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Roll no.:- 1702009

Report Title:- Design and Simulation of Patch Antenna

Objective:- To design a Patch Antenna at 2.4 GHz and simulate the performance using ADS software.

Structure of the Antenna :-

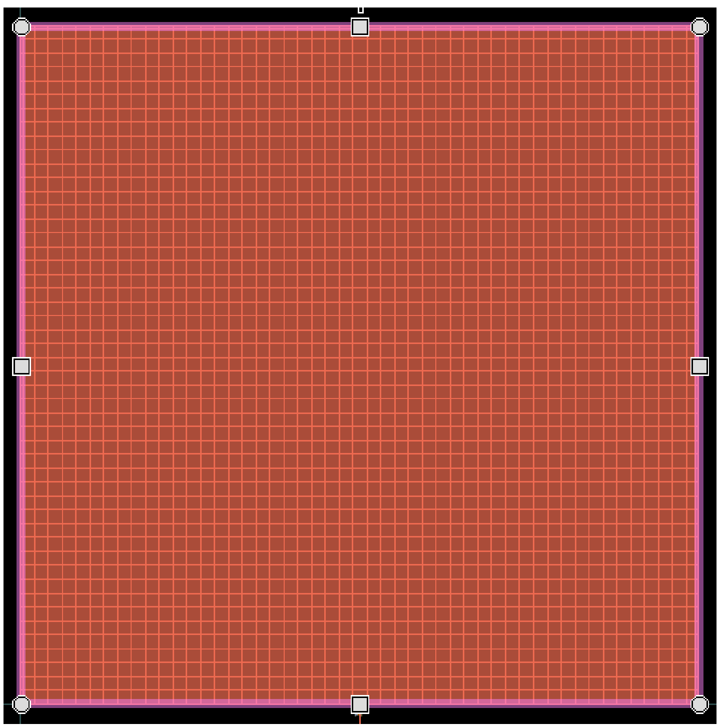

Fig.1.:- Layout of the patch antenna in ADS

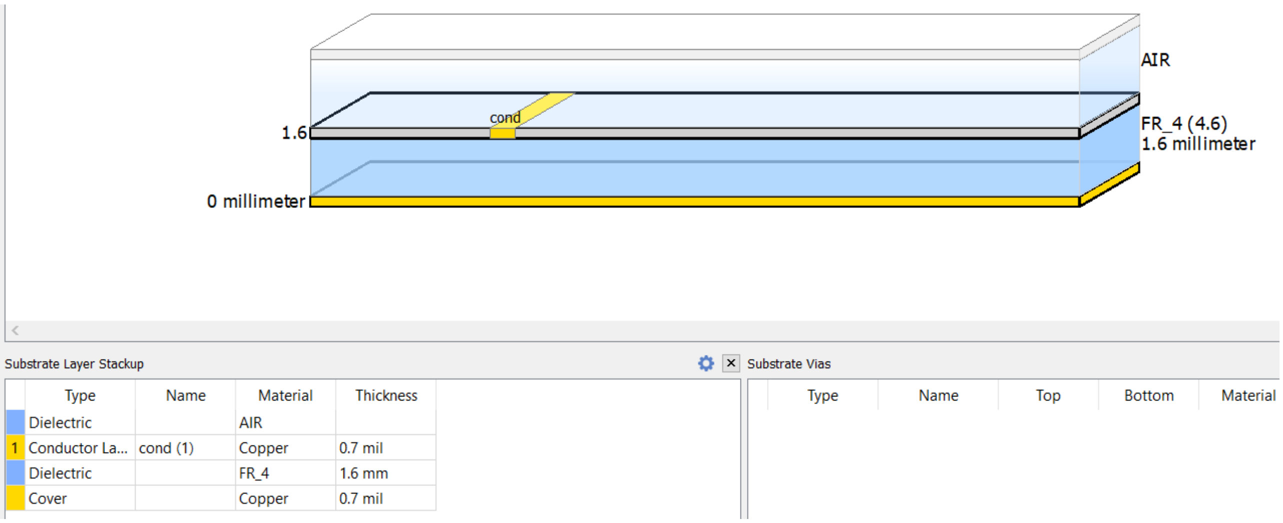

Fig.2.Substrate layer of the patch antenna

The structure of a microstrip patch antenna is shown in the figure.It has mainly 4 parts:- patch,ground plane,substrate,feeding part. Our radiating patch is of square shape though it can be rectangular,circular,elliptical or any other shape. The length and width of the patch that we have used is = 29.2mm.This width/length basically depends upon the desired frequency($L=W=c/(2f\sqrt{Er})$) The patch is layered upon a substrate. The substrate is made of FR_4 material.It's thickness, relative permittivity and TanD values are 1.6mm, 4.6, 0.001 respectively. 0.7 mil copper is used as a conductor,it's conductivity is 5.8E7 S/m. A copper sheet of 0.7 mil is used as a ground plane. Upon the patch, there is air dielectric.

<u>Results:-</u>

Reflection coefficient:-

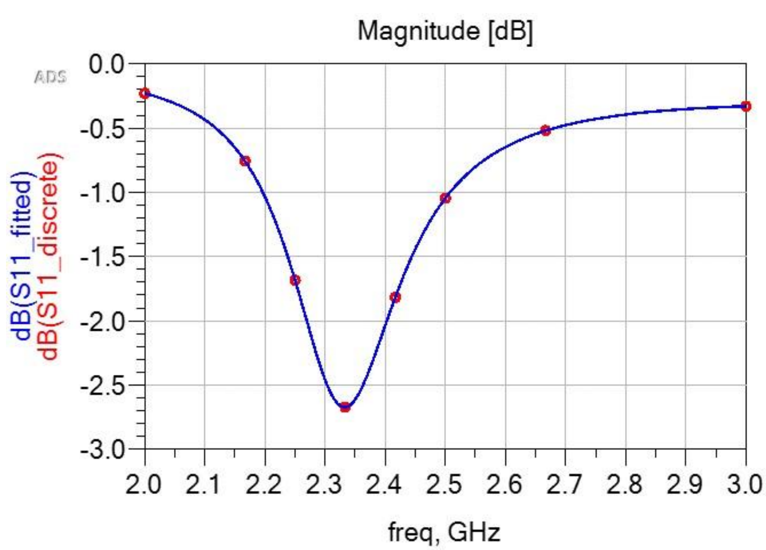

Fig.3.Reflection coefficient vs frequency graph of the patch antenna

Reflection coefficient is a parameter that describes how much of a wave is reflected by an impedance discontinuity in the transmission medium. It is equal to the ratio of the amplitude of the reflected wave to the incident wave. Here,in the figure, the reflection coefficient vs frequency graph is shown.the frequency range is 2 to 3 GHz. From the graph, we can see that the minimum s-parameter frequency happened for around 2.33GHz and for this frequency the reflection coefficient is around -2.7 dB. But it wasn't desired and that is a sign of a bad antenna design. For better performance we have to design such an antenna that has the reflection coefficient of the -10dB and it is used in practical.It represents that the antenna radiates 90% and reflects 10% of the supplied energy. For our design, we can consider below the -20dB. And this desired reflection coefficient should be gained by varying the input supply pin along the width of the radiating patch.

Smith chart:-

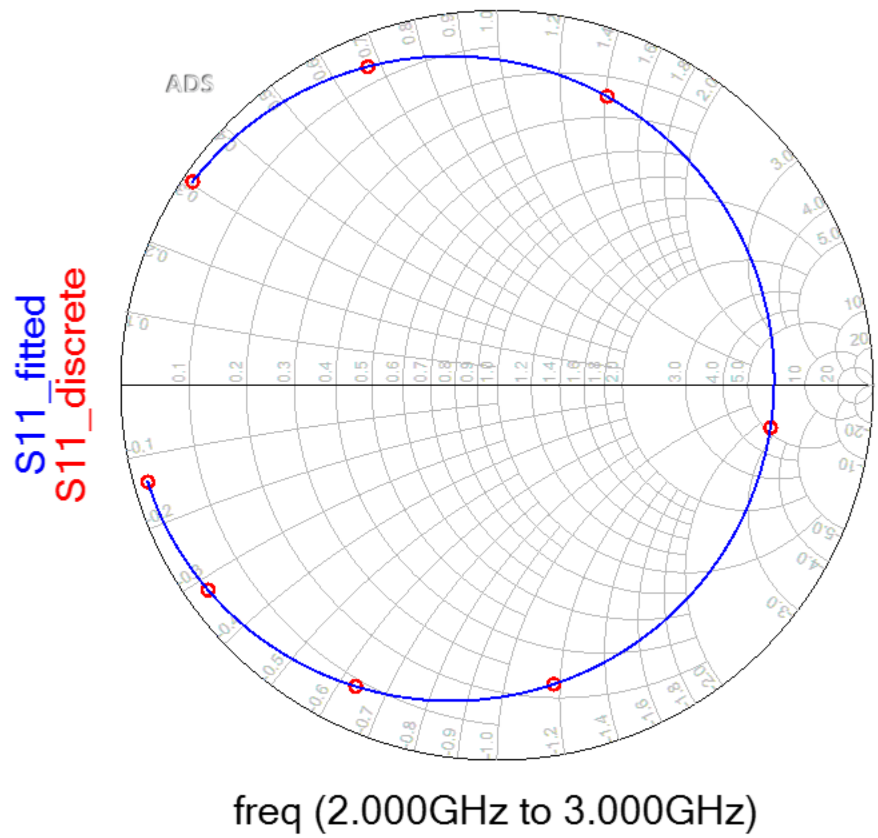

Fig.04. Smith chart of the patch antenna

The smith chart of the patch antenna is shown in the figure. It is connected to the reflection coefficient discussed before. We saw that the reflection coefficient graph wasn't desired.It is due to the impedance mismatching of the antenna.By smith chart,we can understand it more precisely. If there isn't any impedance mismatching, the arc of the smith chart passes through the z=1. But here the arc passes through z=7/8 around. Because here we connected the source pin at the edge of the patch(y=0),at the edge the antenna impedance is high , around 300ohm, but the feeding source line impedance that we usually use is 50 ohm only. So,there happened a big impedance mismatching And for this, our arc didn't pass through z=1 in the smith chart.

Radiation pattern (2D and 3D):-

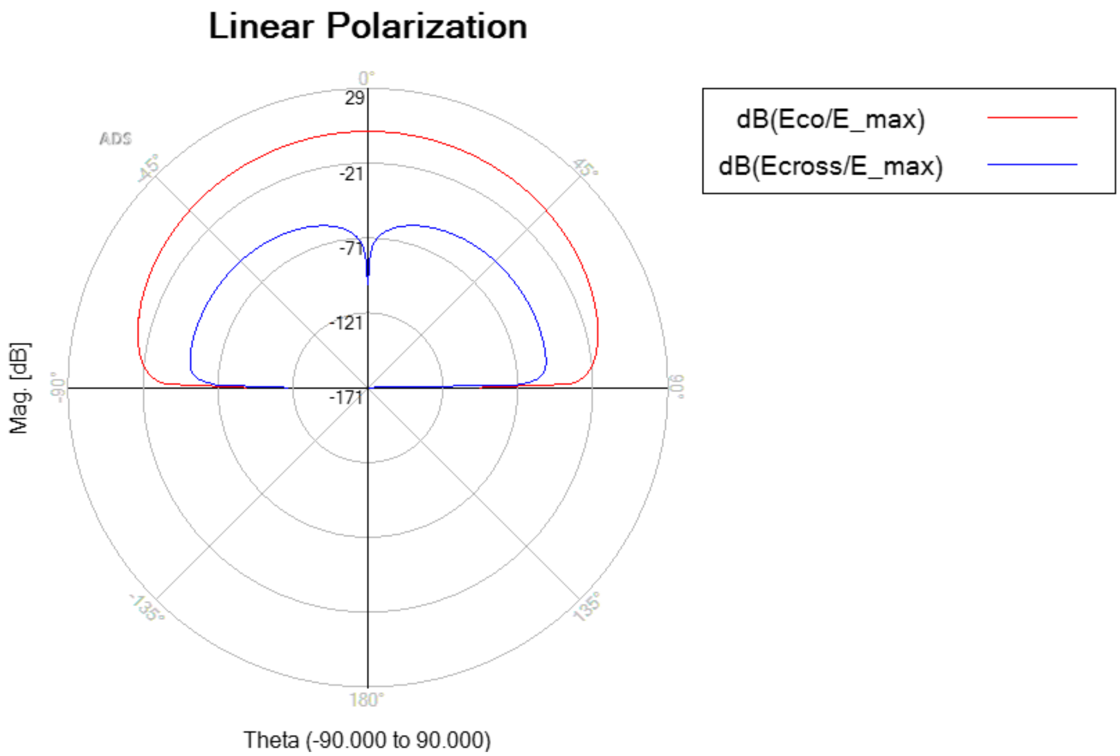

Fig.05. 2d radiation pattern of the antenna

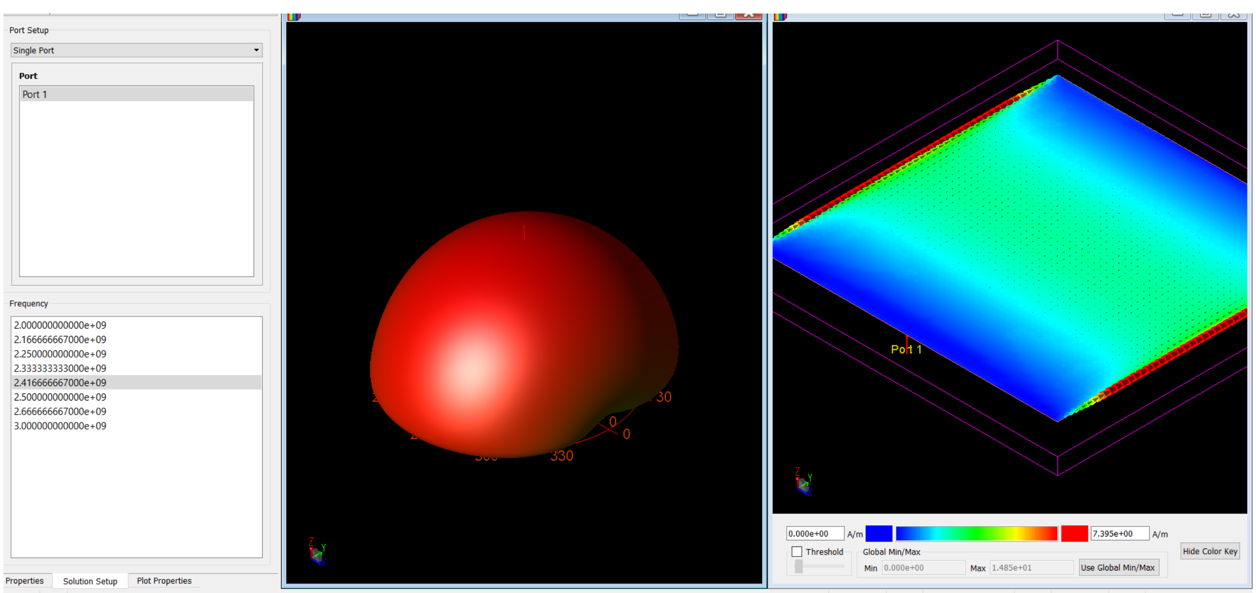

Fig.06. 3d radiation pattern of the patch antenna

There are many radiation properties like power flux density, radiation intensity, field strength, directivity, phase or polarization etc. A graphical representation of the radiation properties of the antenna as a function of space coordinates is called radiation pattern. It is determined in the far field region mostly. In figure 6, there is shown the 3d radiation pattern and the current distribution of the patch antenna for the far field region and for the minimum s-parameter frequency 2.4166 that we got from the s parameter of the antenna. From the pattern, we can understand that the radiation is maximum in the radial z direction. And from current distribution, we can see that at the edge,current density is higher than the center.

In figure 5,there is shown the 2D radiation pattern of the patch antenna. When the transmitting and receiving end antenna have the same polarization, it is called co polarization. The red line in the figure represents co polarization that is our desired polarization.When receiving and transmitting end antennas have different polarization it is called cross polarization.It is shown by blue line in the figure.cross polarization is orthogonal to the co polarization. From the figure we can see that there is a significant difference between the co polarization and cross polarization that is a sign of a good antenna parameter design.

Task:

Change the position of the input pin along positive y-axis direction keeping it in center position. Consider the following advanced position along the y-direction with respect to initial position: 2 mm, 4 mm, 6 mm, 8 mm, 10 mm, 12 mm, 14 mm.

1. Do you observe any changes in S-parameter?
   Answer: Yes, If we change the position of the input pin , then a change occurs in the S-parameter.

2. If the answer to the 1st question is ‘yes’, why did this kind of change occur?
   Answer: Figures 07 to 13 depict the S-parameter for advanced pin position along the y-axis with respect to initial position: 2 mm, 4 mm, 6 mm, 8 mm, 10 mm, 12 mm, 14 mm.

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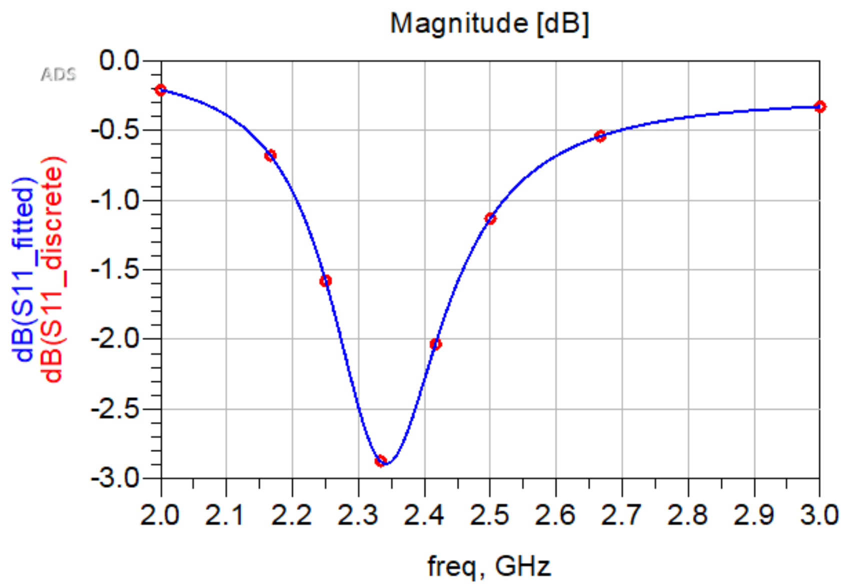

Fig.7. S parameter at y=2mm

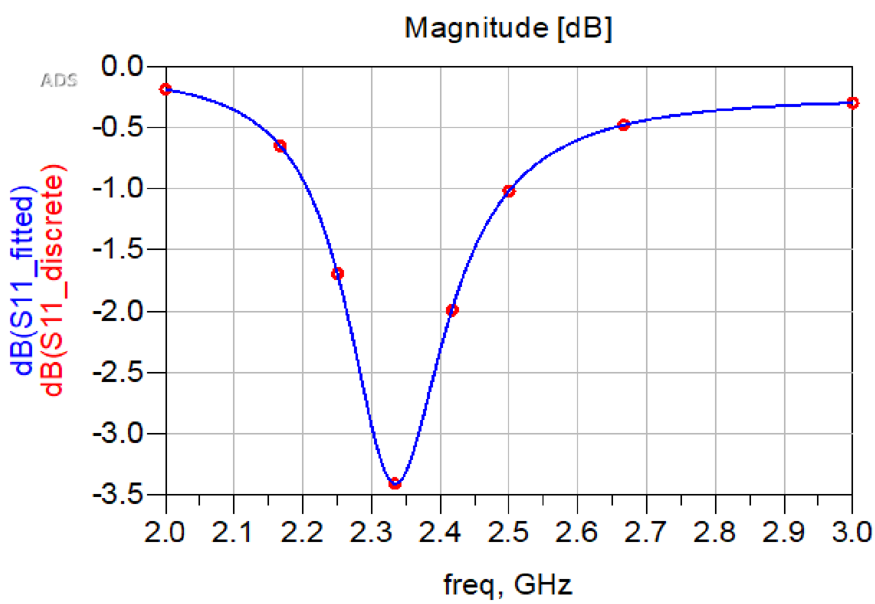

Fig.8. S parameter at y=4mm

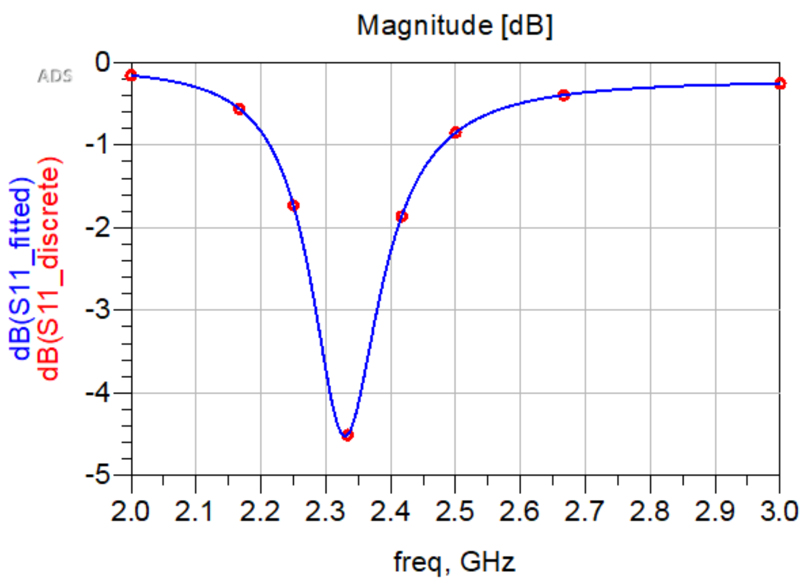

Fig.9. S parameter at y=6mm

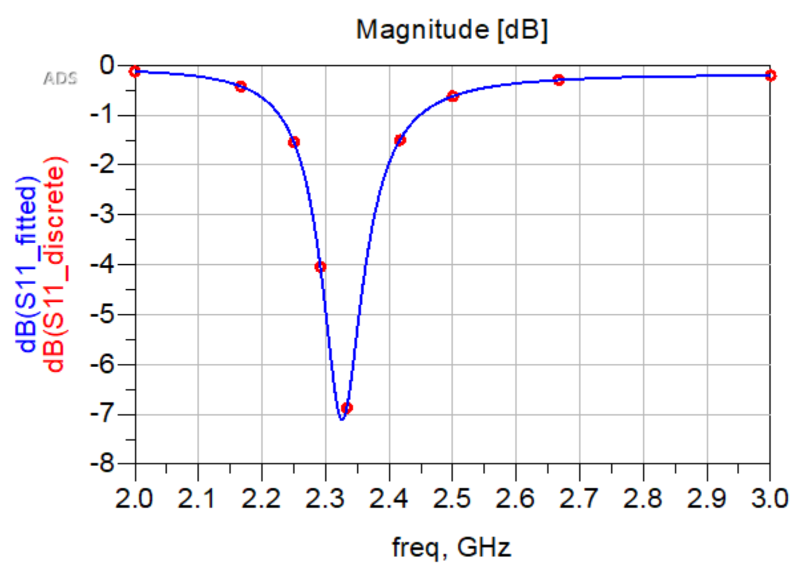

Fig.10. S parameter at y=8mm

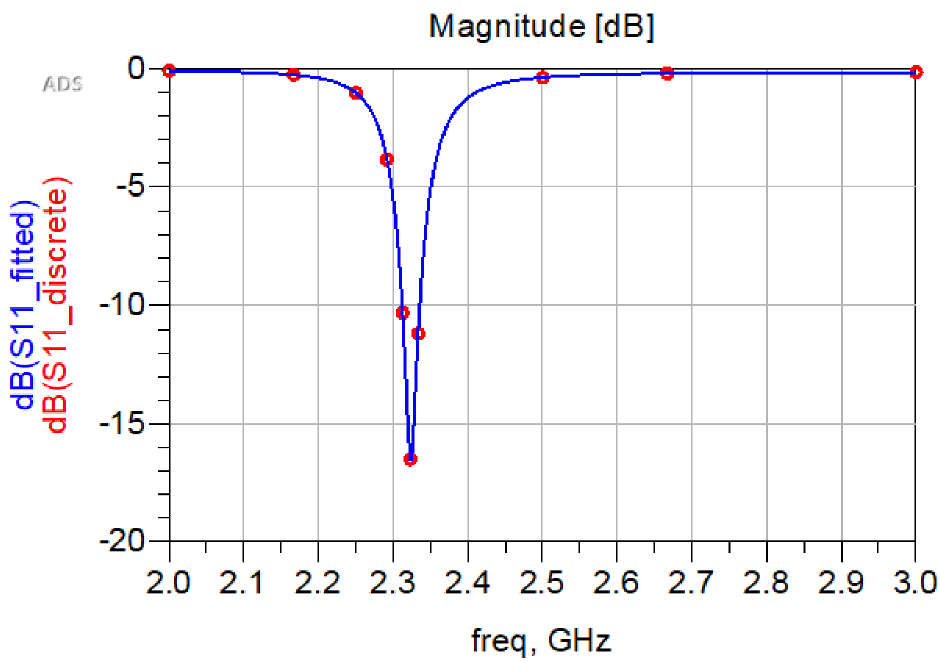

Fig.11. S parameter at y=10mm

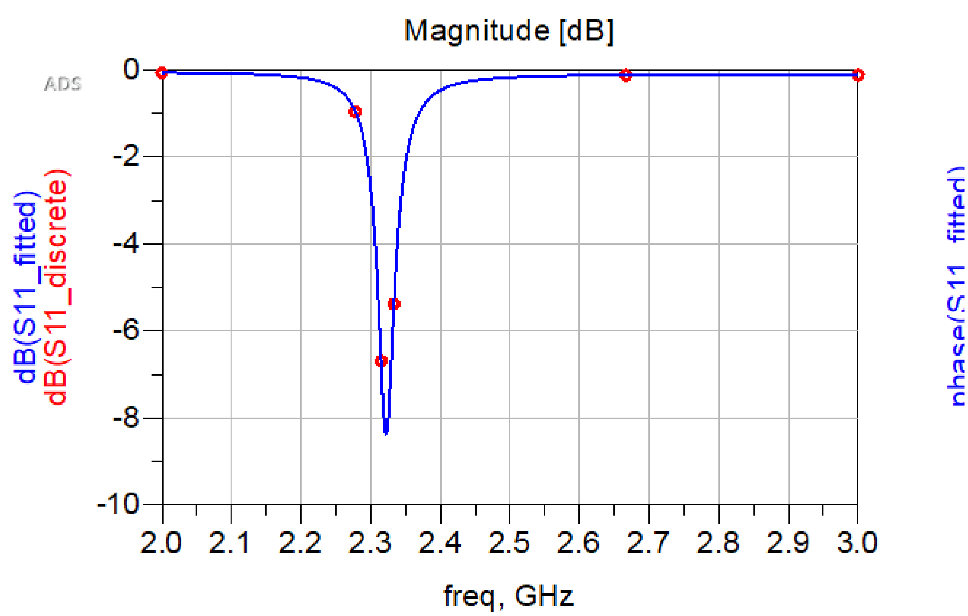

Fig.12. S parameter at y=12mm

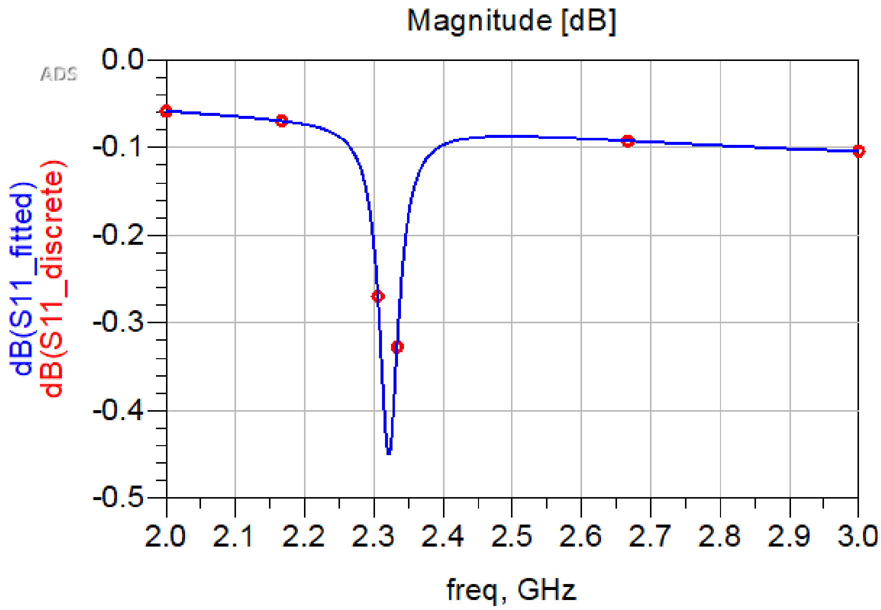

Fig.13. S parameter at y=14mm

<u>Reason of change in s parameter:-</u>

From figure 7 to 13 we can see that, If we gradually increase the input pin from 2mm to 10mm, the s-parameter in dB value decreases. But when again we increase the input pin upto 12mm and 14 mm from the edge,the s parameter value increases.the reason will be quite clear if we consider the figure given below:

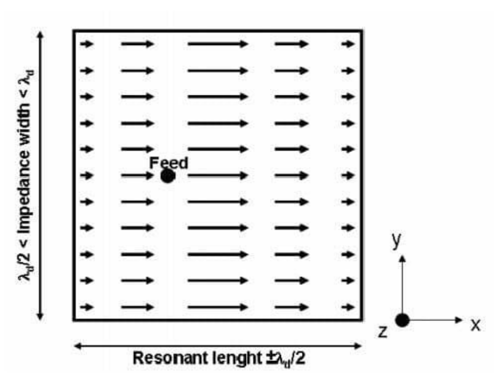

Figure 2: Current distribution on the patch surface

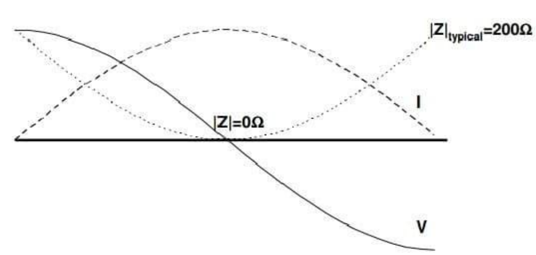

Fig.14:- Voltage,current and impedance distribution along the patch's resonant length.

we can see from the figure 14 that at the edge of the patch ,the impedance is maximum.when we move upward to center of the patch ,impedance decreases and the impedance is minimum at the center of the patch antenna, and the impedance gradually increases after crossing the center and becomes maximum again at the opposite edge. The source input pin that is usually used has an impedance value of 50 ohms. So, the input pin and patch antenna has a greater mismatch at the edge, and the mismatch decreases while the input pin advances towards y-direction and after reaching the advanced position y=10 mm from the edge,the mismatch got the minimum value so,we get the value of reflection coefficient is -17dB around which is the standard for design.when,again we advance from 10mm upward, the mismatch becomes considerably increased.Therefore, if we change the input pin,we observe the change in s-parameter.

3. Which position is optimum for your antenna and why-explain?
Answer:- At the y=10mm position along the y axis from the edge is the optimum position for my antenna. Because at this position,the antenna impedance is mostly near about 50 ohm with respect to the other position. So we can tell that, at this position the antenna load impedance slightly matches with the source.It is not perfectly matched,but mismatch can be neglected. So,we got the optimum reflection coefficient value of 17dB around. And it is very clear from the smith chart also. Because for this position the smith chart arc is near about z=1 with respect to the other position.