Multi Band Multi Polarized Microstrip Patch Antenna

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***Abstract*—Microstrip antennas have many advantages in communication system. It is required in high performance wireless applications. But microstrip antennas do have some considerable drawbacks like narrowband performance due to its resonant nature. The paper covers three aspects of Microstrip antenna designs. The first is the design and analysis of single feed Dual band and Dual polarized rectangular Microstrip antenna which operates at the central frequency of 2.9 GHz & 3.8 GHz. Radiation at frequency 2.9 GHz is Linear polarized & at frequency 3.8 GHz is circular polarized and the second aspect is the Bandwidth enhancement with Multi-frequency & Multi-polarization rectangular Microstrip antenna which operates at three sub-bands at frequency 5.75 GHz , 13.5 GHz & 19.4 GHz. Radiation at frequency 5.57 GHz Provides Linear polarization and at frequency 13.5 GHz & 19.4 GHz circular polarization Both antennas have been modeled, designed and simulated. Basically, transmission line and cavity model have been used to model both antennas.First, the design parameters for dual band and dual polarized of rectangular patch antenna have been calculated from the transmission line model equation. The antenna design is extended to enhancement of bandwidth of multi-frequency and multi-polarization rectangular Microstrip patch antenna using the slots at radiating edges. Proposed antenna has been simulated using IE3D^{TM} electromagnetic software which is based on method of movement (MOM).For rectangular Microstrip antenna design FR4 Substrate which is based, Microstrip board with dielectric constant 4.4 and the substrate height is 1.58 mm, scaling factor 0.95 and loss tangent is 0.025.**

The project provides a detailed study of how to design and fabricate a probe-fed Square Microstrip Patch Antenna using IE3D software and study the effect of antenna dimensions Length (L), and substrate parameters relative Dielectric constant (ε), substrate thickness (t) on the Radiation parameters of Bandwidth and Beam-width.

Index Terms—IE3D^{TM}, Microstrip antenna,Dielecric constant, Multiband

III. INTRODUCTION

Microstrip antennas are one of the most widely used types of antennas in the microwave frequency range, and they are often used in the millimeter-wave frequency range as well. (Below approximately 1 GHz, the size of a microstrip antenna is usually too large to be practical, and other types of antennas such as wire antennas dominate). Microstrip patch antenna consists of a patch of metal that is placed on the top of a grounded dielectric substrate of thickness *h*, with relative

permittivity and permeability (ε andμ),(usually μ =1). The metallic patch may be of various shapes, with rectangular and circular being the most common. Most of the discussion in this section will be limited to the rectangular patch, although the basic principles are the same for the circular patch. Many of the CAD formulas presented will apply approximately for the circular patch if the circular patch is modeled as a square patch of the same area.

IV. MULTI-FREQUENCY MICROSTRIP PATCHANTENNAS

In principle, multi-band planar antennas should operate with similar features, both in terms of radiation and impedance matching, at two or more separate frequencies. As is known, a simple rectangular microstrip patch can be regarded as a cavity with magnetic walls on the radiating edges. The first three modes with the same polarization can be indicated by TM_{10}, $TM_{20}$and TM30. TM_{10} is the mode typically used in practical applications; TM_{20} and TM_{30} are associated with a frequency approximately twice and triple of that of the TM_{10} mode. This provides the possibility to operate at multiple frequencies. In practice, the TM_{20} and the TM_{30} modes cannot be used owing to the facts that the TM_{20} pattern has a broadside null and the TM_{30} pattern has grating lobes.

So the simplest way to operate at dual frequencies is to use the first resonance of the two orthogonal dimensions of the rectangular patch, i.e., the TM_{10} and the TM_{01} modes. The features of these antennas are their capability of simultaneous matching of the input impedance at the two frequencies with a single feed structure, and that the two different frequencies excite two orthogonal polarizations can be realized. Orthogonal modes may also be excited by two separated feeding points.

The most popular technique for obtaining a dual-frequency behavior is to introduce a reactive loading to a single patch, including stubs, notches, pins, capacitors, and slots. In, by

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these reactive-loading approaches, one can modify the resonant mode of the patch, so that the radiation pattern of the higher order mode could be similar to that of the fundamental mode.

According to the design concept in, we propose a similar but different slot- loading approach to a square patch antenna fed by CPW in next few sections, dual- frequency operation with an extended frequency-ratio range can be obtained. And furthermore, by using the similar slot-loaded approach, a triple-frequency operation with a single feed can be realized.

V. DESIGN OF SINGLE FEED DUAL POLARIZED AND DUAL FREQUENCYRECTANGULAR PATCH ANTENNA

The three essential parameters for the design of a rectangular Microstrip Patch Antennas are:

- Frequency of operation (*fo*): The resonant frequency of the antenna must be selected appropriately. The Mobile Communication Systems uses the frequency range from 1800-5600 MHz. Hence the antenna designed must be able to operate in this frequency range. The operating frequency selected for my design is 3.0 GHz .
- Dielectric constant of the substrate (ε_r): The dielectric material selected for my design is FR4 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.

Table 4.1 Design parameter of proposed Microstrip antenna

Shape	**Dual band and dual polarized antenna**
Dielectric constant	4.4
Frequency of operation	3 GHz
Height of the dielectric substrate	1.588mm
Feeding method	Probe
VSWR	1.5:1
Polarization	Dual Polarization (Linear and circular)
Gain	5 dBi- 6.5dBi

- Height of dielectric substrate (*h*): For the microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.59 mm.

The essential parameter specifications for the design of the rectangular microstrip patch antenna are as in Table 4.1

To design the rectangular MSA that operates at frequency around 3 GHz, the optimal **width** canbe found using

$$w = \frac{c}{2f_0\sqrt{\frac{\epsilon_r+1}{2}}} = \frac{1}{2f_0\sqrt{\mu_0\epsilon_0}}\sqrt{\frac{2}{\epsilon_r+1}}$$

To find the effective dielectric constant (ε_{eff}) and when w/h>1, we can use

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2} = \left[\sqrt{1+\frac{12h}{w}}\right]$$

For ε_r=4.4, h = 1.588 *mm* and W = 30.4*mm*, and since w/h = 19.14 *mm* which is greater than 1, we get:

$$\varepsilon_{reff}=4.013$$

It is right to have like this value for ε_{eff}, because $1 \leq \varepsilon_{eff} \leq \varepsilon_r$ is valid all the time. The effective length we can be found using

$$L_{eff} = c/2f_0\sqrt{\epsilon_{reff}}$$

To find the length extension, we use

$$\Delta L = .412h\frac{(\epsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\epsilon_{reff}-0.248)(\frac{w}{h}+0.8)}$$

The actual length of the patch can be found using

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

The dimensions of the ground plane can be given by:

$$L_{ground} = 6h + L$$
$$W_{ground} = 6h + W$$

From above calculation we have seen that, with the increase in h, the fringing fields from the edge increase, which increases

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the extension in length ΔL and hence the effective length, thereby decreasing resonating frequency on the otherhand with the increase in h, the w/h ratio reduces which decrease ε_l and hence increase the resonant frequency. However, the effect of the increase in ΔL is dominant over the decrease in ε_l. Therefore the net effect is to decrease the resonant frequency. So w/h ratio should be greater than 1

VI. Bandwidth Enhancement Multiband and Multi-polarized Rectangular Microstrip Patch Antenna

We have seen that dual band and dual polarization with less bandwidth. In This paper introduces a novel E-shape microstrip patch antenna for Bandwidth enhancement with multi-band and multi-polarization facility using single layer structure. This E-shape antenna operates at three sub-bands, namely 5.75, 13.5 and 19.4 GHz with 20%, 70%, and 10% bandwidths respectively. By using only single patch a high impedance bandwidth is achieved. The proposed antenna has simple structure consisting E -shape on a rectangular patch dimension of the antenna come around 35mmX30mmX1.25mm and fed by 50 probe feed. The impedance matching and radiation characteristics of the designed structure are investigated by using MOM based IE3D™. It has two ports excited with microstrip line feed mechanism. The simulation results show that the antenna offers excellent performance for UWB application ranging (5.35GHz to 6.52GHz) and (8.42GHz to 17.4) and (18.5GHz to 20.65GHz) simultaneously**.**

VII. Geometry of Proposed Antenna

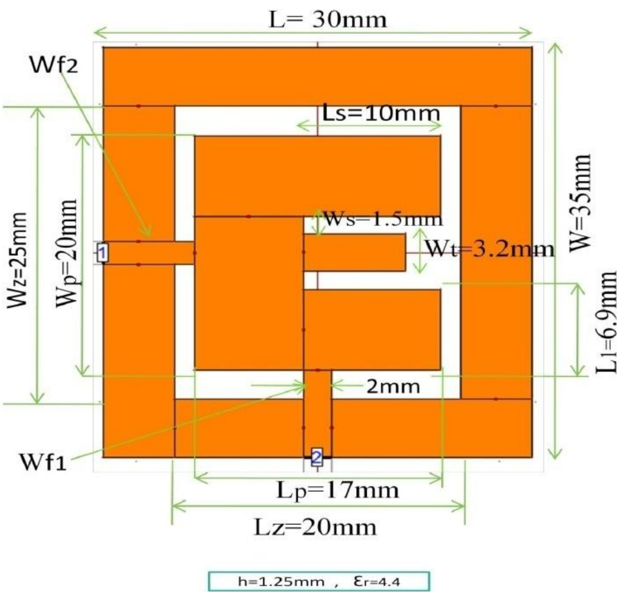

Figure 1.Geometry of the proposed dual feed Microstrip patch antenna

The geometry of the proposed antenna is shown in fig.1The rectangular patch of dimensions L x W separated from the ground plane with a foam substrate of εr, thickness h, inside the rectangular E-shape placed at the center. The initial rectangular patch is groundless with parameters width Wp and length Lp. It is fed by two Microstrip lines at the center of each side with widths Wf1 and Wf2.

In this case both lines are chosen to be 50Ωwith the shown ground underneath. The partial ground has width (W) and length (L) with hollow rectangle inside (Wz and Lz). Two parallel slots are incorporated inside the rectangular patch antenna to perturb the surface current path, introducing local inductive effects that are responsible for multi-mode excitation. The two slots and the center arm dimensions of the E-shaped patch control the higher resonant frequencies. On the other hand, the two perpendicular excitation ports are controlling the polarization whether it is linear or circular.Designed with multi polarized and multi frequency with a dual line feed rectangular microstrip E-shape patch antenna.

Two parallel slots are incorporated to perturb the surface current path, introducing local inductive effect that is responsible for the excitation of the second resonant mode with rectangular slots. Dual frequency operations can be realized by exciting the Microstrip patch antenna using a single feed [5] or dual feed [6]. Dual Feed has the advantage of facilitating the use of multi polarization therefore it attracts many researchers [7- 10]. But most of these introduced antennas are based on multilayer structures. Therefore, this paper, introduces a novel E-shape Microstrip patch antenna for multi-band wireless applications and multi-polarization facility using the advantage of a single layer structure.

Proposed E-shaped Microstrip patch antenna provide wide band with compact size that provides a bandwidth(VSWR < 2) is approximately equal to 70%.This bandwidth covers the high speed WLAN frequency bands (5.35 – 6.52 GHz and 8.42 –17.4 GHz and 18.5–20.65) and the proposed antenna is very promising for various modern communication applications.

VIII. Stimulated Results And Analysis

In order to evaluate the performance of the proposed antenna, the antenna is simulated through the simulation tool IE3D™. The analysis of the antenna for different physical parameter values has been done by varying one of them and keeping others as constant. It is carried out here to expose the flexibility in designing this antenna.

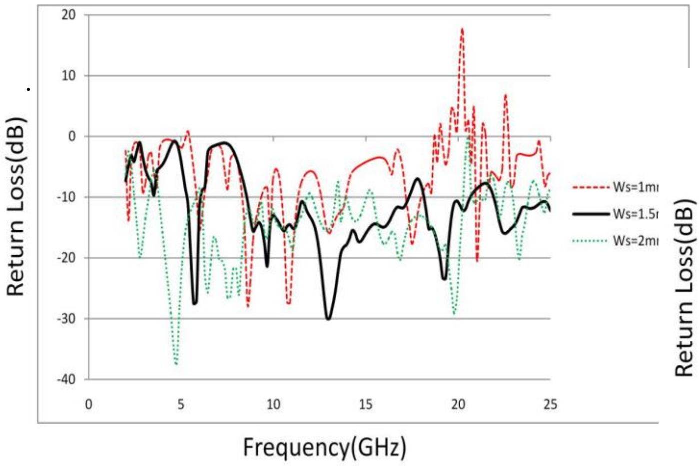

Fig: 2Simulated return loss(S11) curves for different Ws values

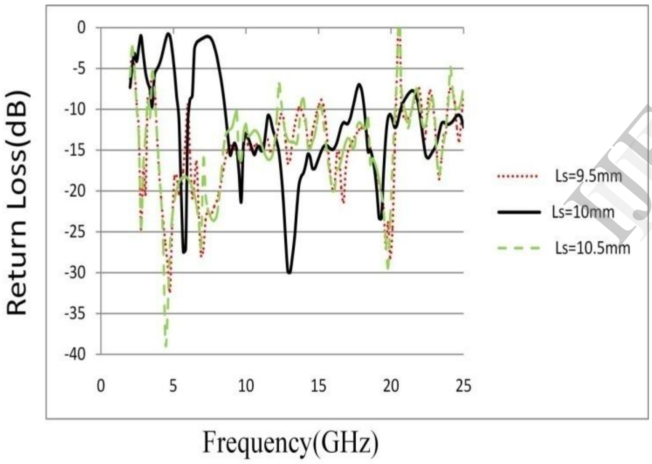

Fig.3simulated return loss curves for different Ls values

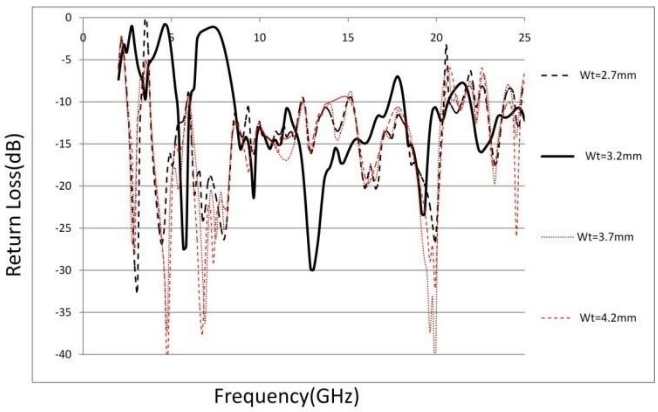

Fig.4simulated return loss curves for different Wt values

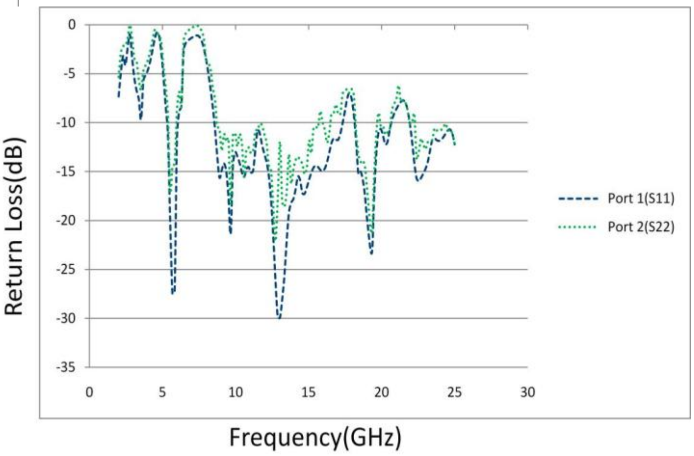

Fig.5Simulated Return Loss for both port1(S11) &Port 2(S22)

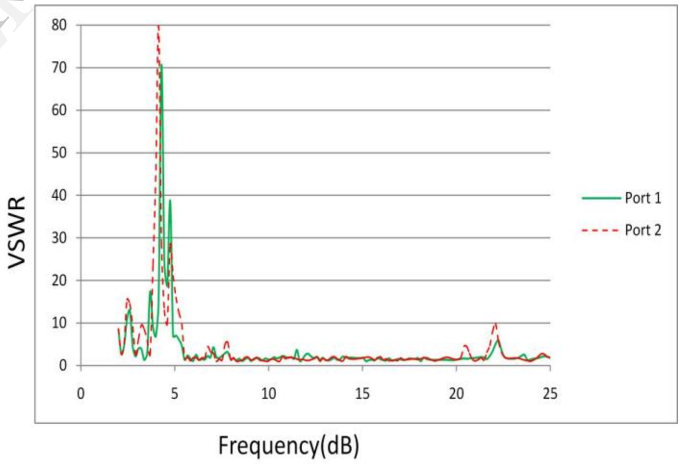

Fig.6. Simulated VSWR for Port1 & Port2

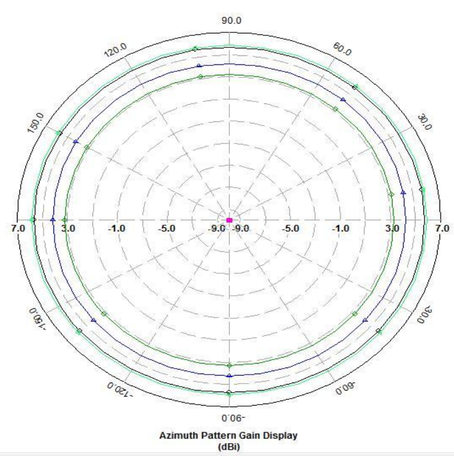

Fig.7The simulated radiation patterns at different frequencies of H(x-y) Plane

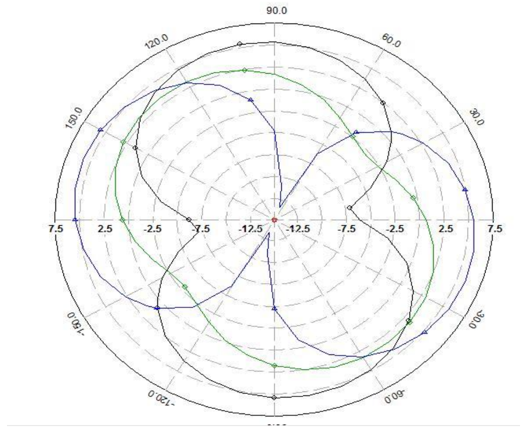

Fig.8. The simulated radiation patterns at different frequencies of .E(x-z) Plane

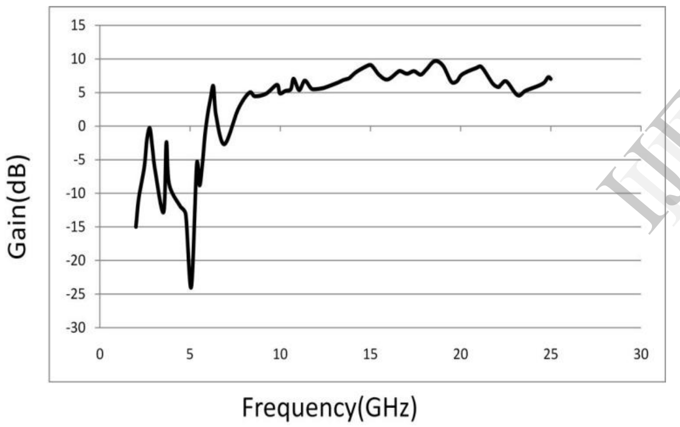

Fig.9Simulatedgain (dBi) of E-shaped microstrip patch antenna

IX. Conclusion

Two aspects of Microstrip antennas have been studied in this thesis. The first aspect is the design of dual band and dual polarization rectangular Microstrip antenna and second is the bandwidth enhancement of multi-frequency and multi-polarized rectangular microstrip antenna. A simple and efficient technique of probe feeding and line feeding method has been introduced for an impedance matching improvement of the antennas. Main concern of the thesis is to study of Dual band and dual polarization patch antenna using different techniques and frequency ratio of the Microstrip antenna. The dual band and dual polarized Microstrip antenna is a more conventional approach for the implementation of a broadband antenna and for satellite communication where the low frequency ratio is used. Dual polarization antenna are used in weather radar.

In general weather radar transmit and receive microwave at one polarization usually horizontal polarization but additional information that can be obtained from nature of the target, it requires more than one polarization. First, proposed dual band & dual polarized rectangular Microstrip antenna is designed to operate at frequency 2.9 GHz is Linearly polarized and at frequency 3.8 GHz is circularly polarized. Second, proposed Multi-frequency and multi-polarized microstrip antenna is operates at three sub-bands viz. 5.75 GHz, 13.5 GHz and 19.4 GHz. At frequency 5.75 GHz is Linear polarized and at frequency 13.5 GHz & 19.4 GHz is circular polarized. The physical parameters of the novel structure as well as its partial ground plane are analyzed. Return loss at both ports (S11, S22) are carried out to fulfill the requirements of the targeted communication system.

The parametric study provides a good insight on the effects of various dimensional parameters. In Dual band & Dual polarized antenna the simulated results agree with experimental results. By locating the feed point at the base rather than the tip of the center arm, the resonant frequency of the second resonant mode can be tuned without affecting the resonant.

X. Future Work

- Radiation pattern and gain measured of prototype Dual band & Dual polarized antenna will be carried out in future.
- Fabrication of Multi-band & Multi-polarized antenna will also be carried out in future.
- PSO technique will be applied to the proposed antenna in future.

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