Compact Rectangular Microstrip Patch Antenna With Multi-Frequency Operation Using Slot Loaded Ground Plane

Riya Bhattacharyya, Priyanka Deb Sinha, Partha Pratim Sarkar

***Abstract*— With development of communication, compactness or size reduction and multi frequency operation of microstrip antennas have become important design considerations for practical applications. Here a new microstrip antenna loaded with slot on the ground plane has been designed and studied. The overall electric length of the antenna has been increased largely and hence the size of antenna is reduced to 80%, compared to an ordinary microstrip antenna with the same resonant frequency. In addition to this, antenna may also be used in multi frequency bands. Antenna is simulated using Ansoft Designer v2.**

***Index Terms*—Compact, Gain, multi frequency bands, Percentage Bandwidth, resonating frequency.**

I. Introduction

Micro strip antennas fulfill most of the wireless mobile communication requirements. They are light weight, low volume, simple to manufacture, cost effective, capable of dual and triple frequency operations. These antennas have increasingly wide range of applications in WLAN, WiMax, Mobile & Satellite Communication, RFID, GPS, and Radar. The size of antenna is extremely an important parameter for most wireless communication systems. But it is desired that the antenna of reduced size should have equivalent operation in comparison with the ordinary reference antenna and it should also be kept in mind that the bandwidth and gain have to be compatible with the designed antenna. Various shapes of slots and slits have been embedded on patch antennas to reduce their size. This technique is used to increase the surface current path because to decrease the resonant frequency of an antenna for a given surface area, the current path must be maximized within the area [1] .In this paper, it has been shown that the size of the antenna is reduced by 80% furthermore it operates at four frequency bands when the ground plane is loaded with various shapes of slots.

II. Antenna Design

From simulation based on Ansoft Designer v2 software it is found that the Width (Wp) and Length (Lp) of the Conventional Rectangular microstrip patch antenna operating at frequency 5.65GHz are 14mm and 11mm respectively with substrate thickness h=1.6mm and dielectric constant εr=4.4(FR-4 EPOXY).Figure1 shows the structure of the conventional microstrip antenna with an infinite ground plane with dimensions of length(Lg)=20mm and width(Wg)=20mm.

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Coaxial probe-feed is located as shown in Figure1.Figure 2 shows the configuration of antenna2 designed with properly

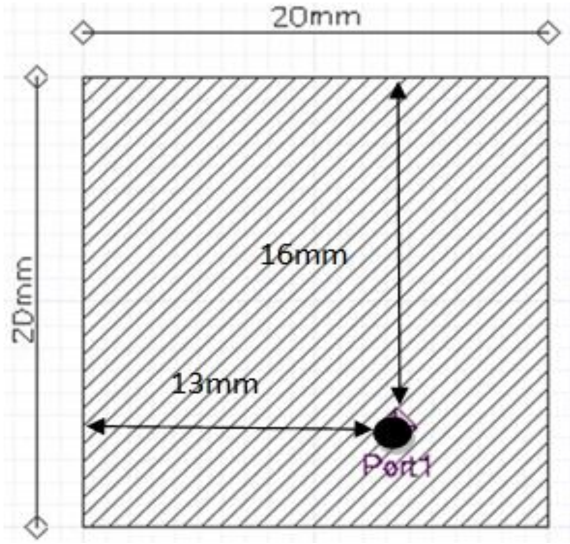


Fig. 1. Configuration of the ground plane (conventional antenna1)

positioned rectangular patch on the ground plane where the dimensions of patch is length(Lp)=11mm and width(Wp)=14mm.Figure3 shows the configuration of antenna 3 with clear view of finite slotted ground plane.

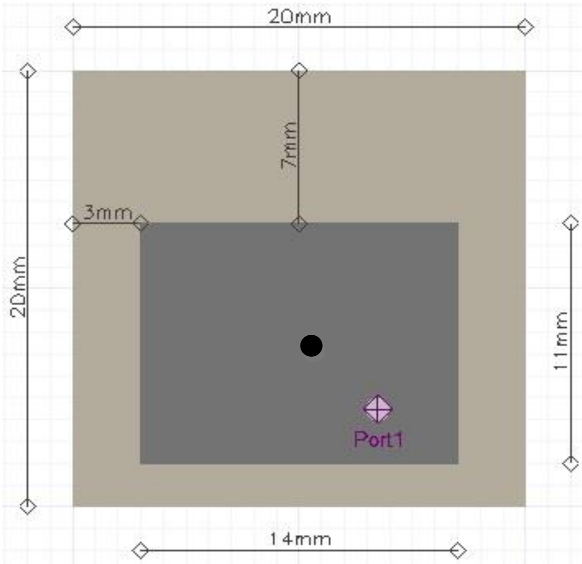


Fig. 2. Configuration of the ground plane with properly positioned rectangular patch (Conventional antenna 2)

For proposed antenna 3 size reduction is achieved when the slotted ground plane is realized by etching off a double Z shape (merged vertically) from the ground plane. Depending on the shapes and dimensions of the slots, the surface current distribution in the ground plane is disturbed, resulting in a controlled propagation of the electromagnetic waves through the substrate layer and surface current density becomes stronger around the slots which creates extra resonance path and varies the resonant frequency of the antenna [1][4]. For the proposed antenna structure, due to the slotted ground plane it produces a high effective dielectric constant, thereby decreasing the resonant frequency [2][5]. The optimum result for antenna structure3 is achieved. All the three antennas are designed on FR-4 EPOXY substrate. The ground plane size was optimized to achieve broad impedance bandwidth. The optimum result is achieved for ground plane of width Wg=20mm and Length Lg=20mm.To achieve wideband operation, all the parameters such as dimension of the ground plane, length and width of the slot, position of the slot on the ground plane, position of patch above the ground plane, position of the feed point were optimized by using ANSOFT V2, a software capable of simulating finite substrate and a finite ground structure [3][6]. The figure of the proposed antenna3 and the dimensions of the designed slotted ground plane are given below,

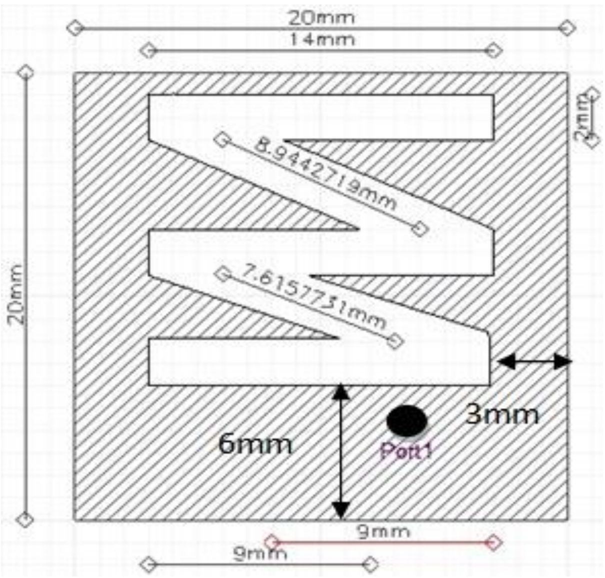


Fig. 3. Configuration of the slotted ground plane (Proposed antenna 3)

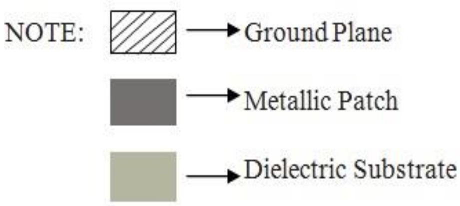
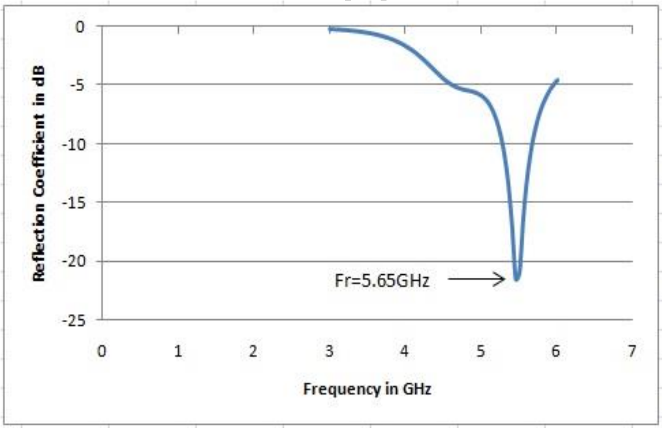


Fig. 6. Reflection Coefficient Vs Freq for Antenna 3

III. RESULTS

To take insight into the physical behavior of the proposed antenna, Reflection coefficient versus frequency & Gain versus frequency curves are studied for both conventional reference antenna and modified proposed antenna.



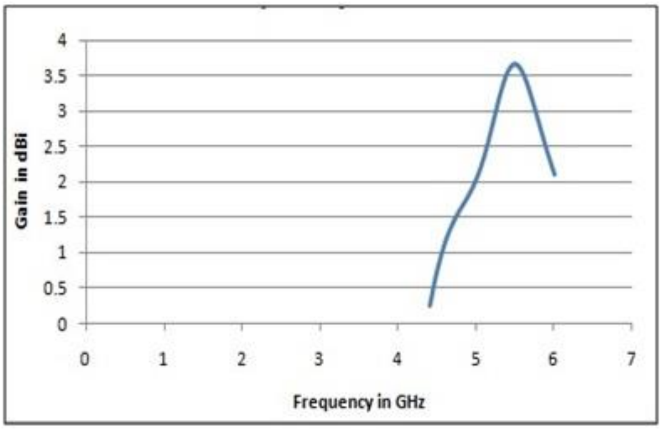
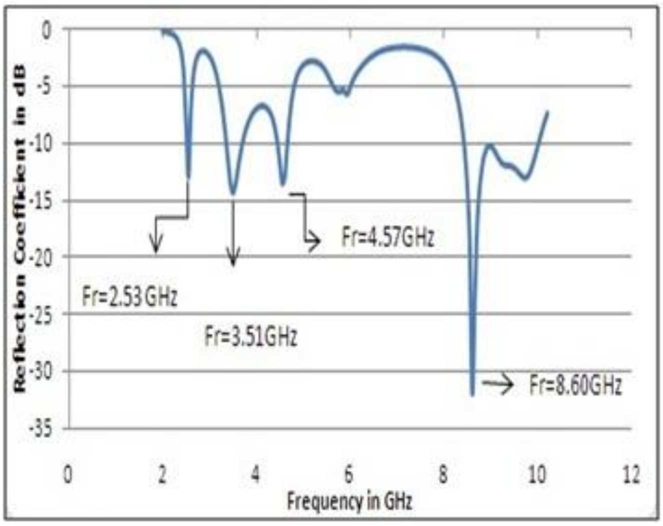


Fig. 5. Gain Vs Freq for Antenna 2

Fig. 4. Reflection Coefficient Vs Freq for Antenna 2



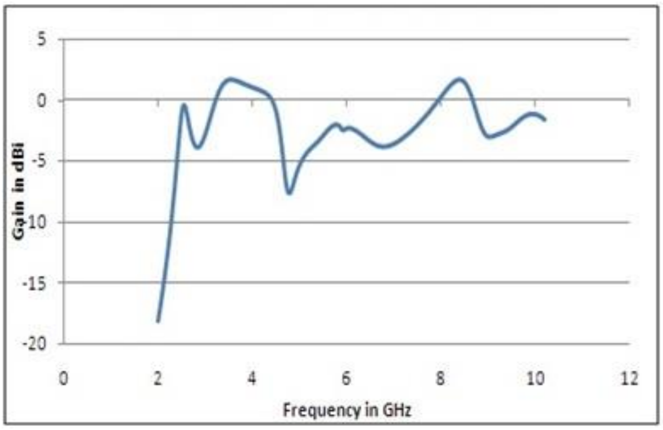


Fig. 7. Gain Vs Freq for Antenna 3

IV. DISCUSSION

The antennas are simulated using Ansoft Designer V.2 which is based on Method of Moment. The -10dB percentage bandwidth is calculated by:

$$\left\{\frac{\textbf{(Higher frequency-Lower frequency)}}{\textbf{Resonant frequency}}\right\} \textbf{*100\%}$$

Considering the length and breadth of reference antenna be L_1 and B_1 respectively, which is resonating at f_1 and if the designed antenna is resonating at f_2 where $f_2<f_1$, then without modification for an antenna to resonate at f_2, if the required length and breadth is L_2 and B_2 respectively , then percentage size reduction is calculated as :

$$\left\{\frac{(L_2*B_2)-(L_1*B_1)}{(L_2*B_2)}\right\}*100\%$$

From the above mentioned formulizes we have got %bandwidth and the Gain of the conventional reference antenna as 8.14% & 3.6 dBi respectively. The proposed antenna operates at four multiple frequency bands, whereas the reference antenna only at single band. The first band is of 2.7% bandwidth & gain -0.48dBi, the second band is of 10% bandwidth & gain 1.61dBi, the third band is of 5% bandwidth & gain -0.18dBi and the fourth band is of 18.7% bandwidth & gain 0.94 dBi. As it can be seen in this figure, the first resonance occurs at **2.53GHz**, in comparison with the antenna with the equal size but without defected ground structures that has a resonance frequency at 5.65 GHz. A rectangular patch with the resonance frequency at **5.65 GHz** must have a total area of about **2139.544mm^2**. The proposed antenna with the total area of **428.621mm^2** operates at this frequency. So the size reduction of this approach is about **80%** in comparison with the reference ordinary patch.

V. CONCLUSION

Here a double Z shaped slotted micro strip antenna is proposed. Using these slots, the surface current path is increased and thus the resonant frequency is decreased to a great deal. When compared with an antenna of the same resonance frequency, a reduction of about 80% is achieved in antenna size. Besides that this antenna is capable of operating at more than one frequency bands. This antenna can be used in applications where the overall volume of the structure is an important factor, and also there is a matter of passing and rejecting multiple bands simultaneously such as mobile terminals etc.

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