Modern Digital Communication Techniques
Prof. Suvra Sekhar Das
G. S. Sanyal School of Telecommunication
Indian Institute of Technology, Kharagpur

Lecture - 01
Introduction to Digital Communication System

Welcome to the course on Modern Digital Communication Techniques. This is the 1st lecture and in introduction lecture, I have given you an overview of the syllabus. So, we do not cover it again in this particular lecture, but we slowly go into the details of digital communications. We will begin with some of the basic tenets and how do we start looking at systems. So, what I would begin with is one of the important statements of famous author and researcher and scientist in the domain of digital communications that is Robert Gallagher and what he said is effective communication is fundamental to a civilized society. That is very important. So, without communication, we will be like no where we know this. So, it is more of a necessity and what we are going to explore in this particular course is the way to design a system for effective communication.

Since we are taking this particular course on digital communications, we would assume that you have a prior knowledge about analogue communications.

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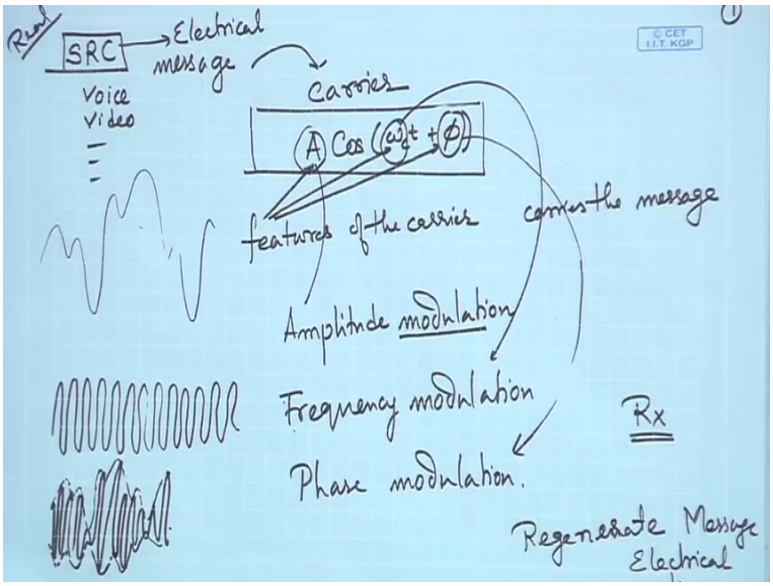

So, if we look at or if we try to recall what you studied in Analogue Communications, you would generally have a source and we could say there is a source that is present and

from the source, this particular source could be generally a voice source. This particular source could be a video source or could be any other kind of source that we are used to. So, when you studied the Analogue Communications, you are generally concerned with the analogue sources and mostly what you studied was some kind of message requires to be put on to a carrier.

Carrier means it carries, right. So, when we say it takes on some, it is a carrier. What we say is that it has some attributes. What you have studied is the attributes of a typical carrier or a carrier is typically a sinusoid wave and in a sinusoid wave, you could write it is as let us put cosine omega c t plus some phase. So, this is the typical expression which you are used to and what you studied is that this feature which is the amplitude, this is the frequency and this is the phase. So, we could say these are different features of the carrier.

Now, this carries your message. It carries the message, right. So, it carries the message on these fundamental parameters by which the carrier is defined. So, what you have studied is one could vary this amplitude and what you would get is amplitude modulation. So, that means, in other words we are talking about modulation or modulating. That means, you change this as per the original message.

When you talk about this, you are talking about the frequency, you talk about frequency modulation. So, generally when you talk about frequency modulation, you usually assume or you consider that you are not going to touch the amplitude. This remains constant with time. This becomes a function of time and the third is the phase modulation. So, why you studied different ways of actually changing a carrier signal. It carries some message. You also studied the receivers, the different circuits by which one could demodulate an amplitude modulated signal typically the envelop detector. Then, you had frequency decimator for this frequency modulator and phase matching for the phase demodulation purpose.

So, you could demodulate the signal and regenerate the message at the receiver. Generally this source is some real source and here you generate the electrical signal. Similarly, at this point we are talking about the electrical message signal which again passes through some transducers to become the original message. For example, the speaker if there is a voice over here, right and typically our message, this electrical signal

could take a shape which is like this continues variation and the carrier as you can clearly see over here, it is carrier frequency which is a much higher frequency compared to this speed at which the message varies and then, this is imposed on to this.

If we talk about amplitude modulation, then you would apply some scaling factor with this, so that it does not cause a reverse swing. You can still do it, but generally you would not allow the signal to go to the opposite phase within the modulation period and you would limit the amount of modulation that is available and your modulated signal would occupy some shape which is governed by this envelop and it is not an exact picture, but you would have a modulated signal which would look like this, an amplitude modulated signal which is quite easy to draw.

Now, when we go to the domain of digital communications, we are changing our perspective and there are fundamental reasons why we should go to a digital communications which will slowly involve, but before we go on to, let us look at what the fundamental difference between this analogue commutations and a digital communication is and how do you transit into digital communication as easy steps as possible, so that at least you are able to visualize. What I want to convey to you is that all your understanding of analogue communications would come and help you in visualising digital communication systems once you get into the domain of digital. When you go into the details modules and parts of it, you would require a way of expressing them that will slowly involve with time.

So, now instead of using this particular signal as we have drawn over here, the difference that you get is this source is no longer analogue.

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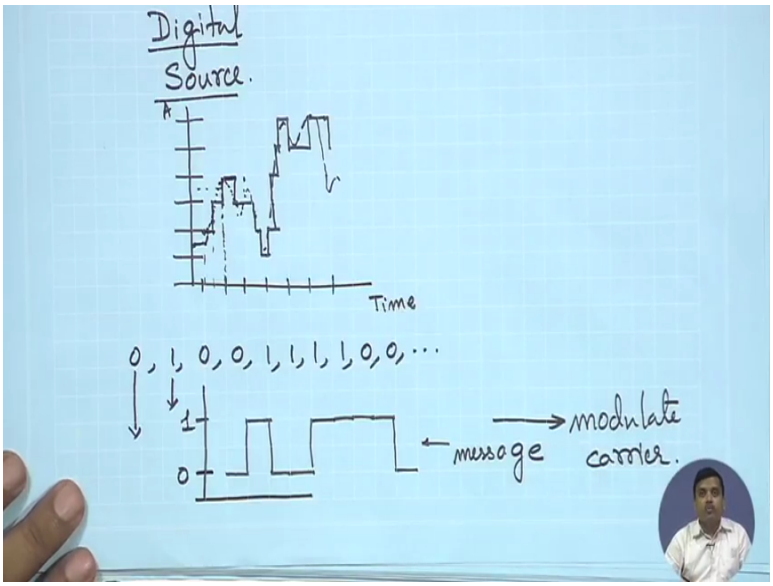

You have this digital source. That is one of the important thing is now when we say it is a digital source, what we mean is that this continues wave gets converted to some digital. At some point, there are methods of doing it and in this particular course, we will go through those particular ways of converting analogue signal to digital and how do we move forward, but assuming at this point that there is some device which converts it to digital, we will take a bit of view, so that things are easier for us now.

So, we say there is a digital source and by this we mean that it takes discrete amplitude values. So, if this is the amplitude scale and if this is the time scale, we would say that if this is the time scale and if this is the amplitude scale, we say it does not take a quantinum set of value. It take this discrete values and in time unit, it is going to take this value at discrete units of time. That means, suppose I take this particular picture and I draw it here. It may not be exact, but it will be somewhat similar to what we have. So, what we will do to convert it to digital? Let us say in this time instant, I would choose the value which is given by this in this time period.

At this instant of time, I would choose this particular value and in this instant of time, I would choose since it is above threshold, I would choose here. So, roughly speaking, very roughly speaking if I want to sample here, I would get a better resolution picture. I could say that I have a message which is almost like the one that I have drawn. What I am trying to emphasize at this point is that it is taking discreet values, right and the wave

shape looks similar, only it is discrete. There are several advantages of going digital and the advantages will come clear as we progress into this particular domain, but this is one way of differentiating between the analogue signal and a digital signal.

Now, when do we have digital sources, very simple situation if you are thinking of sending an image, now if you look at today's sources, you usually use a camera which is digital. If you use a voice recorder, generally you have the voice recorder in your phone or any other voice recording device generally they convert it into digital domain and if you are thinking of videos, you also have digital video cameras. So, finally all these sources they generate digital signal. Now, you are well aware that when you look into these voice sources, these dot AMR or dot MP3 files or we look into dot MPG or you look into dot JPG files inside. Finally they are zeros and ones without you will understanding analogue to digital communications, this part you are very well custom to you.

So, if I ask you now that you send these files across from a transmitter to the receiver using a knowledge of analogue communications, what you are going to do? The very simple answer can you motivate it by the analogy that we have got over here of converting analogue to digital. What we can think of is suppose I have a sequence of zeros and ones in my files, some random sequence of zeros, some random sequence of ones and so and so forth. So, once we have this, what we can simply do is I really thought as zero and I really thought as 1 and I associate this 0 with one particular amplitude level. Let us say 0 is here. Just indicate 0 and this indicates 1 and I would know that I have to send these zeros and ones over a certain finite duration of time and when I say that I would send it finite duration of time, I would restrict 0 to within a certain particular duration and I would restrict one to certain particular duration. This particular duration of time which is fixed is usually known as the bit duration in the current context or it will be extended to the definition of symbol duration in the appropriate context.

So, as of now since we are talking about one bit every time being send i would say that the symbol is made up of 1 bit. So, what we are going to do is, our source will convert it into some source which will keep on generating 0, 1, 0, another 0, another 1, another 1, another 1, another 1, another 0, right and so on and so forth. So, this particular wave

form which is been sent would represent the sequence of zeros and ones that was stored originally in the file.

Now, if you studied analogue communication, we can simply say that this particular sequence is my message and this message I will use to modulate the carrier. So, when I modulate the carrier, I could go back and say that I could module the amplitude, I could modulate the frequency, I could modulate the phase instead of having a continues wave form. Now, I will simply say my input wave form is as simple as this particular shape if you would ask that what would be a similar continues wave form if you say that.

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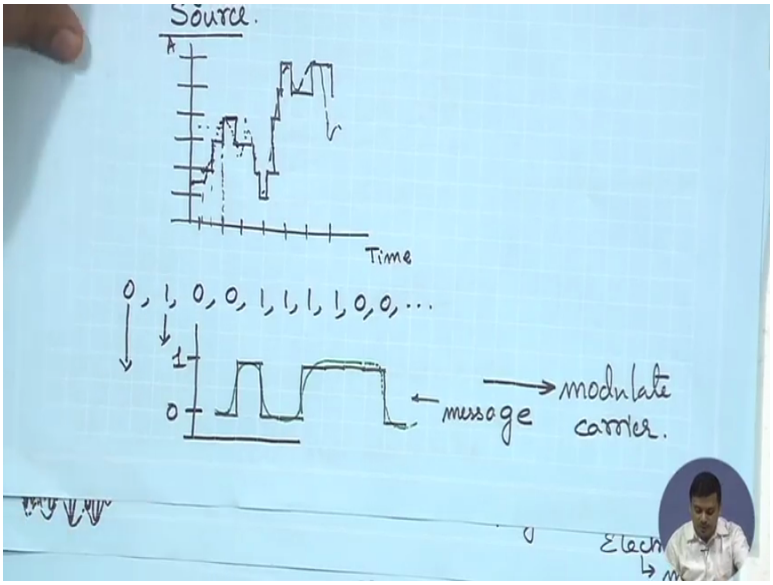

I would say that well, probably the continues wave form I can imagine just closes to this could look something like this. I would use a dotted shape rather like this. So, if my continues input symbols was like this, I would stress this point because since we are transiting from analogue to digital, I would say let us imagine that my source wave form was like this.

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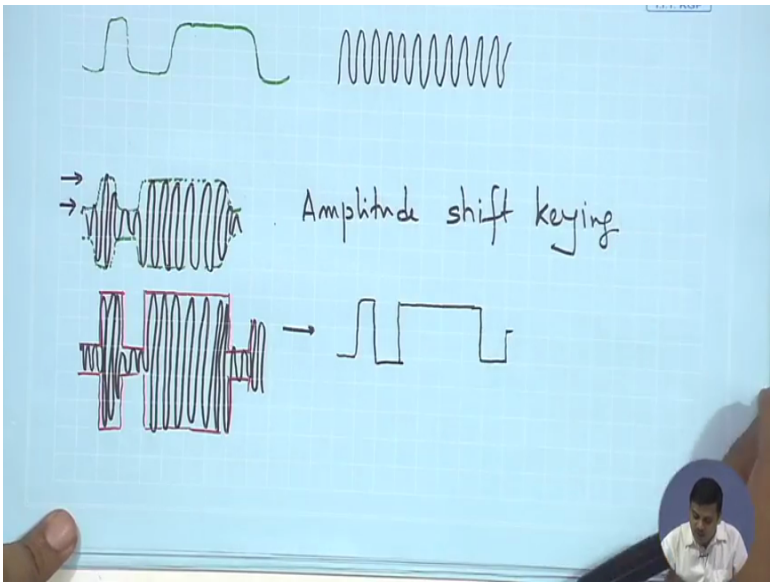

Let us imagine. No harm in imagining this particular thing, 1 2 3 4 and I want to send this is a big difficult thing not at all because if I think of sending it over a carrier which has representative picture like this. I would say I have generated something which is I need to rescale it. That is it and then, it is just the earlier amplitude modulation that I could be using and my new modulated signal would be like this. So, this is no different than the amplitude shift keying. What it says is that you shift the amplitude from one level to another level that means, if I choose between two amplitude levels and I send it, I actually see a digital communication wave form.

Now, if nobody tells you that whether this wave form is generated or if I would look at another very precise wave form, let us say I take the input wave form as this I can still send this particular wave form through a analogue modulator and I would get a signal which would look like this. So, all I am trying to tell you is that you can still use your knowledge of analogue communications and use it to transfer digital information and it will become in digital communication system. So, when your analogue, when your amplitude modulation receiver acts on this particular signal, it is going to generate the amplitude, it is going to take, going to generate the envelop of the amplitude, envelop of the carrier or the amplitude, it is going to generate this wave form.

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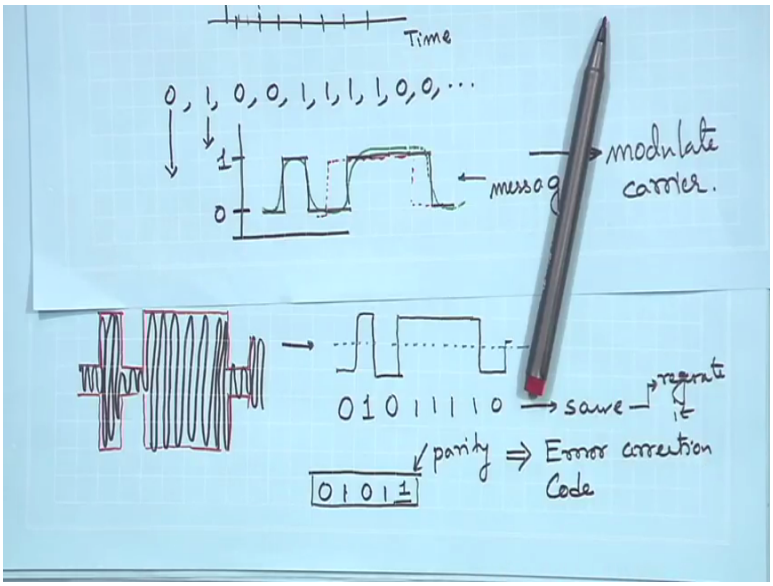

Now, once you have generated this, you can reuse your earlier mapping that if the signal level is here, I would consider as 0 has come. If the signal level was there, I have consider the 1 has come. So, going by this, I would say at this point, I would setup a decision threshold somewhere in between and I would say whenever the signal is below this decision threshold, there is a 0 which is been received and when the signal is above this decision threshold, 1 is being received, 0 is being received, 1 is being received, 1 is being received, 1, 1, 0 and so on so forth.

Now, once you have decided that this is the received signal, you can now save it in your computer or in your phone and you can regenerate it and it becomes the image which was stored originally in your computer or in your phone cam, on your phone or in a special memory device and it regenerated and projected on the other screen. Same goes with your mp3 or mp files. So, what I am simply demonstrate at this point is that your knowledge of analogue communication could be used sufficiently towards establishing a digital communication system in a very initial format. Now, when we do this particular thing, there could be several issues rise, several questions could come up. Why at all are we going for this digital that will become slowly clear as we progress this particular course.

As you can see here, one of the interesting features is that this digital communication system I have sent a sequence of 0 1 0 0 1 1 1 1 1 and so on, but here somehow I have

received something else because of some issue. So, probably what we can say that there has been error into the system, right. If this was an analogue communication system, what we are basically talking about is this particular wave form that we have here is now received in a little bit different way. So, as if my 1 has started to be generated at this point, please note this point. So, I have this 0 has been received as a 1 or sometimes we can say that we have missed out this particular 0 and instead we have written the next one. It is your interpretation or you can say that this 0 has become a 1 and 1 particular one is become a 0 as if the wave form has changed like this in this particular picture, right.

In analogue communications, this distortion is almost impossible to correct because we do not know what is going on. You do not know what is the message because this message is something which is generated at the source. If you knew the message which is to be sent, then you would not send the message. That means, if I know already what will be sent to me, what is the need to send that particular message. So, that means at a receiver we do not know the source message of. So, this particular mistake will not be captured and will be used as it is in the analogue communication.

However, in a digital communication system we are having these sequences. So, when we have these sequences, the advantage of digital one of the different advantage of the digital communication system is that we can employee something known as forward error correction code. Well, in general error correction code, you can use a forward error correction code or you can use a reverse error correction code. Now, details of it again I am not covered in this particular course, but time and again we will discuss little bits of it through which something will be clarified. For instance, we can discuss very little bit as of now.

We can say that let us form a group of two bits or let us form groups of four bits. When we from groups of four bits, we have add one parity along with that. So, suppose my sequence is 0 1 0 1 sequence, right suppose I have the sequence whereas, say I want to have an odd parity, I am have one extra bit over here which will be used to complete the parity to make it odd parities. As of now I have two 1. So, if I put one more 1, I will get three 1.

So, I will know whenever I receive five bits, 1 2 3 4 5, the sum of ones should be odd if it is not. So, I will know there is an error in the system in that group of five bits. What we are going to do is, the transmitter is going to ask the receiver please send the bits again. Once the receiver sends the bits again and it checks the parity, if it finds the parity to be, it keeps these bits for saving or regeneration at the receiver.

So, what I mean to say is that because we have converted to digital, we have the scope of adding the parity, right and this leads us to put in error correction code which is the huge benefits. Why? The reason is you can now device a mechanism. That means, you can create system by which you can try to make errors as low as possible and that is one of the fundamental tenets of the digital communication and this is because of the modern techniques of communications and that is why we have this subject called Modern Digital Communications because there are so many new things into it. Of course, we are not going deeper into digital, into error correction codes, but all I am saying that this point of time is that this particular technique is one unique advantage which motivate us to take this kind of communication systems.

Now, beyond this if we look into it, since we have gone into the domain of digital one of the things is that it is probably bit easy to handle digital systems. It is bit easier to handle digital sequence compared to analogues. These circuits are easier and there is a huge amount of digital signal processor and processing capabilities already available one of the simplest things is your computer, your phone, which carries huge amount of digital processing power. So, if you are using a digital system, you already have a huge amount of knowledge and you have a huge capability with you which can be used towards making things better and better and better.

Now, this is just one particular example that I pointed out. With time you will come to know many other details. So, one of the important things that we see is that the digital is somehow become a natural phenomenon as of now. Now, this does not restrict the use of analogue communications, this does not trend as useless because finally, these signals should go over these carriers, right. So, you need this carriers. So, all your knowledge of analogue communications are necessary because finally, you need to build the transmit of front end.

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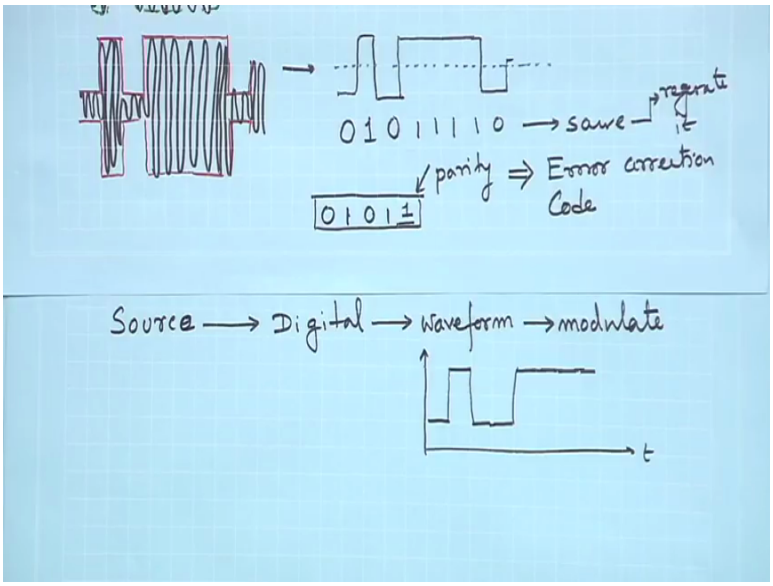

Let us say you have this source. The source is converted to let us say digital, right. Digital is converted to some wave form as explained here, right.

Now, this wave form is still digital wave form if you look at it or you can well if you are very restricted, you can say well it is not digital, it is analogue, but its discrete in amplitude. It take certain definite values and then, this diagram should change also little bit in the sense I cannot draw this. This thing I would draw in that case of picture which is this followed by this, followed by this another 0. Let us say 1, a 1, and a 1, this is the wave form that I should draw to make it appropriate. This is the time axis, this is the amplitude axis. So, if I am going to use real systems, we are going to have certain transition and these are some number of slope. So, making idealistic assumptions that well this is digital we have some wave form.

Now, this is finally, used to modulate your carrier as you typically do in analogue communication system, otherwise you see here the reverse process is followed over here and once you are there, you are back into the domain of digital communications. So, what we are going to study is a huge amount of digital processing techniques, principles design philosophies which handle bits and convert them to wave forms and back from wave forms to bits in this particular course.

So, from the next lecture onwards, we will look at the waves by which we are going to visualise the digital communication system, so that you can categorise, break it down

into smaller parts and start handling one unit at the time, so that finally you are able to design a complete digital communication system.

Thank you.