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DESIGN AND MODELING OF INSET FEED MICROSTRIP PATCH ANTENNA FOR GSM 1.5GHZ IMT SERVICES

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Abstract

Ever growing global support as International Mobile Telecommunication) IMT service band two candidate bands are 1.35-1.4GHz and 1.42- 1.51GHz. The band 1.42-1.51GHz has been already used in Japan and Europe for commercial IMT services. The band provides considerable amount of bandwidth, better coverage in outdoor and building areas and cost efficient. For radiating at this frequency the antenna should be efficient, low cost and compact. Microstrip Patch Antenna (MPA) is having advantage of compact design, light weight, easy fabrication method and low profile over the conventional antennas. Due to their planar structure Microstrip Patch Antenna are widely used in wireless communication, satellite communication and in many areas where electromagnetic waves are used. Mobile communication requires compact, inexpensive and low profile antennas. Microstrip Patch Antenna satisfies all these requirements. This paper presents the design and analysis of inset feed Microstrip Patch Antenna. The design is simulated and analyzed for 1.5GHz band for GSM (900/1500) IMT Services. The electric field norm plot, radiation pattern are analyzed. Directivity is approx. 7dB and return loss (S_{11}) calculated is –20.5dB and front to back ratio is calculated as 15dB.

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I. Introduction

To become global International Mobile Telecommunication (IMT) service, there is widespread commitment by 1.42-1.51 GHz. IMT services in supported by almost all countries in ITU Region 1 and 2. The two bands for IMT services are 1.35-1.4 GHz and 1.42-1.51 GHz. The frequency band 1.42-1.51 GHz has already been used in Japan for commercial IMT service, while in other countries this frequency range is mostly used for radar, fixed links and aeronautical telemetry. The consideration of this band has several benefits which include considerable amount of bandwidth, cost efficient due to this can be expanded with current unused band [1]. With ever increasing need of higher data rates in mobile communication with smaller size of device, it is important to design an efficient and portable antenna for mobile communication. Antenna is interface of channel with communication system [2]. Microstrip Patch Antennas is used mostly due to its low profile conformal design, inexpansive design, easy fabrication and versatility in design in terms of realization [2]. It can provide good directional patterns according to applications. Figure 1 shows the structure of Microstrip Patch Antenna, the antenna is made up of conducting ground plane and dielectric above it and the conductive patch is placed over the substrate [3]. Generally the patch is of the material which is conducting in nature such as copper and can be of any metal and can take any shape [4-5]. The design of patch is fed with different feeding methods like Quarter-Wavelength Transmission line, Coaxial cable or probe feed, Coupled feed, Inset Feed and Aperture Feed [6-7]. The disadvantages of feeding methods are that there is undesirable impedance mismatch with conventional 50Ω line [8]. To minimize the mismatch quarter wavelength transformer can be employed between 50Ω line and microstrip feed but this approach also have disadvantages that it increases the size of antenna hence overall design size is increased [9]. The impedance is higher than 50Ω if it is fed from edges and if it is fed from centre the impedance is lower [10-12]. Thus the optimal feed point is between edge and center.

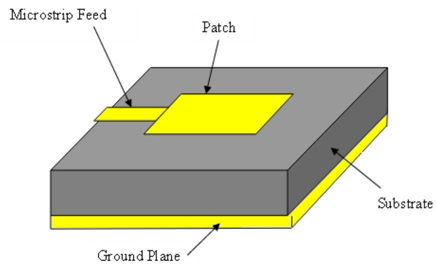

Figure 1. Structure of Microstrip Patch Antenna.

The current at the end of the patch is low and as we move towards the center, the current increases [13]. If the patch is fed near the center, there is reduction in the impedance [16-18].

II. Design Parameters

A. Design of Inset feed

Due to Sinusoidal Distribution in current as shown in figure 2, moving along distance R, from the ends, the value of current is increased by

$$= \cos \pi\left(\pi \times \frac{R}{L}\right). \tag{1}$$

If the wavelength is $2L$, the phase difference is given by

$$\left(\pi \times \frac{R}{L}\right). \tag{2}$$

As the current increases, there is decrease in the magnitude of voltage using $Z = V/I$. The input impedance is given as

$$Z_m(R) = \cos^2\left(\frac{\pi R}{L}\right) Z_m(0), \tag{3}$$

where $Z_{in}(0)$ is the impedance if fed from end.

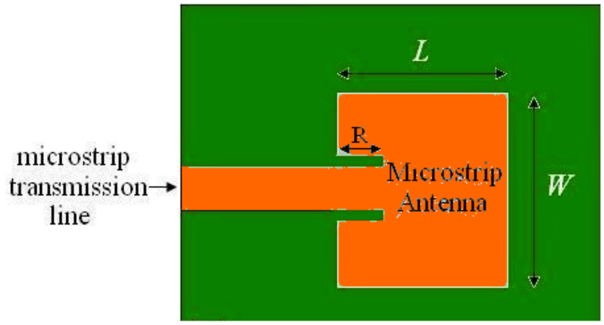

Figure 2. Inset fed microstrip antenna.

B. Design of Microstrip

The width of Patch Antenna can be calculated with [14]

$$W = \frac{v_0}{2fr}\sqrt{\frac{2}{\varepsilon_r + 1}}. \tag{4}$$

The length of Antenna can be calculated with [15]

$$L = \frac{v_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \tag{5}$$

and

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \tag{6}$$

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}. \tag{7}$$

III. Modeling and Analysis

The design is modeled using the equations in software environment for analysis. The Model design is shown in Figure 3.

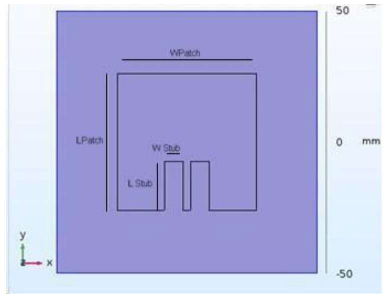

Figure 3. Dimensions of Patch Antenna with Inset feed.

The design structure of Microstrip Patch Antenna is shown in Figure 4.

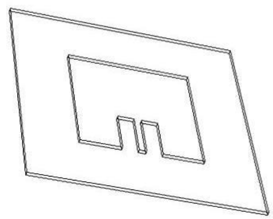

Figure 4. Structure of Microstrip Patch Antenna.

Electromagnetic frequency domain was used to model the design with 1.5 GHz frequency which was applied on the lumped port. The analysis of design was done. Table 1 shows the design values used for model.

Table 1. Description of model.

Description	**Value**
Substrate thickness	0.1524cm
50 ohm line width	0.32 cm
Patch width	5.3 cm
Patch length	5.2 cm
Tuning stub width	7 cm
Tuning stub length	1.9 cm
Substrate width	10 cm

Substrate length	10 cm

Tetrahedral meshing is done. There are five elements per wavelength in the meshing. In meshing 51546 tetrahedron values, 3310 prisms, 7226 triangles 400 quad, 670 edge elements and 44 vertex elements are used. Inside design of patch maximum element size of 20.900 is taken with curvature factor of 0.6. The meshed structure is shown in Figure 5.

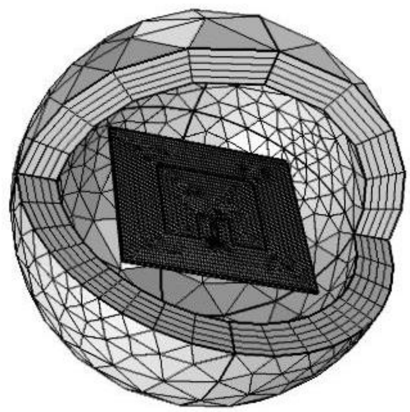

Figure 5. Meshing of design.

IV. Results and Discussion

The modelling and simulation of design is done on 4x2.60GHz processor speed. The simulation used physical memory of 2.3 GB. The frequency 1.5 GHz (GSM 1500) is fed to lumped port as discussed which is in center of patch. The figure 6 shows electric field distribution plot. The figure shows the current distribution over the patch.

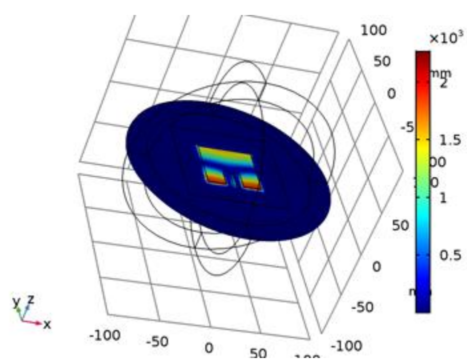

Figure 6. Electric field distribution plot for 1.5 GHz.

Figure 7 shows the 2D radiation pattern in *H* Plane and *E* plane. The radiation patterns shows directive beam due to ground plane which block radiation towards back side. The calculated antenna directivity is 6.9 dB and the front to back ratio in radiation pattern is more than 15 dB. The calculated S11 parameter is – 20.5 dB which is much better than desired – 10 dB. The 3D radiation pattern is shown in figure 8.

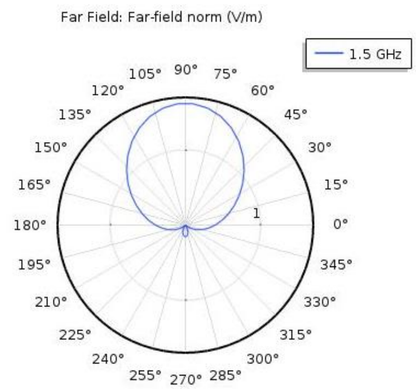

Figure 7. 2D Far Field radiation plot.

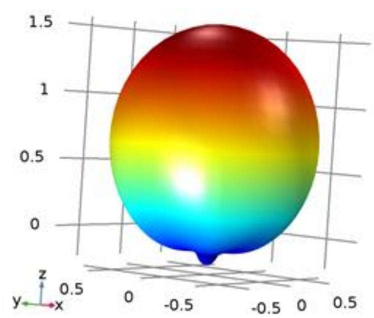

Figure 8. 3D Far Field radiation plot.

V. Conclusion

Microstrip Patch Antenna is widely used in mobile and wireless communication due to its small profile, less size, inexpansive and easy fabrication and better directional features. The simulation and modelling of the work is done for the investigation and analysis of the Inset feed Microstrip Patch Antenna. The parameters like electric field intensity, directivity, front to back ratio, Insertion loss S_{11} and radiation far filed plot were calculated for GSM 1550 (1.5 GHz) IMT Band. The Design showed good response for 1.5 GHz. The designed antenna has directivity 6.9 dB with front to back ratio of 15dB. The insertion loss is better which is calculated as – 20.5 dB than desired – 10dB.

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