Principles of Communication- Part I
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Module No 3
Lecture 14
Double Sideband (DSB) Suppressed Carrier (SC) Modulation, Spectrum of DSB-SC Signals and Coherent Demodulation

Hello welcome to another module in this massive open online course. So today let us start looking at double sideband modulation.

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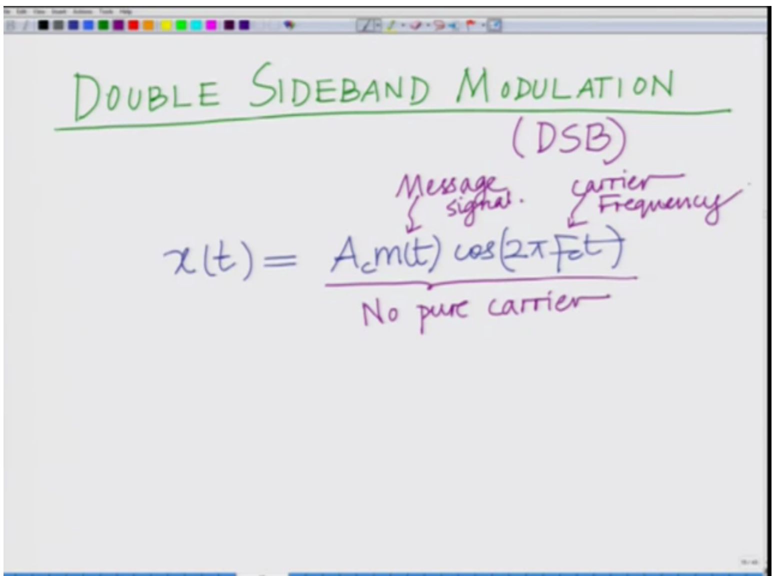

It is a, this is a different modulation scheme it is a form of amplitude modulation termed double sideband modulation also generated by abbreviation DSB. DSP stands for double sideband, okay. In the double sideband modulation scheme the modulated signal x(t) is described as follows. X(t) equals Ac m(t) cosine two pi Fct, now observe that in this amplitude modulated signal there is no pure carrier component, correct? We simply have the carrier that is modulated by the message Ac m(t) is the message signal cosine two pi Fct carrier at carrier frequency Fc, okay. So m(t) is the m(t) is your message signal and this Fc as we have already seen many times before this is the carrier frequency, okay.

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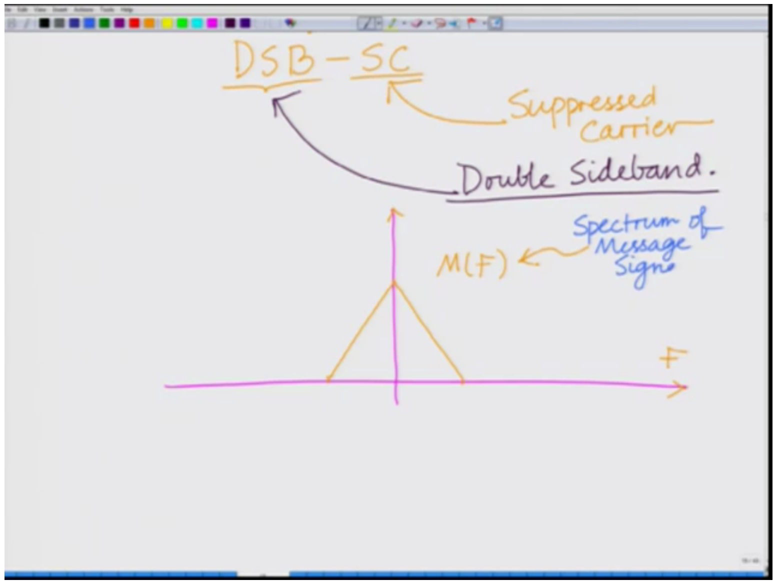

Now since there is no pure carrier, alright. This is also termed as DSB-SC where DSB as you would know already know this stands for double sideband SC stands for suppressed, correct? SC stands for suppressed and DSB stands for double sideband, DSB stands for double sideband, SC stands for suppressed carrier. Let us look at the spectrum of DSBSC signal. Let us start by considering a typical spectrum of the message signal m(t), correct? Typical signal message spectrum M(F) this is the frequency axis, alright. In the frequency domain this is the spectrum M(F) is the spectrum of the message signal spectrum of the message signal.

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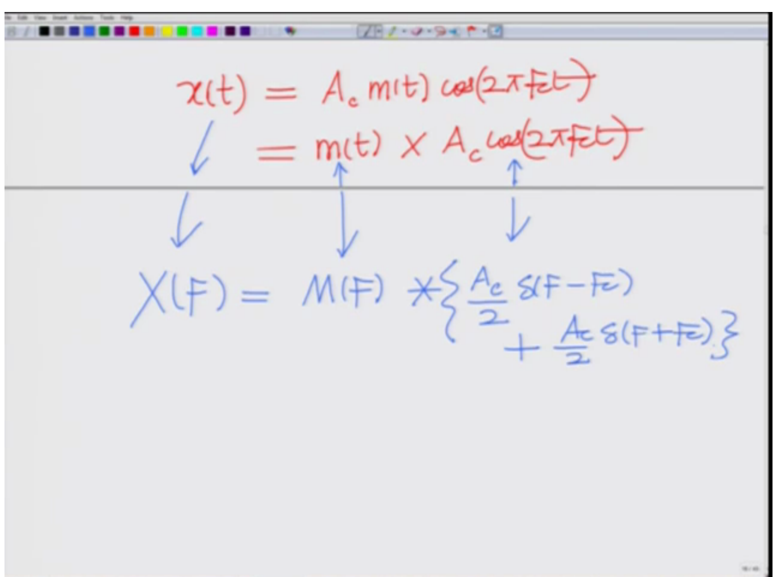

X(t) equals Ac m(t) cosine two pi Fct, okay. I can write this as the product of m(t) with Ac cosine two pi Fct, correct? xt is a modulated signal, correct? I can write this as a product of the message signal m(t) with Ac cosine two pi Fct, it is a multiplication in the time domain which means the frequency response X(F), right? Is the frequency response M(F) convolved with the frequency response of the carrier Ac cosine two pi Fct.

So multiplication in the time domain is convolution in the frequency domain therefore we have, correct? We have already seen this before therefore X(F) is equal to M(F) the message spectrum convolved with the spectrum of, so m(t) has spectrum M(F) Ac cosine two pi Fct has spectrum Ac by two delta F minus Fc that is impulse scaled by Ac by two and shifted to Fc in the frequency domain plus Ac by two delta F plus Fc that is impulse shifted to minus Fc and scaled by F scaled by Ac by two. So this is the spectrum of Ac cosine two pi Fct and convolution M(F), alright.

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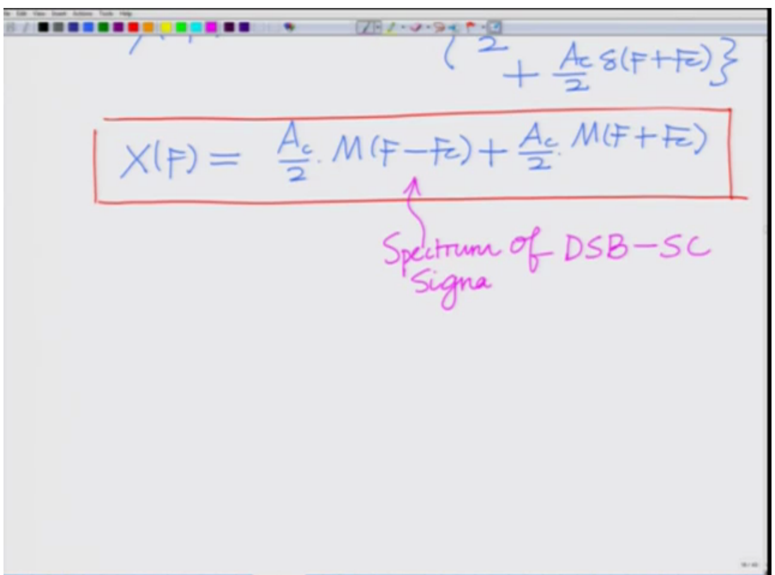

So just M(F) convolved with delta f minus Fc that is, alright. That is so it is Ac over two mf convolved with F minus delta F minus Fc is M(F) minus Fc that is spectrum of M(F) shifted to FC plus Ac by two M(F) convolved with delta F plus Fc the spectrum M(F) shifted to minus Fc that is M(F) plus Fc, okay. So this is the spectrum of the DSBSC signal. This is the spectrum of the double sideband suppressed carrier. This is the spectrum of the DSB-SC signal, correct? Which is X(F) that is Ac by two M(F) minus Fc that is spectrum M(F) minus Fc that is spectrum

M(F) shifted to Fc is scaled by Ac by two and Ac by two M(F) plus Fc that is spectrum of M(F) shifted to minus Fc and scaled by Ac by two, alright.

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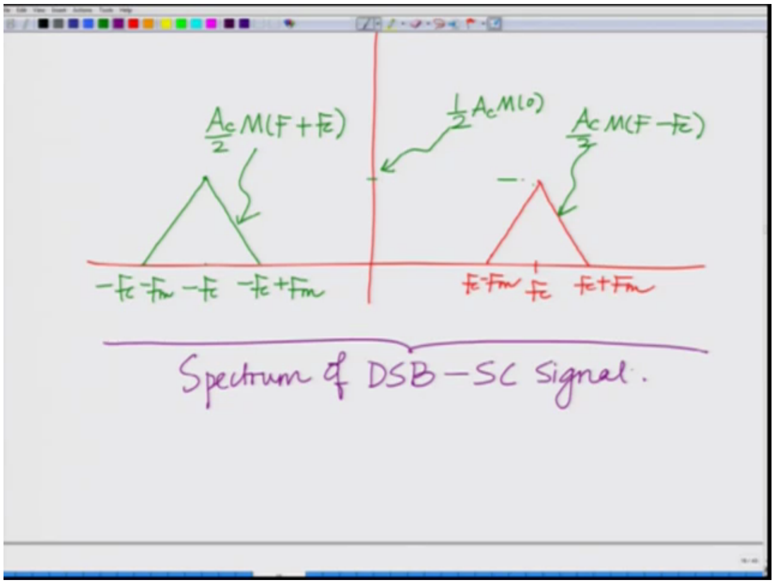

So let us now describe this schematically, I can draw this so I have at Fc, alright. I have Fc this is Fc plus Fm, Fc minus Fm, correct? In the maximum frequency component of the message signal we denoted by Fm minus Fm to Fm, correct? And then what we have is we have this point will obviously be half Ac M of zero that is a spectrum at zero because this point remember this point is M of zero. So this point is half Ac M of zero, correct?

M of zero is the spectrum at F equal to zero, correct? This is basically your Ac by two M(F) minus Fc correspondingly on the negative will have an image of this on the negative frequency axis, correct? You will have an image of this on the negative frequency axis. This is minus Fc minus Fc plus Fm minus Fc minus Fm, correct? Correct, so this is the image and this is the and this is basically corresponds to Ac by two M(F) plus Fc that is the spectrum M(F) shifted to minus Fc and scaled by Ac by two.

Alright so you have two bands one from Fc minus Fm to Fc plus Fm and the other from minus Fc minus Fm to minus Fc plus Sm Fm and as you can see there is no pure carrier component that is unlike the conventional AM signal where you had impulses denoting the pure carrier there are no impulses which means the pure carrier component is absent you only have the carrier that is modulated by the message, okay. So this is the spectrum of the DSB-SC signal, so let me characterize that so this is the spectrum of the DSB SC signal.

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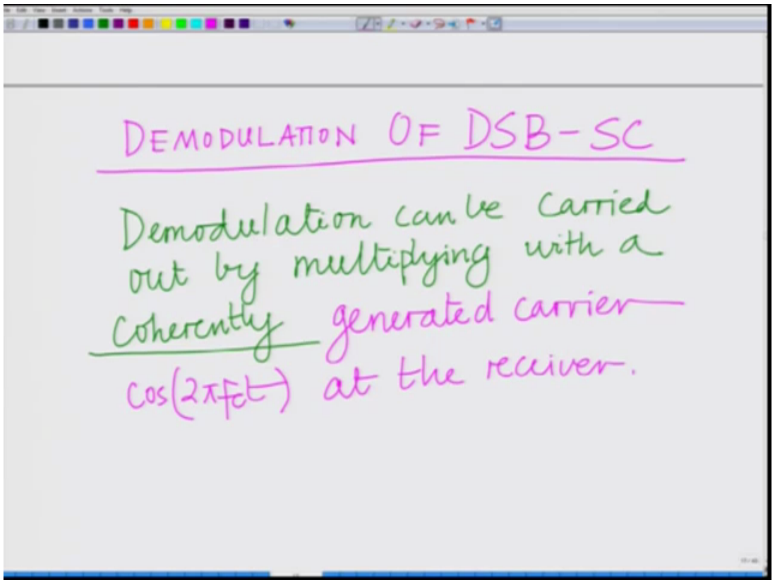

Let us now look at the modulation of the DSB SC signal. Let us now look at the modulation of the DSB SC signal. The demodulation of a DSB SC signal before demodulation we can multiply it again by the carrier which is also termed as a coherent carrier I am going to explain this later. So demodulation can be carried out by multiplying by the by a coherent, coherently generated carrier cosine two pi Fct at the receiver, okay. So demodulation can be let us note that down demodulation can be carried out by multiplying with a coherently, this is an important term coherently generated carrier cosine two pi Fct at the receiver. So demodulation can be carried out multiplying by with a coherent carrier cosine two pi Fct at the receiver.

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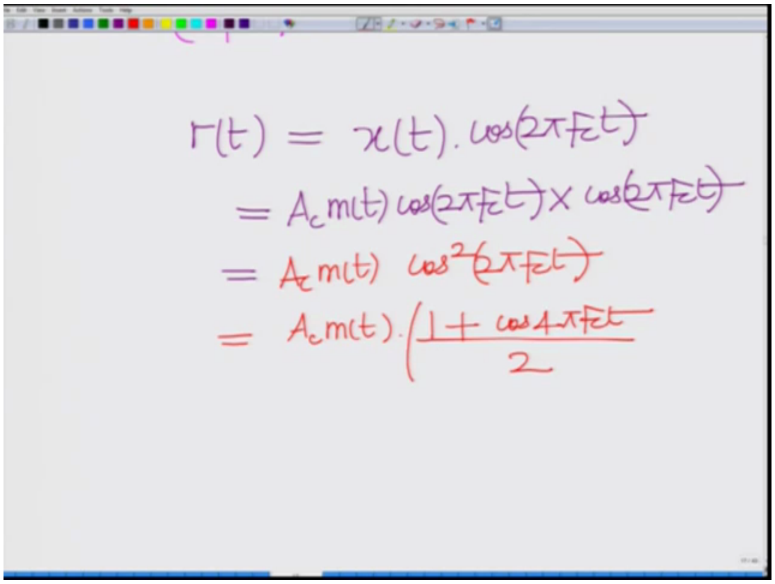

Let us look at that. Let us look at our signal x(t) at the receiver we can express r(t) equals x(t) the modulated with the coherent carrier that is cosine two pi Fct which is equal to Ac m(t) cosine two pi Fct times cosine two pi Fct which is basically you can write this as Ac m(t) cosine square two pi Fct which is basically your Ac. Now cosine square two pi Fct can be written as one plus cosine four pi Fct divided by two, alright. Cosine square x x one plus cosine two x divided by this cosine square theta is one plus cosine two theta divided by two.

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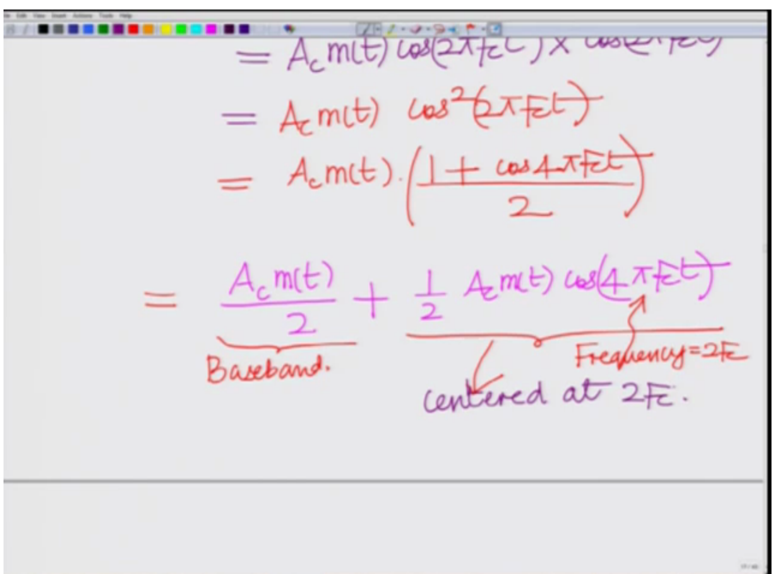

And now we observe something interesting I have Ac m(t) divided by two plus half Ac m(t) into cosine four pi Fct and if you observe this if you observe this is cosine four pi Fct corresponds to a frequency that is the frequency is equals two Fc. This is of course your baseband that is centered at zero this is at frequency two Fc, so this is centered this component if you can look at this is centered because of the cosine four pi Fct this is centered at two Fc, alright. So we have two components, one is Ac m(t) divided by two which is in the baseband which is m(t) scaled by Ac by two so naturally it is in the baseband that is from minus Fm to plus Fm, correct?

However m(t) multiplied by cosine a four pi Fct cosine four pi Fct has frequency two Fc which means it is the spectrum of the spectrum of m m(t) that is M(F) shifted to two Fc and minus two Fc, so this is far away from the base (())(14:50) and there this component can be removed by filtering to get recover m(t).

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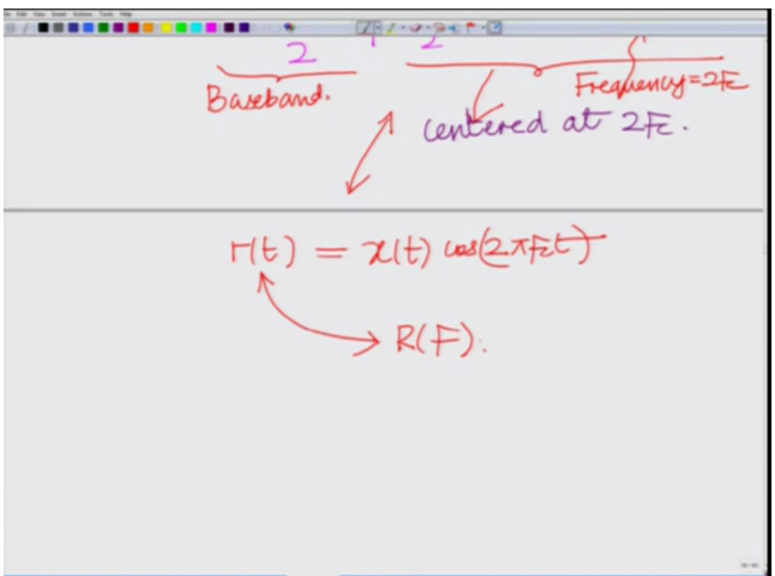

So let us look at the spectrum to understand this better let us look at the spectrum, so the spectrum of this that is r(t) equals x(t) cosine two pi x(t) multiplied by the coherent carrier and if I look at the spectrum of this that is R(F) I can draw it as follows.

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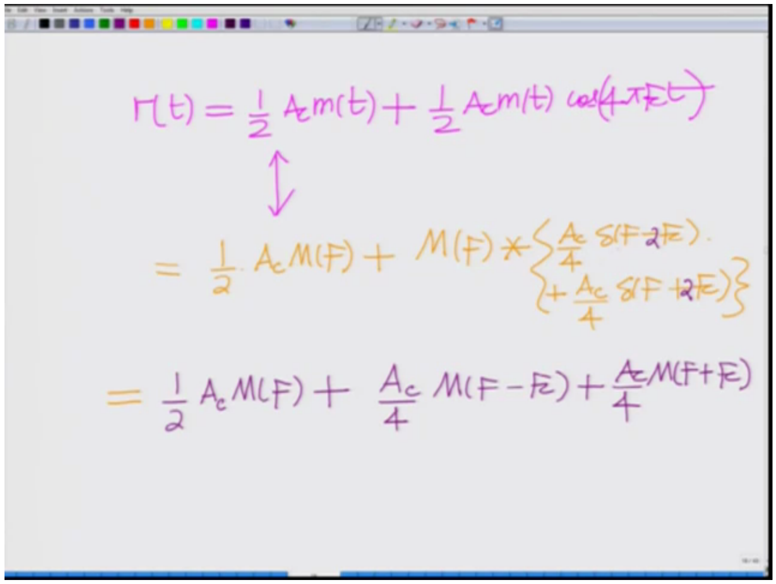

Look at this r(t) equals half Ac m(t) plus half Ac m(t) cosine four pi Fct the spectrum of this half Ac m(t) has the spectrum half Ac M(F) plus of course I have M(F) convolved with the spectrum Ac divided by four because I have m(t) multiplied by Ac over two cosine four pi Fct which means in the frequency domain it is a spectrum M(F) convolved with the spectrum of Ac over two cosine four pi Fct which is Ac over four delta F minus Fc plus Ac over four delta F plus Fc which is equal to half Ac M(F) plus Ac over four M(F) minus Fc plus Ac over four M(F) plus F M(F) plus I am sorry M(F) plus this has these are components at two Fc. I am sorry cosine four pi Fct has components at two Fc, so this is Ac over four delta F minus two Fc plus Ac over four delta F plus two Fc so this is Ac over four M(F) minus two Fc Ac over four M(F) plus two Fc

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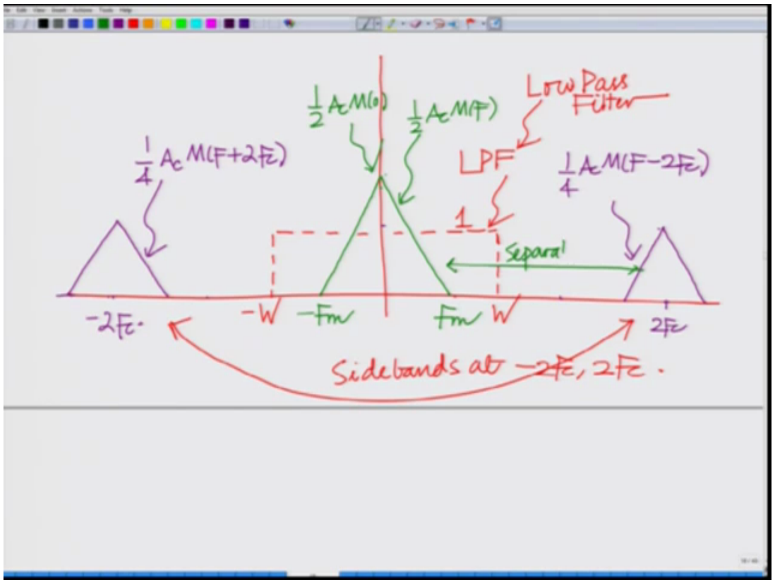

And therefore naturally when I draw the spectrum of this I am going to have the baseband component, correct? That is your half Ac M(F) that is going to be there, this point this is your half Ac M(F) this point is half Ac M zero and then you are going to have, so let us say this is Fc you are going to have bands at two Fc that is side bands at two Fc. And so this is at two Fc you have a component which is basically this component is your half or rather one over four one over four Ac M(F) minus two Fc and similarly on the other side at minus two Fc you are going to have another component which is basically at minus two Fc, this is your one over four Ac M(F) plus two Fc correct, so you have these two bands at two Fc and minus two Fc and therefore now I can have a low pass filter, correct?

I can have low pass filter because there is baseband is separated from the side bands at minus two Fc and Fc I can now have a low pass filter I can now pass this signal through a low pass filter that is minus W to W this is a low pass filter this is your low pass filter and these are the side bands, correct? These is the baseband and these are the side bands at minus Fc and two Fc, side bands at minus two Fc, Fc and the base band that is Ac over two M(F) this can be separated from the side bands by passing it through a low pass filter between minus W and W.

And W can be chosen appropriately, alright because there is significant separation, alright because Fm is much that is maximum frequency Fm is much less than Fc, so naturally maximum frequency Fm is much less than two Fc and it is much less than two Fc minus Fm. So if you can see there is a significant separation, correct? Here if you can look at this there is a significant separation.

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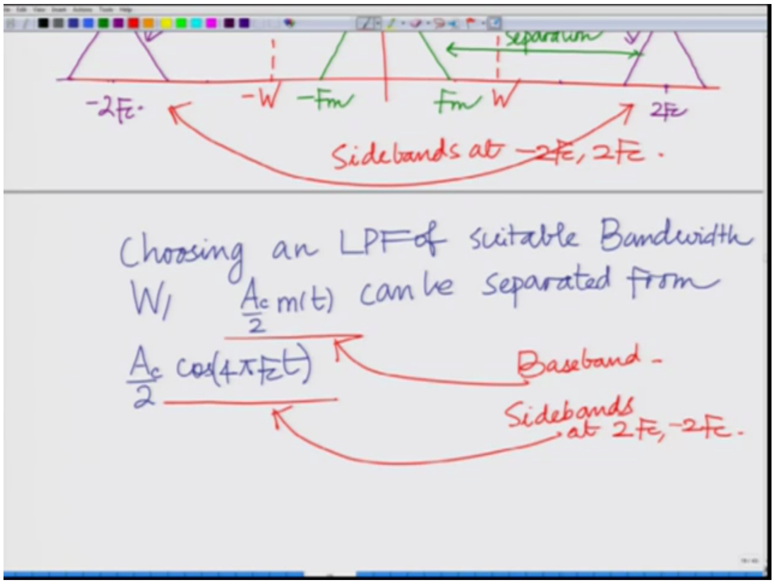

So choosing a low pass filter of bandwidth W LPF of bandwidth of let us say suitable bandwidth. Let us make it suitable bandwidth W Ac over two m(t) can be separated from Ac over two cosine four pi Fct, correct? Because this is your base band this is in the baseband and this is actually these are the side bands at two Fc, minus two Fc.

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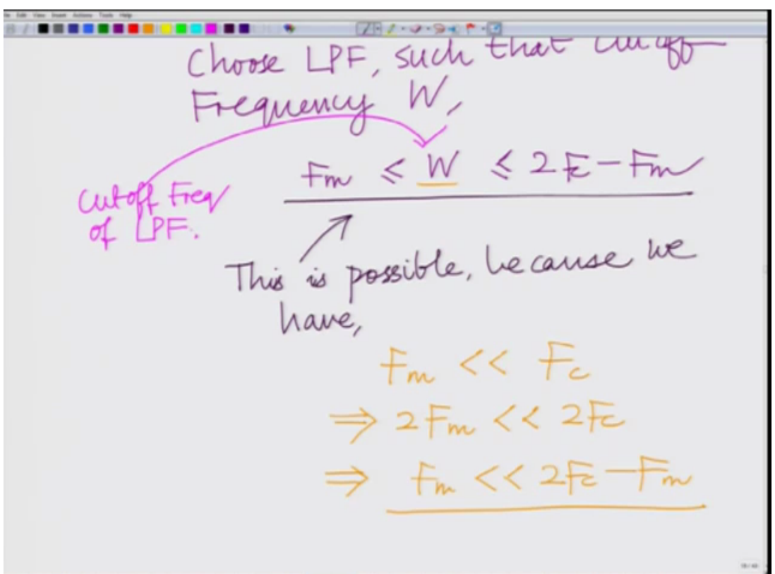

And the LPF the low pass filter, correct? Low pass filter is chosen such that choose LPF such that cut-off frequency W, that is we must have Fm now as you can look at this, this is very interesting you have Fm should be less than two Fc minus Fm. That is we should have Fm less than equal to W less than equal to two Fc minus Fm and this is possible because because we have Fm that is maximum frequency component much less than equal to Fc which means two Fm much less than or equal to two Fc which means which implies automatically that Fm is much less than or equal to Fc minus Fm. So this because Fm the message frequency is much less than or equal to the carrier frequency Fc.

This is indeed possible and therefore you can choose an appropriate cut-off frequency W of the this W is termed as the cut-off frequency, alright. So that is the cut-off frequency cut-off frequency of the (Lp) LPF one can choose the cut-off frequency of the LPF appropriately, right. Such that its much greater than Fm much less than two Fc minus Fm. So the LPF blocks the the (bla) blocks the site bands at minus two minus two Fc and two Fc.

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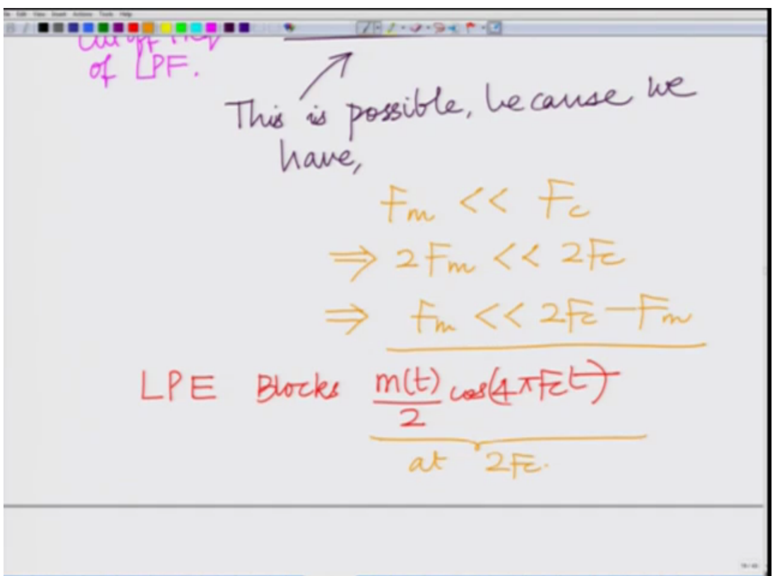

So the LPF basically LPF blocks the component cosine two pi Fct m(t) by two cosine four pi Fct, this is the component at two Fc, right? The carrier has a common frequency cosine corresponds to cosine four pi Fct corresponds to the frequency two Fc, alright. So in this module what we have seen is we have seen a new form of amplitude modulation that is double sideband modulation which has no pure carrier does not transmit the pure carrier therefore it is also known as DSBSC double sideband suppressed carrier, alright.

We have seen the spectrum of the DSB SC signal and also how to the demodulate the SB DSBSC signal by multiplying with a coherently generated carrier cosine four pi cosine two pi Fct at the receiver and finally filtering using an appropriate filter low pass filter with an appropriate cut-off frequency W such that you retain the baseband component while filtering out the side bands which are at minus two Fc and Fc. So we will stop here and continue with other aspects in the subsequent modules, thank you.