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UWB Antenna with Dual Band Notch Characteristics

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Abstract*: In this paper, the layout of solid planar ultra-wideband (UWB) printed microstrip patch antenna with double band notch characteristics is obtained. The antenna has overall dimension of 21.8x24.1 mm^2 which is compatible with wireless devices. The proposed antenna comprises of tapered rectangular radiating patch with partial ground to enhance bandwidth that covers the UWB frequency span from 2.5 GHz-11 GHz. For impedance matching a Quarter wave transformer along with feed line is used. To obtain dual notch characteristics complementary split ring resonator (CSRR) and electronic band gap (EBG) are used. For obtaining C-Band (3.8 GHz-4.2 GHz), CSRR slot is etched on patch, while for X-Band (7.25-8.4 GHz) a couple of L shaped slot loaded EBG structures are embedded near the feed line. The effects of every individual structure over band notch characteristics are furthermore investigated. All simulation work has been accomplished by using electromagnetic software Ansys HFSS.

***Index Terms*: CSRR Antenna, Dual Band Notched Antenna, Microstrip Antenna, Planar Antenna, UWB antenna.**

I. INTRODUCTION

In recent communication development fast speed, reasonably priced and also featherweight systems are to the greater extent required in wireless communication. Antenna plays an indispensible part in the sector of wireless communication. Printed microstrip antennas have been extremely esteemed in topical years as of their smallness, light weight, low profile and low cost. Numerous printed antennas by means of single, multiband or else wideband features have been reported in the [1–22].Ultra Wide Band (UWB) has received greater responsiveness in wireless communication as it provides high enactment omnidirectional radiation pattern alongside with simple configuration and smaller size [1].

UWB is a wireless communication technology which uses very little energy pulsation in addition to envision for small range along with great bandwidth communications by consuming enormous share of radio spectrum. UWB is high speed substitute of standing wireless technologies for example WLAN, Hyper-LAN. UWB has customary uses in medical imaging and radar. Most topical applications embrace target sensor statistics collection, indoor communications by virtues of widespread bandwidth, correctness in locating and tracking, great transmission speed, and also little power dispersion [2].

It is quite challenging to originate an antenna which operates in UWB since antenna has to fulfill the necessities, for instances, wider impedance bandwidth, constant gain, omnidirectional radiation pattern, great radiation efficiency, easy manufacturing, low profile etc. [3]. In this frequency range, some narrow bands are also present, like that Wi-MAX (3.30–3.70 GHz), Wireless-LAN (5.20–5.80 GHz), satellite communication services of X band (7.25–8.40 GHz) and also ITU 8 GHz (8.025–8.40 GHz) band. So the overlain frequency bands requisite to filter out and to circumvent electromagnetic interference. As a result, it is desirable to design UWB antenna by means of band notch characteristics to lessen the intricacy of the system by eliminating unwanted interference and make it cost effective by removing the requirement of additional band-stop filter [4].

Several researches have been done for implementing band notch characteristics in the UWB antenna since last few years. These comprise various kinds of slots upon ground plane or upon patch, usage of SRR, folded strips, tuning stub, meandering, resonated cells on CPW as well as EBG structure either upon patch or upon ground plane [5-21]. Slots etching can be done as, etching of C-shaped slot, V-shaped slot, S-shaped slot, U-slot [5], slit in the ground plane [6], C-shaped parasitic structure in ground [7], symmetrical rectangular slits [8], multiple fractal shaped slot [9] defected microstrip line and π shaped slot [10], T-shaped stepped impedance resonators (SIRs) [11], arc-carved slot as well as parasitic element [12], M-shaped slot [13] parasitic patches [14], CSRR in patch [15], CSRR and RA-EBG near feed [16], SRR in addition S-Shape Slot [18], Modified Pentagon Shaped Monopole Antenna [19], Defected Ground Structure for UWB Applications[20], Compact circular monopole antenna for UWB [21], Analysis of Sunflower shaped monopole antenna [22].

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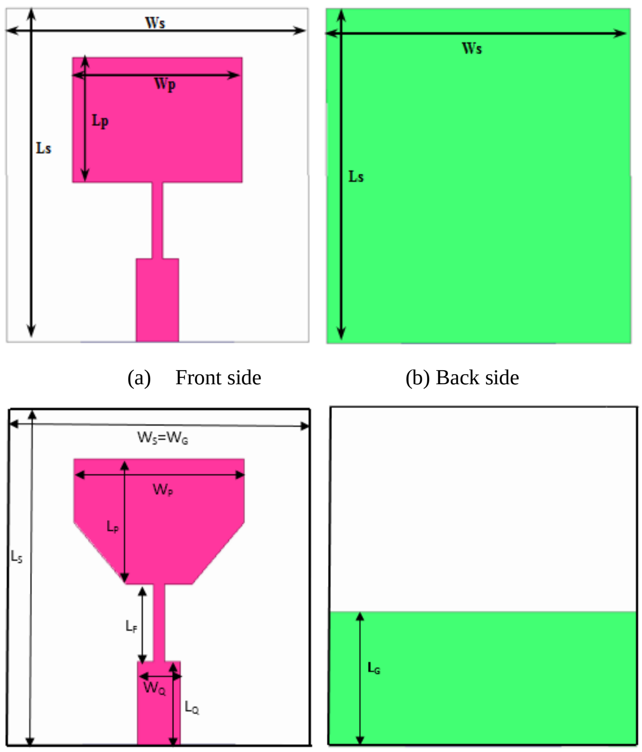
Here in this paper, a UWB antenna is proposed with double band notched features for X-band (7.5-7.75, 7.9-8.4 GHz) and downlink frequency C-band (3.8-4.2 GHz) via CSRR slot upon patch, as well as pair of L shaped slot loaded Electromagnetic band-gap structures are embedded nearby the feed line. The overall antenna dimension is 21.8x24.1mm^2. The parametric variations for all the parameters are also presented and investigated. The whole work is systematized just like that; Section II defines the antenna design, synthesis and also validation. Section III refers to result analysis and lastly section IV describes conclusion of the work. Entirely simulation work is conceded via Ansys electromagnetic software HFSSv15.

II. ANTENNA DESIGN

While designing an antenna, several substrates could be used to recognize decent response in addition dielectric constants are typically in the sort of $2.2 \leq \varepsilon_r \leq 12$. Commonly FR4 substrate is used as it has greater dielectric constant which consequences to a less significant patch size, lower gain and higher tangent loss. The designing of band notched ultra-wideband to resonate above the whole UWB bandwidth beginning from 2.5 GHz to 11 GHz taking place with the concern of rectangular microstrip antenna arrangement which is chamfered by an angle 40^0 and partial ground that also depicted in Fig 1. The optimized antenna has fed up with microstrip feed line. To achieve proper 50Ω characteristics impedance matching between patch and feed line quarter wave transformer used. The partial ground plane intensely combined through the radiating component. In addition the aimed antenna is proficient at associating numerous resonances prominent to the widespread functioning band.



(a) Front side (b) Back side

(c) Front side (d) Back side

Fig.1 (a) & (b) Primary Antenna (c) & (d) UWB Antenna

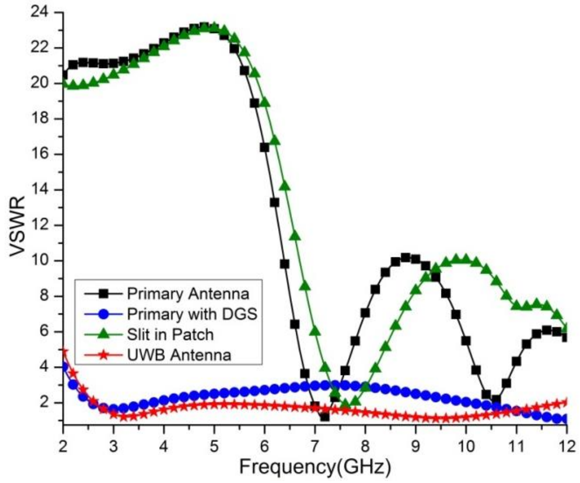


Fig.2 Comparative analysis of VSWR v/s frequency plot

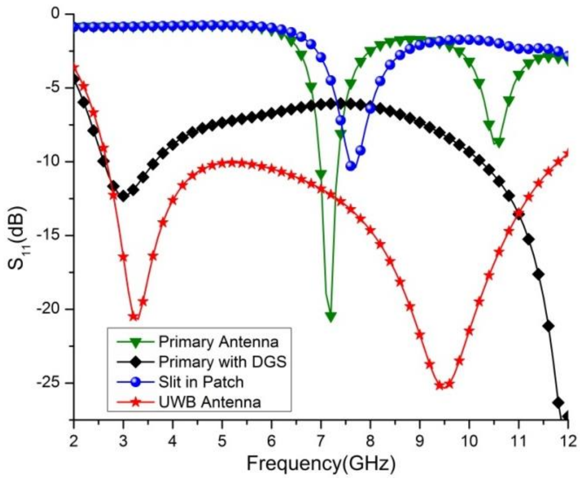


Fig.3 Comparative analysis of Reflection Coefficient v/s frequency plot

Dual band notching is produced when CSRR slot cut in the patch as well as embedding combo of Electromagnetic band-gap structure nearby the feed line. This innovative antenna by way of CSRR in patch has produces first notch aimed for C-band applications at 3.70-4.20 GHz and second notch with pair of EBG near feed line at 7.2-8.4 GHz band for X-band applications.

A. CSRR Loaded Antenna Design (C Band Notch)

Filtering characteristics have attained using CSRR slot upon patch which provides band notching at C-band as displayed in Fig.4 and Fig.5.

The length of proposed CSRR slot could be computed from the equation (1) and (2) as discussed in [14].

$$L_{eq} = 2\pi R - G \qquad (1)$$

$$f_0 = \frac{c}{2 * L_{eq} * \sqrt{\frac{\varepsilon r + 1}{2}}} \qquad (2)$$

Where, f_0= resonant frequency, ε_r= dielectric constant of substrate, R=inner radius of the ring, G= gap between the ring and L_{eq}=equivalent electrical length of CSRR slot.

The significance of equivalent electrical length L_{eq} altered according to modification in gap "G".

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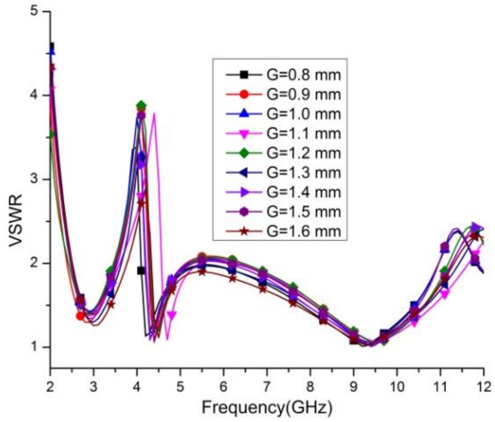


Fig.4. Variation in VSWR accroding to Gap "G"

Fig.4 shows that the notched band for C-band is found at G= 1.2 mm. We have simulated the result of G= 0.8mm to 1.6mm with a step of 0.1 mm while keeping R_1 and R_2 constant.

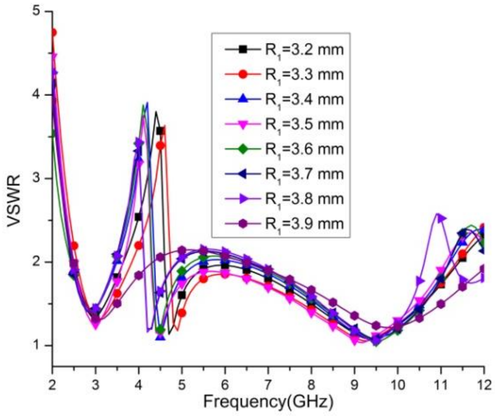
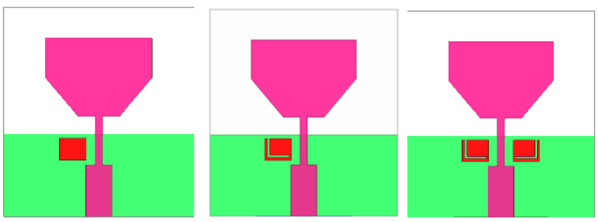


Fig.5. Variation in VSWR accroding to variation in inner readius "R_1"

As shown in the Fig.5, the notched band for C-band is found on the dimensional parameter R_1= 3.6mm, G=1.2mm and R_2= 3.95mm. In the Fig.5, R_2 is kept constant and thickness of slot is varied according to the value of 'R_1'. We have simulated the result of R_1=3.2mm to 3.9mm by the step of 0.1mm while keeping the value of G= 1.2mm and R_2= 3.95mm constant.

B. *L Shaped Slot Loaded with EBG Pair Antenna (X Band Notch)*

Here a pair of mushroom EBG (M-EBG) cell near the feed line of the metallic patch as displayed in Fig.6 is used for band notching characteristics. To create band notch at X-band applications (downlink frequency 7.25-7.75 GHz and uplink frequency 7.90-8.40 GHz), we have suggested an EBG cell integrated with L shaped slot and grounded using via.



(a) (b) (c)

Fig.6. The geometry of EBG structure(a) EBG structure (b) EBG with L-shaped slot (c) Pair of EBG

From fig.7 we can easily determine that the above single EBG produces notch at a higher frequency. So for further analysis, we cut L-shaped slot in this structure. This type of structure has been shown in fig.6. From the above two structures, it can easily be depicted that this combination doesn't cover required band. So again to lower the frequencies we modified the structure. In this way we put pair of EBG near feed line and then make it a symmetrical EBG structures. Now after analyzing this structure on HFSS it rejects band at 7.21-8.51 GHz.

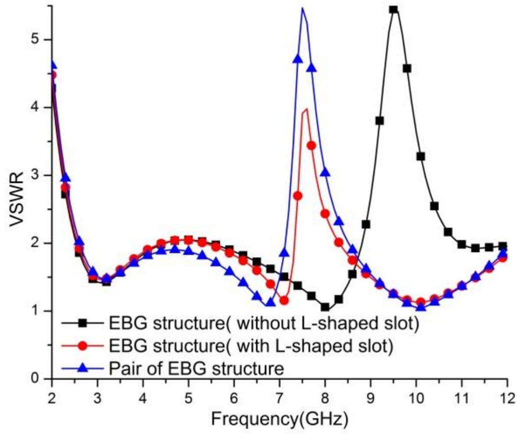
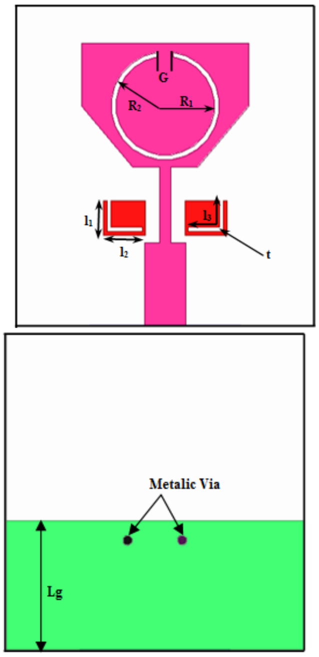


Fig.7. Variation in VSWR accroding to Gap "G"



(a) Front view (b) Back view

Fig.8. The geometry of Proposed Antenna

Fig. 8 displays antenna with double band notch features which has been accomplished by above given approaches as defined in the section A and B; the band notch characteristic obtained by implementing CSRR slot in the radiating patch and EBG structures. All the optimized dimensions have been presented in Table 1.

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Table 1: Optimized Dimensionality of Proposed Antenna

Parameter	Unit(mm)	Parameter	Unit(mm)
W_S	21.8	t	0.3
L_S	24.1	R_1	3.6
W_G	21.8	R_2	3.95
L_G	9.8	G	1.2
W_P	12.2	l_1	2.5
L_P	9	l_2	2.8
L_F	6	l_3	4.2
W_Q	3.06	L_Q	6.2

The desired dual band notch characteristics have been succeeded by above defined approaches for the UWB antenna. The considered UWB antenna offers the VSWR range below 2 except the notch bands as revealed in Fig.9.

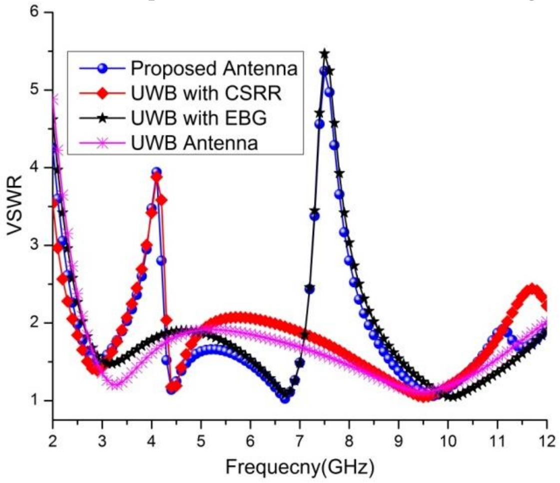
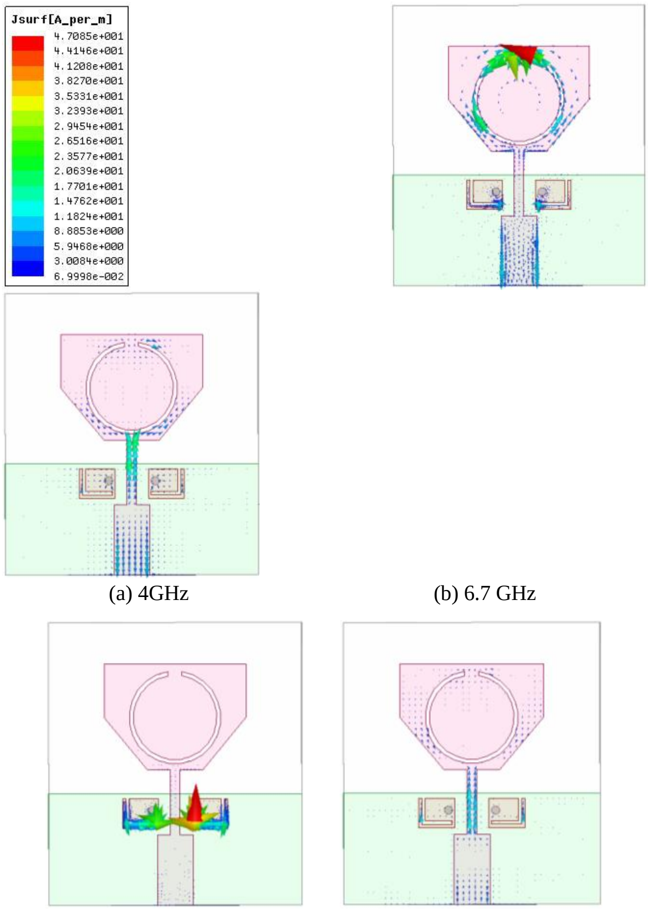


Fig.9. Simulated VSWR of Suggested antenna.

The simulated results in terms of VSWR is shown in Fig. 9 which has lower cut-off frequency (f_L) = 2.5GHz and upper cut-off frequency (f_H) = 11GHz. The VSWR coefficient for the frequency range 3.8 GHz-4.2 GHz and 7.2 GHz-8.5 GHz is greater than 2 which means that the antenna is not radiating for this frequency band and it will remove any interference arising from these bands. It concludes that the antenna rejects the frequency band of C-band and X-band both.

III. RESULT AND DISCUSSION

The influence of vector current upon the proposed antenna on numerous frequencies has been obtained in Fig.10. At anticipated notched band frequencies like of 7.7GHz and 4GHz, the scattering of vector current is irregular and also rigorous at slot edges as revealed in Fig.10 (a) and (c), while in Fig. 10(b) the current distribution is identical at 6.7 GHz and 9.7 GHz frequency which acts like pass band for antenna structure.



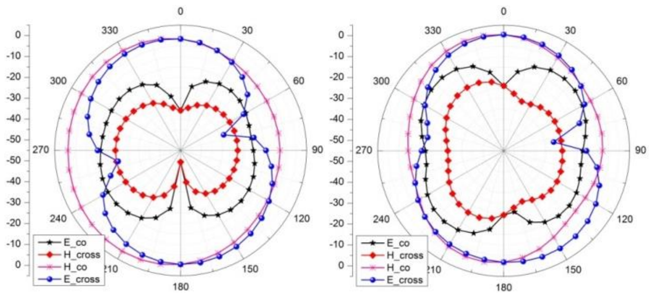
(a) 4GHz (b) 6.7 GHz

(c) 7.7 GHz (d) 9.7 GHz

Fig.10. Current Distribution of proposed antenna

So compared H-plane & E-plane patterns on 6.70 and 9.70 GHz for co and cross polarizations have been displayed in Fig.11 (a-b).

The radiation patterns of the presented design show the acceptable matching results with pass band characteristics. Fig.12 shows the antenna radiation efficiency and peak realized gain. It can be observed that gain is approximately below -8dBi for notched frequency band whereas 4dBi for other frequencies, similarly efficiency is approximately 25% for notched bands which reflects that antenna has successfully stopped the desired bands.



(a) 6.7 GHz (b) 9.7 GHz

Fig.11. Current Distribution of proposed antenna

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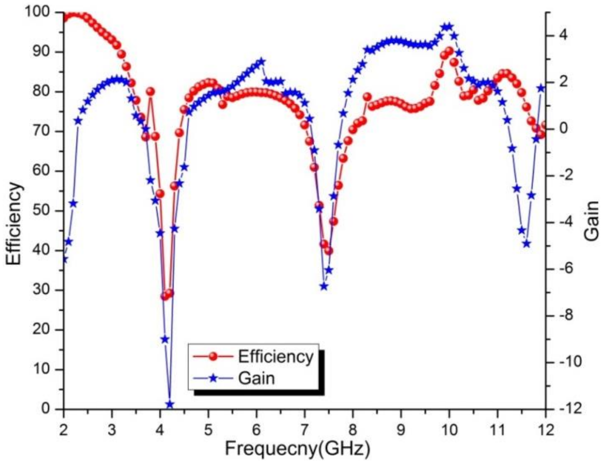

Fig.12. Realized Peak Gain and Antenna Efficiency vs. Frequency Graph

IV. CONCLUSION

Above recommended antenna involves UWB band varying from 2.5-10.8 GHz. EBG structure and CSRR slot with band-deny filtering feature have been adopted to depreciate the interference issue from X-band and C-band applications. Recommended antenna has simple configuration and 21.8x24.1mm^2 compact size. Simulated results pointed out that above recommended antenna is conceivably a noble claimant for band notched purpose in the UWB range.

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