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Novel band-notched UWB antenna for WUSB system

He Xiaoxiang Deng Hongwei

(College of Information Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China)

Abstract: A simple and compact microstrip-fed ultra wideband (UWB) printed monopole antenna with band-notched performance is proposed for wireless universal serial-bus (WUSB). The antenna is composed of a U-shaped line radiator and a small strip bar and is partially grounded, so that the measured impedance bandwidth of the antenna is about 7. 88 GHz covering 3. 12 to 11 GHz with VSWR below 2, and the expected band rejection of 5. 06 to 5. 89 GHz is also obtained. The characteristics of the proposed antenna are analyzed, and the geometric parameters for optimal performance are investigated in detail. A relatively stable, quasi-omnidirectional and quasi-symmetrical radiation pattern is also found. The proposed band-notched UWB antenna requires no external filters to avoid interference with other systems, and thus, greatly simplifies the system design of an ultra wideband WUSB communication system.

Key words: wireless universal serial-bus (WUSB); printed antenna; monopole antenna; ultra wideband (UWB); band-notched

In the short-range communications[1] of a wireless personal area-network (WPAN) containing consumer electronics (CE) and computer-associated devices, a combination of wired universal serial-bus (USB) technologies and ultra wideband (UWB) wireless technologies is needed. The wireless universal serial-bus (WUSB) provides instant UWB connectivity for a wide range of devices[2]. A high performance antenna with high data rates and high-speed interconnects and low-power consumption is important for short-distance wireless communications under 10 m in the WUSB system[3].

Recently, a considerable amount of researches have been devoted to the development of an ultra wideband (UWB) antennas[4] in order to enable high data transmission rates, low power consumption and simple hardware configuration in the WUSB system. The UWB antennas of such systems are also required for small-size, non-dispersive and wideband properties. In 2002, the commercial applications of the frequency band from 3. 1 to 10. 6 GHz were approved by the Federal Communications Commission (FCC) in America. Besides the considerations of ultra wideband performance, the designation of antennas for UWB communication also needs a band-rejection filter to avoid interference with existing wireless networks with standards such as IEEE 802. 11a in the USA (5. 15 to 5. 35 GHz, 5. 725 to 5. 825 GHz) and HIPERLAN/2 in Europe (5. 15 to 5. 35 GHz, 5. 47 to 5. 725 GHz)[5]. As a result, UWB transmitters cannot cause any electro-magnetic interference on nearby communication systems such as wireless LAN (WLAN) applications. However, the use of a filter can increase the complexity of the UWB system. To tackle this problem, many novel UWB planar antennas[6-13] with band-notched characteristics have been presented. In these designs, the filter can be eliminated and the radio frequency systems can be simplified. Among the newly proposed UWB antenna designs, the printed monopole antennas[8-13] have received much attention due to their wideband matching characteristics, omnidirectional radiation patterns, high radiation efficiency and compact size. These antennas make use of different structures to meet the requirements of return loss and radiation patterns. These structures include the following configurations: two monopoles with a small strip bar[8], half-bowtie shape[9], a coplanar waveguide (CPW) resonant cell (CCRC)[10], and a new folded strip monopole antenna with band-notched characteristics[11]. Furthermore, other antennas are shaped as a planar half-ellipse-shaped radiation patch[12] and a main patch with a inverted U-slot[13] etc. The time domain performances of these monopoles are investigated by either simulation or measurement or by both.

In this paper, a novel and compact ultra wideband printed monopole antenna with the band-notched performance for WUSB applications is proposed. To achieve ultra wideband and band-notched characteristics, the proposed antenna consists of a U-shaped line and a small strip bar. The measured frequency bandwidth with VSWR below 2 of the antenna covers 3. 12 to 11 GHz with expected band rejection of 5. 06 to 5. 89 GHz, which satisfies the WUSB system requirements very well.

1 Antenna Design

The fabricated UWB antenna is shown in Fig. 1 and the geometry of the proposed microstrip-fed monopole antenna is illustrated in Fig. 2. The antenna is fed with 50 Ω microstrip line and is printed on the FR4 substrate ($L_{sub} \times W_{sub}$) with the height (h) of 1. 5 mm and relative permittivity ε_r =

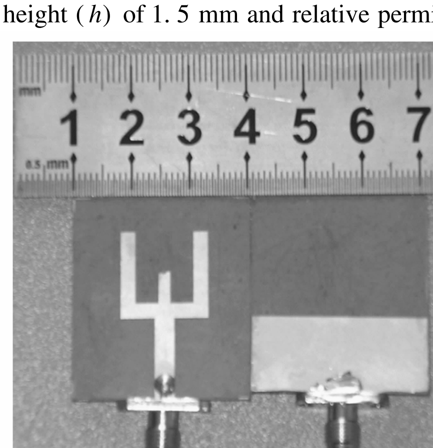

Fig. 1 Antenna prototype (front view and back view)

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Biography: He Xiaoxiang(1976—), male, doctor, associate professor, eexxhe@ nuaa. edu. cn.

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3. 5. The ground plane has the dimension of $W_{sub} \times L_g$ so that ultra wideband characteristic is obtained. To avoid the interference, the strip bar with the dimension of $W_s \times L_s$ is located in the U-shaped line radiator.

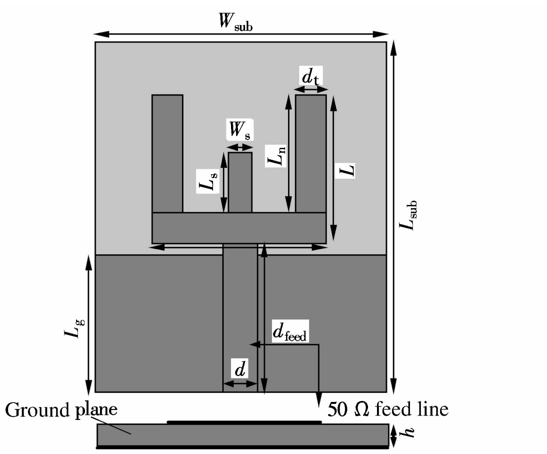

Fig. 2 The geometry of the proposed UWB band-notched antenna

A band-notched characteristic is mainly controlled by the length (L_s, W_s) of the small strip bar, and the length (L) of the monopole mainly determines the first and second resonant frequency of the monopole antenna. The first and second resonant frequencies (f_1, f_2) are determined by[8]

$$f_1 = \frac{c}{2L_1\sqrt{\varepsilon_r}} \tag{1}$$

$$f_2 = \frac{c}{2L_2\sqrt{\varepsilon_r}} \tag{2}$$

where

$$L_1 = L + \frac{W-d}{2} \tag{3}$$

$$L_2 = L_n + \frac{W-d}{2} \tag{4}$$

The strip bar length L_s at the centre of the radiator is approximately determined by

$$L_s = \frac{\lambda_g}{4} = \frac{\lambda_0}{4\sqrt{\varepsilon_r}} = \frac{c}{4f_n\sqrt{\varepsilon_r}} \tag{5}$$

where c is the speed of light and f_n is the central band-notched frequency. The parameters of the proposed antenna are optimized with Ansoft HFSS after the calculation with the formulations outlined above. The main parameters of the antenna are shown in Tab. 1.

2 Antenna Characteristics

To verify the high performance of the proposed antenna, VSWR is simulated using Ansoft HFSS and measured with a vector network analyzer of the Agilent Company (N5230A). The simulated and measured results are plotted and compared in Fig. 3. It can be seen that, the two results are in fairly good agreement. The antenna covers a 7. 88 GHz bandwidth from 3. 12 to 11 GHz with a rejected band

Tab. 1 Geometry dimensions of the antenna

Parameters	Size/mm
L	15
W	15
L_s	5. 5
W_s	2
L_g	13
d_{feed}	14
L_{sub}	35
W_{sub}	31
d	3. 3
d_t	2. 5
L_n	12. 5

from 5. 06 GHz to 5. 89 GHz, which completely satisfies the WUSB system requirements. When the strip bar is eliminated, the band-notched performance of the antenna disappears, as are the measured and simulated results plotted in Fig. 3. As a result, the small strip bar plays an important role as a band-notched filter to eliminate the limited band as is expected.

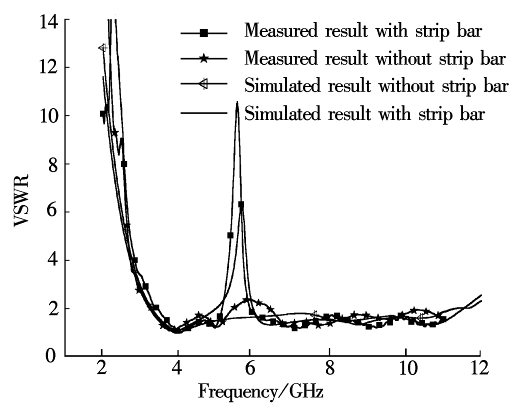

Fig. 3 Measured and simulated VSWR of the antenna

Furthermore, the effects of the length (L_s) and width (W_s) of the strip bar on the band-notched performance of the antenna are investigated thoroughly with the other parameters unchanged. Return loss of the antenna with different lengths and widths of the strip bar are simulated and plotted in Figs. 4(a) and (b). As the length of the strip bar increases from 5. 1 to 5. 9 mm, the central frequency of the rejected-band varies from 6. 11 to 5. 18 GHz almost linearly and the bandwidth is decreased. On the other hand, as the width (W_s) of the strip bar increases from 1. 5 to 2. 5 mm, it is clear from Fig. 5 that the bandwidth and the centre frequency of the rejected-band increase slightly. Generally speaking, from the simulation results shown in Figs. 4(a) and (b), it can be concluded that the notched-band is affected by the length and width of the strip bar. The bar has almost no effect on the return loss of the other band for its inherent bandwidth.

As shown in Fig. 4(c), when the length of the U-shaped strip increases from 14. 5 to 15. 5 mm and the other parameters are unchanged, the first central frequency decreases almost linearly from 4. 09 to 3. 95 GHz, which agrees fairly well with the calculation results of Eq. (1) (declines from 4. 020 to 3. 688 GHz). For the U-shaped printed monopole,

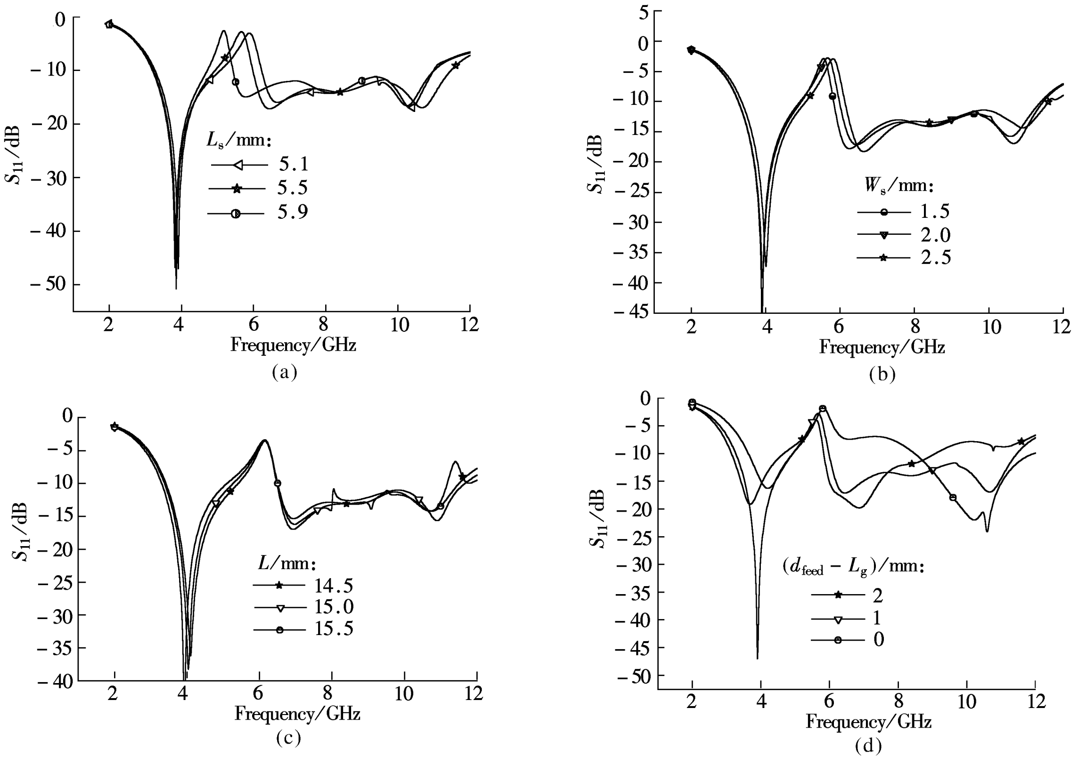

Fig. 4 Return loss optimization of the antenna. (a) Simulated return loss for different lengths of the strip bar; (b) Simulated return loss for different widths of the strip bar; (c) Simulated return loss for different lengths of the U-shaped strip; (d) Simulated return loss for different lengths of the ground plane

the ground plane serves as an impedance-matching circuit. The length of the horizontal gap between the patch and the ground has an important effect on the whole band performance as shown in Fig. 4(d).

Fig. 5 shows the measured gains of the proposed antenna. The gain in the low frequency band is about 3 dBi, and in the high frequency band about 1 dBi, and the sharp decrease of the antenna gain is observed in the notched frequency band. Although the gain in the high frequency band is not very large, it is fairly stable compared to the frequency. As a result, the antenna is almost non-dispersive in the band of 6.5 to 11 GHz. Radiation patterns at different frequency points are also investigated, the patterns in the H-plane are measured, as shown in Fig. 6. The quasi-omnidirectional and symmetrical patterns in the y-z plane in the whole band are obtained, which are necessary in the WUSB communication system. The quasi-omnidirectional performance in the high frequency band is worse due to interference of high modes. The patterns in the E-plane simulated with HFSS are also presented in Fig. 7.

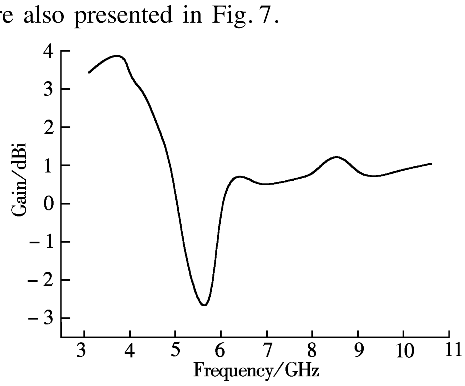

Fig. 5 Measured antenna gain

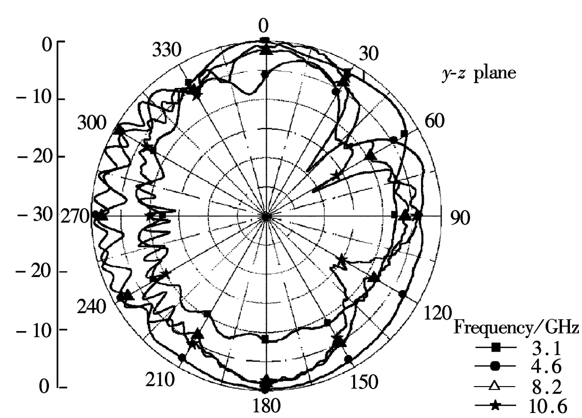

Fig. 6 Measured radiation pattern in H-plane

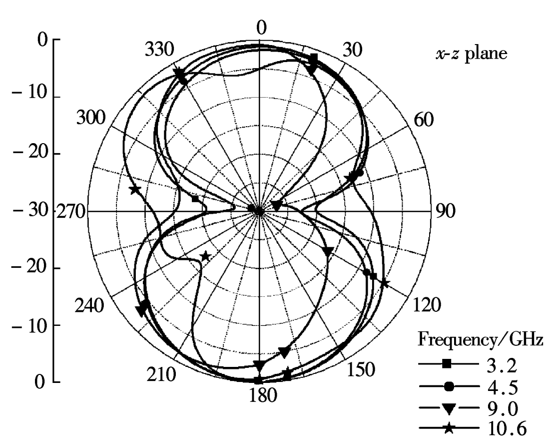

Fig. 7 Simulated radiation pattern in E-plane

3 Conclusion

A novel and compact wide-band microstrip-fed monopole antenna with band-notched characteristic for WUSB applications is proposed. To achieve wideband and band-notched characteristics, the antenna consists of a U-shaped line radiator with a small strip bar. The band-notched UWB antenna is designed, simulated, measured and analyzed in detail in this paper. The measured or simulated results validate that the antenna satisfies the requirements of WUSB communications. Valuable future research can concentrate on the minimization of the antenna.

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References

[1] Zhang Hua, Zhao Hongxin, Hong Wei. Design of 2. 14 GHz RF module for short-range wireless communications [J]. *Journal of Southeast University*: *Natural Science Edition*, 2004, **34**(1): 10 − 14. (in Chinese)

[2] Su Saou-Wen, Chou Jui-Hung, Wong Kin-Lu. Internal ultra-wideband monopole antenna for wireless USB dongle applications [J]. *IEEE Trans on AP*, 2007, **55**(4): 1180 − 1183.

[3] Wong K L, Wu C H, Su S W. Ultra-wideband square planar metal-plate monopole antenna with a trident-shaped feeding strip [J]. *IEEE Trans on AP*, 2005, **53**(4): 1262 − 1269.

[4] Zhong Shunshi, Liang Xianling, Yan Xiaorong. UWB planar antenna technology [J]. *Chinese Journal of Radio Science*, 2007, **22**(2): 309 − 315. (in Chinese)

[5] Schantz H G, Wolenec G, Myszka E M. Frequency notched UWB antennas [C]//2003 *IEEE Conference on Ultra Wideband Systems and Technologies*. 2003: 214 − 218.

[6] Cheng Yong, Lü Wenjun, Cheng Chonghu, et al. Compact frequency notched ultra-wideband antenna for multiple application [J]. *Journal on Communications*, 2006, **27**(4): 131 − 135. (in Chinese)

[7] Kerkhoff Aaron J, Ling Hao. Design of a band-notched planar monopole antenna using genetic algorithm optimization [J]. *IEEE Trans on AP*, 2007, **55**(3): 604 − 610.

[8] Chung K, Hong S, Choi J. Ultrawide-band printed monopole antenna with band-notch filter [J]. *IET Microw Antennas Propag*, 2007, **1**(2): 518 − 522.

[9] Cho Young Jun, Kim Ki Hak, Hwang Soon Ho, et al. A miniature UWB planar monopole antenna with 5 GHz band-rejection filter and the time-domain characteristics [J]. *IEEE Trans on AP*, 2006, **54**(5): 1453 − 1460.

[10] Qu Shiwei, Li Jialin, Xue Quan. A band-notched ultrawideband printed monopole antenna [J]. *IEEE Antennas and Wireless Propagation Letters*, 2006, **5**: 495 − 498.

[11] Ma Tzyh-Ghuang, Wu Sung-Jung. Ultrawideband band-notched folded strip monopole antenna [J]. *IEEE Trans on AP*, 2007, **55**(9): 2473 − 2479.

[12] Kim Ki-Hak, Park Seong-Ook. Analysis of the small band-rejected antenna with the parasitic strip for UWB [J]. *IEEE Trans on AP*, 2006, **54**(6): 1688 − 1692.

[13] Chung Kyungho, Kim Jaemoung, Choi Jaehoon. Wideband microstrip-fed monopole antenna having frequency band-notch function [J]. *IEEE Microwave and Wireless Components Letters*, 2005, **15**(11): 766 − 768.

WUSB 中新型带陷 UWB 天线

何小祥　　邓宏伟

(南京航空航天大学信息科学与技术学院,南京 210016)

摘要:给出了一种紧凑的可用于 WUSB 的新型带陷超宽带印刷单极子天线. 天线由内嵌条带的 U 形环组成并采用部分接地技术,从而使天线具有带陷超宽带特性. 实测结果表明该天线输入端驻波比小于 2 的绝对阻抗带宽为 7. 88 GHz,覆盖了 3. 12 ~11 GHz 的频率范围,其中 5. 06 ~5. 89 GHz 范围内具有带阻特性. 讨论了各几何参数对天线性能的影响,同时获得了该天线相对稳定的、近似全向且对称的测试方向图. 由于此种天线无需额外的带阻滤波器来隔离天线与其他通信系统的干扰,从而大大简化了 WUSB 系统的设计.

关键词:WUSB;印刷天线;单极子天线;超宽带;带陷

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