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Compact EBG Controlled Antenna with Defected Ground Configuration

M.S.S.S. Srinivas[*,], T.V. Ramakrishna[***], B.T.P. Madhav[****]**

Abstract: Two monopole antenna models are designed in this work with defected ground structure and electromagnetic bandgap (EBG) loading. Antenna model 1 is the combination of monopole on front side and defected ground structure (DGS) on back side. Antenna model 2 is the combination of monopole on front side and EBG loaded DGS on back side. Monopole antenna with DGS is resonating at dual band and monopole with EBG and DGS is resonating in the wideband. Both the designed antennas are covering operational bands of worldwide interoperability for microwave access (WiMAX) and Wireless LAN (WLAN) with omni directional radiation pattern and stable gain. The proposed antennas are having the advantages of simple fabrication, compactness and excellent radiation characteristics, which can be applied to wireless mobile communication system.

Keywords: Compact Antenna, Defected Ground Structure (DGS), Electromagnetic Band Gap (EBG), Monopole, Wireless LAN (WLAN), Worldwide Interoperability for Microwave Access (WiMAX).

1. INTRODUCTION

The applications with microstrip patch antennas are increasing day by day with demand in advanced communication technology. These structures are very simple and compact models can be generated with little effort. The main advantages includes planar structure, easiness in the construction, placement with microwave and millimetre wave integrated circuits (MMIC) and radio frequency integrated circuit (RFIC) possibility and impedance matching achievability etc. Wide variety of narrowband, wideband and broadband antennas with this microstrip technology was experimented by researchers and achieved desired results according to their specifications [1-6].

Dual, triple and multiband antennas are very useful in the communication applications especially in the mobile communication to cover different applications like Global Position System, Bluetooth, Wi-Fi, WLAN etc. Wideband antennas are also needed in commercial communication applications [7-8]. Design and development of such antennas with desired results involves lot of effort in modelling and material based construction. Modern days researchers are working on specific structures like EBG's and metamaterials to improve the performance characteristics of the advanced antennas and to reduce the losses associated with the operation [9-10]. The electromagnetic band gap structures are used to reduce the surface wave related problems and to improve the gain and directivity of the antenna models. These are also called as photonic band gap structures and are using in different domains of engineering. The periodic structures will provide band stop and band gap characteristics when electromagnetic waves passes through them [11-12].

The present work deals with the design and implementation of two antenna models, one is based on defected ground structured monopole antenna designed to operate at dual band. Second one is based on the electromagnetic band gap structured model, which is the modified structure of antenna model 1. In the first model design rectangular radiating element with DGS is used and in the second model DGS with EBG is proposed. Both the antenna models are designed on both high frequency structure simulator (HFSS)

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and computer simulation technology (CST) softwares and examined their performance characteristics and outcomes are presented in this paper.

2. ANTENNA GEOMETRY

The radiating patch elements of the antenna model are constructed with rectangular shaped conducting elements and are printed on a dielectric substrate with relative permittivity of 2.6 and height of 1.6 mm. The total volume is 35 × 35 × 1.6 mm as given in Figure 1 and Figure 2. The designed antennas having operational bands which cover the WiMAX and WLAN, and fed by a microstrip line that can be simply connected with the patch element on the top side of the substrate. This line feed is connected to a 50 ohm SMA connector. All the designed structures are simulated through HFSS and CST for validation.

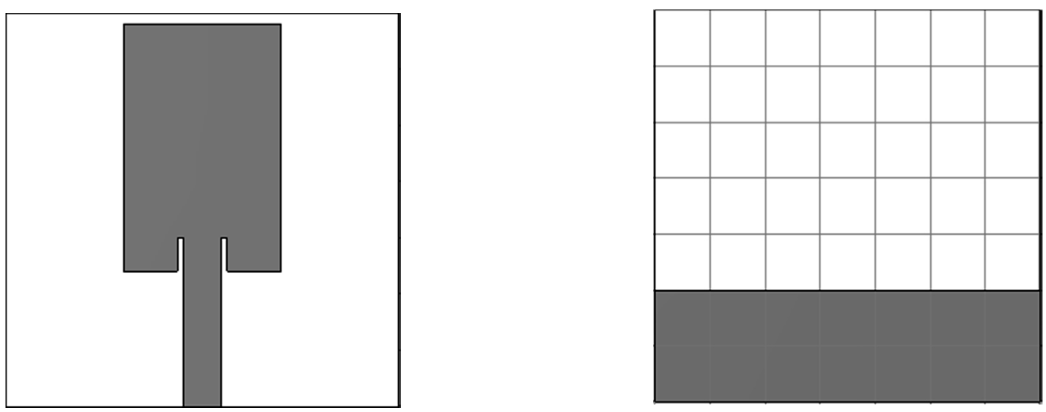

Figure 1: Monopole Antenna with DGS, (a) Front View, (b) Back View

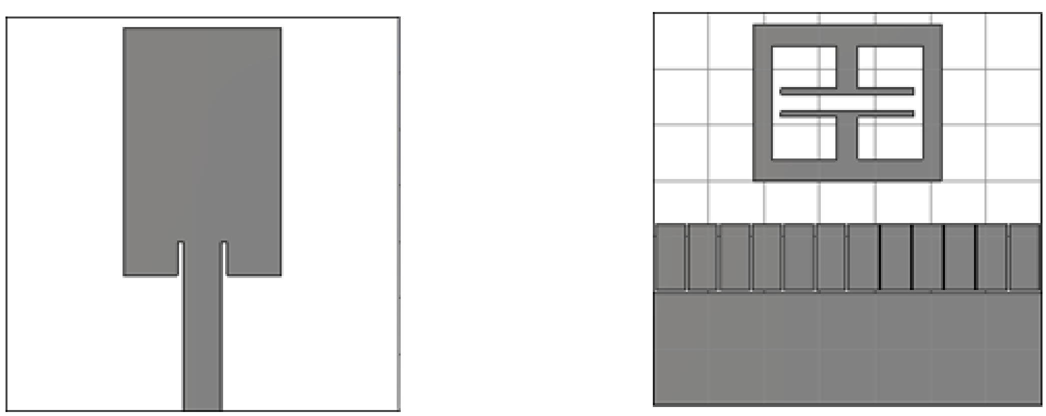

Figure 2: Monopole antenna with EBG loaded DGS, (a) Front View, (b) Back View

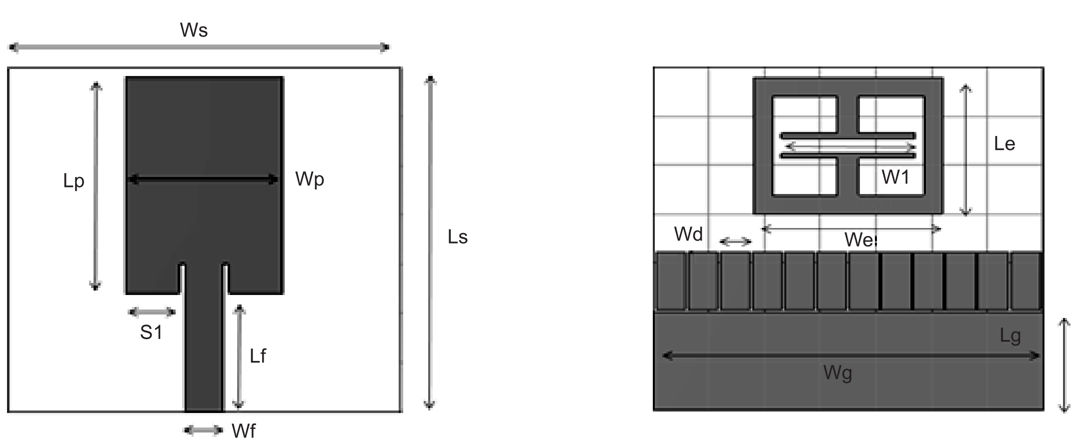

Figure 3: Antenna Geometry

Table 1
Antenna dimensions in mm

Ws	Ls	Wp	Lp	Wf	Lf	S1	Wg	Lg
35	35	14	22	2.75	15	5.125	35	10
Wd	We	Le	W1	Ld				
2.9	17	14	12	6.2				

3. RESULTS AND ANALYSIS

The simulation of the antenna models are carried on HFSS and CST tool and presented in this section. From Figure 4 we can observe that the dual band monopole antenna is resonating between 2.3-3.06 GHz and 4.8-5.6 GHz. An impedance bandwidth of 21% at fundamental resonant frequency and 46% at second resonant frequency. A band of 1.8 GHz is been rejected in this model. Figure 5 shows the wideband antenna reflection coefficient characteristics. Wideband antenna is resonating between 2.8-4.2 GHz with bandwidth of 1.4 GHz and impedance bandwidth of 39%. Dual band antenna is working in the WiMAX and WLAN bands with proper impedance matching.

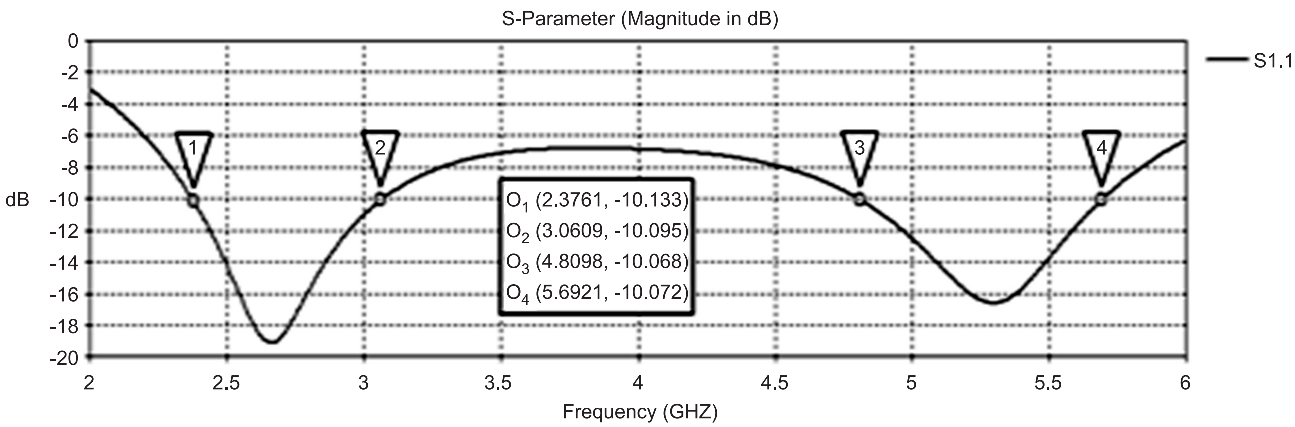

Figure 4: Returnloss Vs Frequency of dual band monopole antenna with DGS

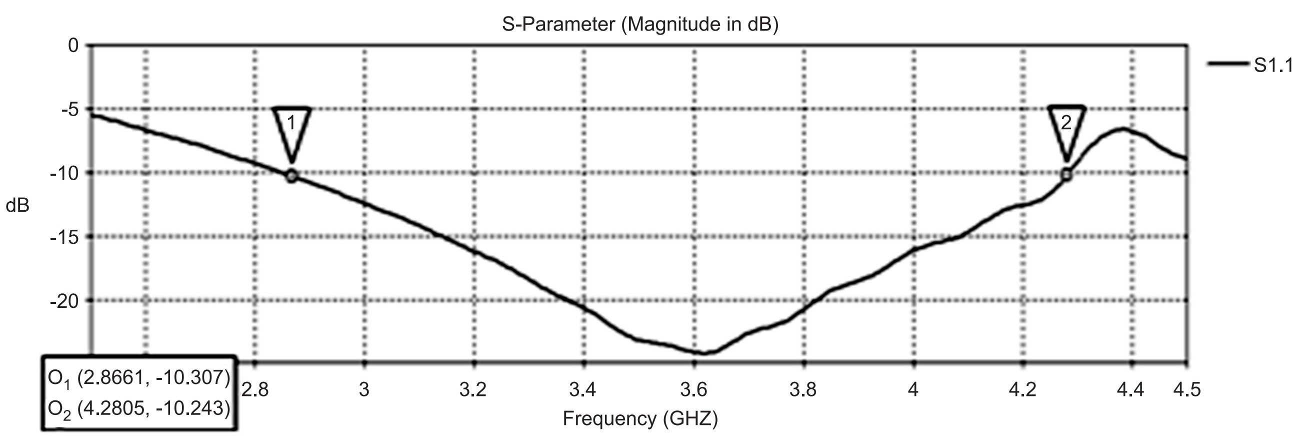

Figure 5: Returnloss Vs Frequency of wideband monopole antenna with EBG & DGS

The time domain analysis of the designed models are presented in Figure 6 and 7. Result shows the normalized source and received pulses for designed antenna models. The pulse fedility values are larger than 0.5, which gives acceptable range for the case of wide band antennas.

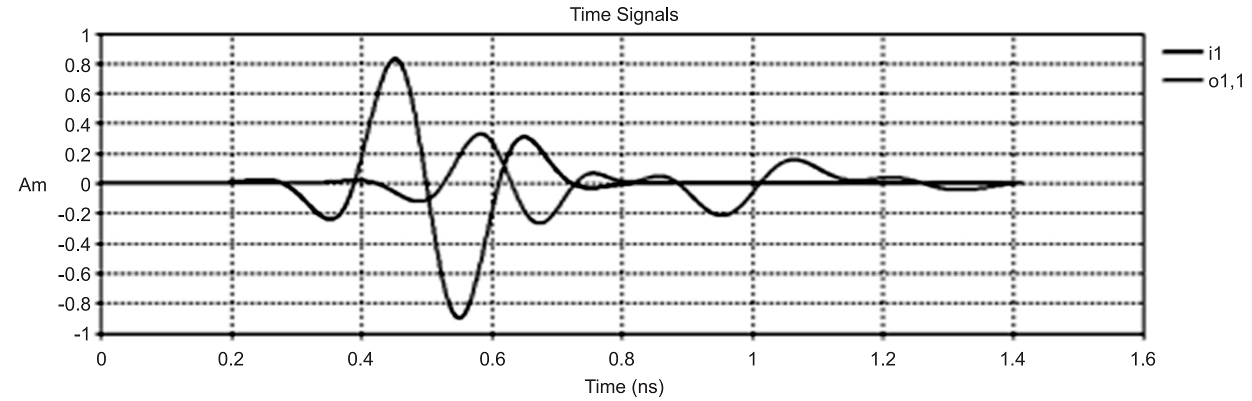

Figure 6: Normalized source and received pulse when aligned face to face for antenna 1

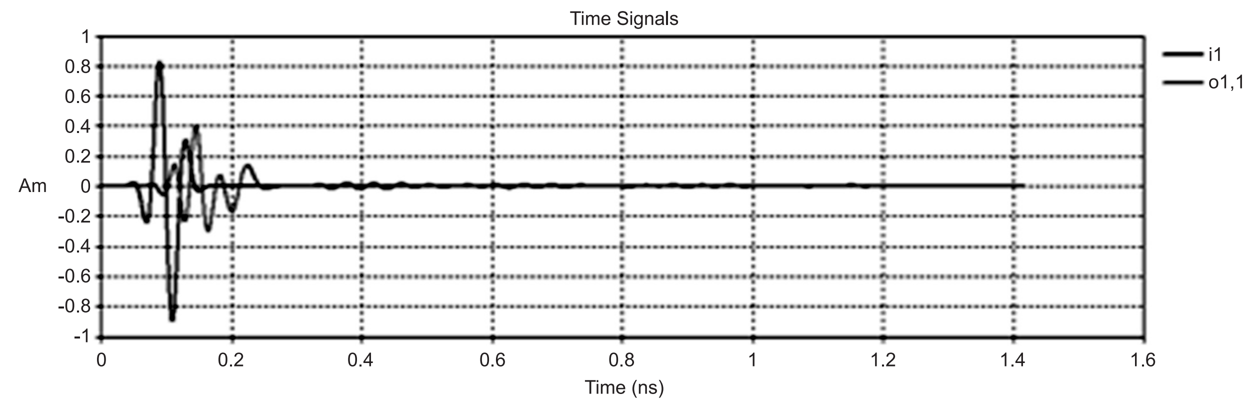

Figure 7: Normalized source and received pulse when aligned face to face for antenna 2

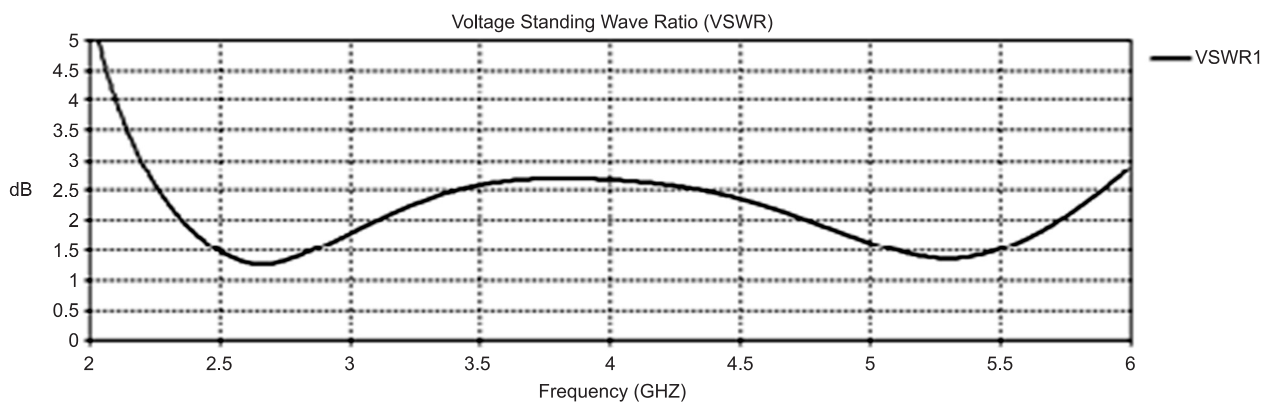

Figure 8: VSWR Vs Frequency of dual band monopole antenna with DGS

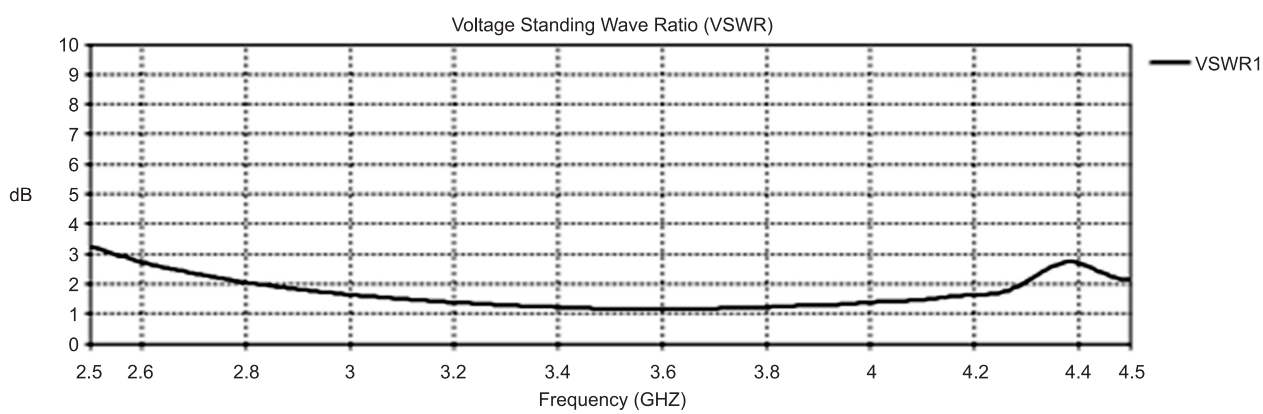

Figure 9: VSWR Vs Frequency of wideband monopole antenna with EBG & DGS

The voltage standing wave ratio (VSWR) is used to measure the impedance match or mismatch between the antenna and transmission line. A VSWR of 1:1 ratio will indicate a perfect match, and a VSWR of ∞:1 will indicate the worst case. In the case of microstrip patch antennas we consider the 2:1 ratio for the VSWR and for the designed antenna models the value of VSWR is in the prescribed range at resonant frequencies. Figure 8 and 9 shows the resultant of simulation characteristics of VSWR for dual band and wide band antennas. Figure 10 shows the radiation characteristics of the wide band monopole antenna with EBG in finite element method based HFSS tool. Subsequently using CST microwave studio tool, the corresponding radiation pattern curves at different resonant frequencies are presented from Figure 11 to 13.

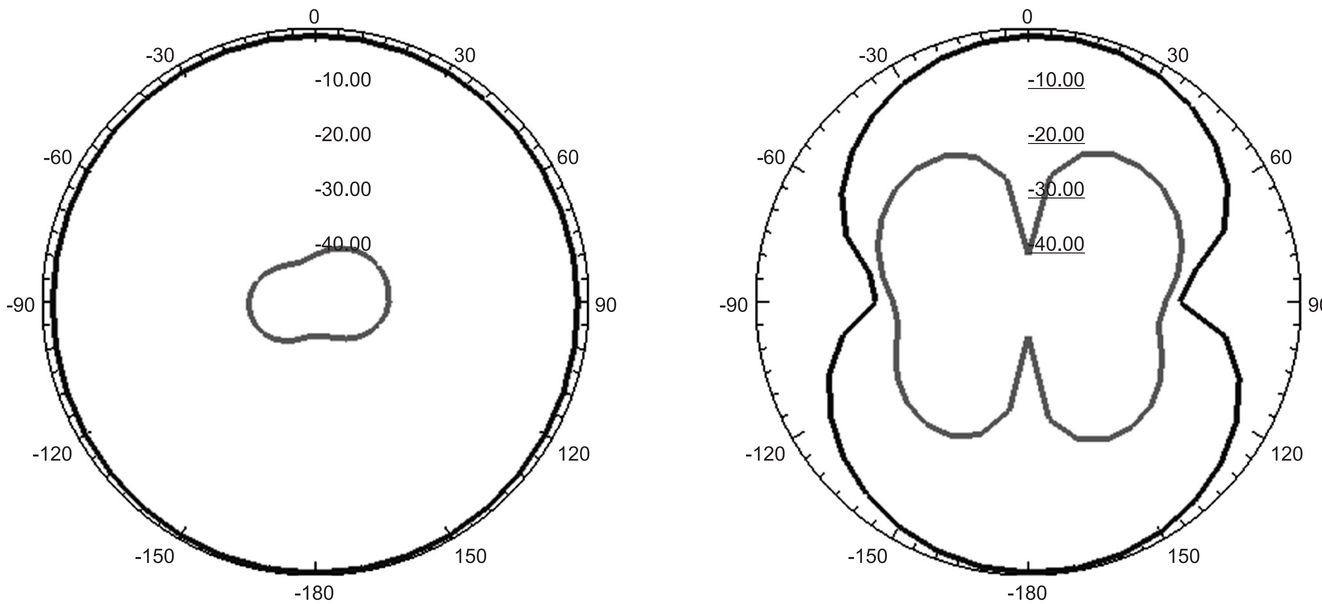

Figure 10: Radiation Pattern in E and H-Field for wideband monopole antenna with EBG (HFSS)

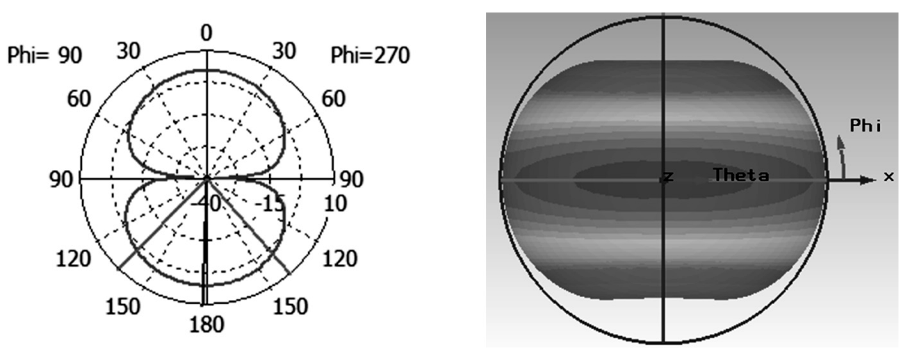

Figure 11: Radiation Pattern of dual band monopole antenna with at 2.6 GHz (CST)

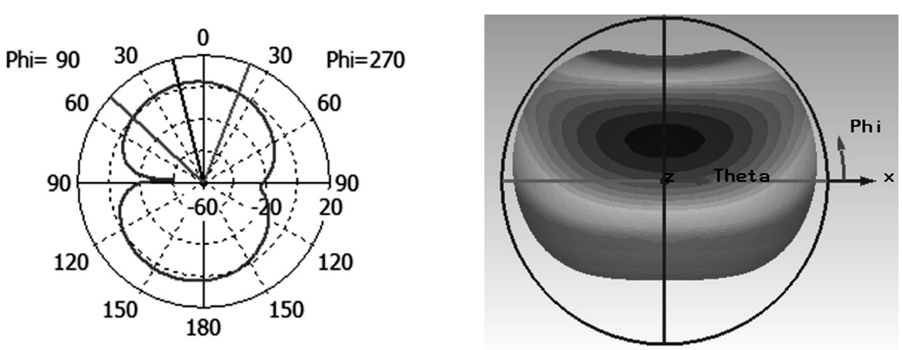

Figure 12: Radiation Pattern of dual band monopole antenna at 5.2 GHz (CST)

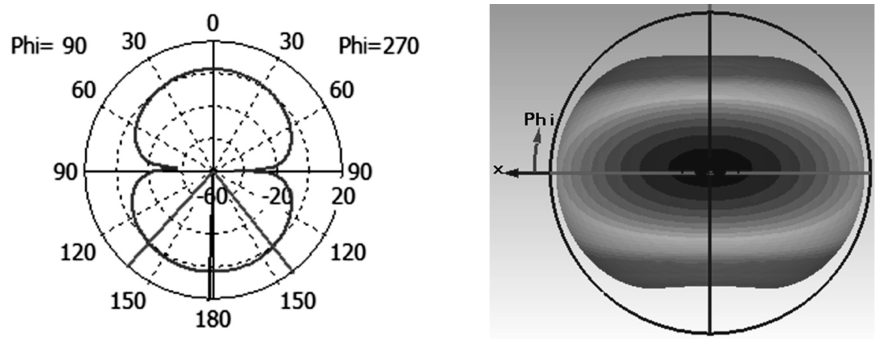

Figure 13: Radiation Pattern of wideband monopole antenna with EBG at 3.6 GHz (CST)

The far field radiation patterns of the designed models are presented in Figure 14 and 15 with respect to field intensity. The far field concentration at corresponding position and angle can be clearly observed from the presented results. The surface current distribution plot of designed antenna models at corresponding resonant frequencies are provided in Figure 16. The current distribution plot will provide the movement of change on the surface of the antenna at particular resonant frequency and clearly the mode of propagation can be analyzed.

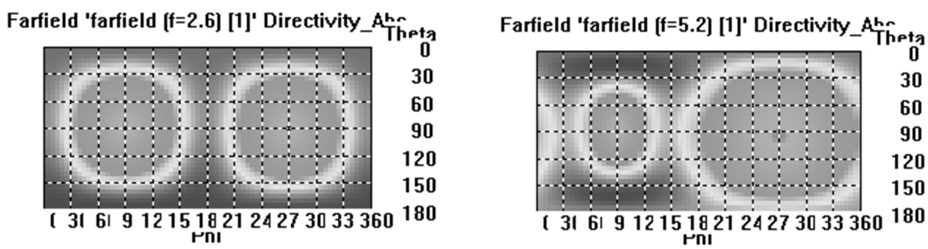

Figure 14: Far field radiation intensity of dual band monopole antenna at 2.6, 5.2 GHz

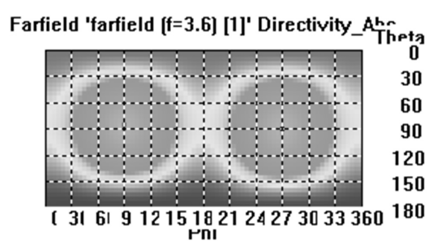

Figure 15: Far field radiation intensity of wideband monopole antenna with EBG at 3.6 GHz

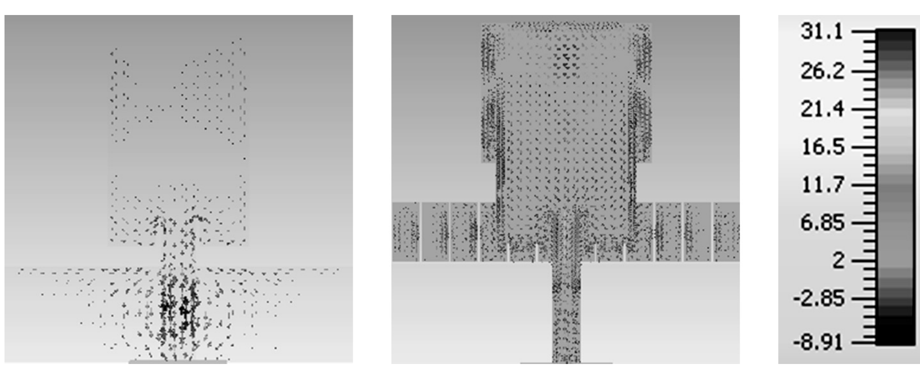

Figure 16: Surface current distribution on dual band and wideband antenna

4. CONCLUSION

Defected ground structure model and EBG loaded antenna models are analyzed and presented in this work. Monopole antenna with DGS is resonating at dual band and monopole with EBG and DGS is resonating in the wideband. The dual band monopole antenna is resonating between 2.3-3.06 GHz, 4.8-5.6 GHz and providing an impedance bandwidth of 21% at fundamental resonant frequency and 46% at second resonant frequency. Wideband antenna is resonating between 2.8-4.2 GHz with bandwidth of 1.4 GHz and impedance bandwidth of 39%. The proposed structures are providing excellent bandwidth and radiation characteristics with considerable gain for desired band of applications.

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