Principles of Communication- Part I
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Module No 4
Lecture 19
Introduction to Single Sideband (SSB) Modulation

Hello welcome to another module in this massive open online course. So in this module let us start looking at single sideband modulation which is also abbreviated as SSB, alright. So what we want to start looking at is basically we have looked at double side (mod) double sideband modulation already that is DSBSC double sideband suppressed carrier.

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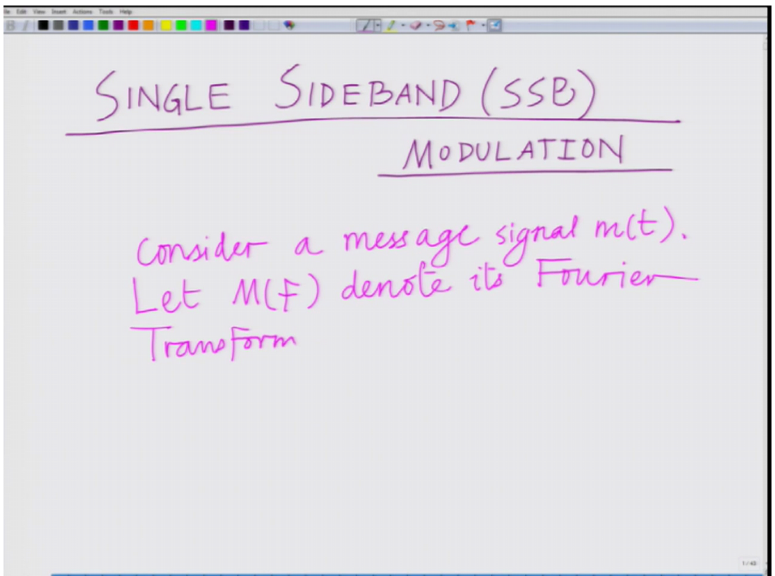

Let us now start looking at single side band which is also termed as SSB, correct? Single sideband modulation which is also termed as SSB, okay. SSB stands for single sideband, alright. We have looked at double sideband in which both the side bands are transmitted, correct? Let us now start looking at single sideband modulation, for this purpose considered a message signal m(t), alright. So let us start by considering a (messe) as usual. And let M(F) denotes it is Fourier transform that is M(F) is the Fourier transform of m(t), correct?

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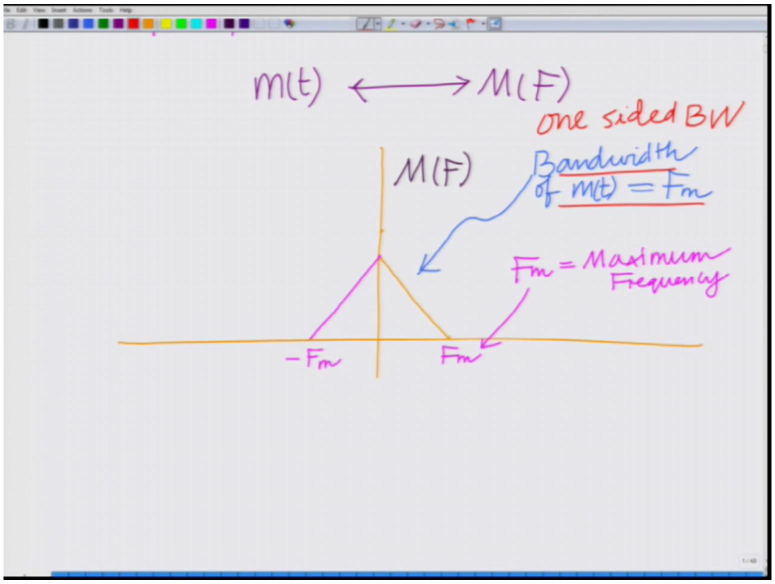

We have an message signal m(t) and it is Fourier transform given by M(F), okay. Let us draw this schematically over here we have our message signal we have our message signal m(t) I am drawing the Fourier transform, so let us say the Fourier transform is between minus Fm it is minus Fm to Fm where Fm equals the maximum frequency of or the maximum frequency component correct?

We have also say that the base bandwidth, so this is your spectrum M(F) of m(t) in fact this is the baseband spectrum and we also say that the bandwidth the baseband bandwidth, the bandwidth of this baseband signal which is the one-sided bandwidth, bandwidth of m(t) equals Fm, okay. This is also known as the one-sided also known as the, this is also known as the one-sided bandwidth of the, okay. So as usual we are considering the spectrum M(F) with maximum frequency component Fm that means it spans from minus Fm to Fm, alright. The one-sided bandwidth of the signal of this baseband signal is Fm, okay.

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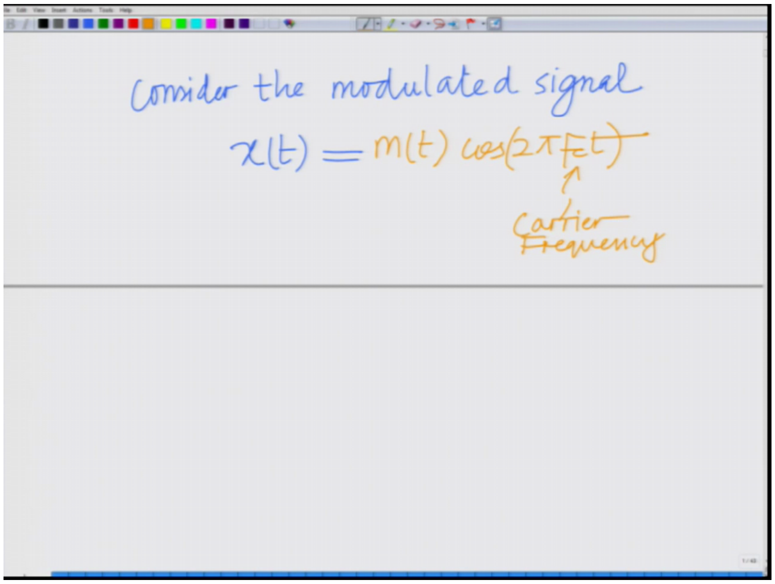

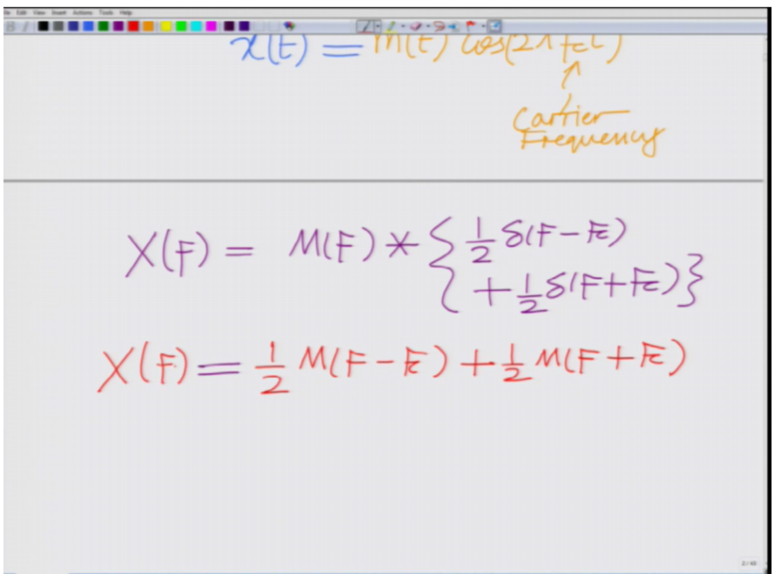

Now consider the modulated signal, let us again start by considering the modulated signal, consider the modulated signal x(t) equals power double sideband suppressed carrier signals that is modulated by cosine two pi Fct where Fc, remember this is the carrier frequency m(t) is your message signal x(t) equals m(t) cosine two pi Fct therefore this is a multiplication of two signals in the time domain therefore the Fourier transform f X(F) is given by the convolution of M(F) with that of cosine the spectrum of cosine two pi Fct which is basically impulse of scaled by half at Fc plus impulse scaled by half at minus Fc that is Delta F half delta F minus Fc plus half delta

F plus Fc. We have already seen this spectrum is basically equal to half M(F) minus Fc plus half M(F) plus Fc this is the spectrum of the modulated signal.

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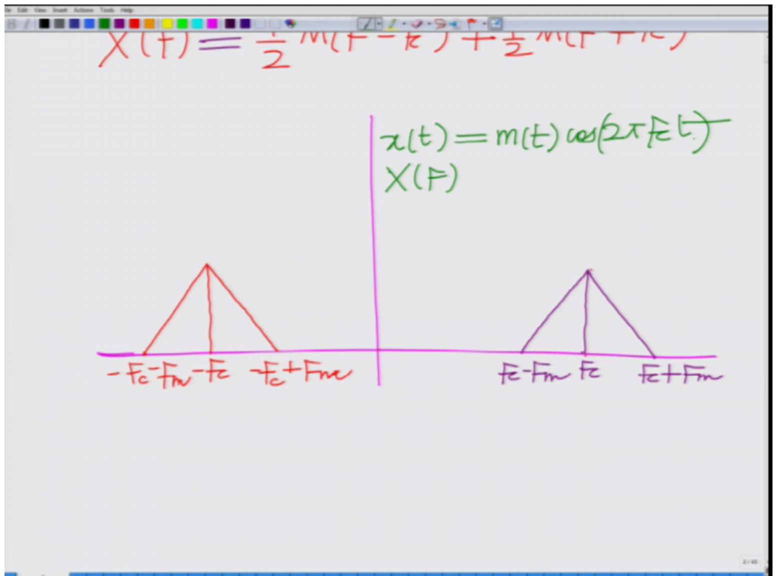

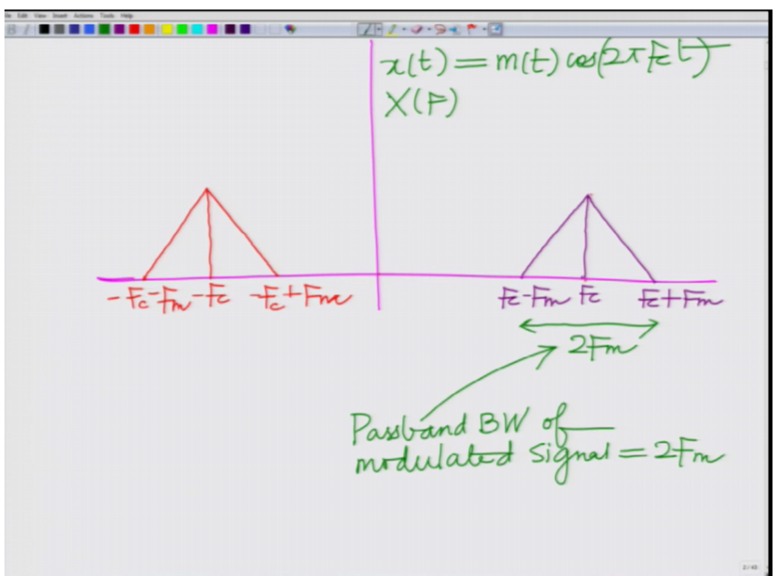

Now if you look at the spectrum of this modulated signal and we have already seen this before that is going to look as follows that is going to comprise of M(F) we already seen this shifted multiplied a (fact) by a factor of half and shifted to Fc, so this is Fc plus Fm and Fc minus Fm symmetric about, correct? And now if you look at this there is going to be another component which is between this is M(F) plus Fc this is the this is on the negative frequency side that is from Fc or minus F minus Fc minus Fm to minus Fc plus Fm, alright.

So the spectrum of X(F) where your x(t) equals the modulated message signal that is m(t) cosine two pi Fct and if you look at the bandwidth of this signal that is m(t) cosine two pi Fct this is known as the pass band bandwidth that is the that is the spectrum occupied on the positive frequency side by this pass band signal. The pass band bandwidth is two Fm, the pass band bandwidth of the modulated signal equals two Fm that is also the spectral band occupied on the that is a spectral band that is occupied by this positive by this pass band signal on the positive frequency side, alright.

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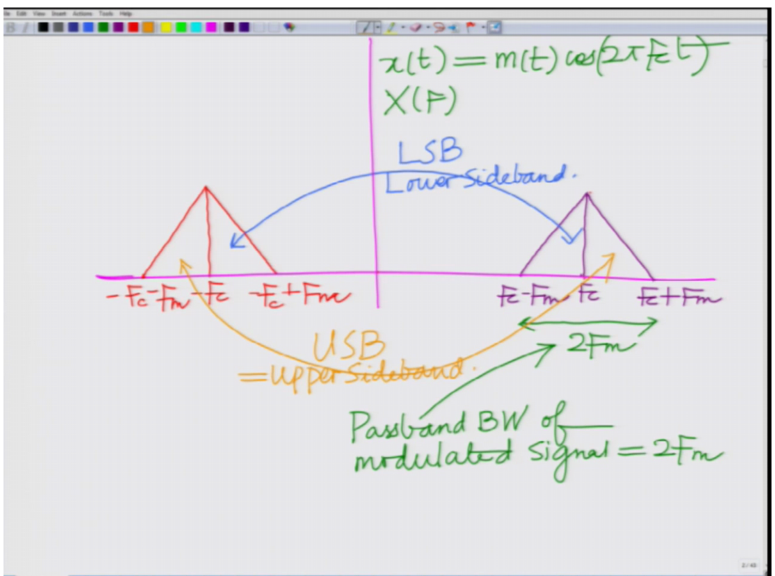

So this is the double sideband and remember this is a double sideband modulated signal (bet) because it comprises of two side bands. And what are the two side bands? We have already seen this, these two bands if you look at between minus Fc to minus Fc plus Fm, Fc minus Fm to Fc Fc minus Fm to Fc this comprises the lower sideband or LSB. LSB equals the lower sideband and the other two bands that is minus FC minus Fm to minus Fc and Fc to Fc plus Fm now these two, okay let me just draw this separately.

These two bands if you look at these two bands which I am drawing by this orange colour here these comprise the USB which is basically the upper side band. Upper side band the acronym for that is USB.

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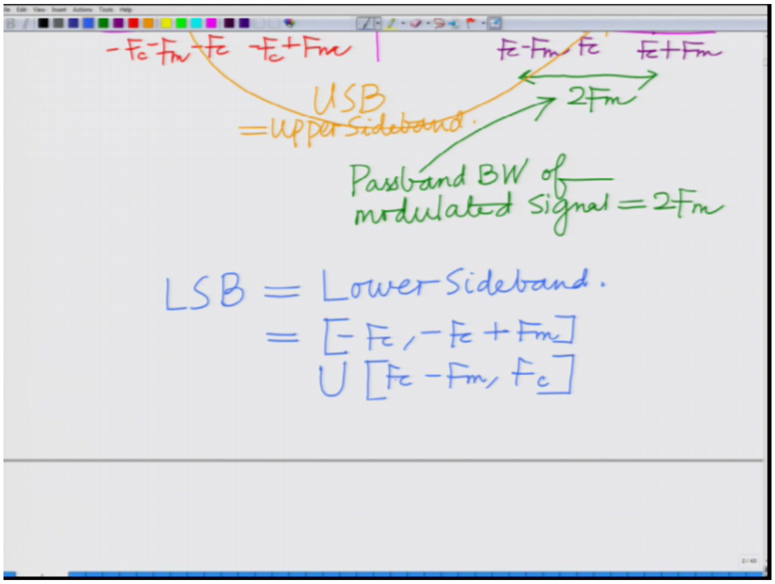

So we have the upper side band and we have the lower sideband just to write it down clearly we have the LSB that is equal to the the lower sideband and that comprises of the intervals minus Fc to minus Fc plus Fm Union together with Fc minus Fm to Fc this is the lower sideband that is minus Fc to minus Fc plus Fm to Fc minus Fm t Fc.

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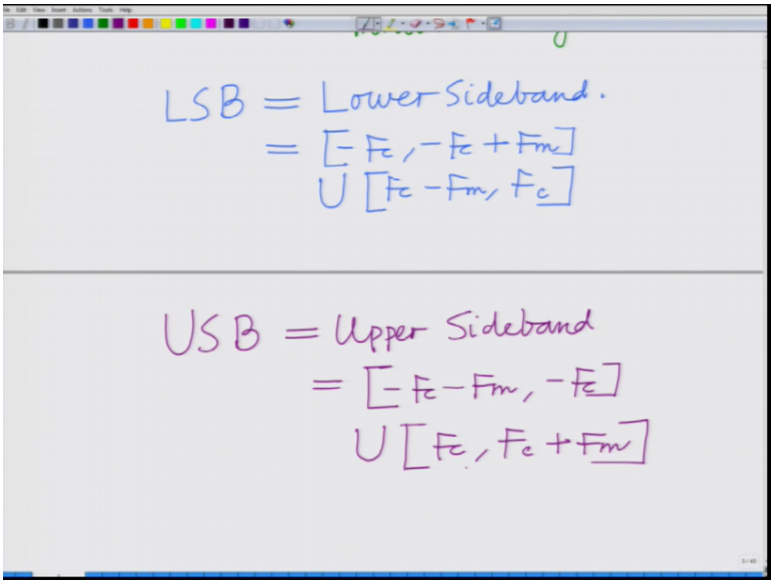

Then we have the upper side band that is denoted by USB that is equal to the upper side band and that comprises of the bands minus Fc minus Fm to minus Fc union Fc to Fc plus Fm. So we have two side bands we have the upper side band we have the lower sideband of the signal, correct? And we have the upper side band of the signal.

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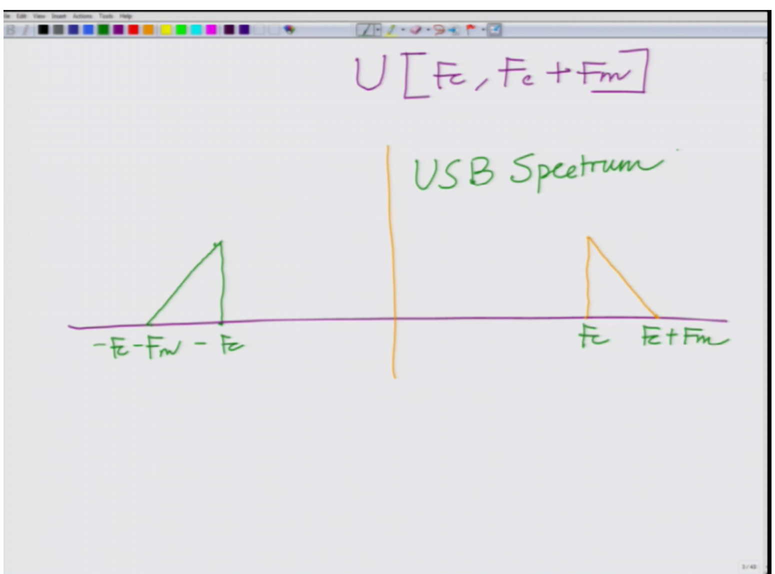

Now let us try to draw these two signals these two spectra separately that is a lower sideband the upper side band and the lower sideband. So naturally the lower sideband spectrum will look as follows this is going to be the lower sideband of the spectrum is going or the upper sideband of the spectrum is only going to include the upper sideband, so if you only include the upper side band that will be so that will be this is from Fc to Fc plus Fm minus Fc and this is minus Fc minus Fm, so this is going to be your minus Fc minus Fm to minus Fc, correct?

So something like this, this is from minus Fc minus Fm so this is the upper side band spectrum, so this is your USB or your upper side band spectrum.

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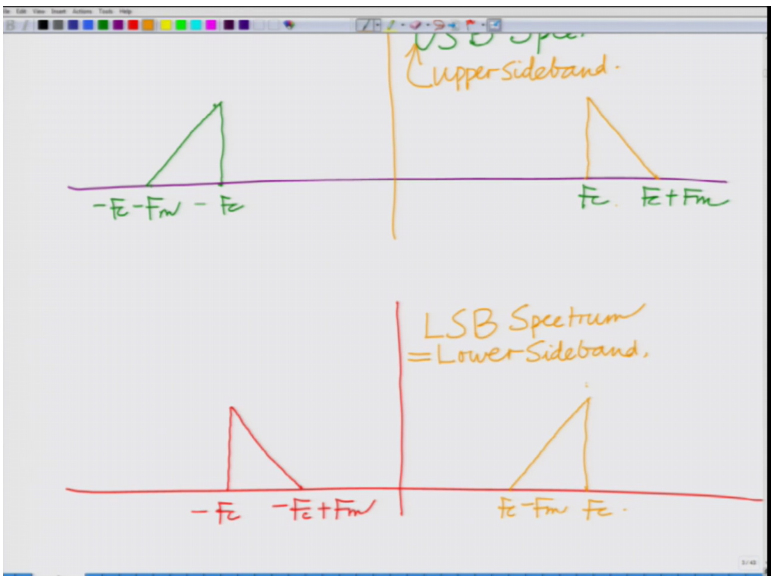

And now if we include only the lower sideband that will give me the LSB spectrum. The LSB spectrum will look something like this that will contain the lower side bands so that will be minus Fc to minus Fc plus Fm and it will be a symmetric component on the positive side. So it will be Fc minus Fm to Fc, alright. So this is the USB spectrum this is the lower LSB spectrum. So this is the LSB spectrum and again just to remind you USB equals upper side band LSB equals the lower sideband and therefore what is the big advantage of transmitting only one sideband that is either the upper side band or the lower sideband over the double sideband modulation over a system which employs double sideband suppressed carrier modulation.

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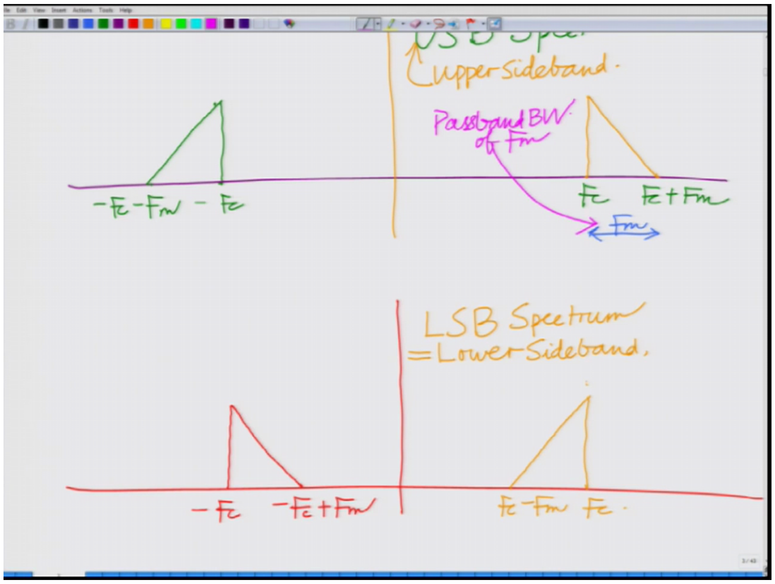

And now you can clearly see that both USB and LSB if you look at the pass band bandwidth of both USB the USB pass band bandwidth is from Fc to Fc plus Fm which means it has a pass band bandwidth of means this scheme has a pass band bandwidth of Fm and similarly the LS LSB signal also has a pass S Fc minus Fm to Fc that is it has a pass band bandwidth of Fm.

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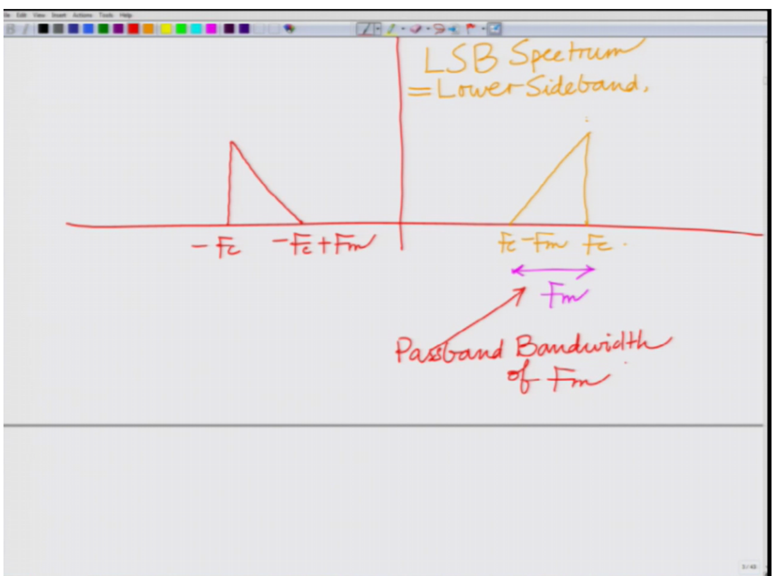

So it has a pass band signal it has a pass band bandwidth of Fm. So you can clearly see that the double sideband suppressed carrier signal has a pass band bandwidth of two FM where both the upper side band and the lower sideband which basically any single sideband modulated signal has a pass band bandwidth of only FM and therefore it results in a bandwidth saving of, so from two Fm you are going to Fm so it results in a bandwidth saving of fifty percent in comparison to, so depending on the way you look at it results in a fifty percent savings of, results in a required bandwidth is reduced by a factor of half.

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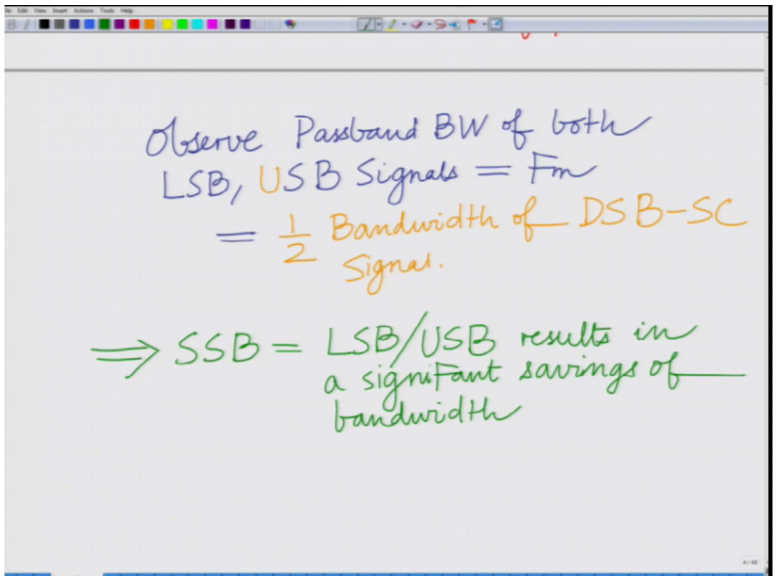

So observe that the bandwidth of, so the idea behind so observe the pass band bandwidth of both LSB, SSB signals equals Fm which is equal to half bandwidth of your DSB or DSBSB signal implies which implies that your, I am sorry this is LSB and USB which implies that SSB which is either LSB or USB which is SSB which is equal to either, so I am writing this as LSB slash USB single sideband can be either LSB that is a lower sideband or upper side band results in a significant results in a significant savings in bandwidth.

Specifically how much bandwidth is there? The bandwidth required in comparison two double side band modulation is reduced by a factor of half therefore the spectral efficiency doubles that is spectral efficiency which is defined as the information content divided by the bandwidth since the bandwidth is decreasing by a factor of half while the information content is remaining the same the spectral efficiency doubles.

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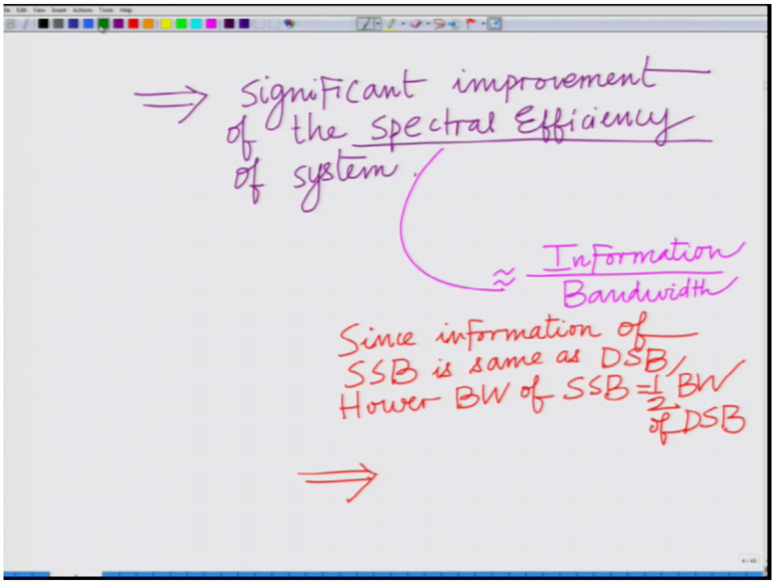

So the spectral efficiency implies this leads to a significant improvement of the so-called, we have not defined it precisely the spectral efficiency, correct? Spectral efficiency of system and also although we have not defined it precisely you can see the spectral efficiency is approximately basically information there is a precise way of characterizing the information by the end (())(18:23) but we are not looking at that information divided by the bandwidth. Since information is constant and bandwidth is and also let us note that, since information of SSB is same as DSB and however bandwidth of SSB equals half bandwidth of DSB this implies, so information content is the same bandwidth is reduced by a factor of half therefore spectral efficiency of SSB twice that of USB.

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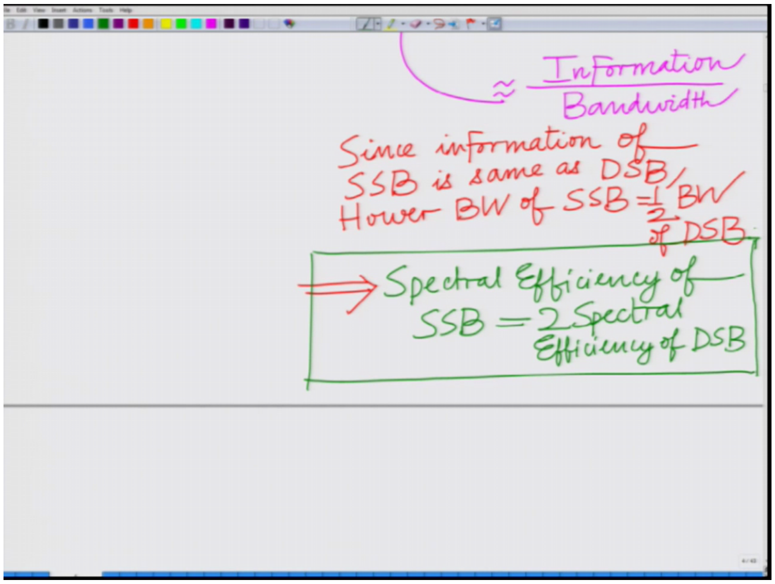

Therefore the spectral efficiency of SSB spectral efficiency equals twice the spectral efficiency of DSB that is double sideband modulated signal and this is an important result. So SSB is a very important scheme or it is a very efficient scheme because it results in a significant reduction band with precisely how much reduction in bandwidth (reduc) leads to a **a** decrease of leads to a decrease of the DSB bandwidth by a factor of half, alright.

So we have seen that if you look if you consider a message signal m(t) and a DSB that is double sideband modulated message signal that is x(t) which is given as m(t) cosine two pi Fct this has two sideband which is the lower sideband and the upper side band and one can therefore (transm) and the DSB signal has a pass band bandwidth of two Fm but the LSB or the lower sideband signal or the upper sideband signal has only a pass band requires a pass band bandwidth of Fm therefore the bandwidth required in single sideband modulation that is either LSB or USB is reduced by a factor of half decreases by a factor of, right.

It is reduced by a factor that is it the bandwidth required in LSB or USB is half that half the bandwidth that is required in DSB therefore spectral efficiency improves spectral efficiency doubles for the same information since the bandwidth bandwidth decreases by a factor of that is bandwidth is half of that of DSB the spectral efficiency is double that of DSB, alright. So we will stop here and look at other aspects in particular various ways of generation of these SSB that is single sideband modulated signals in the subsequent modules, thank you very much.