Communication Engineering
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Lecture - 26
TV Transmission

We will continue our discussion, today on television signal transmission that we briefly started yesterday.

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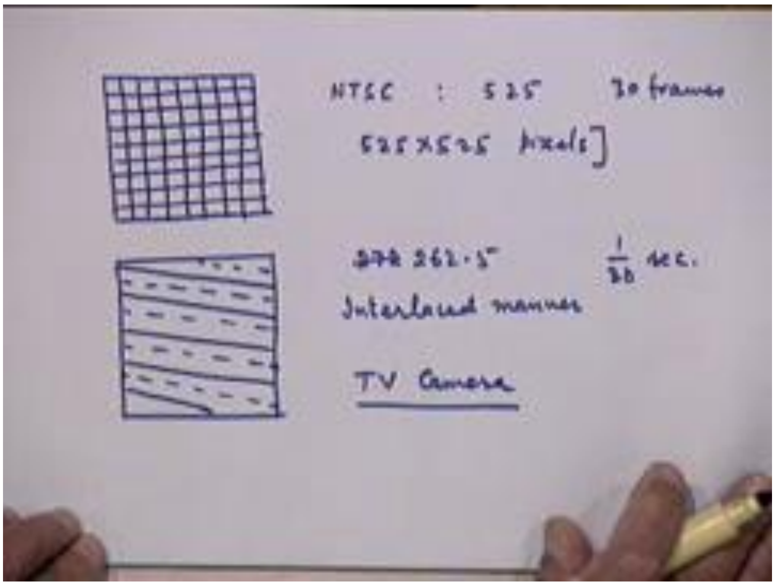

So, if you may recollect, we talked about the picture elements. We said that we will view a picture as frame successive pictures or successive frames. And we will kind of think of each frame consisting of a large number of small picture elements. That is the view upon this frame as if which is composed of a very fine grid of picture elements.

And the scanning process that we go through kind of implies that we are viewing this frame as so many picture elements. Now, the number of this element depends on who many lines is how many lines you used to scan the pickup frame. And we said that in one of the standards in the NTSC standard the number of lines per frame is 525. So, which essentially kind of implies, hat you are viewing as if this picture contains 525 into 525 picture elements, pixels.

The scanning processes of course is not exactly like this, the scanning process is a little different in the sense that you have a scanning process which goes from left to right like that and also the scanning are interlaced. Basically, these 525 lines that we are obtaining are obtained by first going through one set of lines like this, half the number of these lines. So, in let us say we will call it, how much will it be half of it, 262.5, so half of the lines are scanned first.

And then we come back to the top and scan in the regions intermediate between these lines, this has a better effect from the perception point of view. Because, you will return to the top within normally we transmit 525 lines at 30 frames per second. That is we transmit 1 frame any frame of 525 lines every 1 by 13 second. But, when we do like this, this repetition occurs after every this is done every 60 times per second.

So, effectively it is the same thing effectively it is 525 lines or a 30 frame per second basis. But since they return to the top very quickly and also cover the region in between regions the perception quality of the picture is much superior this is called interlacing. So, the scanning is done in an interlaced manner. So, the really speaking one frame consist of two scanning's, one frame you can cons consist of a scanning's like this followed by a scanning like this which is completed in one by 30 seconds. Each of this individual scans being completed in one by 60 seconds.

Of course, these 30 seconds and 30 and 50 these figures drawn from the power line frequency which is typically used in American system and the NTSC is an American standard. Whereas, the PAL system, the European standard and the corresponding frame rates are 50 frames per second or 25 frames per second. So, it is different for the different standards that we have.

And we also discussed yesterday the scanning mechanism the way the picture, the way the TV camera generates the electrical signal. Typically, as I said there are many kinds of TV cameras quickly we are verifying, so that the comfortable about the whole thing, there are many kinds of TV cameras. But, each of them basically does more or less similar things, this scanning processes is carried out.

Basically, in optical system focuses this portion of the picture on some surface which produces charge proportion to the intensity of these lines, the intensity of the videos pixel elements. So, as it is scanned the optical system, the optical beam is being scanned an optical system maps the scanning on to a surface which can be charged depending on the intensity of light that is coming through.

So, the charging is done on some mosaic some surface, which was in some photocathode kind of thing. Basically a photocathode or some kind it could be photocathode in the case of a tube it could be charge coupled device which produces a charge that we want. So, basically the light intensity is converted to a charge pattern right is that.

The charge pattern is then scanned by an electron gun in an electron gun; we are familiar with that we used in the oscilloscopes. So, now this electron beam is scanning this charge surface, there is a charge surface which is which is which has a pattern like this only thing is there is a more positive charge. Therefore, there is a brighter intensity and there is less positive charge therefore, there is smaller intensity.

So, this kind of pattern whatever is actual intensity pattern that gets mapped in the form of charge density from this charge surface. And then an electron gun is passes an electron beam through the surface in the same scanning mode, it scans this charge in the same way. And depending on the amount of charge either less number of electrons will get absorbed or more number of electrons will get absorbed.

And the return path in the electron gun, the current that will be produced by the electron gun will be dependent on how much charge is there at each point in the surface essentially that is what happens in a camera tube. So, if for example, there is more positive charge at a certain point, the more electrons will get absorbed at that point and the corresponding current that will get generated will be smaller.

So essentially, brighter elements which will correspond to more positive charge in that surface will produce a smaller amount of current. Whereas darker elements which have less charge at the corresponding points on that surface will absorb less number of electrons and will produce a larger amount of current.

So, the current that we produce, therefore becomes proportional to the amount of charge that you create an amount of charge that you create will depend on the intensity level at a particular pixel that is the mechanism through which these things happen. So, basically a dark side will be dark pixel will be associated with the large current and the light pixel will be associated with the small current that is typically.

So, this is how a typical TV camera works, but the mechanisms will differ from device to device. They will differ slightly, but the principle will more or less remain the same right therefore, essentially we do something very similar, so, that is how it will happen.

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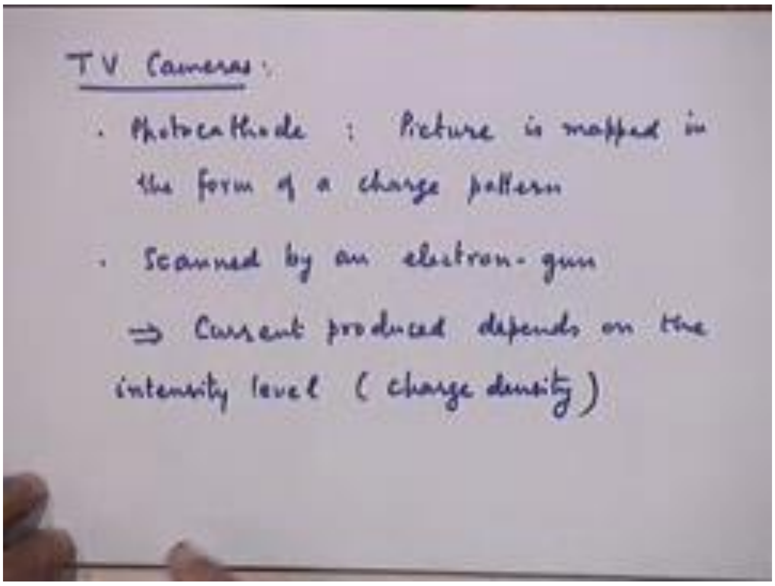

So, basically there is a photocathode, in which the desired picture that you are scanning is mapped in the form of a charge pattern and this charge pattern is then scanned by an electron gun. There by the current produced depends on the intensity level with essentially means charge density here. Because, the intensity level gets mapped into kind of charge density, but I am not going into very detailed discussion of the precise construction of these various devices.

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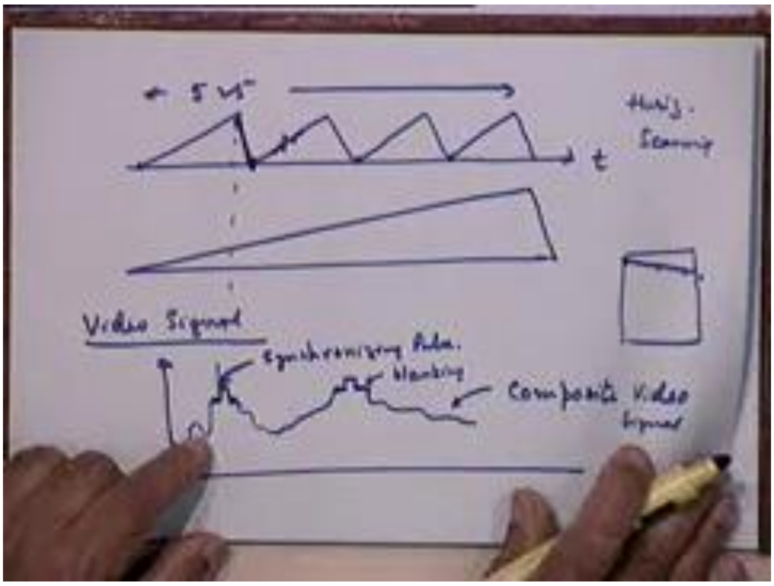

Let us look at we also saw very briefly the scanning pattern, the horizontal scanning pattern and the vertical scanning pattern. Let me just repeat that once again this is the saw tooth waveform which depicts the way, the scanning is done left to right that is the horizontal scanning, this shows horizontal scanning and this shows vertical scanning. Of course, I should show a break here, because there will be 525 such horizontal scans corresponding to one vertical scanning

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Well if I am considering the whole thing as one, yes you can write, yes you are right actually it is interlaced. But, if I look at if I forget that detail it is more or less like this. So, the exact timings can be worked out for this saw tooth waveforms, so what was the resulting video signal look like that is the picture signal that finally, gets generated.

As I said we finally produce a current, corresponding to each of these scans which may vary arbitrarily and the high values of the current. So, if I am plotting current here the high value of the current will correspond to black and the low levels of current will correspond to a white. So, we will have some composite picture signals like this.

Now, typically you add here this you will have to repeat this operation of scanning at the receiver later. You will have to move from left to right to generate the picture of I mean TV tube at the receiver. So, it is important that precisely the instance of this horizontal scan the time intervals of horizontal scan and the time intervals of vertical scan at the receiver.

So, we will have to transmit some synchronizing information along with your picture signal along with the video signal, so corresponding to this you generate some synchronization signal at this point at the corresponding points. Typically the levels of these signals are kept above the black level, so that they are not visible as the picture is being produced at the receiver, so they are kept at the top. So, we will have a pulse like kind of thing here and also a signal something like that.

So, this is your actual video on top of that at the light point there is a synchronizing signal which shows that the next scan next horizontal scan will occur here. So, this point we have just mapped here in a form of this pulse signal.

Student: ((Refer Time: 14:48))

So, that the receiver knows at this point it has to start rescanning from left to right.

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That is a rate the precise timing that the precise timing are used left to right scanning it has to be synchronized with the incoming timing, where signal is coming it is starting at the certain time we do not know at what time it is starting. So, we need to know that the precise timing for every left to right, scanning and every vertical scanning right every horizontal scanning every vertical scanning.

Of course, once you have established the synchronization then it will become more or less automatic. But initial synchronization requires that this timing information to be available.

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If the synchronization is not there you will not be able to see the picture properly, because the picture will keep on you are just getting some signal, how the scanning process is is being done. The scanning process requires that there is a saw tooth signal, which moves the beam from left to right.

At the left part of the picture should correspond to the left part of the screen and the right part of the picture should correspond to the right part of the screen. Unless you synchronize these things, how will you ever see the picture, otherwise you will just maybe the starting point is in the middle and something else is happening here and something else is happening. So, the picture will be all jumbled up right.

Because, the scanning the left part of the picture now you are scanning, as you are scanning at the transmitter this portion should be reproduce in the screen at the receiver on this at this point only and not somewhere here or here or here. So, unless when to start the scanning at this point with respect to the incoming picture signal you will not know where will this get map to, so we have to have very precise information about this.

And this pulses, which are put on top of this will give that information to us, these are called synchronizing pulses, so this is the synchronizing pulse that is, we will have the synchronizing pulse by every horizontal scan and every vertical scan. Of course, the vertical pulse synchronization information can be derived from the horizontal pulse synchronization, so we do not have to make a special effort for that.

But this has to be therefore, every such period, so this is typically how your composite video signal will look like. Actually you see a slight flat portion were either side of this synchronizing pulse which is called a blanking pulse, a blank blanking level to them horizontal blanking level. This is basically you want to make sure that in the retrace path I mean in this path, I think I am not drawn a very good picture here, this pulse actually gets synchronized with let me draw a fresh thing it will be better.

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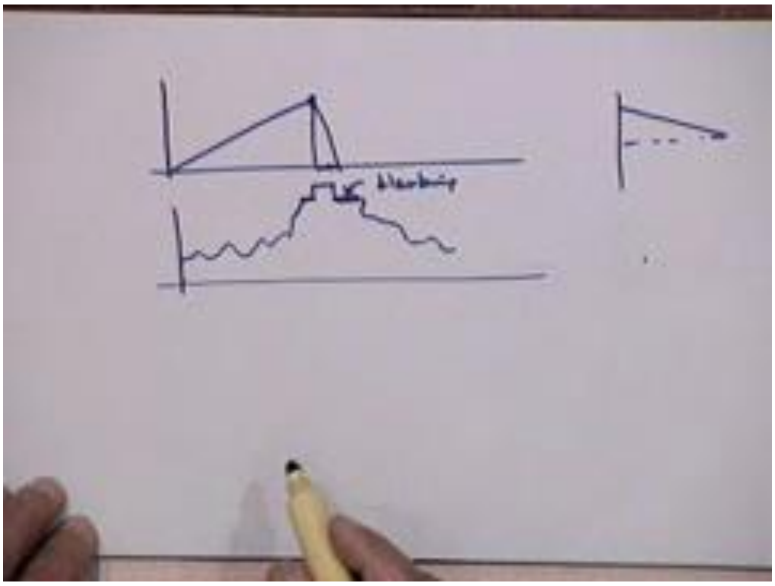

Let me just draw one such waveform to let me show that they are same, so picture signal is coming and at this point I have a pulse like that. So, basically this pulse is made to synchronize with the speech. So, basically this giving away information and at this point the retrace is occurring and during the retrace at the receiver I do not want anything to come on the screen. So, this is also you make sure at this point the level that is transmitted the voltage level the current level that is transmitted corresponds to the black region.

So, the being the retrace portion of the as the as the scanning is going from right to left right it takes the finite amount of time this is the time that it takes this much time, the picture is blanked out. So, this is a blanking level and then the scanning starts from here there is some more slightly more detailed information.

That is some detail about the composite video, and the fact that there is synchronizing information and blanking information extra on this composite video which is also transmitted along with the signal.

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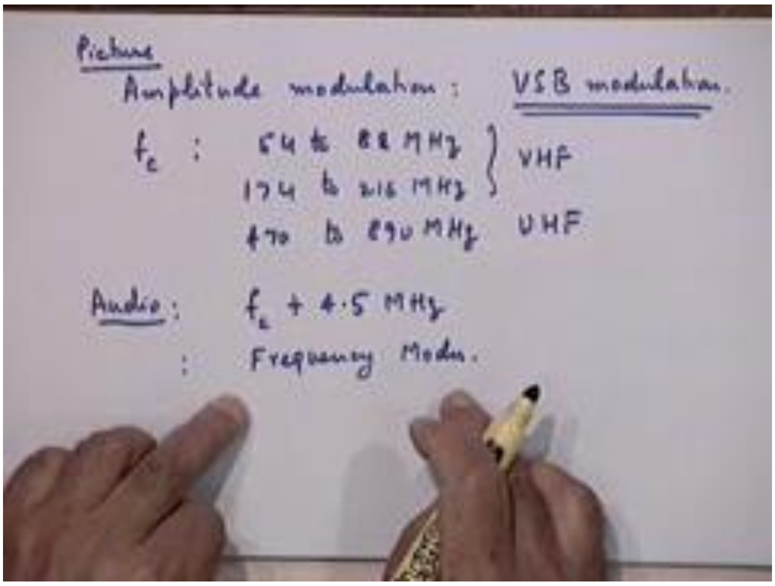

Let us next come to how this video is transmitted, the transmitted if the transmission is done using amplitude modulation on a carrier and as we will soon see the picture signal has a very large bandwidth. I mentioned earlier its it has the bandwidth of the order of 4.5 megahertz we will soon how that figure comes in a few minutes it is just a very simple calculation to see that.

But because here, we have a very large bandwidth, it will be definitely not a good idea to transmit either DSB AM or DSB SC kind of modulation. And as I mention to you the video signal is transmitted by our vestigial sideband modulation, so using some appropriate carrier frequency f sub c.

The carrier frequency f sub c could lay in one of the various possible bands typical channels for these are 54 to 88 megahertz that is one band then there is 174 to 216 megahertz and then there is 470 to 890 megahertz. These are some of the standard bands which are used for transmitting pictures these are the two VHF bands and this is a UHF band.

So, you could transmit choose a carrier frequency in one of these bands and transmit them. So, the carrier as far as the picture signal is concerned, I will talk about VSB in little more detail in the contents of picture transmission in a few minutes. But, let us also remember that along with the picture signal they have to transmit a voice signal, because

TV transmission is transmission of two signals. Actually if it is color TV transmission it is transmission of several signals right not just two signals.

But the least, we have to do is transmit both the picture signal and the audio signal. So, the audio signal that is as far as the picture is concerned transmission of the picture signal as far as the audio signal is concerned, it uses a carrier it uses another carrier you can call it a sub carrier whatever you like.

The second carrier which is removed from this carrier by 4.5 megahertz, so the audio carrier is f c plus 4.5 megahertz and that is because the band width the base band width of the picture signal is 4.5 megahertz approximately. So, you space the audio signal away from the video signal by this much amount.

And the modulation used for audio, in most pictures transmission standards is frequency modulation. So, the audio signal frequency modulates the carrier of this frequency and these two signals are transmitted together. So, we actually have we used two carriers here.

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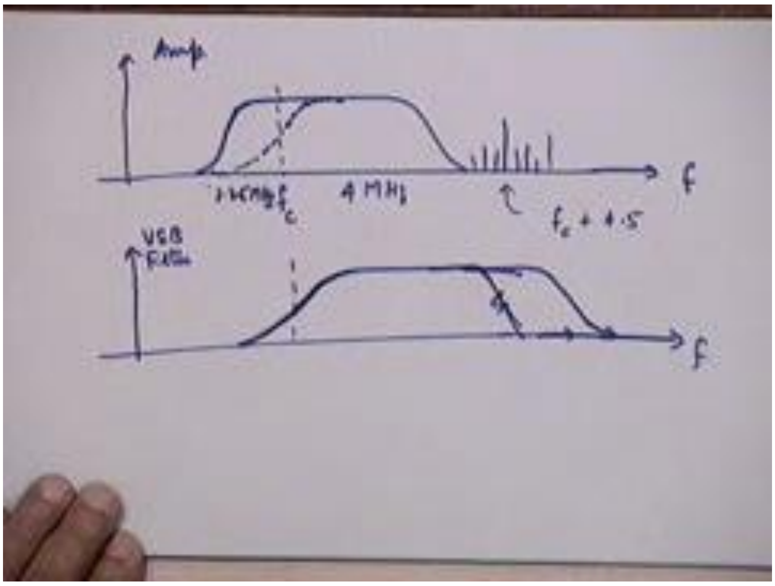

So, if you want to draw the spectrum of the transmitted signal, this is what it will look like. So, let us say this is your f sub c this is one side of the upper side band of the picture signal DSB mod DS amplitude modulation, the lower side is transmitted the low the lower side band is cutoff.

But as you notice, I am not applied the VSB principle here, what is the VSB principle, that I must have something like that is the VSB principle. All I do is I just cutoff the bandwidth of the lower side band, so that the overall transmission bandwidth is small.

This precise spectral shaping there are need for proper reconstruction of the modulating signal at the receiver, why this shaping was required, so that you could reconstruct the modulating signal properly at the receiver with simple envelope detection or simple synchronous demodulation either way. It was required for the distortion less reconstruction. This precise spectral shaping is actually carried out at the receiver rather than at the transmitter.

So, it is both convenient that way, because I do not have to do a very precise kind of filtering which is what is implied here at the typically high voltage levels that I have to deal with at the transmitter. Particularly in the conventional picture to use the signal levels are pretty high.

All I am saying is there is nothing much to explain, except to say that this precise spectral shaping that is required for VSB modulation is done at the receiver and not at the transmitter, this is the conventional way of maintenance. As far as the transmitter is concern all you make sure that your transmission bandwidth is reduced that is the purpose of VSB modulation

You do transmit a portion is lower side band without regard to this shaping; basically you make sure that, all the relevant portion is transmitted, because anyway you are occupying that bandwidth, so the precise shaping is done at the receiver. So, suppose this is 4 megahertz this part, this for the sake of my discussion and let us say this is 1.25 megahertz you are transmitting a portion of the lower side band. So, total transmission bandwidth is reduced from 8 megahertz to 5.25 megahertz.

But, the precise spectral shaping which we need to be which is required to be done for proper reconstruction of modulating signal after demodulation is directly received. So basically, what we are saying is at the receiver, we will have a VSB filter which will precisely satisfy your requirements which will have this shape.

That is as far as the video is concern, so this is the VSB filter at the receiver and your audio signal is sitting here somewhere. So, this is the carrier for the audio which is at frequency f c plus 4.5 and this has its various side bands etcetera in the FM signal all around this carrier.

So, your receiver filter actually will have the pass band like this, it will pass this complete signal, the video signal plus the audio carrier signal all this would be pulsed and on this side there will be a spectral shaping before it is fed to the demodulator. So, at the receiver you will do all this filtering and this spectral shaping, so that is a typical picture for. So, this is a frequency domain picture this is f.

Spectrally this is how the video and the audio signals are multiplexed together, so this is another example of multiplexing. You are transmitting two signals simultaneously, because you need to transmit the picture signal along with the voice signal along with the audio signal. So, and that is this multiplexing is done in the frequency domain any questions from this. Now, just to complete this discussion, let us have a very brief que through a schematic diagram of precisely, what you do at the transmitter, TV transmitter and what do you do at the receiver.

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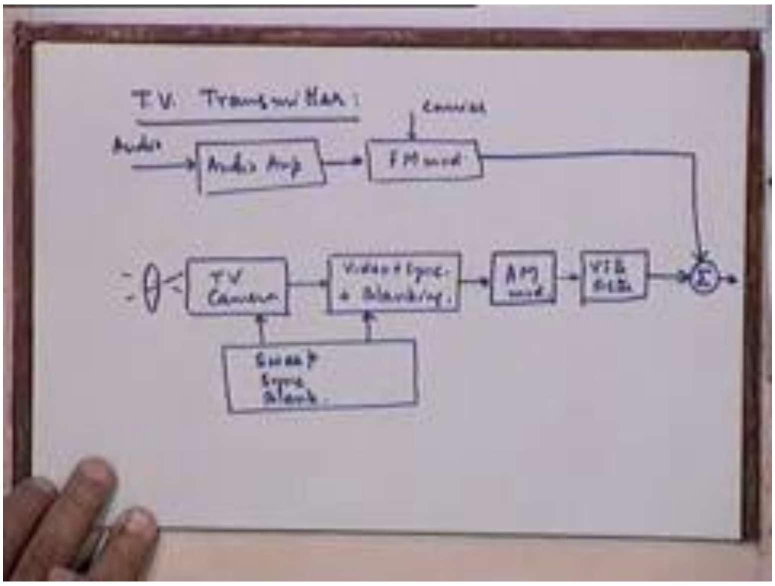

So, TV transmitter and after this we will return to the basic question of the bandwidth, we have assumed that it is 4 megahertz 4.5 megahertz where does it is it will come from we will discuss that.

So, even though we have to transmit two signals, the audio signal and the picture signal. So, let me start with the picture signal, you have some optical system which is picked up by a TV camera followed by a TV camera which generates the necessary video composite video signal. So, it generates the video plus the synchronizing pluses plus the blanking pulses it does all this

There is some electronics associated in this camera which will do all this maybe that electronics items shown here, so this electronics generates these scanning waveform, then sweep waveforms that are required and generates the sync pulses generates the blanking pulses. So, these signals from here go to these two blocks, so that you finally, get your composite video file.

Then, there is the amplitude modulator, AM modulator. So, I do have a VSB filter here so to say, but this VSB filter is of a very, very crude type. It does not do the precise spectral shaping that is required to be done for vestigial side band is basically.

Student: ((Refer Time: 31:38))

The basic purpose is only to cutoff the one of the side bands. The reason why we are kind of taking the precise shaping to the receiver is because typically at the receiver, one has to work with much lower voltage levels, much lower signal levels and this is a low voltage electronics. We have to work with rather than a high voltage electronics to design those filters, basically that is convenient more than anything else. There is no reason as far as the principles are concern. Along with this, you have the audio signal, audio amplifier, the frequency modulator, and then some suitable carrier and these two are added and transmitted.

Student: ((Refer Time: 32:47))

What is the use of?

Student: ((Refer Time: 32:52))

No, not

Student: ((Refer Time: 32:56))

I mean I do not want to transmit 8 megahertz if I want to use DSB AM if I do not cutoff I will be actually transmitting a band signal of 8 megahertz bandwidth. So, all I do is I have a rough kind of filter which removes all energy beyond less than one point f c minus 1.25. So, most of the lower side band is cutoff, except the portion which will be required for shaping at the receiver.

Student: ((Refer Time: 33:32))

This value

Student: ((Refer Time: 33:36))

The lower one is the VSB filter that we will be using at the receiver to carry out the shaping.

Student: ((Refer Time: 33:41))

Of course, what you are saying is that, the receiver filter the receiver front end RF filter will be searched, then it passes the video signal passes the audio signal and also carries out the VSB filters here, that is what we are saying. This receiver filter the RF receiver filter it will allow this video signal to pass through it will allow this audio signal to pass through and it will also carry out the VSB spectral shaping that is required for proper infrastructure. So, that is a very, very sketchy description of the transmitter TV transmitter just basic principles level.

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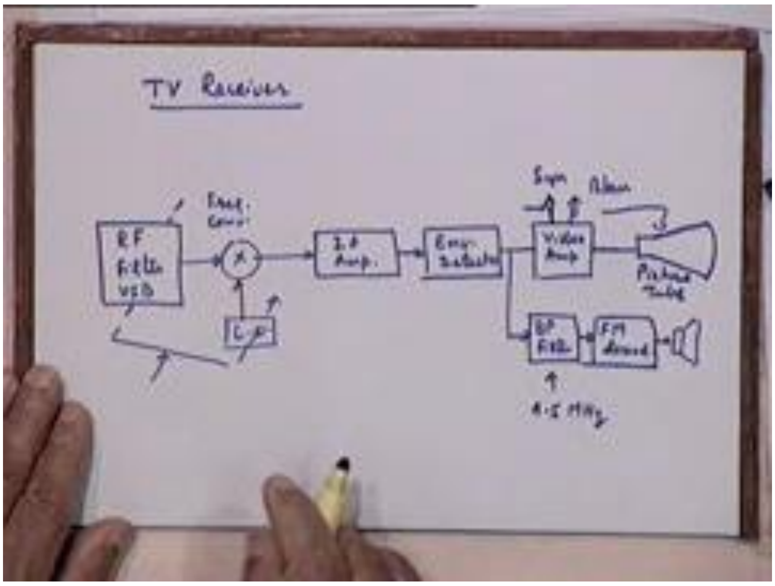

Next we come to the receiver, I am sure you can draw the diagram yourself, so you start with the RF filter which has those characteristics that I just mentioned. It is also a VSB filter, along with other functions it also carries out the VSB filtering or VSB shaping function spectral shaping function plus, of course it provides the required amplification.

Most RF filters in any radio receiver could be actually RF amplifiers, they will also be providing some gain because, the signals coming in that you are picking up from your internal typically will be very weak a few micro volts, 10’s of micro volts. They have to be amplified to suitable levels, so that further electronics can take care of them properly the mixers be IF amplifiers etcetera of course provides further gain and things like that.

So, this is followed by the frequency conversion as here shown that is there is a concept of intermediate frequency just like the super heterodyne receiver, so these two there is a local oscillator here. A local oscillator frequency and these are joint to an end the center frequency and the RF filter here, followed by actually most of the precise filtering and the shaping will be done by the IF stage as I mentioned earlier also.

The IF amplifier and basically now what we are doing is we are picking up this entire signal by picking up this entire signal and trying to just detect this as such and that is done through an enveloped state. You are not doing any frequency demodulation at this stage that will be done later.

Because that the VSB signal can be demodulated using an envelope detector, if you use particularly if you try the method of local addition of local carrier. So, using a simple envelope detector you can get this composite signal (Refer Slide Time: 23:53) by reconstructed the constant base band signal reconstructed the only thing is that this base band signal will also contain this FM signal.

Now, with the carrier frequency of after reconstruction after envelop detection, what will be the carrier frequency of the audio signal 4.5 megahertz, not f c plus 4 f c would have gone the demodulation would take care of all carrier frequencies. So, this contains the video signal plus your audio signal, so you need to separate them all clearly.

So, there is a video amplifier here, which will have a bandwidth now of only this much the video amplifier will have a bandwidth only corresponding to this point ((Refer Time: 23:53)). And so there is a video amp and there is let us say you will have a band pass filter here around 4.5 megahertz followed by your limiter discriminator your FM demodulator followed by audio amplifier etcetera, I am skipping those details and that is your audio signal. The video amplifier output which provides in the composite video along with the synchronizing information etcetera. All that is fed to a picture tube

Student: ((Refer Time: 38:53))

Just a second and this picture tube also gets its synchronizing information etcetera from here I am skipping the details, so synchronizing information and the blanking information all that goes to the picture tube. So, this is again very rough sketching information about the TV receiver.

Yes, there was a question does not it.

Student: ((Refer Time: 39:31))

That is right the center frequency is 4.5 megahertz correct alright

Student: ((Refer Time: 39:49))

Student: ((Refer Time: 39:52))

There is no special effort needed for that, we do not need, because they come together.

Student: ((Refer Time: 40:04))

There are no major delays to worry about, appreciate the point, but there is no major delays to worry about here one does not have to worry about these too much.

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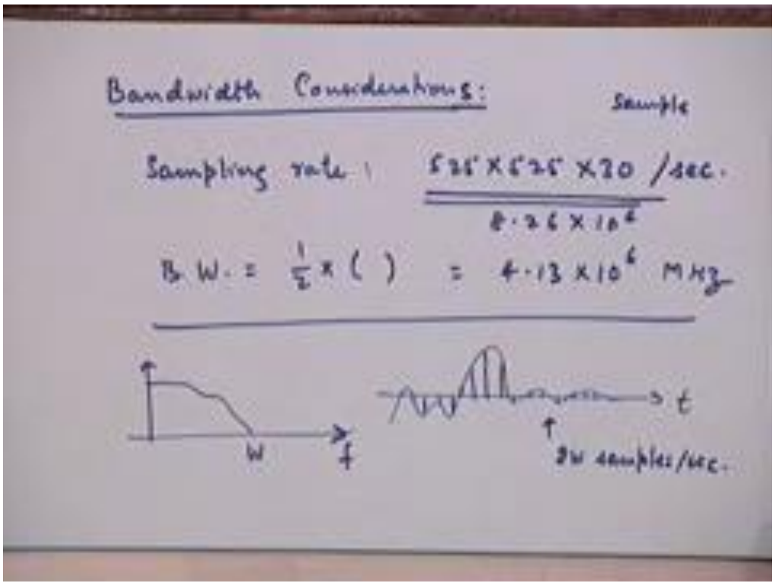

Next let us come consider, how we got this figure of about, 4 megahertz for the bandwidth of the audio signal video signal. Let us consider the bandwidth issue now. Let us recollect, what we started with, when we talked about the picture signal really speaking. The bandwidth comes from the wave we depicted the picture has composed of so many picture elements, these are the where you can think of a picture from the point of view of perception, it will look good to us.

If we have these pix suppose I just have each of these pixels available to be separately and not the complete picture; that means, I could still reconstruct the picture is not it. Put this pixels together here, I if have just samples of this picture which is pixels essentially samples here these many samples in this frame is good enough.

And, but only thing is from away from perception point of view, I must have successive frames coming at this rate 30 frames per second with. So, many picture elements in each frame, so that gives me the kind of sampling rate that is associated with the sampling process in the picture that is good enough for my perception by the eye.

So, as if I am representing the pictures by so many samples the number of samples is 525 into 525 and these many samples whole frame are to be repeated at the rate of 30 frames per second. Every 1 by 13th second I must have so many samples available to me for reconstruction.

So, basically how many frames or how many samples we are talking about, so sampling rate that we are talking about overall sampling rate is 525 into 525 into 30 is it true. Every second, I need to have it is 30 frames per second, so this is the number of samples that I look at per second

Student: ((Refer Time: 42:49))

Let us say that pixels are now talking of thinking of pixel as a sample. So, I need to transmit, so many samples per second of proper reconstruction by the human eye perception mechanism.

So, now from a sampling theory point of view if you have a certain sampling rate this is a sampling rate and see that this sampling rate is adequate for our reconstruction of original signal. This is of course an empirical observation, what does it mean in terms of bandwidth, the bandwidth should be half of this, because the required sampling rate is about twice the higher frequency composite containing the.

So, from that point of view our bandwidth really becomes half of this value, so if you want to compute this terms are to be some 8.26 into 10 to the power 6 picture elements per second. So, half of this is equal to some 4.13 into 10 power 6 megahertz, so that simple calculation establishes the bandwidth that repeat. Of course, this is not a mathematical proof of the bandwidth of the picture signal, this is an empirical proof based on the fact, that these many samples for checking or adequate for reconstruction by our way.

Student: ((Refer Time: 44:24))

Because your

Student: ((Refer Time: 44:28))

No this has nothing to with do about VSB.

We are talking of picture signal, properties of picture signal independent of how we transmit it. If since it is adequate to represent the picture by so many samples and we transmit so many samples at the rate of 30 sample 30 frames per second. The overall sampling rate at which we are transmitting information is this much they are representing information not transmitting representing information.

They are representing 30 frames each frame containing so many samples and the total number of samples that I look at one second is this much, this much is required for proper reconstruction. That means if this so much sampling rate is adequate for something the bandwidth should be about half of that from sampling theorem. I am using the result of the sampling theorem here.

Remember the sampling theorem from your signals and your systems course.

Student: ((Refer Time: 45:28))

I do not know whether that is correct, but let me repeat the sampling theorem for you, of course, I will consider it again when we need to discuss it in the contents of digital communication. But, the sampling theorem states that if you have a signal to the certain bandwidth using the frequency domain, so you have some corresponding time domain signal here.

This is the frequency domain representation; this is the corresponding time domain signal. The sampling theorem states that if I want to sample this time domain signal at a particular rate at a rate higher than a certain rate and it is always possible for me to reconstruct this continuous time signal from the discrete samples.

So, why is sampling rate is, more than 2 W, so if W is the bandwidth the sampling rate here is two samples per second. If I have 2 W samples per second or more half the continuous time wave form either always get the continuous time signal back through some suitable filtering mechanism that is what the sampling theorem says.

So, this result comes from sampling theorem not from anything else. So, from if therefore, so many samples are adequate for reconstruction this is based on our empirical observation; that means, the required bandwidth must be half of this. That is the resultant is

Student: ((Refer Time: 47:13))

4.13 into 10 to the power 6 hertz or 4.13 megahertz, thank you for pointing that out.

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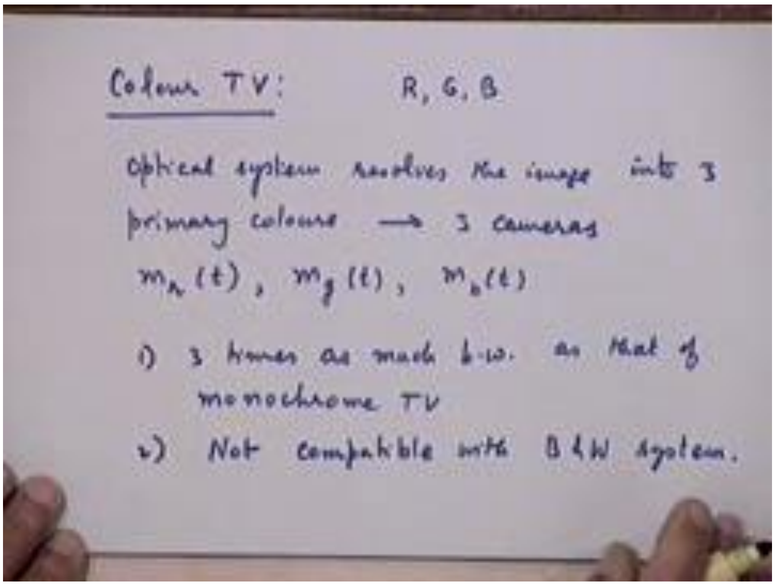

A few words about color television just a few words, because I do not think I will have the time to go into much more detail. But, for those are few who are interested in more detail a very good amount of material is available in book by lateritic. I like to recommend that book for those of you who would wish to know the precise mechanism of color transmission in more detail.

But roughly, the difference between black and white and color television is primarily this instead of picking up one signal which is proportional to the intensity level of the picture you need to somehow pickup three signals. So, obviously, require three different cameras, which are sensitive not just to the intensity or the brightness level of the picture element, but to the colors three basic colors.

So, basically the three primary colors as are the yellow the red and the blue, but of course we know one does not use this three gives some other three which more or less of the same purpose. That is because of the availability of various kinds of phosphorus which are sensitive to various kinds of colors.

So, the typical three basic colors they used are the red, green and the blue, because phosphorus these are all easily available. In a for example, if you have phosphor which is sensitive for these it will produce when it is start by the electron gun it will produce the green color, we probably do not have which will goes which will produce the yellow color.

So, these are the three basic colors, so we have three cameras which are sensitive to these. So, you have an optical system which resolves the image into three primary colors basically by using three different camera, camera tubes or cameras whatever you like to call it, so let us call this signals it emitting three signals, let us call it m sub r t m sub g t and m sub b t. The red color signal the green color signal and the of course, the signals are not color they represent the three different colors.

Now, if you transmit these three first of all, now there is a problem of three signals having to be transmitted, they are big issues here; we have to be very careful. The signals transmission, if each of them suppose has a 4.5 megahertz bandwidth you are in trouble so, that is one issue.

The second issue is you would like to make sure again there is a compatibility issue just like the monophonic FM transmission and the stereophonic FM transmission. When they were designed when the stereophonic system came in you have to make sure, then the monophonic system also is able to receive the signal and joined.

So, similarly when the color transmission came of course, now it is only color transmission, but when it came there was a lot of black and white transmission and there were lot of black and white TV receivers. So, we have to make sure that this transmission is compatible with the corresponding receivers.

Of course in today's contents, it is not very relevant, but that time it was definitely very relevant. So, these the two basic details of the two problems, one is 3 times as much bandwidth as that of monochrome TV and secondly not compatible with if you want to transmit these three signals and not that is not compatible with black and white system.

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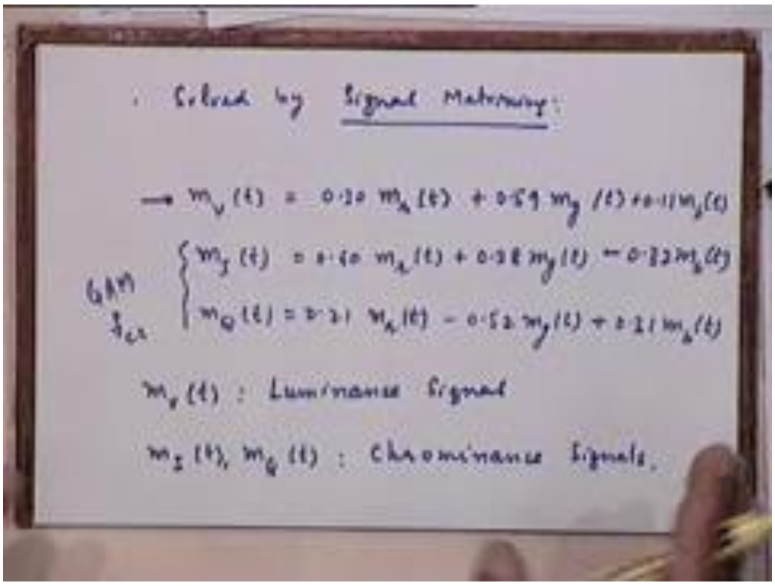

When these two problems are solved by for us called signal matrixing of some kind, that is we use these three basic signals to generate another set of three signals, by taking the linear combinations which has some special properties. And then we use the special properties to both conserve bandwidth as well as to make it compatible with the black and white transmission.

So, we generate three signals and call it m v t, which is there is some where is this coefficient values come do not ask here at this moment. Because they come from a lot of experimentation they are we obtaining empirically and not they do not come from any theory and m sub q t.

So, you take three appropriate linear combinations of the three RGB signals that you have and construct a set of another set of three signals which are equivalent to represent the same information is like a matrix multiplication. You will have a matrix consisting of these nine elements that matrix multiplies this vector of m r m g and m b and produces another vector that they contain a same information.

We are transforming the original signals into another set of three signals and it is a reversible transformation that is given these I can always go back to RBG, I invert by using an inverse matrix that is always possible. However, the significance of this combining is the following, one is first of these three signals essentially becomes very similar to the black and white signal that you have.

So, we call it the luminance signal, so m sub v t is called the luminance signal and it has more or less all the properties that match very closely with the black and white signal which carrier the intensity information. The other two as exclusively carry more or less the color information there color information.

So, again these coefficients are chosen such that the efficiently these features of human color vision. The way the human eye perceives various colors, all that has been taken into account in arriving at this coefficients, so m sub I and m sub q t are called the chrominance signals.

Now, that takes care of the compatibility problem, because what is it mean? That the black and white receiver will only use this signal it will not use this signals for reconstruction, always that the problem is not as simple as that, but at the moment I think that that kind of argument will surprise. The problem of bandwidth is still an issue because we still need to transmit three signals.

Now, this is a matter of detail, I will not go into the details as I said if you are interested in detail please read it from Lattice book. But, I will just make a statement the statement is it turns out that if I do things little cleverly choose certain ways of modulating these three signals on to different sub carriers.

I can choose all this various of sub carriers, that I need within the video band; I do not need to go outside the video band. Because the detail spectrum of the video signal has certain features which makes it possible to do that number 1. Number 2 the way it is done is such that it is still possible to separate all the three signals at the receiver and they do not cause any interference with each other, but the details I am I am going is restrict here.

So, actually these two signals are transmitted in a in a using quadrature amplitude modulation that I will use a subs subscript I and q using quadrature amplitude modulation on an appropriate sub carrier that we call it f sub c which is chosen carefully. So, that the bandwidth problem is also solved here, except to say this I will not go into more details, I will stop here today.

Thank you very much.