MULTI STEPPED SLOTTED PARTIAL GROUND PLANE DUAL NOTCHED ULTRA WIDE BAND RECTANGULAR MICROSTRIP ANTENNA

SYEDA RAFATH ARA, DR. S. N. MULGI

Abstract: In this paper a compact multi-stepped, corner truncated, partial slotted ground plane monopole rectangular microstrip antenna is presented for ultra wideband and dual notch properties. The antenna operates between 1.67- 9.57 GHz exhibiting dual notch bands from 3.88 - 4.66 GHz and from 6.01-7.61 GHz. The antenna shows a wide bandwidth of 143.13% in its operating frequency range. The radiation characteristic of the antenna is mainly omnidiectional. The proposed antenna gives a maximum gain of 4.28 dB in its operating band at 3.36 GHz. This antenna is simple in its design and uses the low cost substrate material for its fabrication. Te proposed antenna may be useful for systems the modern communication systems like ECM E/F, GPS, DCS, PCS, IMT, and UMTS.

Keywords: Dual notch band, Monopole, Multi-stepped, Partial Ground Plane, Slotted, Ultra Wide Band,

Introduction: The planar UWB microstrip antennas proposed in the last few years were considered as the first choice and more suitable for many wireless communication applications because of their properties like wide operating band with omni directional radiation patterns and stable gain. The Federal communication commission (FCC) standards requirement in communication system and Ultra wideband (UWB) systems in particular, it is the need of the hour to design UWB microstrip antennas possessing the inherent properties such as low power consumption, low cost, precise positioning and promising for short-range high-speed indoor data communications [1]–[3]. The planar rectangular monopoles [4] have proved themselves as a good example for UWB applications due to their merits such as simple in design, easy fabrication, acceptable radiation pattern and large impedance bandwidth. However, some narrowband systems operating in frequency such as WiMAX (3.3 GHz-3.8 GHz), WLAN (5.15 GHz–5.825 GHz) and X-Band satellite downlink satellite communication band (7.1 GHz–7.9 GHz), which cause interference in UWB range. To overcome such interference within UWB range various methods and techniques have been proposed in the literature to obtain the band-notch characteristics of UWB microstrip antennas designs such as different shapes radiating patches, cutting slots in patch radiator, putting parasitic elements near the patch [5-10], defective ground plane such as partial, slotted and using tuning stubs in the ground plane or in antenna microstripline feed [11}-[20]. In this paper a novel UWB microstrip antenna having the multi stepped radiating patch and the slotted partial ground plane is presented to achieve the UWB with notch band characteristics. This kind of antenna is found rare in the literature.

Design of UWB Microstrip Antenna: The geometry of conventional rectangular microstrip antenna (CRMSA) is shown in Fig. 1(a) and optimized geometry of the proposed antenna is as shown in Fig. 1(b). The antennas shown in Fig. 1 uses a modified glass epoxy substrate of relative permittivity ε_r = 4.2 and a loss tangent (δ) of 0.02 for its fabrication. The designed frequency of the antenna is 3 GHz. The length (Ls) and width (Ws) of the substrate is 60 mm. The L_p is length of patch W_p is width of the patch. The 50Ω SMA connector is used at the tip of the microstripline feed of width W_f=3.2 mm and length L_f = 23.3 mm to excite the antenna. A gap 'g' (2 mm) is maintained between patch and partial ground plane for obtaining good impedance matching. The dimension L_s and W_s of Fig.1 (b) antenna is same as conventional rectangular microstrip antenna shown in Fig. 1(a). In Fig.1 (b) asymmetrical slotted partial ground plane of length L_g and width W_s with a rectangular slot of length 'a' and width ' b' is placed on the back side of the radiating patch. The patch is truncated at two opposite ends at n_1 and n_2 Also, the radiating patch is multi stepped as shown in Fig1. (b).The design details are listed in Table I.

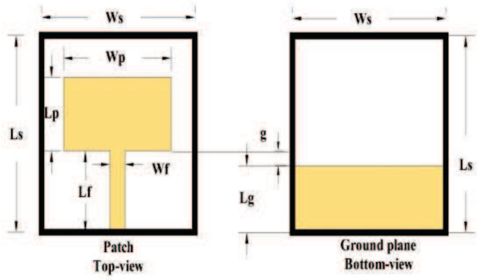


Figure 1(a): Geometry of the conventional rectangular microstrip antenna (CRMSA)

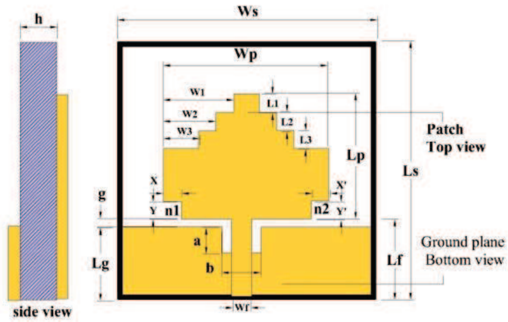
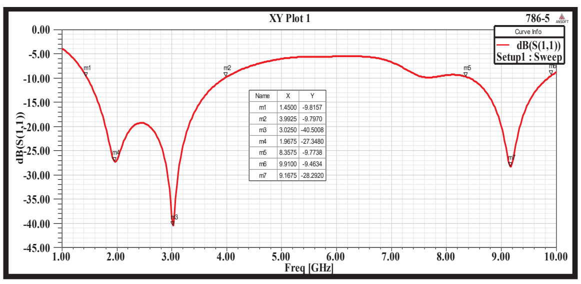


Figure 1(b): Geometry of the side and top view of optimized proposed microstrip antenna (OPMA)

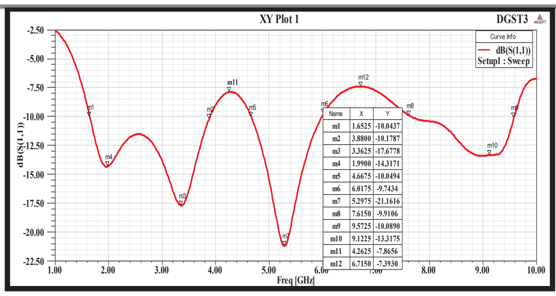
Table-I

Parameters	Value in mm	Parameters	Value in mm
L_s	60	n1 and n2 (X× Y),(X′× Y′)	5.5×4
W_s	60	$W_1 \times L_1$	13×4
L_p	24	$W_2 \times L_2$	10.5×4
W_p	31	$W_3 \times L_3$	8×4
L_f	23.3	g	2
W_f	3.2	Slot (a× b)	5×5
L_g	21.3		

Results and Discussions: The CRMSA and OPMA are simulated using 3D full-wave electromagnetic Ansoft HFSS software. Fig. 2(a) and (b) show the simulated return loss of these antennas. From Fig 2(a) it is seen that, the antenna resonates for the dual band with a bandwidth BW1 (1.45-3.99 GHz) = 93.38% and BW_2 (8.35-9.99 GHz) = 17.88%. The maximum gain of 4.13 dB is achieved in its operating band. The insertion of corner truncations at the lower ends of the patch and slotted partial ground make the antenna to resonate for UWB from 1.67- 9.57 GHz with maximum bandwidth of 143.13%. Further, the use of symmetrical multi-steps on the radiating patch introduces dual notches at frequency ranges from 3.88-4.66 GHz and from 6.01-7.61 GHz respectively with highest bandwidth of 80.65 %GHz.



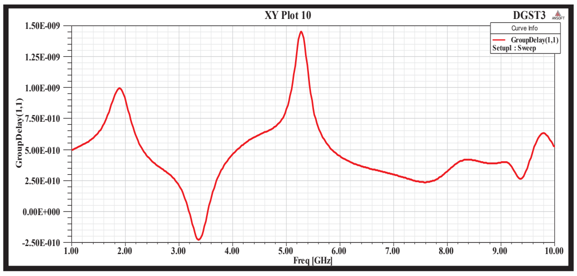
(a) Return loss versus frequency plot of CRMSA



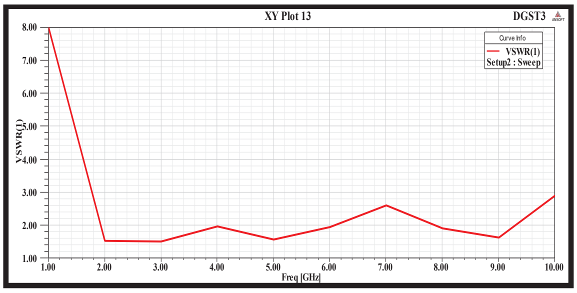
(b) Return loss versus frequency plot of OPMA

Figure 2: Simulated return loss versus frequency plot of (a) CRMSA, (b) OPMA

The simulated group delay and VSWR versus frequency plots of the OPMA are shown in Fig. 3(a) and (b). From these figures it is observed that, the VSWR and group delays remain almost constant throughout the operating band of the antenna.



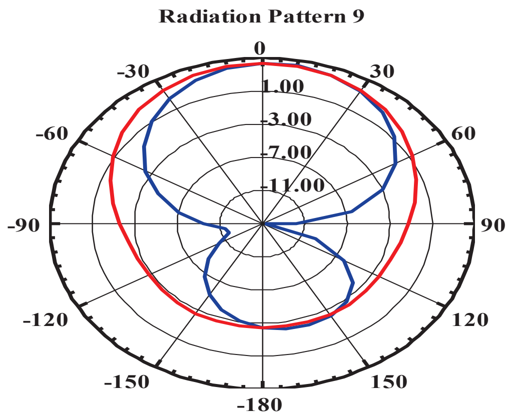
(a) Group delay versus frequency plot of OPMA

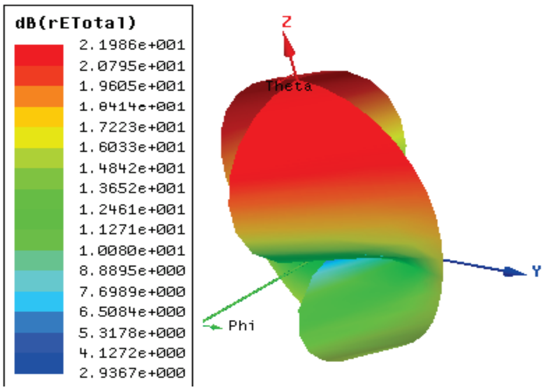


(b) VSWR versus frequency plot of OPMA

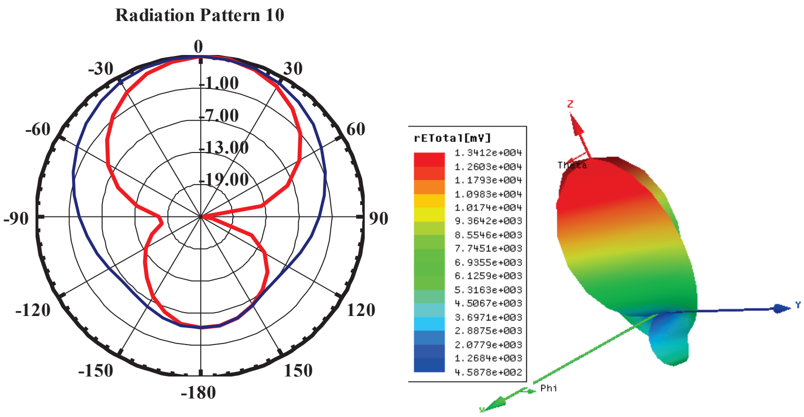
Figure 3: Group delay and VSWR versus frequency plots of OPMA

Fig. 4 shows the simulated 3D and 2D radiation pattern of OPMA in the X-Y plane at resonant frequencies within pass band (1.99, 3.36 at the lower band, and 5.29 at the middle band and 9.12 GHz at the upper band). It is seen from these figures that, nearly omni directional radiation pattern is observed at the lower middle and upper band.

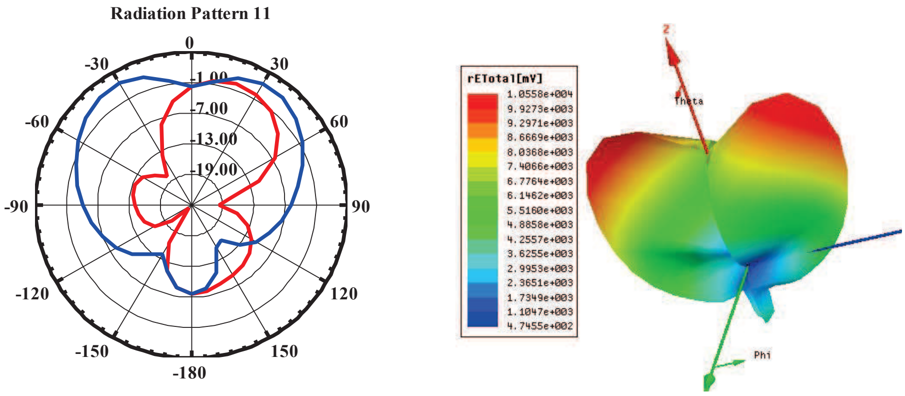




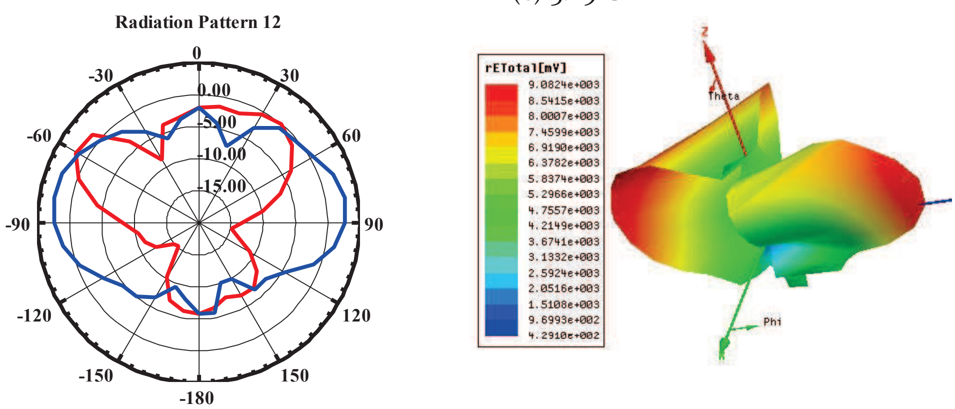
(a) 1.99 GHz



(b) 3.36 GHz



(c) 5.29 GHz



(d) 9.12 GHz

Figure 4: 2D and 3D E-plane (x-y plane) radiation pattern with particular azimuth angle of, 0° and 90° measured at (a) 1.99 GHz, (b) 3.36 GHz, (c) 5.29 GHz and (d) 9.12 GHz of the OPMA

The simulated result for maximum gain in dB and radiation efficiency of the OPMA is shown in Fig. 5(a) and 5(b) respectively. The gain and efficiency are simulated at the fix point on azimuth angle of at 0° and 90°. The maximum gain of 4.28 dB is achieved at 3.36 GHz. From these figures it is also found that the efficiency remains almost stable in the operating frequency range of the antenna.

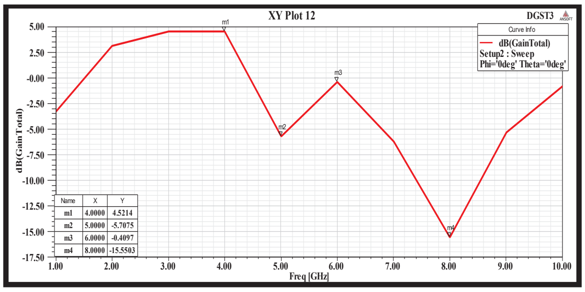


Figure 5(a): Simulated gain versus frequency plot of OPMA

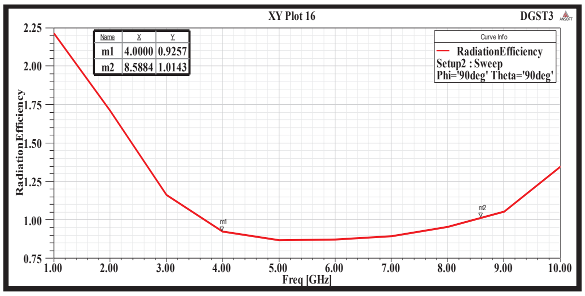
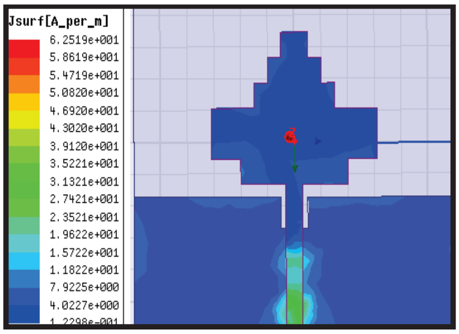
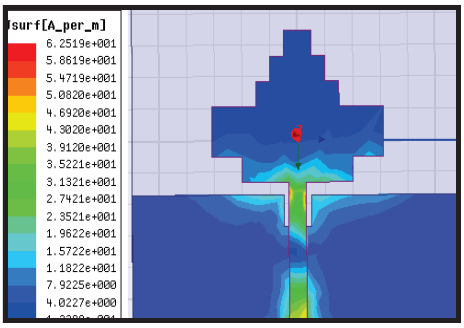


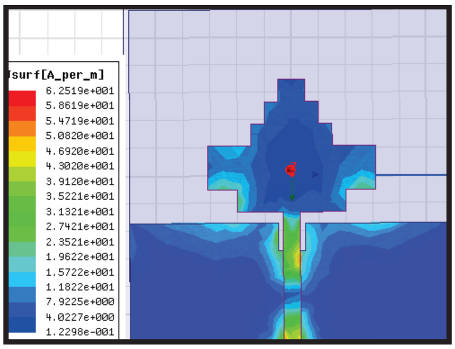
Figure 5(b): Simulated Radiation efficiency (η) versus frequency plot of OPMA



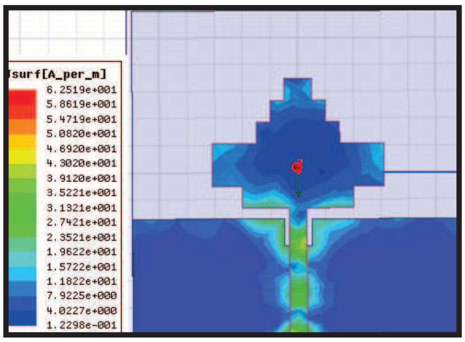
(a) 1.99 GHz



(b) 3.36 GHz



(c) 5.29 GHz



(d) 9.12 GHz

Figure 6: Simulated current distributions (in A/m) at (a) 1.99, (b) 3.36, (c) 5.29 and (d) 9.12 GHz of OPMA

Fig. 6(a)-(d) shows the simulated surface current distributions for the minimum return loss ($|S_{11}|$) of OPMA at 1.99, 3.36, 5.29 and 9.12 GHz respectively. From these figures, it is observe that, most of the current concentrates across the feed line element and at the centre on ground plane resulting in the creation of notched bands in the UWB range of OPMA.

Conclusion: A compact, simple, low cost, UWB with dual notched band antenna with multi steps, corner truncations on patch radiator and slotted partial ground plane is presented. The proposed OPMA gives a maximum bandwidth of 143.13% with dual notch band characteristics which may be used as a good tool to minimize the potential interference between WiMAX and UWB systems. The antenna exhibits nearly omni directional radiation patterns in its operating band with highest gain of 4.28 at 3.36 GHz. This antenna may be useful for GPS, DCS, PCS, 3G-IMT-2000, UMTS-2000 in wireless communication.

References:

1. F. C. Commission, "Revision of Part 15 of the commission's rules regarding ultra-wideband transmission systems, FIRST REPORT AND ORDER," *ET Docket 98-153, FCC 02-48,* pp. 100-118, 2002.
2. G B. Latré, B. Braem, I. Moerman, C. Blondia and P. Demeester, "A survey on wireless body area networks," *Wireless Networks,* vol. 17, pp. 1-18, 2011.
3. E. G. Lim, Z. Wang, C. U. Lei, Y. Wang and K. Man, "Ultra Wideband Antennas–Past and Present," IAENG International Journal of Computer Science, vol. 37, pp. 304-314, 2010
4. U. Chakraborty, B. Mazumdar, S. Chowdhury and A. Bhattacharjee, "A Compact L-slot Microstrip Antenna for Quad band Applications in Wireless Communication," Global Journal of Researches in Engineering (F) Volume XII Issue II Version I Feb, 2012.
5. J Mardani, H., Ghobadi, C. and Nourinia, J. "A Simple Compact Monopole Antenna with Variable Single- and Double-Filtering Function for UWB Applications," IEEE Antennas and Wireless Propagation Letters, **9**, 1076-1079.
6. Chen, W.-S. and Ku, K.-Y, "Band-Rejected Design of the Printed Open Slot Antenna for WLAN/WiMAX Operation," IEEE Transactions on Antennas and Propagation,**56**,1163-1169.
7. E. G. Lim, Z. Wang, C. U. Lei, Y. Wang and K. Man, "Ultra Wideband Antennas–Past and Present," IAENG International Journal of Computer Science, vol. 37, pp. 304-314, 2010.
8. M. Li, T. Ni, S. M. Zhang, J. Huang and Y. C. Jiao, "UWB printed slot antenna with dual band-notched characteristic," Progress In Electromagnetics Research Letters, vol. 25, pp. 143-151, 2011.
9. Y. D. Dong, W. Hong, Z. Q. Kuai and J. X. Chen, "Analysis of planar ultra-wideband antennas with on-ground slot band-notched structures," Antennas and Propagation, IEEE Transactions on, vol. 57, pp. 1886-1893, 2009.
10. G. P. Gao, Z. L. Mei and B. N. Li, "Novel circular slot UWB antenna with dual band-notched characteristic," Progress In Electromagnetics Research C, vol. 15, pp. 49-63, 2010.
11. Y. C. Lin and K. J. Hung, "Compact ultra-wideband rectangular aperture antenna and band-notched designs," Antennas and Propagation, IEEE Transactions on, vol. 54, pp. 3075-3081. 2006.
12. Islam MT, Azim R, Mobashsher AT. Triple band-notched planar UWB antenna using parasitic strips. *Progress in Electromagnetics Research*. 2012; 129:161–179.
13. Li Y, Li W, Ye Q. A," CPW-fed circular wide-slot UWB antenna with wide tunable and flexible reconfigurable dual notch bands," *The Scientific World Journal. 2013;2013:10pages.40291*
14. Nazli H, Bicak E, Turetken B, Sezgin M., "An improved design of planar elliptical dipole antenna for UWB applications," *IEEE Antennas and Wireless Propagation Letters. 2010; 9: 264–267.*
15. Qing X, Chen ZN, "Compact coplanar waveguide-fed ultra-wideband monopole-like slot antenna," *IET Microwaves, Antennasand Propagation. 2009;3(5):*889–898.
16. C Azim R, Islam MT, Misran N. , "Compact tapered-shape slot antenna for UWB applications" *IEEE Antennas and Wireless Propagation Letters.* 2011; 10:1190–1193.
17. Latré, B., Braem, B., Moerman, I., Blondia, C. and Demeester, P. (2011) "A Survey on Wireless Body Area Networks," *Wireless Networks*, **17**, 1-18.
18. Choi, S.H., Park, J.K., Kim, S.K. and Park, J.Y., "A New Ultra-Wideband Antenna for UWB Applications," Mi-crowave and Optical Technology Letters, (2004) **40**, 399-401.
19. Mardani, H., Ghobadi, C. and Nourinia, J. "A Simple Compact Monopole Antenna with Variable Single- and Double-Filtering Function for UWB Applications," IEEE Antennas and Wireless Propagation Letters, (2010) **9**, 1076-1079.
20. Li T, Zhai H, Li L, Liang C, Han Y., "Compact UWB antenna with tunable band-notched

characteristic based on microstrip open-loop resonator," *IEEE Antennas and Wireless Propagation Letters. 2012; 11:1584–1587.*

* * *

Syeda Rafath Ara, Dr. S. N. Mulgi
Dept. of P. G. Studies and Research in Applied Electronics,
Gulbarga University,Kalaburagi-585 106, Karnataka, India