Research Journal of Applied Sciences, Engineering and Technology 10(3): 247-252, 2015
DOI: 10.19026/rjaset.10.2484
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: November 25, 2014 Accepted: January 23, 2015 Published: May 30, 2015

Research Article

Design and Analysis of Compact Coplanar Wave Guide Fed Asymmetric Monopole Antennas

B.T.P. Madhav, Harish Kaza, Jagadish Kumar Vaka, K. Sravan Kumar, N. Sriharsha, J. Jaswanth Kumar, D.S. Siddharth and D. Sai Teja Reddy
Department of ECE, K L University, Guntur DT, AP, India

Abstract: A compact CPW-FED monopole antenna for wireless communication applications is presented in this study. The proposed antenna models consisting of very compact size of 27.5×13 mm on RT-Duroid substrate of $\varepsilon_r = 2.2$ with thickness of 1.6 mm. The proposed antenna structures cover the frequency bands of C and Ku. In addition, the antenna exhibits monopole like radiation characteristics and good antenna gain of more than 1.6 dB in c-band and 2.79 dB in Ku-band, which is suitable to integrate with the devices for wireless communication devices for communication system applications.

Keywords: C-band, Coplanar Waveguide (CPW), ku-band, monopole antenna

INTRODUCTION

Demand for dual, triple and multiband antennas are increased recently in the portable wireless communication devices (Sadasivarao and Madhav, 2014). With the advantages of small size, low cost and simple configuration various types of printed antennas suitable for communication applications have been reported such as ,monopole antennas of double T-Shaped (Madhav *et al*., 2014b), E-Shaped (Madhav *et al*., 2014c), Slot antenna with L-Shaped strips (Madhav *et al*., 2013) and dipole antennas (Madhav *et al*., 2014a). To cover different bands simultaneously, several antennas have been proposed (Ramkiran *et al*., 2014). Most of the antennas focus on the modification of the radiating patch or the ground plane. Researchers reported number of antennas which can cover dual, triple and multi bands suitable for different communications systems.

Among the well-known multiband antenna prototypes, the planar and coplanar monopole antennas of various configurations have become popular because they provide attractive antenna characteristics, namely: low profile, light weight, low cost versatile configuration for exciting dual or multi resonance modes and exhibiting wide impedance bandwidth with desirable radiation characteristics (Habibulla *et al*., 2014; Thomas and Sreenivasan, 2009; Zhang *et al*., 2011). The real challenge comes into the picture when a compact antenna is designed with multiband characteristics (Ali Nezhad and Hassani, 2010; Wei *et al*., 2010; Kuo and Wong, 2003).

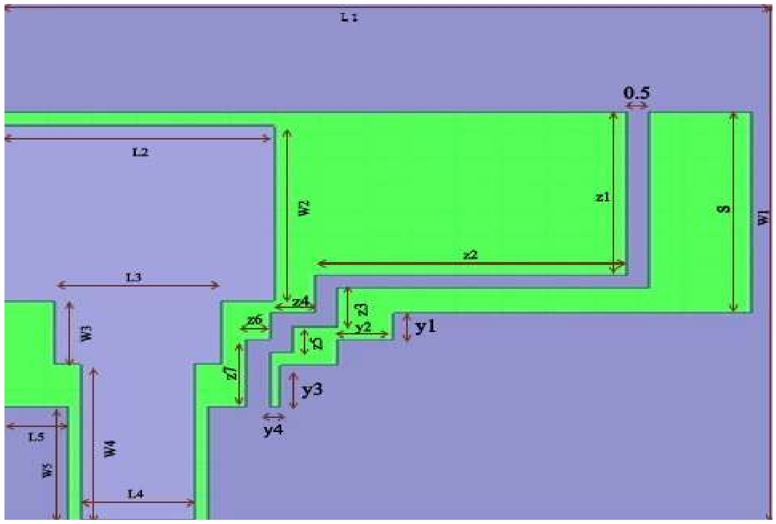
In this study, a relatively small monopole antenna is presented for wireless communication applications. The current antenna models are providing dual, triple and wideband characteristics with good impedance bandwidth. The antenna performance is simulated using ANSYS HFSS prior to its fabrication. The effects of the antenna's key structural parameters on its performance characteristics are also analyzed.

MATERIALS AND METHODS

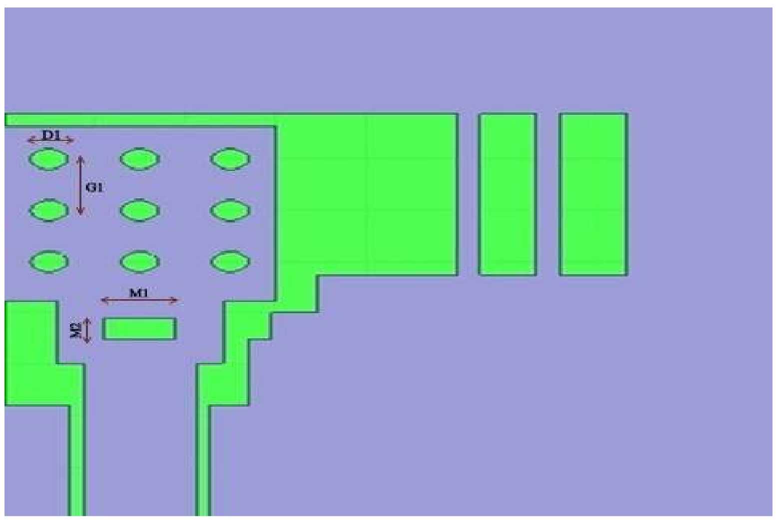
ANSYS HFSS is used to design the proposed antenna model and Finite Element Method based simulation results are collected from this Electromagnetic tool. RT-duroid substrate with dielectric constant 2.2 is used as substrate material in this antenna design.

Antenna design and parameters evaluation: The geometry of the proposed model, shown in Fig. 1, consists of a coplanar waveguide fed monopole antenna with a strip structure interconnecting the upper and lower grade sections that surround the antenna's radiating element to provide dual frequency operation. The parameters of the proposed antenna is shown in Table 1, were optimized using ANSYS HFSS. Four models are designed in this study and analysis is presented regarding the bandwidth improvement. Figure 1a shows the coplanar wave guide fed asymmetric monopole antenna, which consists of rectangular patch with slotted ground plane adjacent to radiating element. Figure 1b shows the circular slot aperture monopole antenna with rectangular slot on the feed line. Figure 1c shows the asymmetric rectangular slot aperture monopole antenna with circular slot on the feed line. Figure 1d shows the asymmetric slot ground monopole antenna.

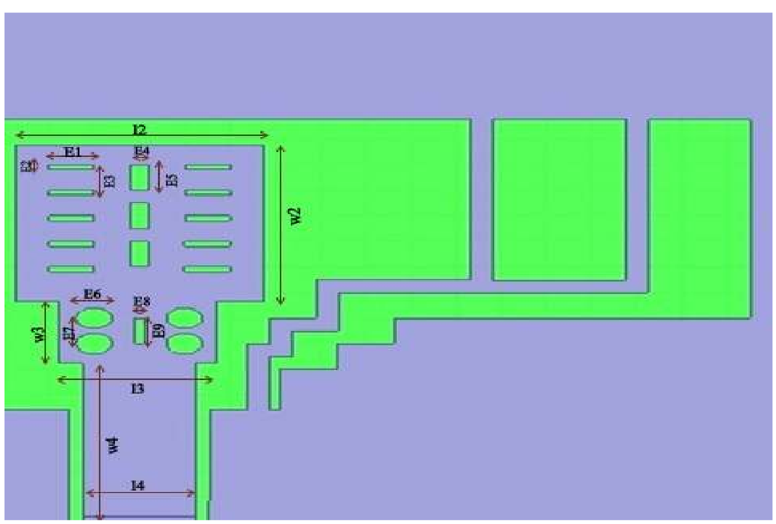
Corresponding Author: B.T.P. Madhav, Department of ECE, K L University, Guntur DT, AP, India


L1
0.5
L2
W2
z1
S
W1
z2
L3
z4
z3
z6
y2
y1
W3
z5
z7
y3
y4
L5
W4
W5
L4

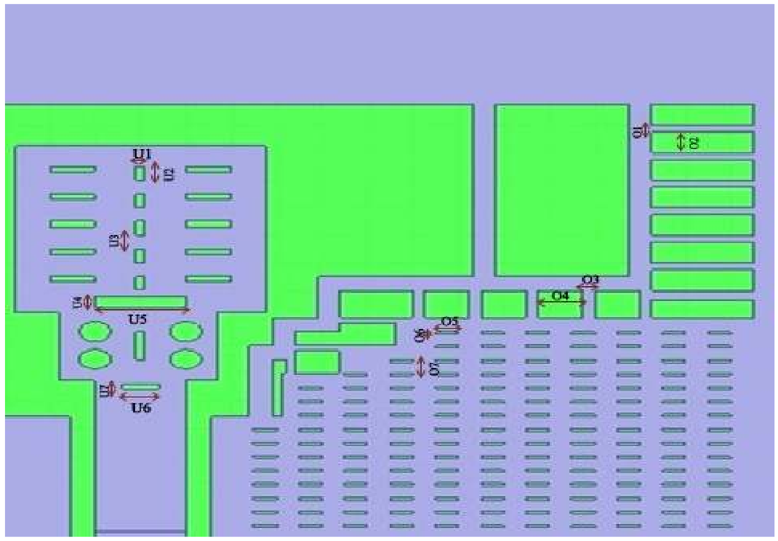
(a)


D1
G1
M1
M2

(b)


l2
E1
E2
E3
E4
E5
w2
E6
E8
w3
E7
E9
l3
w4
l4

(c)



(d)

Fig. 1: (a) Coplanar wave guide fed asymmetric monopole antenna, (b) asymmetric circular slot aperture monopole antenna, (c) asymmetric rectangular slot aperture monopole antenna, (d) asymmetric slot ground monopole antenna

Table 1: Antenna dimensional parameters

Parameters	Length (mm)	Parameters	Length (mm)	Parameters	Length (mm)
L1	17.00	y2	1.250	E7	1.00
W1	20.00	y3	1.600	E8	0.20
L2	6.00	y4	0.225	E9	1.00
W2	6.78	D1	0.800	U1	0.20
L3	3.67	G1	2.000	U2	0.50
W3	2.43	M1	1.600	U3	0.50
L4	2.50	M2	0.800	U4	0.40
W4	6.00	l2	5.500	U5	2.00
L5	1.45	w2	6.080	U6	0.80
W5	4.38	l3	3.470	U7	0.20
z1	6.25	w3	2.430	O1	0.25
z2	6.85	l4	2.500	O2	0.75
z3	1.50	w4	6.000	O3	0.25
z4	1.00	E1	1.000	O4	1.00
z5	1.00	E2	0.200	O5	0.50
z6	0.50	E3	0.800	O6	0.10
z7	2.60	E4	0.400	O7	0.40
s	7.75	E5	1.000		
y1	1.00	E6	0.800		

Table 1 shows the dimensional characteristics of the proposed models. Iteration by iteration, all these models are providing excellent bandwidth improvement with the addition of slots on the structure. The detailed performance evaluations of these models are presented in the subsequent sections.

RESULTS AND DISCUSSION

The evolution of the proposed wideband antenna design and its corresponding simulation reselection co-efficient results are presented in Fig. 2. The results show wide impedance bandwidths obtained between 2.4 to 16 GHz with reflection co-efficient ≤-10 dB, which meets the bandwidth requirements of communication bands. Coplanar waveguide fed asymmetric monopole antenna is resonating at two bands i.e., narrow band of 5.6 GHz (5.4-5.8 GHz) and wideband of 11-16 GHz. Impedance bandwidth of 7% at 5.6 GHz and 38% at 13 GHz is obtained from the model 1. Asymmetric circular slot aperture monopole is radiating in the wideband of 10-17 GHz with bandwidth of 7 GHz. Asymmetric rectangular slot aperture monopole is radiating between three bands of 2.4 and 7 GHz narrow bands and 9-14 GHz wideband. Asymmetric slot ground monopole antenna is resonating between narrowband at 2.4 GHz and wideband of 5-15 GHz. An impedance bandwidth of 5% at 2.4 GHz and 111% between 5-15 GHz is obtained from the proposed slot ground monopole antenna.

From the results it is been observed that, the slots on the ground plane affects the bandwidth and the magnitude of the resonance of the monopole antenna. The feed length parameter severely affects the first resonant mode in terms of its reflection co-efficient

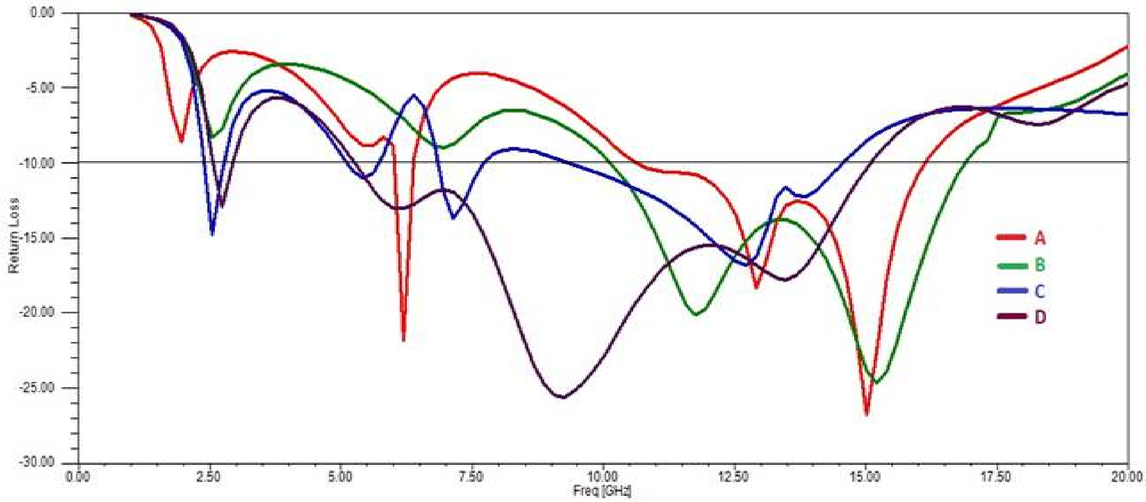


Fig. 2: Return loss vs. frequency

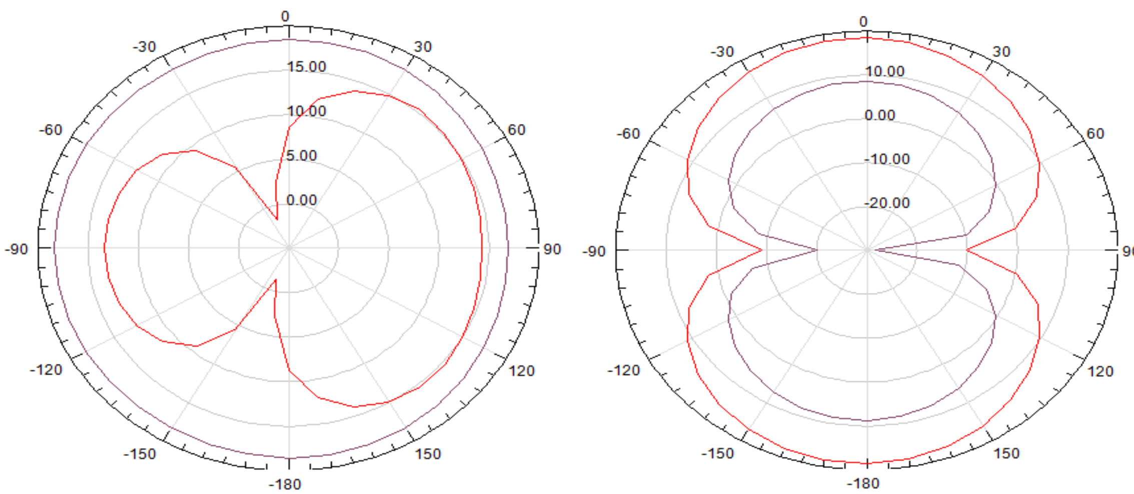


Fig. 3: Antenna radiation pattern in E and H plane at 12 GHz

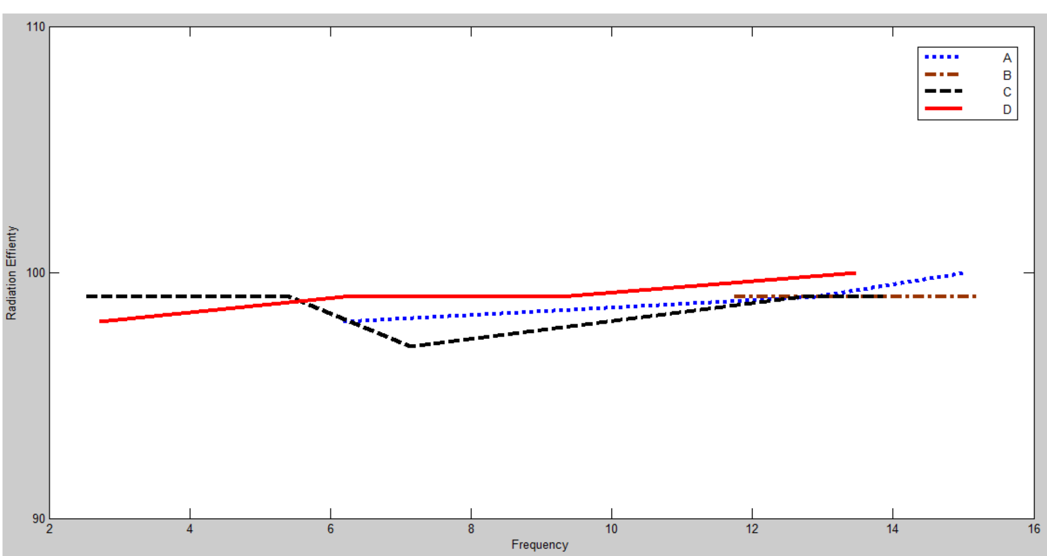


Fig. 4: Frequency vs. efficiency of the proposed antenna models

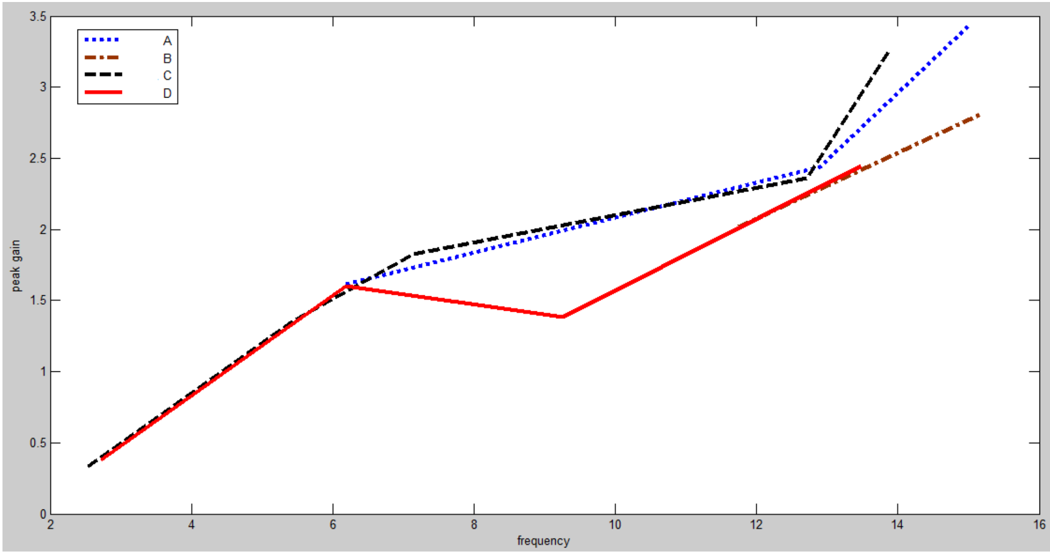
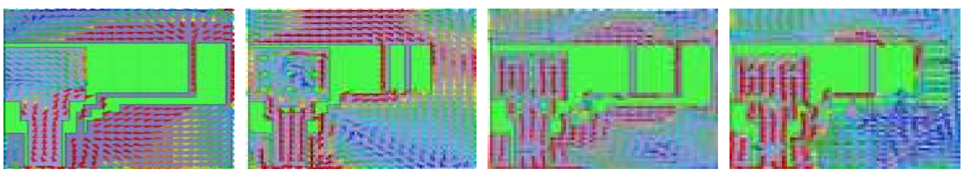


Fig. 5: Frequency vs. gain of the proposed antenna models



(a) (b) (c) (d)

Fig. 6: Surface current distribution of the proposed models at 12 GHz

magnitude and centre frequency. The optimized values are computed from the parametric analysis results and with assiduous care during fabrication.

The simulated radiation patterns at 12 GHz in the XZ-Plane (H-Plane) and YZ-Plane (E-Plane) are studied and presented in Fig. 3. The radiation pattern is omni-directional in the H-Plane and the monopole in E-plane. The radiation characteristics of the antenna are stable within the operating bands and the cross polarization radiation patterns are relatively small.

Figure 4 shows the frequency vs. efficiency of the antenna models. A stable efficiency of more than 98% is attained for the case of slot ground monopole antenna. For the case of rectangular slot monopole antenna efficiency is decreased in the frequency band of 5 to 7 GHz. The remaining two cases show the efficiency of more than 95%.

The gain response of the proposed antenna as a function of frequency is plotted in Fig. 5. Stable gain in the resonating bands is observed from the gain plot. From the gain plot we can observe the increment of gain in all the models. A peak realized gain of 3.2 dB is attained for the case of asymmetric monopole antenna. The gain of the proposed antenna satisfies the requirement of the communication applications.

Figure 6 shows the surface current distribution of the proposed models at 12 GHz. Figure 6a shows the maximum intensity on the feed line in Y-direction for asymmetric monopole antenna and Fig. 6b shows the circular oriented current distribution on the surface of the radiating element. Figure 6c and d shows the equal magnitude of current distribution on the feed line and radiating element with opposite polarity.

CONCLUSION

Compact wideband monopole antennas are presented using a special ground structure, which comprises a strip line interconnecting the ground sections surrounding the patch, results in an effective resonant mode antenna without comprising its physical size. The current antenna models exhibiting excellent impedance bandwidths at resonant frequencies. The effect of antenna key parameters and their corresponding results are studied to acquire the deeper understanding and insight on the antenna. The proposed models have several advantages like small in size, excellent radiation characteristics in the desired band and ease of fabrication with CPW feeding. These properties make the antenna suitable for communication system applications in C and Ku bands.

ACKNOWLEDGMENT

Authors wholeheartedly express their deep gratitude towards the Department of ECE and management of K L University for providing Excellent R and D Facilities at our work place. Further B T P Madhav likes to thank Sri Koneru Satyanarayana, President, KLU for providing excellent R and D facilities in the University.

REFERENCES

Ali Nezhad, S.M. and H.R. Hassani, 2010. A novel triband E-shaped printed monopole antenna for MIMO application. IEEE Antenn. Wirel. Pr., 9: 576-579.

Habibulla, K., B.T.P. Madhav, K. Mallikarjun, K. Bhaskar, N. Sri Harsha and M. Nakka, 2014. Uniplanar wideband/narrow band antenna for wlan applications. World Appl. Sci. J., 32(8): 1703-1709.

Kuo, Y.L. and K.L. Wong, 2003. Printed double-T monopole antenna for 2.4/5.2 GHz dual-band WLAN operations. IEEE T. Antenn. Propag., 57(9): 2187-2192.

Madhav, B.T.P., S.S. Mohan Reddy, J. Ravindranath Chowdary, V. Vinod Babu, S.S. Satya Parthiva and S. Kalyana Saravana, 2013. Analysis of dual feed asymmetric antenna. Int. J. Appl. Eng. Res., 8(4): 361-367.

Madhav, B.T.P., G.S. Krishnam Naidu Yedla, K.V.V. Kumar and R. Rahul, 2014a. Fractal aperture EBG ground structured dual band planar slot antenna. Int. J. Appl. Eng. Res., 9(5): 515-524.

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

Ramkiran, D.S., B.T.P. Madhav, N. Haritha, R. Sree Ramya, K.M. Vindhya and S.P. Abhishek, 2014. Design and analysis of microstrip slot array antenna configuration for bandwidth enhancement. Leonardo Electron. J. Pract. Technol., 25: 72-83.

Sadasivarao, B. and B.T.P. Madhav, 2014. Analysis of hybrid slot antenna based on substrate permittivity. J. Eng. Appl. Sci., 9(6): 885-890.

Thomas, K.G. and M. Sreenivasan, 2009. Compact triple band antenna for WLAN/ WIMAX applications. Electron. Lett., 45(16): 811-813.

Wei, H., Y.Z. Yin, X. Yang, K. Song, Z.Y. Liu and L.H. Wen, 2010. A wide open U-Slot antenna with a pair of symmetrical L-strips for WLAN applications. Propag. Electromagn. Res. Lett., 47(16): 141-149.

Zhang, N., P. Li, B. Liu, X.W. Shi and Y.J. Wang, 2011. Dual-band and low cross-polarisation printed dipole antenna with L-slot and tapered structure for WLAN applications. Electron. Lett., 47(6): 360-361.