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Triple Band Reflector Based Square Shaped Microstrip Patch Antenna With Band Gap Structure For Uwb Application

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Abstract: In this proposed paper Ultra Wide Bandwidth (UWB) antenna with Deflected Ground Structure (DGS) for wireless communication is presented and analyzed. Our proposed antenna design is consisting of L inverted L slots and U-slits on the radiating patch and Band Gap Structure (BGS) at the ground with triband frequency operation in various wireless communications. This triband antenna is designed using the FR4 substrate with permittivity level of 4.4. The proposed antenna dimension is 22.7 x 22.7mmwith gain of 3.2 dB. The antenna proposed in this paper operates at triple bands centered at 3.7 GHz, 6.7 GHz, and 9.5GHz with corresponding return loss of -11.8dB, -20.1dB and -13.0dB.

Keywords: DGS, BGS, Slot, Slit, triple band, wireless.

1.Introduction

In present day bull market Micro-strip patch antenna or aerials are extremely important for wireless applications such as WLAN, RADAR, and Satellite communication. The size of the patch antenna is very small, weight less and fabrication process easy [1]. In micro-strip patch antenna, the ground and patch are made of same material where as the substrate is made from the different material [2]. The micro-strip patch antenna provides good return loss, high efficiency [3] and to obtain the desired results the feed line is varied along the edge of the patch of the antenna [2].

Many techniques have been used in the micro-strip antenna to enhance the bandwidth of antenna such as adding parasitic element and band gap structure [4]. The proposed antenna is backed with Band gap structure that forms an artificial magnetic conductor which increases the performance of the antenna [5]. In micro-strip antenna Band Gap Structure (BGS) technique is found useful in suppressingthe surface waves and also found to be effective for bandwidth improvement. This technique in the proposed antenna produces high gain and efficiency with low interference [6].

The reflector antenna is proposed in order to simplify the antenna complexity [7], the reflector is a device that reflects electromagnetic waves. Antenna reflector can act as the standalone device for redirecting radiofrequency energy. The reflector helps to modify the radiation pattern of the antenna by increasing gain in a given direction. The reflector rejects the unwanted signal on the side and rear of the antenna [15].

In recent years Defected Ground Structure (DGS) have been widely used in micro-strip patch antenna [8] and DGS opens the door to microwave researches in wide range [9]. The Defected Ground Structure is

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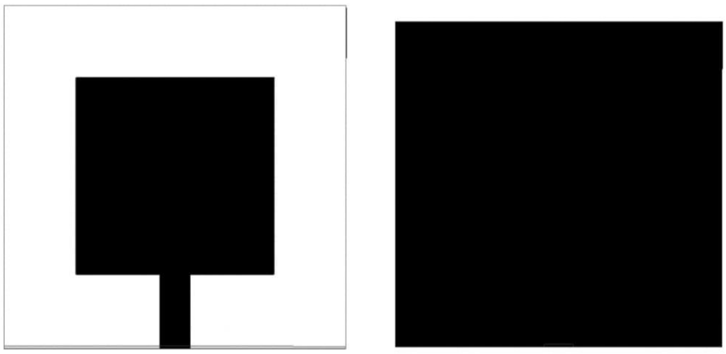
making defects or slots on the ground of the patch antenna [8]. The periodic or aperiodic etched on ground plane of microwave circuits are referred to as DGS [9]. This technique is used to reduce the size of the antenna into compact and enhancement of bandwidth [8]. In the proposed design parasitic elements are introduced, by adding the parasitic elements can enhance the bandwidth of the antenna. In micro-strip patch antenna gives narrow bandwidth, by introducing parasitic elements can able to transform the narrow band into a wide band [10, 11].

2.Design and Analysis

In the proposed paper comparing the three designs of micro strip patch antenna that are modeled and analyzed with tested results and simulated results. In the very first the antenna is designed in full ground. In normal the micro-strip patch antenna gives the narrow bandwidth, to achieve wide bandwidth in the patch antenna various technique are implemented. From this first design can only achieve the narrow bandwidth, in upcoming design have implemented various techniques and modified to achieve increased bandwidth. The achieved results of the first design are also attached below**.**



(A) **(B)**

Figure 1. Iteration 1 design of patch with full ground (A) Patch (B) Ground

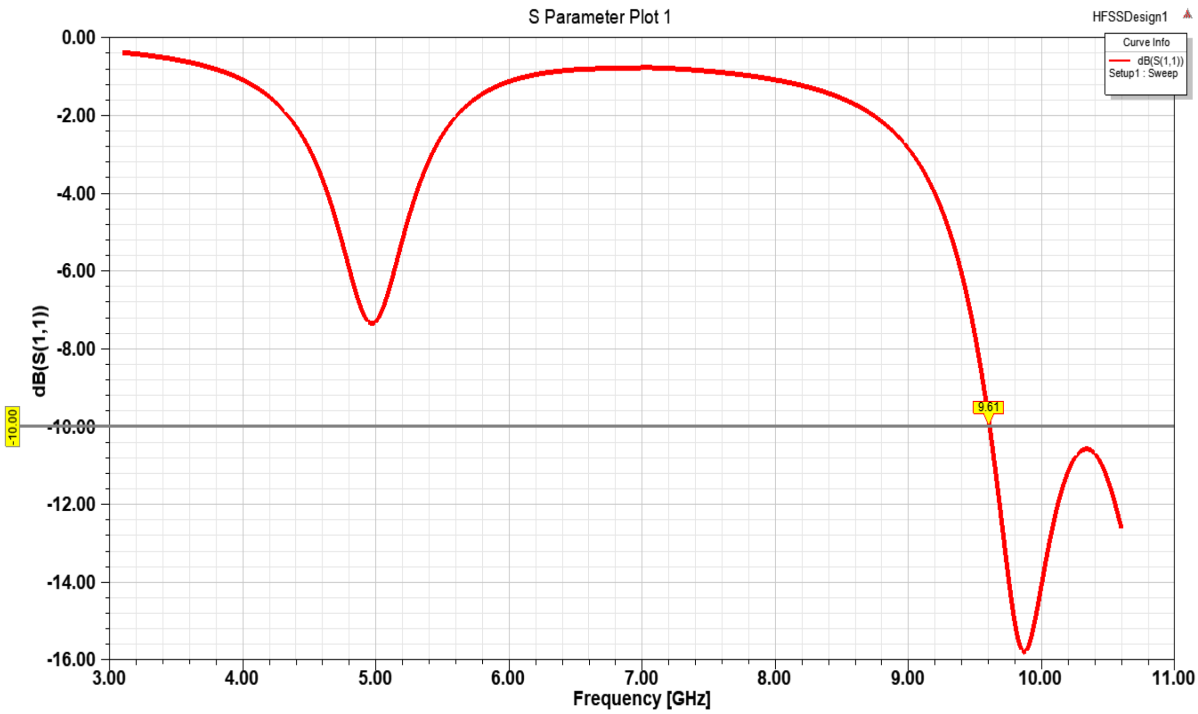


Figure 2. S parameter of patch with full ground

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In the next design the reflector is implemented in the patch antenna of full ground. In this design resonator of 1mm is introduced to achieve the increase bandwidth. By implementing this technique in the patch in full ground can achieve wide band width. The reflectors have the ability to reflects the electromagnetic waves in wide bandwidth. By making this modification achieved wide bandwidth.

(A) *(B)*

Figure 3. Iteration 2 of antenna design of reflector with full ground (A) Patch (B) Ground

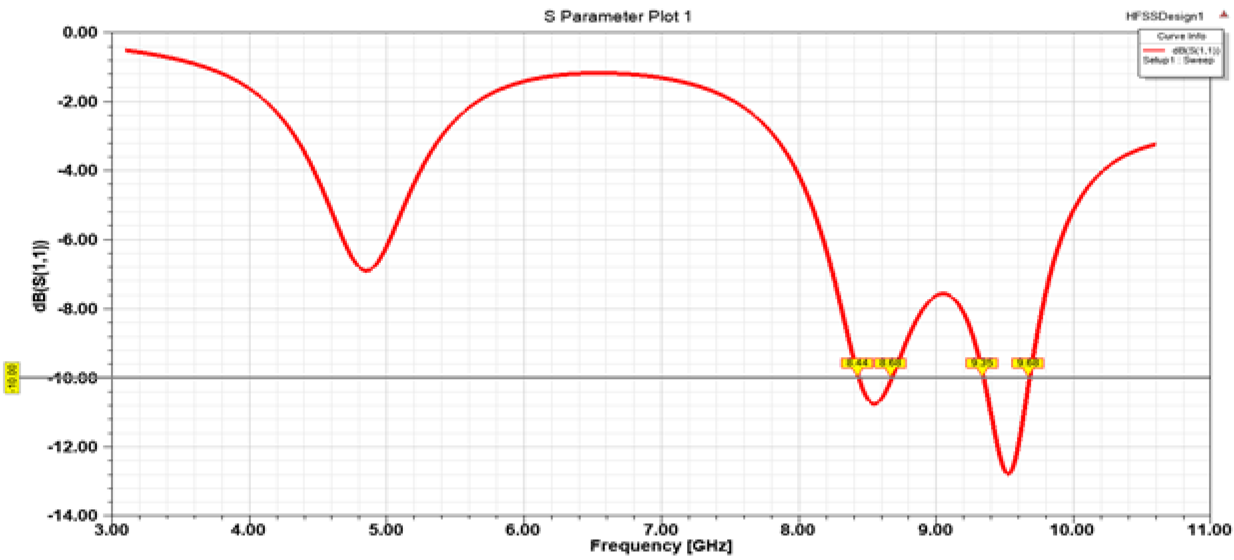

Figure 4. S parameter of Reflector with full ground

In the final design various techniques are implemented such as defected ground structure with adding parasitic elements. The defected ground structure is making slots or defects in the ground plane, by using this technique can able to reduce the dimensions of the antenna. In the final design four square slots are imposed and reduced the size of the antenna into compact. The implementing of parasitic elements such as capacitor, inductors can enhance the bandwidth still better. Here 5 x 3 mm capacitor is implemented in this design and enhance the bandwidth when compared to the other two designs. By this modification in the antenna it provides good return loss, with high gain, high efficiency of 99.9% and the voltage standing wave ratio of the antenna is unity. This antenna works on multiband application in amature radio, aeronatical mobile radio, and in broadcasting.

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(A) *(B)*

Figure 5. Iteration 3 of antenna design with parasitic elements (A) Patch (B) Ground

The figure 5 represents the final design, which have done many modification and changes in the design to achieve better return loss, gain, wide bandwidth.

Specifications	Dimensions
Substrate	22.7 x 22.7 mm
Ground	4 x 4 mm
Radiating patch	13.13 x 13.3 mm
Feed line	6.6 x 2 mm
Capacitor	5mm x 3 mm
Resonator	2 x 7 mm
L Slot	1 x 3 mm
U slit	1 x 2 mm

Table:1 Overall Dimension of proposed antenna

3.Result and Discussion

The return loss of designed antenna should remain at negative values, so the designed antenna has low range of signal reflection. The final designed antenna is showing active response in multiple frequencies centered at 3.7 GHz, 6.7 GHz, 9.5 GHz with corresponding return loss of -11.8dB, -20.1dB, -13.0dB, all the values are in negative so the designed antenna has low range signal reflection. When compared to other design the return loss of proposed antenna design is low at obtained frequencies, so this antenna signal deviation is low.

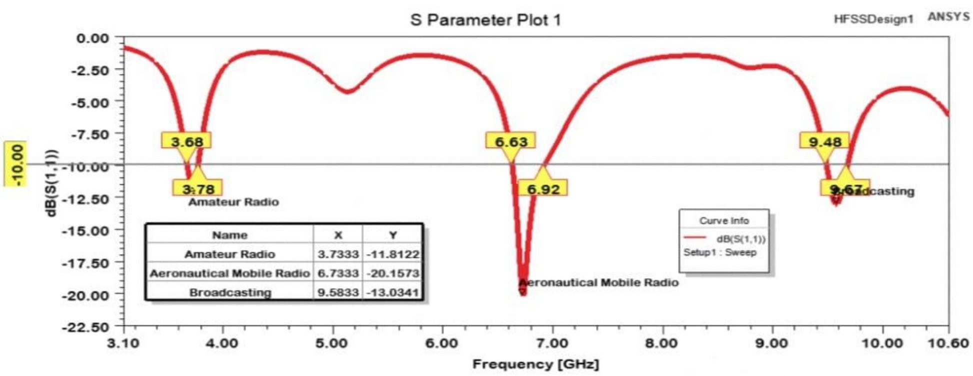

Figure 6. S parameter of proposed antenna

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The VSWR of the designed antenna lies near to unity so it 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.

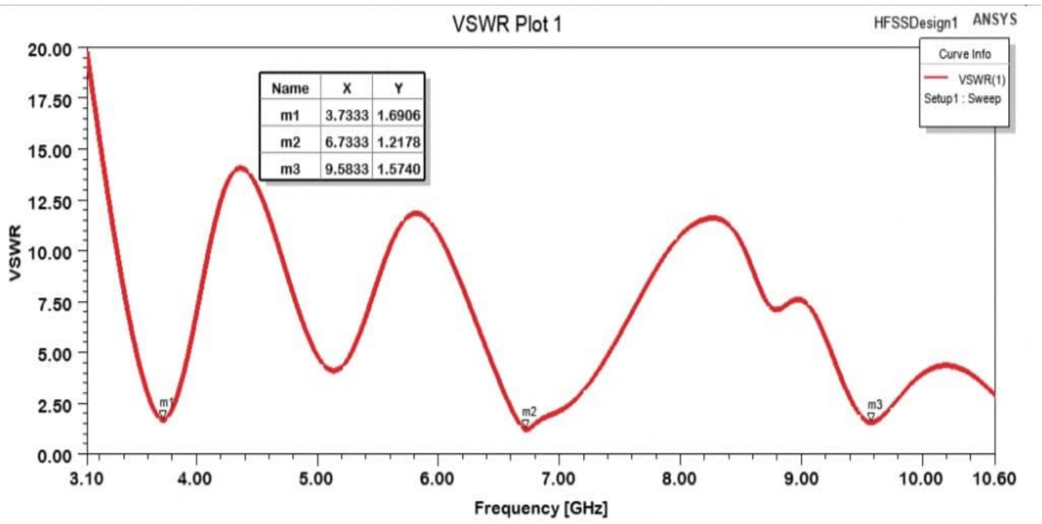
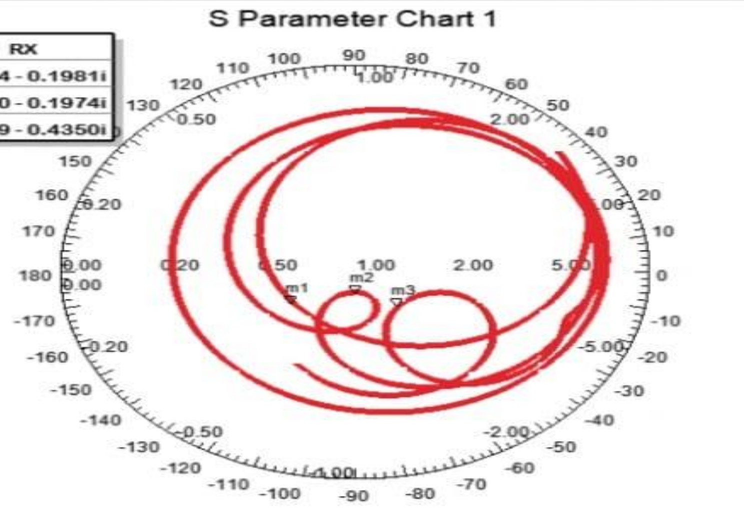


Figure 7. VSWR of proposed antenna

The smith chart is a tool for visualizing the impedance of a transmission line antenna system as a function of frequency. It can be used to solving problems with transmission lines and matching circuits. It simultaneously displays various parameters including impedances (Z-parameters), admittances (y-parameters), reflection coefficients. The proposed design Y parameters, Z parameters, reflection coefficient are plot in the smith chart and analyzed.



Name	Freq	Ang	Mag	RX
m1	3.7333	-144.9986	0.2567	0.6284 - 0.1981i
m2	6.7333	-84.3532	0.0982	1.0000 - 0.1974i
m3	9.5667	-46.8846	0.2222	1.2749 - 0.4350i

Figure 8. Smith chart of proposed antenna

The gain of the proposed multiband antenna is 3.2 dB. The gain pattern is called as the plot of gain at function direction. The gain is represented in 3D polar plot using the HFSS software. When compared with other design by implementing reflector, DGS and parasitic elements the gain of the antenna is improved and it is analyzed.

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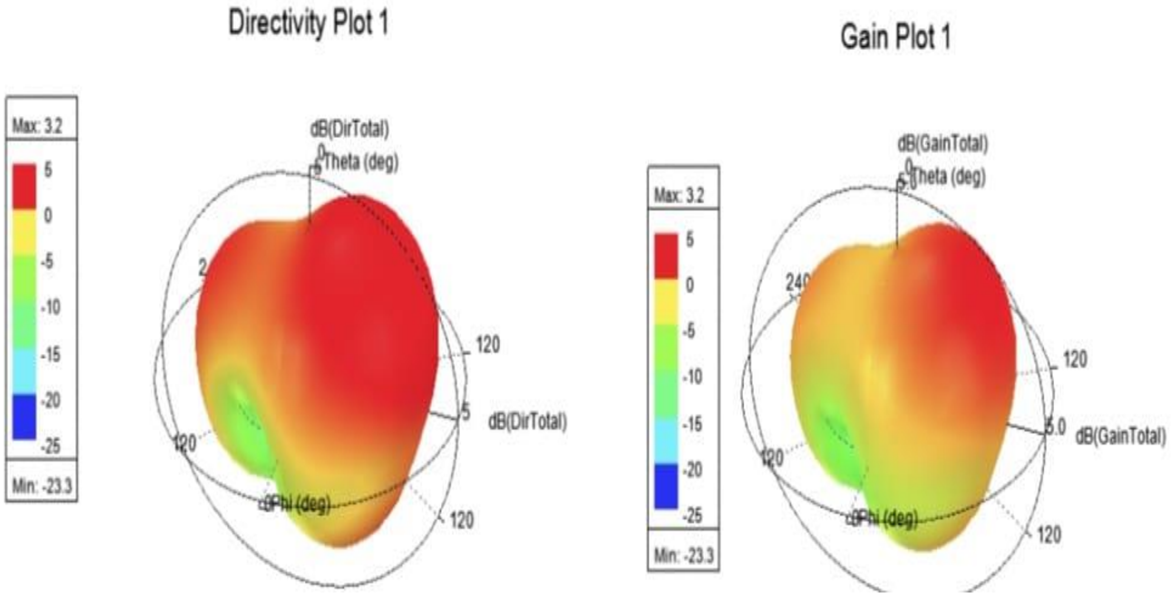

Figure 9. Gain of the proposed antenna

The strength of the radio waves of the antenna at different directions is said to be radiation pattern and considering azimuth and elevation angle of the antenna. For every antenna, near end radiation should be zero and far-end radiation should form a fan shape radiation pattern. In multi band operation this radiation pattern of this antenna shows better pattern this proves that designed antenna performance rate is high on compared to other design.

The figure 10 represents the radiation pattern for the 3.7 GHz frequency application, such as aero mobile communication in 0, 90, 180 and 360 degrees and analyzed by the HFSS software. The power is transmitted at the far end of the designed antenna by working in azimuth and elevation angle.

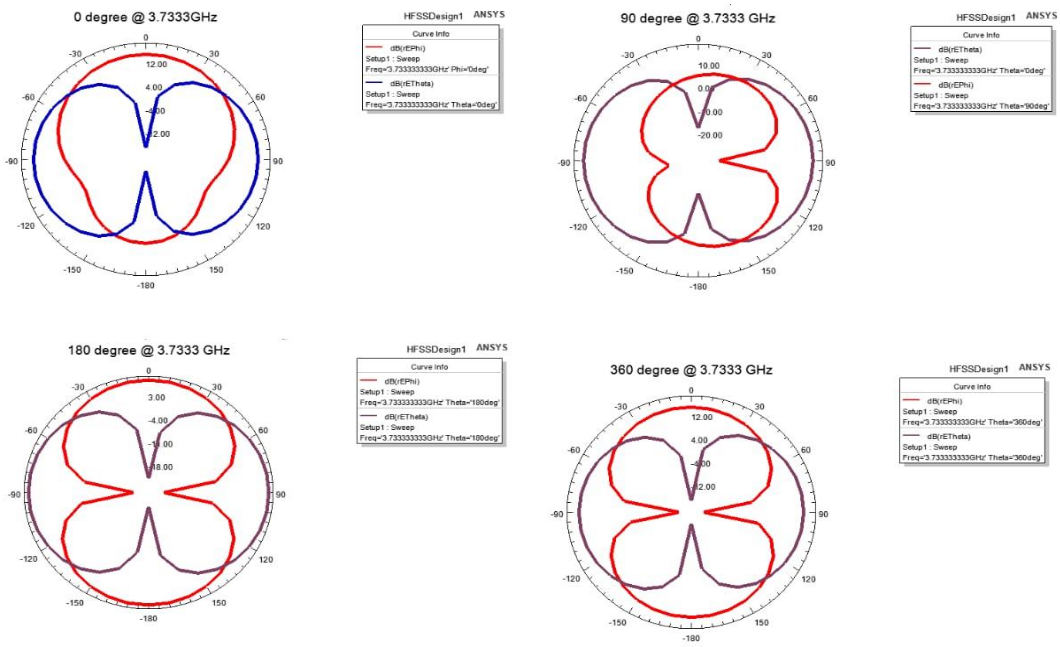

Figure 10. Radiation pattern of 3.7 GHz application

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The figure 11 represents the radiation pattern for the 6.7 GHz frequency application such as broadcasting in 0, 90, 180 and 360 degrees and analyzed by the HFSS software. The full power is transmitted at the far end of the designed antenna by working in azimuth and elevation angle.

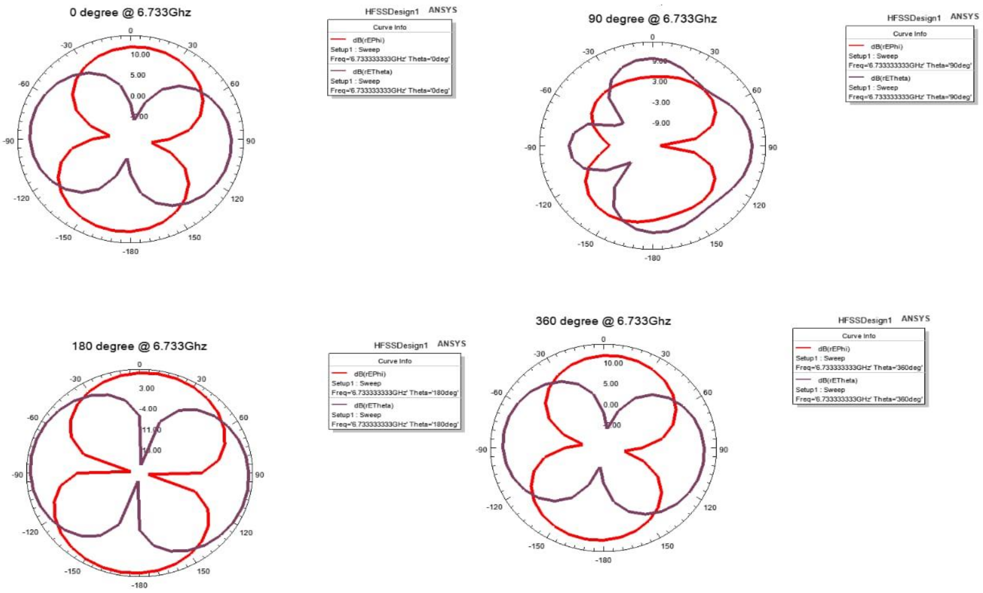

Figure 11. Radiation pattern of 6.7 GHz application

The figure 12 represents the radiation pattern for the 9.5 GHz frequency application such as ham radio in 0, 90, 180 and 360 degrees and analyzed by the HFSS software. The full power is transmitted at the far end of the designed antenna by working in azimuth and elevation angle of 0, 180 and 360 degree, so this antenna worked linearly polarized.

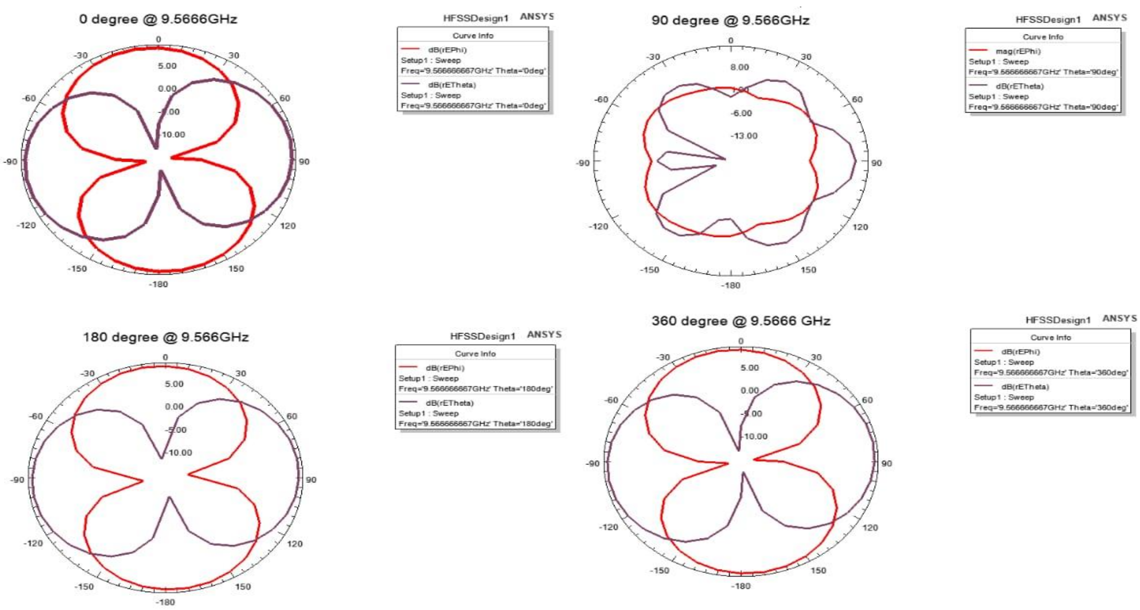

Figure 12. Radiation pattern of 9.5 GHz application

The radiation intensity of the antenna is a far field parameter which can be obtained by multiplying the radiation power density. The figure 13 represents the radiation intensity of designed antenna. From the graph can analyze the radiation intensity of proposed antenna, by adding reflectors and parasitic elements in antenna it provides reduced radiation intensity.

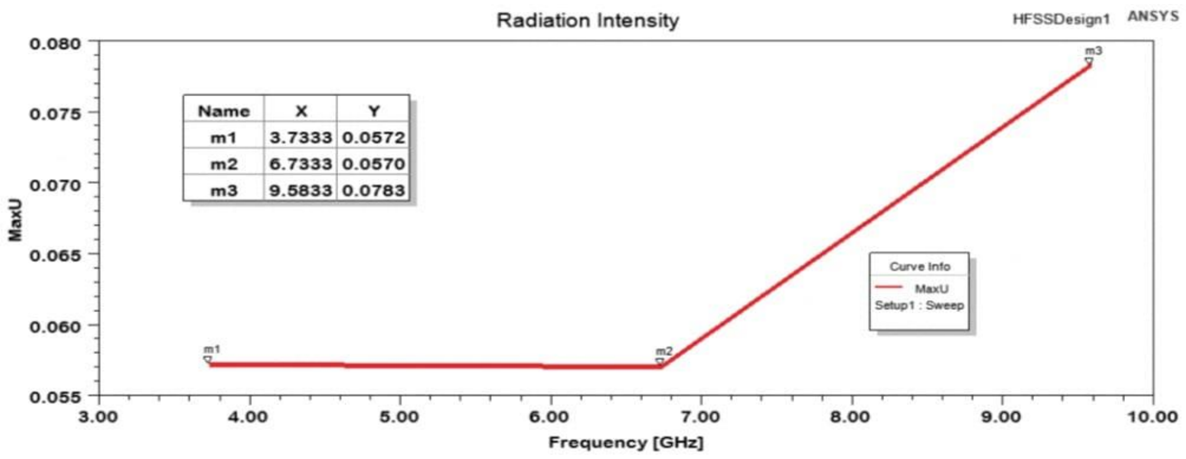

Figure 13. Radiation intensity of proposed antenna

The radiation efficiency of antenna in performing is known as antenna radiation pattern. It is defined as the ratio of power dissipated into space to the net power delivered to the antenna bytransmitter circuits. The figure 14 represents the radiation efficiency of designed antenna. By implementing various techniques, optimization and parasitic elements in antenna so it provides good radiation efficiency values which is analyzed from the graph.

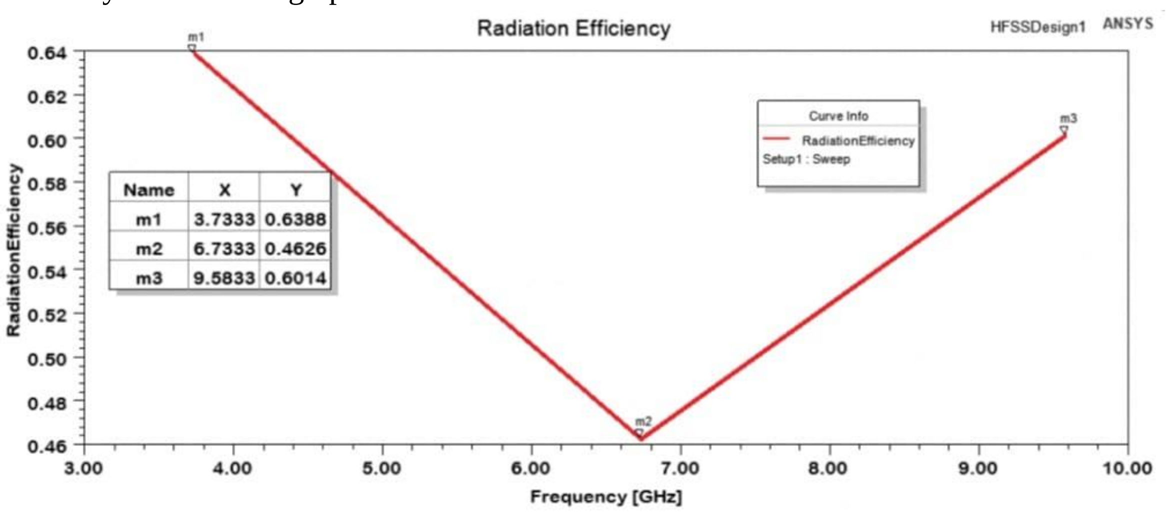

Figure 14. Radiation efficiency of proposed antenna

The front to back ratio is defined as the ratio of power gain between the front and rear of directional antenna. For receiving antenna, the ratio of received signal strength when antenna is rotated 180 degree. This ratio compares the gain in specified direction and this is expressed in dB. The figure 15 represents the front to back ratio of designed antenna. This graph is analyzed by comparing the gain of designed antenna in specified direction and this shows better FBR on compared to other design proposed.

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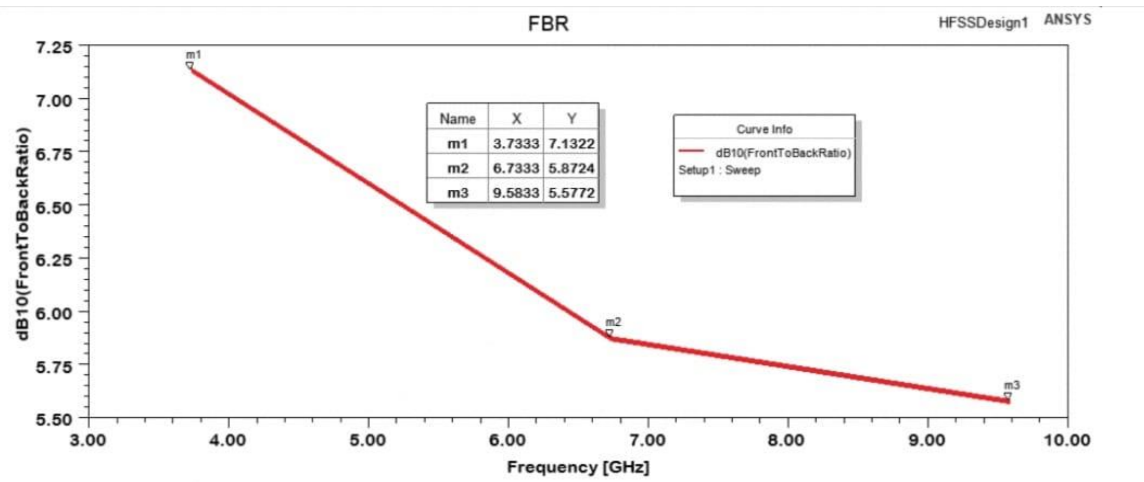

Figure 15. Front to Back Ratio of proposed antenna

Sl.No.	Frequency (GHz)	Return Loss (dB)	Bandwidth (MHz)	VSWR	Gain (dB)	FBR (10dB)
1.	3.7333	-11.8122	10	1.69	2.8	7.13
2.	6.7333	-20.1573	29	1.27	2.95	5.87
3.	9.5667	-13.0341	19	1.57	3.2	5.57

Table: 2 Overall performance of proposed antenna

The below graph is the comparison graph all three designs which is compared and analyzed in this proposed paper. This below graph represents the clear variation on each design the variations are occurred due to the modification and techniques implemented in each design. From this comparison it proves that proposed designed antenna shows better performance when compared to other.

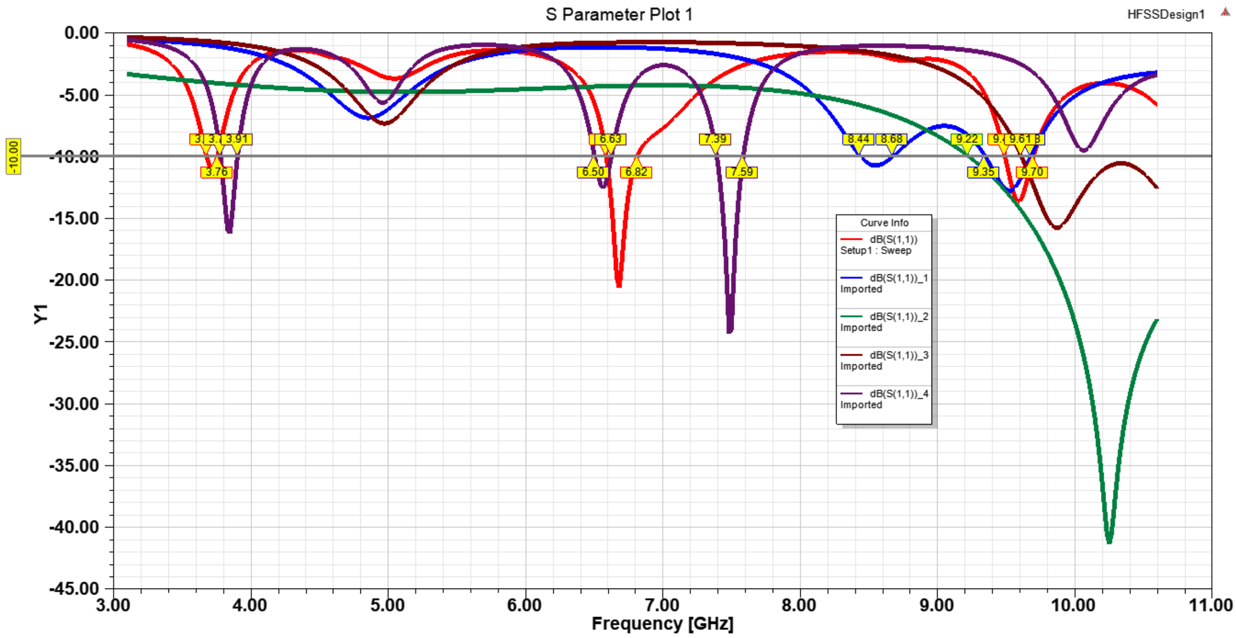

Figure 16. Comparative graph of proposed antenna in various iterations.

Iterations	**Return loss**	**VSWR**	**Gain**
1	-8 dB, -16 dB	1.8	2 dB

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 76 - 87
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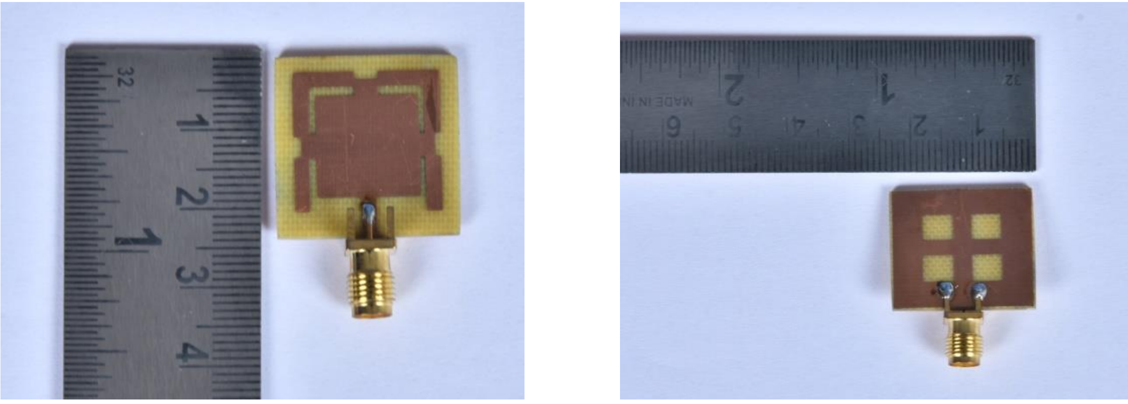
2	-11 dB, -12 dB	1.7	2.7 dB
3	-11.8 dB, -20.1 dB, -13 dB	1.5	3.2 dB

Table: 3 comparative table on iterations

The proposed final design is simulated and fabricated and this fabricated antenna is tested in the standard testing environment, this shows exact and better tested values without any loss on comparing to simulated results. The table 4 shows the comparative results which obtained in tri band operation of the proposed antenna and figure 18 represents the tested results of proposed antenna.



(A) (B)

Figure 17. Fabricated antenna of proposed design (A) Patch (B) Ground

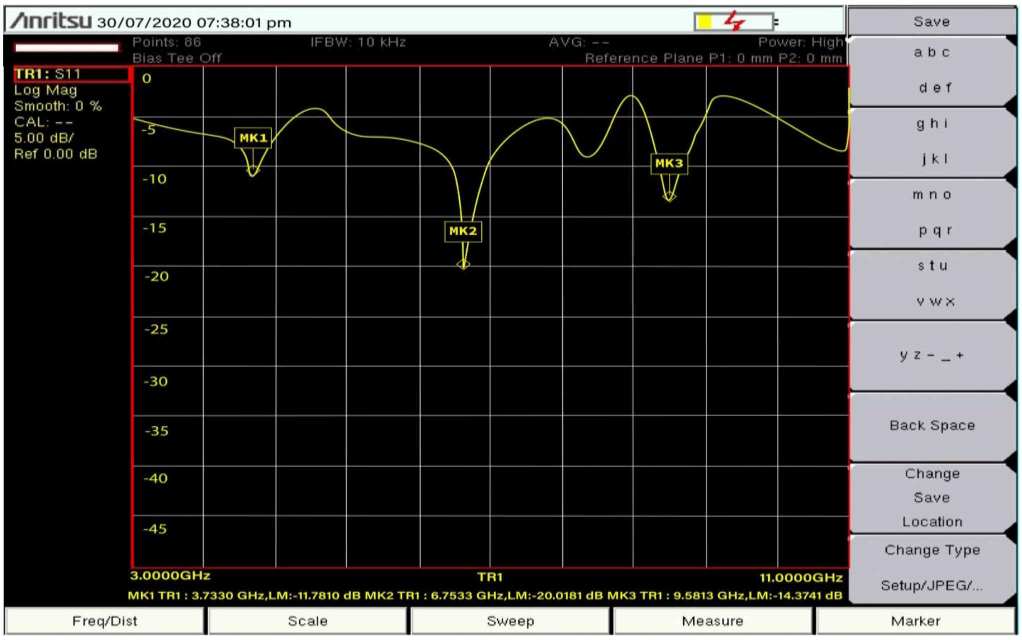


Figure 18. Tested results of fabricated antenna

Frequencies	Simulated results	Tested results
3.7 GHz	-11.8dB	-11.78dB
6.7 GHz	-20.1dB	-20.01dB
9.5 GHz	-13.0dB	-14.37dB

Table: 4 comparison table of proposed antenna

4.Conclusion

Our presented antenna bears some advantages such as compact size and it supports various applications in multiband frequencies. The observed gain of designed antenna is 3.2dB in operating condition is analyzed with the resultant efficiency of designed antenna is 95.9%. This designed antenna plays role in aero mobile communication, broadcasting and in military uses such as ham radio. From the analysis the designed antenna achieved better gain and efficiency with less dimensions when compared to other antenna design. This is achieved by making modifications in existing design and implementing new techniques.

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