Antennas
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Module - 12
Lecture - 55
IE3D Session TA-III

Hello everyone in today's lecture we will see how to design a stacked microstrip antenna using IE3D.

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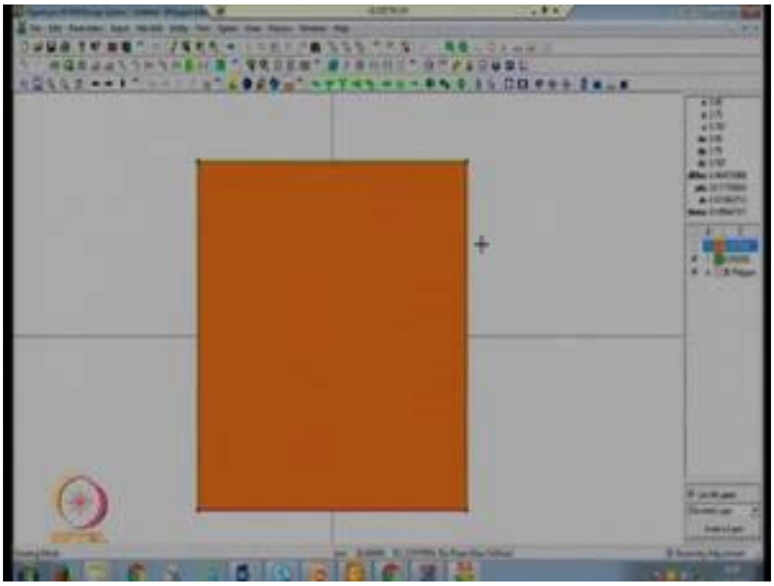

So, let us start how to design an IE3D first we will have to select a new file, here we are going to use infinite ground plane. So, there is no need to change the sigma value at z is equal to 0. So, next we have to introduce one dielectric layer. We are going to use the same substrate as we have used in the previous designs. So, the layer thickness is 0.787 the dielectric constant of the substrate is 2.2 low stangent is 0.001 now press ok, now press ok.

The dimensions of the patch on h is equal to 0.787 and because we are going to design a stacked geometry. So, we are going to introduce one more substrate layer on which we will design another patch and that dimensions you can find using the formulas available in the book or you can also use a line gauge option of the IE3D. So, first design a simple microstrip patch antenna the dimension found out to be 10.5, 10.5 by 10.5 at thickness of the substrate is 0.787 now press ok. Now we have designed a one patch at z is equal to 0.787 because in a stacked geometry we have one substrate below this there is a infinite ground plane on above of this substrate there is a metallic patch that we have designed now. Now to design an electromagnetically coupled stacked microstrip antenna we have to introduce some air gap, we will introduce the air gap between another layer of substrate we will take another layer of substrate. Another layer of the substrate we can introduce one more patch on the above of the upper substrate on the bottom of the upper substrate. In the first case if we design the patch on the top of the upper substrate it is simply known as electromagnetically coupled microstrip antenna.

If you design this patch on the bottom of the upper substrate it is known as electromagnetically coupled microstrip patch antenna in inverted mode. So, we are going to design EMCP in inverted mode. So, first we have to go to the basic parameter window. So, select this option basic parameter.

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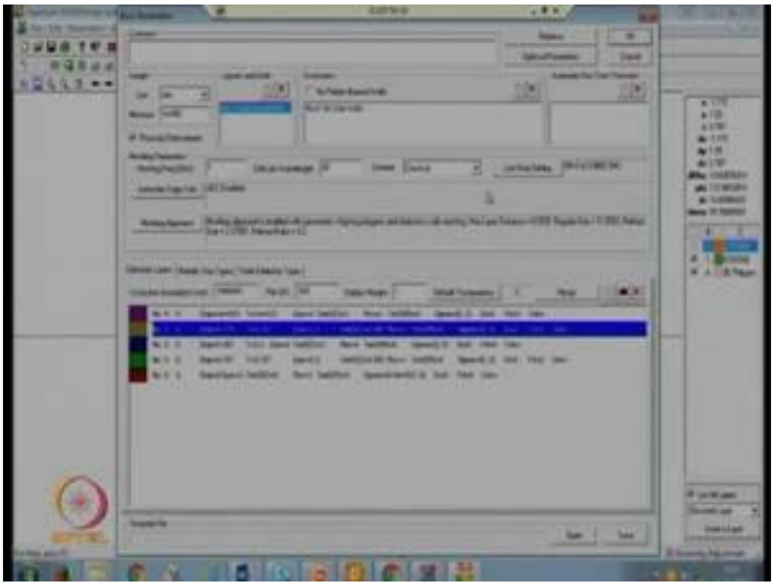

Now, we have to introduce one air gap layer. So, to introduce the air gap there are two options to create a layer either you use this option or you use the next one. If you use this option you will only have to give the thickness of the substrate no need to give the z top value. So, to introduce one air gap layer click on this substrate layer because we are going to introduce air on the above of this substrate, so click on this substrate layer than go this option click on this. Now, substrate thickness here the substrate thickness is the air gap thickness.

The air gap thickness that we have optimized is 2.6 mm. So, substrate thickness which is the air gap which is 2.6 the dielectric constant, the dielectric constant of the air is 1, so 1 is here low stangent is 0 and other values will remain same, now press ok. So, we have introduced one more layer at z is equal to 3.387 which is about 2.6 mm from the below substrate layer. So, we have introduced one air gap layer. Next task is to generate one more substrate on this layer z is equal to 3.387. So, we are going to introduce one more substrate by clicking on this click on this and introduce a new layer with thickness is equal to same as we have because we are going to use the same substrate with same characteristics. So, the substrate thickness is 0.787 dielectric constant of the substrate is 2.2 low stangent is 0.001 now press ok.

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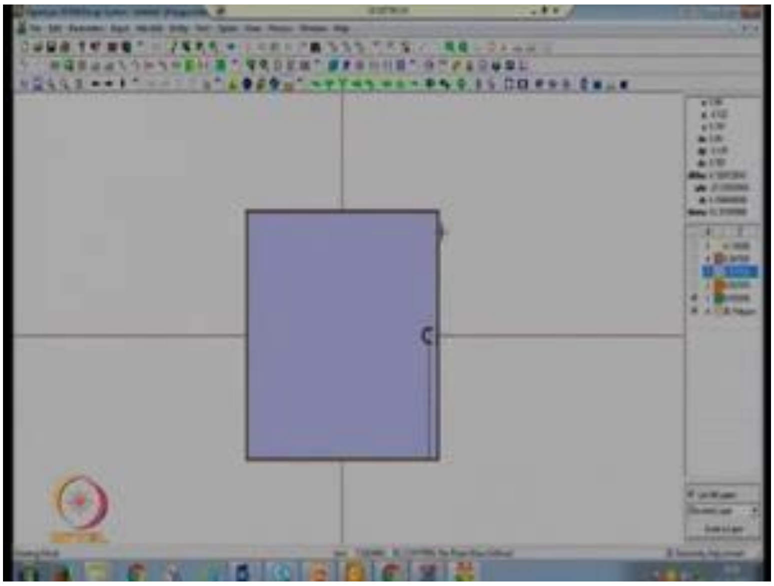

Now, we have introduced one air gap above air gap we have used one another substrate on the bottom of the upper substrate we are going to design a patch which have a dimensions that we have calculated using the formulas and the value is 10.7 by 10.7. So, click on the rectangle and in this case the z coordinate will be equal to 3.387 this is our substrate. So, thickness of this substrate is 0.787 after that we have air gap of 2.6, so the z valve will be equal to 3.387. So, at 3.387 we have to design one patch with value 10.7 by 10.7 now press ok. So, you can see at 3.387 we have introduced another patch and at

0.787 we have one another patch with dimensions less than the patch dimensions at 3.387.

So, next task is to feed this antenna. We are going to feed the lower patch and the upper patch will be electromagnetically coupled to the lower patch that is why this antenna is known as electromagnetically straight microstrip antenna. So, to feed the antenna go to the entity pro feed to patch and the optimized feed location for this antenna is x is equal to 4.8 press enter 16, in this case to optimize we have taken as a radius of the probe is 0.3 mm press ok. In this case you can see the feed location is no more l by 6 it is much higher than l by 6 why? Because in this case the bandwidth is very much higher than the simple micro strip antenna, bandwidth in terms of VSWR or you can say impedance variations. So, if the impedance variations are less bandwidth will be more. So, in this case the impedance variations along the patch are very less. So, at the edge the impedance is approximately equal to 50 ohm.

So, that is why we have shifted our feed location towards the edge. So, on next we have to save this geometry. So, save this geometry as EMCP MSE; now simulate this geometry take 30 mess cells per wave length enter the frequency. So, as this antenna is very high bandwidth, you can simulate this antenna from 8 gigahertz to 11 gigahertz. So, number of points you can take as a 301. So, next is AEC enable, press ok, then radiation pattern press ok because this antenna have a multiple layer. So, this antenna for simulations it will take more time compared to simple microstrip antenna.

The advantages of using this stack geometry is the bandwidth of this antenna is large compared to the simple microstrip antenna and also you will see a little improvement in the gain if we decrease the number of mess cells then definitely it will take less time, but may decrease your accuracy of the results.

So, now you can add plot s parameter in dB you want to see the Smiths Chart, Smith Chart at VSWR plot we have added 3 graphs you can close this window.

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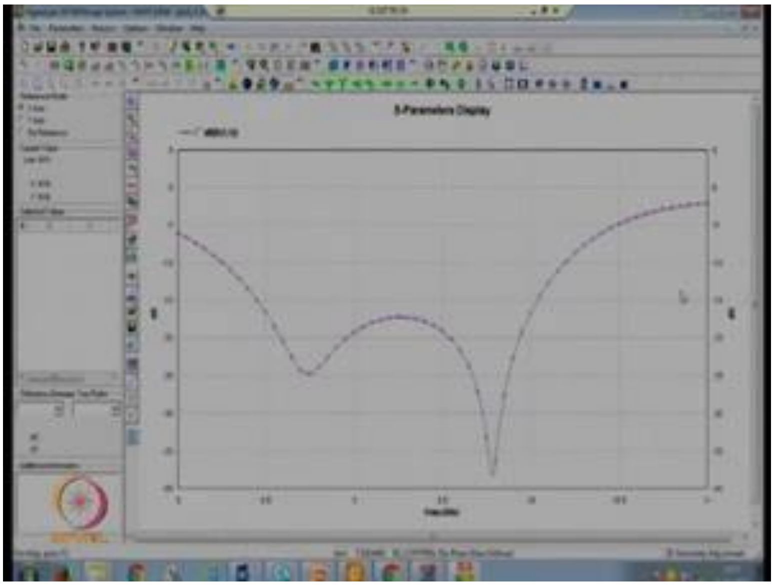

And now you can see the results - s parameter is less than minus 10 dB from approximately it is 8.25 you can see 8.25 and up to 10.2, so very large bandwidth. It is approximately 2 gigahertz if you calculate in percentage it will give you roughly 21 percent. So, a very large bandwidth we have obtained using stacked geometry.

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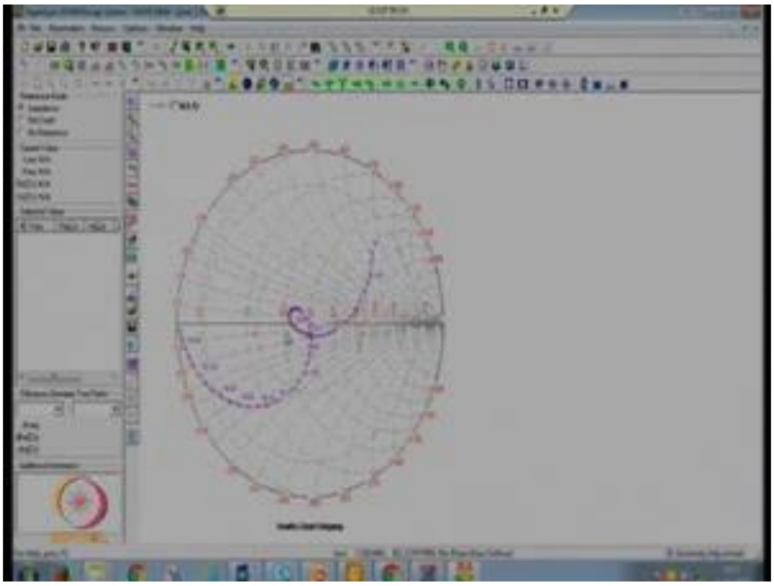

This is the smith chart, you can see a loop - this loop is because there are two patches resonating at different frequency this you can also see in the s parameter, one patch is resonating nearly at this frequency another is resonating at this frequency. So, you can see the bandwidth is improved by approximately 18 percent.

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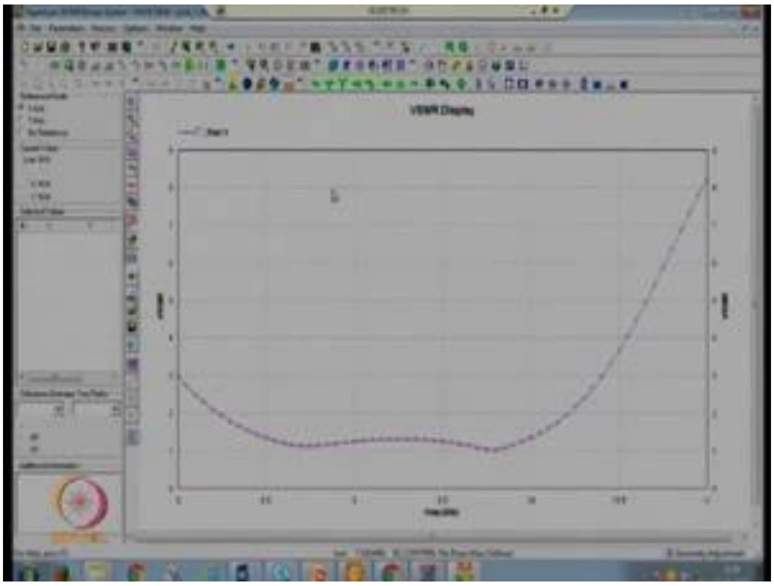

This is a VSWR plot VSWR is less than 2 from 8.2 to 10.2. Next we want to see the gain you can see the gain press maximum ok.

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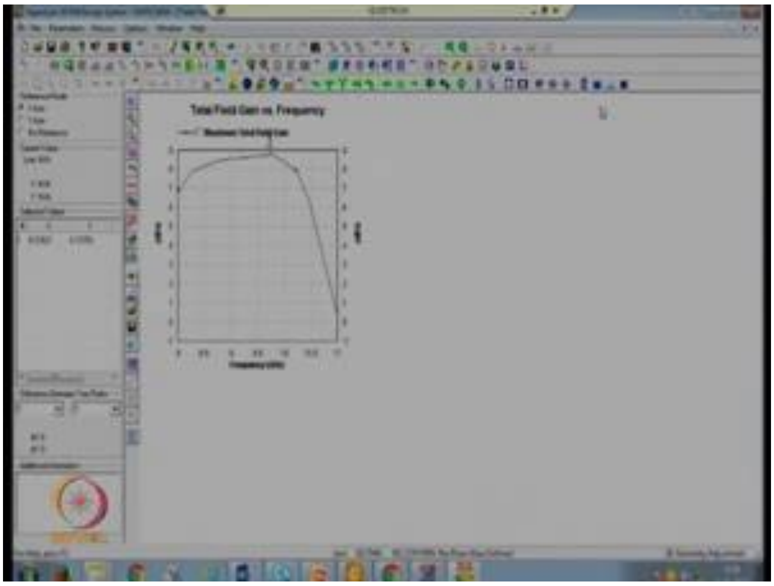

And you can see gain is also increased in the previous simple MSA design the gain was approximately 6.9 or you can say 7 dB i, in this case the maximum gain is 8.7 dB. So, approximately 1.7 dB improvement in the gain and you want to see the 3-D geometry of this design go to the window 3-D geometry display.

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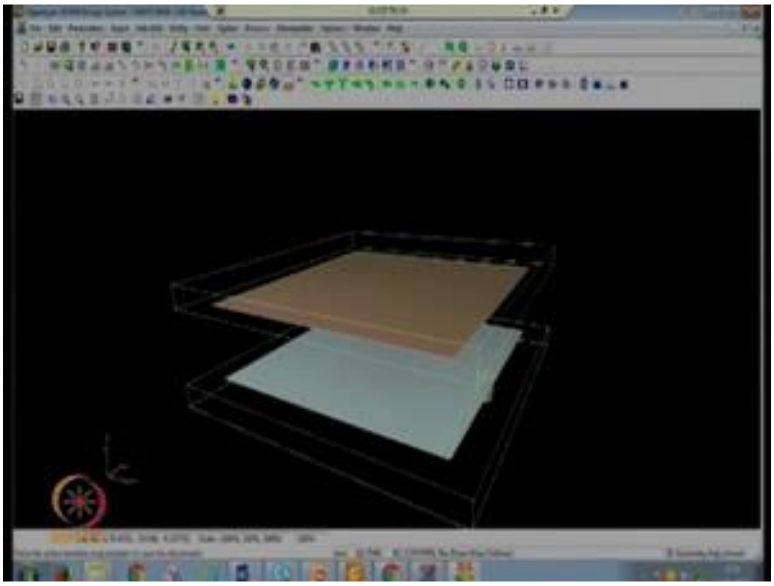

So, this is 3-D geometry of our antenna. So, you can see this, this is our lower substrate, this is upper substrate, on the bottom of the upper substrate we have introduced one patch on the top of the lower substrate we have introduced one another patch and this is our coaxial feed we have given feed to the lower patch. So, this is the 3-D geometry you can see in realty it is not possible to suspend the upper patch or substrate on the air. So, you can use some sort kind of support on the four corners of the substrate.

So, this is electromagnetically coupled microstrip antenna next we are going to design a simple 3-D wire monopole antenna. We will design a monopole antenna on a infinite ground plane first and then we will go to the finite ground plane, so file new. For infinite ground plane there is no need to change the sigma value, now press ok.

Now, we are going to design a monopole at 750 megahertz approximately. So, if you find the height of a monopole antenna which is approximately lambda by 4. So, at lambda by 4 if you calculate it will give you 90 mm approximately and in this we are assuming that monopole is of cylindrical wire. So, cylindrical wire means we have to take a circle and the radius of that wire is 10 mm. So, the radius of that wire we have taken as a 10 mm at a height of you can say at a height of 90 mm. So, the value of centre z coordinate will be equal to 90 mm because we are going to design a circle at a height of 90 mm with radius of the circle 10 mm, then press ok. Now, you can zoom out.

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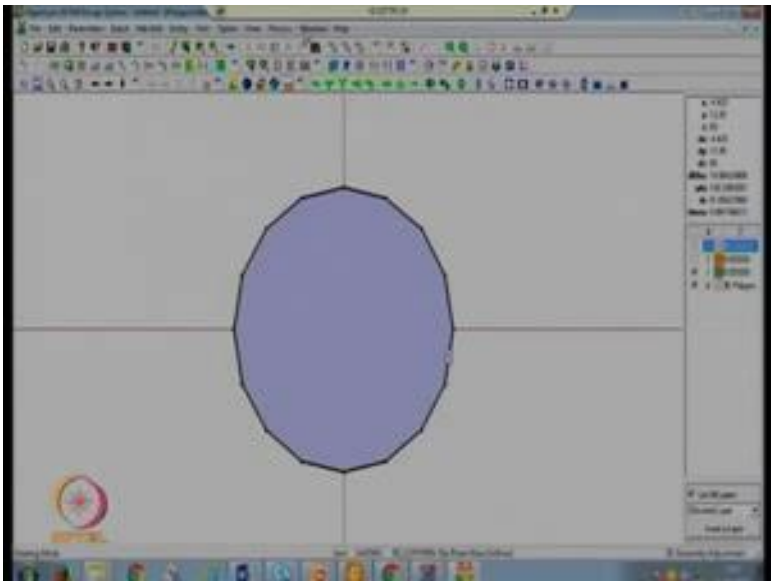

So, you can see there is a circle at a height z is equal to 90 mm. Next we are going to feed it; till now we have only designed one circle to design a cylindrical wire we have to feed it go to the entity, pro feed to patch because this circle is designed with centre 00. So, feed location will also be 00 and the number of segments of the circle 16 start z coordinate 0, end z coordinate 90, negative level 0, positive level is generally taken as a 1 by 100. So, if you take 1 by 100.9 and radius we have to take the same radius of this feed as we have taken for the circle at z is equal to 90 mm. So, the radius of the circle is 10 mm then press ok.

Now, this is your simple monopole antenna with infinite ground plane. You can see the 3-D geometry by going to window option then 3-D geometry display. You can zoom out this and this is a simple monopole antenna with height 90 mm and radius of a wire 10 mm.

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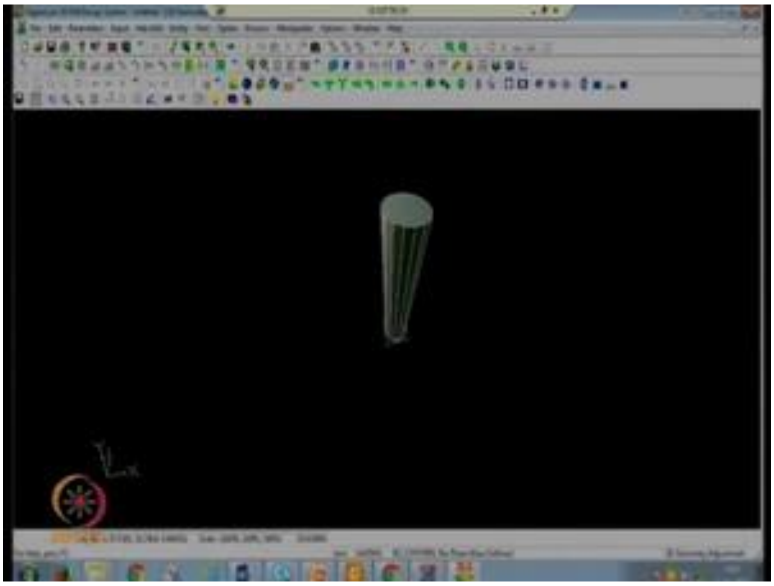

So, next you want to simulate it, before simulation we will save this geometry monopole with infinite ground plane save. So, this is a monopole antenna with infinite ground plane. So, meshing frequency you can take as a 2 gigahertz because this antenna is designed at 750 megahertz approximately automatic s cells you can take as a 1 and number of mess cells you can take 30.

Now next task is to enter the frequency components, you can simulate it from 0.5 gigahertz to 1.5 gigahertz. You can take number of points as, because the difference is 1.5 minus 0.5 which is 1 gigahertz. So, if you want to take the step of 0.01 gigahertz we have to take 101 number of frequency components now press ok, you want to see the radiation pattern, press ok, radiation patterns press ok, now simulate it. So, in this window you can add results s parameter dB you want to see the Smith Chart you can add the Smith Chart, VSWR.

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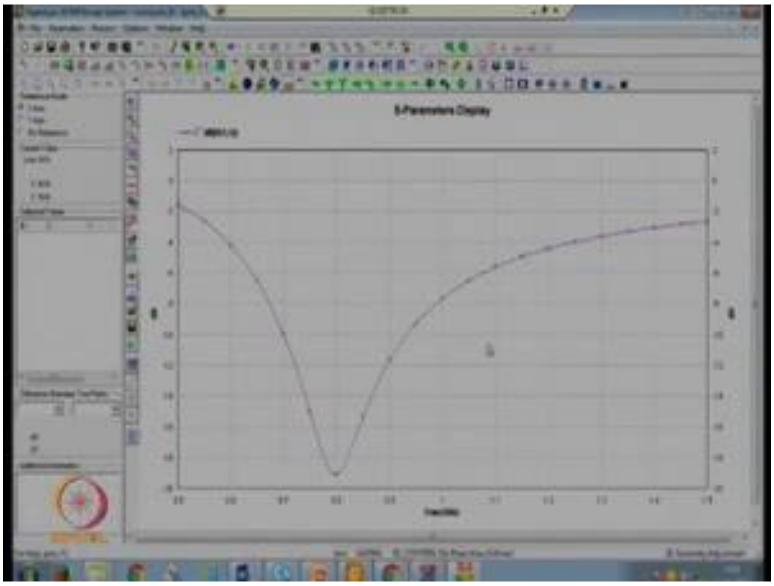

So, you can see this antenna is approximately resonating at 0.8 gigahertz which is 800 megahertz and the bandwidth of the antenna is from 0.7 to 0.93 gigahertz for minus 10 dB.

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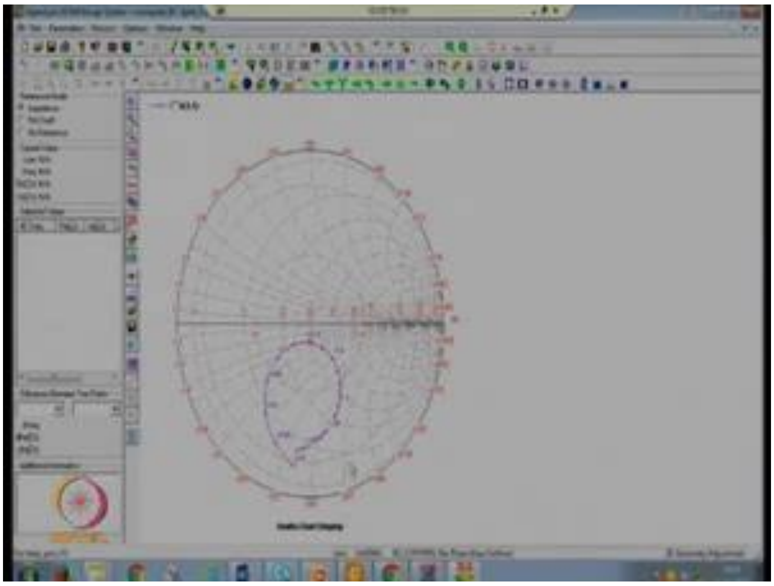

So, this is our s parameters, this is the smith chart, this is VSWR.

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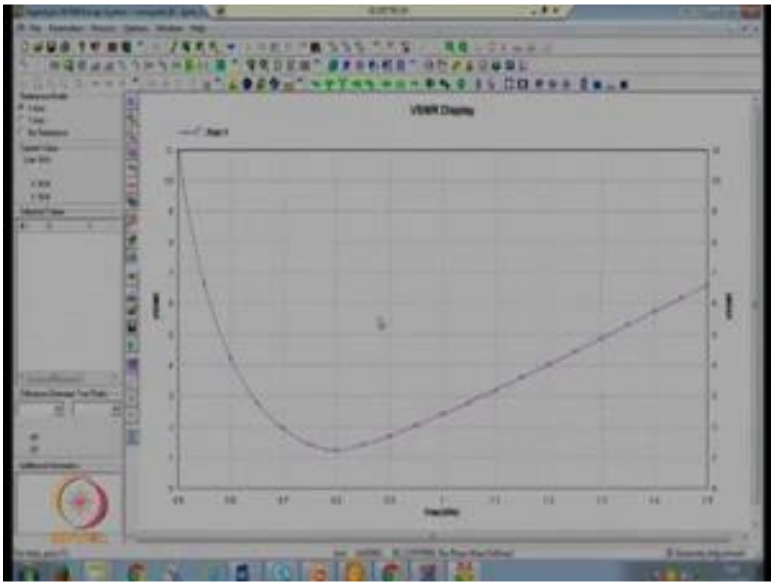

Next is to you want to see the radiation pattern 3-D radiation pattern; this is the 3-D radiation pattern.

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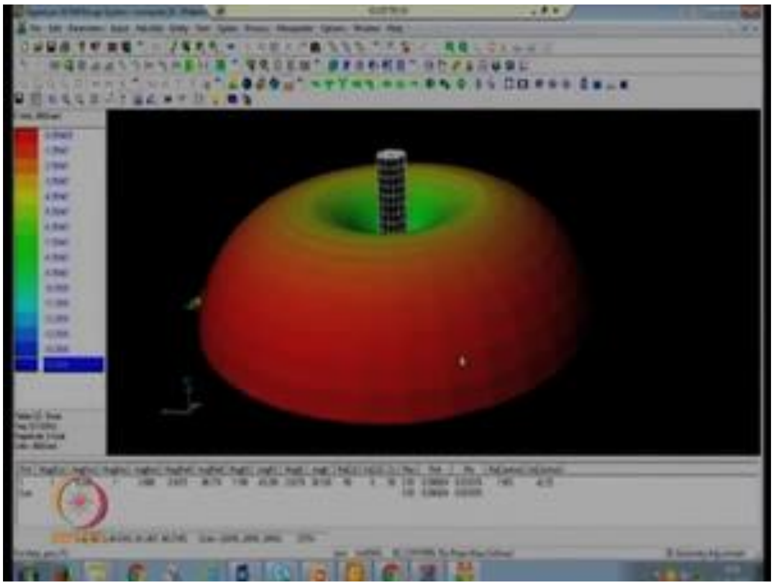

You can see there is no back lobes are there because we have taken the ground plane as infinite size. So, there is no radiations on the back side. Next we will design with finite ground plane then you will see there will be back radiations also. So, if you want to see the 2-D radiation pattern add plot because it is resonating approximate layer 0.7 to 0.95.

So, you can take as 0.75 as one point E theta E 5, 5 0 and 590 you want to see in the polar form.

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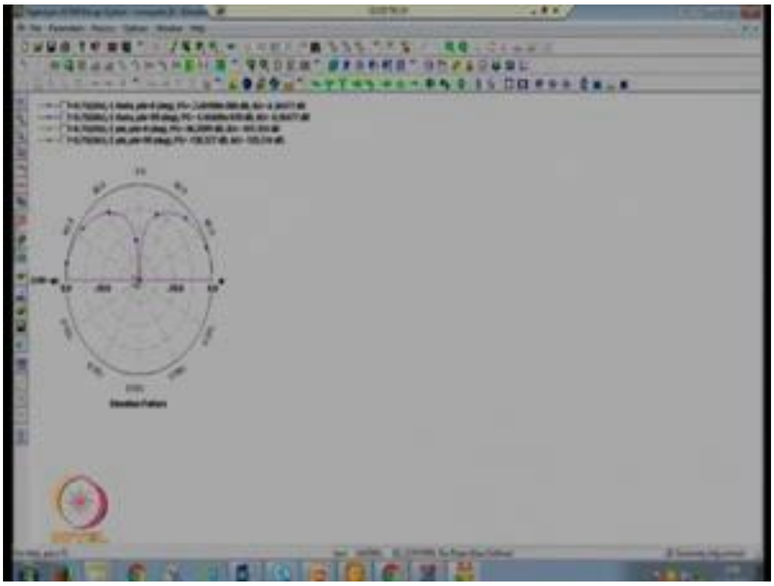

So, this is the, you can see the radiation pattern is half of figure of 8, you can modify the graph parameters. So, this you can see there is no back radiation because we have taken the size of a ground plane as infinite. You want to see the gain plot - go to the window gain versus frequency next press ok.

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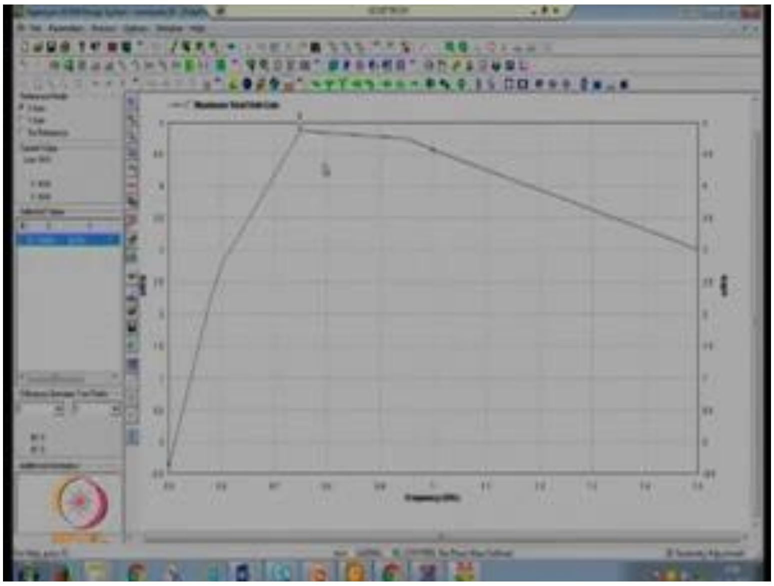

So, approximately you can see the gain over the bandwidth is more than 4 dB the maximum gain is approximately 4.8, you can see the maximum gain is 4.8 at 0.75 gigahertz. So, this is the simple monopole antenna with infinite ground plane.

Next we will design a simple monopole antenna with finite ground plane. We will generate a new file. So, in this case at z is equal to 0 we will replace this 4.9 into 10 to power 7 value with 0. So, we have replaced the conductivity with 0. So, now, there is no ground plane at z is equal to 0. Now press ok, whatever we are going to design at z is equal to 0 will be of metal. So, at z is equal to 0 there is no ground plane. So, first of all we have to find out the radius of the ground plane because in this case we are assuming that the ground plane is of circular because we have taken the cylindrical wire. So, the symmetricity will not be lost if we take the circular ground plane. So, we have taken a circular ground plane after optimization or you can say because in the theory we have seen the ground plane radius should be greater than the lambda by 4 of the antenna.

So, you can take the radius of the ground plane is approximately greater than the height of the antenna which is lambda by 4. So, you can take as 160 mm or you can take more, you can optimize this value, now press ok.

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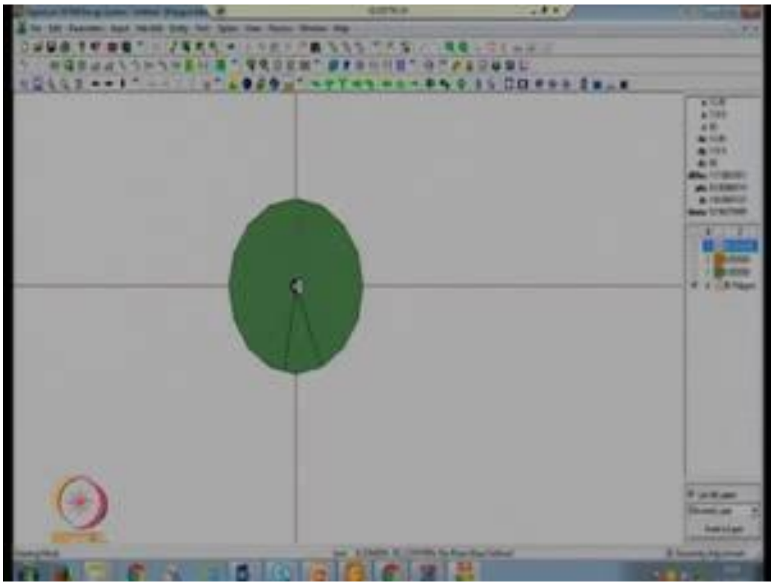

Now, you can see there is a one circle at z is equal to 0. So, this is out ground plane next we are going to design our monopole. So, the height of the monopole is 90 mm. So, take another circle, but at this time the height will be equal to 90 mm, put z is equal to 90;

radius of the monopole cylindrical wire is 10 mm now press ok. Now you can see there is another circle at z is equal to 90 mm.

Next task is to feed this antenna which will generate our monopole wire pro feed to patch. So, for pro feed to patch go to the entity, pro feed to the patch centre will remain 00, number of segments for circles 16 start z coordinate 0, end z coordinate 90, negative level which is 0, positive level 100 of a thickness of our antenna that is in this case the height is 90 mm, so 1 by 100th of 90 you can take as a 9 or a 1 by 1000 also in some cases if the height is very large you can take as a 1 by 1000. So, in this case you can take as a 0.9 and the radius of the wire is 10 mm, now press ok. .

So, this geometry is a monopole antenna with finite ground plane, you can see this using window option go to 3-D geometry.

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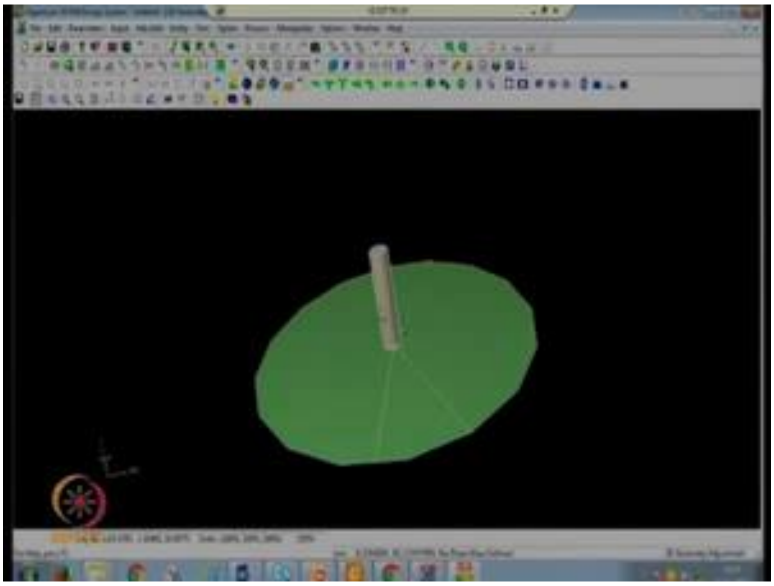

You can see this green color shows ground plane and this wire is our monopole. So, this is a monopole antenna with finite ground plane. So, we can change the radius of this finite ground plane easily. Next save this geometry, so monopole with finite ground plane now simulate this maximum frequency 2 gigahertz, we will take less number of mess cells because this we have designed with the finite ground plane if we take a more number of cells it will take very large time now press enter to give the number of samples, start frequency 0.5 gigahertz, end frequency 1.5, number of samples you can take as a 101 which will give you 0.01 gigahertz as a step, so press ok. You want to see the radiation pattern press ok, radiation pattern AEC enable, you want to see AEC enable, ok.

Now, in this case if we see the radiation pattern you will see the radiation pattern will no longer be a half figure of it, it will be a complete figure of it because we have not taken infinite ground plane we have taken a finite ground plane and a finite ground plane monopole antenna is equivalent to a dipole antenna. So, in this case the gain will also be less because there are some back radiations also. So, the area covered by the antenna is more, so gain will be less. So, now, you can add s parameter clause dB you want to see the smith chart now close this window, now you can see this antenna is resonating approximately at 780 megahertz and less than minus 10 dB bandwidth is from 0.7 to 0.89. So, this is resonating it, 787 megahertz, now you want to see the Smith Chart this is Smith Chart, now you want to see the 3-D radiation pattern then press ok.

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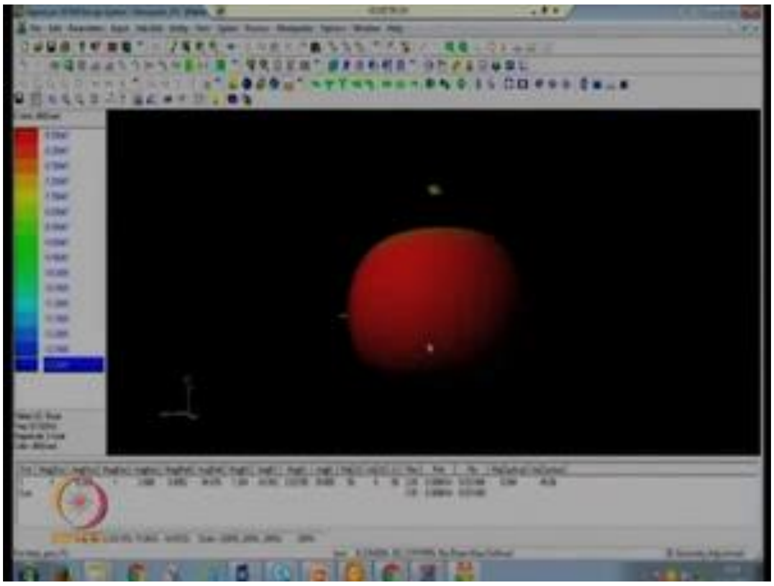

In this case you can see there are back radiations also. So, you want to change the frequency here it is 0.5 gigahertz, this 0.6 gigahertz, 0.75, 0.87 where it is resonating, this is not completely figure of it, but yes it is radiating more in the upper direction if you further reduce the size of the ground plane it will become figure of it. You can see the two d radiation pattern by going to the window option, then see 2-D radiation pattern add float because it is resonating at 0.75 approximately. So, you can take 0.75.

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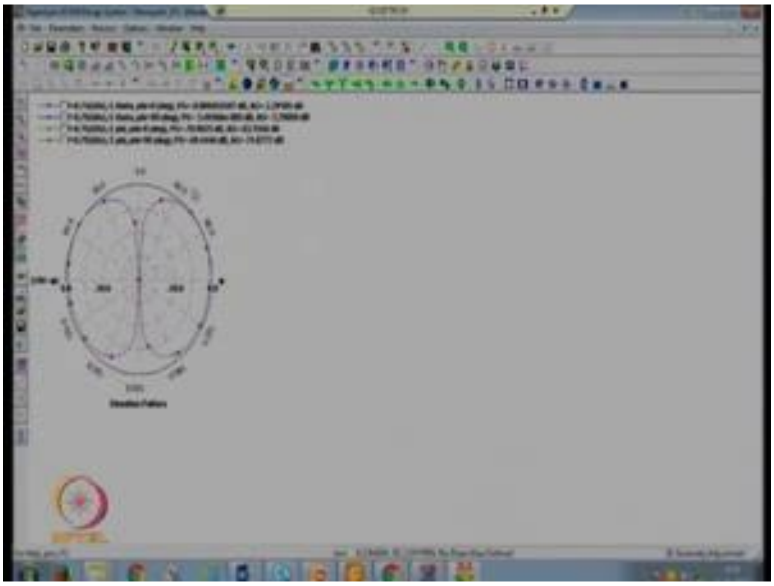

So, E theta, E 5, 5 0 and 5 90 you want to see the polar clot dB custom form then click continue modify the graph parameters minus 40 - 0 to 10. So, you can see proximately of figure of 8. So, this is our radiation pattern of a monopole antenna which is equivalent to a radiation pattern of dipole antenna.

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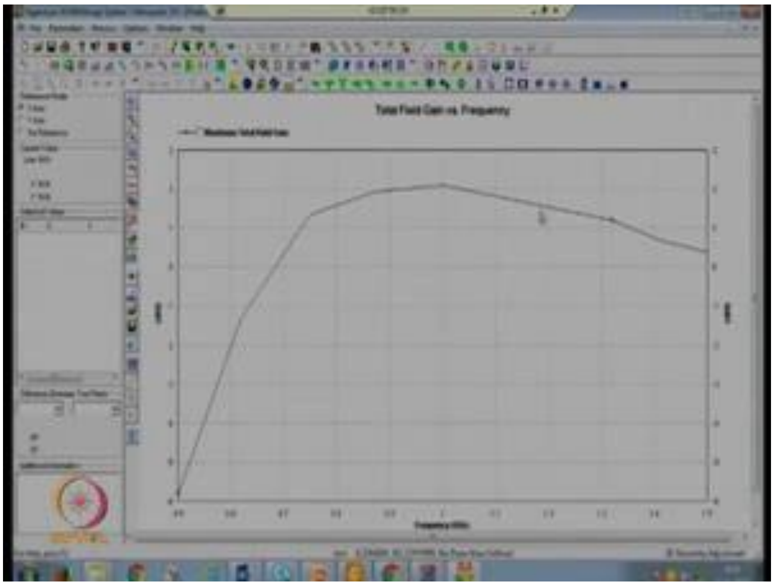

So, we can say a monopole antenna with finite ground plane is equivalent to a dipole antenna. Next you want to see the gain - gain plot go to the max, you can see the gain is two dB which is the gain of a dipole antenna, in previous case where we have taken as a infinite ground plane the gain was 4.5 dB. So, you can see the gain is also reduced because the area covered is increased. So, in this case gain is less because of finite ground plane.

So, with this I conclude today's lecture. In today's lecture we have designed one electromagnetically coupled microstrip antenna to increase the bandwidth and in that we have seen that gain is also improved by 1.7 dB, next we have designed one monopole antenna with finite ground plane and infinite ground plane.

Thank you.