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Design of 4.4GHz Microstrip Patch Antenna for Drone Application

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ABSTRACT

This paper proposes design of 4.4GHz Microstrip Patch Antenna (MPA). In the design, patches are mounted on Arlon AD270 (tm) substrate having dielectric permittivity. Microstrip Patch Antenna is designed by using edge feeding technique. The VSWR measurement becomes zero at 4.4GHz resonant frequency. The Bandwidth, Quality factor and some other parameters are more efficient compared to other techniques. This project helped us to achieve 95% of efficiency.

KEYWORDS: Microstrip Patch Antenna, 4.4GHz, Edge Feed, HFSS Simulation Software

1.INTRODUCTION

Antennas are key components of any wireless system . An antenna is a device that transmits and/or receives electromagnetic waves. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. An antenna must be tuned to the same frequency band that the radio system to which it is connected operates in, otherwise reception and/or transmission will be impaired. The receiving antenna as a part in the system is responsible of turning the electromagnetic waves into its original form (electrical signal in wire). The properties of the transmitting and receiving antennas are fully represented by Maxwell's equations. The dipole antenna was the first type of antenna to be ever used and the simplest one to study and understand, it is a straight wire fed from the center. To tune the wire to be effective to transmit and receive electromagnetic waves, the length of it should be half the wavelength of the operating frequency. We can say that antennas are the backbone and almost everything in the wireless communication without which the world could have not reached at this age of technology.

2. MICROSTRIP PATCH ANTENNA

Microstrip antenna (also known as a patch antenna) is one of the latest technologies in antennas and electromagnetic applications. It is widely used now days in the wireless communication system due to its simplicity and compatibility with printed circuit technology. Microstrip geometries which radiate electromagnetic waves were originally contemplated in the 1950s.

The concept of microstrip antenna was first proposed by Deschamps in the year 1953. Gutton and Baissinot presented a patent in on the microstrip in the year 1955. Early microstrip lines and radiators were specialized devices developed in laboratories. No commercially available printed circuit boards with controlled dielectric constants were developed during this period. So, this antenna didn't become practical till 1970s when it was developed further by Robert E.Munson.Development during this decade was accelerated by other researchers by the availability of low-loss tangent substrate materials. Other factors for the development include improved photo lithographic techniques, better theoretical modelling and attractive thermal and mechanical properties of the substrate. The first practical antenna was developed by Munson and Howell. Since then extensive research and development of microstrip antennas and their arrays have led to diversified application within the broad field of microwave antennas

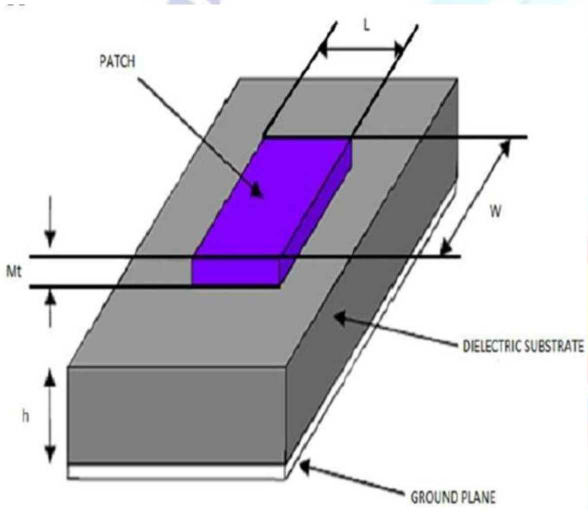

Fig: Structure of Microstrip patch antenna

Advantages of Microstrip patch antenna

- Low profile and light in weight and volume
- Low fabrication cost
- Can be produced by printed circuit technology
- Can be designed for both linear as well as Circularpolarization
- Can be designed for both dual or multi-frequency operations
- Planar, which can also be made conformal to a shapedsurface

3. FEEDING TECHNIQUES

The feed guides the electromagnetic energy from the source to the region under the patch. Some of this energy crosses the boundary of the patch and radiated into space. The signal in a microstrip patch antennas is fed by a variety of methods. The methods of feeding are categorized into two categories namely contacting and non-contacting. In the contacting method, the input radio frequency power is fed directly to the patch by a connecting element such as a microstrip line. In the non- contacting scheme, often regarded as indirect one, electromagnetic field coupling is done to transfer the power between them microstrip line and the radiating patch.

The four most popular feeding techniques are:

- ❖ Microstrip line feed
- ❖ Coaxial probe feed
- ❖ Aperture coupled feed

Proximity coupled feed

Microstrip Line feed

In this type of feed technique, a conducting strip is connected directly to the edge of the Microstrip patch. The conducting strip is smaller in width as compared to the size of the patch. This method is the easiest to fabricate as this feeding arrangement and radiating patch can be printed on same dielectric substrate. This arrangement provides a planar structure. Due to this advantage a large array may be designed using edge-fed patches

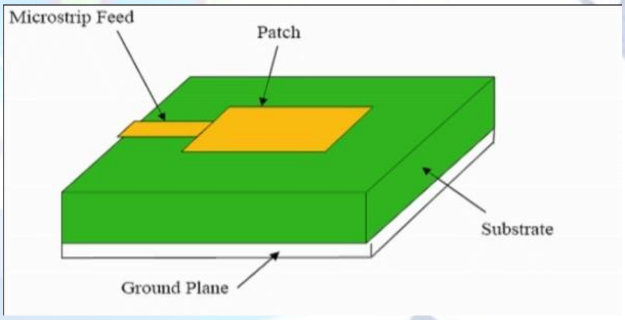

Fig: Microstrip Line Feed Technique

4. DESIGN PARAMETERS

There are several design parameters to design a microstrip patch antenna. They are

1. Resonant Frequency(fr)
2. Dielectric substrate (εr)
3. Substrate Height(h)
4. Lambda
5. Patch Length (L)
6. Patch Width (W)

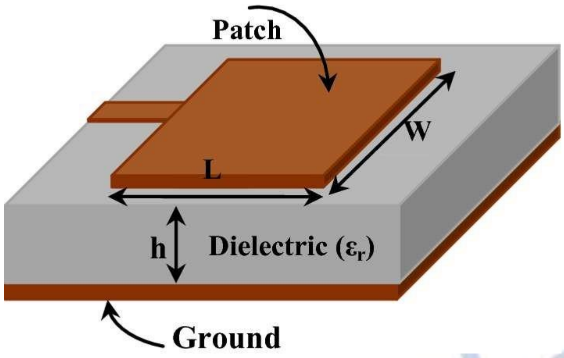

Fig: Construction of Microstrip patch antenna

5. DESIGN EQUATIONS

1.The effective dielectric constant of the substrate is

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

2.The width of the patch antenna,

$$W_{patch} = \frac{c}{2f_r\sqrt{\left(\frac{\varepsilon_r+1}{2}\right)}}$$

3.The effective length of the patch antenna ,

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}}$$

4. The extended length due to fringing fields,

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

5. The actual length of the patch antenna,

$$L_{patch} = L_{eff} - 2\Delta L.$$

6. METHODOLOGY

This section presents the steps that are includes in the layout of the proposed antenna design. The patch antennas are designed considering an Arlon AD270 (tm) substrate with a thickness of 1.5888mm and an estimated dielectric constant(εr) of
2.7 at an operating frequency of 4.4 GHz. The High Frequency Structure Simulator(HFSS) software is used to design and to plotthe results .

Design of Rectangular Microstrip Patch Antenna

In this design rectangular patch is connected to 50 Ω feed line and is excited using edge feeding technique.

Table 1: Dimensions of Rectangular MPA

Parameters(mm)	Rectangular Patch
Length of patch	20.01
Width of patch	25.06
Length of Ground Plane	29.5428
Width of Ground Plane	34.5928
Length of the Substrate	29.5428
Width of the Substrate	34.5928
Thickness of the Substrate	1.5888
Length of 50Ω Feedline	10
Width of 50Ω Feedline	2

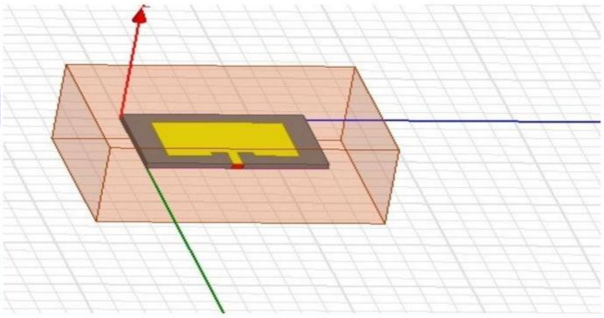

Fig: Rectangular Microstrip Patch Antenna

7. RESULTS

The propounded antennas are designed and simulated usingHFSS.

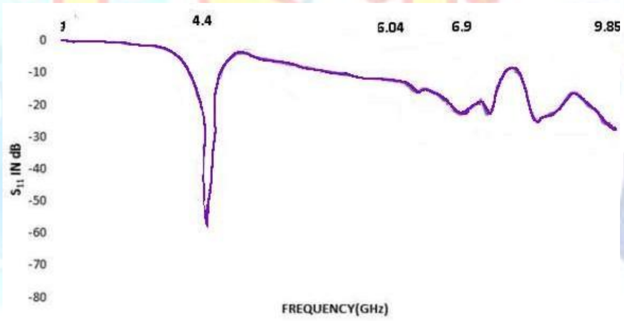

Fig: Return Loss Plot

Fig: Graphical Representation of Parameters

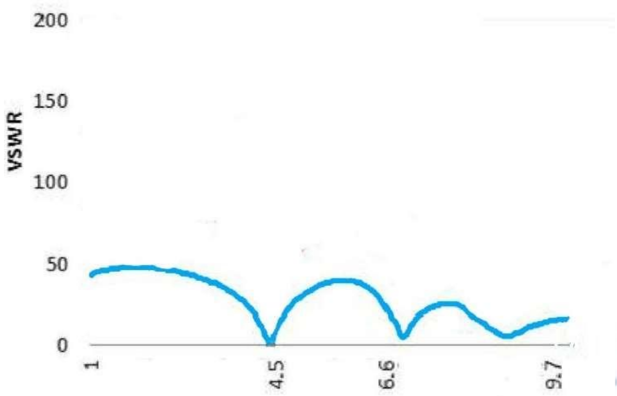

Fig: VSWR Plot

Table 2: Performance Analysis of 4.4 GHz MPA

Parameters	Rectangular Patch Antenna
Resonant Frequency (GHz)	4.4
Radiation Efficiency	0.95
Front to Back Ratio	18.735
Quality Factor	20
%Bandwidth	5.01%
Accepted Power	0.00972
Radiated Power	0.009297

The plot gives return loss at feed position where input to the patch antenna applied. Front to Back ratio of an antenna defined as the Power radiated in the desired direction to that of Power radiated in opposite direction which shows the performance of an antenna. Here the power radiated is 0.009297. The bandwidth of theantenna is 5.01% which is more accurate.

8. CONCLUSION

After designing and observing the performance analysis of various parameters of 4.4GHz Microstrip Patch Antenna (MPA), we can conclude that the rectangular patch antenna performs well at 4.4Ghz resonant frequency and it's bandwidth is also very sufficient to use this antenna in drone applications. About 95% of efficiency has been obtained by this MPA at 4.4GHz.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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