Compact, Multi-band Microstrip Antenna with High Gain

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Abstract In this paper, theoretical investigations of a printed microstrip antenna, using coaxial probe feed method is presented. The proposed antenna provides promising enhancement of gain. It also gives triple frequency bands. The high gain with triple band is obtained using E shaped patch and slitted rectangular ground plane. The simulation is carried out using a Method of Moment (MOM) based ANSOFT software. This novel designed antenna of high gain (more than 6dBi) and triple band is described in detail in this study. The proposed antenna is simple in structure compared to the regular stacked or coplanar parasitic patch antennas. It is highly suitable for wireless communications.

Keywords Microstrip antenna · Compact · Multi-frequency · High gain

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1 Introduction

A microstrip patch antenna [1] is one of the most commonly used printed antennas in practice. It enjoys its advantages of low profile, simple structure, low cost, and omnidirectional radiation patterns [1, 2]. Dual-frequency microstrip antennas with a single feed are required in various radar and communications systems, such as synthetic aperture radar (SAR), dual-band GSM/DCS 1800 mobile communications systems, and the Global Positioning System (GPS) [3]. Now a days the optimization of the design and efficiency of printed antennas are most important in communication systems [4–7].

In this study, a simple E shaped patch antenna on a slotted rectangular ground plane has been presented to exhibit multiband operation. This antenna is fed by co axial probe. The proposed design is on regular electrically thin microwave substrate Glass-PTFE.

2 Antenna Design

The configuration of the compact triple-band antenna is shown in Fig. 1. The antenna consists of an E shaped microstrip patch, supported on a slitted rectangular ground plane. The patch antenna is printed on a Glass-PTFE substrate with a

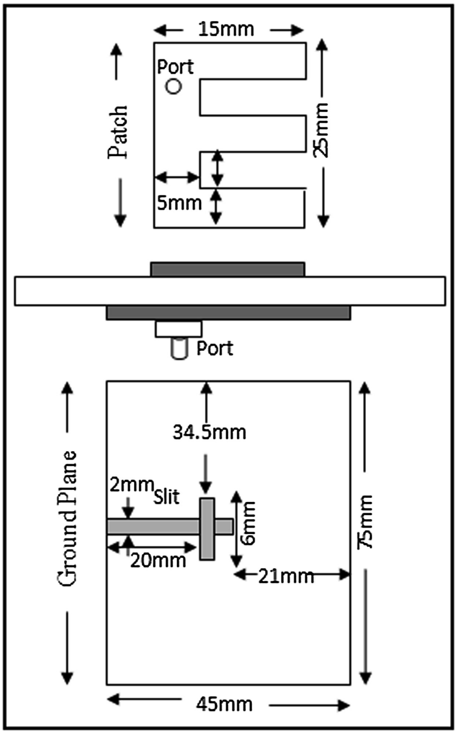

Fig. 1 Design of the antenna

relative permittivity of 2.5 and thickness of 1.6 mm and is fed by coaxial probe feed method.

The feeding point is so positioned to obtain better impedance matching. The dimension of the patch is 15 mm × 25 mm. Each arm of the E shaped patch has equal dimension i.e. 10 mm × 5 mm. A cross shaped slit is embedded on the rectangular ground plane of 45 mm × 75 mm dimension. The patch is embedded at centre position w.r.to the ground plane.

3 Results and Discussions

Simulated results have been obtained by ANSOFT based on MOM. The length and width of the microstrip patch antenna, operating at 5.8 GHz are 15 and 25 mm respectively with substrate thickness h = 1.6 mm and dielectric constant $\varepsilon_r = 2.5$ (PTFE). After loading the slit on the ground plane the width (W) and the length (L) of Antenna are calculated from conventional Eqs. 1 and 2 [1].

$$fr = \frac{C}{2W}\sqrt{\frac{2}{(1+\in_r)}} \tag{1}$$

$$L = Leff - 2\Delta L \tag{2}$$

where,

$$\frac{\Delta L}{h} = 0.412\frac{(\in_{reff}+0.3)(\frac{W}{h}+0.264)}{(\in_{reff}-0.258)(\frac{W}{h}+0.8)}$$

$$\in_{reff} = \frac{(\in_r+1)}{2}+\frac{(\in_r-1)}{2\sqrt{(1+12\frac{h}{W})}}$$

$$Leff = \frac{C}{2f_r\sqrt{\in_{reff}}}$$

where

Leff	Effective length of the patch
L	Length of the antenna
W	Width of the antenna
Fr	Resonant frequency of the antenna
C	Velocity of light
$\Delta L/h$	Normalized extension of the patch length
$\in_{reff}$	Effective dielectric constant

The slotted antenna resonates at 1.4 GHz frequency.

$$\text{Compactness} = (\text{Area of the slotted antenna} - \text{Area of the without slotted antenna}) \times 100\,\% \tag{3}$$

Using the Eq. 3 one gets 94 % size reduction of the designed antenna.

Figure 2 shows the comparative study of the Reflection Coefficient versus Frequency plot for antenna without slot and with slot. The reference antenna resonates at 5.8 GHz at reflection coefficient of –15.8 dB whereas the slitted antenna resonates at 1.4 GHz frequency. From this figure it is shown that the designed antenna resonates at three different resonant frequencies. The frequency ratio of

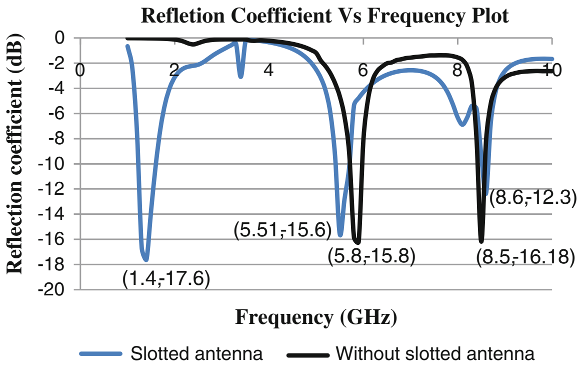

Fig. 2 Comparative study of the reflection coefficient versus frequency plot of reference and slotted antenna

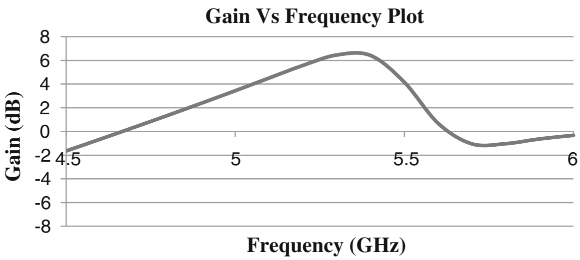

Fig. 3 Gain versus frequency plot of the slotted antenna

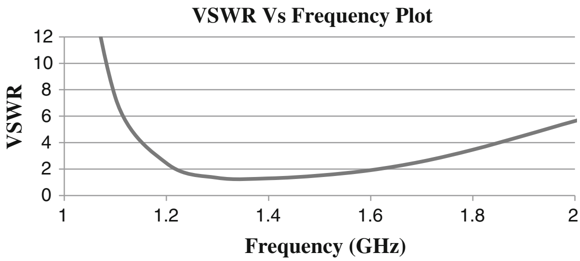

Fig. 4 VSWR versus frequency plot

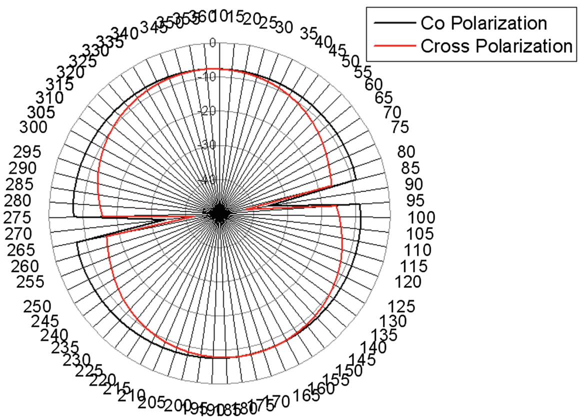

Fig. 5 Theoretical co and cross radiation pattern at 1.4 GHz frequency

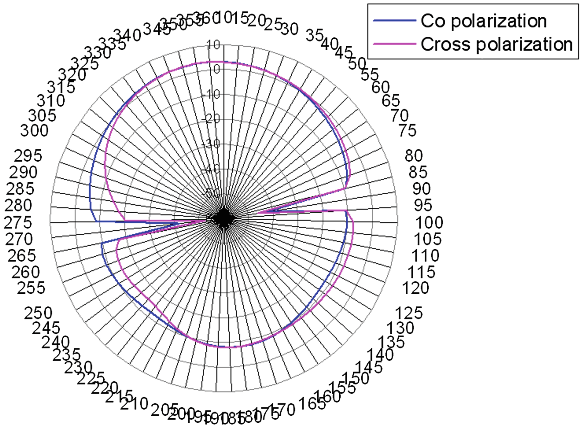

Fig. 6 Theoretical co and cross radiation pattern at 5.51 GHz frequency

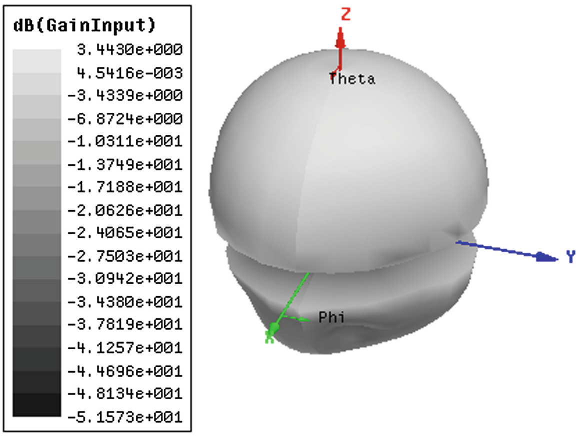

Fig. 7 Theoretical 3D radiation pattern at 5.5 GHz frequency

3.93 between the two operating frequencies has been obtained. The theoretical gain versus frequency plot is shown in Fig. 3. The gain of this antenna is high which is up to 6.7 dBi. Figure 4 shows the VSWR versus frequency plot. Figures 5 and 6 show the theoretical Co and Cross radiation patterns at 1 and 5 GHz resonant frequencies respectively of the designed antenna. Theoretical 3D radiation pattern at 5.51 GHz is shown in Fig. 7.

4 Conclusions

The proposed antenna design makes the reference antenna resonating at three different frequencies. The proposed design also results in size reduction of about 94 %. A gain of 6.7 dBi has also been achieved. The radiation pattern of the antenna is acceptable for use with practical communication designs. Here, the designed antenna may be used in compact wireless communication like compact handheld mobile phone, MRI Instrument etc.

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