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OCTABAND MICROSTRIP PATCH ANTENNA USING DGS FOR S-BAND, C-BAND & X-BAND APPLICATIONS

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Abstract - *A miniature version of octaband antenna is proposed for various communication applications in S-band, C-band and X-band. The proposed antenna has a defective ground structure (DGS) to improve the performance of the antenna. The ground plane has L-shaped slots and the patch consists of a rectangular slot to enable multi frequency band operation. This antenna is designed on FR4 substrate with dielectric constant 4.4, thickness 2 mm with dimensions of 40 X 40 X 2 mm3.The design of the structure and result analyzation is carried out using High Frequency Structural Simulator (HFSS) software. The proposed antenna exhibits return loss of -24dB, -21dB, -13dB, -16dB, -19dB, -15dB, -12dB, -15dB at 3.2GHz, 4.6GHz, 5.6GHz, 6.6GHz, 8.1GHz, 9.1GHz, 10.1GHz, 11.6GHz respectively with VSWR < 2 for all the eight bands. The observed results suggest that the proposed antenna can be employed for multiple wireless communication applications.*

Key Words: Multiband antenna, Octaband, HFSS, DGS, S-band, C-band, X-band, Microstrip patch antenna.

1. INTRODUCTION

Considering the smaller size, less weight and inexpensive characteristics of microstrip patch antennas, they are of high demand in the recent wireless applications [1, 2]. Microstrip patch antennas are being employed in various applications, beginning from simple telemetry antennas to sophisticated radar systems [8]. The microstrip patch antennas operating in multiband are extensively used in core areas like Satellite and Military communications. These low profile antennas can easily be fabricated and integrated in to modern telecommunication systems. However, the microstrip antennas have limitations in case of Bandwidth, Gain and Efficiency. To improve the performance of the antenna, defective ground structure (DGS) has been introduced on the ground plane. The DGS structure can be implemented by just etching a part of the ground in appropriate shape [3, 4]. The proposed antenna itself exhibits multi frequency operation rather than using individual antenna for each frequency band thereby reducing cost and space required.

In this paper, an octaband antenna is designed incorporating a rectangular slot on the radiating patch since it enhances the overall performance of the antenna [5]. In reference [6], dual band monopole antenna is achieved using rectangular DGS structures and in reference [7], triple band antenna is achieved using DGS structure and L-shaped slots on the patch. Similar multiband antennas are designed in references [9-11] by etching slots on the monopole structures. The proposed antenna also consists of two L-shaped slots on opposite edges of the ground plane resulting in defective ground structure. The substrate used for the simulation is FR4 having dielectric constant of 4.4 and loss tangent of 0.02.The size of the antenna is a major concern especially for mobile applications with regard to the space available on the devices[12]. The process of miniaturization is kept in mind while designing the proposed antenna making it suitable to be embedded in to smaller areas.

2. ANTENNA DESIGN

The design of the defective ground structure (DGS) and the microstrip patch are shown in Fig-1. An FR4 substrate of dielectric constant 4.4 is placed on the defective ground plane with the thickness of 2mm.

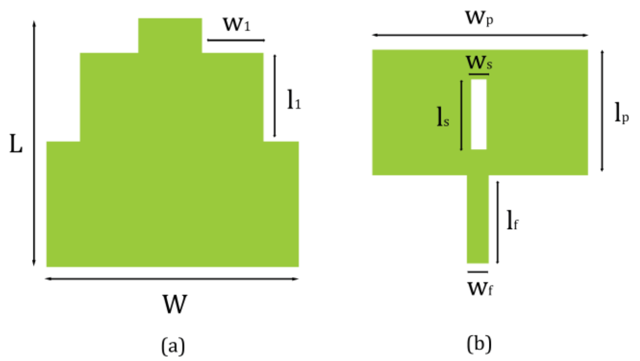

Fig-1: (a) DGS ground plane (b) Patch design

First, the ground plane of dimension L x W is taken and two L-shaped slots of size l_1 x w_1 are etched on both edges of the ground plane facing each other as shown in the Fig-1(a). A rectangular patch of size l_p x w_p is placed on the FR4 substrate of thickness h=2mm with a rectangular slot of size

l_s x w_s at the centre of the patch as shown in Fig-1(b). A microstrip feed line of size l_f x w_f is placed from one end of the patch to provide feed to the antenna. Table-1 shows the parametric dimensions of the entire antenna design.

Table -1: Dimensions of the Proposed Antenna

Parameter	Dimension (mm)
L	40
W	40
l_1	15
W_1	10
l_p	20
w_p	30
l_s	10
w_s	2
l_f	15
w_f	3
h	2

3. RESULTS AND ANALYSIS

The antenna design and simulation is carried out by High Frequency Structural Simulator (HFSS) software. The HFSS model of the Octaband microstrip patch antenna with DGS is shown in Fig-2. The antenna parameters such as Return loss, VSWR, Radiation patterns, E & H plane distributions are analyzed in each of the below sections.

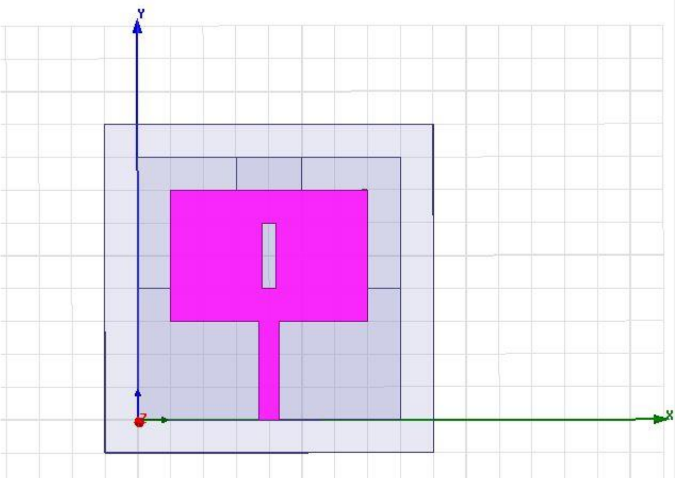

Fig-2: HFSS model of the Octaband antenna (Top view)

3.1 Return Loss

The ratio of power reflected to the power delivered is termed as Return Loss. It is usually represented in negative logarithmic dB. The return loss plot of the Octaband antenna is shown in the Fig-3. Return loss values for all the eight resonating frequencies are given in the Table-2.

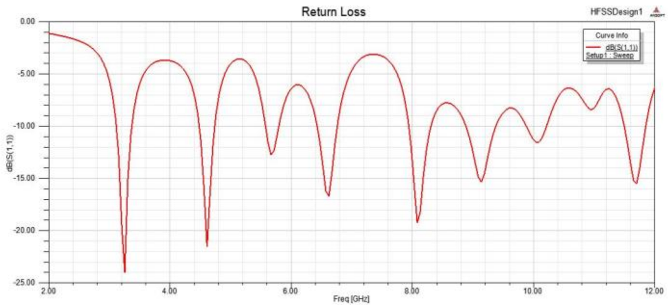

Fig-3: Return Loss (S_{11}) Plot of Octaband antenna

Table-2: Return Loss values of resonant frequencies

Frequency(GHz)	Return Loss (dB)
3.2	-24
4.6	-21
5.6	-13
6.6	-16
8.1	-19
9.1	-15
10.1	-12
11.6	-15

3.2 VSWR

The voltage standing wave ratio is the measure of mismatch between the transmission line and the antenna. The recommended VSWR is < 2 and close to unity. The VSWR plot for the Octaband antenna is shown in the Fig-4. Observed VSWR values for all the eight bands satisfy the condition with values close to unity.

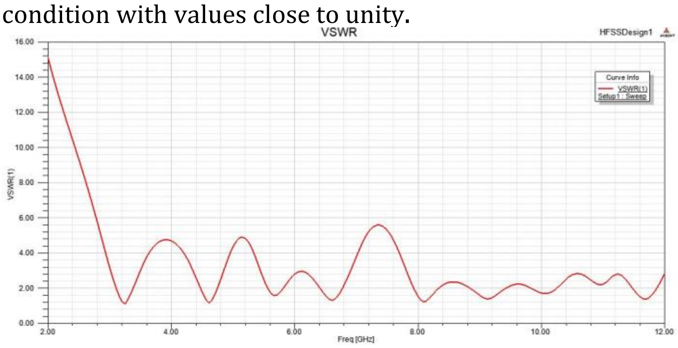

Fig-4: VSWR Plot of the Octaband antenna

3.3 Radiation Patterns

The graphical representation of the power radiated by the antenna as a function of direction is termed as Radiation Pattern. The 2D radiation patterns for the Octaband antenna at Phi=0 deg, Phi=90 deg for all theta at resonant frequencies are shown in the fig-5 (a),(b),(c),(d),(e),(f),(g),(h).

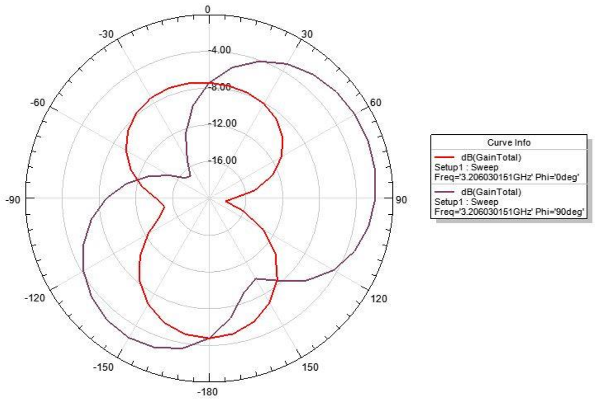

Fig-5(a): 2D Radiation pattern at 3.2 GHz

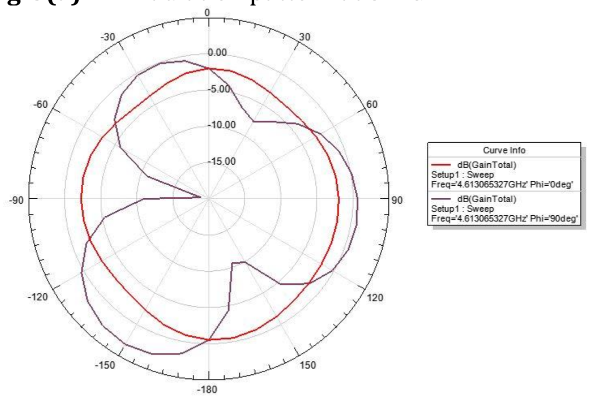

Fig-5(b): 2D Radiation pattern at 4.6 GHz

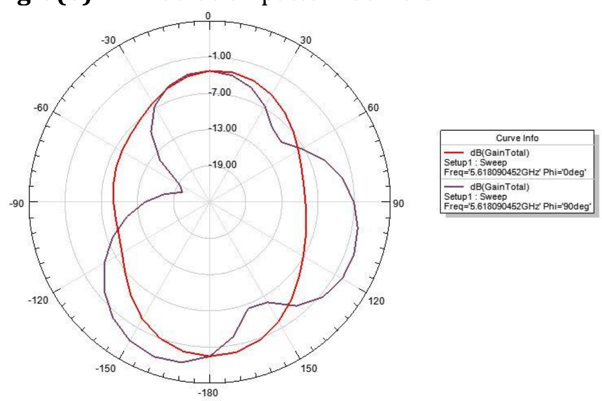

Fig-5(c): 2D Radiation pattern at 5.6 GHz

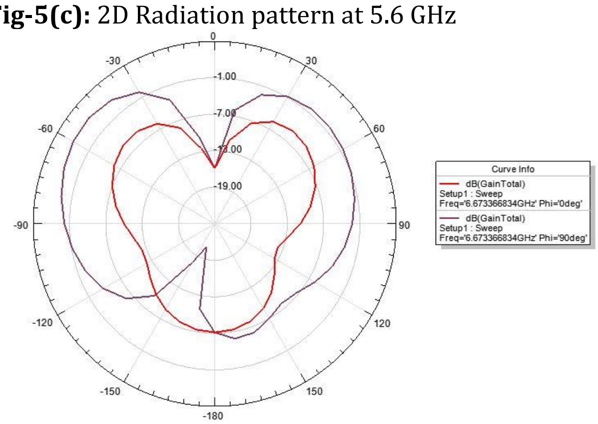

Fig-5(d): 2D Radiation pattern at 6.6 GHz

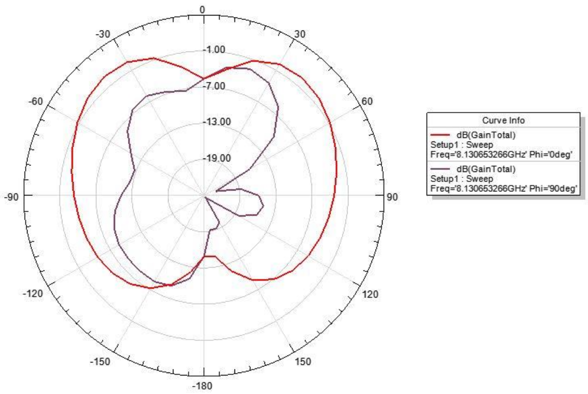

Fig-5(e): 2D Radiation pattern at 8.1 GHz

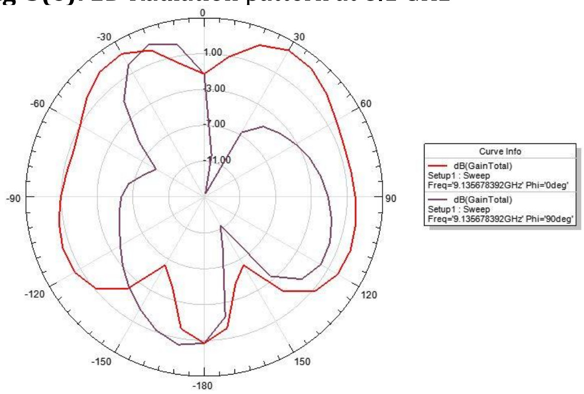

Fig-5(f): 2D Radiation pattern at 9.1 GHz

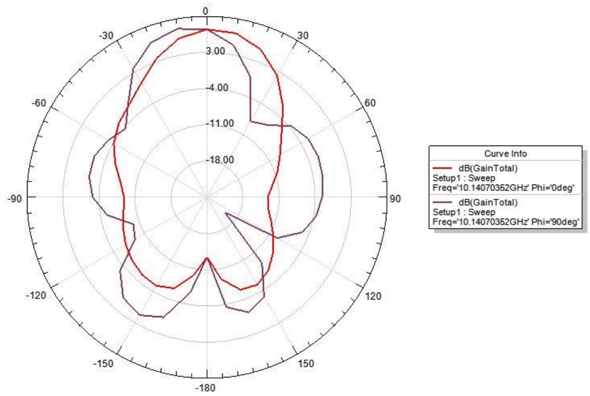

Fig-5(g): 2D Radiation pattern at 10.1 GHz

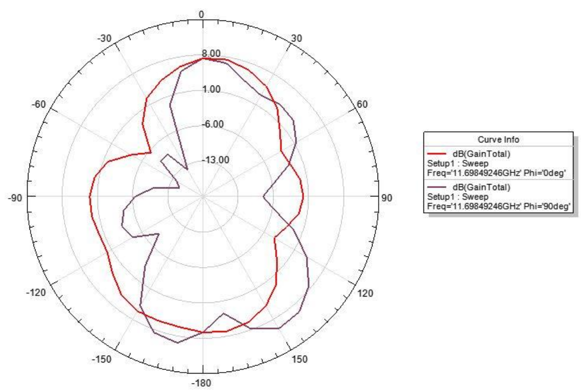

Fig-5(h): 2D Radiation pattern at 11.6 GHz

3.4 3D Polar Plot

The three dimensional polar plots of the Octaband antenna at all the resonating frequencies are shown in the Fig-6(a),(b),(c),(d),(e),(f),(g),(h).

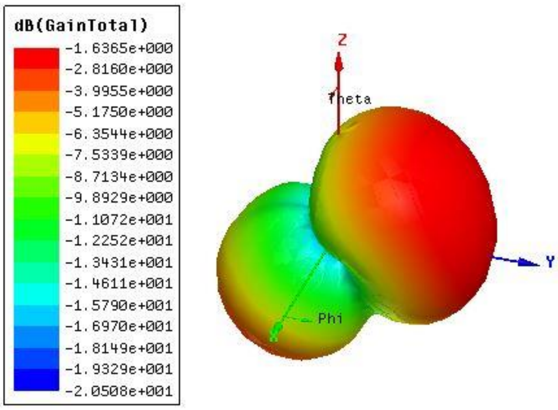

Fig-6(a): 3D Polar plot at 3.2 GHz

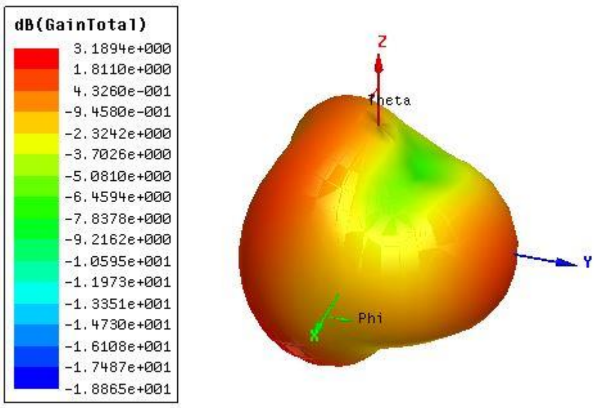

Fig-6(b): 3D Polar plot at 4.6 GHz

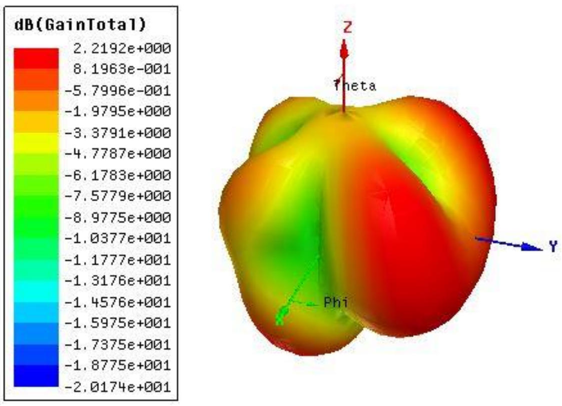

Fig-6(c): 3D Polar plot at 5.6 GHz

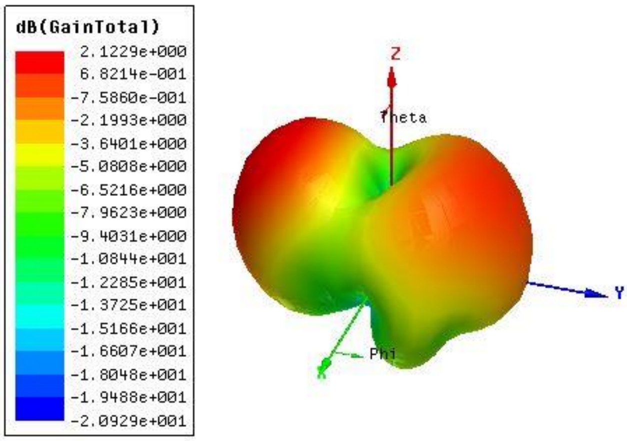

Fig-6(d): 3D Polar plot at 6.6 GHz

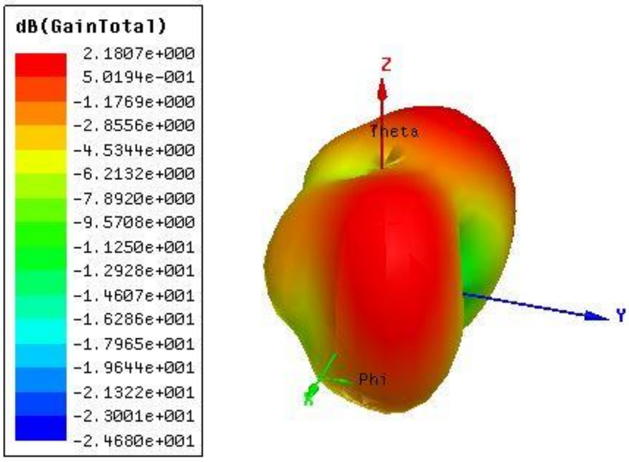

Fig-6(e): 3D Polar plot at 8.1 GHz

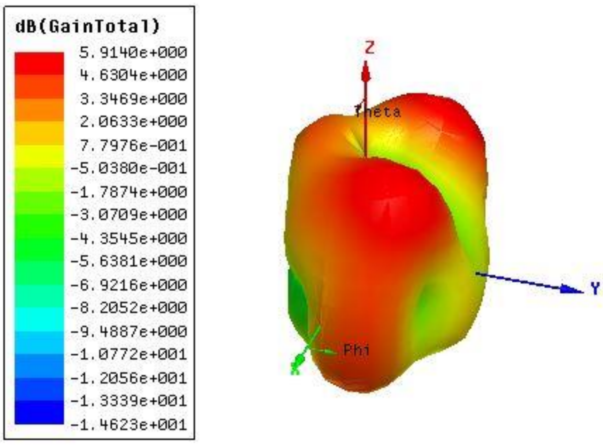

Fig-6(f): 3D Polar plot at 9.1 GHz

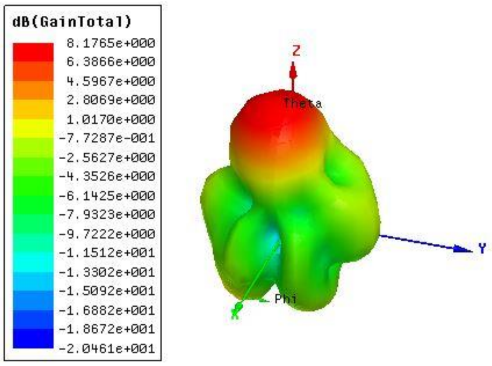

Fig-6(g): 3D Polar plot at 10.1 GHz

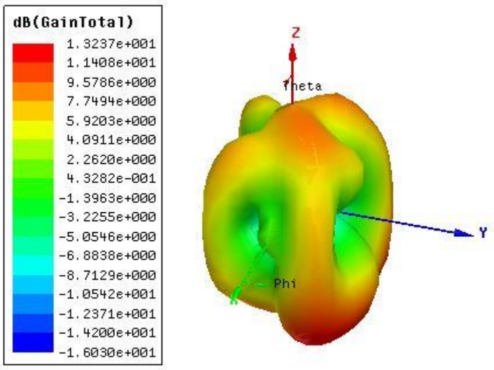

Fig-6(h): 3D Polar plot at 11.6 GHz

3.5 E-field distribution

The direction of electric field lines at each point in the field comprises the Electric field distribution on the surface of the patch of the antenna. The E-field distribution of the Octaband antenna is shown in the Fig-7.

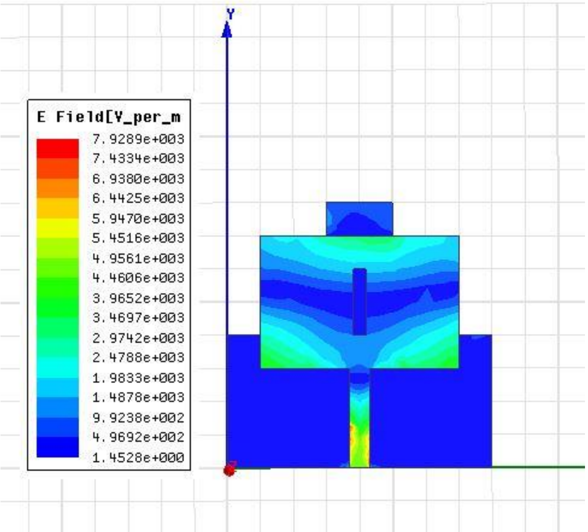

Fig-7: E-field distribution on the Octaband antenna

3.6 H-field distribution

The direction of the Magnetic field vector determines the Magnetic field distribution on the surface of the patch of the antenna. Usually it is perpendicular to the E-field vector. The H-field distribution of the Octaband antenna is shown in the Fig-8.

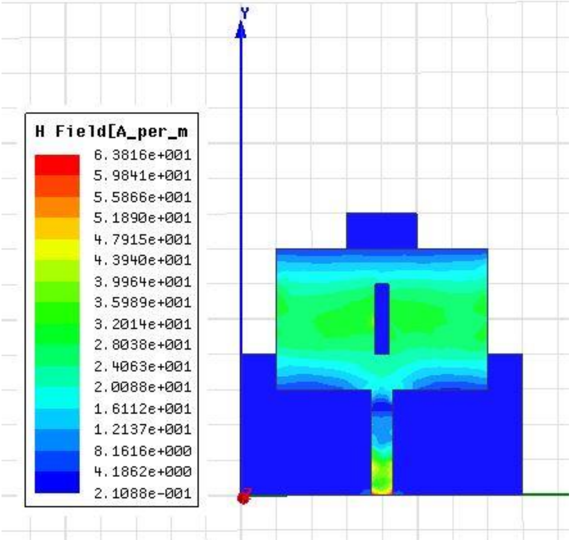

Fig-8: H-field distribution on the Octaband antenna

4. CONCLUSION

In this paper, a multiband antenna is presented that radiates at eight frequencies such as 3.2GHz in S-band, 4.6GHz, 5.6GHz, 6.6GHz in C-band, 8.1GHz, 9.1GHz, 10.1GHz & 11.6GHz in X-band. Defective ground structure (DGS) is introduced for better performance of the antenna with a rectangular slot on the radiating patch to enable multiband operation. The design parameters and results observed using HFSS such as return loss, VSWR, Radiation patterns, 3D polar plots, E & H- field distributions are presented in the above sections. This Octaband antenna can be employed for several wireless applications including RADAR, Satellite communications, Military, traffic control and other Government institution applications.

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BIOGRAPHY

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