Compact Wrench-Shaped Resonator Loaded UWB Antenna with Notched Frequency Characteristics

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***Abstract*—In the manuscript, the design of a wrench-shaped resonator loaded ultra-wideband (UWB) antenna has been proposed using notched frequency characteristics. The antenna is composed of the patch with microstrip feed line, a wrench-shaped resonator, and a slotted partial ground plane. A notched frequency is created due to the electromagnetic coupling of wrench-shaped resonator. In order to observe the effects of wrench-shaped resonator, a parametric study has been executed. Measured results are compared with simulations (with and without notched bands) and a stable similarity has been observed. The surface current, radiation patterns and the impedance (imaginary and real) have ensured the compression of wanted notched frequency bands.**

***Index Terms*— Wrench-shaped resonator; UWB Antenna; Band notch function; Notched Frequency.**

I. INTRODUCTION

Alleviating the interfering signals between the narrow band systems and UWB antennas have delivered stable motivation in UWB antenna design with notched frequency characteristics. The federal communications commission (FCC) allocated the 3.1-10.6 GHz frequency band for unlicensed radio communication. In order to attain the feature, different design configurations are reported in the literature with modified radiating element or/and the ground on the planar UWB antennas [1-18]. Quintuple [1-4], quadruple[5-8], triple[9-11], dual[12-14] and single [15-18] notched frequencies have been attained with UWB antennas applying different design configurations. Quintuple notched band have been executed using open-circuit stubs, C-shaped slots, U-shaped slots, and nested C-shaped slots [1], by embedding five half/one-wavelength M-shaped resonators into the feed-line, the ground and the radiator [2], by integrating five c-shaped slots [3], and by inserting an open-loop resonator, two defected ground structures and a pair of arc-shaped slots[4].However, Three crescent-shaped resonators on the patch and an inverted U-slot on the ground are applied for creating quadruple notched frequencies[5]. By embedding H-shaped resonator on the patch, another design is exhibited in [6]. Other antennas such as inserting T-shaped parasitic strip L-shaped open circuit stub, and C-shaped slots [7], and four U-shaped slots on the patch [8] are also applied properly. In the way, triplee notched bands are presented in the UWB antennas by using twoelliptic single complementary split-ring slots and locating two rectangular split-ring resonators [9], by adopting integrated microstrip resonators, and spiral loop resonator (SLR) [10] and by integrating a modified H-shaped resonator [11].However, dual notched bands are proposed with applying dual pairs of SRRs [13], etching a partial annular slot[14],one semi-circular with one rectangular and partial concentric annular slot with another rectangular slot [12]. A single notched frequency is also observed by loading a pair of SRRs [15], incorporating a rectangular slot[16],using the isolated slit, the parasitic strips, and the open-end slits [17], and designing the strip[18].

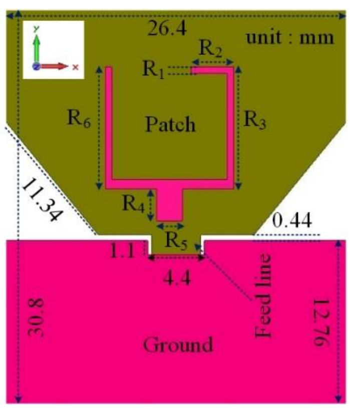
The manuscript explains a compact UWB antenna with notch function using a wrench-shaped resonator. The wrench-shaped resonator are located on the back side of the patch which initiates a notch function. The radiation is alleviated at the band-notch frequency owing to the effects of the wrench-shaped resonator (strong magnetic coupling). The effects are applied for filtering and eliminating the interference resulted in UWB systems.

II. ANTENNA DESIGN

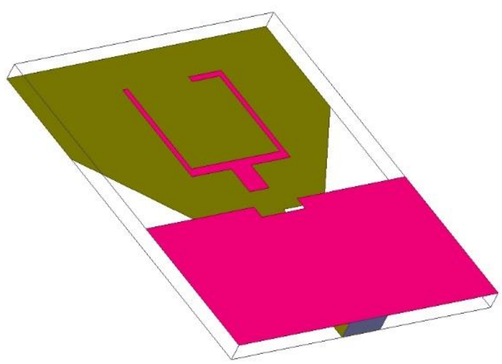
The presented antenna design layout loaded with wrench-shaped resonator is indicated in Figure 1. The antenna is composed of microstrip feed line, a wrench-shaped resonator, and a slotted partial ground. It is fabricated on 1.524 mm thick RO4003 dielectric material. This design is optimized using HFSS simulation software and is verified with fabricated prototype. The patch size is 26.4 mm × 17.60 mm where the partial ground is 12.76 mm. The microstrip feed length is 13.20 mm and width is 3.85 mm for delivering 50Ω input impedance. 35 µm copper cladding is applied for metalizing the ground, feed and the patch of the presented antenna. The overall optimized antenna size is 26.4 mm × 30.8 mm and easily integrated into portable devices.

A wrench-shaped resonator has been etched on the upper portion of the ground to initiate a notch function as shown in Figure 1. This wrench-shaped resonator has three vertical and two horizontal arms on the upper portion of the ground plane. The optimized design parameters of the wrench-shaped resonator are as follows: R_1=0.5 mm, R_2= 3.3 mm, R_3=9.5 mm, R_4= 2.5 mm, R_5=2 mm, R_6=9.5 mm. Excessive space is not needed for integrating the wrench-shaped resonator on the upper portion of the ground and however, the overall size of the designed antenna is kept unchanged.

The input impedance is shown in Figure 2 with and without wrench-shaped resonator. It is found that at the notched frequency, the impedance is very high (not close to 50 ohm property). The antenna is almost well-matched except notched frequency. A parametric study is done to study different effects on the resonator performances. Figure 3 exhibits the effect of R_5 on the VSWR characteristics. It is seen that the increase or decrease of R_5, centre frequency is shifted at the higher frequency. The effect of R_1 is indicated in Figure 4 on the VSWR characteristics. It is also found from the plot that the increase or decrease of R_1, centre frequency of notched band is shifted at the higher frequency. Figure 5 illustrates the effect of R_2 on the VSWR characteristics. It can be observed that R_2=3.3 mm is the optimum value due to the well-matched impedance.



(a)



(b)

Figure 1: The designed antenna (a) geometric layout (b) 3D view

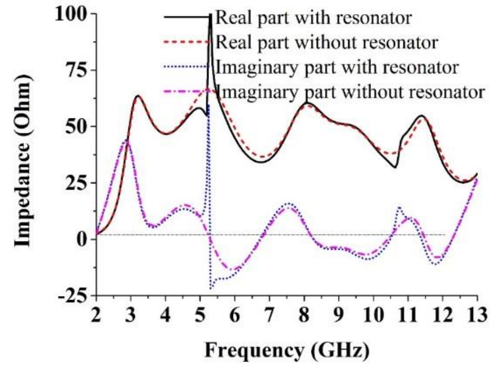


Figure 2: The input impedance of the antenna (real & imaginary part)

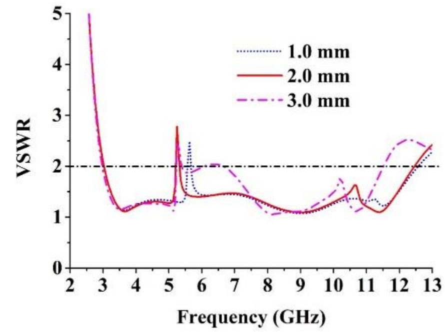


Figure 3: Simulated VSWRs for different values of R_5

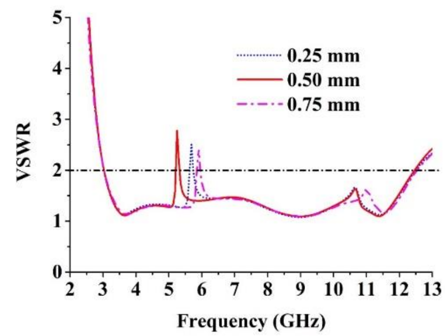


Figure 4: Simulated VSWRs for different values of R_1

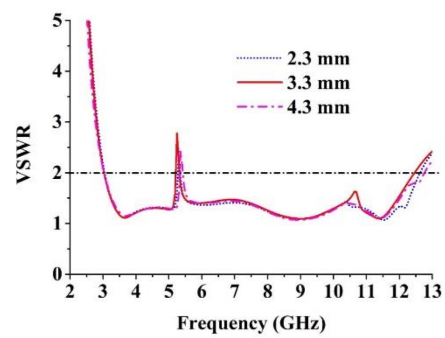


Figure 5: Simulated VSWRs for different values of R_2

III. Results and Discussion

Figure 6 illustrates the VSWR curve of the designed antenna with and without wrench-shaped resonator. The VSWR properties of the reported antenna have been measured using a power network analyzer (PNA) N5227A. 5.31-5.51 GHz notched bands are observed from the measured result on the operating 3.05 GHz to 12.70 GHz frequency bands. A harmony is noticed between simulations and measurements. The gain is indicated in Figure 7. It is seen from the graph that the gain is very stable on the operating bands except notched frequency bands.The normalized radiation patterns are illustrated in Figure 8 at 3.50 GHz and 6.50 GHz frequency. It is found that dipole like and nearly omnidirectional radiation pattern have been attained in the E-plane and H-plane, respectively at both frequency (3.50 GHz &6.50 GHz). Fig. 9 shows the surface current at 3.50 GHz, 4.50 GHz, and 6.50 GHz. It can be found that most of the currents flow on the bottom edge of the microstrip feeding and around the wrench-shaped resonator at 3.50 GHz frequency. At 4.50 GHz and 6.50 GHz frequency, majority current flow at the resonator, the gap (between patch & ground) and along microstrip feeding.

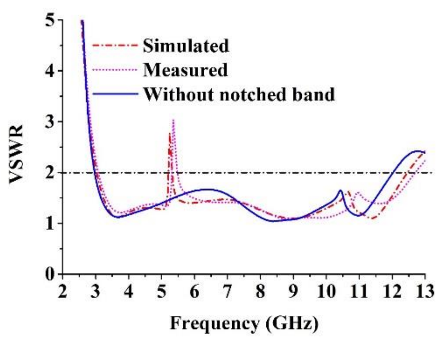


Figure 6: VSWR curves of the presented antenna

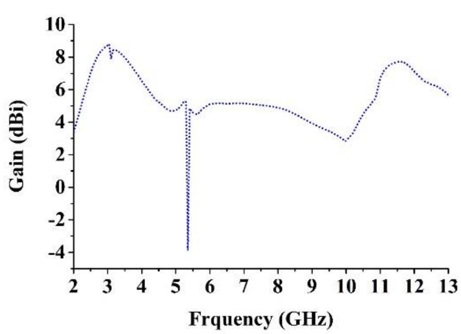


Figure 7: Gain of the presented UWB band-notched antenna

IV. Conclusions

A wrench-shaped resonator loaded ultra-wideband antenna is proposed with band notch function. The wrench-shaped resonator is located on the back side of the antenna patch. This resonator creates notched frequency using electromagnetic coupling. The resonator dimensions and the presented design are free from each other. By shifting the resonator dimensions, notched band has been customized to the wanted bands remaining the antenna dimension unchanged.

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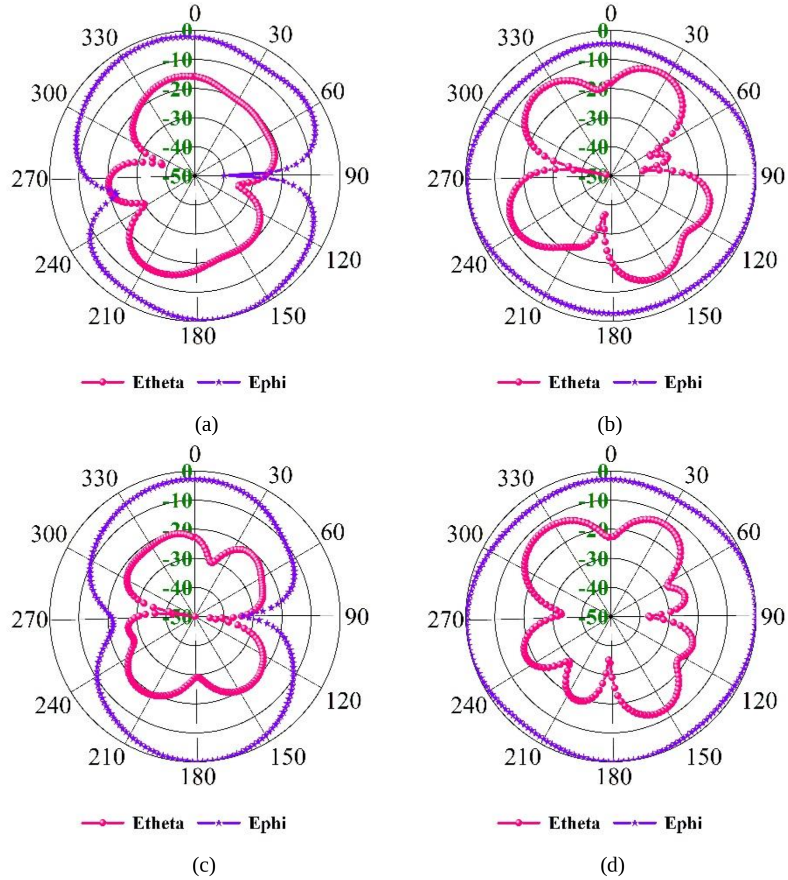
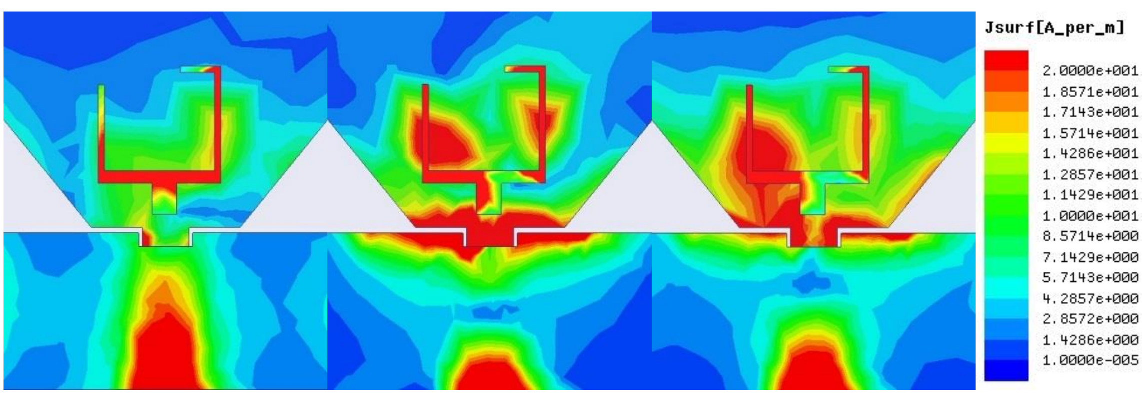


Figure 8: The normalized radiation pattern (a) E-plane at 3.5 GHz, (b) H-plane at 3.5 GHz, (c) E-plane at 6.5 GHz, and (d) H-plane at 6.5 GHz



(a) (b) (c)

Figure 9: Surface current distribution at. (a) 3.5 GHz, (b) 4.5 GHz (c) 6.5 GHz