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Design and Analysis of Rectangular Microstrip Patch Antenna for Handheld Cell Phones

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Abstract- *Nowadays, microstrip patch antenna becomes popular in wireless communications due to their low-profile structure, Lightweight& low volume, low fabrication cost. So that they are extremely compatible with embedded antennas in handheld wireless devices. In this project, the rectangular microstrip patch antenna is designed for an operating frequency of 1.9 GHz, and the substrate used is FR4 epoxy having a low dielectric constant of 4.4, the dielectric loss tangent of 0.02, and the substrate thickness is 1.6mm. This design is simulated by HFSS and used to obtain the most suitable configuration in terms of desired values of Return Loss (RL), Voltage Standing Wave Ratio (VSWR), and bandwidth by using 4.4 dielectrics constant and varying the length inset feed. We get the RL is –15.4142dB, VSWR is 1.4083; this indicates there are no losses, the gain is 1.3069dB, the directivity is 1.4087dB, and the BW is 78.5MHZ by using the inset feed line of 9.8291mm. When the inset feed line decreases to 9.1062mm, the RL becomes -12.7351 dB, VSWR is 1.600, and the BW is 50.6MHZ. Therefore, the BW is enhanced from 50.6MHZ to 78.5MHZ.*

Keywords- *Microstrip patch antennas, FR4 epoxy, HFSS*

I. INTRODUCTION

Wireless technology is one of the main areas of research in the world of communication systems today, and a study of communication systems is incomplete without an understanding of the operation and fabrication of antennas. Therefore, we are going to study and know about the microstrip patch antenna. Microstrip antennas are low profile, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs. The main disadvantages of such antennas are their low power, low efficiency, poor polarization purity, poor scan performance, spurious feed radiation, and very narrow frequency bandwidth. Mobile communication requires small, low-cost, low-profile antennas. Microstrip patch antenna meets all requirements, and various types of microstrip antennas have been designed for use in mobile communication systems. The design focus on the rectangular shape of the microstrip patch antenna using microstrip line feed and transmission line model. The design is implemented by simulating the software HFSS.

II. DESIGN SPECIFICATION

The parameters used for designing are:

- Frequency of operation (f_0): Since the Personal Communication System uses the frequency range from 1850-1990 MHz Hence the antenna designed must be able to operate in this frequency range. The resonant frequency selected for this design is 1.9 GHz.

- The dielectric constant of the substrate (ε_r): The dielectric material selected for this design is FR4 epoxy, which has a dielectric constant of 4.4. A substrate with a low dielectric constant has been selected since it improves the bandwidth of the antenna.

- Height of dielectric substrate (*h*): The dielectric substrate height is selected as 1.6 mm. Hence, the antenna must not be bulky

Table I: Simulation parameters.

Parameter	***Value (mm)***
Substrate dielectric constant, ε_r	4.4
Dielectric loss tangent	0.02
Substrate thickness, h (mm)	1.6
Ground plane length, L_g	49.8966
Ground plane width, W_g	57.6458
Patch length, L (mm)	40.2966
Patch width, W (mm)	48.0458
Width of feed, ωo (mm)	2
Inset feed line, y_0(mm)	9.8291
Inset gap, G (mm)	0.74705

III. HFSS DESIGN MODEL

Using the above parameters, we design the microstrip patch antenna for handheld cell phones at the operating frequency of 1.9GHZ in the HFSS, and we finally get the design model as shown in the figure below.

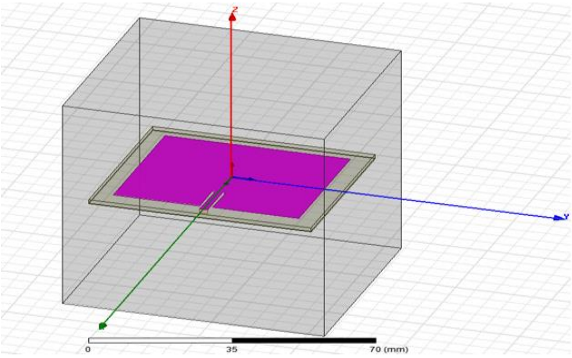

Figure 1. Proposed designed model using HFSS.

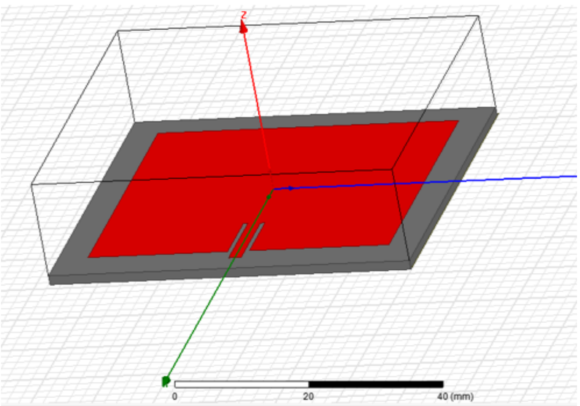

Figure 2.Reference designed model using HFSS.

It has been designed rectangular microstrip patch antennas operating at 1.9GHZ for handheld cell phones, and the characteristics of proposed antennas have been investigated through different parametric studies using HFSS.

The proposed antenna consists of a rectangular patch etched on top of the substrate and a ground plane on the other side. The parametric studies have been performed using the Parameter Sweep option in HFSS to obtain the suitable position and width of the ground plane.

We observed that the changing dimension, length, and position of the inset-feed or feed line and gap cause noticeable changes in antenna performance; that means improved bandwidth and decreased return loss, which indicated better impedance matching.

Bandwidth is calculated in the ***s***-parameter plot or RL graph at -10dB, which is the range frequency between higher and lower frequency, and the operating frequency is placed at the center.

$$BW = f_m - f_l$$

A. For Reference Design

When the inset feed line y_0 is 9.1062mm, the remaining design parameters are the same as the proposed antenna design. This is used as a reference to compare the RL, VSWR, and bandwidth with the original design or design B. The following images show the simulation of the reference design of the return loss, voltage standing wave ratio, gain, and directivity.

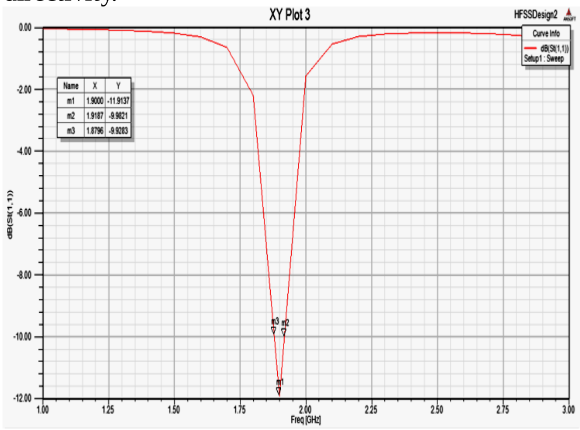

Figure 3.Return loss of the reference design.

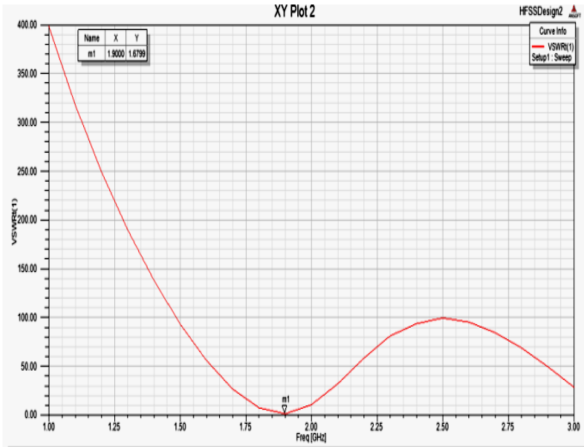

Figure 4.Voltage standing wave ratio of the reference design.

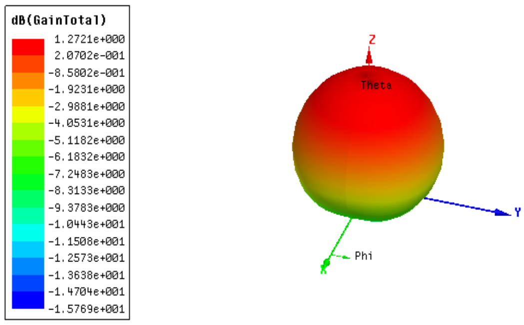

Figure 5.Gain of the reference design.

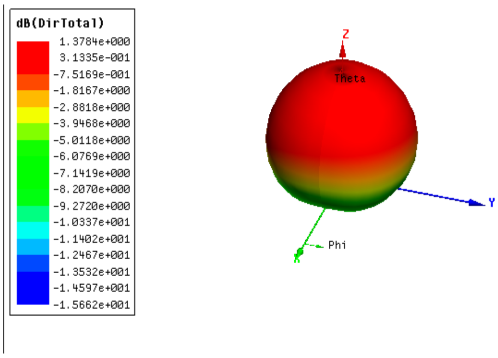

Figure 6.Directivity of the reference design.

B. For Proposed Design

The proposed antennas were designed properly, considering all the dimensions, positions, lengths, widths, and design parameters of ground plane/ substrate, patch, gap, and feed line.

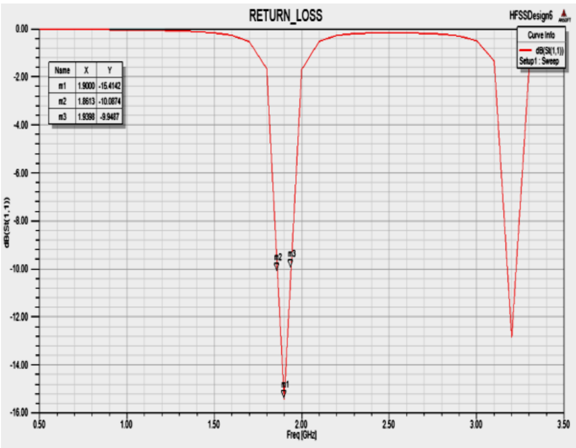

Figure 7.Return loss of proposed design.

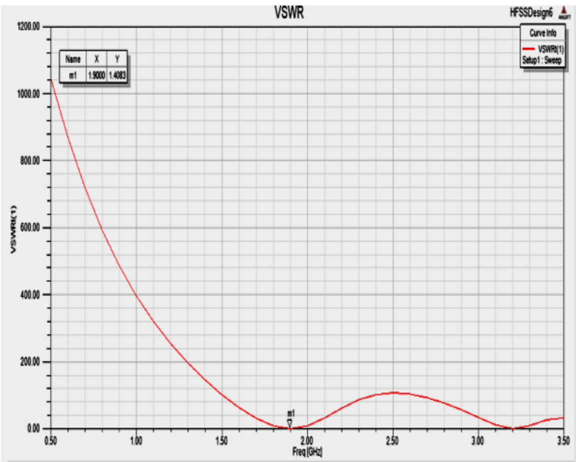

Figure 8.Voltage standing wave ratio of the proposed design.

The observed gain for the designed antenna is 1.3609dB; this value is used for handheld mobile antennas in the transmitter and receiver because patches in mobile operate at unity gain. The maximum directivity is 1.4087dB.

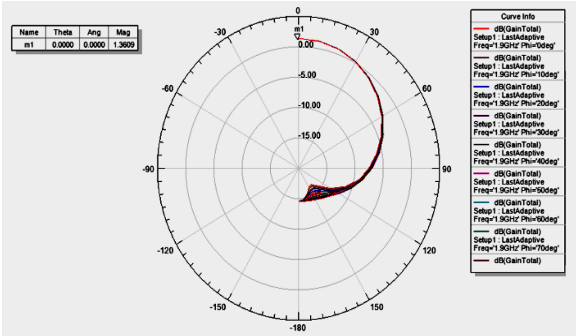

Figure 9.Gain of a proposed design.

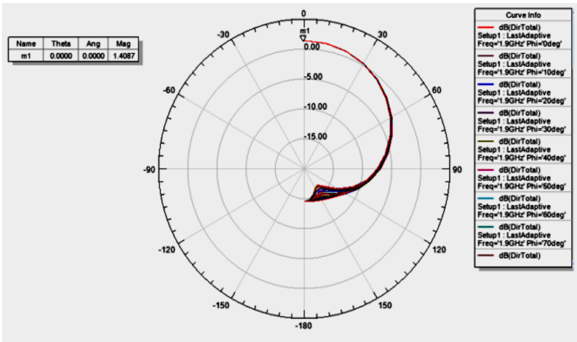

Figure 10.Directivity of the proposed design.

Therefore, the proposed patch antenna efficiency becomes:

$$\text{Efficiency }(\%) = \frac{\text{Gain}}{\text{Directivity}} \times 100\%$$

$$= \frac{1.3609}{1.4087} \times 100\%$$

$$= 96.6\%$$

IV. COMPARISON OF THE REFERENCE AND PROPOSED DESIGN

Comparing the reference and proposed designed antennas in terms of return loss, voltage standing wave ratio, gain, and directivity is shown below.

Table II: RL, VSWR, BW, and other parameters designs parisons for two designs of patch antennas.

Parameters	***For Reference Design***	***For Proposed Design***
f_0	1.9GHZ	1.9GHZ
ε_r	3.6	3.6
L_p, W_p, L_g, W_g	Same	Same
y_0	9.1062mm	9.8291mm
RL	–12.7351 dB	–15.4142 dB
VSWR	1.6	1.4083
Bandwidth (MHZ)	50.6	78.5
Gain	1.3235	1.3609
Directivity	1.4393	1.4087
Efficiency	92%	97%

V. CONCLUSION AND FUTURE WORK

The designed microstrip patch antennas have achieved better operating bandwidth of 125.1MHZ, a considerable reduction in return loss, which is -

23.8282 dB, and VSWR is 1.1376, which indicated better impedance matching, stable radiation patterns, a gain of 1.3039, directivity of2.291, and the antenna efficiency is 49.75% by using microstrip feed line techniques and transmission line model as a method of Analysis for lower substrate dielectric materials of epoxyKevlar_xy and the inset feed line y_0 is 9.8291mm.

For further work on the rectangular microstrip patch antenna, we recommend to those like researchers and other interested person's they can improve the bandwidth of the patch antenna by analyzing the thickness of the substrate, choosing the right material of having good relative permittivity value for the selected operating frequency and by calculating the exact impedance matching position of the inset feed which is placed on the patch.

In the future, we will study further antenna and extend this concept to microstrip patch array operating at a multiband frequency for many applications, for instance, cellular phones, remote sensing, communications, and search radar.

ACKNOWLEDGMENT

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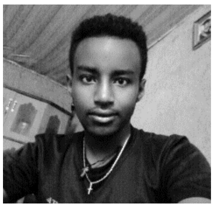

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