Dual Band-Notched Ultra-Wideband Antenna for 802.11a WLAN Environments

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Abstract—Band-reject UWB antennas have recently been considered for efficient communication between devices in WLAN environments. In this work, a new concept of a dual band-reject antenna is investigated. The antenna rejects efficiently the 802.11a interfering signal at two narrowband frequency ranges, while it receives the UWB signal in between them. Designs and simulation and measured results are presented in this work.

Index Terms *–Antennas, Band-reject, Slot, UWB*

Introduction

Recently, the trend in Ultra-WideBand (UWB) antennas has widely focused in the use of novel designs that with the use of stubs [1], or slots [2] manage to reject a desired range of frequencies from the particular receiver's response. In this manner, an UWB radiator that fulfills the FCC rules for the respective communication – mostly handheld - devices and systems [3] can function with improved performance in an environment where 802.11a WLAN equipment can be active. In this work, a novel antenna design for improved signal reception is presented and discussed.

Design Concept and Structure

From the radiator's point of view, improved reception is achieved by neglecting a specific frequency range, which in turn depends on the geographical region the radiators are used in and often varies from country to country. Currently, the 802.11a bands in the United States are: R_1=[5.15-5.35 GHz] and R_2=[5.725-5.825 GHz]. Band-notched or band-reject antenna designs up-to-date, reject the entire Rr=[5-6 GHz] range efficiently. This attribute is beneficial since any signal in the mid-range frequency of Rr will practically not be received and thus it will not distort the received UWB signal. On the other hand, any information contained in the range Ra=[5.35-5.725 GHz] will also be rejected, resulting in less received information and thus shorter range of coverage, lower signal quality and higher battery consumption.

In this work, a second slot is added on the radiator, several microns away from the first in order to achieve the desired double-notch needed in the frequency domain for efficient rejection of the signal at both WLAN frequencies. At the same time, any signal in-between the two rejected bands (i.e. in the R_i = [5.35-5.725 GHz]), will be on the whole received by the antenna resulting in better signal restoration, since a wider part of the transmitted signal's spectrum is now available to the decoder.

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A slotted UWB antenna can be modified into a dual-notched antenna with the addition of a slot placed at a relatively short distance from the first. The length of each slot determines the rejection band's center frequency, while the width, shape and distance between each other determine the bandwidth and sharpness of the rejected regions. The distance from the ground plane affects the quantity of signal rejection. Thus, the shorter slot defines the center frequency of the higher rejection band, while the longer, the center of the lower rejection band. When the slots are placed closer to the ground plane, the $|S_{11}|$ at the rejected frequencies increases, resulting in a lower level of received signal.

With the above characterization available, the antenna was designed and optimized in order to achieve the required input impedance over the entire UWB frequency range. Several UWB radiators can be utilized for the proof of concept of this research. As in filter design, a rectangular (brick-wall) rejection range in the frequency domain is unfeasible so it was not attempted. On the other hand, optimization of the antenna response with respect to the dimensions of each slot was accomplished using a MoM commercial software [4]. In this work, a CPW-fed UWB antenna was chosen due to its uniplanar nature and thus ease of fabrication. The substrate chosen was a flexible LCP layer of 100μm thickness with ε_r=3 and tanδ=0.003. The signal conductor is spaced 100μm from the adjacent grounds. The structure's details are shown in Fig. 1, while its dimensions are summarized in Table I.

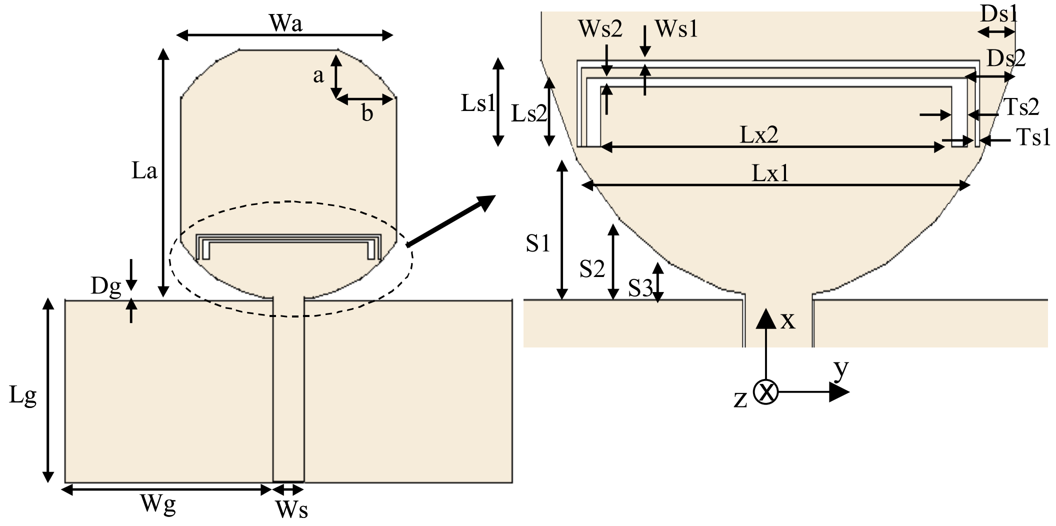

Figure 1. Layout and design parameters of the dual band-notched UWB antenna.

Table I.

UWB Antenna Dimensions

Param.	Length (mm)	Param.	Length (mm)	Param.	Length (mm)	Param.	Length (mm)	Param.	Length (mm)
La	24.6	Ws	1.5	Ls1	2.3	Ts1	0.2	Ds1	1.6
Wa	21.3	Dg	0.14	Ls2	1.8	Ts2	0.65	Ds2	2.15
Lg	18	a	4.7	Ws1	0.2	Lx1, Lx2	18, 17	gap	0.1
Wg	20.4	b	5.7	Ws2	0.21	S1,S2,S3	1, 2.1, 3.7		

Measured and Simulated Results

The antenna was fabricated and measured at the facilities of Georgia Institute of Technology, using standard photolithography techniques. Simulated and measurement results are compared in Figs. 2-4.

The simulated reflection coefficient response is shown in Fig. 2. The magnified rejection area is shown in Fig. 2b. It is clear that in the WLAN frequency ranges of R1 and R2 the antenna has very high input impedance which results in $-4\text{dB} < |S_{11}| < -2.2\text{dB}$. At the same time, a large part of the desired intermediate range R_i signal is being received.

Simulated gain throughout the entire frequency range is shown in Fig. 3. Gain is fairly constant from the lower frequencies (3GHz) up to the high-end of the UWB range (10.6GHz), except from the rejected bands where it drops by approximately 3dBi. In addition, at the same rejected band, antenna efficiency reduces to less than 50%. This is attributed to the fact that currents around the slots are of opposite directions and thus cancel the radiated fields of each other. The placement of two slots instead of one makes this cancellation possible at the two different frequencies for which they are designed. Finally, in Fig. 4, the simulated radiation patterns of the antenna at various frequencies are plotted. The dipole-like patterns indicate the antenna can be used as a receiver for any UWB application.

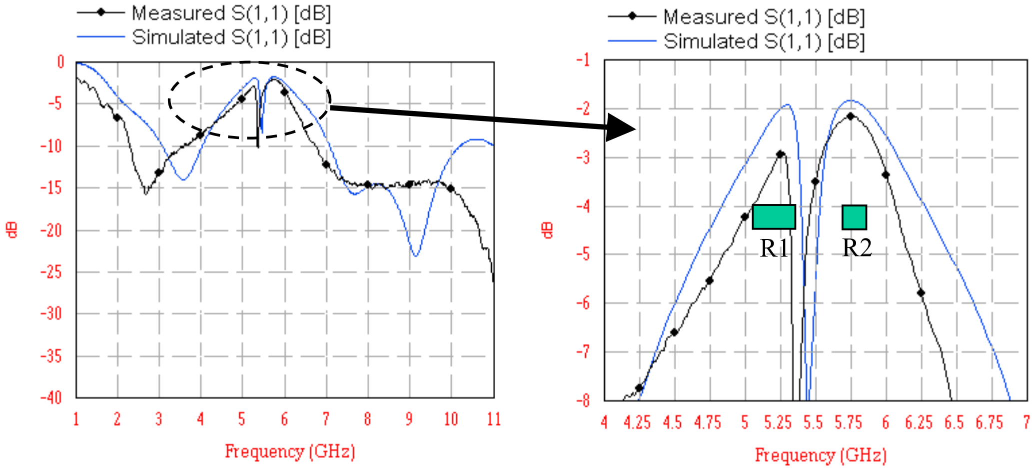

Figure 2. Simulated and measured frequency response of the dual band-notched UWB antenna for a) the entire UWB range and b) the rejected frequency range only.

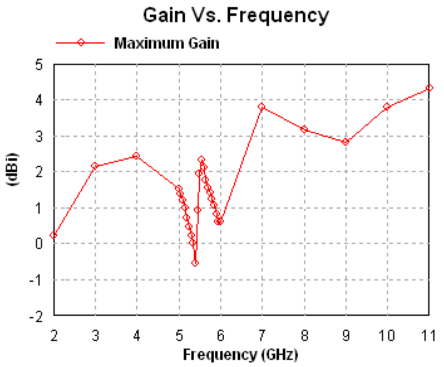

Figure 3. Simulated gain of the antenna with respect to frequency.

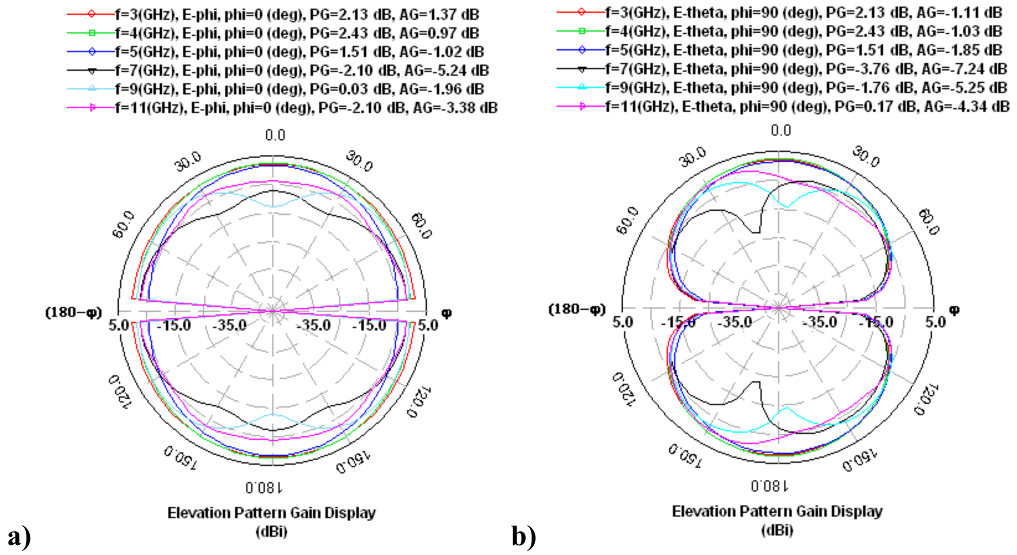

Figure 4. Plots of antenna radiation patterns at different frequencies in a) the received bands and b) the rejected bands. The omnidirectional H-plane (y-z) is shown on the left, and the eight-shaped E-plane (x-z), on the right.

Discussion and Conclusions

The concept of simple-notched antennas for 802.11a WLAN environments was expanded into the double-notched ones, with the addition of a slot next to the initial one. The slot dimensions are varied in order to achieve the desired band-reject characteristic. These dual band-notched UWB antennas have a dual rejection characteristic and can receive signals in the intermediate frequency range between 5.35-5.725 GHz.

Future work combines methods to control the steepness of the rejection bands, while investigation on the reconfigurability of such antennas in order to enable their tunability at different frequencies and so to make them suitable for applications in different geographical regions is under consideration. Measurements and comparison of different band-rejection methods and structures will be presented.

References:

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[3] IEEE Std. 802.11a-1999(R2003), Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: High-speed Physical Layer in the 5 GHz Band, 12 June 2003.

[4] IE3D™ is a trademark of Zeland Software Inc.