A Novel Design of Rectangular Patch Antenna for Broadband Applications

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***Abstract*—This paper presents the design and simulation of Rectangular Microstrip patch Antenna with wideband operating frequency. The slot will provide the broad bandwidth which is required in various applications like remote sensing, biomedical application, satellite etc. Antenna design is simulated using HFSS version 12 software. Coaxial feed technique is used. The performance of the designed antenna was analyzed in term of bandwidth, return loss, and radiation pattern. The design was optimized to meet the best possible result. Substrate used is Copper. The results show this antenna is able to operate from 1 to 5 GHz frequency.**

Index Terms— broadband, coaxial feed, HFSS (High Frequency Structure Simulator) version 12 software, Rectangular micro strip patch antenna.

I. INTRODUCTION

In high performance aircrafts, spacecrafts, satellites, missiles and other aerospace applications where size, weight, performance, ease of installation and aerodynamics profile are the constraints, a low or flat/conformal profile antenna may be required[5]. In recent years various types of flat profile printed antennas have been developed such as Microstrip antenna (MSA) strip line, slot antenna, cavity backed printed antenna and printed dipole antenna. When the characteristics of these antenna types are compared, the micro strip antenna is found to be more advantageous. [1][3]. Microstrip antenna are conformable to planar or non planar surface, simple and inexpensive to manufacture, cost effective compatible with MMIC designs and when a particular patch shape and excitation modes are selected, they are very versatile in terms of resonant frequency, polarization, radiation patterns and impedance. Apart from numerable bandwidth problem. In order to overcome this disadvantage many techniques have been proposed[6][7], such as increasing thickness of substrate, changing shape of Patch, adding additional stack or layer, instead of these I had added slots which provide wider band. A microstrip antenna in its simplest configuration consists of a radiating patch on one side of a dielectric substrate ($\varepsilon r \leq 10$), which has a ground plane on the other side. The patch conductors, normally of copper and gold, can assume virtually any shape, but conventional shapes are generally used to simplify analysis and performance prediction. A patch antenna is a narrowband, wide-beam antenna. Feeding in microstrip is achieved through use of coaxial line with an inner conductor that terminates on the patch. The placement of the feed is important for proper operation of the antenna [8].

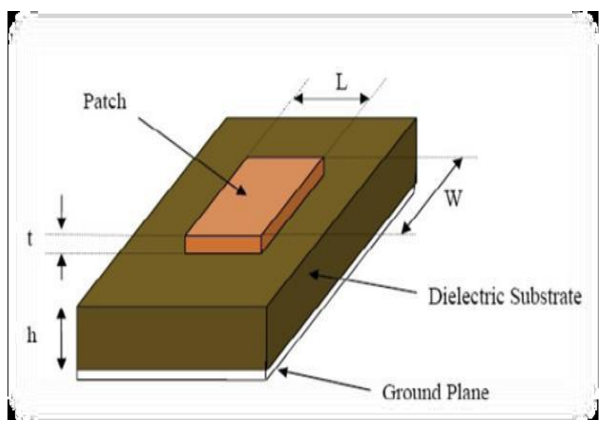

Figure 1-Rectangular Patch Antenna

II. Radiation Mechanism of Proposed Patch Antenna

Radiation from Microstrip antenna can be determined from the field distribution between patch metallization and the ground plane. Consider a Microstrip antenna that has been connected to a microwave source. The energization of the patch will establish a charge distribution on upper and lower surfaces of the patch, as well as on the surface of the ground plane. The –ve and +ve nature of the charge distribution arises because the patch is about a half wave long at the dominant mode. The repulsive forces between like charges on the bottom surface, around its edges, to its top surface. This movement of charge creates corresponding current densities Jb and Jt at the bottom and top surface of the patch. Consequently, the patch can be modeled as a cavity with electric walls (because the electric field is near normal to the patch surface) at the top and below and four magnetic walls along the edges of the patch (because the tangential magnetic field is very weak). Only TM modes are possible in this cavity. The four sidewalls of the cavity represent four narrow aperture or slots through which radiation takes place.

III. Geometry of proposed Patch Antenna

The width and length of the microstrip antenna are determined as follows:

A) *Width of the Patch [2]*

The width of the antenna can be determined by

$$w = \frac{c}{2\,fo\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \qquad (1)$$

B) *Length of the Patch[2]*

The effective constant can be obtained by

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2} \qquad (2)$$

Where

ε_{reff} = Effective dielectric constant

ε_r = Dielectric constant of substrate

h = Height of dielectric substrate

W = Width of the patch

The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is given empirically by

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{w}{h} + 0.8)} \qquad (3)$$

The actual length L of the patch is given as

$$L = \frac{\lambda_0}{2} - 2\Delta L \qquad (4)$$

C) *Feed Location Design [2]*

The position of the coaxial cable can be obtained by using

$$x_f = \frac{L}{\sqrt[2]{\varepsilon_{reff}}} \qquad (5)$$

Where

x_f is the desire input impedance to match the coaxial cable and ε_{reff} is the effective dielectric Constant

$$y_f = \frac{w}{2} \qquad (6)$$

D) *Ground Dimension*

For practical considerations, it is essential to have a finite ground plane if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, the ground plane dimensions would be given as

$$L_g = 6h + L \qquad (7)$$

$$W_g = 6h + W \qquad (8)$$

Table 1 Parameters of proposed antenna

Length of Patch	50mm
Width of Patch	50mm
Length of Substrate	51.5mm
Width of Substrate	51.5mm
Feed position-x	29
Feed position-y	25

IV. SIMULATION & RESULTS

I had design Rectangular patch for wideband applications as shown in figure2. First of all I had design rectangular patch using simulation software name HFSS which uses finite element method. FEM is the basis of simulation in HFSS. HFSS divides the geometric model into a large number of tetrahedral elements. Each tetrahedron is composed of four equilateral triangles and the collection of tetrahedra forms what is known as the finite element mesh

Following is my design, I had started with simple patch of Rectangular shape and found that it is having return loss i.e. S11< -50 from 1 GHz to 5 GHz.

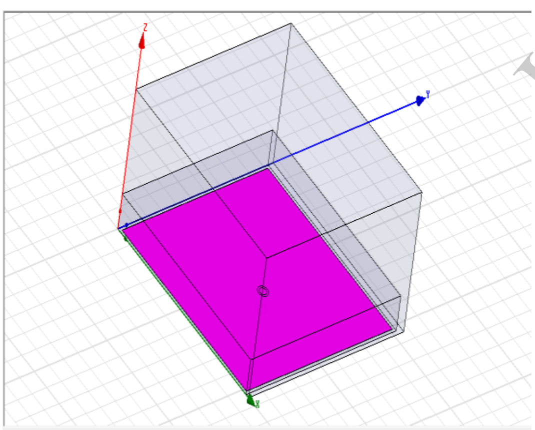

Figure 2 - Rectangular patch with no slots added

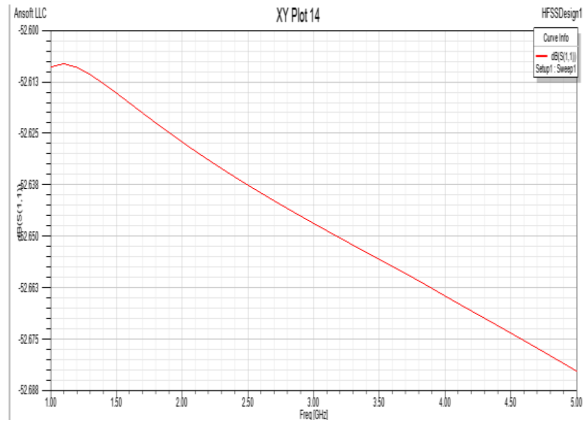

Figure 3 – Return loss v/s Frequency plot of Rectangular Patch with no slots added.

My aim was to design microstrip patch antenna for wideband applications so I modify my design and started adding slots then total 14 slots are added with width of 1mm each and I conclude that and antenna can work from 1 GHz to 5 GHz and return loss parameter also improve from previous design as shown in figure 5.

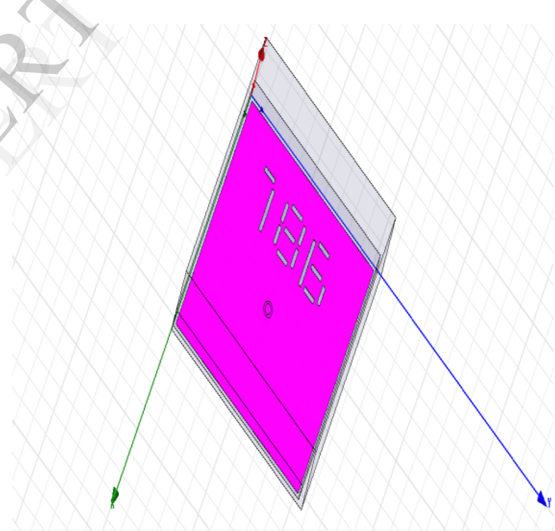

Figure 4- Proposed Rectangular Patch Antenna with 14 slots added

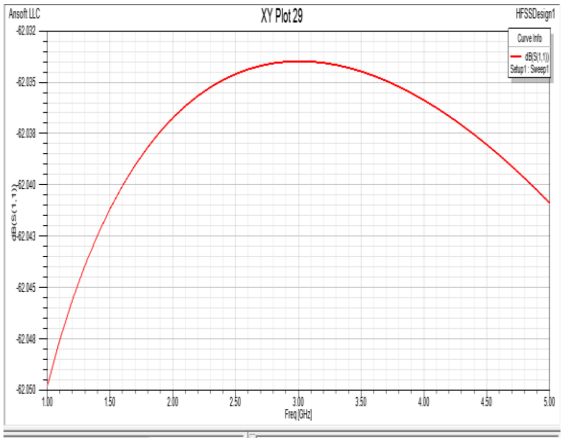

Figure 5– Return loss v/s Frequency plot of Rectangular Patch Antenna with 4 slots added

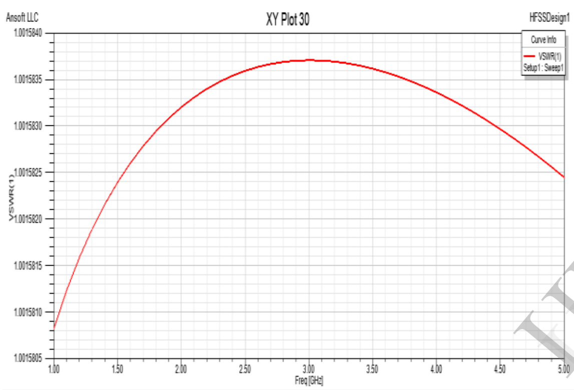

Figure 6- VSWR v/s frequency of Rectangular Patch Antenna with 14 slots added

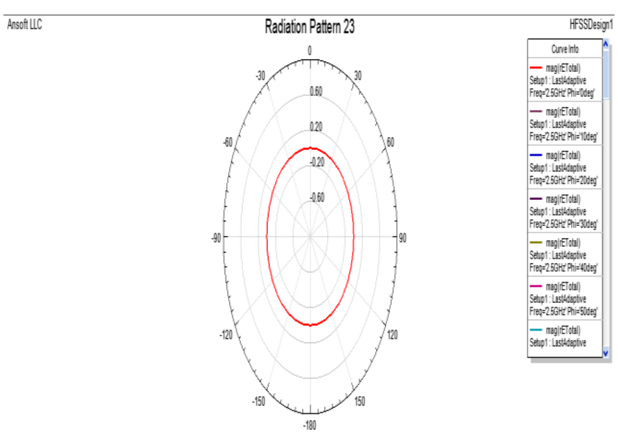

Figure 7- Radiation Pattern of Rectangular Patch Antenna with 14 slots added

V. Conclusion and Future Work

Conclusion can be discussed in two portions-

A) *Return Loss*:-In the first Design return loss i.e. S11<-50 at frequencies from 1 GHz to 5 GHz as shown in figure 3 which says that antenna is radiating at these frequencies . In the second design S11<-60 shown in figure 5 which is improvement from previous design. From figure 6 Standing waves are at acceptable level. I got stabilized result in final design.

B)*Radiation Pattern*:-In first design Radiation Pattern is Directional which is required in applications such as radar to detect particular target. In the final design Radiation Pattern is Omni directional (Figure 7) which is applicable to Broadband applications.

Changing shapes and modifying this design bandwidth greater than 5GHz can be achieved.

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