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HELICAL SHAPED MULTIBAND MICROSTRIP ANTENNA FOR WIRELESS COMMUNICATION

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ABSTRACT

In this paper detailed investigations have been performed on the design of a multiband microstrip patch antenna of given specifications using IE3D, an electromagnetic simulation package by Zeland Software Inc. The antenna was fabricated using FR4 substrate and characterized by measuring return loss, radiation pattern (6 GHz) and gain. Here a new idea of square spiral patch has been used to minimize the return loss of the antenna. Multiband antenna systems forms a part of new research area, since nowadays the communication engineers are more interested in higher data rates and improved spectral efficiencies, leading to the 4G technologies. In Multiband microstrip antenna systems, patch antenna are capable of transmitting and receiving signal at multiple frequency band. In this paper, a brief review of square spiral patch design is discussed.

Keywords: Helical, IE3D, VSWR, Return loss (S11), Gain, Directivity, Dielectric Constant (ἐ), Duriod, FR4.

I. INTRODUCTION

The purpose of this work is to design a microstrip patch antenna using commercial simulation software like IE3D. The IE3D by Zeland Software Inc. has been considered as the benchmark for electromagnetic simulation packages. It is a full wave, method of moment (MOM) simulator solving the distribution on 3D and multilayered structures of general shape. The primary formulation of the IE3D is an integral equation obtained through the use of Green's functions. In the IE3D, it is possible to model both the electric current on a metallic structure and a magnetic current representing the field distribution on a metallic aperture [1]. The specifications for the design purpose of the structure are as follows

Dielectric Constant (ε_r): 4.4

Height of substrate (h): $0.003\ \lambda o \leq h \leq 0.05\ \lambda o$

Length of patch (L): $0.33\lambda o < L < 0.5\ \lambda o$

Resonance frequency (fo): 10.65 GHz

VSWR: 1 - 1.4

These specifications were chosen to design a lightweight and compact square spiral patch [2].

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II. THEORY

The rectangular microstrip antenna is a basic antenna element being a rectangular strip conductor on a thin dielectric substrate backed by a ground plane. Considering the patch as a perfect conductor, the electric field on the surface of the conductor is considered as zero. Though the patch is actually open circuited at the edges, due to the small thickness of the substrate compared to the wavelength at the operating frequency, the fringing fields will appear at the edges (Figure 1).

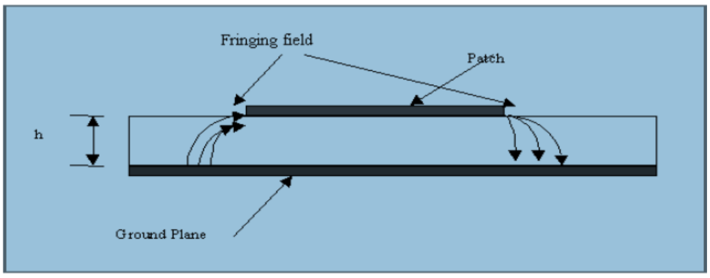

Fig. 1: Microstrip Patch Antenna.

III. DESIGNING

3.1 Design Calculation of Microstrip Patch Antenna

Designing of microstrip patch require some calculation to be done before like length, width, effective dielectric and length extension etc. Now the formulae and there corresponding calculation is given below:-

- Calculation of the width (W):-

$$W = \frac{C}{2fo\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

W = 8.6 mm.

- Calculation of effective dielectric constant (ε_{reff}):-

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

${}_{reff}$ =3.645.

- Calculation of effective length (L_{eff}):-

$$L_{eff} = \frac{C}{2f_{o\sqrt{\varepsilon_{reff}}}}$$

L_{eff} = 7.377mm.

- Calculation of length extension(ΔL):-

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

ΔL = 0.118mm.

This length extension is due to fringing effect [2] in between ground and patch. Therefore, this length extension must be subtracted from calculated effective length to know the actual length.

- Calculation of actual length (L):-

$$L = L_{eff} - 2\Delta L$$

L = 7.14mm.

Here micro strip line feed [2] is used as feed method. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planer structure [5].

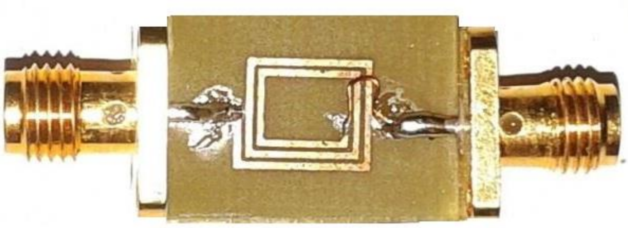

Fig. 2.1 Physical Realisation of the Proposed Square Spiral Antenna

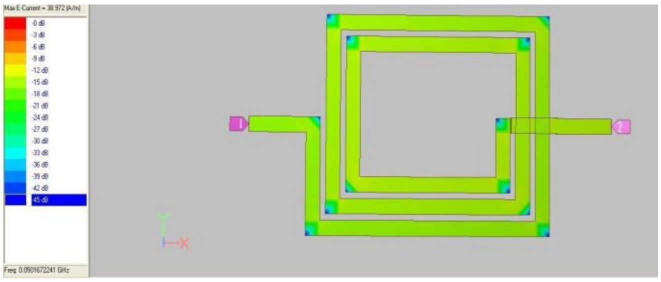

Fig. 2.2 Current Distribution Plot

3.2 Geometry of Proposed Square Spiral Patch Antenna

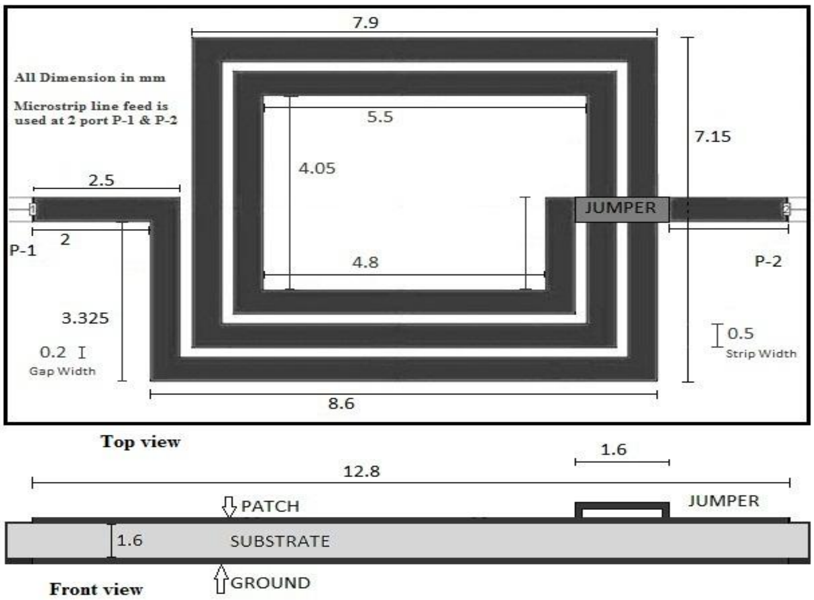

Fig. 2.3 Geometry of the Proposed Square Spiral Antenna

The geometrical structure of the antenna is shown in Fig 2.3 and its Physical realisation is given in fig2.1 The antenna consists of rectangular slot with width 'W' of 8.6mm and length 'L' of 7.15mm. The strip width 'W_{strip}' of 0.5mm and gap width 'W_{gap}' of 0.2mm. In this study, the dielectric substance (FR4) with thickness of 1.6 mm with relative permittivity of 4.4 is chosen as substrate to facilitate printed circuit board integration. The feed line width and 0.5 mm. Fig 2.2 gives current Distribution plot in patch antenna. Here we see that there is loss at every corner edge of patch. This is due to sharp bend in the design.

IV. SIMULATED RESULT AND ANALYSIS

The analysis and performance of the proposed antenna is explored by using IE3D for the better impedance matching.

4.1 Radiation Pattern

An antenna's radiation pattern is the characteristics that most affect system coverage and performance. The radiation pattern of antenna simply describes how an antenna focuses or directs the energy it radiates or receives. Antenna radiation pattern are typically presented in the form of a polar plot for a 360° angular pattern in one of two sweep planes and it is presented on a relative power dB scale as shown in Figure 3.

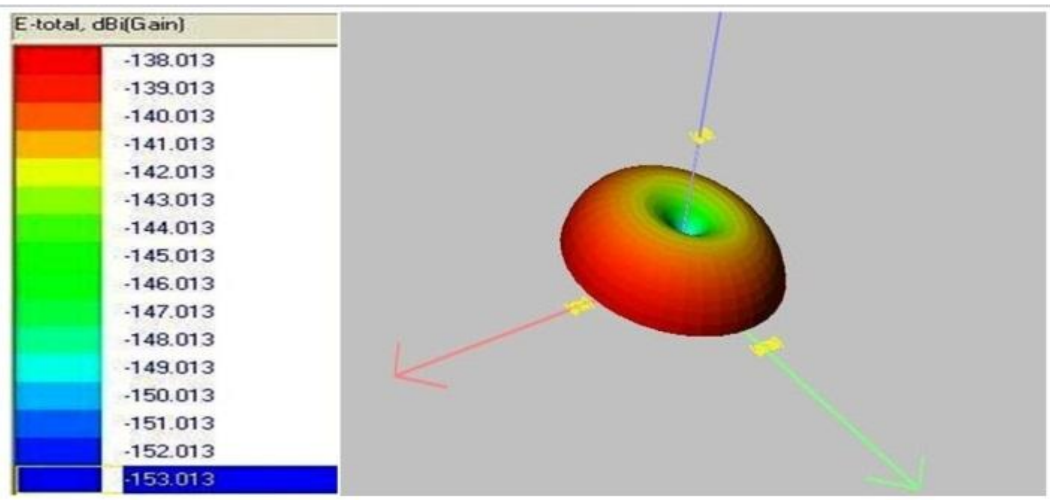

Fig.3 3D Radiation Pattern of Spiral Microstrip Antenna

4.2 Return Loss

Return loss is the loss of signal power resulting from the reflection caused at a discontinuity in a transmission line or optical fiber. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. It is usually expressed as a ratio in decibels (dB)

$$RL(dB) = 10log\frac{P_i}{P_r}$$

Where, RL (dB) is the return loss in dB

P_i is the incident power.

P_r is the reflected power.

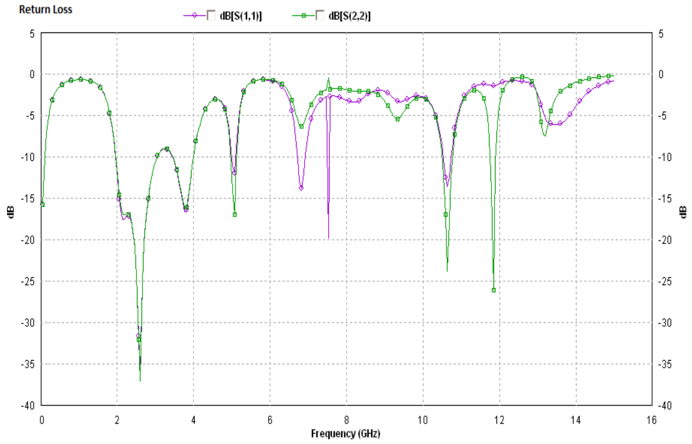

Fig. 4 Simulated Return Loss of Proposed Antenna.

4.3 VSWR

VSWR (Voltage Standing Wave Ratio) is the ratio between the maximum voltage and the minimum voltage along the transmission line. The VSWR is given by the equation shown below

$$VSWR = \frac{1 - \Gamma}{1 + \Gamma} \qquad \Gamma \text{ is reflection coefficient}$$

The VSWR indicate that how closely or efficiently an antenna’s terminal input impedance is matched to the characteristic impedance of the transmission line. The larger the number of VSWR, the greater the mismatch between the antenna and the transmission line.

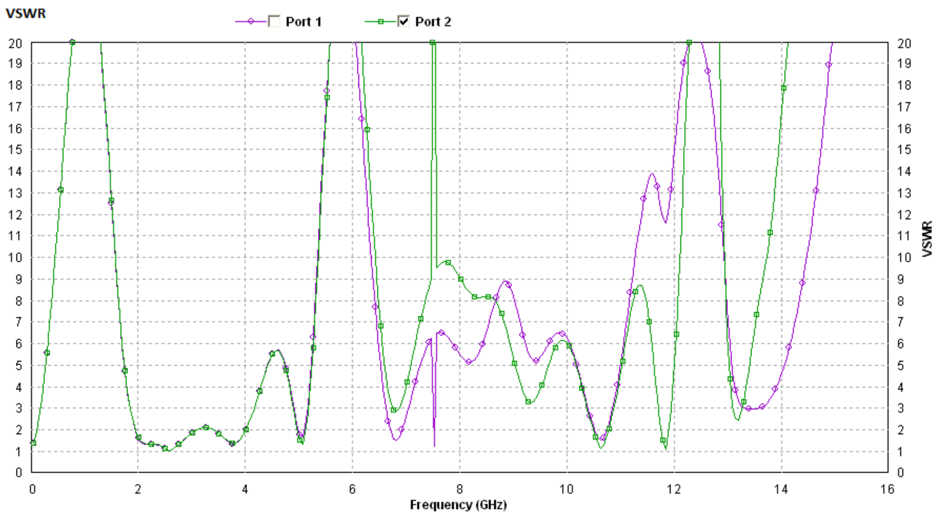

Fig. 5 Simulated VSWR of Proposed Antenna.

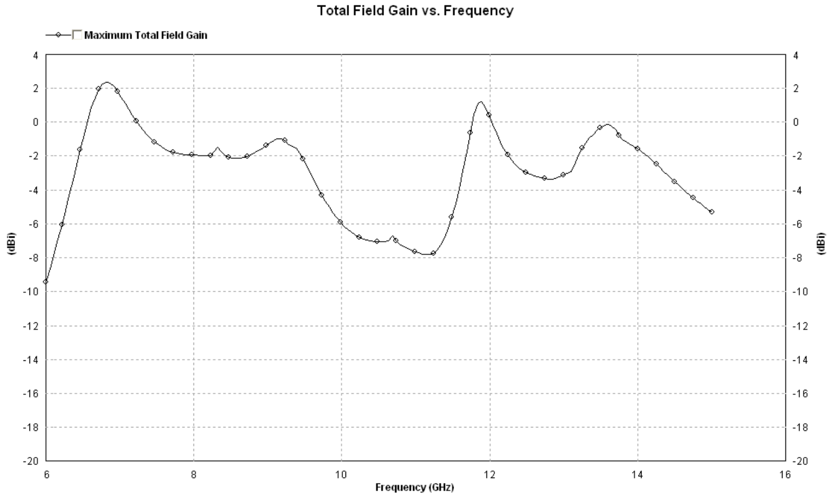

Fig. 6 Simulated Gain Vs Frequency of Proposed Antenna

Here we notice that VSWR at obtained frequency band is in the tolerance limit. At 2.6 GHz VSWR measured is almost ideal i.e.1.032.

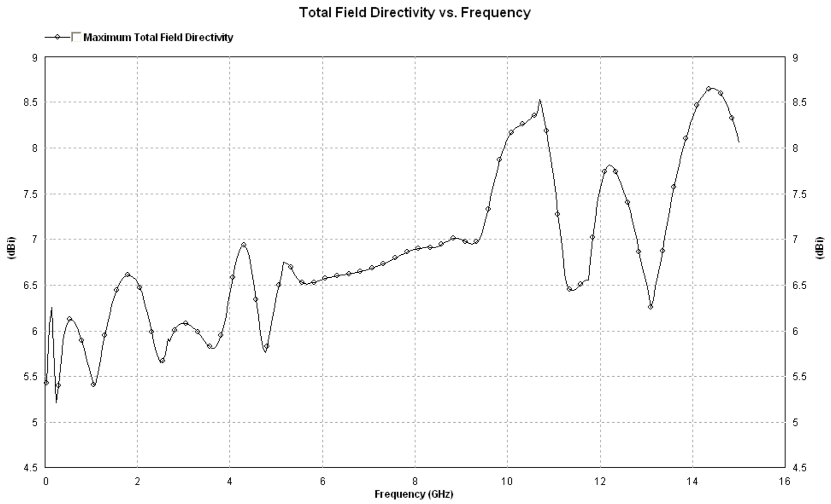

Fig. 7 Simulated Directivity Vs Frequency of Proposed Antenna

Resonance frequency *(GHz)*	**Return loss (*dB*)**	**VSWR**	**Directivity (*dBi*)**
2.60	-36.85	1.032	5.73
5.06	-16.90	1.33	6.47
7.52	-19.61	1.2	6.7
10.63	-23.7	1.19	8.3
11.83	-26.01	1.11	7.08

Table-1 Tabular Representation of Simulated Result

The simulated return loss of the proposed antenna is shown in Fig. 3, which clearly indicates that six bands of frequency are obtained in between frequency range 1 GHz – 12 GHz for VSWR less than 2. The multiple wideband is due to multiple resonances introduced by the rectangular spiral structure of the patch antenna [2]. The resonant frequency and bandwidth are controlled by the size of the strip, gap between strips, antenna Proper geometrical selection of the antenna parameters result in variation of field distribution, which in turn affects the characteristics of the proposed antenna.

V. CONCLUSION

This paper introduces a compact micro strip antenna for wireless applications. The proposed geometry for this microstrip is rectangular spiral structure. This antenna is flexible and can operate at various frequency bands with high radiation efficiency. Variation in strip width and inter-strip gap width improves the radiation properties in terms of return loss, impedance and gain. The antenna is quite small in size in single layer structure. This patch antenna operates efficiently at various frequency bands like 2.6 GHz, 3.7 GHz, 5 GHz, 6.81 GHz, 7.5 GHz, 10.5 GHz, and 11.8 GHz with VSWR in between 1-1.4. Thus, this antenna can find application in various wireless fields like WiMAX, IMT and WLAN etc. Therefore, the proposed antenna is very promising for various modern communication applications.

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