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Gain and Directivity Enhancement of Rectangular Microstrip Patch Antenna using HFSS

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ABSTRACT

In the recent years the improvement in communication systems requires the development of low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a wide spectrum of frequency. This technological trend has focused much effort into the design of a Micro strip patch antenna. In this paper, we designed a rectangular micro strip patch antenna at 3.8GHz and study the effect of antenna dimension Length (L), Width (W), substrate parameter relative dielectric constant (Єr) substrate thickness (h) and radiation pattern using Ansoft HFSS. It even describes the increasing effect of Gain and Directivity. The Proposed antenna also presents the detail steps of designing the micro strip antenna and the simulated result. The feeding technique used to feed the antenna is coaxial probe feeding technique. Micro strip patch antenna is used in many fields like Antenna and mobile communication, Filters, PCB board model and EMC and EMI. Rogers RT/duroid 5880 (tm) substrate with a dielectric constant of approximately 2.2, is a feed and has a partial ground plane. The gain and directivity of the designed antenna is 7.7082 dB and 7.76882dB respectively.

Index Terms: Micro strip patch antenna, Radiation pattern, Ansoft HFSS (High Frequency Structural Simulator) and Rogers RT/duroid 5880.

1. INTRODUCTION

Antennas play a vital role in the field of wireless communications. Some of the antennas are parabolic reflectors, patch antennas, slot antennas, and folded dipole antennas with each type having their own properties and usage. Micro strip antenna technology began its development in the late 1970s. Micro strip patch antenna is one of most important component of communication systems. By definition, an antenna is a device used to transform an RF signal, travel into an electromagnetic wave in free space. The rectangular micro strip antennas play a vital role in wireless communication due to its low-profile, small-size and light weight. A Micro strip Patch antenna consist of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is made up of conducting material such as copper or gold. The radiating patch and the feed lines are photo etched on the dielectric substrate.

Micro strip antennas are characterized by a larger number of physical parameters than microwave antennas. They can be designed to have many geometrical shapes and dimensions but rectangular and circular Micro strip resonant patches have been used in many applications. In this paper, the design of probe feed rectangular micro strip antenna is for satellite applications is presented and is expected to operate within 3.8 GHz frequency span. This antenna is designed on coaxial probe feeding technique and its performance characteristics which include Return Loss, Gain, Directivity, VSWR, and input impedance are obtained from the simulation.

2. STRUCTURE OF ANTENNA

Micro strip patch antenna consist of patch on its top side, a radiating patch on one side of the dielectric substrate and a ground plane on the other side. The micro strip patch antenna consists of three layers. The top layer shows the patch, the middle layer shows the substrate and the bottom layer constitutes the ground plane. The patch is generally made of conducting material such as copper or gold. The general structure of the micro strip patch antenna is shown in figure 1.

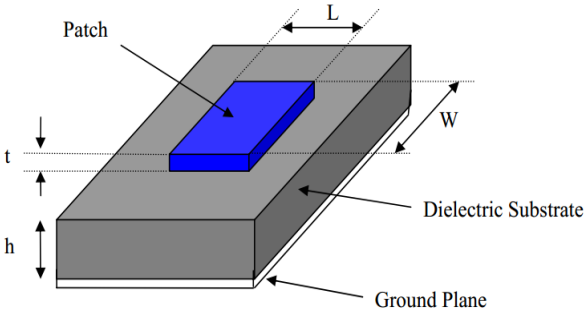

Fig.1. Structure of Micro strip patch antenna

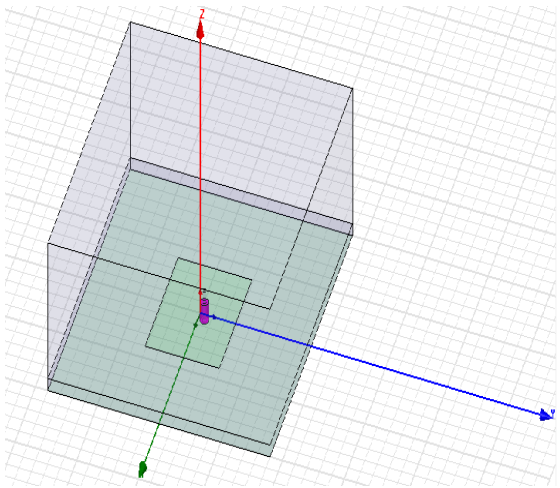

Fig.2. Rectangular micro strip patch antenna design

3. DESIGN OF PROPOSED ANTENNA

In this paper Rectangular micro strip patch antenna is designed at 3.8GHz frequency and simulated. The radiating part (patch) is the dominant figure of a microstrip antenna; the other components are the ground and substrate, which are on the two sides of the patch.

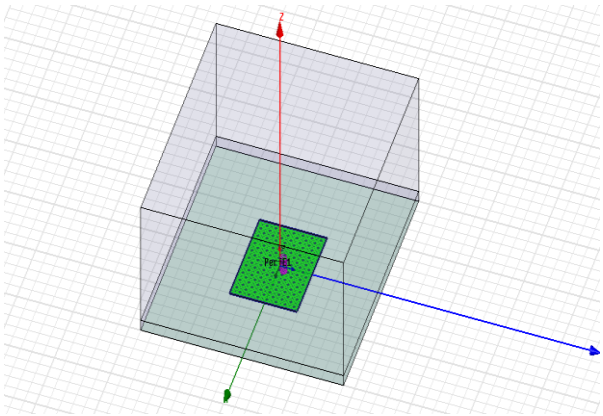

Fig.3. Assign boundaries of Perfect E1

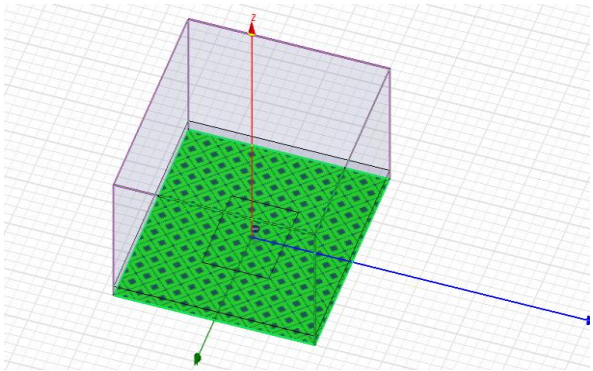

Fig.4. Assign boundaries of Perfect E2

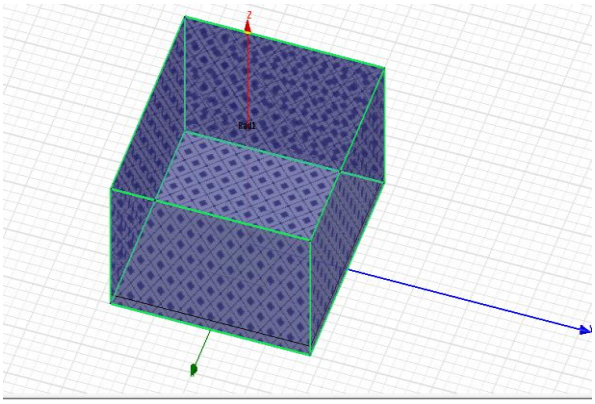

Fig.5. Assign boundaries of radiation

The figure 2 represent the microstrip patch antenna design. The figure 3, 4 and 5 indicate the assign boundaries of perf E1, perf E2 and radiation .We have analyses the results using HFSS software. The design consideration is as follows:

3.1 Design Considerations:

Substrate material: Rogers RT/duroid 5880
Relative permittivity: 2.2
XSize-15mm
YSize-14mm
Height-3.2mm

The Micro strip patch antenna is designed by using Ansoft HFSS. The cost of Ansoft HFSS is very low and it has the simple procedures to design antenna in a very efficient manner.

By simulating this antenna we can get the frequency response, gain, directivity and the radiation pattern. There are many analyzing methods for calculating length, width and height. We use the transmission line analyzing method for the antenna design, which includes mathematical calculations in the antenna design. The design flow of the micro strip antenna was shown in figure 6.

3.2 Calculation for the Antenna Width (W)

The Width of micro strip patch antenna is given by eqn (1)

$$W = \frac{C}{2 f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (1)$$

Where, C is velocity of light, f_0 is a resonant frequency and ε_r is a relative dielectric constant. In this equation we are substituting C=3*10^11mm/s, ε_r =2.2 and f_0=3.8GHz, finally by solving this equation we get the width value as 31.3mm.

3.3 Calculating the Height of the Antenna

The height (H) of the antenna is given by eqn (2) and is written as,

$$H = \frac{0.3C}{2\pi f_0 \sqrt{\varepsilon_r}} \quad (2)$$

By substituting all the values and solving the equation we get the height of the antenna as 2.54mm for 3.8GHz or the standard height of the micro strip patch antenna is 3.2mm and it is used for the simulation.

3.4 Calculating the Antenna Length (L)

It includes four steps:

Effective Dielectric Constant

Before calculating the length of the antenna we should calculate the several other computations, the first step is to find the effective dielectric constant of the substrate.

The effective dielectric constant value should be closer to the dielectric constant of the substrate. The effective dielectric constant value is given in eqn (3)

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{\frac{-1}{2}} \quad (3)$$

By substituting all the values and solving the equation we get the effective dielectric constant value as 1.45mm for 3.8GHz.

Extensive Length

The tangential fields of an antenna are in phase and by combining they will produce the maximum radiation pattern along the two sides of the antenna. The micro strip antenna looks larger in size when compared to its actual size due to its fringing fields so the length of the antenna is extended by its two sides along a path distance of ΔL and it is given in eqn (4).

$$\Delta L = 0.412h\frac{(\varepsilon_{re}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{re}-0.258)(\frac{w}{h}+0.8)} \quad (4)$$

By substituting all the values and solving the equation we get the extensive length of the antenna as 1.82mm. for 3.8GHz.

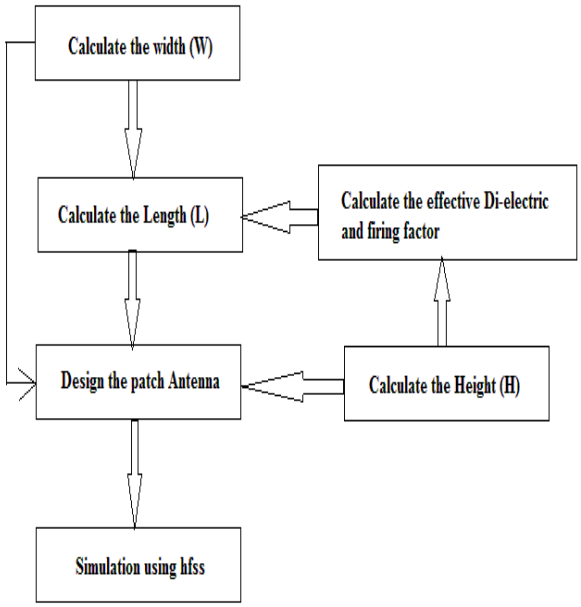

Fig.6. Design flow of micro strip patch antenna

Effective Length of the Antenna

The effective length of the of antenna is given in eqn (5) and which helps to find the original length of the rectangular micro strip patch antenna and it is written as,

$$L_{eff} = \frac{C}{2f_0\sqrt{\varepsilon_{re}}} \quad (5)$$

This is used to calculate the narrow bandwidth of the antenna structure and various parameters of the antenna. By substituting all the values and solving the equation we get the effective length of the antenna as 32.5mm for 3.8GHz.

Actual Length of the Antenna

The actual length of the antenna is calculated by substituting the effective length and the extensive length of the antenna is given in eqn (6),

$$L = L_{eff} - 2\Delta L \quad (6)$$

By substituting all the values and solving the equation we get the length of the antenna as 28.26mm for 3.8GHz.

4. ROGER RT/DURIOD 5880(TM)

The dielectric value of Roger material is 2.2 which is the most recommended material for the designing of the micro strip patch antenna. By using these materials the values of designing parameters and the size of the antenna is reduced. It produces the maximum radiation pattern along its transmission side. This material is used because the entire structure of the antenna is minimized, cost of the designing procedure is reduced and at the same time we get output of the micro strip patch antenna in a good and accurate manner.

5. SOFTWARE TOOL

HFSS (High Frequency Structural Simulator) is the software used for the simulation and modeling of the antenna. It is one of the antenna designing tool and it is a high performance full-wave electromagnetic (EM) field simulator for the 3D volumetric passive device. It follows simple procedure for designing the micro strip patch antenna.

6. SIMULATION RESULTS USING HFSS

Nowadays it has become common to check the system performance through simulation before making it as real time application. A simulator "ansoft HFSS" is used to check the gain, directicity, return loss, polarization, and radiation pattern. This simulator helps to reduce the cost of fabrication.

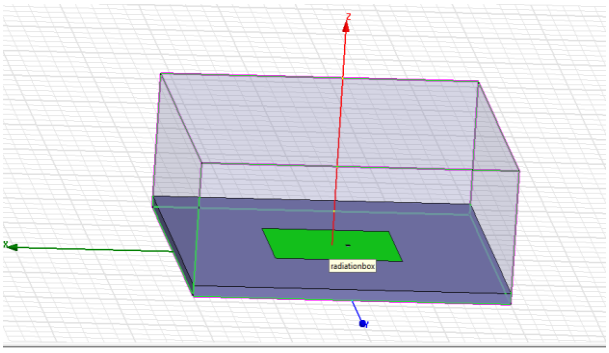

Fig.7. Three dimensional view of antenna

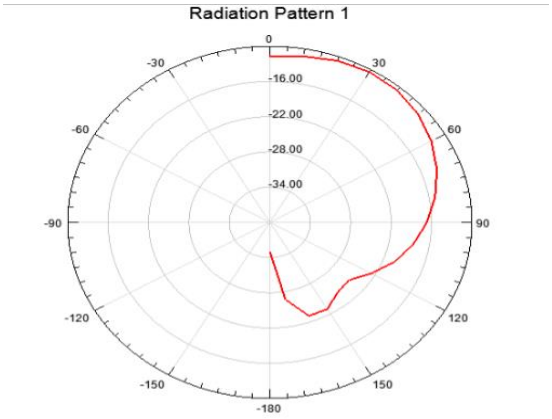

Fig.8. Radiation pattern

The design and analysis of the rectangular micro strip antenna was designed at a frequency range of 3.8GHz. The rectangular antenna is more advantageous than other types because their design structure is simple and have positive radiated edges on the both sides of the antenna. The three dimensional view of the simulated micro strip patch antenna is shown in the figure below.

The radiation pattern is defined as the directional dependence of the strength of the signal or the strength of the electromagnetic waves

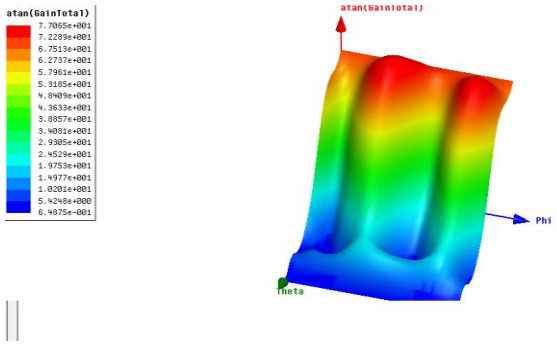

Fig.9. Gain for 3.8GHz

The gain of an antenna is defined as the ratio between the maximum radiation intensity in a given direction to the maximum radiation intensity from a reference antenna in the same direction, the achieved gain of the micro strip patch antenna is 7.7082 dB for 3.8GHz , where the figure 9 shows the gain of the antenna.

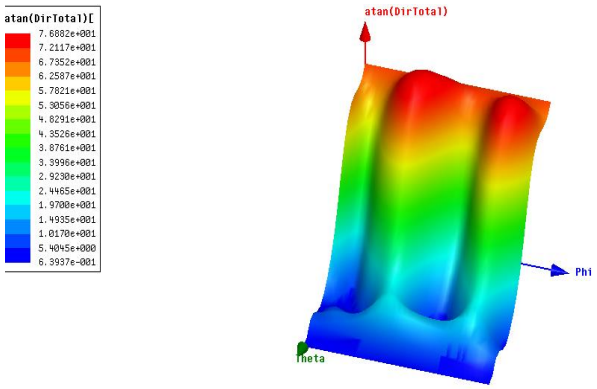

Fig.10. Directivity for 3.8GHz

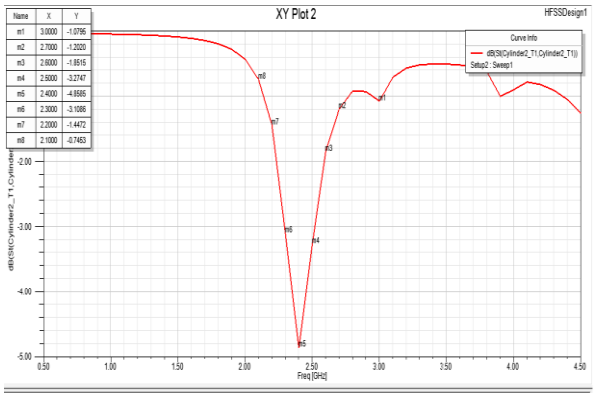

Fig.11. Frequency response for 3.8GHz

The figure 10 shows the directivity of the antenna and it is defined as the ratio between the maximum radiation intensity to the average radiation intensity of the antenna, the achieved directivity of the micro strip patch antenna is 7.6882 dB for 3.8GHz.

Table 1. Micro strip patch antenna parameters for 2.4GHz and 2.5GHz Frequency range

Frequency (GHz)	Gain (dB)	Directivity (dB)
2.4	4.2978	4.3668
2.5	4.4487	4.5157
3.8	7.7065	7.6882

7. CONCLUSION

The rectangular micro strip antenna was designed and analyzed with a frequency range of 3.8GHz and is simulated by using the Ansoft HFSS software. The frequency response, radiation pattern are obtained, the designed antenna gain value is7.7065 dB for 3.8GHz, directivity value is 7.6882 dB for 3.8GHz.

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