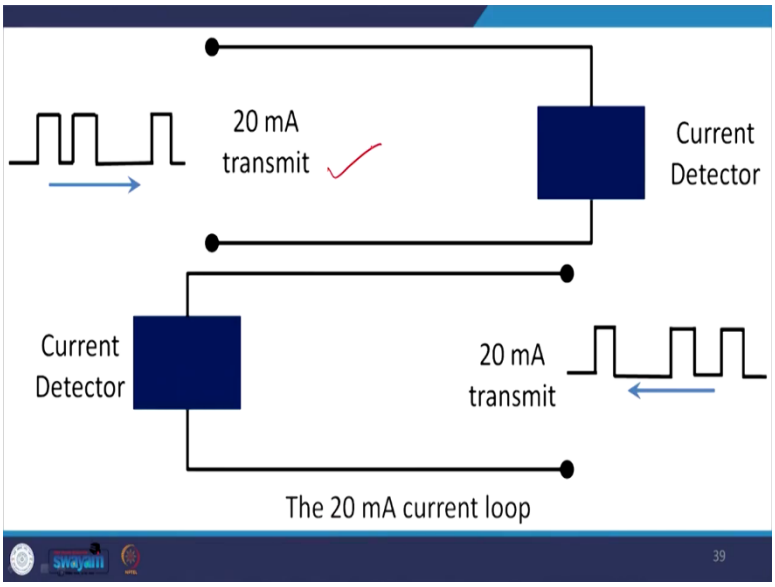

This is how this 20-milliamp current loop works.

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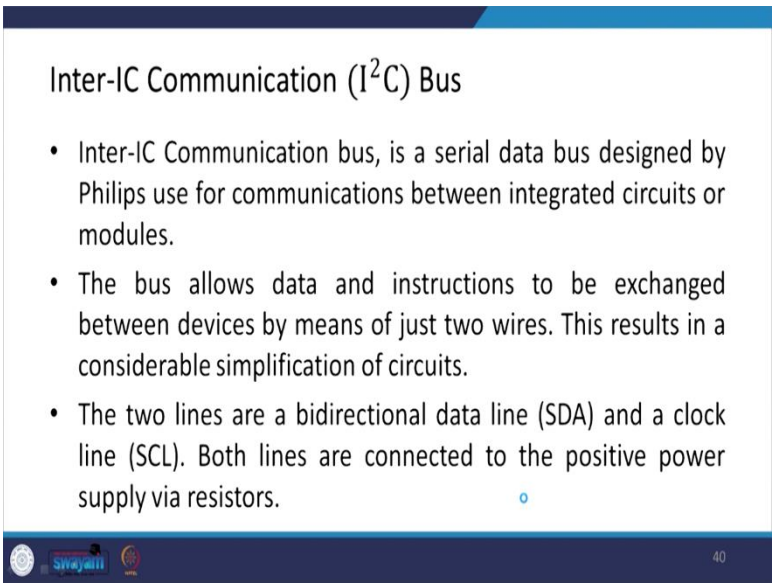

Next, let us look at the I^2C bus. The inter IC communication bus is a serial data bus designed by Philips, and it is used for the communication between integrated circuits or

modules. The bus allows data and instruction to be exchanged between devices by means of just two wires, and this results in a considerable simplification of the circuit. The two lines are a bidirectional data line and a clock line. Both lines are connected to the positive power supply via resistors.

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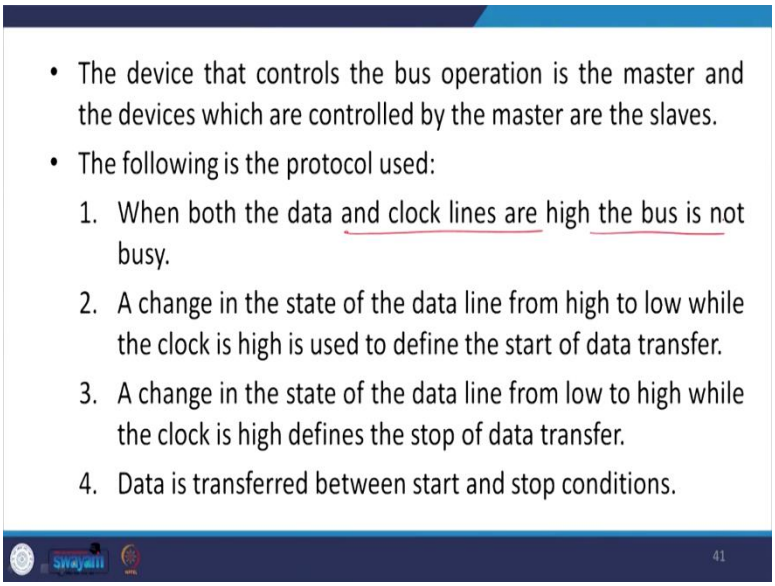

The device that controls the bus operation is the master, and the device which is controlled by the masters are the slaves, and the following is the protocol used. When both the data and clock lines are high, the bus is not busy. A change in the state of the data line from high to low while the clock is high is used to define the start of the data transfer, and a change in the state of the data line from low to high, while the clock is high, defines the stop of the data transfer. Data is transferred between the start and the stop conditions.

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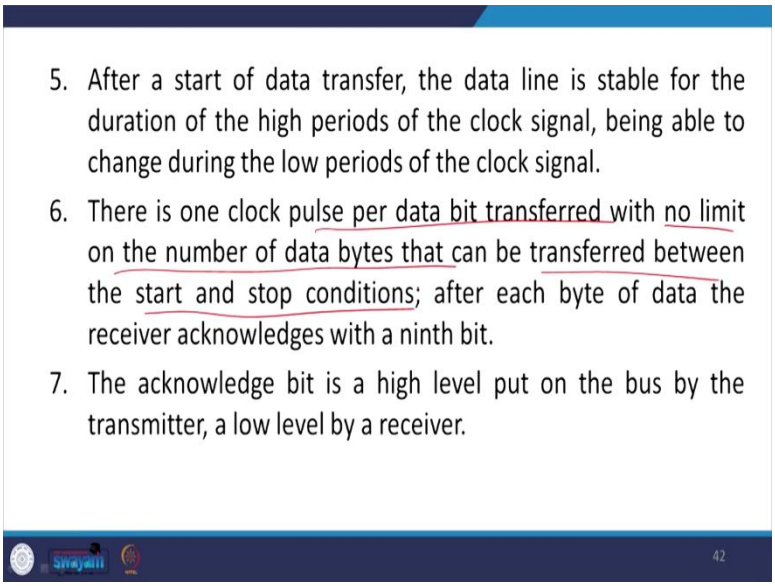

After the start of data transfer, the data line is stable for the duration of the high period of the clock signal being able to change during the low periods of the clock signal. There is one clock pulse per data bit transferred with no limit on the number of data bytes that can be transferred between the start and stop conditions after each byte of data the receiver acknowledges with the ninth bit. The acknowledge bit is a high level put on the bus by the transmitter, a low level by a receiver.

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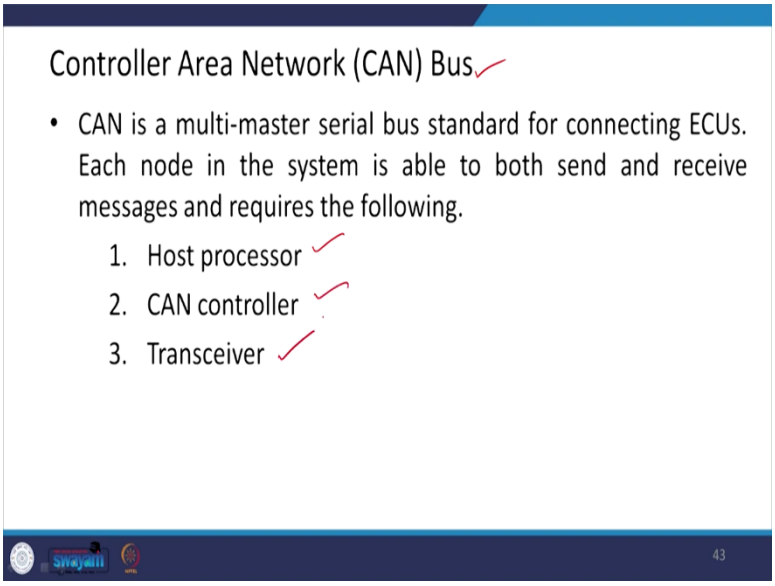

Next, let us look at the CAN bus that is the controller area network bus. CAN is a multi-master serial bus standard for connecting ECU's. Each node in the system is able to both send and receive messages and requires the following; a host computer, a CAN controller, and a transceiver. Next, let us look at the USB.

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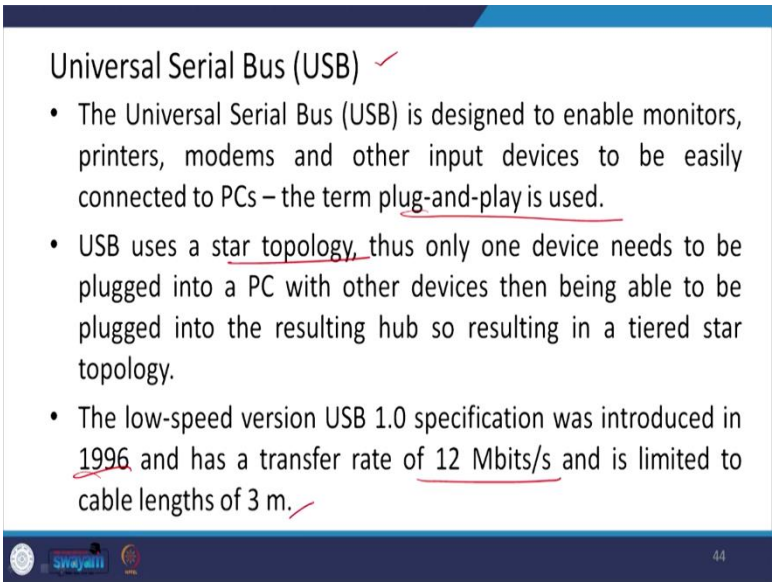

The universal serial bus is a very popular form. So, the universal serial bus or USB is designed to enable monitors, printers, modems, and other input devices to be easily connected to the PC. The term plug and play is used. USB uses a star topology. Thus, only one device needs to be plugged into a PC with other devices then being able to be plugged into the resulting hub, resulting in a tiered star topology. The low-speed version USB 1.0 specification was introduced in 1996, has a transfer rate of 12 megabits per second and is limited to a cable length of 3 meters.

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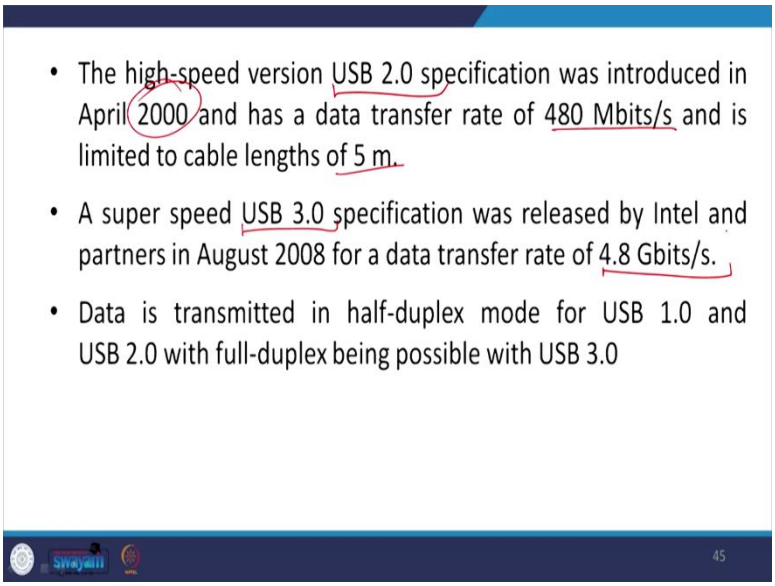

The next version was USB 2.0, which was introduced in April 2000 and had a data transfer rate of 480 megabits per second and is limited to the cable length of 5 meters and then, we have the USB 3.0 also came with a data transfer rate of 4. 8 gigabits per second.

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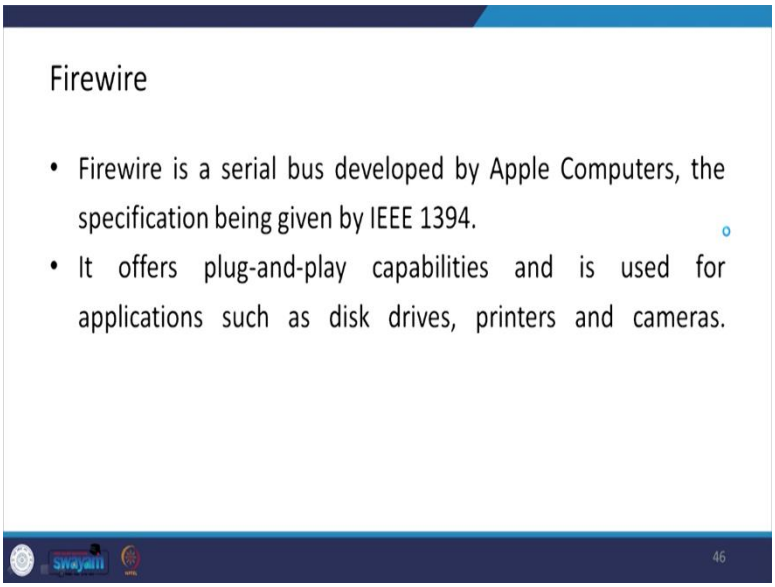

Firewire, firewire is a serial bus developed by Apple Computers, the specifications were given by IEEE 1394, and it offers plug and play capabilities and is used for applications such as disk drives, printers, and cameras.

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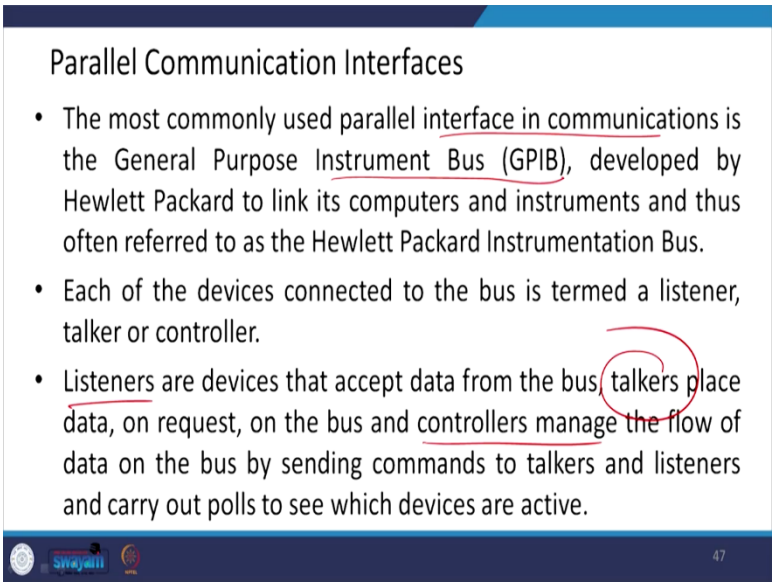

The parallel communication interface, as I said, the most commonly used peripheral, used parallel interface in communication is the general-purpose instrument bus is that is (GPIB), developed by HP to link its computer and instruments and thus often referred to as HP instrumentation bus. Each device connected to the bus is termed listener, talker, or controller. Listeners are devices that accept data from the bus, talkers place data on request on the bus, and controllers manage the flow of data on the bus by sending commands to talkers and listeners and carrying out polls to see which devices are active.

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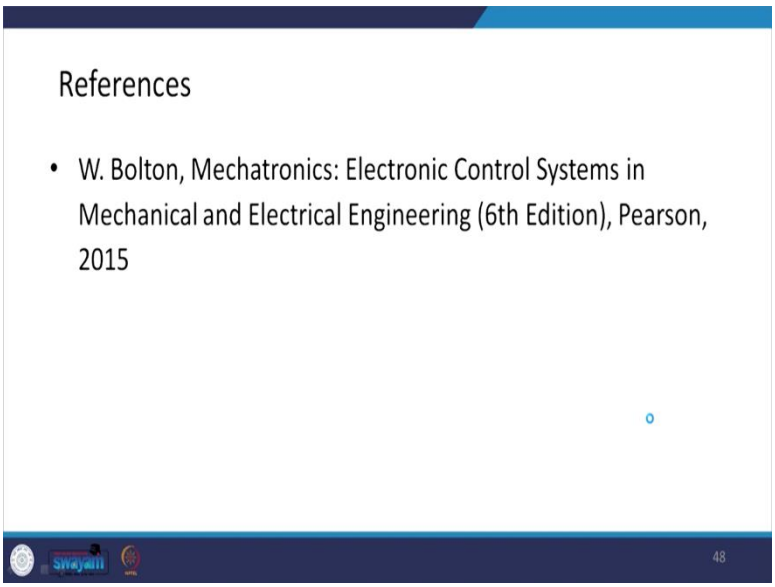

So, this is all about these two lectures, and you can further read if you are interested in this in Bolton, as I indicated earlier.

And thank you and good luck.