A COMPACT UWB ANTENNA USING IDCLLR AND PARALLEL SLIT WITH TRIPLE BANDS NOTCHED CHARACTERISTICS

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ABSTRACT

In this paper a compact ultra-wideband (UWB) antenna with notch characteristics is presented which shows triple notches at different frequencies over the band of operation. By using C-shaped ground the overall dimensions of antenna is reduced to 24mm×28mm×1mm. Initially, inter-digital capacitance loading loop resonators with small size are implemented which give dual notch characteristics. Further, by inserting two parallel C shaped slits near feed line third frequency rejection band is achieved. Several properties of antenna such as impedance bandwidth, frequency notched characteristics, radiation patterns, and good gain have been investigated numerically and experimentally in detail. The proposed antenna covers the FCC defined UWB frequency range (3.1 to 10.6 GHz).

KEYWORDS: *UWB Antenna, IDCLLR, C Shaped Ground, Slit*

I. INTRODUCTION

An ultra-wideband (UWB) technology is a promising asset for future short range data and voice communication. Currently, this technique is used mainly in radar and sensor application. The Federal Communication Commission (FCC) first approved rules for the commercial use of ultra-wideband (UWB) in 2002 [1]. The commercial uses of frequency band for UWB radio system from 3.1 to 10.6 GHz were approved by FCC in which there might exist other wireless narrowband standards such as lower and upper wireless local area networks WLAN (5 – 5.35 GHz and 5.725 – 5.825 GHz). However, in order to avoid interfering with other nearby communication system UWB antenna with frequency notched function is desirable [2].

Various methods have been proposed to achieve band-notched functions and they can be classified into two categories. The first is by embedding slots on patch or on ground plane such as fractal shaped slot [3], U-shaped slot [4], V- shaped slot, T –shaped slot, H – shaped slot, and C – shaped slot [5]. And the other is by inserting diverse parasitic elements on the patch near feed line such as SRR, IDCLLR, slits etc. [6, 7].

By the first method UWB antennas have only one notched band because of strong coupling and slot also affect the efficiency and radiation pattern of the antenna. A pair of SRR placed near feed line is able to produce two rejection bands but not all the rejection bands are desirable notches in UWB operation band and width is still too wide [7].

To achieve efficient dual notches a pair of IDCLLR is used which is compact in size and can generate suitable notched bands that can be tuned respectively [8]. The resonance frequency can be varied by adjusting the slot dimensions for all this methods.

In this design a compact UWB antenna with triple notch characteristics is presented. The proposed antenna has been designed to excite dual and triple independent notches at various frequencies across

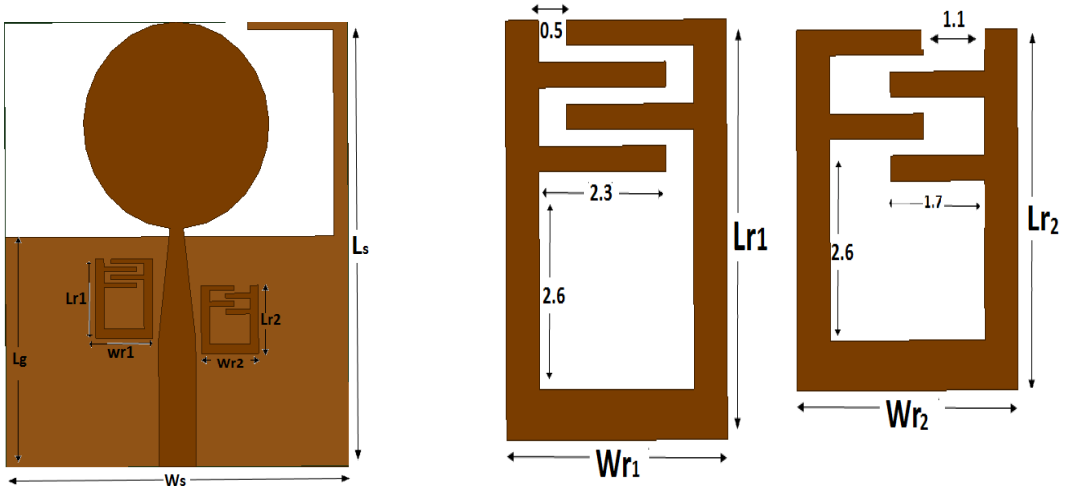
the band of operation. By etching two parallel slits near feed line, triple band notched characteristics for the proposed UWB antenna can be excited to reduce interferences between UWB system and narrowband system. Details of antenna design and simulation are presented in Section II. Measured results are presented in Section III to demonstrate the performance of proposed antenna. Conclusions of this study are drawn in Section IV.

II. DESIGN AND IMPLEMENTATION

The following subsections describe the design and implementation of the proposed antenna.

2.1. Compact UWB Antenna with Dual-band Notches

Figure 1 shows the basic geometry of proposed UWB antenna for dual band notch characteristics. The antenna is designed on C-shaped ground which helps in increasing the current path [11]. The proposed antenna is constructed on a rectangular microwave substrate with relative permittivity of 2.65 and thickness of 1 mm and is fed by 50Ω micro strip feed line. The antenna is optimized by HFSS v.13 EM software which covers a wide bandwidth of 3-13 GHz with VSWR<2.



(a) (b)

Figure 1: (a) Geometry of proposed antenna (b) IDCLLR.

2.2. IDCLLR

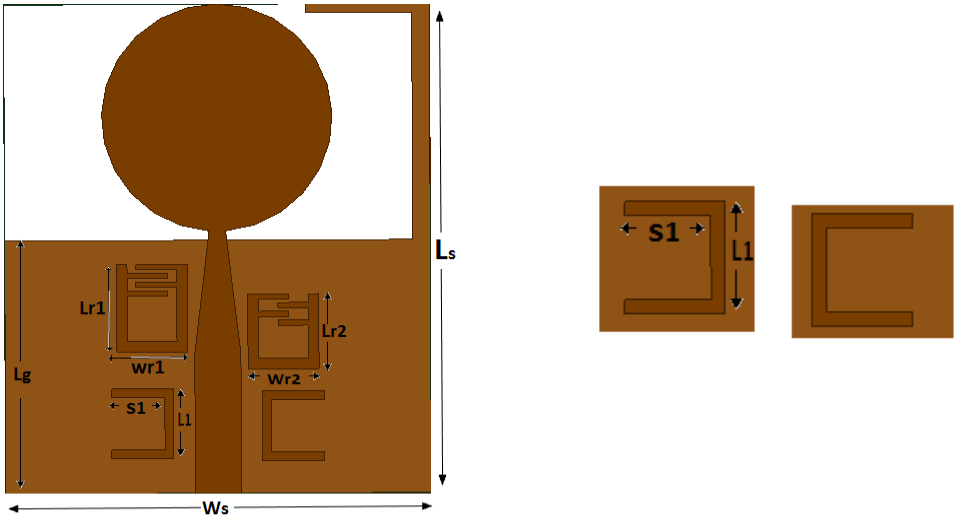
An IDCLLR is composed of a metallic split ring with inter-digital loading in a gap which is depicted in Figure 1(b). It can be considered as an electrically small resonator and behaves as a parallel RLC circuit as the inter-digital loading enhances the equivalent capacitance. As suggested in [9], the resonant frequency of IDCLLR is, $f_0 = (L_0C_0)^{-½}/2\pi$ and the width of band gap is proportional to $(L_0/C_0)^{½}$ [10]. Where, L_0 and C_0 are the equivalent inductance and capacitance of IDCLLR, respectively. Therefore, by properly designing the dimensions of the IDCLLR, The resonant frequency can easily be tuned to match the desired band.

Table 1: Dimensions of the proposed geometry

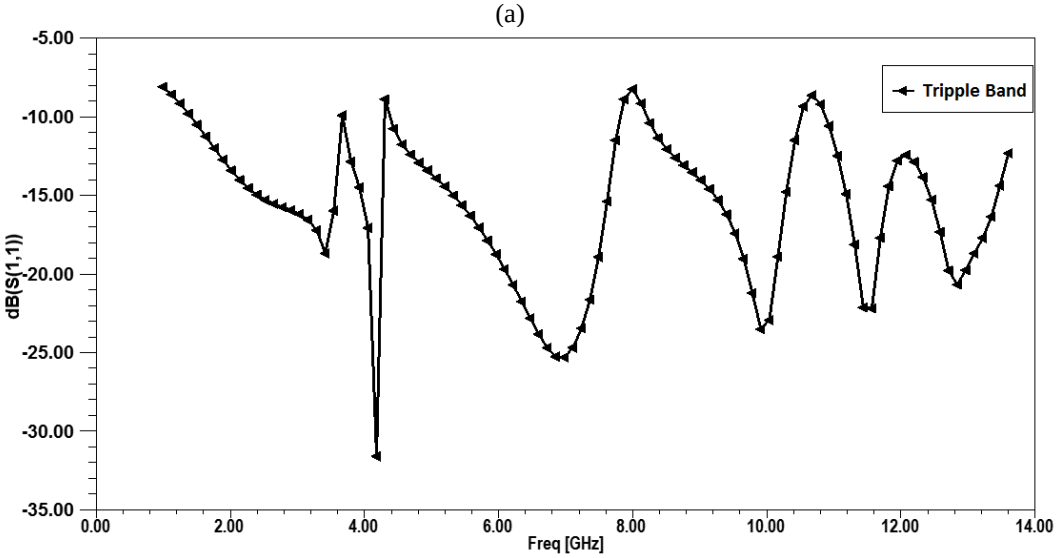
Parameter	L_{r1}	W_{r1}	L_{r2}	W_{r2}	L_s	W_s	L_g	Radius	Feed length
Value(mm)	5	4	4.3	4	28	24	14.5	6.5	15

2.3. Compact UWB Antenna with Three-band Notches

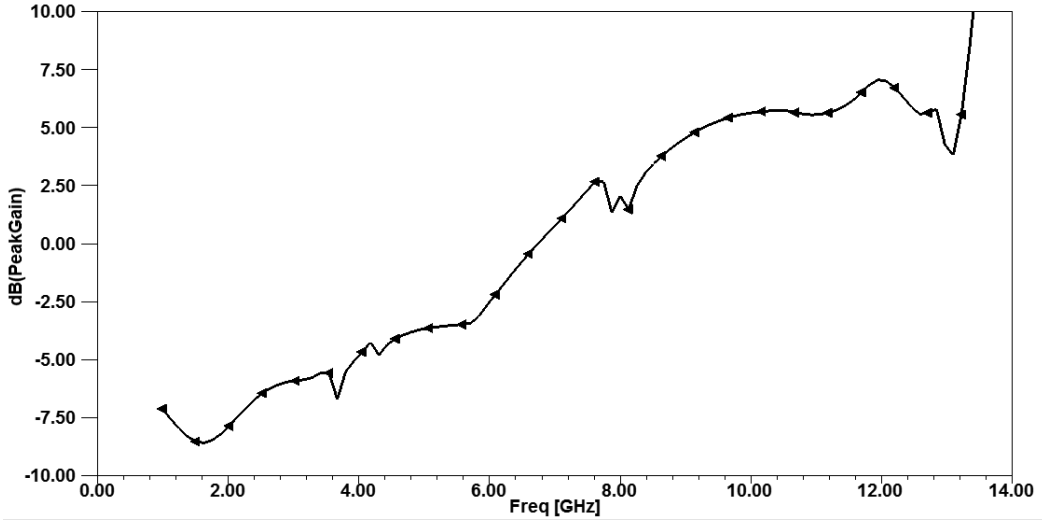
For three notch characteristics, one can achieve using the same antenna geometry with two additional slits on the metallic patch as shown in Figure 2(a). The VSWR characteristics of antenna are shown in Figure 2(b). It may be noted that the three notches are excited at about 3.3 GHz, 4.1GHz, and 6.1GHz.



(a)



(b)

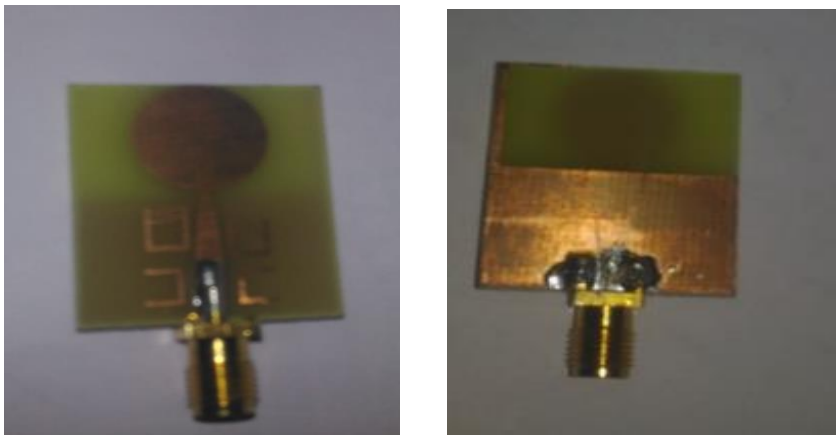


(c)

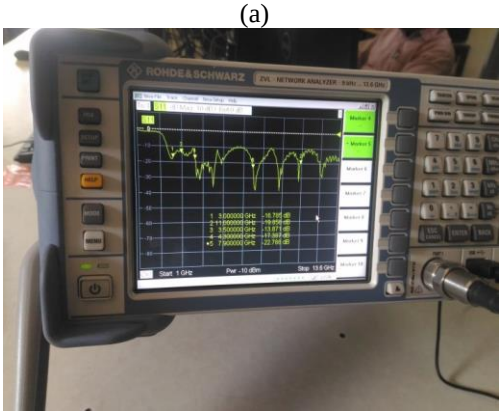
Figure 2: (a) UWB antenna with three notch characteristics (b) VSWR of triple band-notched UWB geometry (c) Gain of the proposed antenna.

III. EXPERIMENTAL VALIDATION OF THE GEOMETRY AND DISCUSSIONS

The geometry shown in Figure 2(a) with its optimized dimensions was fabricated and tested. The substrate used for the fabrication is the FR4 glass epoxy with dielectric constant of 4.4, and a thickness of 1 mm. A photograph of the fabricated prototype is shown in Figure 3(a) and its S11 measurement setup is shown in Figure 3(b). The VSWR comparisons of measured and simulated values are compared in Figure 4. From Figure 4 it may be noted that the measured results are fairly agreed with the simulated values. The radiation patterns are presented at several frequencies in the operating bands of frequencies (excluding notches) to demonstrate the proper working of antenna at desired bands of frequencies (Figure 5).



(a)



(b)

Figure 3: (a) Fabricated prototype (top and bottom views) (b) Photograph of measurement setup (S_{11}).

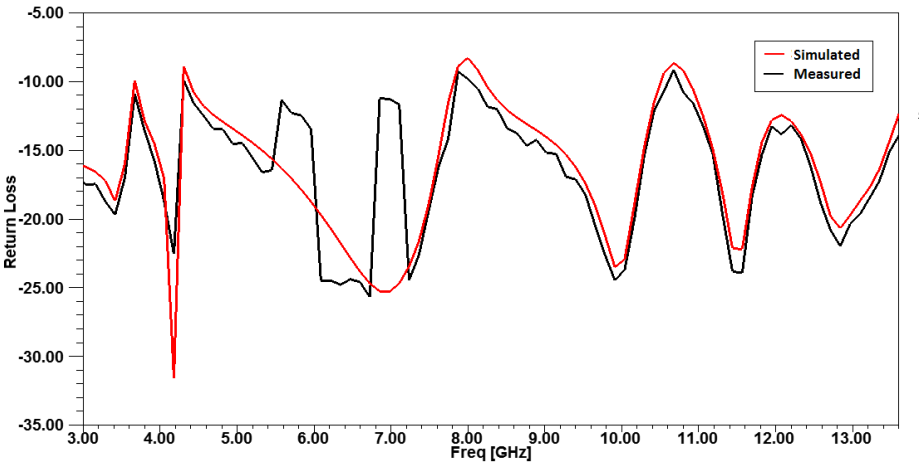
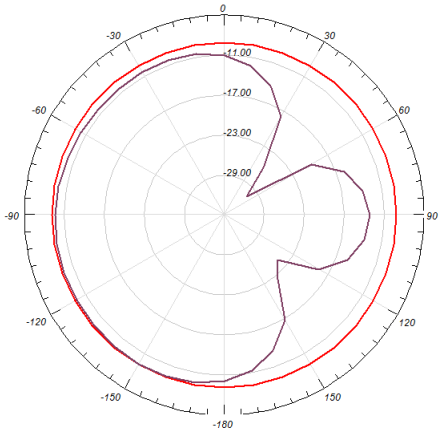
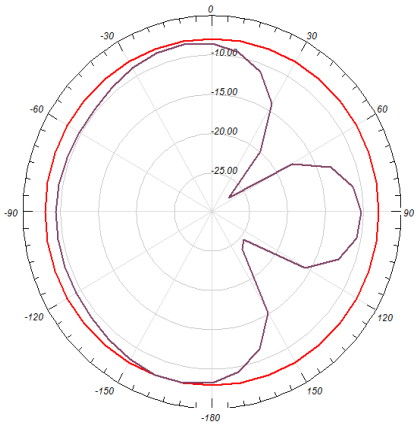


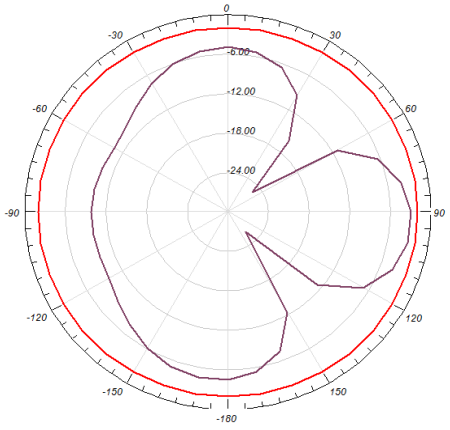
Figure 4: Return loss vs. frequency comparison of measured and simulated data.



(a) 3.3 GHz



(b) 4.1 GHz



(c) 6.1GHz

Figure 5: Radiation patterns at various frequencies

IV. CONCLUSIONS

In this paper a compact ultra-wideband (UWB) antenna with notch characteristics is presented which shows triple notches at different frequencies over the band of operation. By using C-shaped ground, the overall dimensions of antenna are reduced to 24mm×28mm×1 mm. Initially, inter-digital capacitance loading loop a resonator with small size is implemented which gives dual notch characteristics. Further, by inserting two parallel C shaped slits near feed line third frequency rejection band is achieved. The proposed antenna operates in the FCC defined UWB frequency range (3.1 to 10.6 GHz). The simulated results reveal that the antenna has a stable far field radiation pattern in E- and H-planes throughout the bands of operation with good gain except at the notched frequency. The presented antenna is suitable for commercial UWB applications. Future includes the fine tuning of the notches and to increase the number of notches as required.

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