A Study of Micro-strip Patch Antenna at 2.45 GHz

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ABSTRACT

Through this paper we present here the simulation and performance analysis of a single element rectangular microstrip patch antenna of 2.45 GHz. The antenna is designed over a Flame Retardant-4 (FR-4) substrate with dielectric constant (ε0) of 4.4, thickness (h) of 1.5 mm. The optimum design parameters of the antennas are selected to achieve the compact dimensions, as well as the best possible characteristics such as resonant frequency, high gain, high radiation efficiency etc. Microstrip line feed is used. The rectangular micro strip patch antenna was analyzed using Ansys HFSS and also made a comparison among the different substrates which shows different results based on same or different parameters. Our aim is to introduce different antennas in this field and to work with new kind of antenna designs.

Keywords: 2.45 GHz, Patch Antenna, Micro-strip, Substrate, Copper.

1. INTRODUCTION

In recent years there is a need for more compact antennas due to rapid decrease in size of personal communication devices[1]. As communication devices become smaller due to greater integration of electronics, the antenna becomes a significantly larger part of the overall package volume. This results in a demand for similar reductions in antenna size[2]. In addition to this, low profile antenna designs[3] are also important for fixed wireless application .The microstrip antennas[4] used in a wide range of applications from communication systems to satellite and biomedical applications[5].

Antennas are metallic structures designed for radiating and receiving electromagnetic energy. An antenna[6] acts as a transitional structure between the guiding device (e.g. waveguide, transmission line) and the free space.

The essential construction of an Micro strip Patch Antenna(MPA) includes a metallic radiating patch[7] component, which is combined into a grounded dielectric substrate as shown in Figure 0 .The forms that the MPA[8]can represent are such as rectangular shapes, trigonal, hexagonal, circular, and so on. Different dielectric substrates are used in the MPA which determines the size and performance [9]. The patch antenna is also termed the voltage radiator[10]. It is well-known that the use of substrate material in the design of radio frequency (RF) or microwave frequencies circuits is common for printed circuit board (PCB) materials and has some important challenges[11].

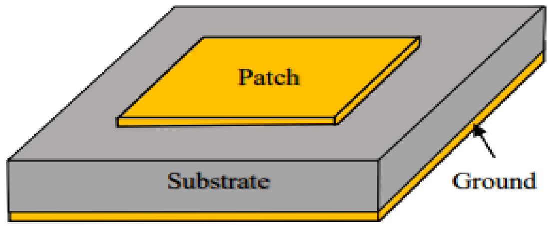

Figure: 0

2. CLASSIFICATION OF PATCH ANTENNA

The shapes that are commonly available for any kind of patch antenna are rectangular, circular, dipole, triangular, square and elliptical with rectangular and circular shapes. The various shapes are illustrated in fig 1.

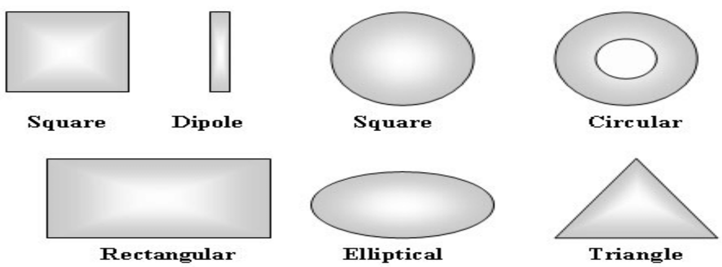

Figure: 1 Different patch antenna shapes(conventional)

Using different kind of Patches left us with different outputs as follows:

Table 1: Comparison of various performance parameters of different patches of micro-strip antenna

S. No.	Shape of Patch	Return loss vs. frequency	Gain (dB)	Lower cut off frequency (GHz)	Higher cut off frequency (GHz)	Bandwidth (GHz)
1.	Circle (Radius: 30)	-16.50	8.1756	6.80	7.43	0.63
2.	Rectangular (60, 50, 0)	-19	6.7619	7.33	8.47	1.14
3.	Ellipse (Major Axis:20, Ratio:2)	-25	7.2326	6.90	7.96	1.06
4.	Pentagon (Side: 44.36mm)	-23	9.0943	7.30	8.54	1.24
5.	Hexagon (Side: 35mm)	-22	7.4406	7.30	8.52	1.22
6.	Square (60, 60, 0)	-21	8.2799	6.53	7.45	0.92

Except for these we can also use our custom Patches like the one we've used in this journal.

3. METHODOLOGY OF DESIGNING THE ANTENNA

The following formulas are proposed to be used while designing and developing a micro-strip patch antenna. First calculate the width (W) of Micro-strip patch Antenna. Width of micro-strip patch antenna is given by

W= C/ C/2f0√ ε_r +1/2

Substituting C= $3*10^8$ m/sec; ε_r=4.4 and f0 = 2.45 GHz

We get W = 38.00 mm

ΔL= 0.412h (%5reff + 0.3) (W/h + 0.264)/ (ε_{reff} – 0.258) (W/h + 0.8)

The actual length is obtained by:

L= Leff - 2 ΔL Substituting the values

L=27.9 mm

By using above formulae we get L = 30 mm and W = 36 mm

So, micro-strip patch dimensions decided by using above formulae and L = 27.9 mm and W = 38 mm is calculated by taking these dimensions antenna is simulated by using HFSS 5 Software.

The main objective is to design small size patch antenna for wireless applications. The substrate used for the antenna design is FR-4 (Ɛr=4.4) dielectric material because of its moderate dielectric permittivity. The height of the dielectric material is chosen to be 1.6mm which is the default size of FR-4 material. The width of the conducting patch element is 36mm and length is 30mm for the frequency of 2.45 GHz. The most important element is feeding the strip for connecting the probe to the antenna, for which microstrip feed line method is used for better impedance matching. The strip has a width of 3mm and length of 4 mm, which is attached to the rectangular patch antenna as shown in fig 1.

Our patch has a unique pattern. It has 5 5x4 mm^2 and 4 2x2 mm^2 rectangular holes on it.

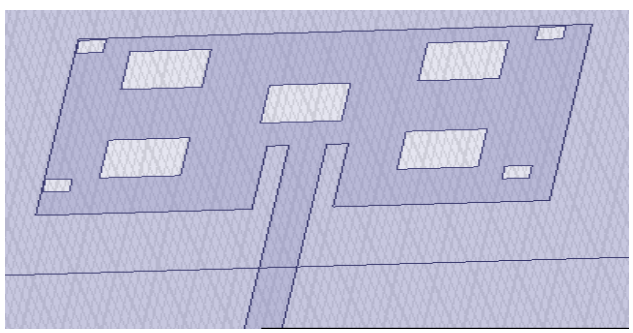

Figure: 2 The proposed antenna

Our target is to verify the radiation graphs with the best of our knowledge.

4. PROCESS TO FOLLOW

The flowchart according to which one can thoroughly understand the entire process of working is shown below:

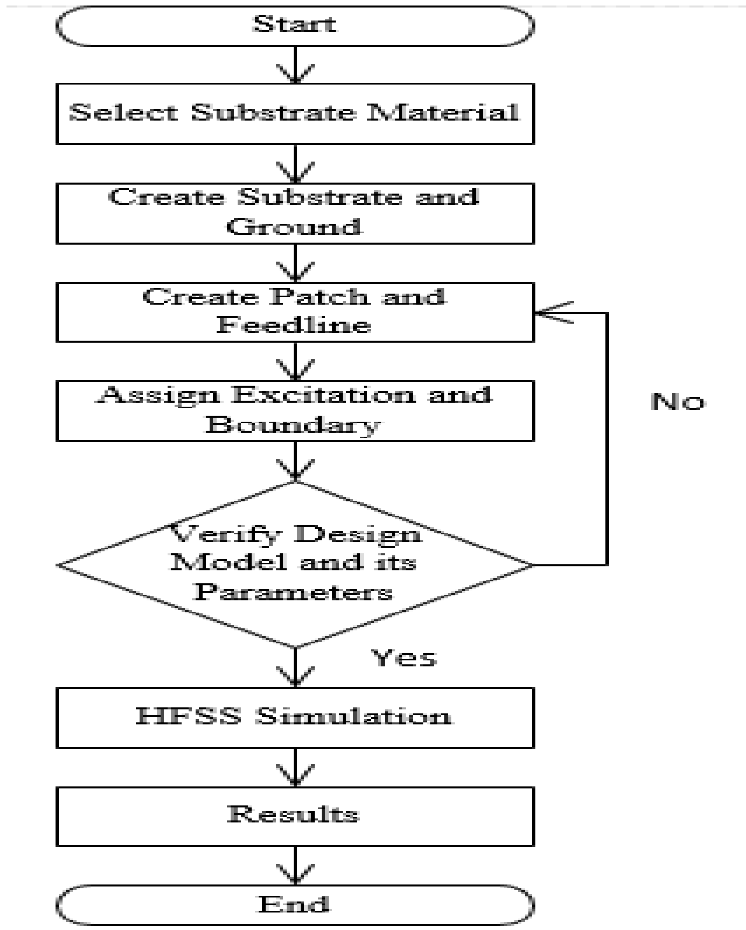

Figure: 3 Flow chart of the simulation process

5. OUR 2.45 GHZ MICRO-STRIP PATCH ANTENNA

We made our antenna's various parts using various elements.

PARTS	MATERIAL
Substrate	FR-4
Feedline	Copper
Patch	Copper
Ground	Copper

The overall antenna design is given below.

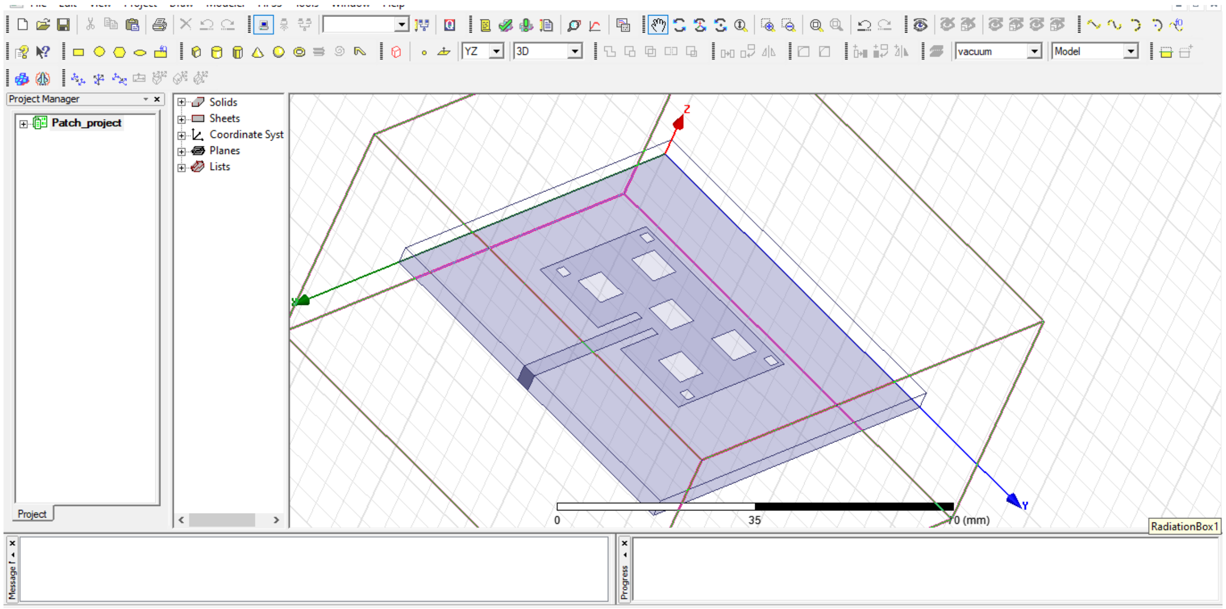

Figure 4: YZ plane representation

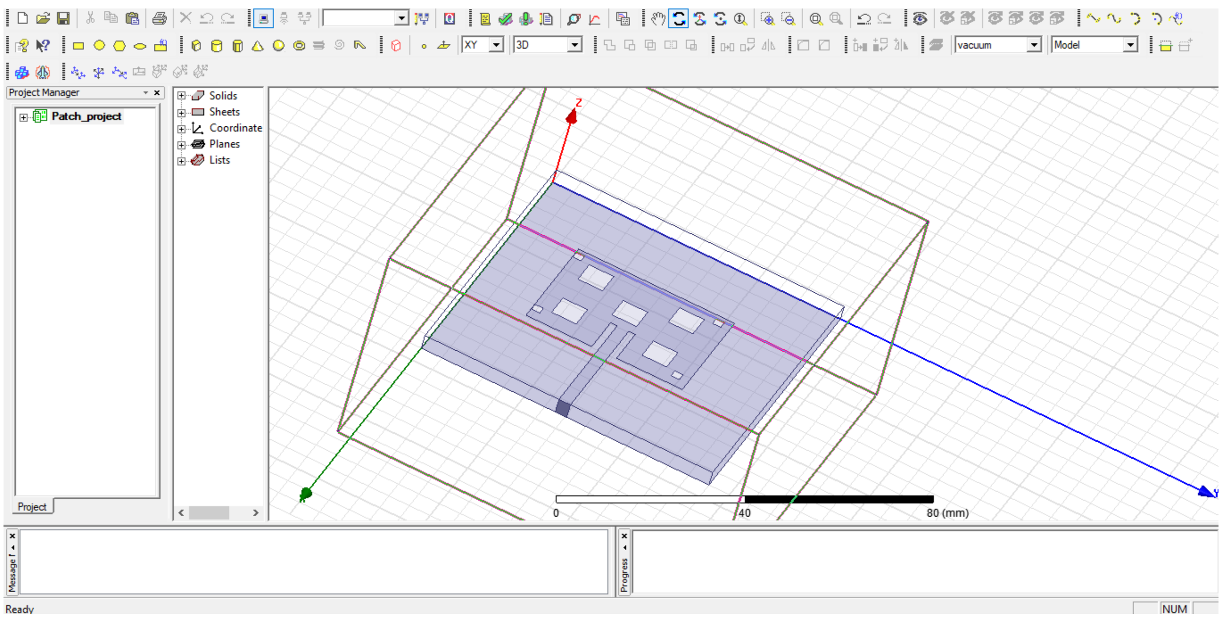

Figure 5: XY plane representation

6. RESULTS

THE GIVEN INSTRACTIONS AND THEIR CORRESPONDING OUTPUT GRAPHS ARE SHOWN BELOW:

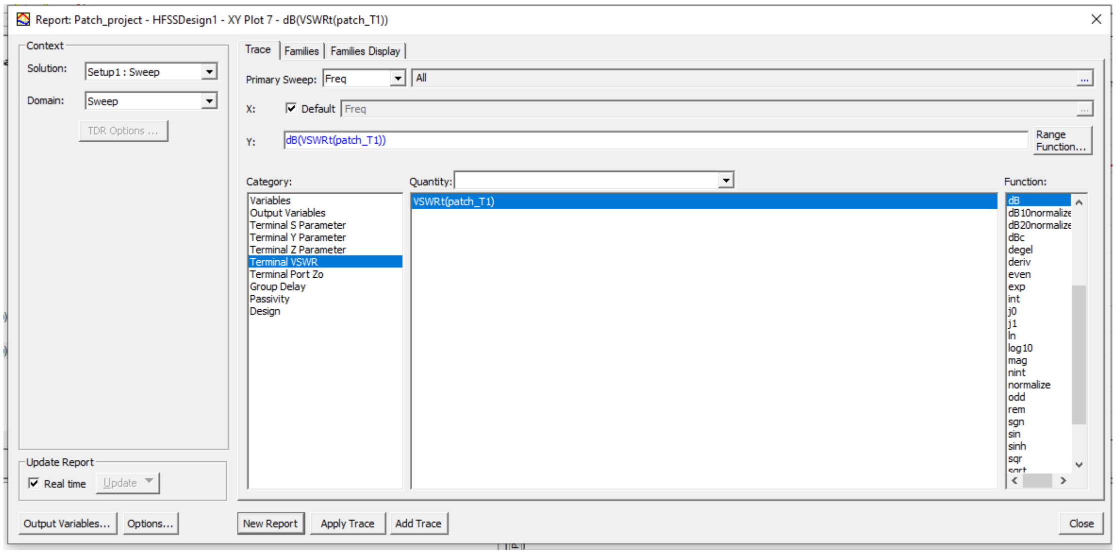

Figure: 6

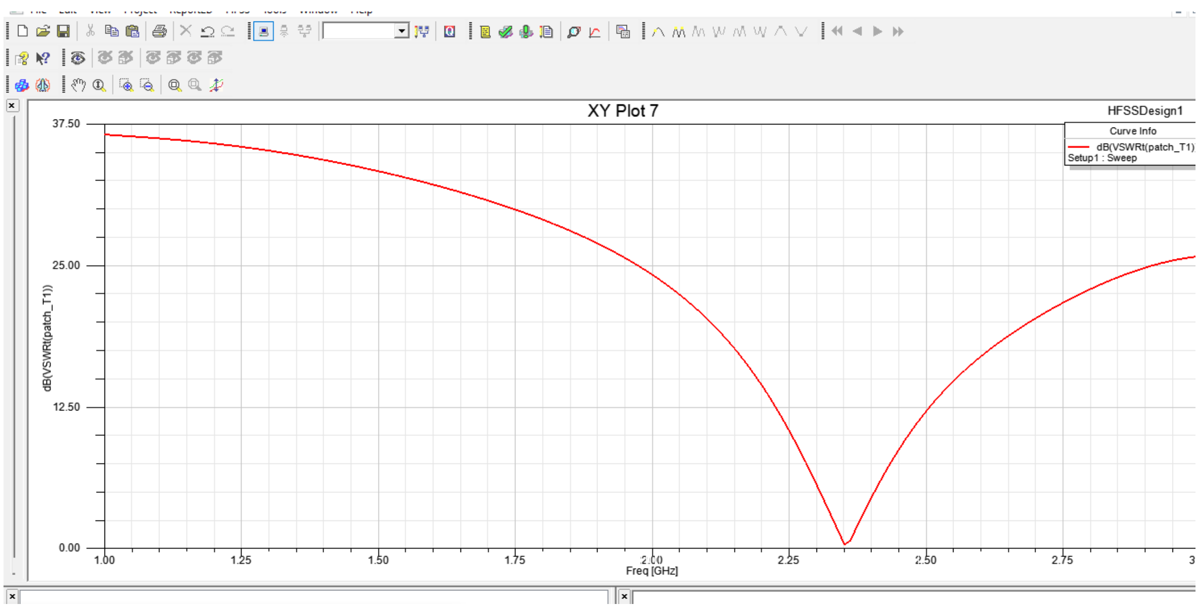

Figure 7: VSWR- FREQUENCY GRAPH

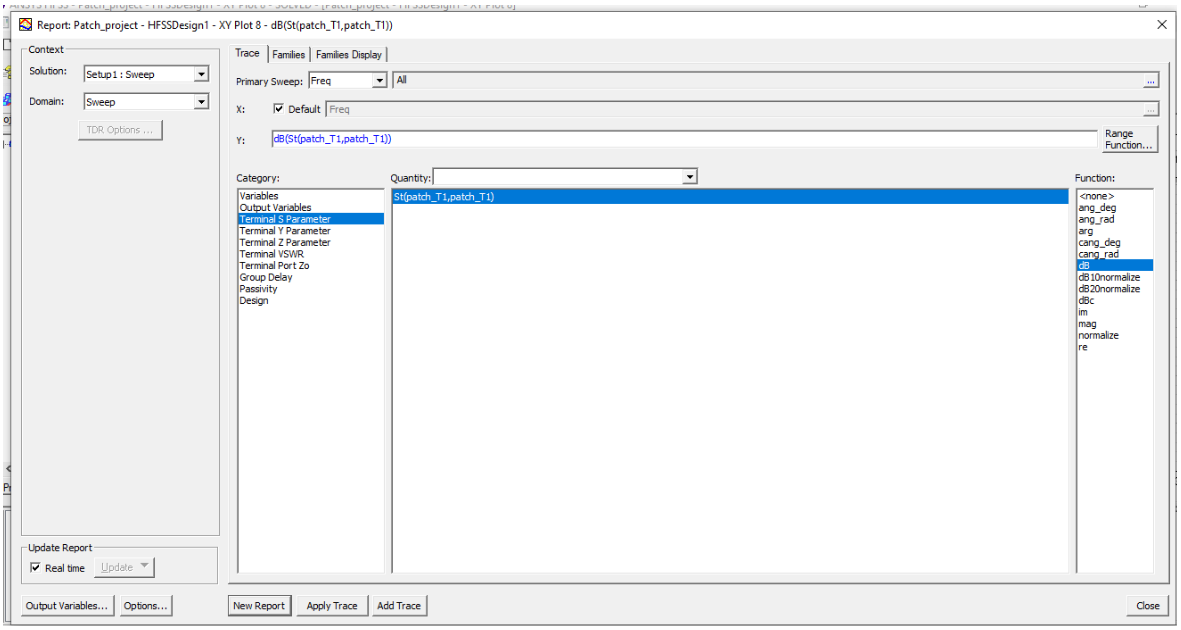

Figure: 8

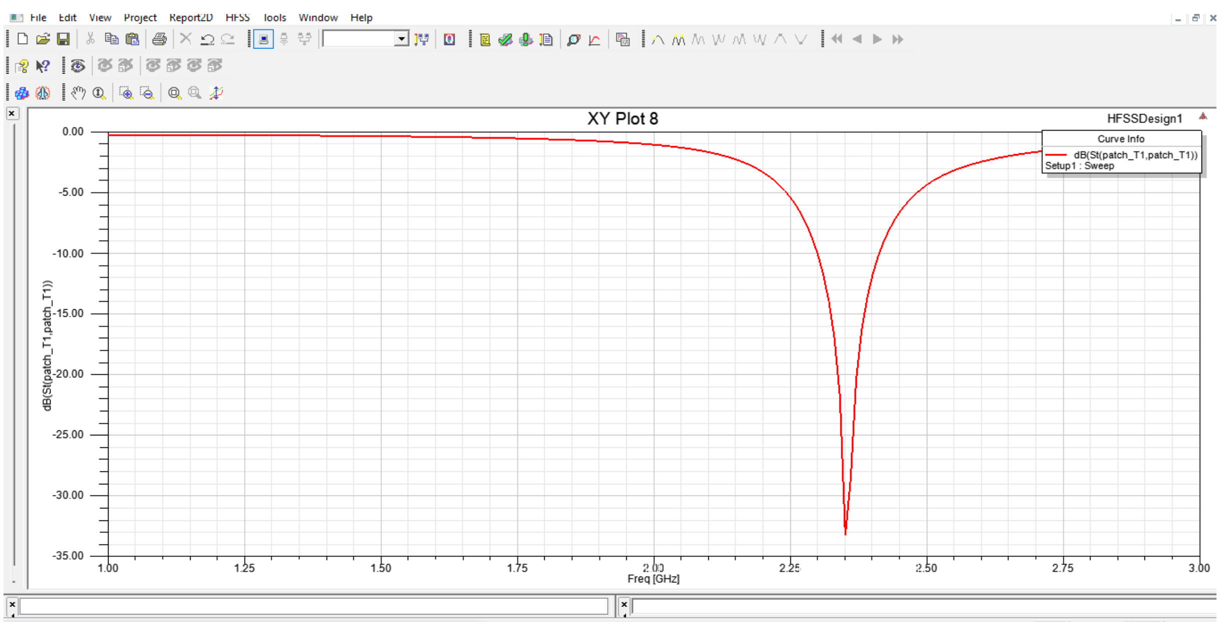

Figure 9: TERMINAL S PARAMETER- FREQUENCY GRAPH

7. CONCLUSION

In this paper, an rectangular shaped with rectangular slits antenna for 2.45 GHz applications is presented. The introduction of an rectangular slot on the radiating element of the microstrip antenna allows an operating frequency of 2.4 GHz and bandwidth of 550 MHz. The introduction of the additional improvements the partial ground plane shifted the frequency to 2.45 GHz, a bandwidth of 220 MHz and a reduction in the size of the antenna10.44% compared to the previous step. The proposed antenna is designed on FR-4 substrate and the acquired out-comes indicate that the designed antenna has good gain and an adequate impedance matching. The effect of the length of the ground plane and the positioning of the rectangular patch were studied. Enhance the efficiency parameters of the antenna have been also achieved. The outcomes make the rectangular patch microstrip antenna with multiple rectangular slits a suitable choice for 2.45 GHz multi-direction implementations. This paper's primary objective is to support the efficiency of the microstrip patch antenna through new approach.

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