



Effect on Total Field Gain and VSWR Due To Variation of Dielectric Constant of Rectangular Microstrip Patch Antenna Using IE3D Software

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ABSTRACT: This paper describes effect on total field gain and VSWR due to variation of dielectric constant of microstrip patch antenna. In this paper rectangular patch with probe to feed technique is used. In this paper we design and simulate a rectangular microstrip patch antenna operating at a frequency of 11 GHz. The rising importance of wireless communication and multimedia services increasing the efforts to the design and implementation of microstrip patch structures. A patch antenna is advantageous because of its low cost, small size, ease of fabrication, and can easily be integrated into many commercial transceiver systems. The performance of antenna is studied in terms of parameters like length, width, patch height of antenna. The paper describing how VSWR and total field gain can vary due to change of dielectric constant and gives a better understanding of design parameters of an antenna and their effect on return loss plot. Finally simulation is done using design software IE3D.

KEYWORDS: Microstrip patch antenna, probe feed, VSWR, gain, return loss, IE3D.

I.INTRODUCTION

Antenna is part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves. Microstrip antenna is only one such type of antenna. A microstrip device in its simplest form is a sandwich of two parallel conducting layers separated by a single thin dielectric substrate. The upper conductor is thin metallic patch (usually Copper) which is a small fraction of a wavelength. The lower conductor is a ground plane which should be infinite theoretically. The patch and ground plane are separated by a dielectric substrate which is usually nonmagnetic. Here the dielectric constant of the substrate ranges from 2.2 to 3.0. The patch can assume any shape such as rectangular, circular, triangular, elliptical, helical, circular ring etc. Microstrip antenna elements radiate efficiently as devices on microstrip printed circuit boards. Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. The patch is generally made of conducting material such as copper or gold and can take any possible shape. A patch antenna is a narrowband, wide-beam antenna fabricated by photo etching the antenna element pattern in metal trace on the dielectric substrate.

In telecommunication, there are several types of microstrip antennas(also known as printed antennas) the most common of which is the micro-strip patch antenna or patch antenna. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a plane. Common micro-strip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

possible. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.

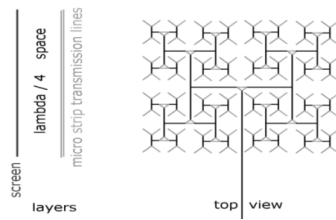


Fig.1 The inner view of a patch antenna.

II. BASIC PATCH ANTENNA GEOMETRY

In its most basic form, a Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 1. [2] The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

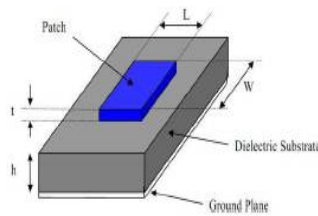


Fig 2 Structure of a Microstrip Antenna.

III. FEEDING TECHNIQUES

The two techniques available to feed or transmit electromagnetic energy i.e. induce excitation to a microstrip antenna are contracting (feeding is done directly via a connecting element such as microstrip transmission line and co-axial probe) non contracting types (like aperture coupling, electromagnetic field coupling is done to transfer power between the microstrip line and the upper conductor).

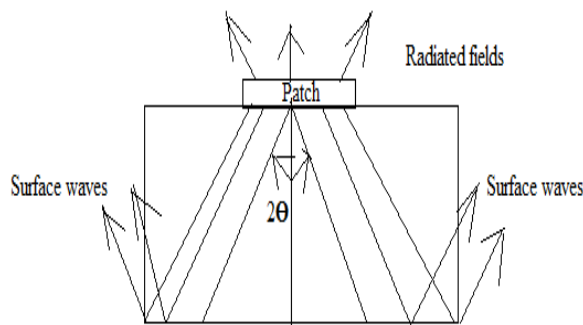


Fig.3 Formation of surface waves.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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Vol. 5, Issue 4, April 2016

A. MICROSTRIP LINE FEED TECHNIQUE

The simplest way to feed a microstrip patch is to connect a microstrip line directly to the edge of the patch. In this case both the patch and the lines are located on the same substrate. The matching between the characteristic impedance of the microstrip feed line and the patch can be done by selecting the right depth of the inset.

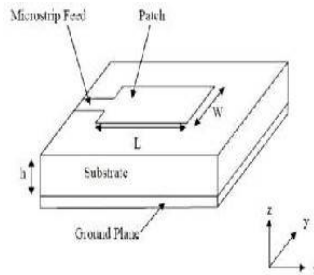


Fig.4 Patch antenna with microstrip line feed.

IV. FRINGING EFFECT

The radiation from microstrip antenna can be found from the patch spaced of a wavelength above a ground plane. When the length of the patch is about half a wavelength long, then the radiation generates from the fringing electronic fields between the patch and the ground plane. Further, it is assumed that there is no variations of electric field along the width and the thickness of the antenna. The fringing electronic field is an effect of the electrons congregated at the surface of the conductor, especially at the edge. So that most of the radiated power is distributed from the edge of the patch.

V. MODELLING TECHNIQUES

To understand and analysis the behaviour of microstrip antennas choosing model to simulate the performance is very helpful in antenna design stage. There are two types of modelling technique available.

- 1) Transmission line model
- 2) Cavity model

VI. FOMULAS USED FOR ANTENNA DESIGNING

Here the formulas used for antenna designing are described below where W is the width of the proposed antenna, L is the length of the antenna, ϵ_{reff} is the effective permittivity of the antenna, which is given by:

$$\epsilon_{\text{reff}} = (\epsilon_r + 1) / 2 + (\epsilon_r - 1) / 2 * [1 + (12(h/w))]^{-0.5}$$

Calculation of Length Extension ΔL , which is given by :

$$(\Delta L/h) = 0.412 [(\epsilon_{\text{reff}} + 0.3) * ((w/h) + 0.264)] / [(\epsilon_{\text{reff}} - 0.258) * ((w/h) + 0.8)]$$

For effective radiation, the Width W is : $W = \lambda_g / 2 * [(\epsilon_r + 1) / 2]^{-0.5}$

Now, to calculate the Length of patch becomes: $L = \{(\lambda_g / 2) * (\epsilon_{\text{reff}})^{-0.5}\} - 2 * (\Delta L)$

The Effective Length of the patch L_{eff} now becomes : $(\lambda_0 / f_0) * (\epsilon_{\text{reff}})^{-0.5}$

Length and Width of ground is : $L_g = 6h + L$ & $W_g = 6h + W$.

Where,

μ_0 = Permeability constant.

ϵ_0 = Permittivity of a free space.

ϵ_r = Relative permittivity.

h = Height of a patch antenna.

f_0 = Resonant frequency.

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λ_g =guided wavelength.

VII. DESIGNING

First a simple rectangular microstrip patch antenna has been designed using IE3D software

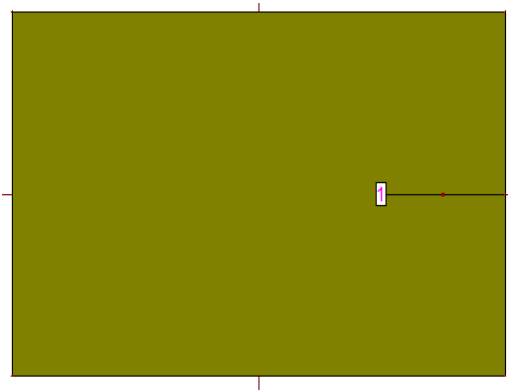


Fig.5 Design of a Rectangular Microstrip Patch Antenna.

Design parameters are as follows:-

Patch length (L) = 12mm

Patch width (W) = 8 mm

Dielectric constant (ϵ_r) = vary from (2.2 to 3.0)

Substrate thickness (h) or patch height =1.5 mm

Center frequency=10 GHz

Probe feed distance (dp) =-3 mm (from centre)

Probe feed radius (r_p) =0.006mm

Loss tangent= 0.001

Here, we are showing the dielectric constant is varying from 2.2 to 3.0. From the above parameters, return loss plot is below (-10dB), which is desirable.

VIII. EXPERIMENTAL RESULTS

A. RETURN LOSS PLOT

Here for different values of dielectric constant such as $\epsilon_r = 2.2$, $\epsilon_r = 2.3$, $\epsilon_r = 2.4$, $\epsilon_r = 2.5$, $\epsilon_r = 2.6$, $\epsilon_r = 2.7$, $\epsilon_r = 2.8$, $\epsilon_r = 2.9$, $\epsilon_r = 3.0$ return loss plots are given below :

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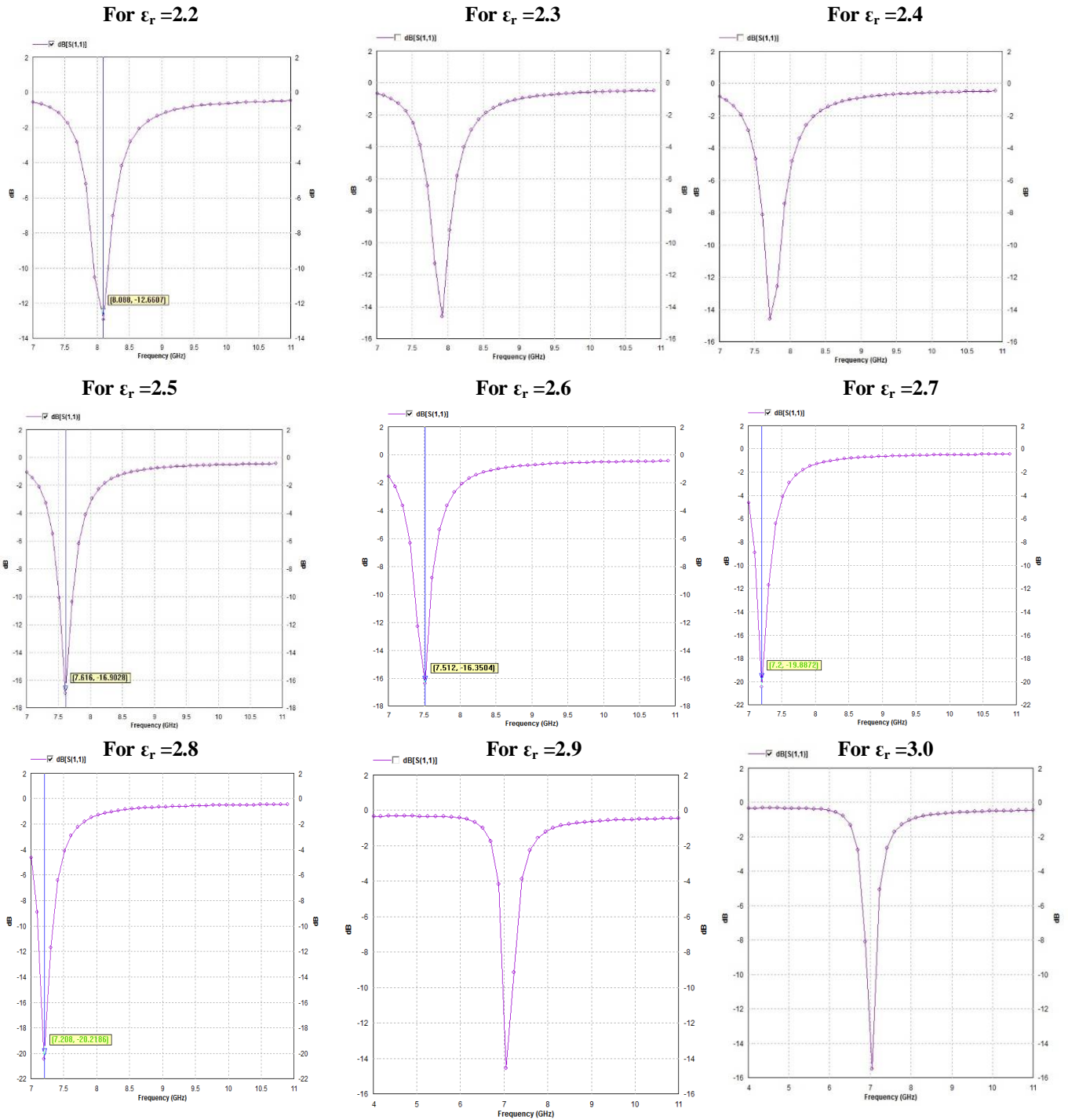


Fig.6 Return Loss plots for various value of Dielectric Constant.

B. TOTAL FIELD GAIN PLOT

Here for different values of dielectric constant such as $\epsilon_r = 2.2$, $\epsilon_r = 2.3$, $\epsilon_r = 2.4$, $\epsilon_r = 2.5$, $\epsilon_r = 2.6$, $\epsilon_r = 2.7$, $\epsilon_r = 2.8$, $\epsilon_r = 2.9$, $\epsilon_r = 3.0$ total field gain plots are given below :

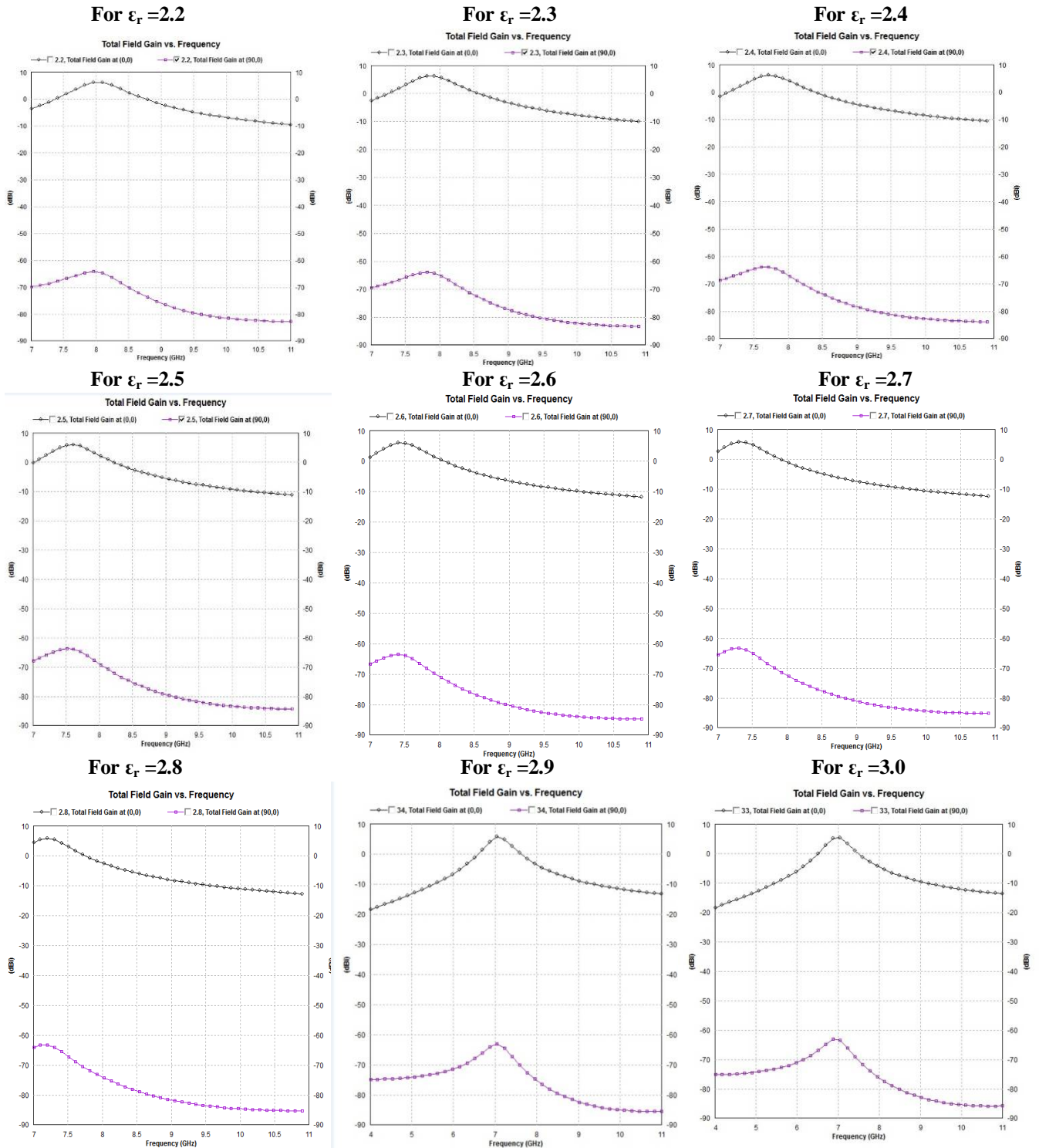


Fig.7 Total Field Gain plots for various value of Dielectric Constant.

C. VSWR PLOT

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Here for different values of dielectric constant such as $\epsilon_r = 2.2$, $\epsilon_r = 2.3$, $\epsilon_r = 2.4$, $\epsilon_r = 2.5$, $\epsilon_r = 2.6$, $\epsilon_r = 2.7$, $\epsilon_r = 2.8$, $\epsilon_r = 2.9$, $\epsilon_r = 3.0$ VSWR plots are given below :

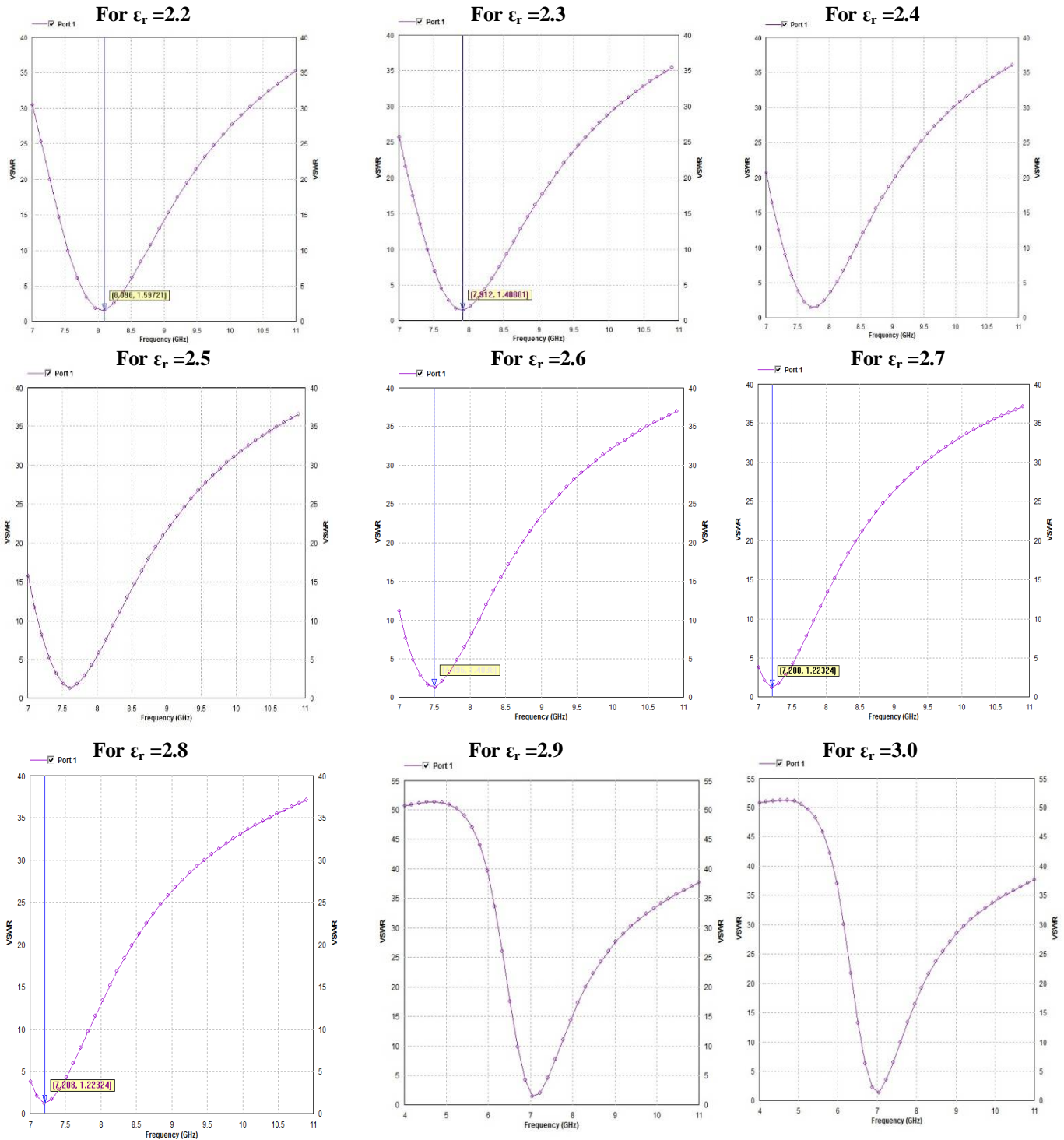


Fig.8 VSWR plots for various value of Dielectric Constant.



International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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IX. EXPERIMENTAL DATA ANALYSIS

Dielectric Constant and VSWR Vs Total Field Gain is given below as in a table

Dielectric Constant	VSWR (dB)	Total Field Gain (dB)	
		At (0,0)	At (90,0)
2.2	1.61	6.12	-64.18
2.3	1.48	6.09	-63.99
2.4	1.47	6.01	-63.80
2.5	1.41	5.9	-63.60
2.6	1.40	5.79	-63.47
2.7	1.30	5.72	-63.35
2.8	1.22	5.68	-63.25
2.9	1.20	5.62	-63.10
3.0	1.10	5.30	-63.00

Table 1: Dielectric Constant and VSWR Vs Total Field Gain

X. CONCLUSION

The Total Field Gain of microstrip patch antenna is decreased by increasing the value of dielectric constant of the microstrip patch antenna and the VSWR plot is also decreasing. So to achieve highly gain microstrip patch antenna low value of dielectric constant desirable. This type of antenna is widely used in wireless communication system.

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