Data Communications
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Lecture-14
Interfacing to the Media

Hello and welcome to today's lecture on Interfacing to the Media. We have discussed various techniques such as encoding, modulation and multiplexing with the help of which you can transmit signal over any transmission medium.

Now question arises, how you interface your equipment to the transmission media, it can be twisted-pair coaxial cable or optical fiber or as well as media but whatever it may be you have to interface your equipment some how to the transmission medium. That is the topic of discussion of today's lecture. Here is the outline of the lecture.

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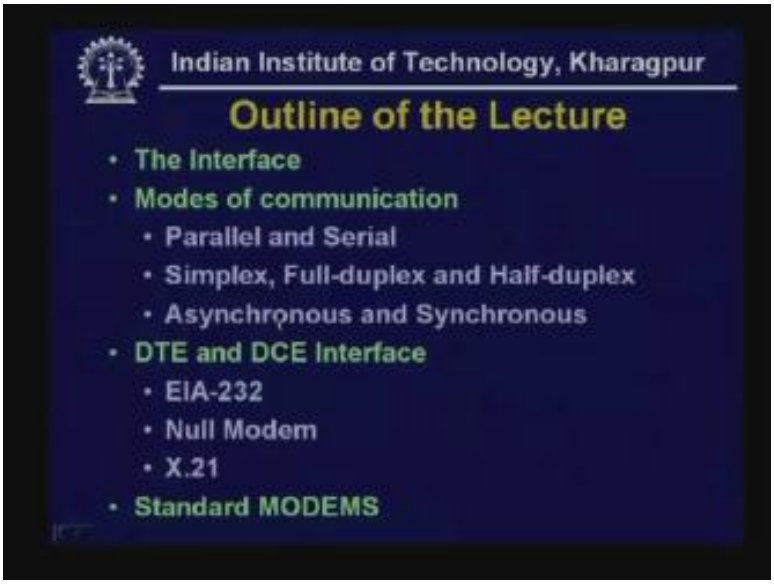

First we shall discuss about the basic concept of the interface where it is required then we shall discuss the various modes of communication between the interface and the user equipment may be the computer. The various modes or transmission techniques are parallel and serial or it can be simplex, full duplex and half duplex or there are two types Asynchronous and Synchronous transmission then we shall discuss about the interface between two equipments like DTE Data Terminal Equipment and data circuit communicating equipment. So the interface between these two has some standards one of them is EIA Electronic Industries Association developed in standard EIA-232.

We shall discuss about it in detail then we shall discuss the concept of null modem which is related to this and another interface although which is not that popular that is X.21. Then we shall discuss about the modems which are actually connected to the medium.

And on completion of this lecture the students will be able to explain various modes of communication, distinguish between half duplex and full duplex modes of communication, they will be able to distinguish between asynchronous and synchronous modes of communication and they will be able to specify the RS-232c or EIA-232 standard used for DTE DCE interface. They will be able to explain the function of a null modem and finally they will be able to explain the functionality and standards used for MODEMS.

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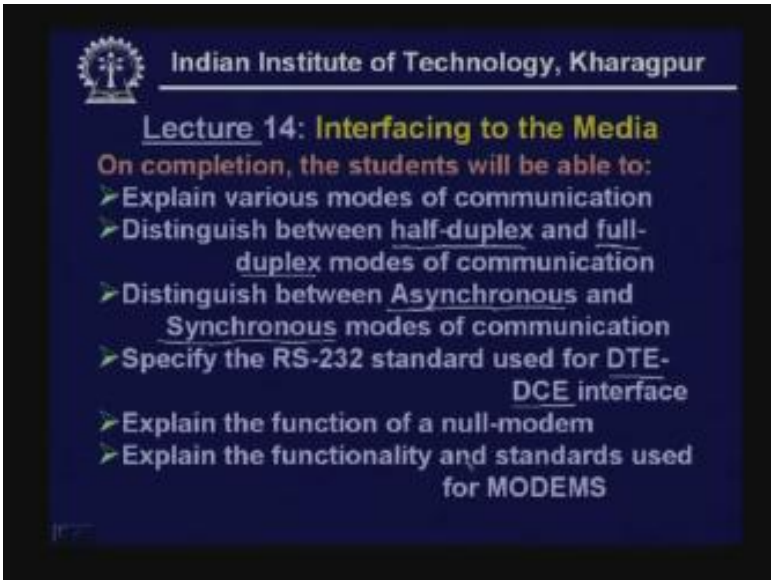

Let us see what we really mean by the interface.

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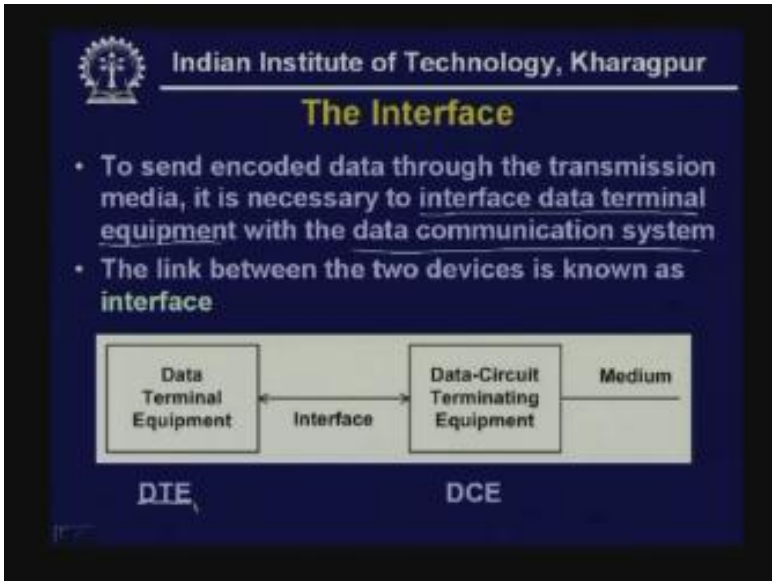

As we have seen to send data through the transmission medium we have to do various encoding techniques that we have discussed in detail. Now that encoded data has to be transmitted and for that purpose it is necessary to interface data terminal equipment. By data terminal equipment we mean the computers and various other equipments. It can be computer, printer, plotter it can be any other equipment which can transmit or receive data. Then another equipment will be required known as DCE Data-Circuit Terminating Equipment.

The Data-Circuit Terminating Equipment will actually interface to the medium. As you can see here Data-Circuit Terminating Equipment is now sending or launching the signal. Obviously we have to develop an interface between this Data Terminal Equipment referred to as DTE and data circuit and Data-Circuit Terminating Equipment DCE. This interface is an electrical circuit. Later on let us discuss how we can send digital signal over this. Some standard has to be used for this purpose. So we shall discuss about this interface in detail. Before that let us discuss about the various modes of transmission rather possible modes of communication.

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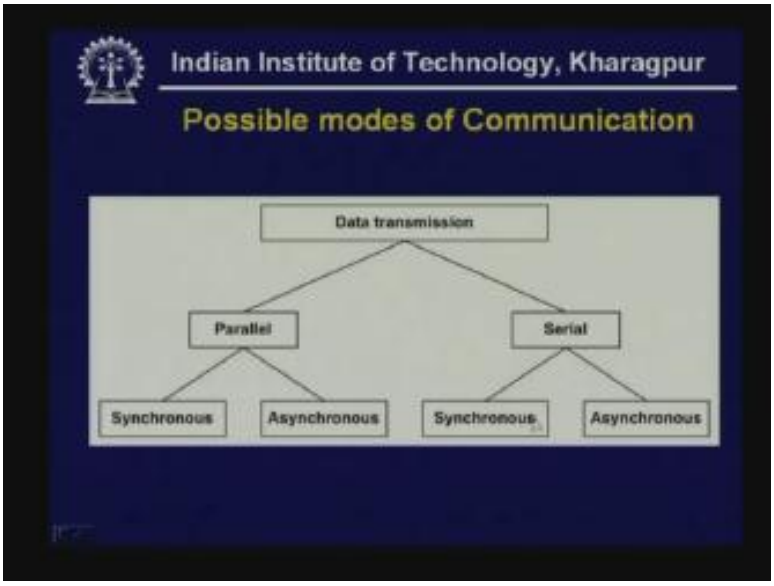

Data can be transmitted in parallel or in serial. Again parallel has two different types synchronous and asynchronous and serial also has two variations synchronous and asynchronous. First let us consider the Parallel Transmission technique.

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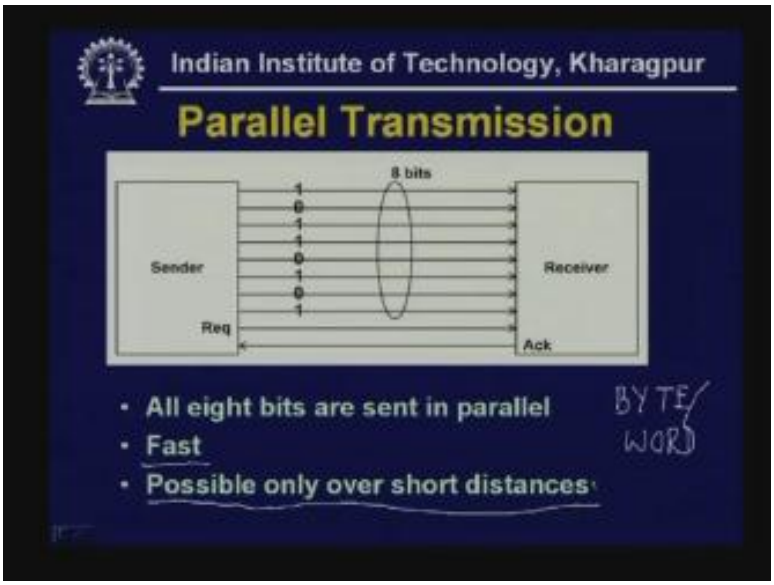

In Parallel Transmission technique as you can see a number of bits usually a byte or a word it can be either a byte that is 8-bit or it can be word. Word can be 8-bit, 16-bit, 32-bit or 64-bit depending on the size of the processor it can be byte or word that is sent in parallel. As you can see all the bits are transmitted parallel between the sender and receiver. Obviously whenever you transmit data in this manner it is very fast because all the bits are going simultaneously.

However, this is possible only over a short distance and this Parallel Transmission is commonly used for transmission of data between the CPU and the memory or between the CPU and other peripherals which are very close to the CPU. That means when two equipments are located very close to each other in few meters or some feet away in distance then this parallel mode of communication is possible. Usually parallel mode of communication is not popular in the data transmission techniques that we are discussing in detail and in that respect normally serial transmission is used. What we really mean by serial transmission?

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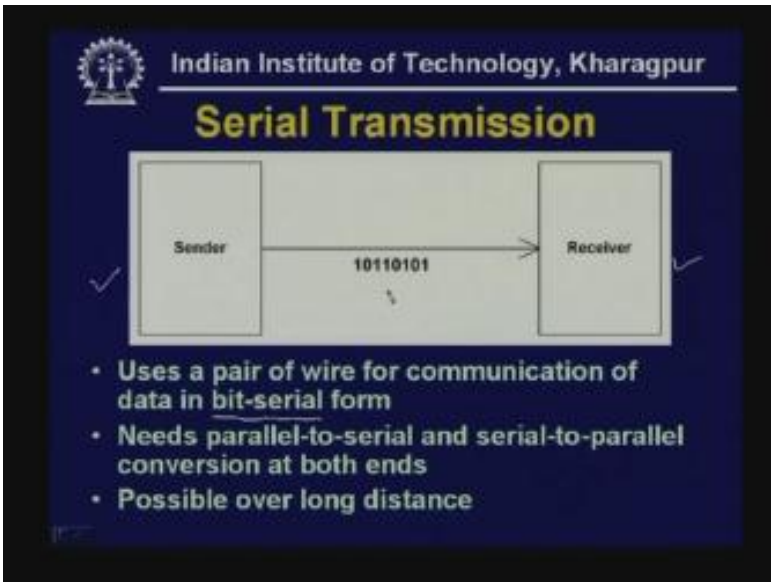

As you can see in serial transmission a pair of wire is used for communication of data in bit serial form. Instead of sending in parallel you are sending it bit by bit. As you can see here we are sending them one by one, first one, then 0, then 1, then 0, then 1 and 0 and 1 and 0 and 1 so in bit serial fashion and of course this will require parallel to serial conversion by the sender and also it will require serial to parallel conversion at the receiving end (Refer Slide Time: 8:00).

However, it has many advantages and particularly it is very suitable for long distance communication. That means serial mode of communication is possible over long distances.

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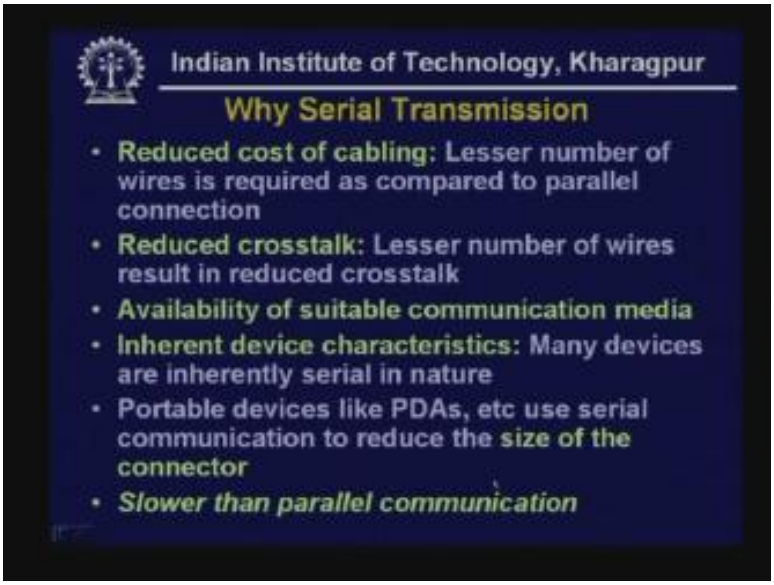

Here various reasons are given to explain why serial transmission is required and in this lecture we shall mainly focus on serial transmission. Now let us see what are the various techniques or why serial transmission is required. First of all it allows you reduced cost of cabling. As we have seen we are using lesser number of bits at a time, we are only sending one bit at a time so you require one pair of wire and you don't require a bunch of wires so it requires lesser number of wires compared to parallel connection.

In parallel communication you require a bunch of wires to be connected between the DTE and DCE which is not required here. Then it leads to reduced cross talk. Because of lesser number of wires it results in reduced cross talk. We have discussed about these cross talks in detail and we have seen that whenever a number of wires are bunched together it leads to cross talk and here in the serial mode of communication cross talk is reduced significantly.

The third important factor is availability of suitable communication media. We are familiar with telephone system, microwave system and satellite network. In all these cases data transmission takes place in serial form. That means if you have to use the popular transmission media like telephone network, satellite network or microwave network we have to use serial mode of transmission.

Fourth point is that there are many devices which have which are inherently serial in nature and in such cases it is natural to use serial mode of communication. For example, whenever we need data from some devices like tape recorder, disks floppies, hard disks etc it is always serial in nature.

Another important factor which is becoming important in the present day context is the availability of portable devices like PDAs, cell phones etc and in such cases you have seen that PDAs and cell phones are very small in use and if we use a parallel connector

having large number of pins it is very difficult to fit in a PDA or cell phone. However, if we use serial mode of communication the number of pins required is small so the connector size is also small so only small connector size can be used for portable devices. That's why serial mode of communication can be used in such cases.

However, as we shall see the serial mode of communication is slower than parallel mode of communication. It is much slower compared to the parallel mode of communication that is possible when we are sending data in parallel form. For example, when we are sending data between computer and main memory there the transfer rate is very high. We cannot transfer data rate at that rate so however that may not be required in many of the applications. Let us see the various modes.

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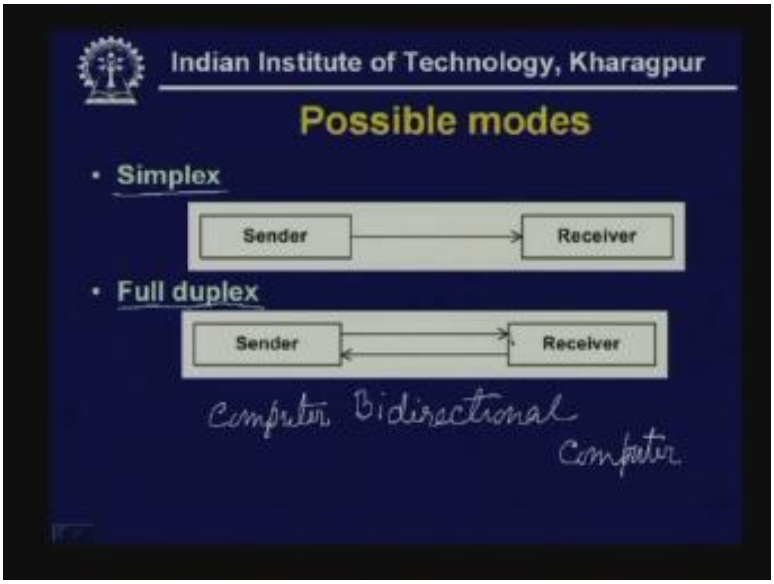

First one is simplex mode. Here as you can see data is unidirectional. Here data is going from sender to the receiver and there is no data going from the receiver to the sender. It is going in only one direction. For example, this can be a computer and this can be a printer so in such cases we can use simplex mode of communication. However, simplex mode of communication cannot be always. As you can see in some situations it has to be in both directions. So here it is bidirectional. For example, here you have got one computer and here you have got another computer so when two computers are communicating with each other it is quite natural that the data transfer will be in both directions. This is known as full duplex.

On the other hand, for the previous one it is unidirectional so it is known as simplex. So, for full duplex communication as you can see we require two pairs of wires for communication of data simultaneously because here it allows simultaneous communication in both directions that's why it is called full duplex. However, there are situations in which it is not possible to have two separate transmission links or channels. In such cases we have to use what is known as half duplex communication. In half duplex

communication as you can see you have got only one channel (Refer Slide Time: 13:36) but communication is taking place in both directions. Obviously the communication cannot take place in both directions simultaneously. Therefore in such case we have some protocol.

For example when a policeman is talking to the headquarters we will find that he is talking then he is telling over then again listening for some time then again starts talking so they have a single communication channel through which the headquarter is communicating with that policeman. So in such a case the technique is known as half duplex. That means a single communication channel is being used for communication in both directions but in one direction at a time. This is known as half duplex communication.

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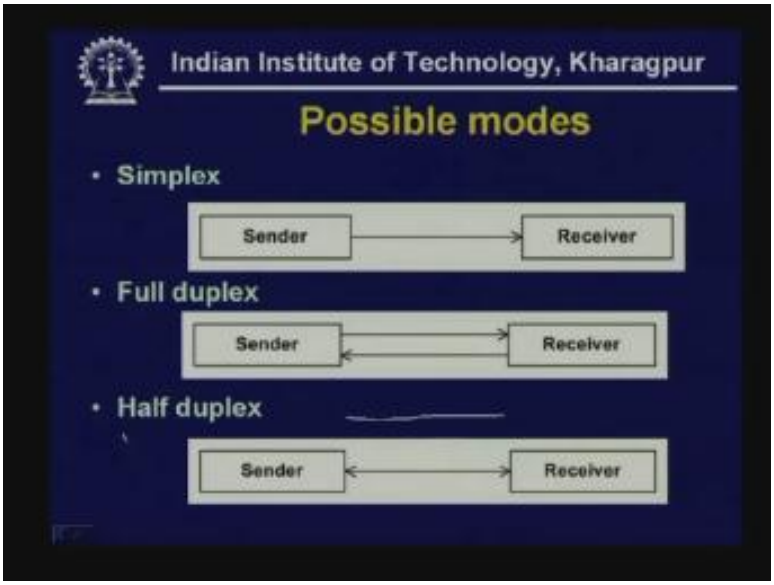

Then comes the other two techniques that is asynchronous and synchronous. Let us see what we mean by Asynchronous Serial Transmission.

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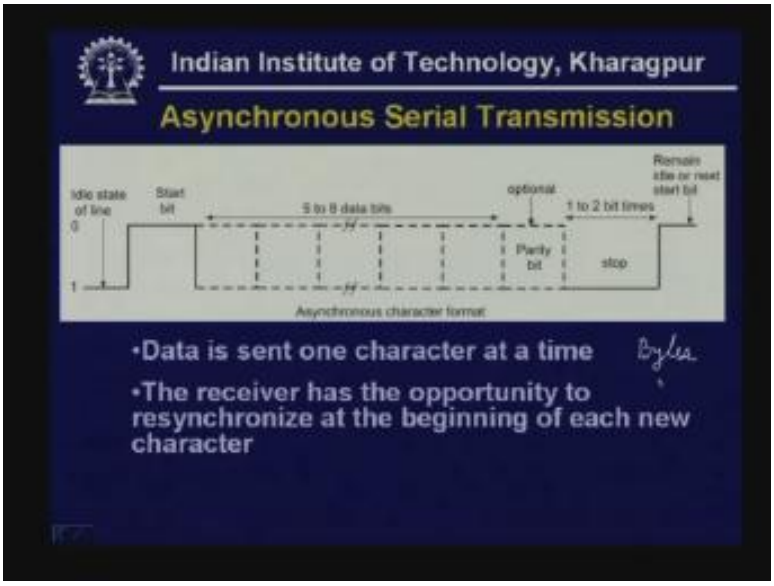

In Asynchronous Serial Transmission what is being done is instead of sending long bits at a time the bits are grouped either in bytes or words and then each such character a byte or a character that is 7-bit ASCII code is sent in the form of a frame and is sent one at a time. As you can see here there is a frame for sending one such character and each character is framed with the help of a start bit in the beginning and one to two stop bits at the end. That means each character has a start bit and one and half or two stop bits and there is an optional parity bit and the character size can be 5 to 8 data bits.

Hence we are not sending more than eight data bits at a time and that five to eight data bits is being framed with the help of a start bit stop bit and if necessary parity bit for error detection. Now, whenever a sender is not sending data the line can remain idle that is you are sending essentially one, the idle state of line is one.

And whenever data transmission starts the line is made 0 signifying that a word is being transmitted and the data transmission ends with the help of stop bits. So after sending immediately sending the stop bit one can send another word in such case the next start bit will start or it may remain idle like this. And in this case the receiver has the opportunity to resynchronize at each new character. So here you can see that (Refer Slide Time: 16:53) before a particular character is received the receiving end can synchronize with the help of this start bit. This has many advantages.

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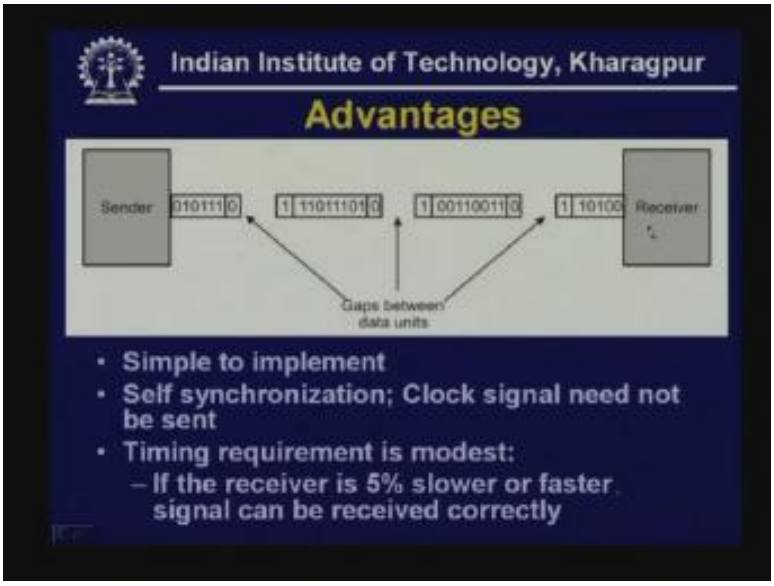

Here it is shown how several characters are being sent from the sender to the receiver. Here you can see one character has been sent and then there is a gap and that gap can be indefinite, it can be of any duration then another character is sent then there is a gap then another character is sent and then there is a gap and so on. And it has been found that this technique is very simple to implement that's why this is quite widely used. And one important characteristic is it is self synchronizing. We have seen that whenever data is sent by the sender at the receiving end it has to be received in a synchronized manner so a 1 is received as 1, a 0 is received as 0 at proper bit position. If it is not received in this manner then it will be incorrect.

Here what is being done is it is synchronized with the help of the start bit at the middle of the start bit then it is sampled at the middle of each of these bits. So as a result it gets synchronized with this particular rising edge and then at the middle of each bit the data is sampled to find out whether it is 0 or 1 and as a consequence the timing requirement is modest.

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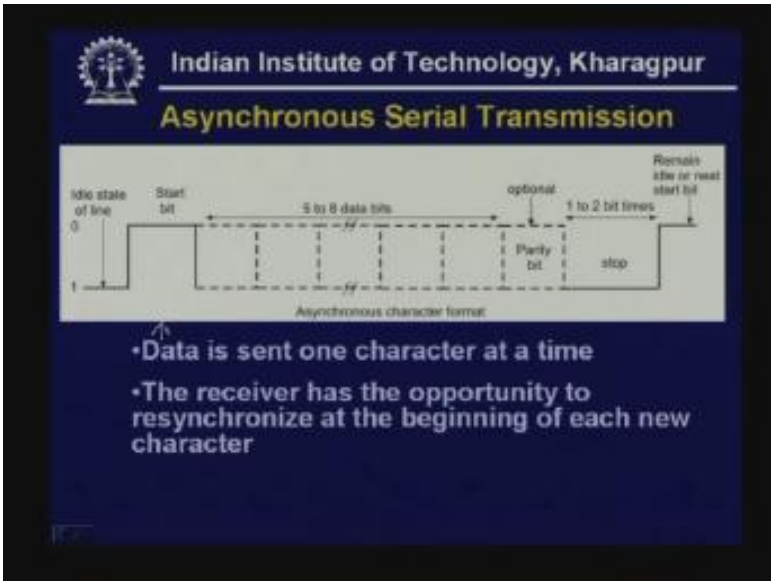

Even if the receiver clock is five percent slower or faster signal can be received correctly because the synchronization is done for each character separately at the beginning of each word but it has some limitation. The limitation is arising because of additional bits like start bits, stop bits which is increasing the overhead. For example, you are sending 8-bit so to send 8-bit you may require 1 stop bit plus 8 data bits plus may be 1 parity bit plus 1 stop bit. So these are the data bits (Refer Slide Time: 19:27) this is parity bit and this is stop bit. So altogether you require 11 bits to send 8 data bits. That means 3/8 is roughly about 30/300/8 that is roughly about 40% so 40% overhead is here. That means to send 8-bits of data three additional bits are required.

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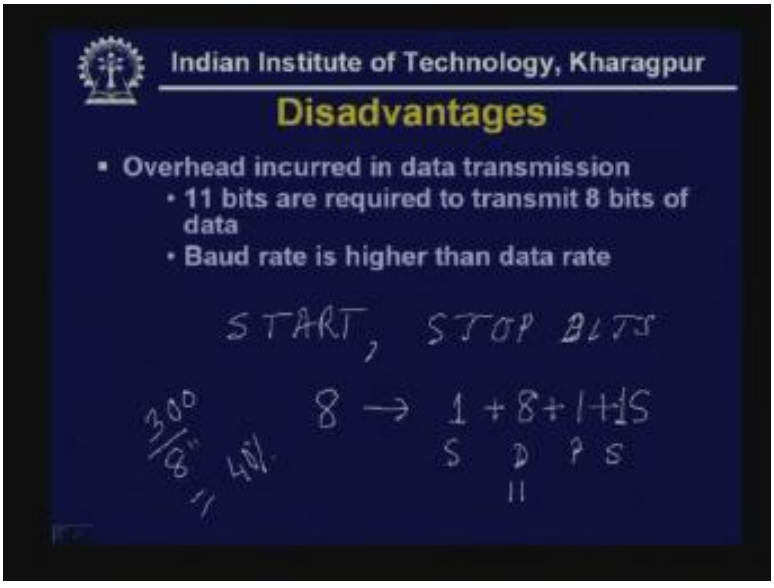

Also, you can think in another way. Here you are sending 11 signal elements to send 8-bit data. That means baud rate is 11 you can say that if you send 8-bits per second then essentially you are sending 11 bits per second signal. That means 8-bit data and 11 bits signal per second that means the baud rate is 11 or data rate is 8. So baud rate is higher than the data rate. You can think in this manner. So this high overhead cannot be tolerated in many situations. Therefore in such a situation we have to go for another alternative that is synchronous mode of communication.

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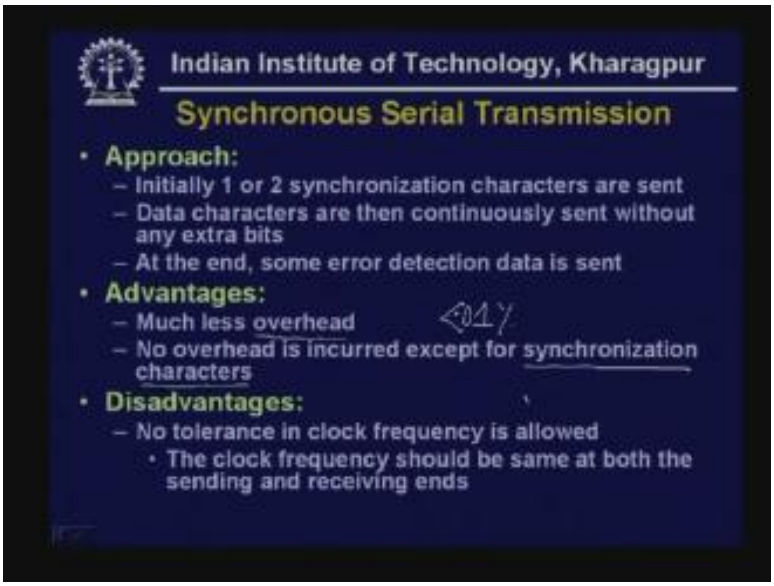

In synchronous mode what is normally done is initially one or two synchronization characters are sent instead of start bit and stop bit for each character. Data characters are then continuously sent without any extra bits. So you are not sending start bit and stop bits for each character. And at the end some error detection data may be sent if necessary. the advantage is here the overhead is much less even less than 1% may be .01% so this kind of overhead is present in synchronous mode and as you can see there is no overhead except for the synchronization character.

Synchronization characters are necessary to identify a beginning of a block of data. However, the main disadvantage here is there is no tolerance in clock frequency. You cannot accept any tolerance because you are sending large number of characters. If there is mismatch in frequency after few bits the receiving end will receive incorrect data that's why here it is necessary to transmit in fully synchronous manner.

Here is the synchronous serial transmission. You can see how it is being done.

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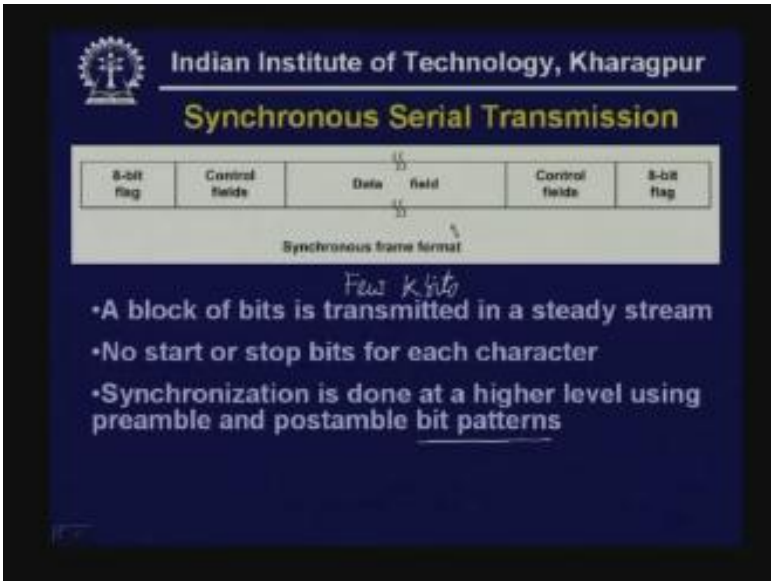

A block of bits is transmitted in a steady stream here is the data field (Refer Slide Time: 22:23) it can be very large, it can be a few kilo bits and there is a preamble 8bit flag and some control bits and there is a postamble control field, there can be error correcting codes and error detection codes and 8-bit flag which is postamble. So preamble postamble is provided along with the data but the percentage of overhead is very small. So here the synchronization is done at a higher level using preamble and postamble bit patterns. So special character is sent at the beginning and the end to mark the beginning and end of a stream of data and this is the synchronous frame format.

Now here one question arises. We have told that the clocks of the two ends must be fully synchronized, how it can be done? One alternative is a separate line can be used for sending clock then at the receiving end that clock will be used for receiving data. But that is not practically feasible unless two systems are located very closely. In such a case the normal practice is to recover data recover clock from the received data with the help of some suitable hardware known as phase lock loop. But the phase lock loop will require some transitions and as we have seen different encoding techniques in detail which are used where synchronization is possible and clock is recovered with the help of phase lock loop at the receiving end. So the synchronous serial transmission will require complex clock recovery circuit so that synchronization is possible.

Now, coming to the question of interfacing we have seen that we have data terminal equipment it can be computer or any other equipment which can send data or receive data and we require a DCE Data-Circuit Terminating Equipment. This Data-Circuit Terminating Equipment will launch the signal in this communication system and at the other end another DCE will receive the signal and it will then send the signal to the DTE at the receiving end. In between you will require interface at both ends between the DTE and DCE.

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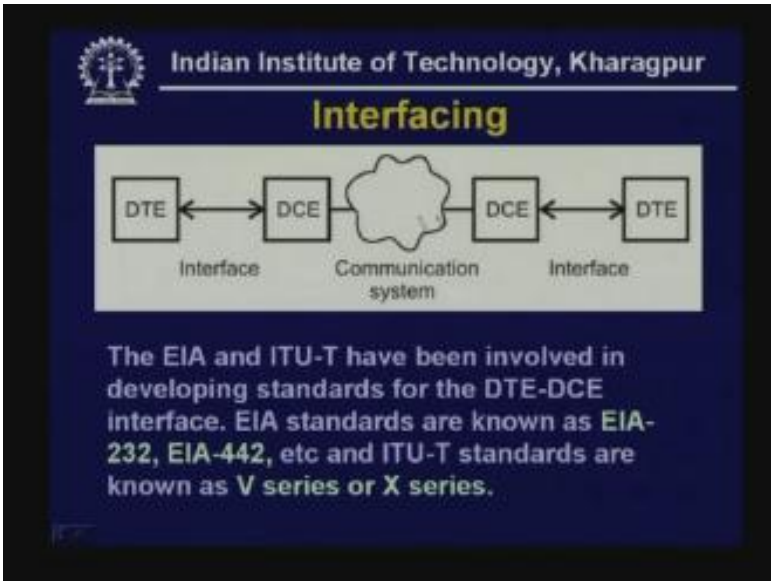

Therefore DCE is usually the modems. The DTEs are computers and various other equipments that we use for sending data. Now the interface has to be universally accepted so that the two equipments one DCE and another DTE manufactured by two different companies can be interfaced. For that purpose some standards are to be used. The standards are developed by two organizations the EIA Electronic Industries Association and ITUT or the DTE DCE interface.

As you can see here the standards developed by EIA is known as EIA-232, EIA-442 and so on. Similarly the ITUT standards are known as V series or X series standards. Here we shall primarily discuss the EIA standards because these are very popular. And as we shall see this interface will require three different components; mechanical, electrical, functional and procedural so let us see what these different components do.

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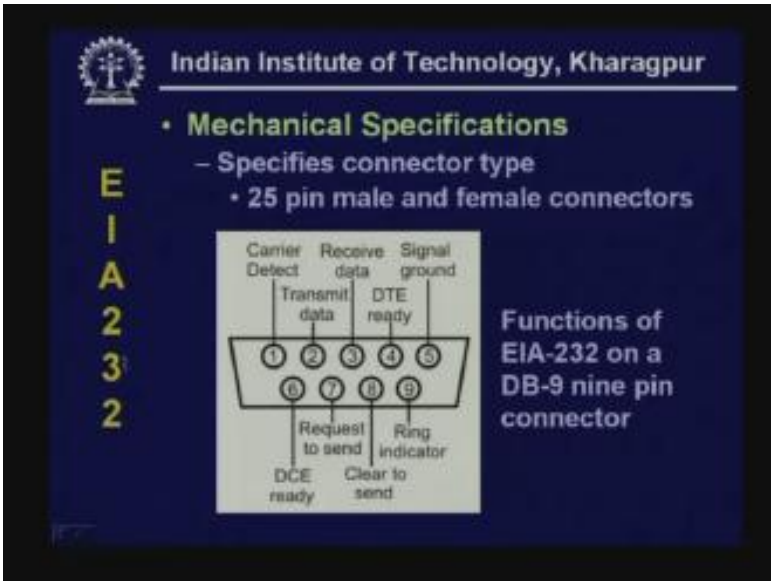

So here the EIA-232 standard has got different versions A B C and presently D. The mechanical specification specifies the connected type. You will require a connector and a cable to connect two equipments. So the mechanical standard specifies that and in the main standard a 25 pin male and female connectors are suggested and these connectors are used for linking DCE with a DTE. However, all the 25 pins are not used, nine of them are commonly used as it is shown in this particular diagram so subsequently a DB-9 nine pin connector has been developed which is commonly used. This is smaller in size and the various signals that are present on these pins are also shown here.

Then the electrical specification gives you the logic levels, the maximum cable length and the maximum data rate baud rate which can be used for communication between DTE and DCE.

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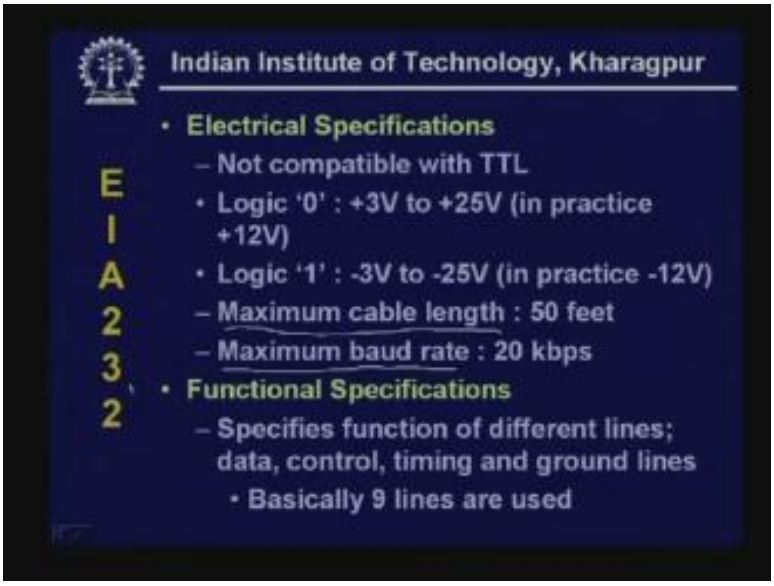

As you can see in EIA-232C the electrical signals levels are not TTL compatible that it is not 0V for 0 and plus 5V for 1 so it is not true. So as you can see here for logic 0 the range is plus 3 to plus 25 usually plus 12V is used. On the other hand, for logic 1: minus 3 to minus 25V is used. In practice minus 12V is used for this purpose. The electrical specification specifies the electrical voltage levels the maximum cable length and the maximum baud rate. These are the three parameters specified by the electrical specification.

Then comes the functional specification. It specifies what are the signal lines that you require. They can be broadly divided into four types namely data lines, control lines, timing lines and ground lines. And for EIA-232C basically nine lines are used as I have shown here. For example, this is the ground signal (Refer Slide Time: 29:10) then you have the transmit data and received data these are the data lines then you have Carrier Detect, DCE ready, clear to send, ring indicator and so on. So these are the timing signals and some of them are control signals.

I shall explain the function in the next specification that is the procedural specification.

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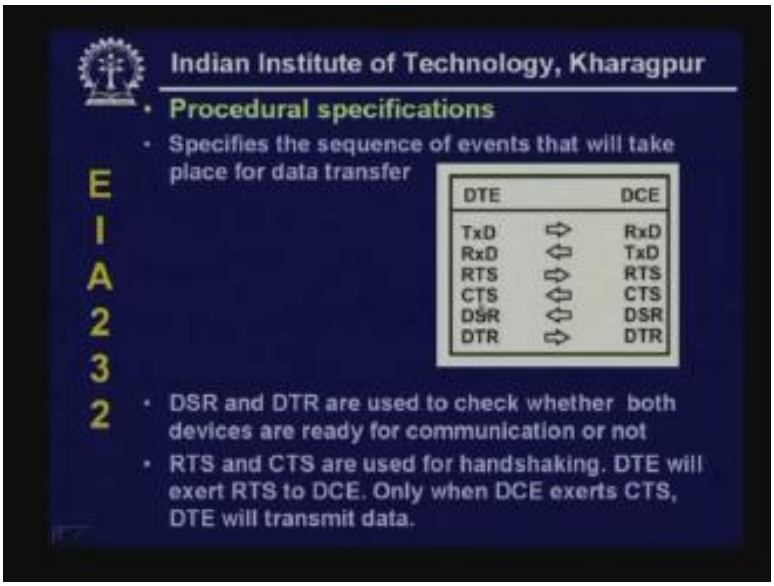

This procedural specification specifies the sequence of events that will take place for transferring data. So, to send data you have to use a sequence so that the transmitter and the receiver can communicate with each other. It is some kind of agreed upon protocol that is being used for communication between the two systems. For example, DSR Data Set Ready and Data Terminal Ready are used to check whether both devices are ready for communication. That means these two DSR and DTR will be used for establishing the fact that both are ready for communication that both have been turned on. On the other hand, the request to send and clear to send are the handshaking signals before the transmission of data can be started. And both these transmit and receive are used for transmitting data between DTE and DCE. Let us see how it is exactly being done.

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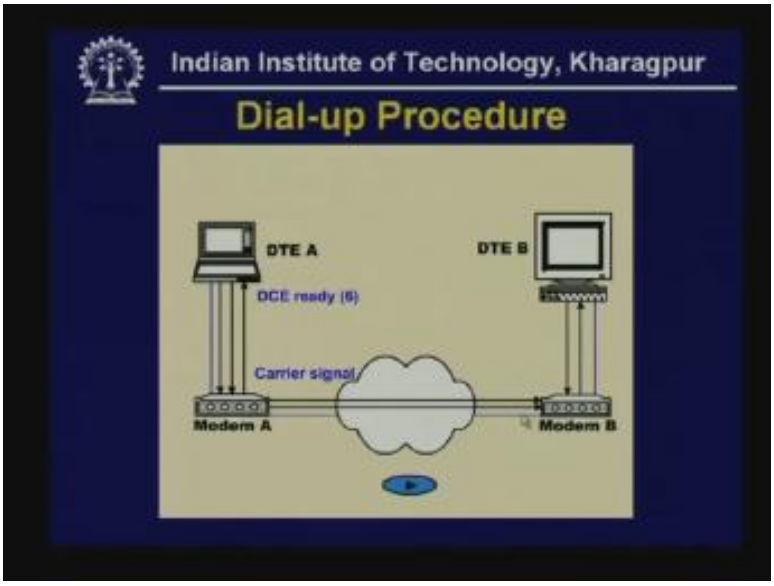

So here we see a DTE on one side and DTE on the other side. This is a DCE modem A modem B connected through a transmission media. So first the DTE sends the DTE ready signal to the modem in response to that and also it sends the telephone number that it is connected through the telephone system. So telephone number is sent to the data lines and in the receiving end the modem sends the ringing signal that goes to the other end and whenever the modem receives it a ring indicator signal goes to the other end DTE. In response to that the DTE sends DTE B where at the other end the DTE ready signal informs the modem that the DTE is ready for receiving the data and in response to that a carrier signal is sent by the modem B to the modem A and after receiving that carrier signal the modem A sends a DCE ready signal informing that the DCE or modem is ready for transmission and also it sends a carrier signal to the other end and after receiving that modem it sends a signal detector to the DTE B. Now the system is ready for communication. A link or a channel has been established. Now both DTEs are ready for communication. Let us see how it is done.

Here as you can see before transmission of data the DTE A sends a request to send asking the modem whether it can send data or not in response to that the modem responds giving a hand shaking signal known as clear to send. And after receiving that the DTE A will send the transmitted data which will go to the other end and as it goes to the other end as you can see the DTE B will receive the data. After receiving the data the communication is complete. This is the procedure. So, at the beginning of each communication for sending each character of data a request is sent then clear to send command is given followed by transmission of data to the other end. This is how character by character is sent one after the other between two DTEs.

So apart from RS-232 standard some other standards have been developed by Electronic Industries Association. I am briefly comparing the RS-232 with two other standards RS-423 and RS-422. The reason for that is RS-232 was developed long back when the data

rate requirement was much smaller. As you have seen only 20 Kbps can be sent which is very low in today's standard. So, to improve the performance this RS-423 and RS-422 were introduced.

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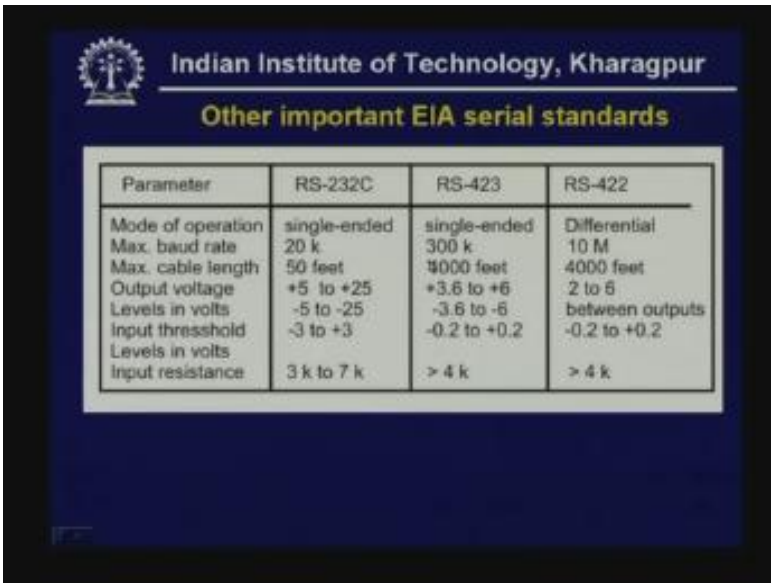

As you can see the baud rate here is more as 300 k for RS-423 and 10 Mbs for RS-422. Then the cable length is also increased. Instead of 50 feet for others RS-423 it is 4000 feet and also for RS-422 it is 4000 feet. These are the output voltage levels; plus 5 to plus 25 for 0 and for minus 5 to minus 25 for 1. On the other hand, for RS-423 it is plus 3.6 to plus 6 for 0 and minus 3.6 to minus 6 for 1. But here it is 226V between outputs, here it is balanced. Balanced means differential as you can see and differential means the data is sent between two wires. When it is unbalanced you are sending data through one wire and there is a common ground line.

On the other hand, there is a common ground line but the data is sent between these two wires that's why it is called balanced. This helps to reduce the noise because all the noise persists through the signal so as a result whenever you use unbalanced or single ended communication the noise immunity is much less compared to the balanced mode of communication. Here because of higher data rate and longer distance this balanced mode of communication is necessary. So the input threshold in this case is minus 3 to plus 3 for RS-232C and here the threshold is much less minus 0.2 to plus 0.2. Now the same is true for RS-422. So these are the input resistances. They are high input impedance that is 4k and more than 4k it is more than 3k to 7k here.

So in brief this is the comparison of the other standards and here is an important concept known as null modem in the context of this DTE DCE interface. We have seen that whenever the data transmission is to take place over long distance the two DTEs will require two DCEs and then to telephone network through communication can be done.

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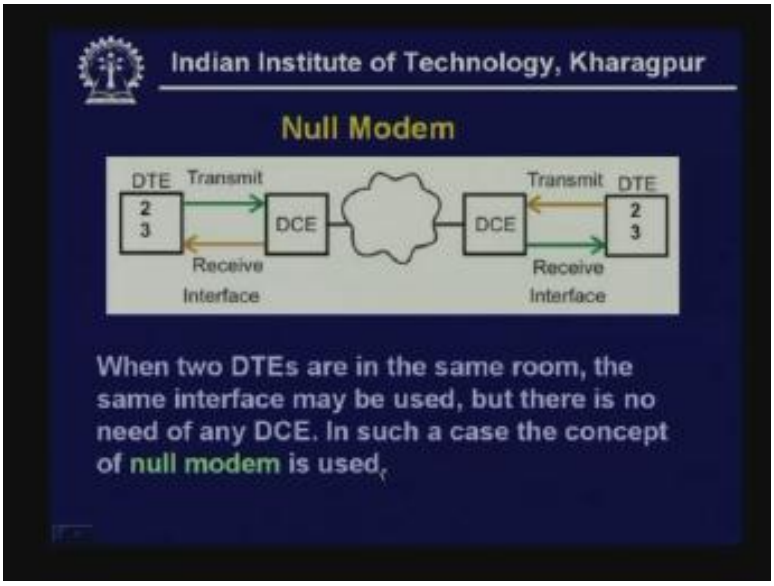

However, when two DTEs are in the same room the same interface may be used but there is no need of any DCE. In such a case the concept of null modem is used. That means whenever the communication is over a very short distance there is no need for any DCE. However, we can make use of the good old RS-232 or EIA-232. How it can be done is explained here.

So instead of this DCE telephone network and DCE at the other end this is being replaced by a cable. So, null modem is nothing but a cable as you can see. However, the wires are swapped it is because the transmit signal has to go to the receive line and this transmit signal has to go to the received line. So a null modem is nothing but a cable with two female connectors at both ends. In the previous case (Refer Slide Time: 38:02) here we used a female connector here we used a male connector. Similarly here is a female connector there is a male connector. But in this particular case we have to use female connectors at both ends because both ends are DTEs and wires are swapped as necessary for communication between two DTEs.

But the important point is DTE is fooled here. DTE has the illusion that it is connected to a modem but in practice it is not it is connected to a cable and that cable is connected to the DTE. So this is the null modem concept. Whenever we have to use the 25-PIN connector some of the wires have to be looked back and some of the wires have to be cross connected. Various cross connections and loop back lines are shown in this null modem when 25-PIN connector is used that is used in the standard RS-232.

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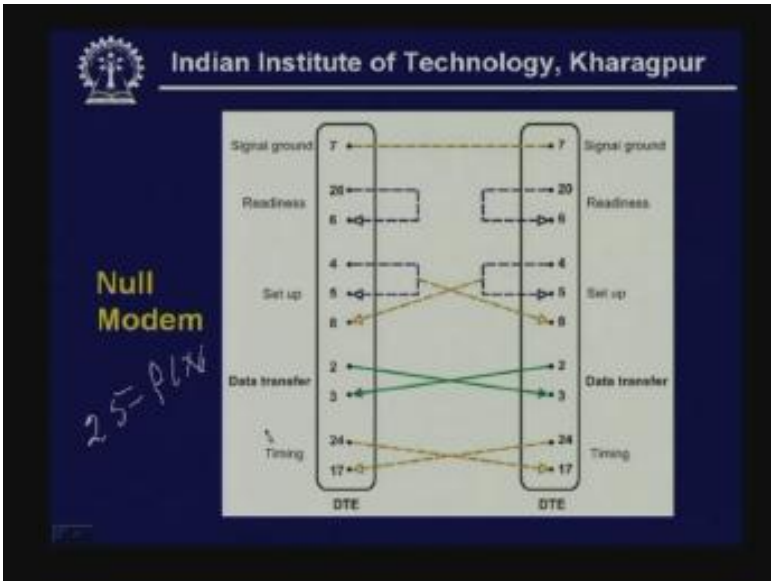

Another standard which has been proposed by ITUT to overcome the limitations of EIA-232 is the X.21. This X.21 was designed by the ITUT to overcome the limitations of EIA-232 and pave the way of all digital transmission. That RS-232 was developed in the era of analog transmission or analog communication. On the other hand, the X.21 was developed to facilitate digital transmission. What has been done here is most of the control circuits are eliminated by data traffic so that the number of pins required is small and it is replaced by data traffic that means with lesser pins but data lines have used for sending the control signals.

As I have already explained it works in the balanced circuits and data rate is 64 Kbps so it is relatively high compared to 20 Kbps. It uses a 15-PIN connector which is known as DB-15 connector and there are various timing signals used for byte control. Here it uses timing lines for byte control and pin 3 and pin 5 which are control and indication are used for handshaking. As you have seen, the request to send and clear to send are used in case of RS-232 but here that control and indication lines are used for that purpose. So in brief this gives the overview of X.21.

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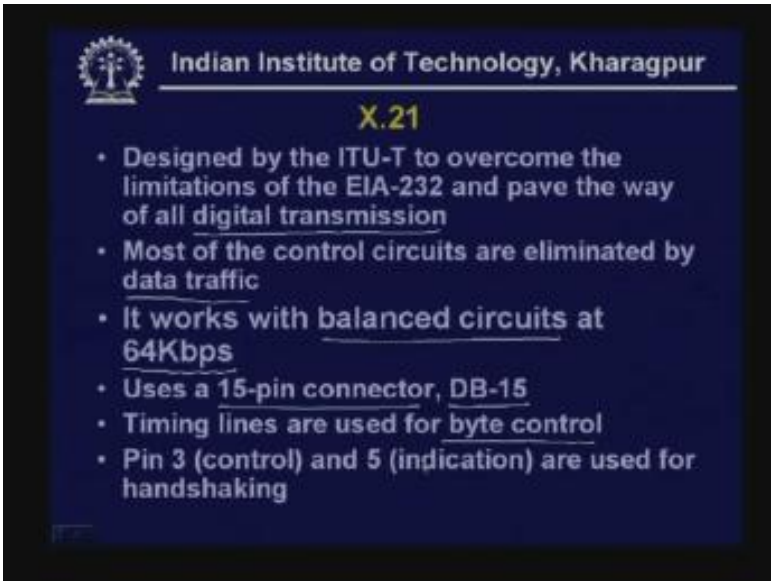

Now we shall require another important component for interfacing DTE to the communication media. We have seen the interface and now the modem is required and we have already discussed modem in detail. As you know MODEM stands for modulator plus demodulator so it is performing two functions modulation and demodulation and the modulator as you know converts digital signal into a analog signal using ASK, FSK, PSK or QAM modulation techniques and the demodulator converts analog signal back into digital signal.

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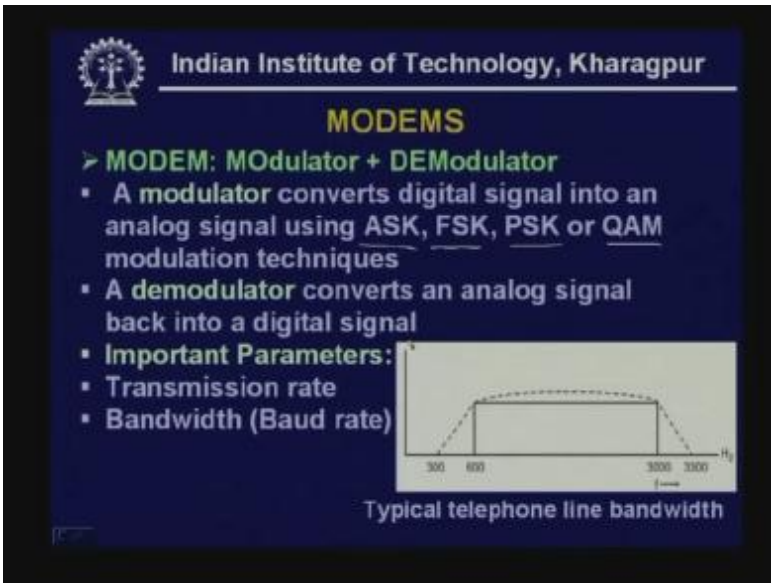

Here there are two important parameters as you know the transmission rate and the baud rate. Here are the various baud rate and data rate is explained based on different modulation techniques. As you have seen using smaller baud rate we can achieve bit rate or data rate.

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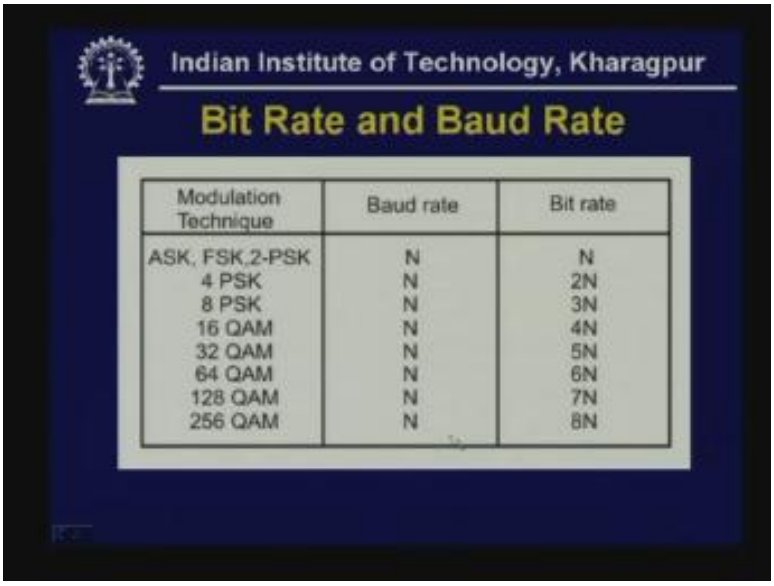

If we use 256 QAM it can be eight times. for example if we are using the typical telephone line having the bandwidth of 2400 that is the baud rate so we can multiply it by 8 if we use 256 QAM that will be data rate. So 8 into 2400 can be the data rate in this particular 256 QAM. And some modems have been developed by ITUT and Bell laboratories. The modems developed by Bell laboratories are known as bell modems and ITUT developed modems are V series modems.

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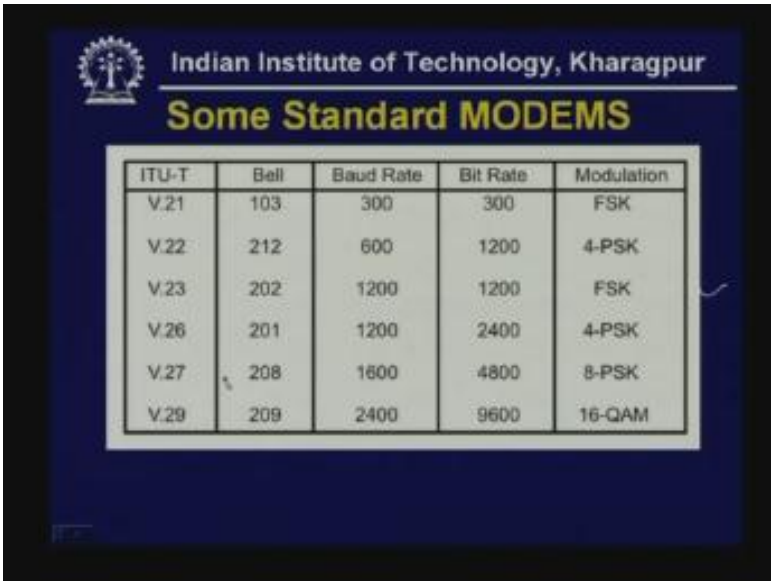

So some of these standard modems are shown here and some of them are equivalent as you can see V.21 is equivalent to Bell 103 modem having baud rate and bit rate of 300 and modulation used is FSK. And V.22 is the ITUT standard and standard bell modem is 212 having baud rate of 600, bit rate of twelve hundred which uses 4PSK and V.23 which is equivalent to bell modems 202 uses baud rate of 1200, bit rate of 1200 and uses FSK Frequency Shift Keying. V.26 bell modem equivalent is 201 uses baud rate of 1200, bit rate 2400 using 4PSK Phase Shift Keying and V.27 is equivalent to bell modem 208 baud rate of 1600 and bit rate is 4800 using 8PSK and V.29 which is equivalent to bell modem 209 provides baud rate of 2400 with bit rate of 9600 that uses 1600. There are other standards providing at most 33.6 Kbps of data transfer using modems. That is the maximum possible data transfer rate in using modes.

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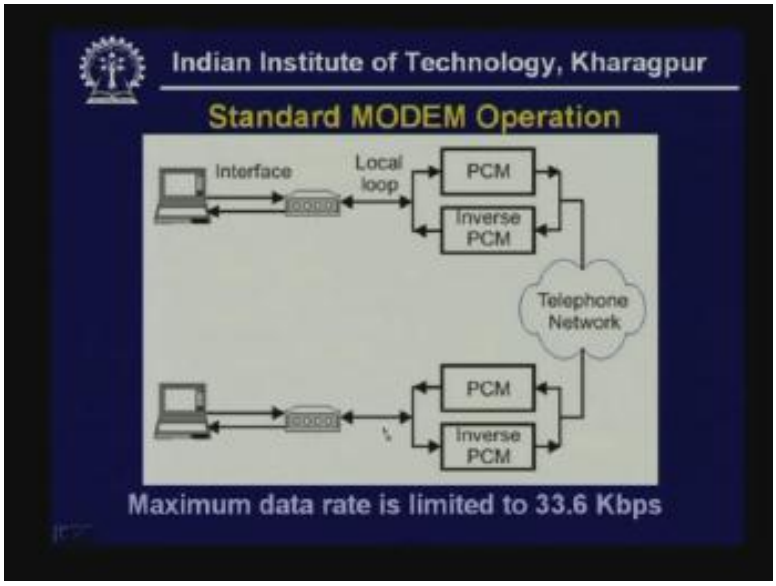

Here the standard modem operation is explained as how it is connected to the telephone network and how it works. As you can see this is the DTE or the computer and here are the modems and this is the interface it can be RS-232C RS-232 or EIA-232 whatever you call it and these are the two modems at both ends. and these modems are connected by local loop to the switching exchange and in the switching exchange it is converted into digital form by using PCM so the digital data goes through the digital telephone network and through the telephone network at the other end it is again converted by inverse PCM and that goes to the other side of the modem and again that interface is there which is connected to DTE. That's how the communication takes place. And because of the quantization possible quantization is done in PCM the data transmission is restricted by Nyquist which we have already discussed in detail and based on that maximum data rate possible is 33.6 Kbps so data transmission rate is not really very high you cannot really go beyond this when you have got this system.

However, nowadays other types of modems that are becoming popular are known as 56K modems. You may be asking how it is possible to transmit at such high rate of 56 kilo bits does it violate Nyquist criteria? In practice it is not. Let's see how it is being done.

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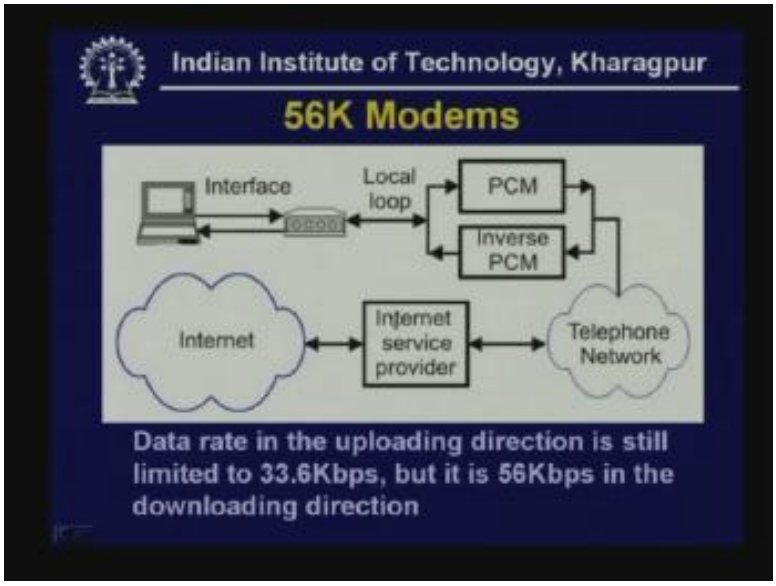

This 56K modems can be used when the other end is not connected to the standard analog telephone system but it is a digital one which is essentially the internet service provider. As you can see there are two types of signals present here. One is going from this DTE through the local loop using the PCM and it goes to the internet service provider. In this uploading direction data transfer rate is still 33.6 Kbps because of the presence of PCM here in this particular direction (Refer Slide Time: 47:10).

However, when the data is being sent by the internet service provider through the digital telephone network then there is no PCM involved here. The data is going through the inverse PCM and it is going through the local loop to the modem. In such a case the data transmission rate possible is 56 Kbps. So in the downloading direction or down link direction as you can see high data transfer rate is possible in the reverse direction. The reason for that is in this case PCM is not present so there is no question of quantization error and no question of violation of the Nyquist rate.

So we find that the 56K modems allows you data transmission at higher rate from the internet to the user which is particularly in that direction where we require high data rate, usually we are downloading more data from the internet than we are sending towards the internet. So here are the 56K modems.

So, to summarize, in this lecture we have discussed about the interface between the data terminating equipment that is your computer and other peripherals and the Data-Circuit Terminating Equipment or DCE which is commonly a modem and the standard interface that is EIA-232 has been discussed in detail. Other standards also we have discussed briefly like X.21 and some other standards proposed by EIA like EIA-422 and EIA-423 and we have discussed operation of modem how modem communicates through the telephone network between two DTEs and also we have discussed the function of the 56K modem in detail as how it provides you higher data rate.

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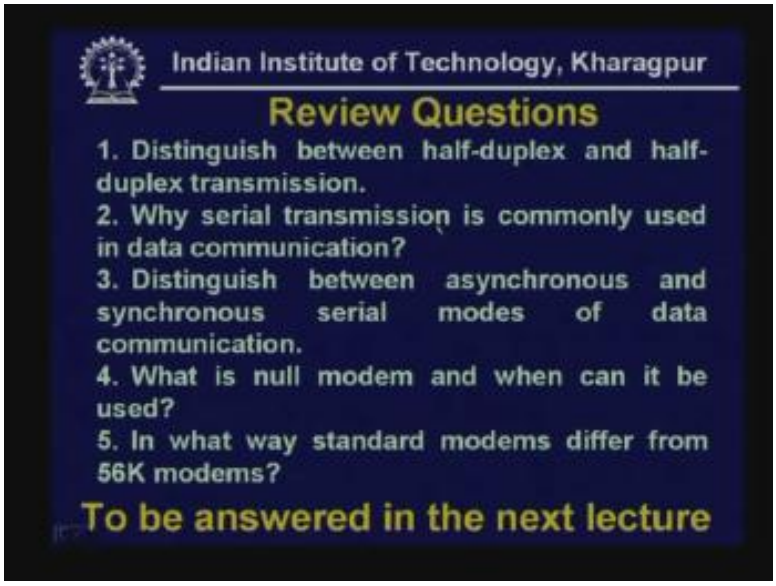

Now it is time to give you review questions.

1) Distinguish between half duplex and half-duplex and full-duplex transmission.
2) Why serial transmission is commonly used in data communication instead of Parallel Transmission
3) Distinguish between asynchronous and synchronous serial modes of data communication
4) What is null modem and when can it be used
5) In what way the standard modems differ from 56K modems

These questions will be answered in the next lecture.

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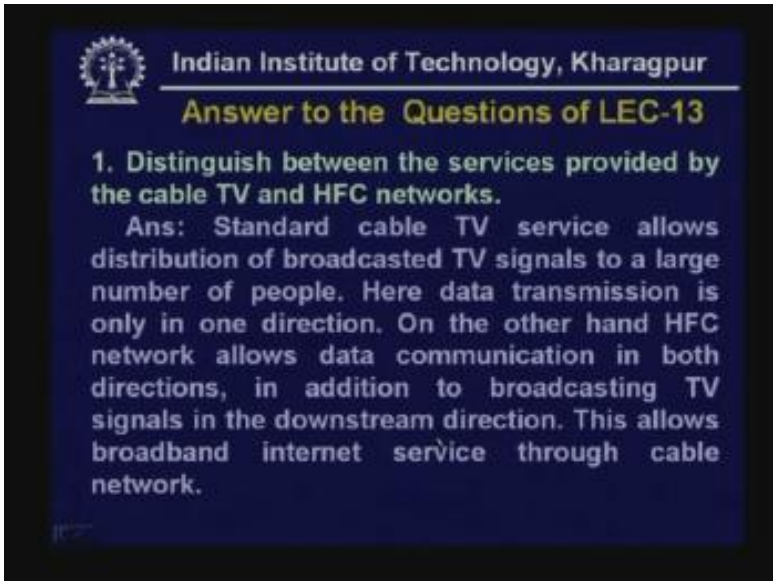

Answers to the questions of lecture-13:

1) Distinguish between the services provided by the cable TV and HFC networks.

The standard cable TV service allows distribution of broadband TV signals to a large number of people. Here data transmission is only in direction. On the other hand, in HFC Hybrid Fiber Coaxial network the data transmission is in both directions. So in addition to broadcasting TV signal in the downstream direction it allows broadband internet service which is bidirectional through the cable network.

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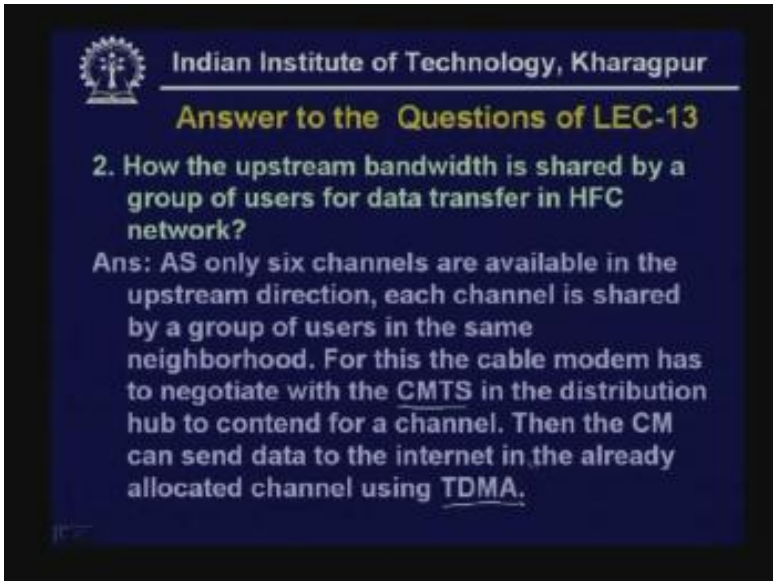

2) How the upstream bandwidth is shared by a group of users for data transfer in HFC network?

As we know only six channels are available in the upstream direction so each channel is shared by a group of users in the same level. for this the cable modem has to negotiate with the CMTS in the distribution hub as CMTS is present in the distribution hub to contend for a channel then the CM can send data to the internet in the already allocated channel using TDMA Time Division Multiple Axes. So, this concept of multiple axes will be discussed in more detail later on.

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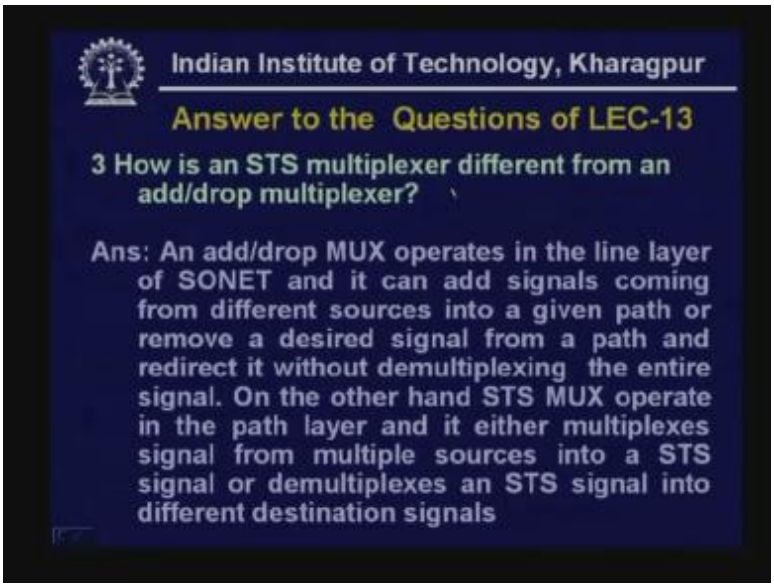

3) How is an STS multiplexer different from a add drop multiplexer?

The add drop multiplexer operates in the line layer of SONET and it can add signals coming from different sources into a given path or remove a desired signal from a path and redirect it without demultiplexing the entire signal. On the other hand, STS multiplexers operate in the path layer and it either multiplexes signal from multiple sources into STS signal or demultiplexes an STS signal into different destinations. We have seen that STS multiplexer signal is responsible for converting electrical signal to optical signal and optical signal to electrical signal.

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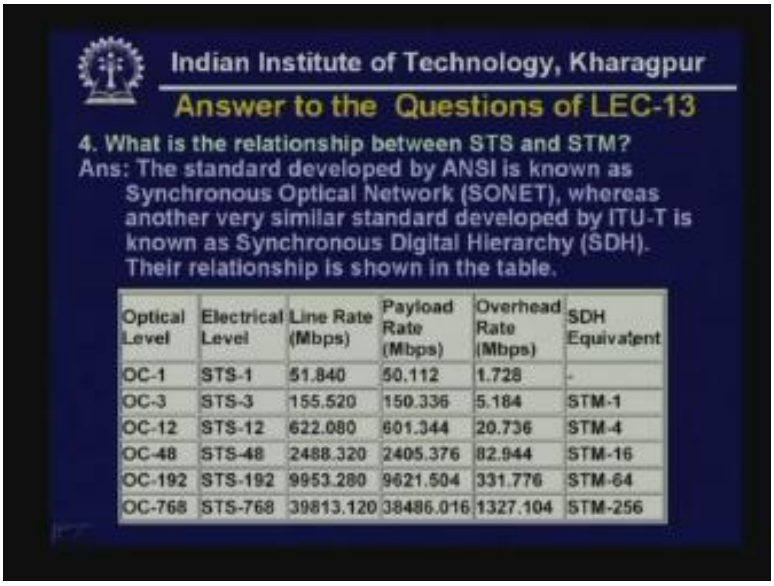

4) What is the relationship between STS and STM?

The standard developed by ANSI is known as Synchronous Optical Network SONET whereas another very similar standard developed by ITUT is known as Synchronous Digital Hierarchy or SDH. Their relationship is shown in this table.

As you can see OC-1 is not present in SDH, it has no SDH value. On the other hand, OC-3 is equivalent to STM-1, OC-12 is equivalent to STM-4, OC-48 is equivalent to STM-16, OC-192 is equivalent to STM-64 and OC-768 is equivalent to STM-256. These are some of the popular signal levels shown here.

We have already discussed in detail the line rate, payload rate and overhead rate for the different levels.

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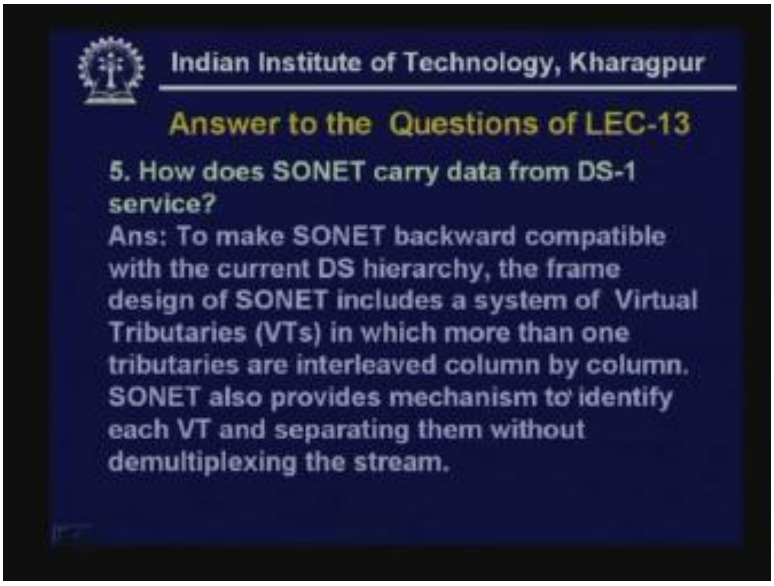

5) How does SONET carry data from DS-1 service?

To make SONET backward compatible with the current DS hierarchy the frame design of SONET includes a system of virtual tributaries in which more than one tributaries are interleaved column by column. And SONET is also provided mechanism to identify each VT Virtual Tributary and separating them without demultiplexing the stream. So with this we come to the end of today's lecture, thank you.