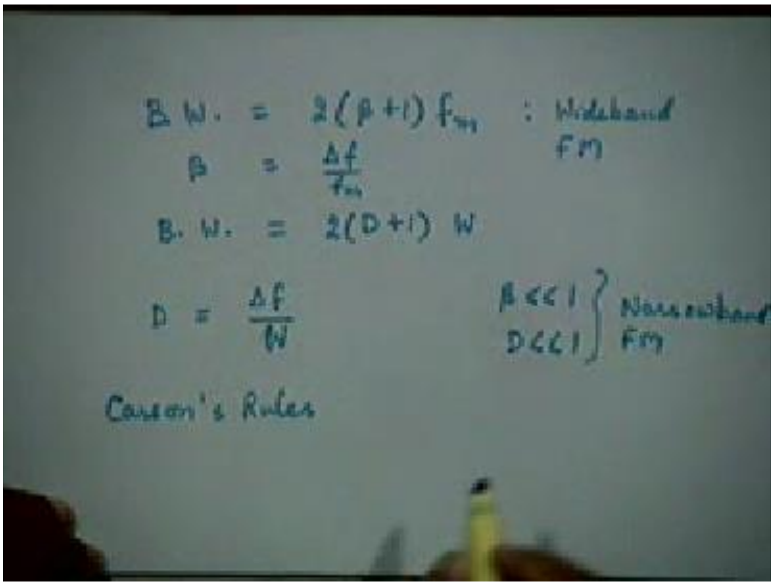
Communication Engineering
Prof. Surendra Prasad
Department of Electrical Engineering
Indian Institute of Technology, Delhi

Lecture - 17
Generation of FM Signals

We will take up the subject Generation of FM Signals today, but before I do that let me quickly review what we did in the previous class.

(Refer Slide Time: 01:29)



We looked at the bandwidth of FM signals and what are the important results that we decide was that the bandwidth of an angle modulated signal is given by, so called Carson's formula, which for the case of a pure sinusoidal signal looks something like this. Where f sub m is the frequency of the sinusoid, beta is the modulation index and this is the case for wideband FM and if you remember how we derived this formula.

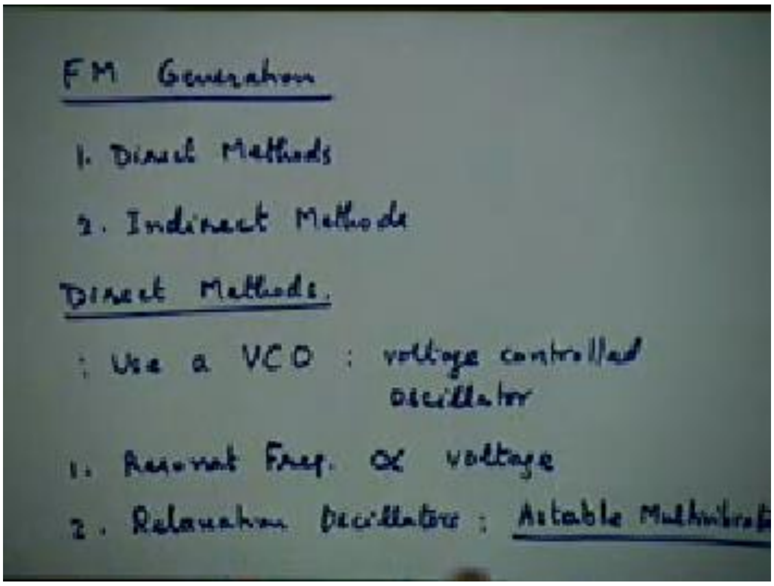
It is basically obtained a series expansion of the FM signal, not the power series expansion. But the series expansion of a FM signal, in terms of the various frequency components present in the signal by making use of a Fourier series expansion of the complex envelope of the FM signal. The complex envelope being e to the power j beta sine omega m t and that is the periodic signal, so we could obtain a Fourier series which you could use to obtain a series expansion of the FM signal itself.

Equivalently we also discussed this was just a matter of discussion we did not derive this, for the general case when the input signal, the modulating signal is not a sinusoid, whereas general signal, message signal m of t. Then the bandwidth formula is more or less the same except that, this beta gets replaced with a factor D and FM get f sub m gets replaced with W, where D we call the deviation ratio, and this defined as delta f by W.

Remember, beta could also be interpreted as delta f by f m, so there is a direct analogy by making use of that analogy and of course, this is based on empirical and theoretical calculations. And these rules for calculating the bandwidth of a FM signal are called Carson’s rules and these are the results for the case of wideband FM, for narrowband FM, what is the case for narrowband FM when beta is very small or in other words, the deviation ratio is much less than 1.

So, either beta is much less than 1 or D is much less than 1, the kind of FM you will work with is narrowband FM and for this case the bandwidth is essentially this becomes a negligible part of the total bandwidth, or essentially it is either 2 f m or 2W precisely the way we had the bandwidth in the case of AM signals. So, this is the review of the bandwidth of FM signals, angle modulated signals can be now quickly review what we discussed so far about generating FM signals.

(Refer Slide Time: 04:49)



As I mentioned for FM generation we have two classes of methods the so called direct methods, and the other ones for the same reason, because they are not direct in sense are called indirect methods of FM generation. Basically direct methods use the concept of a voltage controlled oscillator, so let us talk about direct methods first that is the expansion for VCO, the Voltage Controlled Oscillator.

What is the idea of a voltage controlled oscillator, you have to device a variable frequency oscillator, you can device a variable frequency oscillator in which the frequency can be adjusted by tuning the oscillation frequency. If you have some idea of oscillators you may also know, that the oscillation frequency of an oscillator really depends on the tune circuit present there.

So, I do not know whether you know something about oscillators already, in case you do not know it is basically a feedback amplifier, an oscillator is essentially a feedback amplifier, just to remind you if you do not know, in which the feedback is not a negative feedback or a positive feedback. But, the positive feedback occurs at a certain frequency; you reinforce the positive feedback to happen at a certain frequency.

And therefore, the oscillating frequency will really depend on what is the frequency of the positive feedback happens, and typically that is determined by the resonant frequency of some tuned circuits, which is present in the circuit, we will look at some detail of that a little later. So, basically that is how any oscillator works, but that is not a voltage controlled oscillator, that is not autonomous oscillator, supply the power to the oscillator and in a few nano seconds or micro seconds that will start to oscillate at the frequency of interest; depending on the kind of frequencies you are working with, kind of circuits we have.

A voltage controlled oscillator on the other hand is one where this frequency at which feedback occurs can be controlled by an externally applied voltage, so somehow we have to make in this kind of a system, the tuned frequency or the resonant frequency depend on some voltage. How to do that something we will discuss later that is the idea, if you can do that, then you have what is called voltage controlled oscillator and if you have a voltage controlled oscillator of this kind, your modulating signal can serve as the controlling voltage.

So, if the controlling voltage happens to be the modulating signal, the oscillation frequency will now depend on the instantaneous amplitude of the modulating signal. So basically that is the idea of a voltage controlled oscillator in a nutshell. But I will discuss in some more detail a little later, I will come back to that. But, this is one kind of voltage oscillator that is one based on; let us say using the resonant frequency which is made somehow proportional to the applied voltage.

There are other kinds of voltage controlled oscillators as well, these are called relaxation oscillators or in digital electronics terms, they are more commonly known by Astable multivibrators. In this kind of circuits there is no resonant circuit, there is no L C circuit in this, it is basically based on the operation of a pair of transistors switching between on and off states, and through appropriate feedback a pair of transistors alternatively switch on and off.

At one time one transistor is on the other is off and then, the role gets exchanged with each other and this happens through a feedback mechanism between the two transistors. So, these kinds of oscillators are called relaxation oscillators and they do not use a resonant circuit, there is a reactive component in the circuit, there is a capacitance of some kind, there is a resistance, but there is no resonance factor is missed there.

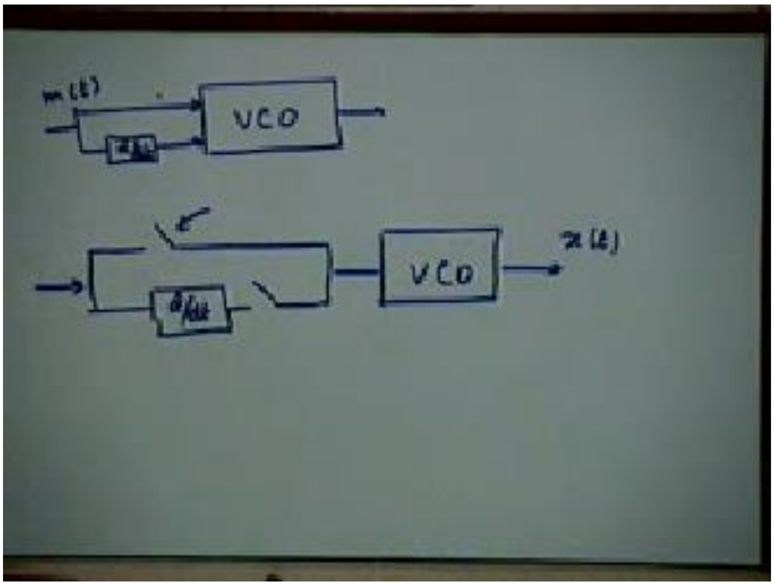
So, these are known by the name Astable multivibrators, basically transistors are used as switches, the transistors can be used as switches and the switches go on and off alternatively. And because it goes on and off alternately, you can tap off the voltage of any particular transistor and that gives you a square wave oscillation, so the output waveform of a relaxation oscillator, unlike that of a resonant frequency oscillator is a square wave.

For a resonant frequency oscillator the output is a sine wave, because there is a resonant frequency and the system oscillates with that resonant frequency produces the sine wave of that frequency. In relaxation oscillator, the system produces a square wave, because it is based on the phenomenon of switching on and off of transistors and therefore, you get a square wave at the output rather than a sine wave.

So, this is in a nutshell, we shall discuss this in some more detail, this is something that you will learn in some other course, like a course in digital electronics, if you have not already done so. So, but then, we have various kinds of oscillations in the first kind also for example, I mentioned the name of klystron, which is self actually like a voltage controlled oscillator for a certain range of frequencies.

But then, how that works requires it to understand, what is the klystron how it works, which is outside of scope at the movement. So at an appropriate time, appropriate course you will learn about klystrons and magnetrons, probably the course has maximum devices. Now, against this we can have indirect methods of generation and let me discuss that first.

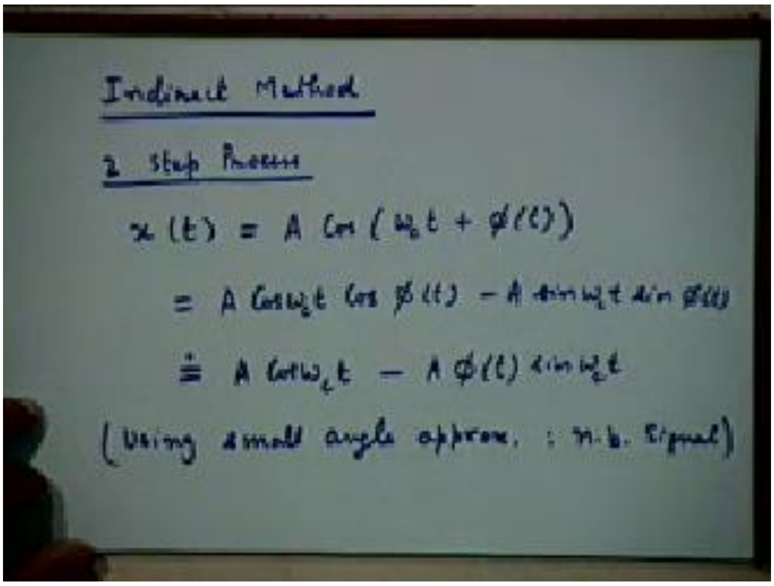
(Refer Slide Time: 12:18)



But, before coming to that, let me also review one more point that I made, that if you have a system for generating FM signals, let us say voltage controlled oscillator. You can use this to generate both FM as well as PM, for FM generation the controlling voltage will be directly signal m t itself; however for generating a PM signal you will have to have a differentiator. So, maybe I can put a switch here, so this switch is on, this signal here x of t would be an FM signal, if this switch is on this will be a phase modulated signal.

So, if we have voltage controlled oscillator of any kind, you can make it work either as a phase modulator or as a frequency modulator that is something that we have discussed earlier.

(Refer Slide Time: 13:40)



So, let us discuss the indirect method in some detail first, what is the basis of an indirect method it is actually a 2 step process, in the first step of an indirect method, so it is a 2 step process will generate a narrowband FM signal. Now, why do we want to do that, because we know that we can in some sense the narrowband FM signal has a spectrum very similar to that of AM signal. Now, that fact can be made use of to generate a narrowband FM signal, to be more explicit let us look at the FM signal or the angle modulated signal.

To see the general form of an angle modulated signal, if we choose this function phi of t as proportional to m t is that phase modulation, if you choose it proportional to the integral of m t is the frequency modulation, that is what we have. So, you have some function of some phase function which is a function of time, which is controlled by a modulating signal m of t. Let us expand this simple geometry A cosine omega c t into cosine phi of t minus A sine omega c t sine of phi of t.

Now, for narrowband FM, a narrowband angle modulation what can you say about this phi of t, is there any properties that you can ascribe to phi of t when the angle modulation that we are generating or that we have is narrowband in nature. What was the condition for narrow band beta is small, beta is much smaller than unity what does it imply on the nature of phi t itself, phi t itself will be small.

Let us say if it is PM this will be beta cosine omega m t, so beta is very small the amplitude of this phase would be very small, so the largest magnitude of phi t would be very small. Similarly, when it is FM the same thing will still happen, because all that happens is it is, suppose m t is cosine omega m t this becomes sine omega m t and these are small and you have the same problem. So, when phi of t is very small you can use approximation that cos of phi of t is nearly 1 and sine of phi t is phi t.

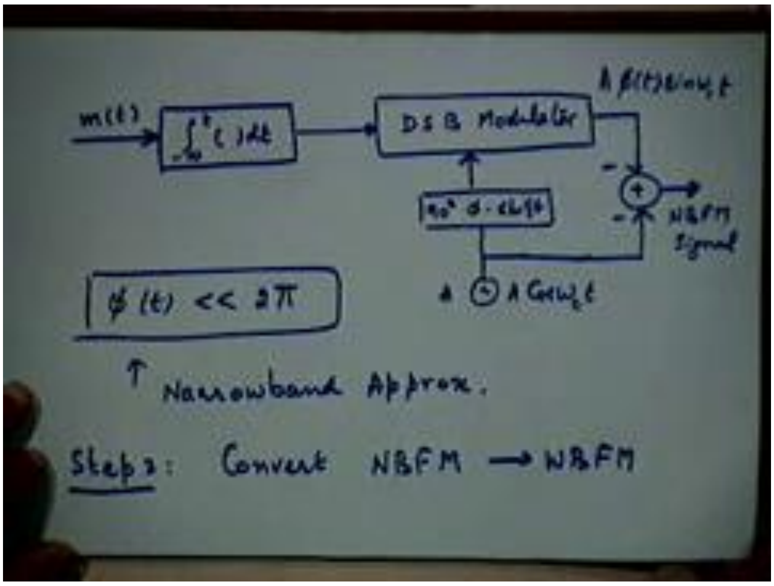
So, you are left with A cosine omega c t this is approximately of course, minus A times phi of t into sine omega c t, sousing the small angle approximation and that approximation is valid, because we are assuming here that this is a narrowband signal, Now, suppose you want to generate this signal, can you tell me how to generate this, this is just the carrier itself to which you are adding what the DSBSC signal, here sine omega c t is the quadrature carrier and phi of t is you can think that as the modulating signal.

In fact, phi of t is k sub f time's integral of m t or k sub f times m t you have access to both of them, so by using an appropriate form of phi of t you can realize the second term of this equation by the DSBSC modulator. So, I do not have to have any voltage controlled oscillator, any Astable multivibrator all I have to do is use the good old DSBSC modulator as a multiplier and generate the signal and this would be a narrow band FM signal.

What is the difference between this signal and the normal AM signal? In the normal AM signal both this term as well as this term, they are carried over the same phase, where the two carriers are in quadrature that is the important difference. I mean that is although they have the same spectral components one of the questions that would have bothered you I do not know whether you thought about it. If two signals have the same spectrum normally you would like to think that they would be the same signals, because spectra and time domain description are equivalent, one implies the other.

So, actually they are not identical in that sense, there is a difference if they were exactly identical the spectral components are same in terms of magnitude, but there is a difference in detail and that is the difference in detail. It looks like the carrier part and the modulated carrier part they are in phase quadrature, so although the basic frequency components remain the same, their relative phase relationships are different, that is something that I have already discussed, whereas the phase gets reversed in the case of the FM signal.

(Refer Slide Time: 19:46)



So, realization of this signal let us say if you are generating FM you start with m of t, then because in FM the phi of t will be proportional to the integral of m t. So, you will have integrated here, integration is very easy to do differentiation, integration are things you can easily do using circuits I am sure you already know that. For example, can you tell me how you can realize approximately an integrator by simply RC elements, simple resistors in series followed by a capacitor in shunt?

Or you can use an operational amplifier to give a more precise integration operation. So, integration is something that you can do a very straight forward manner, this is followed by a DSBSC modulator in which the carrier is 90 degree phase shifted version of the carrier that you start with. So, we have started with let us say I have an oscillator which produces A cosine omega c t is phase shifted by 90 degrees. And these two things are carried or subtracted whatever, subtract in this phase and that produces your narrowband FM signal. Because, this will give you A phi of t sine omega c t, this is A cosine omega c t and that is how it is generated.

Student: ((Refer Time: 21:35))

Yes

Student: ((Refer Time: 21:38))

Very good question, because the question is from this signal we have a constant amplitude that is the question, let me repeat the question ((Refer Time: 21:52)) this is supposed to be the constant amplitude signal, whereas it is appears that now generating this signal by an amplitude modulation process. So, this seems to be some fallacy somewhere in terms of the fact that you started with the constant amplitude signal, but you are using amplitude modulation process to generate it.

Well, the answer is indeed yes there is a problem, you may not remember this is an approximation, whereas remember the fact this is an approximation; this is not the exact signal you really want. But, to extent that is the approximation is valid this signal cannot be approximately constant amplitude, to the extent of this approximation ((Refer Time: 22:38)). Therefore, what is the circumstances under which it is valid phi of t should be much less than 1, as long as that condition is satisfied, this signal will tend to have a nearly constant, I am not saying constant I am saying nearly constant amplitude.

There could be some amplitude variations of very small magnitude

Student: ((Refer Time: 21:39))

Not equal to 1 much less than 1, because that is the condition under which I have derived this equation phi of t should be much less than 1. So that cosine of phi t is approximately 1 and sine of phi t is approximately phi of t. So, the condition is...

Student: ((Refer Time: 23:20))

That is what it means, if I say phi of t is much less than 1basically you are saying it is very small, that is basically what I am saying.

Student: ((Refer Time: 23:34))

That is right

Student: ((Refer Time: 23:38))

That is the other difference that I have discussed, that is the upper side band and the lower side band carriers are the phase reversed with respect to each other. And the other thing is if you look at the time domain, if you think of it consisting of potential carriers, the two carriers are basically quadrature, they are infinite unlike an AM signal these two terms have the same phase, whereas here the two terms are quantity that is all. So, that is the difference, earlier difference was told in the frequency domain this is the difference in time domain.

Student: ((Refer Time: 24:13))

Yes you can check that out, so I hope these questions ((Refer Time: 24:24)), the question was about the amplitude variations, so it is I hope it is clear that amplitude variations to the extent our assumption is valid for phi of t much less than 1 would not be there or would be present in very small magnitude. There could be some amplitude variations and that is a possible problem that you have to keep in mind when you are dealing with narrowband FM signals.

So, let me emphasize again actually more precise way of saying it is, let us put it like this phi of t is much less than 2 pi. I think that is the more precise way of stating the condition, because that is the condition under which cosine phi t can be made approximately mention with the phi of t and sine phi t as approximately equal to phi of t. So, freely speaking this is the condition we are talking about and this is the narrowband approximation, so if this approximation is indeed valid you have to make it valid if you want to use this method to generate the FM signal.

Therefore, what you will get at the output is not a wideband signal, but a narrowband FM signal you have to keep that in mind, that is why I said it is a 2 step process. In the first step we generate in narrowband FM signal and in the second step I convert this narrowband FM signal into a wideband signal, so that is step 2 convert narrow band FM that we have generated so far to wideband FM. There is some talking going on here, if you remember I discussed not to do that, because it gets picked up and the steps also.

If you have a question please raise a question, but do not talk, how do we convert the narrowband FM signal into a wideband FM signal, any suggestions what should we do, what is our let us go back to our definition, ((Refer Time: 26:53)) this is the FM signal. The assumption that we made was that this is very small, so we have to get rid of that assumption as it is very small, we have to allow phi of t to take large values.

We are starting with phi of t with small values, how can I make it large values having got the signal, what I have with me at the input is this signal that I had generated this signal, this is what I have generated which is equivalent to this signal, but phi of t be very small. How do I convert this one with large variations, rather small variations any suggestions

Student: ((Refer Time: 27:32))

Multiplying what

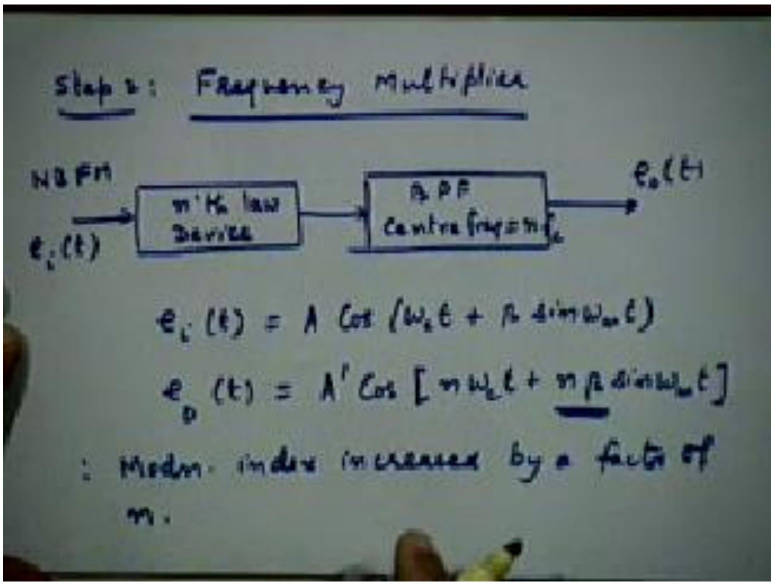
Student: Multiplying the cosine

Somehow we have to multiply the argument of the cosine function that is important not the cosine function itself; you have to multiply the argument of the cosine function, of course in the process that will also modify your carrier frequency. So, if you have a nurture of multiplying the argument of a cosine function that you have generated you will achieve wideband FM and this is done through process called frequency multiplication.

Student: Sir, if we multiply by some cos phi 2 t and then, will get some omega c t plus phi 1 plus phi 2 c, ((Refer Time: 28:16)) phi 2 t is also proportional to m t integral or something is it possible.

It is not relevant to as aback craft for generating FM signal, let us discuss that in the tutorials.

(Refer Slide Time: 28:48)



So, that step of converting a narrowband FM into a wideband FM has to be carried out by what is called, so this is step 2 the frequency multiplier, a frequency multiplier precisely there is an operation I just mentioned. Now, that is, it multiplies the argument of the cosine sinusoidal function by certain factor. Now, again there are certain ways of utilizing a frequency multiplier, I will discuss one of them at the moment which you are familiar already.

May be not by this name, but something that you have used already in some in a context of generating AM signals and this is based on the principle of using a non-linear device. So, you have what is called an nth law device, by nth law device physical device which produces a output which is the nth power of the input, so let us say you have a narrowband FM is a input to the signal, a input to the device it is called the e sub i t. And so e sub it here is A cosine omega c t for simplicity of discussion, let me make this beta sine omega m t, I am taking this to be an FM signal.

So, this is the modulation index beta, so the modulating signal is cosine omega m t, then the output of this device would be the nth power of this, that means it will be cosine to the power n and you can use them all trigonometric identities and that you will make use of the trigonometric identities. Among other terms, you will get one term corresponding to n times this argument, which essentially means we multiply this argument by the factor that you are looking for.

To know other terms what you have to do is have a band pass filter, which is tuned to n omega c, so that is the second stage of this multiplier you have a band pass filter with a center frequency which is equal to m times f sub c. So, that will produce an output e sub 0 t or e sub o t which is some A prime cosine of n omega c t plus n beta sine omega m t and that increases your modulation factor of n, that is the principle.

So, if you have a square law device, you will get n equal to 2, if you have a cubic law you have n equal to 3 and so on and so forth. Usually these multipliers, frequency multipliers are realized as either frequency doublers or frequency tripler, where n is equal to 2 you have the frequency doublers, where n is equal to 3 you have frequency tripler. Because, typical non-linearity is, typical nth law device have powers associated with them of two or three, the non-linearity that you typically get from physical components like junction diodes, p n junction transistors is of the order two or three.

In which case you can typically use frequency doublers and frequency triplers, but it does not mean that you can only do a multiplication by a factor of two or three, because I can put several such frequency multipliers in cascade. And typically they will be cascaded frequency doublers or frequency triplers or I can use any number of them to multiply this argument by any integer and that I used to generate. So, of course in the process we have modified the carrier frequency to anomalously, which is actually useful.

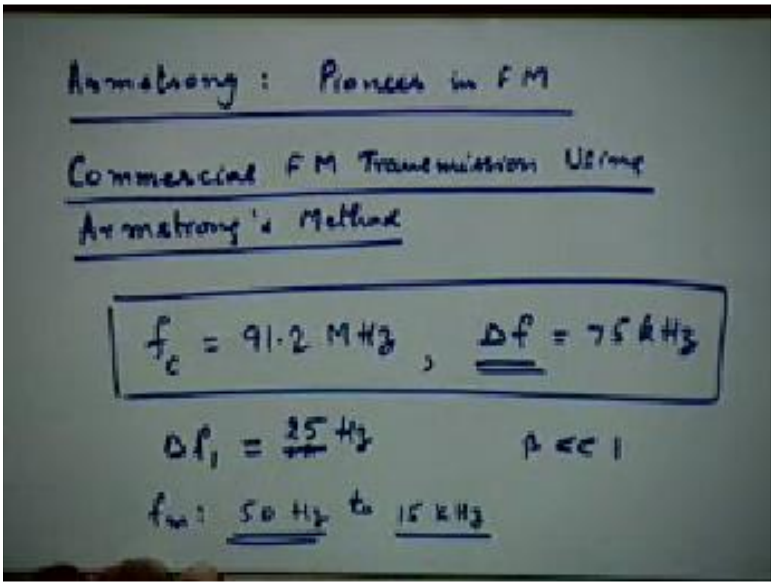
Why it is useful, because typically the carrier frequency that I have is used at the generation of narrowband FM signal becomes much smaller. And I need to build a balanced modulator, that DSBSC modulator is essentially balanced modulator at a much lower frequency, is much easier to realize a balance modulator at a lower frequency than at a higher frequency, because of problems of leakage and things like that. So, balanced modulator is much easier to build at a lower frequency, so initially start a lower carrier frequency suitably, so that I have this, the required carrier frequency after multiplication.

Sometimes I may have to do additional manipulation to make sure that I get the carrier frequency that I want, and I get the modulation index that I want, because we can contradict with each other, so we will look at that. Let us look at this slightly in more detail now, this is the principle, but the detail can be little more involved, this method of realizing a frequency modulator using the indirect method that is was due to a gentleman called Armstrong.

Not Neil Armstrong, you are familiar with Neil Armstrong

Student: ((Refer Time: 35:00))

(Refer Slide Time: 35:02)



This is more historical name in the sense it is older, he was a pioneer in this whole business of making FM popular. In fact I think the entire carrier for the commercial application of the frequency modulation should go to Armstrong. He did absolutely pioneering work in this area; it is another matter that he died as a failed man, because during his lifetime he could achieve his purpose. He kept on telling people and demonstrating by experimental setting up of such stations, that FM is far superior to AM in various OS.

We have not discussed that yet, but we will discuss it later and but, people will refuse to believe him basically for commercial reasons, because there was lot of ((Refer Time: 36:04)) we did not want to change the existing AM stations. So, he died as a failed man, but later it picked up in his name of course, and everything worked very well. Anyway that is just part of the side light, which I wanted to just mention, because some of the things also you should know the history behind how these things were done.

People just did not think of them overnight and they started to work, a lot of great effort went into dealing about these concepts that only on paper, but also realizing them as equipments as systems which we deployed in practice. And lot of hard work goes into that which is invisible in the textbook, but which is very much part of the story which you should know. So, I would like you to read more about Armstrong, it is a very interesting story and slightly tragic one.

Now, when we talk about this commercial exploitation of FM method, this FM method which is based on Armstrong this idea converting narrowband signal to wideband signal which was basically due to Armstrong. So, let us look at a commercial FM transmitted, so to start the discussion let us say we fix a requirement and it will also give us some idea to us to what are the typical values that we use in commercial FM transmitter.

Let us say we want a carrier frequency of 91.2 Mega Hertz what is our FM band here

Student: ((Refer Time: 38:12))

That is only one frequency

Student: ((Refer Time: 38:15))

Good, at least somebody remembers that, so it lies in that band and typical frequency deviations that we are looking for an FM signal, which is commercially being used for broadcast purposes is of the order of 75 kilo Hertz, it is more or less the standard value, that is the kind of frequency deviation you are looking for. And this will cross to wide band FM, because as you can see, how do you decide whether the frequency deviation that you have corresponds to narrowband or wideband FM, you should compare it with highest frequency component present in your modulating signal.

Do you remember that, because your how is beta defined delta f by f m and how is D defined delta f by W and W is the bandwidth of your modulating signal, suppose your modulating signal is let us say voice speech signal or let say you are talking of music. What is the value that you will have for W, it is about 10 kilo Hertz, 15 kilo Hertz of that order, so therefore the ratio will be of the order 5 or more, so definitely not narrowband FM, because for that the ratio should be much smaller than unity.

So, therefore, this is wideband FM we are talking about, so how do we generate this communication that is the ratio. So, if you want to generate using the indirect method. In the beginning I cannot generate delta f is equal to 75 kilo Hertz it is clear. I must choose a value of delta f 1 which produces a beta which is much less than 1 and let us say our

FM the modulating signals that we have will be typically speech audio and music those kinds of things. The typical spectra of these will range from 50 Hertz from the lower end to about 15 kilo Hertz at the higher end.

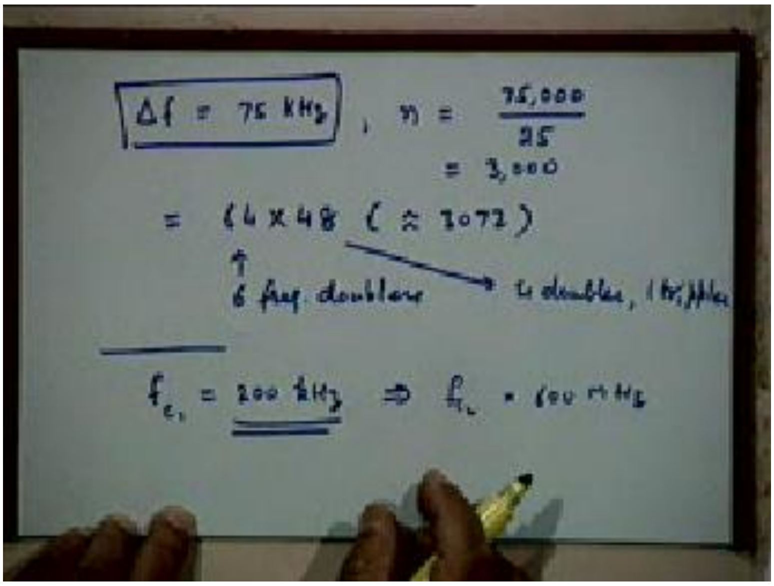
So, keeping that in mind can you recommend a value of delta f 1 that is in the first stage when I generate the narrow band signal, what should be the corresponding frequency deviation keeping just delta in mind? It should be such that, this up on the highest frequency component that you have is much less than 1. Basically you have to define what is much less than 1, it should not be just the highest frequency component there is a slight mistake in what I said. But you make sure that over all the frequency components that you have in the signal. At no frequency beta this condition is satisfied at all those frequencies, so in which case which frequency is more important this one or this one.

Student: ((Refer Time: 41:37))

It is the 15Hertz which is important, I made a small mistake earlier in making my statement, so to make sure that at 50 Hertz the ratio of delta f 1 to f m is at least is not close to 1.Now, in order to avoid too many problems later, except the value of 0.5 will be acceptable. So, in which case I can choose delta f 1 as 25 Hertz this will produce beta equal to 0.5, it is not much exactly less than 1, but it is still the smaller you make it what are the pros and cons, the smaller you make it the better the approximation, but there is another implication also.

That means, you require to have a larger multiplication factor there, so to choose some compromise value, so having decided that, so we already know how to realize the narrowband FM generator, because we have given all the parameters.

(Refer Slide Time: 42:52)



So, how do we get delta f equal to 75 kilo Hertz now, I need a multiplication factor n which will be 75000 up on what was delta f 1, 25Hertz, which is 3000, I need a frequency multiplication factor of 3000 to get my required frequency deviation, peak frequency deviation. You are going for a design process here, we will look at a final picture after the design process is complete, and this is fine this is not a usual; you can always realize any frequency multiplication factor by using cascade of frequency doublers and triplers.

Typically, what you will do is, because you know that you can realize this n in terms of powers of 2, and powers of 3, so it is best to express this n in terms of the closest factors certain factors which I mean unable to realize this factor, in terms of doublers and triplers. For example, this is approximately equal to 64 into 48 is really about 3072 ((Refer Time: 44:12)), design process always you do these approximations. So, if you choose this factor 64 and 48 actual value will turn out to be 3072, rather than 3000 that you exactly got, which is that will give you slightly larger peak frequency deviation. So, you require a 6 frequency doublers and you require how many

Student: ((Refer Time: 44:45))

Again here also you can write 4 doublers and 1 tripler here, so total of 10 doublers and 1 tripler, so far so good there is no major problem here, but there is a problem if you multiply let us talk we did not talk about f c 1. Now, typically as I said there is a few suitably low frequency as the first carrier frequency, where balanced modulators are easy to build and typical values that you would use for that purpose is about 200 kilo Hertz.

In the earlier case it has to be much more than your bandwidth of the signal, bandwidth is 15 kilo Hertz, so we choose a suitably larger value, so this looks like a good compromised value. But, then when you multiply your frequency by a factor of n to get this required modulation index of peak frequency deviation, this frequency will now become

Student: ((Refer Time: 46:00))

You are multiplying this by 3000, so it looks up 600 Mega Hertz, but that is not what you want, so this will imply f c 2 is 600 Mega Hertz, f c 1 I select it on the basis of phi, first consideration should be significantly larger than the highest frequency component in the modulating signal. Secondly it should be small enough, so that after frequency multiplication it is manageable, we are able to still handle these things, and also it should be convenient to build the suitable balanced modulator at that frequency.

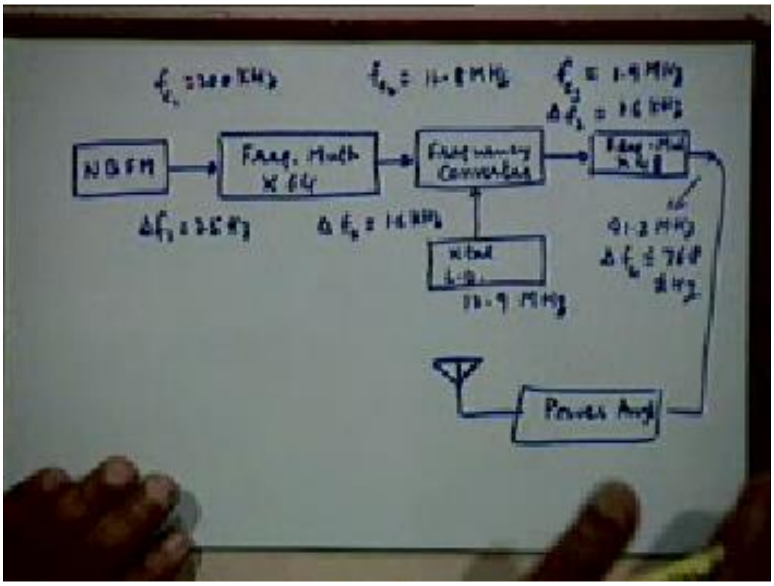
These are the three considerations on the basis of which I will select f c 1, so due to the practical consideration this is the typical value that you might come up with, so how do we now take care of this, what is the answer we have to have mixers in between, you have to have frequency translators in between. So, you just do not multiply the frequency by a factor of 3000, you do it in stages and in between these stages you can bring this down to a suitable value, so that after the multiplication you get the required carrier frequency as well.

You do require a total multiplication factor of 3072, but there is realized in stages rather than in one go and in between the stages you also carry out a frequency down transmission. So, that re multiplication would produce the corresponding required carrier frequency of interest, so that is the basic principle, so let us, yes please.

Student: ((Refer Time: 47:44))

Let me first complete the discussion and I will take up the question after that.

(Refer Slide Time: 47:58)



So, let me draw a diagram, we start with a narrowband FM generator of the kind that we just discussed, then we have a frequency multiplication, let us say by a factor of 64 and now I have a frequency converter here. You may say what is a frequency converter, it is a same they are defined terms which are used to represent mix any frequency conversion they all mean the same thing.

And here I have to choose a suitable local oscillator, so that I get a value of the carrier frequency here after translation which is appropriate, so remember your starting point f c 1 is 200 kilo Hertz and delta f 1 is 25 Hertz. At this point were f c 2 would be 64 times this, which is 12.8Mega Hertz, 64 times 200 kilo Hertz and your delta f 2 would be 64 times this 25 Hertz which is 1.6 kilo Hertz. Now, by choosing a suitable local oscillator let me give some value you will see the actual value in a few minutes.

I will choose a local oscillator here of 10.9 Mega Hertz, so what will happen to the signal here, but this is important to understand your f c 3 will obviously come down by if you take the lower side difference frequency. Rather than taking some frequency you are taking the difference frequency that will become, so f c 3 at this point would be 1.9Mega Hertz and delta f 3 will remain the same.

We are not doing anything here, when you do a frequency translation all you are doing is whatever message signal you have, you are changing the center frequency of that nothing else. So, you will have a FM signal it is frequency is translated to the different center frequency that is all we doing, so nothing none of it is properties regarding this frequency deviation and frequency change.

So, delta f 3remains 1.6 kilo Hertz now why did I choose this term 10.9 Mega Hertz frequency multiplication by a factor of 48, now you can see 48 into 1.9 Mega Hertz will give you the frequency that I am looking for. So, at this stage you get 91.2Mega hertz and of course, you get your delta f 4 which is approximately 76.8 kilo Hertz, which is actually 76.8 kilo Hertz, whereas we wanted 75 kilo Hertz. So, that is the final FM signal you power amplify and transmit through antenna, this is what you will transmit.

So, that is the principle of a commercial FM transmitter based on the indirect Armstrong method, yes now let me take up the question that was being asked there, has it been answered good. So, I think if you are now asked to design an FM transistor based on this principle you will be able to work out the required factors.

Yes please

Student: ((Refer Time: 52:17))

This is not a unique design no design as very unique, but technical considerations, if you are returning 1 over here it may ((Refer Time: 52:32)), for example you have a crystal oscillator, no design is available here keep that in mind.Any other questions? Sowe will stop at this point and will discuss some direct methods for FM generation next time.

Thank you very much.