HEXAGONAL SLOT ANTENNA WITH DUAL BAND NOTCHED CHARACTERISTICS FOR UWB APPLICATIONS

[PAPER ID ICITER-D176]

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ABSTRACT:

Printed hexagonal slot antenna with dual band stop characteristics for ultra wideband applications is presented in this paper. The basic antenna comprises U-shape radiating patch and ground plane with hexagonal slot. By proper alignment and use of hexagonal slot additional resonances and much wider impedance bandwidth is obtained. By embedding inverted L-shape parasitic stubs at the upper edge at the hexagonal slot, obtain the desired band rejection characteristics for WiMAX and WLAN respectively. The operating frequency of proposed antenna is ranged from 2.76~ 11.07GHz with a dual band rejection from 3~4GHz (for WiMAX) and 5~6GHz (for WLAN).The designed antenna is fabricated on a FR-4 glass epoxy substrate having dielectric constant of 4.4 with overall dimensions of 28 x 28 x 1.6mm³. Parametric studies have been conducted by changing length of inverted L-shape parasitic stubs and it is conducted using CADFEKO 7.0 simulation software. Designed antenna exhibits good radiation pattern, efficiency greater than 75% within the entire ultra wideband except for WiMAX and WLAN frequency.

INTRODUCTION:

In Feb 2002, the Federal Communication Commission (FCC) declared the 3.1 to 10.6 GHz unlicensed frequency band for UWB communication[i].Due to the huge industrial introduction in UWB applications companies have produced computer, mobile phones, set-up boxes type applications in market[ii].Other important application of UWB is ranging and localization due to fine delay resolution[iii].Due to the extremely large bandwidth of UWB, the interference between the narrow band and UWB system is a major challenge in UWB. Slot antenna is having slot within the ground plane and it is suitable for application where near-field coupling is required to be minimized. Recently several techniques have been proposed to develop band notch structure in antenna itself such as embedding slots, slits and even parasitic element.

The antenna is operative within entire UWB with tri band notch characteristics [iv].In [v], a UWB wide slot antenna is presented for multi-input multi-output applications with integrated WLAN. The small square monopole antenna has been designed for UWB applications, along with inverted T-shaped slot and conductor-ground plane to improve the impedance bandwidth. WLAN Frequency band notch is obtained by rotated C-shaped strip around the inverted T-shaped conductor back plane [vi] and U-shape strip is parasitically attached to the feed layer [vii].

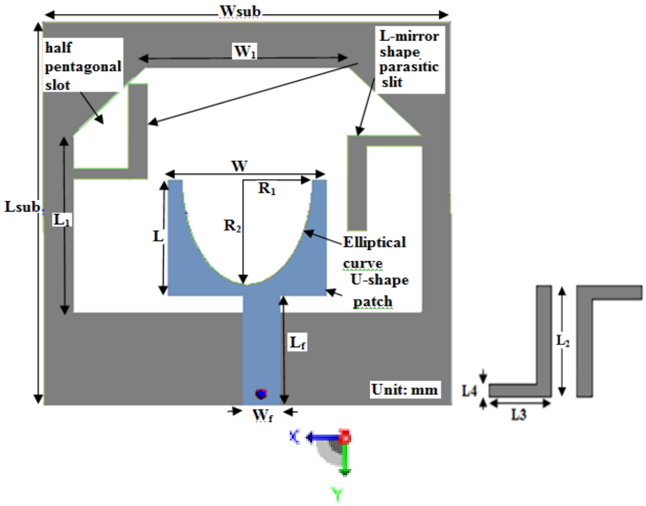


Fig1. Geometry of proposed antenna

In [viii],a planer slot antenna was proposed for UWB application along with dual-band-notch characteristics. They were notch WiMAX and WLAN by using parasitic slit.In [ix], UWB antenna using pair of L-shape slots in the ground plane are used for WLAN rejection, quarter wavelength slots and inverted L shaped slots for triple band notched characteristics [x]. In [xi], the antenna operates at Bluetooth frequency along with band notch characteristics for WLAN band. By inserting a stub in radiating patch and modified G slot defected ground structure in the feeding line, dual frequency bands rejection are obtained [xii].In [xiii], rectangular aperture antenna was proposed along with band notched function. In [xiv], antenna uses Land U-slot to create dual band notch charactristics for C-band satellite communication system and WLAN-band. The antenna operates over the frequency range of 2.75GHz to 15.3GHz with dual notch band characteristics of WLAN and WiMAX. Symmetrical L-shape slots and Inverted U-shape slot are use to achieve notch band [xv].Two inverted L-shaped slots are used for U-NII band rejection [xvi].

ANTENNA DESIGN AND ANALYSIS:

A. DESIGN PARAMETERS:

Substrate (FR4) having dielectric constant 4.4 and thickness of 1.6 is used for manufacturing the proposed geometry. The basic formulas for design of the micro-strip antenna are given below [xvii].
Width of Patch is given by,

$$W = \frac{C}{4f_r} \times \sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

Where C is the velocity of light in free space.

Effective Dielectric Constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + \frac{12h}{W_P}}} \quad (2)$$

Length Extension: Extended distance ΔL along the dimensions of patch length and the normalized extension of the length is given by equation,

$$\frac{\Delta L}{h} = \frac{0.412(\varepsilon_{reff} + 0.3)\left(\frac{W_p}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W_p}{h} + 0.8\right)} \quad (3)$$

Effective Length: $L_{reff} = \frac{C}{4f_r\sqrt{\varepsilon_{reff}}}$ (4)

Length of Patch: Actual length of patch is L_P

$$L_p = L_{eff} - 2\Delta L \quad (5)$$

B. BAND NOTCHED STUB ANALYSIS:

Inverted L- shape parasitic stubs are embedded at the upper edge of the hexagonal slot of the ground plane to create notch in WiMAX and WLAN band rejection. Symmetrical L-shape parasitic stubs on ground plane and inverted L- shape parasitic stubs ground plane are responsible to create notch at WiMAX and WLAN band respectively.

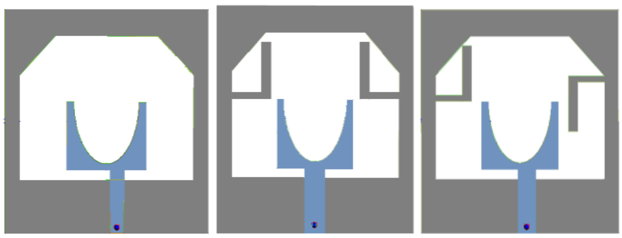
The length of symmetrical L-shape parasitic stubs are calculated by following formula,

$$L_{\text{notch}} = \frac{C}{4F_{notc\ h} \times \sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (6)$$

Optimized value of inverted L shape parasitic stubs are 13.28mm and C is velocity of light in free space.

C. EVOLUTION OF GEOMETRY:

Firstly, the UWB antenna with impedance bandwidth of 2.76 ~ 11.07 GHz is achieved as shown in Fig 2(a) which is printed on FR4 substrate of thickness 1.6mm, loss tangent 0.02 and permittivity 4.4.It is fed by 50Ω micro-strip line. Antenna structure consists of a U-shape radiating patch with elliptical shape which is fed by 50 Ω micro-strip feed line, ground plane along with hexagonal slot. The patch has a width W and length L and it is connected to feed line of width W_f and length L_f. Further, we insert symmetrical L-shape parasitic stubs on a ground plane having hexagonal slot to achieve band stop function as shown in Fig 2(b). This provides band stop function for WiMAX band. Finally, dual band stop characteristics for WiMAX and WLAN bands are attended by inserting inverted L-shape parasitic stubs on ground plane The proposed geometry is shown in Fig2(c).



(a) (b) (c)

Fig 2. (a) The UWB antenna, (b) symmetrical L-shape parasitic stubs, (c) the U-shape patch with inverted L-shape parasitic stubs on ground plane.

The geometrical configuration has been developed and it is shown in Fig.1.In this, the antenna with U-shape patch and hexagonal slot-backed plane with embedded inverted L-shape parasitic stubs are proposed to notch WiMAX and WLAN frequency band respectively from UWB.In this section, dual notched band hexagonal slot UWB antenna with various design parameters is constructed. The simulated results are obtained using CADFEKO 7.0 software [xviii].Fig 2.shows the various antenna geometries used for simulation studies. VSWR characteristics for the UWB antenna Fig 2.(a), symmetrical L-shape parasitic stubs Fig 2.(b) and Fig 2.(c) are compared in Fig.3.

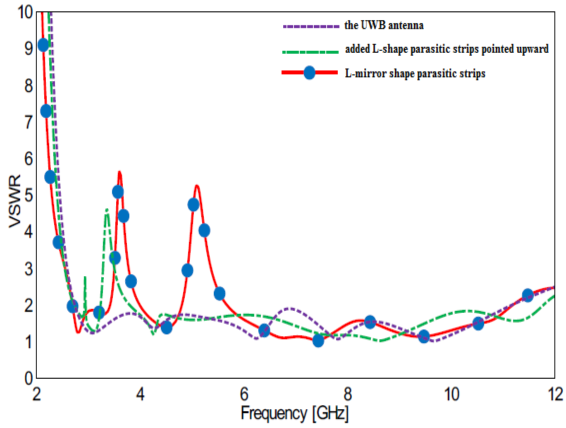


Fig 3. Simulated VSWR Vs frequency for different antenna geometries shown in Fig2.

From the illustrated Fig 3, symmetrical L-shape parasitic stubs are used to provide band stop function for WiMAX whereas inverted L-shape parasitic stubs provides WLAN notching. It indicates the VSWR characteristics of proposed geometry. It shows that antenna operates over entire UWB with dual band notch. The parametric study has been conducted using the CADFEKO 7.0 simulation software. Further to study the detail analysis of inverted L-shape parasitic stubs, parametric studies are conducted. Initially, the graph of length L_2 of the proposed geometry is varied by keeping L_3 and L_4fix is shown in Fig 4.

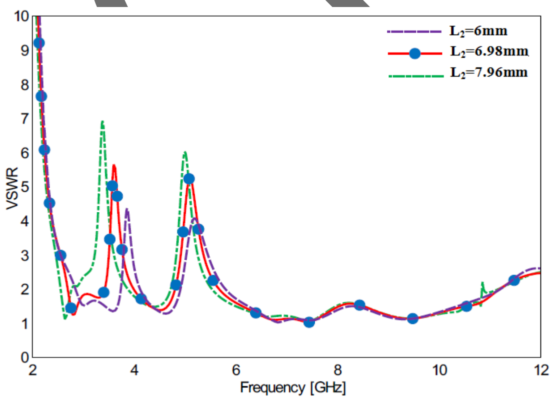


Fig 4.Variations in parameter L_2 of inverted L-shape parasitic stubs

As the length (L_2) increases, the higher edge frequency shift to lower side as shown in Fig 4. At L_2=6.98mm, the band rejection property satisfies well at WiMAX.

The graph of variation in parameter L_3 of inverted L-shape parasitic stubs are shown in Fig 5.It is observed that as the length increases the band rejection shifted towards lower edge frequency as shown in Fig 6.

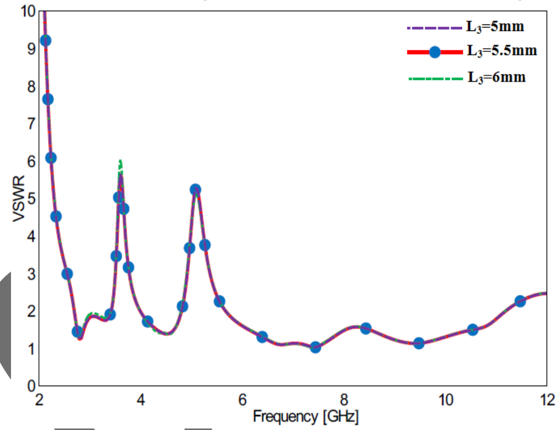


Fig 5.Variations in parameter L_3 of inverted L-shape parasitic stubs of the proposed geometry

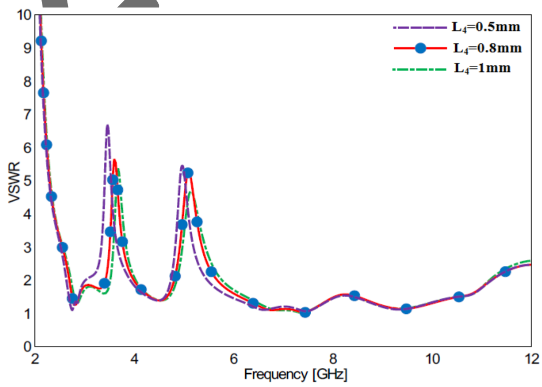
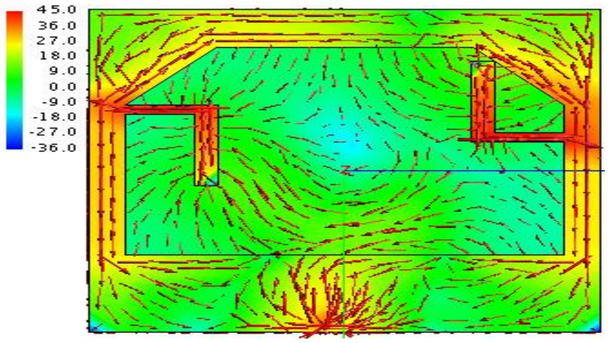


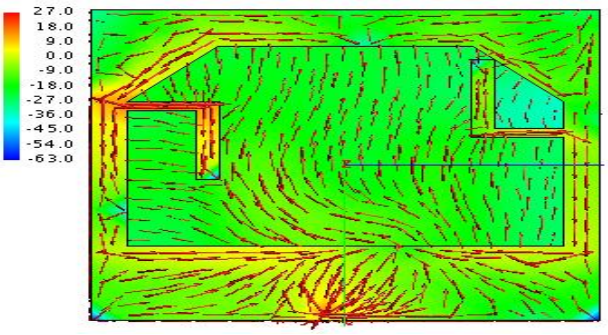
Fig 6. Variations in parameter L_4 of inverted L-shape parasitic stubs of the proposed geometry

This parametric analysis clearly shows the effect of inverted L-shape parasitic stubs on band notching characteristics for WiMAX and WLAN respectively.

The effect of inverted L -shape parasitic stubs are observed in current distributions of proposed antenna at two different frequencies as shown in Fig 6. In Fig6.(a),at notch frequency(3.61GHz) current distribution is stronger and concentrated more along the symmetrical L-shape parasitic stubs. At 5.5GHz, the maximum current is concentrated along the inverted L-shape parasitic stubs placed on ground plane as shown in Fig 6.(b).This shows that, inverted L-shape parasitic stubs are responsible for band notching characteristics.



(a)



(b)

Fig 6.current distribution (a) bottom layer at 3.61GHz, (b)bottom layer at 5.5GHz.

RESULTS AND DISCUSSION:

The simulated VSWR versus frequency of the proposed antenna is illustrated in Fig 7. The proposed antenna exhibits dual band stop function for WiMAX & WLAN, with frequency ranging from 2.76~11.07GHz for VSWR less than 2.Fig.8.illustrate the graph of simulated efficiency characteristics Vs frequency in GHz, which shows that efficiency of proposed antenna is greater than 75% in entire UWB band except WiMAX and WLAN band.

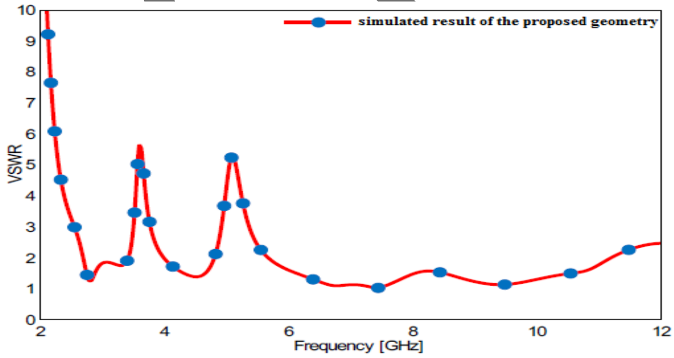


Fig 7.Simulated VSWR characteristics for proposed antenna.

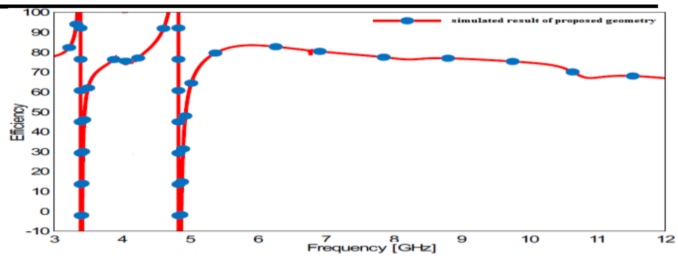
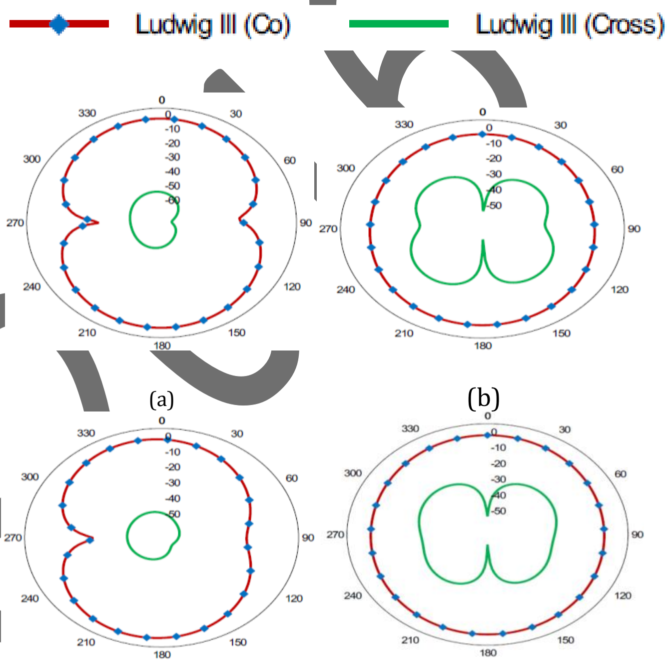


Fig8.Simulated efficiency characteristics for proposed antenna.



(c) (d)

Fig 9.Simulated radiation pattern of the proposed antenna (a) E-field co and cross polarization at 5.09GHz (b) H-field co and cross polarization at 5.09GHz(c) E-field co and cross polarization at 6.95 (d)H -field co and cross polarization at 6.95

Fig.9. shows the simulated radiation patterns of proposed antenna at different frequencies of 5.09GHz and 6.95GHz.The cross-polarization is less as compared to co-polarization. It helps to demonstrate that whether antenna radiate properly or not over the entire frequency range. It can be seen that radiation pattern in H-plane is omnidirectional and dumbbell shape in E-plane.

CONCLUSION:

A compact modified hexagonal slot antenna has been proposed for UWB applications along with dual band notch function. The antenna provides 11.98GHz bandwidth (2.76 to 11.07GHz) for VSWR is less than 2 except for WiMAX (3-4GHz) and WLAN (5~6GHz).Antenna filter out WiMAX and WLAN band by inserting inverted L-shape parasitic stubs in the ground plane. The proposed antenna exhibits efficiency greater than 75%, omnidirectional and directional radiation pattern in H & E plane respectively except the notched band showing the suitability of the proposed antenna for UWB applications.

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