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

Lecture – 60
Lab Session

Hello, and welcome to the concluding session of the course antennas. Today I am not going to take lectures, but today we are going to show you various experiments which we have performed on different types of antennas, we have designed so many antennas, we have fabricated so many antennas. So, today I am standing inside the antenna lab of Electrical Engineering Department IIT, Bombay

So, my students along with the TS they will show you different types of antennas which we have developed at IIT, Bombay. They will also show you how to do the input impedance measurement, VSWR measurement using vector network analyzer. After that they will also show you how to do the radiation pattern measurement.

Now, most of the time people do radiation pattern measurement inside an anechoic chamber using automated measurement tool. However, those are very expensive and not possible for all the people, and then what do you do? So all you need is really is some got an empty room put a transmitting antenna, received antenna and you can do the measurement even in the open room also. So, we will show that in an open corridor so that you can actually see the pattern measurement as well as the gain measurement.

And for gain measurement and especially the half power beam width even an open room is good enough. The problem where we have in the open room is most of the time the null depth may not very sharp or the cross polar level which are below minus 20 dB they may not be good. But otherwise gain measurement as well as the half power beam width and other things are perfectly fine.

So, I hope you will enjoy the show, we see the antennas and see all our young and enthusiastic students as well as TS to show you various antennas and how to do the radiation pattern measurement and impedance measurement of the antenna. So thank you and I hope you enjoyed the show as I enjoyed recording the show. Thank you vey much and I hope you have enjoyed this entire journey. And rest of the journey enjoy with my students. Thank you.

(Refer Slide Time: 02:30)

Student: Now we are going to show various antennas available in our lab. This is a dipole antenna, this is a loop antenna, these are some microstrip antennas, circular microstrip antenna arrays, this is a two by two microstrip antenna array, this is of 3D printed horn, this is a helical antenna, this is a horn antenna designed at 1800 mega hertz, there is a electromagnetically stacked microstrip antenna, planar lobe periodic antenna, it is a E shape microstrip suspended antenna. These are some of the antennas available in our lab

Hello everyone. I am Rinki Chopra, I am a PhD student in antenna lab, I am also a teaching assistant for this course. So, here we are going to show you the basic antennas: monopole antenna, dipole antenna, and loop antenna.

(Refer Slide Time: 03:45)

This is dipole antenna designed at 800 mega hertz. Here Balun is used to feed the power; that is used to provide the different field.

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This is a planar monopole antenna. Here this is taper to widen the band width.

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This is a loop antenna designed at 800 megahertz. Here Balun is used to feed the power.

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Hi. I am Anamika Varma, I am a PhD student. These antennas are designed at 2 gigahertz. This one is square microstrip antenna and this circular microstrip antenna.

(Refer Slide Time: 04:33)

These are the compact versions of the circular microstrip antenna which shorting ports, and in all these antennas power are fed by a semiconductors.

Hi. I am Pratigya Mathur, and I am PhD student at antenna lab in IIT Bombay. Microstrip antennas have a limitation of low gain. This limitation can be overcome by designing antenna arrays. Antenna arrays can be of two types: corporate fed antennas and linear fed antennas.

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This is five element linear microstrip antenna arrays.

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The other type of array is corporate fed antenna array, this is a two cross two corporate fed antenna array designed at 5.8 gigahertz.

(Refer Slide Time: 05:18)

To increase the gain further eight cross eight corporate fed microstrip array has been designed at carbon. This antenna array finds application for satellites and defense purposes.

Hello everybody. I am (Refer Time: 05:32) Sandip Das, presently doing my M. Tech at IIT Bombay. I will be introducing the two conventional techniques which are used to broaden the bandwidth of microstrip antenna.

(Refer Slide Time: 05:42)

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Firstly this is a gap coupled microstrip antenna designed for 3 G band and secondly this is a electro magnetically coupled stacked antenna which is also used for broadening the bandwidth of microstrip antennas.

Hello everyone. My name is Deva Prathim Gosh and I am currently a PhD student at the antenna lab at IIT Bombay.

(Refer Slide Time: 06:08)

So, today I have got for you stacked patch electro magnetically coupled microstrip antenna, wherein we have this bigger square as the ground patch and on top of that we have the main radiating patch which is in the middle which if you can see this. And finally, on top we have the parasitic patch. So, this is designed to work primarily for the GSM 900 band. So, its bandwidth is roughly from 890 to about 1000 megahertz. So, if you recall the GSM band itself is from 890 to 960 megahertz.

So, this is the simple example of how you can use a microstrip antenna with two patches to obtain comparatively higher band width, thank you.

Hello everyone. My name is Anil Kama; I am a PhD student at IIT Bombay. Till now my friends have shown you planar antennas and now I will show you 3D printed antennas.

(Refer Slide Time: 07:10)

So, these are the some of the examples of 3D printed antennas. So, we are this is a simple horn antenna made with using 3D printing technique. Similarly there is another antenna which is 3D printing technique.

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Hello I am Rohini Bhide, working in antenna lab this is reflector antenna which is available in market. It operates at 2.45 gigahertz; it provides us 24 dB a gain which can be used at the high gain application. To make it lighter this strips are used instead of having a metallic plate.

Hello everyone. I am Hemanth Kumar, teaching assistant for this course. I am here to present some of the antennas designed by us.

(Refer Slide Time: 08:01)

This is a basic planar Yagi-Uda antenna designed at 1.12 gigahertz. It is designed on a f r 4 very low cost substrate. It have approximately gain of 6 to 7 dB here. Next is a broad band linear low periodic dipole antenna. This is a dipole arrays, and you can see here is the radiation pattern and here we have to feed the antenna, this is a coaxial feed linear low periodic dipole antenna. This is a helical antenna. Here is the feed and this is designed for FM.

Next is horn antenna: this is our horn antenna designed for 1700 megahertz to 1900 megahertz it have approximately gain of 11 dB here. It have a feed from here this is feed poof feed, you can see inside and here we can see there is a coaxial feed.

Now, we are going to show you how to measure the input impedance VSWR, and reflection coefficient for a given antenna. For measurement we have to use a network analyzer.

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Here we have a network analyzer which can operate from 100 kilo hertz to 8.5 gigahertz. So, we can measure the antennas which have any frequency range from 100 kilohertz to 8.5 gigahertz. So, first step to measure the input impedance or VSWR or reflection coefficient we have to calibrate. So to calibrate we have given some standard loads: one is open, short and 50 ohm match load, because the maximum value of VSWR can be infinity or minimum is 1. 1 is for complete match load and infinity is for open and short load. So we will require three loads: one is open another short and last one is 50 ohm match load. Now we will do the calibration.

We designed this antenna for GSM band, so let us select the frequency range. So, let us first select the frequency range press start, then select the start frequency as 800 megahertz, then select the stop frequency that is roughly select 1.1 gigahertz, because this antenna is designed to operate from 893 megahertz to around 980 megahertz. So, we need to select the frequency range that should be little higher than this or lower then this start frequency. So, that is why we are selecting the start and stop frequency as 800 megahertz and 1.1 gigahertz.

Then we need to calibrate. So, in order to calibrate select the calcite number; go to calibrate for this we need to select the calcite. So, the calcite number is 855158. So, select calcite number, then press calibrate then do one port calibration, because here only when port we are using. To do the calibration firstly connect it with open, after connecting press ok, then connect it to short, again press ok and after that connect it to load then press ok.

Now we know when you connect it to open it provides 0 dB return loss. So, here it is providing 0 dB when we are connecting to open, and same is in case of short. When we connect it to load then it provides us very less reflection efficiency. So, practically when it comes below 20 dB then we say that it is calibrated with the load. So, thing is why we do calibration? So calibration is usually done to account the cable losses. If we have calibrated the cable and we have done the full calibration for this operating rage, now we need to connect it with the antenna.

Here I have connected it with the antenna. Now you can see here in this my response is coming below 10 dB in some frequency range that is my operating band. So, we need to see; what is the band width that it is providing. So we need to put some marker so that we can see what is the operating band width that it is providing. So, just select marker and put it in minus 10 dB end points.

So, here we are providing two markers to select the 10 dB points so that we can get the idea of the operating band width. So, that the band width that we are getting here is from 900 to 1.01 gigahertz; that is my operating band width for this antenna. Now we want to see the depth then we need to put one more marker and then need to see the lower most point. So, the lower most point that we are getting here is at 1 gigahertz. So, this is my frequency range. Now if we want to see the Smith Chart or impedance plot then we need to select this Smith Chart from the format.

Go to format, then select a smith, then select the format r plus j x; now you see here one loop is coming this loop is coming because of the parasitic patch that is placed over here. So, there is a coupling between these two patches that is why the loop is created in this Smith Chart.

Now I would like to show the VSWR plot, we need to select the SWR. So, here you can see the VSWR plot. So, whatever range is coming below 2 that is my frequency range for this antenna, from here you can see from 900 to approx 1 gigahertz my range is coming so that is my frequency operation for this antenna.

Now, we have showed and explained how to measure the impedance VSWR and reflection coefficient, next we will explain how to measure the gain and radiation pattern for a given antenna. We will use one reference antenna over the same frequency range. Now let us see how to measure the radiation pattern and gain.

(Refer Slide Time: 15:04)

Here we are going to measure the radiation pattern and gain of the given antenna. The given antenna is working at 900 megahertz; this is a suspended microstrip antenna working at 900 megahertz. So, before doing the measurements we should have some reference antenna with respect to which we will measure the gain and radiation pattern.

So, we have chosen this reference antenna which is working at the same frequency range. This is a whole antenna its gain approximately 10 dB at 900 megahertz. To calculate the gain of our given antenna we will first place these two antennas at far field distance. The far field distance you can calculate using the formula 2d square divide by lambda. So, at 900 megahertz if you calculate the far field distance it will be approximately 1.8 meter. So, we have taken approximately distance of 2 meter. So, the distance between these two antennas is 2 meter, this is our given antenna and this is our reference antenna.

In the reference antenna we will provide the input. Input can be generated from the network analyzer; it can be generated using a signal generator. So, to give the input to the reference antenna we will use signal generator. This signal generator works from 100 kilo hertz to 6 gigahertz. So, it lies in our frequency range.

So, first we have to select the frequency at which we have to give the input. So, select frequency, click on this, now select the frequency value if we want to measure gain or radiation pattern at 900 megahertz then we have to give the input as a 900 megahertz. Next is we have to give the some amplitude value; amplitude you can select 0 dBm, 10 dBm, maximum value that we can give from this signal generator is 17 dBm, but we are going to use as a 10 dBm. So, select amplitude level which is 10 dBm. To give the input to the reference antenna we have to on this button RF own. So, press this button, so we have clicked on this RF own. Now the input is given to our reference antenna.

Till now we have provided the input to our reference antenna. Now this reference antenna will radiate and this given antenna for which we want to measure the radiation pattern and gain will receive the signal. And the received signal will be measured using the spectrum analyzer.

(Refer Slide Time: 18:06)

This is spectrum analyzer; it works from 9 kilo hertz to 3.6 gigahertz. So, our selected frequency is 900 megahertz, so we will set the frequency first. So, from this you can select frequency; now you have various options the center frequency, start frequency, stop frequency, so we can select start frequency first. Now set this start frequency you can set it at 850 megahertz. The next is stop frequency 1 gigahertz, so we have selected our frequency range. Next you can change the amplitude reference level.

So, to change the amplitude reference level select amplitude reference level, take reference level as a minus 10 dBm or 0 dBm; so let us take minus 10 dBm; so this is our reference level. Now you can see approximately 900 megahertz we are getting some peak. You can measure this received value by selecting the marker. This is our selected marker at 900 megahertz you can see the value is minus 11.4 dBm. So, you can see the received power at 900 megahertz is minus 11.4 dBm.

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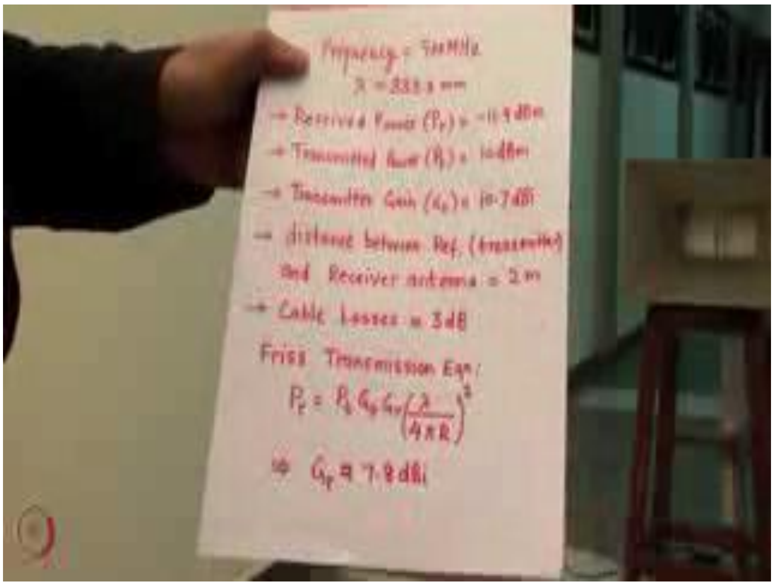

Now, to calculate the gain of our given antenna we have to use FRISS transmission equation. So, FRISS transmission equation will give you the gain of our antenna. So, there are various parameters P t is transmitted power which we have used as a 10 dBm. Next is G t the transmitter gain, which is the reference antenna gain, which is approximately 10.7 dB I at 900 megahertz. Next is G r; this G r value we will calculate from this equation. Lambda is a wavelength which can be calculated from c by f; c is our speed of light frequency, f is 900 megahertz so you can calculate the wave length. Then next R, R is the distance between the reference antenna and the receiver antenna; receiver antenna is the antenna for which we are going to calculate the gain. We have taken the distance between these two antenna as 2 meter.

So, next we have connected the transmitter antenna to the signal generator and the receiver antenna to the spectrum analyzer using the coaxial cables. So, theses coaxial cables have some losses we have included this losses which is approximately 3 dB. Now you can put these values in this equation you can find out the gain of received antenna. So, the gain of the received antenna calculated from this equation is 7.8 dB I.

Till now we have measured the gain of our given antenna, now we will measure the radiation pattern. To measure the radiation pattern we will first align these two antennas; one is our given antenna for which we are going to measure the radiation pattern, next is our reference antenna. There are four types of radiation pattern you can measure: first is E (Refer Time: 21:46) in which both the antenna E plane should be perfectly aligned with respect to each other. So, antenna E plane in vertical direction, this is our reference antenna also have E field in vertical direction. So, in this we have both the antennas E field in vertical direction.

Now to measure the E plane co-polarization we will rotate our antenna from 0 to 360 degree with respect to the reference antenna. At 0 degree the received value will be maximum. So, for other values of the angle we will normalize with respect to 0 degree value. Now this we want to measure the cross pole we have to rotate this antenna by 90 degree in vertical plane direction. Then you rotate this antenna 0 degree to 360 degree in the horizontal plane with respect to the reference antenna, and take the readings the readings will give you the cross polar in the E plane.

Similarly if you want to measure the H plane co-polarization we have to align both the H plane in the same vertical direction. So, we have to rotate this reference antenna in this direction, so this is our H plane. Similarly we can rotate this antenna by 90 degree which will give us the H plane in the vertical direction. Then we can do the same procedure for the radiation pattern. If you want to measure the cross pole in the H plane then we will rotate this antenna in the 90 degree, after that rotate 0 to 360 degree in the horizontal plane with respect to our reference antenna this will give you the cross polarization components in the H plane.

We will show you the demo for the e plane co polarization components. So, to rotate this antenna we have one rotating table, here there is button to rotate this antenna. So, if you press button it will rotate our antenna by the value mentioned in this screen. So, you can see the antenna is rotating by 1 degree angle after every step. Now, we can see the value in the spectrum analyzer. After rotation of a 20 degree approximately you can see the received value is decreased by 1.3 dB approximately, you can see minus 12.8 dBm we are receiving. At 0 degree we have received the value approximately minus 11.4 dBm and now the value is minus 12.7; again if you further rotate this value will further decrease.

Now we will take the reading at 90 degree, now we have rotated our given antenna by 90 degree with respect to the reference antenna. Now we can see the reading what we are receiving. So, the received value you can see is approximately minus 23 dBm which is approximately 11 to 12 dB less than the maximum value. Now we will rotate this antenna further by 90 degree.

Now you can see we have rotated our antenna by 180 degree with respect to the reference antenna. Now the received power will be less because this antenna is pointing opposite to the reference antenna. Now, the reading is approximately minus 30 dBm for 180 degree angle. Now if you want to calculate the front to back ratio: front value was approximately minus 11 dBm and the back value which is at 180 degree is approximately minus 30 dBm. So, if you find out the front to back ratio it will comes out to be equal to 20 dB approximately.

We have measured the radiation pattern from 0 degree to 180 degree, because the antennas are symmetric so there is no need to calculate the radiation pattern from 0 degree to minus 180 degree. So, you can use the same value that we have obtained from 0 to 180 degree and plot the radiation pattern using available softwares. In the similar way you can find out the cross polar for E plane co-pole component in the H plane cross polar component in the H plane. So, you can obtain all these four plots.

Thank you.