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Reconfigurable microstrips patch antenna in frequency and polarization

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ABSTRACT

In this paper RMPA in frequency and polarization is designed and diodes are proposed to be used as switch to change the structure of antenna. Thus by switching diodes ON and OFF the antenna is reconfigured to different frequencies with linear and Circular polarization. The use of circularly polarized antennas presents an attractive solution to achieve this Polarization match which allows for more flexibility in the angle between transmitting and receiving antennas. It reduces the effect of multipath reflections, enhances weather penetration and allows for any orientation to the communication system. The antenna is simulated at 2.4 GHz and 2.2 GHZ using HFSS simulation software. The parameters of antenna such as Reflection coefficient, VSWR, Band width, Axial Ratio, Radiation pattern is measured with and without diodes and results are analyzed using Network Analyzer. The main focus of this paper is to attain reconfigurability so that this microstrip patch antenna is used for Bluetooth, WLAN, WIMAX and Advanced Wireless Service (AWS) applications.

Keywords: *HFSS , Reconfigurable Microstrip Patch Antenna (RMPA), Diodes, Frequency Reconfigurable, Circular Polarization, Reflection coefficient, VSWR , Axial Ratio, Network Analyzer.*

1. INTRODUCTION

Microstrip patch antennas are more popularly used now a days due to its various advantages such as light weight, less volume, compatibility with integrated circuits, easy to install on the rigid surface and low cost. Microstrip patch antennas are design to operate in dual-band and multi-band application either dual or circular polarization. These antennas are used in different handheld communicating devices [1].

In modern communication systems, like cellular phones, personal computer cards for wireless local area networks (WLAN) microstrip antenna are more preferred than any other radiator [2]. The simple Microstrip patch Antenna [4] consists of a dielectric substrate having fixed dielectric constant. Radiating patch is present on one side of a dielectric substrate and a ground plane is present on other side of substrate. The metallic patch may take any geometrical shapes like rectangular, triangular, circular, helical, ring, elliptical etc. The dimensions of the patch are corresponds to the resonant frequency of antenna.

In futuristic world of wireless communication reconfigurable antenna plays an important role as reconfigurbale antenna offer the advantages of compact size, similar radiation for all designed frequency bands,efficient use of electromagnetic specturn and frequency selectivity. Therefore reconfigurable antennas is gaining enormous popularity over year for their applications in communications,electronic survellance . Different methods had been adopted to achieve the reconfigurable aspect of antenna structure; for example, by altering the physical structure of antenna, by changing feeding methods, or by implementing antenna arrays,etc[3].

The additional structure used for making antenna reconfigurable in frequeny so that we have achieved antenna resonance at 2.2GHZ should be of triangular shape to obtain broad bandwidth instead of using any other shape [5].

When both the diodes (D3, D4) are at OFF position with (D1, D2) at ON position, the triangular structures are disconnected to rectangular patch; so only square patch structure is operating. In this case the antenna resonates at a frequency of 2.4GHz(ISM). When both diodes D3 & D4 are at ON position with (D3,D4) at ON position, the triangular structures are connected to square patch and the antenna resonates at a frequency of 2.2GHz(AWS) .Thus by making diodes OFF / ON, the antenna reconfigured to different frequencies. When diodes (D1, D2) and (D3, D4) are at OFF position that is all the diodes are at OFF position, the antenna resonates at a frequency of 2.4GHz with circular polarization. When diodes (D1, D2) and (D3, D4) that is when all diodes are at ON position, the antenna resonates at a frequency of 2.2 GHz with circular polarization.

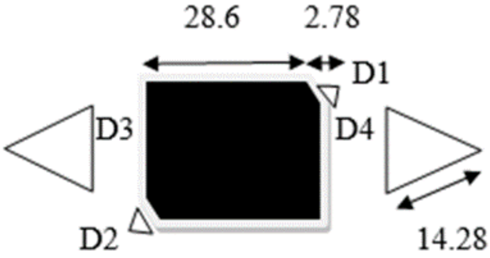

Fig.1 Structure of Final Antenna Design with Dimensions of patch used

2. ANTENNA DESIGN

Three basic parameters for the RMPA design are:

2.1. Operating frequency (f0)

The ISM frequency band is 2400MHz to 2483.5MHz, which is used for Bluetooth, WLAN and other applications. Hence the resonant frequency selected for design is 2.4 GHz.The other frequency band is 2.2GHZ to 2.26GHZ which is used for Advanced Wireless Service (AWS).

2.2. Dielectric constant of the substrate (εr)

The dielectric material selected for design is FR4_epoxy having dielectric constant of 4.4.A substrate having high dielectric constant should be selected because higher the dielectric constant smaller the dimensions of the antenna.

2.3. Height of dielectric substrate (h)

For the microstrip patch antenna which are used in cellular phones or other hand held devices it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate should be small; effects of height is discussed in [4]. Here FR4_epoxy substrate of standard height 1.6 mm is selected. Hence, the essential parameters for the design are:

- Frequency of operation fo = 2.4 GHz, 2.2GHz
- Dielectric constant of the substrate εr = 4.4
- Height of dielectric substrate h = 1.6 mm

2.4 Following steps are followed to design the antenna

a. Width calculation (W)

$$W = 1/(2 fr\sqrt{\mu_o.\varepsilon_o})\sqrt{2/(\varepsilon_r+1)} \quad (1)$$

Substituting εr = 4.4 and fo = 2.4 GHz, we get: W = 0.03803 m = 38.03 mm.

b. Effective dielectric constant calculation(εreff)

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+12\frac{h}{w}\right)^{-1/2} \quad (2)$$

Substituting :εr= 4.4, W = 38.03 mm and h = 1.6 mm, we get : εreff = 4.3996

c. Effective length calculation (Leff)

$$L_{eff} = \frac{C}{2 f_r\sqrt{\varepsilon_{reff}}} \quad (3)$$

Substituting : εreff= 4.3996, c = 3.0e8 m/s and fo= 2.4 GHz we get: Leff=0.028569 m = 28.569mm

e. Actual length of patch calculation (L)

$$L = L_{eff} - 2\Delta L \quad (4)$$

Substituting Leff= 4.3996 mm and ΔL = 0.7243 mm we get: L = 28.30 mm.

3. SIMULATION RESULTS

Considering design parameters as mentioned in section 1.1 (antenna design) and operating frequency as 2.4 GHz &2.2GHz following simulation results are obtained using HFSS software [18] .

3.1 SHOWS ALL DIODES OFF STAGE

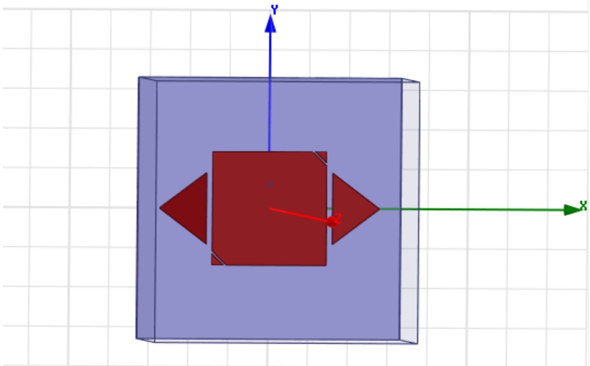

Fig.3.1.a. Simulated Antenna Design

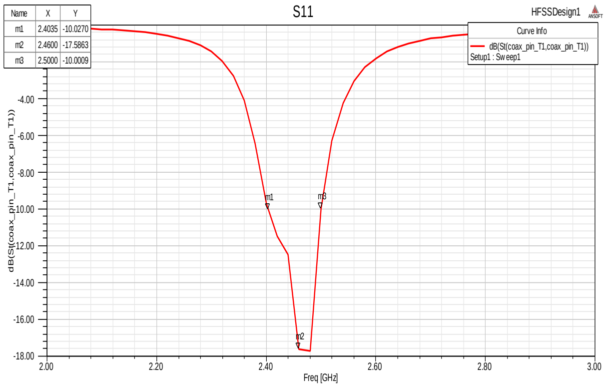

Fig.3.1.b. Simulated Return Loss

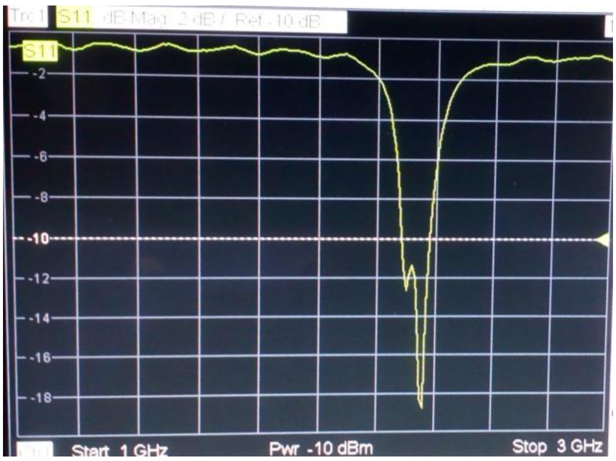

Fig.3.1.c. Measured Return Loss

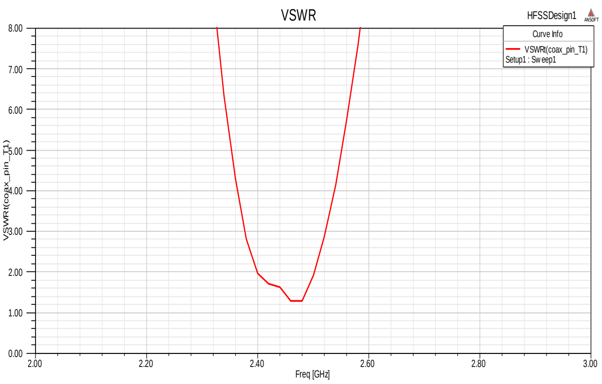

Fig.3.1.d. Simulated VSWR

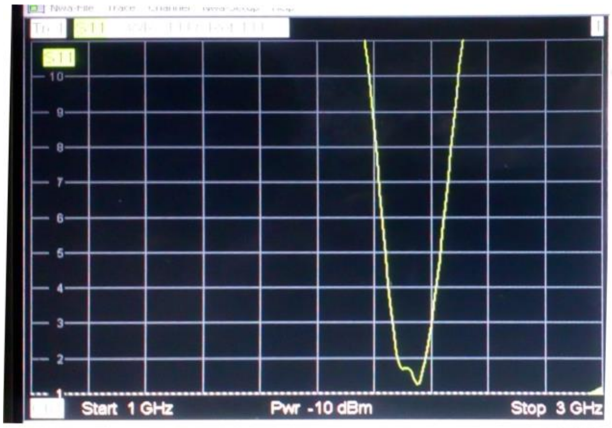

Fig.3.1.e. Measured VSWR

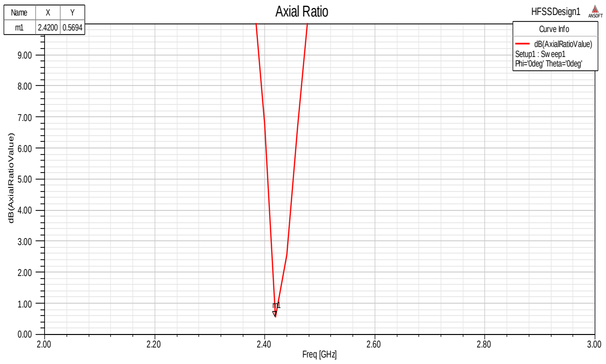

Fig.3.1.f. Simulated Axial Ratio

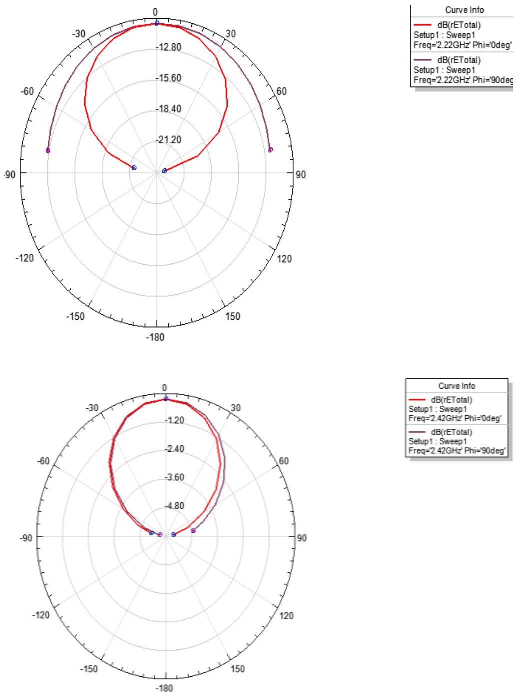

Fig.3.1.g. Simulated Radiation Pattern

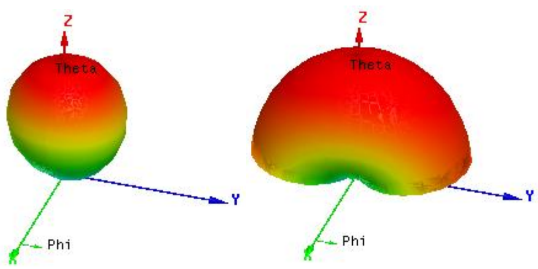

Fig.3.1.f. 3D Polar Plots

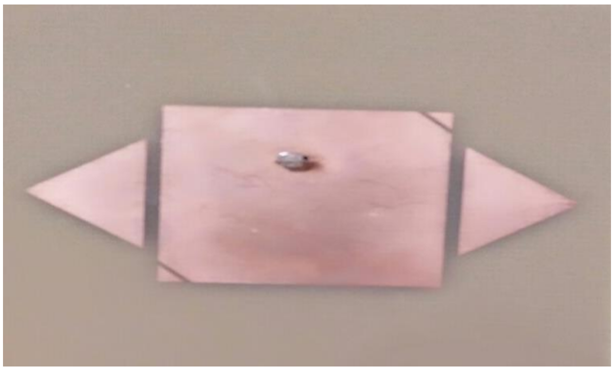

Fig.3.1.i. Hardware Structure

3.2 SHOWS ALL DIODES ON STAGE

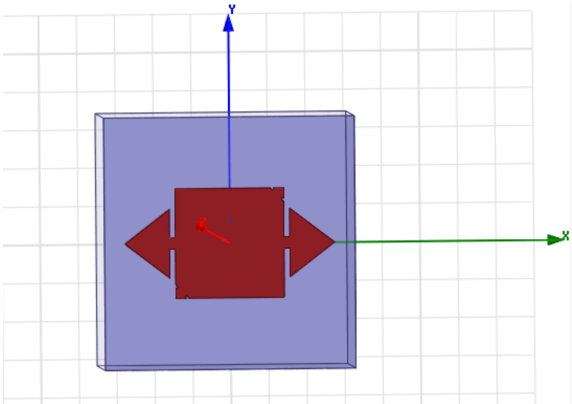

Fig.3.2.a. Simulated Antenna Design

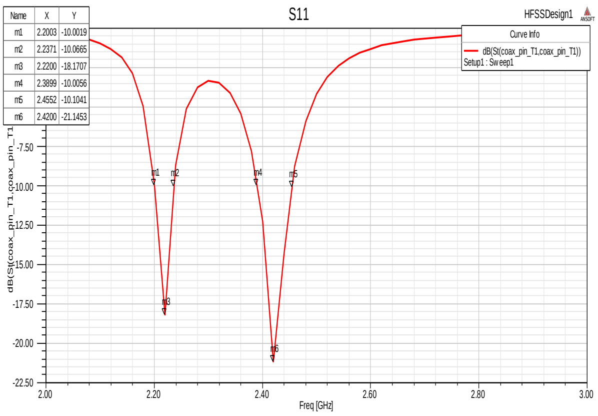

Fig.3.2.b. Simulated Return Loss

Fig.3.2.c. Measured Return Loss

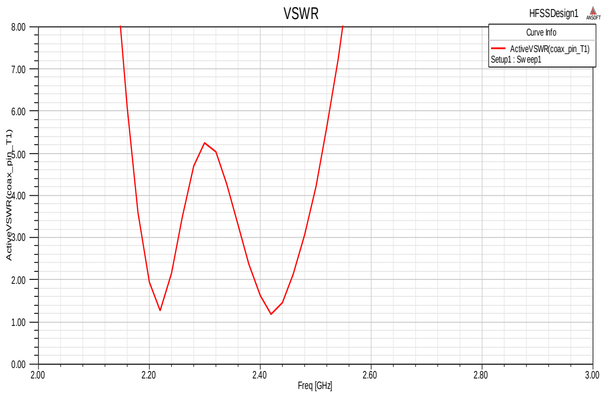

Fig.3.2.d. Simulated VSWR

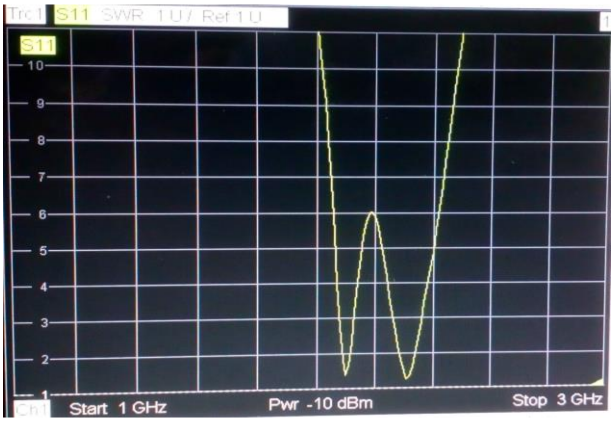

Fig.3.2.e. Measured VSWR

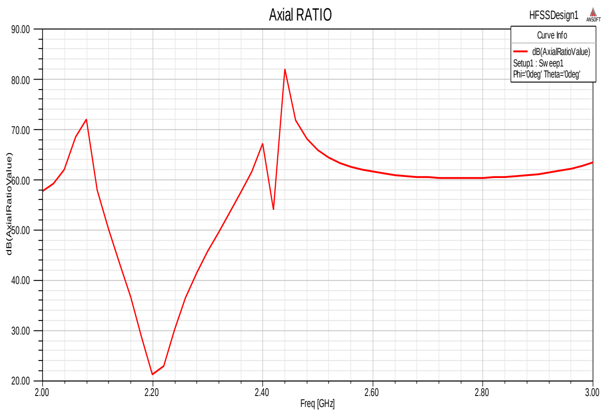

Fig.3.2.f.Simulated Axial Ratio

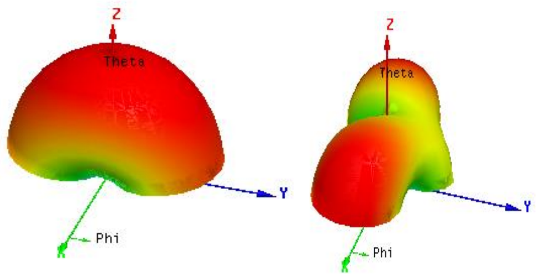

Fig.3.2.g. 3D Polar Plot

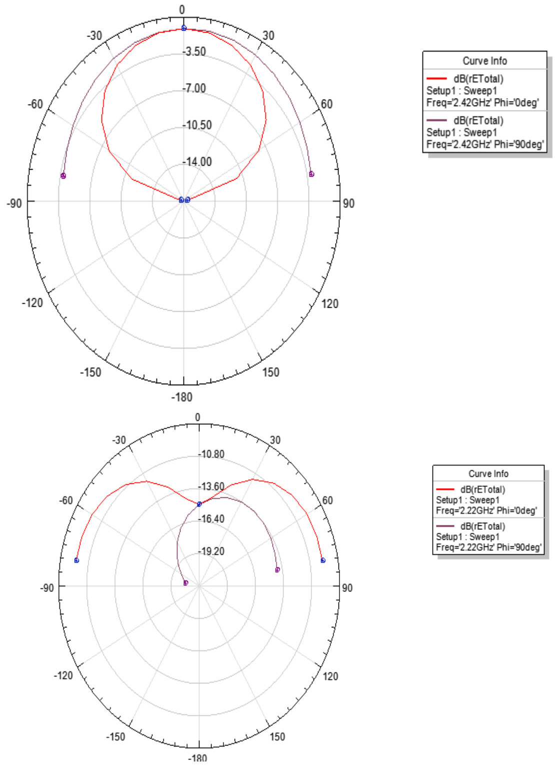

Fig.3.2.h.Simulated Radiation Pattern

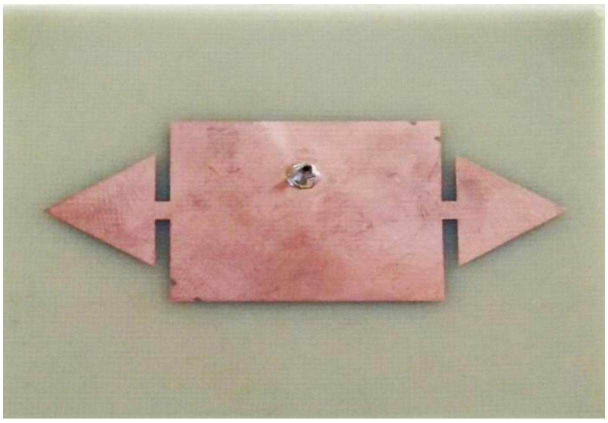

Fig.3.2.i. Hardware Structure

3.3 SHOWS MIDDLE DIODES ON STAGE

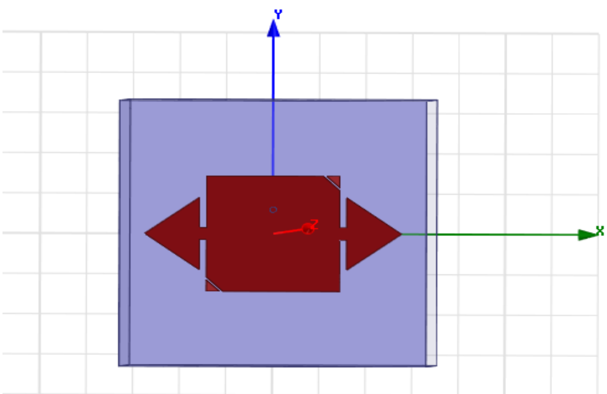

Fig.3.3.a. Simulated Antenna Design

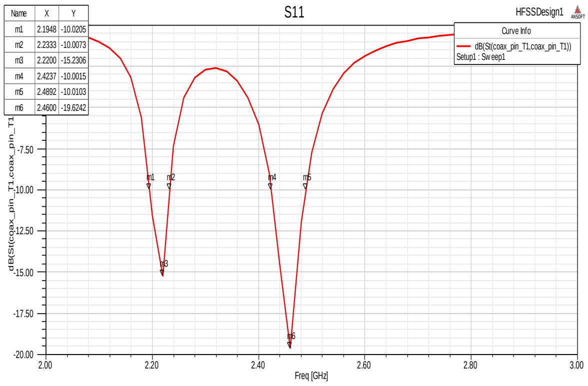

Fig.3.3.b. Simulated Return Loss

Fig.3.3.c. Measured Return Loss

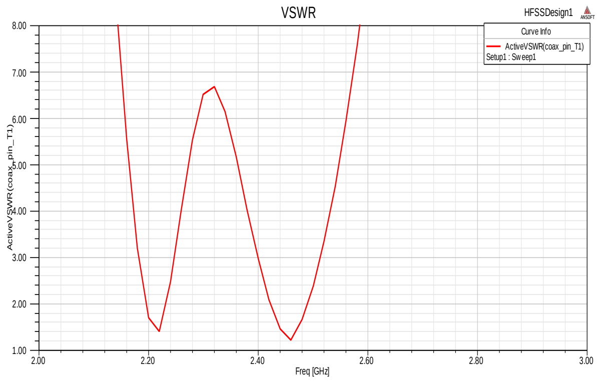

Fig.3.3.d. Simulated VSWR

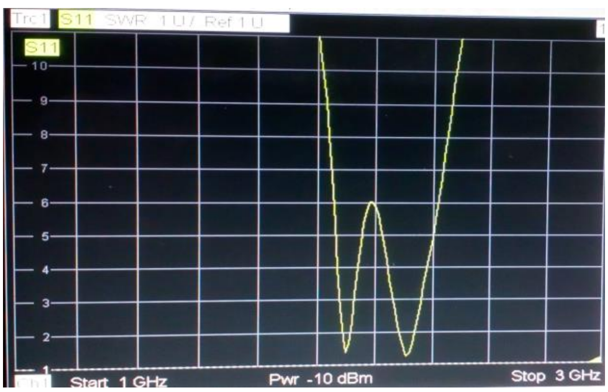

Fig.3.3.b. Measured VSWR

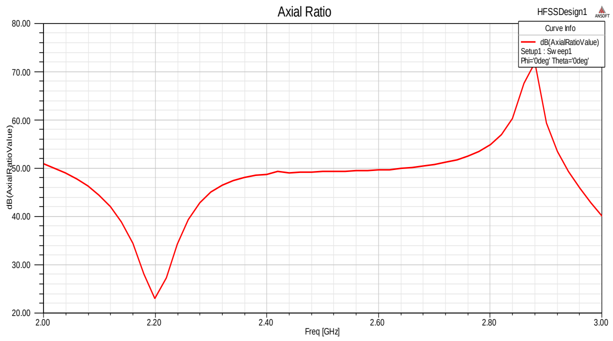

Fig.3.3.e. Simulated Axial Ratio

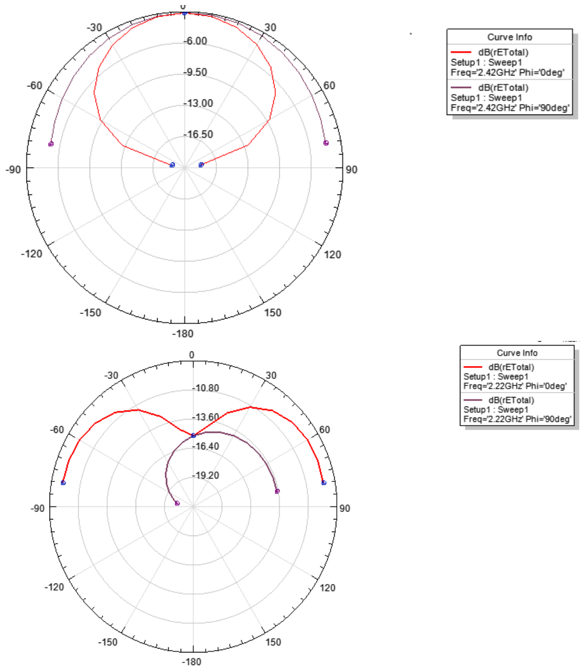

Fig.3.3.f. Simulated Radiation Pattern

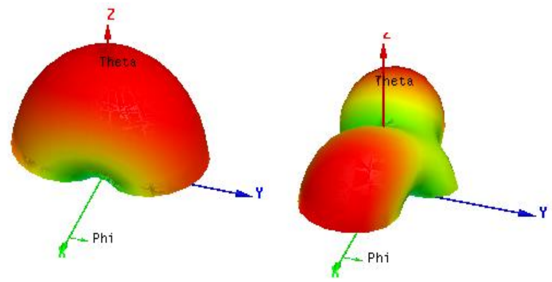

Fig.3.3.g. 3-D Polar Plot

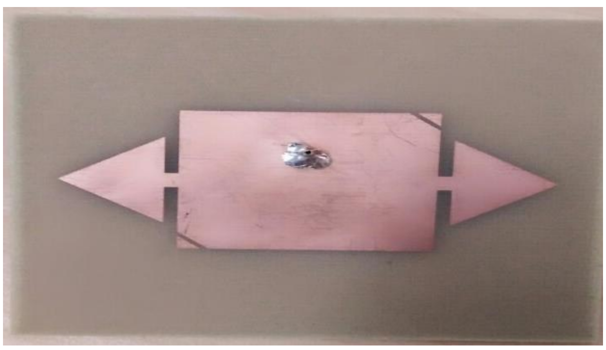

Fig.3.3.h. Hardware Structure

3.4 SHOWS CORNER DIODES ON STAGE

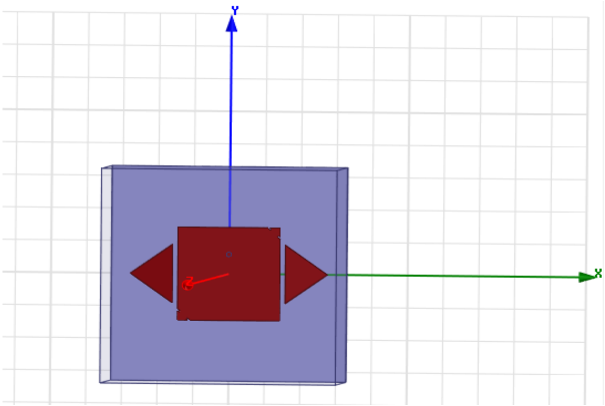

Fig.3.4.a. Simulated Antenna Design

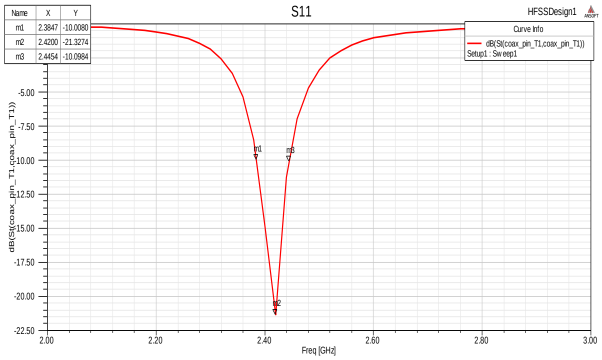

Fig.3.4.b. Simulated Return Loss

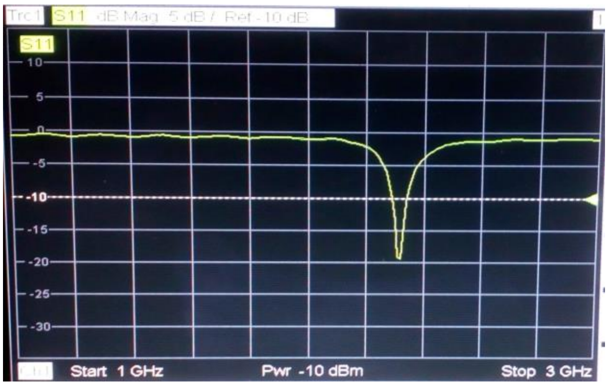

Fig.3.4.c. Measured Return Loss

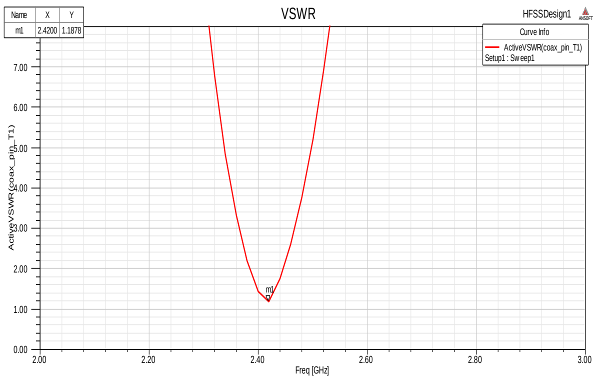

Fig.3.4.d. Simulated VSWR

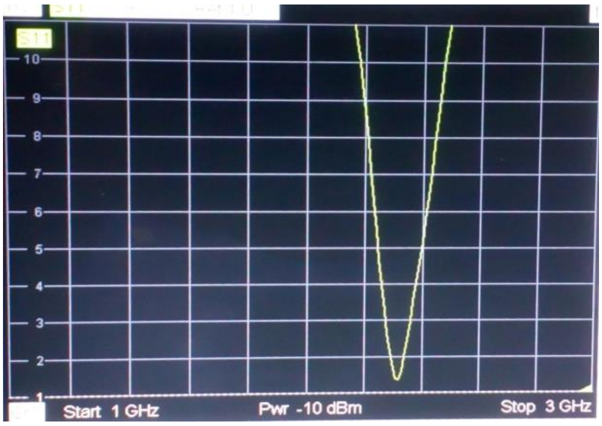

Fig.3.4.e. Measured VSWR

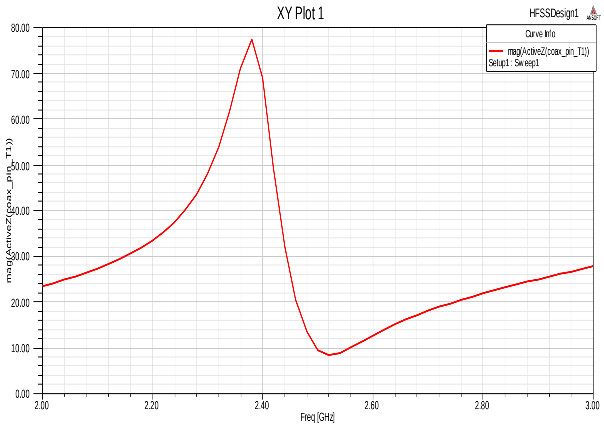

Fig.3.4.f. Simulated Axial Ratio

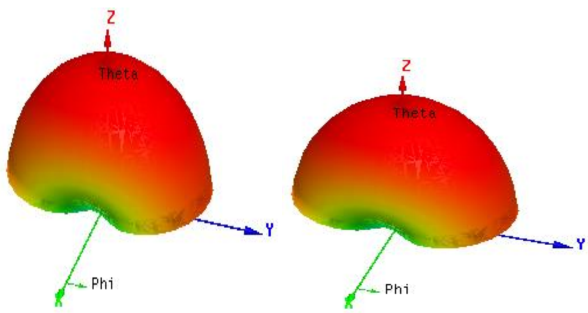

Fig.3.4.g. 3-D Polar Plot

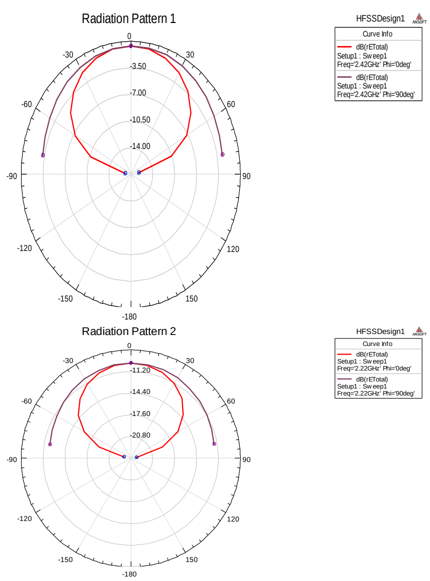

Fig.3.4.h. Simulated Radiation Pattern

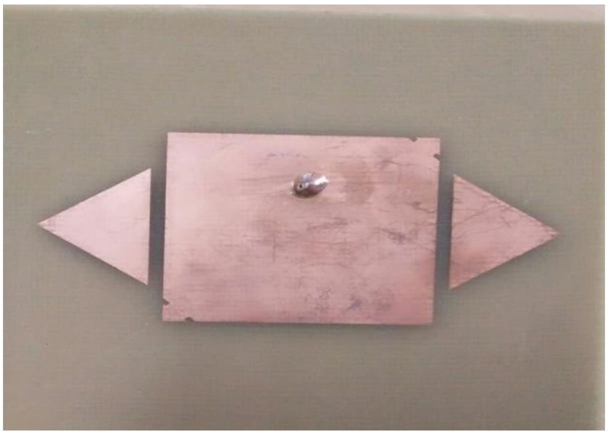

Fig.3.4.i. Hardware Structure

Table-1: Specification Table

Sr. No	Parameter	Value
1	Centre Freq f1	2.4GHz
2	Centre freq f2	2.2GHz
3	Height of substrate	1.6mm
4	Dielectric Constant(€)	4.4

Table-2: Comparison between Simulated and Measured

Values of Parameters for different position of diodes

TYPE	PARAME-TERS	SIMULAT-ED VALUES	MEASUR-D VALUES
` ALL ON	S11(db) [band 1,2]	-21.14,-18.17	-15.92,-18.92
	VSWR	1.2	1.2
	F1,F2,FC [band 1,2]	2.1,2.3,2.2	2.09,2.11, 2.10
		2.38,2.44, 2.4	2.28,2.33, 2.32
	BANDW-IDTH	Band1=0.2 Band2=0.06	Band1=0.02 Band2=0.12
	A.R	70,80	-------
ALL OFF	S11	-17.58db	-18.32db
	VSWR	1.2	1.2
	F1,F2,FC	2.33,2.43, 2.4	2.28,2.38, 2.35
	BANDW-IDTH	0.1	0.1

	A.R	0.56	--------
MIDDLE ON	S11(db) Band1,2	-15.23,-19.62	-15.23,-18.92
	VSWR	1.2	1.2
	F1,F2,FC	2.1,2.3,2.2	2.09,2.12, 2.11
		2.38,2.44, 2.4	2.31,2.37, 2.34
	BANDW-IDTH	Band 1=0.2 Band2=0.06	Band1=0.03 Band2=0.06
	A.R	24 ,70	----------
CORNERS ON	S11	-18.19db	-20db
	VSWR	1.18	1.2
	F1,F2,FC	2.33,2.43, 2.4	2.29,2.34, 2.31
	BANDW-IDTH	0.1	0.05
	A.R	70	--------

4. CONCLUSION

Here, the design of square shaped reconfigurable microstrip patch antenna is present. With the help of diodes the radiating length of the antenna can be increased or decreased. Thus the antenna reconfigured at frequencies of 2.4GHz and 2.2GHz also we made antenna circularly polarized for more effective radiation in all directions.

The designed antenna can be used in Bluetooth, WLAN, WIMAX and AWS applications. By Antenna reconfigurable we can operate in various frequency bands using electronic switches. This electronic method of switching made our project easier than any mechanical method.

Due to all these characteristics of antenna it can be easily used for devices working in wideband area network. Instead of using two different antennas for different frequency in wideband area network we have used single antenna resonating for two different frequencies by switching diodes.

5. ACKNOWLEDGEMENT

It is great pleasure for us to present project " Reconfigurable Microstrip Patch Antenna in Frequency and Polarization" where guidance play an invaluable key and provide concrete platform for completion of project.

We would like to acknowledge our project guide Mr.S. D. Hake sir for whenever we needed his guidance.

always being there whenever we needed his guidance. Also Dr. R. C. Jaiswal sir always took us through the right path for deciding the project topic.We are grateful to each other for always encouraging each other to keep on going towards completion of the project.

We would like to convey our regards to the library staff for helping us find the required reference papers. We would like to extend our sincere thanks to all the teachers and all other individuals who knowingly or unknowingly helped and supported us towards the completion of the project.

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[4] Constantine A. Balanis, Antenna Theory:Analysis and Design,2nd Edition;John Wiley Sons Inc. New York, 2001, pp12-130.

[5] https://www.youtube.com/watch?time_continue=324&v=OtYLzYckVFo

