Antennas
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Module - 08
Lecture – 35
Circularly Polarized MSA – II

Hello and welcome to today's lecture on circularly polarized microstrip antenna. In the last lecture, we started discussing about circularly polarized microstrip antenna and we did looking to why we need circularly polarized antenna instead of linearly polarized antenna because if we use circularly polarized antenna then the orientation of the receiving antenna if it is linearly polarized, it does not really matter. It was still receive the full signal and then we looked into how we can realize circularly polarized microstrip antenna using a very simple technique by feeding a square microstrip antenna with 2 orthogonal feeds with one angle 0 and one angle 90 degree. Instead of square microstrip antenna, we also saw that we could use circularly microstrip antenna by using 2 orthogonally feed and the reason for that is that is square microstrip antenna.

If you feed along, let us say in one access along the center then the null will be there in at the perpendicular direction. So, for example, if this is a rectangular microstrip antenna we feed here that will Exide this particular plane which is E plane and along the center there will be a null and if you feed at this particular point there will be null in the other direction. So, by feeding at those 2 points with one angle 0, one angle 90 degree, we saw that we could get circular polarization and LHCP or RHCP can be obtain which is left hand circularly polarized or right hand circularly polarized antenna can be obtain simply by using feeds like one angle 0, one angle 90 or one angle 0, one angle minus 90 degree.

Then we also saw how this power divider network can be realized and we actually saw that at 2 branch coupler needs the requirement, a 2 branch coupler gives us equal output as well as 90 degree phase difference and then we looked into it that that particular thing if it is then the same plane will actually occupy much larger space. So, in order to reduce the overall area of the antenna then what we have to looked into a configuration where 3 dB 2 branch coupler was realize at the bottom layer and then the square patch was put on the top layer in an inverted configuration and by connecting those output of the coupler to the feed point location, we saw that we could get very broad band circularly polarized

microstrip antenna then we also looked into how we can get circular polarization using single feed microstrip antenna. So, we will continue from there.

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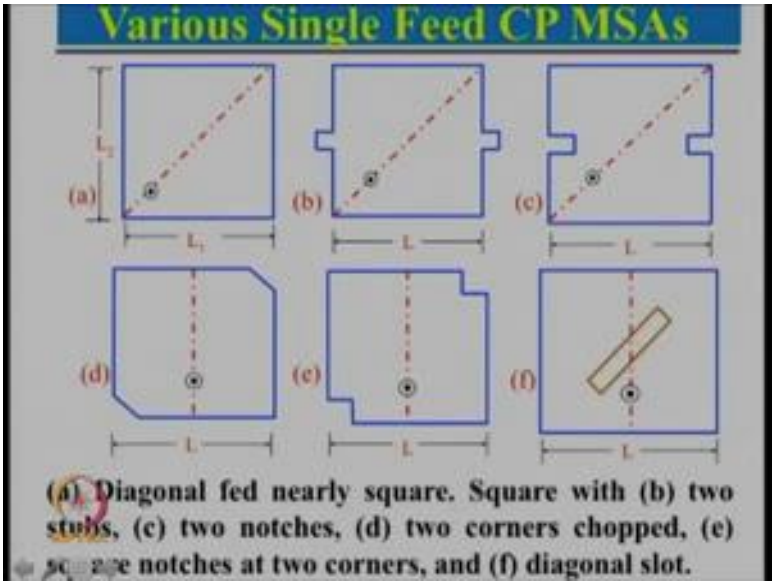

Let us just look at the configuration which we had looked in the last lecture. So, these were nearly square patch I will just go through one more time. So, this length is L 1, this length is L 2 and the ratio of L 1 by L 2 should be a approximately equal to 1.01 to 1.10 depending upon the bandwidth of the antenna and bandwidth is determined by the substrate parameter. So, if epsilon r is low and substrate is thick then it will have a higher bandwidth so in that case will have a ratio which could be maybe close to 1.05 were so, but if the bandwidth is less than the ratio should be small and then we noticed that by feeding this particular antenna along the diagonal. So, what really happens and let us says is if we assume L 1 is longer than L 2 then for L 1 frequency f 1 will be lower and at L 2 frequency will be higher. So, when L 1 is getting excited at lower frequency and since the feed is along the diagonal at this particular polarization will be there.

And that is how the radiation dominant will come from the f one as frequency increases then what happens L 2 will become resonant. So, then this particular portion will become dominant. So, from horizontal it will go to vertical, but in between it will go to circular when the frequencies of f 1 and f 2 will be relatively close and we had seen the resonance curve also that when the resonance cross over takes place at that particular point we will get actual ratio now instead of using a nearly square patch one can also use

a square patch with 2 strips. So, basically now this will be one dimension and this dimension will be slightly more.

That means, frequency will reduce and we again feed along the diagonal in this case, instead of adding is tough notch has been cut over here. So, this length will be less this length is going to be more now instead of that here one can also chop the corners and by cornering cutting the chops along the corner we have a one diagonal length and we have another diagonal length. So, this diagonal length will be smaller giving rise to a slightly different frequency compare to this diagonal length. So, we have feeding in between the 2. So, again this will be let us say 45 degree leading this will be 45 degree lagging and the net result will be 90 degree phase difference instead of chopping the corner we can also cut its notch in the corner with the similar effect instead of that we can even cut a slot here.

In this case will have a diagonal length which will go like this and come over here and another diagonal length will go like this move like this here and then goes here. So, 2 diagonal lengths are different and we are feeding in between the 2 diagonal lengths.

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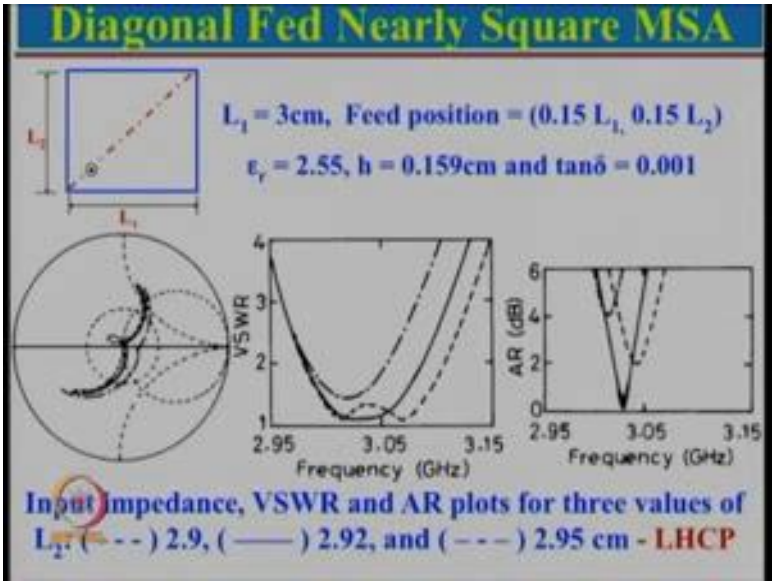

Then we have seen, what is the effect of the length L 2? So, we have taken a fixed length of L 1 and these plots are put different values of L 2. So, just to quickly go through so, L 1 was 3 centimeter feed position is along the diagonal and these are the substrate

parameter and since h is relatively small. So, that is why it has a narrower bandwidth and hence we have taken 3 different values which are relatively close to L 1.

These are 2.9, 2.92, 2.95 so corresponding to 2.9, we can actually see that there is a small loop there, for 2.92 that loop is reduced to kink and then for 2.95, you can see that even the loop is not adjust, little bit bend is there and if is this becomes 3 then this will become a square patch and there will not be any kink or any bend also. Now corresponding to these 3 curve, we get the best AR which is over here and this particular case corresponds to when there is a kink over here basically what this kink implies that over here one of the patch length was dominant and here there is a transition took place other patch length is dominant and at this particular point where there is a transition the amplitude will be approximately equal and hence it is giving a good AR now.

If you look at here corresponding to this curve here, this is the VSWR curve. So, you can see that this is VSWR equal to 2 over here. So, we can see it has a much larger bandwidth then corresponding to the actual ratio less than 3 dB bandwidth. So, we can actually say that even though this has a larger VSWR bandwidth, but it is not the very useful bandwidth because at this particular frequency which is a lower frequency L 1 will be resonant. So, this polarization will be dominant at the higher frequency this will be dominant. So, that will give rise to a vertical polarization and only in between this smaller portion.

Where we can see that actual ratio is less, we will get a circular polarization, now this particular loop over here that actually gives a much larger VSWR less than 2 bandwidth, but it is not at all a useful bandwidth because the polarization dominant here will be horizontally polarized then circularly polarized and then vertically polarized. So, it is not a very good antenna because the pattern is not symmetrical now for this particular feed and L 1 L 2 we get LHCP which is left hand circular polarization. So, instead of feeding along this diagonal, if we feed along this diagonal over here somewhere here then we will get right hand circular polarization. Now even for this feed point we took L 2 which is smaller than L 1, if we take L 2 larger than L 1; that means, instead of 2.92, let us say if we take this as close to Z 3.1, in that particular case what we will get will be a right hand circular polarization. So, one has to be careful to know what kind of a polarization, we will get it. So, now, let us just look at another configuration and this is a nearly square ring microstrip antenna.

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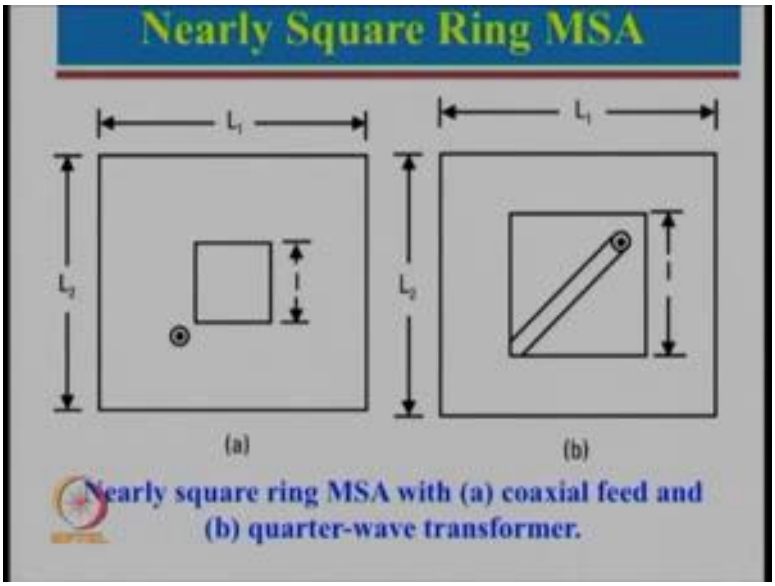

Let me first explain when we discuss about compact microstrip antenna we are actually seen that in a rectangular patch if we cut a slot in between it becomes like a ring microstrip antenna then what really happens we noticed that it actually becomes a compact microstrip antenna. So, now, over here now this particular length has been taken as L 1 here it is L 2 and these this is actually taken as a square. So, that is a L and L and we feed along the diagonal and here we can get a impedance matching and there are several variations possible over here instead of using L 1 L 2 we can use square patch with diagonal cut or we can use square patch with corner chop and other possibilities are there or we can do another thing we can take outer one as a square patch; that means, L one is equal to L 2, but here we can take L 1 and L 2 which are different values. So, then what happens even then we can get a circular polarization now we had also seen that for a compact microstrip antenna when this particular thing increases significantly.

Which is the case over here we can see that a much larger slot has been cut inside the patch. So, in this case what happens impedance will not be equal to 50 ohm just like what we put get here with the matching. So, over here a quarter wave transformer has been used to do the impedance matching and again as I mentioned before L 1, L 2 can be square then this will be nearly square or it can be corner chop or other configuration. So, we looked into it. So, it is not that we can only use the variations of square we can also use the variations of circle and triangle also.

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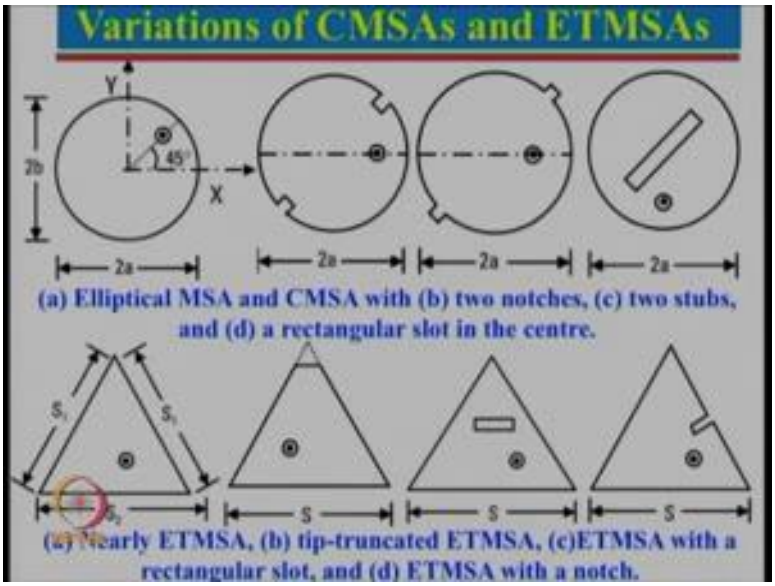

Here is a configuration which is a elliptical microstrip antenna. So, what we really have here is a major access to a minor accesses 2b. So, the ratio of measure access to minor access again should vary between 1.01 to about 1.1 depending upon the bandwidth of the circular microstrip antenna instead of using a circle or here we can say ellipse, we can also use a circle with notches cut in between. So, what really happens now? So, along this dimension length will be equal to the diameter, but over here length will be slightly different.

And we are feeding in between the 2, instead of cutting a notch, we can also add a strip or we can cut a slot in between. So, basically path length this side and the path length this side will be different and we can get circular polarization and again instead of using a circular patch, we can also use triangular patch and its variation. So, this is equilateral triangular microstrip antenna, but it is nearly equilateral why now S 1 and S 1 are equal S 2 is different. So, this again is to be chosen such a way just like in the case of electrical or nearly square. So, the ratio of the 2 again should be between 1.01 to 1.1 and then 1 can use a chopped triangle tip here which is equilateral triangle just similar to this here or one can cut a slot here or one cannot cut a notch here in between.

I generally do not recommend triangular microstrip antenna because it is not a symmetrical configuration. So, hence it does lead to a higher cross polar. So, I generally recommend that you can use the variations of square microstrip antenna or you can use

variation of circular microstrip antenna let us look at some more compact circularly polarized configuration.

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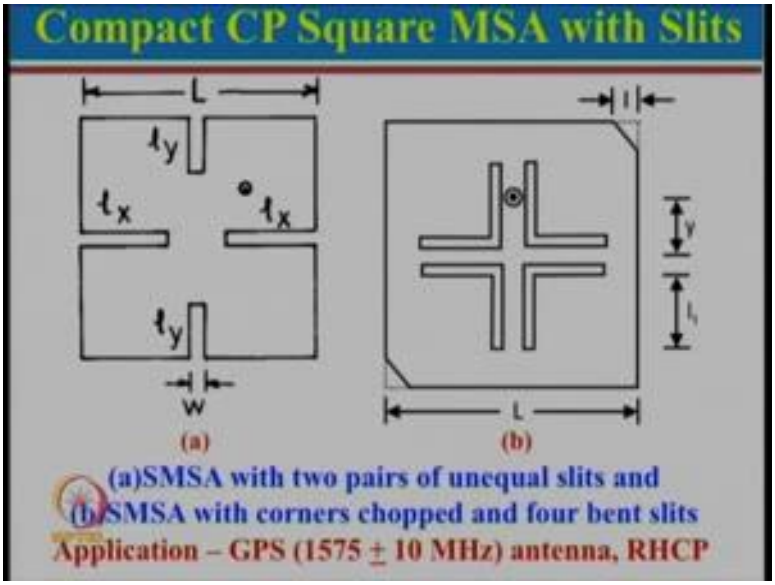

Here there are variations of square microstrip antenna. So, just to mention here, what we have? So, here there is a length L and this is also length L. So, it is a square microstrip antenna and in this square microstrip antenna 4 slots have been cut here. So, here you can see that this length is L X. So, these 2 are same and these 2 lengths are L Y you can just imagine for a minute that if these 2 slots are not there if these 2 slots are not there then what will happen? This actually looks like a H shaped patch and we had discussed about H shaped patch. So, H shaped patch is relatively more compact compare to the square microstrip antenna because imagine again this is not there. So, this will be the one path and then the path will be something like this here. So, path length has increased path length has increased. So, resonance frequency will reduce.

Now instead of thinking this you not think about this is not there. So, now, the path length will be like this here path length. So, this will be you can say rotated H, now when we have slots cut on both the set, you can just say that it is a modified H configuration in both this plane as well as in this plane and we have chosen L X not equal to L Y. So, that the 2 path length will be different and if the 2 path length are different resonance frequency will be different and we can feed along the diagonal to get circular polarization.

Again there are lot of variations possible here one can take all these 4 sometimes people also call these slits are cut in the patch sometimes it is also known as a deep notches are cut in the path where basically meaning the similar thing. So, here now we can also do that L X equal to L Y can be taken and then this can be taken as L 1 and this can be taken as L 2 or one can take L and L here, one can have notches over here and so on. So, there are lots of possibilities are there to do the variation, but just to tell you here. So, one can get a compact circularly polarized microstrip antenna using this configuration, this is another configuration which is a fairly compact configuration.

Now, let us just first see here. So, we if you think that this is not there just imagine that this is not there in that case then this will be one length and this will be the another length and that is why the feed is put between the 2 diagonals to get circular polarization now by cutting these slots in between there 4 of them are there. So, that it is symmetrical configuration. So, in this case now the path length will be not straight from here to here, but it is going to be like this here it will go around it will go around then come back over here. So, path length has increased significantly and hence resonance frequency reduces again we can think about lot of variation. So, here it is a square patch with notches one can use L 1 L 2 and then we can have things over here or we can take these length difference we can take a square patch and so on, but I just want to tell you in all of these cases whether you take L 1 L 2 or you take L with a notch and so on variation in the performance is relatively very very small and this kind of antenna is actually very useful for let us say for example, GPS antenna now.

That is a global positioning system and the frequency of that is 1575 megahertz and the bandwidth is plus minus 10 megahertz. So, the total bandwidth is about 20 megahertz that is about just about close to 1.4 percent of this which is relatively small bandwidth. So, one can use some of these configuration look at now in this particular case here for GPS application, they receive antenna should be right hand circularly polarized antenna. So, now, let us just look at to it.

So, by using this kind of a configuration we can realize a compact antenna everybody wants a compact antenna for GPS application, just think about your mobile phone GPS antenna is inside that as it is inside the mobile phone, there are plenty of antennas are there, there are antennas for 2G application there may be a antennas, for 3G, now 4G is coming, the net should also have a Wi-Fi antenna. So, many antennas are inside your

mobile phone. So, we do want all these antennas to be compact and hence this particular thing finds lot of application. In fact, even think about you might have seen something active GPS also. So, there also use nearly square microstrip antenna.

But on a relatively thick substrate and there use generally high dielectric constant substrate some of them use alumina substrate which has epsilon r equal to 10 some of them use substrate which has and epsilon r close to 6 and of course, you can use that technique which I mentioned you can cut slots or slits and that way you can realize compact microstrip antenna.

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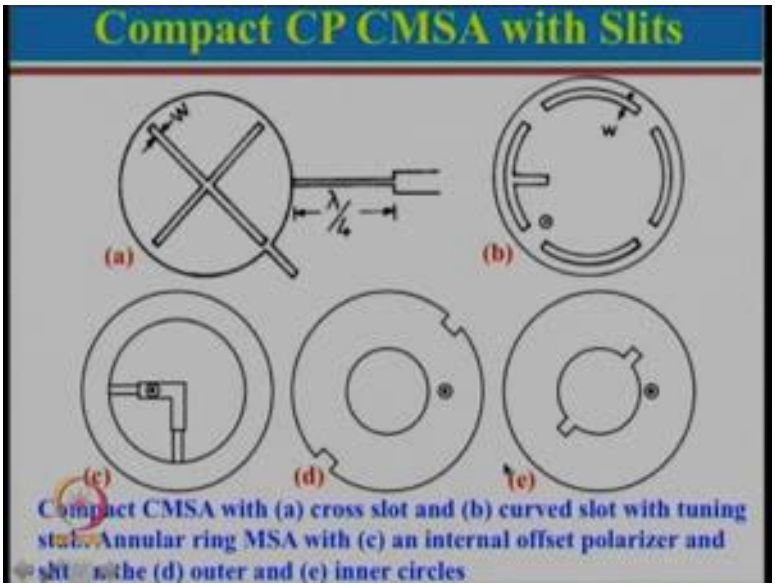

Now, instead of using there is a square variation we can also use the circular variation and I just want to tell that many of these variations are actually important depending upon where you want to install these antennas or where you want to put these antennas. So, here are the compact CP CMSA variation with slits or slots. So, here what we have we have a circular patch over here and then the circular patch these equal dimensions slots are cut here and here is tub has been added to do the tuning.

One can actually see that the 2 orthogonal dimensions will now be not same and we feed along the center of these 2 dimensions and since we are feeding it over here at the periphery at the periphery input impedance were be very high. So, lambda by 4 water wave transformer has been used to do the impedance transformation to match with 50 ohm. So, here again we could have had lot of variation you do not need to have a this

kind of a thing here these 2 slots could have been of different dimension or instead of taking a circle this could have been taken as a ellipse also and that also could have been given circular polarization now instead of using are these you can say plus kind of slot 1 can also cut slot along the periphery. So, here we have a circular patch with these slots which are curve slots and this one here is cut basically to do the impedance matching from here, but this is mainly for circularly polarized tuning.

By cutting this particular thing, changing this dimension, it is easy to do the tuning of the antenna to obtain proper or good circularly polarized antenna. So, we had also seen this configuration for rectangular ring here it is a circular ring. So, again we know this will be a compact configuration and this is another variation that where it is fed over here and here and in this particular point you can even use a lambda by 4 transformer, if required to transform the impedance and over here what you can see that this is the one small length here and this is the relatively larger length. So, this larger length should be equal to this smaller length plus lambda by 4. So, that it provides 90 degree phase difference. So, again here instead of using this kind of a configuration relatively smaller ring has been cut here and then we can cut the notches or add the stuff along this then this can be circular or alternatively.

We can have this circular and we can cut notches or in this case we can add step whatever where you would like to see in a reality this whole thing has been removed from this particular patch over here. So, these are several variations are there similar variations are also there for triangular, but as I mentioned earlier, I generally recommend that you use variations of rectangular or variations of circular microstrip antenna. So, these are all compact configuration.

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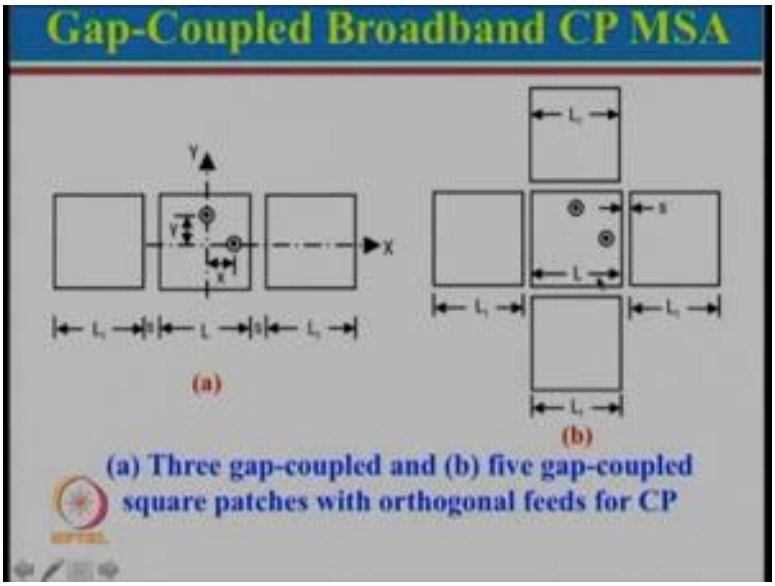

Let us just look at now some broadband configurations also after all we do require broadband circularly polarized microstrip antenna. So, here I just want to tell whatever the broadband configuration we had studied earlier which are also given in chapter 3, 4 and 5 of my book the all can be suitably modified to obtain broadband circularly polarize antenna.

Here is one example, this is a radiating edge gap coupled micro step antenna, if I look from this feed point of view and for this feed point of view, this will be add along the null direction, but if you now look at this particular feed point. So, in this case, now this is radiating it. So, this will be more like a non radiating edge gap coupled configuration. So, what really happens for this particular feed? Let us a choose 1 angle 0, we can choose 1 angle 90 degree or 1 angle minus 90 degree depending upon LHCP or RHCP is required so, but I still do not recommend this configuration very strongly the reason for that is as I mentioned earlier for this feed, this is radiating edge and we know that radiating edge feel it is uniform. So, we may need a little larger gap, but for this particular feed here this will act as a non radiating edge and non along non radiating edge is we actually have a sinusoidal field variation. So, for that particular case coupling will be relatively weak. So, what happens for these 2 feed points then for this feed point, there will be relatively stronger coupling for this it will be relatively weaker coupling.

There will be some difference in the input impedance plot, but it gets a fairly good actual ratio bandwidth so, but I do recommend this particular configuration. In fact, here what we do if this take all the parasitic patches equal when you take all the parasitic patches equal. So, let us again think about the speed point. So, for this feed point, these are the radiating edges these are the non radiating edge, but for this feed point.

Now these are the non radiating edges these are the radiating edges. So, in reality, the response will be similar because we have taken L 1 equal for all the parasitic patches. So, here again we need to feed here let us say 1 angle 0, 1 angle 90 degree for LHCP and that can be obtained by using let us say, we can use on this on the top layer and underneath layer, we can actually designed a 2 branch 3 dB coupler and we can connect over here, but I also want to mention, now it is very broadband configuration. So, even 3 dB 2 branch coupler which generally may have acceptable bandwidth of about 20 percent and these configuration may give us bandwidth of about 25 percent or so.

In that case, instead of using 3 dB 2 branch coupler; 1 can even use 3 dB 3 branch coupler or even 3 dB 4 branch coupler and there is a lot of area available underneath these patches. So, which can be utilized to Exide all these antennas now instead of going planer one can also go vertical also.

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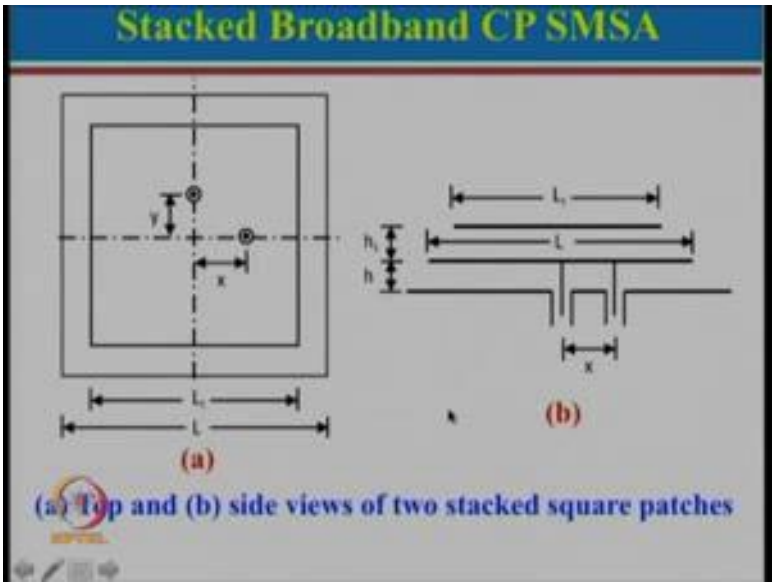

Here is the configuration where this is a stacked broadband circularly polarized square microstrip antenna that is important here. So, we have a square patch at the bottom layer

we have a square patch at the top layer here all the things are taken in here to realize very broadband antenna and again, we can feed here 1 angle 0, 1 angle 90 or 1 angle 0, 1 angle minus 90 for RHCP. So, these are the different configuration.

In the next lecture, we will discuss about some more broadband configuration and will see that how we can also use these circularly polarized antenna in the form of an array and will look into a very nice concept of sequentially rotated circularly polarized microstrip antenna which gives very broadband circularly polarized antenna. So, today we looked at single feed circularly polarized microstrip antenna and its variation then we also looked at compact microstrip antenna configuration and we also looked at a few broadband microstrip antenna configuration. So, will see some more of these in the next lecture and then will see very broadband microstrip circularly polarized antenna.

Thank you. We will see you next time, bye.