Antennas
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Module – 11
Lecture - 52
Yagi-Uda and Log-Periodic Antennas III

Hello and welcome to today's lecture on log periodic antennas in the last few lectures we have been talking about the Yagi-Uda and log periodic antennas. So, we saw that in Yagi-Uda antenna what we can do it is we can get a better gain by properly designing the directors, but we also saw quasi Yagi-Uda antenna where the emphasis one getting a larger bandwidth, but that bandwidth was of the order of 40 to 48 percent whereas in case of log periodic antennas we can get much larger bandwidth compared to the Yagi-Uda antenna. So, we have started with the basic configuration of log periodic antenna where we had seen that array of dipole antennas are there and these arrays of dipole antennas were fed with equal and opposite phase. So, let us continue from here.

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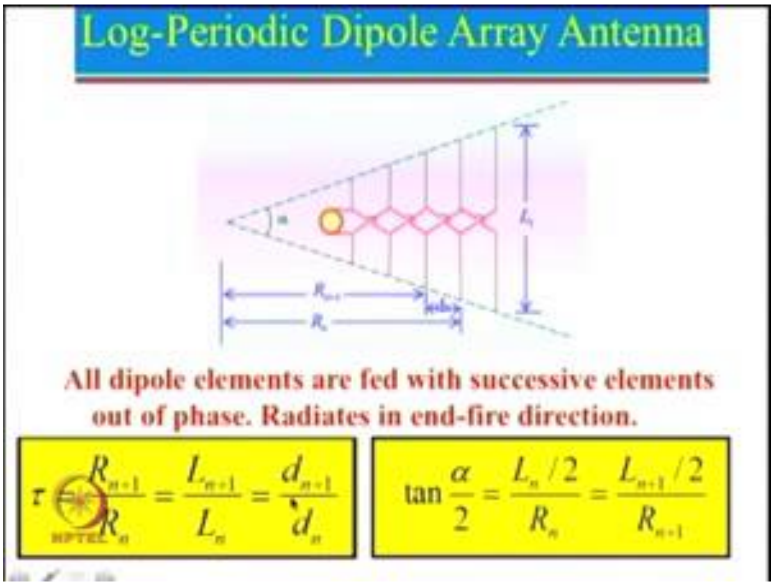

Just a quick revision, so these are the dipole antennas, the length varies from L 1, L 2 to L n plus 1 and then we had also seen that this is fed always from the lower end actually and I will also explained here why we feed from the lower end. So, if we feed from the lower end then we can see that at the lower frequency these will not get excited the power will flow through here and this dipole antenna will get excited at the lowest frequency as frequency of operation increases then from here this dipole antenna will get excited then this dipole antenna will get excited then this dipole antenna will get excited and so on. Where I suppose if we feed this thing from this side, if we feed from this side there are chances that higher frequency this is supposed to be resonant, but at higher frequency there are chances that higher order mores get excited. So, part of the power will be radiated through here and lesser power will there.

In general you should keep a point that always feed from the lower dipole dimension only and not from the higher dipole dimension then another thing we saw that basically the tau factor which is known as a spacing factor and we saw that the spacing factor is constant for R L d even for the diameter and so on and then from here we also saw the angle defined by tan alpha by 2 where alpha is given over here half the angle is this and we saw this expression over here and then we looked at quickly the space factor.

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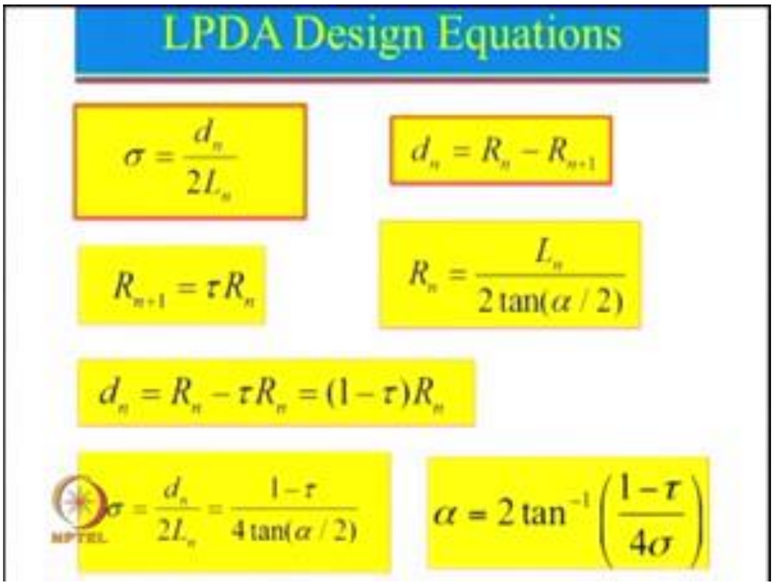

This is the space factor sigma and this determines basically the spacing in this particular direction and I had shown the quick steps and finally, what we want to see is this is the relation where alpha is related to tau and sigma.

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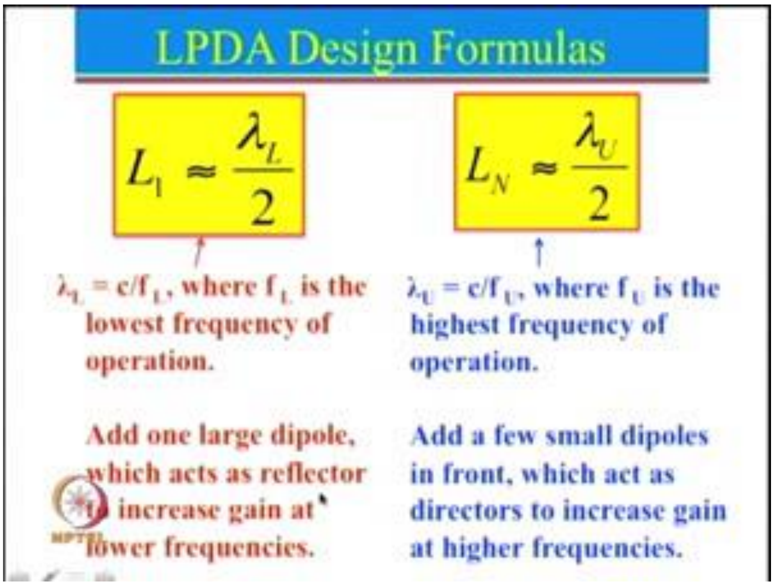

Now start the design procedure. So, let us say we need to design the antenna. So, we start with the lowest frequency and the highest frequency or the upper frequency. So, here the length of the first dipole antenna is approximately equal to the smallest lambda L here I just want to mention lambda L is not small L corresponds to the frequency. So, frequency is smallest, but lambda L will be the largest. So, please do not confuse L is important over here and so we start with this particular value. So, that will be the largest length and this will be the smallest length corresponding to the highest frequencies. So, higher the frequency lambda will be small. So, L n will be half of that.

Now, you can see here this is written as an approximate and you might wonder that earlier I had always mentioned take the dipole dimension as L plus D equal to 0.48 lambda, but here why we have written as lambda by 2 you can see first of all it is approximate second is that this antenna is very broadband. So, small shift in the frequency here and there will not make a difference; however, this is the additional thing which I want you people to really keep in mind when you are designing a log periodic dipole antenna and what we want to tell you is that after this length here. So, this is even the most of the books tell you that you take this as L 1, but what I am recommending is you add one more large dipole behind this L 1 which will act as a reflector to increase E the gain at lower frequency.

Let us say in the figure what we are recommending is that you put one more antenna over here that can act as a reflector antenna now sometimes people do ask whether the reflector antenna should be fed or it can be just put as it is. So, if you use a Yagi-Uda concept you can just put as it is, but if you want to use the log periodic concept then this reflector antenna also can be cross coupled. So, either of the possibilities are there then comes the next part that is the lowest one here. So, the lowest dipole what we again recommend that add a few small dipoles in front which will act as a director to increase gain again.

Let us just look at the figure back here. So, what we are recommending is that after this dipole antenna puts some more element, the reason for that is think about this if we just choose this as the highest frequency dipole antenna then there is a no director in front now applied the logic of the Yagi-Uda. So, here is a 1 fed dipole there is a one reflector having a multiple reflector does not make much of a sense. So, it only has a one reflector it does not have any director in front. So, what will happen if you do not have a multiple elements in the front then the gain will reduce at the higher frequency. So, that is why it is our recommendation when you are designing a log periodic dipole antenna this can be the starting dipole and the ending dipole, but our recommendation is after that you add one larger dipole behind this and a few dipoles in fronts to increase the gain at higher frequency.

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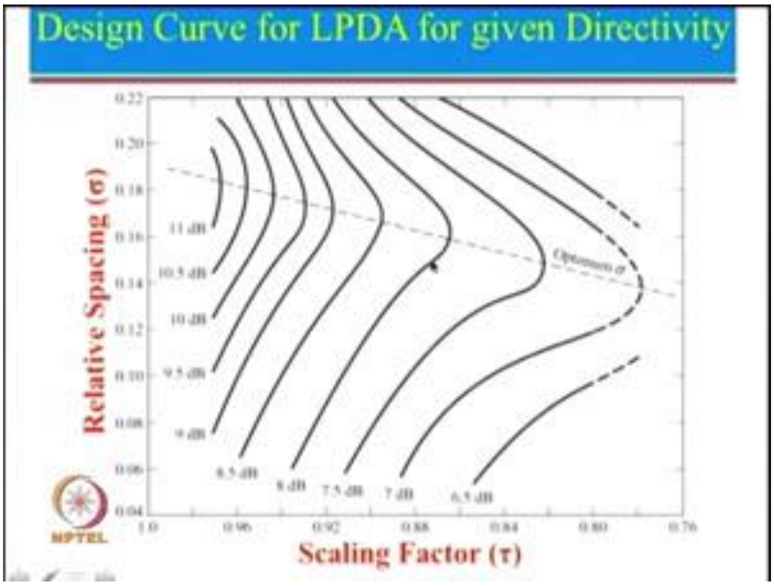

Now how do we do the design? So, let us take the help of all the earlier researchers who have done a wonderful job and they have given this particular directivity curve for different values of the directivity. So, you can see here this is 6.5 dB 7 dB, 7.5, 8, 8.5, 9 and so on. So, let us say you want to design an antenna for directivity of let us say 7 dB for example, so if this the case here, now you can see that 7 dB is constant for all of these cases and what it is written here is that this is that optimum value. So, how this optimum value is coming or if you look at here 8 dB? So, for 8 dB you can see even though you can choose any point here and what is it mean really that any point. So, let us say if I choose this point. So, for this point if you draw the vertical line it will imply tau is equal to 0.92 and if you look at the horizontal that will be somewhere around 0.09. So, you can choose this point, but that is not optimum, but this point if you choose here what it shows here is if you draw the vertical line that will give us a tau value which is close to let us say 0.86 or so and if I draw the horizontal line that will be around 0.16.

Now why this optimum thing coming, I want to actually emphasize here what is happening by moving along this here both tau and space factors are changing and if you take along this thing the most important thing what is happening is I will just go back to the figure again for that particular space factor this distance is approximately equal to lambda by 2 at the region where this particular thing is more resonant and then it will be lambda by 2 at the lower frequency region here. So, when you choose this distance to be approximately lambda by 2 that satisfies a condition of end fire radiation better and that is how this optimum curve has come. So, it is recommended that you choose the values corresponding to this optimum I will also show you one result where we have actually taken a value not over here, but somewhere over here and then I will tell you also what are the pros and cons of that particular case also.

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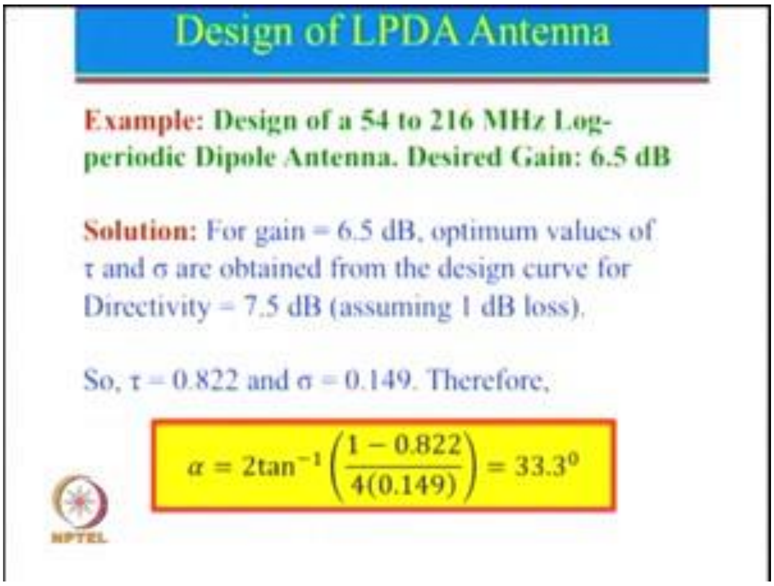

Let us first go with this particular design and then will see what happens if we do not take optimum design. So, here this design is given in the book. So, this is a design of 54 to 216 megahertz, but what I want to emphasize here, if you take the ratio the ratio is 1 is to 4. So, for example, if you design antenna from 1 gigahertz to 4 gigahertz, the similar concept will be available just that starting and ending frequencies are different. So, here the requirement which was given as desired gain is 6.5 dB. So, since the desired gain is written as 6.5 dB, you take directivity curve at 7.5 dB assuming 1 dB loss. So, corresponding 7.5 dB, let us just see where is 7.5 dB, so this is 7.5 dB and that is an optimum point here, you can actually see from here if I draw the line from here, that is close to 0.8 to close to that and if you draw the horizontal line it is close to about 0.15. So, let us see, what are the actual values? The actual points are 0.822 and 0.149.

Once we note tau and sigma from the directivity curve, we can now find the value of alpha which comes out to 33.3 degree.

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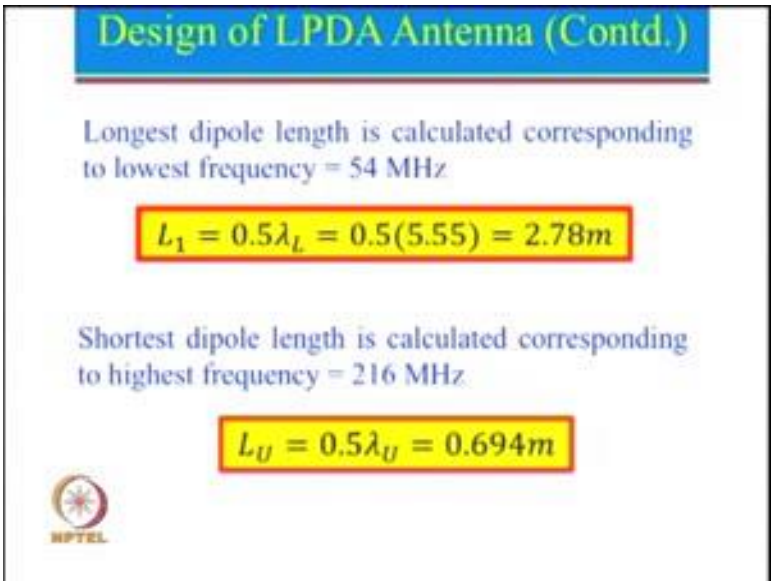

Now that design begins. So, we start with L 1. So, L 1 is 0.5 of lambda L, this L is the lowest frequency which is 54 megahertz. So, that comes out to be 2.78 meter and corresponding to 216 megahertz L U is 0.694; that means, this is the dimension of the smallest dipole. So, now, what we do we start with this value and then let us see what we do.

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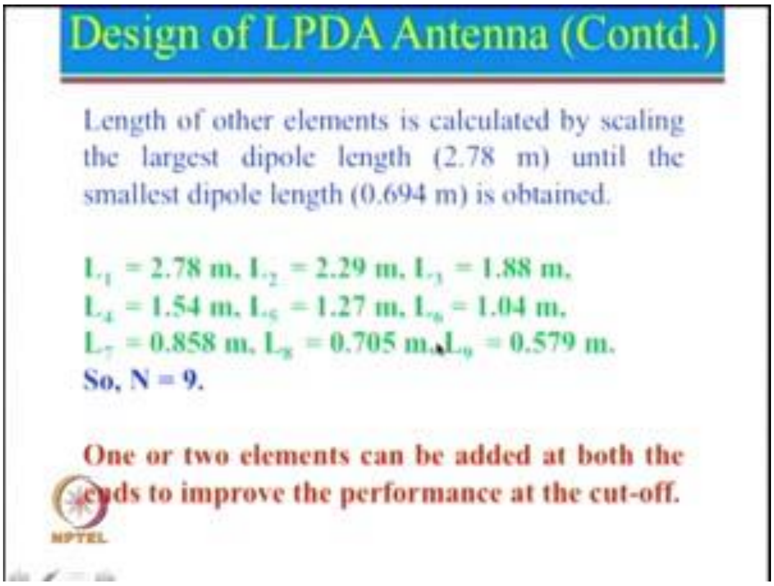

Starting from this particular value which is 2.78 meter you multiply with this tau and what is tau? Tau is equal to let us see here tau is equal to 0.822. So, you keep multiplying with 0.822. So, this 1 multiplied by 0.822; you will get this here multiply with this multiply continue this process till you have crossed this value which is 0.694. So, you can see that you have crossed that value now you can say 0.694, 0.705 are very close, can we stop over here? Theoretically you can stop over here, but then the gain at the higher frequency will not be good. So, that is why this element need to be taken this will give us some decent gain.

If you really count all of these elements they come out to be n number. So, here we have found the length L 1 to L n.

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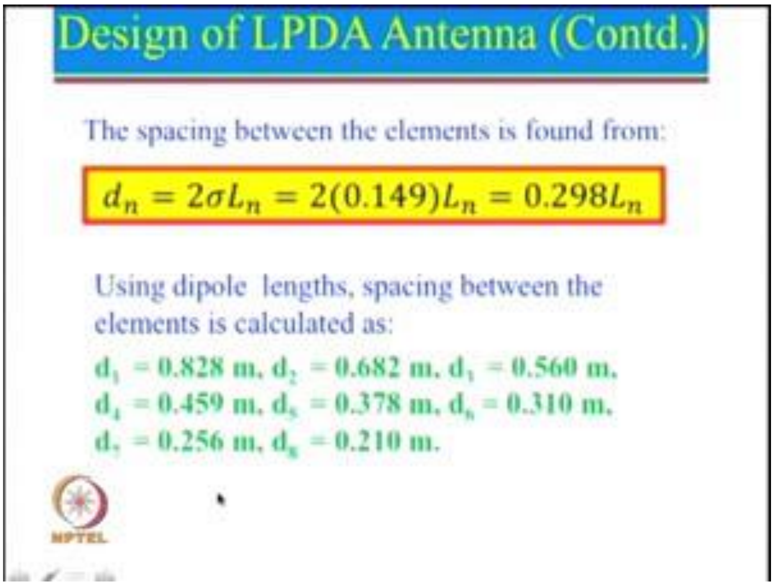

Now, comes the next part, we need to find the spacing between the element. So, over here the spacing is given by this particular expression remember this is a space factor and by using this d n L n. So, for all values of L 1 to this one you can find it his. So, here are the spacing now remember here even though there are 9 elements, there will be only 8 spacing. So, between the 9 elements, there will be only 8 different spacing. So, you can actually see again the figure. So, starting from so, if there are n 9 elements, it will start here from 1, 2 and it will be the 8th spacing here. So, we got all the spacing, now what is not mentioned over here is the diameter. So, diameter as I mentioned earlier you can choose the diameter by given by a formula diameter should be equal to lambda by 100 to about lambda by 20, you can choose the value in between, you can choose the different values of that also.

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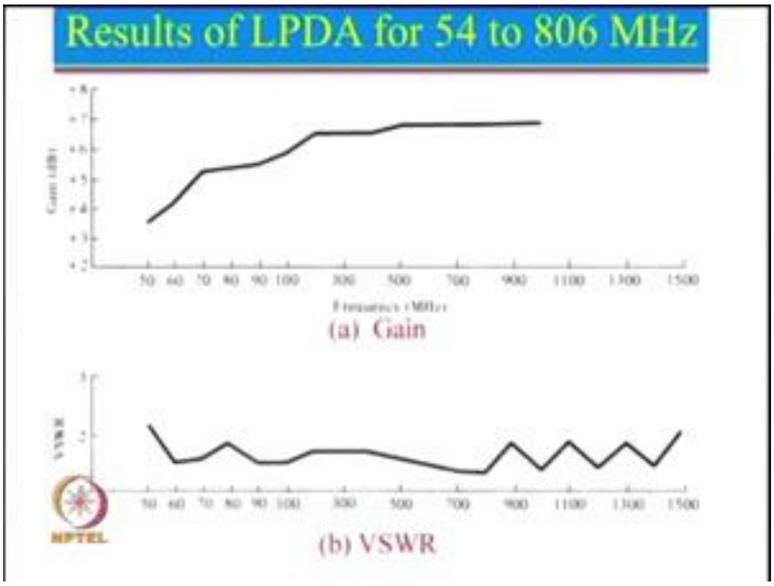

Here are the results, but I want to mention this result is from 54 to 806 megahertz, you can see that this is a very large ratio. So, the ratio is more than 15. So, 1 is to 15 and these are the practical results. So, I will first talk about VSWR. So, you can see here this is VSWR 2 line which is going over here. So, you can see that VSWR is less than 2, then starting from 50 megahertz, even beyond 1500 megahertz also VSWR is also less than 2. So, you can see that it has a very large VSWR bandwidth, now you can see here, now the gain so close to 50, you can see that the gain is about close to 3.5 dB or so and then as we move up, you can see that the gain is close to 7 dB. So, one can actually see that the gain is good at this particular band here, but gain is not. So, good in this particular region the reason for that is for this particular frequency there is a no reflector behind and since there is a no reflector behind most of the radiation is going in the back direction.

In fact, what we recommend you add another reflector then what would have happened that this particular curve instead of starting from here it could have started from here and whole curve would have been something like this. So, just by adding another reflector we would have got relatively a constant gain pack over here.

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Now, let us just look at the radiation pattern and half power beam width. So, here is a half power beam width of that particular antenna you can see that this is a h plane and e plane one can actually see that e plane half power beam width is shown along this axis and frequency is shown over here. So, one can actually see that e plane half power beam width is much smaller than the h plane beam width which is very similar to the case of a Yagi-Uda antenna I had mentioned that for h plane the dipoles are radiating in how many fashion. So, which will have a broader beam width for E plane the dipole radiate in the directional matter and that is why half power beam width is smaller.

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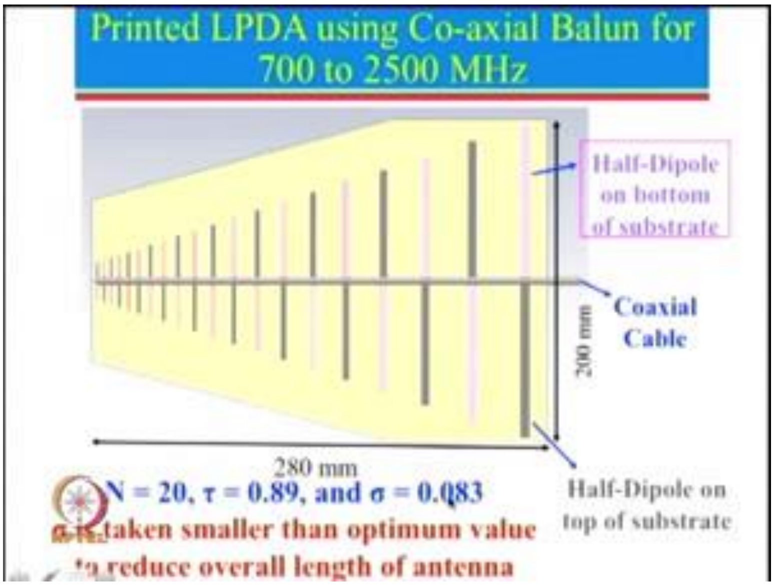

Now let us just look at another design example. So, I just want to mention here in this particular design, we have actually designed the antenna from 700 to 2500 megahertz or just to tell you the reason why we choose this particular thing over here, basically we had the requirement that we wanted to measure the cell phone tower radiation and all these bands start from let us say 800 megahertz. So, for example, CDMA starts at 800 then GSM900 is at 900 then GPS is 1500, the GSM1800 will be 1800 and then we will have 3G which is 2100 then 2300 to twenty and Wi-Fi around 2500. So, we had the requirement for then antenna which was covers from 700 to 2500. So, since the frequency is known you can also see the ratio is close to 1 is to 4 well, it is not exactly 1 is to 4, 700 to 2800 will be there.

Here this design, we have deliberately taken a slightly different case where sigma is taken smaller than the optimum value to reduce the overall length of the antenna. So, just to show you what we have taken over here. So, tau is taken 0.89 sigma is taken as 0.083 and will see that this is not really the optimum 1, this is just to demonstrate you can take non optimum thing also, but it is not really optimum in the real sense. So, you see that 0.89 will be somewhere here and that is what is 0.083. So, that curve corresponds to this curve here whereas, optimum value would have been somewhere here, but just to demonstrate the principle.

But by choosing this value over here, what happens? Space factor is reduced if we choose this value space factor would have been larger. So, by taking a smaller space factor what has been done spacing has been reduced. So, spacing is in this direction as it is you can see along this direction this is the board 200 mm along this it is about 280 mm and this particular antenna has been fabricated on a low cost glassy poxy substrate. So, epsilon R is 4.4 tan delta is 0.02 and so with this particular thing here, number of elements came out to be 20 because we had to cover the band right from 700 to 2500 megahertz.

You can see 1 disadvantage if you do not take the optimum tau becomes larger. So, had we taken the optimum value then tau would have been relatively smaller and if the tau is smaller number of elements would have reduced. So, it is not really always a good thing to focus on this number here because if you focus on this number then n increases, but never the less this has been designed and fabricated and as I mentioned sometimes we learn a lot more if you do not do an optimum design, but I do not recommend this design for your future fabrication please stick to those optimum thing.

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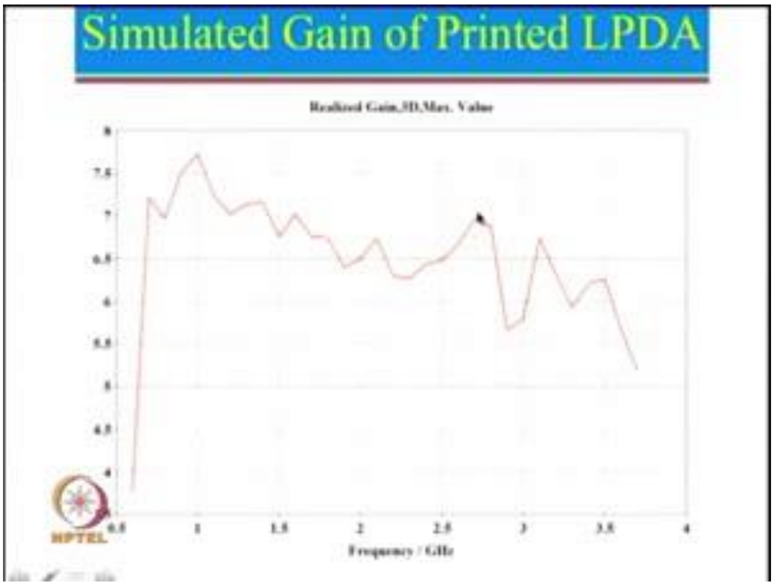

But let us see, what are the results we get for this particular case here? So, here is the gain plot you can actually see here the frequency 0 .5 to 4 gigahertz and this you can see is the gain value in terms of dB our requirement started actually our requirement was around 0.8 because that is where the CDMA band starts. So, starting from here, if you see gain is around 7 dB and the peak gain is around 7.7 and it is kind of decreasing and you can actually see around 2.5, the gain is about 6.5 dB.

If you really see the gain variation is from 7 dB plus minus 0.7, this was not really of our band of interest. So, gain is actually reducing. So, why this is happening why gain is decreasing at higher frequency the reason for that is that if you do not take this optimum value of this space. So, what happens this value has been taken much smaller and if you take this value relatively smaller then what happens this is not effectively giving us a length of lambda by 2 whereas, the feed is actually done in such a way that we are doing orthogonal feed let us just look at the feed how the fabrication has been done. So, this is a PCB on the PCB you can see that this is the one feed line on the backside also the same feed line is going on in the same fashion now the dipoles are printed alternately. So, here you can see one half this is another half one half then another half and so on and then this is printed on the back side.

Now, what is done you can see half dipole on bottom and this half dipole on top of the substrate and now you can even see here that the feed is connected here well that is not really correct you actually see the coaxial cable is connected over here, but feed is not connected here. So, what we have done here and that is what has been recommended in many books and paper? So, what we do for the coaxial cable we remove the outside plastic jacket so; that means, if you remove the outside plastic jacket it will only have the outer ground connector and there will be a centre pin. So, that entire cable without the jacket goes over here and the ground of the coaxial cable now that is soldered underneath this particular thing and then the centre pin of the coaxial cable only comes out here. So, what we do and there is a hole has been drilled over here and that centre pin is gets soldered at this particular point; that means, feed is over here even though the connecter is connected over here. So, here is a coaxial cable.

I will repeat coaxial cable is here that coaxial cable outer jacket is removed only the metallic portion is there that metallic thing which is a ground thing is connected completely soldered all along this and the centre pin only comes over here connects to the top line and then you can see that all these things are connected to the top line and all of these are connected to the bottom line and these 2 are at outer phase and that is how the dipole antennas it is maintained it is out of it, but now as I mentioned since it is not the optimum value of the sigma. So, what really happens that the spacing between the 2 is not really lambda by 2 at the active frequency region what is active frequency region I will just mention that at the lowest frequency this one will excide and maybe little bit of this will excide at the in between frequency these will be excited so; that means, that will form the active region at the highest frequency these dipole antennas will be excited.

That means, as you increase the frequency of operation. So, at the lowest frequency these will be active as frequency increases active region will actually move towards this. So, for any in between thing for example, these will act as these will act as reflector these will act as director for this one over here again all of these will act as reflector and all of these will act as director. So, by choosing this value over here what we have done since the spacing has not been maintained properly that is why you can see that there is a large variation in the gain. So, since our requirement was of the order of this here we did beat the requirement and we did fabricate this particular antenna also and we want to now show you the measured results of this here. So, these are the S 11 of the printed LPDA.

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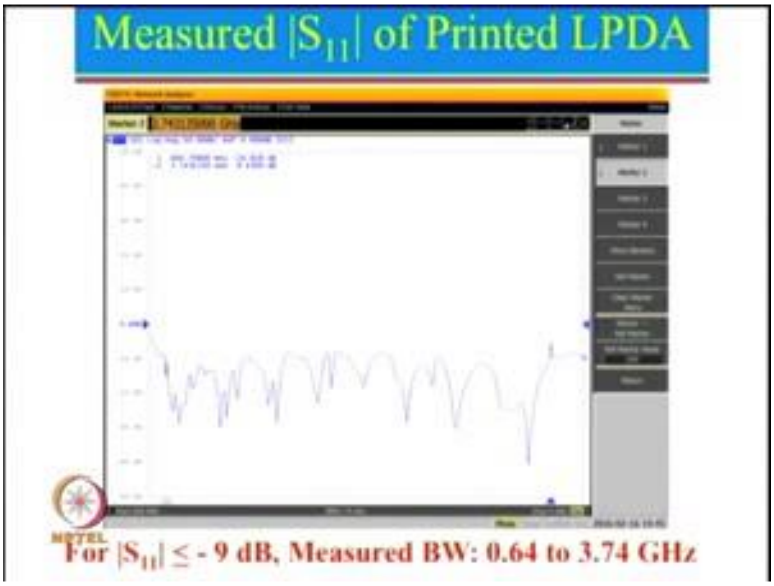

Now, you can see this is the response here actually speaking this is the reference line which is 0 dB this line here which is not very properly visible that is about minus 10 dB, 1 can actually notice that in between it has slightly crossed minus 10 dB line. So, we have defined here S 11 less than minus 9 dB minus 9 dB corresponds to VSWR of approximately 2.1 which is acceptable for very large band antenna and over here over this value bandwidth is from 0.64 gigahertz to 3.74 gigahertz. So, you can see that in a very simple manner one can realize a broadband antenna with gain of around 7 dB plus minus 0.7 dB which can be improved slightly, but you can see that the fabrication is very very simple you just take a glassy posy print it on this use a feed line be careful about the feed line I am repeating it that this is very very important how you feed it otherwise the radiation will not be proper by doing this particular thing then the radiation is of course, in end fire direction.

Just to summarize them we have talked about today log periodic antenna. So, we started with a very simple concept that you start with the lowest frequency to let us say the highest frequency, you choose the dipole antennas corresponding to the lowest and the highest frequency, but what we recommend that you add 1 larger dipole antenna which will act as a reflector and you add a few smaller elements which will act as directors so that you can take care of the decrease in the gate at the 2 end points.

By using this scheme you can get relatively flatter gain over very large bandwidth then we looked at the design for a frequency range from 54 to 216 then we saw the results for 54 to 806 megahertz which basically covers the TV band from VHF to UHF and we had also seen there the problem was the gain at the lower frequency was relatively lower and I told you the solution the solution would have been very simple just put one reflector behind it that would have given us relatively flatter gain and then we used the same concept to extend to cover the cellular bands right from 800 megahertz up to 2500 megahertz and we looked at the simulated results as well as measured results.

We conclude with that today's lecture and in the next lecture, we will talk about reflector antenna. So, several types of reflector antennas, we will talk about plane reflector then we will talk about coordinal reflector and then we will talk about parabolic reflector antenna. So, with that thank you very much, work hard and do lot of design practice and these are very useful antenna for several application. So, do the practice and then do the simulation and fabrication.

With that thank you again, bye.