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Design, Simulation and Fabrication of Parabolic Double Biquad Micro strip Patch Antenna for UWB Applications

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Abstract*: This paper covers the analysis and design of Parabolic double biquad microstrip patch antenna with three different substrates such as FR4_epoxy substrate with a dielectric constant of 4.4 and a thickness of 1.43mm,Arlon substrate having a dielectric constant of 3 and thickness of 0.90mm and Neltec substrate with a dielectric constant of 3.48 and a thickness of 1.43mm .The simulation process has been done through HFSS(HIGH FREQUENCY STRUCTURAL SIMULATOR). The radiation characteristics of the simulated antennas are obtained and compared with that of Fabricated Parabolic double biquad microstrip patch antenna operating at 6.06 GHz in terms of return loss, VSWR. The performance characteristics of parabolic double biquad microstrip patch antenna using FR4_epoxy, Arlon and Neltec substrates are obtained.
Keywords: Parabolic double biquad microstrip patch antenna, HFSS, Bandwidth, Return loss, VSWR.

I. INTRODUCTION

The microstrip patch antenna offers the advantages of low profile, ease of fabrication, lighter in weight, low volume, low cost, smaller dimension, conformity and compatibility with integrated circuits. Microstrip patch antenna can provide dual frequency operations, frequency agility, Omni directional patterning and broad band width .These antennas are used in different hand held communication devices [3].

For feeding the microstrip patch antenna, there are different methods like, line feeding method, coaxial feeding method etc. This paper uses coaxial feeding method. In this type of feeding technique the inner conductor of the coaxial connector extends through a dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane as shown in Fig.1.

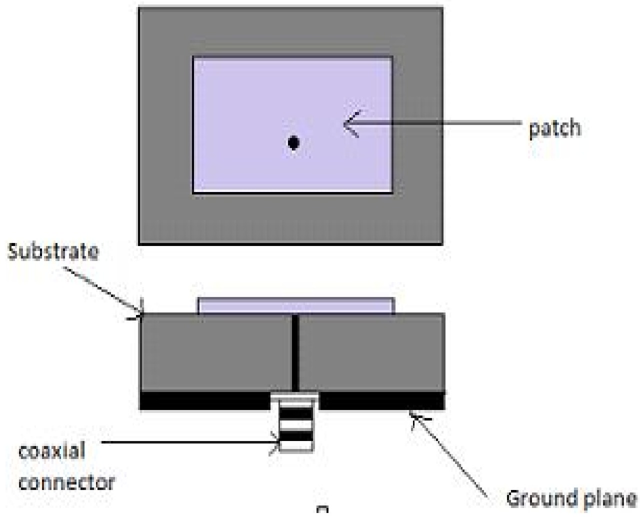

Fig.1.Coaxial Feed or Probe Feed

This type of feed arrangement has the advantage that the feed can be placed at any desired location inside the patch in order to match with its input impedance and is easy to fabricate and has low spurious radiation.

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II. ANTENNA CONFIGURATION AND DESIGN

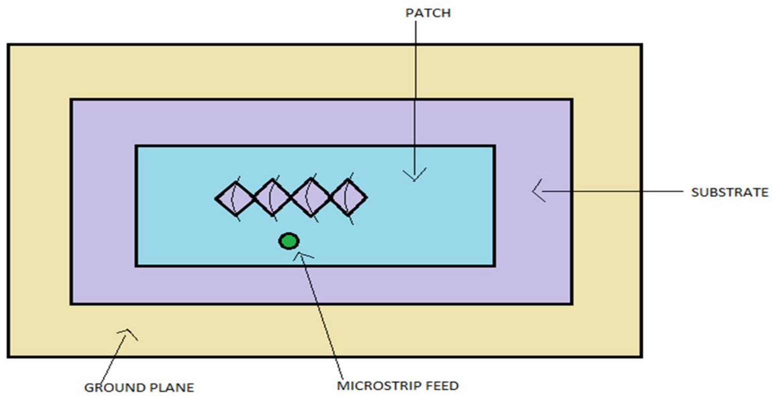

Fig.2.Parabolic Double Biquad .Microstrip patch Antenna

For designing of a microstrip patch antenna as shown in Figure 2, the essential parameters required are resonant frequency, dielectric medium and substrate thickness for which antenna to be designed.
The parameters to be calculated are as under Width (W) of the radiating patch is given by the equation:

$$W = \frac{c}{2f_0\sqrt{\left(\frac{\varepsilon_r + 1}{2}\right)}} \quad \text{----- (1)}$$

Where, fo is the resonant frequency, ε_r is the dielectric constant or relative permittivity and c is the velocity of light in free space. Effective permittivity or effective dielectric constant of the dielectric substrate when W/h > 1, is given by the equation:

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

Length of the active patch (L), which is more responsible for better antenna performance generally lies between λo⁄3 and λo⁄2.However, it is given by the equation

$$L = L_{eff} - 2\Delta L \quad \text{------ (3)}$$

Extended line length ΔL on both sides of the active patch due to the effect of fringing fields [7] is given by the equation:

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad \text{----- (4)}$$

Effective length is calculated by the formula

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad \text{-----(5)}$$

The transmission line model is applicable to infinite ground planes only. However, for practicalconsiderations it is essential to have a finite ground plane. It has been proved that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately the six times the substrate thickness all around the peripheral. Hence, for this design, the ground plane dimensions would be given as:

$$L_g = 6h + L \quad \text{----- (6)}$$

$$W_g = 6h + W \text{ ----- } (7)$$

In this design, desired input feed point Y_f along y-axis will be zero and only desired input feed point axis X_f along x-axis will be varied to locate the optimum feed point. The optimum feed point is given by the following equation [7].

$$Xf = L/2\sqrt{\varepsilon_{reff}} \text{ ----- } (8)$$

$$Yf = W/2 \text{ ----- } (9)$$

III. PARABOLIC DOUBLE BIQUAD MICROSTRIP PATCH ANTENNA DESIGN USING FR_4 EPOXY SUBSTRATE

Parabolic Double Biquad Antenna is a high-gain reflector antenna used for radio, television and data communications, and also for radar, on the UHF and SHF parts of the electromagnetic spectrum. The relatively short wavelength of electromagnetic radiation at these frequencies allows reasonably sized reflectors to exhibit the desired highly directional response for both receiving and transmitting the data.

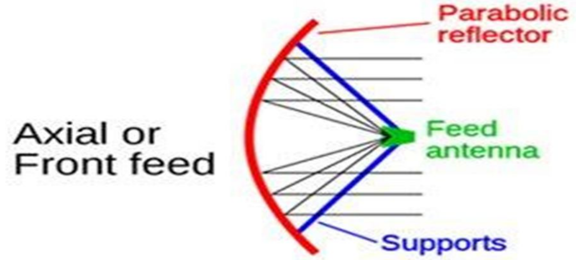

Fig.3.Parabolic Reflector

The Parabolic double biquad microstrip patch antenna consists of an patch,supported on a grounded dielectric sheet of thickness h and dielectric constant εr. A Parabolic double biquad microstrip patch antenna shown in Fig.4:

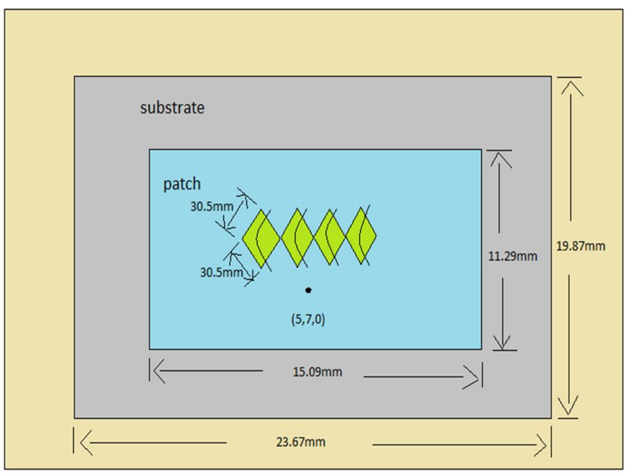

Fig.4:The Parabolic Double Biquad Microstrip Patch Antenna using FR4_epoxy substrate

The Parabolic Double Biquad Microstrip Patch Antenna the parameters are

Resonant frequency=6.06 GHz
Dielectric constant=4.4
Substrate thickness = 1.43 mm
Width of the patch=15.09 mm
Length of the patch=11.29 mm
Length of Ground=19.87 mm
Width of Ground=23.67 mm
Feed position: (5, 7, 0)

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A. Results

Parabolic double biquad microstrip patch antenna using FR4_epoxy substrate resonates at frequencies of 6 GHz and 7.7GHz.The simulated results of designed antenna gives return loss of -16.9553 db and -10.48 db presented in Fig.5 and VSWR of 2.48 and 5.2 at 6 GHz frequency and 7.7 GHz frequency respectively is shown in Fig. 6. The Gain and E-plane radiation patterns are shown in the figures below.

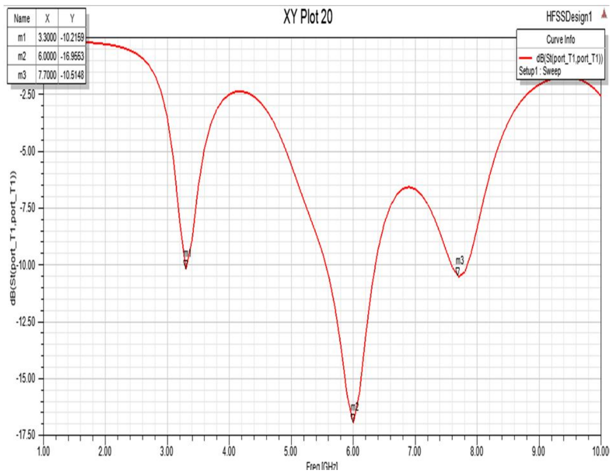


Fig.5. Return loss versus Frequency plot

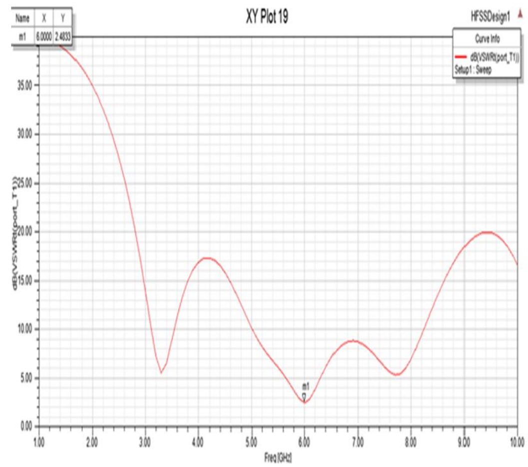
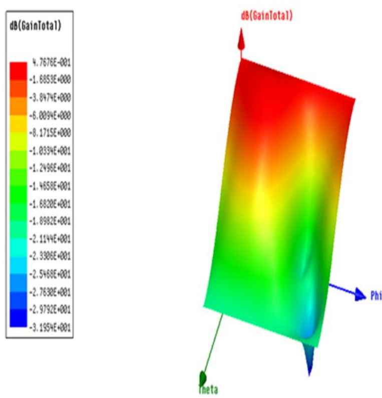


Fig.6. VSWR versus Frequency plot



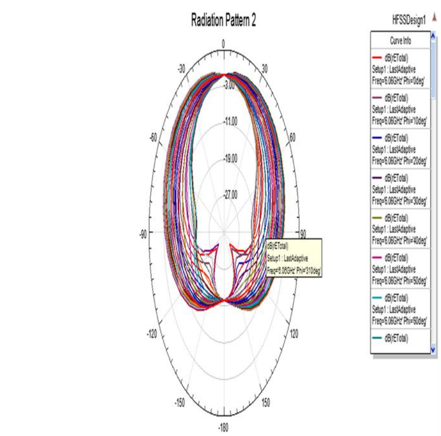


Fig7. 3D polar plot of of Gain for f_0=6.06 GHz, ε_r=4.4 and h=1.43 mm Fig.8.3D polar plot of Radiation pattern for f_0=6.06 GHz, ε_r=4.4 and h=1.43 mm

IV. PARABOLIC DOUBLE BIQUAD MICROSTRIP PATCH ANTENNA DESIGN USING ARLON SUBSTRATE

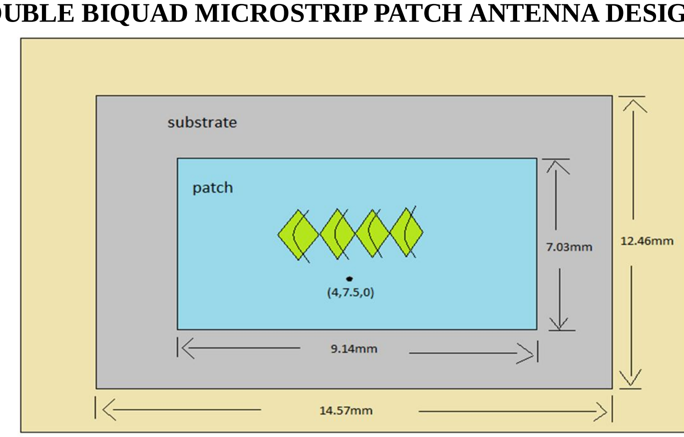


Fig.9. Design of Parabolic Double Biquad Microstrip Patch Antenna using Arlon substrate

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The Parabolic Double Biquad Microstrip Patch Antenna the parameters are

Resonant frequency=11.6 GHz
Dielectric constant =3
Substrate thickness =0.90 mm
Width of the patch=9.14 mm
Length of the patch=7.03 mm
Length of Ground=12.46 mm
Width of ground =14.57 mm
Feed position: (4,7.5, 0)

B. Results

Parabolic double biquad microstrip patch antenna using Arlon substrate resonates at frequencies of 11.7 GHz and 16.7GHz.

The simulated results of radiation characteristics plots for above design are given below. The Return loss versus frequency plot has the peak values of -18.68 dB and -8.72 dB at two resonating frequencies 11.7 GHz and 16.7 GHz respectively is shown in Fig 10.VSWR of 2.02 and 6.33 are obtained at two resonating frequencies 11.7 GHz and 16.7 GHz respectively is presented in Fig.11. It has a Gain of 4.31 dB and E-plane radiation patterns are shown in figure below .

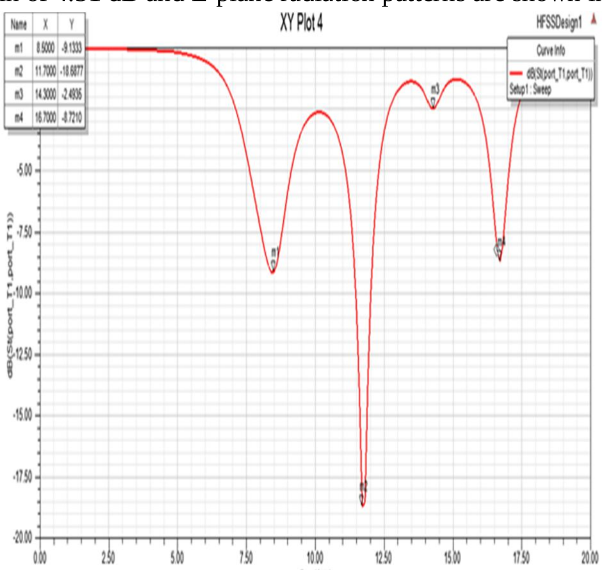

Fig.10. Return loss versus Frequency plot

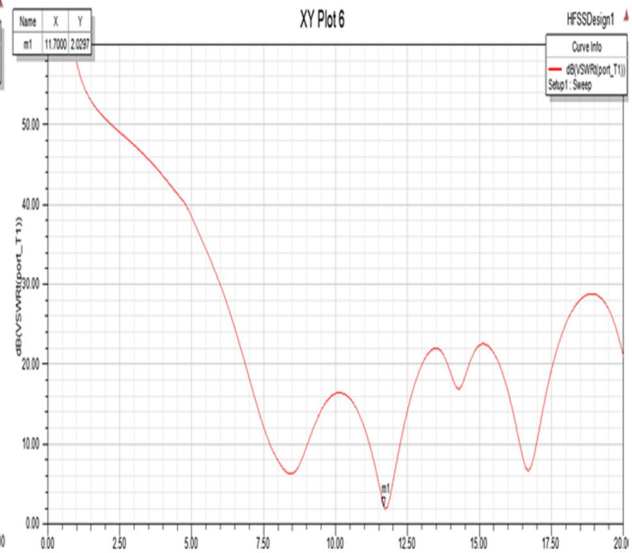

Fig.11. VSWR versus Frequency plot

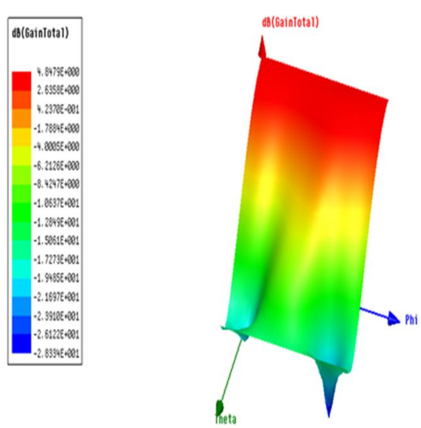

Fig.12. 3D polar plot of of Gain for f_0=11.6 GHz, ε_r=3 and h=0.90 mm

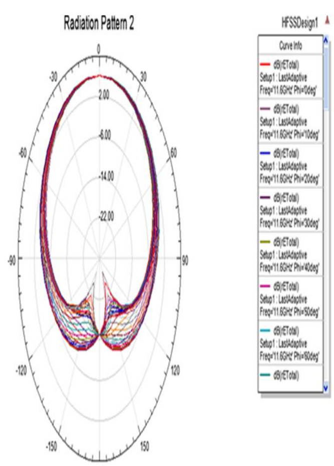

Fig.13.3D polar plot of Radiation pattern for f_0=11.6 GHz, ε_r=3 and h=0.90 mm

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V. PARABOLIC DOUBLE BIQUAD MICROSTRIP PATCH ANTENNA DESIGN USING NELTEC SUBSTRATE

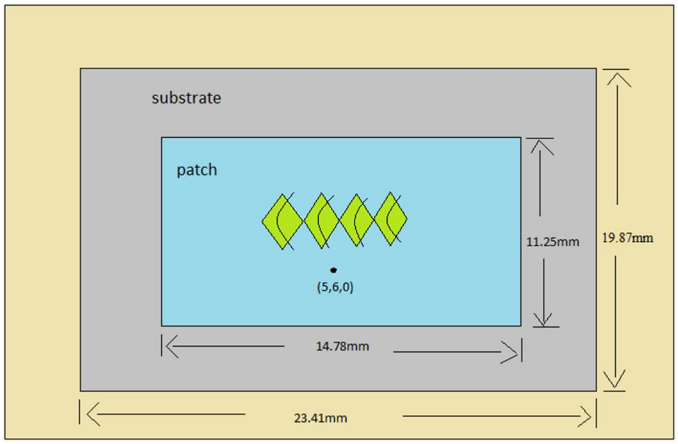


Fig.14. Design of Parabolic Double Biquad Microstrip Patch Antenna using Neltec substrate

The Parabolic Double Biquad Microstrip Patch Antenna the parameters are

Resonant frequency = 6.78 GHz
Dielectric constant = 3.48
Substrate thickness = 1.43 mm
Width of the patch = 14.78 mm
Length of the patch = 11.25 mm
Length of Ground = 19.87 mm
Width of ground = 23.41 mm
Feed position: (5, 6, 0)

C. Results

Parabolic double biquad microstrip patch antenna using Neltec substrate resonates at frequencies of 6.8 GHz and 9.1GHz.
The simulated results of radiation characteristics plots for above design are given below. The Return loss versus frequency plot has the peak values of -13.78 dB and -12.02 dB at two resonating frequencies 6.8 GHz and 9.1 GHz respectively is shown in Fig 15. VSWR of 3.6 and 4.3 are obtained at two resonating frequencies 6.8 GHz and 9.1 GHz respectively is presented in Fig.16. It has a Gain of 3.06 dB and E-plane radiation patterns are shown in figure below.

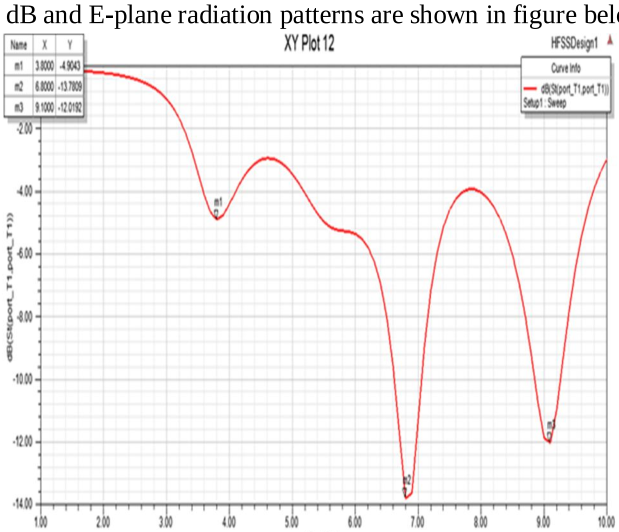


Fig.15. Return loss versus Frequency plot

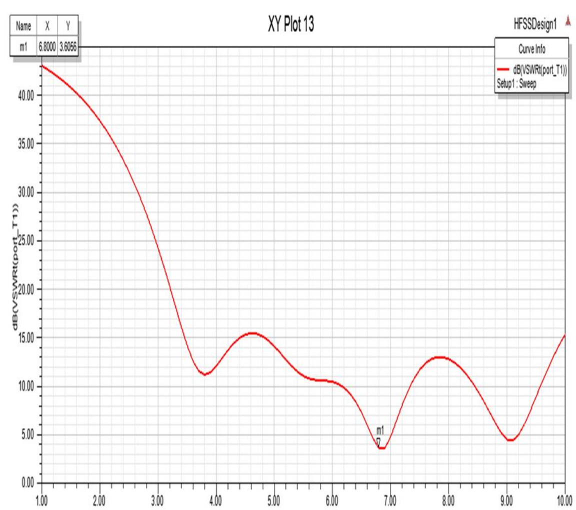
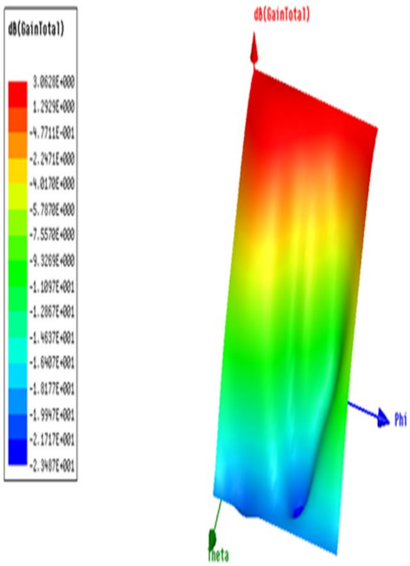


Fig.16. VSWR versus Frequency plot



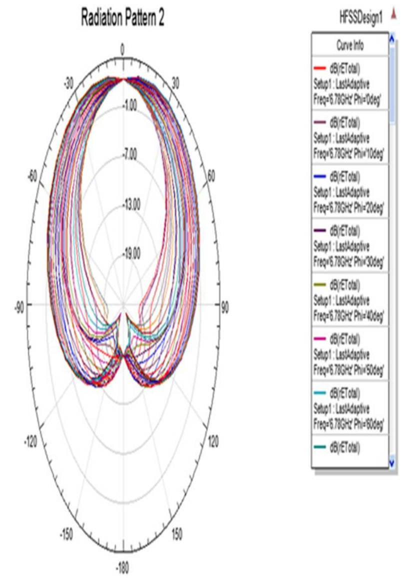


Fig.17. 3D polar plot of of Gain for f_0=6.78 GHz, ε_r=3.48 and h=1.43 mm Fig.18.3D polar plot of Radiation pattern for f_0=6.78 GHz, ε_r=3.48 and h=1.43 mm

Table I Comparison of performance of various substrates for parabolic double biquad microstrip patch antenna

SUBSTRATE	PERMITTIVITY ε_r	FREQUENCY f_r	RETURN LOSS	GAIN	DIRECTIVITY
FR4_Epoxy	4.4	6.06GHz	-16.9553dB	4.7676dB	1.3399dB
Arlon	3	11.6GHz	-18.6877dB	4.8479dB	4.9720dB
Neltec	3.48	6.78GHz	-13.7809dB	3.0628dB	3.0896dB

Parabolic double biquad microstrip patch antenna provides return loss of -16.9553dB, good VSWR 2.48 and better gain of 4.7676dB using FR4_Epoxy substrate.

VI. FABRICATION AND TESTING RESULTS

The Parabolic double biquad microstrip patch antenna is fabricated using FR4_Epoxy substrate is as shown in the figure below:

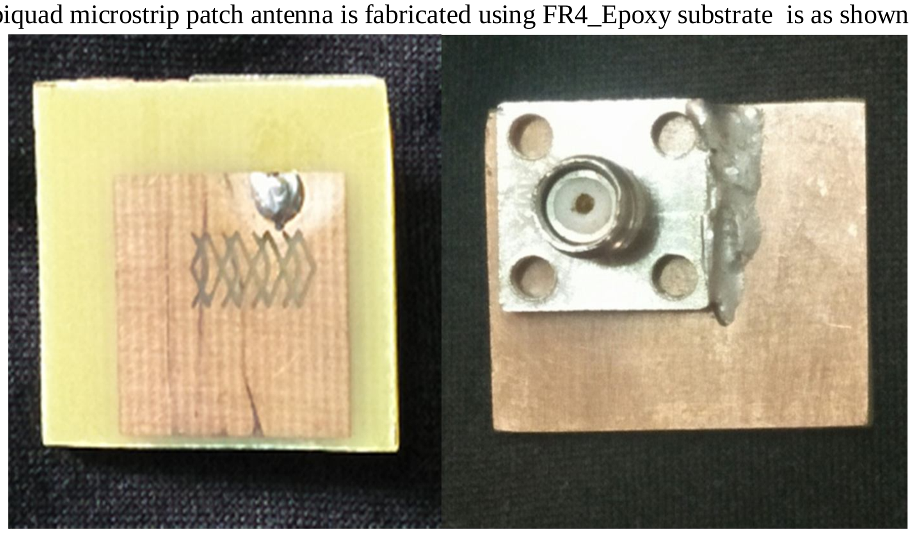


Fig.19 a)Top view b)Bottom view

A. Test Results

Testing using the vector network analyser R&S®ZVL-13 comes with a calibration device by which the cables attached to it can be calibrated and provide accurate results. Before starting the experiment, the centre frequency and the frequency range is to be entered, then the calibration is performed for the specified range. After calibration, the DUT (Device Under Test) is connected and network parameters can be observed.

1) *Return loss:* It is observed from the Figure that the antenna resonates at the chosen operating frequency 5.82GHz with a return loss of -17dB.

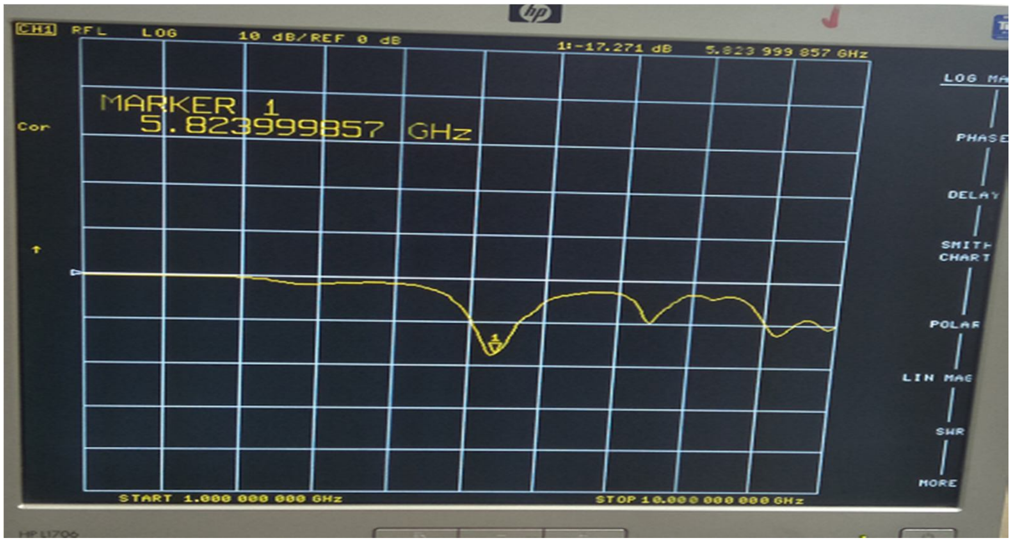


Fig.19.1 Return loss

2) *VSWR:* It is observed from the Figure that the antenna has a VSWR value of less than 2 along the bandwidth from 1 GHz to 10GHz which is acceptable. At the resonating frequency 5.82GHz VSWR value was found out to be 1.32 (less than 2).

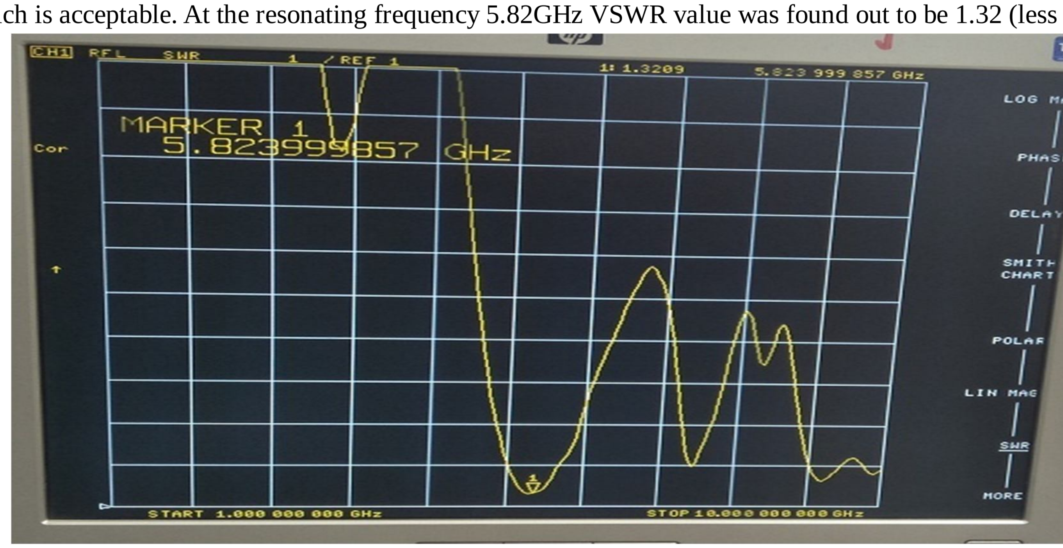


Fig.19.2 VSWR

VII. CONCLUSIONS AND FUTURESCOPE

In this paper the design of Parabolic double biquad microstrip patch antenna using different substrates has been simulated using HFSS. The performance characteristics of simulated antennas are compared in terms of return loss, VSWR, gain and E-plane radiation pattern. Based on the simulation studies the design details of Parabolic Double Biquad Microstrip Patch Antenna have been compiled and a prototype using FR4_Epoxy substrate has been fabricated and its performance characteristics are evaluated using the Rhode and Schwarz Vector Network Analyzer R&S® ZVL-13 setup . The HFSS design achieves the return loss of -16.9dB and corresponding VSWR is 2.4 with a Gain of 5 dB and Directivity of 1.33dB using FR4_Epoxy substrate. The fabricated

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design using FR4_Epoxy substrate achieves the return loss of -17dB and the corresponding VSWR is 1.32. The fabricated antenna has been tested and the test results of the performance of the antenna have been almost close to the simulated values.

We conclude that proposed geometry is applicable for ultra wide band from 6-12 GHz. In future the radiation characteristics of the parabolic double biquadmicrostrip patch antenna can be improved by using different feed techniques.

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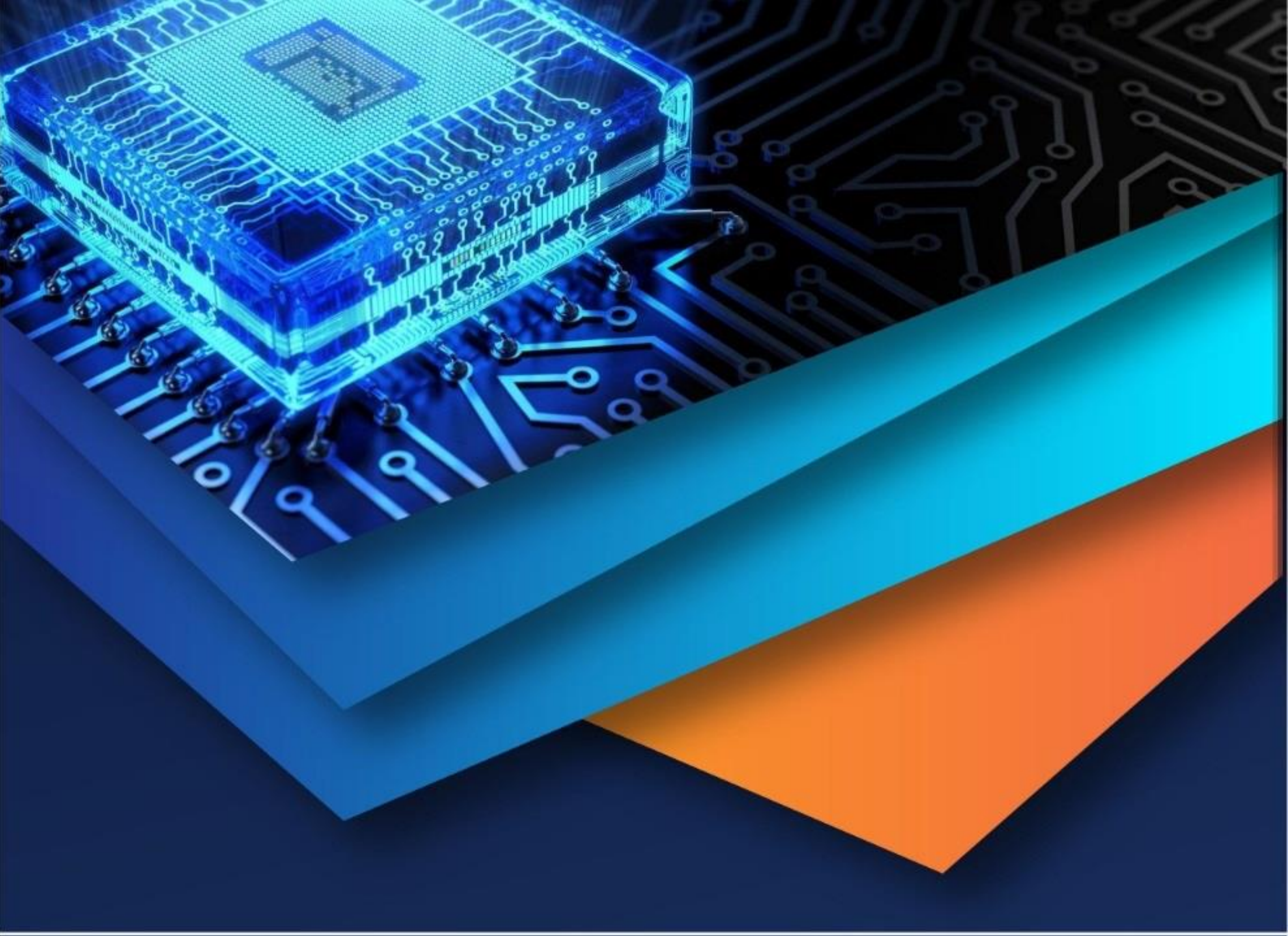

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