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

P. Udayasree[1], N. Krishna jyothi[2]

[1]PG Student, Department of Electronics and Communication Engineering, G. Narayanamma Institute of Technology and Science, Hyderabad, India
[2]Assistant Professor, Department of Electronics and Communication Engineering, G. Narayanamma Institute of Technology and Science, Hyderabad, India
E-Mail: udayasree439@gmail.com

Abstract

This paper covers the analysis and design of Parabolic double biquad micro strip patch antenna with three different substrates such asFR4_epoxy substrate with a dielectric constant of4.4 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 designed Double biquad micro strip patch antenna operating at 6.06 GHz,11.6GHz and 6.78GHz in terms of return loss, VSWR, Gain, Directivity, E-plane radiation patterns, Bandwidth. The performance characteristics of parabolic double biquad micro strip patch antenna using FR4_epoxy, Arlon and Neltec substrates are improved compared to Double biquad micro strip patch antenna.

Keywords--- Parabolic double biquad micro strip patch antenna, HFSS, Bandwidth, Return loss, VSWR.

1. Introduction

The micro strip 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. Micro strip 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 micro strip 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.

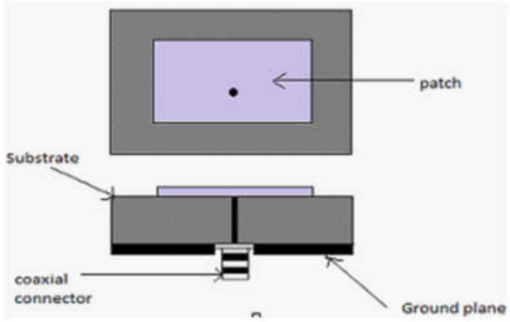


Fig.1.Coaxial Feed or Probe Feed

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.

2. Antenna Configuration and Design

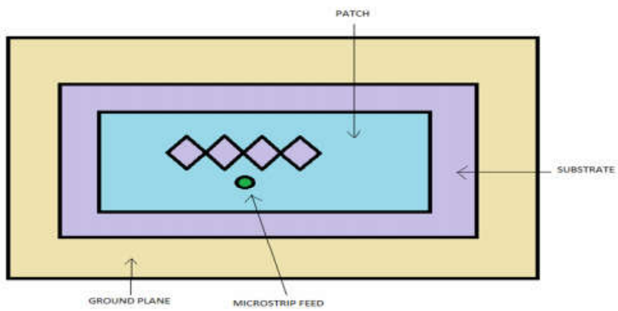


Fig.2.Double Biquad .Micro strip patch Antenna

For designing of a micro strip 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:

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

The transmission line model is applicable to infinite ground planes only. However, for practical considerations 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:

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

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

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].

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

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

3. Design Ofdouble Biquad Microstrip Patch Antenna

The aim is to design a Double biquad microstrip patch antenna and analyze the performance characteristics to improve the signal strength for long distances[7]. The double biquad antenna is simple to build and offers good gain for point to point communication. It consists of four squares of the same size of ¼ mid band wavelength as a radiating element and of a metallic plate or grid as a reflector.

3.1 Configuration 1:

The essential parameters for the design using FR4_Epoxy substrate are

Resonant frequency (f_0) =6.06GHzDielectric constant (ε_r) =4.4

Substrate thickness (h) =1.43mm

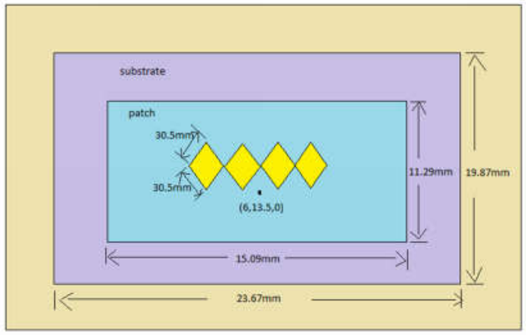


Fig.3. Design of Double biquad micro strip patch antenna for f_0=6.06 GHz, ε_r=4.4 and h=1.43 mm

The Design parameters are optimized and the optimized design is shown in Fig.3with the optimized values given in Table I

Table I optimized design parameters of antenna

L	***W***	***Feed point location***
11.29 mm	**15.09 mm**	**(6,13.5,0)**

The simulated result of S_{11} scattering parameters(return loss) of double biquad micro strip patch antenna operating at 6.06GHz is presented in Fig.4.From the figure the antenna has almost 6 GHz resonant frequency and it has -12.8422db return loss. The value of VSWR at 6.06 GHz is 4.0312 is shown in Fig5.The simulated results for Gain (db) is shown in Fig.6. The measured gain is 2.2694db.This patch antenna is simulated by HFSS.

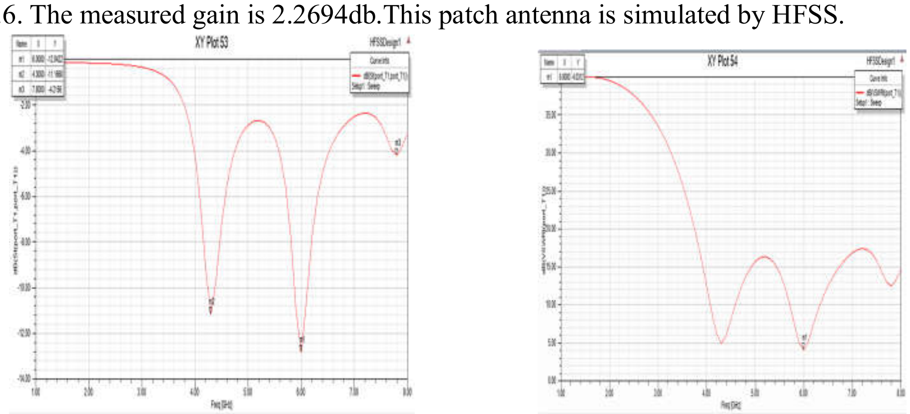


Fig.4. Return loss versus Frequency

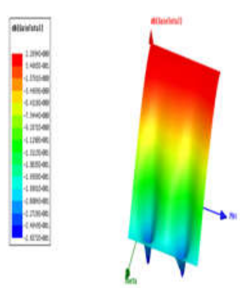


Fig.5. VSWR versus Frequency plot

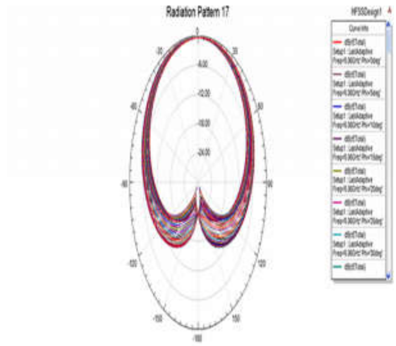


Fig.6. 3D polar plot of Gain for f_0=6.06 GHz, ε_r=4.4 and h=1.43 mm Fig.7.3D polar plot of Radiation pattern for f_0=6.06 GHz, ε_r=4.4 and h=1.43 mm

3.2 Configuration 2

The essential parameters for the design using Arlon substrate are

Resonant frequency (f_0) =11.6GHz,

Dielectric constant (ε_r)=3

Substrate thickness (h) =0.90mm

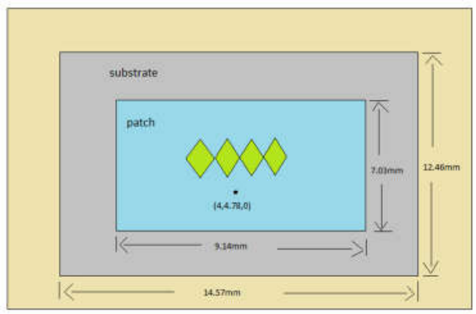


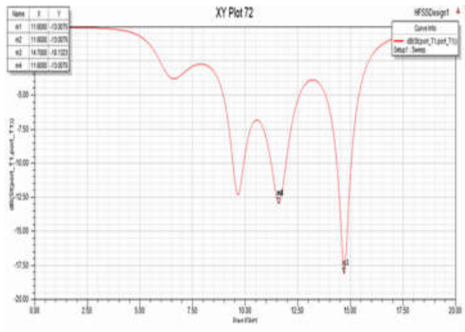
Fig.8.Design of Double biquad micro strip patch antenna for f_0=11.6 GHz, ε_r=3 and h=0.90 mm

The Design parameters are optimized and the optimized design is shown in Fig.8with the optimized values given in Table II

Table II optimized design parameters of antenna

L	***W***	***Feed point location***
7.03 mm	**9.14 mm**	**(4,4.78,0)**

The simulated result of S_{11} scattering parameters (return loss) of double biquad microstrip patch antenna operating at 11.6GHz is presented in Fig.9.From the figure the antenna has almost 11.6 GHz resonant frequency and it has -13.0075 db return loss.



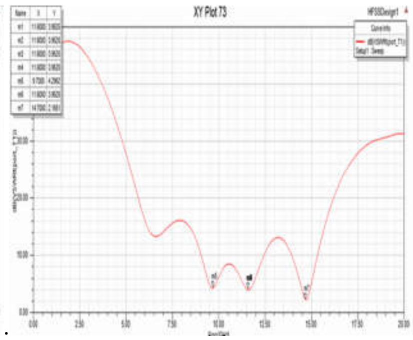
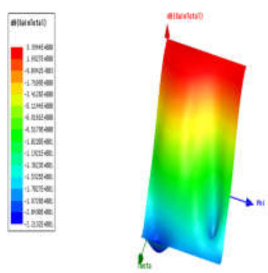


Fig.9. Return loss versus Frequency plot Fig.10.VSWR versus Frequency plot



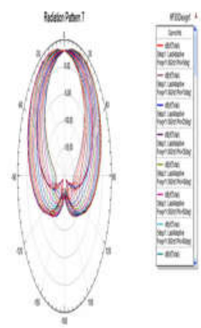


Fig.11. 3D polar plot of Gain for f_0=11.6 GHz, ε_r=3 and h=0.90 mmFig.12.3D polar plot of Radiation pattern for f_0=11.6 GHz, ε_r=3 and h=0.90 mm

3.3 Configuration 3

The essential parameters for the design using Neltec substrate are

Resonant frequency (f_0) = 6.78GHz,
Dielectric constant (ε_r) = 3.48
Substrate thickness (h) = 1.43mm

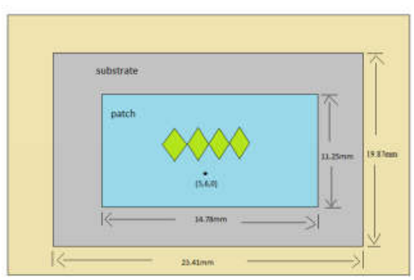


Fig.13.Design of Double biquad microstrip patch antenna for f_0=6.78 GHz, ε_r=3.48 and h=1.43 mm

The Design parameters are optimized and the optimized design is shown in Fig.8with the optimized values given in Table III

Table III optimized design parameters of antenna

L	*W*	*Feed point location*
11.25 mm	**14.78 mm**	**(5,6,0)**

The simulated result of S_{11} scattering parameters (return loss) of double biquad microstrip patch antenna operating at 6.78GHz is presented in Fig.14.From the figure the antenna has almost 6.7 GHz resonant frequency and it has -11.275 db return loss.

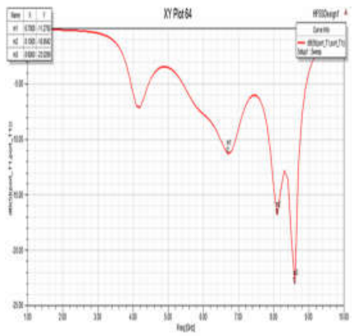


Fig.14. Return loss versus Frequency plot

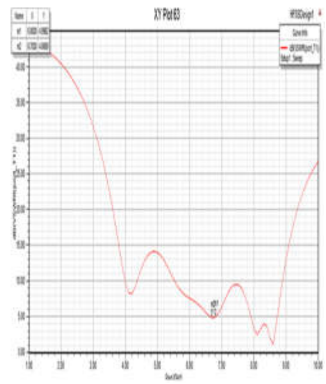
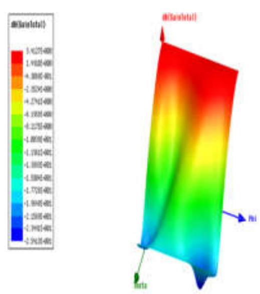


Fig.15. VSWR vesus Frequency plot



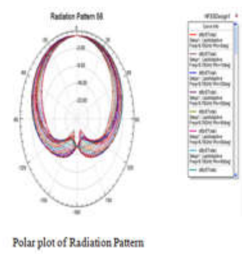


Fig.16. 3D polar plot of Gain for f_0=6.78 GHz, ε_r=3.48 and h=1.43 mm Fig.17.3D polar plot of Radiation pattern for f_0=6.78 GHz, ε_r=3.48 and h=1.43 mm

4. Parabolic Double Biquad micro strip 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.

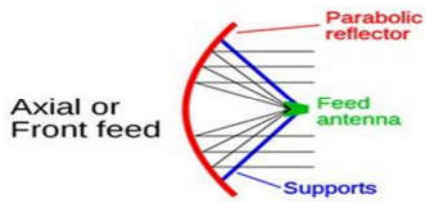


Fig.18.Parabolic Reflector

The Parabolic double biquad micro strip patch antenna consists of an patch, supported on a grounded dielectric sheet of thickness h and dielectric constant εr. A Parabolic double biquad micro strip patch antenna shown in Fig.19:

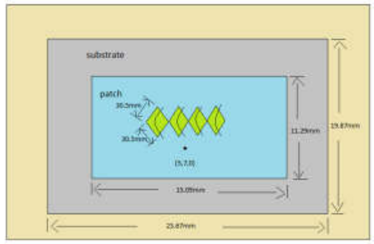


Fig.19:The Parabolic Double Biquad Microstrip Patch Antenna using FR4_epoxy substrate

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)

5. 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.20 and VSWR of 2.48 and 5.2 at 6 GHz frequency and 7.7 GHz frequency respectively is shown in Fig. 21. The Gain and E-plane radiation patterns are shown in the figures below.

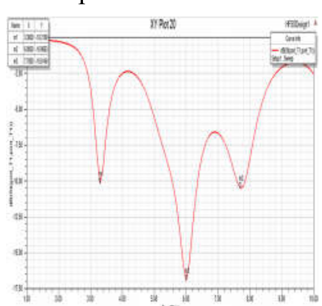


Fig.20. Return loss versus Frequency

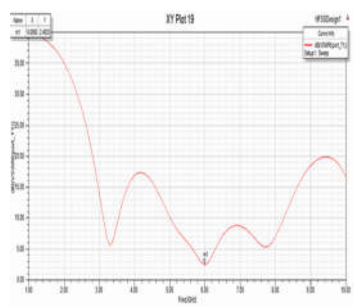
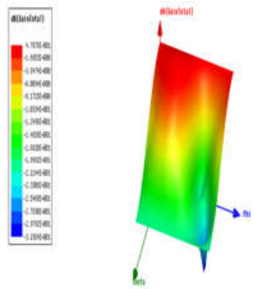


Fig.21. VSWR versus Frequency plot



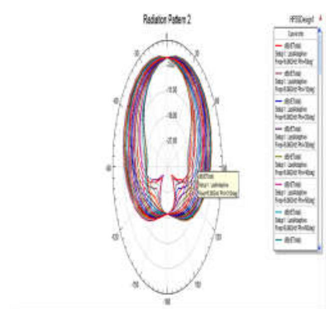


Fig.22. 3D polar plot of of Gain for f_0=6.06 GHz, ε_r=4.4 and h=1.43 mm Fig.23.3D polar plot of Radiation pattern for f_0=6.06 GHz, ε_r=4.4 and h=1.43 mm

6. Parabolic Double Biquad Micro strip Patch Antenna Design Using Arlon Substrate

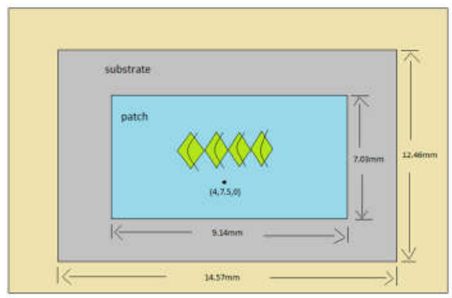


Fig.24. Design of Parabolic Double Biquad Microstrip Patch Antenna using Arlon substrate

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)

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 25.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.26. It has a Gain of 4.31 dB and E-plane radiation patterns are shown in figure below .

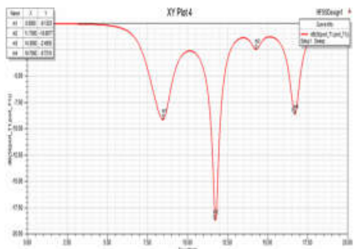


Fig.25. Return loss versus Frequency plot

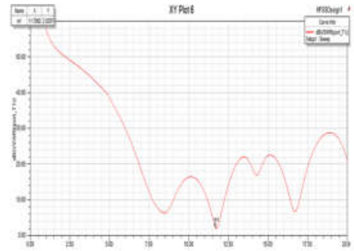
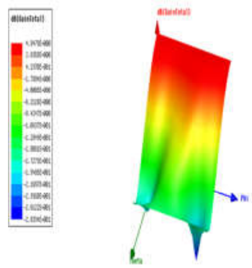


Fig.26. VSWR versus Frequency plot



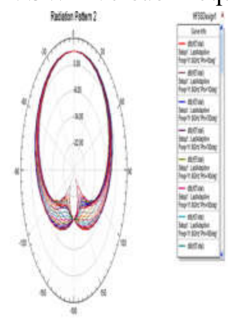


Fig.27. 3D polar plot of of Gain for f_0=11.6 GHz, ε_r=3 and h=0.90 mm Fig.28.3D polar plot of Radiation pattern for f_0=11.6 GHz, ε_r=3 and h=0.90 mm

7. Parabolic Double Biquad Micro strip Patch Antenna Design Using Neltec Substrate

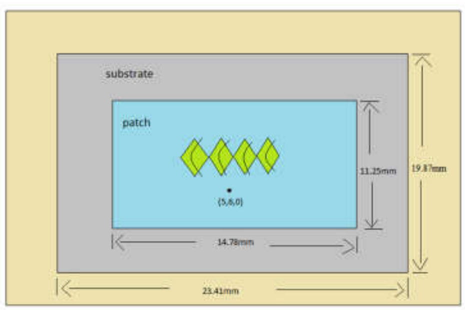


Fig.29. Design of Parabolic Double Biquad Micro strip Patch Antenna using Neltec substrate

The Parabolic Double Biquad Micro strip 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)

Parabolic double biquad micro strip 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 30. 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.31. It has a Gain of 3.06 dB and E-plane radiation patterns are shown in figure below.

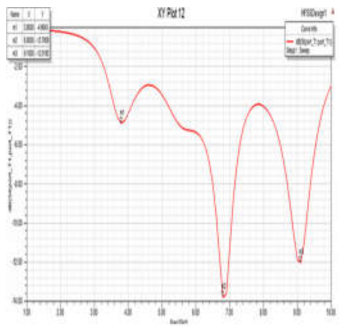


Fig.30. Return loss versus Frequency plot

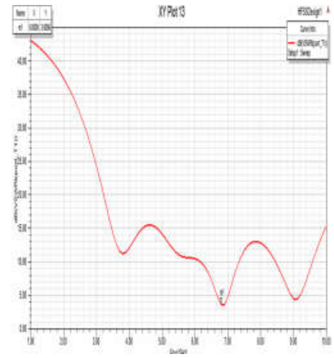
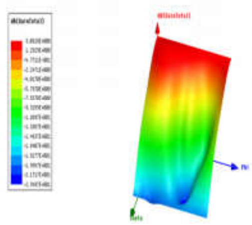


Fig.31. VSWR versus Frequency plot



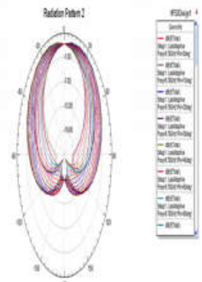


Fig.32. 3D polar plot of of Gain for f_0=6.78 GHz, ε_r=3.48 and h=1.43 mm Fig.33.3D polar plot of Radiation pattern for f_0=6.78 GHz, ε_r=3.48 and h=1.43 mm

Table IVComparison of Double biquad microstrip patch antenna and parabolic double biquad microstrip patch antenna

			DOUBLE BIQUAD MICROSTRIP PATCH ANTENNA			PARABOLIC DOUBLE BIQUAD MICROSTRIP PATCH ANTENNA		
SUBSTRATE	PERMITTIVITY ε_r	FREQUENCY f_0	RETURN LOSS	VSWR	GAIN	RETURN LOSS	VSWR	GAIN
Epoxy_FR4	4.4	6.06GHz	-12.8422dB	4.0312	2.2694dB	-16.9553dB	2.4833	4.7676dB
Arlon	3	11.6GHz	-13.0075dB	3.9525	3.3944dB	-18.6877dB	2.0297	4.8479dB
Neltec	3.48	6.78GHz	-11.2750dB	4.8669	3.4127dB	-13.7809dB	3.6056	3.0628dB

Parabolic double biquad microstrip patch antenna provides low return loss of -18.6877dB, good VSWR 2.0297 and better gain of 4.8479dB compared to double biquad microstrip patch antenna with return loss of -13.0075dB, VSWR 3.9525 and gain of 3.4127dB.

Conclusions and Future scope

In this paper the design of double biquad microstrip patch antenna and 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. The modified double biquad micro strip patch antenna with reflector shows better performance characteristics compared to double biquad micro strip patch antenna. We conclude that proposed geometry is applicable for ultra-wide band from 6-12 GHz. In future the radiation characteristics of the parabolic double biquad micro strip patch antenna can be improved by using different feed techniques.

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