ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 6, June 2014

DUAL STAIRCASE SHAPED MICROSTRIP PATCH ANTENNA

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Abstract: The microstrip antenna finds its place in varied and upcoming technologies because it offers low profile, narrow bandwidth, high gain, and compact antenna element. The biggest disadvantage of microstrip antenna is its narrow bandwidth and poor impedance matching capacity. To make microstrip antenna compatible with commercial applications, the bandwidth enhancement and impedance matching of such antennas has to be done. The impedance matching of antenna depends upon type and position of the feed because impedance matching of source at the feeding point of antenna is very important for efficient operation of antenna. In order to improve the impedance matching a dual staircase shaped microstrip patch antenna is used in this paper. The dual staircase patch is fed with a coaxial feed technique. By using IE3D software, the simulated results gives good impedance matching and the bandwidth obtained is 6% at 3.79GHz frequency. The proposed antenna which comes under S-Band (2-4GHz) of microwaves can be used in RADAR applications like weather radar, surface ship radar, and some communications satellites.

Keywords: Microstrip Patch Antenna, Coaxial Probe feed, IE3D, Return Loss.

1. INTRODUCTION

Due to their many attractive features, microstrip antenna has drawn the attention of researchers over the past work. Microstrip antennas are used in an increasing number of applications, mostly in communications[4].

Microstrip antennas were not used popularly in early 1970s due to the major drawback that these antennas were low in efficiency, low power, poor polarization purity, poor scan performance and very narrow frequency bandwidth (less than 5%). With the evolution of design techniques on microstrip technology, current microstrip antenna can achieve a bandwidth of 30% or more. That‟s the reason why these antennas are more popular in this modern world. These are used in high performance and sized constrained applications. These are mechanically robust when mounted on rigid surfaces and very versatile in terms of resonant frequency, polarization, pattern and impedance match.

Research on microstrip antenna aims to size reduction, increasing gain, wide bandwidth, multiple functionality and impedance matching. Significant research work has been reported on increasing the gain and bandwidth of patch antennas. Many techniques have been suggested for achieving wide bandwidth and impedance matching [5-6]. There are numerous and well-known methods to increase the gain of antennas, including decrease of the substrate thickness, feeding techniques [7-8].

1.1 Microstrip Antenna

The patch of microstrip antenna thickness is very thin in the range of $t << \lambda_0$ (λ_0 is free space wave length) and the height h of dielectric material is between $0.003\lambda_0 < h < 0.05\lambda_0$. For a rectangular path, the length L of the element is usually $\lambda_0/3 < L < \lambda_0/2$. There are numerous substrate that can be used for the design of Microstrip antenna, and their dielectric constants are usually in the range of $2.2 < \varepsilon_r < 12$, where ε_r is relative dielectric constant. The substrate whose size is thick and dielectric constant is in the range of lower end provides better efficiency and bandwidth; but it expenses large element size.

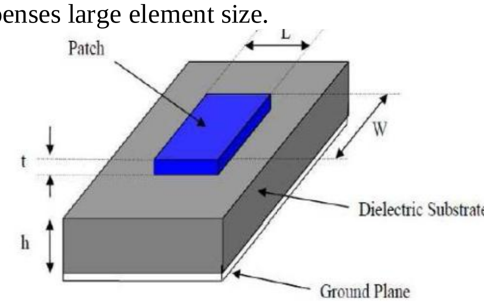


Fig 1 Rectangular Microstrip patch antenna

1.2 Need and Significance of Research

The input impedance matching of microstrip patch antenna actually depends on type and location of feed because

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

impedance matching of source at the feeding point of antenna is very important for its efficient operation. But as mentioned earlier it‟s not a cake walk for a simple microstrip antenna. To solve this problem we are proposing a dual staircase shaped microstrip patch antenna.This antenna is fed with coaxial feed.Also one really worthy advantage of coaxial probe feed is that it has the flexibility to place the feed anywhere on the patch in order to match the input impedance. This gives an easy fabrication and has low spurious radiation. Finding the best feed position is not an easy task, now which is made easy and achievable by IE3D software. In this research, the proposed model is used to estimate the parameters: Return loss (S11), resonant frequency (fr), directivity by using IE3D simulation software with good results.

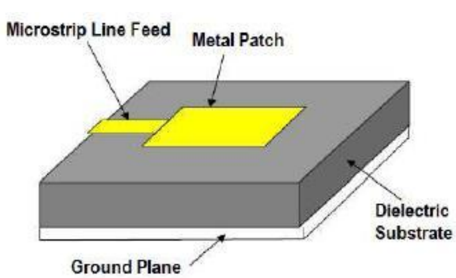
2. FEEDING METHODS (ANALYSIS TO IMPROVE IMPEDANCE MATCHING)

There are several techniques available to feed or transmit electromagnetic energy to a microstrip patch antenna which effects positively to match the impedance with source. But first two are mostly used.

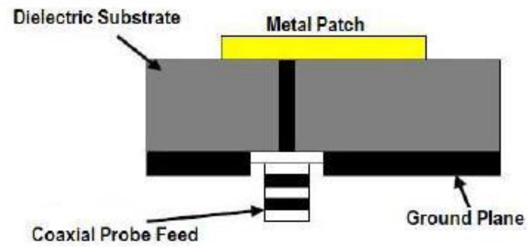
a) Microstrip line feeding.
b) Coaxial cable or probe feeding.
c) Aperture Coupled Feed.
d) Proximity coupling Feed.

a) Microstrip Line Feeding

In this type of feed technique, a conducting strip is connected directly to the edge of the Microstrip patch as shown in Figure 2.1 (a). The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used increases, the surface waves and spurious feed radiation also goes up, which hampers bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation.



(a)



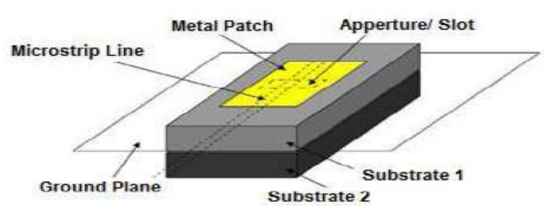
(b)

Fig 2.1 Rectangular Microstrip patch antenna with (a) Inset Line Feeding, (b) Coaxial Probe Feeding.

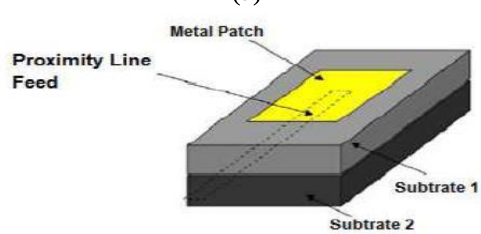
b) Coaxial Cable or Probe Feeding

The Coaxial feed or probe feed is a very common technique used for feeding microstrip patch antennas. As seen from Figure 2.1 (b), the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location on the patch in order to match with its input impedance. However, its major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates ($h > 0.02\lambda o$). Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leads to matching problems. The main aim to use probe feeding is enhancing the gain, narrow bandwidth and impedance matching.

c) Aperture Coupled Feed



(a)



(b)

Fig 2.3 Rectangular Microstrip patch antenna with (a) Aperture coupled, (b) Proximity coupled Feeding.

This feeding technique consist of two substrate separated by

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International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 6, June 2014

a ground plane. Microstrip feed line is connected below bottom substrate whereby electromagnetic energy is coupled with the radiating patch through the aperture slot as shown in fig 2.3 (a). Matching is done by adjusting the width of feed line and the slot‟s length.

d) Proximity Coupled Feed

It is non-conducting coupling technique which offers the opportunity to reduce the feed line radiation and provides very high bandwidth (as high as 13%). while maintaining a relatively thick substrate for the radiating patch as shown in fig 2.3 (b).

3. DESIGN OF DUAL STAIRCASE SHAPED MICROSTRIP PATCH ANTENNA

The topological shape of the patch resembles the staircase shape hence the name "Staircase shaped patch antenna" is given. Significant reduction of antenna size can be realized when the staircase shaped patch is used instead of the conventional rectangular microstrip patch antenna. The slot length and width are important parameters in controlling performance of the staircase shaped patch antenna. The slot length and width of the antenna should be carefully selected to get the optimized performance of the staircase shaped patch antenna.

The following figure shows the structure of dual staircase shaped microstrip patch antenna.

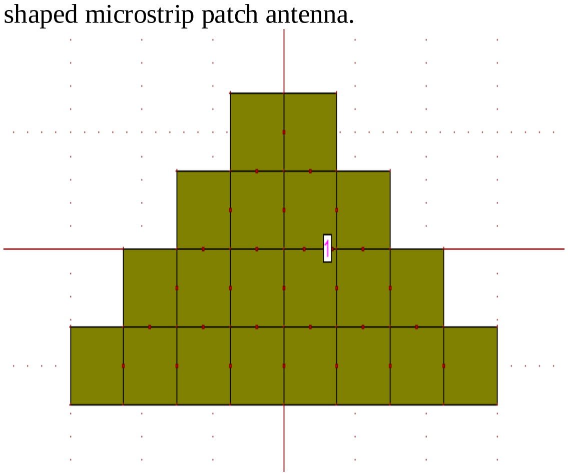

Fig3.1Dual staircase shaped patch antenna

3.1 Design Specifications:

The three essential parameters for the design of a rectangular Microstrip Patch Antenna are[3]:

• Frequency of operation (f_o): The resonant frequency of the antenna must be selected appropriately. The Mobile Communication Systems uses the frequency range from 1800-5600 MHz. Hence the antenna designed must be able to operate in this frequency range. The resonant frequency selected for my design is 3.79 GHz.

• Dielectric constant of the substrate (εr): The dielectric material selected for my design is silicon which has a dielectric constant of 2.55. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.

• Height of dielectric substrate (h): For the microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.59 mm.

Hence, the essential parameters for the design are:

- fo = 3.79 GHz
- εr = 2.55
- h = 1.59 mm

The dual staircase shaped microstrip patch antenna has been designed with over all dimensions W (mm) x L (mm) i.e., length of 30mm and width of 20mm.

3.2 FEEDING:

In this paper coaxial probe feed is used. Coaxial-line feed, where the inner conductor of the coax is attached to the radiation patch while the outer conductor is connected to the ground plane, are widely used. The coaxial probe feed is easy to fabricate and match, and it has low spurious radiatoion. However it has narrow bandwidth and somewhat difficult to model for thick substrates(h>0.02----)[1]

4. RESULTS

The antenna is designed by using IE3D software of Zeland Software Inc. The simulated results are shown in the following figures.

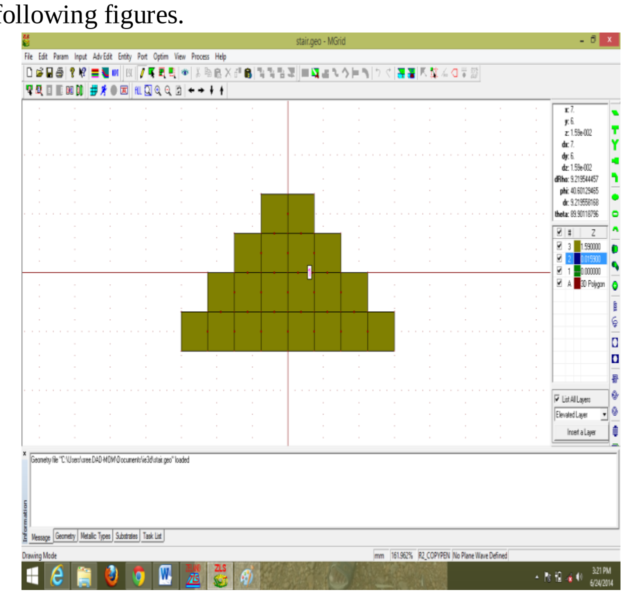

Fig4.1 Designed Patch

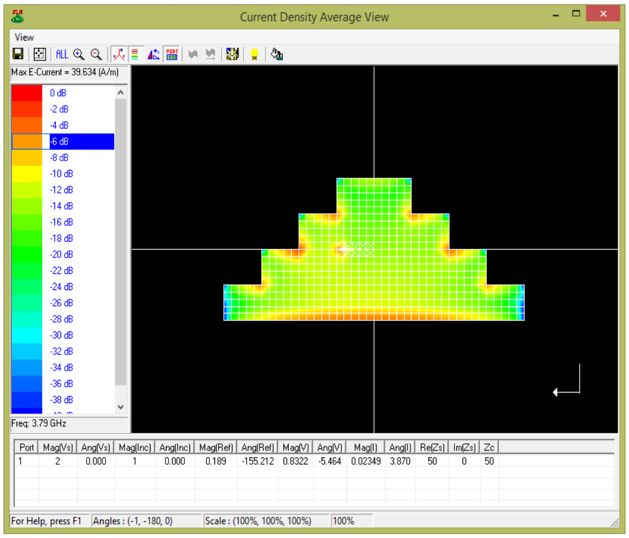

Fig4.2 Current Distribution

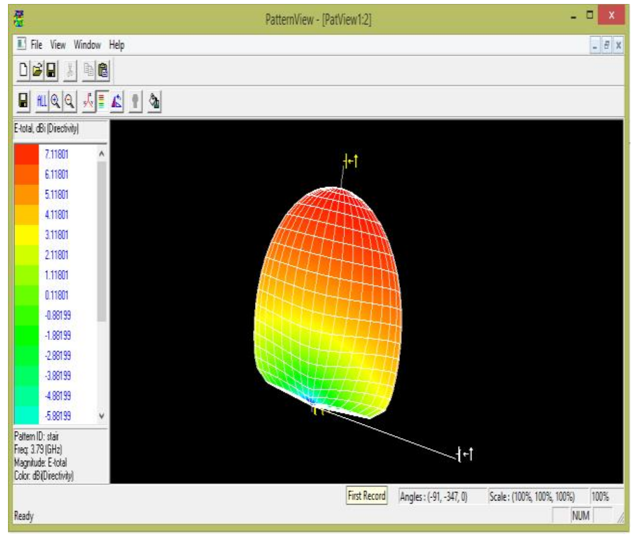

Fig4.5 Radiation Pattern (3D)

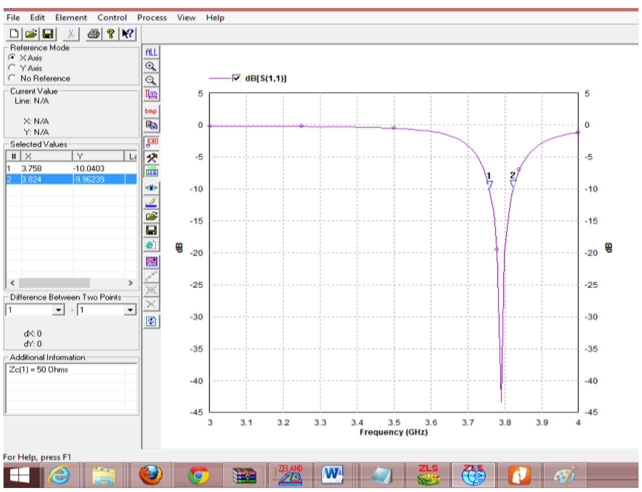

Fig4.3 Return Loss (for 3-4GHz)

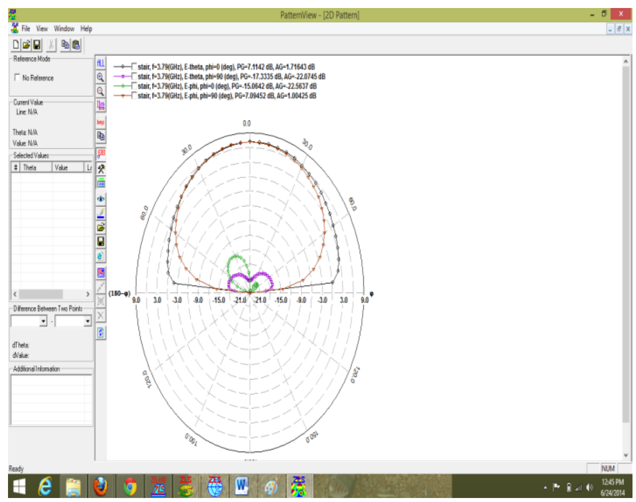

Fig4.6 2D Pattern

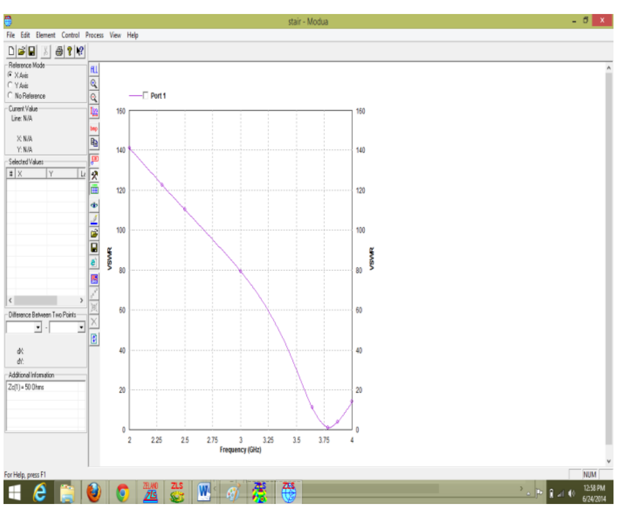

Fig4.4 VSWR Measurement

5. CONCLUSION

Hence a dual staircase shaped patch antenna is designed by using IE3D software for communications. The proposed S-Band patch antenna has a wide range of RADAR and Communication applications .It consists of a staircase patch on a dielectric substrate. Impedance, Gain, Bandwidth and radiation patterns have been computed over a frequency at 3.79GHz. From the data analysis, it has been pointed out that the patch designed by IE3D software gives good result in impedance matching and the bandwidth (6%). As demonstrated by the design, a dual staircase shaped patch antenna at 3.79GHz has been successfully simulated using IE3D. These results are better when we compare with the some existing different shapes of microstrip patch antennas. The future work of this paper is to extend the design for different shapes for good results in all parameters like bandwidth, gain, efficiency etc.

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