Course on Principles of Communication Systems-Part 1
Professor Aditya K. Jagannatham
Department of Electrical Engineering
Indian Institute of Technology Kanpur
Lecture 49
Module 8
Frequency Translation and Super Heterodyne Receivers, Problem of Image Frequency

Hello welcome to another module in this massive open online course right. So we are looking at frequency translation or frequency mixing alright this is also known as heterodyning, ok.

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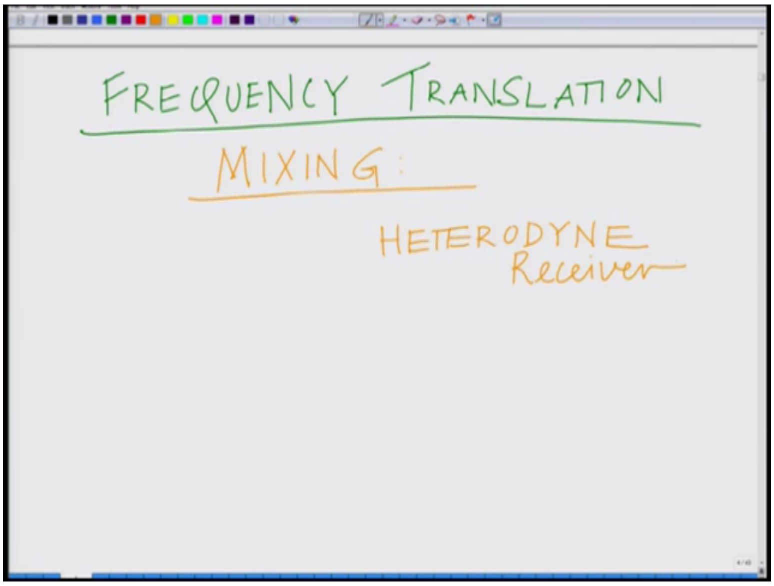

So we are looking at frequency translation or mixing or also known as frequency mixing, ok. And the problem with the heterodyne receiver that we have seen we have seen a heterodyne receiver, ok.

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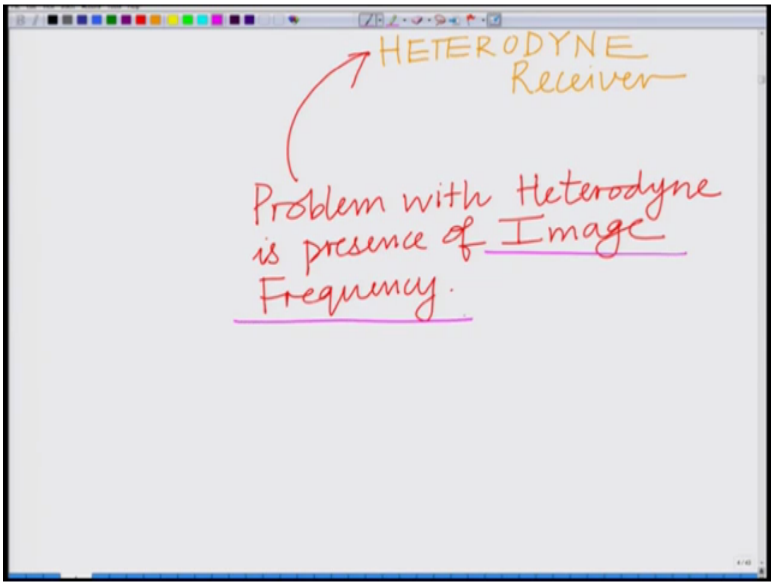

And the problem with the heterodyne receiver is the presence of what is known as an image frequency so problem with heterodyne is the presence of is the presence of what is known as an image what is known as an image frequency.

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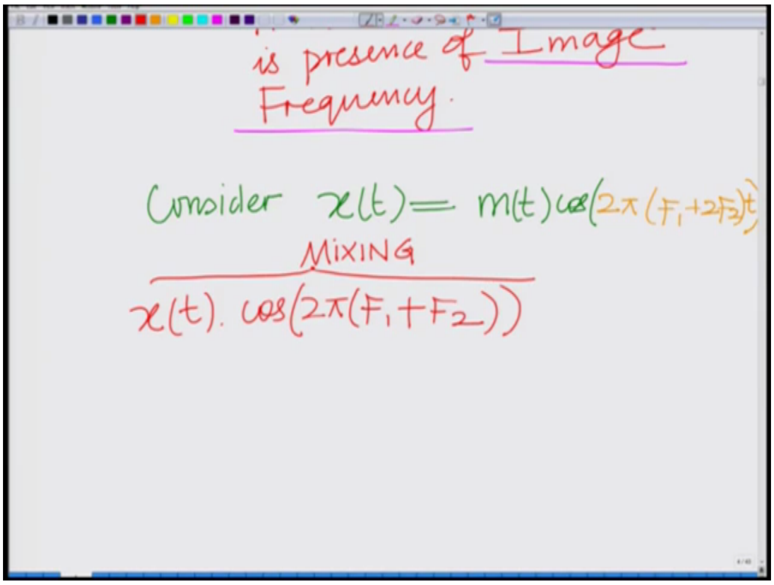

Now what is an image frequency, now consider the signal incoming signal x(t) equals m(t) cosine(2pi(F1 plus 2F2 F1 plus 2F2)t), ok F1 plus 2F2(t), ok. Now this is mixed with again cosine 2pi F1 again this is mixed heterodyne with cosine 2pi F, so we perform x(t) into cosine 2pi(F1 plus 2F2). So this is signal this is mixing, ok so this is mixed with a signal with frequency F1 plus F2.

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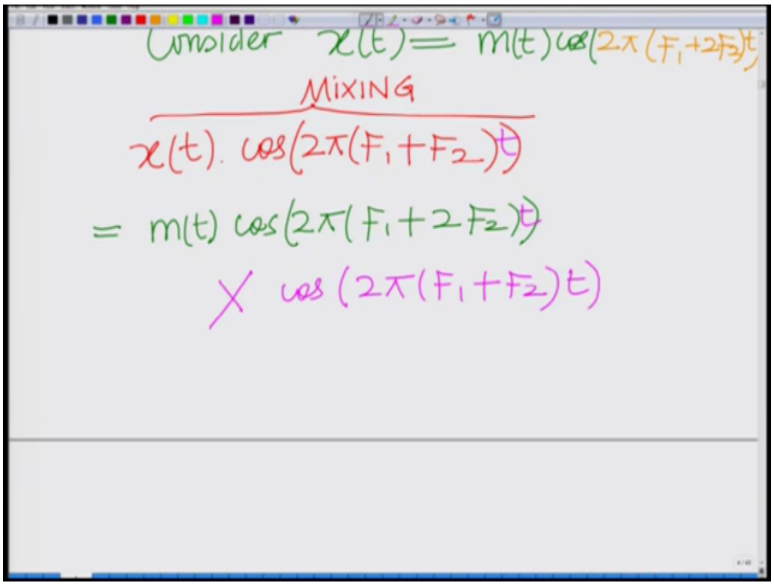

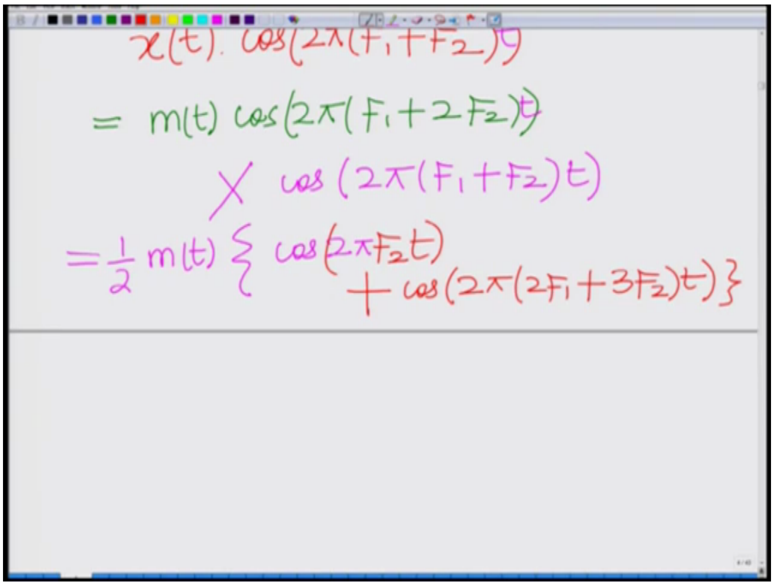

And now if you observe what we get what we get is well m(t) cosine (2pi(F1 plus 2F2)) times cosine (2pi(F1 plus F2)t), ok F1 plus F2(t). Now this is equal to half m(t) { cosine (2pi times the difference of frequencies F1 plus 2F2 minus F1 plus F2 you can see that it again gives the difference F2t correct plus cosine the sum of frequencies F1 plus 2F2 F1 plus F2 that is (2F1 plus 3F2 into 3F2)t)}.

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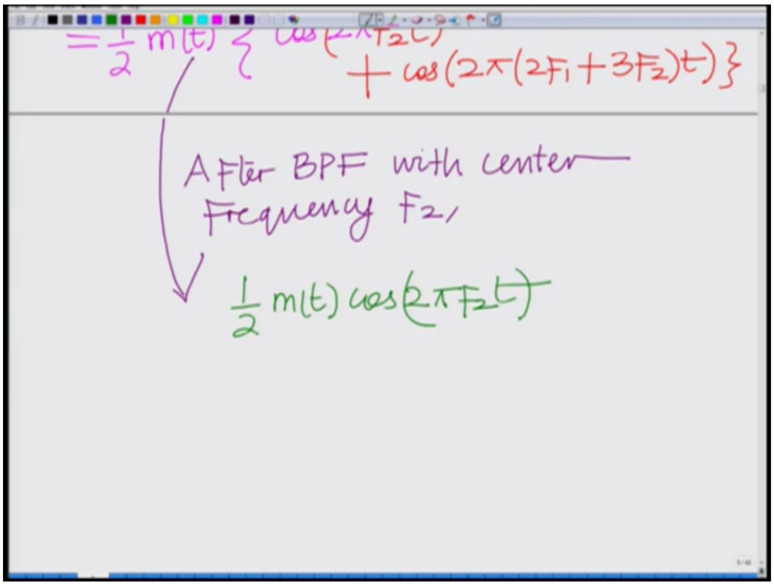

Now if we band pass filter this if we band pass filter this signal the band pass filter at F2 of suitable band width what you can see is we can extract the cosine 2pi F2t component ok. So now after band pass filtering with center frequency after band pass filtering with center frequency F2 what we obtain after BPF what we obtain is half m(t) cosine (2piF2t), ok.

So therefore what you can see is previously we had seen that the frequency F1 is translated to F2 but there is also an image frequency F1 plus 2F2 which will also be translated to F2 and therefore naturally this signal if there is an incoming signal this image frequency F1 plus 2F2 alright if there is an if there is an incoming signal at this image frequency F1 plus 2F2 that is also going to interfere that is going to be translated to F2 and hence interfere with the signal at incoming signal at frequency F1 which is also being translated to F2, ok.

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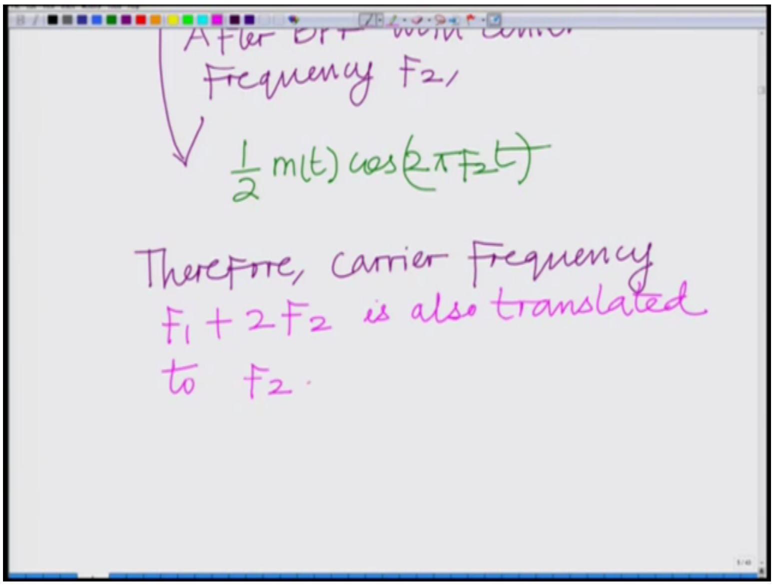

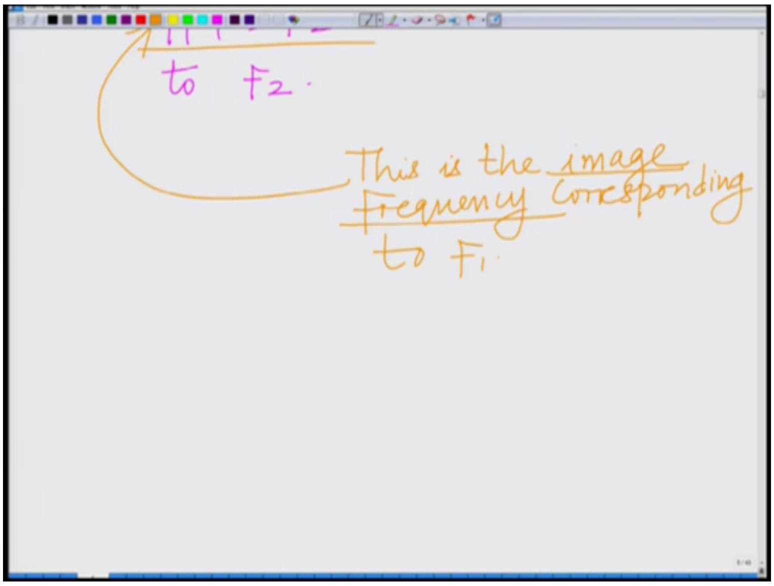

So there is so we have so therefore therefore carrier frequency F1 plus F1 plus 2F2 is also translated to and this F1 plus 2F2 this is termed as the image frequency corresponding to this is the image frequency the image frequency your image frequency this is the image frequency corresponding to F1, ok this is also termed as your image frequency, ok. This is the image frequency corresponded to F1, ok. So that is the problem alright.

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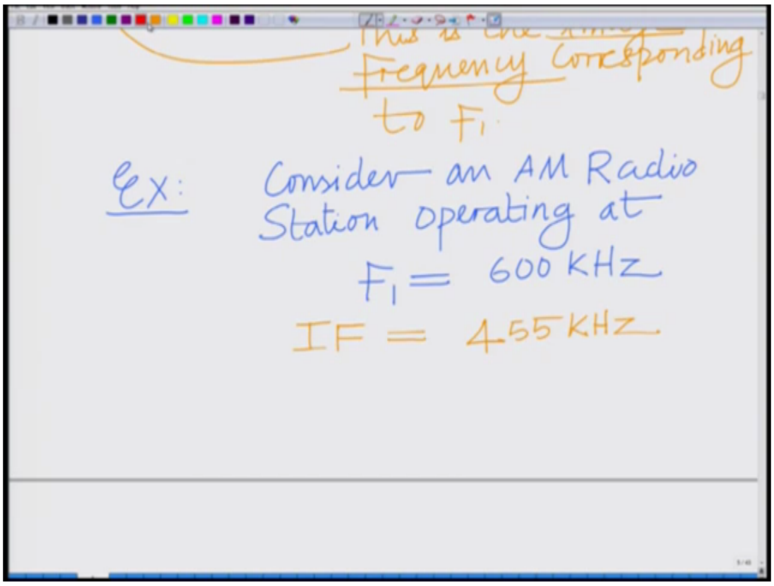

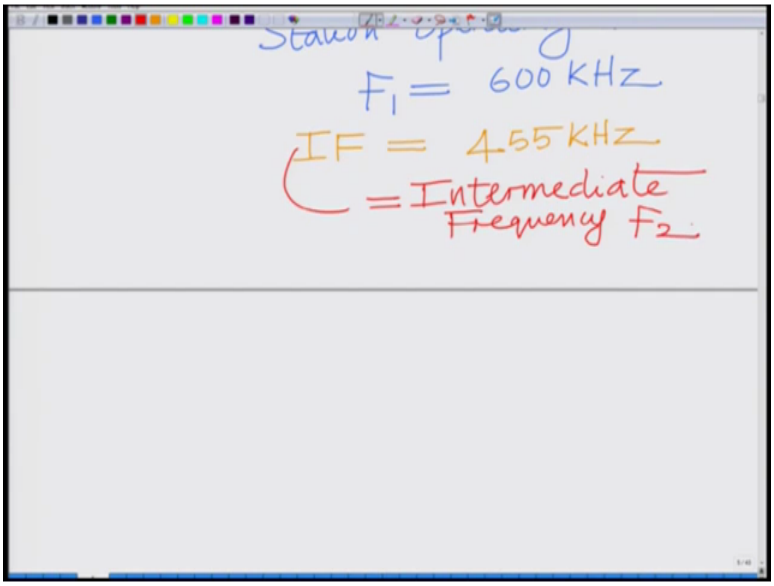

For example let us take an example ok consider an FM station or consider an AM station AM Radio Station operating at operating at F1 equals let us say this is operating at F1 equal to 600 kilohertz. We choose an intermediate frequency IF equals when intermediate frequency ok, remember IF stands for intermediate frequency, so intermediate frequency that is your F2, ok.

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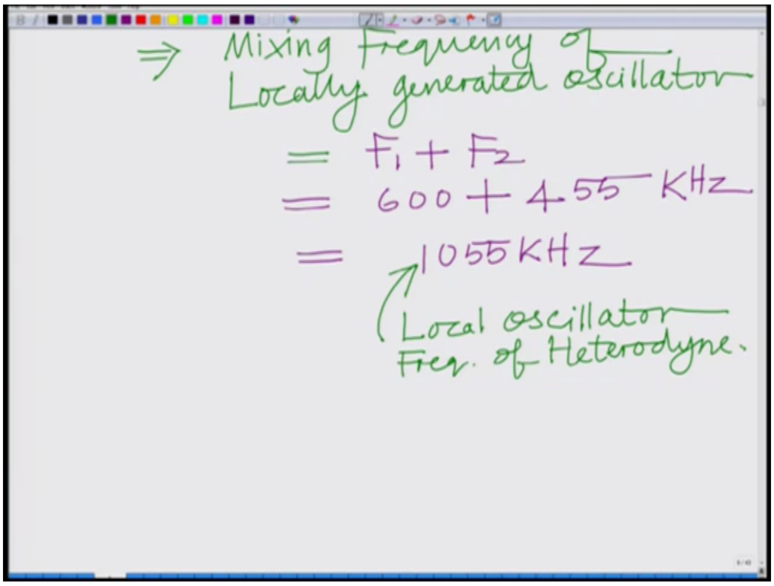

Now therefore the mixing frequency of the locally generated oscillator, this implies the mixing frequency of your this should be well that is F1 plus F2 which is equal to well your AM Station has 600 kilohertz plus intermediate frequency is 455 kilohertz both these are in kilohertz which is equal to well 1055 kilohertz. This is the frequency of the this is the oscillator frequency of the heterodyne, ok. This is the local oscillator frequency of the heterodyne, correct.

However there will also be an image frequency which will also be shifted to the same frequency intermediate frequency 455 kilohertz, alright as we have seen and what is that image frequency.

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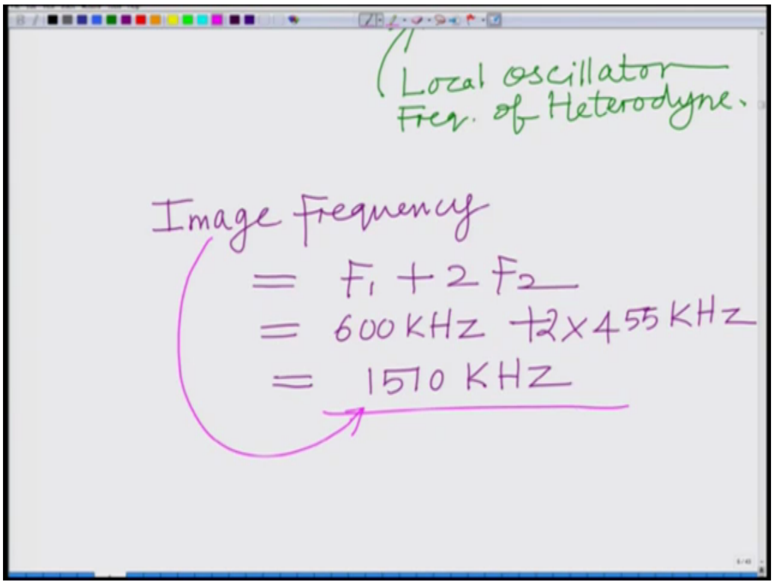

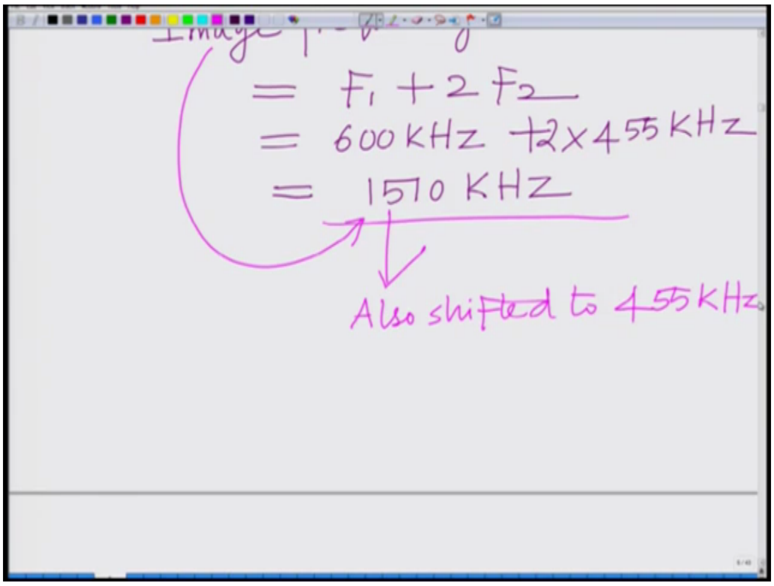

Now the image frequency corresponding to this the image frequency that is F1 plus 2F2 that is equal to 600 kilohertz well plus twice into (450) 2F2 twice into 455 kilohertz ok so that will be your 1510 kilohertz so this is the image frequency (1510) this is also shifted to so incoming signal with this also shifted to to 455 kilohertz, ok.

So therefore that is the problem that this is an important aspect of the heterodyne receiver alright and therefore to avoid this problem of the incoming signal at an image frequency interfering with tour desired signal, the incoming signal has to be appropriately RF pre-filtered alright pre-filtered in the radio frequency alright. So one has to array or one has to design appropriate RF pre-filter to remove the signal and the image frequency ok.

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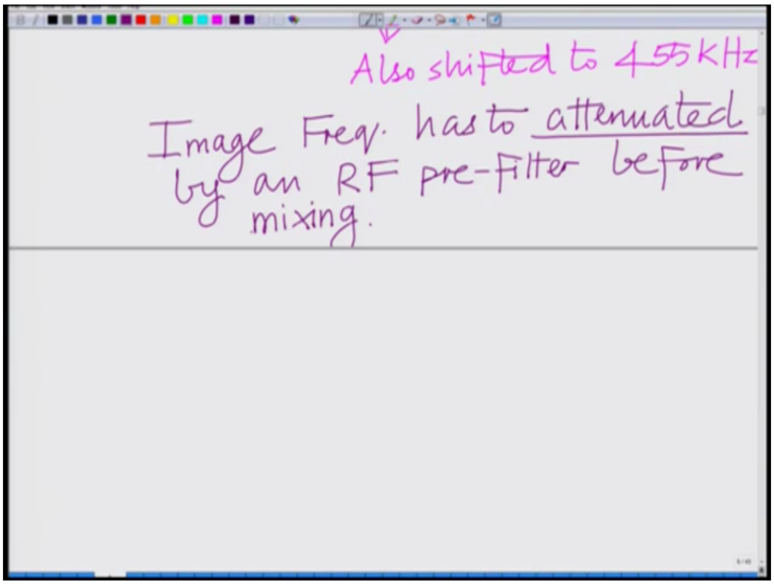

So this has to be removed so to avoid interference so image has to be image frequency signal image frequency has to be suitably attenuated by an RF by an RF pre-filter before by an RF pre-filter before mixing ok so image filter has to be attenuated by an RF filter otherwise it is going to interfere with that desired signal which is being translated to the intermediate frequency, ok alright so that is the problem with the image frequency.

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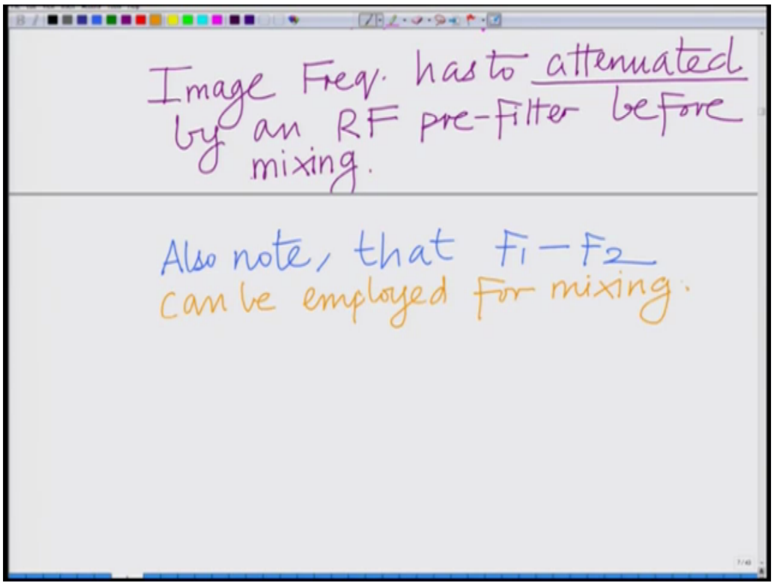

Realize that in the heterodyning also note that we have used F1 plus F2 with the heterodyne that is as the frequency of the locally locally generated oscillator (freq) frequency of the locally generated carrier wave ok. Now realize that one can also use F1 minus F2 where F F2 is the intermediate frequency so also note also note that F1 minus F2 F1 minus F2 can be employed for mixing.

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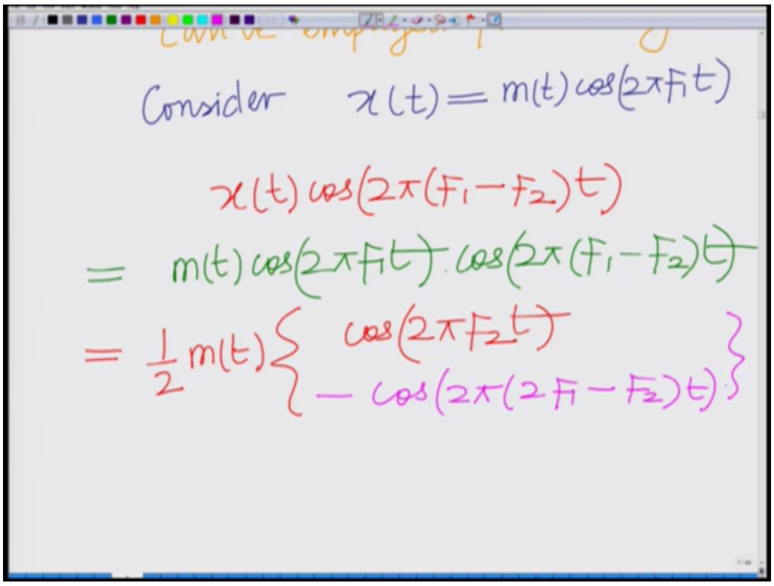

For example consider consider once again x(t) equal to m(t) cosine(2PiF1t). Now this is mixed with x(t) IF F2 is the same so we are mixing with cosine (2Pi (F1 minus F2)t) which gives well m(t) cosine(2piF1t) into cosine (2pi(F1 minus F2)t) and what this gives is half m(t) { cosine (2piF1t) cosine (2pi(F1 minus F2)t) that is cosine 2Pi ok so F1 minus F2 so that will be your basically cosine (2piF2t) minus cosine (2pi sum of the frequencies that is (2F1 cosine 2Pi2F1-F2)t)}, ok.

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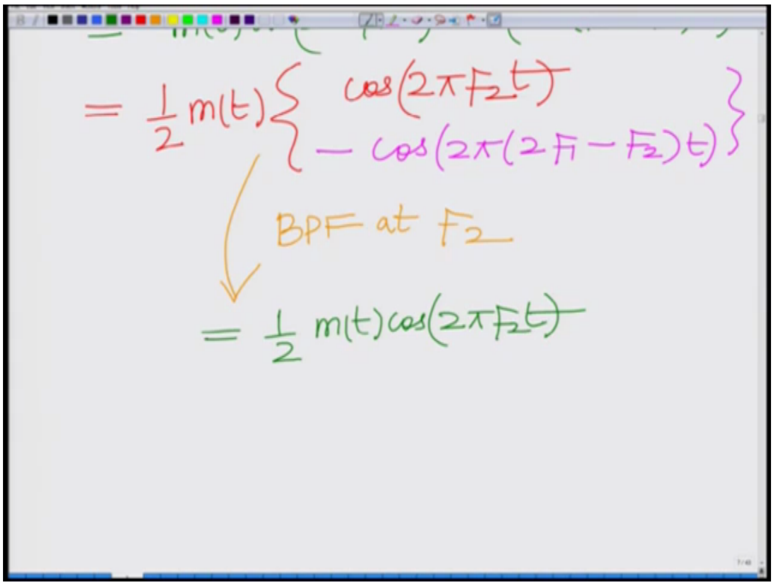

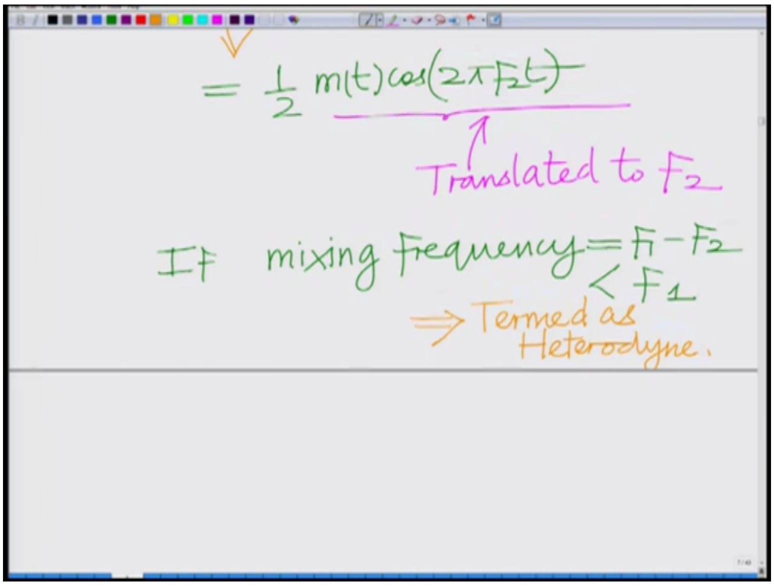

And now again once again if we band pass filter at F2 employing no if you band pass filter band pass filter at center frequency F2 this will yield half m(t) cosine (2piF2t), that is basically employing F1 that is mixing with F1 minus F2 also one can translate to the one can translate signal incoming signal with carrier frequency F1 to the intermediate frequency F2, note that this is also translated also translated to F2, ok.

Now therefore there can be two local therefore there can be two frequencies either F1 minus F2 or F1 plus F2, if F1 minus F2 is employed it is known as the heterodyne, if F1 plus F2 is employed it is known as the super heterodyne that is the mixing frequencies greater than the frequency of the incoming signal, ok. So if if mixing frequency equals F1 minus F2, which is lower than F1 alright this is termed as termed as a heterodyne ok.

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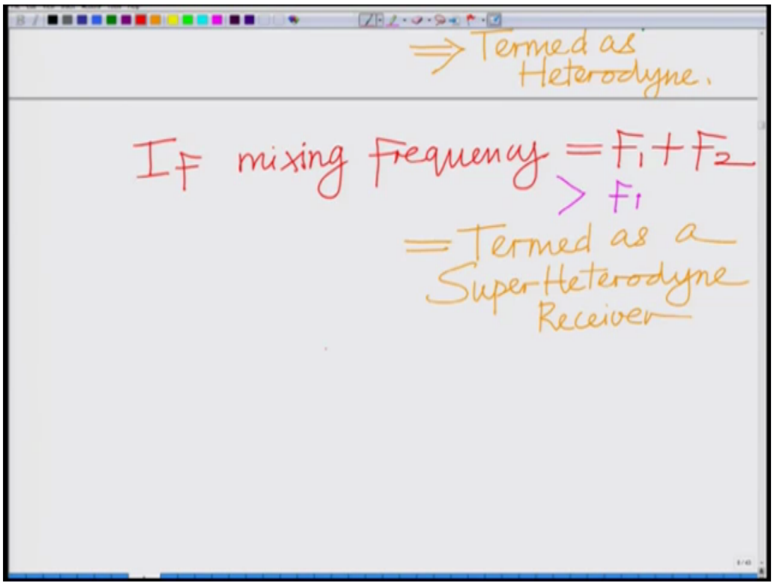

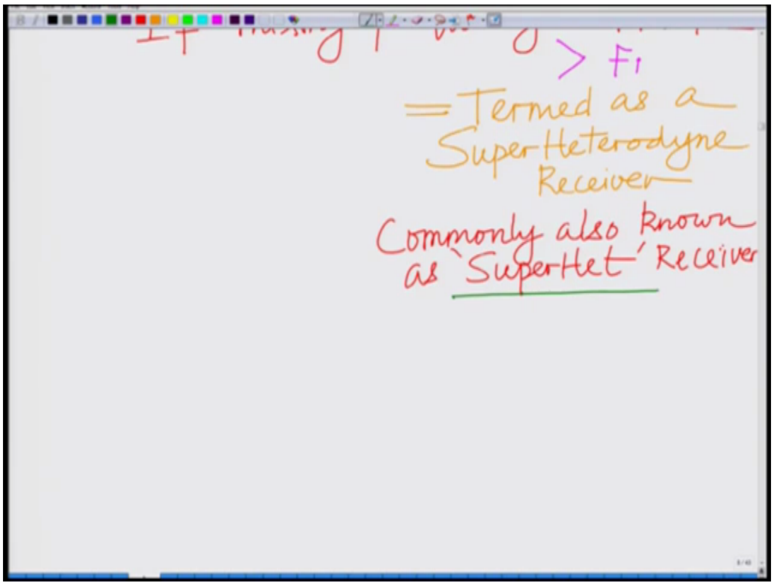

Now if mixing frequency the more popular version if mixing if the mixing frequency equals F1 plus F2 which is greater than which is greater than F1 this is termed as a super heterodyne this is termed as a or commonly also known as a super het simply known as a super het receiver this is commonly also known as a super het receiver, ok this is also commonly simply known as the super het receiver.

So if the mixing frequency is greater the less than F1 it is that is F1 minus F2 where F2 is intermediate frequency it is known as a heterodyne and if the mixing frequencies F1 plus F2 alright which is greater than the incoming frequency F1 alright it is termed super heterodyne alright and super heterodyne is a very important principle because it significantly simplifies the processing of the incoming carrier signal or incoming the (modula) incoming processing of the incoming modulated message signal alright and this has revolutionized communication that design of that of sophisticated communication systems, alright.

So we have seen is this important principle of frequency translation frequency mixing that is heterodyning alright what is what is meant by heterodyning and how is heterodyning carried out alright, we have seen also the problem with an image frequency what the problem with image frequency alright, the existence of image frequency which is also translated to the frequency intermediate frequency F2 which therefore makes it necessary to proprietary pre-filter right so desired suitable RF pre-filter alright to attenuate the incoming signal at the image frequency and finally we have also seen the concept of heterodyne and super heterodyne alright. So we will stop here and look at other aspects in the subsequent modules, thank you.