Antennas
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Module – 09
Lecture - 42
Helical Antennas – III

Hello, and welcome to today's lecture on Helical Antennas. In fact, we have been talking about helical antennas for the last couple of lectures, and we actually looked into that there are three different modes of helical antenna; axial mode, normal mode and conical mode. And as I mentioned conical mode is very rarely used, so we are not going to discuss about that. And we have started our discussion about axial mode, and we have looked into how to design a axial mode helical antenna. So, let us continue from there.

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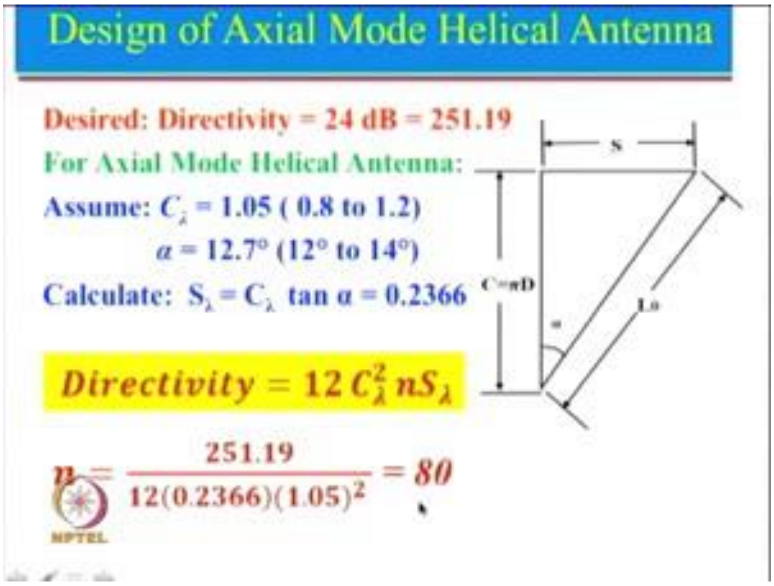

So, we have actually seen the example which is the directivity is given as 24 dB and the numeric value is 251.19 and I just want to mention here that this material has been taken from the cross book, the only difference here is in the cross book they have said this to be gain whereas, I have written this to be directivity and as I mentioned in the previous lecture, the gain of the axial mode helical antenna is at efficiency multiplied by directivity; and efficiency is approximately equal to 0.6.

So that means, the gain of this antenna will be 251 multiplied by 0.6, which is approximately 150, and we have seen that for axial mode helical antenna C lambda should be taken between 0.8 to 1.2. So, it had been taken as 1.05 I normally take this as 1, and alpha was taken as 12.7 which is between 12 to 14 degree. I generally take this to be 13 degree for my design, but this example has been given in the cross book. So, I am continuing with that and once we have assumed these 2 parameter; we can calculate the value of S lambda; by using this expression which is nothing but we can say tan alpha will be nothing, but S divided by C that is what is coming over here. So, we can calculate the value of S lambda here. So, now, we know the expression for the directivity is given by this particular expression here. So, directivity is known, C lambda has been assumed S lambda has been calculated.

So, we can find the value of n by substituting all these values, and that comes out to be 80. Now this is a very large number so that means, the entire helical antenna length will be very very large. So, instead of using n is equal to 80, the other option is that we can use an array of helical antenna.

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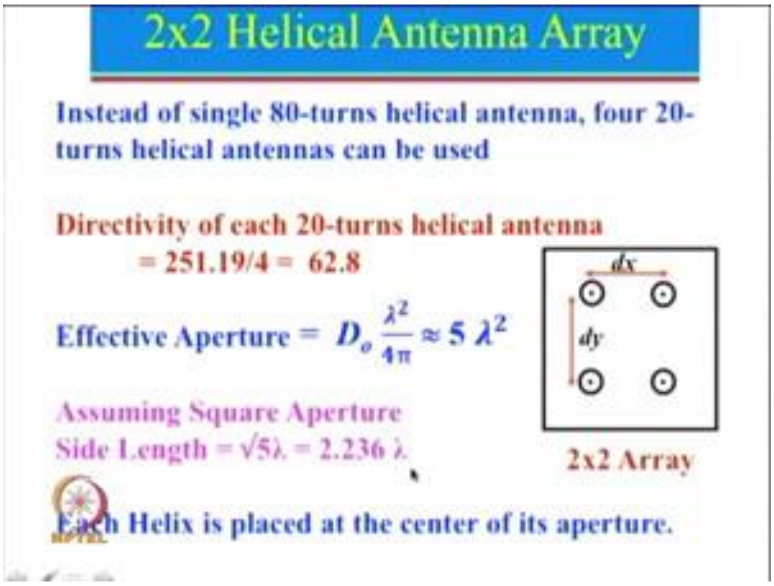

Here is an example of 2 by 2 array, which are actually put something like this here these are total 4 number of elements. So, what we can actually think about it, instead of using one single 80 turn helical antenna, 420 turn helical antennas can be used. So, now, we know that directivity is directly proportional to n so that means, if the number of turns are reduced. So, directivity will also reduce by the same factor, it will come to 62.8 here. So, when we want to put these helical antennas, it is very important where we keep it. Shall we keep it somewhere here between the 2 spacing to be very small or very large, so it is not arbitrary; one has to do some calculations here and for that we can actually use the concept, we have been discussing that directivity is given by 4 pi into A divided by lambda square. So, from that we can find out what is the effective aperture. So, effective aperture is given by this particular expression, and if we now substitute the value of D 0 which is 62.8 divided by 4 phi this is approximately 5 lambda square.

So, assuming that effective aperture is a square aperture; even though I do not 100 percent agree with this particular assumption. So, generally I feel instead of using a square aperture, one should use a circular aperture because let us say this is helical antenna, we should really see the aperture more in the circular symmetry. But anyway circular can be approximated as square and square also makes it easier to place this helical antenna. So, there is not too much of an error here, this is a fairly decent approximation also. So, if you use as a square aperture then side length will be square root of this which comes out to be 2.236 lambda. So, then each helix should be placed at the centre of it is aperture.

So, now you need to think about. So, if this is a square aperture here, then this will be another square aperture and this will be another square aperture, and another one and we are putting the helix at the centre of 2.236. So, this is in the centre of this, this is also at the centre of 2.236 lambda square; that means, centre to centre distance will be also equal to 2.236 lambda.

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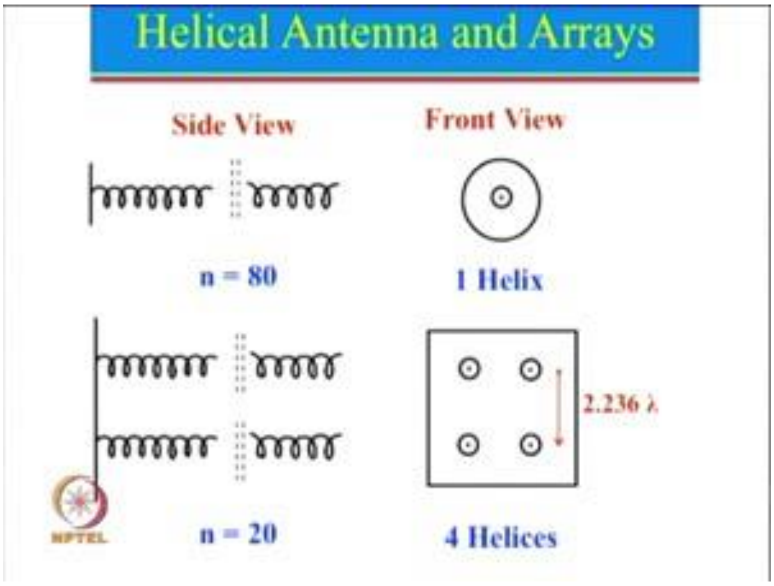

So, in this case d x is equal to d y is equal to 2.236. Let us see this thing in little more detail. So, this is the helical antennas side view, you look from here this is n equal to 80 turn. So, one can see that it will be a very long helical antenna, and this will be the front view where we are basically seeing that the helix is there and this is the you can say is the centre and that is the ground plane size; then comes the next part here. So, this is again a ground plane, and now we actually have a 2 by 2 array, you can see the other one because this will be behind this here. So, side view will only show 2 of these. So, 2 n equal to 20 which is there and 2 by 2 array.

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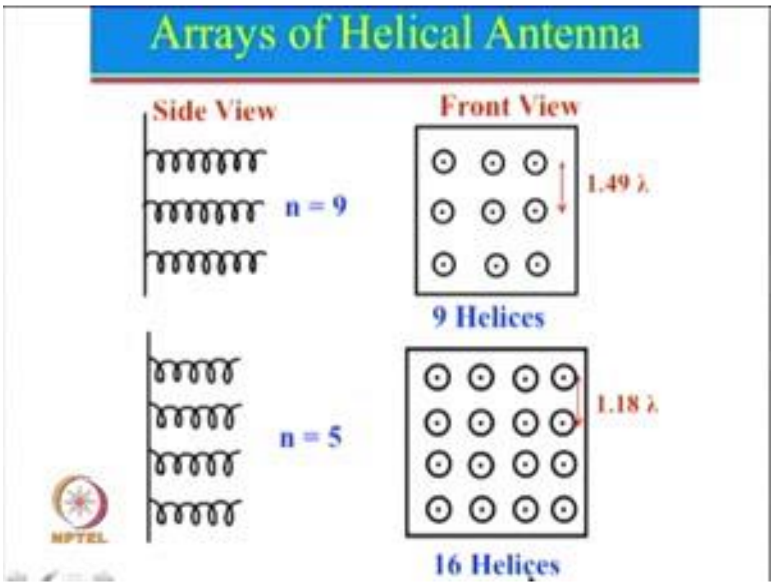

So, this is the 4 helix front view. So, you can see one here, one on the other side and these are the 4. And for n equal to 20, we just notice that the spacing between the 2 helix should be 2.236 lambda. This concept has been extended further; so here we have 9 helix and each helix has 9 turn. So, if you actually see in 9 into 9 is 81, which is approximately equal to 80 turns required to obtain the desired directivity.

So over here now, since the numbers of turns have been reduced; so what will happen? Directivity of each helix has been reduced. Under the directivity of each helix reduces then corresponding aperture area will also reduce and that means, centre to centre spacing will also reduce. So, in this case centre to centre spacing should be about 1.49 lambda. This is another example where 4 by 4 array has been used, total 16 helical antennas have been used, and in this case now each helix has 5 turn. So, 5 multiplied by 16 will be equal to 80. So, now, for n equal to 5 turn, aperture area will reduce further because for n equal to 5 directivity will reduce, correspondingly aperture area will reduce and hence spacing between the elements will reduce. So, you can see that the spacing between the helical antennas is reducing.

Now, comes the next part and that is what will be the mutual coupling between these 2 helixes; because we know that when the 2 antennas are placed closed to each other, there will be some mutual coupling.

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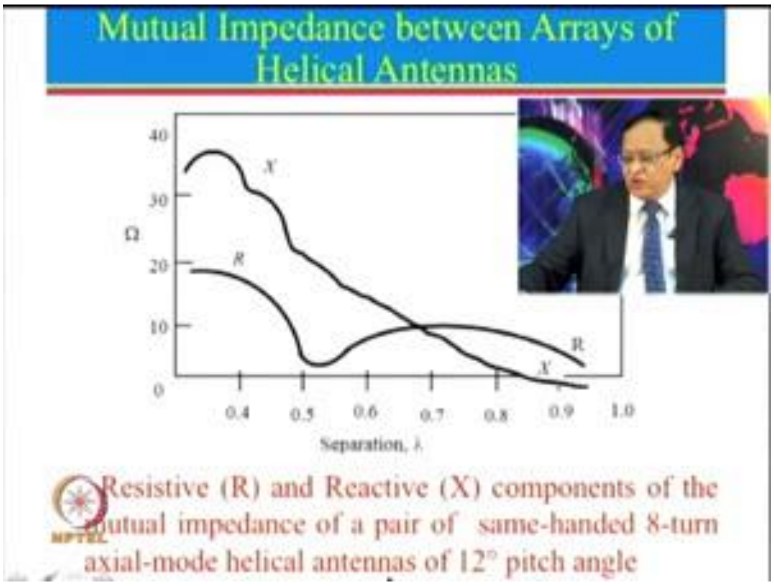

So, here is the plot for the mutual impedance between arrays of helical antenna. So, just to show here, so this is plot here is shown in the form of impedance, curves are given for resisted part as well as reacted part, and this axis here shows separation between the helical antennas normalized with respect to lambda. So, one can actually see that the curves are given let us say for 0.4, 0.5, 0.6, 0.7 and up to 1; and in the previous case we had seen. So, for example, let us just go back we saw that here the spacing is 1.18, here the spacing was 1.49, and for another case spacing was 2.236.

So, this spacing much larger than lambda, and one can actually see that if the separation between the 2 is approximately between 0.9 to 1, we can see that the resistive part of the mutual impedance is almost close to 0, and also the reactive part is close to 0, and anyway even this finite value is let us say about less than 5 ohm, that is not going to make much difference when the circumferential or the peripheral impedance is of the order of 150 ohms. So, this affect can be neglected and that is the beauty of the helical antenna that you can place these helical antennas and they give us a very good circularly polarized antenna performance, and you can use the arrays of these things. In fact, sometimes I also mention these things like a real estate.

Suppose we want to accommodate more number of people, then what are the options? One option is let us we make a 80 storey building; instead of making a 80 storey building, if you need to accommodate same number of the people what we can do? We can make 20 storey building 4 of them, and then the another option can be means we can make 16 buildings of 5 floor each, so that we can accommodate same number of people. So, the same way you can actually apply the same concept here that you want to get the desired directivity. So, either we can go vertically up or we can have smaller building or smaller sized helical antenna. So, depending up on the space available to us, we can arrange these helical antennas for the desired gain.

However, there is another interesting application which was reported long time back, where what they had done? They had used this helical antenna as a feed for a large reflector antenna. So, suppose that this is a large reflector antenna. So, at the focal point we put this helix, and these are circularly polarized helical antenna. So, assuming that the signal is coming from the large distance, so it will come in parallel, so they will reflect from the reflector, and they will focus at the helical antenna or alternatively we can pump in power through the helical antenna, it will go there and then it will radiate parallel if it is a parabolic dish antenna.

Now, one of the another advantage; is that suppose the helical antenna is let us say right hand circularly polarized, then the wave which goes reflects back from the reflector, that will be left hand circularly polarized. So, if we transmit right hand it will reflect back left hand, and since between right hand and the left hand. Generally since the axial ratio is sparely good, the reflected polarization will be at least 20 to 30 dB down, and if that is the case the performance of the helical antenna will not change much. So, this had been used very successfully during early days when they wanted a simple circularly polarized helical antenna.

Of course nowadays there are lot of other options, one can use a circularly polarized micro strip antenna as a feed also which is relatively more compared to helical antenna.

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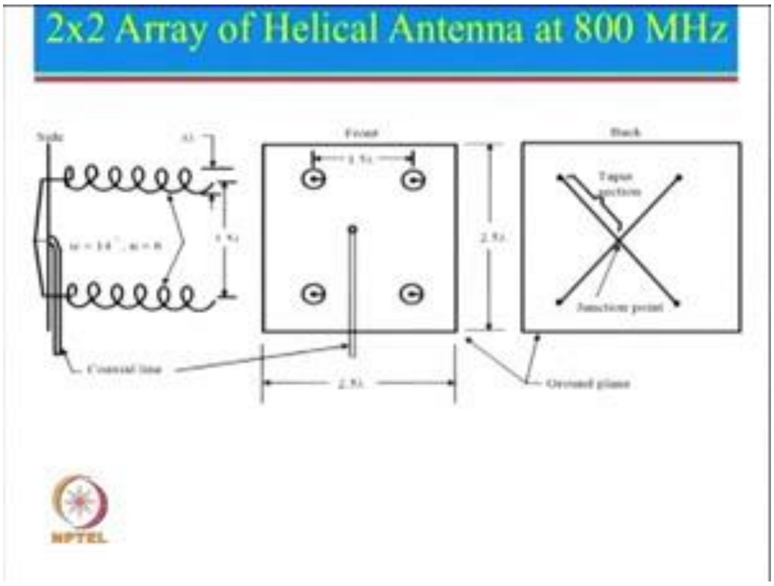

So, let us just see the practical implementation of this 2 by 2 array of helical antennas, and this designed example is again taken from the other books. So, this is antenna has been designed at 800 megahertz. So, just to tell you here one can see here that there is a 2 by 2 array of helical antenna, and each array element has n equals to 6 that mean, it is a 6 turn helical antenna, they have chosen alpha equals to 14 degree, anyway 12 to 14 degree is acceptable.

So, by now using these 4 helical antennas one can get larger gain, and now let us see how the feed network has been done. So, the feed network is shown over here. So, we know that the impedance of a helical antenna can be say 140 to 150 ohm, depending up on how we feed it, but that 140 to 150 ohm in a paper section has been used to transfer this impedance to about 200 ohm; so this one again similar section, so transfers the impedance to 200 ohm.

Now 200 ohm in parallel 4 of them will give rise to 50 ohm. So, at the (Refer Time: 14:07) point we can feed with the coaxial feed with the 50 ohm coaxial line, and the 50 ohm connector and that will work as a antenna. So, we have already discussed about how to design these antennas, so corresponding to 800 megahertz just to tell you. So, what you need to do? Here it is given there what is the diameter 0.3 lambda. So, corresponding to 0.3 lambda one can calculate what will be the c will be pi times this value, and so once we know the frequency, we can calculate what is lambda and then we can find the dimension. And once we choose alpha then we know what will be s lambda, and once we know s lambda and we know c lambda, we will know the length of the one wire, and since we know the number of turns are 6 so the total length will be nothing, but 6 times l. So, that is what we need to do to design this particular antenna.

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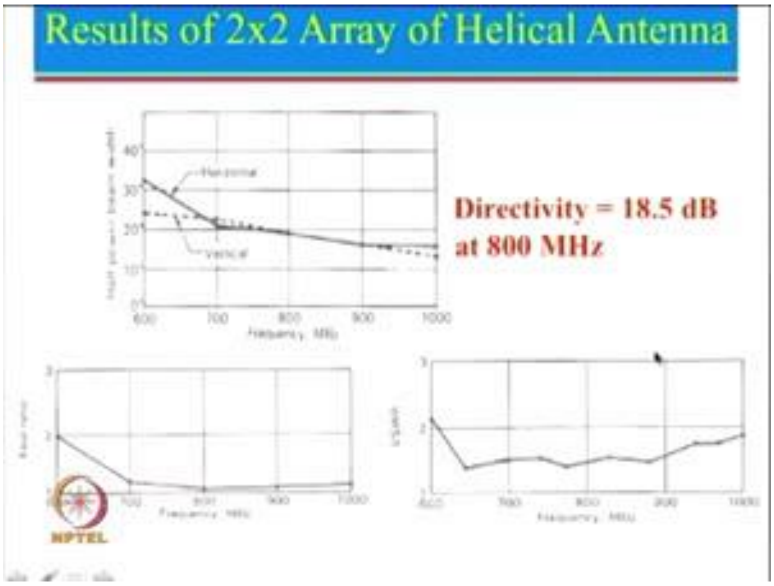

So, the size of the ground plane is also given over here. So now let us see; what are the results we get out of here. So, we will come to this particular here in a little while, but first let us just look at the VSWR performance. As one can see that the antenna was designed at 800 megahertz, and one can see that VSWR less than 2 is there right from 600 megahertz to 1000 megahertz. So, that is a fairly large bandwidth, you can actually thing about the bandwidth is about 400 megahertz approximately. So, 400 divided by 800 that is almost 50 percent bandwidth has been obtained. I still feel the VSWR value could be slightly improved by designing this particular paper section more appropriately, so that it will match better with 50 ohm, but that is still VSWR is less than 2, in fact for most of the region VSWR is actually less than 1.5. So, it is fairly good matched, let us just look at the axial ratio.

So, here axial ratio in the numeric value is shown. So, axial ratio 1 corresponds to 0 dB axial ratio, and axial ratio 2 actually corresponds to 6 dB. So, 6 dB is generally not acceptable. So, we can say that axial ratio is less than 3 dB up to about this particular region, but you can see that the desired frequency range of 800, you can see that the axial ratio is fairly good. Now let us just see the horizontal and vertical component, one can actually see that right from here to here the 2 components are fairly equal, their half power beam width is almost same and that is why what you can see here, this corresponds to a axial ratio. Even here you can see the variation is slightly more than this here, but still small and that is why one can see that it is slightly increasing, but over here one can see that the half power of beam width is varying considerably, and that is why axial ratio is becoming relatively poor.

So, now how we can calculate the directivity; one is simple thing is that we can use the formula also, but these are the measured results. So, from the measure result also we can calculate. So, half power beam width at this point is approximately 20 degree. So, you can use the formula of 32400 divided by 20 into 20 that will give you approximately 18.5 dB directivity and 1800 megahertz, and once again I want to remind this is not the gain of the antenna, gain of the antenna is about 0.6 times this here.

So, please take these things into consideration when you need to design a helical antenna, and I also want to mention people have done lot of experimental work on helical antenna and they have actually speaking perform experiments on multiple number of turns 5 turns to 35 turn, they have given a lot of complicated formulas also where they have done the curve fitting. But I find that the directivity expression by this is very simple it is easy to design and only thing is you take efficiency 0.6 and then we can design the proper helical antenna for the desired gain.

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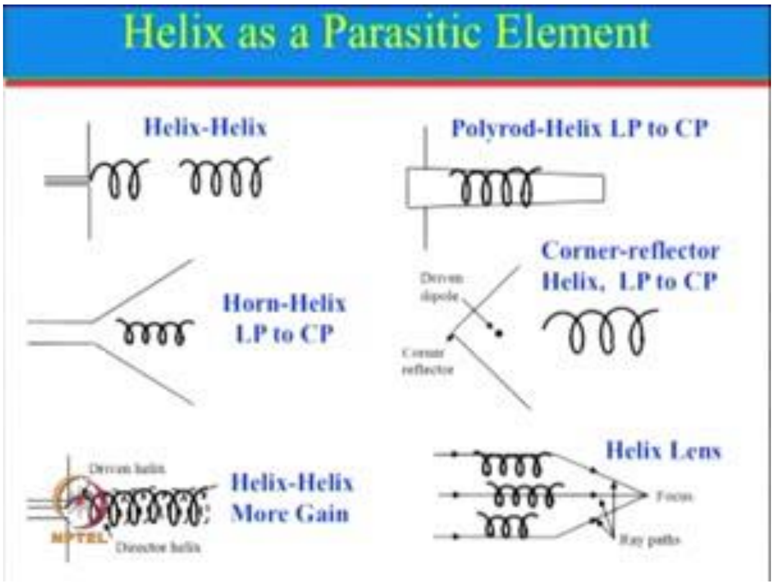

Now, there are many other applications are there of helical antenna. So, besides being used as an antenna, it can be also used as a parasitic element. And it can have several advantages let us see; what are these here. So, here we have a 1 helix here, and then put another helix over here. By putting this over here like this arrangement, you can actually increase the gain of the original helical antenna or one can think other way round. So, suppose if this was the original helical antenna, and by something it actually happened that this wire got broken in between. So, even though there is no physical connection here it is not that the directivity loss will be considerable, it is not that the directive will be now only given by these many terms; but actually speaking because of this here this acts as a parasitic element. So, this one radiates from here, the beam is in this particular direction then these things also will get excited and net effect is that we will still get a higher gain out of this particular thing.

So, this is one of the application we can use helix or you can think even if the wire breaks in between, it will still work as helical antenna. Now this is another very interesting application, where let us say horn antenna which is the linearly polarized. In fact, the next topic after helical antenna you are going to talk about horn antenna; and we will see that majority of the time horn antennas are linearly polarized, and if you want to get circularly polarized, horn antenna we have to do lot of extra work to do that.

So but now let us see here how that linearly polarized waveform can be very simply converted to CP. So, let us say this is a horn antenna, so wave is being launched in this particular fashion, and here we have this helix and by the way there is no feed required here, there is no special connector here nothing, just you have to support this helix somehow at this one. Right now it looks like it is suspended in the air of course, you cannot do that. So, some support structure has to be provided for this particular helical antenna; however, once the wave is launched it goes through here, and then this helical antenna converts this linearly polarized antenna to circularly polarized antenna.

So, it is a very very easy and convenient way, except it requires a proper support. So, now, this is another thing here where this is a normal helical antenna and now another helix has been put around that in the space which is available in between. If you refer I have mentioned about mono filer helix antenna; mono filer will have only one wire, here you can think of a there is another wire which has been put here. So, it is not really mono filer, you can say it is a bifilar now; or you can actually think other way round that this is the driven helix, and this becomes a director helix or we can call it a parasitic helix.

Now, by putting this over here one can realize little more gain, but; however, I just want to mention that gain improvement is just about 1 to 2 dB. It is not very significant improvement, but still 1 to 2 dB gain maybe very good as it is you are not increasing the aperture, all we are really require is a just put another wire in between. So, without increasing the aperture we can actually get a slightly better gain out of this particular helical antenna.

So, it is a very good effective technique to get slightly more gain, which is of the order of 1 to 2 dB. This is another configuration which is a Polyrod antenna, this is basically a dielectric antenna and generally these are linearly polarized antenna. So, by wrapping helical around this particular dielectric, and the wave is being launched will go through here, and then this particular thing will become circularly polarized antenna. Now another application is that let us say this is a corner reflector, I know we are going to talk about these things later on, we have not discussed about reflectors, horn antennas and so on, but we will discuss these things later on.

So, here what we have this is the dipole antenna, which we know will be linearly polarized antenna and then this is the corner reflector put over here, but I can just tell you one can do many other things it can be just a one plane reflector, then dipole antenna or it can be a corner reflector and many a times these corner reflector angle is changed, some corner reflector use 120 degrees angle or 90 degree angle, or 60 degree, 45 degree, 30 degree and here then what we get is linearly polarized antenna and again if we want to get circularly polarized antenna, it is again very very simple just put a helical antenna like this over here, the only few precaution is need to be taken. So, whatever is the frequency of this particular antenna, these helical antennas must be designed for the same frequency range in the axial board.

However we do not need to provide any feed point over here. So, that is why the term parasitic comes here. So, here then what happens? The wave goes reflects back and it goes through over here and that is what will give us circularly polarized antenna. Otherwise if you want to get circularly polarized antenna for dipole we know it will be much more hard work one has to do. So, we need to put a dipole here, then we need another perpendicular dipole and then those 2 dipoles have to be fed with orthogonal polarization; that means 0 degree and 90 degree phase difference with equal amplitude. So, all those things need to be put here, this is one of the very simple and effective way to realize circularly polarized antenna with higher gain compared to the dipole antenna.

This is another arrangement where this has been made more in the form of the helix lens. So, one can actually see that this position is different than these 2 position. Basically if you recall you might be familiar with the helical antenna, you might be familiar with the lens antenna; let us say we have a focal lens and we actually speaking we are familiar with let us say this kind of a lens antenna right. So, what happens when the wave is coming from here, it sees a relatively lesser distance and here the wave has to travel little bit longer distance, but; however, the property of this is that if the things are coming parallely, it will get focused over here, so that is the lens effect. So, here these helical antennas can be used in such a fashion, that they can actually act as a lens antenna and thereby the beam can be focused at a given point.

So, these are the different applications of the helical antenna. So, we will conclude today’s lecture here. So, what we have discussed today mainly the design of the helical antenna for axial mode, and for larger gain requirement what we can do? Either we make a very large tall helical antenna, or we make arrays of this helical antenna of smaller height or smaller number of turns, so that we can get the desired directivity.

Then we also looked at how to do the feed for multiple elements, and we actually can feed from the backside and then use a (Refer Time: 27:41) impedance matching network to match with 50 ohm, and we saw that the results are fairly good stable over 30 to 50 percent bandwidth as far as the VSWR is concerned, but generally axial ratio was below the desired value of 3 dB over 40 percent bandwidth. And even the radiation pattern was symmetrical for fairly large frequency range from 700 megahertz to close to 1000 megahertz.

Then we looked at some of the applications of helical antenna, which are generally good to convert linearly polarized antenna to circularly polarized antenna. So, in the next lecture we talk about normal mode helical antenna how to do the design of helical antenna; and will also tell you what are given in the test books, and how those designs have to be modified to realize practical normal mode helical antenna on finite ground plane.

So, thank you very much will see you next time, and will talk more about normal mode helical antenna. Bye.