A Novel Monopole Antenna with a Band Notch Design for Ultra-Wideband Applications

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1. Introduction

In February 2002 the Federal Communications Commission (FCC) in the United States released unlicensed frequency band of 3.1 to 10.6 GHz for commercial communication applications [1]. So far, ultra wide band (UWB) technique had become the first candidate of short-range high-speed wireless communication systems. The antenna is an important component, which determines the performance of UWB systems; moreover one of principal subjects in UWB device is to design a compact antenna. Recently, UWB antenna development tends to concentrate on small planar antennas [2–3]. UWB antennas are also necessary for the rejection of an interference with existing wireless networking technologies such as IEEE 802.11a in the U.S. (5.15~5.35 GHz, 5.725~5.825 GHz) and HIPERLAN/2 in Europe (5.15~5.35 GHz, 5.47~5.725 GHz) [4-7]. This is due to the fact that UWB transmitters should not cause any electromagnetic interference on nearby communication system such as wireless local area network (WLAN) applications. Therefore, UWB antennas with notched characteristics in WLAN frequency band are desired. To fulfill this requirement, an UWB antenna with a band-stop characteristic is therefore expected. So far, several UWB antennas with the frequency-notch function have been reported. The advantages of slot antennas include wide bandwidth performance and low cost in the printed circuit board process, and also CPW fed slot antenna also have wide bandwidth and easy integration with monolithic microwave integrated circuits.

2. Antenna Design

Fig. 1 shows the geometry and configuration of the proposed antenna. The antenna consists of an accessional ground plane, CPW-fed wide-slot, and a staircase shape radiator with split-loop slit. The proposed antenna has a small size of 14 × 25 mm^2 ($H_o \times W_o$), is printed on one side of a FR4 substrate with thickness of 1.6 mm and relative permittivity of 4.4. The CPW-fed line Ws is fixed at 2.5 mm and the distance of the gap G between the line and the symmetric ground planes is fixed at 0.3 mm to achieve 50 Ω characteristics impedance. The special is inner wide-slot antenna which also has a smaller radiation conductor size of 5 × 7 mm^2 lied within a compact wide-slot size of 9.6 × 21 mm^2 ($H_i \times W_i$). The radiator size can be reduced, which is more than 88 % reduction in comparison with the traditional wide-slot antenna. A half-wavelength split-loop slit resonator designed at the center frequency of the notch-band frequency. The optimized dimensions for the proposed antenna are as follows: W_o = 25, H_o = 14, W_i = 2.1, H_i = 2.7, H_a = 1.5, W_a = 2.6, H_c = 2, H_e = 1.4, H_d = 1, W_d = 1.2, G = 0.3, W_s = 2.5, W = 2.9, H_g = 1.6, W_g = 2.1, W_u = 4, H_u = 1.1, S = 0.3 (unit: mm).

3. Results and Discussions

Simulation design for the proposed antenna is carried out on the full wave simulator. For comparison, the simulated VSWR for the proposed antenna without the inserted split-loop slit is also plotted in Fig. 2. The proposed antenna without split-loop slit operates over 3.0 to 11.0 GHz for VSWR ≤ 2. It is seen that the split-loop slit antenna clearly provides a frequency-notch function. The proposed antenna with split-loop slit provides a sufficiently wide impedance bandwidth of 8 GHz (3~11 GHz), as required by the entire UWB band (3.1~10.6 GHz), and has a frequency notch of 1 GHz (5~6 GHz) for band rejection of the IEEE 802.11a frequency band (5.15~5.825 GHz). Figs. 3(a) and 3(b) show the simulated VSWR for the proposed antenna with various different lengths and widths of the split-loop slit, respectively. Fig. 3(a) shows that the length of split-loop slit may affect the center frequencies from 5.2 to 6 GHz. Fig. 3(b) shows that the width of split-loop slit may affect the center frequencies from 5.2 to 5.7 GHz. Typical radiation characteristics of the frequencies across UWB band for the proposed antenna are also examined. Figs. 4(a)-(f) show the measured far-field radiation patterns, including the co-polarization and cross-polarization in the elevation direction (*x*-*z* planes) and azimuthal direction (*x*-*y* plane) for the proposed antenna at 3.4, 6.35, and 9.41 GHz, respectively. The center frequency notch of antenna is 5.5 GHz. Due to the symmetry in structure, rather symmetrical radiation patterns are seen in the *x*-*z* and *y*-*z* planes, as depicted in the plots.

4. Conclusions

A miniaturized band-notched UWB wide-slot CPW-fed monopole antenna has been presented along with experimental and numerical results. The frequency-notch function was easily achieved by inserting slit into the antenna. By properly adjusting the dimensions of the inserted slit, the proposed antenna revealed good UWB performance, accompanied by a band-rejection function in order to avoid interference caused from the IEEE 802.11a system.

References

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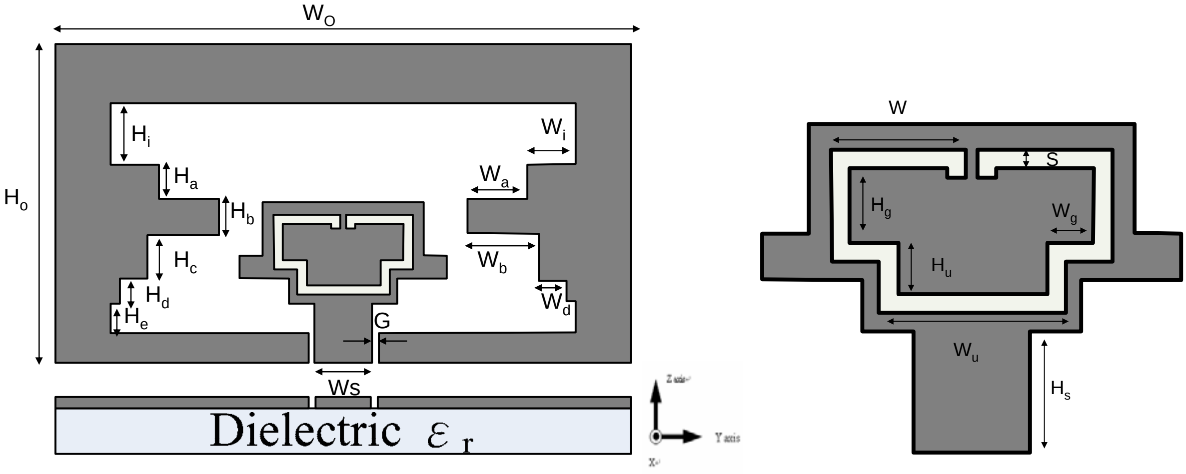


(a) (b)

Fig. 1 The proposed 5~6 GHz notched UWB antenna (a) Geometry and configuration; (b) Split-loop slit inner the radiator

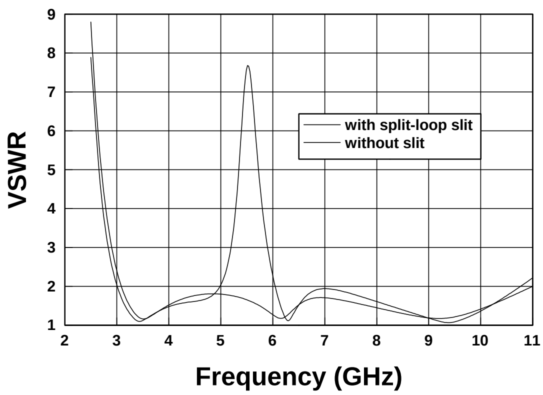
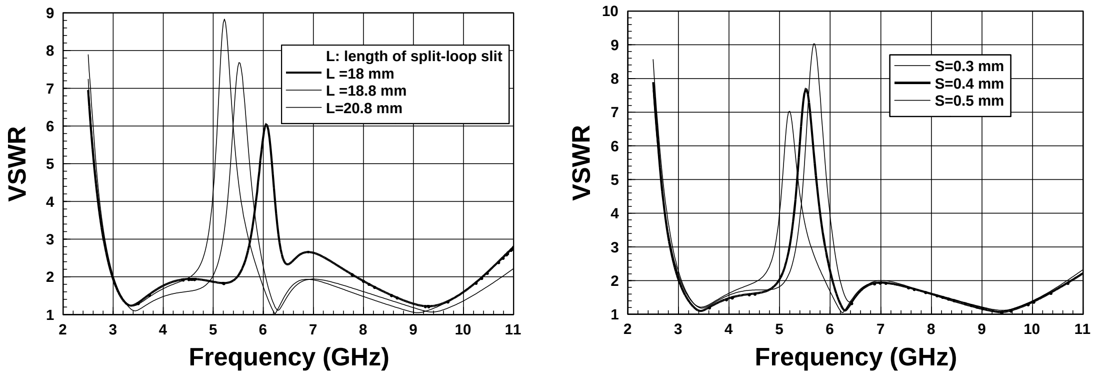
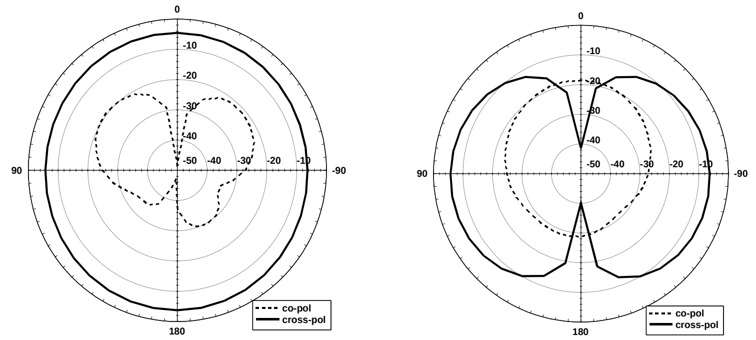


Fig. 2 Simulated VSWR for the band-notch UWB antenna with split- loop slit and without slit

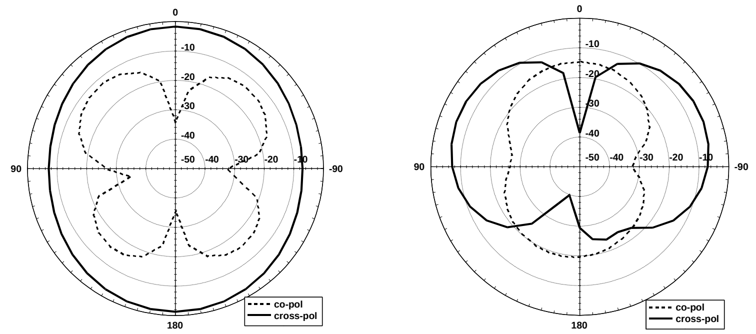


(a) (b)

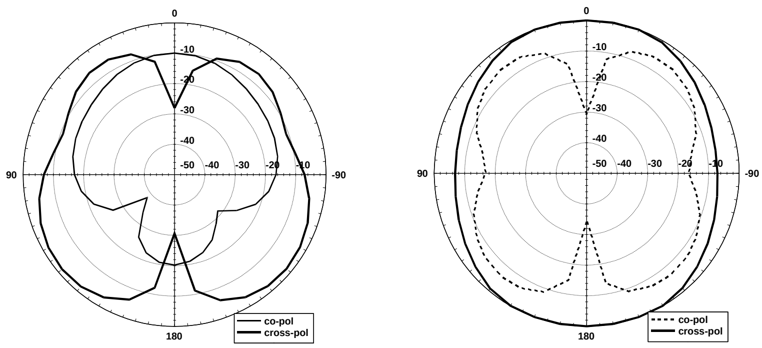
Fig. 3 Effects of the various parameters on VSWR (a) Total length of split- loop slit; (b) Width of split-loop slit



(a) x-y plane (b) x-z plane



(c) x-y plane (d) x-z plane



(e) x-y plane (f) x-z plane

Fig. 4 Simulated radiation patterns for 5~6 GHz notched UWB proposed antenna (a)~(b) 3.4 GHz; (c)~(d) 6.35 GHz; (e)~(f) 9.41 GHz