Principles of Communication- Part I
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Module No 3
Lecture 15
Double Sideband (DSB) Suppressed Carried (SC) Demodulation, Non-Coherent demodulation, Impact of Carrier Phase Offset

Hello! Welcome to this another module in this massive open online course. So you are looking at DSB that is double sideband double sideband modulation with suppressed carrier DSB SC, okay.

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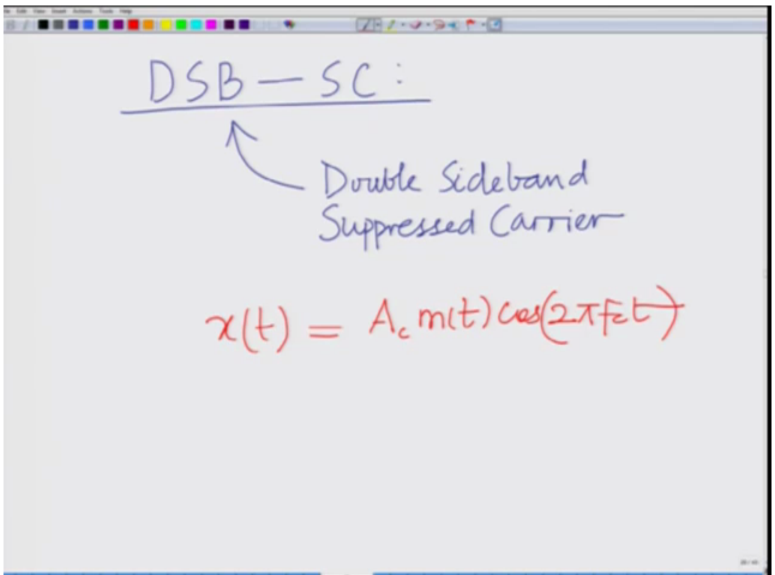

So let us continue our discussion on DSB SC modulation, correct? We have said basically this is your double sideband and SC stands for suppressed SC stands for suppressed carrier, okay.

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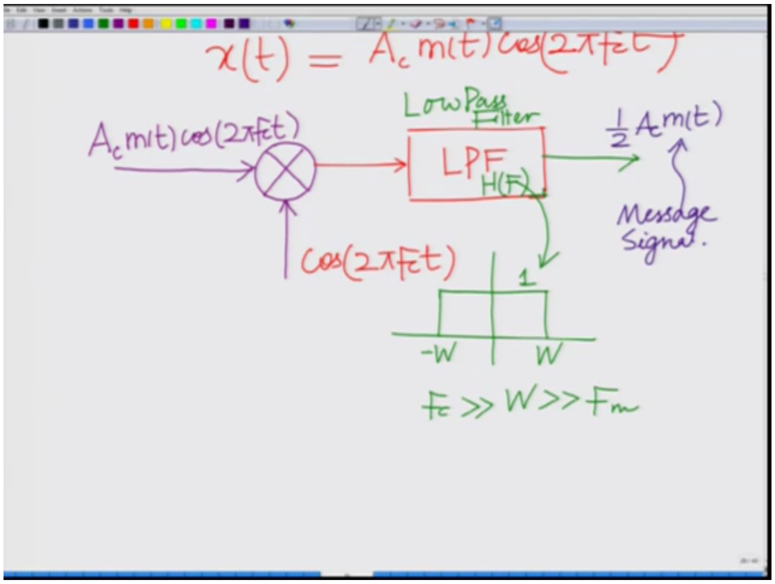

Let us draw a schematic of the DSB SC signal of the DSB SC we have looked at the DSB SC scheme in a DSB SC the modulated signal x(t) is given as Ac that is your Ac m(t) cosine 2pi Fct there is no pure Ac m(t) cosine 2piFct that is the pure there is no transmission of a pure carrier signal this x(t) at the receiver is fed to a demodulator, correct? Alright, this is your x(t) incoming message signal x(t) or let me write it as Ac m(t) cosine 2pi Fct this is the incoming signal this is the demodulating signal, alright.

That is cosine 2pi Fct and the output is passed through a low pass filter LPF or the low pass filter the output is passed through a low pass filter which is cut off frequency W, correct? This is your low pass filter that is the response of the low pass filter 1between minus W to W and 0 otherwise and the cut-off frequency W is chosen such that, well Fc is much greater than the W is much greater than Fm and this is possible because Fc is much greater than Fm and the output of this signal is therefore given of this LPF is given as half Ac m(t) where now we have recovered our message signal or where we have recovered our (messe) message signal m(t), okay.

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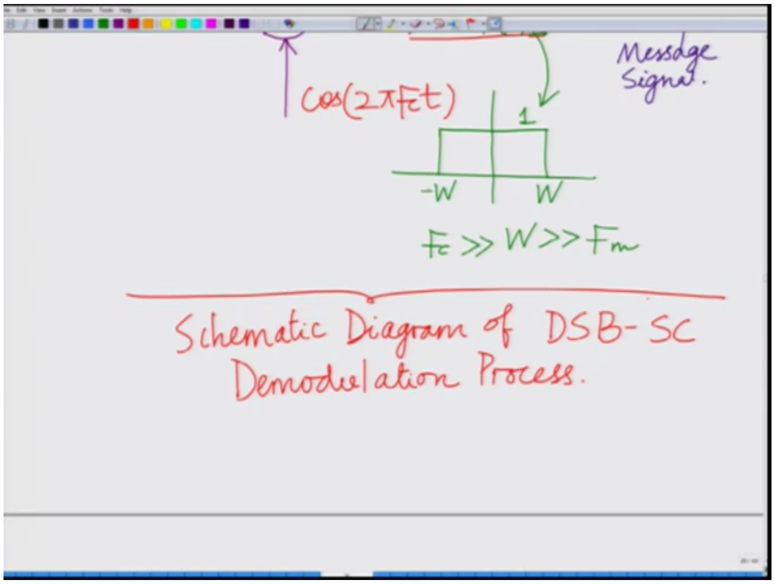

So this is basically the schematic diagram, let me label this thing, this is your schematic diagram, so what is this? This is your schematic diagram of DSB SC demodulation of the DSB SC demodulation process, alright. This is a schematic diagram of the demodulator of a DSBSC system that is double sideband suppressed carrier.

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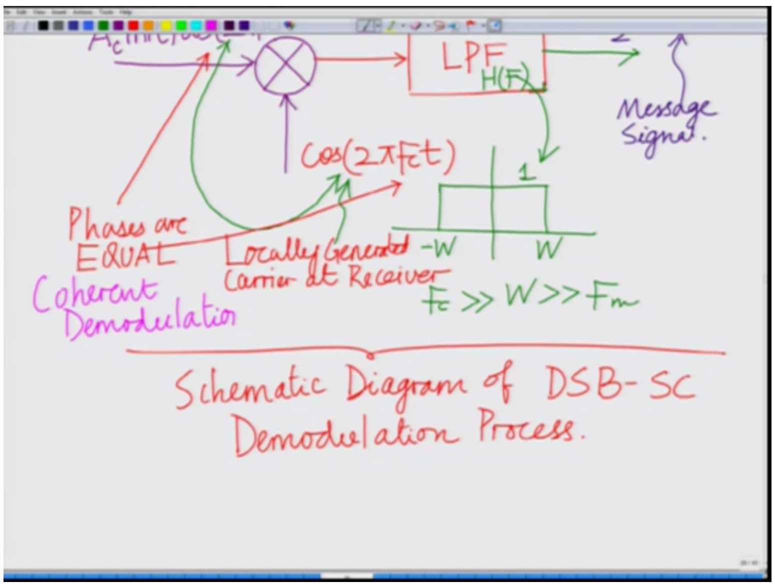

Now in this module let us look at another interesting aspect, now if you look at this, this is something interesting here and you will realize that the success of this demodulation process or the efficiency or will look at in other words also one of the things which we have implicitly assume without without making too much of a fuss or without specifying exactly, how this is done?

What we have assumed is that these 2 cosine waves that is your cosine wave that is the modulating the carrier that is the carrier wave, right? Carrier of the incoming signal, let us that is the Ac m(t) cosine 2pi Fct and the demodulator the carrier there is the carrier generated at the, so we can call this as the carrier in (messe) incoming signal the carrier of the incoming signal, correct? In input signal let us input signal which is basically or carrier in received signal let us put it that way the carrier in the received signal and this is the carrier locally generated carrier at the receiver.

This is the locally (genera) this is the copy of the locally generated, what we have realized is in the demodulation process we need a copy of the carrier that is cosine 2pi Fct locally generated and of course the incoming signal incoming signal is modulated of this carrier cosine 2pi Fct, now what we have assumed is that basically is now of course one thing is the carrier frequency is known, right? This is the carrier frequency on which the the signal is being transmitted is known, alright.

So we can generate a local copy of the carrier at a at the receiver, however what we have also assume and I am not explicitly pointed this out is that this phase of this incoming that is the it’s phase of the carrier in the incoming signal and the phase of the carrier of the locally generated, what we have assumed is that these 2 phases we have assumed here and you will see that we have assumed that these phases are equal and you will realize that the success of the system depends on this fact that is the phase of the carrier in the incoming signal, right? In the incoming signal at the receiver.

And the phase of the carrier at the locally generated of the phase of the locally generated carrier are actually equal or in other words there is no phase offset of the locally generated carrier with respect to the carrier where component in the incoming signal this is what we have implicitly assumed, right? And this is a very big assumption as I am going to demonstrate later, correct? So and this is termed as when these phases are equal this is termed as coherent demodulation. So coherent, what is coherent demodulation?

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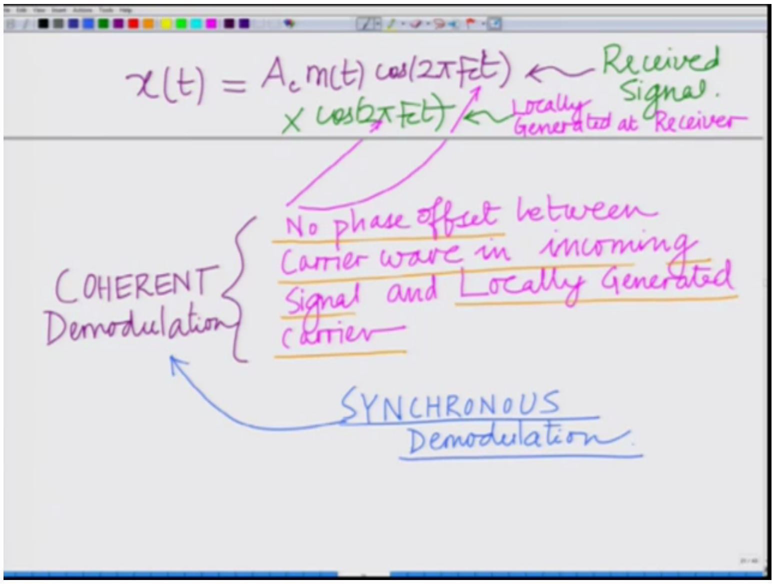

So we have two, we have incoming message signal x equals Ac cosine 2pi or Ac m(t) I am sorry Ac m(t) cosine 2pi Fct, correct? This is your incoming signal received signal one can also say that is probably clear received signal, correct? And we have the carrier that is cosine 2 pi Fct, correct? We are multiplying demodulating this with the carrier, this is the locally generated carrier the locally generating meaning locally generated at receiver and we have assumed that no phase offset between carrier wave in incoming signal and locally generated that is we have assume there is no phase offset between carrier wave in incoming signal and the locally generated between carrier wave in incoming signal and the locally generated carrier and this is termed as coherent demodulation coherent, let me just write it in a bold letters coherent demodulation or basically synchronous demodulation coherence means that is in line, alright.

Something is coherence means coherence basically indicates that the carrier at the receiver is in sync or is in tune with the carrier wave of the incoming signal they are coherent, alright. There is coherence which means that basically something is in line or something is in sync, correct? And it is also termed as synchronous demodulation this is also termed as synchronous, another way is probably even a better term is synchronous coherent demodulation or synchronous demodulation which means both the same thing that there is no phase offset between the carrier wave and the incoming signal and the the the carrier wave that is the carrier that is locally generated by the oscillator at the receiver, correct?

Now in general there can be a mismatch between the phase of the incoming carrier that is there can the phase of the incoming the carrier wave in the incoming signal and the phase of the locally generated signal, alright. There can be a phase mismatch this is termed as a carrier phase offset, okay.

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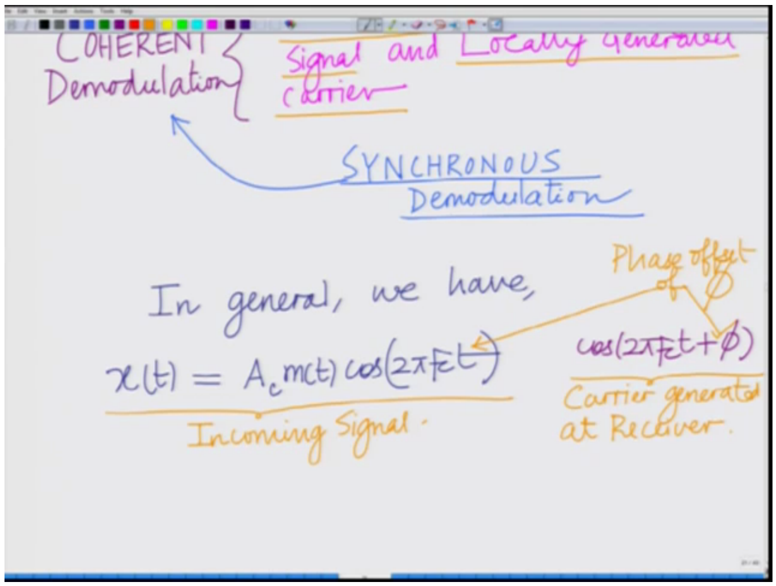

So let us take a look at this in general we have x(t) equals AC m(t) cosine 2piFct and cosine 2pi Fct plus phi, so this is your incoming signal, correct? Once again this is your incoming signal and this is the carrier locally generated carrier, carrier generated at the receiver and now you can see the carrier generated the receiver or the carrier employed for the demodulation at the receiver has a phase offset, now you can see there is a phase offset of phi. So the carrier at the demodulator is offset with respect to the carrier wave in the incoming signal, right? Is offset by a factor of by phi, alright? This is termed as a carrier phase offset or look at this factor phi is termed as the carrier phase offset this is termed as the carrier phase offset, okay.

The carrier phase offset and therefore now the carrier generated at the receiver is no longer coherent, alright? This is no longer coheres or no longer synchronous with respect to the carrier wave in the incoming signal, so the carrier wave at the receiver is no longer synchronized, alright? Is no longer coherent or it is no longer synchronized with the carrier wave in the incoming signal therefore in this scenario what we can see?

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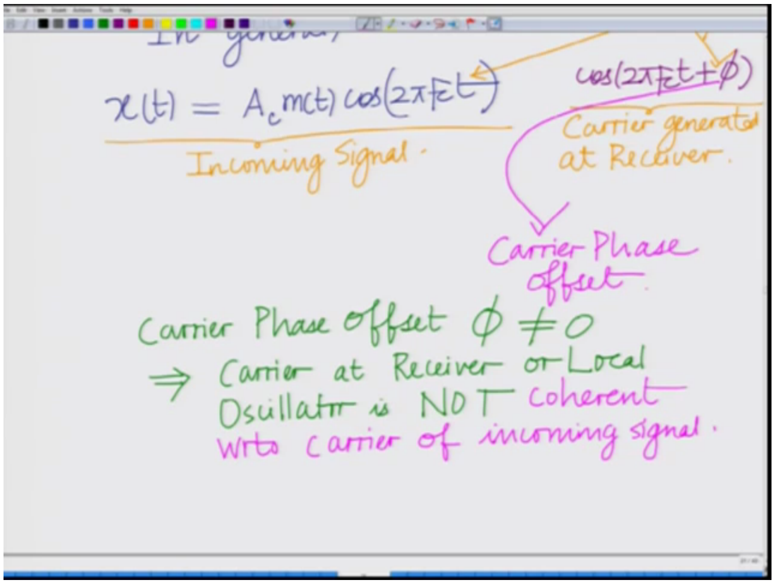

There is a carrier phase offset phi not equal to 0 implies carrier at local oscillator or carrier at receiver or local oscillator or your local oscillator is not coherent carrier of incoming coherent with respect to carrier of incoming signal, alright. So there is non-coherence alright? Is not synchronized the carrier generated at the receiver is not coherent with respect to the carrier wave in incoming signal now what problems does this lead to?

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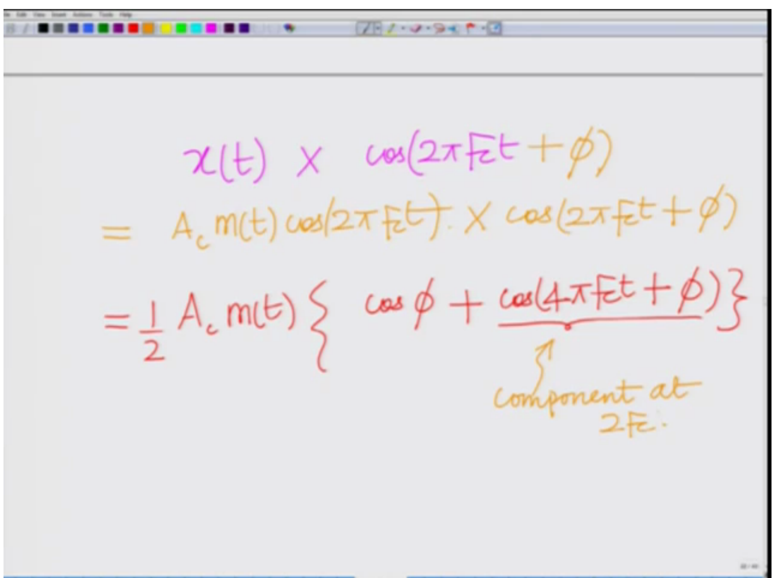

Let us examine that now let us examine non-coherent demodulation we have x(t) multiplied by remember our demodulation process our demodulation process is simply we take as you can see from here what we have is we have x(t) multiplied by cosine 2pi Fct. So for our demodulation process what we employ what we do is to simply take the received signal x(t) multiplied by cosine 2pi Fct which is basically your signal Ac my cosine, sorry now there is a phase offset of Phi Ac m(t) cosine 2pi Fct times, cosine 2pi Fct plus phi which I can write as, well Ac m(t) divided by that is half Ac m(t) times well, cosine 2pi Fct cosine 2pi Fct Phi that is cosine A, cosine B or twice cosine A cosine B is cosine A minus B that is cosine phi plus cosine A plus plus cosine A plus B that is cosine 4pi Fct plus phi.

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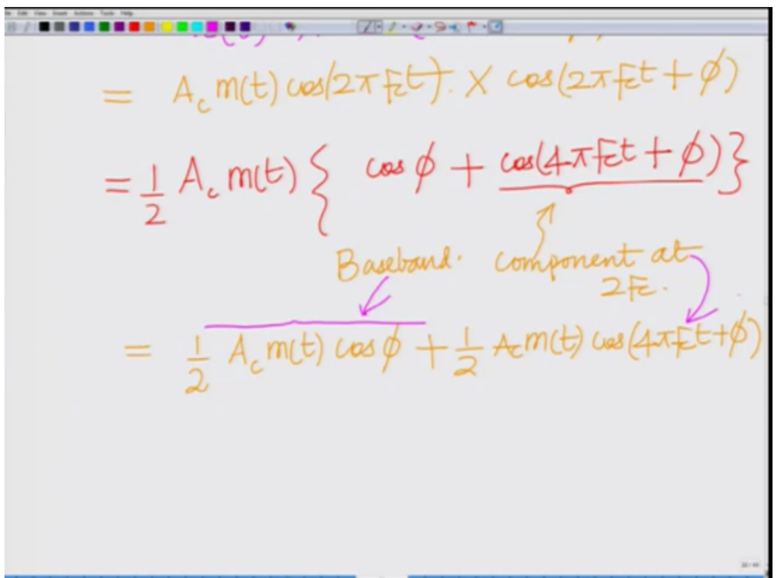

Now you can see this component, this is the component at at 2Fc, okay. And this is of course a constant, so this is a baseband component this is your baseband this gives rise to the baseband component, so therefore what we have what probably we have I think probably I can write one more step half Ac m(t) cosine phi plus plus half Ac m(t) cosine 4pi Fct plus phi and of course this is the baseband and this is your component at 2Fc.

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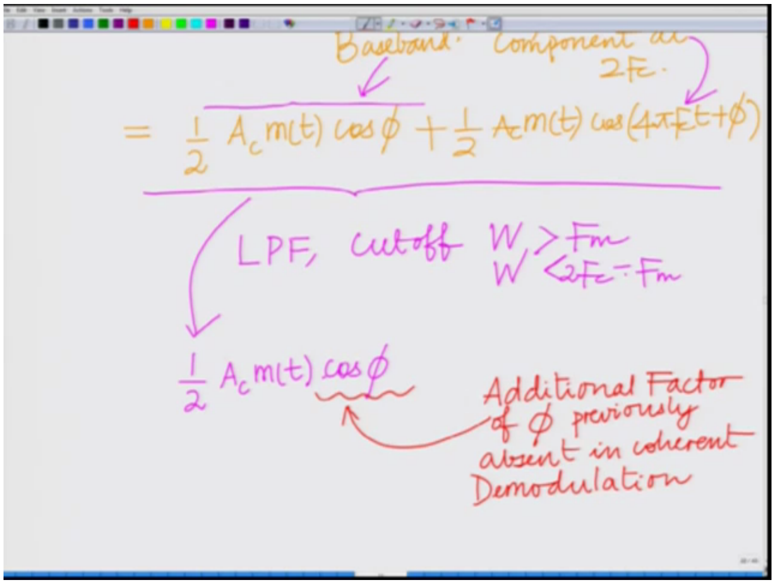

Now when we low pass filter this you take this pass it through low pass filter again the same thing cut off the W greater than that is cut off W greater than Fm and W less than Fc minus Fm, correct? Cut-off is such that basically your W are basically 2Fc minus Fm, correct? 2 Fc minus Fm, okay. And we get what we get is half well, Ac m(t), correct? Cosine phi and now what you see is that you have this additional factor additional factor of phi you have this, additional factor of phi which was previously absent in the case of coherent demodulation. Additional factor of phi previously absent in coherent demodulation, okay. So now we have this additional factor of phi which was previously absent.

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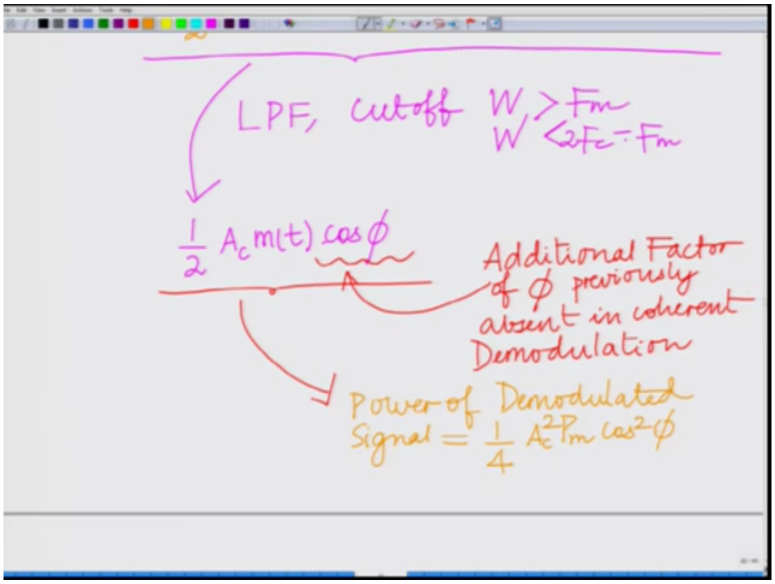

And now we can see there is a problem because this factor of phi results in the (pow) now if you can look at this what is the power of the received signal power of power (())(21:36) power of demodulated signal the power of demodulated signal power of the modulated signal is 1 by 4 Ac square the power of the message signal into cosine square of phi.

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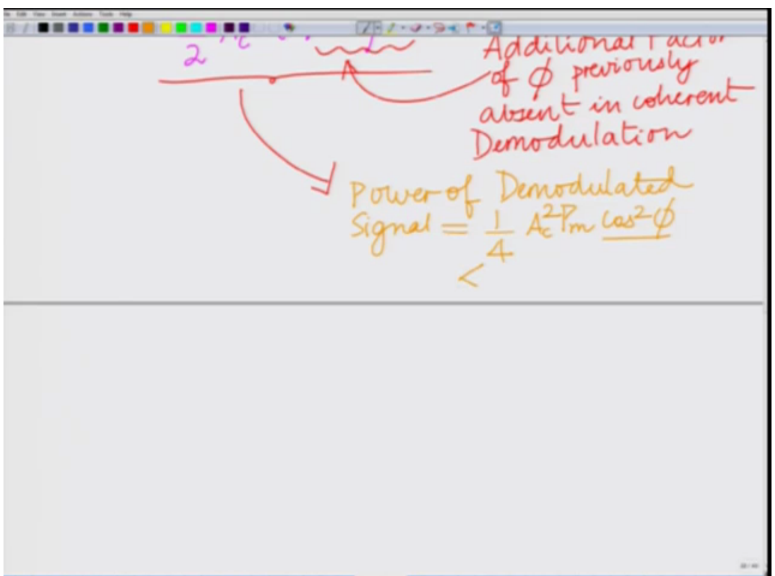

So there is a factor of cosine square phi and remember cosine square phi is less than or equal to one implies the power is less than or equal to 1 by 4 Ac square Pm which is the power in the coherent demodulation, so the power is the power is suppressed or power the output power of the demodulated signal is suppressed by a factor of cosine square phi.

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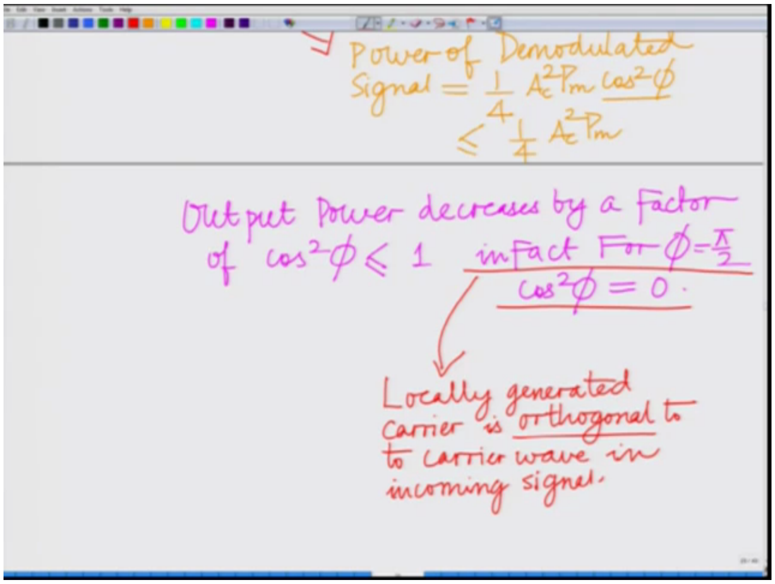

So output power the output power decreases by factor of cosine square phi which is basically less than or equal to 1 in fact for phi equal to pi by two cosine square phi equal to 0. In fact if the phase difference phi is pi by two that is a locally generated carrier is phi by two out of phase with respect to the carrier wave in the incoming signal the output power is 0 as you low pass filter it, right?

Which is basically proportional to cosine square phi is zero or basically the carrier at the locally generated carrier is completely out of sync, correct? So the power it's orthogonal to the carrier wave in the (())(23:42) means in fact if you can see this means carrier wave locally generated carrier is orthogonal carrier wave in incoming signal the locally generated carrier is orthogonal to the carrier wave in the incoming signal and therefore the carrier wave this basically when its orthogonal, right?

When it's orthogonal there therefore what is happening is basically once you demodulate with this orthogonal because which is orthogonal locally generated carrier at the receiver which is out of phase by pi by 2 with respect to the carrier or the incoming signal and low pass filter it the output power is simply 0. And therefore now you can see an offer all the values of phi between 0 and pi by 2 you basically have the carrier the power of the output signal which decreases slowly, so for 0, right?

When phi is equal to 0 you have maximum power of the signal at the output is the low pass filter where phi equal to pi by 2 the the power that is the power of the demodulated signal is basically 0 and therefore for values of phi between 0 to pi by 2 the output power decreases from the full output power the maximum possible output power to zero. And therefore as phi what you can see is as phi increases or as the carrier phase offset increases, right?

The degradation worsens, alright? The received output power the output power at the power of the demodulated signal progressively decreases, correct? The performance progressively worses as carrier phase offset increases carrier phase offset pi increases the output power, power of the output demodulated signal progressively decreases and the performance, alright? Progressively worsens, okay. So that is something that we have to note.

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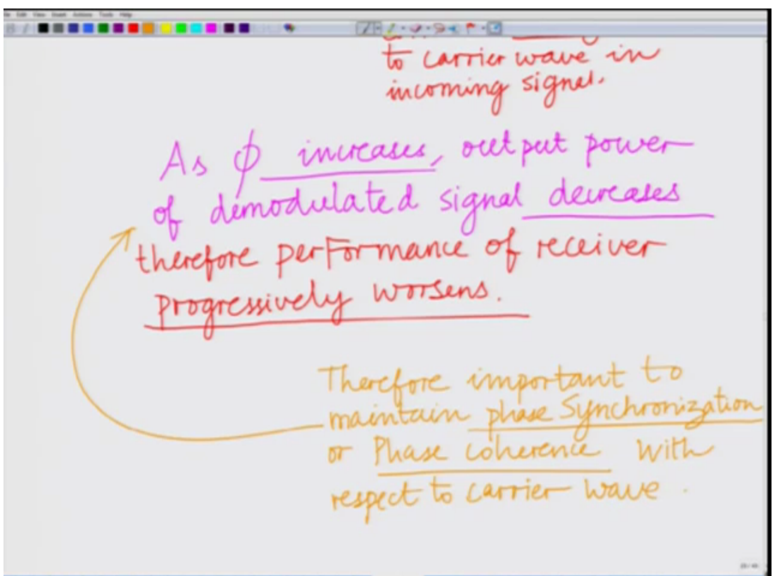

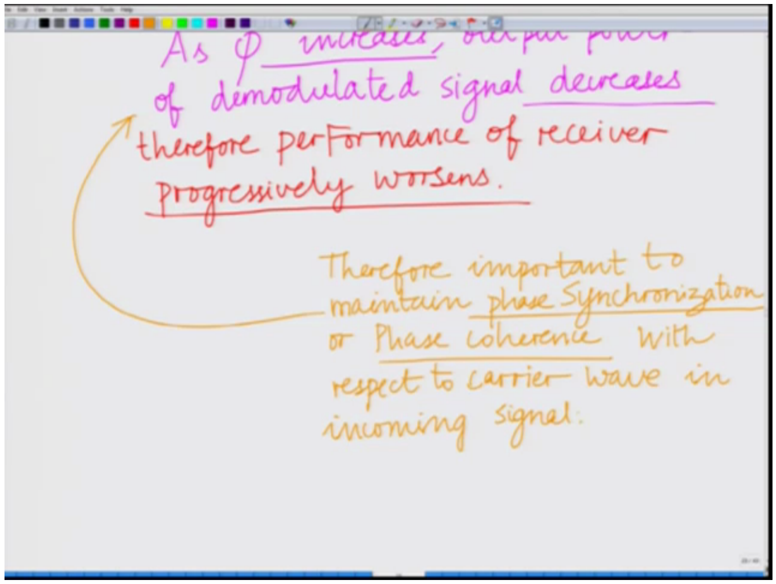

As Phi increases the output power of the demodulated signal as phi increases output power of the demodulated signal decreases therefore performance of performance of receiver progressively worsens. Performance of the receiver progressively worsens as the carrier phase offset increases therefore it’s important to maintain this phase synchronization, right? Therefore important to maintain phase coherence or phase synchronization with respect to the carrier at the receiver, correct?

Therefore it is important to maintain phase synchronization or phase coherence phase synchronization of phase coherence with respect to carrier in incoming signal carrier wave in incoming signal, okay. So therefore what we have seen, so in this module what you have seen is we have examined the impact of the carrier phase offset of the offset in a locally generated carrier, correct? At the receiver what happens when it is used for demodulation when the carrier that locally generated carrier that is used for demodulation the DSB SC receiver has an offset with respect to the carrier wave in the incoming signal we have seen that as the carrier phase offset, we have modeled this carrier phase offset and we have demonstrated that as the carrier phase offset increases, right?

As the carrier phase offset increases the output power of the demodulated signal progressively decreases therefore the performance of the system, right? As the output power progressively decreases the performance of the receiver or the performance of the communication system becomes progressively worse, alright. So we will stop here and continue with other aspects in the subsequent modules, thank you.