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Planar Ultrawideband Antenna with 5.5GHz Band Dispensation Characteristics

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***Abstract*—A compact and simple design of a CPW-fed planar antenna for ultra-wideband application with a band-notch characteristic is presented. The proposed antenna consists of a rectangular metal patch on a printed circuit board fed by a 50Ω coplanar waveguide (CPW) with an overall size of 32X30X1.6mm^3. By cutting a C-shaped slot in the rectangular radiating patch, a frequency band notch will be created. The proposed antenna yields an impedance bandwidth of 3.1-10.6GHz with VSWR$\leq$2, except the bandwidth of 5-6GHz for WLAN. The bandwidth and central frequency of the notched band can be adjusted with ease by proper selection of C-shaped slot.The parameters simulated by CST Microwave Studio. The antenna is successfully designed and simulated. Showing broadband matched impedance, stable gain and radiation patterns over an operating bandwidth.**

***Index Terms*–CPW-fed UWB antennas, band-notched characteristics,equivalent circuit model.**

I. Introduction

In 2002, the Federal Communications Commission (FCC) allowed ultra-wideband (UWB) communication operating in the band of 3.1-10.6 GHz with a -10 dB bandwidth greater than 500 MHz and a maximum equivalent isotropic radiated power spectral density of -41.3 dBm/MHz. This has triggered a large amount of interest in this area due to the promise of unprecedented wireless data rates and precise positioning in a low-cost consumer radio. UWB has become the most promising solution for future short-range high-data wireless communication applications.These UWB systems feature low system complexity and high immunity to multipath cancellation effects in mobile and in-building environments.UWB antenna is quite susceptible to interference by receiving several narrow band signals of neighboring RF systems, such as IEEE 802.11a and HIPERLAN/2 WLAN systems operating at 5.15-5.825GHz. Thus, it is desirable to design a UWB antenna with band-notched characteristics to avoid the potential interference.

Recently, several UWB antennas with frequency band-notch function have been proposed, such Yi-Cheng Lin et al, [1] discussed the design of three advanced band notched(5-6GHz)UWB rectangular aperture antenna. The antenna structure is simple and the aperture size is compact. Broad impedance bandwidth and stable radiation patterns are obtained. Whereas the ground plane dimension is a bit of large. In practice, when integrated with the system board a different ground plane size. The antenna might need a returning for optimized dimension. Wang-Sang Lee et al, [2] proposed wide band planar monopole antennas with dual band-notched characteristics. This technique is suitable for creating UWB antenna. However, the antenna is not suitable for integration and with compact systems. Because its ground plane is very large and it is perpendicular to the radiator , and hence this antenna not low profile antenna.

In this paper proposed a simple and compact CPW-fed planar UWB antenna with band-notch characterisitcs in 5.5GHz(5-6GHz). The band-notch operation are achieved by etching C-shaped slots in the rectangular metal radiation patch [3]–[5]. It is found that by adjusting the total length of the C-shaped slot to be approximately half-wavelength of the desired notched frequency,a destructive interference can take place ,causing the antenna nonresponsive at that frequency. The ability to provide this band-notch function can minimize the potential interferences between UWB system and WLAN systems. The proposed antenna yields an impedance bandwidth of 3.1-10.6GHz with VSWR$\leq$2, except the bandwidth of 5-6GHz for IEEE802.1la and HIPERLAN/2 WLAN systems. Details of the antenna design and simulation are presented in order to demonstrate the performance of the proposed antenna.

The paper is organized as follows. Section II.(A)Gives result and discussion of UWB antenna.(B) Presents the band-notch characteristics ,SectionIII.Equivalent circuit model,Section IV. Time domain characteristics V.Concludes the findings of this paper.

II. Antenna Configuration and performance

A. UWB Antenna Design and Results

The configuration of the UWB antenna(Referred as Antenna 1) is shown in Fig.1 The antenna was fabricated on a 1.6mm FR4 epoxy substrate with dielectric constant $\varepsilon_r = 4.4$ and loss tangent tanδ=0.02.As shown in the figure,a rectangular radiator is fed by a50Ωcoplanar wave guide (CPW) transmission line. . The antenna and feeding structure are implemented on the same plane,only one layer of substrate with single-sided metallization is used, making the manufacturing of the antenna very easy and extremely low cost. The electromagnetic software CST Microwave studio is employed to perform the design and optimization process [6]–[8]. The final parameters of this antenna.L=32mm,L_1=13.6mm,L_2=3.8mm,L_3=0.5mm,L_4=2mm, L_5=4mm,W=36mm, W_2=3mm.Fig.2 shows VSWR of antenna

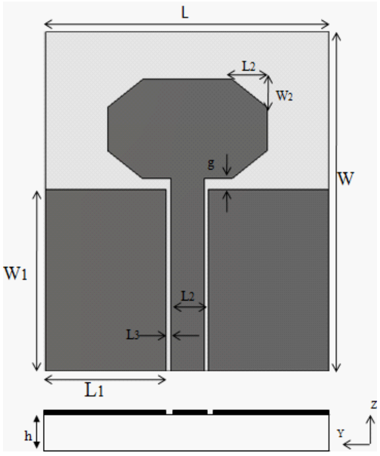


Fig. 1. Geometry and configuration of the UWB Antenna

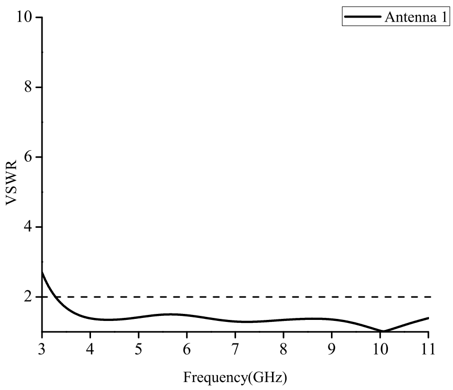


Fig. 2. Simulated VSWR of antenna 1

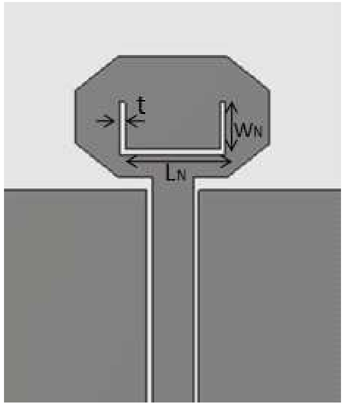


Fig. 3. Geometry and configuration of the Band-Notch Antenna

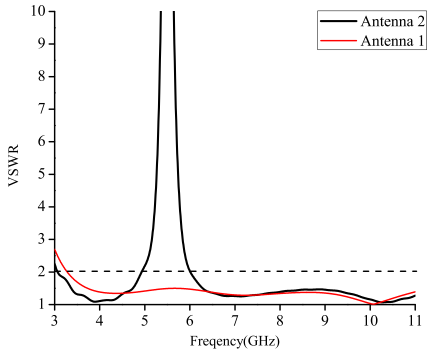


Fig. 4. Simulated VSWR of antenna 2, compared to antenna1

1. If is found that the antenna 1 impedance bandwidth (3.1-10.6GHz) with VSWR$\leq$2.

B. Band-Notched UWB Antenna Design and Results

The UWB system operating between 3.1-10.6GHz causes interference to the existing wireless communication systems. for example the WLAN operating in5.15-5.85GHz. The band rejection filter employed in UWB RF front-ends avoids the interference but gives complications to the UWB system. To overcome this difficult,UWB antenna with a band rejected characteristic is required.Fig.3 shows the geometry and dimensions of the UWB antenna with filtering property operation in the 5-6GHz band.(denoted as Antenna 2)

Fig.4 shows the antenna 2 VSWR with compare to antenna 1 VSWR curve. To investigate on the role of C-shape slot for causing rejected band fig.6. shows current distribution at frequency 3.1&5.5GHz. In 3.1GHz the current distribution mainly flow along the transmission line,while around the C-shaped slot the current is small.At 5.5GHz as show in Fig(b),

$$F_{notch} = \frac{c}{2L\sqrt{\varepsilon_{eff}}} \tag{1}$$

where L is the total length of the C-shaped slot, ε_{eff} is the effective dielectric constant and C is speed of the light. The final design parameter of the C-shaped slot are L_N=9.8mm,W_N=4.7mm, and t=0.5mm. Fig.5 shows the antenna 1 gain is about 2.3-5dBi,it shows antenna 2 sharp gain decrease in 5-6GHz band and good performance at other frequency in the UWB band. the current distribution flows around the C-shaped slot. In this case, impedance mismatch occur,which causes the antenna to be non-responsive at the frequency.The notch frequency given the dimension of the band notched feature can be postulated as [4].The simulated radiated patterns in the H-plane and E-plane of Antenna1 and Antenna2 are plotted in Fig.7(a) and 7(b) respectively. The H-plane radiation patterns are approximately Omni-directional over the entire operation frequencies. The E-plane radiation patterns are same as that of a dipole antenna radiation pattern.

III. Equivalent circuit model

In this section , to discuss the mechanism of the band rejected filtering properties, an equivalent circuit model of the band-notched UWB antenna is presented. The C-shaped slots are modeled as a series stub.Fig.8 shows the conceptual equivalent circuit model [9], [10].

$$FBW = \frac{f_2 - f_1}{f_o} = \frac{1}{Q} \tag{2}$$

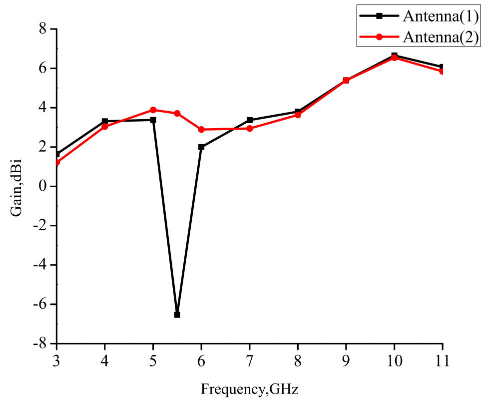


Fig. 5. Simulated Gain of antenna 2, compared to antenna1

$$L = \frac{R_a}{\omega_o Q} \quad (3)$$

$$C = \frac{1}{\omega_o^2 L} \quad (4)$$

Here,FBW represents the fractional bandwidth with the magnitude of the input impedance dropping to 0.707 of its peak value, Q is the quality factor, and ω_o is the center angular frequeny.

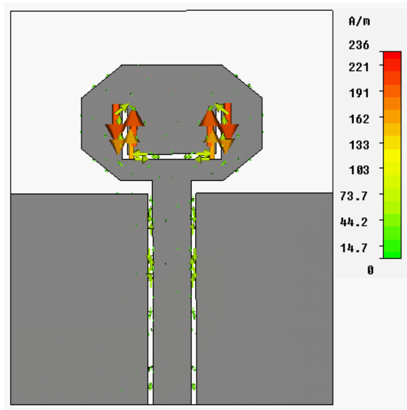
Fig.9 shows the simulated impedance of the band-notch antenna.The resistance and reactance curve in the notch frequency band exhibits a series resonance characteristic. At 5.5 GHz, current is around the C-shaped slot. The impedance is nearly zero(short circuit) at the top of slot and the impedance is nearly zero (short circuit) at the top of slot and the impedance is very high (open circuit) near by the antenna feeding. In this case, the high impedance at the feeding point,in turn, leads to the desired impedance mismatching near the notch frequency at 5.5 GHz.

IV. Time domain characteristics

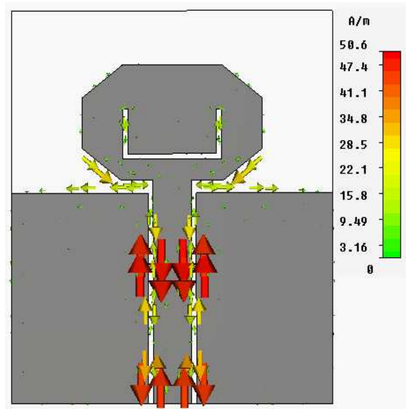
In addition to the distortion characteristic in frequency domain ,it is necessary to consider transmitted and received signal in time domain Fig.10 shows waveforms of transmitted and recevied signal in face to face and side by side receptively To investigate on the similarity of two waveforms well known parameter named correlation factor is proposed [5]. This parameter is shown amount of transmitted signal distortion in location of received antenna. Correlation factor is computed by eq(5).

$$F = \underbrace{max}_{\tau} \left\{ \frac{\int S_1(t) S_2(t-\tau) dt}{\sqrt{\int S_1^2(t) dt} \sqrt{\int S_2^2(t) dt}} \right\} \quad (5)$$

where S_1 and S_2 are transmitted and received signal respectively. If the correlation factor is unit, it means that received signal is same transmitted signal completely and only amplitude of the signal is decrease due to loss of path.But if the correlation factor is less than unit, received signal deviated from transmitted signal. for computing correlation factor, eq(5) is calculated . The transmitted and received signals that obtained from CST microwave studio.



(a)



(b)

Fig. 6. Simulated current distribution at different frequencies (a)3.1GHz (b)5.5GHz

V. Conclusion

In this paper, a CPW-fed patch antenna and its extended band-notched design have been proposed for UWB application. The characteristics of the proposed antennas have been investigated through simulation. The proposed antenna has achieved good impedance matching, consistent gain,and stable radiation patterns over operating frequency band. Furthermore, an extended band-notch design by c-shape slot etched in radiating element. Whereas no returning of the original design is required.

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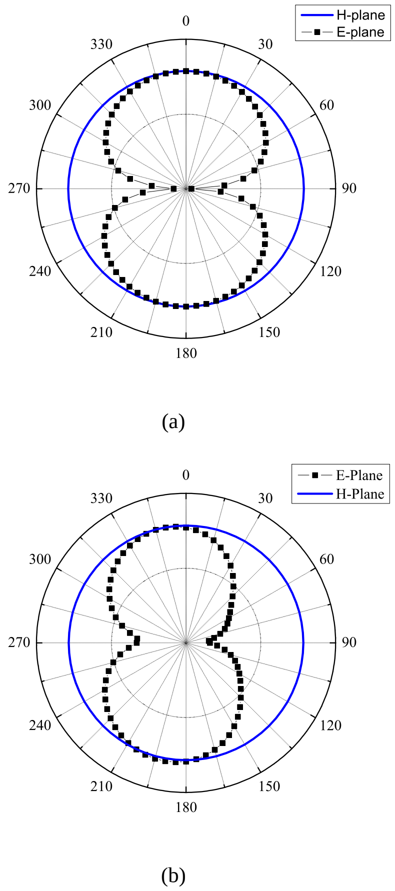

Fig. 7. The simulated radiation patterns at 4GHz and 8.5GHz(a)y-z plane(H-plane) (b)x-z plane (E-plane)

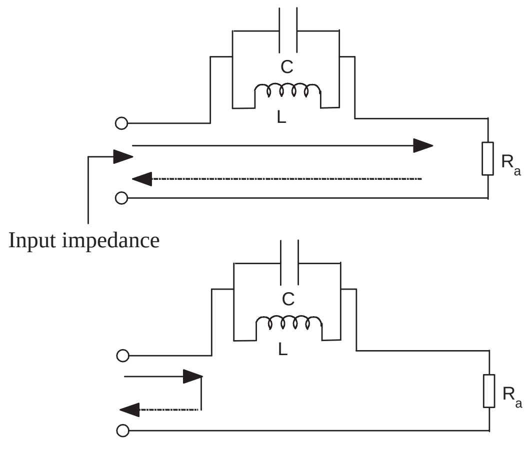

Fig. 8. Equivalent circuit model

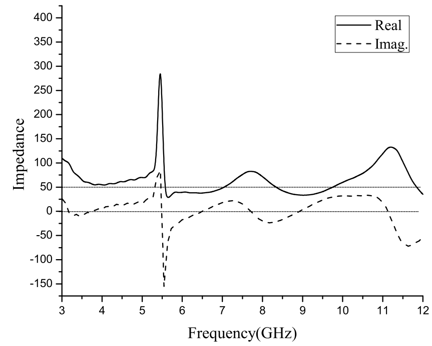

Fig. 9. Simulated impedance of band-notch antenna

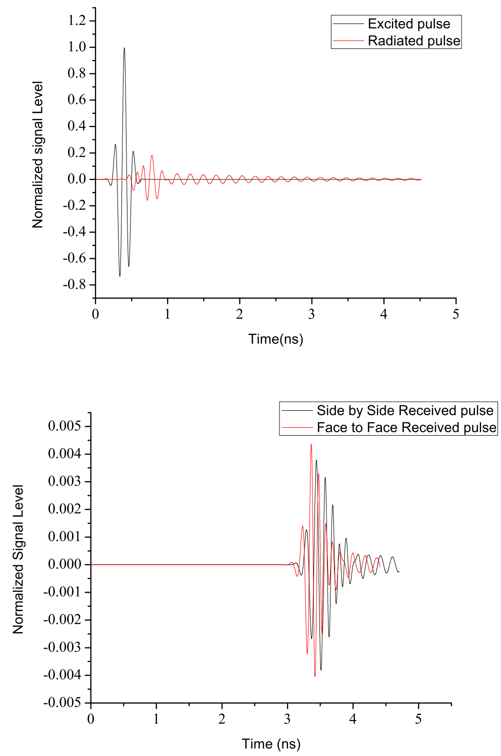

Fig. 10. Time domain of transmitted and received signal

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