DESIGN AND ANALYSIS OF ULTRA WIDE BAND ELLIPTICAL SLOT WITH QUARTER WAVE TRANSMISSION LINE GROUND FOR WIRELESS APPLICATIONS.

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Abstract: UltraWide Bandwidth (UWB) antenna with Deflected Ground Structure for wireless communication is presented in this paper. Our proposed antenna design is consisting of elliptical shape slot at patch and Quarter wave transmission line at the ground with multiband frequency operation in various wireless communications.An antenna is designed using FR4 substrate with permittivity value of 4.4 and thickness of 0.8 mm. The size of the antenna is 50 x 70 mm^{2}presents a high gain of 4 dB with Ultra Wide Bandwidth. In proposed antenna quarter wave ground is imposed with Deflected Ground Structure to achieve overall size reduction. The ultra bandwidth antenna proposed in this paper operates at multiband frequencies centered at 3.0267 GHz, 6.1933 GHz, 9.1911 GHz, 12.1467 GHz, and 15.06 GHz with corresponding return loss of -24.0553 dB, -40.9292 dB, -20.7534 dB, -41.8718 dB, -30.1747 dB.

1. INTRODUCTION

The micro-strip patch antenna revolutionized the electronics domain[3] and plays a prominent role in modern communication systems such as in radar communication, satellite communication and even in wireless communication systems due to its characteristics such as small and simple in structure, weight less and integrated easily[1] also includes properties of patch antenna such as flexibility, multiband operations, compact dimensions, these are considered to be building block of wireless communication[13]. In micro-strip patch antenna, the ground and patch are made of same material whereas the substrate is made from the different material. The feed line is varied along the edge of the patch of the antenna to obtain the desired results[3]. The micro-strip patch antenna provides good return loss, high efficiencyand directionalradiation pattern and works in both dual and multiple frequency bands[13].

The proposed ultra bandwidth antenna is found to be operated in multiband frequency, so it is used in various wireless applications such as in radar, satellite and telecommunication. The designed antenna is operated in five different bands and it will have varied polarization states [3]. The multiband antenna design depends on the utilization of EM solvers which are based on various methods such as MoM, FDTD and FEM methods [4]. In this design to achieve multiband operation the slot technique introduced.

In this multiband antenna Defected Ground Structure is used by introducing slots or defects in ground plane and to obtain multi-band frequency operation circular slot and elliptical slot are used. The antenna can be designed and fabricated easily with improved impedance using DGS technique and also helps to increase the bandwidth & gain [14]. This DGS technique effectively reduces the size of the antenna and elongates surface current on patch of the antenna. Defected Ground Structure (DGS) technique is the

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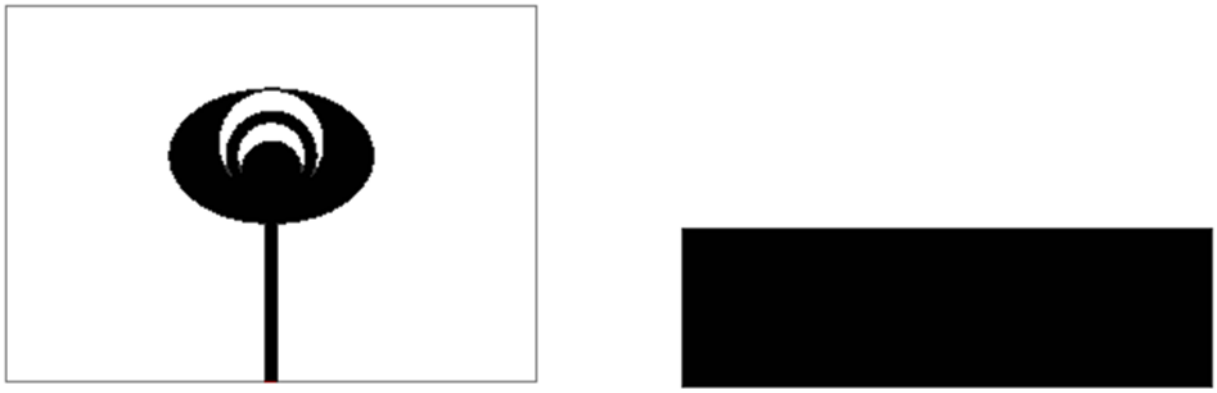
alternative for Electromagnetic Band Gap (EBG) technique [5]. The proposed paper will contribute towards the future study and simulation of patch antenna which operates in multiband frequency with having slots on the surface of patch [4].

The radiating patch of micro-strip antenna can be incorporated in various geometrics such as circular, rectangular, elliptical, triangular, square and annular patch and in this presentation the radiating patch of designed multiband antenna is elliptical patch [8]. To reach multiband operation the patch antenna is imposed with lots of techniques such as slots with various shapes. In this proposed design elliptical shape slots and circular slots are introduced and the slots are cutting away from the top of the radiating element [10].There are four most popular feeding techniques and they are coaxial feed, aperture coupling, proximity coupling, strip line feed. In this proposed design insert feeding technique is used and achieved antenna to work in multiband operation [8].

2. Design & Analysis

To achieve multiband operation the design process of novel antenna is concentrates on ground architecture, substrate selection and design of radiating patch. Here the proposed antenna is designed with FR4 substrate with permittivity value of 4.4 and the thickness of the FR4 substrate taken in this design is 0.8 mm. In this design the slot technique is implemented with the help of (DGS), the Defected Ground Structure technique is making slots or defects in the ground plane of patch antenna. By using of this slot technique can enhance the gain, bandwidth, axial ratio and radiation pattern is also improved. The slot micro-strip patch antenna also plays a prominent role in various applications with small in dimension.



a b

Figure 1 (a) Top view and (b) Bottom view

DIMENSIONS	50 x 70 mm^2
THICKNESS	0.8 mm
FEED LINE	22 x 1.524 mm^2
SLOT ELIPSE	7mm radius
SLOT CIRCLE	4.5 mm radius

Table 1Dimensions of antenna

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The design of the proposed Defected Ground Structure based circular patch antenna is carried out in FR4 substrate. The radiating patch of the designed antenna is made up of copper material. In proposed antenna insert feeding technique is used to match the impedance without making any additional changes in antenna. There are only two methods to design the antennas such as Transmission Line (TL) method and cavity resonant method, in which 99.5 percent of antennas are designed using the easiest transmission line model. The proposed antenna is also designed using the Transmission Line (TL) model. The transmission line model behavior is analyzed by James Clerk Maxwell, Lord Kelvin and Oliver Heaviside. To transmit the high-frequency signal over short or long range distance with minimum power loss a specialized structure is used.

The designed antenna is operated in 3.0267 GHz, 6.1933 GHz, 9.1911 GHz, 12.1467 GHzand 15.06 GHz supporting various applications with Ultra Wide Band. From the analysis of designed antenna, it is evident that the operation in field of mobile communication, broadcasting, satellite communication. The frequency ranges 8 to 12 GHz is mainly used in satellite communication and military applications, so this designed multiband antenna can use in security purposes. The frequency 3 GHz & 6GHz can use in mobile communication and broadcasting.

3. RESULTS & DISCUSSION

The 3D full wave simulation ANSYS HFSS is used for antenna simulation, design and to optimize the antenna. This ANSYS HFSS also used to simulate and model the high frequency components and RF/microwave components. The 3D mode simulator ANSYS HFSS is used to analyze the return loss (RL), VSWR (Voltage Standing Wave Ratio), radiation pattern, gain, directivity and efficiency of presented design which are all considered as the basic parameter of an antenna.

The return loss of the antenna should be obtained at negative values, so that the antenna has low range of signal reflection. The return loss of designed multiband antenna is in negative values, so that the range of signal reflection is low. The general equation for calculating return loss (RL) is given in the equation 1.

$$RL = -20 \log10 [1/ \Gamma] \quad (1)$$

$$\text{Where, } \Gamma = 10^{(-RL/20)} \quad (2)$$

Γ describes the Transmission Coefficient

Using HFSS software the reflection co-efficient of the designed patch antenna is obtained and it shows active response in multiple frequencies centered at 3.0267 GHz, 6.1933 GHz, 9.1911 GHz, 12.1467 GHz, 15.06 GHz with corresponding return loss of -24.0553 dB, -40.9292 dB, -20.7534 dB, -41.8718 dB, -30.1747 dB.

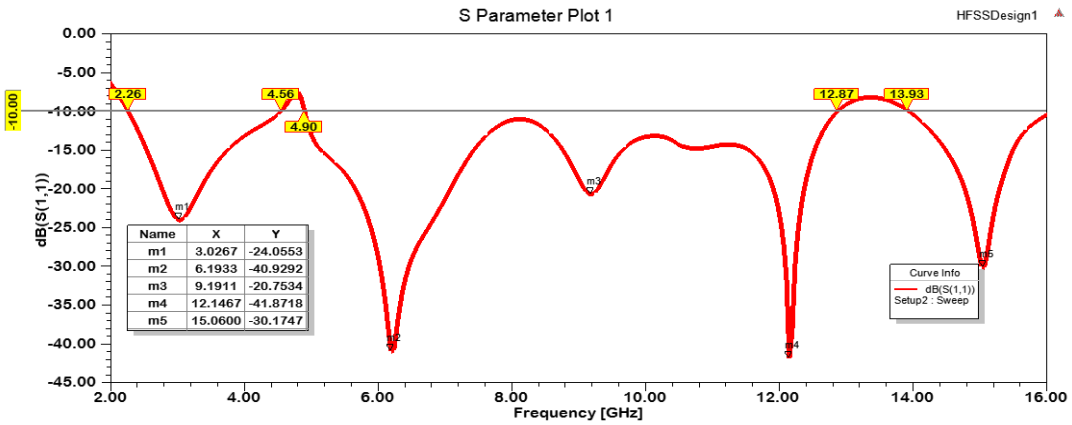

Figure 2 SimulatedS_{11} parameter

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The Voltage Standing Wave Ratio (VSWR) of proposed multiband antenna lies near to the unity. The observed VSWR value proves that given input signal is completely radiated by the antenna without any reflection and it describes that antenna is impedance matched to the transmission line.

The general equation of VSWR is given below,

$$VSWR = \left|\frac{1+\Gamma}{1-\Gamma}\right| (3)$$

The Voltage Standing Wave Ratio of designed circular patch antenna is shown in figure 3

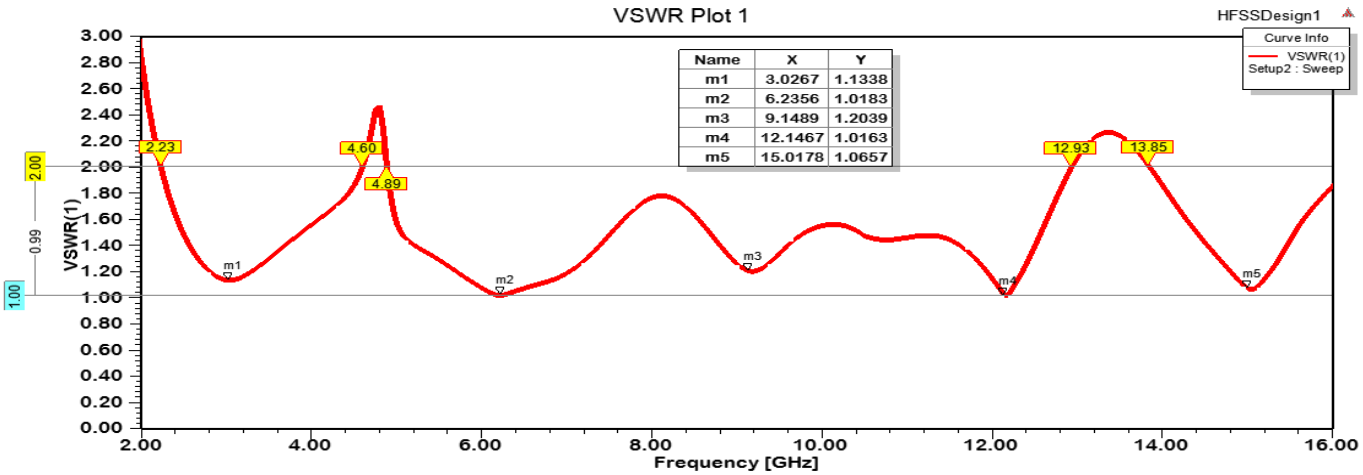

Figure 3 VSWR of the proposed antenna

The strength of the radio waves of the antenna at different directions are illustrated by the radiation pattern and discussed the antennas azimuth and elevation angle. The power radiated by an antenna is said to be radiation pattern. There are some types of radiation pattern such as pencil beam pattern and Fan beam pattern and shaped beam pattern. For every antenna, near end radiation should be zero and far-end radiation should form a fan shape radiation pattern and for patch antenna the radiation pattern is broad.

The figure 4 represents the radiation pattern for multiband frequency of proposed antenna at different angles such as 0 degree, 90 degree and at 180 degree. The radiation patterns for proposed antenna at different angles are analyzed using the HFSS software.

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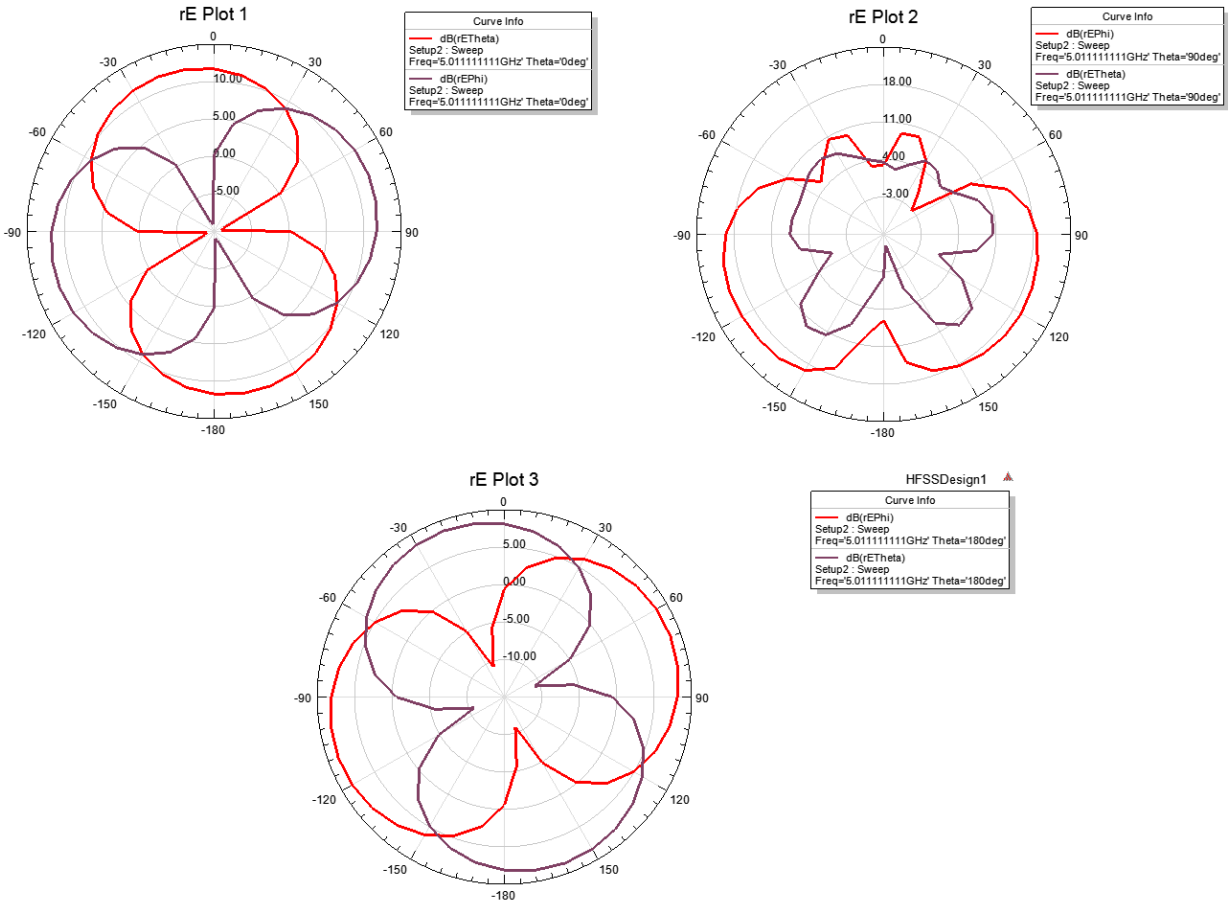

Figure 4 Radiation pattern for proposed antenna

At functional direction the gain pattern is called as the plot of gain. The gain of the proposed multiband antenna is 4.0 dB.The directivity is the measure of the radiation of an antenna in degree in one direction and it is expressed in decibels. The directivity of proposed antenna is 5.0 dB. Using ANSYS software both gain and directivity is represented in 3D polar plot.

Directivity (D) of the antenna can be calculated using the formula given below

$$D = Ae4 / \lambda \qquad (4)$$

Efficiency of the antenna can be calculated using the equation given below

$$\eta = G \lambda 2 / Ae4 \qquad (5)$$

From the obtained value of gain and directivity the efficiency is calculated in terms of % and it is expressed using the symbol η. The efficiency of the proposed antenna is 95.9%. The figure 5 represents the gain and directivity in 3D polar plot.

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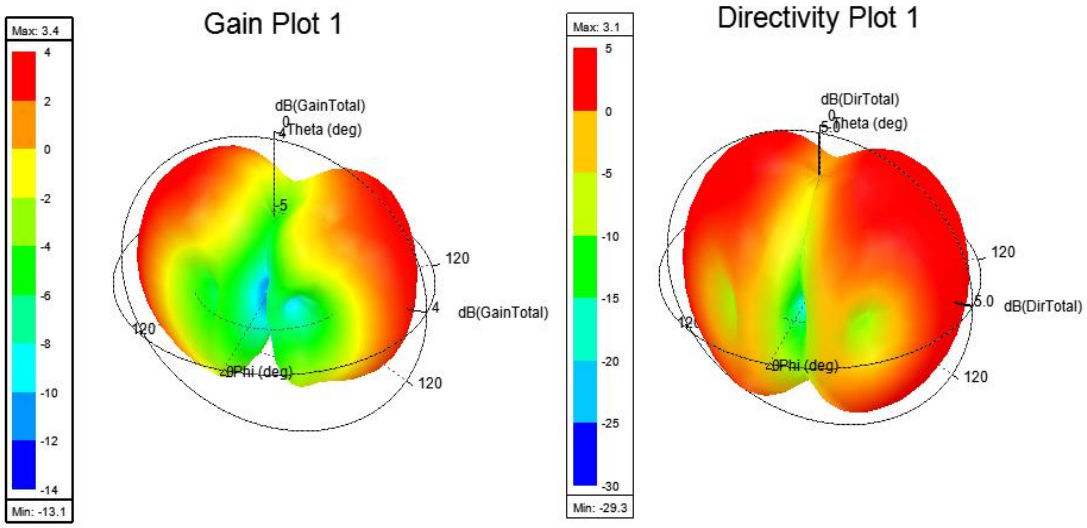
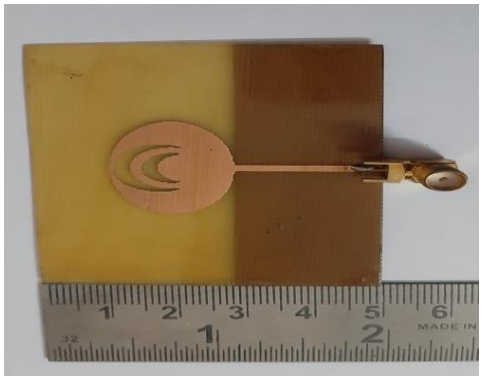


Figure 5 Gain and Directivity of proposed antenna

The prototype of the fabricated antenna is shown in below figure. The fabricated antenna is fed by the SMA connectors. The analysis of the fabricated antenna is carried out in standard testing environment.



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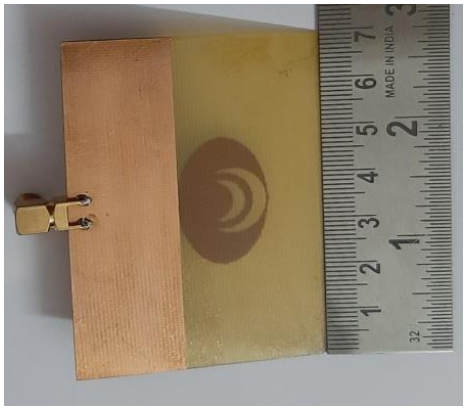

b

Figure 6 fabricated antenna (a) Top view and (b) Bottom view

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The analysis of the fabricated antenna is carried out in standard testing environment. The tested results of fabricated antenna are shown in figure 7, it shows the better performance equivalent to the simulation results.

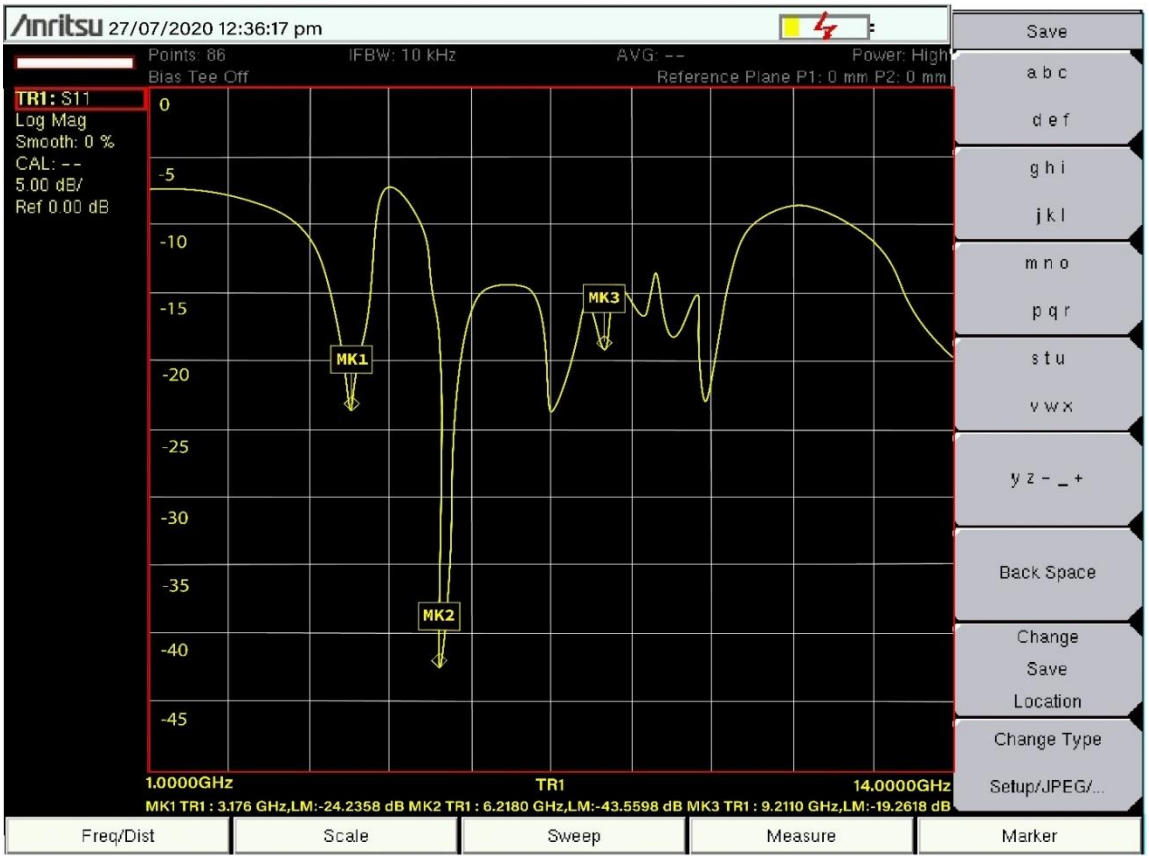

Figure 7Real-time Antenna Testing Result

Table 2 represents the simulated values for proposed ultra bandwidth antenna operated in multiband frequency

Frequency (GHz)	Return Loss (dB)		Bandwidth (GHz)	VSWR	Gain (dB)	Radiation Intensity (%)	FBR (10dB)
	Simulation	Tested					
3.0267	-24.0553	-24.1553	2.3	1.1338	3.5036	17.76	5.2832
6.1933	-40.9292	-40.9300	7.97	1.0183	3.8692	19.39	15.0658
9.1911	-20.7534	-20.7534	7.97	1.2039	4.5648	22.57	3.3655
12.1467	-41.8718	-41.8718	7.97	1.0163	6.7098	37.30	6.4069
15.0600	-30.1747	-30.1760	2.19	1.0657	5.5731	28.68	9.7428

Table 2 Overall Results of Proposed antenna

Figure8 represents the peak gain of proposed antenna from low value gain to the peak gain of the antenna

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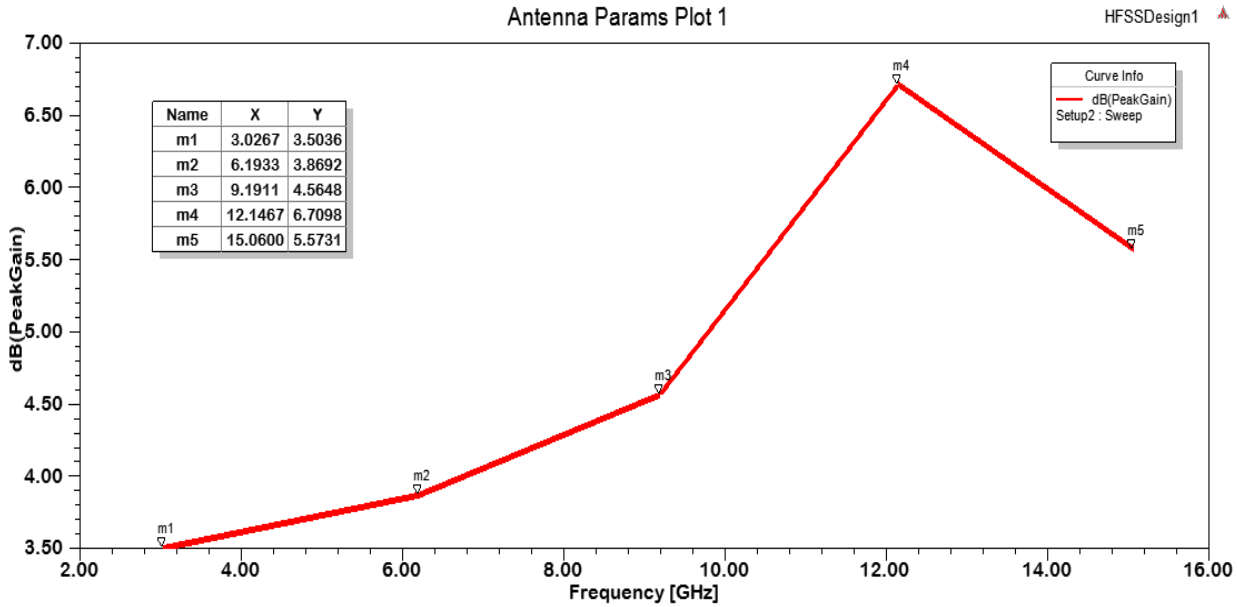

Figure 8 Peak gain of proposed antenna

The front to back ratio of the proposed antenna is shown in figure 9,it is the ratio of the power gain between the front and rear of a directional antenna and the results are simulated using HFSS software.

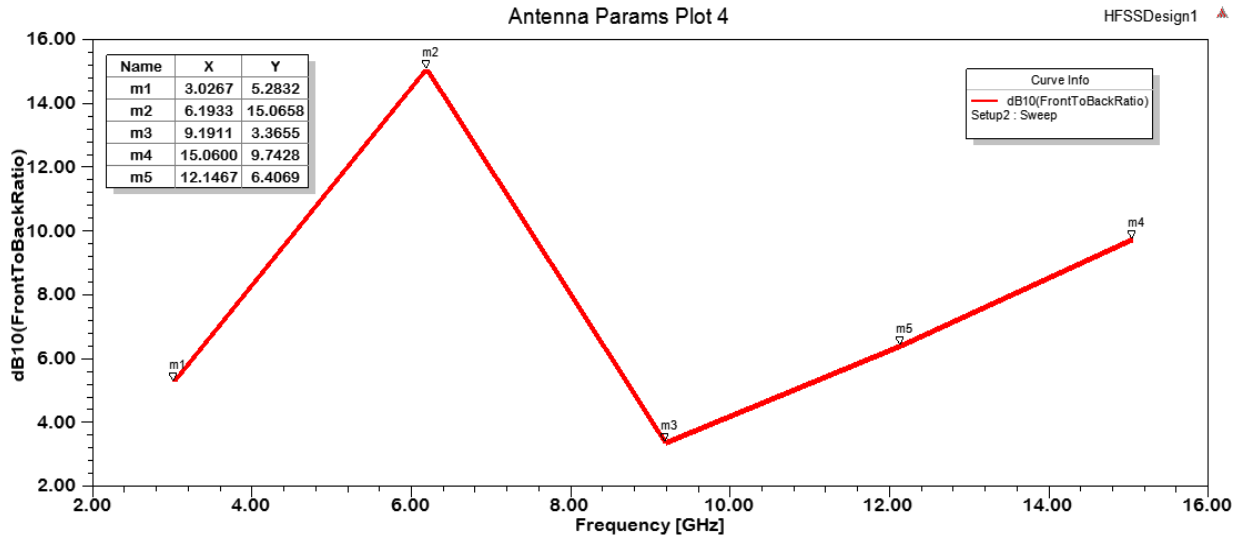

Figure 9 Front to Back Ratio

4. Conclusion

Our presented antenna bears some advantages such as compact size and it supports various applications in multiband frequencies. This designed ultra bandwidth antenna plays role in mobile communication, broadcasting and in satellite communications. From the analysis the designed antenna achieved better gain and efficiency with less dimensions when compared to other antenna design. The resultant efficiency of designed antenna is 95.9% and the observed gain of designed antenna is 4.0dB in operating condition.

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