Band-Notched Characteristic using Ground Stubs for Compact UWB Antennas

Y. F. Weng, S. W. Cheung and T. I. Yuk
Department of Electrical and Electronic Engineering
The University of Hong Kong, Hong Kong
E-mail: [yfweng, swcheung, tiyuk]@eee.hku.hk

Abstract—**In this paper, a pair of very simple ground stubs is used to design a single band-notched characteristic in a compact planar-monopole antenna for ultrawide band (UWB) applications. The single-band notch covers the wireless area network (WLAN) band from 5.15 GHz to 5.825 GHz. The center-notch frequency and notch bandwidth can be adjusted using the dimensions of the ground stubs. Prototype of the proposed antenna is designed and fabricated. The band-notched characteristics, return loss, radiation patterns, peak gains and efficiencies of the antenna are studied using both computer simulation and measurements.**

Keywords - monopole antenna, ultrawideband (UWB) antenna, band notched, ground stub.

I. INTRODUCTION

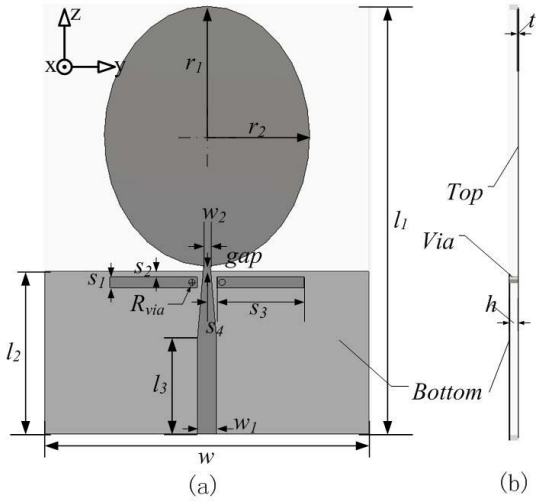
The ultrawideband (UWB) radio system has attracted much attention since the US-FCC approved the frequency band, i.e., 3.1–10.6 GHz in 2002 [1]. Within the UWB frequency band, there are several existing wireless communication systems such as the IEEE 802.11a wireless local area network (WLAN) in the frequency band of 5.15 – 5.825 GHz and the fixed broadband wireless access (FBWA) mainly around 3.5 GHz. As a result, there is a potential risk that the UWB radio system will interfere with these systems, so it is necessary for UWB antennas to have band-notched characteristics in those frequency bands to avoid potential interferences.

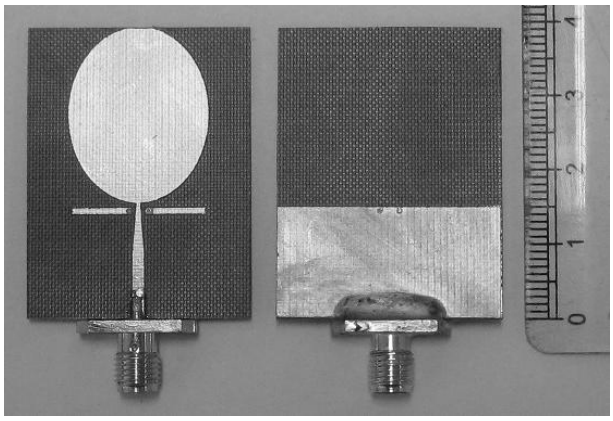
Various design methods have been proposed to implement the band-notched characteristic for UWB planar monopole antennas [2] – [8]. In this paper, we propose a very simple method to realize a single band-notched characteristic for a compact UWB monopole antenna, i.e., use a pair of simple ground stubs along the feed line. The design is studied using the computer simulation tool CST MWS [9] and the Satimo Starlab measurement system. The UWB antenna has a single notch covering the WLAN band at a center frequency of 5.5 GHz. Results show that the proposed UWB antenna has an operating frequency range from 2.57 GHz to over 12 GHz with return loss $\geq$10 dB which fully satisfies the FCC's requirement for UWB applications. The simulated and measured results on the radiation patterns and peak gains agree well.

II. ANTENNA DESIGN

Structure of single band-notched UWB antenna

In our UWB antenna design, we propose to use the planar-monopole technology to achieve a compact size for applications in wireless devices. The UWB antenna consists of an elliptical radiator fed by a 50-Ω microstrip line on one side of the substrate and a rectangular ground plane on the other side of the substrate, as shown in Fig. 1. A pair of stubs, as shown in Fig. 1 (a), is symmetrically placed at a distance of s_4 from the center of the microstrip feed line and connected to ground through a via. The antenna is fabricated on a Polytetrafluoroethylene (PTFE) substrate PCB with a transverse dimension of 30 mm × 39.3 mm, a relative dielectric constant of ε_r = 3.5, a thickness of 0.8 mm and a loss tangent of 0.003. The width of the microstrip feed-line changes gradually from w_1 = 1.73 mm with a distance of l_3 = 9.5 mm to the feed point to w_2 = 0.6 mm near to the radiator, for good impedance matching. The distance, *gap*, between the elliptical radiator and the upper edge of the ground plane is also quite critical for impedance matching and so has been optimized, using the computer simulation software tool CST MWS, to be 0.5 mm. Detailed dimensions of the single band-notched antenna are listed in Table 1.





(c)

Fig. 1 Structure of proposed single band-notched antenna. (a) Top view, (b) side view and (c) photograph of prototype.

TABLE I. SINGLE BAND-NOTCHED ANTENNA DIMENSIONS

Parameter	*Value(mm)*	*Parameter*	*Value(mm)*
l_1	39.3	w_1	1.73
l_2	15	w_2	0.6
l_3	9.5	s_1	0.5
gw	30	s_2	0
r_1	12	s_3	9
r_2	9	s_4	1.0
t	0.035	R_{via}	0.3
h	0.8	gap	0.5

Parametric study of single band-notched UWB antenna

A parametric study of the single band-notched UWB antenna has been conducted by computer simulation to explore how the dimensions and placement of the ground stubs affect the characteristic of the band notch. Results have shown that, at resonance, the energy is coupled from the upper edge of the ground plane to the stubs and then flows back to the ground plane through the vias. Computer simulation results on the effects of the distance between the upper edge of the ground plane and the ground stub, s_2, and the length of the ground stubs, s_3, on the return loss of the antenna are shown in Figs. 2 and 3, respectively. It can be seen that the dimensions s_3 and s_2 determine the center frequency and bandwidth of the notch, respectively. These plots also reveal that when the values of s_2 and s_3 are changed, the return loss in the rest of the UWB band remains about the same. These properties provide the designers with a great freedom to select the notched-band frequency and bandwidth for the antenna.

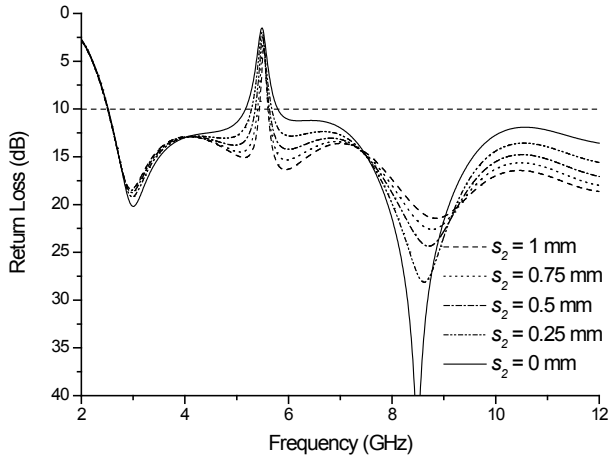


Fig. 2 Return loss for different values of s_2 with other dimensions fixed.

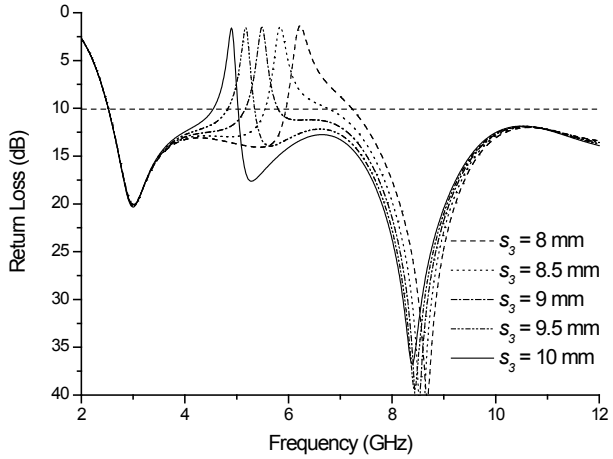


Fig. 3 Return loss for different values of s_3 with other dimensions fixed.

III. RESULTS AND DISCUSSIONS

The design of our band-notched antenna has been fabricated using a PCB with PTFE substrate as shown in Fig. 1(c). The return loss and peak gains across the UWB band, and the radiation patterns at 3, 7 and 12 GHz have been simulated using the CST MWS and measured using the Satimo Starlab measurement system.

The results on the return loss of the antennas are shown in Fig. 4. It can be seen that, the antenna can operate from 2.57 GHz to over 12 GHz with return loss $\geq$ 10 dB which fully satisfies the FCC UWB requirement. In the WLAN band from 5.18 to 6.23 GHz, the measured return loss is substantially smaller than 10 dB.

The simulated and measured radiation patterns of the antenna at the frequencies of 3, 7 and 12 GHz in the two principle planes, x-y and x-z planes, are shown in Fig. 5. At 3, 7 and 12 GHz, Figs. 5(a), 5(c) and 5(e) show that the antenna has approximately stable omnidirectional radiation patterns in the x-y plane. In the x-z plane patterns, Figs. 5(b), 5(d) and 5(f) show that there are two nulls at the z direction. This is similar to that of a typical monopole antenna.

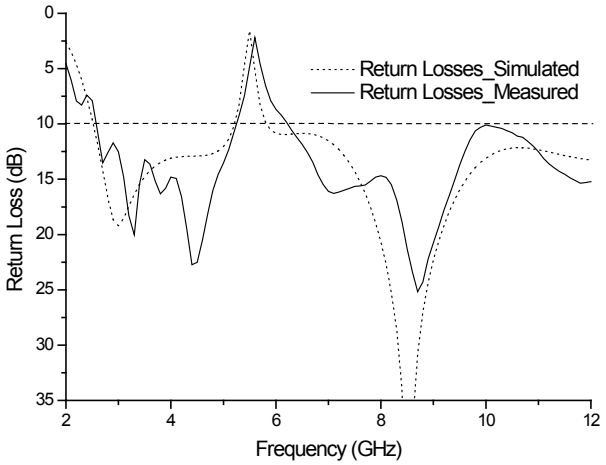
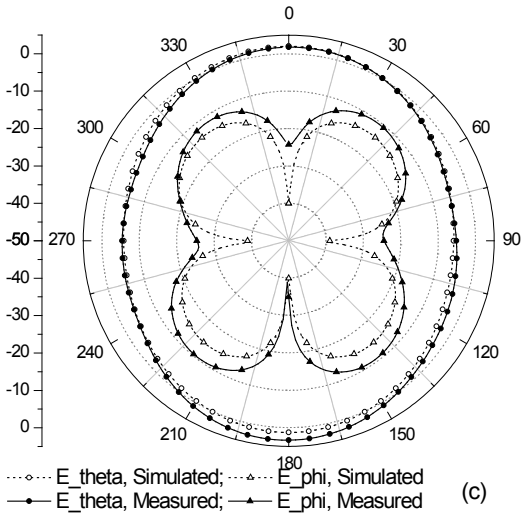
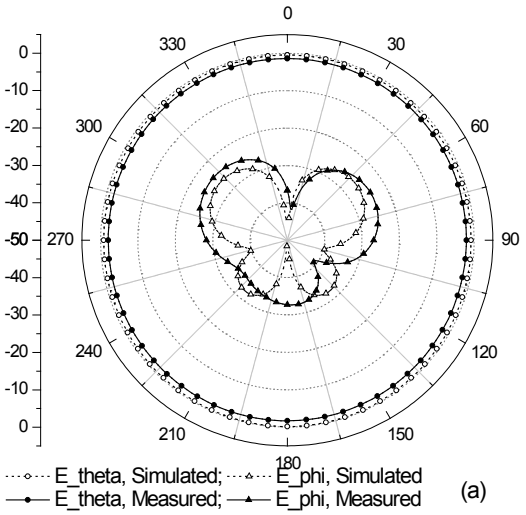
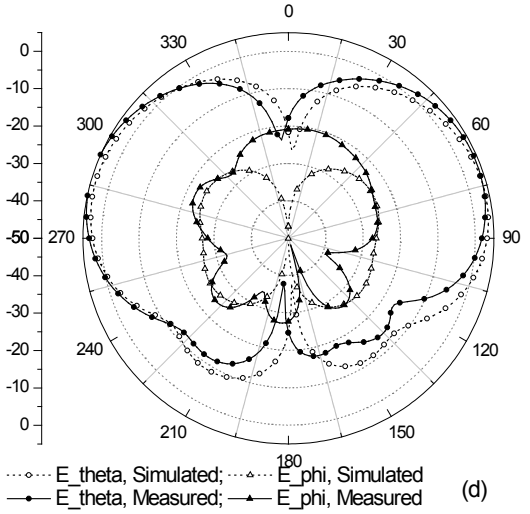
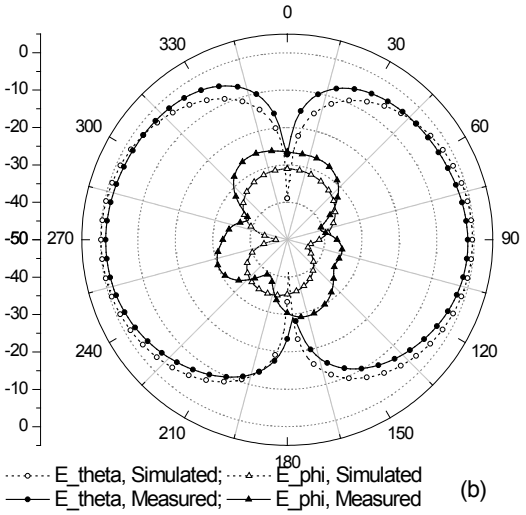


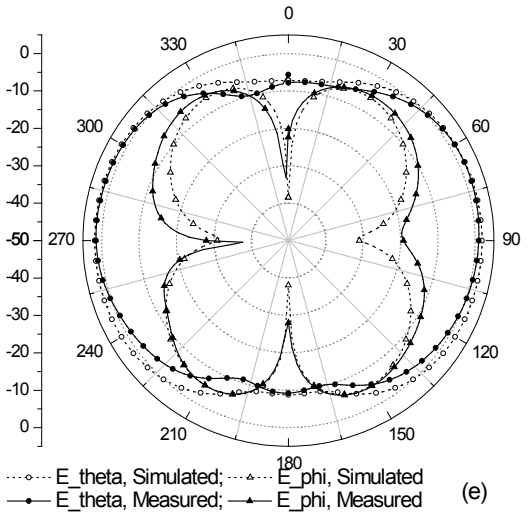
Fig. 4 Simulated and measured return loss of proposed antenna.











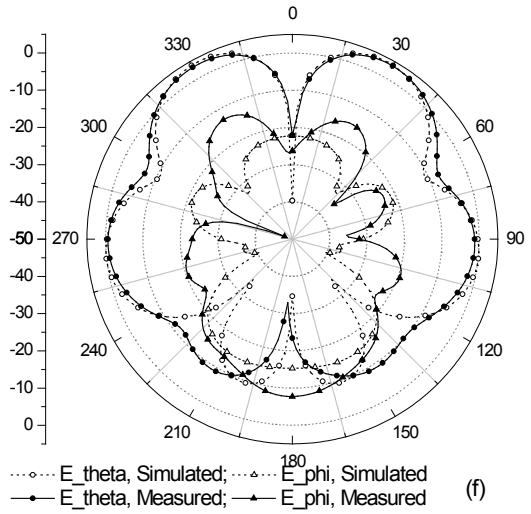


Fig. 5 Simulated and measured radiation patterns of proposed antenna. (a) 3 GHz in x-y plane; (b) 3 GHz in x-z plane; (c) 7 GHz in x-y plane; (d) 7 GHz in x-z plane; (e) 12 GHz in x-y plane; and (f) 12 GHz in x-z plane.

Finally, the simulated and measured peak gains of the antenna are shown in Figs. 6. The average peak gain is about 3.5 dBi over most of the UWB operating frequency range. However, significant reductions in peak gain can be seen at the notched band where the antenna gain is suppressed to -5.4 dBi. All these results indicate that the simple ground stubs works effectively to introduce a single band-notched characteristic for the antenna.

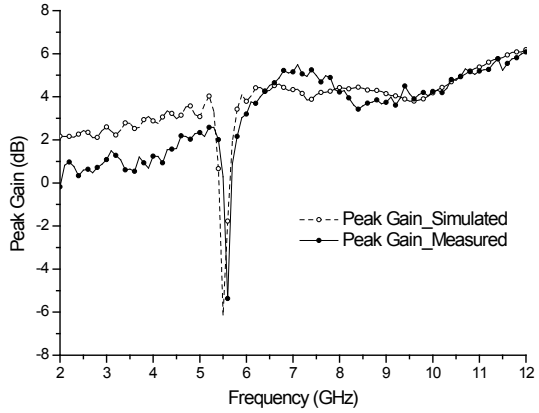


Fig. 6 Simulated and measured peak gains of proposed antenna.

IV. CONCLUSIONS

In this paper, a pair of very simple ground stubs has been proposed to design a single band-notched characteristic for the compact planar-monopole UWB antennas. The proposed idea has been used to design a compact UWB antenna. Studies using computer simulation and measurement on the return loss, antenna patterns, and peak gains of the UWB antenna have been carried out. Results have shown that the antenna has approximately omnidirectional radiation patterns with good band notched performances.

REFERENCES

[1] "Federal Communications Commission Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems," FCC, 2002, First Report and Order FCC, 02.V48.

[2] K. Kim, Y. Cho, S. Hwang, and S. Park, "Band-notched UWB planar monopole antenna with two parasitic patches," *Electron. Lett.*, vol. 41, no. 14, pp. 783–785, Jul. 2005.

[3] T. G. Ma and S. J. Wu, "Ultrawideband band-notched folded strip monopole antenna," *IEEE Trans. Antennas Propag.*, vol. 55, no. 9, pp. 2473–2479, Sep. 2007.

[4] J. Kim, C. S. Cho and J. W. Lee, "5.2 GHz notched ultra-wideband antenna using slot-type SRR," *Electron. Lett.*, vol. 42, no. 6, pp. 315–316, Mar. 2006.

[5] S.W. Qu, J.L. Li and Q. Xue, "A Band-Notched Ultrawideband Printed Monopole Antenna," *IEEE Antennas and Wireless Progag Lett*, vol. 5, pp. 495-498, 2006.

[6] Y.F. Weng, S.W. Cheung and T.I. Yuk, "An Antenna For UWB and Bluetooth Standards with Band-Notched Characteristic" 2009 IEEE International Conference on Ultra-Wideband (ICUWB), 9-11 September 2009, Vancouver, Canada.

[7] Y.F. Weng, S.W. Cheung and T.I. Yuk, "Ultra-Wideband Antenna Using CPW Resonators for Dual-Band Notched Characteristic" 2009 International Conference on Wireless Communications & Signal Processing, 13-15 Nov 2009, Nanjing, China

[8] Y.F. Weng, W.J. Lu, S.W. Cheung and T.I. Yuk, "UWB Antenna with Single or Dual-Band Notched Characteristic for WLAN Band using Meandered Ground Stubs" 2009 Loughborough Antennas & Propagation Conference, 16-17 November 2009, Loughborough, UK.

[9] Availanle on: http://www.cst.com.