Communication Engineering
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Lecture - 8
Amplitude Modulation

If you recollect I introduce to the concept of modulation amplitude modulation yesterday and we were in the process of discussing, one kind of amplitude modulation which is called double side band with suppressed carrier amplitude modulation. We have looked at the waveform, we have looked at the spectrum and we were looking at the demodulation for such a system. How do we get the message signal back from the modulated signal?

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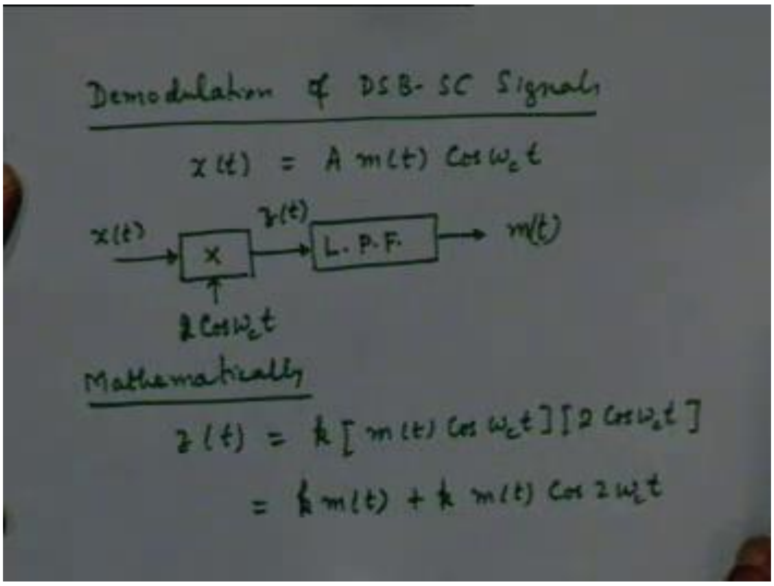

And, we were agreed that in a demodulation process could be very similar to the modulation process, the received signal x of t which is equal to A times mt times cosine omega ct. Once again needs to be translated back we have to go through a translation frequency translation process, so that we get a component around the 0 frequency that is the base band component.

Of course, in the process we will get a component around 2 f c as well and therefore, the demodulator will have the same multiplier that we have at the transmitter, which will multiply the received signal with the carrier 2 cosine omega ct. And followed by a low pass filter while hopefully this should be replica of the message signal mt may be with the scaling constant etcetera. Mathematically speaking you are multiplying xt with, so let us say that the output here it is called the signal z of t.

So, z of t is some constant q that will be associated with this multiplication process of mt into cosine omega ct into 2 cosine omega c t, this is which you are doing mathematically multiplying the received signal with 2 cosine omega c t, I will just introduce a constant k which may be associated with the multiplier. So, they are the, it could be producing output proportionate to the product rather equal to the product right that is acceptable to us.

So, this will be equal to as you can see when you have 2 cosine square omega c t which you can write as 1 plus cos 2 omega ct. So, this will bek times mt the first part plus k times mt cosine 2 omega ct I have skipped one step in the process.

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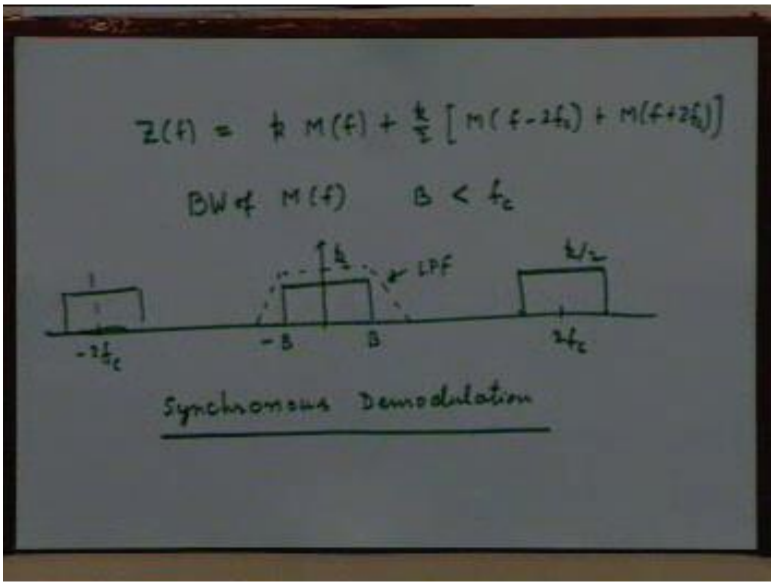

And, in the frequency domain this would appear to be if I take the Fourier transform of the signal this will be, the first part will have a Fourier transform which is k times the desired spectrum m of f plus you have components at, components at the translated version of m f around 2 fc and around minus 2 f c. This is I hope, understood I am just writing the Fourier transform of this, this part is k times mf the Fourier transform of this part is mf minus 2 fc plus mf plus 2 f c as we note if we can assure.

Then, if you note that your fc is suitably chosen, so that what is the requirement for the band width B of or let us say bandwidth of mf are the largest frequency component in m t, if this condition is if this satisfies the condition that B is less than fc then; obviously, it will be also less than 2 fc and these two spectra will not overlap. So, these are non overlapping spectra this is this portion is spectrum is in much higher frequency band than one you need from the spectral domain spectral support of m of f.

And therefore, it would be very easy to separate this out by just putting a low pass filter, so this low pass filter should have a band width of how much, should be with a desired bandwidth of B that is what you want. We want only the desired signal to appear at the output. So this low pass filter should have a bandwidth of B and naturally then, the component which has centered around 2 f c would be eliminated.

So, in the frequency domain what we have is z of f will look something like that; it is a desired component from minus B to plus B. And this part is around 2 fc same thing and this part is around minus 2 fc same thing and if you make the make sure that the low pass filter.

Student: ((Refer Time: 07:28))

Yes, this amplitude is k and this is kby 2 which is not depicted in this diagram you can correct it suitably, so if you have a low pass filter with the response like this let us say of this the signal get eliminated and what you get at the output is, the product of this frequency response with this input spectrum. And therefore, we will just get the m of f back is this clear, so that is a low pass filter transfer function, so that is the demodulation look simple enough there is a small complication which you should be aware of.

The demodulator if you look at, it requires the local carrier at the receiver I must have a replica of the carrier that I use at the transmitter now that is, that does not appear to be a big deal. But, you must remember that there is a requirement here this local carrier must be precisely the same frequency as the one that we have used at the transmitter, you should have precisely the same phase as the phase of the incoming signal in carrier in the incoming signal.

Because, if these two conditions are violated you will not get a perfect demodulation of the kind that we have proved mathematically to be, so the input was being here the modulation has been done by multiplying mt with A cosine omega ct. And we are assuming that the perfect knowledge of frequency of phase of this value is available at the receiver. So, that you can multiply it by a local carrier replica and get your demodulated output.

So, implicit in this demodulation process is a concept of synchronicity between the transmitted carrier and the received carrier and at the local carrier at the receiver. So, therefore, this called this is also called synchronous demodulation.

Student: ((Refer Time: 09:38))

Yes please.

Student: ((Refer Time: 09:40))

Yes, we will just see what will happen if the local carrier has the frequency which is slightly different from the actual value of the carrier frequency. We will see what is the effect it will, it will lightly differs we will see that in a few minutes if I get some ((Refer Slide Time: 10:02)).So, this kind of demodulation is called synchronous demodulation. Whereby, you can imply that the demodulated signal or the local carrier at the receiver should be in the perfect phase and the frequency synchronous with the carrier of the received signal.

Because, if it is not so you will not get a perfect demodulation let us see why, so let us look at the effect of loss of synchronization, if you synch if your synchronization is not perfect what will happen. We also call it the effect of loss of coherence; they are saying that the local carrier and the incoming carrier are coherent with respect to each other for coherence. You mean, essentially it is a term for indicating that they have a same frequency and have the same phase that is what we mean by coherent.

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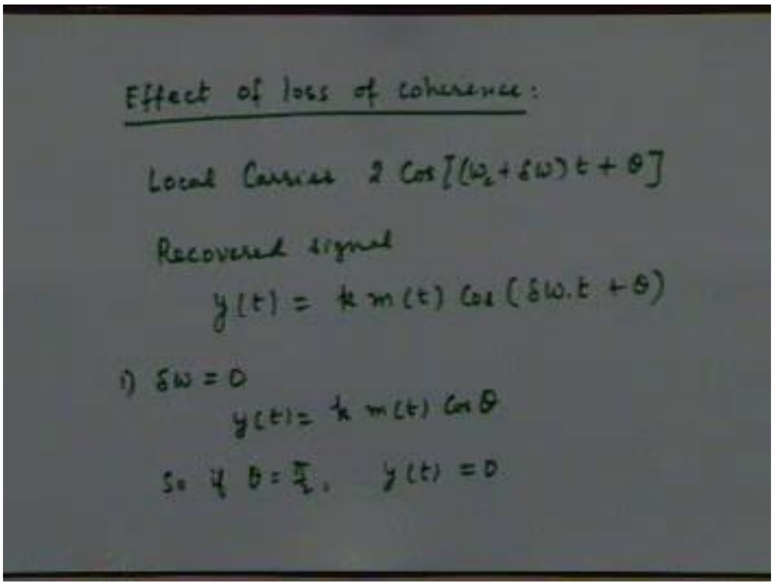

So, there is a if there is a loss of coherent m coherence then there will be some undesirable phenomena taking place, suppose your local carrier is of the kind 2 cosine omega c plus delta omega t plus theta, the incoming carrier is omega ct. But, your local carrier is at a slight frequency perturbation that is not exactly omega c but omega c plus a perturbation delta omega.

And, also there is a phase difference theta, so if you go through the same trigonometric equation once again it is very easy to check just through trigonometric identities then the recovered signal y of t is now, given by not k times mt which was the case earlier. But, can you guess what it could be k time’s mt into cosine of delta omega t plus theta. So easy to check this out multiply the two, apply the trigonometry identities of cos A into cos B and look at the term which is the low pass term.

So, we will get this output rather than k times mtto propitiate what this output is like let us simplify the discussion first, assume that these two frequency perturbation that the frequency at least is perfectly synchronized. So, let us say delta omega is 0 this 1delta omega is 0 now what will happen, soy of t would be k times cosine theta k times mt into cosine theta seems alright it is not it because cosine theta is also a cos term.

But, see what will happen if theta is pi by 2 we would use a signal, so if theta is pi by 2 y of t will be identically 0. So basically cosine theta now becomes a meditation factor, the recovered signal is of course just a scramble there is no distortion in the recovered signal.

The recovered signal is still proportional to mt, but the problem we do have today is we do not have the recovered signal at all. Particularly if your phase difference is as much as pi by 2, so you can see there is a perfect phase matching required phase synchronization required, so is it clear?

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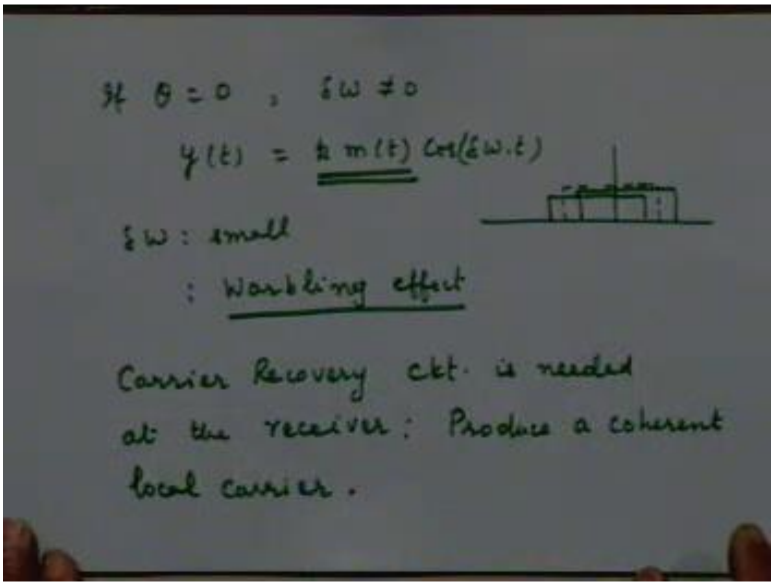

Now, let us look at the case where theta is 0 just to simply the discussion again of course, this does not really simplify too much theta is 0 but delta omega is not 0, soy of t now is equal to k times mt into cosine delta omega t. And now, you can see that there is a distortion as well because, you are getting a function of time which is not the same function of time that you start with that you want. It is being multiplied with another function of time, it is the product of two time functions the one that you want and some additional time functions which is coming in the process just as again.

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

What for you transform the recovered signal y of t, Fourier transform although will tell you what is happening in the frequency domain, but this is what you are getting should I repeat. After multiplying a low pass filter this is the output which you are getting, where as what you wanted was k time’s mt, so instead of getting what you want you get that into something.

Student: ((Refer Time: 15:18))

Delta omega is ((Refer Time: 15:26)) doubt is if you pass this to another low pass filter we get mt back; please remember that this is a modulated signal again. But the modulating frequency is extremely small even if it has a high frequency the low pass filter would not be remove it. Because, the whole things is transmitted around that near frequency, so in fact, the low pass frequency in that case the low pass filter would remove anything that by important case to discuss here is not that case.

But, the case where delta omega is very small because that is likely practically happen, we will have a local carrier we will try to adjust the frequency to be as close to that of the incoming carrier, but maybe there is very small frequency difference left that we will not be able to take care of that. So, this may be of the order of a few hertz may be a tons of hertz at the most hundreds of hertz could be 2 tons of hertz.

If you are using very stable oscillators both at transmitters as well as at the receiver then, the typical frequency difference will not be that high which will be the case in practice and that case basically, what you see is that cosine delta omega 2 will be slowly vary with sine wave. Multiply with m t and this m t is very low frequency here, so delta omega 2 is typically small. So what will you see? We will see here that your incoming signal is multiplied by scaling factor which is sometimes growing up and sometimes reducing significantly.

So, some of the amplitude that will go up and then will come down and then go up and come down and then soon and, so forth they will differs it distortedly wave. Here a distorted measure of the actual signal and the kind of distortion that result is called warbling distortion. This is a kind of warbling phenomena, amplitude going up and down is called warbling effect.

Student: ((Refer Time: 17:32))

The carrier frequency is out that is why it will stay around 0, but in fact, actually what is happening is in the frequency domain, if this was the original spectrum it is slightly shifted. So, you will have a portion like this and a portion like this, the sum of these two is spectra is that you will get, so there is slight frequency shift to the left as well as right. So what we will see as the resultant of these two is no longer the original spectrum where the spectrum is just this pointed here that is what is happening in the frequency domain is that clear to everyone.

So, this therefore is called the warbling effect, so that therefore until I use the import the importance of what we call carrier recovery in this kind of a demodulation, we require a fairly sophisticated a fairly good carrier recovery system. By which we will be able to establish the local carrier which is in perfect phase and frequency synchronism with the incoming carrier and that operation is called recovering the carrier at that receiver.

So, the carrier recovery circuit is needed at the receiver and making the carrier recovery circuit to produce a synchronous carrier produce a coherent carrier, coherent local carrier. And this kind of recovery can be done by using the device called phase amplitude etcetera which we shall discuss when the little later.

So, there are the special circuits for it has to make to carry out this carrier recovery operation to make sure, that the local carrier is in phase and frequency synchronism with the incoming carrier. And that is why synchronous demodulator is typically a complex operation because, we need to worry about this, we need to about carrier synchronization any questions at this stage.

Student: ((Refer Time: 20:24))

Good, that is precisely in what we are going to do next, so as we can see what are the disadvantages of the double side band suppressed carrier modulation is would be to carry out synchronous demodulation which has this composition. So, as just been suggested we should explore the possibility of a scheme in which we actually transmit the carrier also. And see whether that helps us simplify the receiver and that is the precisely in what you are going to discuss next.

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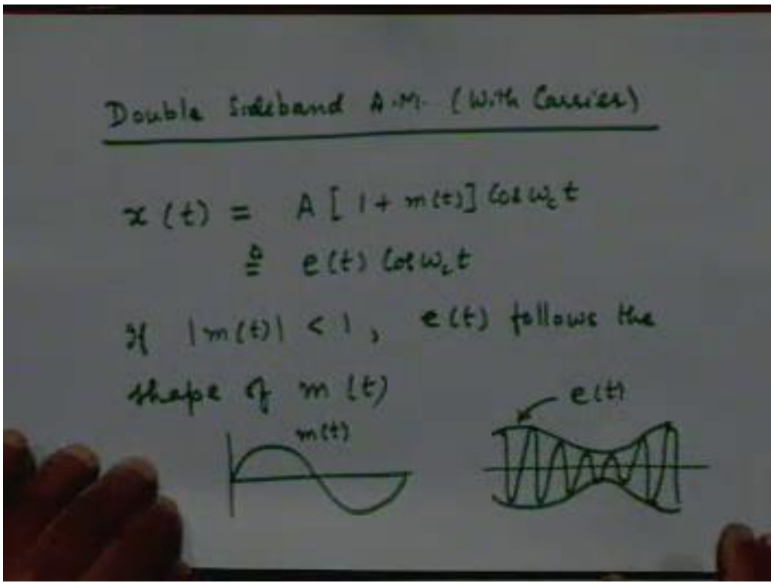

And, that is double side band when both carriers without carrier, so this is no longer suppressed carrier also if carry a component with this. So basically what we are saying is if I take then, generally when refers to amplitude modulation in practice one is typically referring to this situation and not the suppressed carrier situation that we have discussed so far. So, the suppressed carrier situation is used typically or voice used earlier in the earlier days typically for transmitting data signals.

For voice signals, so this is one of the most commonly form of most commonly used form of the amplitude modulation. So basically what we are saying is that in this case you have transmitted signal x of t will of course, contain the path that we have transmitted earlier. But, we also put in a carrier component, so it looks something like this as you can see the second term is precisely the same term that we had earlier A times m t times cosine omega ct.

But, we also adding a term which is equal to A cosine omega c t which is a carrier term, so there is a carrier component specifically introduced along with the message signal along with the rest of the modulated signal to produce the final modulated signal x of t. And, let us define this as some e of t into cosine omega ct where e of t is defined as e time's 1 cosine t. Now this waveform let us look at the time domain behavior of this waveform can be made to have some can be made to have very interesting property under a certain condition.

For example, if I ensure that if the magnitude of the modulated if the magnitude of the waveform in the this equation is always less than 1, think of this as one wave and mt lie in between minus 1 volt and plus 1 volt. So that, I keep basically do the scaling the message waveform in such a manner that amplitude its instantaneous amplitude never exceeds 1, it always lie between minus 1 and plus 1every message will have some limits in which it lies.

Every waveform will have some limits in which it lies I can scale it up or down, so that this condition is satisfied in which in this case a very interesting property that this waveform will have is, that this entity e of t which you can now consider. You see this will be a positive quantity always 1 plus mt will always be a positive quantity, you can think of this as the envelope of the waveform, envelope is always positive.

So, we can see e of t then we have the shape of m t, soe of t follows the shape of mt of course, here is a 1 cos omega may be the constant one along with that. So that costerm 1 can be always taken care of follows the shape of mt.

Student: ((Refer Time: 24:38))

No, in the DSB SC case the envelope is proportional to the modulus of m t, what we like to have is the envelope be proportional to m t itself of course, if I would like to have some reasonable issue which I will come to know in few minutes. How does it help us is something that we have to still discuss, but I just want to point out this interesting fact which was not available to us in the suppressed carrier modulation. Because, there the envelope was proportional to modulus of mt.

There we make envelope proportional to m t of course, the spectrum, so that is as per the waveform goes let me just plot the waveform, so what we are saying is if your message signal is make it as a sine wave for our sake of illustration like this. Your modulated waveform will now look something like that, the instantaneous amplitude of the carrier follows this is the envelope e of t, this amplitude is 1 plus mt and if mod of m t is less than 1 you will see that this will never cross this x axis the time axis.

So, the always there its proportional if it crosses the time axis we will have a problem because, when we lose the proportionality of the envelope that we are looking for with respect to mt two mt.So, that is why this condition is bad that mod of mt should be less than 1, so that is the typical wave time domain waveform of amplitude modulation with carrier. As against the waveform that we saw is to be for amplitude modulation with suppressed carrier without carrier. But before we come to how it helps us how is this property helps us let us also look at the frequency domain.

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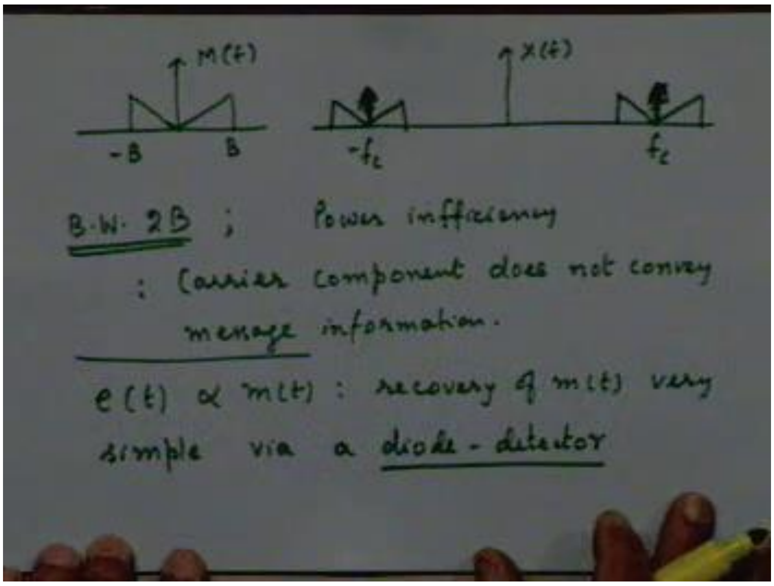

And, to do that this two for convenience I am taking a message waveform spectrum to be something like this here, it has absolutely no reason for this particular choice we have made a we have particular for this choice. But, since I want to show the carrier component a little more clearly I deliberately chosen the message waveform as if it does not have any component present, but there is no requirement of this kind again.

So, suppose your message waveforms have a spectrum between minus B to plus B as transform which is non 0 at instant then, the modulated spectrum x of f the spectrum of the modulated signal in this case would be like this. Where this is around fc this is around minus f c, the same spectrum translated to plus fc and minus fc and in the illumination there will be a carrier component which was not there in the suppressed carrier modulation.

So, the only way the spectrum of the AM signal differs from the spectra of wave signal with suppressed carrier is that this carrier is carrier component is not present, ahead there also raises a question as to why do we call the earlier kind of signal as DSBSC. So, the basically this difference in this case we have localized specific value of the carrier component along with the modulating signal, so the spectrum properties of this signal are to some extent similar to that of the DSB SC.

And, in the sides that the band width required is 2 B as against the message bandwidth of b but, so that is the bandwidth requirement as you can note is various kinds of we have introduced actually a kind of inefficiency here. What kind of inefficiency we have introduced.

Student: ((Refer Time: 29:09))

Yes, we have introduced a kind of power inefficiency not all the transmitted power contains useful information the carrier does not contain message wave message information. It is helpful to us in some other where in the receiver which we have to still see but, by itself as far as the objective is to transformer transmit information that purpose is not being solved by transmission as the carrier component.

So, therefore, in axis this particular component that we are transmitting will actually be waste of power from that point of view. And therefore, there is a kind of power inefficiency that we have introduced by introducing the carrier components in the transmission process, so why should we do that.

Student: ((Refer Time: 29:59))

No, I think you have not understood the point, we were not getting the carrier frequency information we did not have a specific carrier component at fc for example, in this particular case the suppressed carrier spectrum would look like this. So, we do not have a component at fc just because, the spectral density has a component has value at fc. It does not mean that there is a component at fc; yes you can say that there is some energy present in the neighborhood of f c.

But, you cannot say that there is a component at fc there is a difference between there is awe should have some understanding or what does the density function mean and what do impulses in the density function mean. When we have an impulse in the density function that means, we have localized component at that frequency and there is some finite power or energy that we can talk about at that frequency. Otherwise, when you have anywhere value of density function which is not impulsive if you want to ask the question, how much power is carried at less frequency.

Student: ((Refer Time: 31:22))

The answer is 0, so therefore you have to understand that issue there is no carrier component in this suppressed carrier waveform, there is a value of the spectrum at that frequency surely, it could be 0 it could be something finite becoming only spectrum of less in waveform. But, that has to be with less in waveform it can just with the carrier itself, so process of modulation simply shifting the spectrum from one location to another location that is all we have to do.

We are not introducing that we are now calling the carrier component therefore, so let me restore this arrows, so that it can be seen, so there is a power inefficiency let us return to that point. When the power in efficiency is beaten effect for the carrier component, if we had introduced does not convey useful information there is a useful I mean message information, you cannot say them it is entirely useless, so it has some function to perform now, how can we use them one.

Student: ((Refer Time: 32:44))

Sorry.

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

Can you speak with a mike?

Student: ((Refer Time: 32:53))

So, one suggestion that is we need is that the usefulness of this carrier will be that we would be able to recover more easily a coherent carrier at the receiver, that is what we are saying and that can be done, that is the possible way of looking at it. But another possible another answer is that the effect that the envelope follows the modulation, the modulation the actual waveform the desired message waveform can be used to design a receiver. To be design a new demodulator which is extremely simple which does not even requires us to do a synchronous demodulation.

If I do not require it to do synchronous demodulation I do not have to carry out the carrier recovery process and that will lead the receiver very, very inexpensive. Because, I do not require a phase slightly or a complicated carrier recovery circuit to produce a local carrier which is in perfect phase and frequency synchronous with the received carrier and that is the real advantage of AM with carrier.

So, the demodulation can be effected fairly simply by using a very simple circuit which we call the envelope detector, so basically we use the fact that the envelope e of t is proportional to m of t. And that needs a recovery of mt very simple by a device which you call via you call diode detector, so we will soon see that it is, so such a simple device I would settle it through very cheap components in it can effect new modulation.

Whereas the earlier demodulator required you to have a multiplier analog multiplier low pass filter, low pass filter will be required. But also we will require it complex carrier recovery circuit which we will ensure that in that method because, that is fairly complex, but before I.

Student: ((Refer Time: 35:13))

Yes please

Student: ((Refer Time: 35:14))

That is right

Student: ((Refer Time: 35:20))

These can be assured by doing what you when you saying when do not know you have to know that, typically by experience with the how after all the message signal is being produced by some source and we cannot study why the properties of that source. We can find out what is the maximum possible rate of values that we will see at the output of this source. That knowledge is required if you want to ensure that otherwise, if occasionally such a thing happens what we are saying, we will occasionally that distortion coming in which we do not want.

To that extent we have this problem, but that is not a very difficult issue and in many cases you can be anything safe you can attenuate or divide the value which is larger than the expected value would be. So, that is very easy thing to take care of that is not a very big issue here. But before I go onto diode detector which we will agree with that its very simple device let me also define some attributes of the waveform that we have just talked about.

The waveform I am referring to is the, this modulated waveform with respect to this modulation of this waveform you can see that depending on the related value of m t, modulus of m t with respect to 1. You can have a situation where this envelope is fairly above the time axis or it can even touch the time axis. For example, if modulus of m t is equal to 1 then, it will then the envelope will even touch the x axis or the time axis, but even if it becomes more than 1 the envelope will now become in that in length proportional to mod of mt. So, that this portion will go up this portion will come up, so that is what we do not want.

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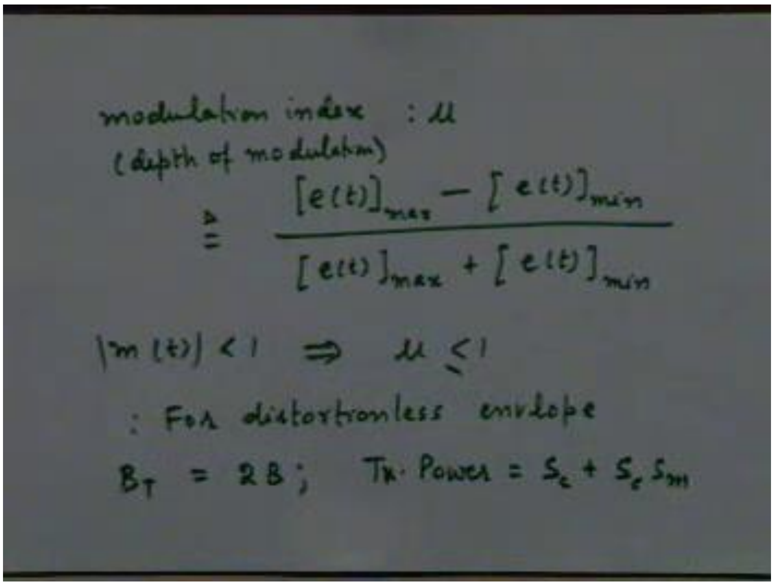

So, define a parameter, so this is called the modulation index or depth of the modulation for alternative value is depth of modulation which indicates this fact, that the waveform either will touch or does not touch basically, what is the relative variation of the envelope from maximum to minimum values. So, and let us precisely values we will define, so we denote this parameter by mew and we define as follows the maximum value of the envelope minus the minimum value of the envelope divided by sum of the two.

So, you can see this in the numerator is this value, the difference between these two values this is the maximum value this is the minimum value, so that is the numerator, the denominator is or maybe you can think of this as divided by 2 just for the sake of this also as divided by 2. So, in that case where the numerator will be half of this value which is one sided expression around the value which will attain will be the main value.

So, you can think of et the denominator as twice the mew value et plus twice the mew value plus twice the mew value minus etis the total expression. So half wave expression divided by the mean value is the modulation index, half the peak to peak expression divided by the mean value of the envelope giving the modulation index also called the depth of modulation. So, clearly if your condition mod of mt less than 1 is satisfied what can we say about this ratio?

Student: ((Refer Time: 39:53))

It will always be could imply that mew is less than 1, sometimes we express it with percentage, particularly when we refer to depth of modulation if it is 1 we call it 100 percent modulation, if it is less than 1 we just multiply it by 100. So, if modulation index is .7 there is 70 percent depth of modulation, so typically the value of modulation index will be less than 1 less than or equal to 1, this is the condition for distortion less envelope.

If you want the envelope to have to follow m of mt without distortion this is the required condition. We already seen that the bandwidth requirement transmission band width would be 2 B, what about the transmitted power, last time we derived this to be equal s sub c into s sub m, where s sub c as the carrier power and s sub m as the message power. So what will it be we have discussed.

Student: ((Refer Time: 41:18))

That is all, we just have to add a sub c to that value out of which, which is the useful power from the point of view of carrying information of interest. This part and that also tells you the power inefficiency what is the power efficiency there.

Student: ((Refer Time: 41:38))

That is right.

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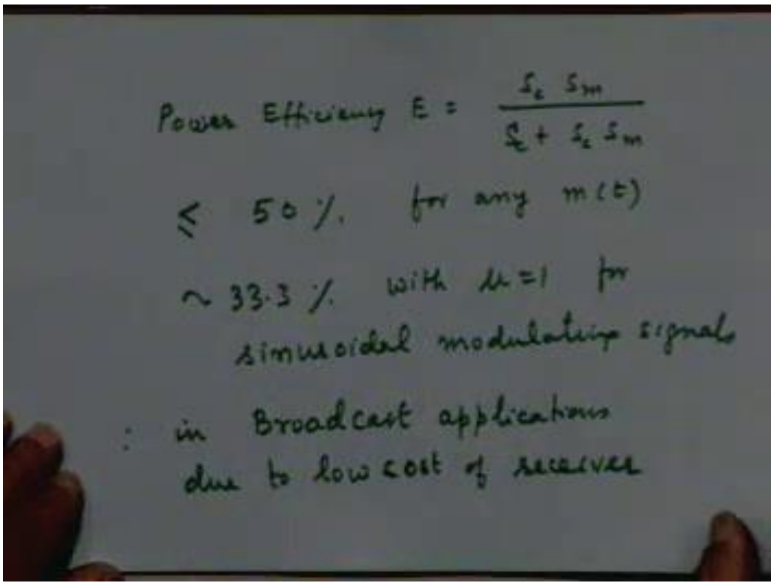

So, since the carrier conveys no useful information about the message you can define this factor power efficiency, call it e or whatever eta or whatever notation you like to use. It is this product divided by s sub c plus s sub c into s sub f typically this value will be less than 50 percent for any message signal, it can be filled I am not proving that here anyone can prove this.

Student: ((Refer Time: 42:23))

Yes, in fact if you take your message signal to be your sinusoidal signal like the one you have discussing here then, one can show very precisely. In fact, I like you to do that as an exercise that in that case the efficiency is of the order of 33.3 percent with modulation index of 1 for sinusoidal modulating signals. So, if your message modulate with this particular case is the one in which say the m, mt is a low frequency sine wave and modulation index is the larger the modulation index larger the power efficiency that you will have.

So, the largest power efficiency that you will get in this case is about 33 percent in general, for arbitrary waveform it cannot be more than 50 percent that can be sure. Because, always that will be less than 50 percent, so therefore, there is a significant power inefficiency involved in this process and one very relevant question to ask at this stage is because, we have not I have not mentioned in the past that the two most important source in communication system are the power that you transmit and the bandwidth.

So, here we are trying to waste power, so one would not like to do such a thing unless one get something significant out of that and simply we can think we can get out of this, is the fact that the receiver is extremely simple. And, that kind of thing is useful if we have one of odd transmitter server and perhaps millions of receivers or hundreds or thousands of receivers. In that case if we waste the power of one location is perhaps worthwhile.

Because, so many receivers becomes simple for, so many producer making the receiver cost much lower than 100 hertz and that is the real benefit. So the real application of this kind of thing would be there in broad cast applications, when you are transmitting at one transmitting station and large number of people are tuning into their receivers and try to recover the demodulated signal. So, therefore if all new frequency can be translated in broad cast applications due to low cost of resulting receiver.

Student: ((Refer Time: 45:13))

Comparatively is good for DSBSC

Student: ((Refer Time: 45:20))

Can be done its not undoable all that is it is its more complex, so if we agree to predict cost for that complex complexity at the receiver we can do it. It is not undoable perfectly doable require a synchronous receiver the fine the way I am doing is does not mean that we cannot have a synchronous receiver. If you are ready to pay the cost for it, let us say inside application power is a very important thing were always thinking to be with, to go further rather go for this it is for efficiency very important requirement in application we will not try to go for this.

We would rather pay this complexity pay for the complexity, at the receiver have more expensive receiver than transmit perform and in some situations that is very much desirable that too in broadcast application this is perfectly acceptable. So, every communication requirement would have a different solution this is not a solution for all kinds of communication requirements, that is something that I mentioned in the beginning and keep on emphasizing again and again wherever required, now let us look at how simple the demodulation is.

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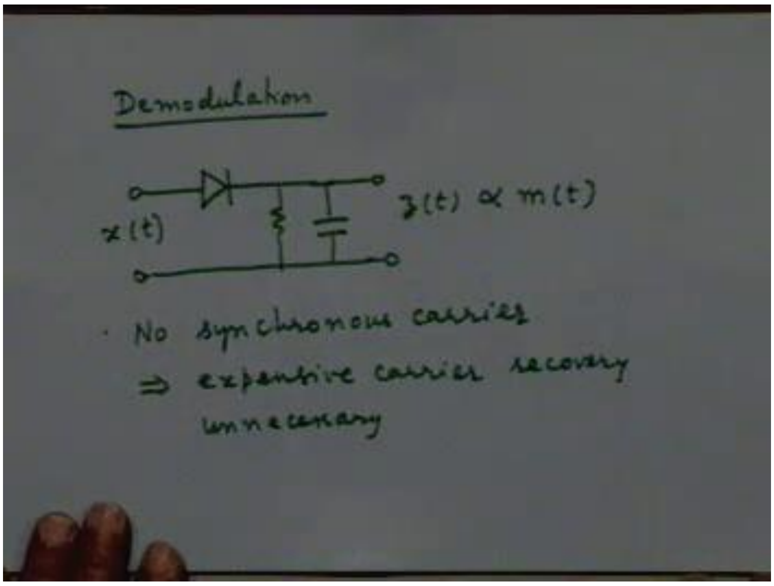

So, let us look at the demodulation process I have this time to introduce the demodulator to it, we will discuss the demodulator in detail next time. So, demodulator now requires precise to these three simple components and this is the demodulation circuit and that could be simpler in this. You have a diode we have a suitable value of resistor here and suitable value of capacitor here, input this modulated waveform x of t and output is let us says of t which is we will soon see proportional to message signal mt.

Phase shift of pi by 2 mt is an arbitrary waveform there is no concept of a phase shift of an arbitrary waveform we cannot talk about delay of a arbitrary waveform unless, it is a sinusoid you cannot talk about phase shift. You can talk about phase shift as a specific frequency component, so please remember there is no concept of a phase shift, but many think side wave of why we are mentioning that I think we are mentioning that because of this side capacitor here.

Student: ((Refer Time: 48:17))

No, you have to look you know this is not the linear circuit do you see that is not it, you cannot just jump to early conclusion here, you have to see how the non-linear surface works for us to do what we have to do.

Student: ((Refer Time: 48:31))

The day you may look upon it as a differentiator, we will look upon it as phase shifter you are looking upon it as a linear circuit which it is not is not it there is a non-linear element sitting there. So, unless you understand the operation of the circuit ((Refer Time: 48:48)). So, let us look at the operation of the circuit is that clear, so the important point is we need to understand this operation for important thing is that if this works then, you do not require any synchronous carrier at the receiver and therefore, have a result you do not require any expensive carrier recovery for it.

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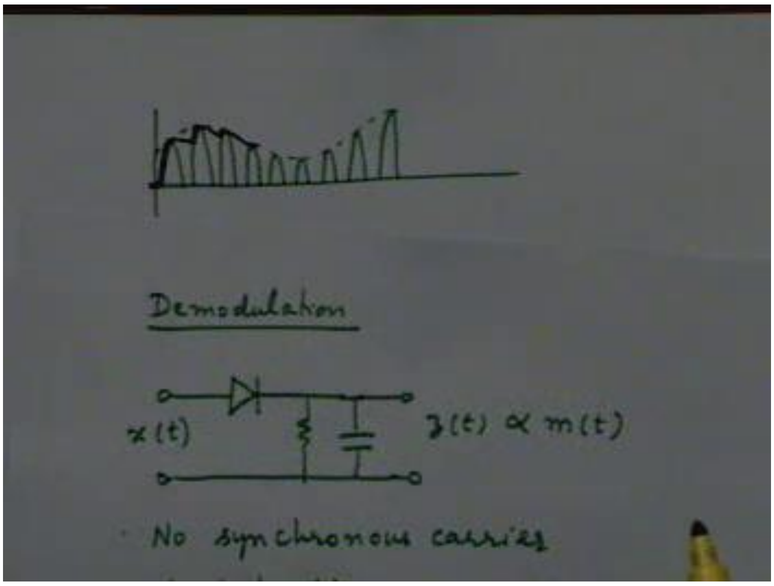

Now, how in this point let me draw a picture let say this is your modulated waveforms this is the envelope of the modulated waveform. Now because with diode we will conduct only when the when that is forward biased, you can think of this action as some kind of a rectification action, but more precisely we will see what is happening. So, obviously we only look at the positive half cycle of the carrier wave, the negative half cycles will cannot make it forward biased with ((Refer Time: 50:25)) necessarily make it reverse biased.

So, we only need to understand what is happening during the positive half cycle of the carrier wave, is that do you agree with that.

Student: ((Refer Time: 50:38))

Please let me to complete I have to still explain to you how it is working, the only point I have made so far is when you forward biased to the diode, they only come during the positive half cycles of the carrier wave is there any debatable point on that. We connect positively the percent we have if we are biasing the negative half cycle, so if you conduct only it can conduct only during the positive cycle positive half of the cycles.

Now, let us say initially it is let us say initially that this capacitor which you have at the output is completely without charge to start with, they do not have charge stored in it, so they may have voltage across this. So, what will happen during the first positive half cycle of the carrier at the circuit c is assuming that this is resistor is pretty large and this is therefore, not very important at this stage basically what will you do.

You will try to try this capacitor to the peak value of the positive half cycle, so that is what will happen let me use a different color, so initially output this was this charge the over to at 0, so it will charge like this. Actually, the charging time cost will be very small let us assume that and to follow this envelope follow this carrier and charge like this and non-emitted carrier. So what is where it is start to this point what is the voltage, here we refer to this peak value and similarly this input value drops below this peak value.

What happens to the diode?

Student: ((Refer Time: 52:33))

It becomes reverse biased stops conducting, so if you if it will stop conducting. However, what will happen due to the effect that there is a resistance here let us say discharge phenomena that will take place. So, this voltage value starts to decrease a little bit depending on the time constant that we are discharging, so let us say it discharges slowly and this is the way it will discharge, is it clear.

And, at this time the positive half cycle comes again, at this point the input voltage exceeds the discharge value of the voltage here and the diode conducts again and again give charges to the peak values and that is the way things will happen and soon. So, as you can see this charging discharging phenomena under certain conditions would produce an output which follows the envelope approximately there will be some which you could always rely by a suitable low pass filter.

So, with this we end the discussion, here today we will start again at this point, but please think about it, and we will start again at this point and make sure that all of you fully understand it.

Thank you very much.