KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY (KIIT)

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LABORATORY RECORD – AUTUMN 2020

MICROWAVE ENGINEERING LAB (EC 3015)

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Section: ETC-06

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Experiment Number	01
Date of Experiment	12/08/2020
Date of Submission	16/08/2020
Name of the student	Debagnik Kar
Roll Number	1804373
Section	ETC – 06

Aim of The Experiment: -

To design a quarter wave transformer for matching a 50 Ω microstrip line with a load of 173Ω

Equipment / Software Required:-

CST Studio Suite 2019 (Student Edition)

Theory:

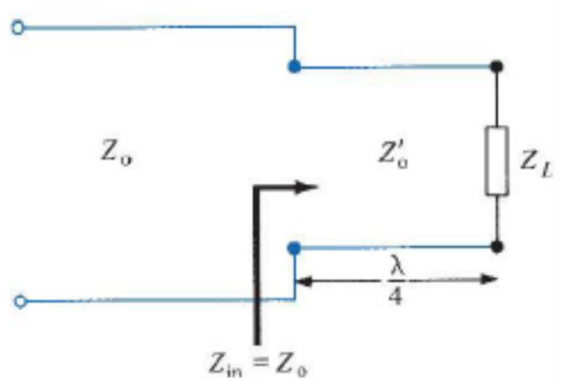

Fig 1.1: Load matching using a quarter wave transformer

When $Z_0 \neq Z_L$, the load is said to be mismatched and a reflected wave exist. So, we use quarter wave transformer for impedance matching.

When $l = \frac{\lambda}{4}$,

$$Z_{in} = Z_0 \left[\frac{Z_L + \frac{jZ_0 \tan \pi}{2}}{Z_0 + \frac{jZ_L \tan \pi}{2}} \right] = \frac{Z_0^2}{Z_L}$$

(1)

A mismatched load can be properly matched to a line (with characteristic impedance Z_0) by inserting prior to the transmission line λ/4 long (with characteristic impedance Z'_0) as depicted in Fig.1.

From (1), $Z^{|}_{0}$ is selected such that (Z_{in}=Z_0)

Therefore,

$$Z_0^{|} = \sqrt{Z_0 Z_L} \tag{2}$$

Note: When microstrip line is used, then guided wavelength must be used, i.e.,

$$\lambda_g = \frac{\lambda_0}{\sqrt{\varepsilon_{eff}}}$$

(3)

where, λ_g= guided wavelength.

When $Z_0 \neq Z_L$, the load is said to be mismatched and a reflected wave exist. So, we use quarter wave transformer for impedance matching.

When $l = \frac{\lambda}{4}$,

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(1)

A mismatched load can be properly matched to a line (with characteristic impedance Z_0) by inserting prior to the transmission line λ/4 long (with characteristic impedance Z'_0) as depicted in Fig.1.

From (1), $Z^{|}_{0}$ is selected such that (Z_{in}=Z_0)

Therefore,

$$Z_0' = \sqrt{(Z_0 Z_L)}$$

Z_0 = 50

Z_L = 173

$Z_0' = \sqrt{(50 \times 173)}$

$Z_0' = \ 93.01 \ \Omega$ (2)

Note: When microstrip line is used, then guided wavelength must be used ,i.e.,

$$\lambda_g = \frac{\lambda_0}{\sqrt{\varepsilon_{eff}}} \tag{3}$$

where, λ_g= guided wavelength.

Substrate: FR4 (Lossless) ($\varepsilon_r = 4.3$)

Width of the substrate is 50 mm and the length are 100 mm

h = 1.6 mm

t = 0.2 mm

W = 2.93 mm (determined using Analysis and synthesis of transmission lines)

ε_{eff} = 3.204

$Z_0' =$ 93.01 Ω length = 17 mm

Therefore, width of the quarter wave line is 0.87mm

Design:

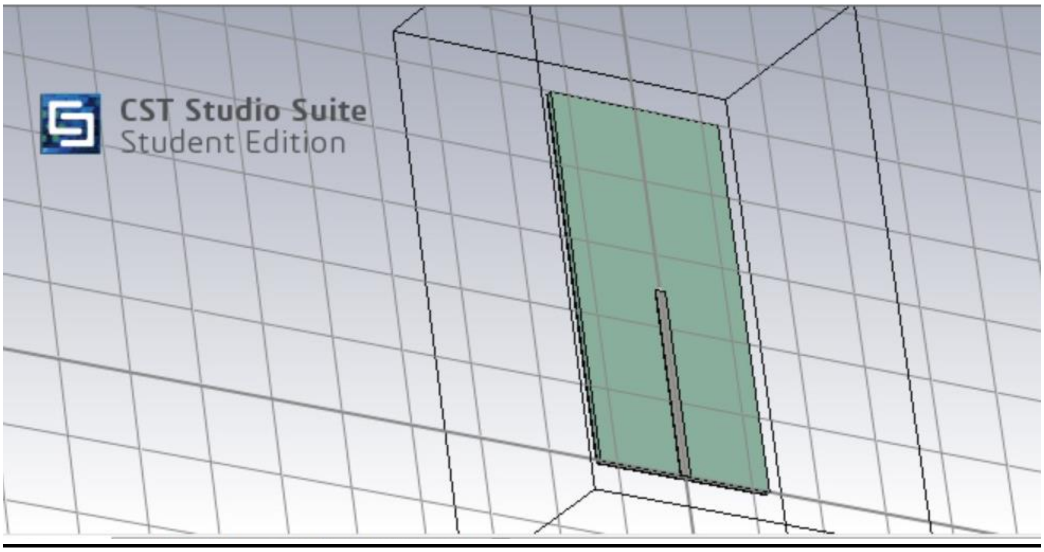


Fig 1.2: Design of microstrip line terminated with the desired load.

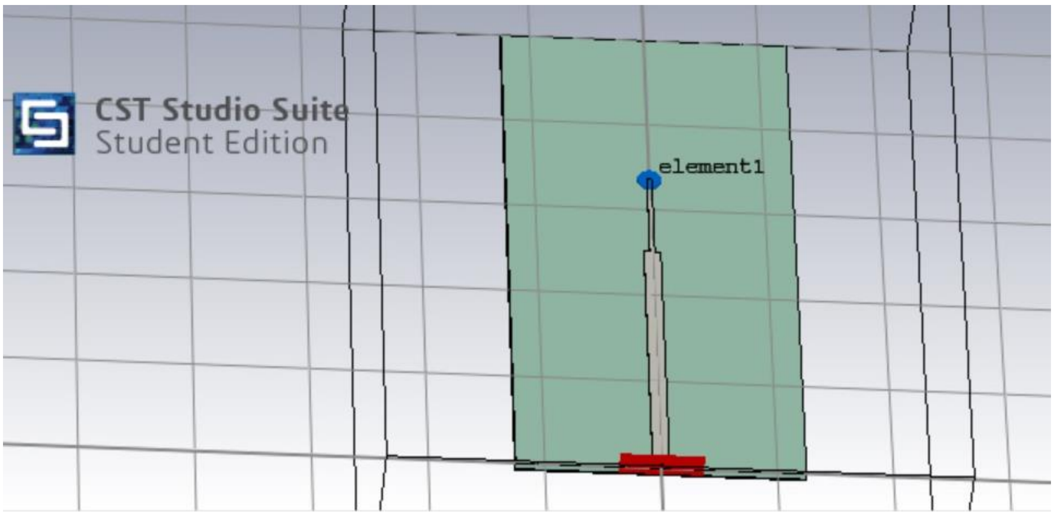


Fig 1.3: Design of microstrip line terminated with quarter wave line and desired load

Output/Graph:-

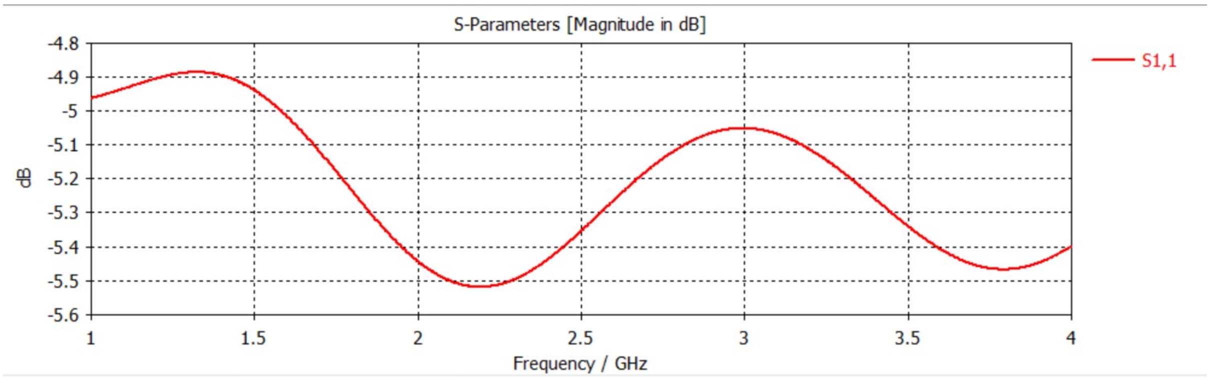


Fig 1.4: Result of the design of the microstrip line

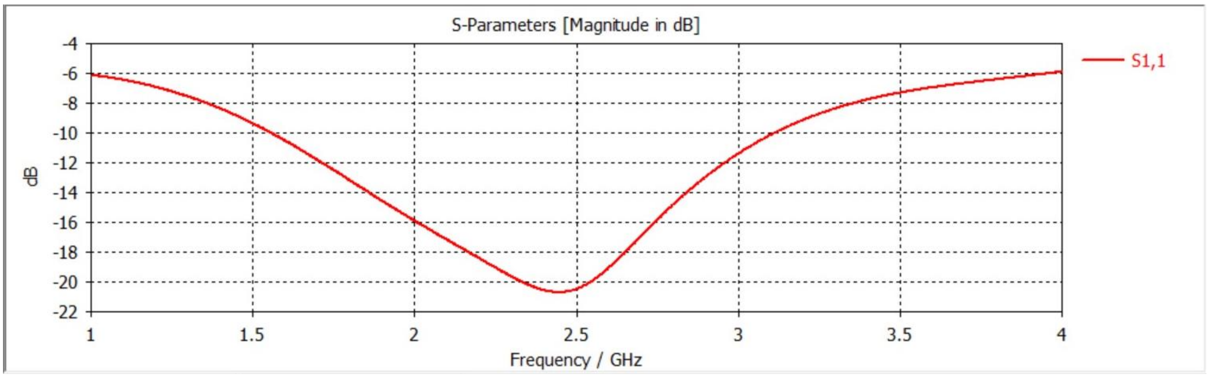


Fig 1.5: Result of the design of the microstrip line terminated by quarter wave line.

Observation of the experiment:

- For fig 4, No resonance is observed around 2.4 GHz which implies impedance mismatch.
- For fig 5, an impedance is achieved at 2.4 GHz by using a quarter wave transformer.

Conclusion:-

The designing of a quarter wave transformer for matching a 50 Ω microstrip line with a load of 173 Ω is successfully achieved.

Experiment Number	02
Date of Experiment	19/08/2020
Date of Submission	24/08/2020
Name of the student	Debagnik Kar
Roll Number	1804373
Section	ETC - 06

<u>Aim of The Experiment :-</u>

To design a wire dipole antenna operating at 373 MHz and to find the directive gain and half power beam width from the radiation pattern.

<u>Software Required:-</u>

CST Studio Suite 2019 (Student Edition)

<u>Theory</u>

The length of the Dipole Antenna is given by the formula:

$$L = \frac{\lambda}{2} = \frac{c}{2f}$$

f = 373 MHz
The length of the dipole is 0.402 m = 402 mm

For the 402 mm length, we have got, 0.373 GHz which is far from our desired result, so we can't consider it as our result.

We know, the input impedance = (73± 40j)

To cancel the complex part, we have to use a shorter length.
I am taking 360 mm to get a value which is nearly equal to the desired result 0.373 GHz

Design:-

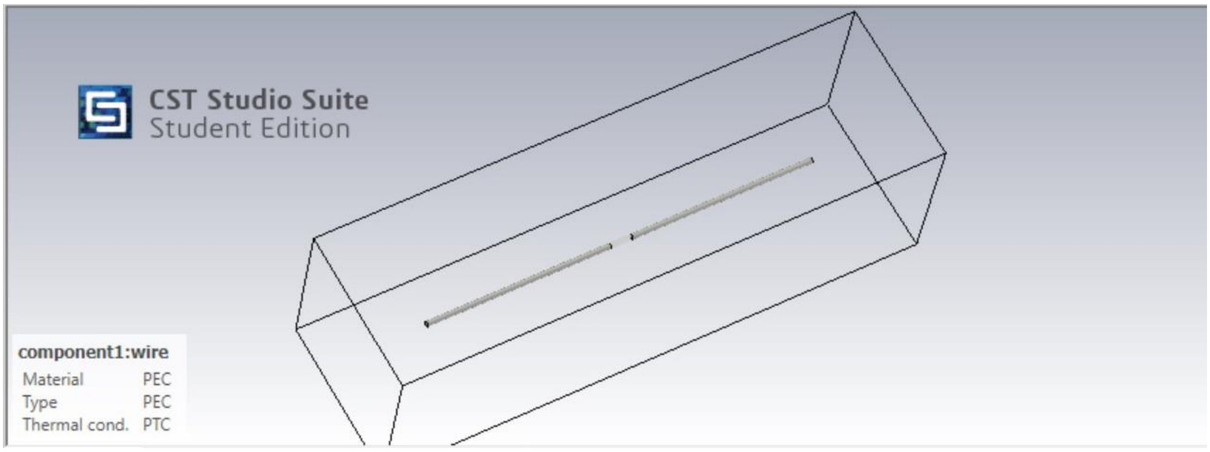


Fig 2.1: Design of wire dipole antenna

Observation:-

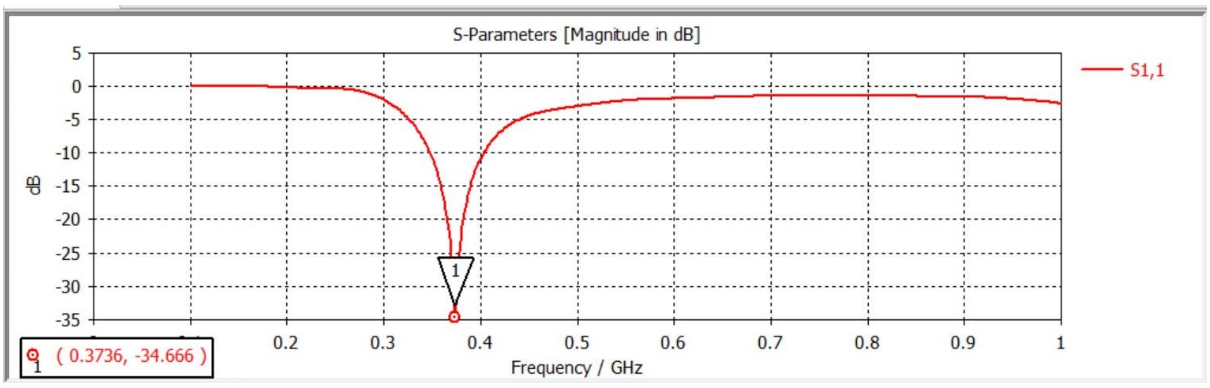


Fig 2.2: S11 Characteristics

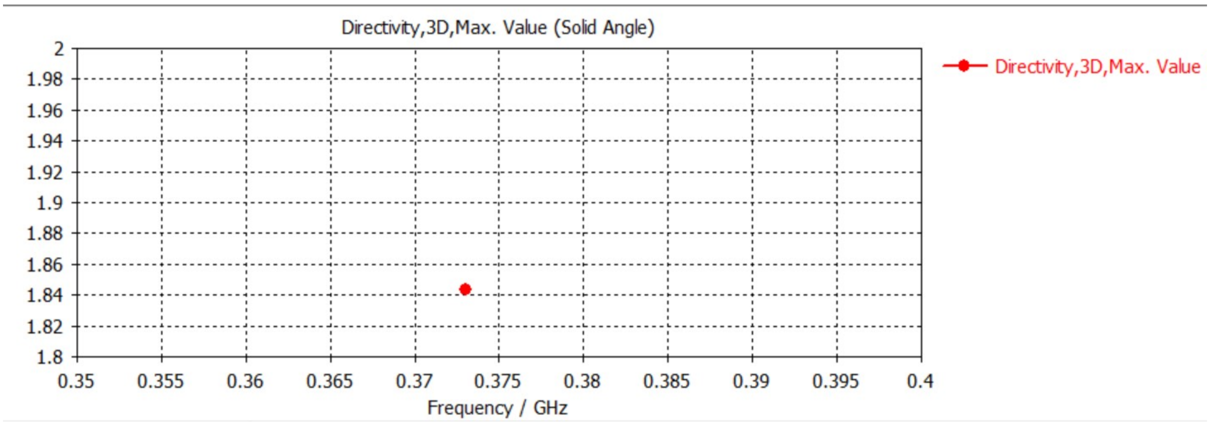


Fig 2.3: Directive Gain

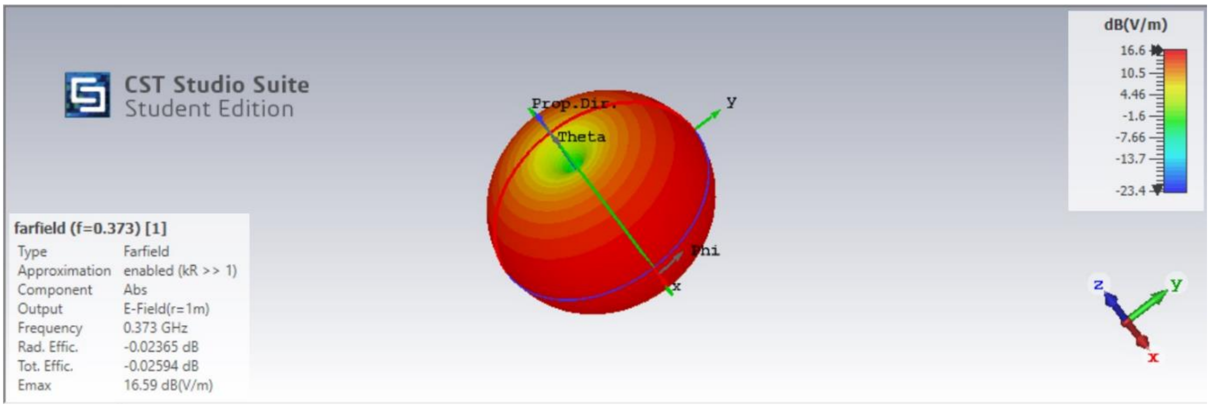


Fig 2.4: Radiation Pattern in X-Z and X-Y plane

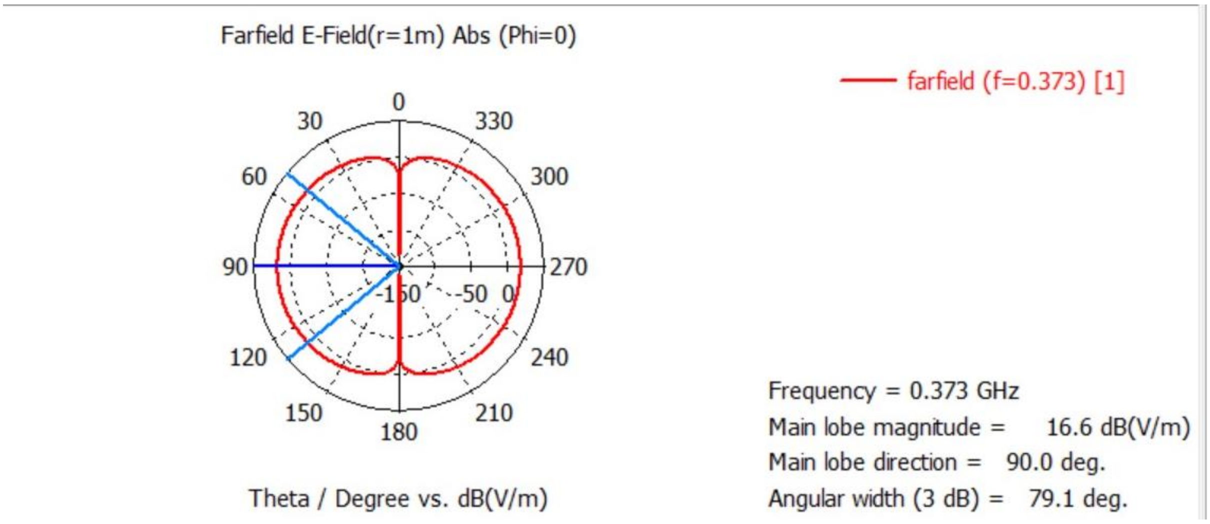


Fig 2.5: Plane radiation pattern and half powered beam width

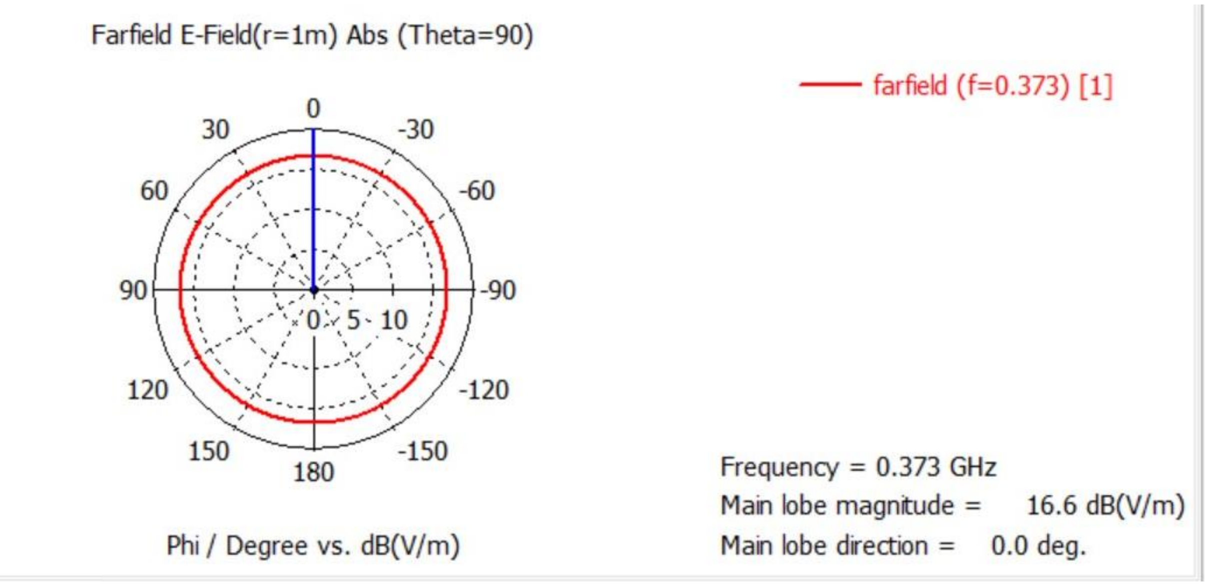


Fig 2.6: H-plane omni-directional Radiation Pattern

Inference of the experiment:

From this experiment, we learnt how to design a wire dipole antenna using CST Studio Suite. We also got to learn about the concept of radiation pattern after performing the experiment

Conclusion:-

A successful design of a wire dipole antenna operating at 373 MHz is successfully simulated on a virtual platform.

Experiment Number	03
Date of Experiment	26/08/2020
Date of Submission	30/08/2020
Name of the student	Debagnik Kar
Roll Number	1804373
Section	ETC - 06

Aim of The Experiment :-

To design Yagi-Uda Array antenna and to find the directivity and Half power beam width form the radiation patterns.

Software Required:-

CST Studio Suite 2019 (Student Edition)

Theory

The Yagi antenna consists of a single 'feed' or 'driven' element, typically a dipole or a folded dipole antenna. This is the only member of the above structure that is actually excited (a source voltage or current applied). The rest of the elements are parasitic - they reflect or help to transmit the energy in a particular direction. The length of the feed element is given as F. The feed antenna is almost always the second from the end. This feed antenna is often altered in size to make it resonant in the presence of the parasitic elements (typically, 0.45-0.48 wavelengths long for a dipole antenna).

The element to the left of the feed element is the reflector. The length of this element is given as R and the distance between the feed and the reflector is SR. The reflector element is typically slightly longer than the feed element. There is typically only one reflector; adding more reflectors improves performance very slightly. This element is important in determining the front-to-back ratio of the antenna.

Calculations:

Operating Frequency: 0.73GHz

Therefore $wavelength, \lambda = \frac{Speed\ of\ light\ (c)}{Given\ frequency(f)}$ = 410.1 meters

Length of feeder: 0.47 λ = 192.75 m

Length of reflector: 0.5 λ = 205.05 m

Length of director: 0.406 λ = 166.50 m

Spacing between the feeder and reflector: 0.25 λ = 102.53 m

Spacing between feeder and director: 0.34 λ = 139.43 m

But the calculated values may not give the desired results so I took the following values instead which is very close to the calculated values but will also give me the desired result.

Length of feeder: 167.5 m

Length of reflector: 179.5 m

Length of director: 141 m

Spacing between the feeder and reflector: 143.34 m

Spacing between feeder and director: 108.52 m

Design:-

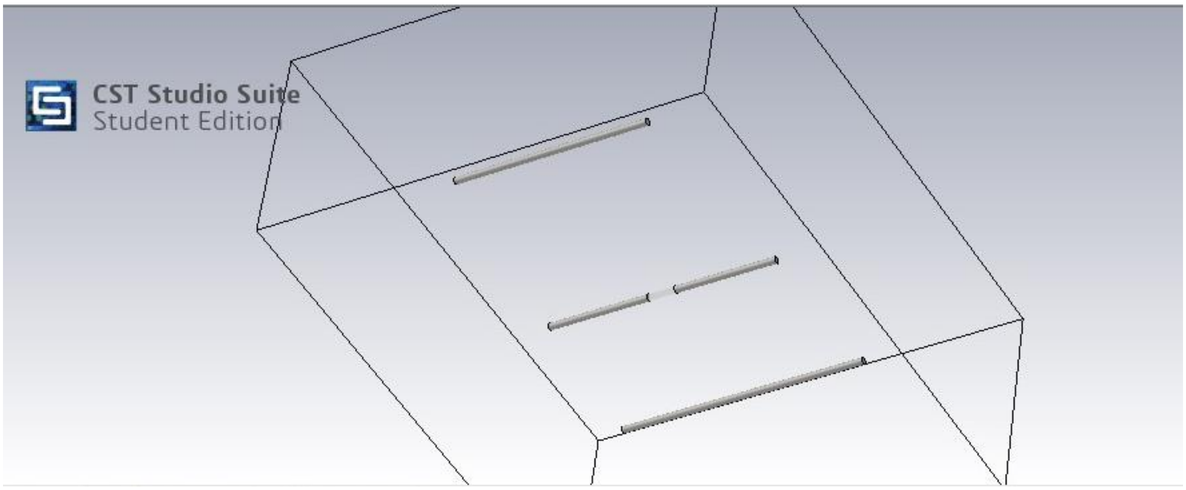


Fig 3.1: Design of the antenna

Observation:-

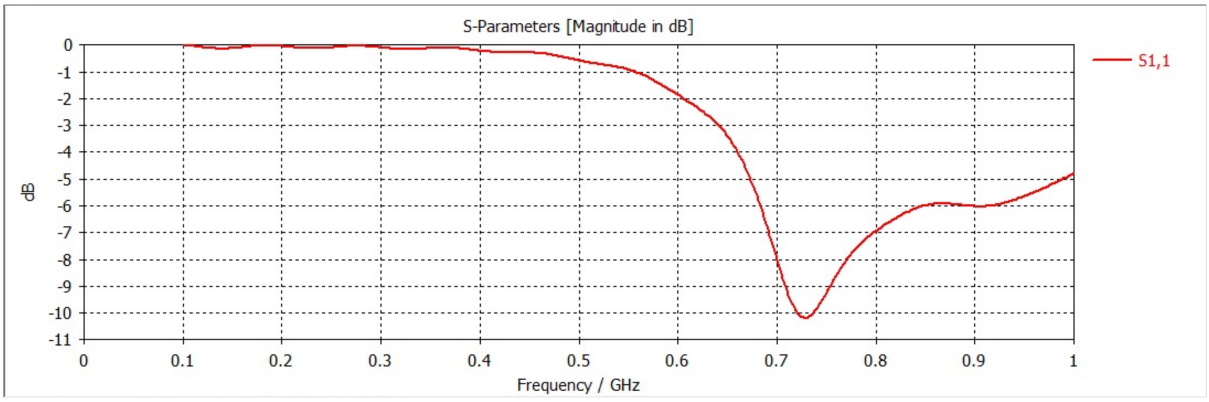


Fig 3.2: S11 Characteristics

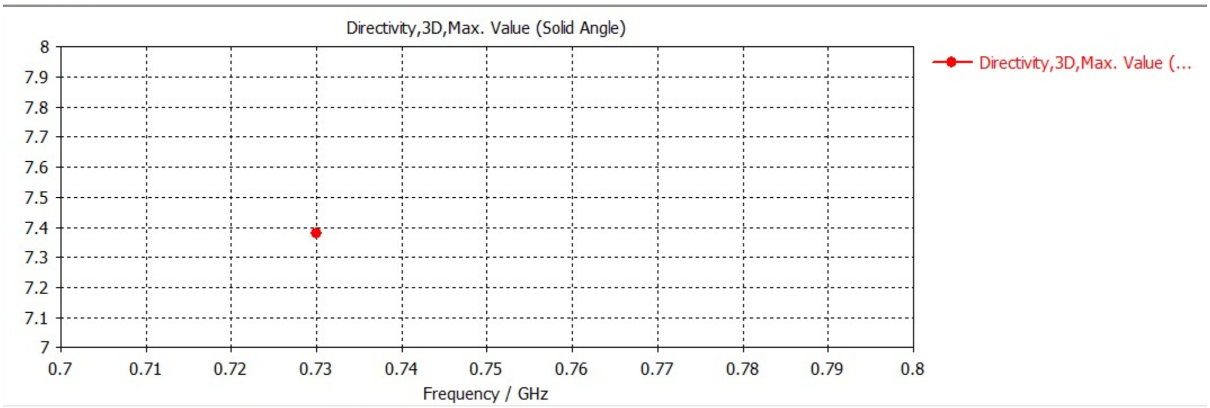


Fig 3.3: Directivity gain

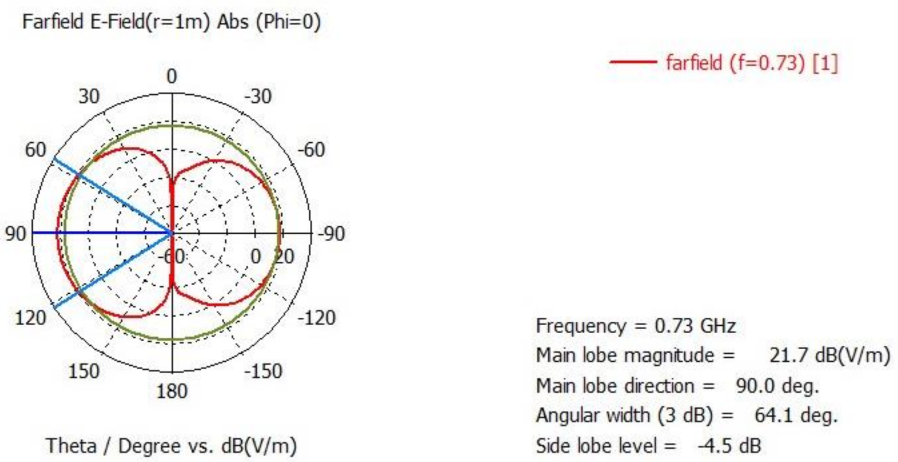


Fig 3.4: Plane radiation pattern and half powered beam width

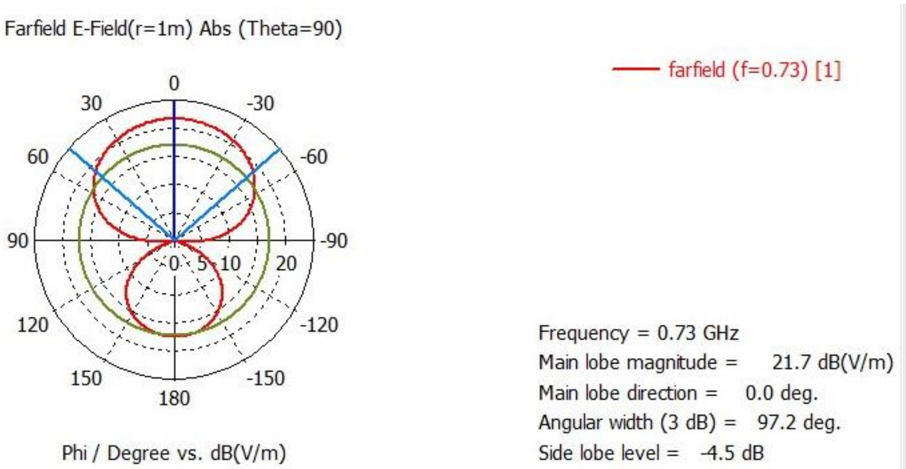


Fig 3.5: H-plane omni-directional Radiation Pattern.

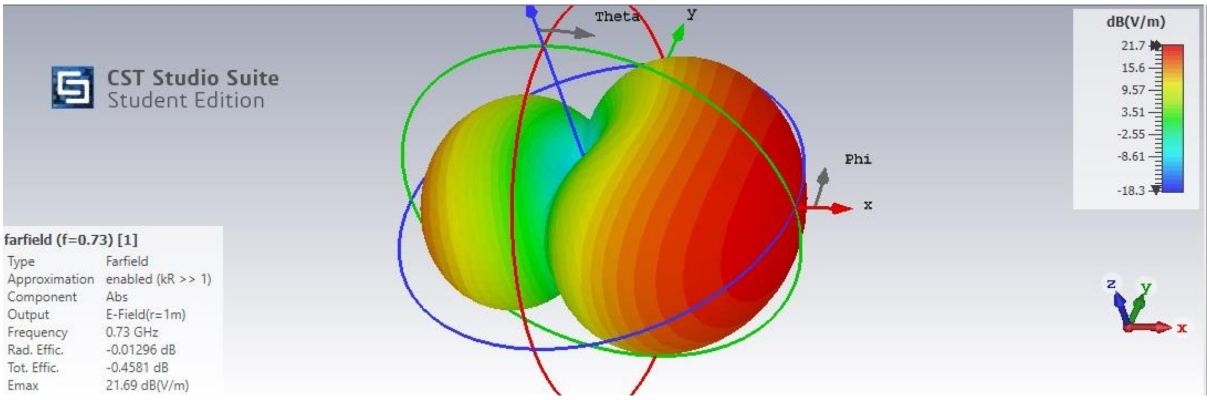


Fig 3.5: Radiation Pattern in X-Z and X-Y plane

Discussion or Inference of the experiment

From this experiment I came to know about the working of Yagi-Uda Antenna and the radiation pattern of it

Conclusion:-

Design of Yagi-Uda Array antenna is executed successfully at 0.73MHz frequency on a virtual platform and the directivity and Half power beam width form the radiation patterns is attached with the lab record.

Experiment Number	04
Date of Experiment	02/09/2020
Date of Submission	03/09/2020
Name of the student	Debagnik Kar
Roll Number	1804373
Section	ETC - 06

Aim of The Experiment :-

Design of a pyramidal Horn Antenna and study its radiation characteristics.

Software Required:-

CST Studio 2019 (Student Suite)

Theory

Design equations

$$\tan\frac{\theta}{2} = \frac{a}{2L}$$

$$L = \frac{a^2}{8\delta}$$

$$\theta = 2.\arctan\left(\frac{a}{2L}\right) = 2\cos\left(\frac{L}{L+\delta}\right)$$

where, θ= flare angle (θ_E for E plane, θ_H for H plane).

a= aperture (a_E for E plane, a_H for H plane)

L=horn length

δ= path length difference

Here We are designing a pyramidal horn antenna operating at 5.5GHz ie λ = 0.054m = 54mm. Take δ = 0.17λ = 0.0092 and L = 160mm

Form $L = \frac{a^2}{8\delta}$ we get, a = 108.5 mm for both E and H plane.

Design:-

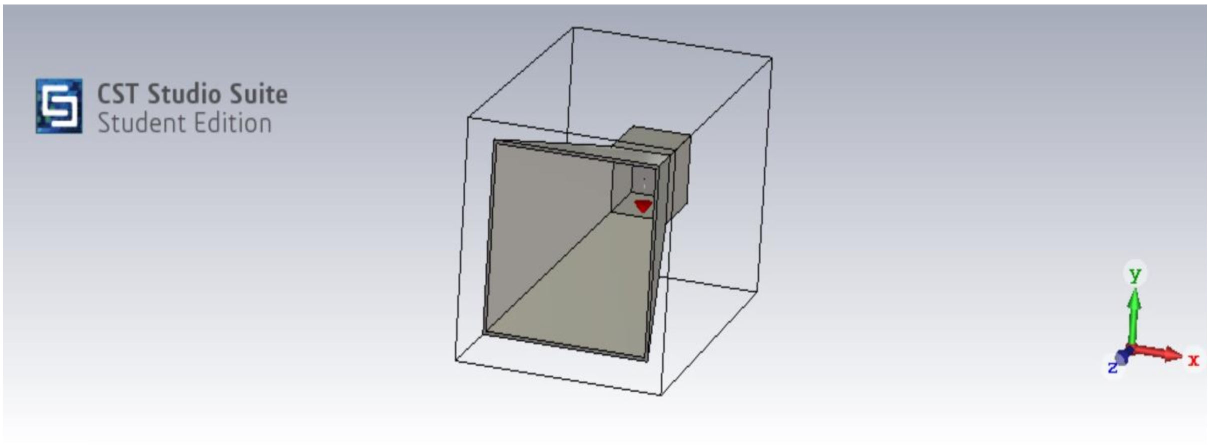


Fig 4.1: 3D model of the design

Observation:-

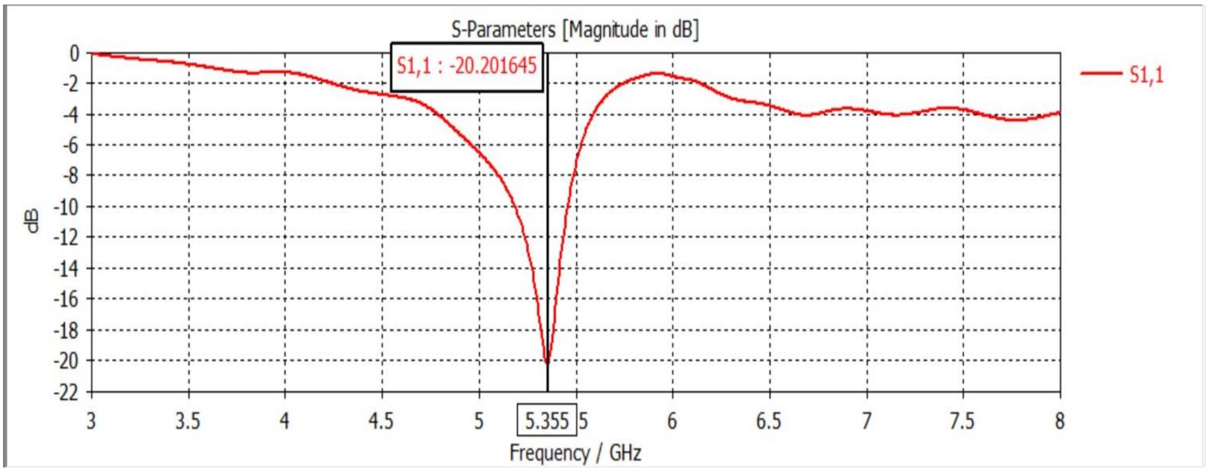
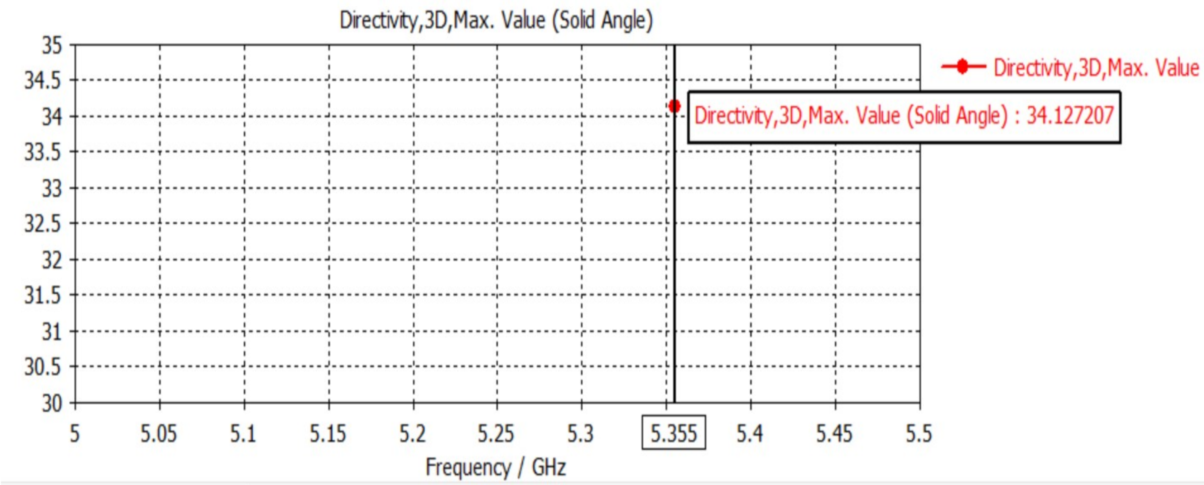


Fig 4.2: S11 Characteristics



4.3: Directivity Gain

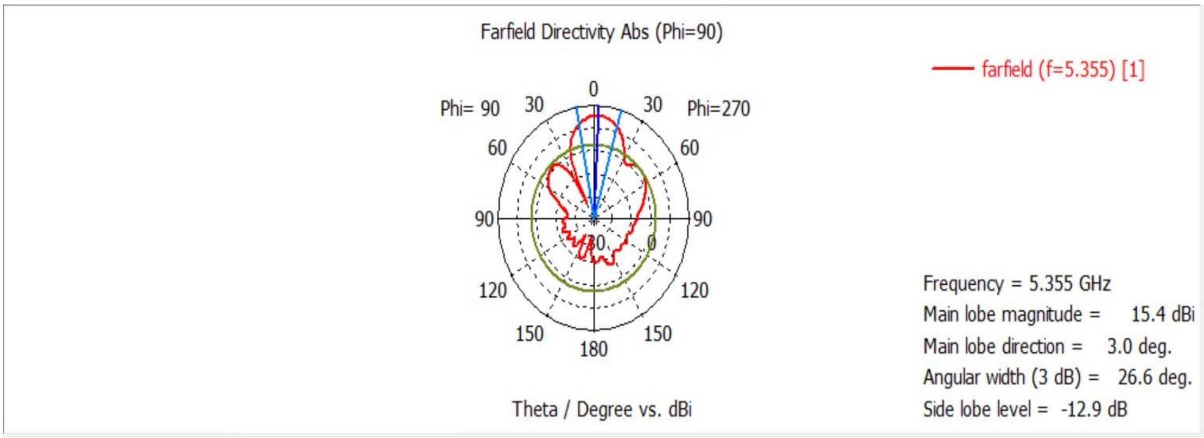


Fig 4.4: Polar Plot

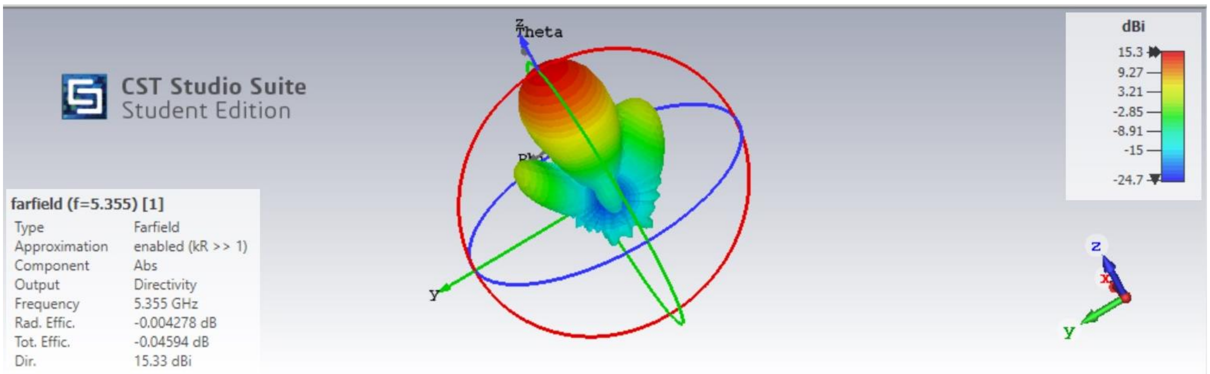


Fig 4.5: Radiation Pattern in X-Z and X-Y plane

<u>Discussion or Inference of the experiment</u>

From this experiment I learnt about the working principle of a horn antenna and the radiation pattern of it.

<u>Conclusion:-</u>

Design of horn Array antenna is executed successfully at 5.5 GHz frequency on a virtual platform and the directivity and Half power beam width form the radiation patterns is attached with the lab record.