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Design of Multiband Microstrip Antenna for Bluetooth, UWB, X-band and Ku band Applications

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Abstract: A compact microstrip fed multiband monopole antenna for Bluetooth (2.4-2.48 GHz), Ultra Wide Band (UWB) (3.1-10.6GHz), X-band (8-12 GHz) and Ku band (12-18 GHz) applications is proposed. The proposed antenna consists of a rectangular patch having central slot with lower edges beveled on one side and rectangular partial ground with central slot having lesser width as compared to substrate on the other side of substrate. The idea of edge beveling is also introduced in this partial ground to increase the impedance bandwidth. This antenna has operating frequency from 2.33-2.58 GHz and resonates at 2.44 GHz for Bluetooth application and 2.98-18 GHz for UWB, X-band and Ku-band applications. In this paper, the shape of ground is proposed so as to improve impedance bandwidth over entire UWB, X-band and Ku-band range. A rectangular quarter wavelength strip is optimized so as to resonate at 2.44 GHz. The proposed antenna is simulated using CST- Microwave Studio. With adjusted parameters the proposed antenna exhibits a broad impedance bandwidth with VSWR ≤ 2.

Keywords: Monopole antenna, Multiband, Ultra Wide Band, X-band, Ku Band.

I. INTRODUCTION

Microstrip antennas are having several advantages such as light weight, low cost, thin profile, conformal to a shaped surface so it can be used in several applications as in aircraft, satellite and wireless communication [1]. One of the most serious problems of microstrip antenna is its narrow bandwidth. Many works have been done and various methods are used to increase the bandwidth of microstrip antenna.

In a February 2002, Federal communications Commission (FCC) allocated 3.1-10.6 GHz frequency band for UWB systems. Today, modern communication systems need a single antenna that can work for multiple frequency bands [2-3]. The future usable devices or other machines that integrate Bluetooth and UWB transmitter or receiver requires a single antenna that can operate for these two bands. To integrate with Bluetooth, the Bluetooth Special Interest Group selected Multiband Orthogonal Frequency Division Multiplexing (MB-OFDM) UWB in 2006 [15].

In the past years, a large number of UWB antennas have been studied and reported in the literatures [1-20]. In order to increase impedance bandwidth of antenna, an array of rectangular microstrip patches arranged in log-periodic way with proximity coupled feed line [3], I-shaped notches on the ground plane [4], U-shaped slot and partial ground plane have been suggested. Attempts have been made to design the feed of microstrip antenna structure for UWB wireless applications [11]. Another various types of antennas with two substrate layer [6], diamond shaped monopole [8], CPW fed fractal patch antenna and swastika slot antenna has been presented for UWB applications [12-13]. The multiple ring slots UWB antenna and T-shaped slot UWB antenna has been introduced for Microwave Imaging [9-10]. UWB can be integrated with other narrow band applications like Bluetooth, GSM and GPS and also interference from other co-existing bands can be reduced by introducing band notched characteristic in antenna design [17].

In this paper author propose a multiband antenna consists of rectangular patch with lower edges beveled to enhance the operational bandwidth of antenna over entire UWB range. In this central slotted part of patch a rectangular strip is inserted to design Bluetooth integrated UWB antenna. To extend the impedance bandwidth and in order to make the proposed antenna design compatible for UWB, X-band and Ku-band applications ground structure with triangular slots which seem like beveled edges is proposed in this paper. Also we can see that with this ground structure return loss also decay in UWB range.

II. ANTENNA DESIGN

Fig 1 and 2 shows the antenna geometry with two different ground structures. The antenna is fabricated on the FR4 substrate of dielectric permittivity $\varepsilon_r = 4.4$, and thickness h=1.6mm having dimensions of 37mm x 45mm. A patch of dimensions 15mm x 15mm having circular and rectangular slot with lower edge beveled is printed on one side and partial ground structure with slots is printed on the other side [15]. A rectangular strip is inserted and investigated so as to resonate over the Bluetooth band. The type of feeding

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used is the microstrip line feeding with dimensions of width 3mm and length 12 mm.

We start with the design of lower edge beveled rectangular patch and partial ground with length 11.5mm. Also a circular slot followed by a rectangular slot is etched on the patch [15]. Fig.1. shows the basic structure of antenna patch. A rectangular strip of width 1.5 mm is inserted in central notched part of the patch. The length of rectangular strip is optimized so as to resonate at 2.44 GHz.

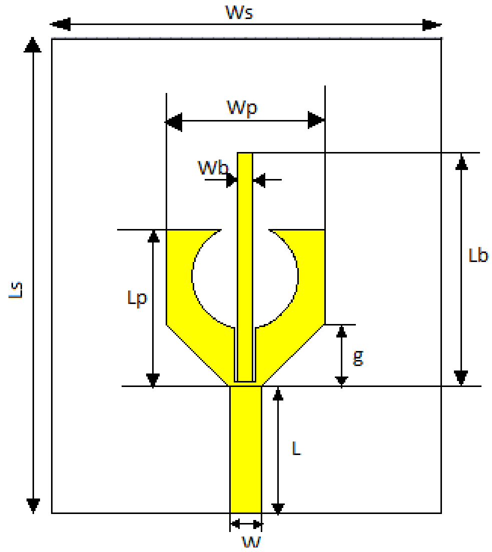

Fig 1 Top View of proposed antenna

The proposed dimensions of antenna that provide good performance are: Ls=45mm, Ws=37mm, Lp=Wp=15mm, Lb=22.05mm, Wb=1.5mm, L=12mm, W=3mm, g=6mm.

Fig.2. shows the back side view of proposed antenna. In this design the idea of beveling edges to increase impedance bandwidth is introduced in the ground plane of proposed antenna design. First we start with a ground plane structure having smaller width as compared to substrate. After this central slot and beveling the lower edges of ground structure is introduced to obtain desired performance of antenna in Bluetooth, UWB, X-band and Ku band frequency range. But further the upper edge beveling is introduced to obtain return loss less than -10 dB over entire UWB frequency range.

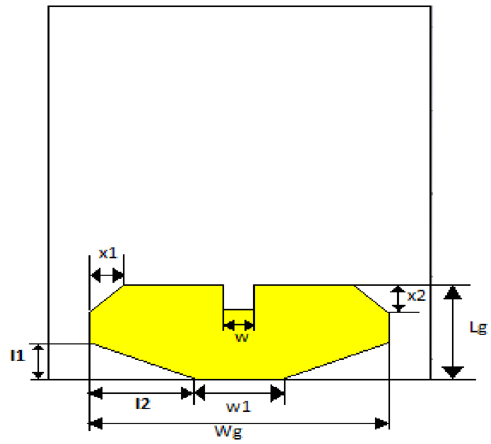

Fig. 2 Ground structure of proposed antenna design

So the rectangular ground structure having upper and lower beveled edges and central square slot is proposed in order to resonate over entire Bluetooth, UWB, X-band and Ku band range.

The proposed dimensions of ground structure are: Wg= 29mm, Lg=11.5mm, w1=8mm, w=3mm, x1=3.5mm, x2=3.5mm, l1=3.5mm, l2=10.5mm

The proposed antenna with beveled edges ground structures stands out as a good candidate for various wireless applications. The final dimension of UWB antenna optimized by CST- Microwave Studio. It is observed that the proposed design accomplish the exhibiting performance, a return loss less than -10dB over Bluetooth, UWB, X-band and Ku band.

III. RESULTS AND DISCUSSION

The microstrip fed antenna was designed and studied to demonstrate the proposed bandwidth enhancement technique. Fig. 3 shows simulated return loss of proposed antenna. We found wide impedance bandwidth with beveled edges partial ground structure.

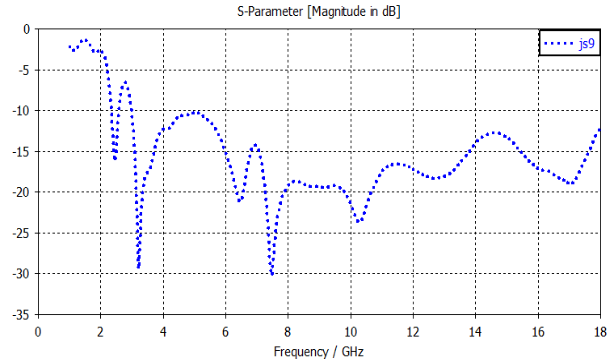

Fig. 3 Simulated reflection coefficient vs. frequency for proposed ground structures

From the return loss plot we can see that antenna resonates at 2.44 GHz for Bluetooth frequency band. Also return loss of proposed antenna design is less than -10 dB over entire UWB, X-band and Ku band frequency range.

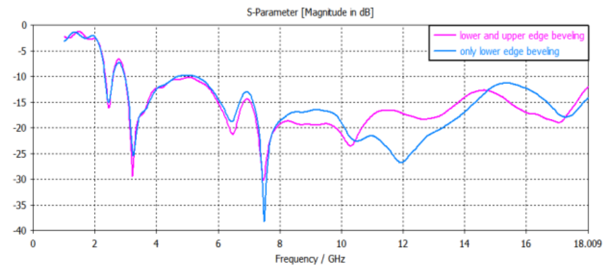

Fig.4 Effect of beveling on return loss

Fig.4 shows the effect of beveling on return loss plot of proposed antenna design. Figure shows return loss with only lower edge beveled and both lower as well as upper edge beveled ground structure. By introducing upper edge beveling return loss decayed over Bluetooth and over entire UWB range. But for Bluetooth frequency range antenna resonates at 2.46GHz.

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Fig.5 shows the optimization of upper edge beveling with x1=x2=2mm and x1=x2=3.5mm. We found best results with x1=x2=3.5mm because with further increasing length and width of beveled portion any significant effect does not observed and return loss starts increasing in UWB range. Also with x1=x2=3.5mm antenna resonates at 2.46 GHz.

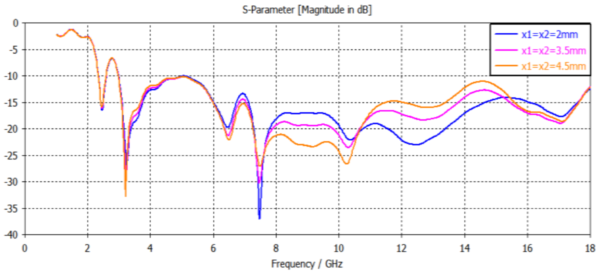


Fig. 5 Effect of length and width of beveling on return loss

To obtain resonating frequency at 2.44GHz we change the rectangular strip length inserted in central part of the patch. With Lb=22.05 antenna resonates at 2.44 GHz. Fig.6. shows effect of strip length on Bluetooth resonating frequency.

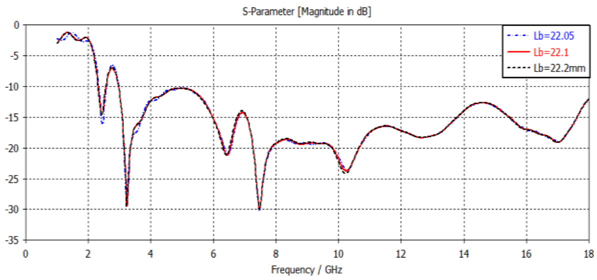


Fig. 6 Effect of strip length on Bluetooth resonating frequency

Fig.7 shows variation of voltage standing wave ratio (VSWR) of proposed antenna according to the frequency with proposed ground structure. It is observed that the value of VSWR ≤ 2 for frequency range 2.33-2.58 GHz and 2.98-18 GHz, Which is sufficient to cover the band allocated by FCC.

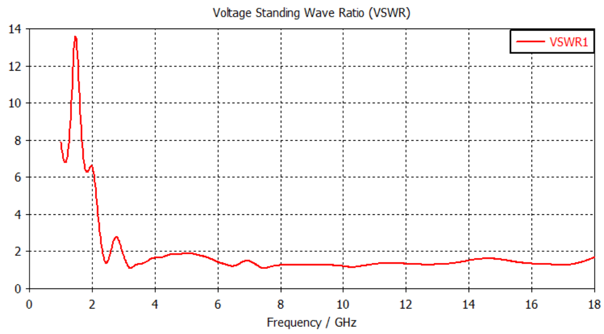
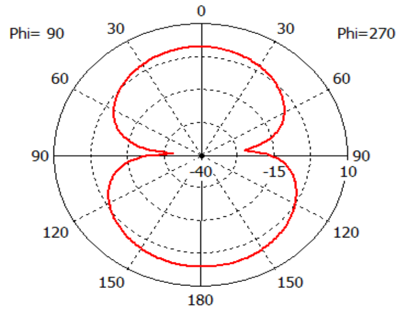
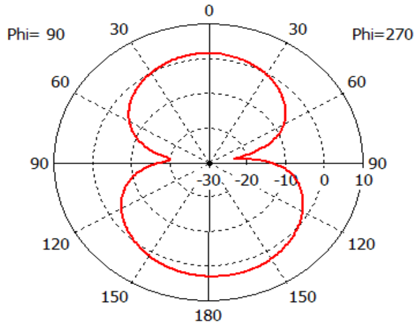


Fig. 7 Simulated VSWR for proposed antenna

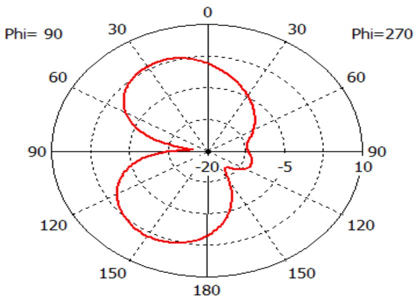
Fig.8. shows the 2D radiation pattern of the designed antenna at 2.44 GHz, 3.23 GHz, 7.46 GHz, 10.3 GHz and 17.05 GHz.



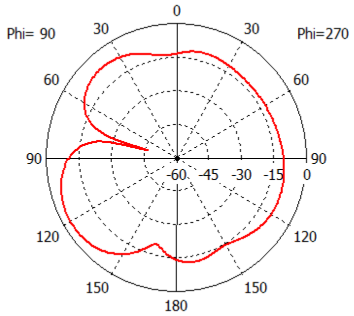
Radiation pattern at 2.44 GHz



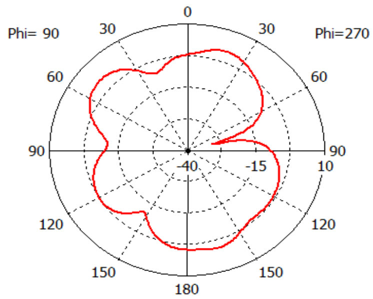
Radiation pattern at 3.2 GHz.



Radiation pattern at 7.46 GHz



Radiation pattern at 10.3 GHz



Radiation pattern at 17.05 GHz

Fig. 8 2D radiation pattern at resonant frequencies

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The simulation results of the gain and 3d radiation patterns are given in the Figure 9 and Figure 10 below

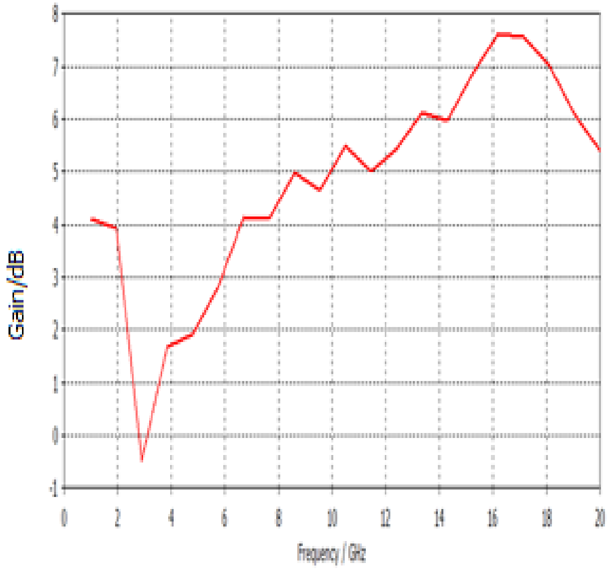
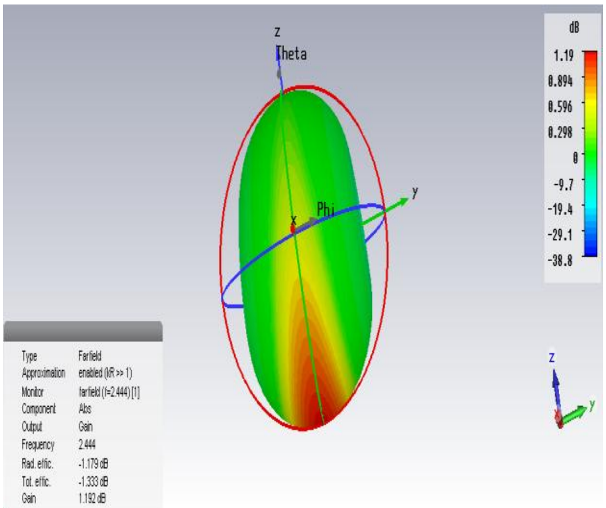
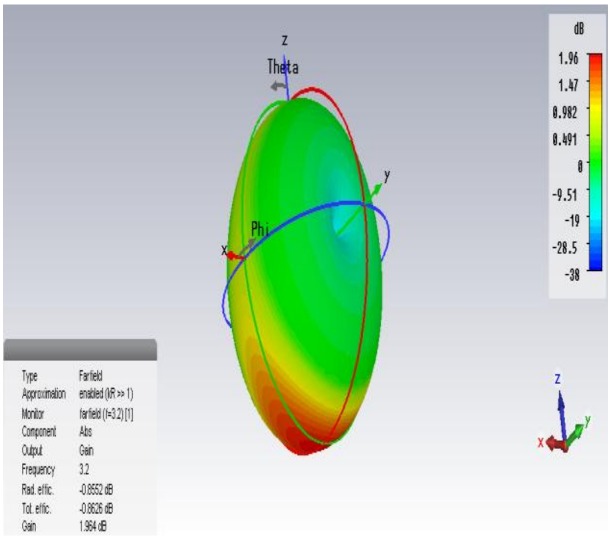


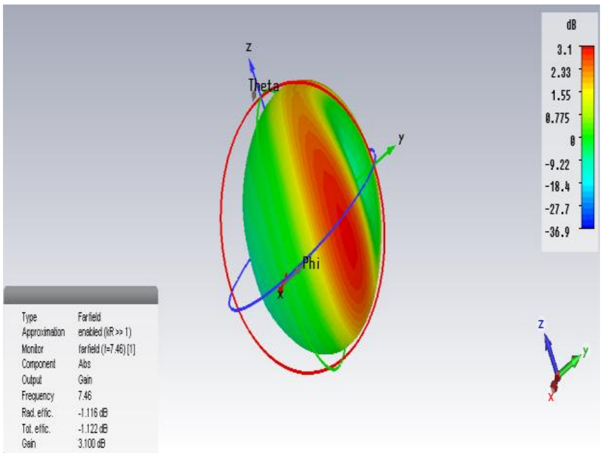
Fig. 9 Simulated gain vs. frequency



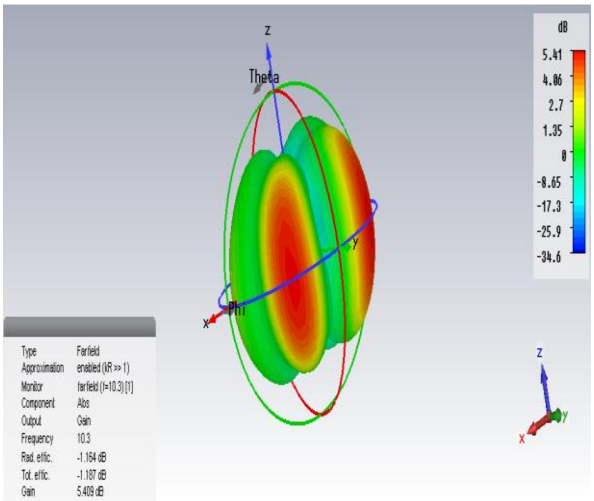
Radiation pattern at 2.44 GHz



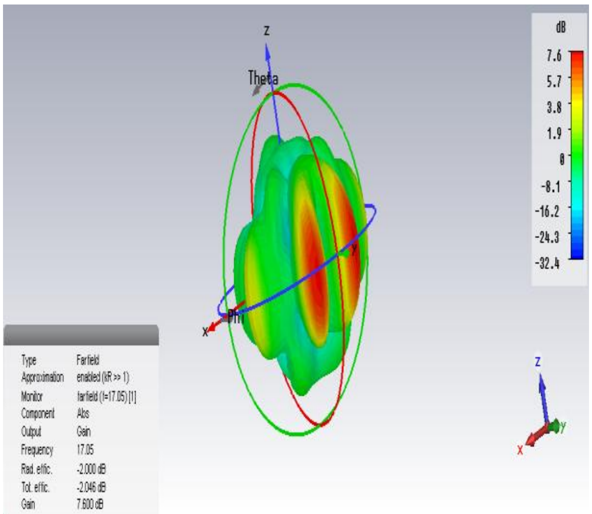
Radiation pattern at 3.2 GHz



Radiation pattern at 7.46 GHz



Radiation pattern at 10.3 GHz



Radiation pattern at 17.05 GHz

Fig. 10 3D radiation pattern at resonant frequencies

IV. CONCLUSION

A compact microstrip fed multiband monopole antenna for Bluetooth, UWB, X-band and Ku band applications is proposed and investigated. The ground structure is investigated by using idea of edge beveling to enhance impedance bandwidth. The proposed ground scheme is an excellent approach, which makes a strong effect on the antenna's impedance bandwidth enhancement for ultra-wideband and other applications. The results proved that the design stands out as a potential candidate for future UWB applications.

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