SIMULATION AND RESULT

Overview of antenna parameters

Depending on different types of parameters value, we can differentiate which antenna works correctly or not. For the microstrip antenna depending on S11 parameter we find out its return loss. Which has shown us antenna's reflection coefficient. Voltage sanding wave ratio (VSWR) is another criterion which shows us, the different property between the feed line and the patch of the antennas. The closest value of VSWR is the 1, that much better. Bandwidth shows us, what is the frequency range of the antenna, where it operates perfectly. Some of the property description is given bellow.

S11 parameter

Basically, S-parameters refer the relationship between input and output of two ports situated in an electronic device. If a system has two ports (port 1 and port 2), then S12 means the power is transmitted from port 2 to port 1. Hence, in general, if SNM is noted and it means the power is transmitted from port M to port N. ports can be placed where term voltage and current are used. Normally, if there needs a communication between two radio like- radio 1 and radio 2, and S11 parameters come, it does mean that radio 1 will transmit reflected power to antenna 1. Similarly, S22 refers the reflected power will be transferred to antenna 2 from radio 2.

However, S11 parameter plays a vital role in antenna design. It is considered as the basic method which is used to measure the input impedance of balanced- fed antennas. It describes how much power is reflected from the antenna. It is known as the reflection coefficient or return loss. It is noted as gamma (Γ) If S11=0 dB, it means all the power is reflected and there is no radiated power. Again, if S11=-10 dB, it means -7 dB is the reflected power if 3dB is considered as delivered part. The remainder of the power is known as accepted by or delivered antenna. This portion is lost or radiated within the antenna. Basically, low loss antenna is the priority but ideally the power which is delivered to the antenna gets radiated.

VSWR

VSWR refers Voltage Standing Wave Ratio. The impedance of the radio and transmission line should be matched to the impedance of the antenna for transmitter or receiver. The VSWR is real and positive number for antenna measurement. The smaller the VSWR is, the better the transmission line is matched to the antenna. It also means that more power is delivered to the antenna. From the upper equation, it can be found that the smallest VSWR is 1. It means there is no power which is reflected from the antenna ideally and there will be a constant magnitude along with the transmission line. It is also related to bandwidth requirement of an antenna. The requirement is given in terms of VSWR. Like- an antenna works at 100-200 MHz and given that VSWR<4. It means the VSWR is less than 4 in the specified frequency. When antenna's impedance is not matched with the receiver, it means that power is reflected, and the reflection coefficient is zero. It is an important parameter but not sufficient to determine antenna function properly.

Bandwidth

It is also a fundamental antenna parameter. It refers that frequency range in which antenna can properly radiate or receive energy. Sometimes, in time of designing, desired bandwidth is one of the most determining parameters. This microstrip patch antenna has narrow bandwidth and cannot be used for wideband applications. Bandwidth is required in terms of VSWR.

Bandwidth sometimes refers as Fractional Bandwidth (FBW). This Fractional Bandwidth is the ratio of highest frequency and the lowest frequency and divided by the center frequency. Basically, it is the ration of frequency range. Hence, highest frequency ranges minus lowest frequency range. If the center frequency is 1000 MHz and the frequency range is 985-1015 MHz then the FBW or Fractional Bandwidth is 0.03 and the ratio is 1.0305:1. The bandwidth of the antenna varies broadly, and it is very low or narrow for patch antenna.

Far field

There are 3 principal fields which surrounds the antenna regions. Such as:

I. Reactive near field
II. Radiating near field (Fresnel Region)
III. Far field (Fraunhofer Region)

Among them, this region is also affected by radiated fields with the help of E-field and H-field which is orthogonal to each other. If D is the maximum linear dimension of an antenna, the following three equation must be fulfilled to be in the region. The equations are:

1. $R > \frac{2D^2}{\lambda}$
2. $R >> D$
3. $R >> \lambda$

The first and second equation describes that the power is radiated in the given direction in parallel way. This means the field is far away which behaves like plane waves. In the First equation (>>) this means “much greater” hence the left side will be ten times larger than the right one. The equation in number 3 describes here is the radiating field only. The near fields have been gone.

Parameter for designing Antennas

The resonant frequency of the antenna is determined by the length of the antenna. For a patch antenna λ/2 is the fundamental mode. The length of the antenna is calculated with this formula:

$$L \approx 0.49\ \lambda_d = 0.49\ \frac{\lambda 0}{\sqrt{\xi r}}$$

Here,

L= The resonate length

λ_0= The wavelength of the free space

λ_d= The wavelength of the PC board

ξr =The dielectric constant

Width

The width of the patch can be calculated with this formula:

$$\text{Width} = \frac{c}{2fr}\sqrt{\left(\frac{2}{\xi r+1}\right)}$$

Here,

C = the speed of the light

fr =The resonant frequency

In this work, we have taken same parameters for five different shapes. Parameters of the antennas are given below:

Table 4.1: Parameter for designing

Parameter	Value (mm)
Width, W	37.60
Length, L	29.38
Width of the ground, Wg	2*W
Length of the ground, Lg	2*L
Height of the conductor, Ht	0.036
Height of the substrate, Hs	1.4
Length of the feed line, Fi	7
Gap between the feedline and the patch, Gpf	1

Microstrip Patch Antenna (MPA) for circular shape

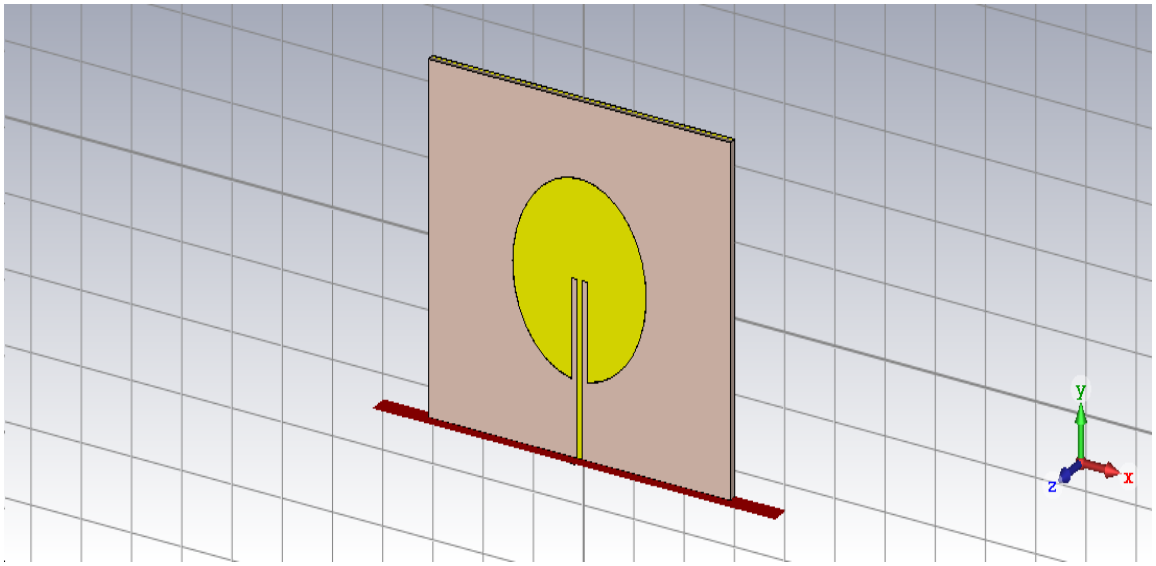

Fig 4.1: Microstrip patch antenna for circular shape

S1,1 parameter

Ideal value of S11=-10 dB, it means -7 dB is the reflected power if 3dB is considered as delivered part. The remainder of the power is known as accepted by or delivered antenna. This portion is lost or radiated within the antenna. So here we can see, for the circular shape we found -53.084 dB. And it is very much good result for return loss.

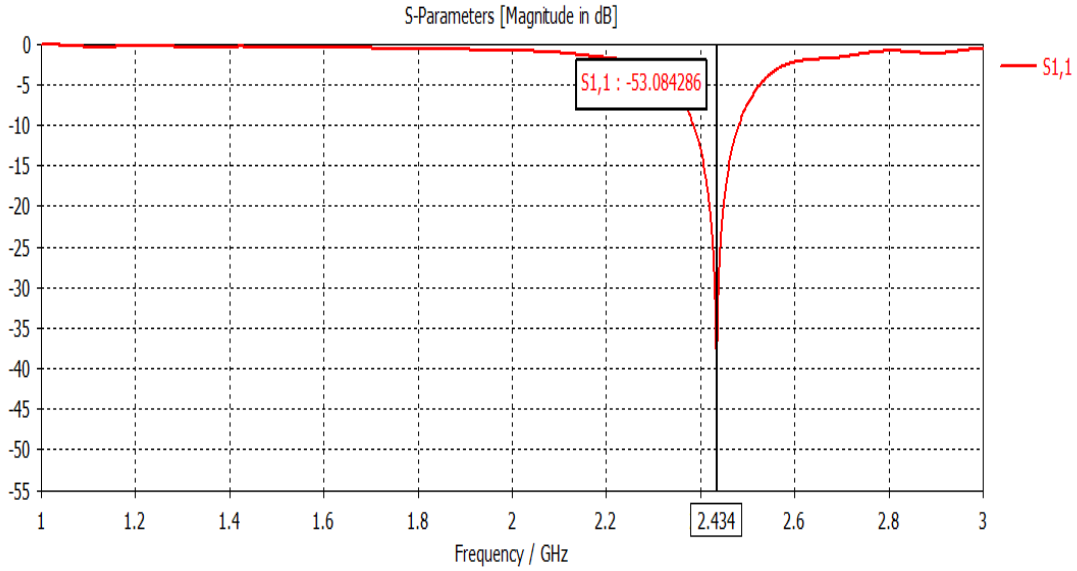

Fig 4.2: S11 parameter for circular shape

Bandwidth

This Fractional Bandwidth is the ratio of highest frequency and the lowest frequency and divided by the center frequency. Basically, it is the ration of frequency range.

F2=2.4735

F1=2.399

$$\text{Bandwidth} = \frac{F2-F1}{F_S} * 100\%$$

For the circular shape, bandwidth is 3.62%

VSWR

VSWR is the numerical value which represents how better the impedance is matched to the radio transmission line and the antenna. This is a passive method which determines whether the antennas are properly tuned or not. VSWR is related to reflection coefficient. For the circular shape, VSWR is 1.0044 for the circular shaped. The reflection coefficient is noted as gamma (Γ). The formula is:

$$\text{VSWR} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

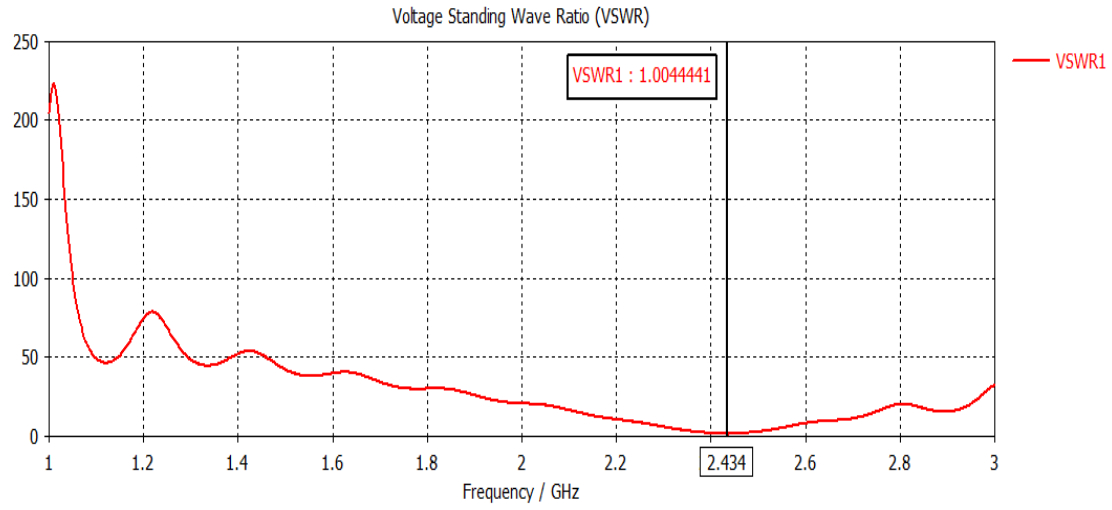

Fig 4.3: VSWR for circular shape

Radiation pattern

Our main lob magnitude is 5.54 dB which means that the maximum radiation that at 5.54dB, which is also known as the main beam. Our main lob Direction is 1.0 deg. This means 1.0 deg. angle it radiates most. And there is no side lob means any direction of the other than in the intended lobe that that contains by the radiation lobe.

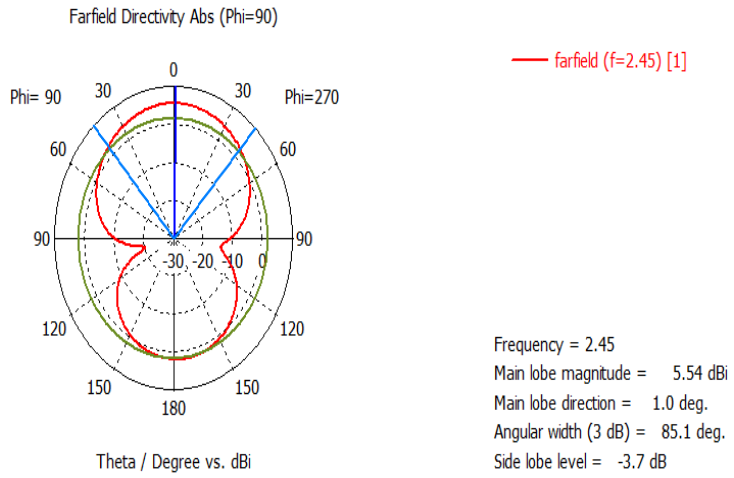

Fig 4.4: Radiation pattern for circular shape

Far field in 3D view

Far Field is the most important parameter because it shows the radiation pattern. Besides, antennas are used for long distance communication and that is the reason behind its importance.

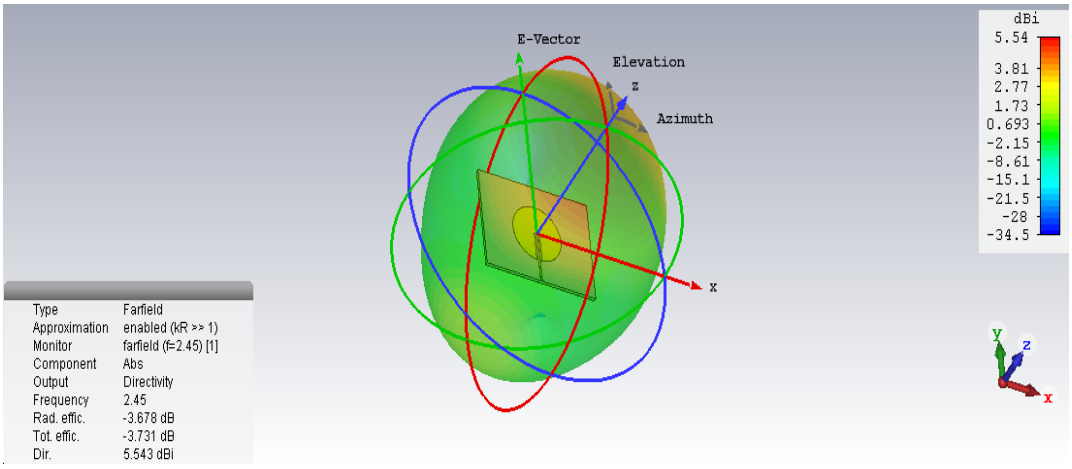

Fig 4.5: Far field for circular shape

Microstrip Patch Antenna for F shape

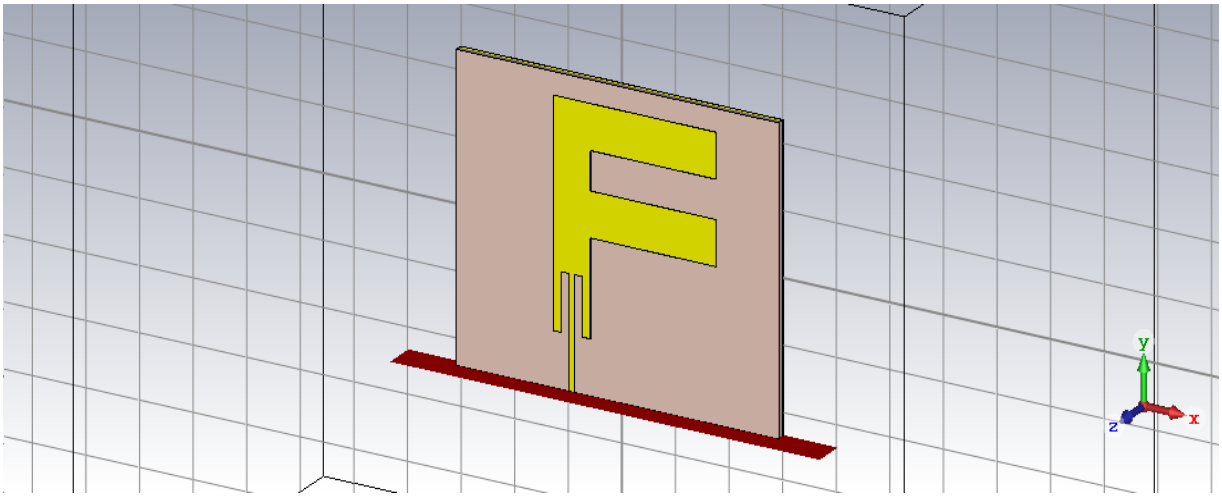

Fig 4.6: Microstrip patch antenna for F shape

S11 parameter

We can see, for the F shape we found -30.016 dB and it is very much good result for return loss.

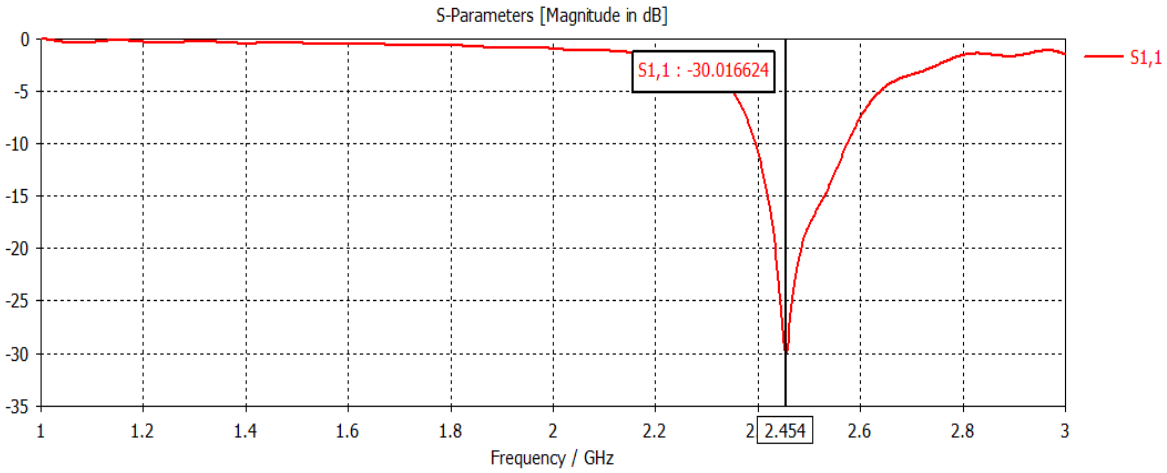

Fig 4.7: S11 parameter for F shape

Bandwidth

Basically, it is the ration of frequency range.

F2=2.3735

F1=2.2994

$$\text{Bandwidth} = \frac{F2-F1}{F_S} * 100\%$$

For the F shape, Bandwidth is 2.98%

VSWR

VSWR is related to reflection coefficient. For the F shape, VSWR is 1.065.

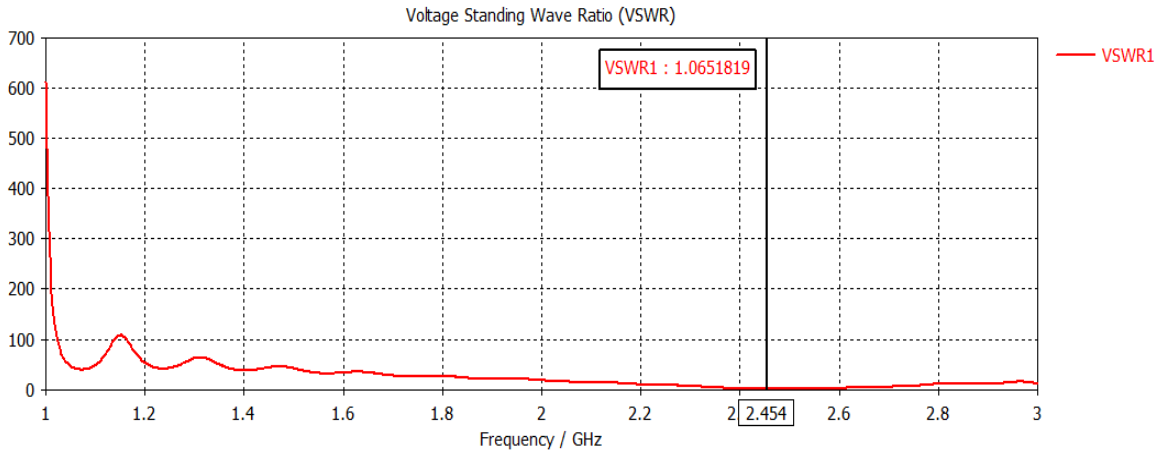

Fig 4.8: VSWR for F shape

Radiation pattern

The main lob magnitude is 4.11 dB which means that the maximum radiation that at 4.11dB, which is also known as the main beam. and main lob Direction is 6.0 deg. This means 6.0 deg. angles it radiates most.

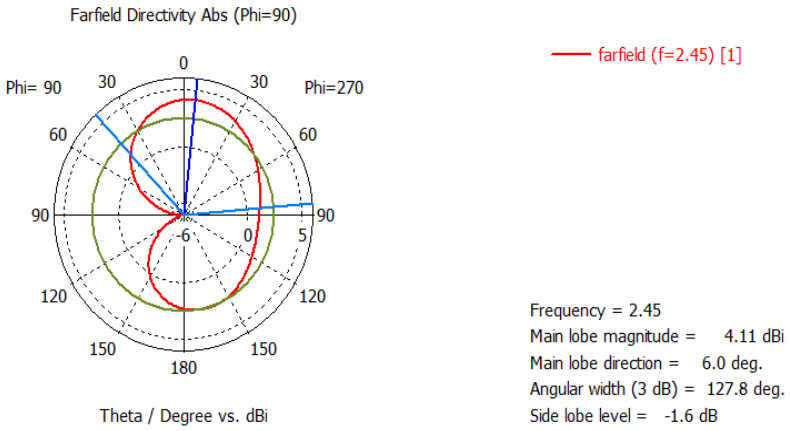

Fig 4.9: Radiation pattern for F shape

Far field

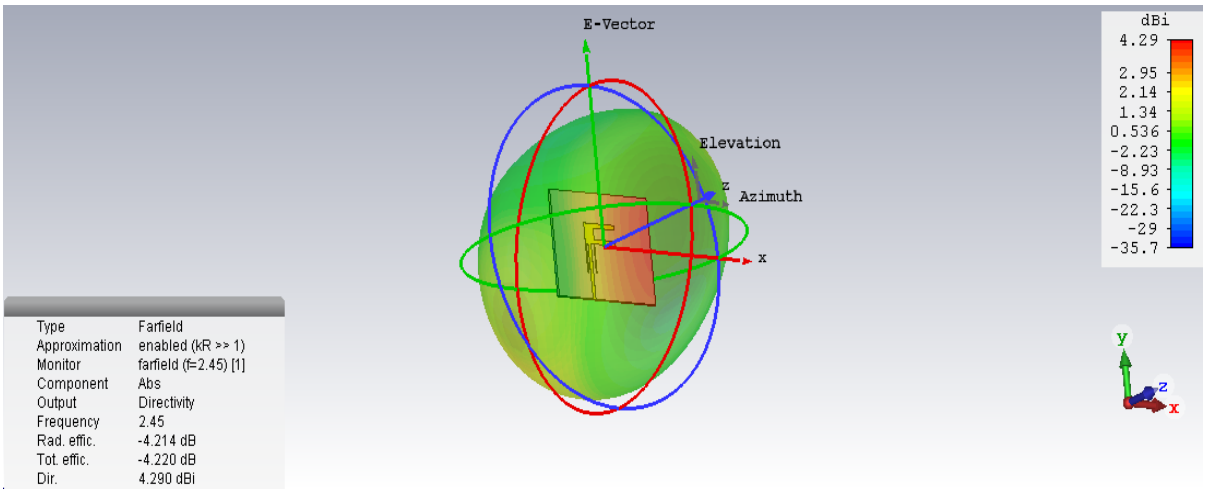

Fig 4.10: Far field for F shape

Microstrip Patch Antenna for triangle shape

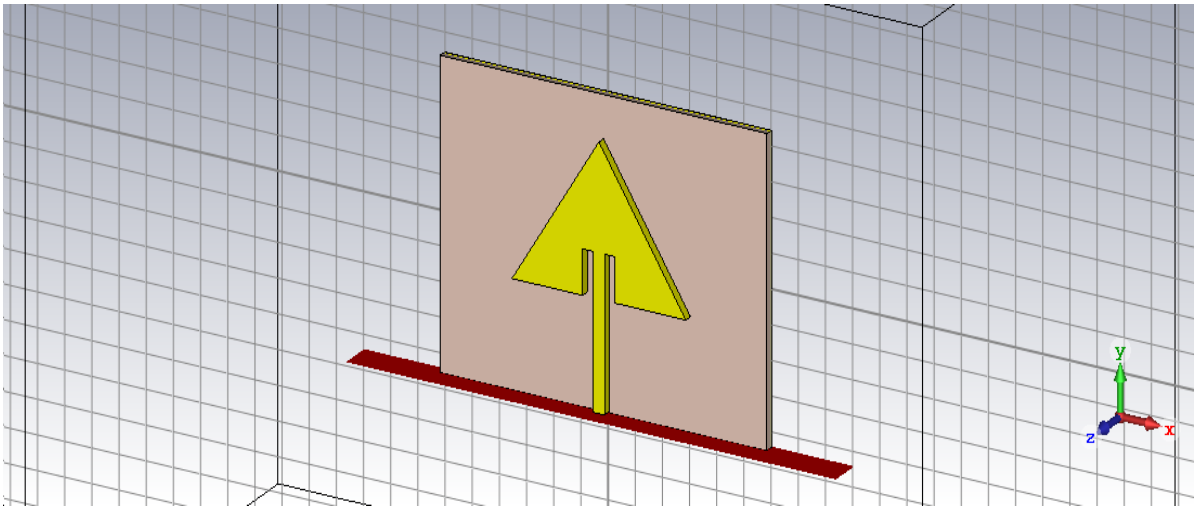

Fig 4.11: Microstrip patch antenna for triangular shape

S11 parameter

We can see, for the triangle shape we found -18.86 dB. And it is very much good result for the return loss.

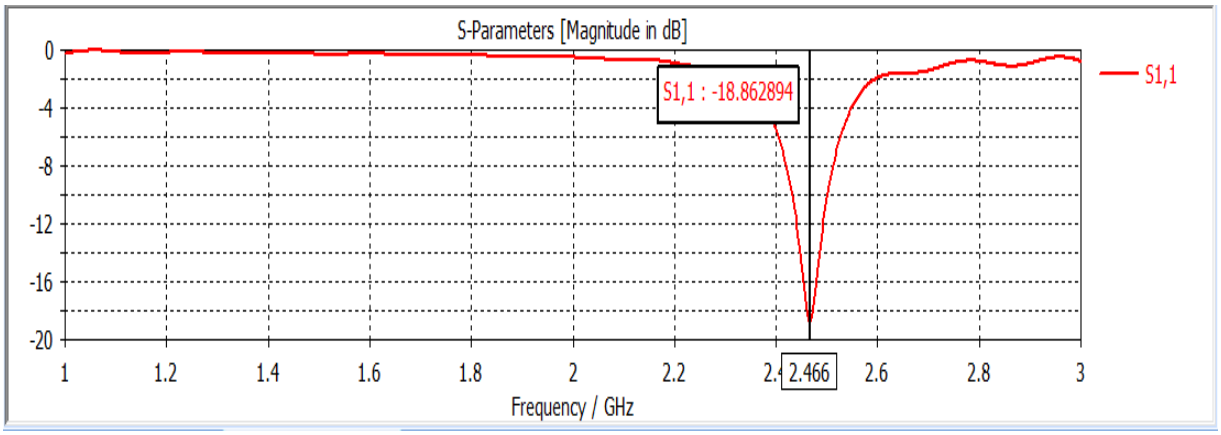

Fig 4.12: S11 parameter for triangular shape

Bandwidth

Basically, it is the ration of frequency range.

F2=2.283

F1=2.138

$$\text{Bandwidth} = \frac{F2-F1}{F_S} \ *100\%$$

For the triangle shape, bandwidth is 2.45%

VSWR

VSWR is related to reflection coefficient. For the triangle shape, VSWR is 1.257 for the triangular shaped.

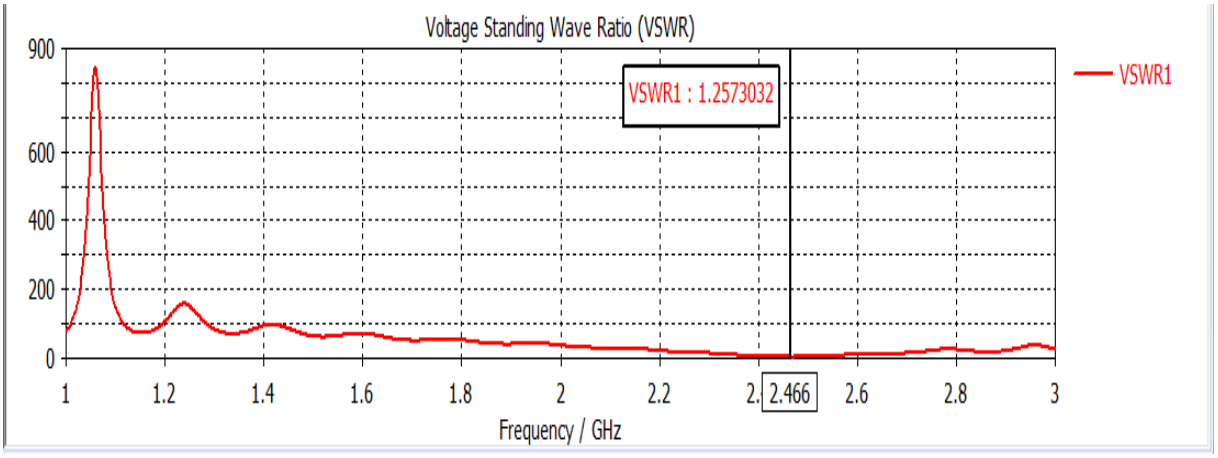

Fig 4.13: VSWR for triangular shape

Radiation pattern

The main lob magnitude is 4.51 dB. and main lob Direction is 4.0 deg. This means 4.0 deg. angle it radiates most. And there is no side lob means any direction of the other than in the intended lobe that that contains by the radiation lobe.

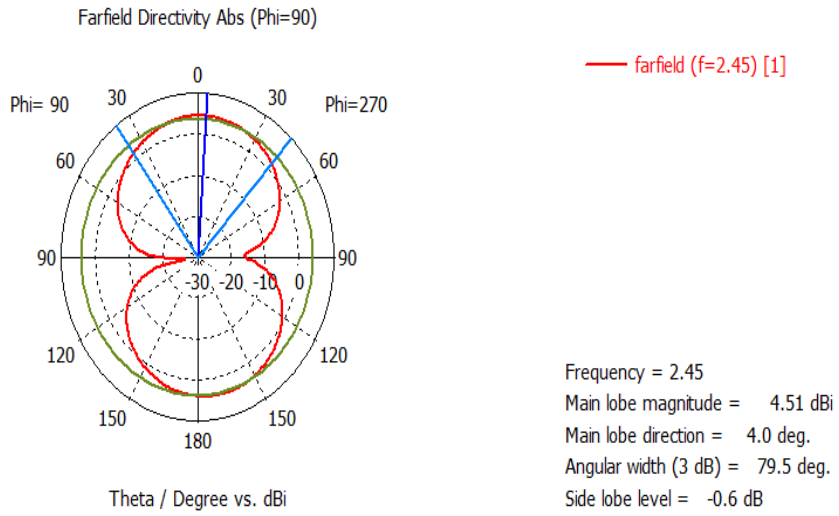

Fig 4.14: Radiation pattern for triangular shape

Far field

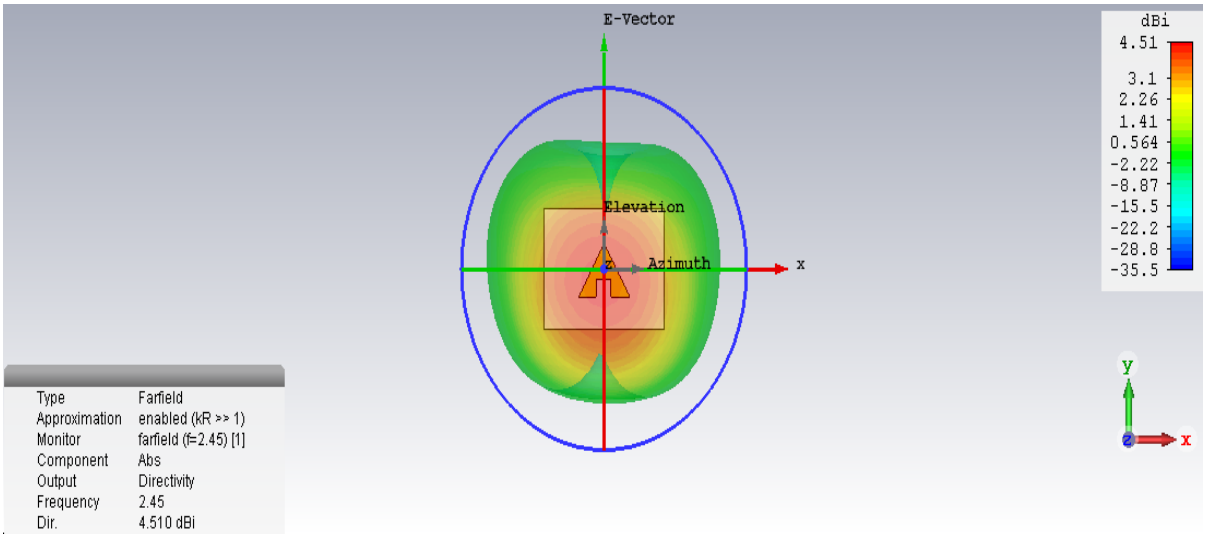

Fig 4.15: Far field for triangular shape

Microstrip Patch Antenna (MPA) for square shape

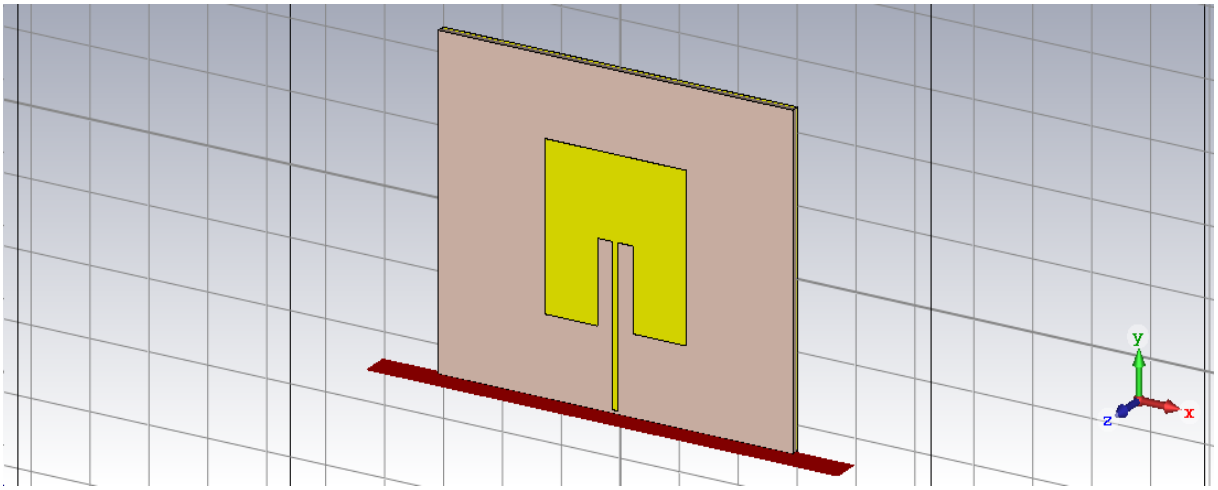

Fig 4.16: Microstrip patch antenna for square shape

S11 parameter

We can see, for the square shape we found -16.38 dB.

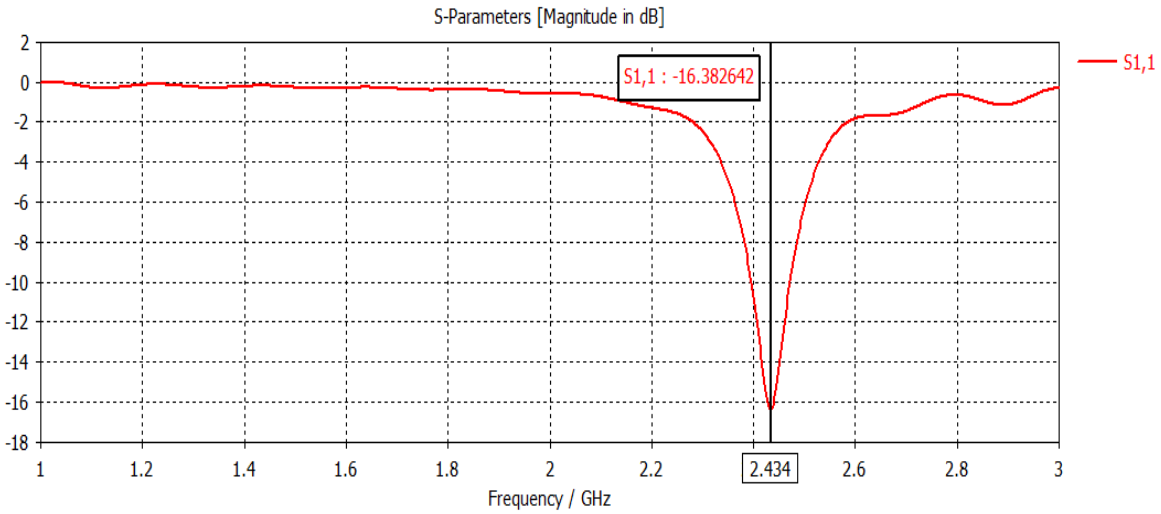

Fig 4.17: S11 parameter for square shape

Bandwidth

Basically, it is the ration of frequency range.

F2=2.1732

F1=2.093

$$\text{Bandwidth} = \frac{F2-F1}{F_S} * 100\%$$

For the square shape, Bandwidth is 2.41%

VSWR

VSWR is related to reflection coefficient. For the square shape, VSWR is 1.357.

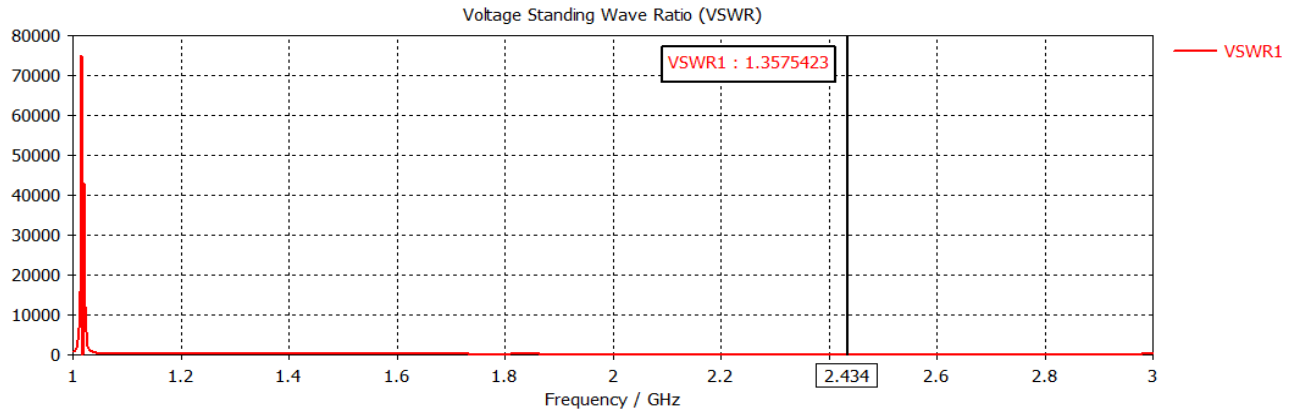

Fig 4.18: VSWR for square shape

Radiation pattern

The main lob magnitude is 3 dB which means that the maximum radiation that at 3dB, which is also known as the main beam. And main lob Direction is 2.0 deg. This means 2.0 deg. angles it radiates most. No side lobe.

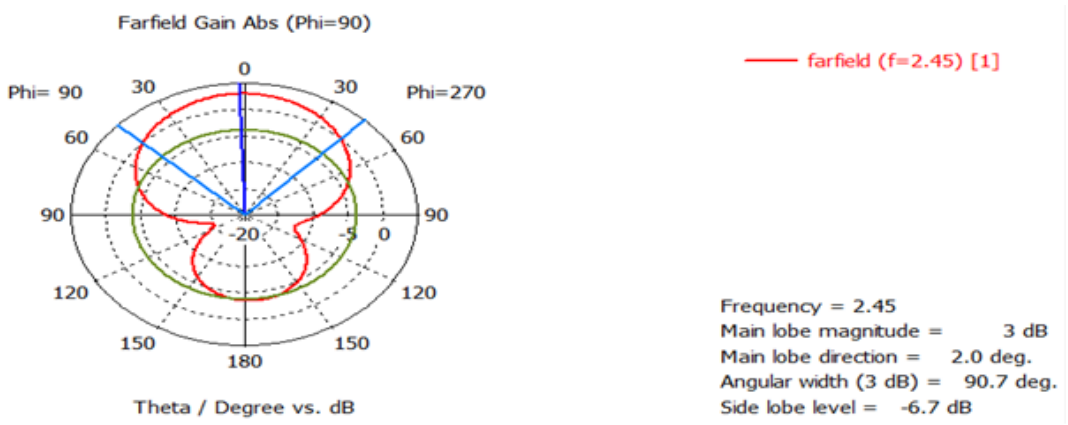

Fig 4.19: Radiation pattern for square shape

Far field

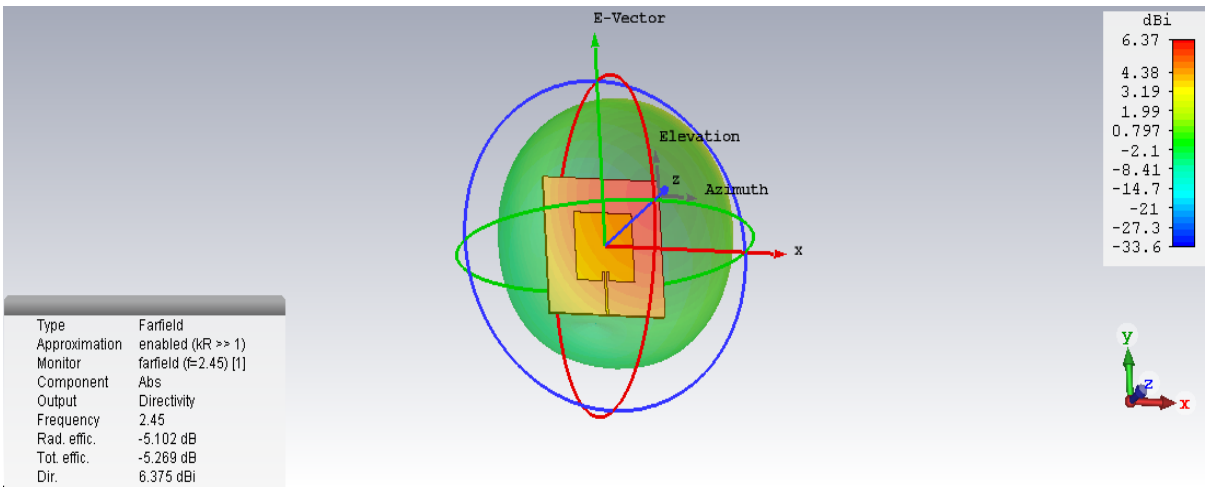

Fig 4.20: Far field for square shape

Microstrip Patch Antenna (MPA) for hexagonal shape

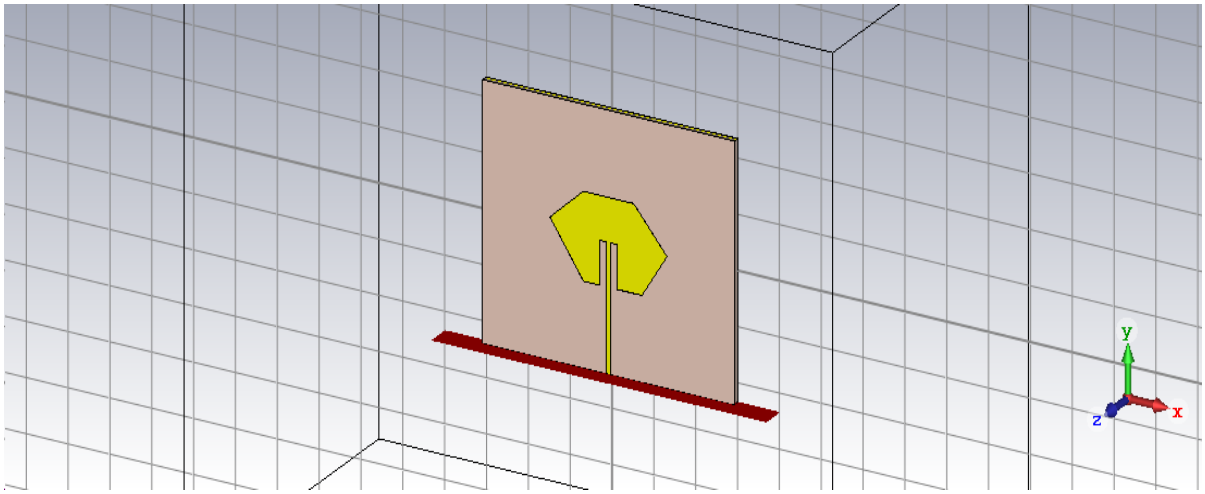

Fig 4.21: Microstrip patch antenna for hexagonal shape

S11 parameter

We can see, for the hexagonal shape we found -14.780 dB.

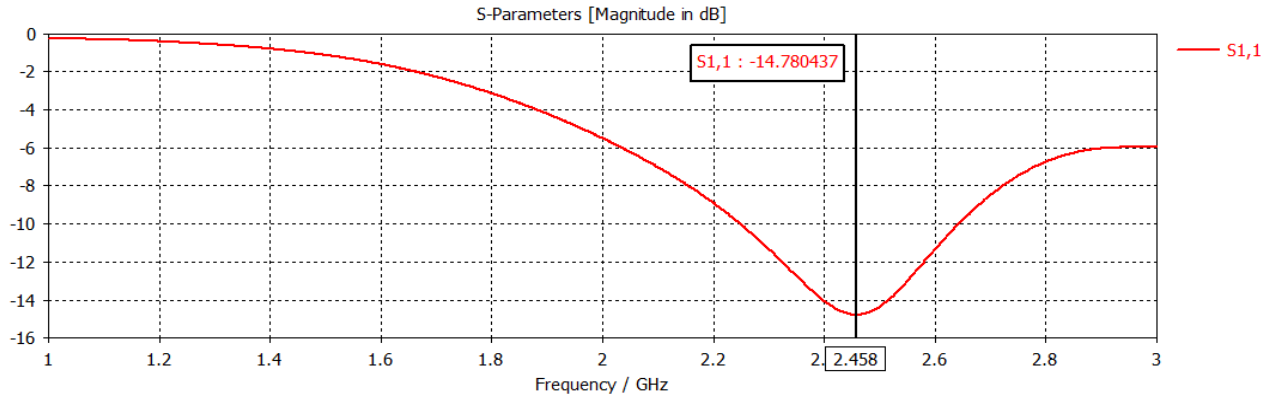

Fig 4.22: S11 parameter for hexagonal shape

Bandwidth

Basically, it is the ration of frequency range.

F2=2.2455

F1=2.0945

$$\text{Bandwidth} = \frac{F2-F1}{F_S} * 100\%$$

For the hexagonal shape, bandwidth is 2.12%

VSWR

For the hexagonal shape, VSWR is 1.446 for the hexagonal shaped.

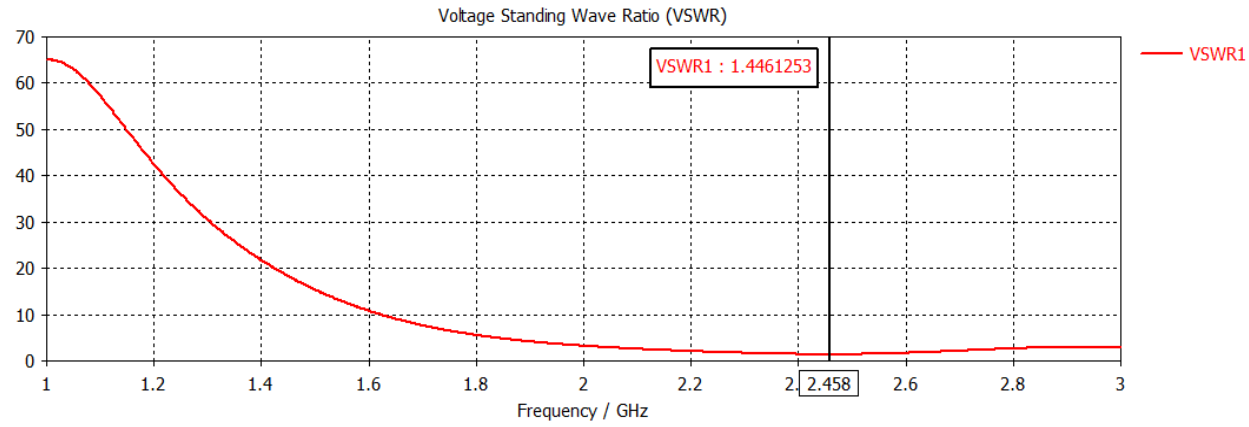

Fig 4.23: VSWR for hexagonal shape

Radiation Pattern

The main lob magnitude is 5.54 dB and main lob Direction is 0.0 deg. And there is no side lob means any direction of the other than in the intended lobe that that contains by the radiation lobe.

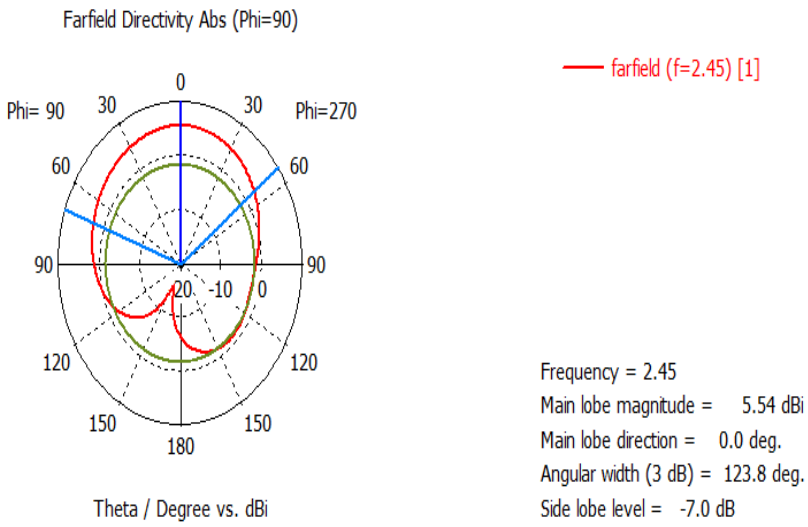

Fig 4.24: Radiation pattern for hexagonal shape

Far field

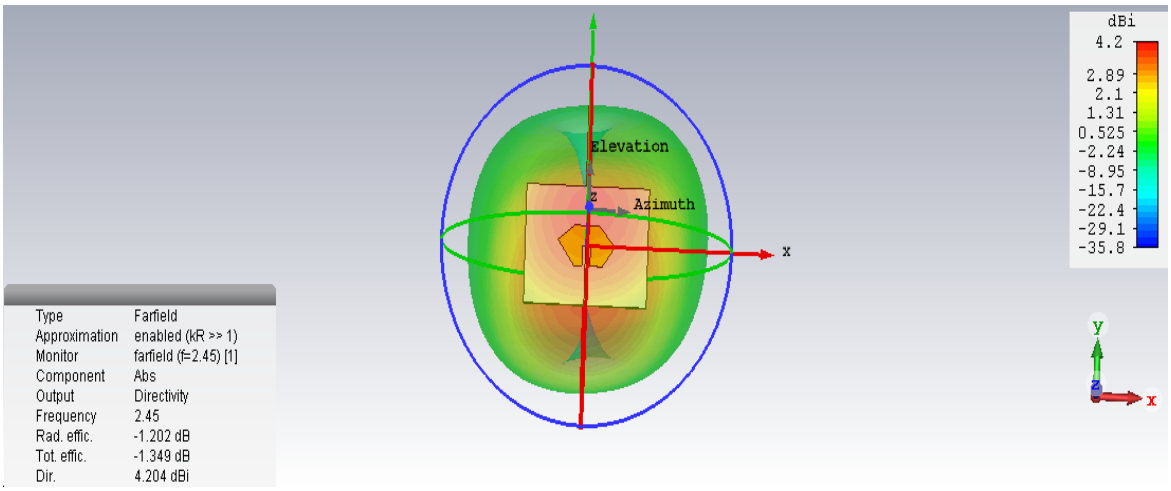

Fig 4.25: Far field for hexagonal shape

Comparison of the parameters for five different shaped antenna

Properties	Circular	F shaped	Triangle	Square	Hexagonal
Return loss (dB)	-53.08	-30.02	-18.86	-16.38	-14.78
Bandwidth (%)	3.12	2.98	2.45	2.41	2.12
VSWR	1.004	1.065	1.257	1.357	1.446
Main Lobe Magnitude (dB)	5.54	4.11	4.51	3	5.54
Main Lobe Direction	1.0^0	6.0^0	4.0^0	2.0^0	0.0^0
Side Lobe level (dB)	-3.7	-1.6	-0.6	-6.7	-7.0