Design of Dual Band Notch Ultra-Wideband Antenna

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Abstract: ***This paper with the design of a compact sized printed micro-strip antenna (MSA) design which covers the entire ultra-wideband (UWB) ranges from 2 GHz-14 GHz with dual wideband notch. The band notch antenna is designed by cutting ring slot in the radiation element of circular shape radiator patch and making L slots in ground plane, in order to avoid the potential interference with coexisting IEEE 802.16 WiMAX signal which operates at 3.3-3.7 GHz and IEEE 802.11a wireless local area network (WLAN) systems operating over 5.15-5.825GHz. For better performance of the antenna FR4 dielectric substrate with high permittivity (ε_r) of 4.4 and low loss is used. Radiation pattern is found omnidirectional with Gain more than 3 dB for dual band notch operation. The parameters are optimized and simulated in CST Microwave Studio.***

Keywords: Ultra-Wideband, micro-strip antenna (MSA), Wireless LAN, Radiation pattern, Gain, CST Microwave studio.

1. Introduction

The present wireless communication systems requires large frequency spectrum, high data rate and enhanced coverage for indoor and outdoor activities. UWB communication systems have attracted considerable attention due to the advantages of high-speed data rate and extremely low spectral power density. Federal Communications Commission (FCC) approved the frequency band from 3.1 to 10.6 GHz for commercial UWB applications. For non-commercial usage this frequency range can be used with -10 dB bandwidth greater than 500 MHz and a maximum equivalent isotropic radiated power spectral density of -41.3 dBm/MHz [1]. For the conventional wireless systems, antenna is an important key part and there are many work is going on for performance enhancement of the antenna. A suitable UWB antenna should be capable of operating over an ultra-wide bandwidth as allocated by the FCC. UWB antennas have wide application into the field of short range wireless communication systems for this various type of antennas are studied into the literature survey [2].

Micro-strip antenna is mostly used planner antenna for short range wireless systems due to following advantages: easy to design; low fabrication cost; light weight; planar configuration, hence compatible with modern wireless communication systems; capability of multi-frequency operation; robustness when mounted on microwave integrated circuits (MICs). However, micro strip patch antennas suffer from some disadvantages as compared to conventional non-printed antennas [3]. Some of their major drawbacks are: narrow bandwidth; low gain and surface wave excitation that reduce radiation efficiency. Bandwidth of the antenna can be easily controlled by the substrate thickness and effective dielectric constant [4-6]. In literatures various designs have been proposed for designing of the UWB antennas. Main focus of this paper is to produce notch band at WLAN frequency. Various techniques have been proposed so for to obtain band notch in UWB operation. The most popular approaches to achieve band-notched designs were embedding half-wavelength slots with different shapes, i.e., U-shaped, C-shaped, and arc-shaped, quarter-wavelength open-ended slots on the radiating patch or its ground plane, and utilizing half-wavelength parasitic elements near the radiator or feed line [7], [8].

In this paper, the novel design of a UWB antenna is proposed with dual wideband notch at 3.36-3.6 GHz and 5.26-5.95 GHz to avoid interference with the licensed WiMAX and WLAN signals respectively. The introduction of band rejection properties by antenna itself, the need of external band-stop filter is eliminated. This band notch performance is achieved using open ended circular ring slot in radiator patch and inverted L-slot in the ground plane side as well as by using high permittivity substrate. The results of reflection coefficient, radiation patterns, radiated power, VSWR and gain response are illustrated and discussed in detail.

The paper is organized as follows. Section II gives antenna configuration and initial design steps. Section III comprises of optimized design parameters and simulation results. And Section IV concludes the findings of this paper.

2. Antenna Configuration

Microstrip antenna presented here comprises of two thin metallic layers one as radiating patch and second as ground plane and a dielectric substrate sandwiched between them. The conductor patch is placed on the dielectric substrate and used as radiating element. On the other side of the substrate there is a conductive layer used as ground plane. Copper and gold is used normally as a metallic layer .The proposed antenna is fabricated on an inexpensive and easily available dielectric material FR4 with permeability of 4.4 with thickness of 1.6 mm and is fed by standard 50 ohm micro strip feed line. Feed line is having different width and length so that it will work for complete ultra-wideband range. Proposed antenna configuration is shown in Figure 1. Radiated patch is of circular shape and ground plane is polygon. The dimensions of the full size antenna's substrate are 40 mm in length and 25 mm in width. Two open ended inverted L shaped slots are printed on the radiator plane of the antenna.

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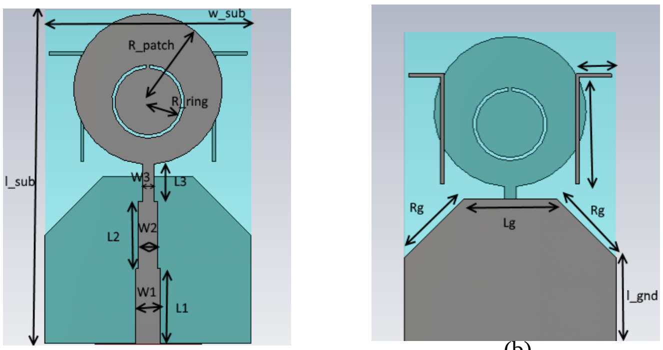
The main reason of choosing the micro strip antenna, it is because the micro strip antenna has a lot of advantages such as ease of fabrication, planar structure, UWB operating characteristic, and also bidirectional radiation patterns. To meet the demands of a reduced antenna size, a higher dielectric constant of 4.4 can be used for this antenna but is in general quite thick and lossy at UWB frequencies. As all know that patch exhibits narrowband characteristics making it challenging to enhance their bandwidth.



(a) (b)

Figure 1: Configuration of proposed UWB antenna with design parameters; (a) Front view; (b) Back View.

3. Simulation Results

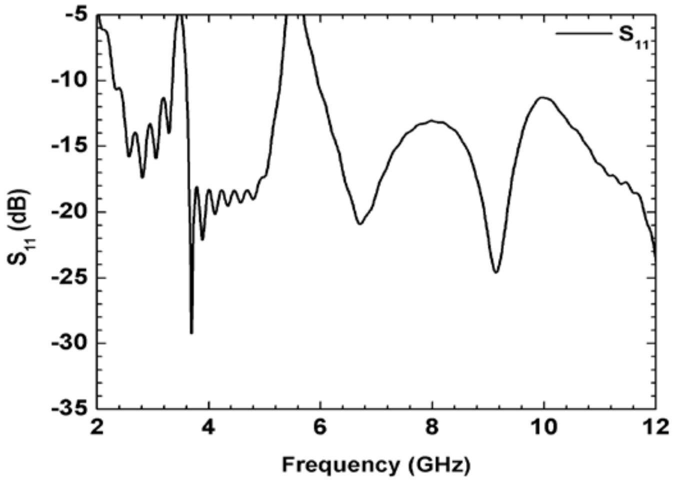
Simulation of proposed antenna given in previous section is performed in CST Microwave Studio and parameters are optimized. The optimized parameters are presented in Table I.

Table I: Design Parameters

Symbol	*Size*	*Symbol*	*Size*
L1	9 mm	w1	3 mm
L2	8 mm	w2	2.4 mm
L3	8 mm	w3	1.4 mm
R_patch	9 mm	w	0.4 mm
t	0.07 mm	h	1.6 mm
ws	4 mm	ls	13 mm
w_sub	25 mm	l_sub	40 mm
Rg	7 mm	Lg	10 mm
R_ring	4 mm		

Reflection coefficient (S_{11}) and Voltage Standing Wave Ratio (VSWR) for the proposed dual band notch antenna are shown in Figure 2 and Figure 3 respectively. From these plots it is clearly observed that reflection coefficient is always lower than -10 dB over the complete UWB frequency range except the operational frequency of WLAN. Two notches are visible for 3.36-3.6 and 5.26-5.95 GHz, which obstruct the radiation from the antenna in this range. VSWR should be less than 2 for proper functioning of antenna and it is clearly visible from the Figure 3 that VSWR is well below 1.5 all over the frequency span, but maximum for these two notch frequency ranges.

Figure 2: Reflection Coefficient (S_{11}) for the



proposed antenna.

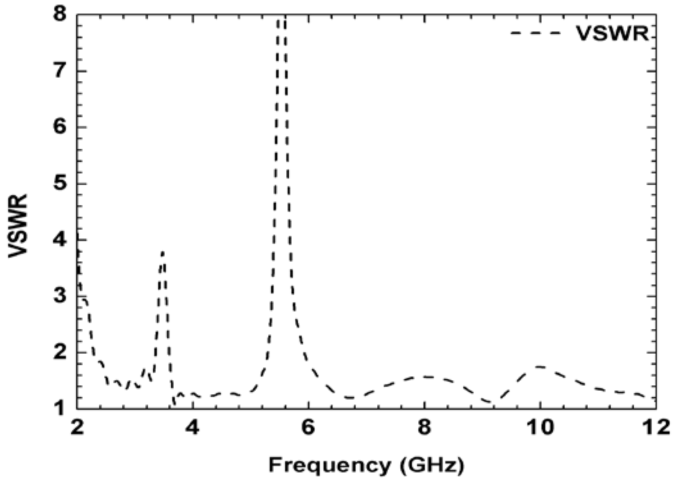


Figure 3: Voltage Standing Wave Ratio (VSWR) for the proposed antenna.

After that we have calculated and plotted radiation efficiency as well as total efficiency for 3 different frequencies 3.4 GHz, 5.5 GHz, and 9.2 GHz. These efficiencies are plotted and shown in Figure 4. Efficiencies are presented in dB and it is clearly visible that radiation and total efficiencies are very less for notch area, which is needed for proposed antenna.

The measured co-polarized radiation patterns in the E and H planes at different frequencies are illustrated in Figure 5. As observed, the radiation pattern is bidirectional in the E plane and omnidirectional in the H plane at 3.4 GHz. It can be regarded as a monopole which features a doughnut-shaped pattern at the fundamental mode. As the operating frequency increases, the radiation pattern in the H plane is quasi-omnidirectional and remains bidirectional in the E plane at 5.5 GHz.

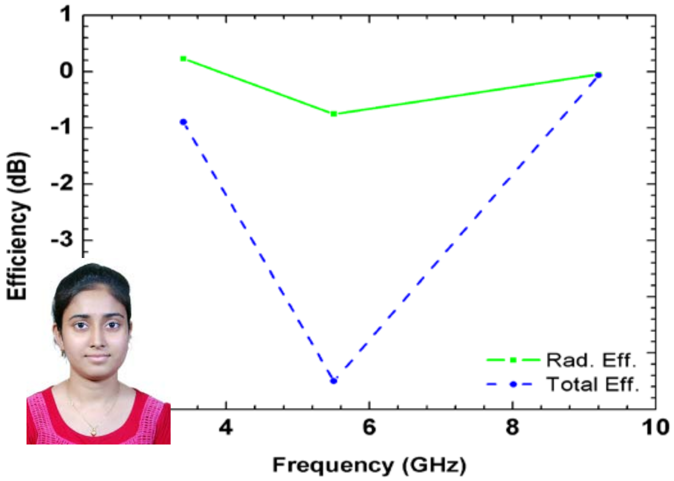


Figure 4: Radiation and Total Efficiency for the proposed antenna for different frequencies.

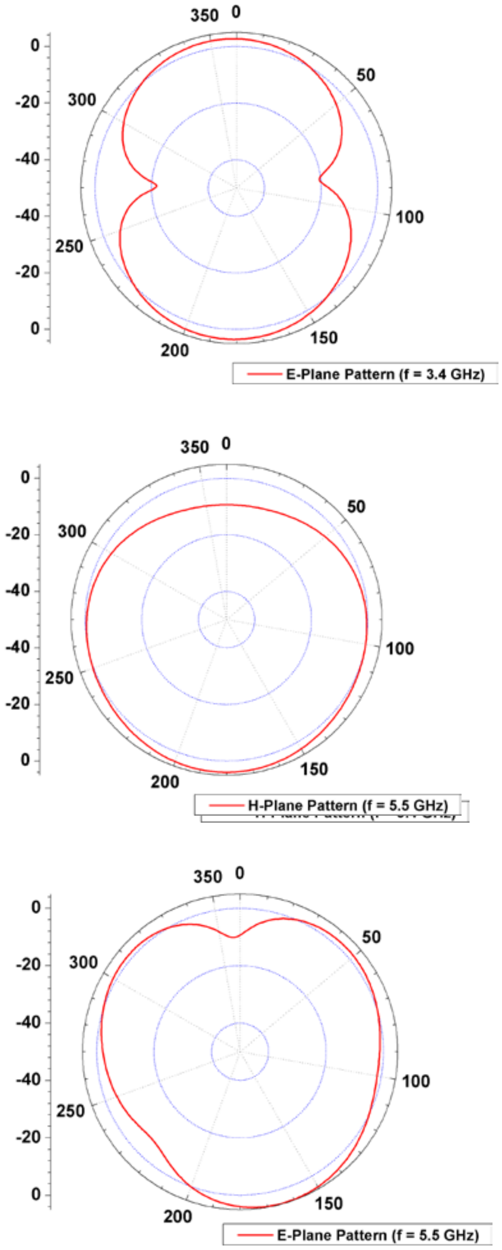


Figure 5: E-plane and H-plane radiation pattern for proposed antenna.

4. Conclusions

In this paper, a novel circular patch, dual notch antenna is designed for UWB applications. Two inverted L-slots are used beside circular radiating patch on the ground plane. This antenna is able reduce the interference from WiMAX at 3.36-3.6 GHz and wireless LAN (WLAN) at 5.26-5.95 GHz. Design parameters have been optimized and antenna performance is simulated using CST-Microwave Studio. Reflection coefficient and VSWR have been calculated and presented over the UWB frequency range. Radiation and total efficiencies have also been presented for 3 different frequencies. E-plane and H-plane radiation pattern have been shown to confirm the omnidirectional operation of proposed antenna. Overall gain obtained from the simulation is more than 3 dBi.

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