A Novel Small E–Ring Shaped Monopole Antenna with Dual Band-Notch Function for UWB Wireless Communications

Nasser Ojaroudi, Mohammad Ojaroudi, Shervin Amiri

***Abstract*— This paper presents an E-ring shaped printed monopole antenna for UWB applications with dual notched bands performance. In order to generate single frequency band notch function, we applied a U-ring shaped monopole antenna, and by inserting a rectangular ring in the centre of it an E-ring shaped radiating patch created and a dual band-notch function can be achieved. The measured bandwidth of the proposed antenna is from 2.75 GHz to 11.43 GHz (110%) for VSWR < 2. The proposed antenna offers two notched bands, covering all the 5.2/5.8GHz of WLAN, 3.5/5.5 GHz of WiMAX and 4-GHz of C bands ranges. Good radiation behavior within the UWB frequency range has been obtained. The antenna has a small dimension of 10 *17 mm^2.**

***Index Terms*—E-Ring Shaped Monopole Antenna, Ultra Wide Band (UWB) Antenna, Dual Band Notch Function**

I. Introduction

COMMUNICATIN systems usually require smaller antenna size in order to meet the miniaturization requirements of Radio-Frequency (RF) units [1]. It is a well-known fact that planar monopole antennas present really appealing physical features, such as simple structure, small size, and low cost. Due to all these interesting characteristics, planar monopoles are extremely attractive to be used in emerging UWB applications, and growing research activity is being focused on them. Consequently, a number of planar monopoles with different geometries have been experimentally characterized [2]-[3].

The frequency range for UWB systems between 3.1–10.6 GHz will cause interference to the existing wireless communication systems like Wireless Local Area Networks (WLAN) in IEEE802.11a which operate in 5.15–5.35 GHz and 5.725–5.825 GHz bands, so the UWB antenna with a band-notch function is required. Lately to generate the frequency band-notch function, several modified planar monopoles antennas with band-notch characteristic have been

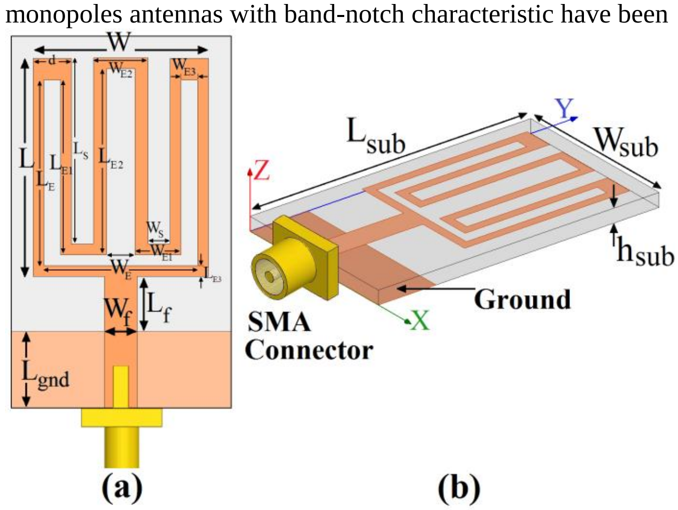

Fig. 1. Geometry of proposed E-ring shaped monopole antenna (a) top view, (b) side view.

reported [4-10]. In [6], [7] and [8], different shapes of the slots (i.e., W-shaped, L-shaped and folded trapezoid) are used to obtain the desired band notched characteristics. Single and multiple [9] half-wavelength U-shaped slots are embedded in the radiation patch to generate the single and multiple band-notched functions, respectively and automatic design methods have been developed to achieve band-notch performance [10].

A novel microstrip-fed dual band-notch printed monopole antenna is presented in this paper. In the proposed structure, single frequency band-notch characteristics is obtained by applying a U-ring shaped structure in the rectangular radiating patch and dual band-notch function is provided by using an E-ring shaped structure for monopole antenna .The dual notched bands, covering all the 5.2/5.8GHz of WLAN, 3.5/5.5 GHz of WiMAX and 4-GHz C bands range. Details of the proposed design and experimental results are also presented and discussed.

II. Antenna Design and Configuration

Fig. 1 shows the configuration of the proposed low-profile planar E-ring shaped monopole antenna that fed by a microstrip line. Antenna is printed on a FR4 substrate with thickness of 0.8 mm, permittivity of 4.4, and loss tangent of

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0.018. In this design, the E-ring shaped structure is applied to generate the dual frequency band-notch function, as shown in Fig.1. The rectangular-shaped ring structure plays an important role to create dual band-stop function because without this structure we have a single notch function and by inserting it, we can gave two notched-band performances.

The simulation software of High Frequency Structure Simulator (HFSS) [11] from Ansoft is used to optimize the design. The structure of the various antennas used for simulation studies shown in Figs.2.

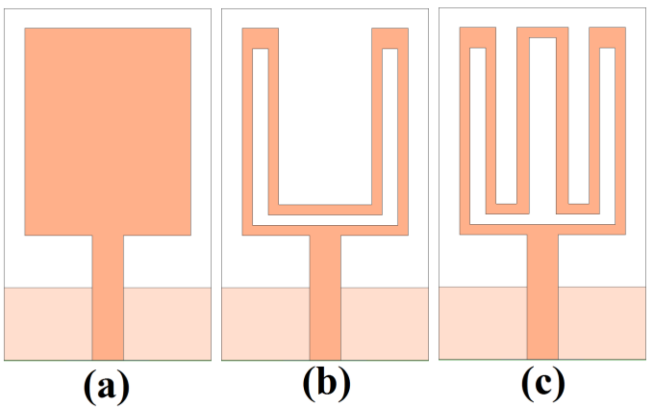

Fig. 2. (a) The ordinary Rectangular antenna, (b) the U-ring shaped structure in the radiating patch, (c) the proposed antenna structure.

To generate single frequency band notch Function (3.3-4.2GHz C-Band) ,we use U-ring shaped structure in the radiating patch of monopole antenna, and by adding a rectangular ring in the centre of the U-ring shaped antenna, the dual band-notch function can be achieved that covering all the 5.2/5.8GHz WLAN, 3.5/5.5 GHz WiMAX and 4-GHz C bands. VSWR characteristics for the ordinary rectangular patch antenna (Fig. 2(a)), U-ring shaped patch antenna (Fig. 2(b)), and the proposed antenna structure (Fig. 2(c)) are compared in Fig 3.

Also input impedance of the proposed monopole antenna structure on a Smith Chart is shown in Fig. 4.

The optimized values of proposed antenna design parameters are as follows:

$W_{sub} = 10mm$, $L_{sub} = 17mm$, $h_{sub} = 0.8mm$,
$W = 8mm$, $L = 10mm$, $W_f = 1.5mm$, $L_f = 2.5mm$,
$W_S = 1mm$, $L_S = 8.5mm$, $W_E = 7mm$, $L_E = 8.25mm$,
$W_{E1} = 2mm$, $L_{E1} = 7.75mm$,
$W_{E2} = 2.5mm$, $L_{E2} = 8.5mm$,
$W_{E3} = 0.75mm$, $L_{E3} = 0.5mm$,
$d = 1.75mm$ and $L_{gnd} = 3.5mm$.

III. Results and Discussions

The proposed microstrip-fed monopole antenna was fabricated and tested to evaluate the dual band-stop performance of antenna and demonstrate the effect of this new design. The test results show that good agreement is obtained between the simulation and measurement.

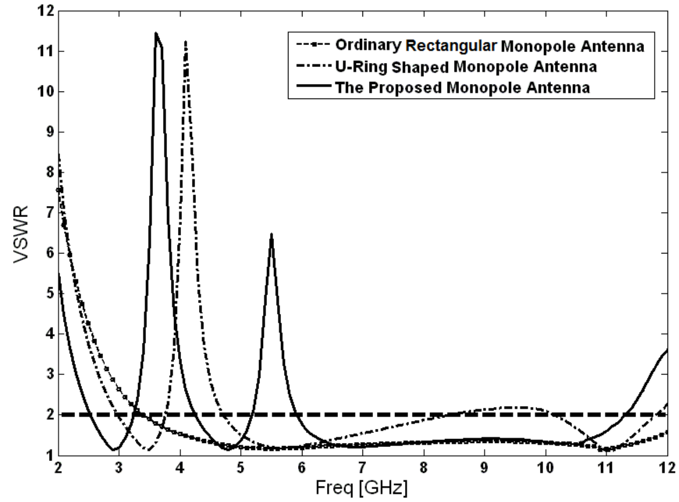

Fig. 3. Simulated VSWR characteristics for the antennas shown in Figure 2

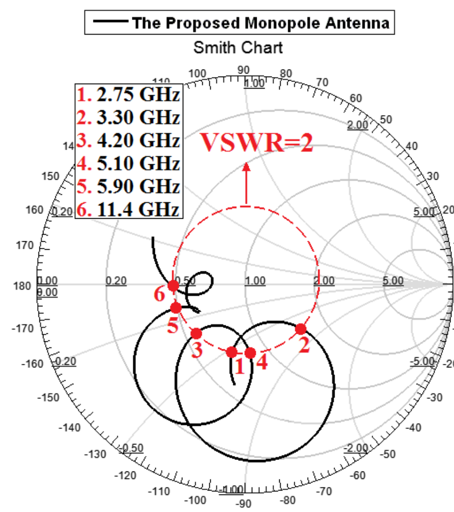

Fig.4. The simulated input impedance on a smith chart of the proposed E-ring shaped monopole antenna.

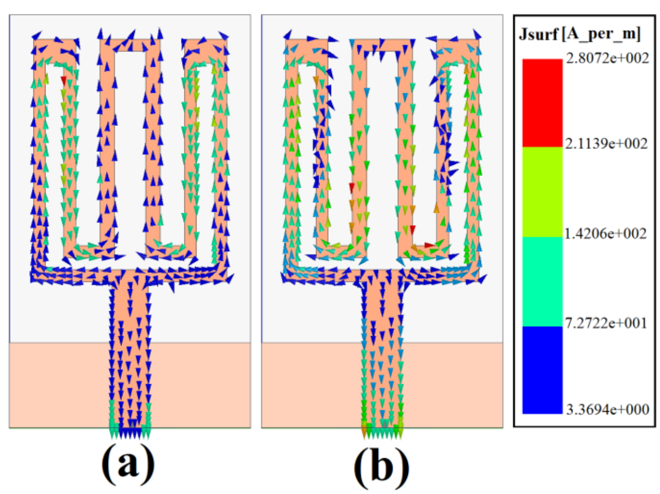

Fig.5 Simulated surface current distributions on radiating patch for the proposed antenna (a) at 3.8 GHz and (b) at 5.5 GHz

The simulated current distribution on the radiating patch for the presented E-shaped monopole Antenna notch frequencies of 3.8 GHz and 5.5 GHz is presented in Fig. 5(a) and 5(b), respectively. It can be observed on Fig. 5(a) and 5(b) that the current Concentrated on the edges of the interior and exterior of the E-ring shaped at 3.8 GHz and 5.5 GHz. Therefore the antenna impedance changes at these frequencies due to the band-notch properties of the rectangular rings.

The simulated VSWR curves with different values of L_s are plotted in Fig. 6. As shown in Fig. 6, when the height of the L_s increases from 6.5 to 9 mm, the centre of lower notch frequency is decreases from 7.5 to 5.1 GHz and also the centre of higher notch frequency is decreases from 4.8 to 3.35 GHz. From these results, we can conclude that the notch frequency is controllable by changing the interior height of the L_s.

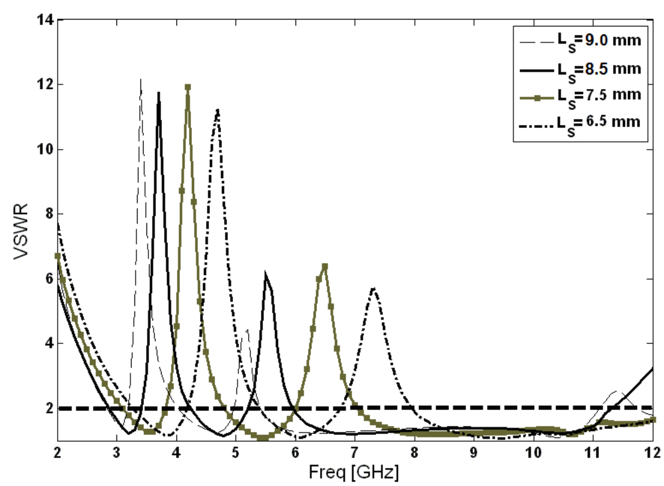

Fig. 6. Simulated VSWR characteristics for the proposed antenna with different values of L_s.

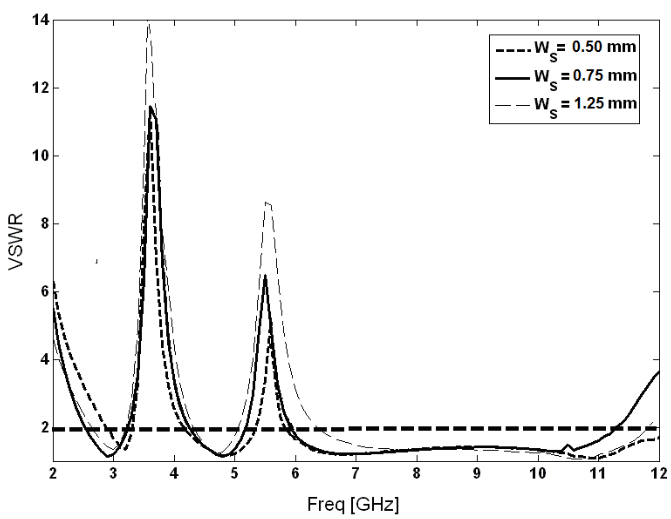

Fig. 7. Simulated VSWR characteristics for the proposed antenna with different values of W_s.

Another main effect of the E-ring shaped monopole antenna occurs on the filter bandwidth. In this structure, the width W_S is the critical parameter to control the filters bandwidth. Fig. 7 illustrates the simulated VSWR characteristics with various width of W_S. As the exterior width of the W_S increases from 0.5 to 1.25 mm, the bandwidth of lower notch frequency is varied from 0.8 to 1.2 GHz and also the bandwidth of higher notch frequency is increases from 0.6 to 1.4 GHz. Therefore the bandwidth of notch frequency is controllable by changing the width of W_S.

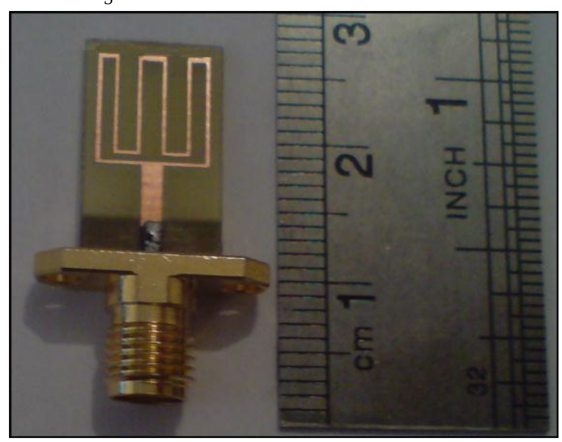

Fig 8. Photograph of the realized E-ring shaped monopole antenna.

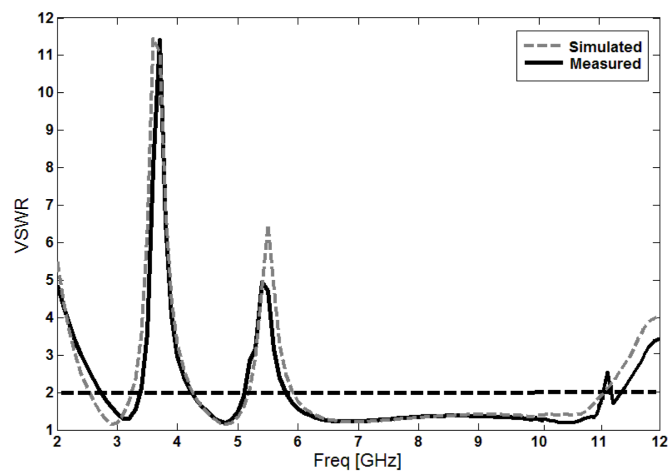

Fig. 9. Measured and simulated VSWR for the proposed antenna.

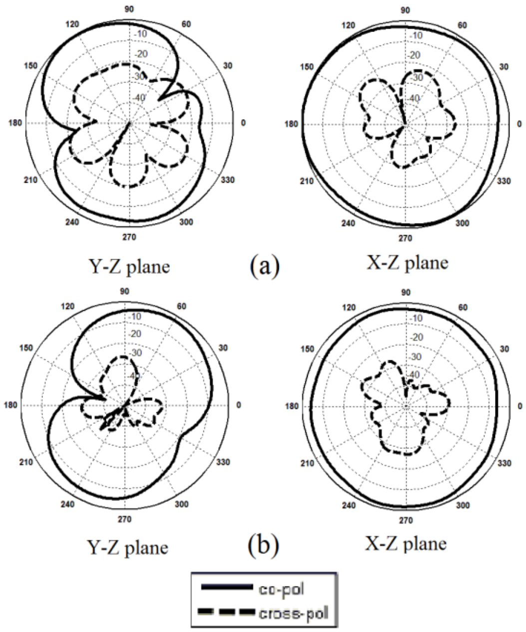

Fig 9. Measured radiation patterns of the proposed antenna (a) 4.7 GHz, (b) 9 GHz.

The proposed antenna with optimal design, as shown in Fig. 8, was built and tested in the Antenna Measurement Laboratory of Iran Telecommunication Research Center (ITRC). The measured and simulated VSWR characteristics of the proposed antenna is shown on Fig. 8 .The fabricated antenna has the frequency band of 2.75 to over 11.43 GHz with two rejection bands around 3.3- 4.2 and 5.1–5.9 GHz. Fig. 9 illustrates the measured radiation patterns, including the Co-polarization and cross-polarization, in the H–plane (x-z plane) and E-plane (y-z plane). It can be seen that the radiation patterns in *x-z* plane are nearly omni-directional for the two frequencies.

IV. Conclusion

In this paper, we propose a novel E-ring shaped printed monopole antenna for UWB applications with dual notched bands performance. In this design, the proposed antenna can operate from 2.75 to 11.43 GHz with two rejection bands around 3.3-4.2 and 5.1–5.9 GHz. By creating an E-ring shaped structure on the radiating patch, dual band notch characteristics can be achieved. The designed antenna has a small size. Simulated and experimental results show that the proposed antenna could be a good candidate for UWB applications.

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