Antennas
Prof. Girish Kumar
Department of Electrical Engineering
Indian Institute of Technology, Bombay

Module - 12
Lecture - 54
IE3D Session TA-II

Hello everyone. I am Hemant Kumar, one of the teaching assistant for this course. In today's lecture we will learn how to design antennas using IE3D. In previous lecture my colleague already introduced the basics of IE3D software. So, in today's lecture, we will design the basic antennas such as microstrip, patch antenna and monopole antenna and some other antennas. So, let us start with IE3D.

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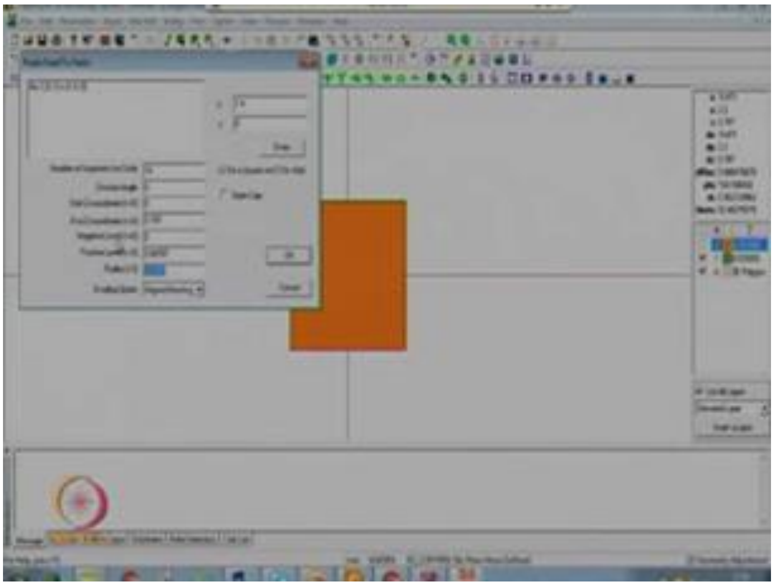

First start with m grid, then we will have this window. In this window we have file option; we will design a new antenna. Here we are going to design a microstrip patch antenna at X-band and the substrate we have used is RT duroid 5880. So, first we have to select the dielectric layer from this option, you can see here z top. Z top is the thickness of our substrate that we can give as 0.031 inches, which is equivalent to 0.787 mm.

Then dielectric constant of the substrate which is 2.2 then low stangent of the substrate 0.001 then press ok. So, we have introduced one dielectric layer, then press ok. So, layout editor window is introduce, in this window we will design our patch antenna. That dimensions of the microstrip patch antenna, you can find out easily using the formals of level. You can also easily find out these using the line gauge in the IE3D software.

So, the dimension found out to be for a microstrip patch antenna at a center frequency of 9.3 gigahertz. So, at 9.3 gigahertz we have founded the patch antenna dimensions which is 10.2 by 10.2. So, we can select a rectangle from this IE3D m grid window rectangle option and we are going to design a metallic patch at z is equal to 0.787. So, the length of the patch is 10.2 mm width 10.2 is we are going to design a square MSA. So, now, press ok. Now you can see a one patch at a layer of 0.787.

So, next task is to give the feed. To give the feed we will go to the entity, option go to entity option then (Refer Time: 03:12) patch. Now the next is where we have to feed the location can be taken as l by 6. So, for this we have optimized this and we have found out the value of feed location is 1.4 mm from the center. So, press enter number of segments for the circle you can take any value between 8 to 16 or 32, it is ok. So, I am taking as a 16, start z coordinate which is 0 and z coordinate that is our substrate height, negative level 0 positive level. It is generally taken as a between 1 by 10 to the 1 by 100th of the substrate thickness. So, it is taken as a 1 by 100th of our substrate thickness that is 0.787 and the radius of a connector which is 0.6 for SMA connector, so 0.6 then press ok.

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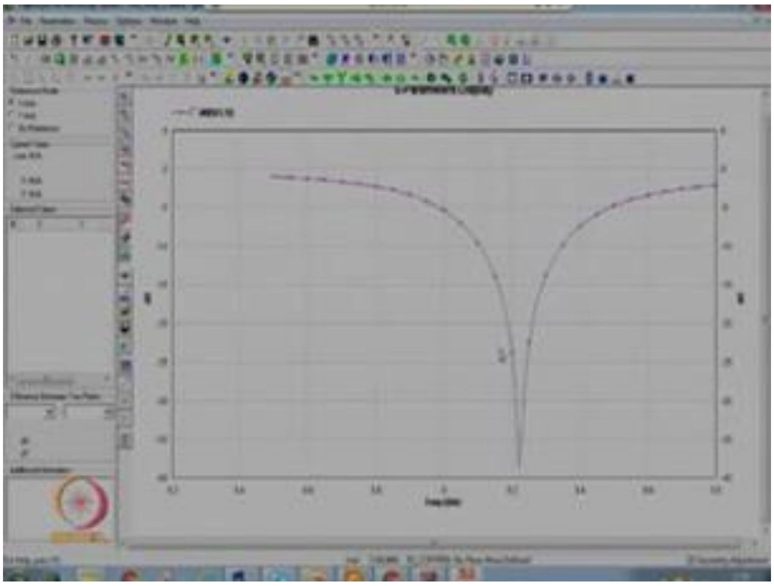

So, you can see we have introduced the coaxial feed. Next task is to save this geometry. So, save this save as, you can save as test x MSA X-band. So, now, we want to simulate it, to simulate we have to give the some parameters first is matching frequency which is the highest frequency. So, the maximum frequency you can take as a 12 gigahertz and the number of cells per wavelength because it is a simple structure 30 match cells are enough and automatic edge cell as in the previous class it was explained what is AEC. So, select AEC layer one then press ok, then we have to give the number of frequency samples. So, enter start frequency 8.5 gigahertz and frequency you want to simulate up to 9.8 gigahertz. The difference between the start frequency and the end frequency is roughly 1.3 gigahertz. So, you can take the number of points such that the step frequency will be 1.01 gigahertz.

So, the software simulates ours design at every 0.10 gigahertz difference. So, you can take as a 131 samples then press ok. If you select this option click on this, then it will select all the points. Then it will simulate at all the points which will take a very high time. So, no need to click on this option. Now it will select some random points and it will simulate on those points and to find out the radiation pattern we have to select this option also click on this a new window will appear here you will see the angle total thetas and total phi's in the 3-D there is a theta elevation angle and phi azimuth angle. So, 37 means because phi varies from 0 to 360. So, it divides the total angle 0 to 360 in 37 samples. So, every sample will be at angle of 10 degree.

Similarly for this theta because theta varies from 0 to 180, it divides the whole range in 37 samples each samples having a difference of 5 degree. So, you can see 0, 5, 10, 15 and in phi you can see 0, 10, 20 degree, and next thing is press now you can simulate it for simulation press it will take 5 to 10 seconds to simulate it. After simulation we will see the characteristics of the antenna s parameters, VSWR, smith chart and then we will see the radiation pattern also. So, now, we see a new window has been appeared. In this window you can see add graph, graph definition in this add graph, delete graph, edit. So, first add graph, in this we will add the s parameters, we can add s parameters, smith chart, VSWR. So, first we want to see the s parameter, click on this. Then we want to see the s parameter in dB. So, click on the dB option then press ok, we want to see the smith chart also. Then press add graph add smith chart press ok.

Then again add graph if you want to see VSWR also, VSWR is generally seen in linear scale. So, click VSWR. VSWR then press ok, now close this window. After closing this window you will see the results. So, this is our s parameter. So, you can see approximately at 9.3 gigahertz it is resonating. So, it have a S 11 less than minus 10 dB from this point which is approximately 9.1 and this point is approximately 9.35. So, you can see a 250 megahertz bandwidth for S 11 less than minus 10 dB as we obtained. So, this is the information you can get from the s parameter.

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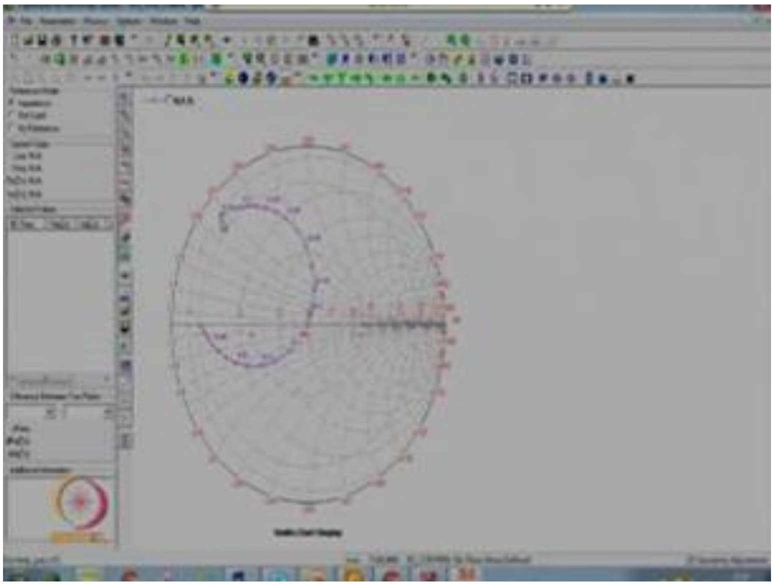

Next is smith chart, this is our smith chart. So, from this chart you can see this is our 50 ohm matched, at this and at this point the frequency is 8.5 and as the frequency is increasing impedance is changing and at approximately 9.3 gigahertz it is matched with 50 ohm. So, it is perfectly matched with 50 ohm.

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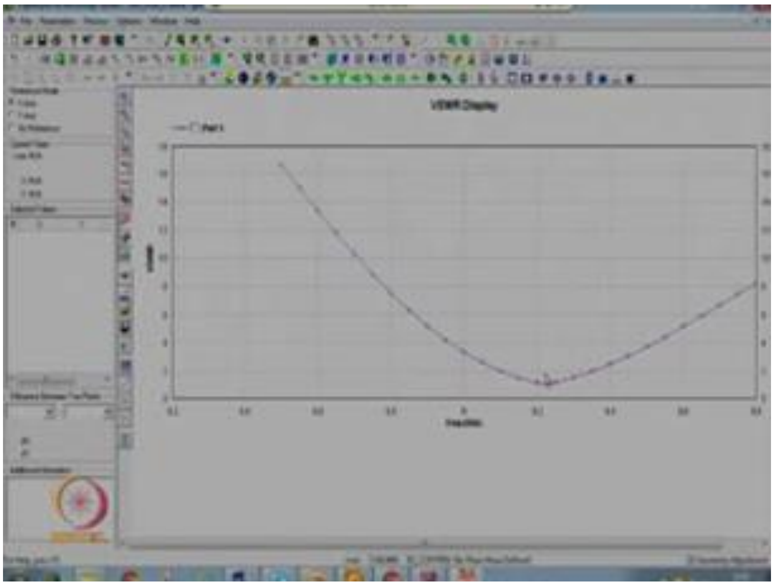

Next is VSWR, VSWR too is equivalent to S 11 or minus 9.6 dB. So, for this you can see the VSWR to bandwidth is from this point which is approximately 9.1 and this is approximately 9.35. So, you can see 250 megahertz bandwidth this is the VSWR float.

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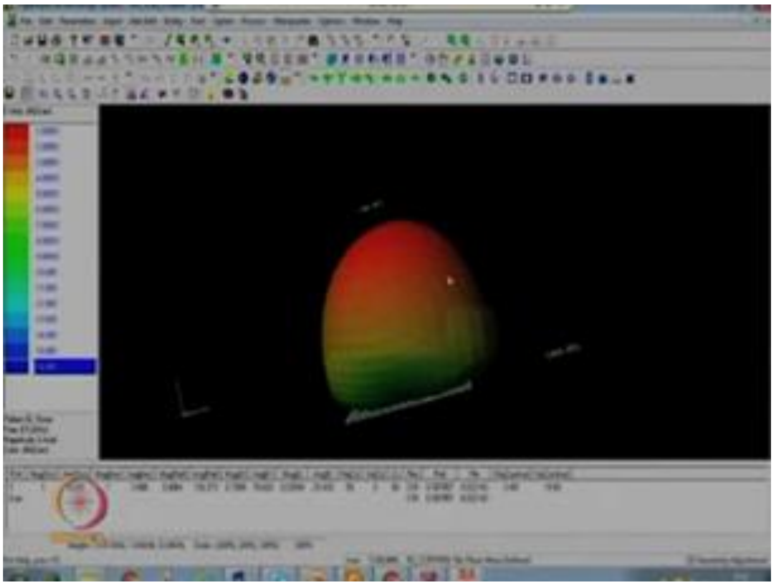

Next you want to see the radiation pattern gain directivity you can go to the window option, window here you can see the 3-D radiation pattern also. There are various tools are there gain versus frequency, effective gain versus frequency, axial ratio efficiency.

So, first you want to see the 3-D radiation pattern you can go to the 3-D radiation pattern just press. So, you can see from this, this is our 3-D radiation pattern.

You want to see the 2-D radiation pattern close this, 2-D radiation pattern define 2-D radiation pattern a new window will appear.

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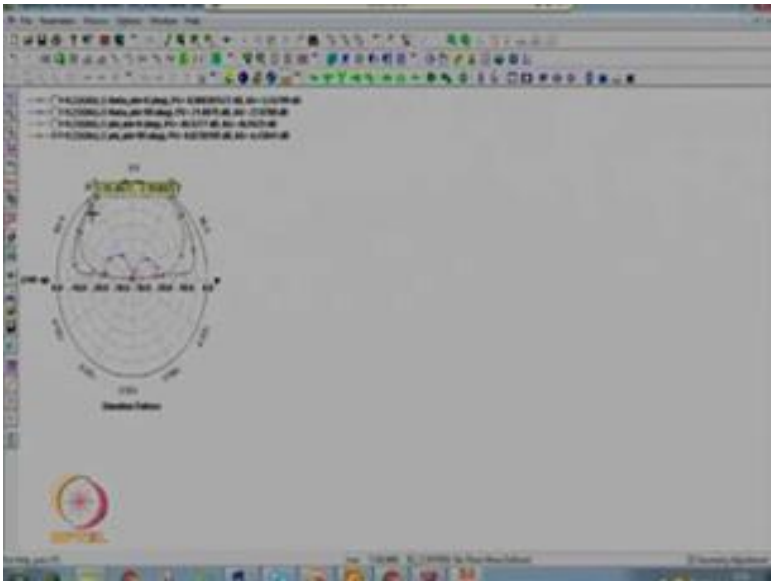

Here you will see add float option click on this, because the antenna is resonating at approximately 9.3 gigahertz. So, you can select the frequency 9.22 approximately which is nearly equal to 9.3. So, you want to see the radiation pattern in E plane, H plane all you have to select E theta and this angle phi 0 click on this this will give you E plane which will give you the E theta 5 0 then E phi 5 0 you have to select 4 loads E theta 5 0, E phi 5 0, E theta 590, E phi 590. E theta 5 0 will give you e co - e co means, electric co polarization electric co polar, co polar component

Similarly, E phi 590 which give you H co pole, in the H plane the co polar component and these 2 components E phi 5 0, E theta 590 will give you the cross polar component. So, next task is to select the load style load style can be in the form of polar plots it can be in the form of Cartesian plots. So, we have option of Cartesian and polar we generally go for polar plot, select polar. Next is scale style you can see the radiation pattern in normalized form or in terms of its gain value or directivity value, it depends upon the option you select scale style dB gain if you select this option then it will show you the radiation pattern maximum value will be equal to the gain of the antenna at that frequency. So, generally we see the normalized radiation pattern to see the normalized radiation pattern select dB custom then press ok, then continue.

Now, you can see there are 4 plots first plot is you can see this one this is e co, E theta 5 0, second - this curve which shows you the cross polar component, third one is also cross polar component in H plane, but very small. So, it is less than minus 40 dB. So, it is not possible to show in this plot next plot is E phi 590 which gives you the H co pole, co polar component in the H plane. So, this is the radiation pattern.

You want to see the beam width of this antenna for 3 dB you can click on this for minus three dB because maximum value is 0 dB and for minus 3 dB you can approximately you can see this is minus 2.95, approximately 3 dB. So, in the right side also you can see 2.9 which is approximately 3 dB. So, beam width is approximately minus 41 degree to minus 41. So, 82 degree is approximately the beam width in the H plane and similarly you can find the beam width in the E plane also because this is a square MSA. So, beam width in E plane and H plane are both same.

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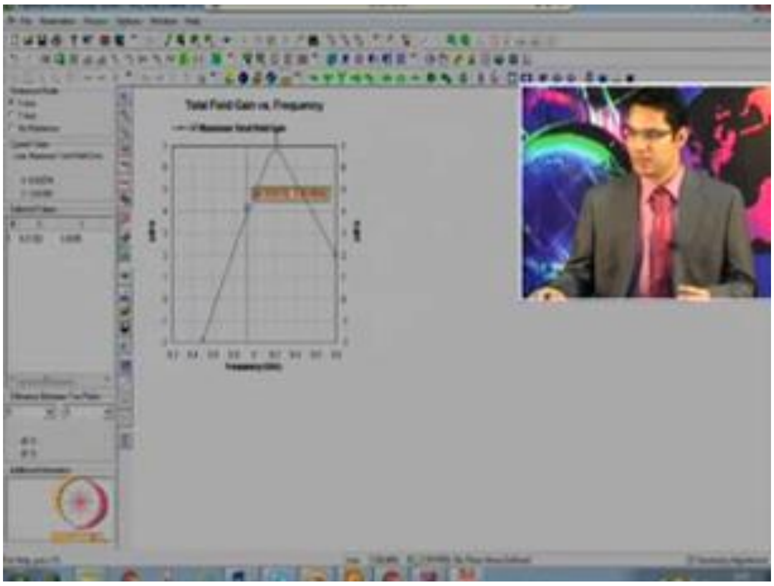

Next is you want to see the gain plot go to the window select maximum it will give you the maximum value of the gain at every frequency sample. So, you can see at approximately at 9.25 gigahertz gain is maximum which is around 6.8 dB i.

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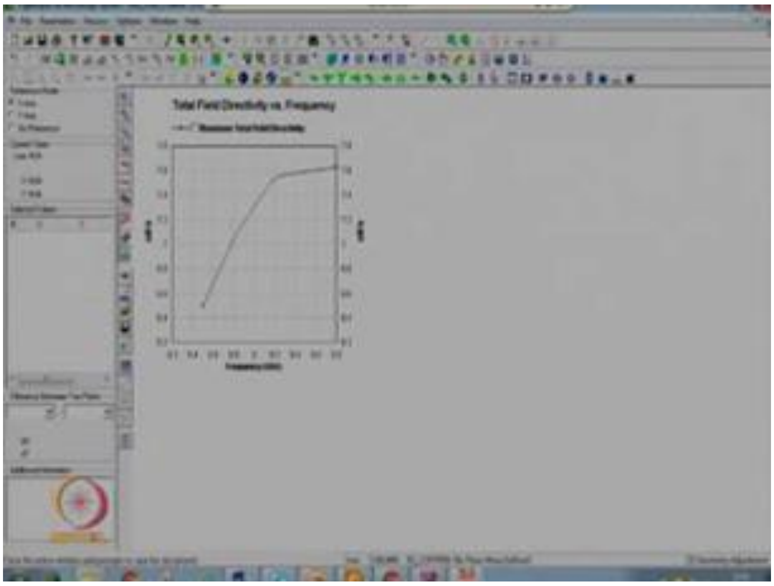

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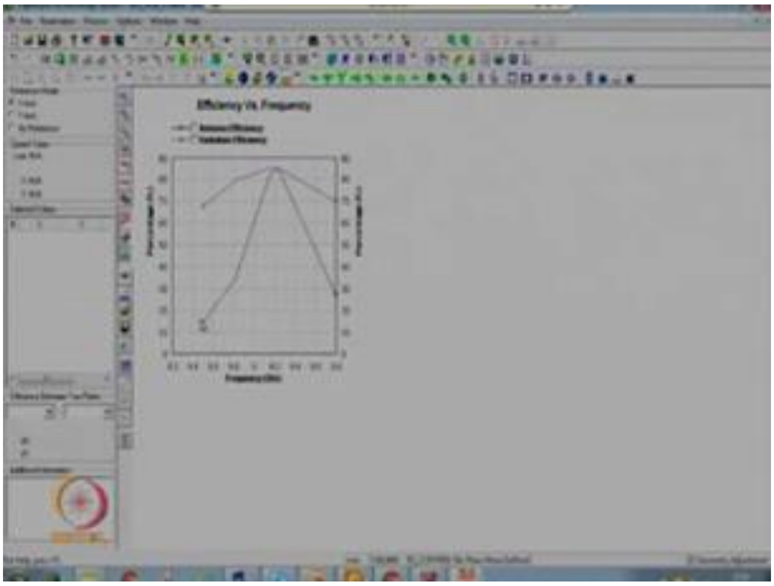

Similarly, you want to see the directivity there is an option to see the directivity versus frequency, maximum press this is the directivity, next you want to see the efficiency there are various efficiencies defined antenna efficiency radiance efficiency and some other efficiencies. So, let us see the antenna efficiency and radiance efficiency. So, this curve shows the radiation efficiency this curve shows the antenna efficiency

In this way you can design a simple microstrip h antenna. In this design we have taken the ground plane as infinite size, but in reality we have a ground plane of finite size. So, now, we will design the microstrip patch antenna on a finite ground plane.

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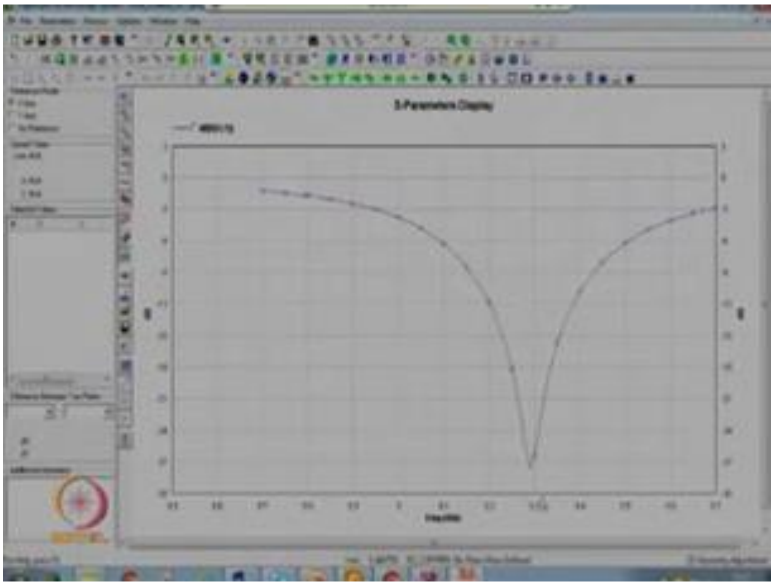

Select new then to design a microstrip antenna on a finite ground plane first task is select the z is equal 0 layer and in this window you can see the real part of the conductivity is 4.9 10 to the power 7. So, it gives you the conductivity value of the ground. So, ground has the conductivity of very large 4.9 10 to the power 7 which is approximately you can say very high value to define the ground plane as a finite size you have to first replace this value with 0. So, after replacing this by a 0 everything at z is equal to 0 is not a metal it is a (Refer Time: 16:18). So, press ok.

Now, at z is equal to 0 there is no ground plane next task is to define a dielectric layer same dielectric layer you can take 0.787 then dielectric constant at the 0.2 10 delta 0.001 then press ok and then press ok. Now you can define a size of a ground generally the size of a ground plane you can say 12 h more or you can say 6 h more on every side of the patch. So, first design a patch at z is equal to 0.787 same procedure to design the patch now we have a patch at z is equal to 787.

Next task is to design a finite ground plane of size which is greater than the patch size by an value of 6 h on every sides. So, you can say 6 h on this sides, 6 h on this side, 6 h on this side, 6 h on this side where h is the thickness of the substrate. So, thickness of the substrate is 0.787. So, you multiply it by 6. So, you can take 5 mm on every side. So, the size of the ground plane is because the size of the patch is 10.2 by 10.2. So, size of a ground plane you can take as a 10 plus 12 into h. So, 10.2 plus 12 into h is approximately 20 mm this finite ground will be introduced at z is equal to 0. So, change the z coordinate in this case 0, length is approximately 20 mm, width approximately 20 mm. So, now, you can see this green patch represents the ground plane and this orange colour represents the patch.

So, next is to give the feed entity same procedure probe feed to patch, so give the feed location press enter then number of segments for circle and the radius of the connector. Now we have designed a microstrip patch antenna on a finite ground plane, now you can save this geometry MSA X-band with finite ground save next task is to simulate it frequency is 12 gigahertz. So, in this case we have taken as a finite ground plane it will also account the ground plane effect, it will take more time compared to the infinite ground plane size. So, in this size you can take less number of file approximately 20 then AEC enable take AEC layer as 1 then enter 8.7 to 9.7, take number of points as 1 0 1. So, that it samples our range of frequency at 0.01 gigahertz press you want to see the radiation pattern click on this press ok, next is to simulate press ok.

Now, this antenna is on a finite ground plane. So, in previous design we have taken as infinite ground plane which is not the real scenario, in the real application you have to use a finite ground plane. So, in this simulation we have taken as a finite ground plane.

Next we will go for a staged MSA. Now simulation is over you can add graph s parameter dB, you want to see the smith chart - smith chart, VSWR you can add VSWR then press ok. So, you can see the results and in the theories are already told that if you take the ground plane size 6 h on every side more than the patch size then the effect of the ground plane can be neglected. So, you can see the, it is also resonating at 9.3 gigahertz you can see the bandwidth for 10 dB you can see the bandwidth is approximately 250 megahertz.

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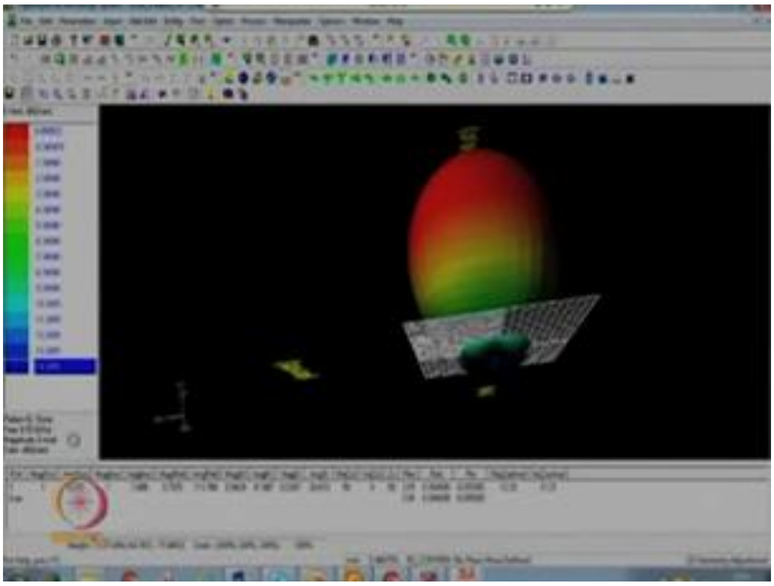

Similarly, you can see the smith chart, this is the VSWR plot, you want to see the gain plot maximum gain. So, this is the gain plot. Similarly you can see the radiation pattern 3-D radiation pattern you can see 2-D radiation pattern this is your radiation pattern, this is at 8.7 gigahertz, in this left side you can see frequency is 8.7 gigahertz you want to change this frequency press n it will go to the next frequency. So, now you can see 8.95 gigahertz 9.2 gigahertz 9.31 gigahertz. So, similarly you can see the radiation pattern at all the frequency.

Next we can make it a circularly polarized antenna, circularly polarized antenna you can design by given it a second feed on a y axis at equal distance as given on the x axis.

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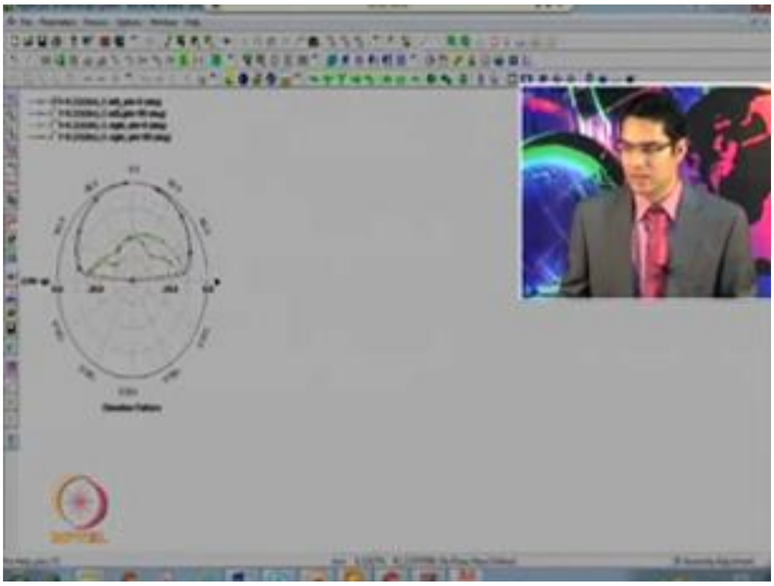

So, here we have given a second feed at the same location as given on the x axis on the first feed. So, you can simulate this for simulation. In the second field you have to introduce a 90 degree phase shift. So, to introduce a 90 degree phase shift you have to modify the inputs from this modify option you can click on this here you can see we have given 0 degree to the first input and 90 degree to the second input. So, then press ok, press ok, every other things are same then press. Now you will see this antenna will become circularly polarized antenna you will see the radiation pattern will give you the circular polarization, instead of linear polarization in single feed antenna

So, it is our. So, you can see it is resonating at approximately 9.3 gigahertz this is smith chart VSWR, now we want to see the radiation pattern at plot, we want to see the radiation pattern 9.3 gigahertz because this is a circularly polarized antenna. So, in this case instead of E theta E phi we will select E left 5 0, E right 5 0, E left 590, E right 590 and the same polar load and scale style you can take as a custom for normalization then press ok, then continue. You can also modify the graph parameters right click on this window graph parameters then start from minus 40 dB and with 0 because it is normalized with respect to the gain. So, NAND value 0 and step you can take a step of 5 or 10 I have taken as a 10 as a step. So, now, you can see the first plot is E left 5 0 and this is your plot.

For second this is your E left 590 other are two plots are E right 5 0 and E right 5 90 these both values are less than the E left value. So, from this you can say that this antenna is left and circularly polarized antenna because the left component value is greater than the E right component value.

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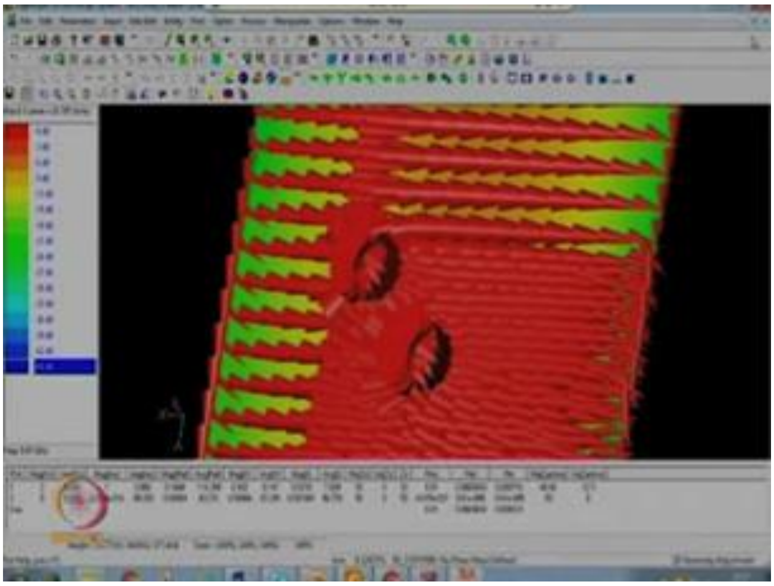

You can also see the current distribution, you can see the current distribution by going to the window option then in the window option you can see there is another option 3-D current distribution display - click on this and you can see a new window will appear in this there is option menu, in the option menu you can click the show 3-D scalar current. After that you can see the 3-D vector current option will appear. So, click on this and on this you can see this is your current distribution you can change the size of this vector go to the option then set graph parameter from this you can change the vector size, vector size is here 0.44 you can modify it to 2 3 any value then press ok, you can see now the vector size is changed and the frequency is 8.5 gigahertz press n so that you can go to the next frequency, so 9.15, so it is 9.3 gigahertz, 9.4. So, this way you can see the current distribution at any frequency value.

So, you want to see the axial value because main property of a circular polarization is its axial ratio is less than 3 dB because axial ratio it is the ratio of major axis to the minor axis. So, the major axis is equal to the minor axis it will give you the value equal to 1. So, axial ratio 1 is equivalent to 0 dB. In practical scenario we generally take any value less than 3 dB will be treated as a circular polarized antenna. So, in axial ratio plot at 5 is equal to 0 the axial ratio value then click 5 is equal to 0, then press ok.

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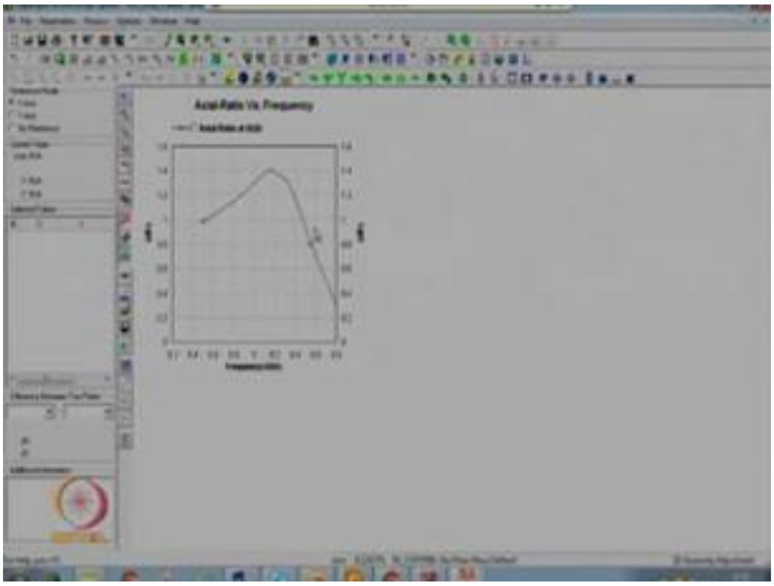

You can see the axial ratio curve in the entire range you can see the axial ratio is less than 1.4 dB. So, you can say that this antenna is left hand circularly polarized antenna with axial ratio less than 1.4 every value which is less than 3 dB will be treated as a circular polarized antenna in general if a value is greater than 3 dB an less than 6 dB it is treated as a elliptical polarized antenna and greater than 6 dB generally treated as a linearly polarized antenna. So, for single feed if you see the axial ratio plot you will see the axial ratio will be greater than 6 dB.

So, in this case we now designed a circularly polarized antenna. So, in today's lecture we have designed two antennas - one is a single feed linearly polarized square MSA with infinite ground plane with finite ground plane. Next we have designed duel feed circularly polarized micro strip antenna with infinite ground plane; you can also design the same antenna using finite ground plane and see the results.

In the next lecture we are going to design a staged MSA to increase the bandwidth because in today's lecture we have seen simple microstrip antenna have a very less bandwidth which is we have seen 250 megahertz approximately 3 percent. So, to increase the bandwidth we will design a staged microstrip antenna and we will also design some other antennas like 3-D wire antenna very simple example of a 3-D wire antenna is monopole antenna. So, we will design these two antennas in the next lecture.

Thank you.