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Compact multiband fractal microstrip antenna

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Abstract
A microstrip antenna consists of a metallic pattern of a dielectric substrate and ground plane. 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. 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

Keywords: Compact multiband and microstrip antenna

Introduction
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 [1-7].
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 MBOFDM UWB in 2006 [3].
In the past years, a large number of UWB antennas have been studied and reported in the literatures. In order to increase impedance bandwidth of antenna, an array of rectangular microstrip patches arranged in log-periodic way with proximity coupled feed line, I-shaped notches on the ground plane, 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 [1]. Another various types of antennas with two substrate layer [6], CPW fed fractal patch antenna, swastika slot [5] and diamond shaped monopole antenna [4] has been presented for UWB applications The multiple ring slots UWB antenna and T-shaped slot UWB antenna has been introduced for Microwave Imaging [6]. 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 [7].

Antenna design
Fig. 1, 2 and 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 × 45mm. The relative permittivity and loss tangent of substrate is 4.4 and 0.02 respectively. A patch of dimensions 15mm × 15mm with lower edge beveled is printed on one side and partial ground structure with slot is printed on the other side of the substrate.

Design Equations
The width of microstrip patch antenna is given by (1)

$$Wp = \frac{c}{4fr\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (1)$$

Effective dielectric constant (ε_{reff}):

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

Effective length (L_{eff}):

$$L_{eff} = \frac{c}{4fr\sqrt{\varepsilon_{reff}}} \quad (3)$$

The length extension (δL):

$$\frac{\delta L}{h} = 0.4129 \frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (4)$$

Length of patch (Lp):

$$Lp = L_{eff} - 2\delta L \quad (5)$$

Substrate dimensions (Ls and Ws);

$$Ls = Lp+6h \text{ and } Ws = Wp+6h \quad (6)$$

Equations (1) to (6) are used for design of monopole antenna. Where c is speed of light, ε_r is dielectric constant of substrate and h is thickness of the substrate.

Basic geometry

We start with the design of lower edge beveled rectangular patch and partial ground with length 11.5mm [8]. A circular slot followed by a rectangular slot is incorporated on the patch. A rectangular strip is inserted in this etched part of the patch to resonate over the Bluetooth band. The dimensions of rectangular quarter wavelength strip are optimized so as to resonate at 2.44 GHz.

The length (Lb) of the rectangular strip monopole is about quarter wavelength of the central Bluetooth band frequency (f_b)

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

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

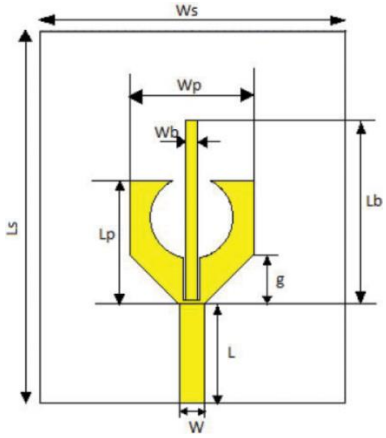

Fig 1: Top View of Proposed Antenna

Table 1 shows proposed dimensions of propsed antenna patch structure that provide good performance.

Table 1: dimensions of the proposed antenna patch

Parameter	Dimension (mm)
Lp	15
Wp	15
Lb	22.3
Wb	1.5
L	12
W	3
g	6

Fig. 2. shows the back side of ground plane structure of antenna. The partial ground structure having smaller width as compared to substrate is proposed.

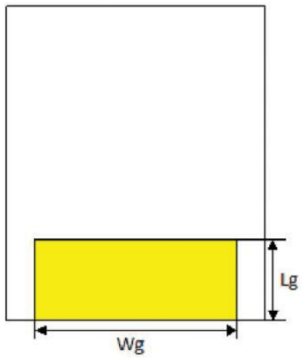

Fig 2: Ground plane structure of basic geometry

Proposed dimensions of ground plane are Lg=11.5 and Wg= 29.

Figure 3 shows the return loss plot of antenna

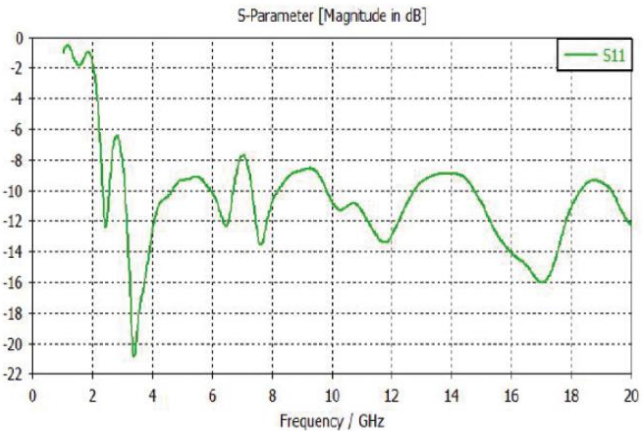

Fig 3: Variation of return loss (S11) vs. Frequency

It can be seen from the graph that return loss plot that antenna resonates over 2.45 GHz. But return loss of antenna is not less than -10dB over entire UWB, X band and Ku-band frequency range.

Conclusion

The antenna structure is simple and etched on FR-4 substrate. The effect of ground structure on return loss is also investigated. Modified ground plane enhance the impedance bandwidth of the proposed antenna.

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