NPTEL

NPTEL ONLINE CERTIFICTAION COURSE

Course
On
Analog Communication

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Lecture 01: Fourier Series

Okay so this is the course of analog communication so what we will do today this for the first class so we will briefly discuss about what should be the outline of this particular course what are the things that should be generally conveyed through this course and what are the concepts that we did build it up in this courses, so that should be our first target so initial one our problem will be spending on that and basically we will try to capture what we mean by communication as such.

And where it is required what are the basic terminology that is being used and communication why those things are required and then we will go into the depth of computation and specially the analog communication, okay.

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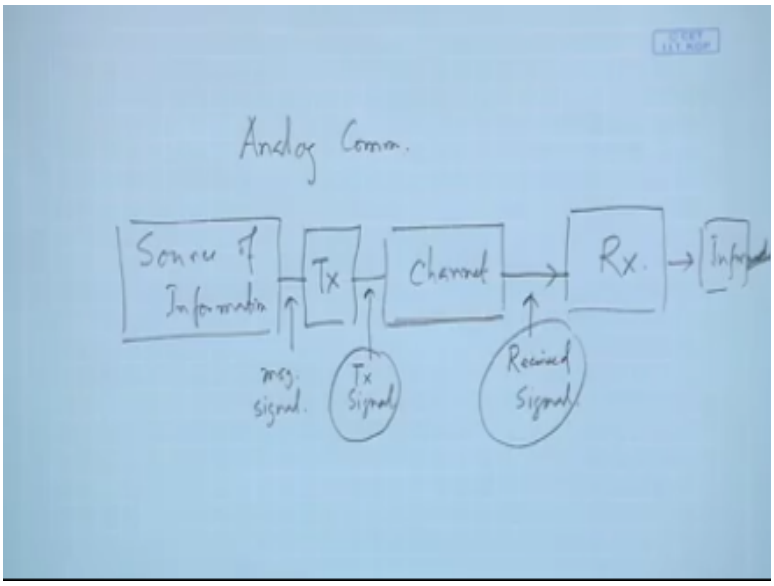

So whenever we talk about analog communication before even talking about analog communication let us try to see what we mean by communication, so communication generally means that we have some source of information so if I just say some source of information, that might be generated from any kind of a source like it might be just voice like now I am talking so this can be a source of information.

Because my voice actually contains some amount of information it might be just the video you are watching it contain information it might be some pictures it might be some text whatever it is, it is some source of information it might be from any particular kind of source but first we have to take the source of information this source of information might have a originator or it might be originated from some particular place in communication what we need that somebody else we need to transmit or we need to actually transfer this information as fast as possible so that is actually communication.

So basically there should be a recipient or I should call a receiver it might be far away from the source itself and source should be associated with a particular transmitter which will take those information convert it into a particular form of signal will be discuss about that later on and then transmit it through a media which is very important in communication it is called channel, and through the channel at as distant place to the receiver it will be transmitted so basically if we just define that is where the message signal comes into picture.

So form the source of information to get the message signal it might be will be discuss about what kind of signal can be generating they are just be told that it might be voice or picture and video it might be just complete the generated data what were it is, so that has to be first transmitted and this is here it is called transmitted signal will see how the message signal and transmitted signal are different there must be risk transmitter must do some processing on the signal to make this communication sustainable.

And make its communication successful and then it will be launched into a channel so channel is a very important part of communication that is the thing which actually either a physically or virtually connects the source to the destination or transmitted to the receiver, so it might be a wireless channel where we just transmitted radiate it in the wireless informs of antenna or other means and then it will be just propagated through electromagnetic wave through the channel and it will be received at the desired location.

Or receiver so that is one form of channel there might be channels which are not like this here so it is like wired channel like our twisted here earlier be used for telephoning or it might be coaxial cable that is being used for television transmission or It might recent advancement which is coming up it is called fiber optic cable, so it might be any kind of channel that effectively transferred this transmitted signal though it.

Okay so that is the functionality of the channel and once this is been transmitted we should be able to get some received signal over here, so after the channel I will might asking should this transmitted signal and receive signal be same effectively not so channel does something to the transmitted signal what are the things that channel does that is also another very important part of communication so we need to know exactly what channel can do to my signal and we need to know how to really come back.

Any kind of impairment said inputs on the transmitted signal because transmitted signal is my information or it is carrying information or it is carrying my informations so we I need to exactly know how it is contaminating by transmitted signal and then in the received signal whatever we get after this contamination or distortion we get it to the receiver and then receiver does something to get back to my information so it is that information, so we have to think about as much faithfully we can actually.

Put from source to receiver better the transmission quality better the communication in that we are putting for so it is very important that whatever we are whatever information where transmitting suppose we are sending an E-mail and that is faithfully transmitted over this entire chain then only we will say that is all valid communication because if I write something and that writing is being distorted, which some grammatical mistakes spelling mistakes some words missing that will not be faith full representation of the input source information.

So that is very important that whatever we do in between in this three blocks of transmission channel of course we do not have any hand we do not have anything in hand so in the transmitted and receive a bloc k knowing what the channel is so we need to very clearly know what kind of channel we have or we need to use or choose channel what kind of channel we should use for a particular transmission, so knowing all this things how do we really do my transmission and how do I do or employ something at the receiver side.

To get back my information faithfully so this is what communication actually does so if you just we have to say some examples there are plenty of examples you know are telephoning is one of the probably oldest example of communication, so where whatever voice signal will generally you can generate so what happens and there are two steps whenever you do communication so the steps up first.

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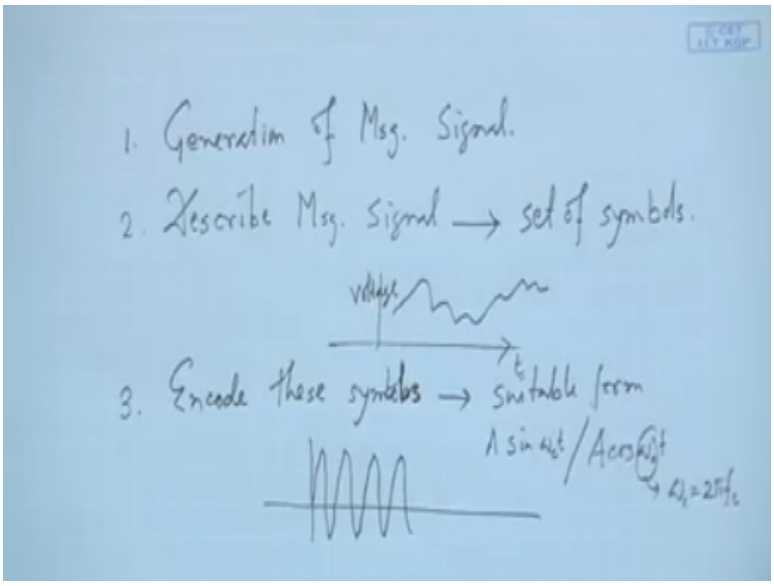

Step 1 generation of message signal okay so that is probably the first step now that is like for I have taken that example of voice communication or you can talk about video communication okay so board casting videos all those things so whatever you do first you generate the message signals so like I am communicating and talking so that is the message signal contain some amount of information in side.

So first generating that message single then what we have to do is second step that we need to describe this message signal in terms of some set of symbols okay so this set of symbols will be mostly electrical so it might be like I am creating I means just delivering our speech now this speech single there will be transitive so most probably which will actually covert it into a equivalent electrical signal so that it can you say that is some symbol said so it might be just voltage level of that electrical signal.

So over time whenever I am means varying my speech or my teach and all those things all those quality of my speech accordingly it will be translated to a equivalent electrical signal which might in times so if we plot that in time voltage so it might look like something like this according to my variation, so this particular signal so we can call that as set of symbol so it might be just time varying voltage level or varying current level whichever way you want to represent it.

So it should be that massage single through a help of trans user whatever form that message signal input single as it must be converted mostly we are talking about the electrical

communication, so it must be converted to equivalent electrical signal, so that is the first stage okay so we should say second stage so third stage of this communication is then we need to encode these symbols into a suitable form that can be transmitted over this media.

Whatever channel they have okay so what do you mean by suitable forms so already we have got this electrical signal is that good enough for transmission, so this is where transmitter we have talked about those 3 stages so this is where after the trans user when my equivalence single may be voice or video whatever it is that is being coveted to electrical signal now it is my task to actually convert this into a suitable form that will be another signal of course.

But that should be suitable form so that it helps in transmitting okay so this is for the transmission purpose, we need to convert it into suitable form so there are multiple suitable form will discuss about them but right now I am just giving one example, so one suitable form is first of all we need to modulate this single y modulation that probably right now it will not be very clear but we will come back to that why that signal needs to be modulated.

But right now we just take that it needs to be modularize what do I mean by modulation so basically this signal as to be ride it by a modulator okay so what is our modulator so modulator generally is a sinusoidal carrier so it is a high frequency sinusoidal carrier okay so we can call that as either sin some A sin $\omega_c t$ of frequency ω_c of 2Π fc or it can be even represented as A cos $\omega_c t$ any form of sinusoidal which as a frequency which is represented by ωc or = 2Π fc, fc is a frequency at sinusoidal okay.

A is the amplitude of that sinusoidal now what we need what we mean by converting into a suitable form is this at this particular sinusoidal we take that as carrier like whenever we are sending suppose letter so what do we do we put in some envelope it is almost means this carrier particularly is almost serving a purpose of an envelope, so it carries the information and at the end it delivers that information and after that it is not required.

So basically we put it inside that inside the envelope like we whenever we mail anything we put inside a envelope in the envelope is carried and the after that envelop will be opened up the letter is delivered then the envelope as no value okay the similar thing this is a carrier and one this carrier we try to put our information, so suppose let us say our information is let us take an example that our information is something like this.

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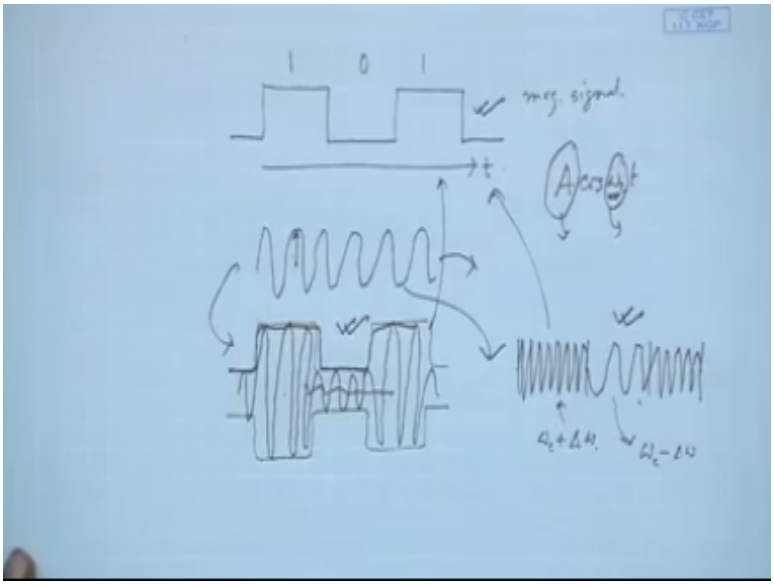

This is one typical signal which is like our information let us say it is a we all are familiar with binary or digital form of data so let us say it is 101 and this is actually time, so this is the signal we want to transmit so what we do is eventually like this we have the carrier we have already seen that the amplitude of that carrier should now vary according to amplitude of this particular message single okay.

So this is our message single converted to electrical and now we have a carrier which is like this a sinusoidal carrier and the amplitude of this carrier which is this path must be varying over time which almost mice this message single so how this will look like if I modulate it should be looking like this so basically the amplitude shoed be having this envelope inside the carrier should raised something like this.

So what is happening as now you can see the carrier almost remains the same it is frequency it is oscillation period and everything that remains in what is on the happening is the amplitude of the carrier is instantaneously varying as the single message single is varying. So it means that this particular carrier is carrying that message single on top of it like an envelope and it is being carried over the amplitude okay.

So there can be another way of doing it any sinusoidal is characterized by two or three things right now we will take two example one is it is amplitude so whenever we write sinusoidal it is A

cos $\omega_c t$ right so the amplitude is 1 part of it which characterizes a sinusoidal or it is a parameter of the sinusoidal another part is this frequency.

So now I have the option of varying any of them okay, so either I can vary this amplitude which I have done over here or what I can do I can keep the amplitude fixed and I can start varying this frequency, okay. So if I wish to vary the frequency how it will look like so the same thing if I modulate with this particular signal it will look like this.

So suppose I have this particular portion 1 this particular portion 0 then 1 then 0 followed by so in 1 I will be giving a frequency which is higher so this will have higher frequency and then while 0 this frequency will be slightly lower that means the oscillation period will be it means the time period will be higher and then again 1 so it will high frequency and so on. So what will be happening if anybody sees this it is actually there is a center carrier and as we are transmitting different kind of symbol let us say for this case 1 and 0 2 voltage level actually.

So basically the carrier frequency is varying it is becoming suppose I have carrier frequency ωc so it is becoming $\omega c+\Delta\omega$ at this format and it is becoming $\omega c-\Delta\omega$ at this moment, okay so that is another way of varying things so basically what will happen now you can see if I transmit either this signal or that signal at the receiver end I will be able to actually decode my symbol because I know either if I know this is means modulated at the amplitude then I know I have to just track the amplitude of the signal how it varies with time forget about the carrier this internal variation I can take out I can just track the amplitude and I can roughly get the signal back.

Or otherwise I can just try to see what is the frequency and how it is varying so if I just means track the frequency I can immediately see this is the portion where high amplitude is being transmitted because high frequency is being transmitted this is the portion where lower frequency is being transmit so therefore automatically the message symbol should be having low amplitude, so basically either this or this will have the same representation at a receiver, okay. So this is where the third step we talking about this third step.

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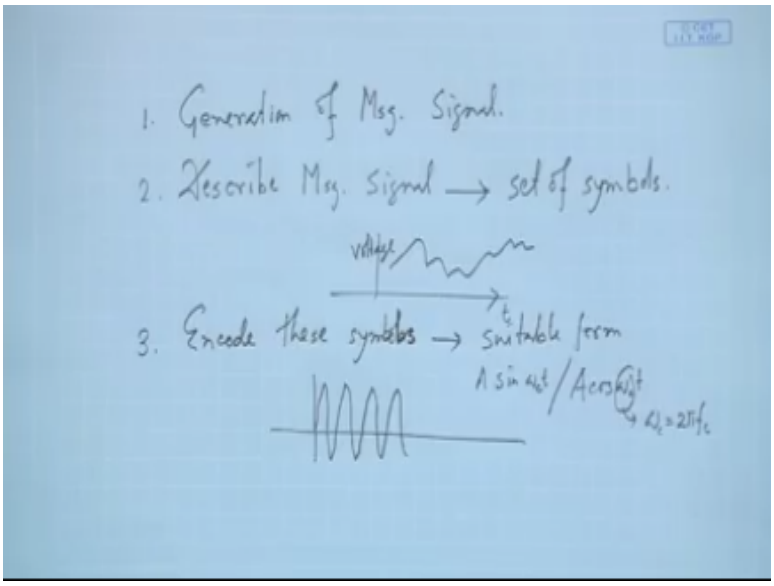

Encode this symbol suitable into a suitable form of signals which is good for transmission so this is what we are trying to do over here. Now you might be asking why we are actually we could have directly transmitted this signal why we are doing these things, so that is the first question probably we will come to any communication engineers mind why we are doing these things, there are few reasons of course the reason will not be directly clear right now but probably little bit a head in the course it will be much more clearer.

But right now we can just say some reason, one of the reason is see look at the carrier deliberately I have chosen very high frequency. The reason is generally whenever you are transferring suppose you are transferring through an antenna okay, and you are receiving through an antenna let us say it is wireless transmission so we are actually putting an antenna. Now the antenna designing guideline is if you have read already antenna designing guidelines and little bit of electromagnetic so you know that if whatever the electromagnetic wave we are putting so whatever that is sinusoidal carrier will be putting that will be converted to the equivalent electromagnetic wave of the same frequency.

Now whatever wavelength it has that in a dimension should be equivalent to that wavelength or okay, so now if I just transmitted at a very low frequency like this one this might be having lower frequency it is varying slowly like the wire signal it varies very slowly it has the highest frequency component which is just 4kHz okay, so whatever wires tonal quality we have it has the highest frequency which is 4kHz, okay.

So and many of them, many of the components wires components are even lower frequency starting from 300Hz to almost like, it does not go up to 4 maybe 3.3kHz or something like that, okay. So if you take those frequency component it is very low frequency correspondingly the wavelength will be very high and what will happen the antenna size because that has to be equivalent to the wavelength size that will be very big, so make a transmission I have to build a huge antenna very big antenna maybe size of this building and all those things.

So that is not really desirable that I want to make a point to point communication between one person to another person suppose he is carrying a mobile phone through he wish to communicate and his antenna is very big that is not feasible or practical so that is why we need to whenever we transmitting things the frequency component of that has to be really high, because we are ready getting through antenna and antenna size if you wish to faithfully transmit and receive that signal antenna size has to be comparable, okay.

So that is one thing which is required so immediately it comes to our mind that maybe the frequency has to be translated or the frequency has to be very high so how I have a voice which is having highest frequency component probably 3.3kHz can I take this to somewhere higher frequency so one way of doing it later on you will see mathematically right now we are not saying we are just stating that it is some way or doing is this modulation or putting it inside the carrier it will actually take it translate it into a very high frequency and effectively what happens their voice modulated with that carrier will have a very high frequency component and correspondingly antenna size requirement will be very low, very small size tiny size antenna will survive.

So that is one very practical reason why we need to do modulation, the second reason is which probably will not be very clear right now but I am just telling it. See on the year if you wish to communicate that is always true that if I wish to communicate what I need this particular air media is a shared media okay, if I wish to communicate so everybody else needs to communicate and they want to communicate whenever they wish if two of us are trying to or multiple of us are trying to communicate simultaneously to multiple other fellows.

And we are using the same media what will happen they will actually come into the same media and they will colloid whatever information we have they will get mixed and then it will be a very difficult at the receiver end to actually segregate them or separate them. Now what I am saying

without any prove later on we will prove that this modulation basically segregate these things before hand.

So whenever we are transmitting what we do I am just telling you the technique later on we will prove that the technique helps so we actually choose different, different carrier frequency so for my transmitting suppose station 1 is trying to transit to station 2.

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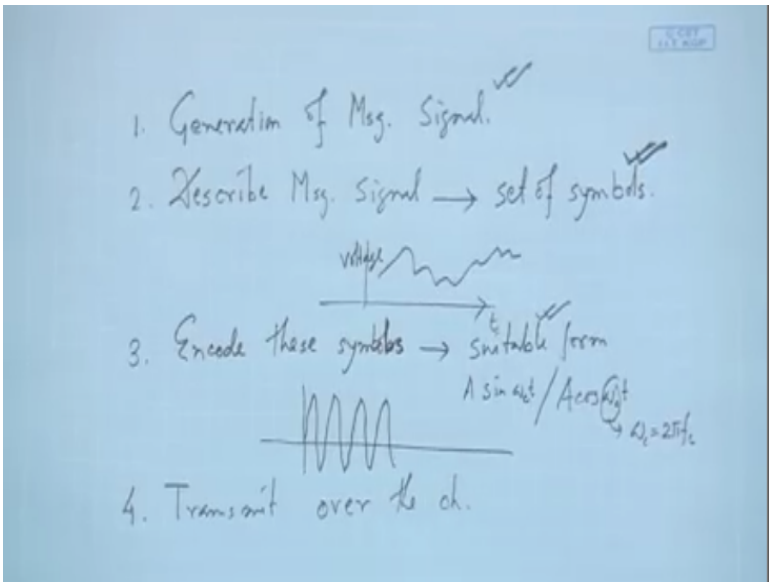

Okay, while is the an station 3 simultaneously wish to transmit to station 4 in the same media now what he can do, he can take a carrier frequency of f1 and he can take a carrier frequency of f2 where f1 is not equal to FEMALE_2>>> two different frequencies and there are some criteria but it should be the separation between them and all those things but right now you are saying but if take you separate frequencies that there is a possibility that both the signals can exist in the media.

But they will not super in force basically they will have different frequencies location in the frequency domain and you can alter on you area will probably at the frequency domain you can always put as filtering to choose your own carrier and that we can modulate it or you can get your signal back.

So this is one way of multiplexing multiple simultaneous transmissions into the same media without disturbing each other oaky or without interfering each other so that another reason why we should actually put a signal into a carrier okay so these things will be forward clear when we defined them more clearly and mathematically okay.

So now going back to our steps so we have discussed about third step right so what should be the fourth step, fourth step is so we have already encoded into a suitable form so whatever might be the requirement we have now discussed about that and we will be actually doing that at the transmitted side.

So this is being done at the transmitter so and this part is being them this is the source where message is related this is what the transmission of converting into electrical signal and then from that electrical signal we actually generate suitable form which can be transmitted so that is the duty of the transmitter and then after the transmitter we actually transmit over the channel.

So that might be done by the help of media or any other form that is required the transmit okay so that is has to be buy attain appear talking about so it can put until suppose it is wireless media through attained commodity into electrical, the electro kinetic wave and radiate it over the channel okay.

So this is the transmission part after the transmission part we need some more things though whatever encoding we have done we have to it is like an envelope we are putting our letter inside the envelope at the other side if I wish to get the message we have to open the envelope we have to tear up the envelope and then read the letter we get the message.

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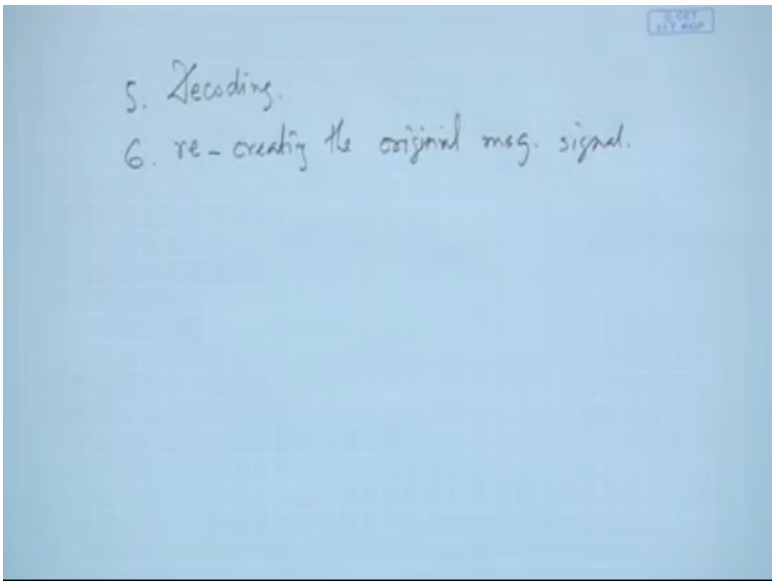

So we have to do the same thing the reverse process so here we are putting inside the envelope that means we are modulating so at the other side we accordingly demodulate the signal so that is the fifth step, fifth step is decoding or demodulating so we are just writing it decoding see why that is greater than it there is multiple other steps also other then demodulation.

The demodulation is one of the steps so decoding is the fifth step and sixth step is from after decoding its again it goes to the transmitter because finally I want to hear it so it should be in my speaker okay so that reverse form of transmission so it recreating the original message signal so that is the four steps which are involved over here.

And in this four step as we have discussed our focus will be transmitter and the receiver what transmitter does what receiver does and we have also choose the media accordingly or the channel accordingly and we need to be aware of what actually channel can do so will next see what are the different characteristics of channels of course going in to the details right now I have just touching up an all the topics.

Which needs to be really discussed to actually deal with communication systems so what we are so far understood what here are the communication system there must be a transmitter okay before that there must be a source and it should be anyway there because otherwise you cannot generate the signal once we get the signal after that we need a transmitter which encode the signal.

The channel may be choose accordingly should be choose wireless channel or fiber optics or coaxial cable some transmission line whatever that media is we have to choose and we have to also know the characteristics of that channel so that is very important that we need to exact the understand the characteristics so that we know how the transmitted signal will be actually interpreted at the other end.

So receive signal will not be transmitted signal will see that in the next particular section will be discussing about that how channel actually degrade the performance and how the channel actually change the signal quality and then we need to know again decode signal to get the message back then again a set of transmission followed by means so what is actually getting the information.

So it can be done okay so this is the chain of the communication now you might be asking what are the different forms of communication that exist we have already discussed about point to point communication so which is like from one particular point to another particular point one particular percent or one particular source to a particular destination that is open form of communication we all aware of starting from telephony to computer communication and all those things.

But there is also another form of communication which is called broadcasting so like radio or television where the sources you need band heat transmits that transmits signal must go to multiple receiver simultaneously so basically the information contain remains the same whatever in broadcasting suppose radio whatever is being transmitted it is not unique for a particular receiver it is same for all the receiver and it as to be simultaneously transmitted to all the receiver and decoded simultaneously by all the receiver.

So that is one form of communication that we already are aware of broad casting so the other form is point to point which is we call it unique casting one particular point to another particular point there is in between some other things which is called selective broad casting or which is also termed as multicasting.

So there if I have multiple receiver not all of them I intent to transmit I might choose some of them but I will still be transmitting same content to all of them simultaneously okay whomever I choose so these are the different forms of communication that we are aware of we have seen that

there are examples of those communication, so what will do in the next section we will start talking about our channel what do we mean by channel and how it actually effects our transmission and why it is very important to know the channel very well before we actually device a communication mechanism.