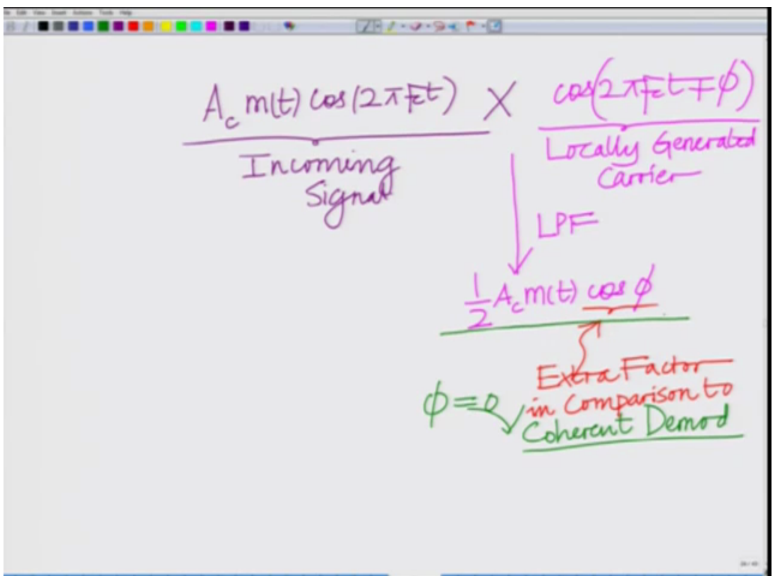
Principles of Communication- Part I
Professor Aditya K. Jagannathan
Department of Electrical Engineering
Indian Institute of Technology Kanpur
Module No 3
Lecture 16
Carrier Phase Offset Example for Double Sideband (DBS) Suppressed Carrier (SC) Demodulation - Wireless Cellular Communication with User Mobility

Hello welcome to another module in this massive open online course, alright? So we are so we are looking at the demodulation of a double side bond double sideband modulated DSB SC that means double sideband suppressed carrier signal when there is a phase offset between the carrier that is generated at the receiver and the carrier the carrier wave component in the incoming signal.

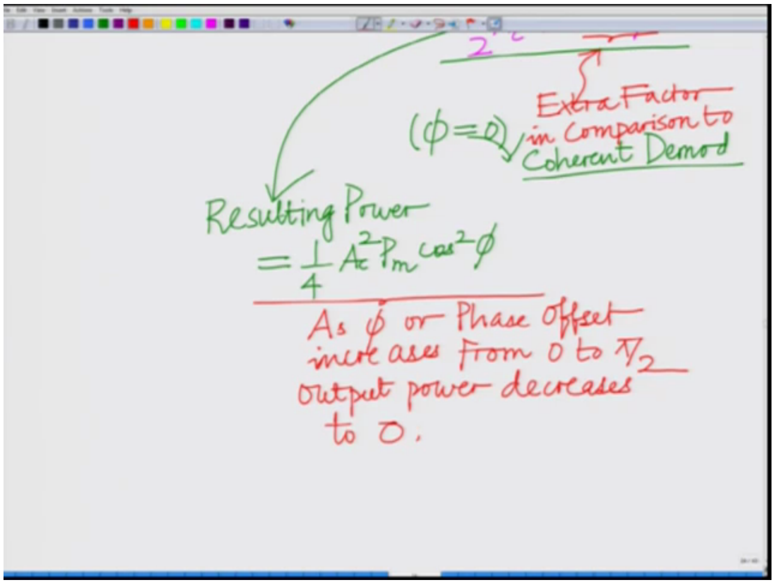
(Refer Slide Time: 0:48)



And we have seen that leads to poor performance so when there is when the incoming message so we have the incoming message signal that is your Ac m(t) cosine phi or cosine 2pi Fct this is your incoming signal and this is demodulated or multiplied by the carrier which is locally generated at the receiver and when there is a phase offset of phi, alright. This is a carrier locally generated or a locally generated carrier and when this is passed through a low pass filter our output signal is half Ac m(t) cosine phi, so this is an extra factor which is arising in comparison to coherent demodulation, correct?

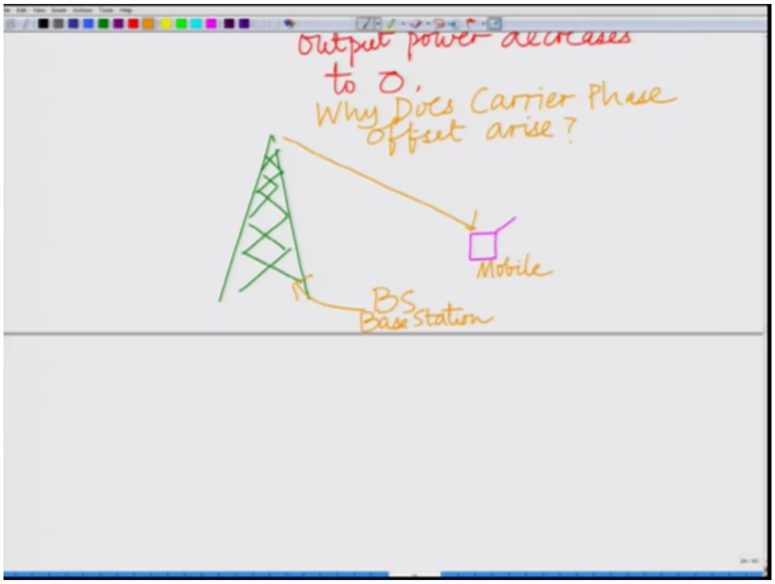
Coherent demodulation means when phi is equal to 0 that is there is phase synchronization phase synchronism between the locally generated carrier and the carrier wave in the incoming signal, so this is an extra factor in comparison to coherent we have already seen this coherent and coherent démodé means phi is equal to 0 and this leads to a power the power of this, correct?

(Refer Slide Time: 3:03)



Coherent demodulation means phi is equal to 0 and power the resulting power equals 1 over 4 Ac square the power in the message signal times cosine square phi which becomes progressively worse as phi which means as phi increases that is as phi increases as phi increases from 0 to pi by 2 or as the phase offset as phi or phase offset increases from 0 to pi by 2 output power decreases to 0. So the performance becomes progressively worse, alright. This is what we have seen, alright.

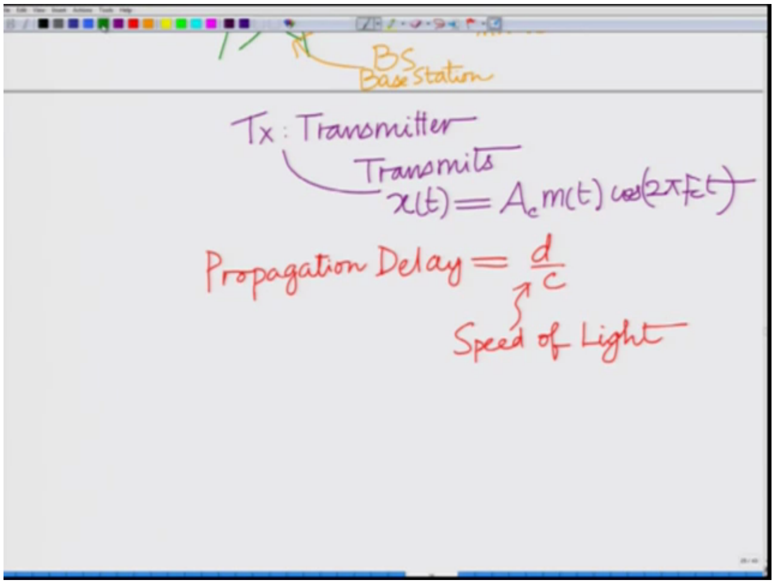
(Refer Slide Time: 4:31)



Now let us understand why this phase offset arises and why is it important to tackle this phase offset, now let us to understand that let us consider for a brief moment a typical wireless communication scenario, alright it is clearly explained its mature apparent when you consider a wireless communication scenario, alright. So let me draw a typical wireless communication scenario, so what we are trying to understand is why does the phase offset arise?

So our question is why does the carrier phase offset on how does carrier phase offset arise in the first place? And I have a mobile let us say a base station which is transmitting to a mobile, okay. I am schematically I am drawing a schematic of a, this is your base station and this is your mobile, okay. And this is the transmitted signal so the base station, so we are considering a typical wireless publication scenario where it the base station is transmitting a signal to the mobile and keep in mind that the mobile user can be moving in this cell, alright. That is the important thing that is the mobile or the receiver is not fixed but the distance that is the user is mobile and therefore the scenario and therefore he he is mobile and therefore he is moving, correct? And something interesting happens as the mobile user moves as we are going to see shortly.

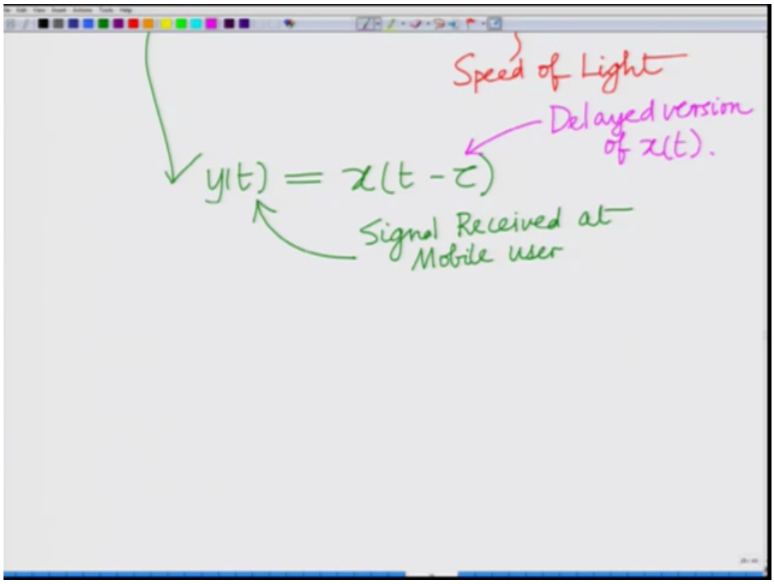
(Refer Slide Time: 6:40)



Now let us assume that this distance of propagation this is the propagation distance this is the propagation distance, okay. And let us say the transmitter that is the transmitter transmits signal or transmits the signal x(t) equals m(t) alright let us go back and let us say this is Ac m(t) cosine 2pi Fct this is a signal that is transmitted by the transmitter, now the propagation distance there is a distance between the transmitter and the receiver.

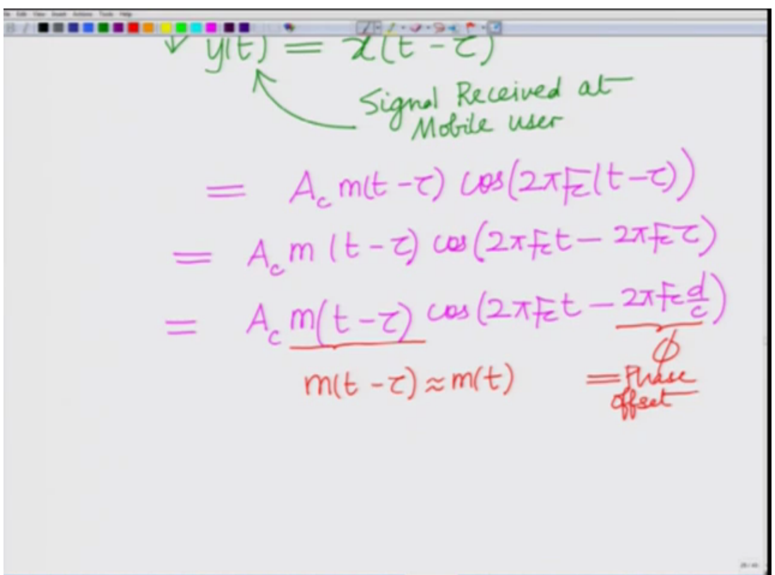
So the signal takes time to propagate from the transmitter to the receiver and the time of propagation the propagation delay obviously depends on the distance between the wireless transmitter that is a base station and the mobile receiver, alright. And the propagation delay is specifically given by the distance d divided by c where c is the speed of light, so the propagation delay now once the signal is transmitted realize that there is going to be a propagation delay d by c where c equals to the speed of an electromagnetic wave or c is basically your speed of light.

(Refer Slide Time: 8:38)



Now as a result of this the signal received that is y(t) is actually not exactly x(t) but x(t) minus Tau or let us call this delay Tau.

(Refer Slide Time: 9:46)

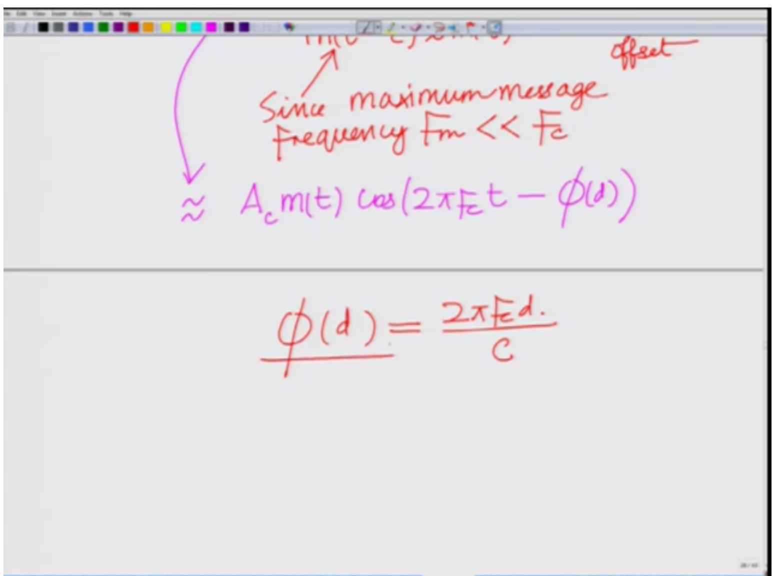


And therefore signal received at the receiver signal received at the mobile user the signal received at mobile user is y(t) which is x(t) minus Tau that is remember delayed version of x(t) and naturally signal x(t) minus Tau implies basically the signal x(t) delayed by tau and therefore the signal y(t) is now if you substitute for x(t) this is Ac of course Ac is a constant m(t) minus

Tau cosine 2pi Fc cosine 2pi Fct minus Tau equals Ac m(t) t minus tau cosine 2pi Fct minus 2pi Fct tau, now substituting tau equal to d over c this is Ac mc or not mc Acm t minus tao cosine 2pi Fct minus 2pi Fc.

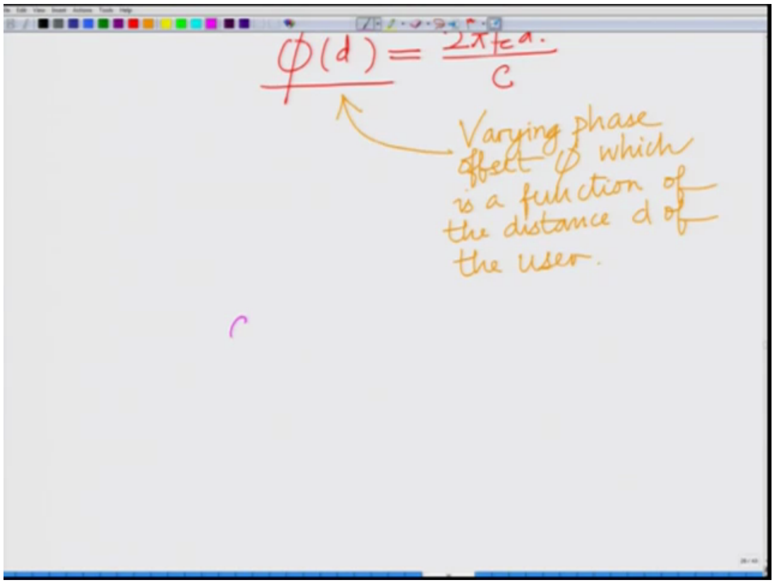
Now substitute for this Tau as d by c, now you can see this is the phase of set phi equals this is phi which is equal to this is your phi which is basically equal to the is equal to the phase offset, okay. Now of course we are not going to see this in detail but we can also say m(t) minus tai is approximately equal to m(t) because the delay because remember the message is varying very slowly the maximum frequency component Fm of the message signal is much lower in comparison to Fc which is the carrier frequency of the which is the carrier frequency therefore for small delay's tau one can say that m(t) minus tau is approximately equal to m(t), alright.

(Refer Slide Time: 11:52)



Since the message is varying since the maximum message frequency Fm is much lower than Fc, correct? Since maximum message frequency Fm is much lower than Fc, correct? Since the maximum message frequency Fm is much lower than Fc I can say therefore that this is approximately equal to Ac m(t) cosine 2pi Fct minus d by minus 2pi Fc d by c minus let us write this as the phase phi which now depends on the distance d the phase phi phi of d equals 2pi Fcd by c.

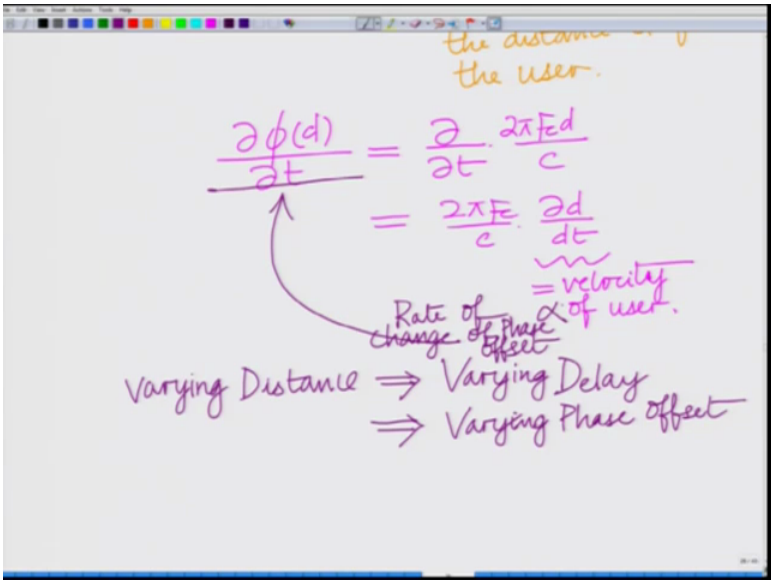
(Refer Slide Time: 13:03)



This is the phase offset the variable phase offset or the varying phase offset and the most important thing is you have to realize that this depends on the distance the varying phase offset phi which depends or which is a function of the distance d which is a function of the distance d the user and that is the important thing. So as the distance d of the user is changing the you remember the user is mobile and therefore as he is moving the distance d is changing as the distance d is changing the delay Tau which is d over c is changing as the delay Tau is changing the phase offset is changing and therefore even though the transmitter the receiver the locally generated (oscillate) the locally generated carrier at the receiver might be synchronized (()) (14:13) with respect to the incoming carrier wave at some point in time very soon because the user is moving the phase offset of the carrier component in the incoming signal is changing, alright.

And the rate of change in fact you can realize you can see easily depends on the rate at which the user that is if user is stationary of course the phase offset is not changing but the you if the user is mobile, right? This phase offset is changing and the rate of change of this phase offset depends on the velocity of the user, if the velocity if the user has a very high velocity than naturally the distance is changing at a very fast rate the distance is changing at a very fast rate implies that the delay Tau changes at a very fast rate if the (dist) delay tau changes at a very fast rate the phase offset Phi d changes at a very fast rate.

(Refer Slide Time: 15:15)

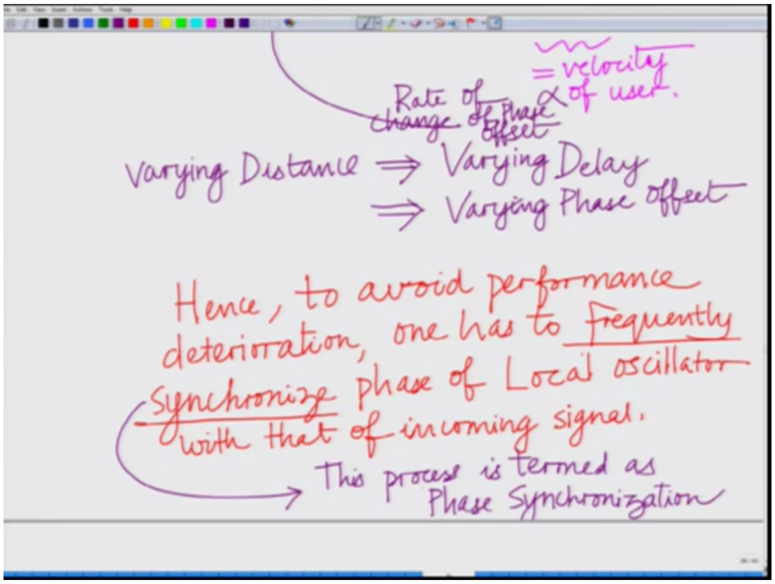


Therefore you can clearly see this quantity d phi d by dd if you can look at this quantity which is let us call this d phi d or let us just denote this by partial derivative d phi d by do d which is equal to do by do d 2pi Fcd by c, correct? Or do phi by do t rather cheesy equal to 2pi Fc by c do d by do t and this is nothing but the velocity. The rate at which the distance d is changing is proportional to the velocity of the mobile user which means if the user is mobile with a very high velocity the phase is changing the distance is changing with a very high velocity.

Therefore the resulting phase offset is changing at a very high velocity which means that there is frequently a loss of phase synchronization between the carrier wave in the incoming signal and the carrier wave that is locally generated at the oscillator and this frequent loss of synchronization means that there is going to be deterioration of performance because of this phase offset and hence one has to (constan) constantly keep re-synchronizing at the receiver in order to avoid this into deterioration of offset in order to avoid deterioration of performance arising from this frequent loss of phase synchronization.

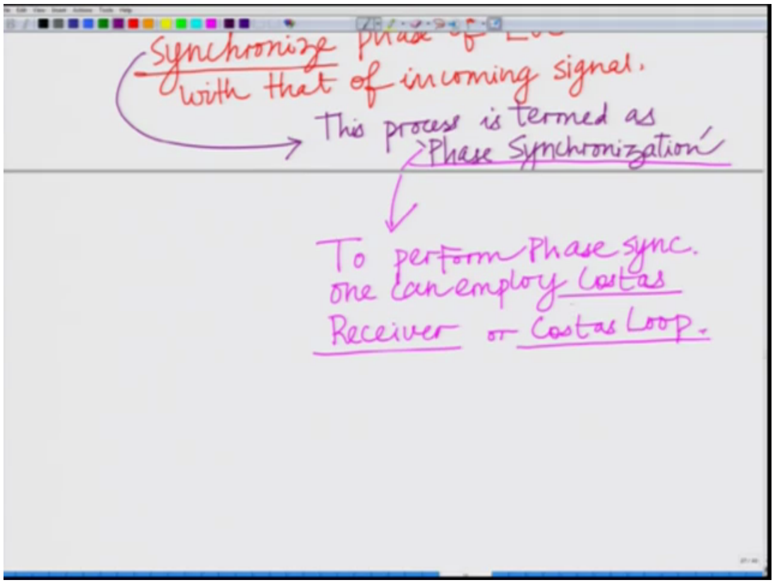
And that is the importance of synchronization or phase (synchro) that is important the phase synchronization because this phase synchronization is constantly being lost because of several factors one of the main factors is because the user the user in a typical wireless communication scenario is mobile which leads to a varying delay and varying delay leads to a varying phase offset, okay. So this leads to (vary) so varying delay let us summarize this varying delay or varying distance let us put it that way let us start with varying distance implies a varying delay implies a varying of phase offset further the rate of change of (pha) phase offset is proportional to the velocity of the user.

(Refer Slide Time: 18:30)



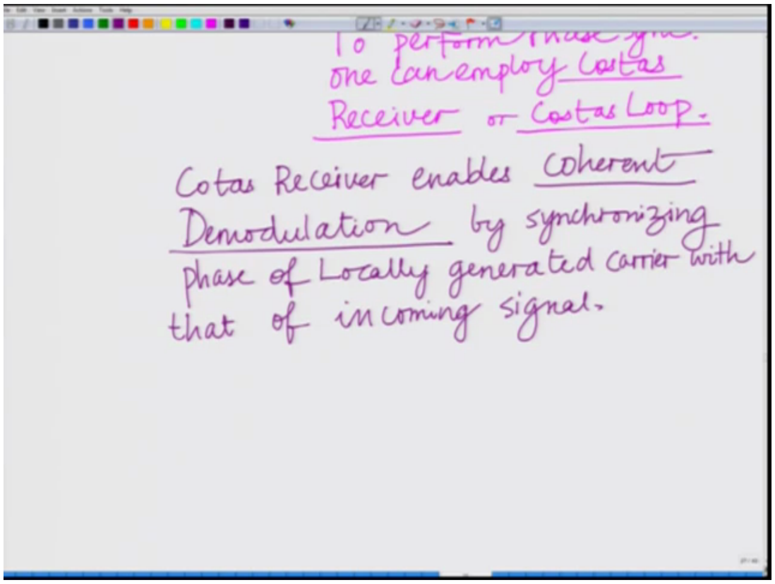
Hence to avoid loss of performance to avoid performance deter deterioration one has to frequently synchronize phase of locally generated carrier with that of the incoming carrier signal or local oscillator which generates the local carrier with that of with that of incoming with that of the incoming signal. One has to frequently synchronize, this process is termed as phase synchronization, this process is termed as phase synchronization this process is termed as phase synchronization and it has to be carried out frequently in order to avoid any performance (deter) deterioration at the receiver and how is this phase synchronization?

(Refer Slide Time: 20:40)



This phase synchronization can be carried out with the help of a Costas receiver and to perform phase synchronization one can employ Costas receiver or a Costas loop, what a Costas receiver does? Is basically it synchronizes the phase of the locally generated carrier with that of the carrier component in the incoming signal there (fi) thereby making that a aligning these 2 phases, right? Making sure that the (pha) the locally generated carrier is synchronous, right? Is in sync with the carrier with the carrier wave component in the incoming signal thereby avoiding the performance deterioration that arises from arises otherwise from non-coherent that is why that basically it aids in coherent the modulation the Costas loop by synchronizing the phase of the locally generated carrier with that of the incoming signal it basically enables coherent demodulation that is the whole idea.

(Refer Slide Time: 22:00)



So (co) Costas loop basically Costas receiver enables coherent demodulation by synchronizing phase of the locally generated carrier with that with that of the incoming phase of the locally generated carrier with that of the incoming signal local generated carrier with that of the incoming signal, alright. So that is basically the idea why we need phase (synchro). So what we have seen in this module is basically we have seen a practical scenario of why this carrier phase offset arises? This arises because in a typical wireless scenario that distance, alright. The distance the propagation distance between the transmitters that is in the downlink, alright.

The transmitter can the user can also be a transmitter but typically in a downlink scenario where the mobile is transmitting the base station is transmitting the mobile and this is also valid for in uplink scenario, alright. Because a, the distance is symmetric, right. So in a downlink scenario when the base station is transmitted into the mobile or the mobile is transmitted into the base station because the user is mobile the propagation distance is changing which results in a varying delay, alright.

Varying propagation delay and that results in a varying phase offset of the incoming signal with respect to that of the locally generated carrier at the receiver and therefore phase synchronization is important and this is carried out using a Costas loop alright. So we will stop here and continue in the subsequent modules, thank you.