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Wideband Defected Ground Structured Monopole Antenna with Electromagnetic Band Gap Loading

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Abstract: Two monopole antenna models are designed in this research 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.

Key words: Compact antenna, Defected Ground Structure (DGS), Electromagnetic Band Gap (EBG), monopole, Wireless LAN (WLAN), Worldwide interoperability for Microwave Access (WiMAX)

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 (Fu and Yuan, 2005; Yang and Rahmat-Samii, 2009; Madhav *et al*., 2014, 2015a, b; Srinivas *et al*., 2015).

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 (Madhav *et al*., 2015a, b; Raman *et al*., 2016). 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 (Lin and Wen, 2008; Kim *et al*., 2011). 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 (Kim *et al*., 2013; Yang *et al*., 2005).

The present research 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) and Computer Simulation Technology (CST) softwares and examined their performance characteristics and outcomes are presented in this study.

MATERIALS AND METHODS

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 dimension of the antenna is around 35×35×1.6 mm. Figure 1 shows the rectangular monopole

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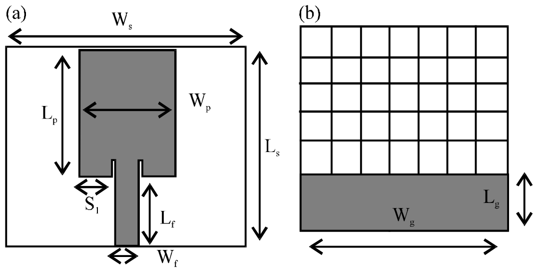

Fig. 1: Monopole antenna with DGS: a) Front view; b) Back view

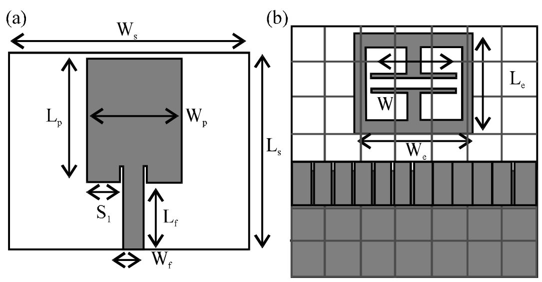

Fig. 2: Monopole antenna with EBG loaded DGS: a) Front view; b) Back view

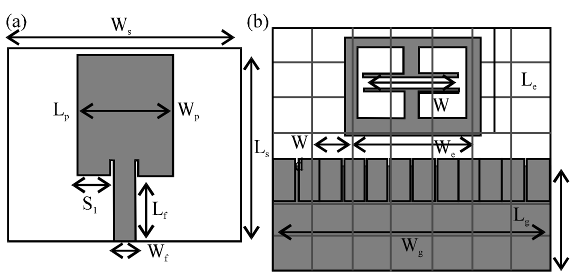

Fig. 3: Antenna geometry: a) Top view; b) Bottom view

on top side of the substrate and the defected ground on the bottom side of the substrate. Figure 2 shows the rectangular monopole on top side and defected ground with EBG loading on the bottom side of the substrate. 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 Ω SMA connector. All the designed structures are simulated through HFSS and CST for validation.

Figure 3 describes the proposed antenna geometry and the dimensional characteristics in mm. 'W_s' is the width of the substrate, 'L_s' is the length of the substrate, 'W_p' is the width of the patch, L_p is the length of the patch, 'S_1' is the patch left side length from feed line, 'L_f' is the feed length and 'W_f' is the width of the feed line. The other side of the substrate is holding the defected ground and the electromagnetic band gap structure has the following dimensions. 'W_g' as width of the ground, 'L_g' as length of the ground, 'We' as EBG width, 'L_e' as length of the EBG, 'Wd' as the distance between slot elements on the ground and 'W' as the width of EBG arm (Table 1).

Table 1: Antenna dimensions in mm

Dimensions	Values
W_s	35
L_s	35
W_p	14
L_p	22
W_f	2.75
L_f	15
S_1	5.125
W_g	35
L_g	10
W_d	2.9
W_e	17
L_e	14
W_1	12
L_d	6.2

RESULTS AND DISCUSSION

The simulation of the antenna models are carried on HFSS and CST tool and presented in this study. From Fig. 4 we can observe that the dual band monopole antenna is resonating between 2.3-3.06 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.

The time domain analysis of the designed models are presented in Fig. 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 wideband antennas.

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 8:1 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 wideband antennas. Figure 10 shows the radiation characteristics of the wideband monopole

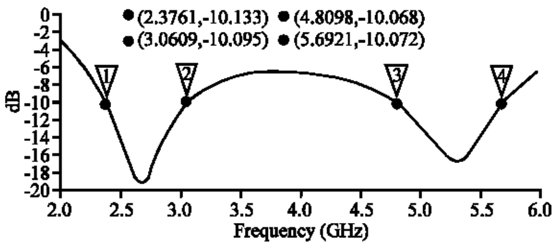

Fig. 4: Returnloss vs. frequency of dual band monopole antenna with DGS

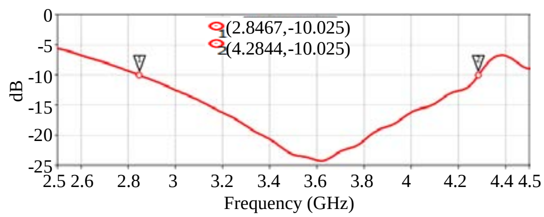

Fig 5: Returnloss vs. frequency of wideband monopole antenna with EBG and DGS

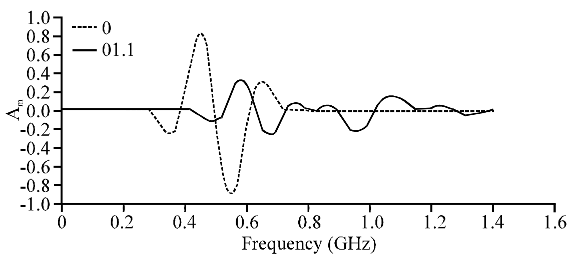

Fig. 6: Normalized source and received pulse when aligned face to face for antenna 1

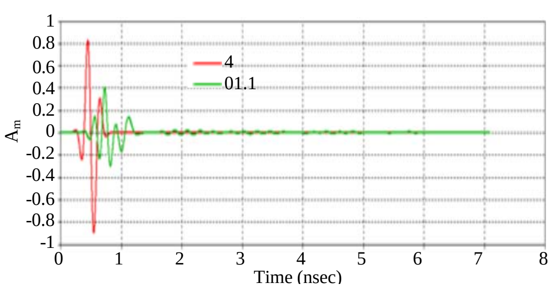

Fig. 7: Normalized source and received pulse when aligned face to face for antenna 2

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 Fig. 11-13.

The far field radiation patterns of the designed models are presented in Fig. 14 and 15 with respect to field intensity. The far field concentration at corresponding position and angle can be clearly observed from the

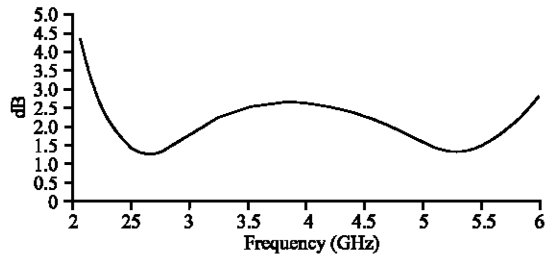

Fig. 8: VSWR vs. frequency of dual band monopole antenna with DGS

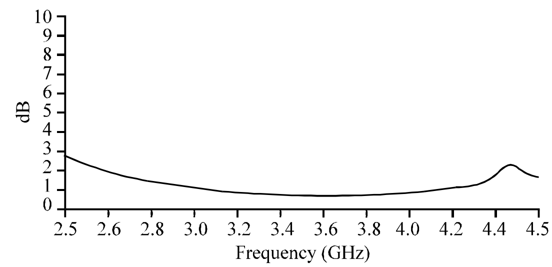

Fig. 9: VSWR vs. frequency of wideband monopole antenna with EBG and DGS

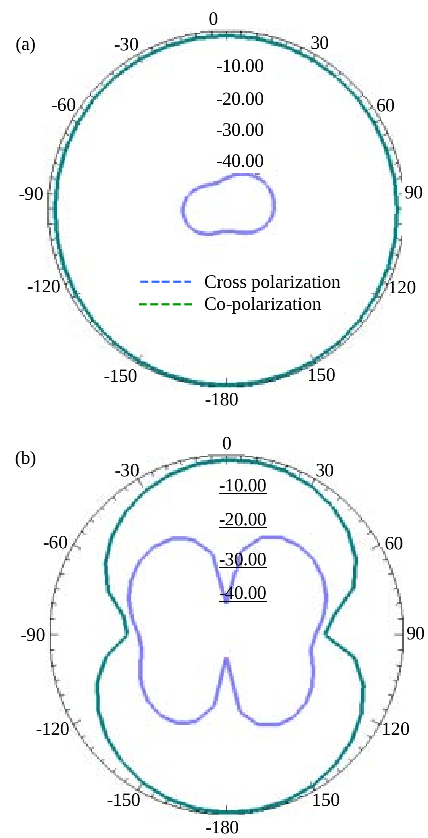

Fig. 10: Radiation pattern in E and H-Field for wideband monopole antenna with EBG (HFSS): a) Cross polarization; b) Co-polarization

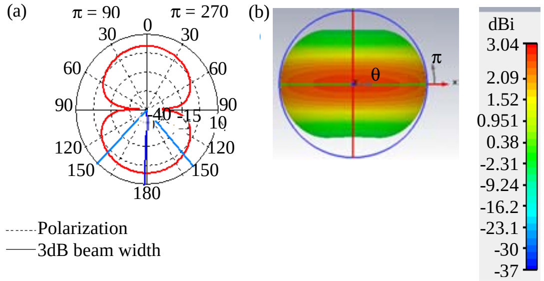

Fig. 11: Radiation pattern of dual band monopole antenna with at 2.6 GHz (CST): a) Polar plot; b) 3D plot

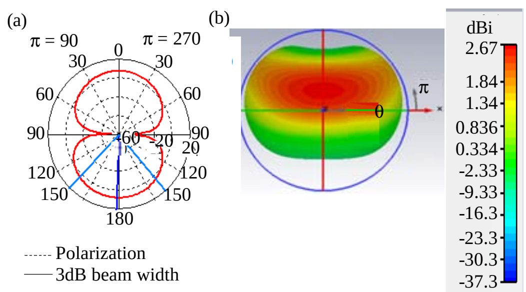

Fig. 12: Radiation pattern of dual band monopole antenna at 5.2 GHz (CST): a) Polar plot; b) 3D plot

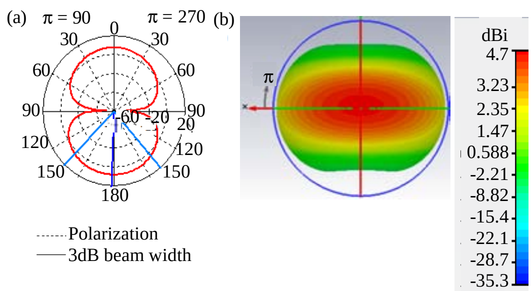

Fig. 13: Radiation pattern of wideband monopole antenna with EBG at 3.6 GHz (CST): a) Polar plot; b) 3D plot

presented results. The surface current distribution plot of designed antenna models at corresponding resonant frequencies are provided in Fig. 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.

To verify the antenna working in real time environment, we fabricated the model on FR4 substrate and tested with vector network analyzer. The measured reflection coefficient is providing exactly similar kind of results with simulation on HFSS. The prototyped antenna

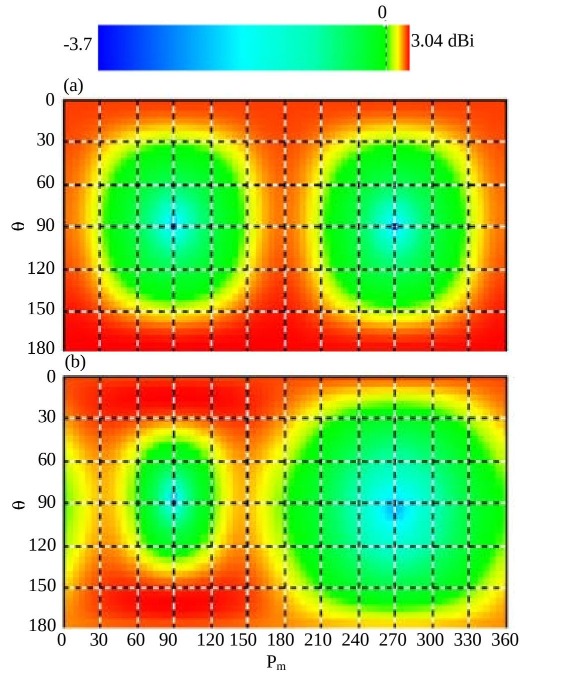

Fig. 14: Far field radiation intensity of dual band monopole antenna at 2.6, 5.2 GHz

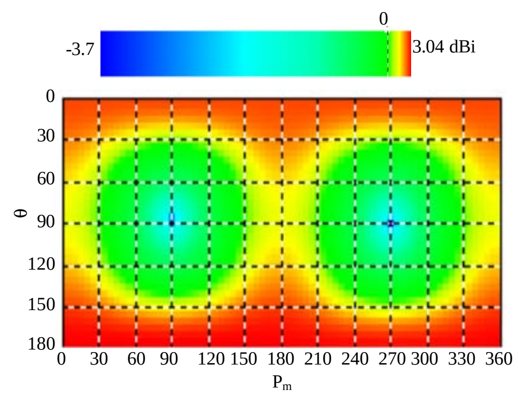

Fig. 15: Far field radiation intensity of wideband monopole antenna with EBG at 3.6 GHz

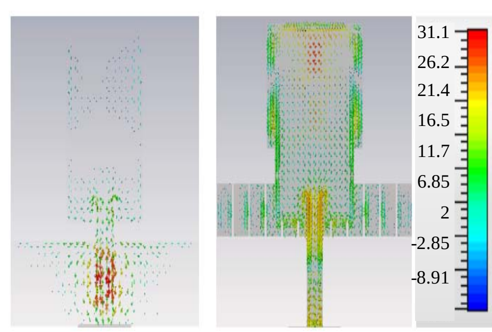

Fig. 16: Surface current distribution on dual band and wideband antenna

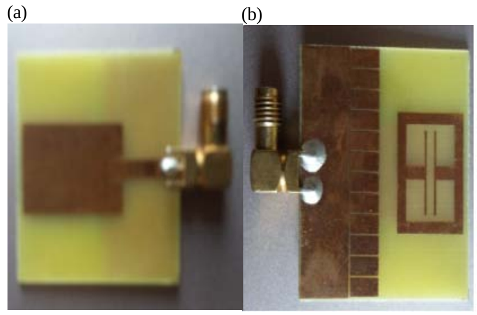

Fig. 17: Prototyped antenna on FR4 substrate: a) Front view; b) Back view

model is presented in Fig. 17. Good agreement obtained between simulation and measurement for the proposed antenna.

CONCLUSION

Defected ground structure model and EBG loaded antenna models are analyzed and presented in thisresearch. 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, 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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REFERENCES

Fu, Y.Q. and N.C. Yuan, 2005. Reflection phase and frequency bandgap characteristics of EBG structures with anisotropic periodicity. J. Electromagn. Waves Appl., 19: 1897-1905.

Kim, S.H., J.Y. Lee, T.T. Nguyen and J.H. Jang, 2013. High-performance MIMO antenna with 1-D EBG ground structures for handset application. IEEE. Antennas Wirel. Propag. Lett., 12: 1468-1471.

Kim, S.H., T.T. Nguyen and J.H. Jang, 2011. Reflection characteristics of 1-D EBG ground plane and its application to a planar dipole antenna. Prog. Electromagnet. Res., 120: 51-66.

Lin, B.Q. and X. Wen, 2008. A novel uniplanar compact EBG incorporated with interdigital structure. Microwave Opt. Technol. Lett., 50: 555-557.

Madhav, B.T.P., D.N. Vaishnavi, G. Vanaja, G. Jayasree and S. Mounika, 2015b. Design And Analysis Of Metamaterial Antenna With Ebg Loading. Far East J. Electron. Commun., 14: 127-136.

Madhav, B.T.P., G.K.N. Yedla, K.V.V. Kumar, R. Rahul and V. Srikanth *et al*., 2014. Fractal aperture EBG ground structured dual band planar slot antenna. Int. J. Appl. Eng. Res., 9: 515-524.

Madhav, B.T.P., M. Sanikommu, M.N.V.S. Pranoop, K.M.C. Bose and B.S. Kumar, 2015a. CPW Fed Antenna for Wideband Applications based on Tapered Step Ground and EBG Structure. Indian J. Sci. Technol., 8: 119-127.

Madhav, B.T.P., V.G.K.M. Pisipati, H. Khan and D. Ujwala, 2014. Fractal shaped Sierpinski on EBG structured ground plane. Leonardo Electron. J. Practices Technol., 13: 26-35.

Raman, Y.S.V., B.T.P. Madhav, G. Mounika, K.S. Teja and S.S. Kumar *et al*., 2006. Analysis of circularly polarized notch band antenna with DGS. ARPN. J. Eng. Appl. Sci., 11: 10140-10150.

Srinivas, M.S., M.B. RamakrishnaT, N. Bhagyalakshmi, S. Madhavi and K. Venkateswarulu, 2015. A Novel Compact CPW Fed Slot Antenna with EBG Structure. ARPN J. Eng. Appl. Sci., 10: 835-841.

Yang, F. and Y. Rahmat-Samii, 2009. Electromagnetic Band Gap Structures in Antenna Engineering. Cambridge University Press, Cambridge, UK., ISBN:978-0-521-88991-9, Pages: 266.

Yang, L., M. Fan, F. Chen, J. She and Z. Feng, 2005. A novel compact Electromagnetic-Bandgap (EBG) structure and its applications for microwave circuits. IEEE. Trans. Microwave Theory Tech., 53: 183-190.