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Comparative Analysis of Microstrip Rectangular Patch Antenna with Different Feeding Techniques using HFSS

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Abstract: Microstrip Antenna consists of a very thin patch placed above ground plane. Purpose of using microstrip patch antenna is to serve maximum number of applications with light weight and low cost antenna considering the easy manufacturing. Patch mounted on substrate can be of any shape and size though every shape and size will make a difference in efficiency of antenna, currently E Patch and U Patch are considered to serve wide area of applications in an optimized way. In this paper we have designed and simulated the rectangular patch antenna and compared the different characteristic parameters of simulated antennas by using the feeding techniques like microstrip line feeding and coaxial feed technique.

Keywords: Microstrip patch antenna, coaxial feed, dual frequency

1. INTRODUCTION

Microstrip patch antenna has various applications in the field of radar, surveillance and communications. Its use is continuously increasing with advancement in technology. It is also used in remote sensing and in bio medical fields. Micro strip patch antenna is basically made of a dielectric substrate as a base on a ground plane and a patch mounted on top of it as radiating substance. The basic advantages of microstrip patch antennas are that they can be easily manufactured with low cost, have less weight and can be integrated by the help of microwave integrated circuits [1-7]. Microstrip patch antennas can also be operated under dual or triple frequencies. Though microstrip patch antennas have many advantages but they have certain disadvantages too like they have narrow bandwidth but this disadvantage can be overcome by increasing the thickness of substrate or by selecting different shapes of substrate. The microstrip u-shape and e- shape patch antennas are providing better results in WiMAX applications.

A. Feeding Techniques

For feeding microstrip patch antenna various feeding techniques can be used such as Microstrip line feed, Co-axial probe, aperture coupling and proximity coupling. Most basic feed of all is Microstrip line feed which consists of a conducting strip which is attached to the patch. The strip is of much smaller width as compared to patch. In co-axial line feed the inner conductor of co axial is connected to the radiating patch and outer conductor is connected to the ground. The aperture coupling has two substrates which are separated by a ground plane. Under the lower substrate the microstrip feed line is coupled with the patch . There is a slot on the ground plane which separates the two substrates. Microstrip line feed and coaxial feed are easy to fabricate but have narrowest bandwidth. Though aperture coupling solves many of the disadvantages but it also has narrow bandwidth and is difficult to manufacture in comparison whereas proximity coupling offers highest bandwidth but it is the most difficult feed when it comes to fabrication [8-10].Microstrip line feed is easy to fabricate and simple to model. The matching of impedances can also be easily done by controlling the inset position .

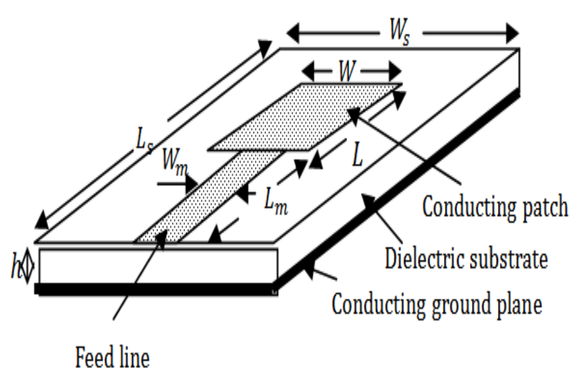

Fig 1) Microstrip line feed

B. *Coaxial Line Feed*

Coaxial line feed is done with the help of probe , in which outer conductor of coaxial is connected with ground plane and inner is connected to the radiating patch, this conductor acts as a power transfer between ground plane and radiating patch via the substrate[10]. Some Advantages of coaxial line feed is that it can be fabricated easily and low spurious radiation.

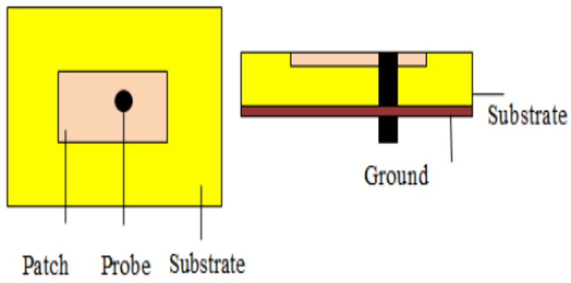

Fig 2) : Coaxial line feed

2. DESIGNING PARAMETERS

Microstrip patch antenna, was designed considering certain parameters like the resonant frequency and dielectric medium. The parameters calculated are as follows.

a) Width (W):

The width of the patch is to be calculated through the following equation

$$w = \frac{c}{2fo\sqrt{\frac{\varepsilon_r+1}{2}}} \qquad ...1$$

Where, w =Width of the patch

C = Speed of light

ε_r= Relative dielectric constant

b) Effective refractive index:

The radiations which are travelling from patch and going to ground, some of them goes through the substrate and other through the air, this process is called fringing. Air and substrate have different dielectric values, so due to that effective dielectric constant has to be found out [3].

$$\varepsilon_{eff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{1/2} \qquad …2$$

c) Length:

Size of antenna increases electrically due to the effect of fringing, to take the factor of increased size in account ΔL (increase in size is calculated) by the following equation:

$$\Delta L=0.412h\times\frac{(\varepsilon_{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{w}{h}+0.8\right)} \qquad …3$$

Actual length of patch is now calculated as

$$L = \left(\frac{c_o}{2f_o\sqrt{\varepsilon_{eff}}}\right) - 2\Delta L \qquad …4$$

d)Width and length of the ground plane:

Length of ground plane (L_g):

$L_g = 6h + L$ ...5

Width of ground plane (W_g):

$W_g = 6h + W$ ...6

3. USING THE TEMPLATE DESIGN OF ANTENNA WITH MICROSTRIP LINE FEED

A. *Designing Procedure:*

The following rectangular patchantenna given in fig 3 has been designed and simulated with the help of HFSS (High frequency structural simulator) Software.

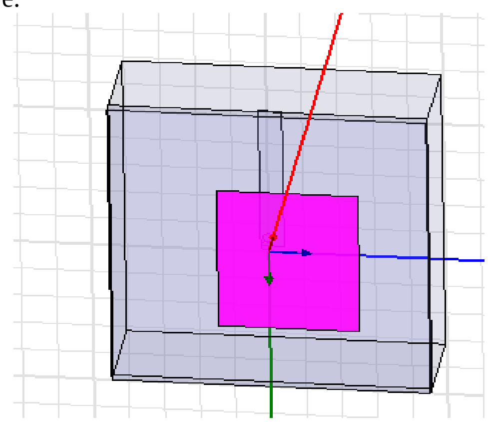

Fig 3) Antenna Design on HFSS

The design specifications of antenna as proposed in fig. 3 is mentioned in table 1:

Table 1: Design Specifications:

Element	Object	Dimension (cm)	Coordinates (x, y, z)
Substrate	Cuboid	20*18*0.64	-10,9,0
Infinite ground	Rectangle	20*18	-10,9,0
Ground Cut out	Circle	R=0.32	-1,0,0
Patch	Rectangle	8*6	-4,-3,0.64
Air	Cuboid	20*18*6.64	-10,-9,0

Substrate used is Rogers RT/Duroid (Relative permeability = 1, Dielectric Loss Tangent =0.0009).

Ground and Patch are assigned perfect E Boundary, Cut Out is assigned with Waveport excitation and air box is assigned with Radiation Boundary and Far Field radiation setup is done to Air box.

B. Simulation Results:

Simulation of above design as proposed in fig. 3 is done on HFSS Software. HFSS provides various result reports in predefined format like VSWR, Radiation pattern, S Parameters.

3.1 *VSWR*

VSWR indicates the power reflected by antenna, that means lesser the VSWR better will be the matching of antenna with transmission line

$$VSWR= (1+|\Gamma|) / (1-|\Gamma|) \quad ....7$$

$$\Gamma = (V_r/V_i) \quad ......8$$

$$\Gamma = (Z_i-Z_s) / (Z_i+Z_s) \quad ...9$$

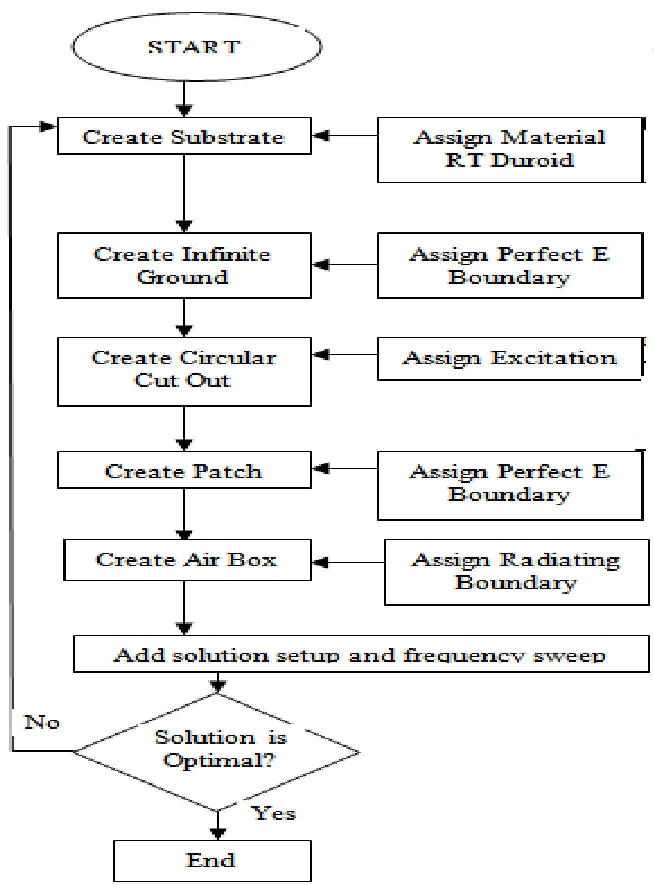

Fig 4) Flow Chart of Design Procedure

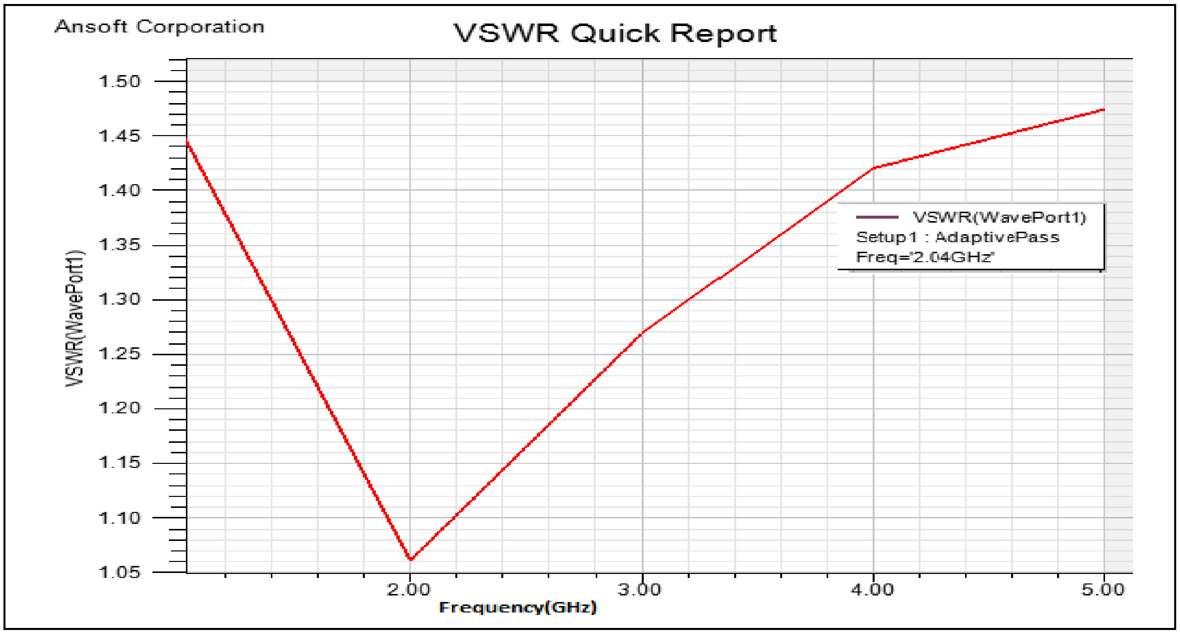

Fig 5) VSWRVs Frequency

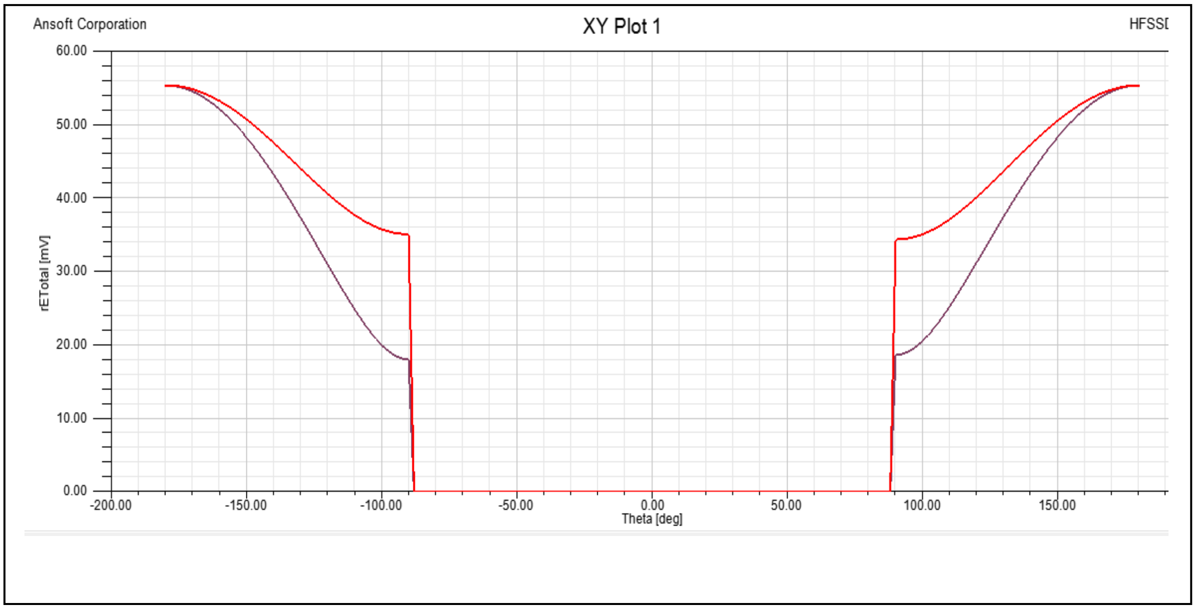

Fig. 6) Radiation pattern in rectangular coordinates

As observed from fig. 5 VSWR Vs. Frequency plot the proposed antenna resonates at designed frequency (2.04 GHz) and has minimum VSWR value (1.06) at 2.04 GHz**.**

3.2. Radiation Pattern

Radiation Pattern of a particular antenna describes the power radiated by antenna with respect to direction (Angles). In the fig 6, the graph is plotted between radiation electric field vs angles. It is observed from the graph that the antenna is off up to 100 degree in both planes and beyond these limits antenna is radiating symmetrically.Front to Back Ratio: 0 dB as pattern is symmetric and is giving same radiation in front direction as well as in back direction.3dB Bandwidth is observed as60 dB.

3.3. 3D Radiation Pattern

3D Radiation Pattern of a particular antenna describes the radiation given by antenna with respect to direction (Angles) in a 3-Dimensional figure. In figure 7, the 3D plot is plotted in theta and phi plane. The electric field values are given in the table in these planes.

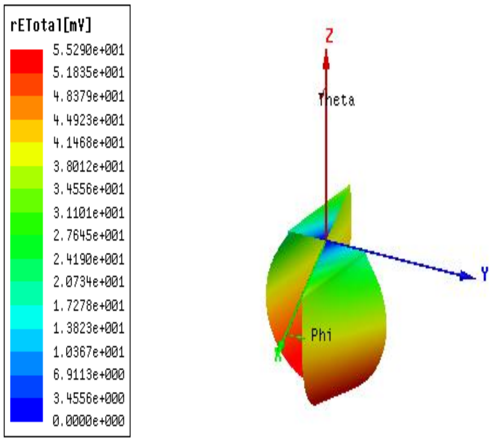

Fig 7) 3D Radiation Pattern

3.4. S- Parameters

S-Parameters in general define the relationship between different electrical networks. S_{11} indicates the power reflected from a antenna. So lesser the value of S_{11} lesser will be the value of losses.as observed from the plot the value $S_{11}$is -30.5 dB at 2.04 GHz

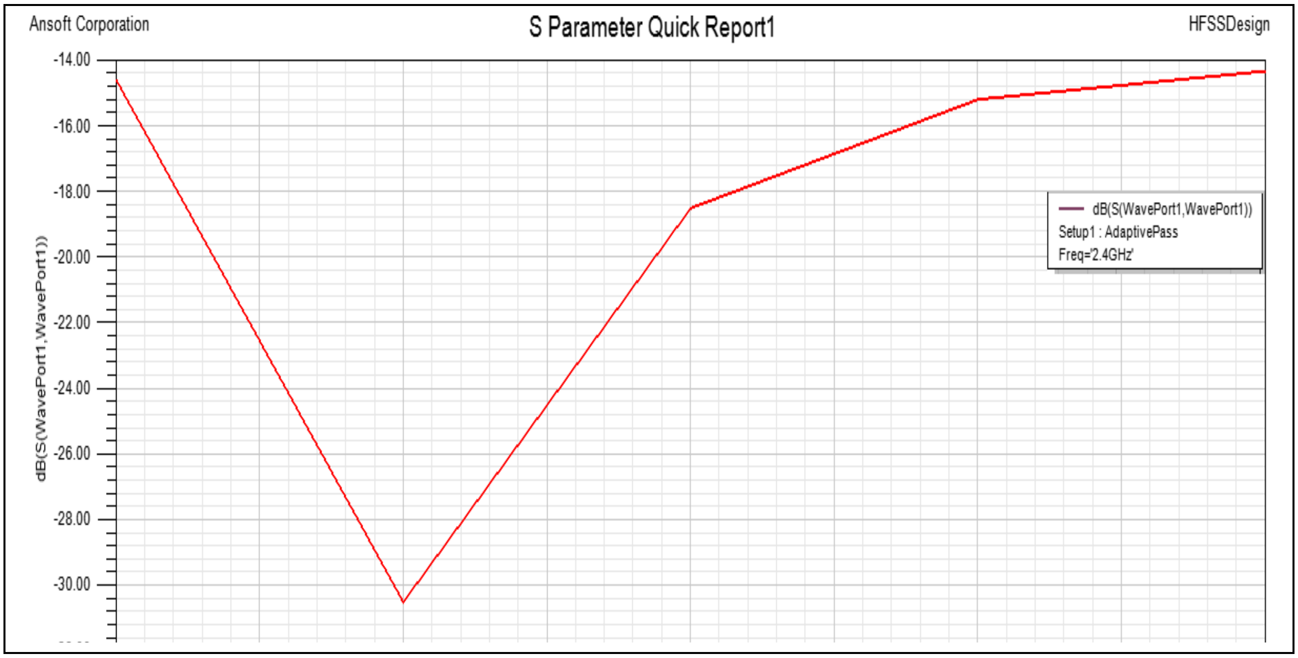

Fig 8) Return loss,S_{11} (dB) vsFrequency(GHz)

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4. DESIGN OF ANTENNA WITH COAXIAL FEEDING

A. Designing Procedure:

The rectangular patch antenna as proposed in fig.9has been designed and simulated with the help of HFSS (High frequency structural simulator) Software and feeding is done by coaxial feed technique.

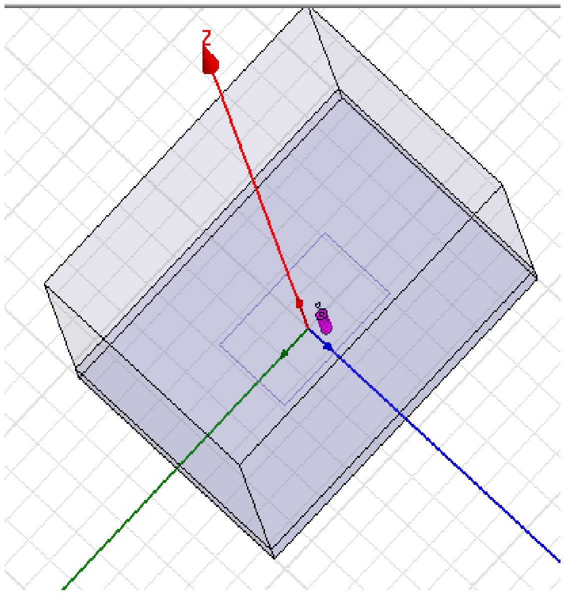

Fig 9) Design of patch antenna with Coaxial Feed

B. Design Specifications:

Element	Object	Dimension(cm)	Coordinates (x,y,z)
Substrate	Cuboid	20*18*0.64	-10,9,0
Infinite ground	Rectangle	20*18	-10,9,0
Ground Cut out	Circle	R=0.32	-1,0,0
Patch	Rectangle	8*6	-4,-3,0.64
Air	Cuboid	20*18*6.64	-10,-9,0
Probe	Cylinder	R= 0.14 H= 0.64	-0.3,0,0
Co-Axial Pin	Cylinder	R= 0.14 H= 1	-1,0,0

Substrate used is Rogers RT/Duroid (Relative permeability = 1, Dielectric Loss Tangent =0.0009). Probe is assigned with wave portexcitation. Ground and Patch are assigned perfect E Boundary, is assigned with Radiation Boundary and Far Field radiation setup is done to Air box.

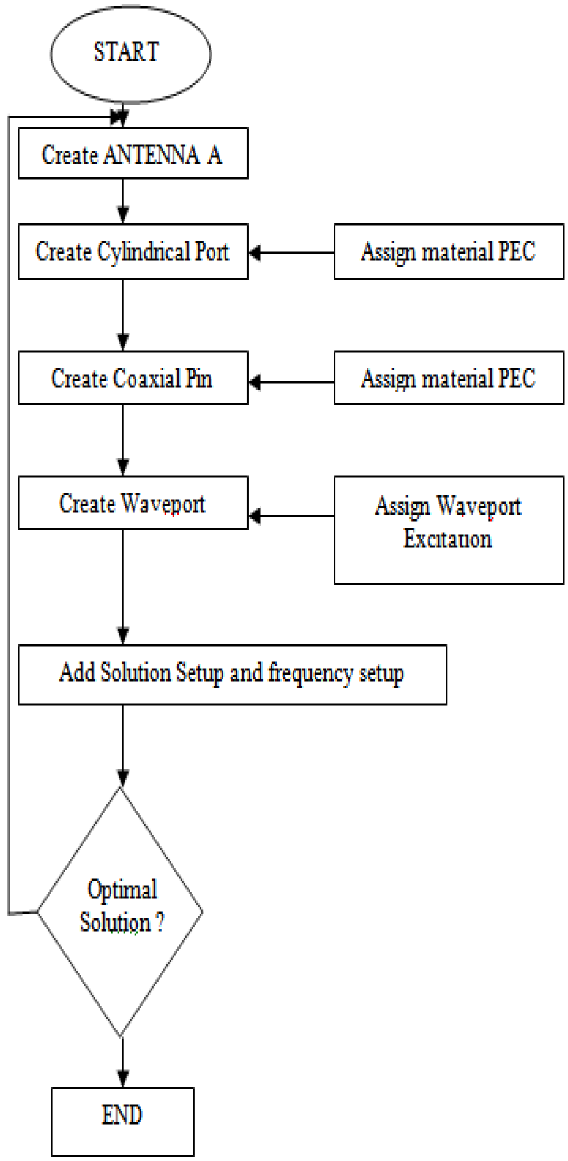

Fig 10) Flow chart of antenna with Co-axial field

C. Simulation Results:

Simulation of proposed design is done on HFSS Software. The following results were obtained:

4.1 *VSWR*

From the graph as plotted in fig. 11, it is observed that The value of VSWRis minimum at design frequency 2.35 GHz.

4.2 Radiation Pattern

The polar pattern of the proposed antenna is given in fig. 12.From the radiation pattern we can find the

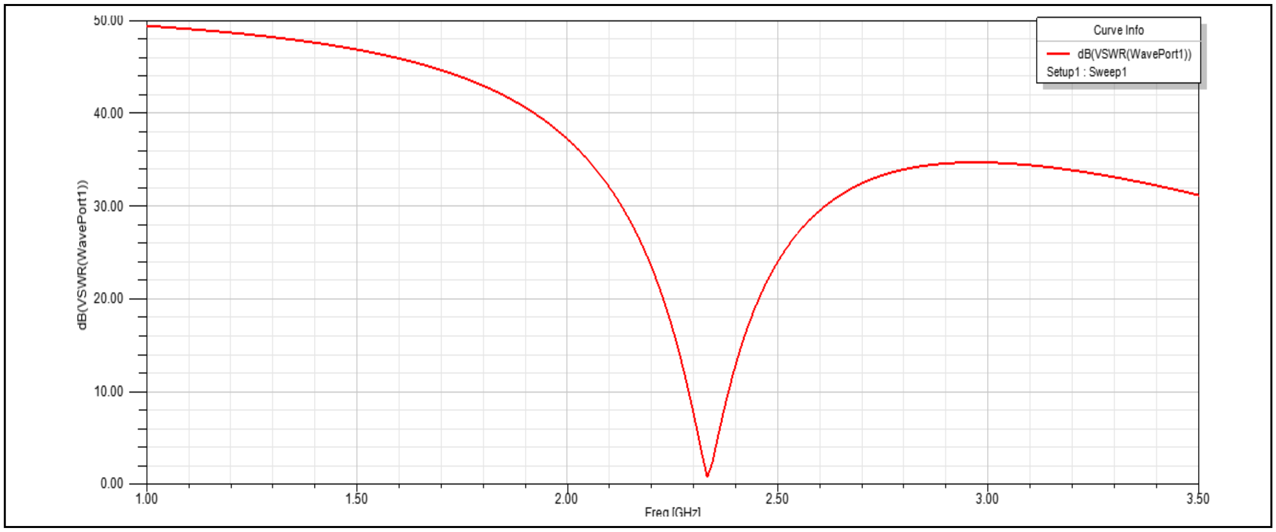

Fig 11) VSWR Vs. Frequency

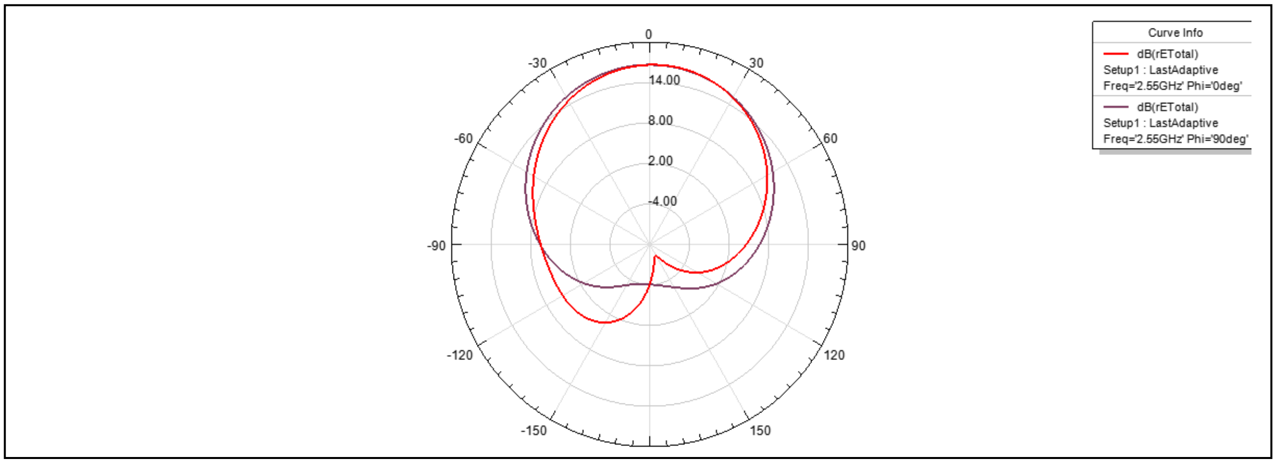

Fig 12) Polar plot of radiation Vs Angle

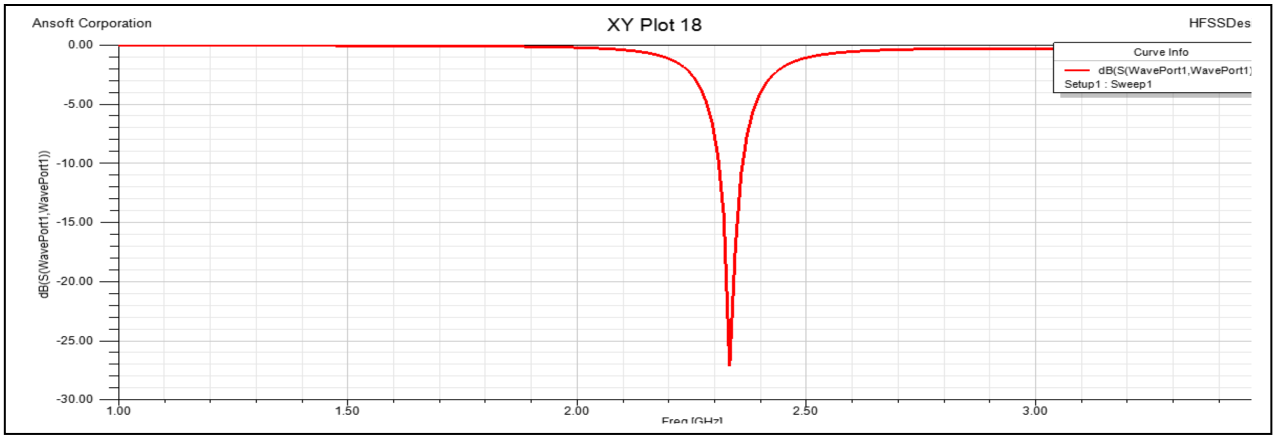

Fig. 13) Return loss, S_{11}(dB) Vs Frequency (GHz)

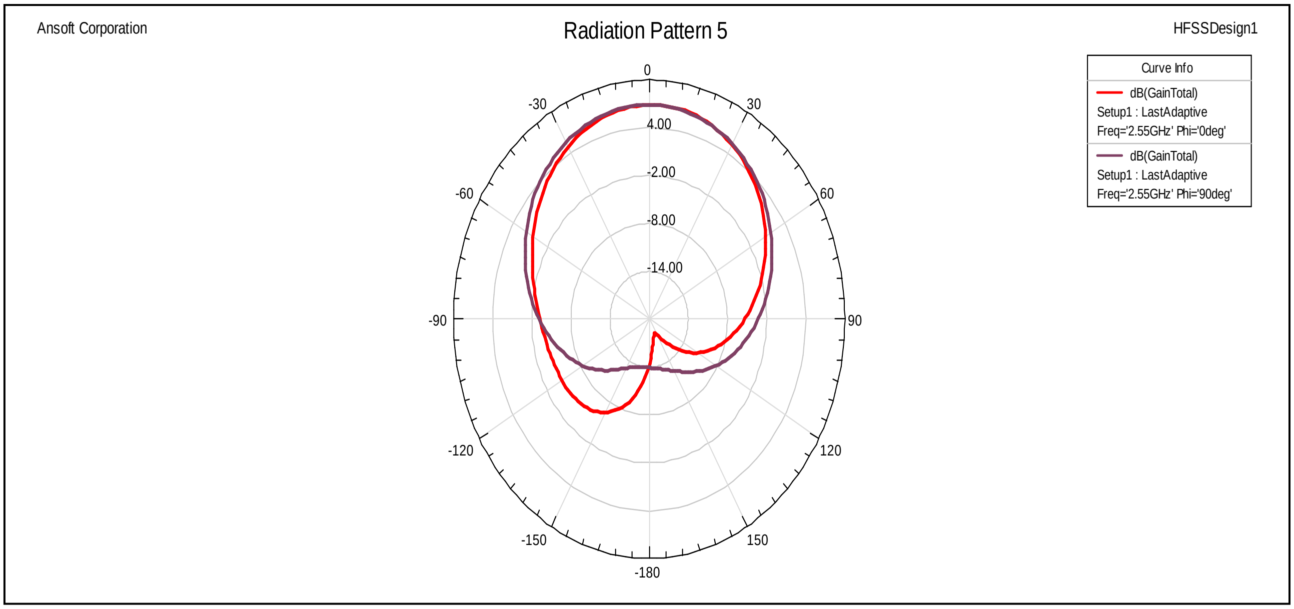

Fig 14) Gain Vs Angle

Maximum radiation is at 0 degrees and is reported as 16.62dB and at 180 degrees it comes out to be 4.06dB .The Front to back ratio is observed as 12.56 dB and the value of 3dB Bandwidthis observed as 80 degrees. As observed from Polar Plot Antenna B gives better directivity than Antenna A

4.3 S Parameters

As observed in the figure 13, the value of S parameter S_{11} is 27.2 dB at designed frequency 2.55 GHz.

4.4 Gain

Gain is like a figure of merit for antenna, it tells about the efficiency by which an antenna converts input to the output. As observed from the plot, the gain is symmetrical up to 90^0 in both side of the planes.

5. CONCLUSION

In this paper, the design and simulation of rectangular patch antenna on Rogers RT/Duroid substrate at 2.55 GHz is proposed. The antenna is fed by coaxial feed and microstrip feed keeping the same design parameters. The results were compared for two antennas with different feeding techniques. It is concluded that Microstrip line feed gave better VSWR but poor directivity and front to back ratio whereas antenna with co-axial line feed gave better directivity and front to back ratio(12.56dB) .

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