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Design of Double Notch Band Half-Elliptical Shape Reconfigurable Antenna for UWB Applications

Abstract- A compact ultra-wideband (UWB) reconfigurable antenna with dual band-notched properties is presented in this paper. The dual notch band half – elliptical reconfigurable antenna is fed by (50 Ω) microstrip feed lines and it is printed above an FR-4 substrates (32 \times 32.6) mm² dimensions. This dual band notched characteristic is accomplished by embedding two crossing U-shaped slot in the half-elliptical radiating patch of the proposed reconfigurable antenna. The modeling procedure and performance evaluation of the presented antenna was achieved by using the electromagnetic simulator software, (CST) Computer Simulation Technology. The measured bandwidth of the presented antenna for (VSWR < 2) spans 2.6 GHz to 12 GHz, which covers the entire UWB band of 3.1 GHz to 10.6 GHz, with a controlling dual notched band (VSWR > 2) in 3.5 GHz and 5.2 GHz. The presented antenna is appropriate for UWB applications with another benefits of reduces the interference effect with the wireless local area network (WLAN) systems that operating in 5.15–5.35 GHz band (IEEE 802.11a), as well as reducing the interference effect with the Worldwide Interoperability for Microwave Access (WiMAX) application, which operates in 3.5 GHz band (IEEE 802.16e). The parameters that affect the efficiency of the antenna as regards to its frequency domain and radiation pattern qualities are studied.

Keywords- Reconfigurable Antenna, Notch Band, UWB.

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1. Introduction

The UWB technique during the last 20 years has been used for many applications, for example, sensing and military applications, radar, etc.

Since 2002, there are a large number of researches has been studied for this brilliant technology [1]. Until now this technique developing for wireless communication with a high data rate for many applications.

The Federal Communications Commission (FCC) for commercial use allocated the frequency band from 3.1 GHz to 10.6 GHz. To reach such a condition, there are a large number of an excellent antenna designs about this topic, one of these antennas was the half-elliptical microstrip antenna, which is used to operate on the overall UWB frequencies [2]. Many other microstrip patch shapes have been investigated with the UWB technique in the literature [3-6]. While the antenna design with a notch band characteristics have been studied [7-10].

Reconfigurable antenna used to alter the radiation pattern, polarization, or the operational frequency to making the antenna more functional with the varying in the system parameters. The reconfigurable antennas have a suitable competence to radiate other patterns on different polarizations and frequencies are essential in the modern communication systems. For instance, the UWB applications. These requirements used to

enhance the performance (e.g., radar, control, beam steering, direction finding and command) within a minimum volume space as possible. Reconfigurable antennas used as a solution to these problems. The reconfigurable antenna techniques have been effectively verified as described in [11-13].

The broad frequency range of UWB systems will cause an interference effect with the existing wireless communication systems, for instance the Wireless Local Area Network (WLAN) for (IEEE 802.11a) with operating frequency (5.15–5.35) GHz band [14]. And the Worldwide Interoperability for Microwave Access (WiMAX) for (IEEE 802.16e) with operating frequency (3.4-3.7) band [15], so the UWB antenna with a band reject performance is necessary.

To solve this problem, several novel microstrip antennas with band-notched property have been proposed recently. The most common and easiest method is embedding a narrow slot within the radiating patch of the presented antenna and changing the direction of current flow on its metallic parts.

2. Antenna Structures

The geometrical simulation and the photo of the designed half-elliptical ring reconfigurable

antennas was shown in Figure 1. The UWB reconfigurable antenna patch can extend the operating frequency band by expanding the width of the radiating patch. The proposed antenna is fed by (50 Ω) microstrip feed lines and it is printed above an FR-4 substrates with a relative permittivity equals to 4.3 (32 × 32.6) mm² dimensions and heights (h) of 1.5 mm. The UWB characteristic has been achieved by optimizing the parameters (i.e., R1, R2 and R3) of the patch and the height (Lg) of the ground plane. Table 1 indicates the optimum values for each parameter in the proposed antenna parameters.

The proposed antenna was a compact Ultra Wide Band (UWB) Reconfigurable antenna with a dual band-notched characteristic is presented as shown in Figure 1.

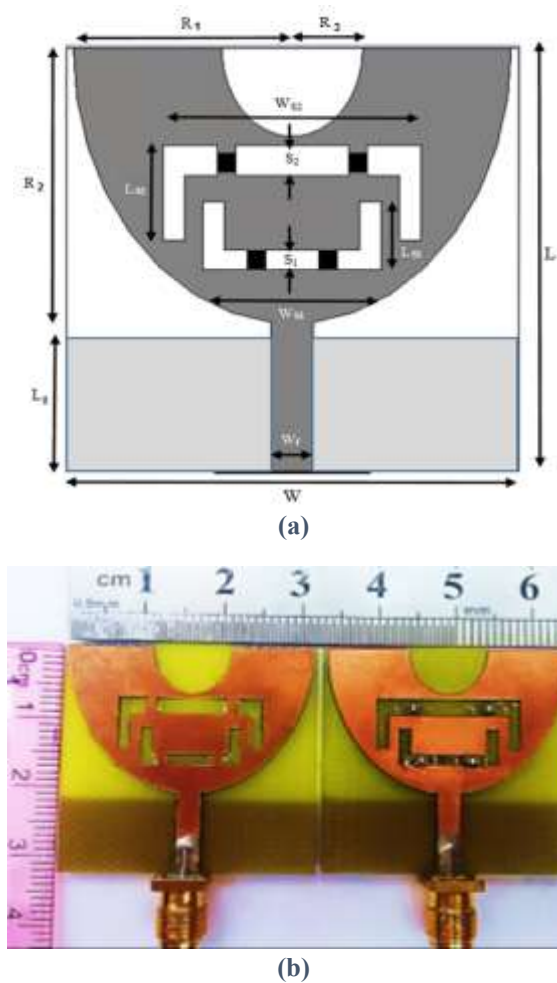


Figure 1: Switchable Band Notch Half Elliptical Reconfigurable antenna. (a) simulation design (b) practical design

Table 1: Parameters of the proposed antenna.

Parameter	Values/m	Parameter	Values/m
W	32	Ws2	18.24
L	32.6	S1	1.5

Lg	11	S2	2.4
Ls1	5.25	R1	15.5
Ls2	7	R2	21.2
Wf	3	R3	5
h	1.5	R4	6.8
W _{S1}	12.6		

At the notch band frequencies, the currents pass nearby the embedded slots are the most considerable factor, even with oppositely flowing directions around the slot boundaries. Consequently, the preferred attenuation close to the notch band frequencies can be created. Figure 2 shows the current distribution for the term when all switches are on or off states.

3. Simulation and Measurement Results

The theoretical and practical results of the Voltage Standing Wave Ratio (VSWR) and radiation fields are calculated in this part. The simulated bandwidth of the designed antenna is shown in Figure 3. While Figure 4 shows the VSWR experimental and simulated result in both cases when all switches are on and again when they are off.

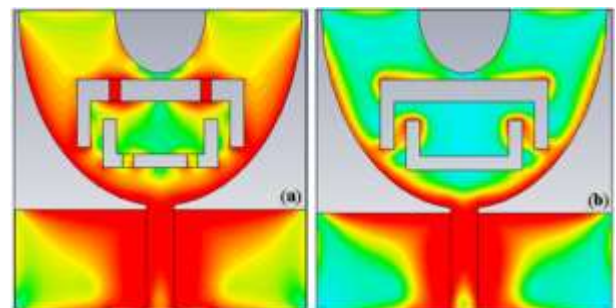


Figure 2: The surface current distribution in the proposed reconfigurable antenna. (a) All switches are on. (b) All switches are off

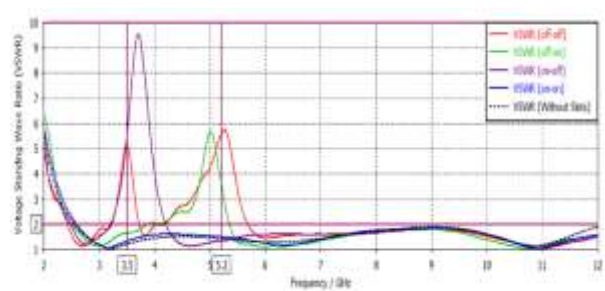


Figure 3: The simulated VSWR results with varying switching states for the reconfigurable antenna

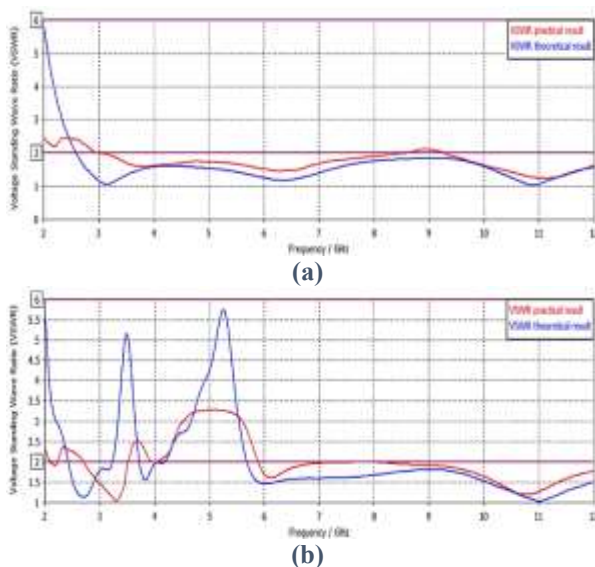


Figure 4: The measured VSWR results with different switching states for the reconfigurable antenna (a) all the switches are on (b) all the switches are off

There are an agreements between the theoretical and practical results can be observed in Figures 3 and 4. In case of all switches are off, the simulated band width of the proposed reconfigurable antenna for (VSWR < 2) extends (2.5 to 12 GHz) with band notch (VSWR > 2) in (3.5 and 5.2) GHz, on the other hand the experimental results of the practical design bandwidth reduced to (2.7 – 12) GHz. However, in case of all switches are on, the simulated band width of the reconfigurable antenna for (VSWR < 2) expands from (2.6 to 12) GHz, but the measured bandwidth of the practical design reduced to (3.1 GHz - 12 GHz), in spite of this, the proposed design still covering the overall UWB frequency bands.

It is clear to notice that there is some divergence between the theoretical and the practical results. The difference is possibly produced by the impurities of the constructed materials, the tolerance of manufacture and the effect of the SMA connectors. However, the operating frequency bands of the reconfigurable antenna are very suitable with the UWB conditions in addition to minimizing the interference effects (3.5) GHz WiMAX and (5.2) GHz WLAN systems.

The notch band function is principally produced by the position, width (WS1, 2), length (LS1, 2) of the Π -shaped slot.

To examine the (WS1, 2), (LS1, 2) parameters, many antenna designs for the same proposed antenna with different values for (WS1, 2), (LS1, 2) parameters has been considered. As shown in Figures 5.

Figure 5 (a) show the effect of the WS1. The suitable value for this parameter has been optimized to cover the notch band of the (5.2 GHz), with an insignificant effect on the (3.5 GHz) notch band. In Figure 5 (b) different value of the WS2 has been taken, the most appropriate value for this parameter is very suitable for the (3.5 GHz) notch band with a minor effect on the (5.2 GHz). On the other hand, the parameters (LS1, 2) have a considerable effect on the notch band characteristics. As shown in Figures 5 (c) the presented reconfigurable antenna design with a different value to the (LS1) parameter has been also taken, and the optimum value is the best result for the (5.2 GHz) notch band. Also, Figure 5 (d) shows another effects due to the values of the (LS2), it is clear to notice that the best option was the most important value to the (3.5 GHz) notch band.

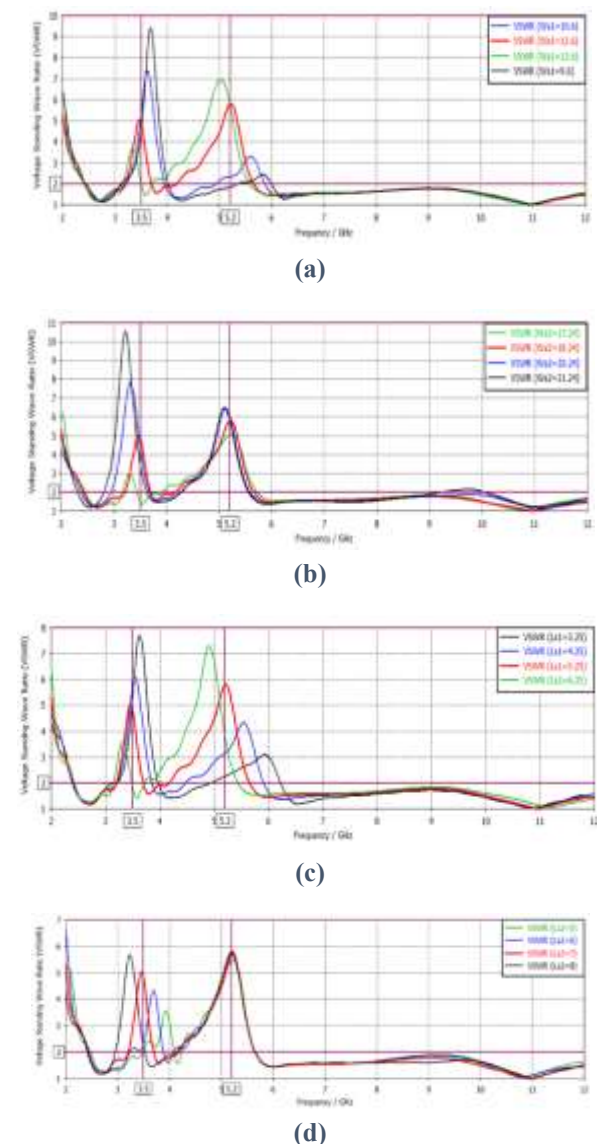


Figure 5: The simulated VSWR results with a various values for the slot width (WS1, 2) and length (LS1, 2) parameters for the designed

reconfigurable antenna (a)WS1 (b)WS2 (c)LS1 (d)LS2

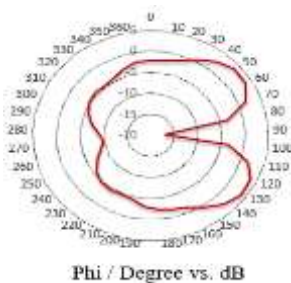
These simulated results gave the better values to the most effected parameters to create an excellent notch band performance.

The overall results of this proposed reconfigurable antenna can be summarized on the following table:

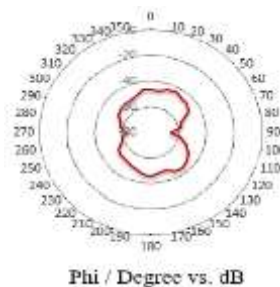
Table 2: The half-elliptical reconfigurable antenna results

Switch States	Operating Frequency	Gain	Directivity	Main lobe Direction	Null Direction	Angular width
off-off	2.7-12 GHz <u>With</u> 3.5 & 5.2 GHz <u>Notch</u>	4.839 dB	5.218 dBi	130 ⁰ - 50 ⁰	90 ⁰	42.5 ⁰
on-on	2.6-12 GHz	4.016 dB	4.805 dBi	126 ⁰ - 54 ⁰	90 ⁰	40.7 ⁰
on-off	2.5-12 GHz <u>With</u> 3.5-3.9 GHz <u>Notch</u>	3.555 dB	4.318 dBi	129 ⁰ - 51 ⁰	90 ⁰	44.7 ⁰
off-on	2.5-12 GHz <u>With</u> 5.1 GHz <u>Notch</u>	3.918 dB	4.689 dBi	126 ⁰ - 54 ⁰	90 ⁰	41 ⁰

The theoretical and practical results of the radiation fields for the x-y plane of the proposed antenna was shown in Figure 6. This Figure demonstrate the simulated results of the radiation patterns are essentially in agreement with experimental results.



(a)



(b)

Figure 6: The radiation patterns with varying switching state of the proposed reconfigurable antennas (a) The simulated result (b) The experimented result

4. Conclusion

The antenna structure has been designed and manufactured; the antenna performance has been investigated by using the electromagnetic simulator Computer Simulation Technology (CST) to compare between the simulated and experimented results. The previously results lead to the following explanations:

There is some deviation between the simulated and the experimented results, this inaccuracy probably caused by the impurities of the constructed materials (FR-4 of the substrate and copper of the patch and ground plane), the imperfection of manufacture, and the effect of the SMA connectors.

All the geometrical parameter affects the UWB band performance of the offered reconfigurable antenna; on the other hand, some of the antenna parameters may have the major effect. Specially, the dimensions of the radiating patch, the length (Lg) of the ground have big effects on the operational frequency band.

Reducing the length of the ground plane can be used to achieve the UWB bandwidth requirements.

However, the proposed antenna has a small size (32 × 32.6) mm² and presenting a bandwidth (2.6-12 GHz), with a notch band in (3.5 and 5.2) GHz. With the reasonable gain approximately to

(3.5-4.8 dB) this proposed antenna succeeded to be a suitable reconfigurable antenna design with the UWB applications.

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