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Ultra-Wideband Antenna with C-Slot For WLAN Band Rejection

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Abstract
A compact ultra-wideband (UWB) antenna is proposed with band notched characteristic. The antenna has compact size of 14×18 mm². A novel stepped rectangular slot is inserted on the antenna to obtain good impedance matching and wide bandwidth. An embedded C-slot in the radiating patch avoids potential interference from WLAN band. The simulated results confirm that the antenna has operating frequency band of 4.1 to 12.5 GHz with notched band of 4.9 to 6.1 GHz.

Key Words
Ultra-wideband, Band notched, WLAN

I. Introduction

Ultra-wideband (UWB), a radio transmission technology which occupies an extremely wide bandwidth exceeding the minimum of 500MHz or at least 20% of the centre frequency, is a revolutionary approach for short-range high-bandwidth wireless communication. Differing from traditional narrow band radio systems (with a bandwidth usually less than 10% of the centre frequency) transmitting signals by modulating the amplitude, frequency or phase of the sinusoidal waveforms, UWB systems transmit information by generating radio energy at specific time instants in the form of very short pulses thus occupying very large bandwidth and enabling time modulation.

Due to the transmission of non-successive and very short pulses, UWB radio propagation will provide very high data rate which may be up to several hundred Megabytes per second, and it is difficult to track the transmitting data, which highly ensures the data security. For the same reason, the transmitting power consumption of UWB systems is extremely low in comparison with that of traditional narrow band radio systems. Moreover, the short pulses give rise to avoidance of multipath fading since the reflected signals do not overlap the original ones. Because of these alluring properties, UWB technology is widely employed in many applications such as indoor positioning, radar/medical imaging and target sensor data collection.

One of the challenges for the implementation of UWB systems is the development of a suitable or optimal antenna. The first important requirement for designing an UWB antenna antenna is the extremely wide impedance bandwidth.In 2002, the US FCC allocated an unlicensed band 3.1G Hz to 10.6GHz on the frequency spectrum for UWB applications. Hence, up to 7.5 GHz of bandwidth is required for a workable UWB antenna. And commonly, the return loss for the entire ultrawideband should be in the criterion of less than -10dB. So far, for size reduction, and bandwidth enhancement numerous monopole antennas have been proposed by employing various promising feed structures such as the probe [1]-[5], the microstrip [6]-[9]. In these presented monopole antennas, a large solid ground plane having the shape of a square, rectangle, circle, or ellipse is usually adopted. Different from this, here a partial ground structure is used and found to be a simple and effective method to reduce the antenna size [10].

Several narrow band communication systems such as IEEE 802.11a wireless local area network (WLAN) bands (5.15-5.35 GHz and 5.725-5.825 GHz) in USA and high performance radio local area network/2 (HIPERLAN/2) bands (5.15-5.35 GHz and 5.470-5.725 GHz) in Europe, exist in ultra-wide bandwidth. Hence, potential interference from these bands should be avoided for good performance of UWB antenna. UWB filters [11] have been designed to suppress the undesired bands. However, use of filter increases complexity of overall UWB system. Hence, it is required to design UWB antenna with band-notched characteristics.

In this paper, a compact UWB slot antenna is presented with band-rejection characteristic. By inserting a C-slot in the radiating patch, the interfering signals from WLAN band are avoided. Paper is organized as follows. Section II briefly presents the antenna design. Simulation results and discussions are addressed in section III. Finally, conclusions are drawn in section IV.

II. Antenna Design

The antenna is designed to fabricate on FR4 substrate with dielectric permittivity , loss tangent tanδ= 0.02 and thickness h = 1.6 mm. The antenna has compact size of 14×18 mm² and is fed by 50Ω microstrip line. A single metallic layer and small size make the antenna to integrate with RF front ends easily. A novel stepped rectangular patch was chosen to obtain wide bandwidth and good impedance matching over the bandwidth. To match the impedance of a microstrip line with enlarged width, which has smaller characteristic impedance and therefore can improve coupling, to the standard 50Ω microstrip line, a tapered microstrip line transformer [12] is designed. Fig.1 shows the geometry of the proposed antenna.

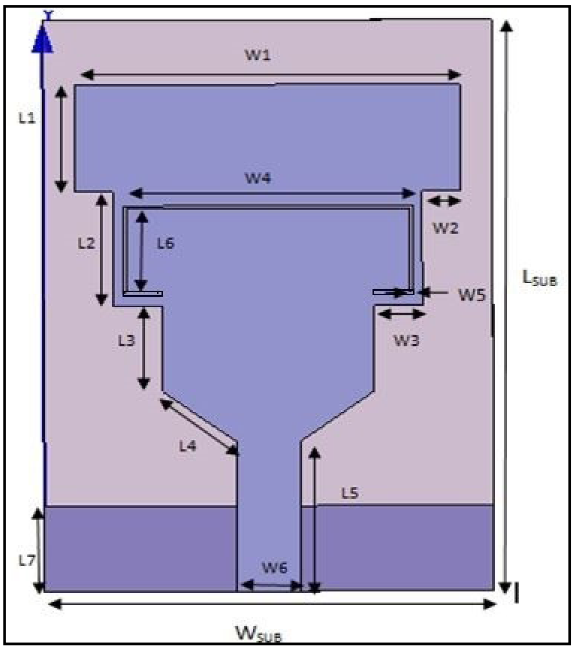

Fig. 1 : Proposed antenna geometry

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Here a C-shaped slot [13] is inserted in the radiating patch of antenna to avoid interference from WLAN and HIPERLAN/2 bands. Slot is considered as half wave resonator. So guided wavelength is used to obtain total length of C-slot. When the length of the C-slot is about half of guided wavelength λ_g, the slot resonates at notch frequency f_0 and behaves as short circuit in parallel to input impedance of the antenna. Hence, the antenna does not work in the frequencies around f_0 and it avoids the potential interference from WLAN. Dimensions for the proposed antenna is as follows (in mm): W_{sub}= 14,L_{sub} = 18,L_1 = 3.75,L_2 = 4,L_3 = 3,L_4 = 2.9,L_5 = 5.25,L_6 = 2.9,L_7 = 3,W_1 = 12,W_2 =1.2,W_3 =1.5,W_4 =8.9,W_5 =0.1,W_6 =2

The total length of C-slot is denoted by L_{Slot} and it is obtained by

$$L_{Slot} = \frac{\lambda_g}{2} = \frac{c}{2f_0\sqrt{\frac{\varepsilon r+1}{2}}} \qquad (1)$$

Where λ_g is guided wavelength corresponding to notch frequency f_0, c is velocity of light in free space and $_r$ is dielectric permitivity of FR4 substrate. C- slot is designed theoretically to resonate at notch frequency f_0 = 5.5 GHz to obtain total length of C-slot according to equation 1. The length L_{Slot} is practically equal to $0.6\lambda_g$ where $\lambda_g = \frac{\lambda_0}{\varepsilon_{eff}}$. Here, λ_0 is wavelength corresponding to the notch frequency f_0= 5.5 GHz, ε_{eff} is effective dielectric permittivity of dielectric substrate and ε_r is dielectric permittivity of the substrate.

III. Results and Discussion

Antenna design is done using hfss version 13 [14]. Fig.2 shows the return loss plot [15] of the final antenna. Here antenna has an impedance bandwidth from 4.1 to 12.5GHz with a notched band from 4.9 to 6.1GHz, which is the WLAN rejection region. Here return loss plot is below -10dB from

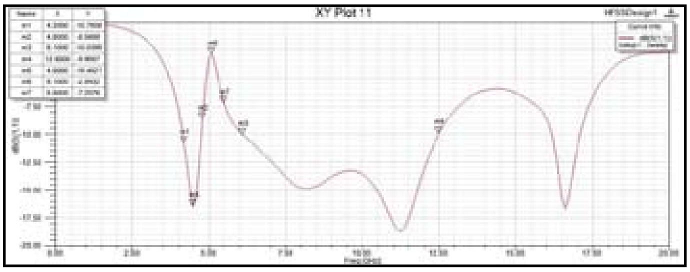

Fig. 2 : Simulated return loss plot of proposed antenna

4.9 TO 6.1GHz. So interference from WLAN can be avoided. Fig 3 shows the 3D polar plot of the antenna., which indicates the maximum gain of the antenna. Here antenna has a peak gain of 3.169dB, which is a permissible value for ultra wide band antennas.

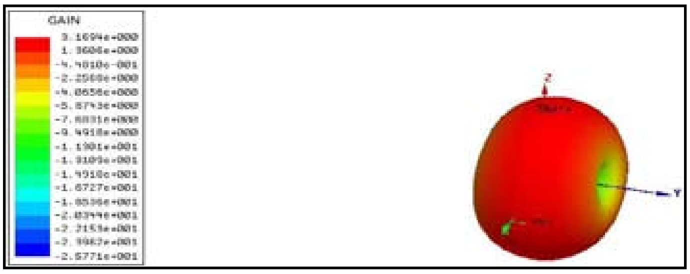

Fig. 3 : 3D polar plot-gain

In practical case directivity of an ultra-wide band antenna should be greater than gain. The proposed antenna has a peak directivity of 3.3415dB which is greater than gain. Fig.4 shows the 3D plot of directivity.

One notched frequency band is achieved by embedding C-shaped slot in the radiation patch. As shown in Fig.5, in this structure at the notch frequency, the current flows are more dominant around the C-slot structure. Therefore, the resultant radiation fields cancel out, and high attenuation near the notch frequency is produced. Hence, the antenna does not radiate efficiently in that frequency.

Optimetric analysis is done for different length of the C-slot. If the total length of C-slot increases the notch frequency of WLAN changes as shown in Fig.6. This is mainly due to the fact that the length of slot L_{slot} is inverselyproportional

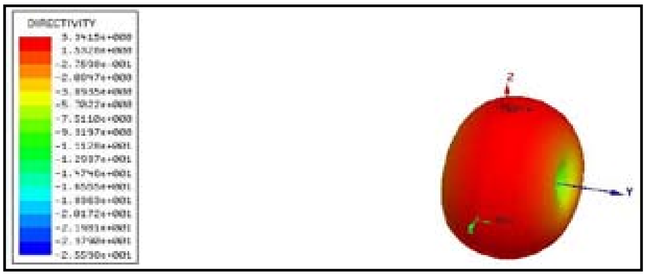

Fig. 4 : 3D polar plot-directivity

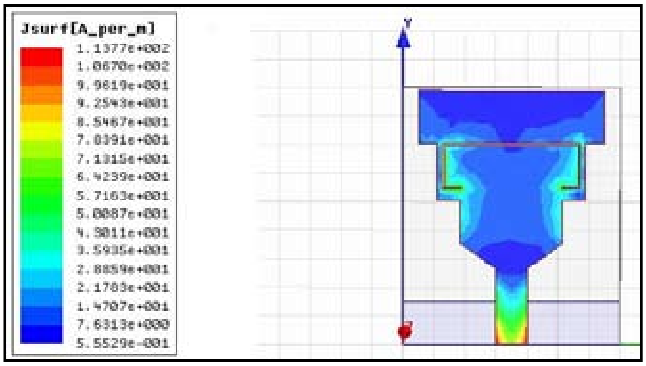

Fig. 5 : Simulated current distribution on the patch to notch frequency f_o of slot.

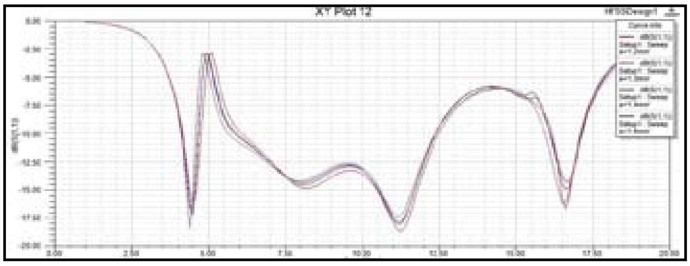

Fig. 6. Optimetric analysis for different length of the slot

The antenna is fabricated on FR4 substrate with dielectric permitivity ε_r, loss tangent tanδ = 0.02 and thickness h = 1.6 mm. The antenna has compact size of 14×18 mm^2 and is fed by 50Ω microstrip line. Fig.7 and 8 shows the front and rear side of the fabricated antenna.

Fig. 7 : Front face of the designed antenna

Fig. 8 : Rear face of the designed antenna

Fabricated antenna is tested using Rohde and Schward network analyzer network analyser which has a frequency range up to 8GHz. Tested result is shown in Fig.9. Due to

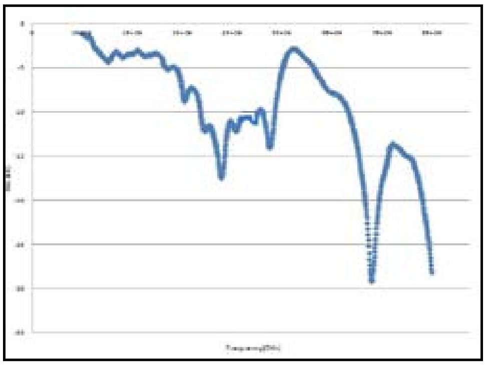

Fig. 9 : Tested return loss plot

practical difficulties antenna is measured only up to 8GHz. Here antenna has a frequency range from 3.4GHz to 8GHz and a band rejection from 4.9 to 6.1GHz. There is a small deviation from the simulated result it may be due to the error in soldering.

IV. Conclusion

A compact printed planar UWB slot antenna is presented with band notched characteristic. The desired notched band of 4.9-6.1 GHz is obtained by inserting C slot in radiating patch to avoid interference from WLAN and HIPERLAN/2 bands. The antenna operates from 4.1 GHz to 12.5 GHz, except over notched band of 4.9-6.1 GHz. The radiation patterns are stable over UWB. The gain of antenna is almost flat except in the notched band. The antenna can be easily integrated with microwave integrated circuits. The antenna is good for portable UWB systems.

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