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

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Abstract – *A compact microstrip feed 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 suggested. The basic antenna structure consists of a rectangular patch with lower edges beveled on one side and 'V' shape partial ground having central slot with lower corner intercepted by a rectangular strip place at bottom on the other side of substrate. Also this ground structure is modified by adding a rectangular strip connected to upper corner of 'V' shape ground to obtain desired performance. The idea of lower edges beveling is introduced in order to increase the impedance bandwidth. A circular slot is etched on the patch to provide better radiation pattern and impedance bandwidth. This antenna has operating frequency from 2.33-2.59 GHz and resonates at 2.44 GHz for Bluetooth application and 2.88-20 GHz for UWB, X-band and Ku-band applications with WLAN band notch characteristics. In this paper, the shape of ground is optimized so as to improve impedance bandwidth over entire UWB, X-band and Ku-band range. Also we can see that rectangular quarter wavelength strip inserted in central part of patch is optimized so as to resonate over Bluetooth band. The proposed antenna was simulated using CST- Microwave Studio. With adjusted parameters the proposed antenna exhibits a broad impedance bandwidth with VSWR ≤ 2.*

Key Words: Monopole antenna, Multiband, Ultra Wide Band, X-band, Ku band, Notched Frequency

1. INTRODUCTION

Microstrip antennas 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 [2].

Recently, ultra wideband (UWB) system has been considered and almost recommended for applications in wireless communication due to its capability to provide high speed connectivity and large bandwidth transmission. The UWB system has frequency range between 3.1-10.6 GHz. The problem of interference of UWB with co-existing bands can be reduced with band notched characteristics [2, 3, 5, 7].

Since from the past years, Bluetooth has been widely used in portable devices such as mobile phones, PDA's and notebooks, etc. covering the 2.4-2.482 GHz band. To integrate UWB with Bluetooth, the Bluetooth Special Interest Group selected MB-OFDM UWB in 2006 [8].

In the past years, a large number of UWB antennas have been studied and reported in the literatures [1-16]. 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], CPW fed fractal patch antenna, swastika slot [12,13] and diamond shaped monopole antenna [15] has been presented for UWB applications 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 [15, 17].

In this paper a multiband antenna consists of rectangular patch with lower edges beveled to enhance the operational bandwidth of antenna over entire UWB range. The central part of patch is notched by a circular slot followed by a rectangular slot to improve radiation pattern and impedance bandwidth. In this central notched part a rectangular strip is inserted to resonate over Bluetooth band. To extend the impedance bandwidth and in order to make the proposed antenna design compatible for X-band and Ku-band applications modified ground structure is suggested. Also we can see that with this modified ground structure return loss also decay in Bluetooth and UWB range. The proposed antenna is successfully designed and the simulated results show reasonable agreement with the bandwidth requirement.

2. ANTENNA DESIGN

Fig 2 and fig. 4 shows the antenna geometry with two different ground structures. The antenna is fabricated on the FR4 substrate of dielectric permittivity ε_r =4.4, and thickness h=1.6mm having dimensions of 37mm x 45mm. A patch of dimensions 15mm x 15mm with lower edge beveled is printed on one side and 'V' shape partial ground structure with central slot is printed on the other side. A circular slot followed by a rectangular slot is incorporated on patch. A rectangular strip is inserted in this slotted part of the patch to resonate over the Bluetooth band. The type of feeding used is the microstrip line feeding with dimensions of width 3mm and length 12 mm.

2.1 Basic Design

Fig.1 shows the top view of proposed antenna. We start with the design of lower edge beveled rectangular patch and partial ground with length 11.5mm. A circular slot followed by a rectangular slot is etched on the patch in order to increase impedance bandwidth. A rectangular strip of width 1.5 mm is inserted in central notched part of the patch [8]. The length of rectangular strip is optimized so as to resonate at 2.44 GHz. From fig.2 we can see that in back side view of basic design 'V' shape partial ground with lower corner intercepted by a rectangular strip place at bottom is proposed in order to increase impedance bandwidth over X-band and Ku-band. A slot of 3mm x 3mm slot is etched in central part of the ground to achieve reflection coefficient ≤ -10 dB from 3-10 GHz band.

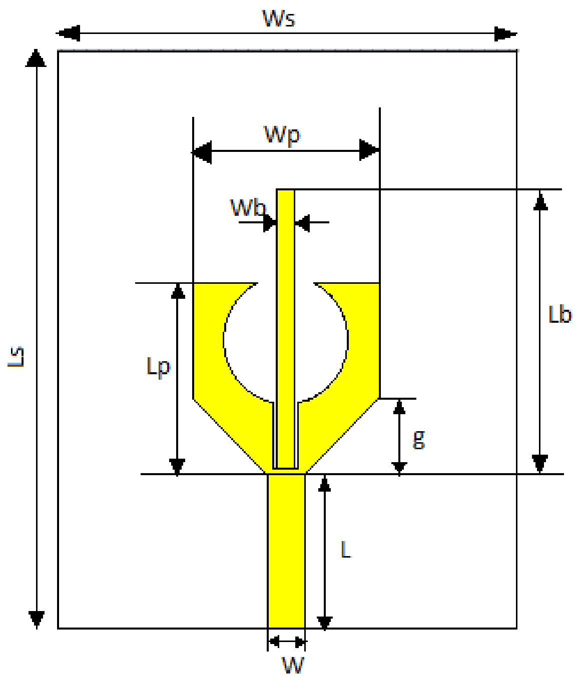


Fig-1: Top view of antenna

The proposed dimensions of antenna that provide good performance are: Ls=45mm, Ws=37mm, Lp=Wp=15mm, Lb=22mm, Wb=1.5mm, L=12mm, W=3mm, g=6mm.

A rectangular quarter wavelength strip inserted in central part of patch to resonate over the Bluetooth band. The length (Lb) of the rectangular strip monopole is about quarter wavelength of central Bluetooth band frequency (f)

$$Lb = \frac{c}{4f\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

Fig.2 shows back side of antenna with proposed dimensions.

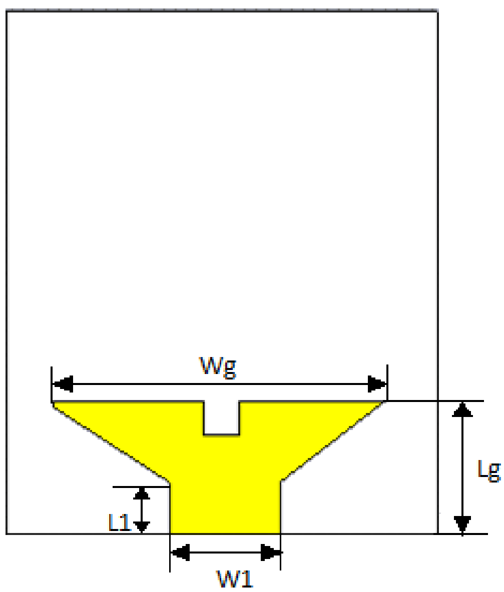


Fig-2: Back side of proposed antenna [Wg=28.5mm, Lg=11.5mm, L1= 3.5mm, W1=9.5mm]

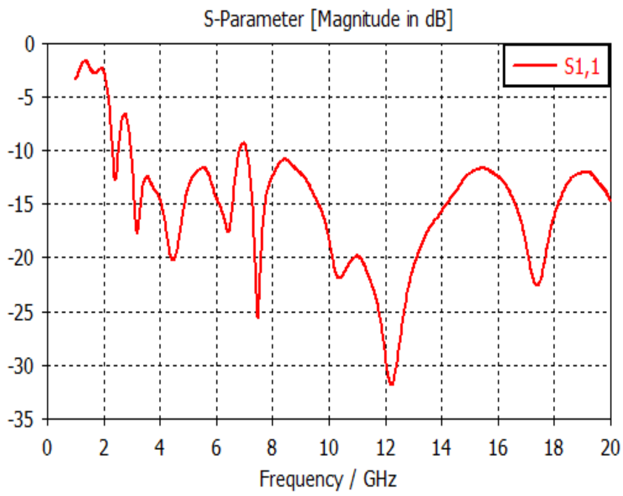
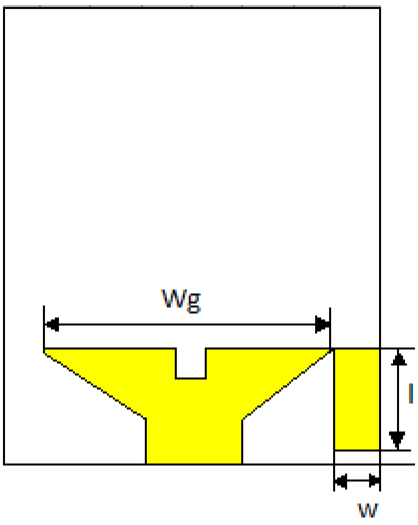


Fig-3: Simulated return loss of proposed antenna

2.2 Modified Ground Structure

In fig 3 we can see that return loss of antenna is not less than -10db over entire UWB range. To achieve better performance in terms of return loss over Bluetooth and UWB range and to introduce band notch characteristic ground structure is further modified as is shown in fig.4. A rectangular strip is attached to left corner of 'V' shaped ground to obtain desired performance with dimensions l=10mm, w=4.5mm. Modified ground structure has all other dimensions similar to basic ground structure.



Fig–4: Modified Ground structure

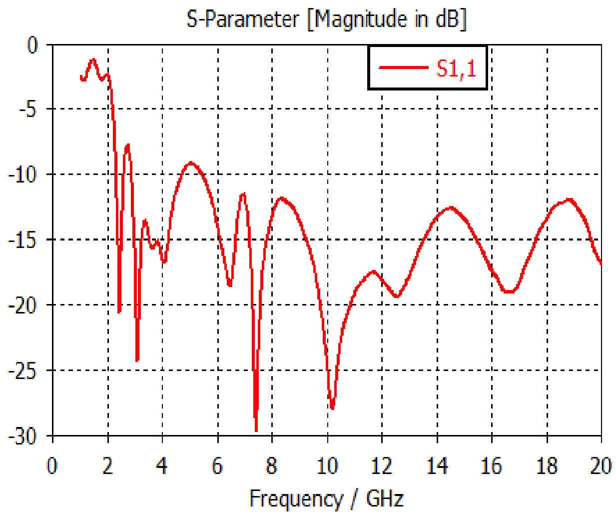


Fig -5: Simulated return loss of proposed antenna with modified ground structure

From fig 3 we can see that return loss decay over entire Bluetooth band and UWB range with modified ground structure. Also WLAN band frequency notch is obtained by this modification in ground structure. The proposed antenna with modified ground structures stands out as a good candidate for various wireless applications. The final dimension of UWB antenna is investigated by CST-Microwave Studio. It can be seen that the proposed design accomplish the exhibiting performance, a return loss less than -10dB over Bluetooth, UWB, X-band and Ku band. So the proposed antenna with modified ground structure can be efficiently used for various wireless applications. The characteristic of antenna is observed using simulation.

4. RESULTS AND DISCUSSION

The microstrip fed antenna was designed and studied to demonstrate the proposed bandwidth enhancement technique. Fig. 4 shows the comparison of return loss with two different ground structures.

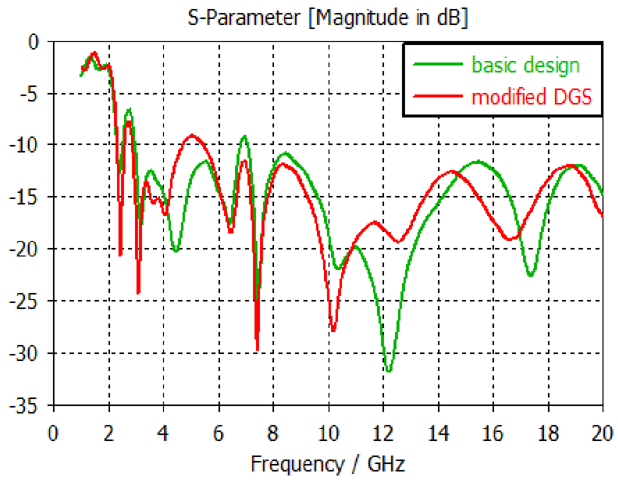


Fig-6: Simulated reflection coefficient vs. frequency for proposed ground structures

Fig. 5 and fig. 6 shows variation of voltage standing wave ratio (VSWR) of proposed antenna according to the frequency.

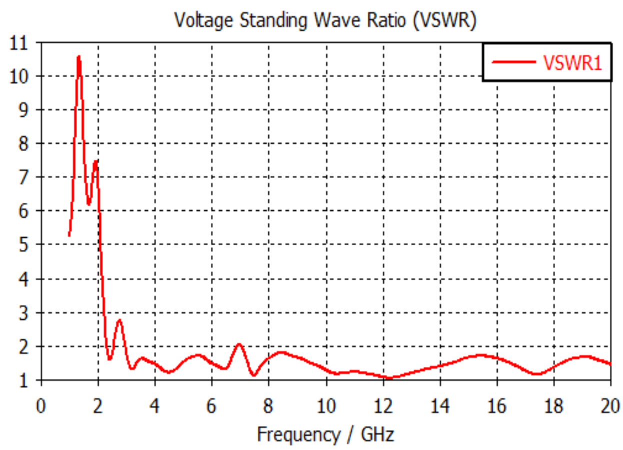


Fig-7: VSWR for basic design

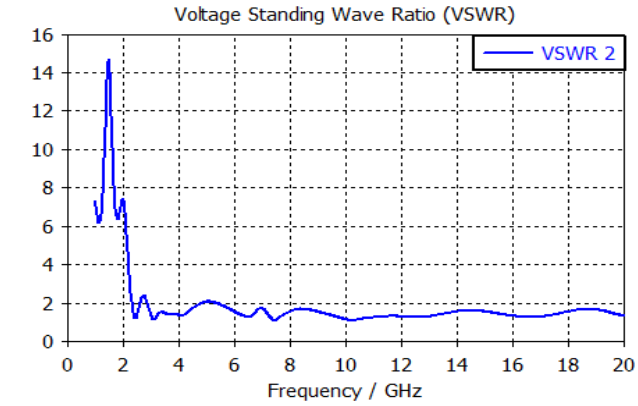
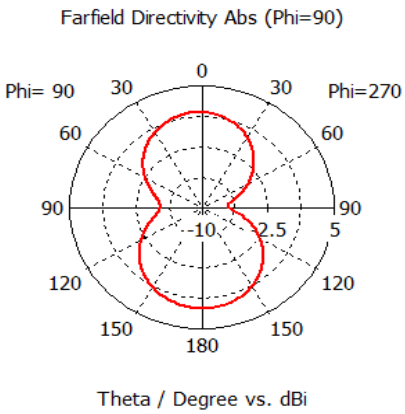


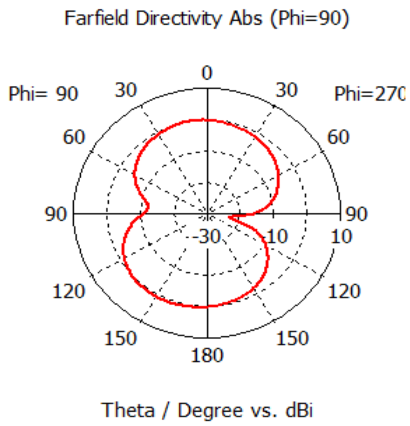
Fig-8: VSWR for modified ground structure

We notice that the value of VSWR ≤ 2 for frequency range 2.33-2.59 GHz and 2.88-20 GHz with 5.2 GHz WLAN notched band, which is sufficient to cover the band allocated by FCC.

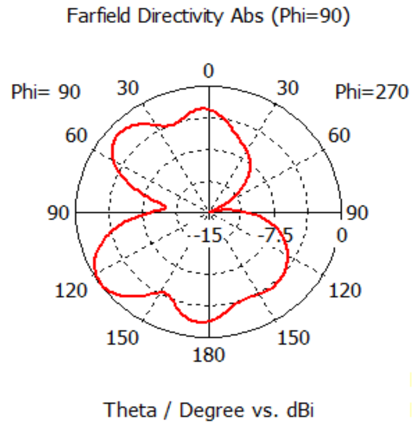
The simulation results of far-field radiation pattern at following frequencies: 2.44 GHZ, 7.42 GHz, 10.2 GHz and 16.7 GHz are shown in figure 9.



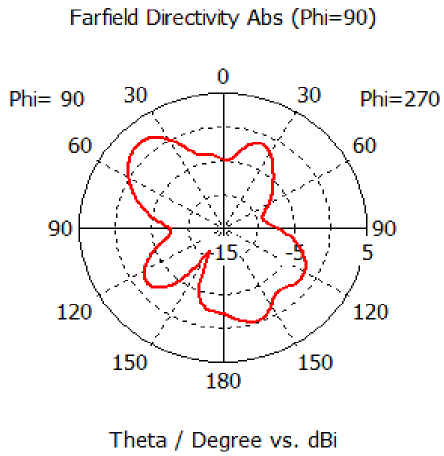
Radiation pattern at 2.44 GHz



Radiation pattern at 7.42 GHz



Radiation pattern at 10.2GHz



Radiation pattern at 16.7 GHz

Fig-9: Far-field radiation patterns for proposed antenna

3. CONCLUSIONS

A compact microstrip fed multiband monopole antenna for Bluetooth, UWB, X-band and Ku band applications is proposed and investigated. The dimensions of the central rectangular strip monopole which is responsible for resonate over Bluetooth band are investigated. Also the antenna design is optimized with two ground structures. 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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