

Design ultra-wideband antenna have a band rejection desired to avoid interference from existing bands

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ABSTRACT

Ultra-wideband antenna with band notch for rejecting bands. Rectangular slots are introduced on an arborescent patch to get UWB, coverage from 3.1–10.6 GHz. The antenna structure is fancied on FR4 the substrate with a size of 24 mm×24 mm×1.6 mm, a band notch located at 4.7 GHz is generated by adding the rectangular slot on the patch this microstrip antenna is simulated by computer simulation technology, the simulated and manufactured results show the antenna for wireless communication, to reduce the problem of interference in bands in communication systems by using the current distribution techniques, large bandwidths are reduced and unwanted bands are rejected by inserting notch such as rectangular slit and side slot on the patch. The presented antenna, use current redistribution technology, for the antenna designed by adding a rectangular aperture on a rectangular patch to change the current path to a zero value. Despite the fact that these antennas have strong band-notch characteristics and can match the criteria of UWB communication applications.

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1. INTRODUCTION

The interfering bands are the wireless local area network WLAN band, C-Band, Wi-MAX, and satellite communication X-Band. Ultra-wideband technology has high data rate transmission is firmly interfered with by several narrow bands preoccupying the UWB spectrum [1]. Due to its transmitted high data rate, ultra-wideband UWB technology is widely employed in the field of wireless communication [2]. When numerous radios are operational at the same time increases interference [3].

The federal communications commission issued an order allowing the free use of UWB in the frequency range of 3.1 GHz to 10.6 GHz. Since then, FCC researchers have focused their efforts on upgrading UWB antennas. Furthermore, numerous existing narrowband wireless communication systems operating in the (3.1–10.6) GHz range, such as the 5.7–5.8 GHz bands, generate electromagnetic interference with UWB applications. To avoid this, a variety of techniques are employed [4]. Developed prototype parallel and series types of band rejection filters using a hydroacoustic layer HAL surface acoustic wave SAW resonator [5]. For example the filter consists of well as six-coupled circular ring resonators CRRs in-ground planer [6]. inserting dual resonance at the patch element of the UWB antenna so this antenna manufacturing and structure become more complex [7]. To improve UWB transmission and receiving systems, these undesired narrowband signals must be rejected, the use of external bandstop filters increases the size, expense, and complexity of the system. In comparison to other alternatives [8]. A tiny four-element planar UWB MIMO antenna with a band rejection range of 4.91 to 6.41 GHz. The ground plane has an L-C

linked to it. The antenna is $50 \times 50 \text{ mm}^2$ in size, thus it's suitable for large spaces [9]. As a result, for UWB antennas such as a planar UWB antenna with triple-band notch characteristics, Wi-MAX, WLAN, and X-Band satellite rejection, notching the above-mentioned bands without affecting the required qualities is crucial [10]. Ultra-wideband filter antenna with sharp and strong rejection band slots is used in many designs. Scoping is accomplished at the bottom layer using a sharp bandwidth filter BSF with numerous rejection bands and one component line resonator [11], by inserting split-ring resonators on the radiating corrective element for band rejections characteristics of single-band and dual-band first class for WiMAX/WLAN applications [12]. A slotted electromagnetic gap (EBG), structure is used near the feeding line triple notches in 3.5-3.7 GHz [13]. Asemi-octagonal C-shaped opening is inserted into the upper patch. The hatch was used for rejecting at 4 GHz [14]. Small metal patches on insulating substrates with short holes are used to construct EBGs, which can create a stopband to block electromagnetic waves at a specific frequency [15]. The proposed antenna was designed by modeling a three-layer circular equivalent circuit model, EMF was formed when it was magnetized, and the field was introduced to the CSRR [16]. Also, design EBG structures consist of rectangular connectors attached to the radiator [17]. By inserting L-shape on patch to eliminate first-order 3.5 GHz electromagnetic interference to a narrow-band network operating at 3.3-3.7 [18]. For WLAN band rejection at 5.3 GHz, SRS is implemented in the UWB antenna architecture, and slot is dimensioned in the X-band satellite communications system reject range at 7.4 GHz [19]. Medical imaging detection applications, a broadband antenna with stopband filter [20]. open-loop release. OISRR introduces an RLC resonator connected in parallel to the band rejection [21]. The presented antenna, use the technique of redistribution of current, for the designed antenna is by adding a rectangular slot on a rectangular patch to change the current path to zero value, so removing band that causes interference, the design small in size.

2. ANTENNA DESIGN

The antenna is made by three-layer, the ground plane is the first layer, substrate is the second layer, and patch plane is the third layer. with dimensions of the antenna are $24 \text{ mm} \times 24 \text{ mm} \times 1.6 \text{ mm}$. To achieve UWB by adding slit its dimensions on the tree shape dimensions a_1 , b_1 , a_2 , b_2 , a_3 , b_3 , and a_4 , b_4 respectively, to operating at UWB range, 3.1-10.6 GHz as shown in Figure 1. The antenna is simulated using CST where an FR4 substrate with relative permittivity ϵ_r of 4.3, with $h=1.6 \text{ mm}$ thickness of substrate, and thickness of ground is 0.035 mm , all dimensions are illustrated in Table 1.

Table 1. Dimensions of antenna

Parameters	Value (mm)	Parameters	Value (mm)
L_s	24	a_1	7.6
W_s	24	a_2	9
f_1	2	a_3	5
W_g	17.5	a_4	6
L_g	8.1	b_1	0.5
W_f	3.1	b_2	0.5
L_f	8	b_3	0.5
L	1.9	b_4	0.5
w	4	f_2	2
$f_3=f_4=f_5$	2	Z	6
f_6	3	V	9.5
f_7	1.4	X_5	3
X_1	2.5	X_6	1.4

The required design equations to create the antenna are listed in [22].

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{-1/2} \quad (1)$$

Where ϵ_{eff} is the effective dielectric constant (w , h) is the width of the patch and the thickness of substrate in respectively

$$L_g = L + 6h \quad (2)$$

Where L_g & L is the length of ground plane and length of patch plane in respectively.

$$W_g = W + 6h \quad (3)$$

Where W_g the ground plane width.

$$\lambda = \frac{c}{f} \quad (4)$$

Where (λ , f , c) is the wavelength, frequency and speed of light in space in respectively

$$\lambda g = \frac{\lambda}{\sqrt{\epsilon_{eff}}} \quad (5)$$

$$L_f = \frac{\lambda g}{4} \quad (6)$$

Where L_f is the feed line length

2.1. Band notch design

There are narrowband wireless communication systems that cause interference with the UWB system. WLAN systems operating at 5.1–5.8 GHz are an example. SHF and satellite services use the 4.5-5 GHz, WiMAX 3.3–3.7 GHz band, and the ITU 8 GHz band, 7.7-8.2 GHz band. The usual approach of suppressing undesired potential interference of the UWB, by adding slits with dimensions v , z on the patch. The idea of the presented antenna consisted of adding a rectangular notch at the left side of the radiated patch as illustrated in Figure 2. The procedure entails rerouting the current to zero as shown in Figure 3(a). This leads to rejecting all frequency that causes interference. In this design, we remove the frequency is 4.7 GHz because this band is in the range of UWB frequency that causes interference. The current is high density so to get to frequencies 3.8, 7.5, 10.3 GHz respectively are shown in Figure 3(b).

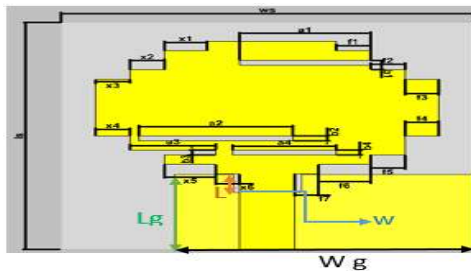


Figure 1. Proposed antenna without notch

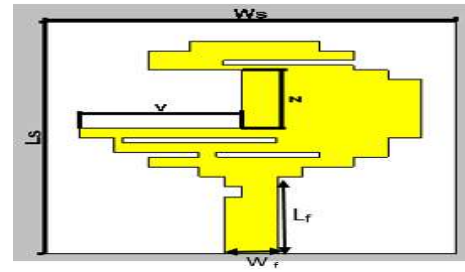


Figure 2. Proposed antenna with notch

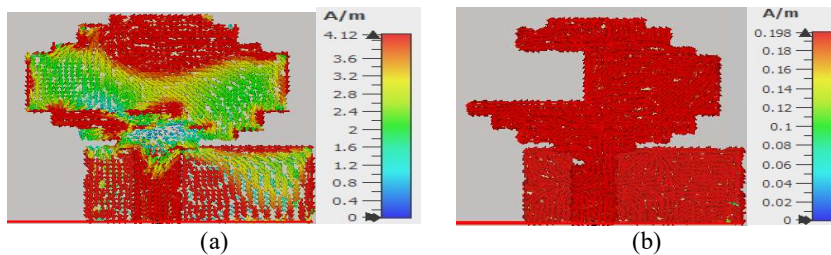


Figure 3. Current distribution (a) at $f=4.7$ GHz and (b) at $f=3.1$ GHz

3. RADIATION PATTERNS FOR E-PLANE AND H-PLANE

Radiation patterns of the antenna in the H-plane and E-plane, as can be seen the suggested filtering antenna emits an omnidirectional radiation pattern. However, ripples can be noticed in the reported radiation patterns due to the patch's small size as shown in Figure 4(a) to (f) respectively.

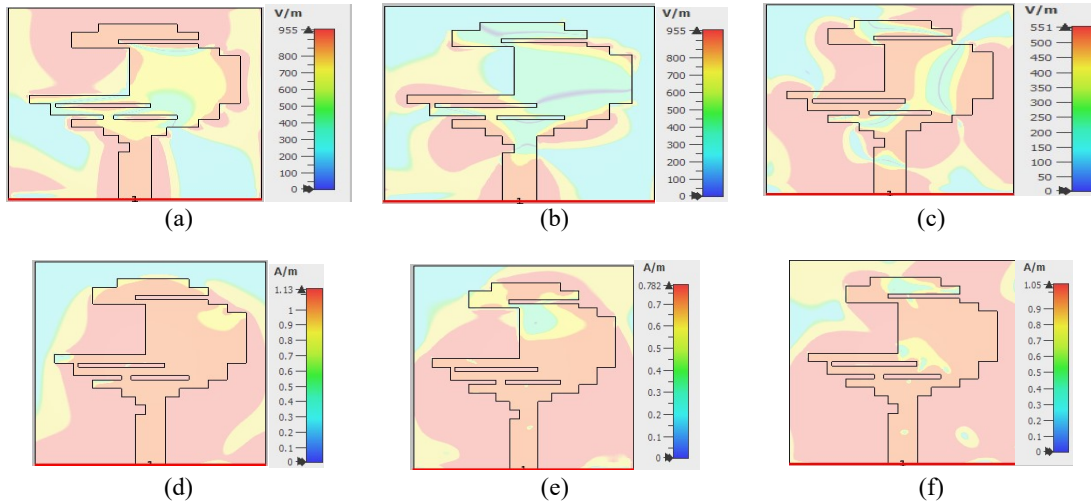


Figure 4. E plane and H plane in (a), (b), (c), (d), (e), (f) respectively, (a) E- plane at $f=3.2$ GHz, (b) E-plane at $f=7.5$ GHz, (c) E-plane at $f=10.3$ GHz, (d) H-plane at $f=3.2$ GHz, (e) H-plane at $f=7.5$ GHz, and (f) H-plane at $f=10.3$ GHz

4. RESULTS AND DISCUSSION

Before adding slit v, z , the reflection coefficient vs frequency without notch, the frequencies that have been obtained are 3.8, 4.7, 7.5, and 10.3 GHz in correspondingly as shown in Figure 5. Then, using the redistribution current technique, a slit on the patch forms a rejecting band at 4.1-4.8, as illustrated in Figure 6, the reflection coefficient against frequency with notch.

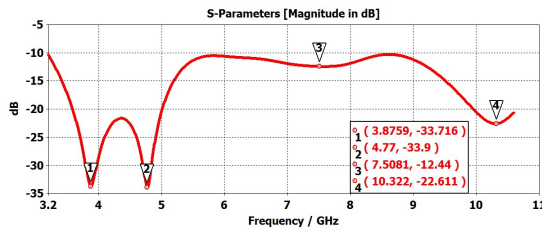


Figure 5. The reflection coefficient without using notch

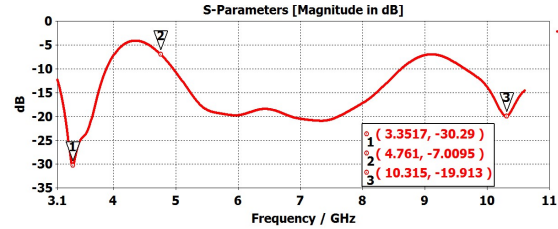


Figure 6. The reflection coefficient with using notch

The parametric sweep of the slit (v, z) is used to identify the best size and location of the slit in the patch of the proposed antenna, and the slot lengths are tweaked to obtain corresponding notch bands at the desired frequency bands as illustrated in Figure 7. The maximum gain after using notch is (2.03) dB, and the voltage standing wave ratio is equal to (1.2) as shown in Figure 8 and Figure 9.

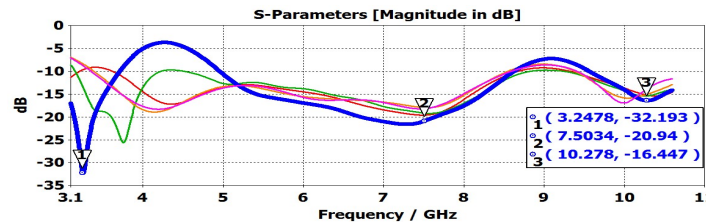


Figure 7. Sweep parameters of the slit with notch dimension (v, z)

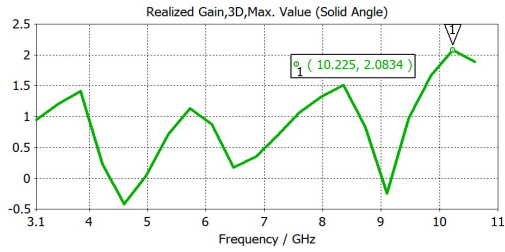


Figure 8. Maximum gain after using notch

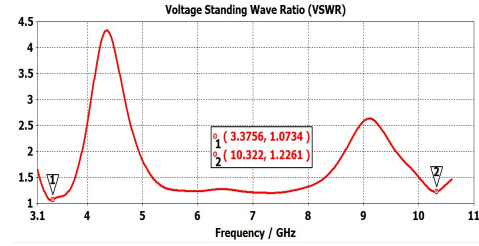


Figure 9. Voltage standing wave ratio

The front view and back view of manufacturer antenna in Figure 10, also the reflection coefficient of the manufactured antenna, and simulation result in Figure 11. The suggested antenna provides bandwidth from 3.1 to 10.6 GHz with a band rejecting at $f=4.7$ GHz, according to simulation and manufacturing findings. Figures 12(a) and (b) shows omnidirectional radiation with a large half-power beam width of 3 dB of 175.0 degrees at the resonant frequency of 3.1 GHz; with a center frequency of 7.5 GHz, the resultant 3 dB beam width is 102.3.

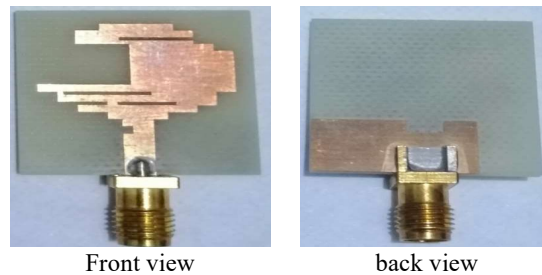


Figure 10. Front view and back view of manufacturer antenna

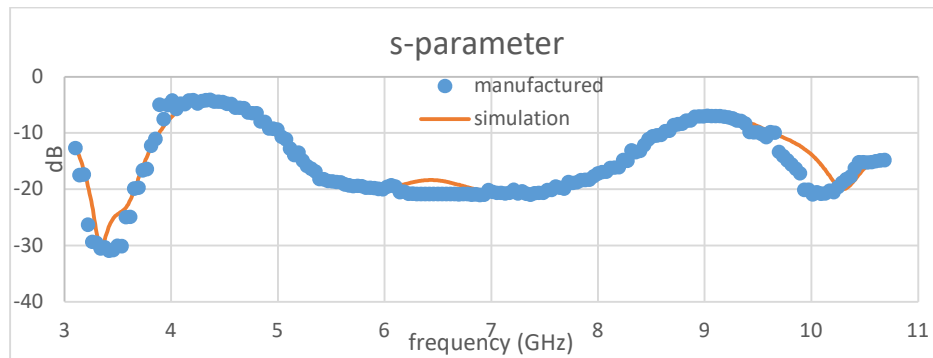
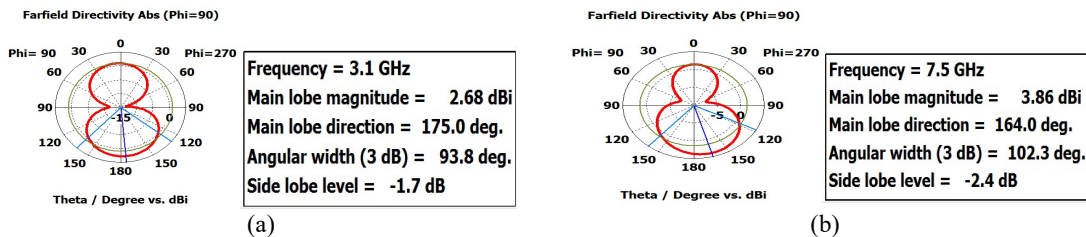


Figure 11. Simulation and manufactured with using notch in the patch

Figure 12. The fair field 2D/3D (a) at $f=3.1$ GHz and (b) at $f=7.5$ GHz

Comparing this presented design, with other designs Table 2, showing the technique used in designs depend on the current distribution on the patch, more effective than the other works that use complex techniques in removing frequency bands.

Table 2. Comparison between this design with other work

Ref	(Size in mm)	Notch stricture	Notch band (GHz)
[23]	25x25x1.6	hexagonal holes that are smaller	5.1-5.9
[24]	45x21x1.6	One side of the elliptical piece has a slit etched into it.	3.3-3.7
[25]	45x35x0.6	Circular ST-SSR on the patch	3.45-3.80
[26]	30x40x0.76	A complementary split ring resonator (CSRR)	3, 6.8
This design	24x24x1.6	Rectangular slits	41-4.8

5. CONCLUSION

The Antenna that has been proposed operates in the frequencies band of the UWB is 3.1-10.6 GHz, with a rejection band of 4.3–4.8 GHz, with stable gain, an improvement in group delay by inserting notch at the feeder. The proposed antenna is easy to fabricate and small in size. and susceptibility in rejection of unwanted frequency bands, the results show that unwanted bands, used by other wireless applications can be removed. and it's suitable for UWB applications.

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