Computational Electromagnetics and Applications
Professor Krish Sankaran
Indian Institute of Technology Bombay
Lab Tour - 3

(Refer Slide Time: 00: 30)

Student Teacher conversation starts

So Hemant could you please explain about this particular device.

Yes this is a rectangular pyramidal horn antenna. And main part of this horn antenna is this wave guide. This is a rectangular wave guide

ok

Have a dimensions 40mm by 120 mm

ok

And the length of this wave guide is 110mm

ok

And this is fit using a coaxial connector.

So this part is the coaxial connector

Yes this is a coaxial connector. And we can see inside this we have fit (())(01: 01) throat; this one.

ok

And this throat have a length of around Lambda by 4.

Ok

So this is working as a lambda by 4 monopole antenna . And the aperture part is this length of this aperture you can see the width, hieght of the aperture is around 450 mm

ok

And the narrower aperture dimensions is 320 mm. And the length of this flare is 250mm And the length of this wave guide is 110 mm So the total length of this antenna is 360 mm

Ok this is mainly used as a reference antenna

This is mainly used as a reference antenna for GSM and CDMA , so to measure the radiation pattern and the gain of any other antenna. You can use this as a reference antenna

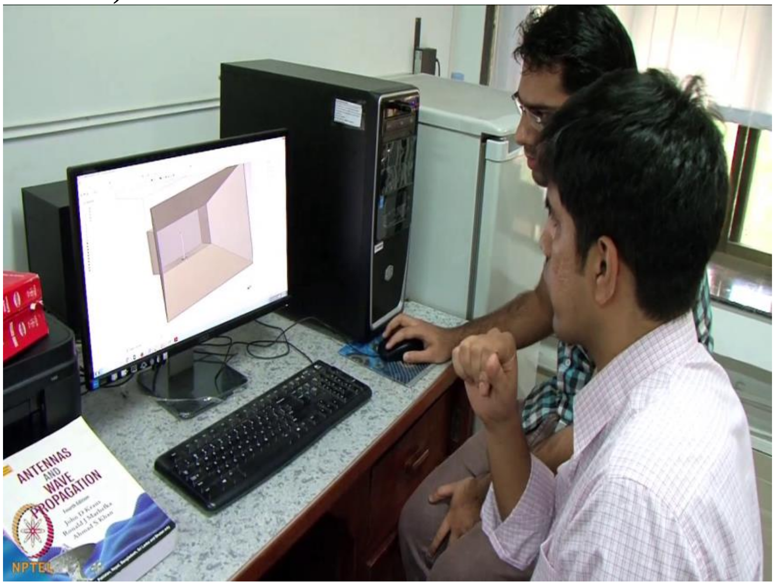
Ok, then I know that you have also simulated this antenna using some simulation tool.

We have used various simulation tools and we have simulated and we haveverified the results.

Could you please show us some of your simulation results.

ok

(Refer Slide Time: 02: 07)



So hemant so what you have basically showed us is physical horn antenna; so what you have done here is if I understood correctly. you have taken the physical dimension of the horn antenna. You have put into a simulation tool with all the dimensions in.

Yes sir

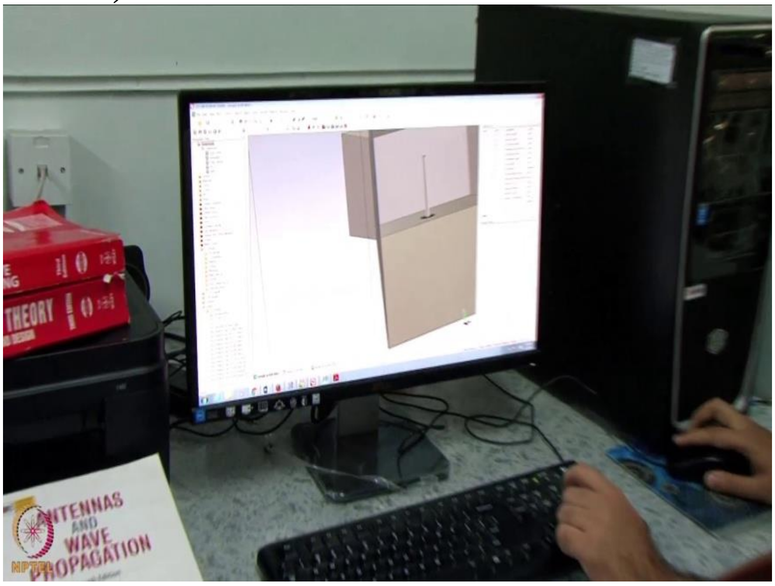
And you explain me the feeding is going to be very critical. So could you zoom it in and show us some

(Refer Slide Time: 02: 29)

This is a coaxial connector

Yeah

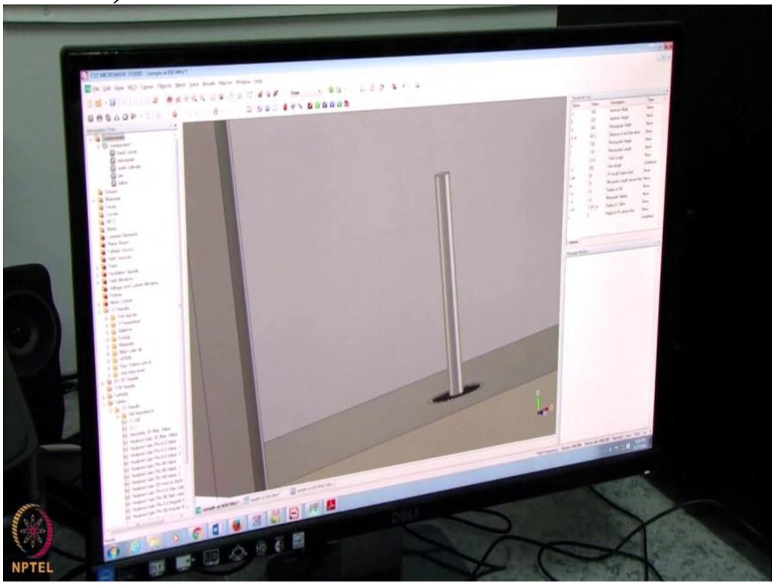
(Refer Slide Time: 02: 33)



And inside this we can see there is a throat;

ok

(Refer Slide Time: 02: 36)



This one and the length of this throat is around Lambda by 4 at frequency of operation around 850Mhz. So this is very important how to feed the antenna.

So I think the discretization around that part is going to be very critical; is it also possible to also see this discritization?

Yes we could show this discritization we can see like this

(Refer Slide Time: 02: 58)

Could you zoom it out umm zoom it in a little bit

Yes sure sir

(Refer Slide Time: 03: 02)

So this is the entire Flaring region

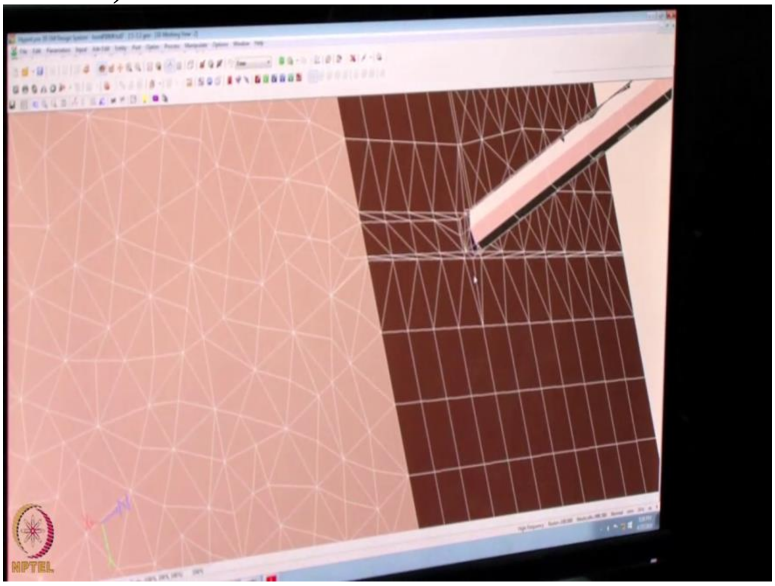
Yes Sir

(Refer Slide Time: 03: 05)

So when we see the small area is very very finely discritized

Yes

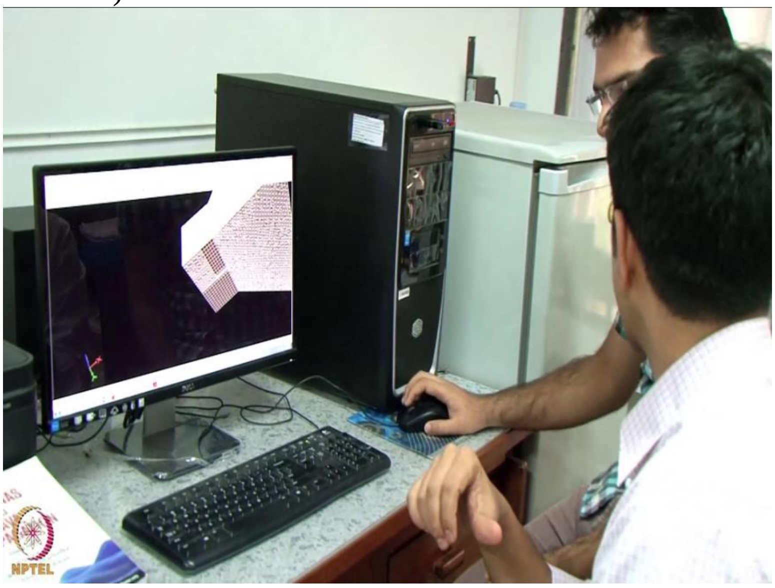
(Refer Slide Time: 03: 11)



And you have a tetrahedral measure also a rectangular mesh ok. So could you zoom it out and show us a little bit on the wave guide side.

Yes sir

(Refer Slide Time: 03:18)



So have the results of the simulation are comparable to ;

Yes it is comparable

So could you show us a little bit on the results

Yes sir

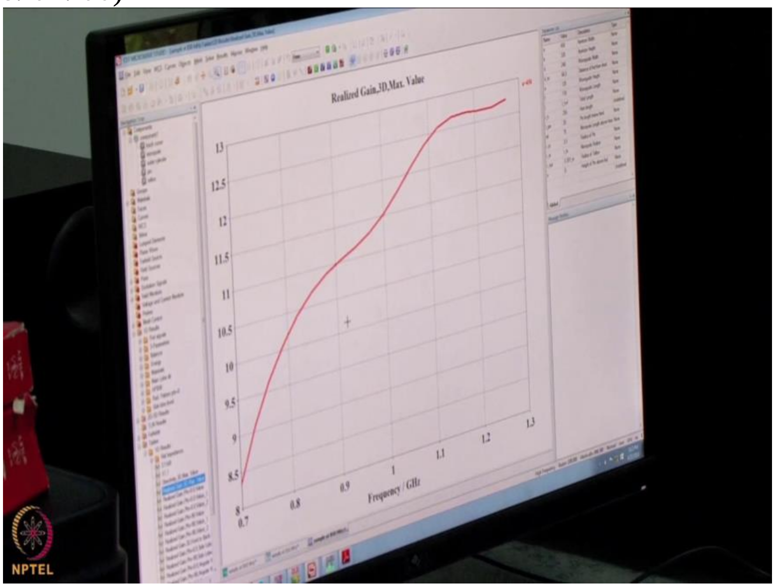
(Refer Slide Time: 03: 36)

Results first we all this about the first parameters the reflection(())(03: 40) and that can be seen from here one day results S 11 and we can see the S parameters are below 10 degree minus 10 degree from 700 to around 1139 Htz

ok

So the maximum, you can see the peak is at 850 MHz around minus 39 db.

(Refer Slide Time: 04: 00)



and the gain for this antenna can see this is varying from 8.4dbi to around 12.5 dbi. frequency range

So the main idea of simulation the computational simulation is to get reasonable idea about what is the S 11 parameters should be, and also the gain is going to be.

Yes ; because we are going to measure the radiational (())(04: 24) of other antennas, so we are making a reference antenna.

So the idea of this particular simulation is to get the good understanding of the reference antenna

Yes Yes

So that the other antennas which are measured based on this will be more accurately

I can also show you the i3D simulation for the same.

Yeah

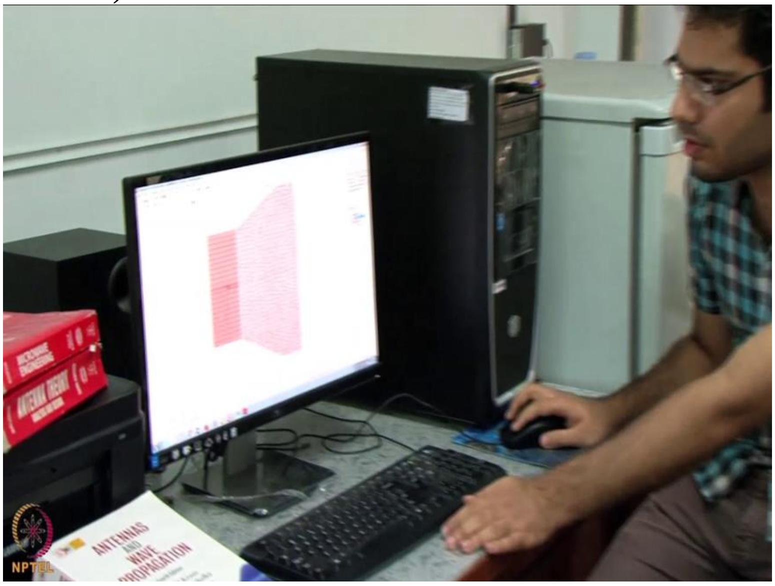
(Refer Slide Time: 04: 43)

So this is the meshing view

Could we look at the different dimensions of

Yes

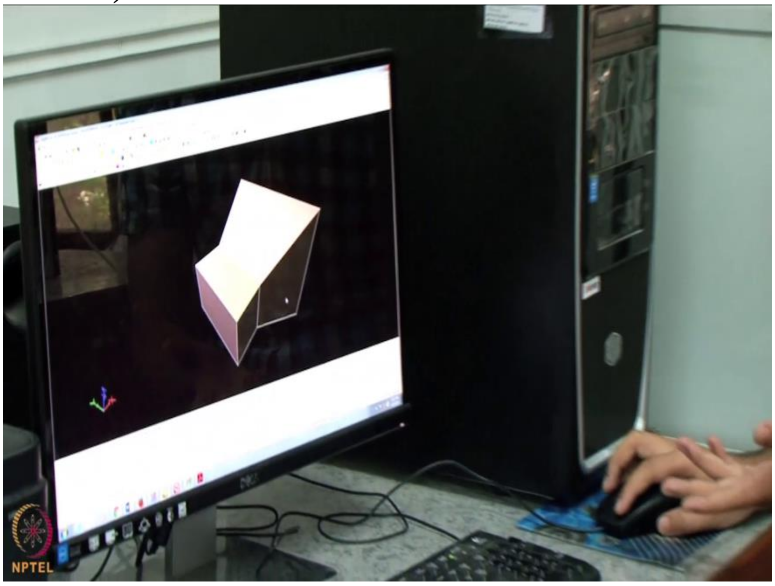
(Refer Slide Time: 04: 55)



So I am showing you the 3D geometry for this

Yeah

(Refer Slide Time: 05: 00)



So in 3D geometry we can see the dimensions of this wave guide. This width is 240 mm and this height is 120 mm , so it have a lower cut off frequency around 600 MHtz. So there is no (())(05: 12) in our working frequency. So the length of this waveguide is optimized to 110 mm.

ok

(Refer Slide Time: 05: 19)

And the flaring we have done this width this wider dimension of the aperture is 450 mm and narrower aperture is 320mm and the length of this horn is around 250 mm. And we can see the gain of this antenna is varying from 8.4 db to around 12.5 db

Excellent so these are the main results so these are the main things. So the main idea of simulating this reference antenna is if you are going to use this antenna as the basis for evaluating the other antenna. So in that sense the gain and also the S 11 parameter

GSM 896 and CDMA (())(05: 56)

ok

Thank you!

Student Teacher conversation ends

(Refer Slide Time: 06: 01)

We are in the antennas Lab which is one of the most important labs in the micro wave engineering where we simulate various kind of antennas. And today we are going to look into a special type of antenna which we call it as patch antenna.

(Refer Slide Time: 06: 21)

So why we call it as patch antenna is because we have a kind of a metal layer which is sitting on a dielectric. So in this case we are using a Effa 4 substrate which is a fire retardant substrate with a dielectric permittivity which is roughly 4.

(Refer Slide Time: 06: 39)

And then we are also having another material which is a airlon which is a relative permittivity of 2.55. So we are going to simulate this particular kind of antenna using a method called as Method of moments. And the reason why we are going for method of moments particularly is because the phenomenon which we are interested in this kind of model are the surface phenomenon. So we are not going to discretize the volume we are only going to focus on the surface aspect. So that way we can get the best result in terms of accuracy and computational time. And one of the students here is going to help us to model this kind of antenna using the method of moments solver. And we are going to use a ie 3D solver. And let us here from him how he is going to go from the physical model the model which he is going to build on the virtual platform. And we will see what are the results that we are going to look into and how this entire project can be done using IE 3D.

(Refer Slide Time: 07: 47)

So let us have a discussion with a student

Student Teacher coversation starts

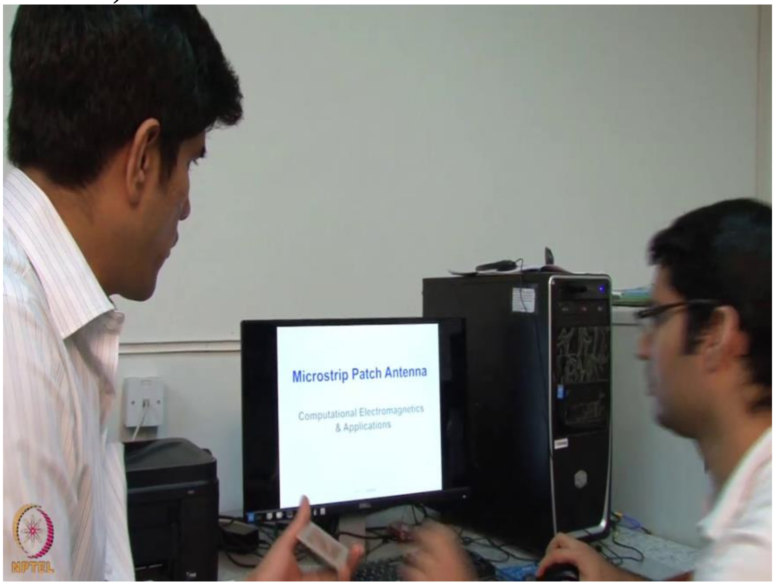
So Hemant: So you have been working on this particular kind of antenna

Yes

And, so could you please explain us what you are doing or explain us how you are going from the physical model, what is the problem that you are going to solve. And I know that you have done a power point presentation where you have explained step by step what you have done. So could you please explain us?

Sure sir

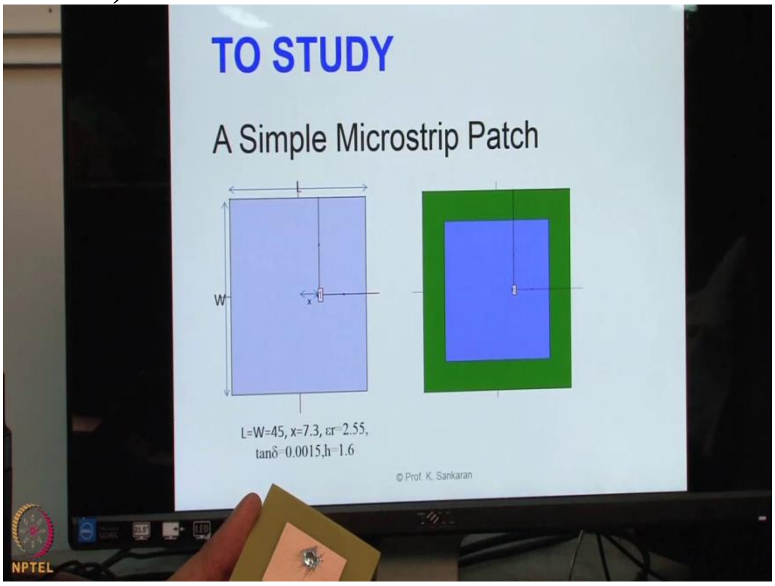
(Refer Slide Time: 08: 17)



So this is a Microstrip patch antenna

Simulation and we are doing this as part of the computational electromagnetic and application course so could you please explain what you have done?

(Refer Slide Time: 08: 30)



Yes We have taken a patch antenna this one is a patch antenna and this is a ground

ok

So from here we can see this is a ground layer this green part

ok

This is a patch

Ok so you basically have a kind of a metal layer which is at the bottom of the electric access to ground.

yes sir

And then you have on the top the (patch) antenna itself

ok

So this antenna is working at 2.03 GHz

ok

So using the formulae (())(08: 54) in the literature we have found that L equal to W equal t 45 (())(09: 00)

Basically you are starting with a length so it is equal to the width so its a kind of a square Microstrip patch

And the Phi point is decided based on the input impedance. We can simulate it in IE3D and we can see as we are moving the free point away from the center the impedance will shift towards the higher value.

ok ok

From center we will have to optimize this free point at a point where we are getting 50Ohms impedance. Because we are fit at a coaxial field. So the coaxial field have a input impedance of a 50 Ohms. So to match the input impedance with coaxial field SMA connector we have to shift we have to optimize this.

So basically we have the basic sourcing is coming from the coaxial field and the impedance for that particular coaxial field is a 50Ohms resistance.

And now what we are doing is we are trying to match it such a way that whatever energy is getting feeded does not get reflected. So maximum ERG transfers.

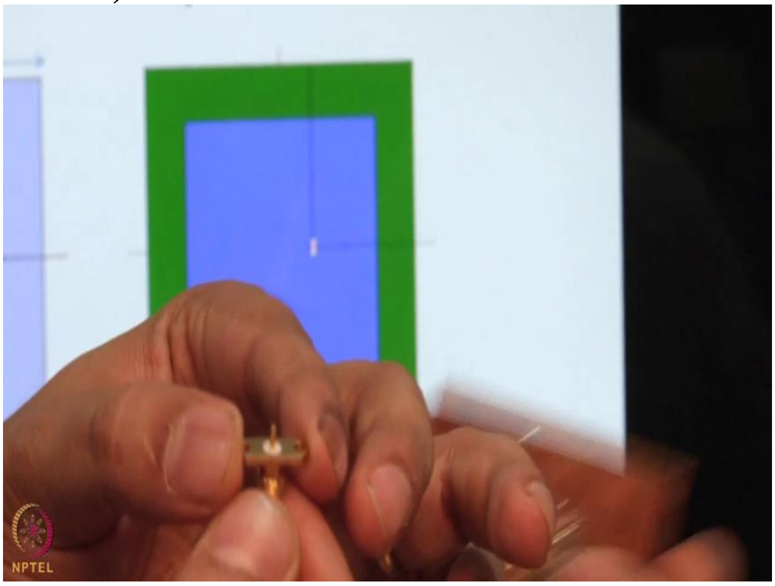
We have to go to minimize the reflection.

Ok so that is the reason for matching the impedance.

So you have basically used the kind of a simulation to find out where the position will be appropriate for you to match it for the input impedance of the (())(10: 27)

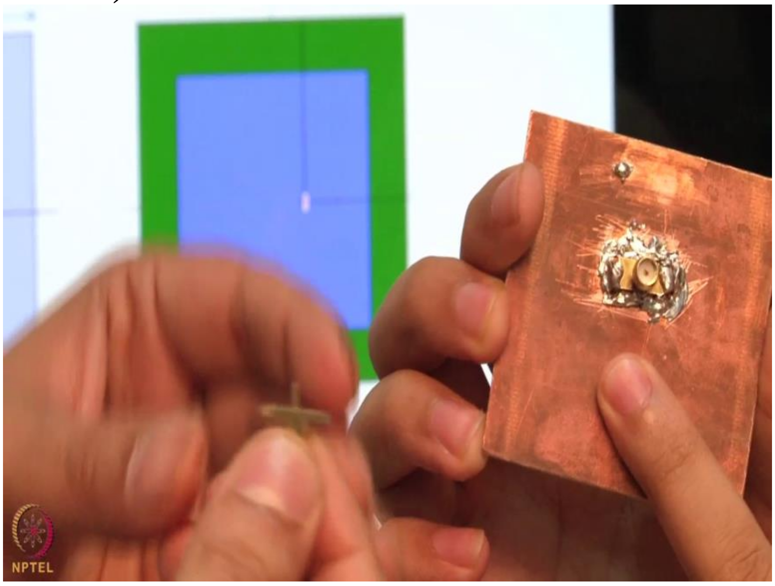
Excellent ok

(Refer Slide Time: 10: 30)



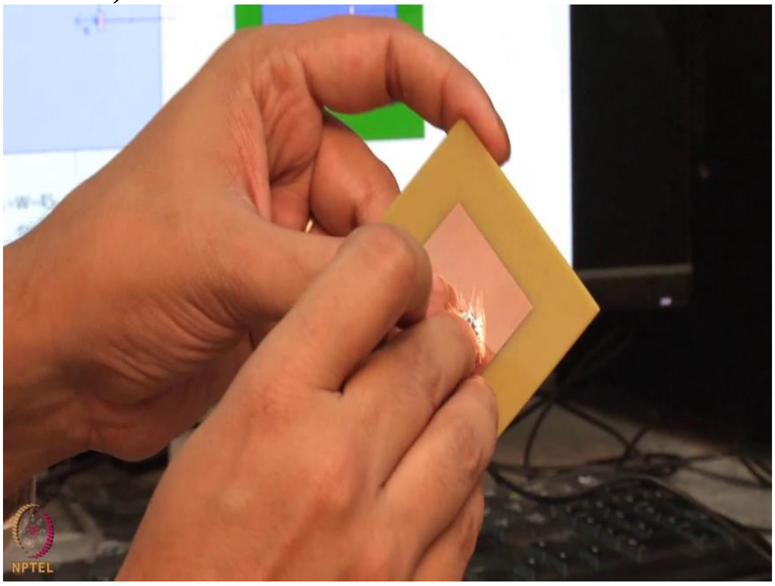
So this is a SMA connector and this point is the inner conductor of the SMA coaxial cable. And you can here white middle layer . That is the Teflon layer and the outer is again metal.

(Refer Slide Time: 10: 50)



So outer is connected to the metal arm from the ground layer

(Refer Slide Time: 10: 54)



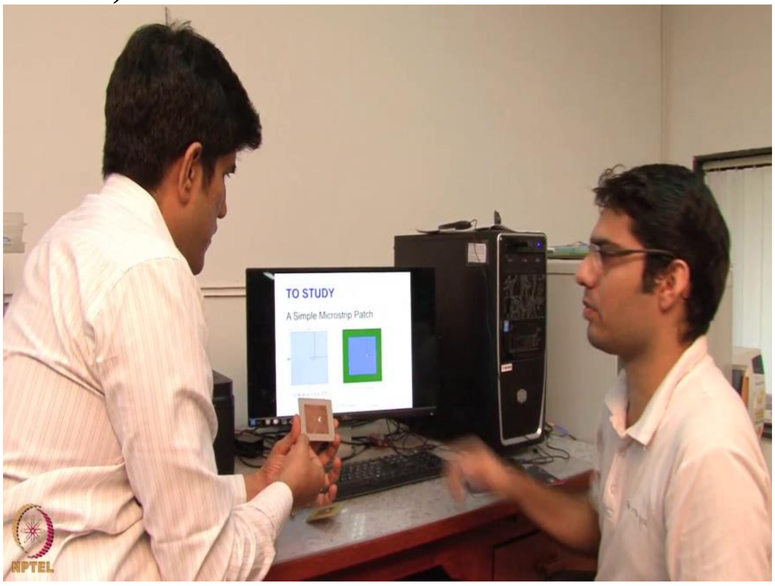
And the inner is connected to the patch

So basically you have a teflon layer that is also insulating between the bottom layer and the top layer. So its kind of coming from inside and then this point is exactly matched so that the input impedance is 50Ohms. And what kind of a connector is this one?

SMA Connector

Ok

(Refer Slide Time: 11: 19)



Could you please go forward and then explain us further? So what are these x and

x is a distance from center to the field

ok so the (())(11: 26).So you are basically modeling it as a 2D problem.

Yes as a 2D problem

So you are taking the x axis at this axis and y axis at this axis

This is your x axis and this is your y axis and you are trying to compute from the center what is (()) (11: 42). And this is equal to 7.3Nm ok ok ok

And this is a dielectirc constant of (())(11: 50) this one is our avlon material, this is our different substrates. So basically for this avlon material you have taken this x as 7.3 so this is centimeter or milimeter? MM .

So this is in millimeters and you are talking about epsilon r 2.25

What is this tan

This is the loss tangent of the substrate (())(12: 15) as .0015.

So these are computed based on basic

And the thickness of this substrate is H 1.6

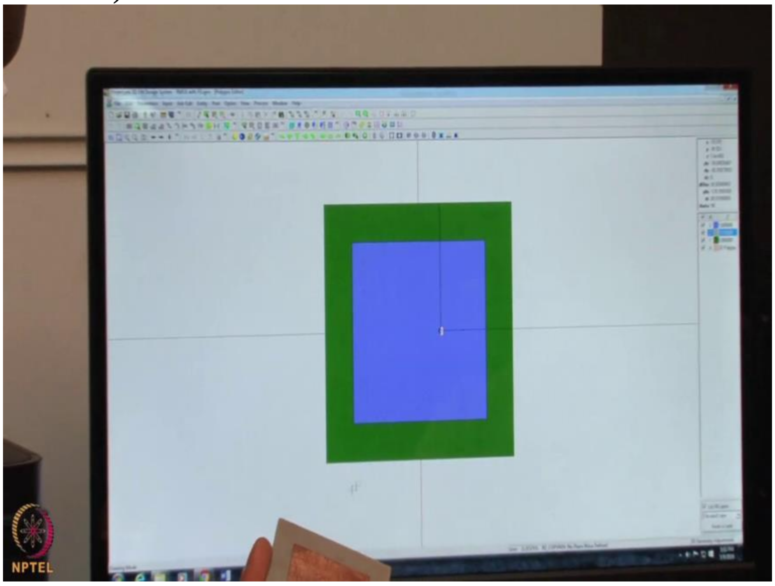
So this is 1.6 centimeter

Yes

so then we can go forward

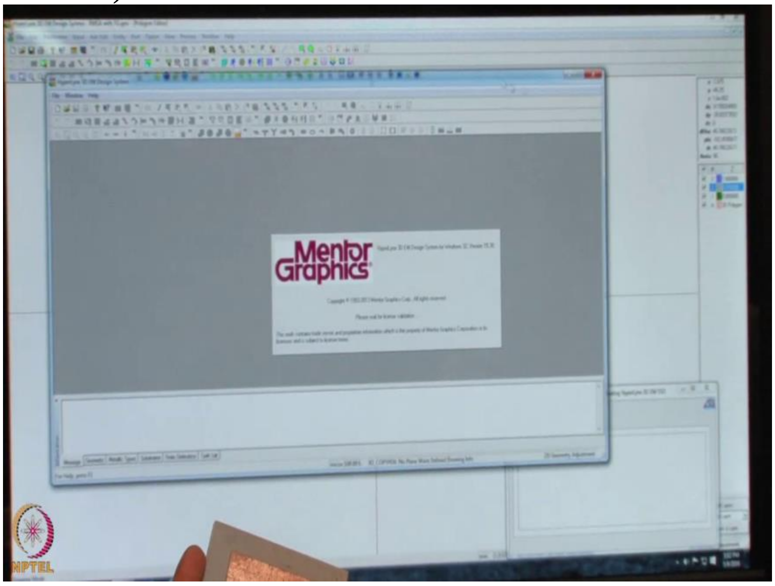
Now we can show you the simulation

(Refer Slide Time: 12: 30)



So first show us how we are doing the entire model (()) (12: 33) physical model to the virtual model.

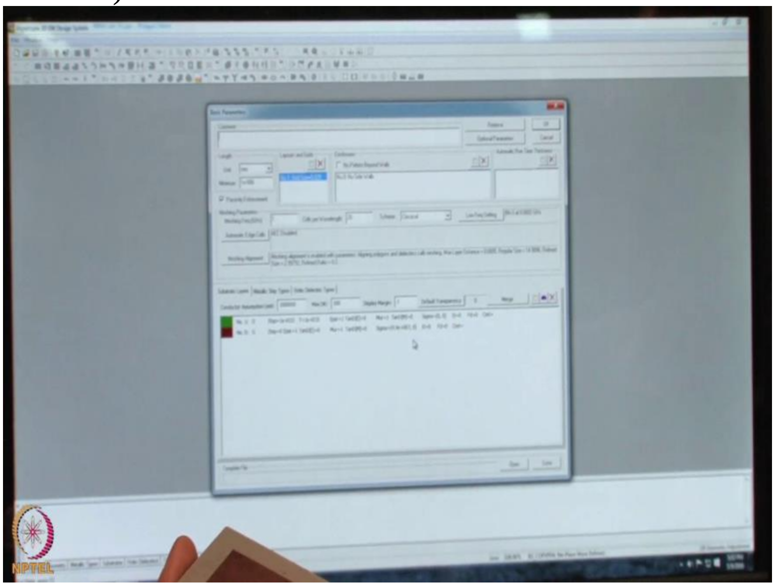
(Refer Slide Time: 12: 40)



So here is Mgrid we have opened. So Mgrid is basically a kind of a geometrical design platform

Yes

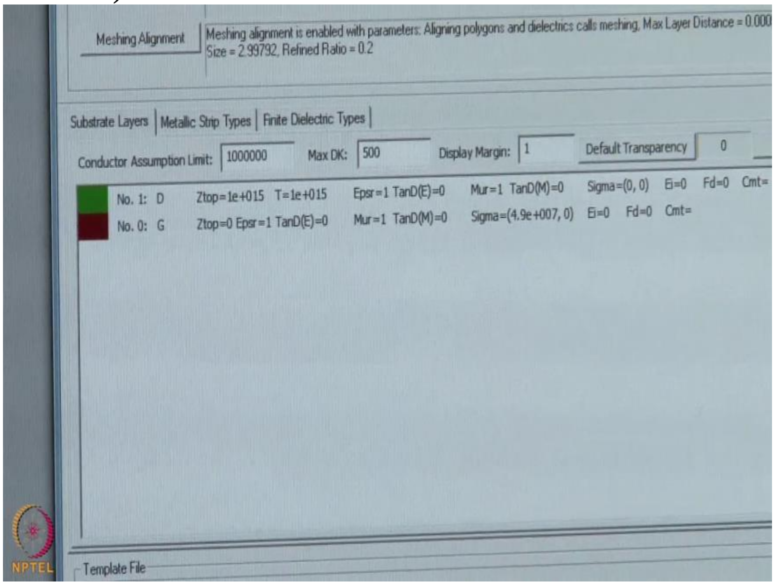
(Refer Slide Time: 12: 45)



So we are going to open a new file you are going to design. So there are two layers there is a ground we can see here z top is 0 hence it is a ground and the sigma is infinite it has a infinite conductivity

ok

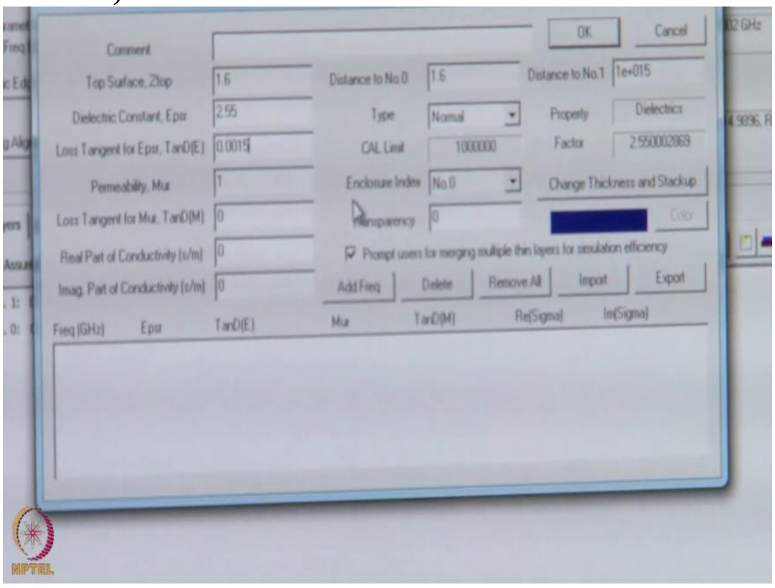
(Refer Slide Time: 13: 10)



And above layer is d that is an infinite this 1e 10 to the power 15 high value

So it is treated as infinity so we have to make a patch at a distance so at a height of 1.6

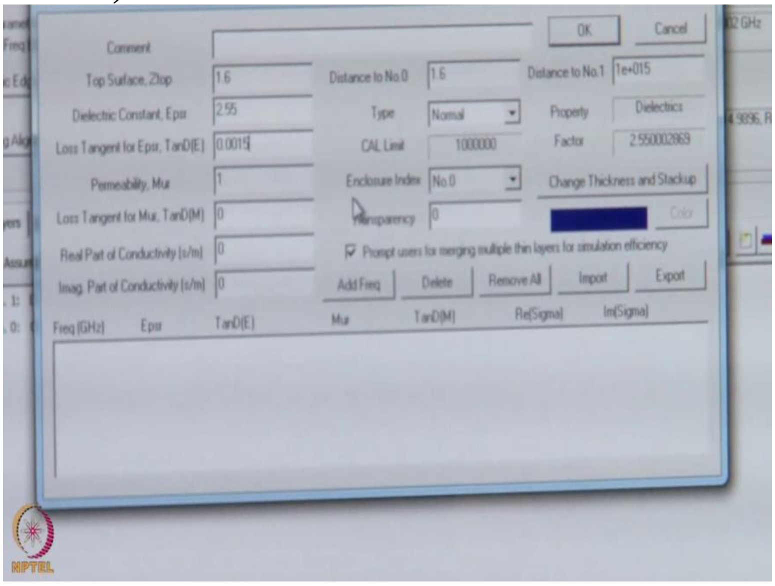
(Refer Slide Time: 13: 20)



So we have to insert a one layer at a distance of 1.6m. z top should be at 1.6mm and the epsilon should be 2.55. And the Tan delta is the loss tangent substrate is 0.0015

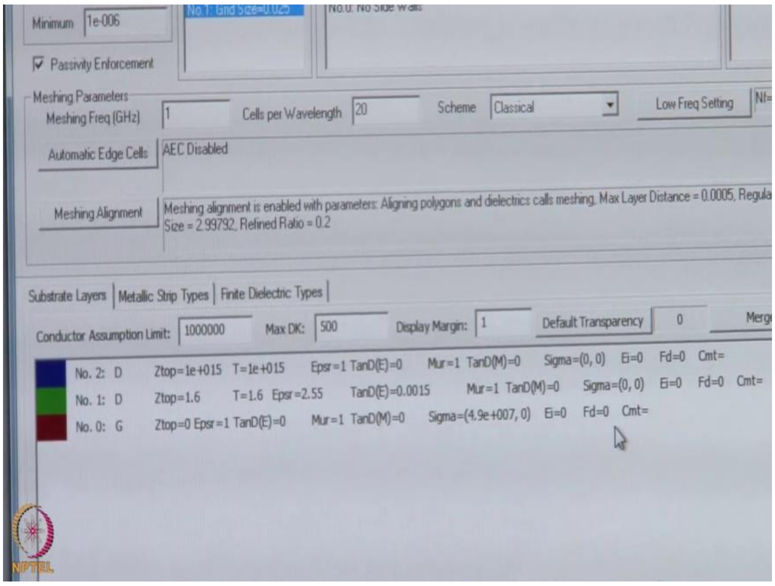
ok

(Refer Slide Time: 13: 38)



And permeability is 1 and the other things we are not going to change.

(Refer Slide Time: 13: 43)



So we can see a new layer

ok ok

And as this layer is in IE basically this sigma is infinity means the bottom layer is the infinite to low so we have to finite it. Means we are taking a finite grond.

ok ok

So we have to also make it a year. Because sigma is infinite forward conductor and 0 for area so we are going to make it 0.

ok

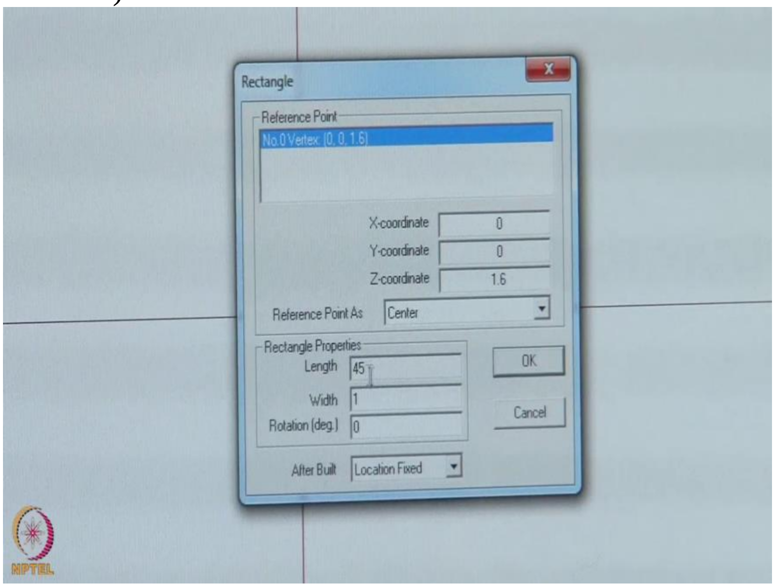
So there is no conductor at bottom

Ok

(Refer Slide Time: 14: 20)

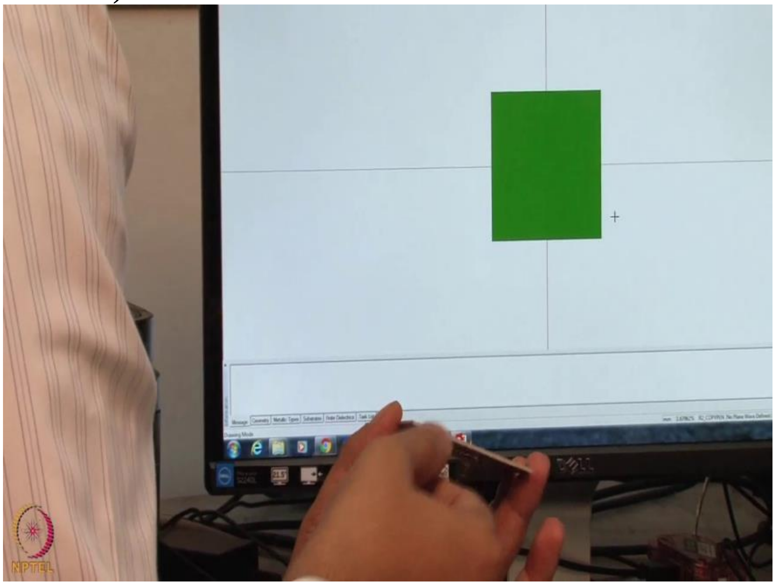
So we have a new window editing window where we will design our patch antenna in this window. So firstly we have to design a square patch antenna

(Refer Slide Time: 14: 28)



So we will select this rectangle, we can see x cordinate y coordinate z coordinate we have to design a patch antenna at a height of 1.6. So z is 1.6 and X cordinate Y cordinate we can take anywhere bydefault we are taking 0 so that it will become at a center both x axis and y axis. So the length of this antenna is 45mm. We have already calculated it And width is also 45mm then we will press ok

(Refer Slide Time: 15: 02)

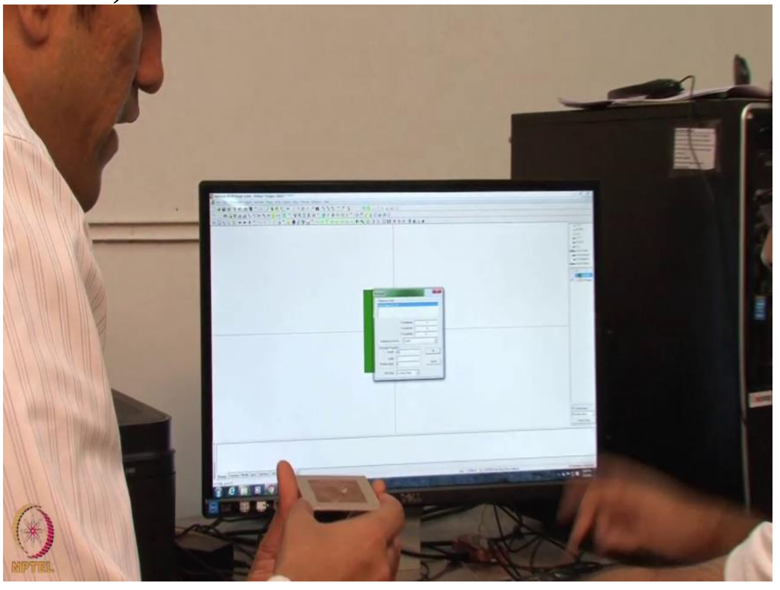


So this is a patch (())(15: 04) at a distance of 1.6

We are seeing now is the entire patch this is the ground plain or on the top.

it is at a height of 1.6 there is no ground plain

(Refer Slide Time: 15: 24)



Now this time we will take z coordinate equal to 0we take ground plain larger than the patch.

ok

So it has been observed that if you take a finite ground plain of a size 12 h greater than a patch antenna surface. if the patch length is l and we are taking a finite ground plain length is equal to patch of patch length plus 12h

ok

So H is a thickness of our patch (())(15: 58)

So in this case how much you are going to choose

So we are going to choose 45 mm plus 12 into 1.6, it is around 18 mm. So we can take around 54 64 Ohms

So the ground plain dimensions are going to depend on the dielectric thickness itself

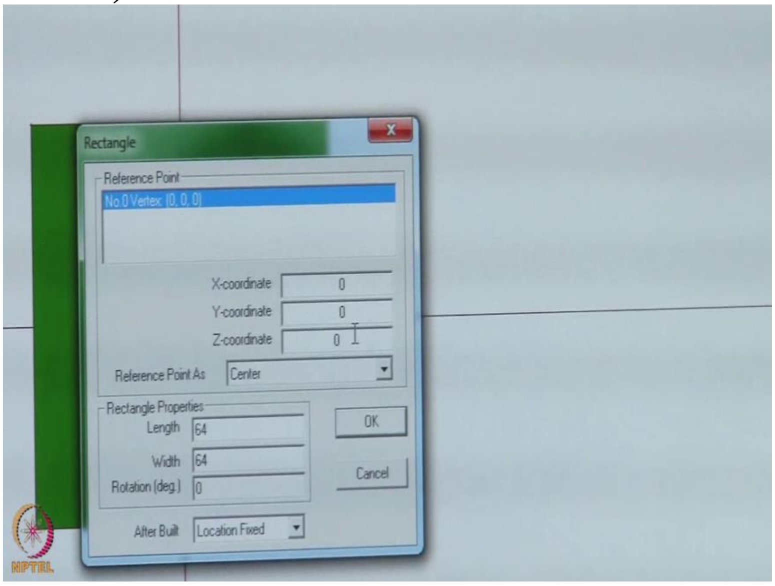
Yes

So the thicker the dielectric you are going to have a bigger patch.

These are the observations

ok

(Refer Slide Time: 16: 24)



So we are going to take 64 Ohms and Z is 0

ok

(Refer Slide Time: 16: 30)

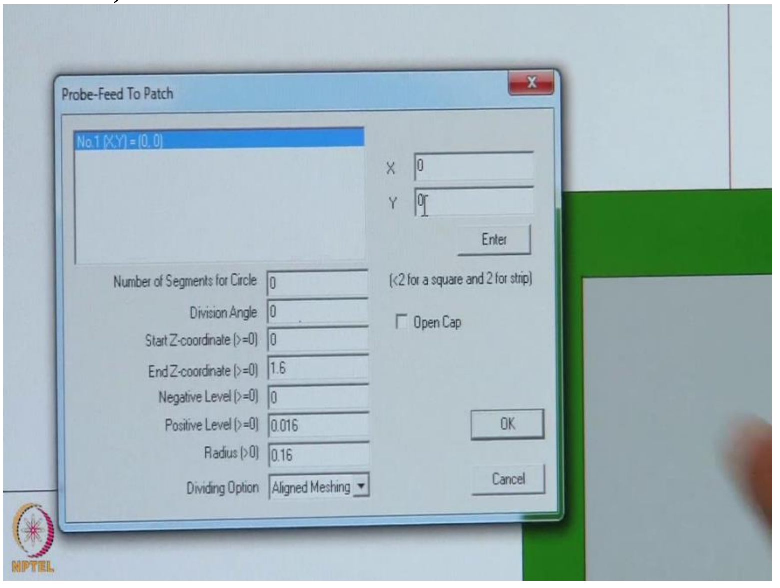
So this green the bigger one is bigger square is finite ground so we can see this is a finite ground. So when we select our 1.6 this is our patch antenna

So this is exactly this one what we have

And now we are going to feed it.

There are various ways to feed a Microstrip patch antenna, like Mocrostrip line feed inset feed excel feed aperture couple feed. But in this and all these are different means have this advantages and disadvantages. But we are going to use a coaxial able. So to feed this antenna we are going to use coaxial field. We will go to the entity there is a Probe feed to patch.This connector we are going to use the SM connector. Its dia inner dia is 1.2mm.

(Refer Slide Time: 17: 24)

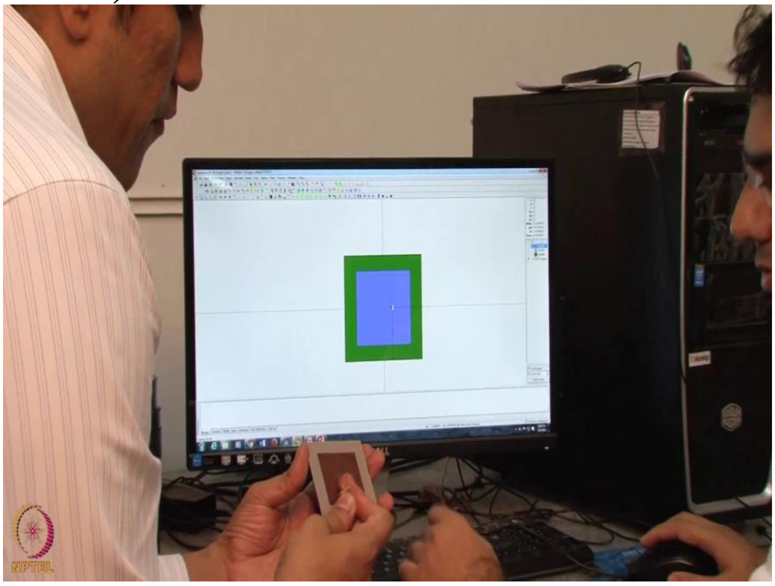


So we can see a new window is appeared Probe Feed to Patch. So X and Y will decide the position or the location of the feed.

So you said that it is 7.6 umm

7.3 mm so x is 7.3 mm and y is 0 So we will have to enter the, so at 7.3 there will be feed. So number of segments for the cycle can generally taken as16. But it depends means we cannot make perfect circle. So to make a circle you know simulation generally we take 16 segments so if we take a 4 segment it will become a square so we are taking it 16 segments.

(Refer Slide Time: 18: 08)



And the start jet coordinate: start jet coordinate will tells us the this particular thing so it should be 0

ok

And jet coordinate is 1.6 mm because we are going to feed the patch at a distance of 1.6 from the ground. So and this radius the inner dia is 1.2mm its radius is 0.6mm.

Exactly

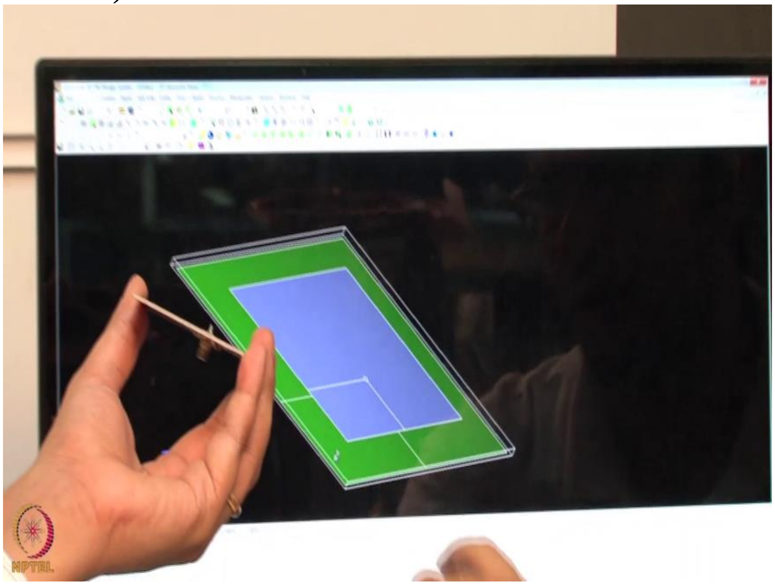
Right now you can see press ok there is a

So you are basically guessing this particular area where the feed is coming in. And this is 7.6 umm

This is 7.3

7.3 mm from the main center and 0 from the center so it is exactly on the y equal to 0 line and 7.3 mm away from the centre

(Refer Slide Time: 19: 00)



And we can see the 3D geometry.

So the 3D geometry is basically showing is the both the ground playing it shows the feed and also it shows the top patch

(Refer Slide Time: 19: 14)

This is a ground green one , this is our patch you can see this is our second domain so you are seeing the feed that is basically coming from bottom.

So let us go directly into the simulation now. So now knowing this how to model this on a IE3D here. Let us look at the simulation example.

So first of all we have to save this file.

So for simulation this is a simulation , so this is a meshing frequency there are various parameters in this window. We have to set these parameters

So what you are saying that you are going to create this.

So we are going to 2.03 (())(20: 00). So matching frequency is the highest frequency we are going to choose.

Then it is the lowest wavelength and then we will know the self step wavelength. So you can take it as a 3.

So you normally use Lambda as 20 in this case or 27 step.

If it is a simple patch antenna we generally take 30 steps (())(20: 20)

And if it is a very complex structure like arrays of the patch then we can think about means less than 30 and 20.

(Refer Slide Time: 20: 30)

So I think its one thing that is important to explain here is since we are doing a kind of surface discretization we can afford to have very fine grid. Whereas in the finite difference method or you know finite element method lambda by 20 or lambda by 30 is prohibited. So we cannot simulate a bigger problem using such a fine grid.So in this case we are going for lambda by 20 or lambda by 30. So because we are only interested in the surface aspect and its easier to do that. So its not going to be very costly for simulation.

(Refer Slide Time: 21: 08)

Here is another tab is automatic steps So it is always should be AEC enabled. So it automatically means the mesh size it automatically defines;

ok

Auto vary means when there is a field it makes it fine or fine meshing and there is no changes so then at that place it makes it coarser.

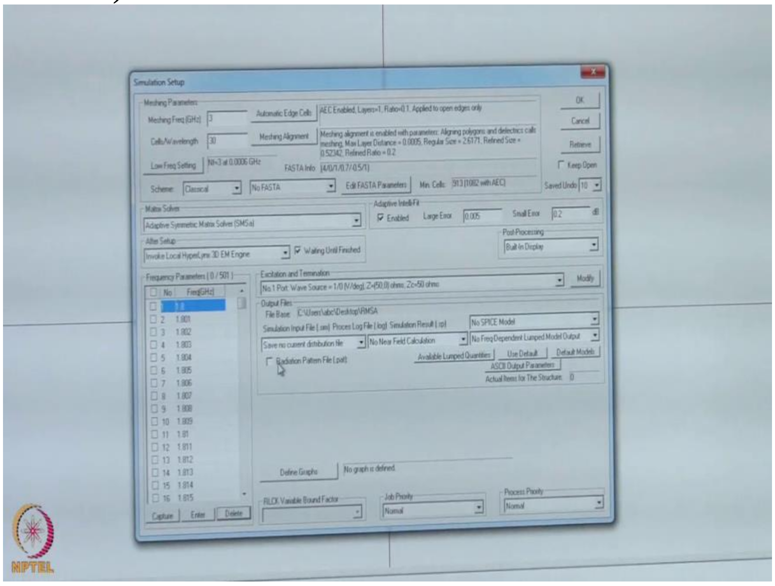
So what is important is the surface meshing also we have to make sure that near the feeding area the meshing should be fine enough to capture the resolution.

Yes

Whereas in the outer area you can have a coarse mesh. So that is what is being controlled by this particular parameter. And ok so let us move forward.

Then next thing is we have to define the number of samples frequency samples this simulation software is going to simulate it.

(Refer Slide Time: 22: 00)



So we have to enter the number of points let us we can take it 0.5 we can take it from 1.8 to 2.3 GHz.

So it is basically the frequency of range that we are interested in.

Yes Strings and the number of samples within this range. Let us take 501so we have taken 501 with samples. 0.001 at 1 MHz at every 1 MHz it will c to a.

Ok

So these are the number of terms at which this will

So since its a frequency domain approach what we need to do is we need to simulate the same problem for different frequencies in order to get the bradband simulation of this particular patch antenna. So we are doing roughly 500 steps to do the entire simulation from 1.2 to 2.3. So roughly this is going to be 501 steps. That means doing the same simulation 501 times.

ok let us go forward

At different points. It will simulate at 1.8 another point 1.8 so its there is a time stepping or a frequency stepping in this case is going to be there are free 1 MHz

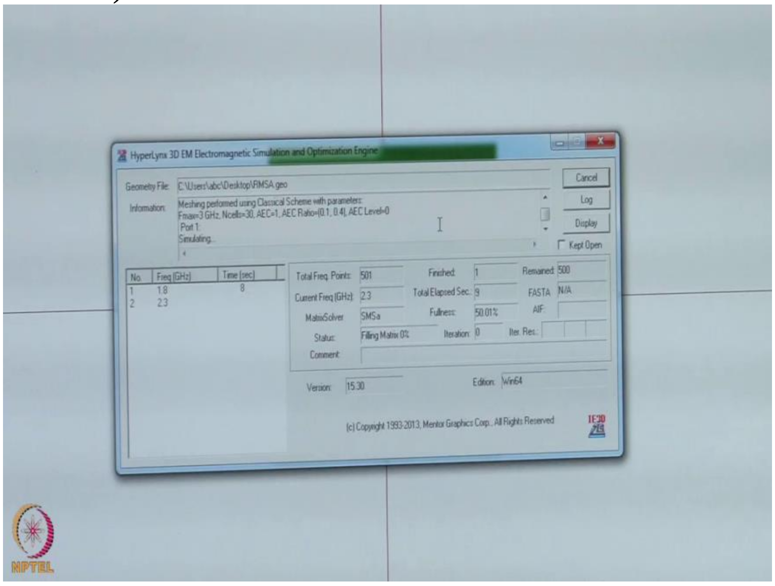
ok

Actually if we want to simulate it at every point 501 points we have to select this

Ok

Means it will select all otherwise it will take random points ; 10 to 20 random points it will select and automatically simulate it at the point.So we are not going to take all these points for sure (())(23: 40)do now just for the time (())(23: 43) ok. Next thing is we have to see the radius of (())(23: 47)

(Refer Slide Time: 23: 50)



so we have to select this here another window will appear this will give us the radiation pattern at different angles. Theta is equal to 0 to 5 means again we are taking 37 samples. For 5 axis we are taking 37 samples so 5 varies from 0 to 360 degree so every 10 degree we are taking one sample and theta 0 to 180.

So this is basically this one and then this one is here. So the theta is basically the one which is going to from top to this point so its a 180 degree angle. And what we are interested is also a circle which is 0 to 360 degree till the feed. So we have taken in the theta direction we have taken 37 samples so every 5 degree.

So shall I ask you how we can do the antenna radiation now. Just press ok and then here we can simulate it like this. It will take some time to simulate it.

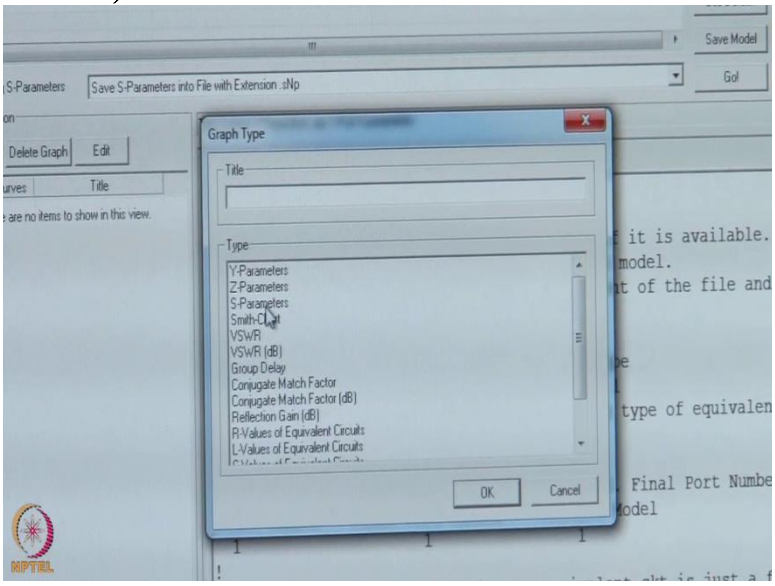
So what is a rough ((())(24: 51) it depends upon the discretization and frequency samples and number of cells per wavelength and your computer means you can say means your computer RAM or (())(25: 06)

And normally what kind of methods you normally use other than method of moments for simulating this kind of patch antenna.

CST simulations are (())(25: 19) Also finite element methods do you use? No we do not use

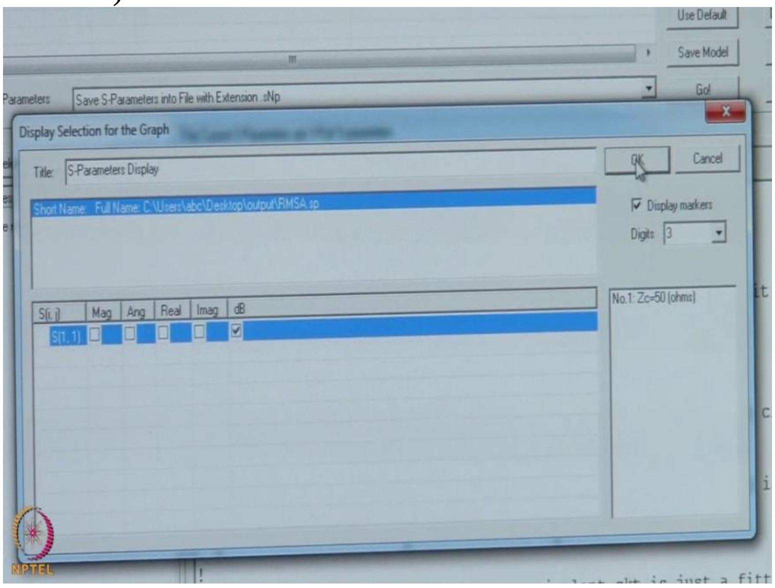
So let us look into the simulation result itself

(Refer Slide Time: 25: 03)



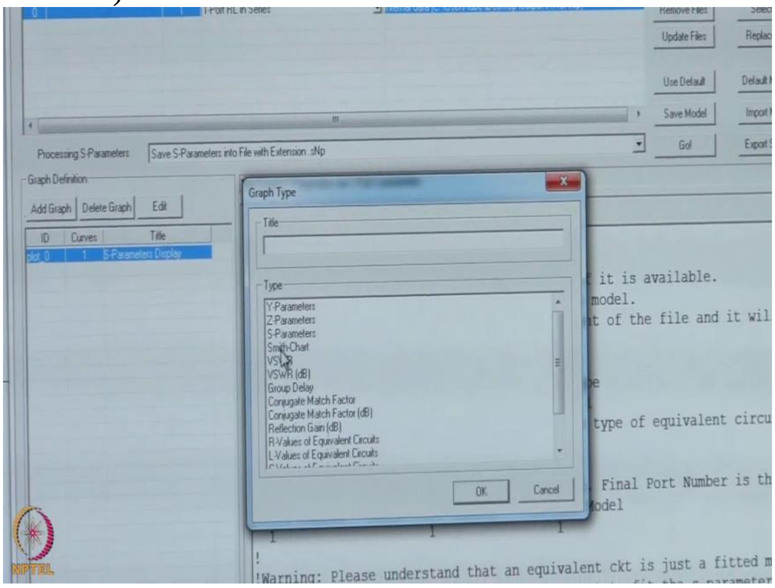
So the simulation is over we can see there is option of air graph so let us click on this you can see there are various parameters Y parameters Z parameters S parameters which are (())(25: 44) Firstly we have to see s parameters. So we can select this S parameter then press ok

(Refer Slide Time: 25: 50)



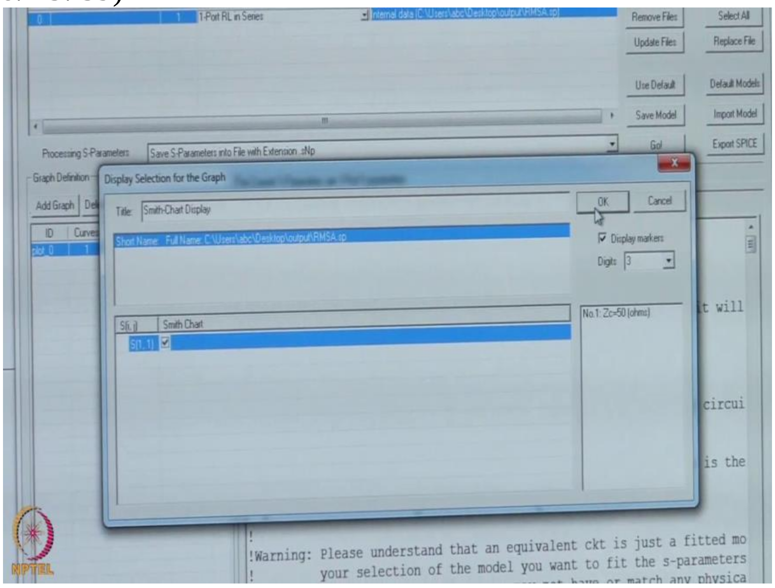
Then we can see the S parameter magnitude, angle, Real, db Let us look into the decimal parts then press ok

(Refer Slide Time: 25: 57)



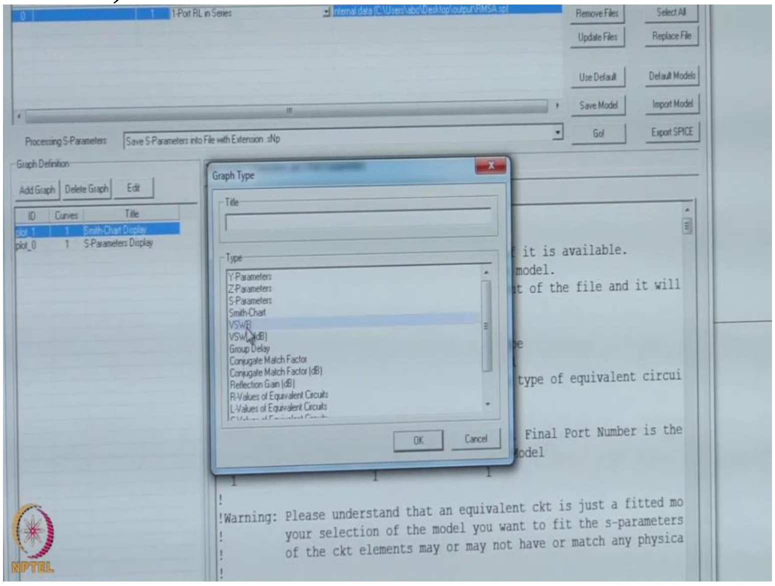
Next thing we can see the Smith chart also

(Refer Slide Time: 25: 59)



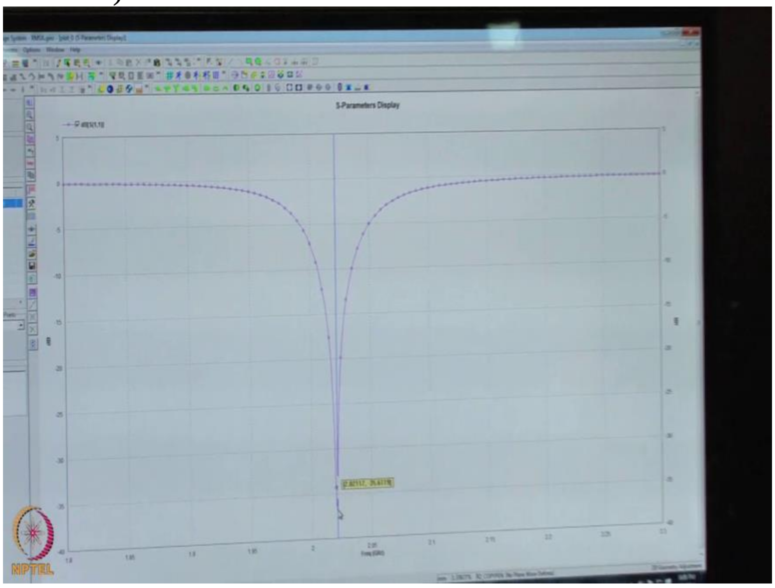
So add graph , smith chart (())(26: 02) Radiation pattern we have to define seperately.

(Refer Slide Time: 26: 08)



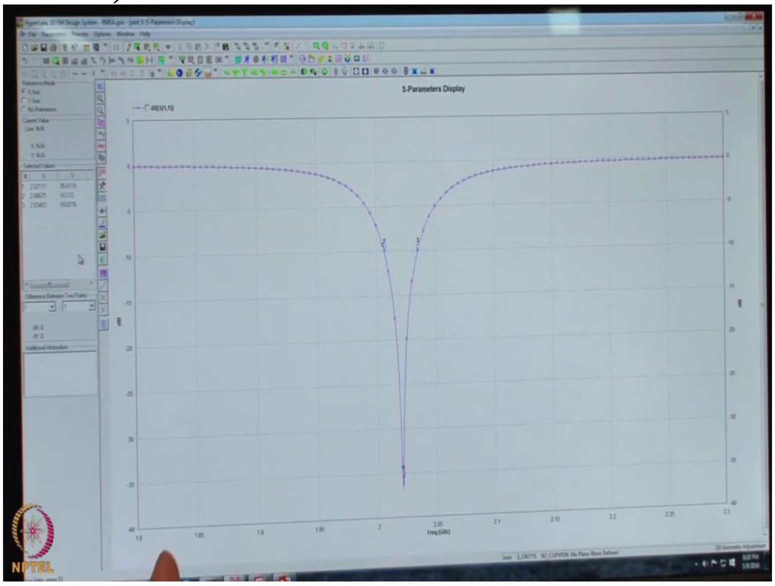
Next is VSWR we can see also the VSWR. So now close this window

(Refer Slide Time: 26: 11)



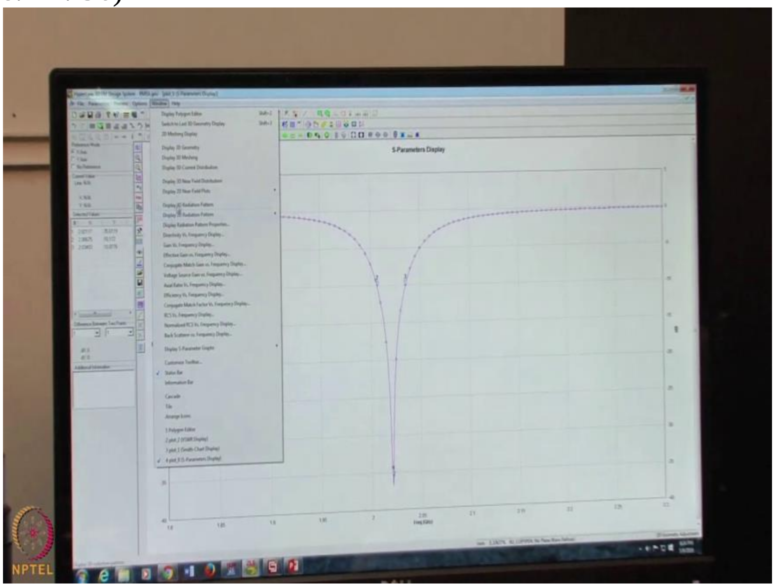
So now we are plotting the S parameter here. so x axis is defined is a frequency So we are going from 1.8 to 2.3 So 2.3 and similarly the Y axis is represented invisible so we are computing that S 11 parameter. So let us see what the result says. So you can say you are getting a very minus 35 degree at a frequency 2.02 GHz. So we started the antenna at 2.03 GHz. We have used the fromulas available in the literature. Based on formulas we have decided the length and the width of other parameters.

(Refer Slide Time: 27: 00)



And based on that we got 2.0211GHz. So and next thing we can see the minus 10 generally in the antenna we discuss about the bandwidth impedance bandwidth. for VSWR or S 11 is less than minus 20. So we can see the bandwidth of this antenna for minus 10 degrees from 2.006 to 2.03 GHz. So its quite a different range. So you can calculate so this is roughly around 30 MHz. So as we can see in this particular S parameter we are seeing for the miles 10 GB So we are having roughly 30 MHz

(Refer Slide Time: 27: 56)

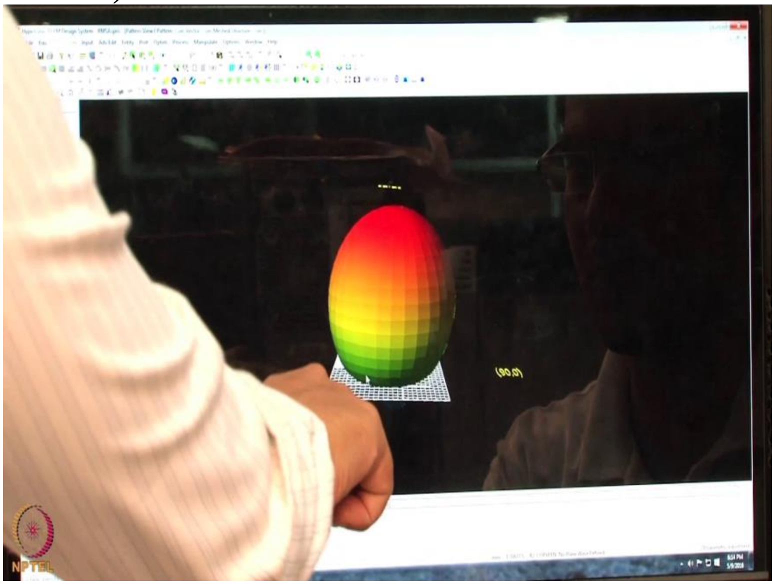


So this is the kind of a range what we are getting for the S11 parameter So if you want to imprve this one what you are saying is we can go with different kind of material which will have a different loss tangent. so this will increase the (())(28: 11) bandwidth. SO what normally is the application you said that eve though the loss tangent in this case is different and it gives us a 30 MHz it behaves better yes in this case it has been observed also as you increase the dielectric constant because upper four have more dielectric constant compared to this alone substrate. So as we increase the Epsilon r generally the bandwidth decreases as we increase the Epsilon r and bandwidth also depends upon the thickness of (())(28: 44) But here we have taken the same thickness we are varying only the Epsilon r and loss tangent

So this is going into basic electromagnetic theory of modelling antenna. From the methodolical point of view you have used the method of momentsto compute this one and you also explained we are taking 501 points well what we see here is not 501 points it is randomly choosing some points. And again you explained us different materials how you can improve the S11 parameter or minus 10 db loss aspect of the antenna itself.

So can we now look into the method itself and see how the accuracy of themethod is going to impact how you can see the parameters that you are extracting in terms of accuracy. So may be you can explain us that with radiation pattern itself. So next we can show you the radiation pattern the window so in this we can see a 3D radiation pattern (())(29: 44) radiation. Firstly we will see a 3D radiation pattern.

(Refer Slide Time: 29: 50)



So a new window will appear from here we can see this is our patch antenna so basically you have the zoom it in so that we can have a look. So what you have is a ground play this is a ground play and then you have a (())(30: 03) you can say this is our (())(30: 05) pattern. At the frequency of 1.8 this is the lower frequency range we are looking into we can change shift with the next frequency (())(30: 14). So we can say at 1.9 to 5 GHz we can see all if it is are admins it is a scale that we have a maximum value of the electric so it is dbi value you are computing and its the maximum that you are having. S it will go higher up in the frequency. So at 2.0 at one file and this is 2.021 ghz 2.05 so initially the game is low at the certain frquency so it is game play its basically going to change and then at some pont the maximum gain is appearing for certain frequency. So can whhch it is resonating

Initially we said that we are going to choose Lambda by 30 and what s interesting for us to know is in the method of moments how do you understand whether the discretization what you are using is good enough to resolve the proble in accurate way. So how do you normally do as an engneer who is designing this antenna hence we are using I3D software we are not using numerical technique here we are using experiment just a simulation you are using a thumb figure yes we are using a thumb rule just we are doing the simulation at 30 cells per wavelength and agan we are doing simulation 35 cells per wavelength. We are comparing the results if there is not a large difference then we can see a lambda by 30 means 30 (())(31: 52) SO we have optimized for our idea. So here is kind of a thumb figure like as in practical experience shows you that if you start with a 35 cells wavelength and you try to increase it to 40 cells or you are going down then basically the result itself will show whether its enough cells are there for the problem to be resolved during method of moments.

So thanks a lot Hemant kumar you have done a excellent job in explaining us and also through the students how you can model such patch antenna using method of moments and its the examples are very good and thank you for your time

Thank you sir!

Student Teacher conversation ends"