Research Journal of Applied Sciences, Engineering and Technology 11(5): 488-494, 2015
DOI: 10.19026/rjaset.11.1852
ISSN: 2040-7459; e-ISSN: 2040-7467
© 2015 Maxwell Scientific Publication Corp.
Submitted: April 27, 2015 Accepted: May 28, 2015 Published: October 15, 2015

Research Article

Defected Ground Structured Monopole Antenna for Broadcasting Satellite Communication Applications

K. Kumar Naik, B.T.P. Madhav, G. Vanaja, K. Sreeharsha, S.L. Tejaswini,
G. Vamsi Krishna and V. Rasagna
Department of ECE, K L University, AP, India

Abstract: Design of antennas for satellite communication applications like Global Positioning Systems, Geo Informatics Systems became crucial for real time data collection and transmission. A novel Defected Ground structure planar monopole antenna for broadcasting satellite communication applications is proposed in this study. The proposed model has a unique structure with the combination of rectangular, arrow lined and T-slotted inverted U-shaped structure as a radiating element on the topside of the substrate. The ground plane on the bottom side of the substrate consisting of a rectangular slotted defected ground structure. The designed antenna has a small overall size of 32X26X0.8 mm with polyster as a substrate material. The results show that the antenna gives monopole like radiation pattern and a good antenna gain over the operating bands. The proposed antenna performance characteristics are well suited for fixed and broad casting satellite communication applications.

Keywords: Broad casting Satellite Communications (BSC), Defected Ground Structure (DGS), inverted U-shape, monopole antenna, T-slot

INTRODUCTION

The design of an antenna with multi band and wide band characteristics systems has increased has increased in the communications systems with improvement in their compactness (Madhav *et al*., 2014a; Rafi and Shafai, 2004; Madhav *et al*., 2010; Prabhu Kumar *et al*., 2011). Day by day the demands of compact antennas with simple structures are increasing in the communication engineering. The antenna with various structures has become a familiar candidate because of its attractive characteristics including low cost, low profile and less weight and versatile structure for exciting wide impedance bandwidths (Baskaran *et al*., 2011; Madhav *et al*., 2013a, 2013b, 2013c). The difficulty in designing antenna challenges engineers when the size of the antenna reduces and the number of operating frequency bands increases. Different structures with different configurations are proposed by the researchers in the literature (Boyes *et al*., 2012; Madhav *et al*., 2013d). Some of the promising feed structures such as probe, Microstrip and coplanar wave guide feeding. Generally in the monopole antennas large ground planes with different shapes of rectangle, circle, square or ellipse are usually adapted. This slotted ground planes with different structures forms Defected Ground Structures (DGS) (Yoon *et al*., 2007; Gupta *et al*., 2005).

Defected ground structures when integrated with planar feeds will suppress higher harmonics in the antenna design. Dum-bell shaped defected ground structures are proposed by the researchers to address the suppression of harmonics up to second level. Further improvement in the suppression of harmonics was done by Mandal and Sanyal (2006). To suppress up to 3rd harmonic a pair of dum-bell shaped DGS were employed beneath the Microstrip feed (Madhav *et al*., 2014b). As per the design point of view the physical area of the defect appears to be an important aspect, especially in the field of microwave integrated circuits (Madhav *et al*., 2014c; Syam Sundar *et al*., 2014). Smaller defect in terms of the operating wavelength is always preferred to make the design compact leaving maximum area for integrating other devices. This study focus on the low profile Microstrip feed monopole antenna on defected ground structure for wideband operations. The radiating element used in this model is the combination of square, arrow shaped line and inverted U-shaped element. The proposed model is designed and simulated using commercial electromagnetic tool HFSS. The complete parametric analysis with its performance characteristics of the designed models are analyzed and presented in detail in this study.

Corresponding Author: K. Kumar Naik, Department of ECE, K L University, AP, India
This work is licensed under a Creative Commons Attribution 4.0 International License (URL: http://creativecommons.org/licenses/by/4.0/).

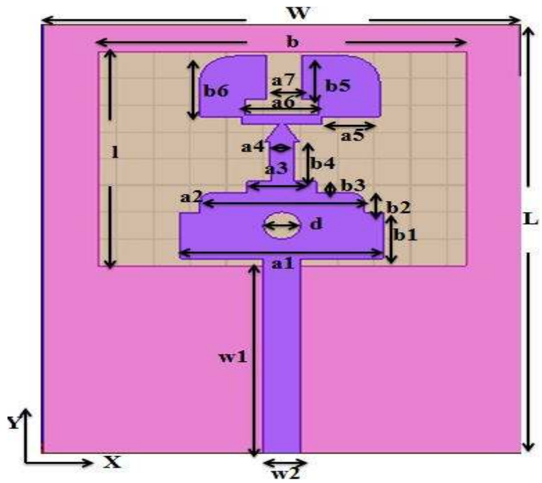


Fig. 1: Antenna model 1

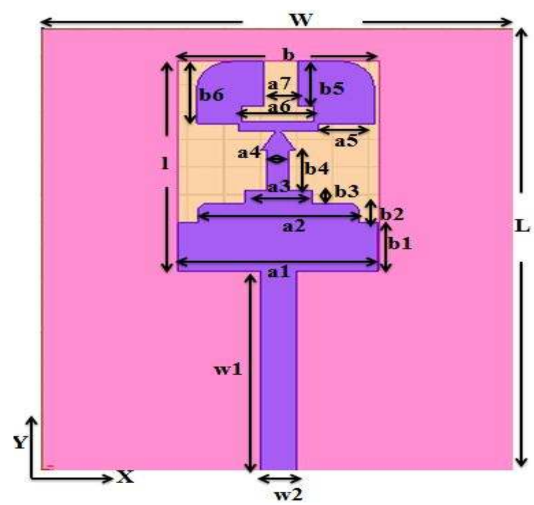


Fig. 2: Antenna model 2

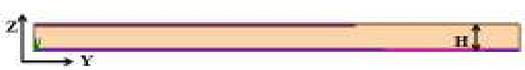


Fig. 3: Side view of antennas

Table 1: Antenna parameters

Parameters	Antenna 1 values (mm)	Antenna 2 values (mm)
W	26.0	26.00
L	32.0	32.00
l	16.0	15.24
b	20.0	11.10
w1	14.5	14.50
w2	2.0	2.00

MATERIALS AND METHODS

Two models are designed and analyzed in this study for wideband applications up to 12 GHz with first model and up to 23 GHz for second model. These two models are covering bandwidth of 16 GHz. The first model consisting of a circular slot on the rectangular step shaped radiating element with the combination of arrow shaped and inverted U-shaped elements as shown in Fig. 1. The entire radiating element with feed line stands on one side of the substrate and the bottom side of the substrate consisting of a wide slotted defected ground structure as shown in Fig. 1. Figure 2 shows same radiating element like structure in Fig. 1, without circular slot on the rectangular step shaped radiating element. These antennas are designed on a thin flexible substrate of polyster with the thickness 0.8 mm during the design process first the patches, substrate and ground plane for dimension using manual slot cutting EM-tool. The design process is complex by taking initial dimensions of pure rectangular Microstrip topologies with known procedure. Two rectangular patches are established to resonated two frequencies. These two resonances were overlapped by integrating them in single radiating structure. This can be achieved by using a common feed line connecting the patch elements. The proposed structure is relatively complex and was obtained as the result of an optimization process within the solver used. The detailed dimensional characteristic of the proposed models are tabulated in Table 1 and 2 (Fig. 3).

RESULTS AND DISCUSSION

Figure 4 shows the return loss characteristics of the antenna models in their operating frequency range. Antenna1 shows the narrow band characteritics at 2.5 GHz and wideband characterictics between 7-12 GHz. An impedance bandwith of 8% is showing fundamental at resonant frequency and an impedance bandwith of 56% is showing at second resonant frequency band. Antenna 2 is giving a huge bandwidth from 12 to 23 GHz that means 11 GHz with impedance bandwidth of 58% in the operating band. The same characteristics of antenna1 and antenna 2 can be observed in the VSWR curve of Fig. 5.

The radiation characteristics of the antenna models are shown in Fig. 6 and 7. Figure 6a shows a passive omni directional radiation pattern of antenna 1 at 12 GHz. Figure 6b shows the H-plane radiation pattern of antenna 1 in the form of 8 shaped radiation with nulling st 90° and 270°. Figure 7a and b shows antenna 2 radiation charactertics at 12 GHz.

Figure 8 shows current distribution on the radiating element of the antenna models at 12 GHz. It is been observed that the current intensity is more on the radiating element for antenna 2 compared with antenna 1. This is because of the wide band characteristics of the antenna 2 at higher resonant frequency. Figure 9 shows the current distribution of the antenna models on the ground plane at 12 GHz. From Fig. 9 we observed that the most of the current elements are focused around the slotted portion of the defected ground structure which is giving rise to the additional resonant frequency at higher bandwidth.

Table 2: Patch dimensions

Parameters	a1	a2	a3	a4	a5	a6	a7	b1	b2	b3	b4	b5	b6	H
Values (mm)	11	8.9	3.7	1.2	3.14	4	1.9	3.5	1.5	0.9	2.9	3.3	4.5	0.8

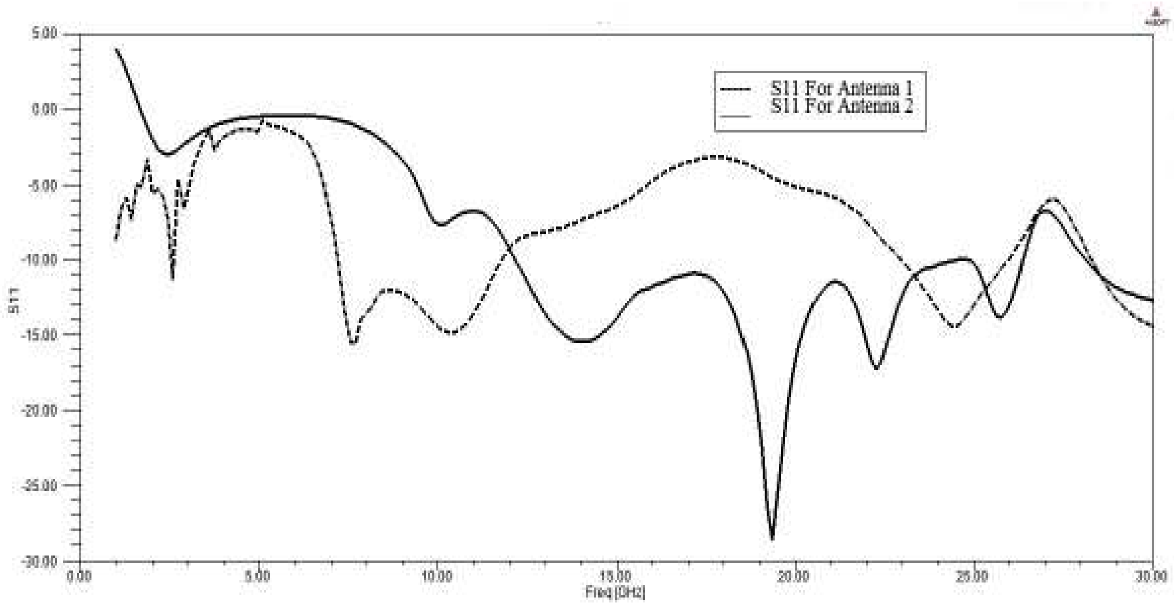


Fig. 4: Return loss vs. frequency of the two models

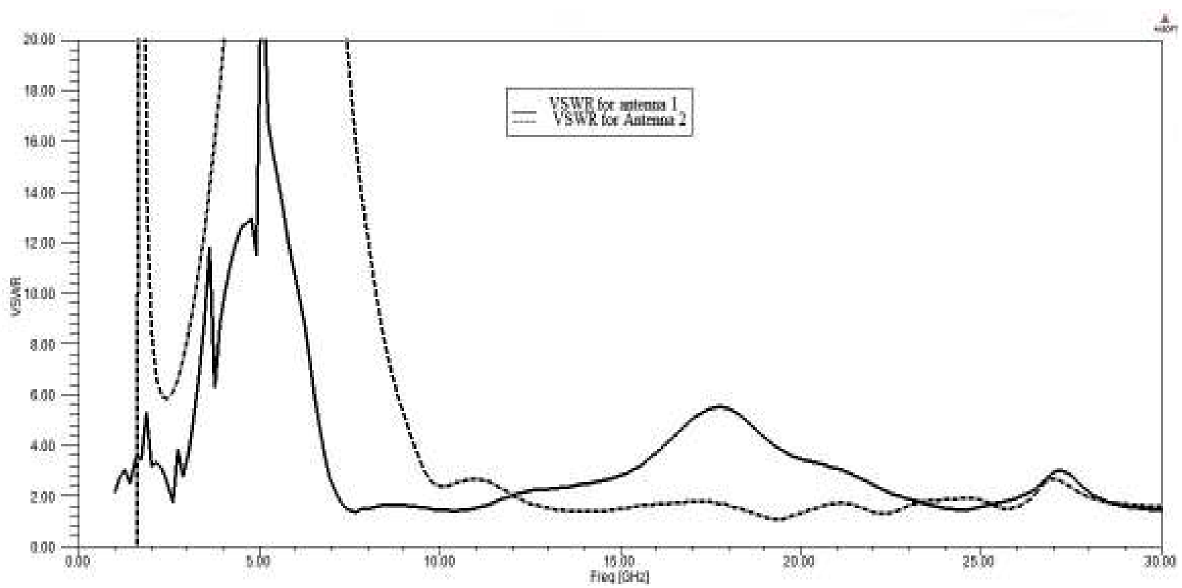
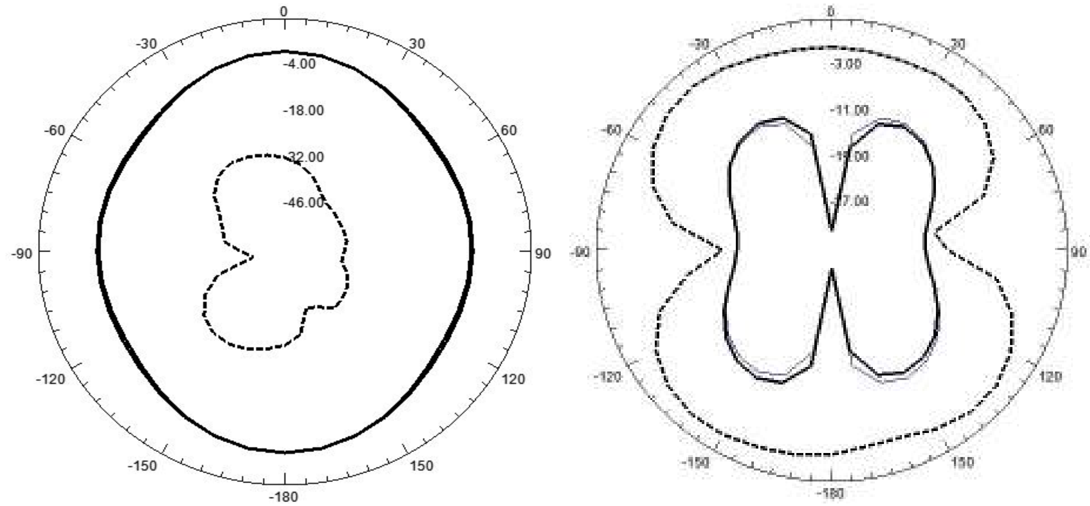


Fig. 5: VSWR vs. frequency of the two models

Figure 10 shows frequency vs. gain plots of the antenna models it is been observed that the antenna-2 is giving gain more than 5.5 dB at higher resonant frequency and average gain of 3 dB at lower resonant frequency antenna1 is producing an average of 2.8 dB at its operating frequency.

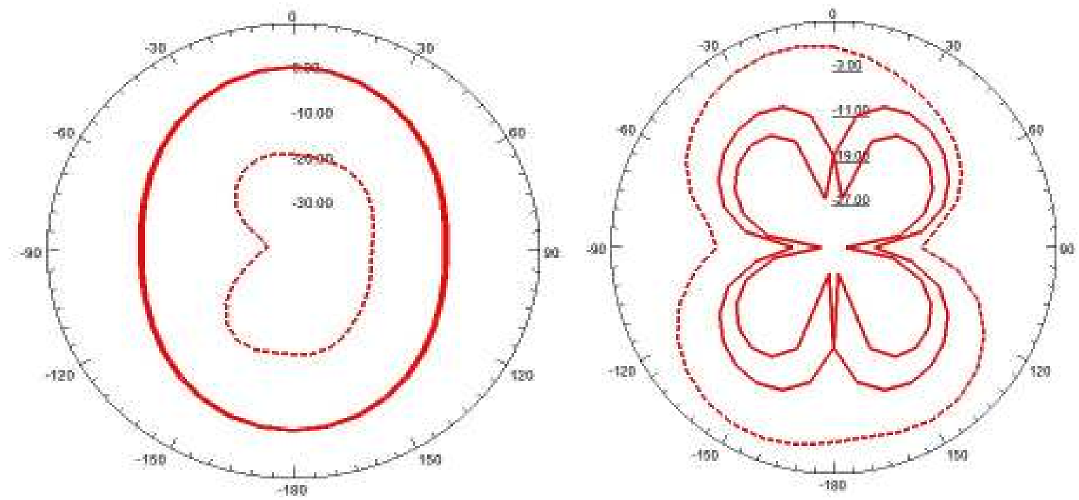
Figure 11 shows frequency vs. directivity of the models. Peak directivity values of antenna 1 and 2 are giving similar results of peak gain values in Fig. 10. Figure 12 shows the efficiency of the antenna models at their respective operating frequency bands. A minimum frequency of 99% for antenna 1 at lower resonant frequencies is obtained and a maximum efficiency of 103% is achieved for the case of antenna 2, at higher resonant frequency the overall efficiency of antenna models at their respective resonant frequencies are almost 100%.

Figure 13 shows the fabricated prototype of the antenna model on 0.8 mm thickness substrate material. The substrate material is flexible and occupies less



(a) (b)

Fig. 6: (a): E-plane radiation plot of antenna-1; (b): H-plane radiation plot of antenna-1



(a) (b)

Fig. 7: (a): E-plane radiation plot of antenna-2; (b): H-plane radiation plot of antenna-2

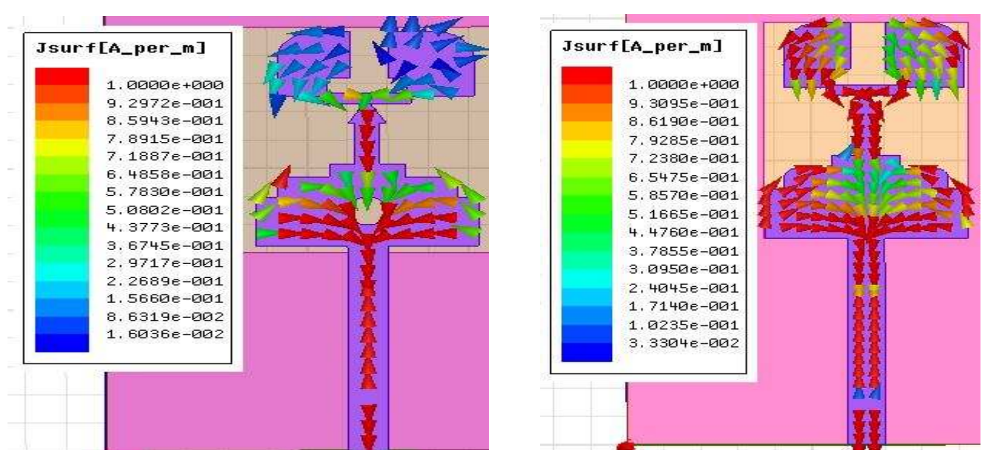


Fig. 8: Current distribution on the radiating element of antenna at 12 GHz

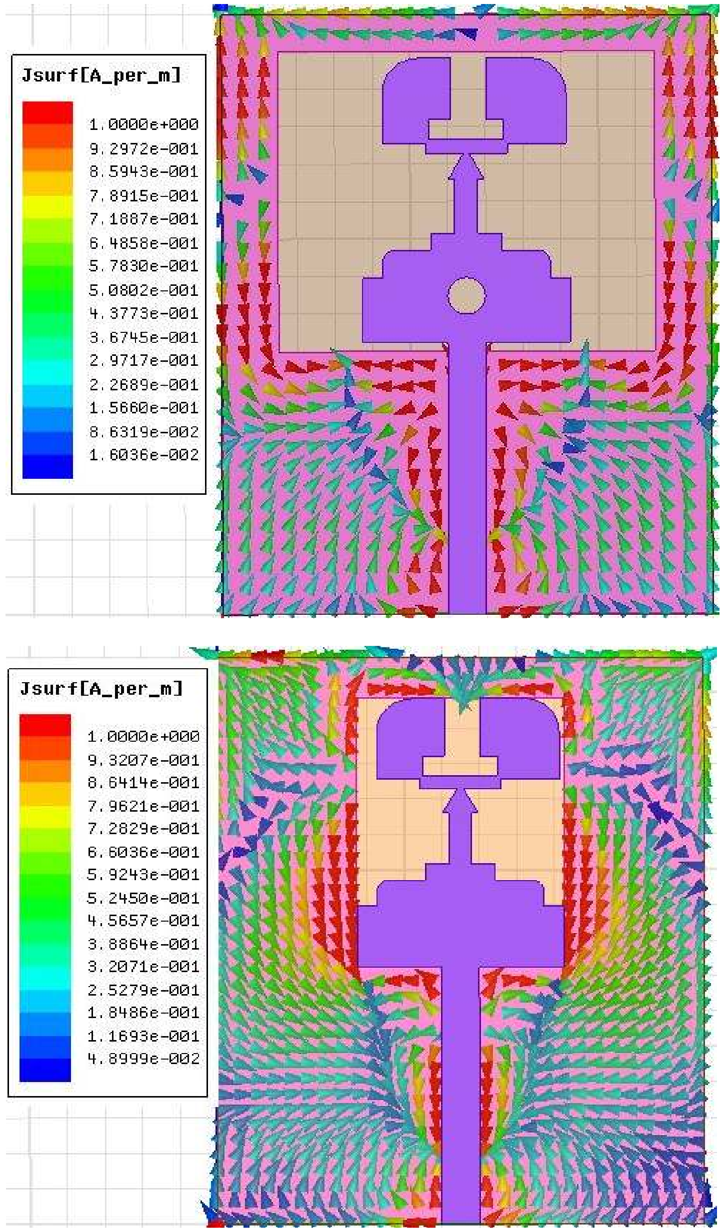


Fig. 9: Current distribution on the defective ground of antenna at 12 GHz

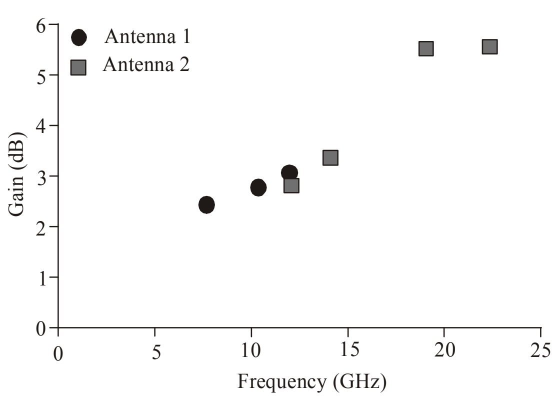


Fig. 10: Frequency vs. gain

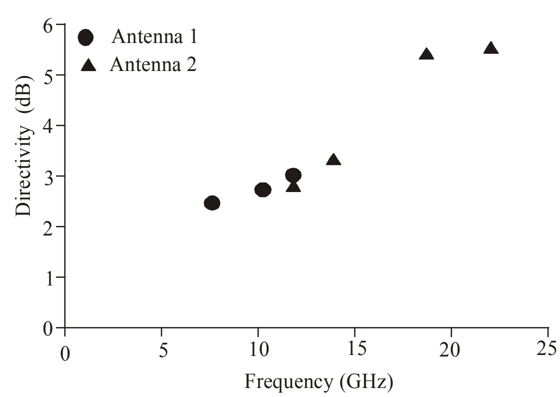


Fig. 11: Frequency vs. directivity

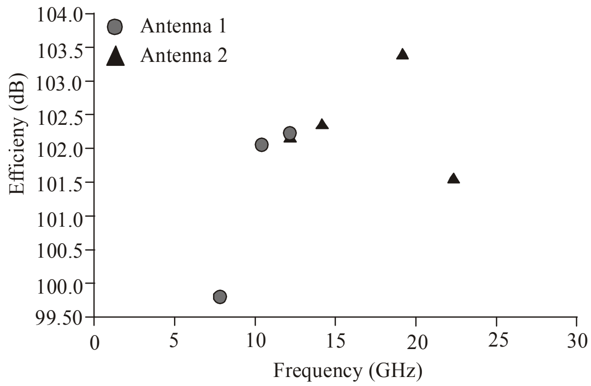


Fig. 12: Frequency vs. efficiency

(a) (b)

Fig. 13: Fabricated prototype of antenna model; (a): Top view; (b): Bottom view

height compared to the tradiaional antenna models. The top view and the bottom view of the antenna model is shown here. The ground plane is having discontinuity in the structure, which giving rise to additional resonant frequency with defected ground structure. The measured S11 parameter from ZNB 20 vector network analyzer is shown in Fig. 14. A high bandwidth can be observed from the measured results and which is similar to the simulation results from the HFSS tool. Small mismatch in the frequency bands are due to the connector losses and material losses.

CONCLUSION

Defected ground structure planar monopole antennas for broad casting satellite communications is proposed in this study. The designed monopole antennas are giving excellent wideband characteristics in their operating frequency range. The overall dimension of the proposed models is occupying a compact size of 32×26×0.8 mm. The antenna performance characteristics with respect to their parameters are studied. The proposed model is giving an average gain and directivity of more than 3 dB and efficiency is almost 100% with good radiation characteristics at their operating frequency bands. The prototyped model results are in good agreement with the simulated results, which gives support to use the current model in desired band of operation.

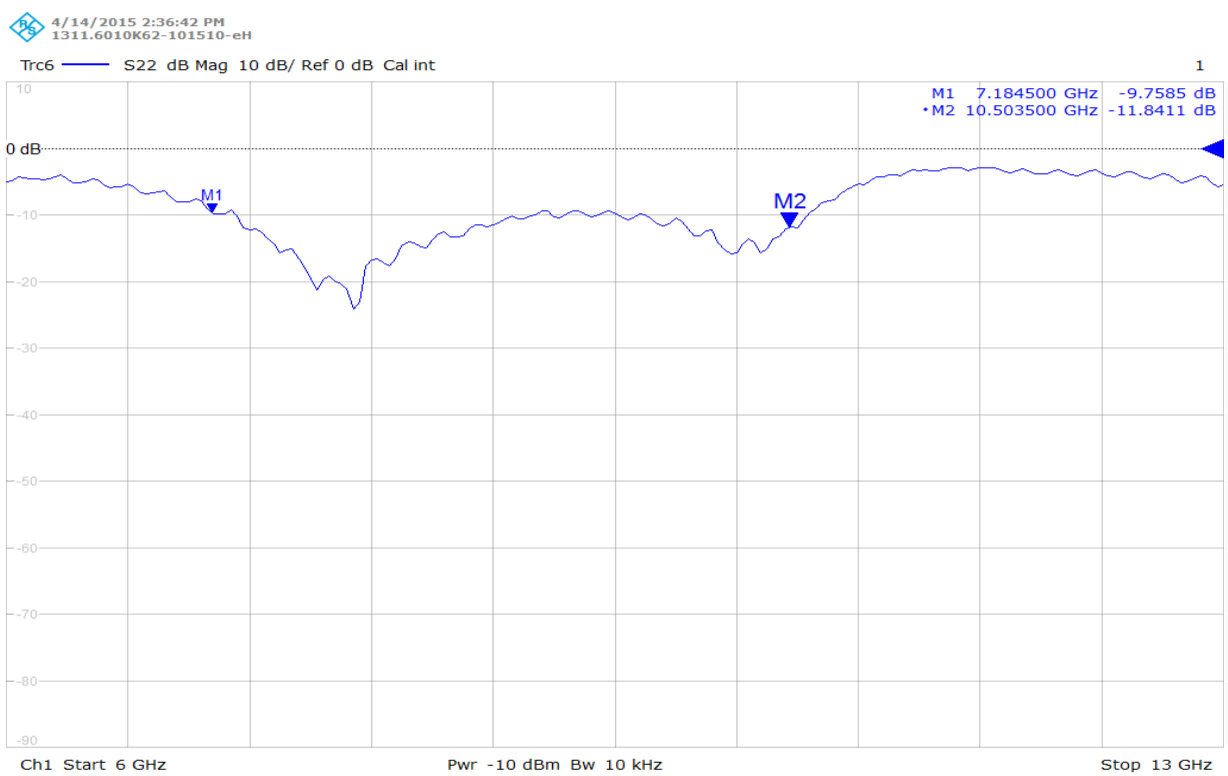


Fig. 14: Measured S11 from ZNB 20 vector network analyzer

ACKNOWLEDGMENT

Authors like to express their gratitude towards the department of ECE and management of K L University for their support and encouragement during this study. Further Madhav likes to express his gratitude to DST through FIST grant SR/FST/ETI-316/2012.

REFERENCES

Baskaran, K., C.P. Lee and C.K. Chakrabarty, 2011. A compact Microstrip antenna for ultra wideband applications. Eur. J. Sci. Res., 67(1): 45-51.

Boyes, S.J., P.J. Soh, Y. Huang, G.A.E. Vandenbosch and N. Khiabani, 2012. On-body performance of dual-band textile antennas. IET Microw., Antenna. P., 6(15): 1696-1703.

Gupta, S., M. Ramesh and A.T. Kalghatgi, 2005. Design of optimized CPW fed monopole antenna for UWB applications. Proceedings of the Asia-Pacific Microwave Conference (APMC, 2005), pp: 1-4.

Madhav, B.T.P., V.G.K.M. Pisipati, H. Khan, V.G.N.S. Prasad and K.S.N. Murty, 2010. Ultra wide band liquid crystal polymer microstrip elliptical patch antenna. J. Theor. Appl. Inform. Technol., 20(2): 105-109.

Madhav, B.T.P., G. Vaishnavi, V. Manichandana, Ch. Harinath Reddy, S. Ravi Teja and J. Sesi Kumar, 2013a. Compact sierpinski carpet antenna on destructive ground plane. Int. J. Appl. Eng. Res., 8(4): 343-352.

Madhav, B.T.P., D. Ujwala, J. Ravindranath Chowdary, A. Siva Nagendra Reddy, Ch. Kranthi and S. Kumar Bidichandani, 2013b. Design and analysis of new sierpinski carpet fractal antenna. Int. J. Microwave. Appl., 2(3): 108-112.

Madhav, B.T.P., H. Khan, D. Ujwala, Y. Bhavani Sankar, M. Kandepi, A. Siva Nagendra Reddy and D. Nagajyothi, 2013c. CPW fed serrated antenna performance based on substrate permittivity. Int. J. Appl. Eng. Res., 8(12): 1349-1354.

Madhav, B.T.P., S.S. Mohan Reddy, B. Sanjay and D. Ujwala, 2013d. Trident shaped ultra wideband antenna analysis based on substrate permittivity. Int. J. Appl. Eng. Res., 8(12): 1355-1361.

Madhav, B.T.P., S. Chhatkuli, A. Manikantaprasanth, Y. Bhargav, U. Dinesh Naga Venkata Sai and S. Feeraz, 2014a. Measurement of dimensional characteristics of microstrip antenna based on mathematical formulation. Int. J. Appl. Eng. Res., 9(9): 1063-1074.

Madhav, B.T.P., K.V.V. Kumar, A.V. Manjusha, P. Ram Bhupal Chowdary, L. Sneha and P. Renu Kantham, 2014b. Analysis of CPW fed step serrated ultra wide band antenna on rogers RT/duroid substrates. Int. J. Appl. Eng. Res., 9(1): 53-58.

Madhav, B.T.P., S.K. Kotamraju, P. Manikanta, K. Narendra, M.R. Kishore and G. Kiran, 2014c. Tapered step CPW-fed antenna for wideband applications. ARPN J. Eng. Appl. Sci., 9(10): 1967-1973.

Mandal, M.K. and S. Sanyal, 2006. A novel defected ground structure for planar circuits. IEEE Microw. Wirel. Co., 16(2).

Prabhu Kumar, K., Dr.P.S. Brahmanandam, B.T.P. Madhav, K.Ch. Sri Kavya, V. Shiva Kumar, T. Raghavendra Vishnu and D. Rakesh, 2011. Uniplanar quasi yagi antenna for channel measurements at X band. J. Theor. Appl. Inform. Technol., 26(2).

Rafi, G.Z. and L. Shafai, 2004. Wideband -slotted diamond-shaped microstrip patch antenna. Electron. Lett., 40(19): 1166-1167.

Syam Sundar, P., B.T.P. Madhav, D. Sri Harsha, P. Manasa, G. Manikanta and K. Brahmaiah, 2014. Fabric substrate material based multiband spike antenna for wearable applications. Res. J. Appl. Sci. Eng. Technol., 8(3): 429-434.

Yoon, H.K., W.S. Kang, Y.J. Yoon and C.H. Lee, 2007. A CPW-fed flexible monopole antenna for UWB systems. Proceeding of the IEEE International Symposium on Antennas Propagation Society, pp: 701-704.