Data Communication
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Lecture No # 6
Unguided Media

Hello and welcome to today's lecture on unguided media.

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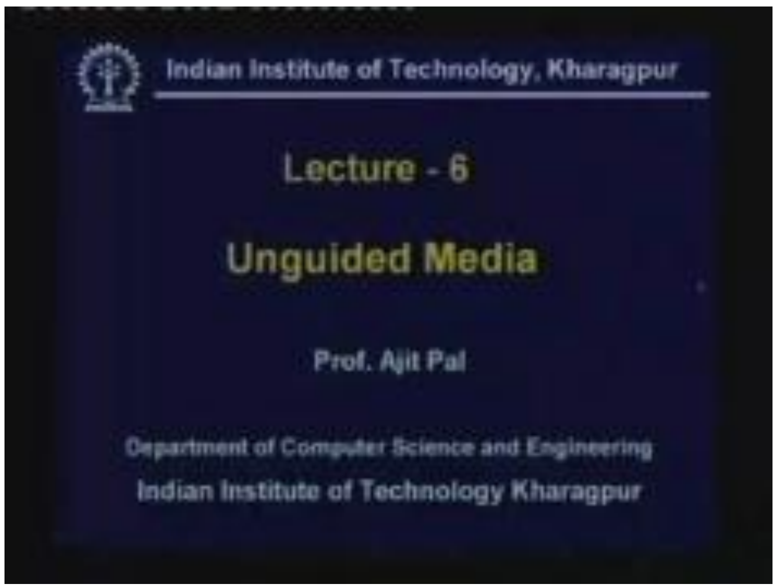

On completion of this lecture the students will be able to explain:

Propagation methods in wireless communication system
Broadcast radio communication
Terrestrial microwave communication
Satellite microwave communication
Infrared communication and
Compare wireless communication techniques.

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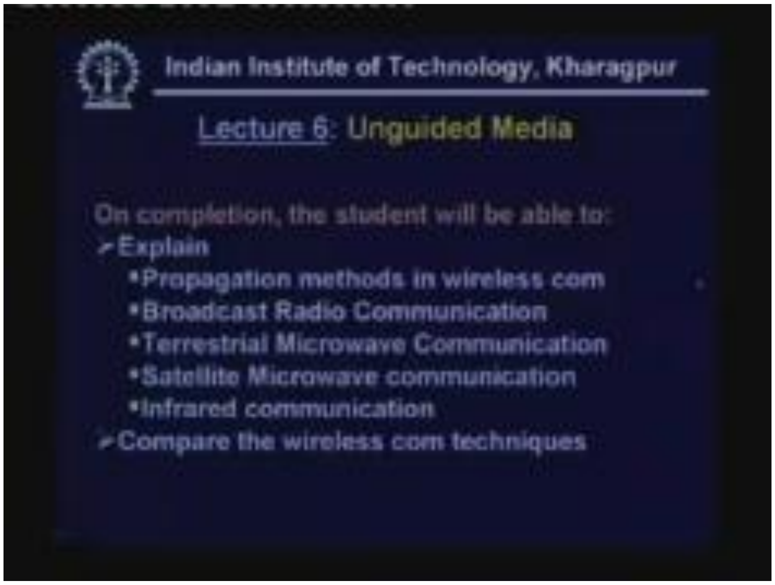

Here is the outline of this lecture:

I shall give a brief introduction about this lecture, why this wireless communication is so important in the context of data communication systems. Then we shall discuss about spectrum of wireless communication, various frequencies kept spectrums that are used for wireless communication then various configurations which are used for wireless communication.

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Then we shall discuss various propagation methods such as broadcast radio in the context of wireless communication then we shall discuss broadcast radio, terrestrial microwave and satellite microwave and finally the infrared communications. So essentially we shall be covering these four wireless communication techniques such as broadcast radio, terrestrial microwave, satellite microwave and infrared communication.

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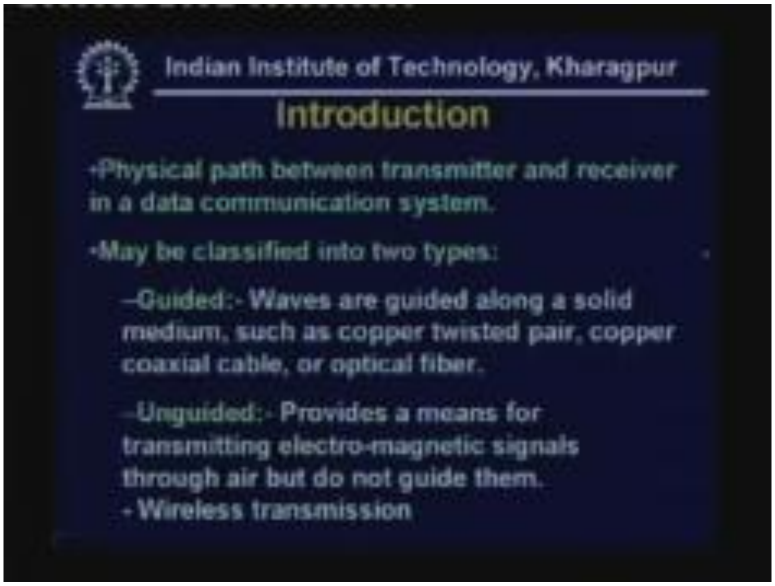

As I mentioned in the earlier lecture the communication media provides the physical path between transmitter and receiver in the data communication system. As you know it can be divided into two broad types; guided transmission media and unguided media. And in the last lecture we have discussed in detail the various guided communication media such as twisted pair of cable, coaxial cable and fiber optic cable.

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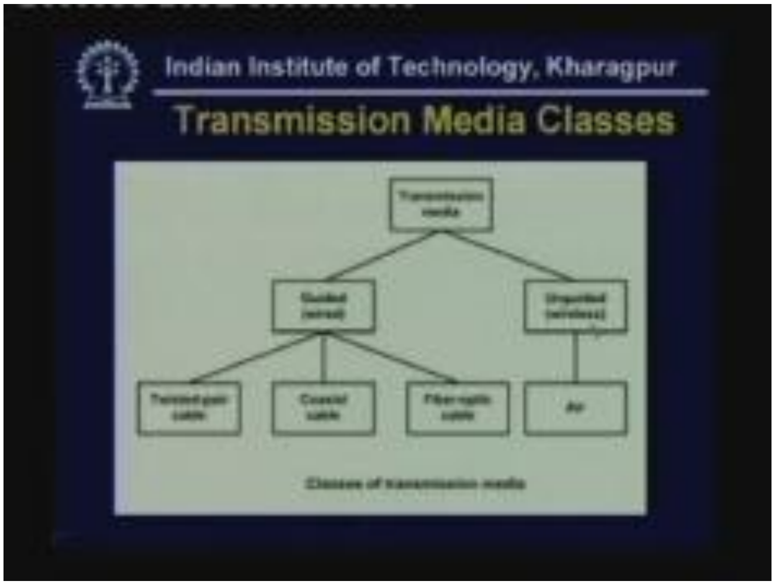

Now in case of unguided media it provides a means for transmitting electromagnetic signals through air but do not guide them so we may call it wireless communication. The question naturally arises as why wireless communication is so important so it is with the proliferation of portable mobile equipments such as laptops, palmtops, cell phones, PDAs and so on. What is happening is people are carrying various electronic equipments with them. As a consequence they want to communicate from any location so how that is feasible. That cannot be supported by guided or wired communication media. So, any time communication is feasible only by wireless communication and that is the topic of today’s lecture.

Broadly as you can see the electromagnetic spectrum used for wireless communication is divided into three parts; the radio wave and microwave again this can be divided into two parts radio communication and microwave communication as we shall see then there is infrared and then light wave. So this wireless communication is possible in these three ranges.

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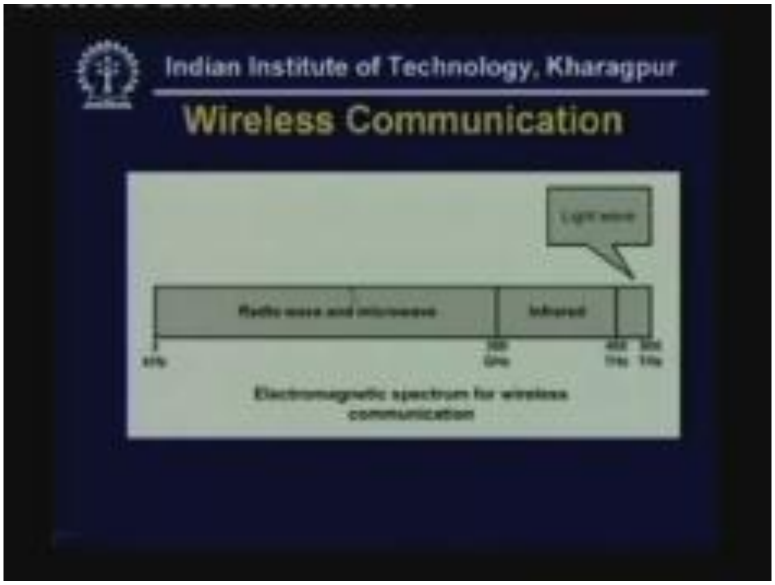

Now, in case of wireless communication as I mention in the last lecture communication is dependent on the antenna. Antenna plays a big role in wireless communication. The characteristics of the antenna and the frequency spectrum that it transmits in the air will play an important role. Or in other words it will decide the quality of transmission, the bandwidth of signal and various other things.

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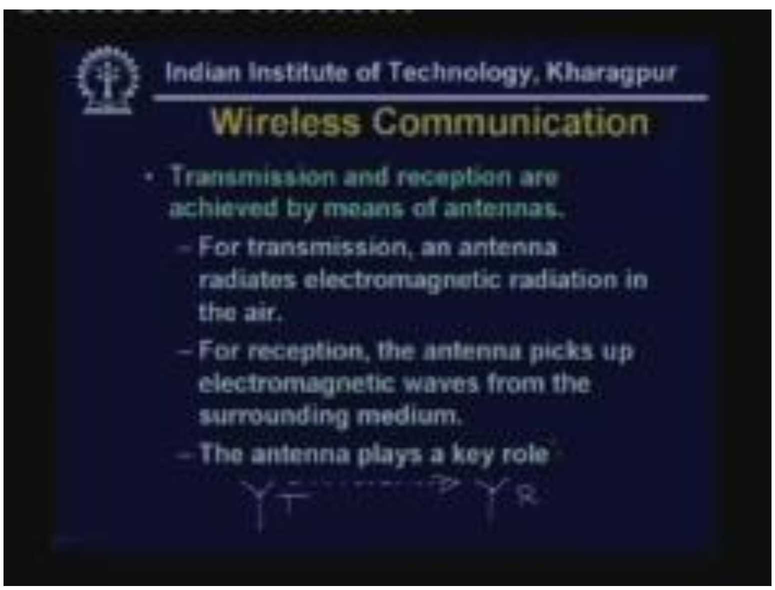

So, for transmission what we require is an antenna that radiates electromagnetic radiation in the air and for reception we also require another antenna that will pick up electromagnetic waves from the surrounding media. So it is somewhat like this (Refer

Slide Time: 5:50) you have got an antenna which is the transmitter and here you have got another antenna so this is your transmitter and this is your receiver so electromagnetic signal that is passing will go from one to another through this antenna. And in this case as I mentioned an antenna will play a very important role a key role as we shall see.

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Basically there are two types of wireless communication. In one case it is called point to point communication and in this case transmitting antenna puts out a focused electromagnetic beam in a particular direction. So the antenna will focus a signal in a particular direction and in that case the transmitter and receiver must carefully align and obviously this will allow point to point communication. So in this configuration you have got two antennas which are communicating with each other so it is a point to point communication. This is one possible configuration. The second possible configuration is the transmitter signal spreads out in all directions. In such a situation wherever the signal spreads out in all possible directions the signal can be picked up by many receivers with the help of antennas. So the signal can be received by many antennas which is known as broadcast communication. We have got two basic configurations; point to point and broadcast. So there are various ways of doing it.

Now let us discuss the various propagation methods, the methods by which communication takes place in the air. First one is known as ground propagation. Ground propagation will take place below two mega hertz. We have seen that this ground propagation is possible below two mega hertz and in this particular case communication take place with the help of ground signals.

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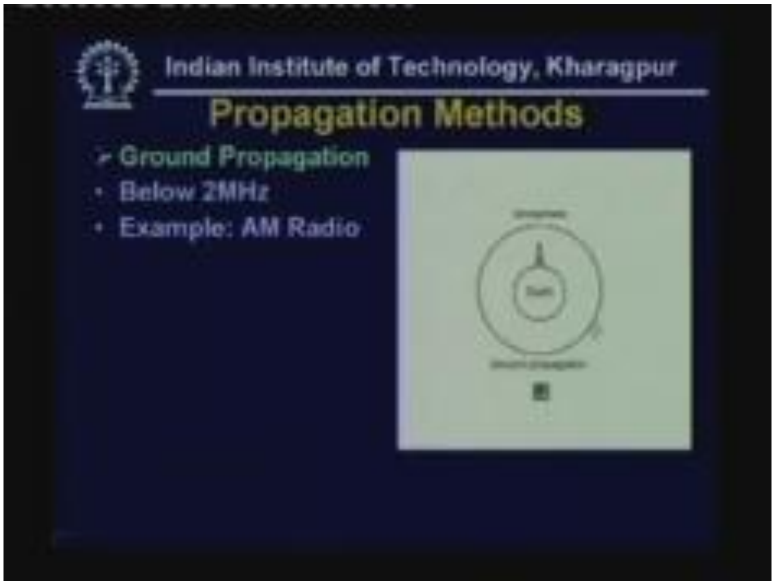

Before that let me explain the overall situation. suppose this is earth then you have got air then there is ionosphere, why it is called ionosphere is because in that upper layer of the atmosphere the air is in charged condition that means ionized condition, there are positive and negative particles that’s why it is called ionosphere. So you have got earth then I have shown an antenna and here is the ionosphere. So ionosphere will play an important role in some cases as we shall see but let us see what happens in case of ground propagation.

In case of ground propagation as you can see ionosphere does not play any role. So what is happening here is the signal is propagating in all directions and signal is hugging the earth. So the signal is propagating by hugging the earth so around the ground the signal is going on. As a result with along the ground it can propagate over long distances. One typical example is AM radio which we listen like Calcutta A, Calcutta B and so on. That AM radio is the example of this ground propagated signal. Now this is the first mode of communication.

The second mode of communication is known as sky propagation. This sky propagation is possible for frequency range from 2 to 30 MHz, 2 to 30 MHz of signal can propagate through air and in this case the mode of propagation is known as sky propagation. Why it is called sky propagation? In this scale as we shall see the electromagnetic signal which will come out from the transmitter will go to the ionosphere layer then it will bounce back. Let us see how it happens.

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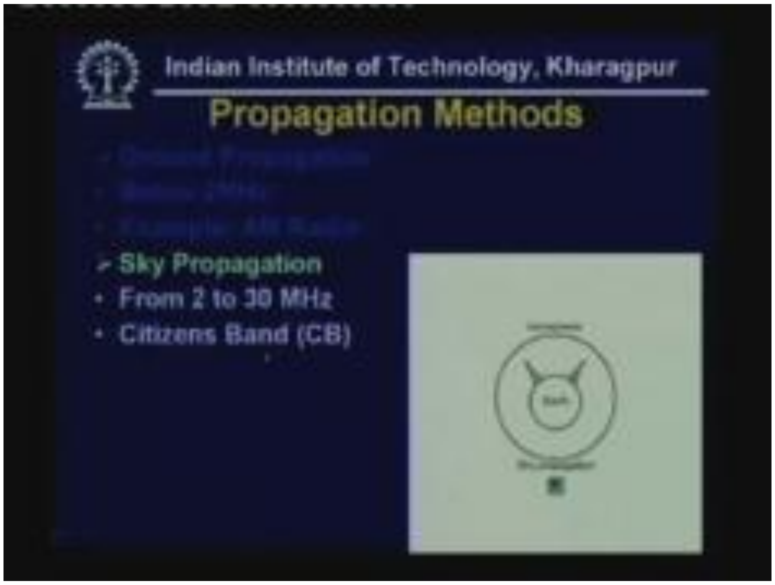

So as you can see the way in which signal is propagating then it is reflected back by the ionosphere and it is receiving the antenna. So the signal gets reflected by the ionosphere and comes back to the receiving antenna. In this case the ionosphere plays a very important role because as you ionosphere is at a much upper layer of the atmosphere and with the help of this sky propagation the signals can be sent over a very long distance. For example we hear Voice of America radio picking and various short wave signals that comes through sky propagation and the citizens when radio is in thousand in range. So sky propagation is very useful for long distance communication with the help of the ionosphere.

Then the third mode of communication as I mentioned is the line of sight communication that is above 30 MHz. And above 30 MHz the signal behaves somewhat light as the frequency is very high and the wavelength is small so in this case it has to be a point to point communication. The signal gets obstructed if there is building, if there is some artificial or natural structure. So in such a case you must have line of sight propagation.

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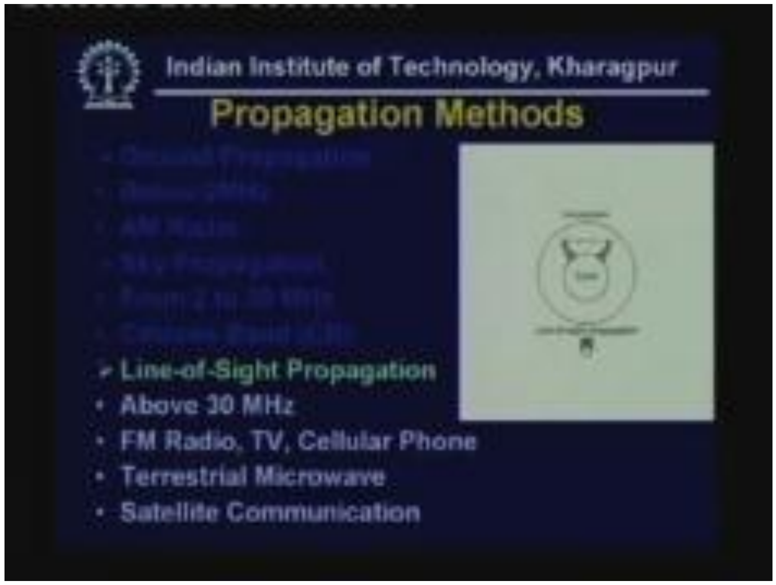

Here we have got two antennas both are communicating with each other with the help of line of sight communication. So in this case the requirement is that the antenna must be relatively quite so high so that the line of sight communication is visible and as you know that FM radio, television signals, cellular phone, terrestrial microwave, satellite microwave all these uses the line of sight communication. That means sky propagation and ground propagation is essentially broadcast communication.

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On the other hand communication which takes place for frequencies above thirty mega hertz is line of sight communication.

The wireless transmission techniques can be broadly divided into three types as I mentioned earlier. First one is radio wave, second one is microwave and the last one is infrared. So first one is in the radio frequency range, second one is the microwave range and this is essentially light and we have the very high frequency range that is infrared as you have seen in that frequency spectrum. These are the broad wireless communication techniques that we shall discuss.

First let us consider the broadcast radio. As I mentioned the broadcast radio operates in this range 30 MHz to 1 GHz and in this case the communication is omnidirectional in nature. Omnidirectional in nature means it propagates in all directions from the antenna. As you can see here the signal is propagating just like a wave in all directions from the antenna just like if you throw a stone in a pond the waves propagate in all directions with that as the center point.

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Similarly here the antenna is the center point with that antenna is the center point the wire is propagating in all possible directions as you can see here. So this wave propagation is omnidirectional in nature which propagates in all direction.

But here the communication has to be line of sight. This is a very important characteristic in this case. The signal gets obstructed by other structures so it has to be line of sight communication. And as a consequence the distance that it can communicate distance that can be covered is given by this relation 7.14 root Kh. This is the equation that is used for maximum distance where h is the height of antenna so h is essentially height of the antenna and this k is a correction factor that is equal to 4 by 3. That means there is some bending of this electromagnetic signal as it goes from the transmitter to the receiver. As a result it covers a little more than what is possible by line of sight communication. So that factor is taking care of by k and as you can see here the distance that it can cover is 7.14

so that's what you normally do. As you can see in this particular case you have put the antenna height quite high.

Usually there is a tower on which the transmit data antenna is installed or that antenna is on the top of a root or antenna is on top of a building or sometimes on top of a mountain. So, to cover a larger area usually the antenna is placed on some height and that height of the antenna is made higher so that you can reach longer distance and in this frequency range 30 MHz to one GHz it can penetrate well that is one advantage as well as disadvantage.

What is the advantage? The advantage is that this type of signal you can receive inside your room because the antenna can be inside the house or inside the room. So the signal can penetrate the wall and can reach you so that way it is advantageous but its disadvantage is there is no privacy. And since it is a broadcast signal it can be received by many people. So if you want to send some private signal which should not be communicated to others you cannot do that. However, you can do that by using encryption which we shall discuss later.

And for these types of signals the ionosphere is transparent. What do you mean by that? For this kind of communication the signal passes through the ionosphere, it is does not get reflected by the ionosphere. So the problem of multipath communication does not exist. In other words multipath communication leads to many problems. What are the problems that can arise? Because of that you can have some kind of fading which you must have observed in case of short wave radio. Whenever you listen to some short wave radio which comes by sky propagation and not this range so in such a case what happens is there is fading. So in this particular case there is no problem of fading and multipath propagation does not take place, you receive signal directly from the transmitter to receiver that is an advantage in this particular frequency range 30 MHz to 1 GHz.

However, here the attenuation is dependent on two parameters and it is given by this relationship 10log4 pi d by lambda square. So as you can see here d is the distance and the attenuation increases at the rate of b squares. And as the distance increases the attenuation increases significantly that's why longer the distance the weaker the signal becomes. Moreover the attenuation is inversely proportional to the square of the wavelength. That means higher frequencies are attenuated more than the lower frequencies. This is another characteristic of the frequency range and these types of signals are less sensitive to rainfall.

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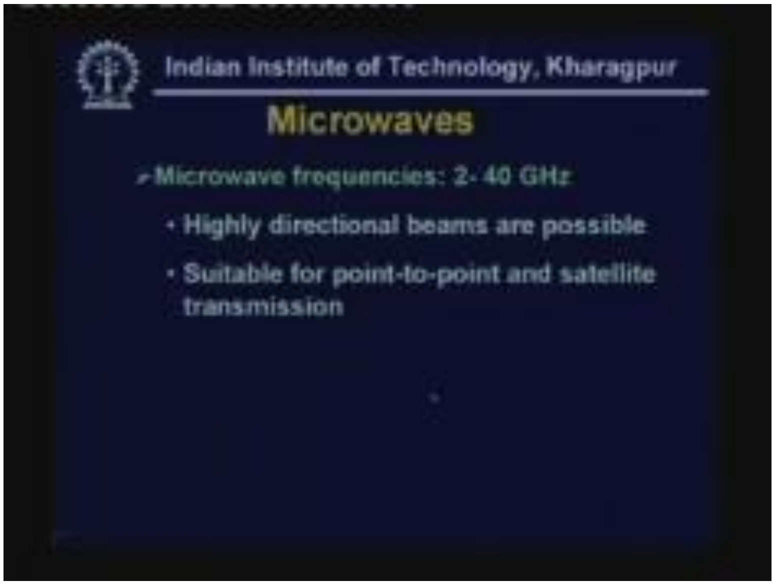

And as I mentioned signal can travel long distances and multipath interference does not exist in this particular case. So these are the several parameters or characteristics of broadcast radio.

The typical applications of broadcast radio are FM radio, television, data networking etc. After broadcast radio communication comes the microwave frequency, microwave frequency lies in the range 2 to 40 GHz. So in this case range 2 to 40 GHz is quite a high frequency and in this case it is possible to have very highly directional beams. that means you can send highly directional beam from the transmitter towards the receiver and you can have point to point communication and that's why it is very suitable for point to point and satellite transmission. And for that purpose usually we use two different types of antennas. As you can see here this antenna is known as horn antenna, this is known as horn antenna. So here the signal comes (Refer Slide Time: 21:40) and then it gets reflected by this particular shape of the antenna then all the rays travel in a particular direction so there is some kind of parallel beams of light that goes in a particular direction.

Therefore from the transmitter it comes here to the antenna then it gets reflected in this way then it reaches another type of antenna which is known as dish type of antenna. This is known as dish type antenna and this is horn type antenna.

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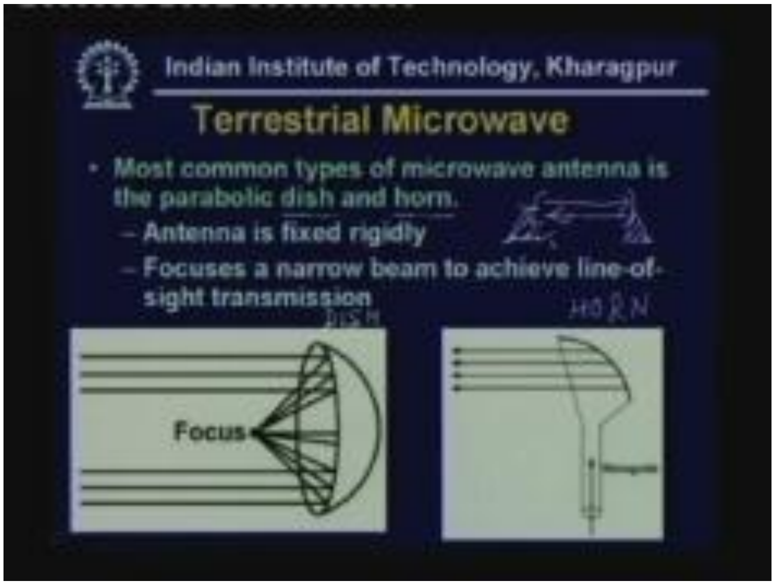

So here you can see that the horn type of antenna receives parallel signals then it focuses it at a particular point and at this point some sensor is kept and then this signal is taken to the amplifier for amplification and for other things. So both these antennas are fixed rigidly because here it has to be of point to point communication. So the antenna must be placed very rigidly in one place like this and this is another antenna placed very rigidly in another place with the help of some structure which helps us to have point to point communication between these two antennas.

So it can focus a narrow beam to achieve line of sight communication as I mentioned with the help of these two types of antennas. This microwave communication has got two varieties; first one is terrestrial microwave. In case of terrestrial microwave it is used for long haul communication and usually it uses this 4 by 6 GHz band.

Obviously since the frequency is in the lower end it requires bigger antenna of 10 m or more diameter and it is primarily used for long haul communication. Long haul communication means whenever we have to transmit signal over a long distance. For example, let us assume that this is the surface of the earth then you can erect antenna like this (Refer Slide Time: 24:02) so it will transmit in this direction then you can place another antenna here so it will receive signal from this so it will go here then after receiving it it will do the amplification and transmit to another antenna.

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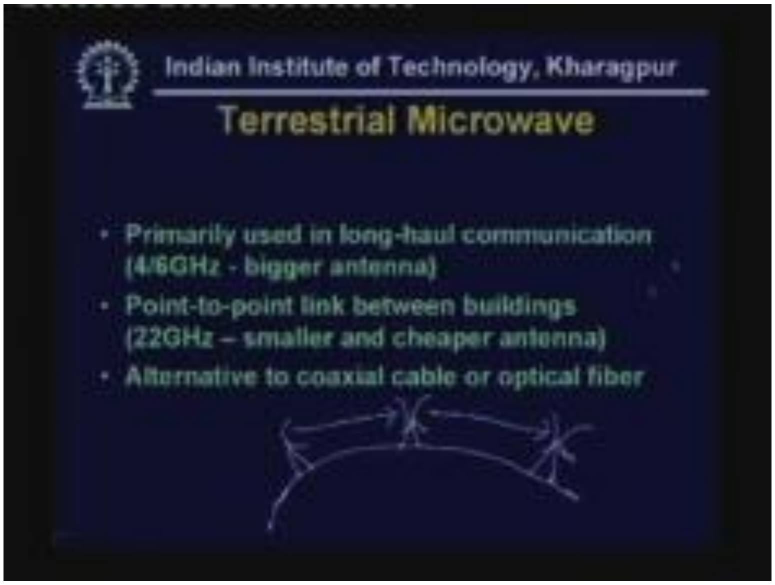

In this way a cascade of antenna can be used one after the other to send signal over a long distance. So, not only this type of communication is possible by this but you can also have point to point link between buildings. In this particular case you can use higher frequency so that antenna size is small which is of 20 GHz so the antenna will be smaller in size and cheaper in cost.

And this terrestrial microwave can be used as an alternative to coaxial cable and optical fiber. As you know coaxial cable and optical fiber is also used for long haul communication in telephone. Instead of using the coaxial cable and optical fiber one can use terrestrial microwave. But in this case as I mentioned the antenna has to be properly placed and then the height should be proper and distance should be adjusted so that the signal reaches the antenna and the signal is amplified and then be transmitted. So essentially they are acting as repeaters. And as I mentioned in this case also the formula of maximum distance d is equal to 7.14 root kh is applicable.

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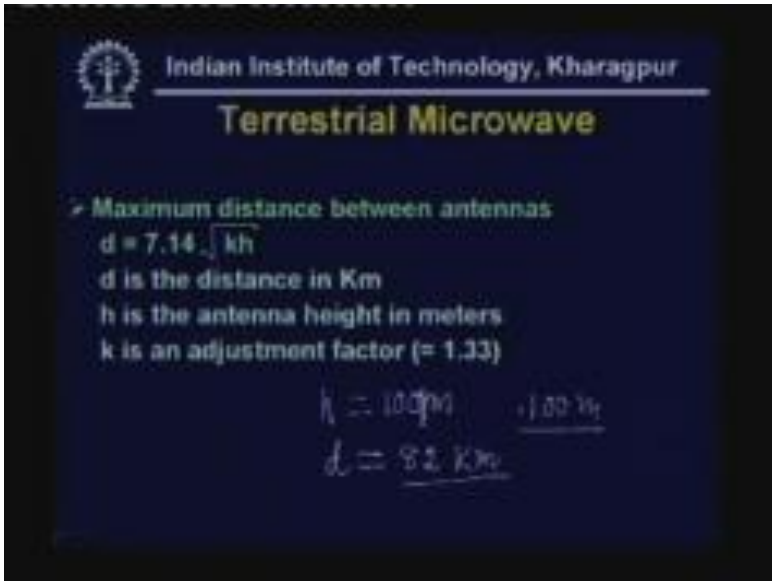

Here d is the distance in kilometer and h is the antenna height in meters. And as i mentioned the value of k is an adjustment factor because it is not fully line of sight but the signal gets bent and the adjustment factor is 4 by 3 that is 1.33.

Let's assume that antenna height h is equal to 100 m. So, if we substitute this here by taking the value of k is equal to 4 by 3 then you will find that the distance is roughly equal to 82. As this is 100 m this will be roughly equal to 82 Km so with antenna of height 100 m you can have the distance that can be covered as 82 Km. So here the height of the antenna is in meters and distance is in kilometers.

Therefore with an antenna height of 100 m you can cover a distance of 82 Km that's why we will be finding repeaters at a range of 60 to 80 or 100 Km distance because antenna height is typically around 100 m.

For example, if you come from Calcutta to Kharagpur near Paspura so it is midway that means around 60 Km you will find there is microwave towers which are acting as repeaters between the signals coming from Calcutta to Kharagpur or Kharagpur to Calcutta. This is the distance and height relationship then comes the transmission characteristic that is attenuation. Therefore as I mention here also the attenuation characteristic is 10log4 pi d by lambda square that means the attenuation is proportional to distance square and inversely proportional to wavelength or attenuation is proportional to frequency. That means higher frequency signals are attenuated more.

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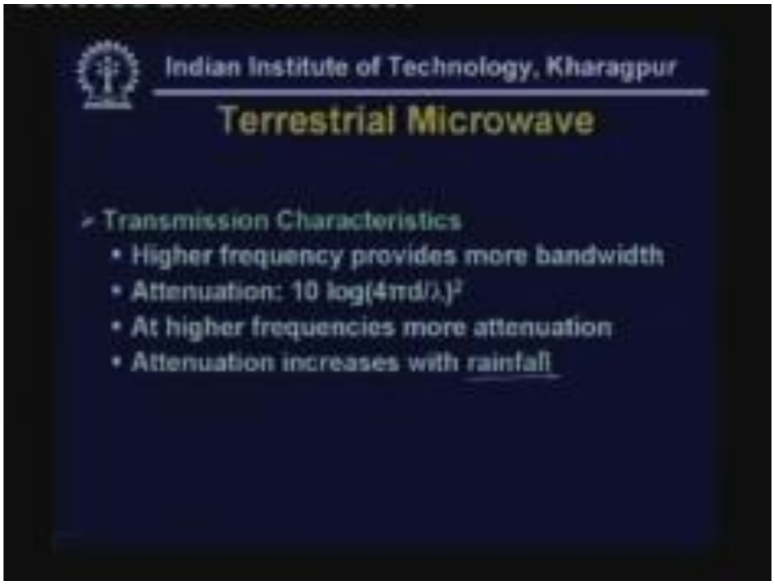

However higher frequency signals provide more bandwidth. That means we prefer to use higher frequency bandwidth, higher frequency for communication because it gives you higher bandwidth. But higher frequency gives you more attenuation. So it's some kind of trade off so we have to judiciously select the frequency so that you don't have much of attenuation but at the same time get reasonably good bandwidth.

For microwave signals attenuation increases with rainfall. This is a very important factor. That means the frequencies in this range are affected severely by rainfall. Apart from distance, apart from frequency we can see rainfall plays a very important role in attenuation. That means when the weather is bad or during rainy conditions the signal will be poor and that is the reason why more error occurs during rainy season. The signal to noise ratio degrades so as a result more error occurs in the signal.

We have discussed the terrestrial communication now comes the satellite microwave communication. We have seen in the previous slide that distance d is proportional to 7.14 root kh. That means if we can make the height very high we can probably cover a very large distance so why not put an antenna in the sky that is the basic idea of satellite microwave. So, in satellite microwave what we are trying to do is we are trying to put a relay station in the sky at a very large distance. So in this case we shall see the antenna height is quite large for example it can be as high as 36000 kilometer. Hence this will allow to cover a very large distance.

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And here with the help of this microwave you can link two or more earth stations. There can be two earth stations and essentially that antenna in the sky the satellite will be acting as relay station. Thus with the help of that relay station two or more ground stations can communicate with each other because we can have two different modes of communication. Again it can be point to point or broadcast. Let us see the configurations.

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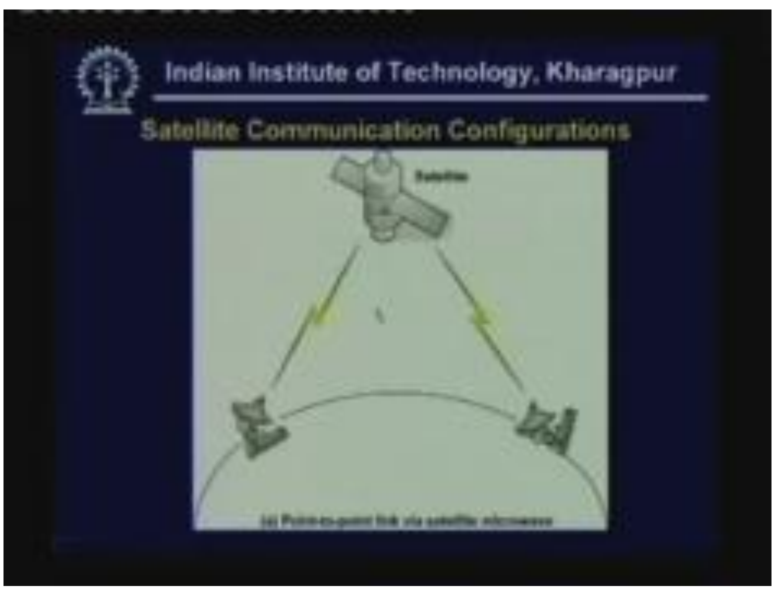

So in this particular case as you can see it is a point to point communication. Here we have got the satellite in the sky and here you have got the two ground stations. This is one ground station and this is another ground station. So here there is a point to point link and here the signal is going from this ground station to the satellite, here it is received and then amplified and returns back to the station so signal from here also goes to the satellite, here it is received then amplified and then it is returned back to this ground station (refer Slide Time: 31:55) so this way it can cover a very long distance. And this is the second alternative where you can achieve broadcast with the help of satellite microwave.

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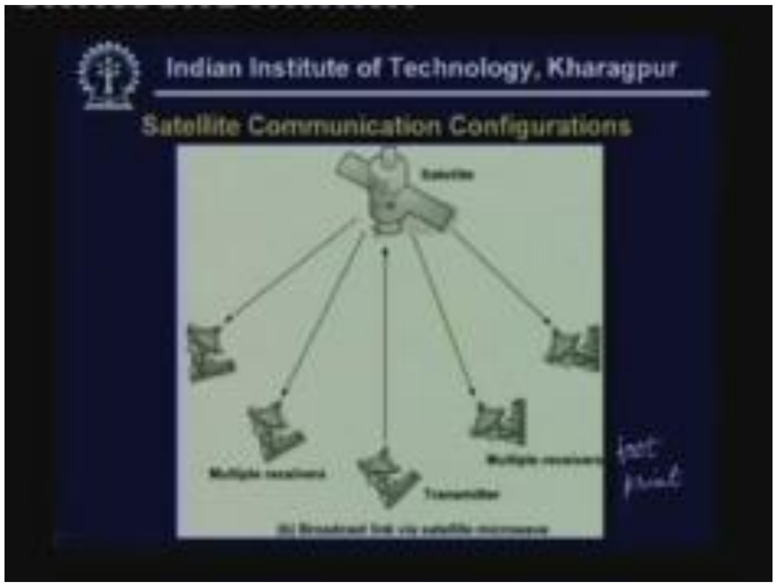

Here you have got the satellite and it can cover a quite large area which is in the footprint it is called the footprint of the satellite. All the ground stations which is under the satellite in the footprint of the satellite can receive signal from here. So here you have got one transmitter so from this transmitter the signal goes to the satellite and then it is transmitting to a number of stations, it is broadcasting the signal to a number of other stations. So you can see here this is broadcast link via satellite microwave communication.

Now question arises as where do we put the antenna in the sky? There are two alternatives. One alternative is the satellites can be about say 800 m above the earth that is one possibility but not very high. Then a large number of satellites can rotate and with the help of that communication can be done. But it has been found that the most conventional way or the most popular way is geostationary orbit.

Let us go back to the previous diagram (Refer Slide Time: 33:45), in this case the advantage is what we want is that the satellites should remain stationary with respect to the sky with respect to the earth. That means if this is the earth and here there is a ground station and here is another ground station they want to communicate with the help of the satellite. So here you have got the satellite (Refer Slide Time: 34:11) and if the communication has to be reliable and steady it is essential that this satellite remains stationary with respect to the earth, so how that can be achieved. That can be achieved by placing the satellite in the geostationary orbit and the distance is about 35784 Km so distance is high it is quite large. So at this height you have put the antenna and it remains stationary because it is placed in geostationary orbit so relative position of this ground station with respect to the satellite does not change.

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What are the advantages of this?

One big advantage is that the satellite can cover a very large distance because the height of the antenna is very large and it can be shown that with the help of three antennas the entire globe can be covered.

For example, here you have got your earth so one satellite here, one satellite here, and 120 degree apart from this you have another satellite and here you have another satellite (Refer Slide Time: 35:40) so with the help of these three satellites one can cover the entire earth so the entire globe can be covered with the help of three satellites so this is a big advantage, the height it is utilized and you can see to communicate any ground station on the earth only three satellites are sufficient so this is one very big advantage. However, now there is competition to put satellites in the sky. All the countries are competing with each other to put a satellite of their own in the sky and that has created a problem and particularly we cannot have many satellites, there is some restriction.

For example you have got only 360 degrees. So when you have got three sixty degrees in the geostationary orbit then a minimum of four degree spacing is required if we use 4 by 6 GHz band and a minimum of three degree spacing is required if we use 12 by 14 GHz band and as we shall see these are the popular frequency bands used for microwave communication.

So the number of satellite is restricted because of these minimum spacing required so that there is no interference between the signals of generated by two satellites because they are using this common frequency bands 4 by 6 GHz frequency band or twelve by 14 GHz frequency band

Then one another very important characteristic is that you can have the number of transponders and a single orbiting satellite operate on a number of frequency band called transponders that means the single satellite can operate on a number of frequency bands during that four or six 4 by 6 GHz frequency band.

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And with the help of number of transponders the communication with many ground stations is possible. Moreover the satellite receives transmission on one frequency band amplifies and repeats the signal and transmits it onto another frequency band so you have got two frequencies as you can see. One is known as uplink frequency and the other one is the downlink frequency. So here is your satellite and here is your ground station. These two can communicate with the help of two frequencies. Therefore you have to use two separate frequencies so that there is no interference and with this a two way communication is possible.

And here is the common frequency bands used as you can see C band 4 by 6 GHz band and here the downlink frequency range is 3.6 to 4.2 GHz then uplink frequency band is 5.925 to 6.425 GHz so this is downlink frequency band and this is the uplink frequency band. Similarly for q band this is 12 by 14 GHz band and as you can see here the downlink frequency is 11.7 to 12.2 GHz and uplink frequency is from 14.0 to 14.5 GHz.

Similarly there is another frequency band known as ka frequency band which is in the range of 18 by 28 GHz, the downlink frequency is 17.7 to 21.0 GHz and uplink frequency is 27.5 to 31.0.

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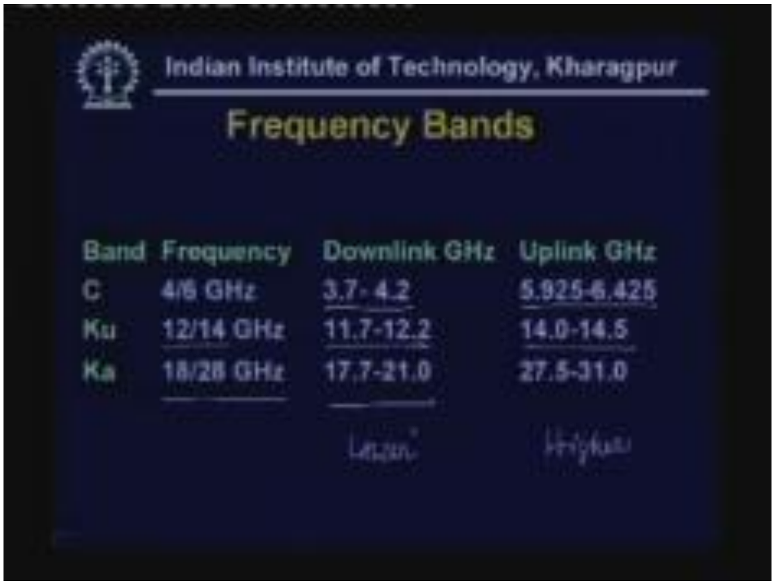

Here one point you must notice that downlink frequency band is lower and here we are using higher frequency, the uplink frequency is higher, what is the reason? One possible reason for that is, as you know higher frequency is attenuated more because the attenuation is proportional to frequency square or 1 by lambda square. So since the satellites are powered by solar cells there is constraint on the availability of power so the satellites could not put high power.

On the other hand ground station can put much higher power in the antenna so uplink frequencies with higher frequency bands can drive with higher power which can sustain higher attenuation. On the other hand downlink frequencies transmitted by satellites which are powered by solar cells cannot have very high power so they choose lower frequencies so the attenuation is lesser for downlink signals than the uplink signals. Therefore here the uplink signals are compensated by higher power of the ground stations.

There is another very important innovation which is the Very Small Aperture Terminal, it is a very low cost solution. Here as you can see a number of subscriber stations are equipped with low VSAT antennas. Particularly whenever communication has to be established among a number of geographically dispersed stations this is a very convenient technique of achieving it.

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Here what can be done using some protocol these stations can share a satellite channel for transmission to a hub station this is hub based, there will be a central station called hub station and the hub station can exchange messages to each of the subscriber as well as relay messages between the subscriber. So we can see here this VSAT is a very low cost alternative to have communication among number of stations. Let us see how this is done.

This is the typical VSAT configuration and this is the hub. Here you have got the hub and these are the ground stations. Here (Refer Slide Time: 42:45) as you can see the size of these antennas is small and that's why it is named so.

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VSAT stands for Very Small Aperture Terminal. By Very Small Aperture Terminal we mean that the diameter of this antenna will be quite small compared to the hub. And in the hub the diameter can be around say ten meter. On the other hand these VSAT terminals can have much smaller diameter around say 1 m a little more than a meter in diameter, it depends on the frequency ((43:27)) that is being used. For q band satellite it can be quite around 1 m even lower.

So you can see here how communication is taking place. So each of these VSAT antennas can send signal as you can see here 1 2 3 so it can send n such stations and as we can see here they are going in some time division multiplex form that will go to the hub. Then the signal coming from the hub is broadcasted by this satellite and it goes to all the other stations. That means here you have got a number of other stations known as the slave stations which will be receiving this signal. So here you can see that each is being sent at the rate of 56 Kbps. So this 56 kilo bits, 56 kilo bits are all time shared and it is reaching the hub. On the other hand 256 Kbps data rate is coming from the hub to the satellite then it is broadcasted to all the VSAT receivers here.

What are the advantages of this satellite communication? One advantage is wide geographical areas as I mentioned. You can go for a very large area. For example, with the help of three satellites you can go for the entire globe. Another very important advantage is independence from terrestrial communication infrastructure. Whenever you want to have wired infrastructure you have to first lay the cable.

For example, in our country recently there was deployment of optical fiber cable by Reliance and various other groups so you have seen that cable length is really very complex and it is a tedious process. That is not required and that kind of infrastructure is not required. You simply put a VSAT antenna and do the communication, it can be anywhere. And because of this it has got very high availability particularly in wired configuration you have seen that there may be many problems because it is relayed through a number of stations but it is essentially direct and the only link is the satellite and as a consequence the availability of this satellite microwave communication is very high. Another important feature is that the communication costs are independent of the transmission distance.

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Whenever it is a wired communication depending on the distance the charge varies even for our telephone calls.

For example, if you want to make a call from kharaghpur to Calcutta the charge is much less than if you want to make a call from kharaghpur to Bombay because of the higher distance that means STD rates varies from with the distance. But here that is not so. Here the communication costs are independent of the transmission distance. You can go from any point to any point in the country for any point to any point in the other part of the globe and the cost of communication is same and it is a very flexible network configuration. Why it is flexible is because it can be very easily scaled up in number of stations that can be communicating with each other can be increased very easily and in a flexible manner and it is also because you don't have to deploy anything but the antennas at different locations. So this allows a rapid network deployment.

Another very important advantage is centralized control and monitoring. You have got a central hub by monitoring and controlling and it is that you have a very good control that's why the centralized control and monitoring is visible in this particular technology. And as a consequence this satellite microwave communication is becoming very popular and it is finding use in various areas. I have listed only a very limited number of applications but the application domain is very high and it is numerous.

For example, it is used for television distribution. We are familiar with the LPTS Low Power Transmitters and high power transmitters that is I use. Actually the Low Power Transmitters and high power transmitters are receiving the satellite signals from the studio with the help of the satellite signals and it is also used for long distance telephone transmission.

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Long distance telephone transmission is possible with the help of this satellite communication. As we have seen you can put repeaters at a distance of about 60 to 80 Km and you can achieve that signal with the help of this VSAT. Instead of terrestrial you can use either terrestrial microwave or you can use VSAT satellite and you can set up a private business network using VSAT. For example an organization can have offices in different parts of the country and if they want to communicate with each other they can have VSAT antennas at various places and the main hub in one place.

This will allow them to have private business network or they can set up an intranet where the lands of an organization in different places can be linked with help of VSAT antennas to set up an intranet which we shall discuss in more detail later.

And many other applications like video conferencing in-house training these can be done with the help of this satellite microwave communication. These are some of the important areas where it is being used. NICNET for example is national informatic center informatic center, they are having VSAT antennas in all restricted quarters with their central hub in Delhi so they collect all the data with the help of VSAT antennas so it is called NICNET, this is one such very important area.

For example another project is educational research network. This educational research network was also set up with the help of VSAT antennas and by using this satellite microwave network. Nowadays you will find advertisement in TV for DD direct that means in your home you can receive television signals by a very small antenna and a small set top box so that is also possible with the help of this satellite microwave signals. And the NPTEL project for which this lecture is getting recorded will also transmit signals to various colleges in a country with the help of satellite microwave system.

However, this has got a number of disadvantages. One very important disadvantage is long propagation delay.

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as we have seen, in case of satellite the antenna is located at a distance of 36000 Km away from earth, the signal has to travel 36000 Km and it has to return back to the receiver for another 36000 Km. So this round trip delay is about one quarter of a second. That possesses a problem particularly to identify whether two stations are sending together that means collision detection is difficult, so that has to be taken care of.

Another disadvantage is it is inherently a broadcast facility. So since it is inherently a broadcast facility the antenna transmits something and the entire number of receivers are listening to it so it is difficult to transmit private data.

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However, this can be taken care of by suitable encryption technique. So new techniques are emerging with the help of which security can be achieved. We shall discuss about this later on.

Finally because it is passing through the medium there are various problems. You have performed error control. Data can be corrupted and sometimes it faces the problem of slow and fast communication known as flow control.

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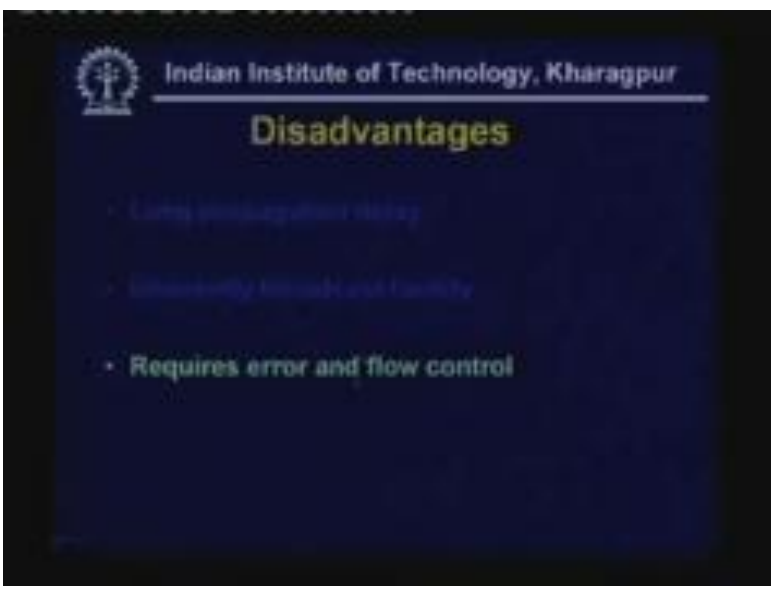

So you have to perform error control or flow control for reliable communication. We shall discuss about these two issues; error controller and flow control later on.

Finally comes the infrared communication in the range of .03 to 200 terahertz. It is very useful for point to point and multipoint applications within confined areas such as a single room. Here it uses transceivers that modulates non-coherent infrared light. In this case also since it is light it has to be a line of sight either directly or via reflection from the light colored surface or walls, ceiling of the room etc.

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One advantage is in this case the signal does not penetrate walls so secrecy can be very easily maintained. Another very important advantage is there is no frequency allocation issue so there is no license required. Particularly in this context IRDA plays a very important role, IRDA stands for Infrared Data Association. This is a consortium of 150 companies to maintain and develop standard. So IRDA has developed some standard with the help of each. Communication can be performed over very short distance.

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So the objective is to have device to device seamless communication over a short distance typically 1 m. So, particularly we have found that nowadays if we want to connect your laptop to a computer you have to use a cable or if you want to connect a printer to a laptop you have to use a cable, so that can be avoided with the help of this IRDA communication infrared communication. Here there is no need for cable because sometimes cable also posses a problem.

However, the data rates are not very high. Initially it was 2400 bits per second to 115.2 Kbps and it has now been extended to 1.15 to 4 megabits per second. And a layered protocol has been developed. Here is the physical layer irPHY and this is the data link layer having three components HLDC, irLAP and irLMP. These protocol layers have been developed by the IRDA Infrared Data Association.

For example, here you have got a transmitter, it can transmit over an angle of 15 to 30 degree and here is a receiver which can receive with an angle of 15 degree and communication can be done with the help of 1 m. Therefore this is the IRDA standard that has been developed for infrared communication. With this we come to a conclusion on this data communication by using wireless communication.

Here are the review questions.

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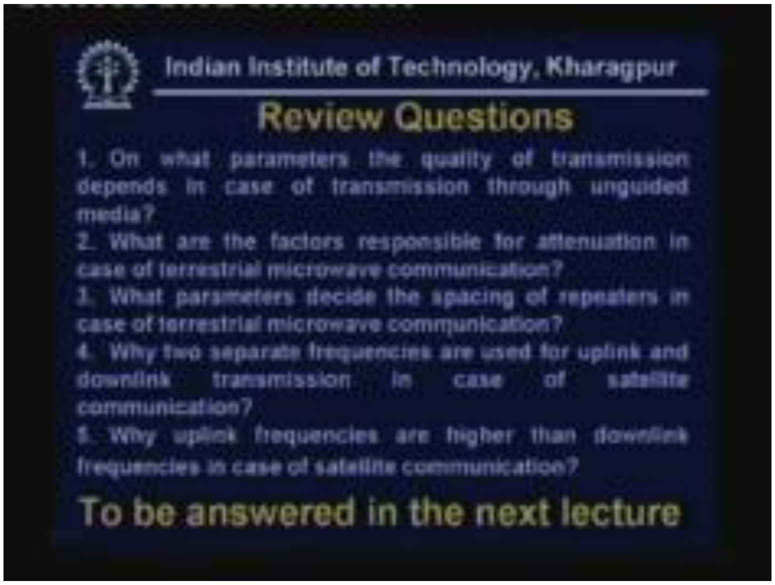

1) On what parameters the quality of transmission depends in case of transmission through unguided media?

2) What are the factors responsible for attenuation in case of terrestrial microwave communication?

3) What parameters decide the spacing of repeaters in case of terrestrial microwave communication?

4) Why two separate frequencies are used for uplink and downlink transmission in case of satellite communication

5) Why uplink frequencies are higher than downlink frequencies in case of satellite communication?

These questions will be answered in the next lecture. Here are the answers to the questions of lecture number 5.

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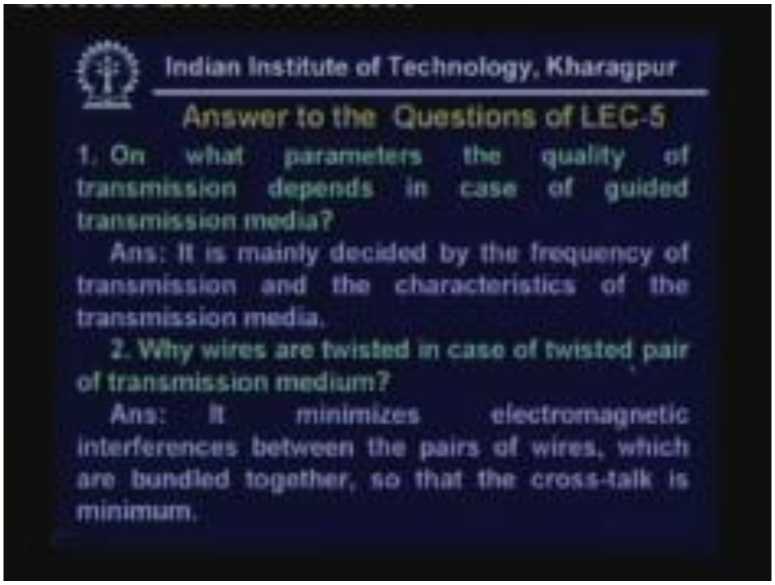

1) On what parameters the quality of transmission depend in case of guided transmission media?

As I have discussed it is mainly decided by the frequency of transmission and the characteristics of the transmission medium. That happens in case of guided media.

2) Why wires are twisted in case of twisted pair of transmission media.

As I have discussed in the last lecture it minimizes electromagnetic interference between the pairs of wires which are bundled together so that the cross talk is minimal.

3) Give a popular example where coaxial cables are used for broadband signaling.

One popular use is cable TV you are familiar with, that is where it is used.

4) Find out the critical angle for a step indexed optical fiber for n1 and w is equal to 0.04.

So n1 was 1.48 given. So here the calculation has been given and as you can see here you can find out the angle which is roughly equal to 82 degree for these parameters.

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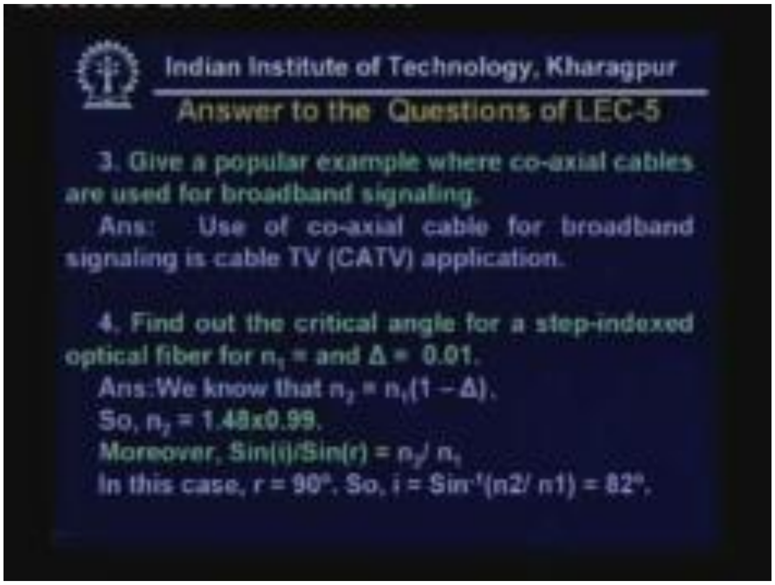

It can be very easily found because the angle of reflection and refraction is 90 degree so from that you can very easily calculate it.

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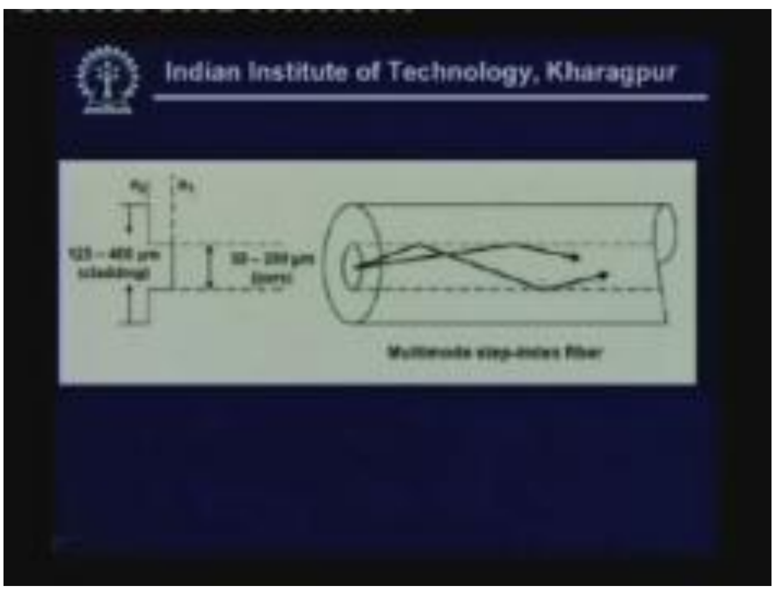

And as you can see here the angle of reflection incidence has to be more than 82 degree so that you have got reflection and other signals will pass out through the cladding material. So here is the answer for the last question.

In what way multi-mode and single-mode fibers differ?

Essentially it is the core diameter that is the difference here and the cladding diameter and repeater spacing is 2 Km for multi-mode fiber and for single-mode fiber as we can see here the code diameter is 8 to 12 micron, cladding diameter is 125 micron and the repeater spacing is 20 Km.

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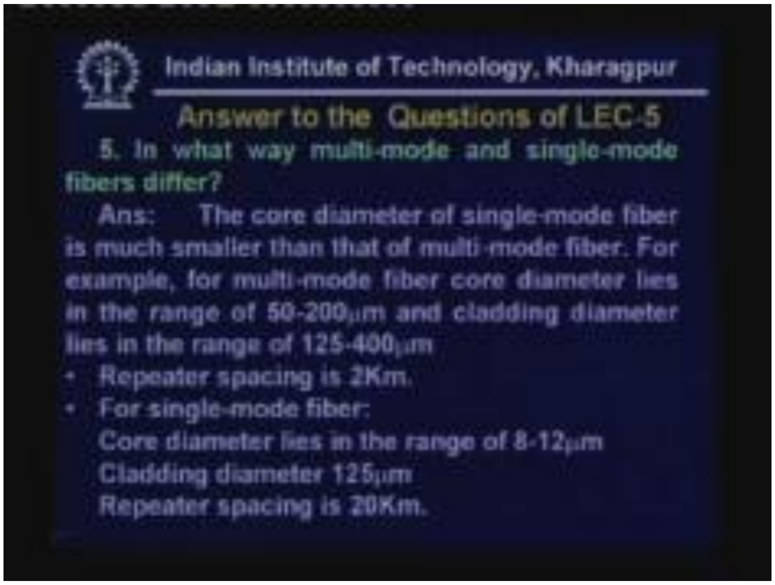

So with these we come to the end of this lecture thank you.