DESIGN OF LINEARLY POLARIZED RECTANGULAR MICROSTRIP PATCH ANTENNA

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Abstract - *In this project, a novel particle swarm optimization method based on IE3D is used to design Inset Feed Linearly Polarized Rectangular Microstrip Patch Antenna. The aim of the thesis is to Design and fabricate an inset fed rectangular Microstrip Antenna and study the effect of antenna dimensions Length (L) , Width (W) and substrate parameters relative Dielectric constant (εr) , substrate thickness on Radiation parameters of Band width. Low dielectric constant substrates are generally preferred for maximum radiation. The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Other configurations are complex to analyze and require heavy numerical computations. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna. In view of design, selection of the patch width and length are the major parameters along with the feed line depth. Desired Patch antenna design is initially simulated by using IE3D simulator. And Patch antenna is realized as predesign requirements.*

Key Words: *Helical, IE3D, VSWR, Return loss (S11), Gain, Directivity, Dielectric Constant (έ), FR4.*

1.INTRODUCTION

The purpose of this work is to design a microstrip patch antenna using commercial simulation software like IE3D. The three essential parameters for the design of a rectangular Microstrip Patch Antenna:

1.1 Frequency of operation (f_o): The resonant frequency of the antenna must be selected appropriately. The W I M A X Communication Systems uses the frequency range from 5250-5850 MHz. Hence the antenna designed must be able to operate in this frequency range. The resonant frequency selected for my design is 5.4 GHz.

1.2 Dielectric constant of the substrate (ε_r): The dielectric material selected for our design is FR-4 which is Teflon based, Microstrip board, which has a dielectric constant of 4.4. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.

1.3 Height of dielectric substrate (h): The height of the dielectric substrate is selected as 3 mm. Hence, the essential parameters for the design are:

f_o= 5.4 GHz ε_r = 4.4 h = 3 mm

2. 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)

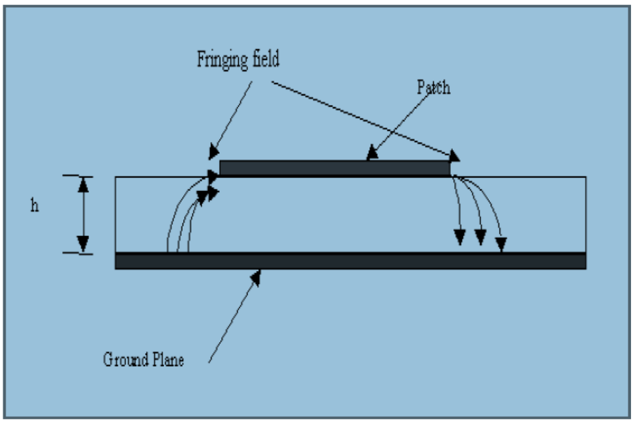

Fig. 1-Microstrip Patch antenna.

3. 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 = .0169 m=16.9 mm

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

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

ε_{reff} =3.66097

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

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

L_{eff}= 14.51776mm.

- 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 = 1.31884mm.

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 = 11.87232 mm.

Here microstrip 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].

3.2 Geometry of proposed microstrip patch antenna.

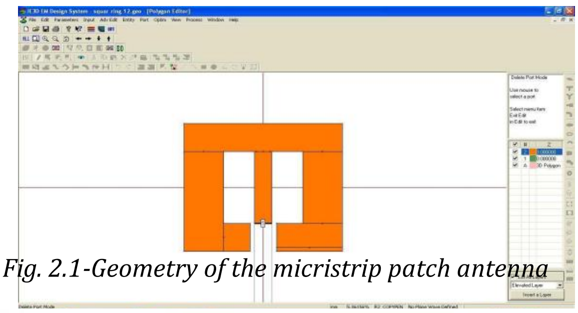

Fig. 2.1-Geometry of the micristrip patch antenna

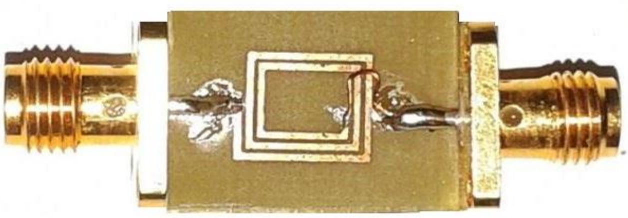

Fig. 2.2-Physical Realisation of the proposed square spiral antenna.

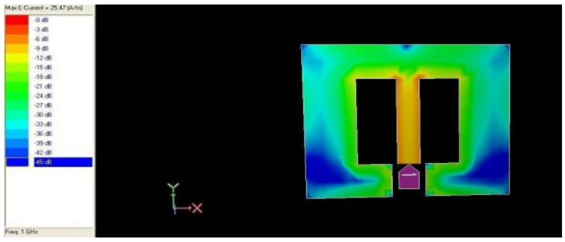

Fig. 2.3- Current Distribution Plot.

The 3D current distribution plot gives the relationship between the co-polarization (desired) and cross-polarization (undesired) components. Moreover it gives a clear picture as to the nature of polarization of the fields propagating through the patch antenna. Figure 4.7 clearly shows that the patch antenna is ***linearly polarized***.

4. 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 Since a Microstrip patch antenna radiates normal to its patch surface, the elevation pattern for φ = 0 and φ = 90 degrees would be important. Figure 4.5 below shows the gain of the antenna at 5.4 GHz for φ = 0 and φ = 90degrees.

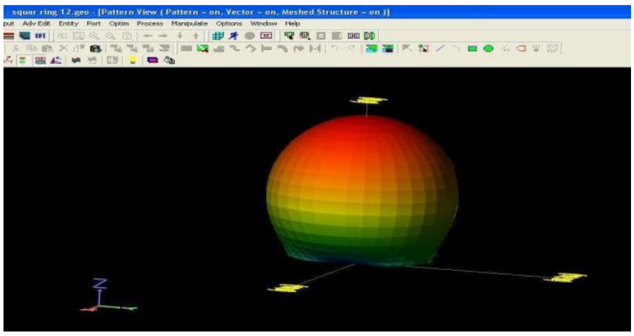

Figure 3.1:*3d Radiation Pattern forφ = 0andφ= 90 degrees*

4.2 Return loss

A frequency range of 4-7 GHz is selected and 50 frequency points are selected over this range to obtain accurate results.

The center frequency is selected as the one at which the return loss is minimum. As described in chapter 2, the bandwidth can be calculated from the return loss (RL) plot. The bandwidth of the antenna can be said to be those range of frequencies over which the RL is greater than -8.04dB (-8.04 dB corresponds to a VSWR of 2 which is an acceptable figure) 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.

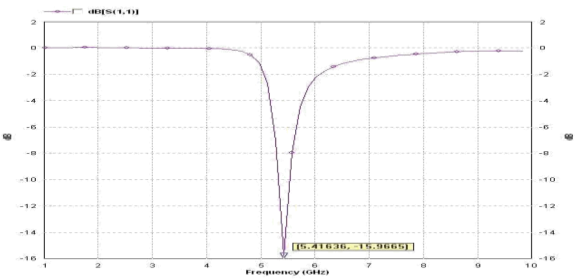

Fig. 3.2-Simulated return loss of proposed antenna.

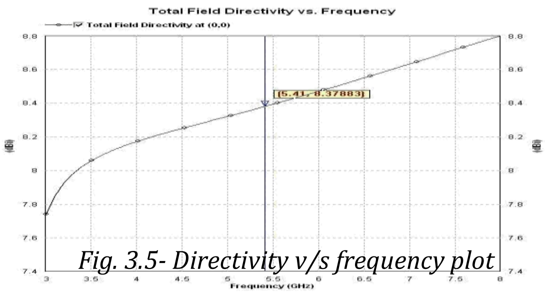

Fig. 3.5- Directivity v/s frequency plot

The optimization of the Microstrip Patch is partially realized which concludes that the PSO code was functioning correctly. The aim of the project is fulfilled and we have successfully designed a multiband microstrip antenna with mo more than 6 frequency band. The result is both physically tested and simulated on Zealand. The result is mentioned in tabular form.

Table-1 *Tested Result Table*

Resonance Frequency (GHz)	Return Loss (Tested) (dB)
4.0	-1.5
4.6	-1.7
5.2	-3.3
5.67	-8.04
6.0	-4.6
6.5	-3.7
7.0	-4.3

5. CONCLUSIONS

This paper introduces a compact microstrip 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 4 GHz, 4.6 GHz, 5.2 GHz, 5.67 GHz, 6 GHz, 6.5 GHz, and 7 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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BIOGRAPHIES

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