Loaded notched dual compact rectangular ultra-wideband applications monopole antenna

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ABSTRACT

This work presents a rectangular of microstrip ultra wideband patch antenna for worldwide interoperability for microwave access (Wi-Max) and wireless local area network (WLAN) with a dual band-notched feature. The planned an antenna consists the rectangular of patch antenna with the largely deficient of ground structure. Through inserting slots in the radiating patch, dual notch characteristics may be produced. The suggested antenna is $20\times30\times1.6$ mm^3 in volume. The first notch, made by slots operating at the first notch, produced by slots running at 3.5 GHz, for Wi-Max (from 3.3–3.7 GHz), while of a second, created by slots operating at 5.5 GHz, for WLAN (from 5.1–5.8 GHz). An antenna covers the whole ultra-wideband frequency range (3.1–10.6 GHz). Computer simulation technology (CST) 2021 simulation software used for simulate proposed of antenna. A simulated antenna's emission pattern is almost omnidirectional, and the recommended antenna's gain is approximately constant over the ultra-wideband (UWB) spectrum, excluding notch areas.

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1. INTRODUCTION

Wireless communication has advanced significantly during the last few decades. The market for wireless local area network (LAN) equipment has expanded significantly. Before developing a new wireless local area network (WLAN) system, it is necessary to gain a deeper understanding of wireless channels operating in the chosen environment's frequency operating bands. Because the 2.4 GHz industrial, scientific and medical (ISM) band is not licensed, the majority of WLAN devices experience interference from devices operating in the same frequency spectrum [1]-[3]. 802.11g and IEEE 802.11b technologies operate in this ISM band. 802.11a IEEE uses 5 GHz, which is cleaner, to facilitate high-speed WLAN. This means it has an interference-free spectrum, which boosts its productivity. The likelihood of data collisions is reduced, allowing us to remain connected. Laptops, mobile phones, PDAs, and all other wireless communication devices rely on antennas for radio wave transmission and reception [4]-[9]. A microstrip patch antennas are an excellent candidate for such applications due to their low cost; low profile; and the compatibility. While there is a trade-off between gain, bandwidth, and above-mentioned characteristics. To solve these challenges, techniques such as substrate thickness, of partial grounding, meandering, and inset feeding have been proposed. Different slots were set to maximize gain at the required frequency and to ensure the even and focused electric field distribution. The size and location of these slots are modified to achieve the desired effect [10]-[13]. In 2002, the federal communication commission (FCC) approved for mercantile purposes an ultra-wideband

(UWB) at the frequency of 3.1 GHz – 10.6 GHz [14]-[16]. UWB systems of communication have become the most prolific ones amongst the technologies of wireless communication so that it is capable of supporting high data rates 110 Mbps – 200 Mbps and are of low power spectral density (no more than -41 dB/MHz), which is why, it is utilized for applications of shorter extent (i.e., indoors) [15]-[20]. In UWB systems of communication, antennas represent the major part of a system. It has to be low profile, compact, and positioning a range of the wide frequency of 3.1 GHz – 10.6 GHz. Those design requirements became one of the active topics for the researchers in the past years. The existence of the system of narrow-band communications such as worldwide interoperability for microwave access (WiMAX) 3.30 GHz – 3.80 GHz, and HLAN 5.725 GHz – 5.85 GHz and WLAN 5.15 GHz – 5.35 GHz for standards IEEE 802.11a and X-band satellite communications (7.9 GHz – 8.4 GHz) represents the main concern for UWB antenna designers. The design of UWB antenna with band-notches properties is preferred in stated of design band-pass filter which increases the size of board [21]-[24].

In this work, a comprehensive study of a planar antenna system with both WLAN and WiMAX bands notched is presented, for UWB applications. The overall size of the compacted structure is 30×20×1.6 mm^3. The proposed antenna system consists of a slotted rectangular patch monopole with micro-strip feed line, placed on a rectangular substrate and gives linear polarization, and slotted partial ground plane. The proposed antenna gives a good performance voltage standing wave ratio (VSWR) < 2, average gain 5.4 dB; and symmetric radiation of patterns. As well as, the proposed antenna has a good bandwidth 3.1 GHz – 10.6 GHz, which encompasses the whole UWB applications. This antenna designed to mitigate mutual interference between existing narrow-band services. The CST software is used for designing and simulating the suggested structure.

2. DESIGN AND ANALYSIS OF ANTENNAS

Figure 1 and Figure 2 depicts the antenna as intended. The antenna is made of FR-4, which a relative dielectric constant of 4.3, a height of loss a tangent ($tan\delta$) 0.02; 1.6 mm. A patch and ground are constructed entirely of annealed copper with a thickness of t = 0.035 mm. The optimal values for the antenna parameter that we found through a parametric research are listed in Table 1. The simulation results were obtained using CST software.

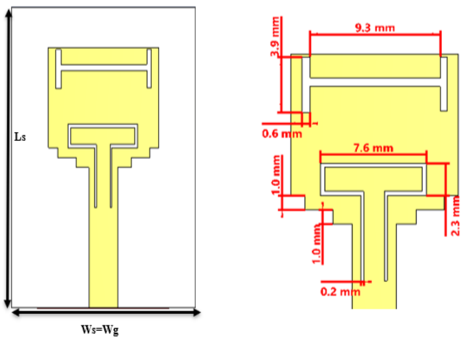


Figure 1. Antenna as intended from the anterior view

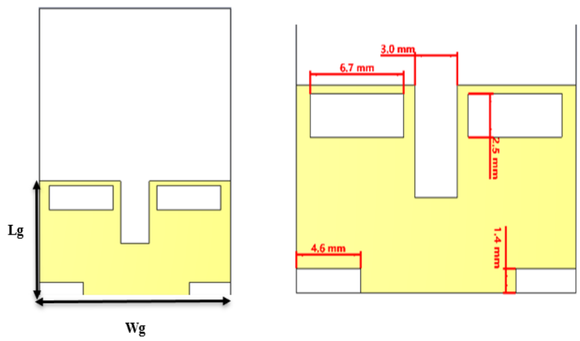


Figure 2. Antenna as intended from the posterior view

The fundamental challenge in in-band notching implementation is selecting the appropriate location of notching structures in the feed line, radiating patch, or ground plane. The proposed notching structures are angled for maximum current density. The antenna is evaluated with and without band notching. The first form UWB antenna is built, and the results show that it covers a wide frequency range without a single notch. Slots in the radiating patch create band-notch functionality. Figure 1 and Figure 2 shows the proposed design with a band notch. The band notch is implemented using the [25].

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \quad (1)$$

And

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\frac{1}{\sqrt{1+12(\frac{w}{h})}} \quad (2)$$

In which c represents of speed-light in a vacuum and ε_r specifies the relative a permittivity of the PCB material.

Table 1. Shows proposed antenna's final dimensions

Parameters	Value
L_s	30 mm
W_s	20 mm
L_g	12 mm
W_g	20 mm
L_f	14 mm
W_f	3.1 mm
h	1.6 mm
t	0.035 mm

3. RESULTS AND DISCUSSION

An antenna system was built and submitted to establish the design's validity and performance. The suggested antenna's reflection coefficient has been studied as shown in Figure 3. Frequency range of 3.1 GHz – 10.6 GHz is achieved with return loss (S_{11}) less than -10 dB, and for WiMAX and WLAN frequency bands are notched.

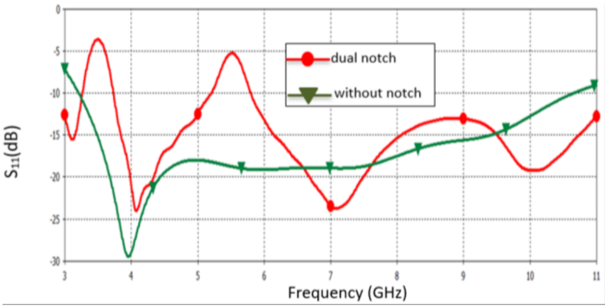


Figure 3. Reflection coefficient of UWB antenna with and without notches

Figure 4 Presents the simulated VSWR of the dual band-notched antenna. This antenna operates with frequency range between 3.1 and 10.6 GHz with a VSWR > 2, with the exception of two a blocked-bands 3.3 GHz – 3.7 GHz, and 5.1 GHz – 5.8 GHz, respectively. The gain bandwidth produced by simulating model is shown in Figure 5. Notched antenna gain nearly equal to that of the reference antenna (without notches). Referred to Figure 5, the gain characteristics are nearly flat across the whole UWB frequency range. However, two distinct gain drops can be noticed for each of the two-notch bands. The suggested antenna's maximum gain was calculated to be 5.4 dB.

Figure 6(a) and Figure 6(b) depicts the surface current distributions at 3.5 GHz, and 5.5 GHz. High current distributions are shown in red colour, whereas low current distributions are shown in blue colour. The surface current noticed to be strongly concentrated in the area surrounding the slots, indicating that a significant amount of electromagnetic energy is accumulated around the slots, result in reducing the radiation efficiency across the rejected bands. Microwave Studio software analyzes the dual-band notch UWB antenna's far-field radiation properties at 4.4 GHz; 6.5 GHz; and 10.6 GHz can be seen in Figure 7 to Figure 9. Also, 3D radiation patterns are shown in Figure 10 to Figure 12. Gain of antenna determined to 5.47 dB at 10.6 GHz and 3.51 dB at 4.4 GHz. In summary, the gain rose as the frequency of proposed UWB antenna increased.

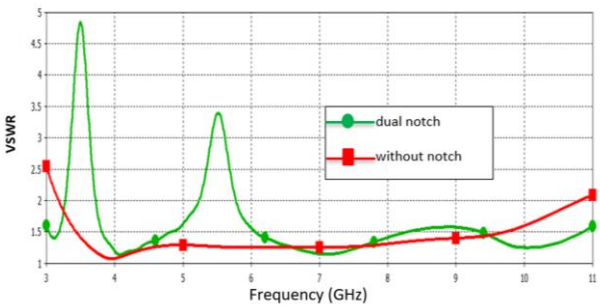


Figure 4. Shows proposed antenna's simulated VSWR

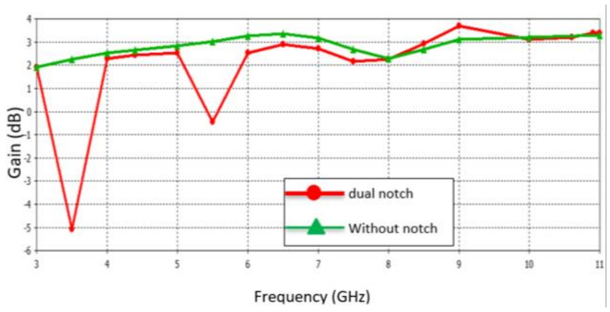
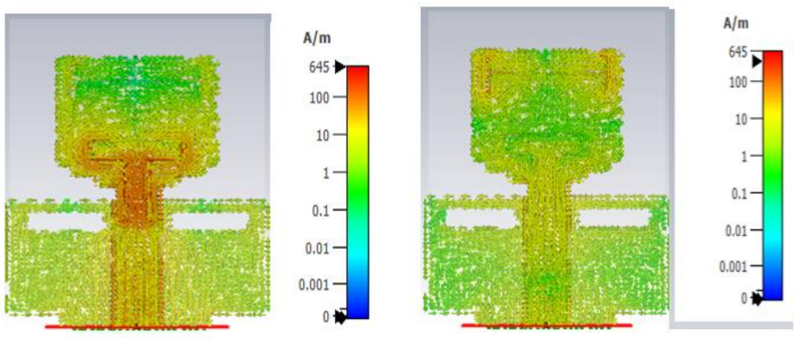


Figure 5. The suggested antenna's gain



(a) (b)

Figure 6. Surface current distributions: (a) at f = 3.5 GHz and (b) at f = 5.5 GHz

Furthermore, dimensions, bandwidth, gain, and applications substantiate the design concept. The suggested antenna's nearly consistent an emission pattern and maximum gain of 5.4 dB qualify it for usage in UWB applications. Table 2 shows the comparision this presented design, with other designs that work achieved WiMAX and WLAN.

Table 2. Comparison among our work and other article reference

Ref.	Size (mm^3)	Band-notch	Technology
[26]	40×50×1.64	WiMAX (3.35–3.8) GHz WLAN (5.1–6.1) GHz	WiMAX obtained through the etching of a single slot bevel radiating patch WLAN obtained by of a rectangular slot and U-shape slot
[27]	30×30×1.6	WLAN (5.1–5.9) GHz	Obtained by using CSRR
[28]	37.8×27.1×1.6	WiMAX (3.2–3.67) GHz WLAN (4.32–5.8) GHz	Inverted pi-slot in the radiating element and DSRRs
This design	30×20×1.6	WiMAX (3.3–3.7) GHz WLAN (5.1–5.8) GHz	WiMAX obtained by a slot on the upper of patch, WLAN obtained by a slot upper feed line

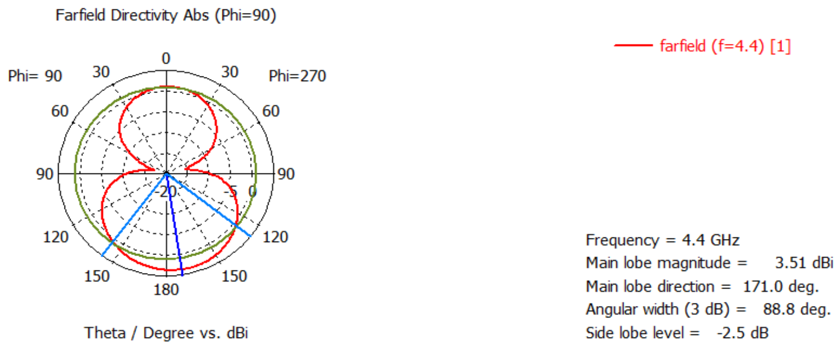


Figure 7. Proposed UWB of antenna with dual of notched band its radiation of patterns simulated at 4.4GHz

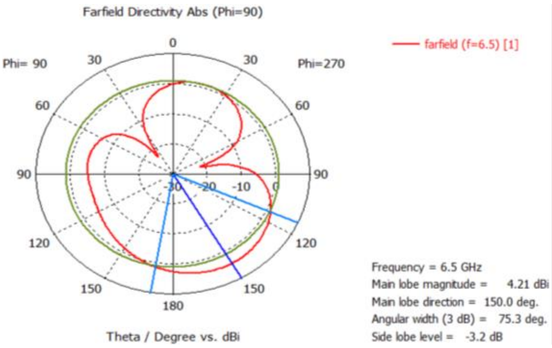


Figure 8. Proposed UWB of antenna with dual of notched band its radiation of patterns simulated at 6.5 GHz

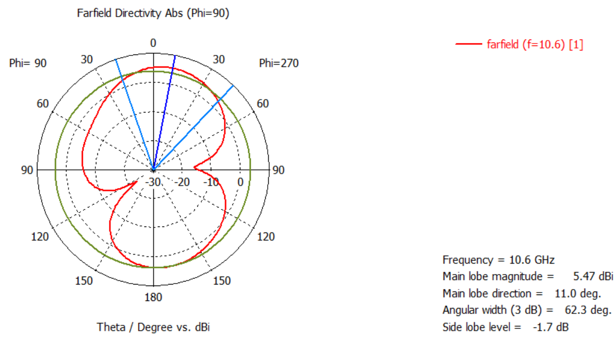


Figure 9. Proposed UWB of antenna with dual of notched band its radiation of patterns simulated for at 10.6 GHz

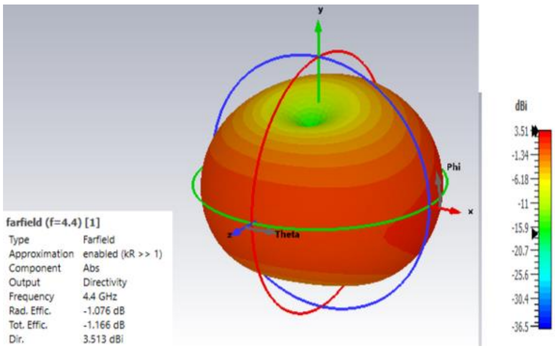


Figure 10. The proposed antenna's 3D radiation of patterns for 4.4 GHz

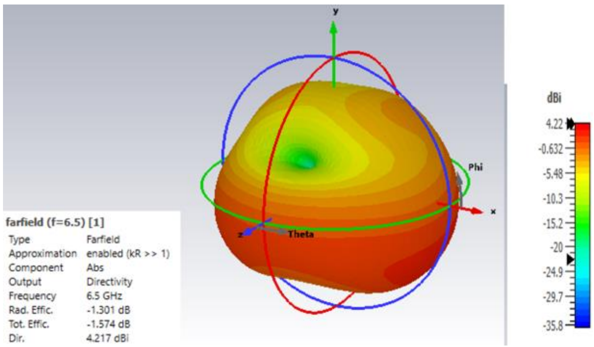


Figure 11. The proposed antenna's 3D radiation of patterns at 6.5 GHz

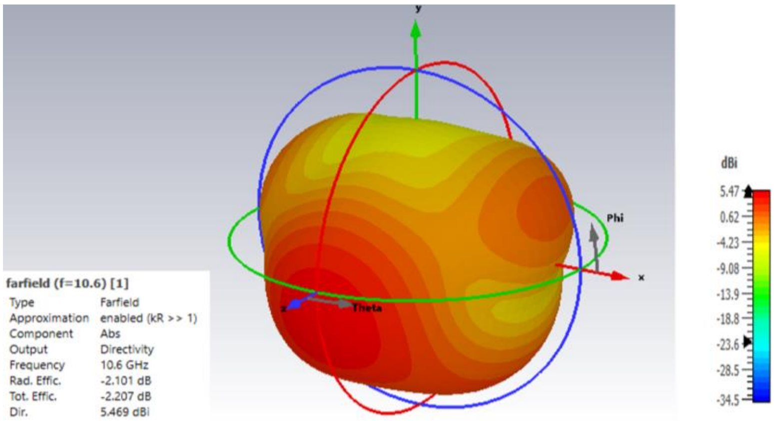


Figure 12. The proposed antenna's 3D radiation of patterns at 10.6 GHz

4. CONCLUSION

This work proposes and analyzes compact UWB of antenna with dual a band-notched features. Primitive UWB antennas are made of FR4 substrate and have a rectangular radiation patch. The small patch has two slots for 3.5 GHz and 5.5 GHz of dual band notching. We conclude that using two slots gives us good bandwidth and impedance matching. A smaller antenna with good of radiation a characteristic for all operating frequencies was also designed. We presented and analyzed the measur and simulate of return loss; VSWR. Results reveal that antenna good emission patterns, gain, and of reflection coefficient.

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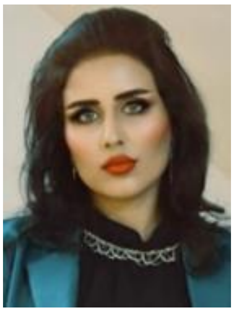

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