Dual Band Notch UWB Antenna

Ranu Yadav, S. K. Bhatnagar
Department of Electronics & Communication Engineering, Swami Keshvanand Institute of Technology, Management and Gramothan, Jaipur-302017 (INDIA)
Email- ranuyadav000@gmail.com
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Abstract- UWB is a radio communication technology that utilizes very low energy pulses and is intended for short-range-cum-high-bandwidth communications by using an enormous portion of radio spectrum. UWB is very high speed alternative to existing wireless technologies such as WLAN, Hyper-LAN. Compact planar ultra-wideband (UWB) printed microstrip patch antennas with dual band notch attribute is structured in this paper. The antenna has total dimensions of 21.8x24.1 mm^2, which is well suited with wireless devices. The proposed antenna comprises of chamfered rectangular radiating patch along with partial ground to boost bandwidth that covers the UWB frequency range from 2.5 GHz-11 GHz. A Quarter wave transformer along with feed line is used for impedance matching. To obtain dual notch characteristics at C-band (3.3 GHz-3.9 GHz) and X-band (7.4 GHz-8.8 GHz), a complementary split ring resonators (CSRR) is used in partial ground and patch both. The impacts of ringson band notch characteristics are also examined. All simulation work has been completed by utilizing electromagnetic software Ansoft High Frequency Structure Simulator (HFSS).

Keywords – UWB antenna; CSRR Antenna; Microstrip Antenna; Planar Antenna; Band notched Antenna

1. INTRODUCTION

In current communication scenario, wireless communication systems are more demanding due to lightweight, low cost and fast speed and antenna plays a momentary role in the area of wireless communication. UWB has received greater gravitation in the area of wireless communication as it delivers high performance, produces omni directional radiation pattern along with simple configuration and smaller size. The ultra-wideband (UWB) technology is a radio technology that practices exceptionally low energy level for short-range, high-bandwidth communications over a huge segment of the radio spectrum. UWB has customary applications in radar and medical imaging. Latest applications incorporate precision locating and tracking, target sensor data collection and wireless communications because of its virtues of wide bandwidth, high transmission speed, and low power dispersion [1]. It is quite challenging to design an antenna that operates in the UWB band since it needs to fulfill the necessities such as ultra-wide impedance bandwidth, constant gain, omni directional radiation pattern, low profile, easy manufacturing, high radiation efficiency and many more [2]. In this gigantic frequency range, some narrow frequency bands likewise exists, such as the Wi-MAX (3.3–3.7 GHz), Wireless-LAN (WLAN) (5.15–5.825 GHz), X-band satellite communication services (7.25–7.75 GHz) and ITU 8 GHz (8.025–8.4 GHz) band. The overlapped frequency bands are required to filter out to evade the electromagnetic interference. Therefore, it is desirable to design UWB antenna with band notch features to minimize the intricacy of the system by wiping out the undesirable interferences and make it financially savvy by expelling the prerequisite of additional band-stop filters. Several investigations have been accomplished for implementing band notch features in the UWB antenna from the last few years. These incorporate several types of slots on ground plane or on patch, use of split ring resonators, tuning stubs, meandering, folded strips, and resonated cells on CPW, EBG structure etching either on patch or on ground plane [3-8]. Slots etching can be done in different shapes such as etching of C-shaped slot, S-shaped slot, U-slot, V-shaped slot [3-4], a quasi-complementary split ring resonator (CSRR) in fed line[5], a quarter wave tuning stub in a large slot on the patch [6], capacitively loaded loop (CLL) resonators in fed [7], a parasitic slit along with tuning stub used [8], rectangular slot on patch.The SRR structure is intended by two concentric metallic rings with a split on contrary sides. CSRR is negative image of the SRR. SRR and CSRR are electrically small LC resonant elements with a high quality factor at microwave frequency and can be utilized as periodic structure of metamaterial [9]. The narrowband resonance attributes of CSRR affect only the target frequency band and geometrical region on UWB antenna. It is a key to resolve mutual coupling among the band rejection elements. Besides, the CSRR offers enough space on conventional compact UWB antenna to entrench the band rejection elements due to the sub wavelength resonant structure of the CSRR. Later, progresses in split ring resonator (SRR) and its complementary structure (CSRR) have significantly risen given the simplicity to produce band-notch characteristics because of their performance properties and low space necessities [10].

In this paper, a compact UWB planar microstrip antenna is proposed with band indent features for X-band (7.4 GHz-8.8 GHz) by incorporating a pair of CSRR slot on ground plane. The overall antenna dimension is 21.8x24.1mm^2. The parametric variations for all the slot parameters are also introduced and examined. The entire work is composed as pursues, Section II depicts the antenna design, synthesis and measurement. Section III depicts result and validation and finally section IV describes conclusion of the work. All the simulation work is carried using Ansys electromagnetic software HFSSv15.

2. ANTENNA DESIGN

While designing a microstrip antenna, various substrates usually in the range of $2.2 \leq \varepsilon_r \leq 12$ can be utilized to accomplish worthy response. Generally, FR4 substrate is used as it has higher dielectric constant that results to a smaller patch size, lower gain and higher tangent loss. The designing of band notched ultra-wideband is started with the consideration of rectangular microstrip antenna structure which is chamfered by an angle 40^0 and partial ground, because it is easily matched over the entire UWB bandwidth starting from 2.5GHz to 11 GHz and it is depicted in Fig 1(a). The optimized antenna is fed with microstrip feed line and to accomplish 50Ω characteristics impedance matching between patch and feed line quarter wave transformer is used. The radiating element coupled strongly with the conducting partial ground plane and the designed antenna is equipped for supporting various resonances leading to the wide operating band. This novel antenna with CSRR-1 in ground has the first notching 7.5-8.4 GHz band for X-band applications.

2.1 X-Band notched antenna design

To achieve filtering characteristics we have created a pair of CSRR slots in partial ground to obtain notch in X-band, as shown in Fig. 1(b). The formula for calculating CSRR slot dimension is given below [11]

$$R_1 = \frac{L_{eq} + G}{2\pi}$$

where, L_{eq}= equivalent length of CSRR ring, R_1= inner radius of ring, G= gap in the ring having optimized value 0.5mm.

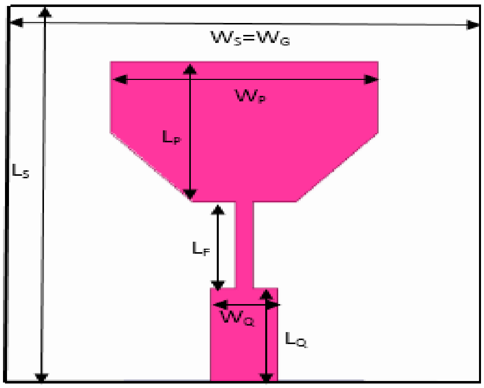
To calculate the value of inner radius R_1 of the CSRR slot, the value of L_{eq}must be known. L_{eq} can be calculated as

$$L_{eq} = \frac{c}{2f_0\sqrt{\epsilon_{reff}}} \quad \text{...... (7)}$$

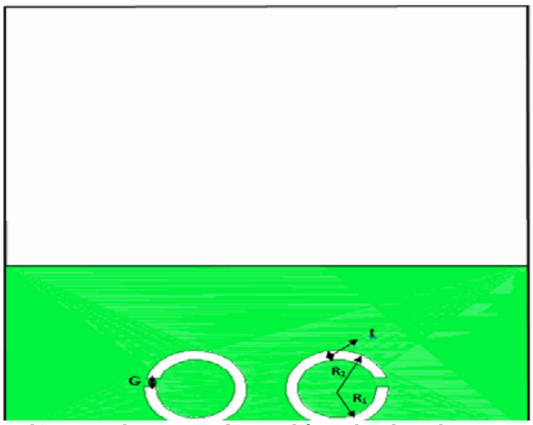
Where, f_0= frequency for X-band notch range. Outer radius R_2 is obtained by adding't' to 'R_1'. The value of equivalent length L_{eq} varied according to variation in gap "G" which is shown in Fig. 3.

Effect of Gap in the Ring

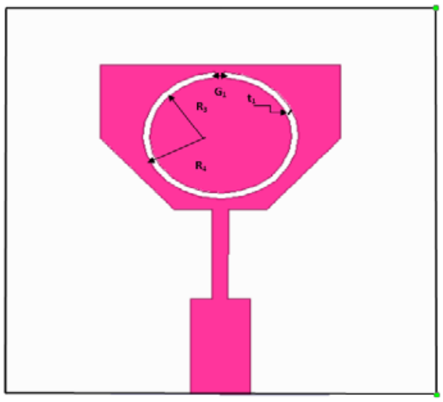
As shown in the Fig. 2, the notched band for X-band (7.4 GHz-8.8 GHz) is found at G= 0.5mm. We have simulated the result of G= 0.4mm to 0.8mm with a step of 0.02, while keeping values of R_1, R_2 and t constant.At G= 0.5mm the desired notch band is obtained. If we increase the value of 'G' further, the notch starts shifting towards higher frequencies.



(a) UWB antenna geometry (Front side)



(b) CSRR slot on partial ground for X-band notch



(c) CSRR slot on patch for C-band notch

Figure 1 : Geometry of proposed antenna for band notch

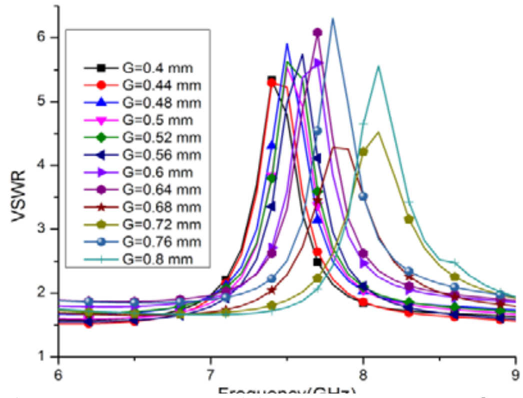
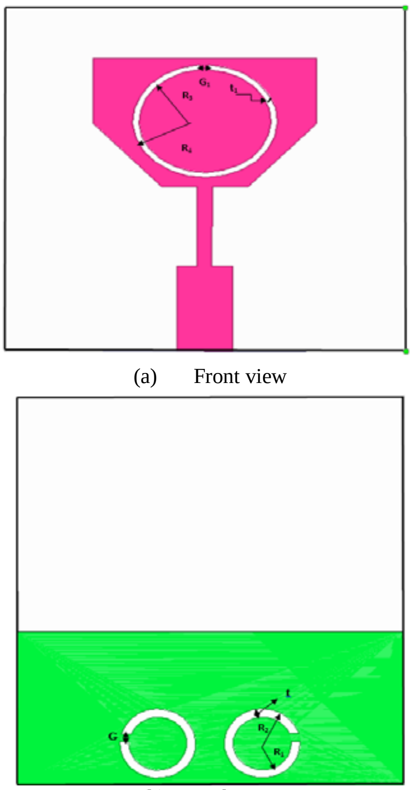


Figure. 2 Variation in Gap (G): VSWR v/s Frequency plot

2.2 C-band notched antenna design

Here, another notch is obtained by etching a CSRR slot on patch which provides band notching at C-band as shown in Fig.1(c). The length of proposed CSRR slot can be determined from equation (1) and equation (2).

Fig. 2 presents the proposed antenna with dual band notch characteristics that has been achieved by below given methods as described in the section A, B and C, the band notch characteristics is obtained by etching CSRR slots in ground and radiating patch.



(a) Front view

(b) Back view

Figure 3 : Geometry of Proposed Antenna

The desired dual band notch characteristics have been achieved by the above described methods for proposed antenna.

3. RESULT AND DISCUSSION

The designed primary UWB antenna offers the VSWR range below 2 except the notch bands as illustrated in fig.3.

The effects of vector current on the proposed antenna at different frequencies have been presented in Fig. 4. At preferred frequencies of 4GHz and 7.7GHz which comes under notched band, the distribution of vector current is non-uniform and are concentrated at slot edges as appeared in Fig.4 (a) and (b).

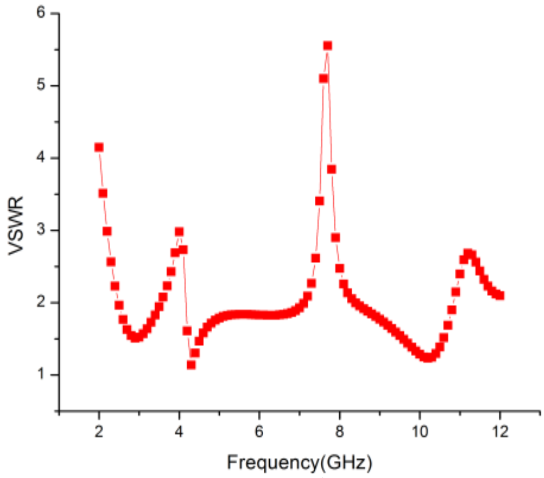
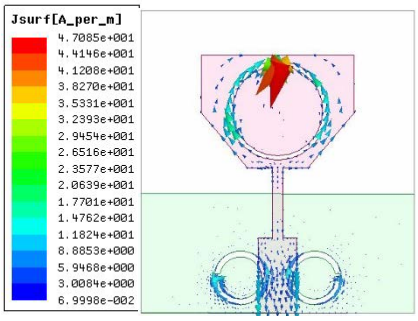
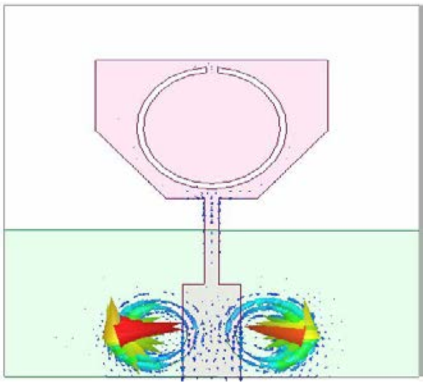


Figure 4: VSWR magnitude of proposed antenna

The fabricated antenna design is presented in Fig.6. The model number N9981A of VNA is used on which measured results are obtained. Simulated and measured VSWR result of dual band notch antenna has been shown in Fig. 7. Y-axis on the graph represents VSWR value while X-axis represents frequency. The antenna with CSRR slots successfully exhibits notched band of 3.8-4.2GHz and 7.5-8.5GHz, maintaining broadband performance from 2.5-10.8GHz (UWB frequency band) with VSWR less than 2. Overall gain of antenna is less than 2dBi for pass band frequency range.



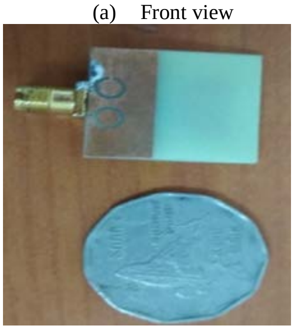
(a) 4GHz



(b) 7.7 GHZ

Figure 5: Current Distribution of proposed antenna

(a) Front view



(b) Back view

Figure 6: Photograph of Fabricated Antenna

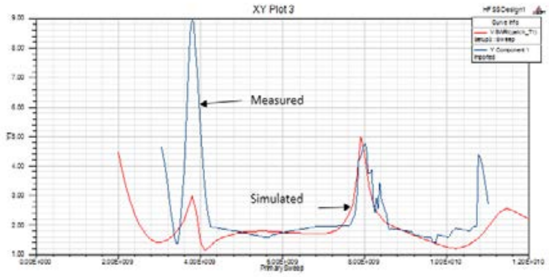


Figure 7: Comparison between simulated and measured VSWR

The proposed antenna shows good agreement between the simulated and measured VSWR as illustrated in Fig.7.

4. CONCLUSION

Proposed antenna covers UWB band ranging from 2.5GHz to 11GHz. Band stop filtering characteristics of CSRR slots have been used to minimize the interference problems from X-band and C-band applications. This antenna has a simple structure and compact size of 21.8x24.1mm^2. Results of this antenna indicate that proposed antenna can be a good entrant for the band notched application in UWB spectrum.

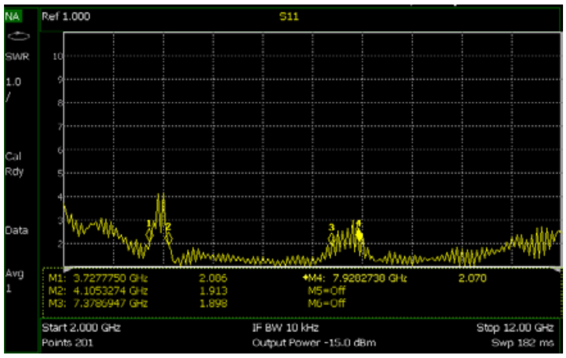


Figure 8 : Measured result of VSWR on VNA

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