Principles of Communication- Part I
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Module No 5
Lecture 26
Introduction to Vestigial Side Band (VSB) Modulation and Non-Ideal Filtering, Spectral Efficiency

Hello welcome to another module in this massive open online course. So today we will start talking about vestigial sideband modulation, alright.

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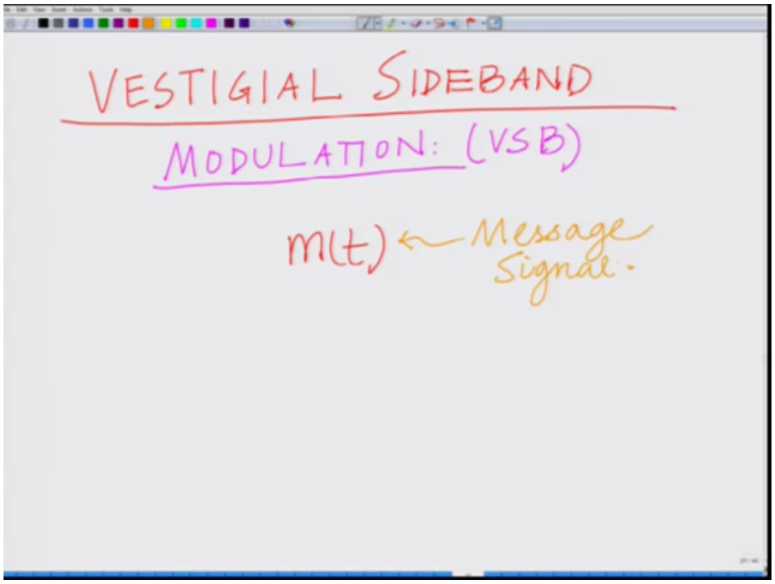

So the next topic or next different form of modulation that we are going to be interested in is vestigial sideband this is another form of modulation, we have seen single sideband modulation so this is vestigial sideband modulation also abbreviated as VSP vestigial sideband modulation. And we have already seen the motivation for vestigial sideband modulation and that can be expressed as follows, let me just remind you again why we need vestigial sideband modulation, okay.

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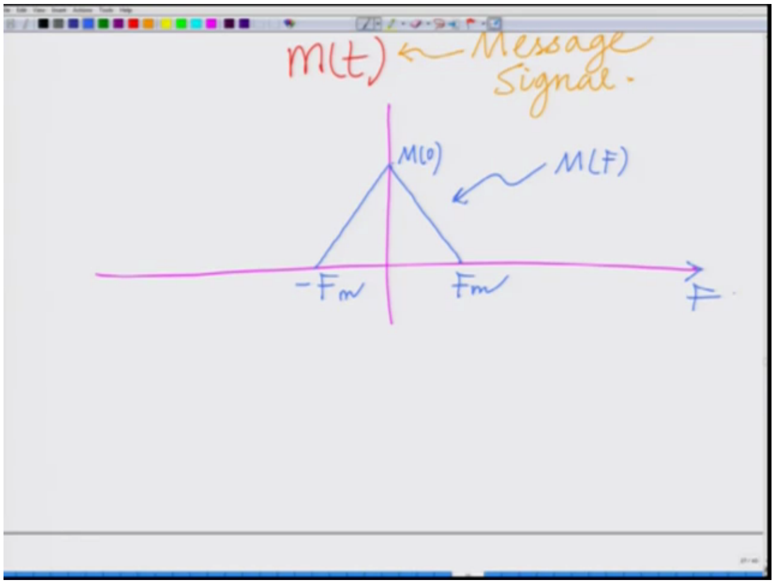

So let us consider a message signal m(t) this is our message signal this is our message signal empty which has the following spectrum let us say m(t) has the spectrum which looks like this that is from minus Fm to Fm, this point is M zero so this is your spectrum M(F) in the frequency domain.

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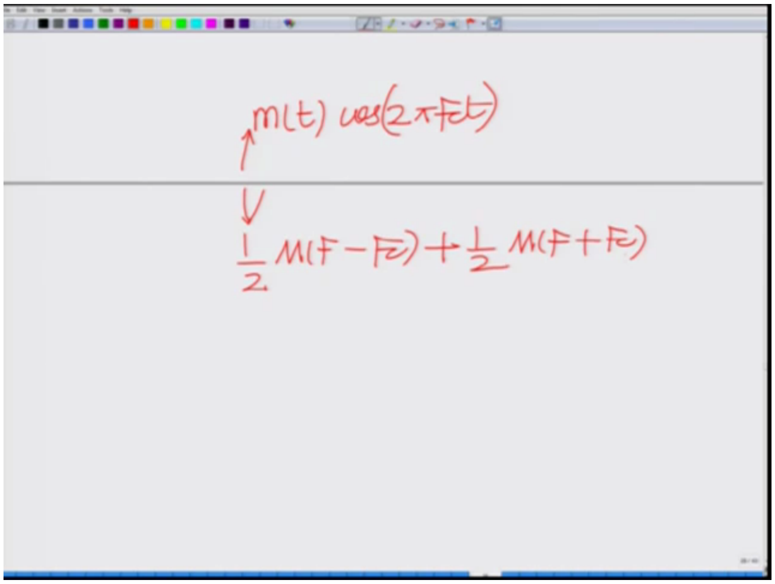

Now when we let us consider a modulated version of m(t) that is m(t) cosine two pi Fct which as we have well familiar has the spectrum half M(F) minus Fc plus half M(F) plus Fc that is M(F) shifted to Fc and M(F) shifted to minus Fc.

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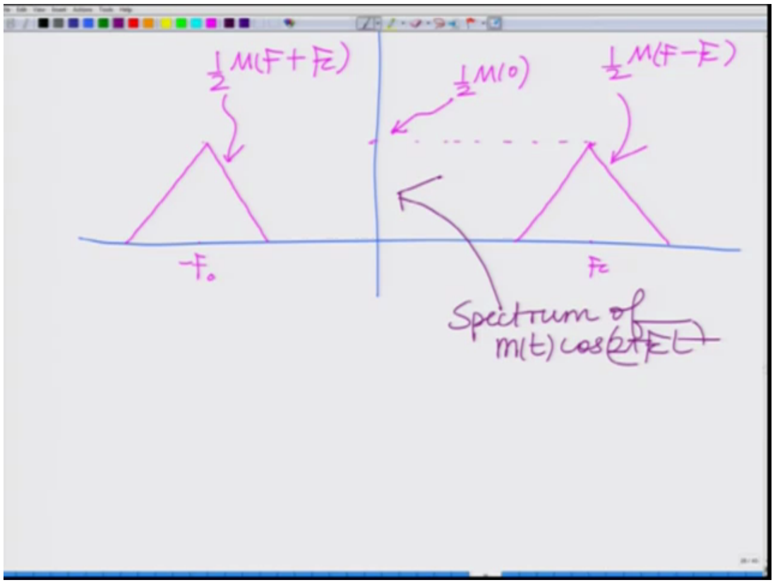

If you look at that spectrum that is going to look something like this first shift M(F) to Fc, correct? You shift M(F) to Fc and scale it by a factor of half. So this height here is going to be half of M zero. So this corresponds to your factor of half (())(2:53) Fc and if you look symmetrically and this side you will have your half M(F) plus Fc that is shifted to minus Fc so this is your half M(F) plus FC and this is a spectrum as I have already said this is a spectrum of m(t) cosine spectrum of m(t) cosine two pi Fct.

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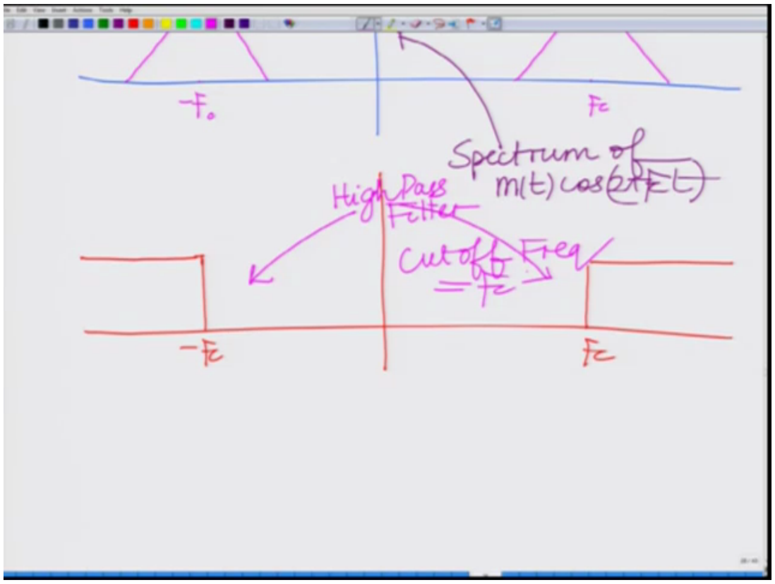

Now if we want to generate a single side band modulated signal all I have to do is high pass filter this with a cut off of. so I have to take high pass filter cut off of this has to be a high pass filter and cut off frequency equals Fc if you take this high pass filter cut-off frequency FC that is which has response unity for all frequencies greater than Fc and it is exactly zero for all frequencies which are less than Fc and there is a sharp cut-off at Fc so if I pass my DSBSC that is right but double sideband modulated suppressed carrier signal m(t) cosine two pi Fct through this high pass filter I get the output is yours.

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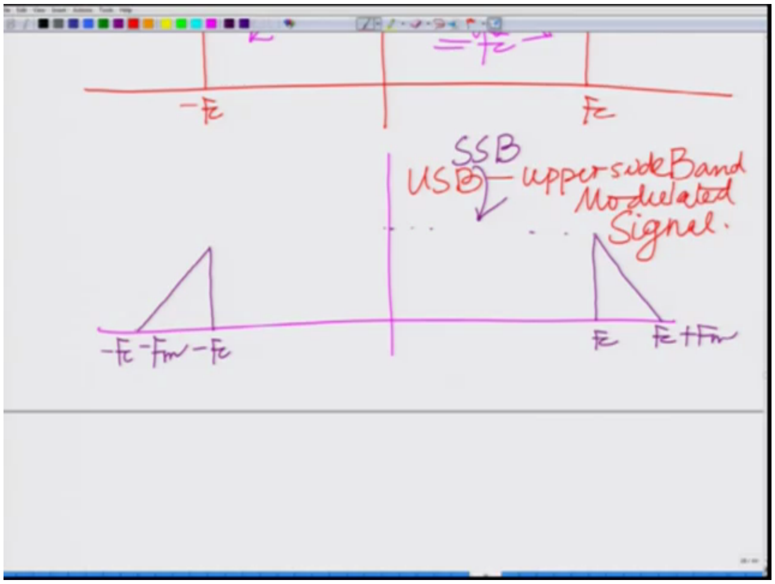

So this is Fc this is Fc plus Fm and again once again this is half m zero and similarly on minus Fc this is going to be minus Fc this is going to be minus Fc minus Fm and this is your SSB, correct? In fact this is your USB signal that is upper side band modulated signal this is the upper side band modulated signal and in fact to generate the lower side band modulated signal you have to pass it through an ideal low pass filter with cut-off Fc, okay.

And the problem that we have said in generation of this upper side band modulated signal through this method remember this method is the frequency discrimination whether if you remember this is the this technique of passing it through this high pass filter.

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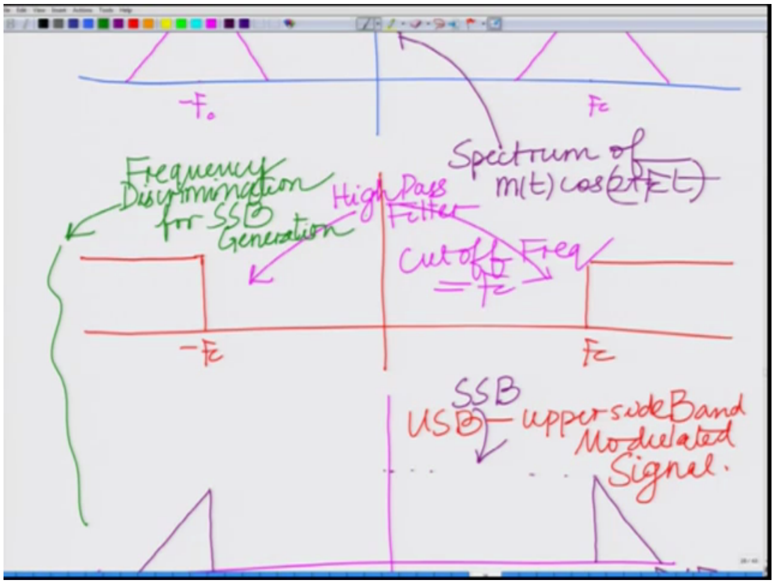

This technique is termed as frequency discrimination, okay. Frequency discrimination for SSB Generation.

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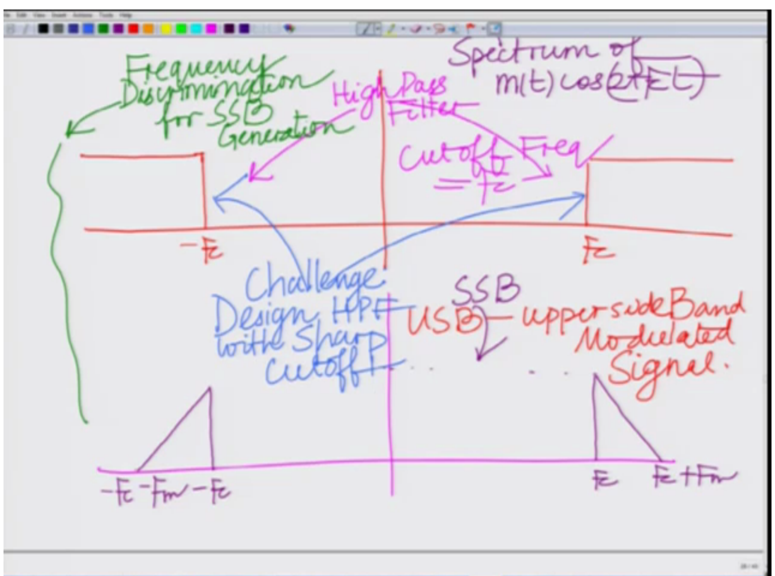

And the problem with this or rather the challenge is to generate high pass, the challenge of this to design high pass filter with such sharp such sharp cut-off frequency that is in fact practically very challenging if not impossible because frequently no matter how well your filter is designed it always has a small transition band, a transition band is a band in which it is transitioning from the zero, so there is a stop band remember this band where it is zero frequency is the stop band pass the frequency band which is allowing the frequencies to pass that is gain of unity is the pass band and there is a small transition band a finite transition band in which it is transitioning the filter is transitioning from zero to one.

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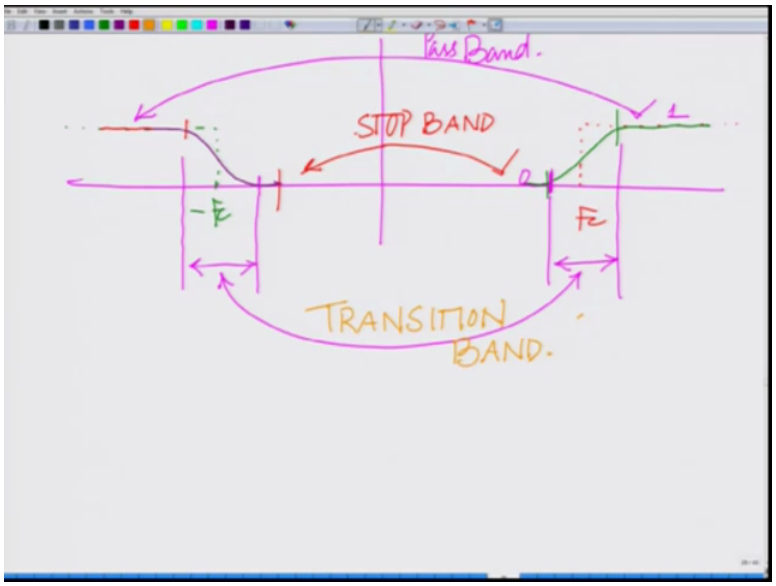

And that gives rise to non-ideality, so what happens is frequently we have your let me just draw this thing over here, so your high pass filter is this is your Fc we need a sharp cut-off at Fc this is your ideal and what we have is something that looks something that looks like this that is this is basically, so this is your stop band this is the passband and similarly on the negative frequencies side if I have to draw this minus Fc the ideal one would be something like this and what we would have is something like looks like this.

So this is your stop band, this whole area is your stop band where attenuation is zero or very low this area which is basically over here, from here to here so this part is your passband where the attenuation is equal to one but this part if you look at this part where it is rising from, so here it is zero here it is one and this particular part where it is rising from zero to one and similarly over here if you look at this particular part where it is rising from zero to one.

These two are the these two are the transition bands, okay. So where it is not zero and it is not one but the filter magnitude response lies between zero and one this is a transition band let me just write that with bold so that this is your transition band and this transition band and what happens when you take have this non-ideal filter and basically you pass the same DSBSC double sideband modulated signal that is m(t) cosine two pi Fct, alright.

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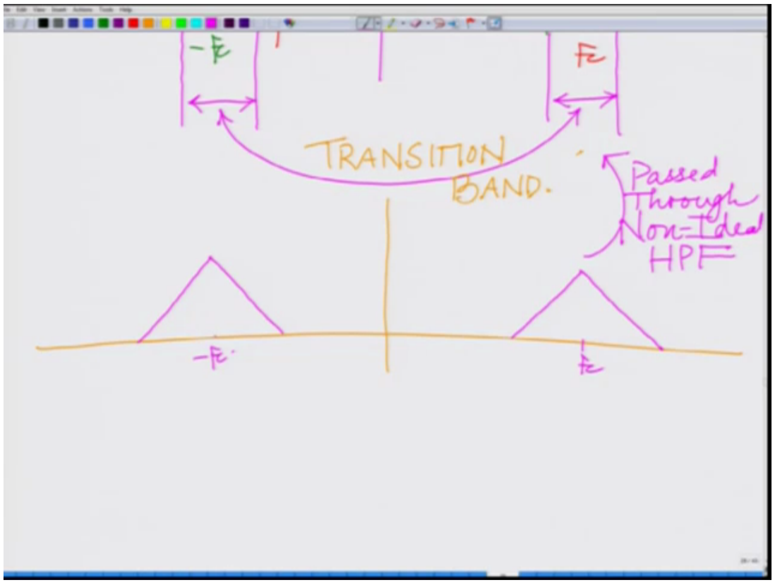

When you pass it through this that is of course you have something like this over here, so you have this is Fc this is your M(f) minus Fc that is shifted to Fc, so this is your Fc and this is your this is your minus FC and when you pass this so this is pass through non-ideal HPF high pass filter with a transition band.

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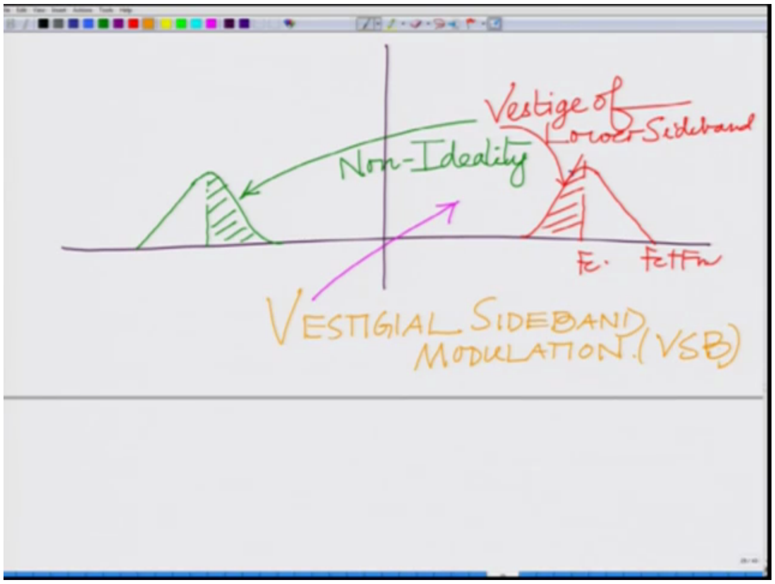

And that gives rise to a signal that looks like that gives rise to the signal, so that gives rise to some signal which is not exactly the upper side band modulated which does not, so it has something which looks basically like so if you look at if I were to draw this signal approximately so this is Fc so it would be something that looks like like this. It picks up a small, so what we have is this is your Fc this is your Fm.

What we have here is a small vestige. Vestige of your lower sideband, okay. And similarly over here when you pass this through your this non-ideal high pass filter, what you pick up is basically what you pick up is something that looks like this. This is a vestige of the vestige of the lower side and this is basically your non-ideality or the impact of (nin) non-ideality. So this is your, what is this? This is your now so what you have is basically because you are passing this through a non-ideal filter high pass filter, which has a small transition band that is it is not exactly zero for F less than Fc and one for F greater than Fc it has a small transition band where it is transitioning from zero to one.

It picks up a small portion of the lower sideband this small portion is termed as a vestige a vestige is typically means in English it means a small portion a small piece, so it picks up a vestige of the lower sideband of the lower sideband hence this is termed as vestigial sideband modulation. So this signal which is basically not exactly so this signal is termed as your (ves) let me just again write it in bold let me just write it in bold. This signal is termed as your vestigial VSB which picks up where the which contains which contains a vestigious of the other sideband.

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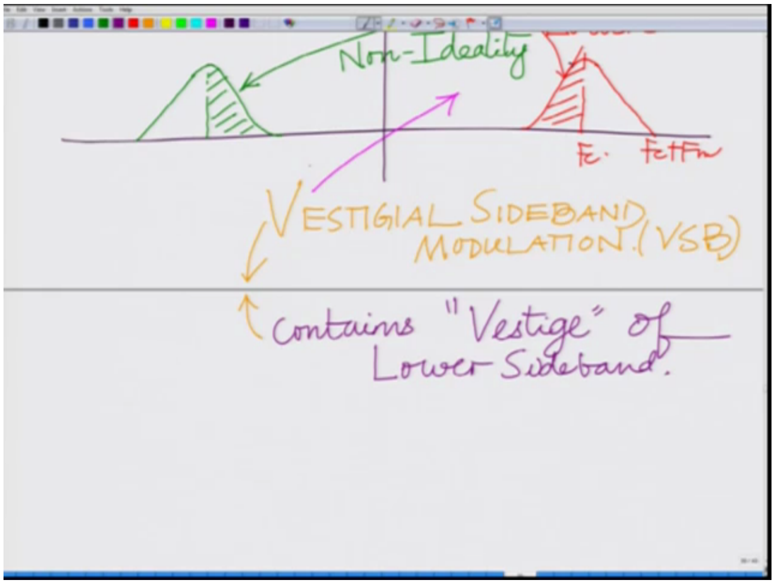

So which contains for instance the upper side band contains a vestige of your lower sideband. Ideally it is not supposed to contain any part of the lower sideband but because of the non-ideality of the filter it contains a small portion or a vestige of the lower sideband this is termed as vestigial sideband modulation, alright. And the advantage of this of course it is nonideal, now the point here is look at this it requires a slightly higher bandwidth than the upper sideband modulation because if you look at the bandwidth that is required USB signal requires a bandwidth of only your Fm, correct?

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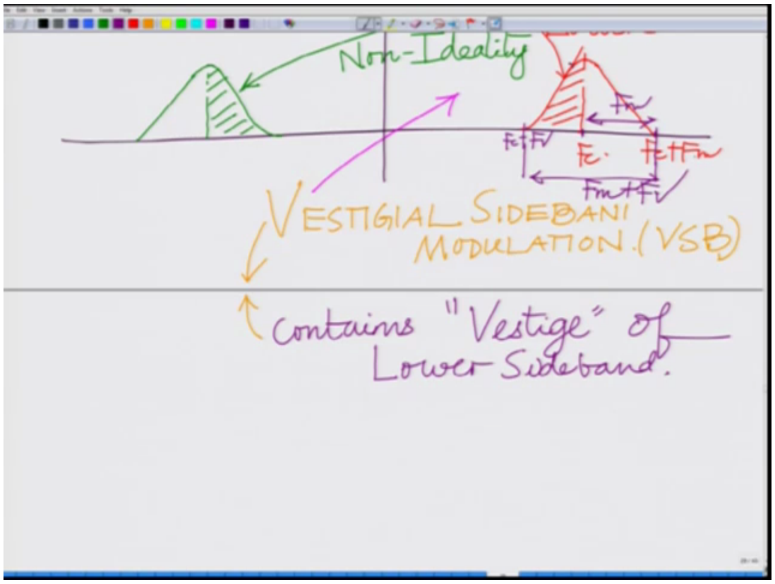

Passband bandwidth of Fm which is of course half that of the DSB which requires DSB requires passband bandwidth with two Fm, however this requires a slightly higher bandwidth Fm plus if you call this Fc minus Fv F vestige.

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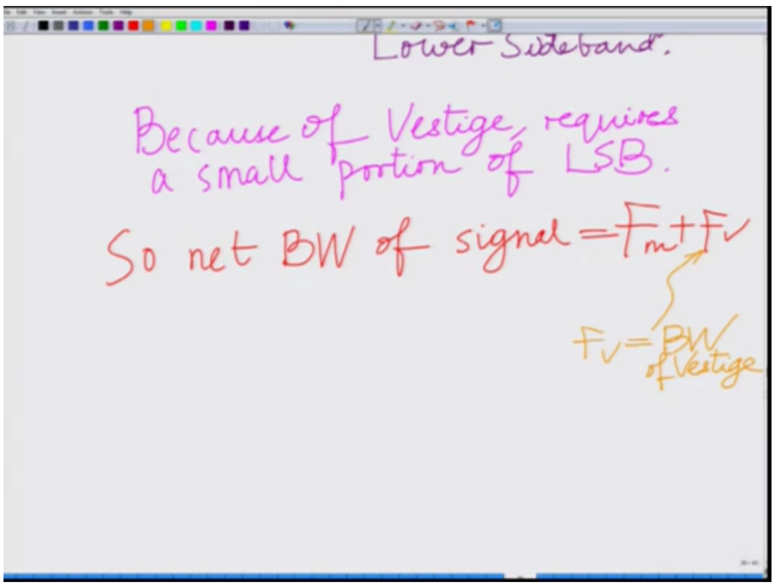

So this requires a bandwidth of because of the vestige you require because of the vestige that is small portion of the requires a small portion of LSB, so net bandwidth of the signal equals Fm plus Fv where Fv remember is the bandwidth of the Vestige. Fv equals bandwidth of the vestige.

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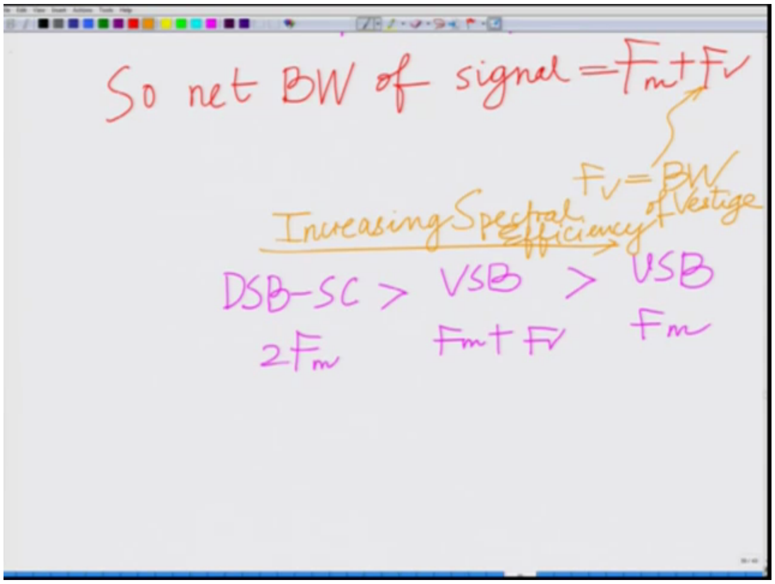

So if you look at this therefore now remember DSBSC double sideband modulated suppressed carrier has a bandwidth of two Fm which is greater than your vestigial sideband modulation which has a bandwidth of Fm plus Fv, okay. Which is greater than the bandwidth of your single sideband modulation or upper side band modulated signal which is bandwidth of Fm therefore F upper side band modulation that is single sideband with upper sideband that has simply bandwidth of Fm which is less than Fm plus Fv the bandwidth of vestigial sideband therefore it is more efficient than vestigial sideband modulation which is which is inter-more efficient than double sideband modulated suppressed carrier.

So this is basically increasing spectral efficiency from double sideband, this is increasing so you can see that the double side vestigial sideband modulation is a trade-off it is a trade-off it has a bandwidth efficiency or spectral efficiency that is less than that of upper sideband modulation but more than that of double sideband suppressed carrier, however it offers an advantage that is it has a much lower complexity in comparison to your upper sideband modulation since designing these filters these nonideal high pass filters it is much more easier compared to the designing of the ideal high pass filter with upper sideband modulation, okay.

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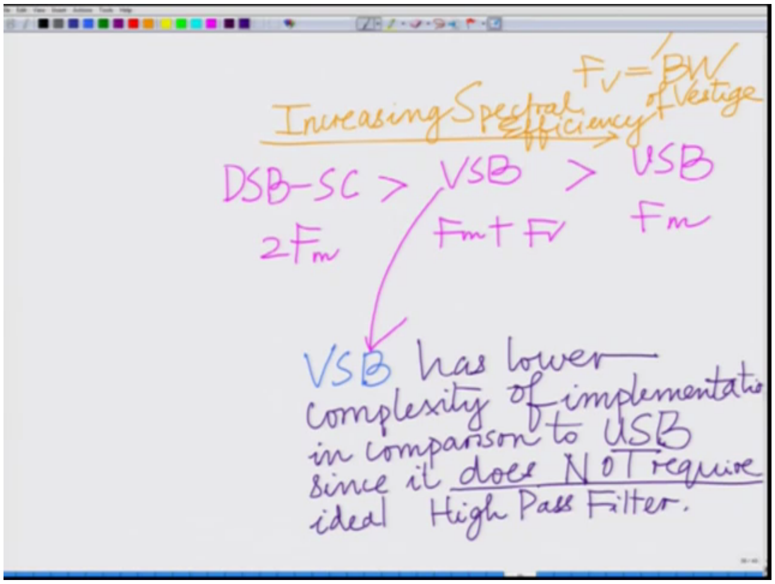

So however the VSB has lower complexity. Complexity meaning the implementation complexity. Complexity of implementation in comparison to USB since it does not require ideal high pass or low pass filter ideal high pass filter. Similarly since it does not require since it does not require ideal high pass filter similarly one can think of a vestigial sideband modulated signal with a lower sideband transmitted and picking up a vestige of the upper sideband, okay. So both these things are possible in vestigial sideband either you can have, what we have shown here is a non-ideal high pass filter with the upper side band and a small vestige of the lower sideband but analogusly you can also think of a non-ideal lowpass filter which transmits the lower sideband and a small vestige of the upper side band, okay.

So both these things are possible but since they are similar we will just restrict our (discu) discussion to the case of vestigial sideband modulation with the upper side band modulated and the vestige of the lower sideband, okay. So that is the first point so now the other thing we have to talk about is basically this is your vestigial sideband modulation so because of the slightly larger bandwidth it is slightly lower if slightly lower spectral efficiency compared to upper side modulation but it has a lower implementation complexity.

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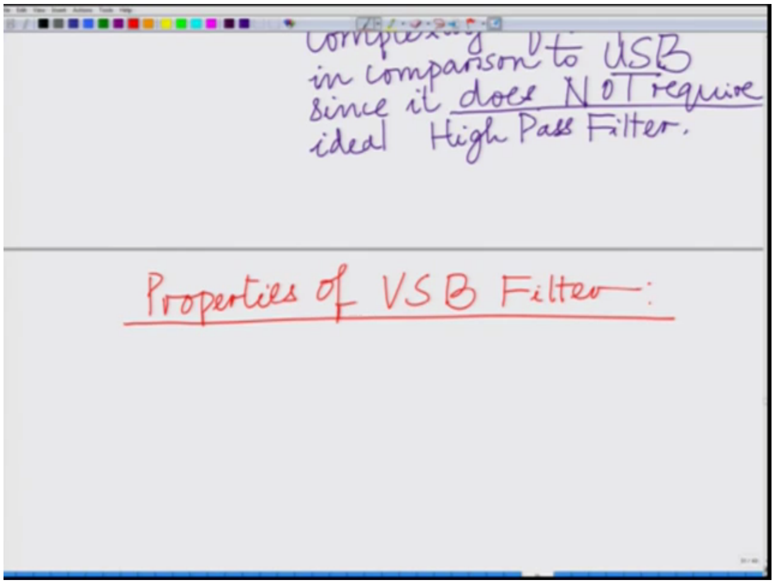

Now let us look at the properties of the VSB filter. So what we would like to do is let us look at the properties of the VSB filter, okay. So we would like to look at the properties of the VSB filter so what we will do is since we have already covered some aspects of the VSB in this module that is an introduction to VSB and also describe the basic functioning of the VSB and the spectral efficiency we will end this module here and we look at the properties that is how to exactly implemented this vestigial sideband modulation and what property the nonideal high pass filter is to satisfy we will look at that in the subsequent modules, thank you.