A Compact Monopole CPW-Fed Band Notch Square- ring Antenna for UWB Applications

Deepak Kumar, Tejbir Singh, Vikash Gupta, Hema Singh

Abstract- This paper presents the design of compact CPW-fed band notched UWB square ring antenna. The main objective of this proposed research work is to reduce the size of antenna and avoid interference between UWB and WLAN application at 5.5GHz. The antenna consists of a square-ring metal patch and 50Ω coplanar waveguide fed. The structure of the antenna is miniaturized by optimizing its square ring profile and the required total size to obtain only 35×31 mm dimension. The antenna is then modified to possess band rejection at the wireless local area network (4.8–6.2 GHz) band by adding two slits within the CPW element. The geometry parameters of antenna are investigated and optimized with HFSS. The result show that the proposed antenna achieves an impedance bandwidth of 3.1-10.6GHz with VSWR<2, except in the band of 4.8 – 6.2 GHz. An omnidirectional radiation pattern and stable gain are observed except notched band.

Keywords- Coplanar waveguide (CPW), Microstrip antennas, wireless communication, UWB, band notched, HFSS.

1. NTRODUCTION

In February 2002, the federal communication (FCC) allocated the 3.1 -10.6 GHz spectrum for unlicensed use of UWB [3]. a considerable amount of researches have been devoted to the development of Ultra Wideband (UWB) antenna [1-2], for its enabling high data transmission rates, low power consumption and simple hardware configuration in communication applications. Since that UWB technology has been rapidly advancing as a promising high data rate wireless communication technology for various applications. Beside the consideration of ultra wideband performance, the design of antennas for the UWB communication also need a band-rejected filter to avoid an interference with existing wireless networks with standards such as IEEE 802.11a in U.S.A (5.15GHz-5.35GHz, 5.725GHz-5.825GHz) and HIPERLAN/2 in Europe (5.15GHz-5.35GHz, 5.47GHz-5.725GHz) [4] so that UWB transmitters can not cause any electromagnetic interference on nearby communication system such as Wireless LAN (WLAN) applications.

However, the use of a filter will increase the system complexity. To tackle this problem, many novel antennas [5~14] with band-notched characteristic have been presented. In these designs, the filter can be eliminated and the radio frequency systems will be simplified. Among the newly proposed UWB antenna designs, the printed monopole antenna [6~14] has been received much attention for their wideband matching characteristic, omnidirectional radiation patterns, high radiation efficiency and compact size. These antennas make use of different structures to meet the requirements of return loss and radiation patterns. These structures include two monopoles with a small strip bar [7], half-bowtie shape[8], coplanar waveguide (CPW) resonant cell (CCRC) [9], a new microstrip-fed folded strip monopole antenna with band-notched characteristics [10], a planar half ellipse- shaped radiation patch with an ellipse-shaped slot and three steps, and the parasitic strip [11], the main patch by inserting a modified inverted U-slot [12], two L-shaped slots in the radiation element [13]. Some of the important properties of UWB antenna are compact size, omnidirectional radiation pattern, wide impedance bandwidth, low power consumption, ease of manufacture and unipolar configuration. Now a day's printed monopole antenna with large bandwidth are highly in demand as they have most of the above properties. A conventional Coplanar waveguide (CPW) on a dielectric substrate consists of centre strip conductor with semi-infinite ground planes on either side is used to feed the printed antenna which offers various advantages over Microstrip feed line such as lesser dispersion characteristics at higher frequencies, broader impedance bandwidth, coplanar configuration and it does not require backing ground.

The allocated bandwidth of UWB spectrum already occupy the some narrow band services such as wireless local-area network (WLAN) IEEE802.11a and HIPERLAN/2 WLAN operating in the 5–6 GHz band. Some time there is also use of filters to remove this existing band from UWB spectrum, but it makes system complex. This problem is solved by notching the existing frequency band from UWB frequency spectrum so that interference does occur. Thus the UWB antenna with a notched WLAN band from 4.8-6.2 GHz is designed to

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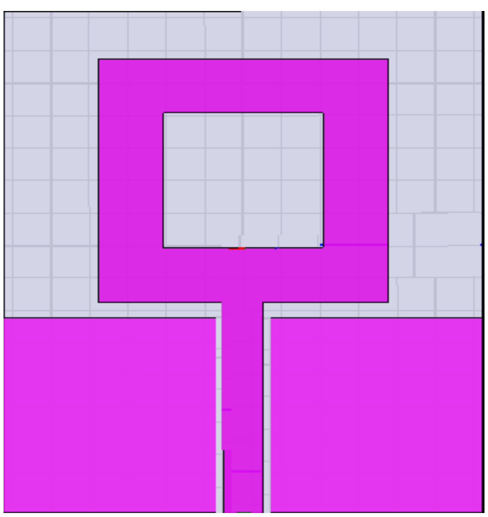
minimize the interference between UWB system and narrowband system (WLAN).

This paper presents a simple and compact CPW-fed UWB printed antenna with single notch of WLAN band. The ground plane at each side is modified for better matching impedance and CPW fed. The single band notched characteristics is achieved by simply etching slot from the ground plane.

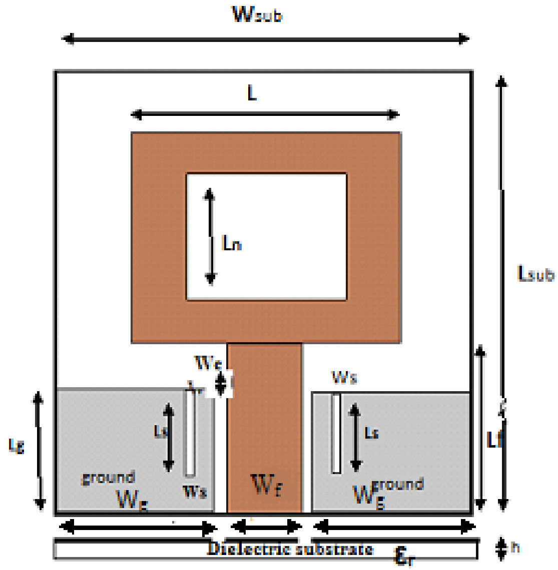
It can be observed that without slot designed antenna shows the UWB characteristics from 3.1 to 10.6 GHz with VSWR< 2 and after etching slot from the ground plan it has band notched characteristics from 4.8 to 6.2 GHz with VSWR>2. The designed antenna is simulated with HFSS 13 and various antenna parameters have been observed as a result.

2. Antenna Design

The geometry of the proposed antenna is shown in Fig. 1 with various dimensions. The antenna is mounted on FR-4 printed circuit board substrate (W_{sub}xL_{sub}=35×31) with a dielectric constant of ε_r=4.4 and thickness of h=1.6mm. The CPW feed line has a single strip with a dimension of W_f x L_f and gap of distance Wc is made for a 50 Ω characteristic impedance. The radiating part of antenna is square ring patch at the middle of substrate with outer length and inner length of L and Ln respectively.

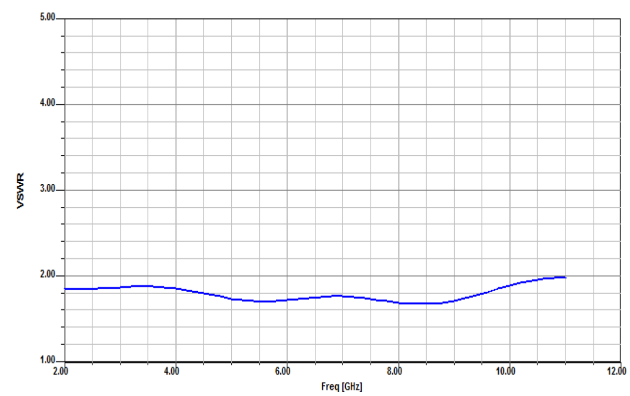


(a)

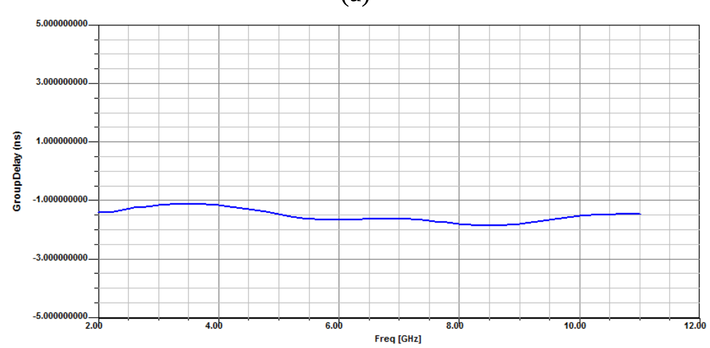


(b)

Fig. 1: Geometry of the proposed CPW-fed UWB antennas (a) without notch, (b) with single notch



(a)



(b)

Fig. 2 Simulated VSWR and Group delay of antenna (a) without notch with optimal dimensions.

Fig. 2 shows the characteristics of the measured and simulated VSWR and group delay of antenna (a). A good agreement in simulation can be observed. It is found that the input impedance of the antenna is well matched as the bandwidth covers the entire UWB band (3.1–10.6 GHz) and goes beyond the required 10.6 GHz with .The ground plane of dimension L_g

X W_g is used in this antenna configuration near the both side of CPW feed line of spacing Wc.

TABLE I

DIMENSIONS OF ANTENNA

Parameter	W_{sub}	L_{sub}	W_f	L_f	L	L_n	L_g
Size(mm)	31	35	3.3	14	15	8.3	13
Parameter	W_g	W_c	L_s	W_s	h	ε_r	--
Size(mm)	13.35	0.5	7.5	0.3	1.6	4.4	--

The slot of dimension Ls X Ws is etched from both side of the ground plane. The width and location of those slots can also adjust the notched band. The length of the slot etched from the ground plane near by the feed line can be given as f_{notch}.

$$f_{notch} = \frac{c}{4L.\sqrt{\varepsilon_{eff}}}$$

Where L is the total length of the slot, c is the velocity of light and ε_{eff} is the effective dielectric constant. This is approximately found as below.

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2}$$

The antenna is called square ring due to square ring look and a WLAN band is notched from UWB using the slot cut-outs from the ground. The antenna design software package, called Ansoft HFSS 13.0 has been used to develop and simulate this antenna.

3. RESULTS AND DISCUSSION

The designed antenna is simulated and result show that the voltage standing wave ratio (VSWR) of antenna is less than two (VSWR<2) from frequency range of 3.1 to 10.6 GHz and greater than two (VSWR>2) in 4.8 to 6.2 GHz. The simulated VSWR of antenna without any slot and with slot are plotted in fig (3). It is observed that notched band at 5.5 GHz is obtained by simply etching a slot in the ground plane and in notched band 5.2to 5.9 GHz for WLAN VSWR is greater than 3. Thus the interference between UWB system and WLAN system can be removed effectively. It can also be observed that the notched band can also be affected by the length, width and location of the slot.

The variation of the simulated VSWR with different slot length is shown in fig (4) and it shows that with increasing the length of slot (Ls) in ground plane the centre frequency of corresponding notched band will become smaller. If we observed the variation of VSWR with varying the width of slot (Ws) in ground plane it shows that the notched band becomes wider with increasing slots widths. And compared result is shown in fig. (5).

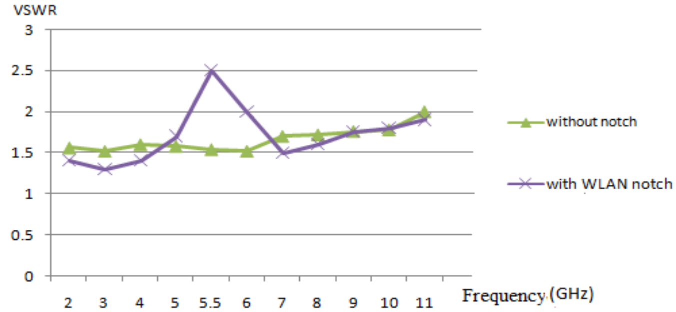


Fig. 3: Simulated VSWR of antenna with WLAN notch and without notch

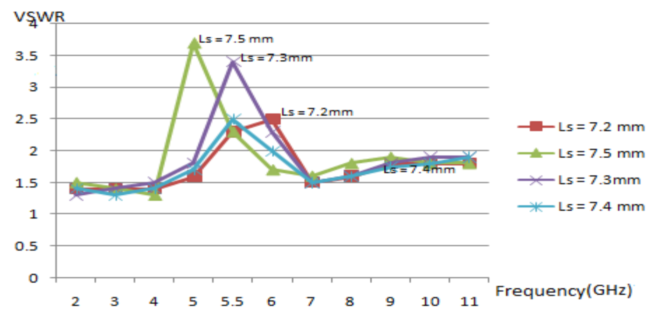


Fig. 4: variation of the simulated VSWR with different slot length (Ls) in the ground plane.

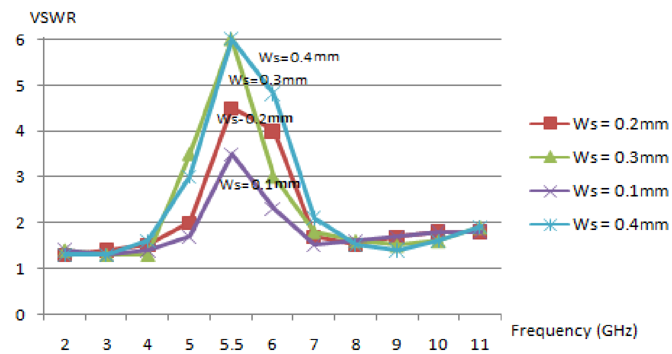


Fig. 5: variation of the simulated VSWR with different slot widths (Ws) in the ground plane.

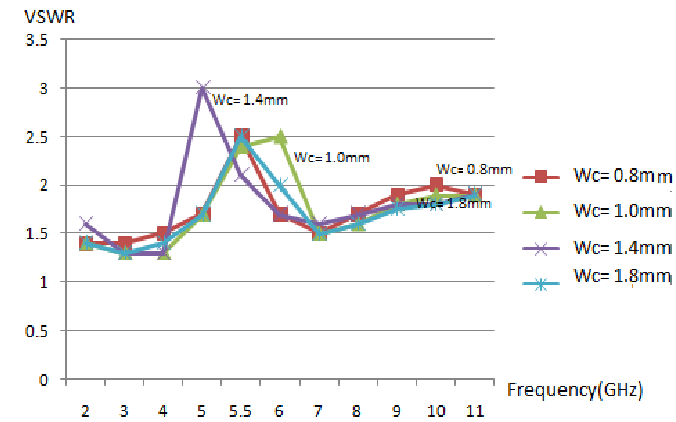


Fig. 6: variation of the simulated VSWR with different location of the slot (Wc) in the ground plane.

The fig (5) shows the variation of simulated VSWR with varying the location of the slot in ground plane from fee line. Both the bandwidth and the centre frequency of the notched band change .and notched band will get smaller if slot is nearer to the feed line.

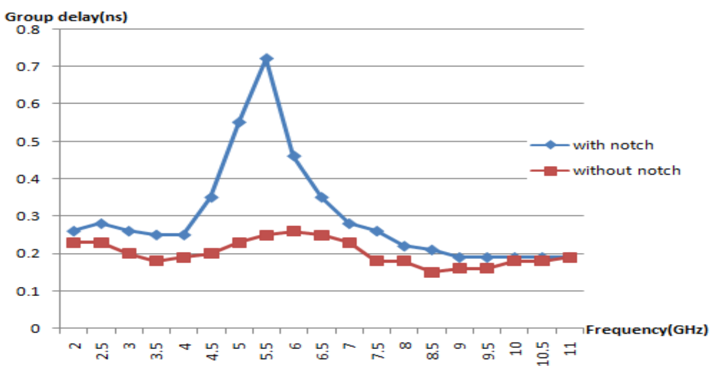


Fig. 7: simulated group delay of antenna with and without notched.

The UWB system is based on pulse communication so a linear phase response is required. Fig. 6 shows the simulated group delay of antenna with and without notched. The variation of the group delay of antenna without notch over the UWB band is less than 1 ns. The group delay variations of antenna with notch highly exceed 4 ns in the area of notch band, which can depreciate phase linearity. However, in the un-notched frequency part, the group delay variations are minute showing good quality characteristics. These group delay characteristics demonstrate that the proposed antennas exhibit phase linearity at required UWB frequencies.

Fig.8, the radiation patterns at frequencies 3GHz, 5GHz, 7GHz, 9GHz, are simulated with Ansoft HFSS. The antenna radiates quasi omnidirectionally and symmetrically in y-z plane in the very wide frequency band. As a result, the proposed antenna can be used in several applications including mobile communications, wireless networks and sensor networks etc.

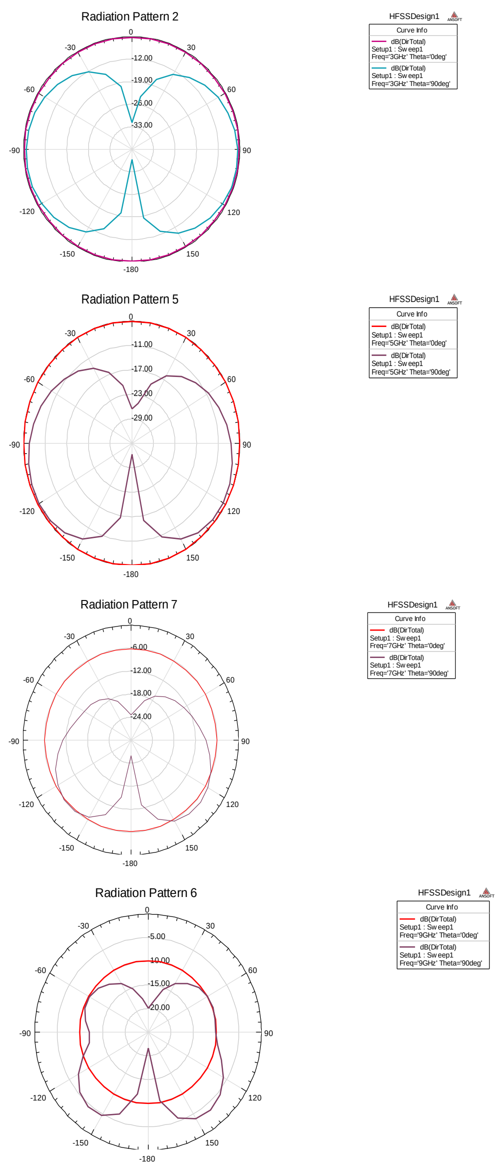


Fig. 8. Simulated radiation far-field patterns for the proposed antenna operation at (a) 3 GHz, (b) 5 GHz, and (c) 7 GHz and (d) 9GHz

4. Conclusion

A compact CPW-FED band notched UWB square ring antenna is designed and simulated through HFSS 13.0. The designed antenna is very simple in size and look because it has only one small slot cut in ground plane. This antenna may be used for UWB application with band reject of wireless local area

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network (WLAN). The designed antenna has satisfactory performance in terms of VSWR, group delay and the far-field radiation patterns.

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