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Design of a Band-rejected UWB Planar Monopole Antenna with two parasitic Patches

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1. Introduction

Since a technique of ultra wide-band(UWB) system had been developed, there has been rapid growth of broad band antenna techniques. Since UWB antennas have typically been designed with a specification of constant gain and linear phase response. Among existing antennas, planar monopole antennas are very suitable for UWB applications due to the good impedance matching, stable radiation patterns, and high efficiency over bandwidths. In accordance with the regulations released by FCC, the UWB systems have been collocated to the bandwidth from 3.1 to 10.6 GHz. However, the use of 5.15~5.825GHz band is limited by IEEE 802.11a and HIPERLNA/2. Therefore, a band-rejection filter should be necessary in UWB RF front-ends, and this will provide complication for UWB system.

To overcome this disadvantage, several antennas with band-rejected characteristic have been researched due to the advantages of composing more simply RF front-end [1]-[2]. In this paper, a parametric study of a planar monopole antenna with a simple band-notching feature is presented. The proposed antenna is designed to reject the limited band by attaching two parasitic patches on the bottom layer of the antenna. This antenna not only satisfies all UWB band but also rejects the limited band in order to avoid possible interference with the existing 5.15~5.825GHz band. Moreover, the proposed antenna has a planar structure of small size and omni-directional pattern. Their features are very attractive to UWB application.

2. Antenna Design

Fig. 1 shows the geometry of the proposed planar monopole antenna. This antenna is printed on an FR4 substrate with thickness of 1mm and relative permittivity of 4.6. The proposed antenna is composed of the radiation patch, partial ground, steps, and two parasitic patches. The antenna size is

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30 x 30 mm^2 and has feeding structure of a 50Ω microstrip line. The radiation patch was fabricated as bow-tie shape in order to enhance the bandwidth. The top arch shape, steps, and h of radiation patch were optimized to cover the low frequency of UWB band. The dimensions of step1, step2, and step3 are 0.5 x 0.5 mm^2, 0.5 x 0.75 mm^2, and 0.75 x 0.75 mm^2, respectively. The edge of ground was constructed as an arch shape in order to improve higher frequency of UWB band. Two parasitic patches have the dimensions of 1 x 16 mm^2. They play a role as filter to reject the limited band, 5.15~5.825 GHz. Fig. 2 shows the measured results for the proposed antenna in terms of a different values of L, that is, various lengths of parasitic patches. For L = 14, 16, and 18 mm with other dimensions fixed, their respective lengths correspond approximately to a quarter-wavelength of the frequency at about 6, 5.5, and 5 GHz, respectively. It means that the notch frequency can be changed by tuning the length L. The proposed antenna has L = 16mm due to rejecting the limited band, 5.15~5.825 GHz. At the notch frequency, the current flows are more dominant around the parasitic patch, and they are oppositely directed between the parasitic patch and the radiation patch [3]. This causes the antenna to be operated as a transmission line-like mode and transforms the antenna input impedance to be nearly equal to zero at the notch frequency.

3. Result

The antenna dimensions depicted in Fig. 1 are selected with the band rejection to operate at a bandwidth between 3GHz and 18GHz (VSWR below 2) with the band rejection 5.1~6GHz. The antenna geometry was fabricated and measured using an HP8722D network analyzer. To design and analyze the proposed antenna, simulation was carried out using CST MICROWAVE STUDIO to understand the behavior of the antenna model and optimize the suitable parameters. The measured and simulated results of the VSWR for the optimized dimensions are shown in Fig. 3. It is apparent that the proposed antenna can satisfy the UWB band (3.1~10.6) GHz released by FCC for VSWR<2 with rejecting 5.1~6GHz band, which includes the limited band by IEEE802.11a and HIPERLAN/2. By attaching two parasitic patches, it is clearly observed that the proposed antenna has not only the notched band, but also more improved bandwidth at low frequency region.

The radiation patterns of the proposed antenna were numerically calculated using CST MICROWAVE STUDIO, and compared with the measured values. The measured and simulated radiation patterns of the proposed antenna in elevation planes are shown in Fig. 4. The measured and simulated results agree well with each other. As shown in Fig. 4, the proposed antenna has an acceptable omnidirectional radiation pattern. However, as the frequency goes higher, the patterns are tilting somewhat upward from the horizontal plane. Fig. 5 shows the measured gain of the proposed antenna with and without the parasitic patches. A sharp decrease in antenna gain in the notched frequency band at 5.5GHz can be observed. For other frequencies outside the notched frequency band, the antenna gain is about the same for both proposed antenna with and without the parasitic patches.

4. Conclusion

A band-notched UWB planar monopole antenna with parasitic patches for achieving the band-rejected characteristic has been proposed, and implemented. The proposed antenna indicates not only a broad impedance bandwidth but also a good radiation performance while retaining the small volume of 30 x 30 x 1 mm^3. These features are very attractive for UWB applications.

Reference

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[2] Yongjin kim and Do-Hoon Kwon: 'Planar ultra wide band slot antenna with frequency band notch function'. *IEEE Antennas Propag. Soc. Symp.*, 2004, vol.2, pp. 1788–1791

[3] Kerkhoff, A. and Hao Ling: 'Design of a Planar Monopole Antenna for Use With Ultra-Wideband (UWB) Having a Band-Notched Characteristic', *IEEE Antennas Propag. Soc. Int. Symp.*, 2003, vol.1, pp. 830–833

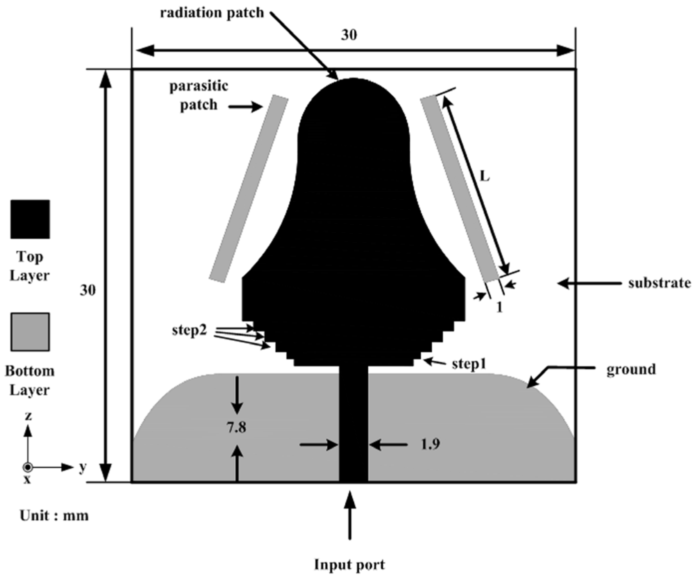


Fig. 1. The geometry of the proposed antenna

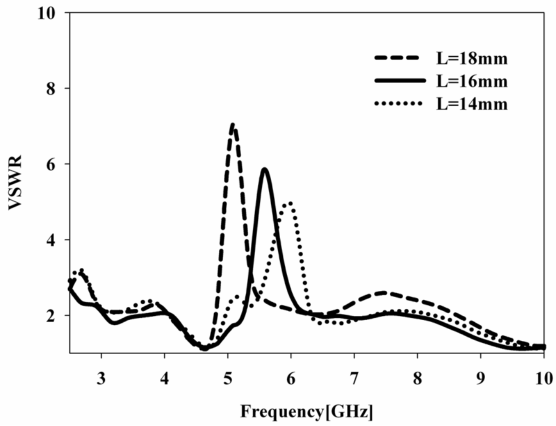


Fig. 2. Measured VSWR for the proposed antenna in terms of L

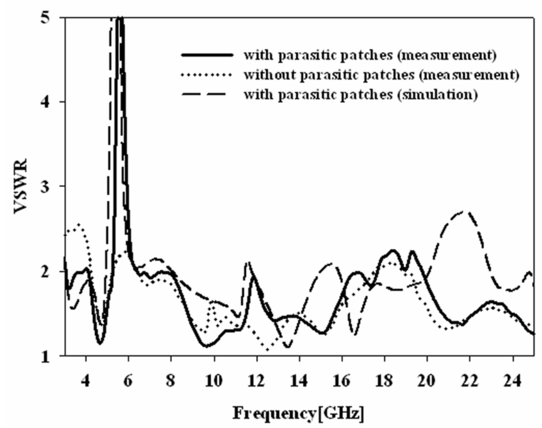
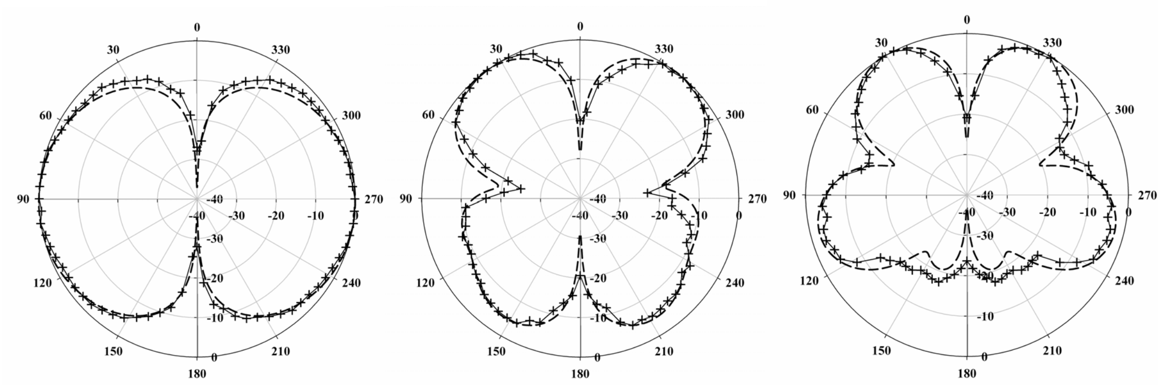


Fig. 3. The comparisions of the measured and simulated VSWR values



(a) at 3GHz (b) at 8GHz (c) at 12GHz

Fig. 4. Measured and simulated elevation radiation patterns
(++++: Measured result, - - - -: Simulated result)

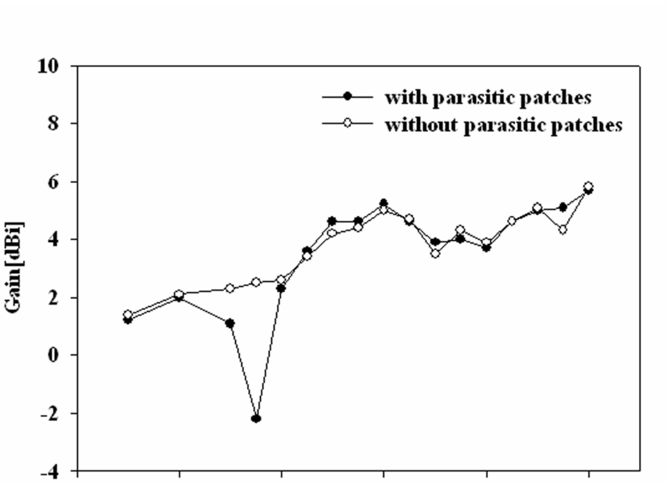


Fig. 5. Measured gain of the proposed antenna