Rectangular Patch Antenna for High Gain and Vertical Polarization

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Abstract- **A microstrip rectangular patch antenna is designed which is having vertical polarization at endfires. This antenna is designed on long rectangular microstrip patch having periodic shorting-vias along both sides of its length and at both end of patch. The antenna satisfies the requirements of low profile antenna where there are limited choices like PIFA in case of monopoles. Basically this design will generate two different resonant modes when we add columns of shorting-vias along the longitudinal direction. Complete design gives 2-8 dB gain improvement as compared to semi shorted patch. Addition of second resonant frequency will ultimately result in gain improvement.**

Keywords- microstrip antenna, PIFA, low profile, shorting-vias, high gain.

I. INTRODUCTION

Microstrip antennas are popular for their low cost, light weight, easy fabrication, mass production [2]. These advantages employed microstrip antennas from rockets and missiles in early days to mobiles and GPS in modern era. Another important parameter related to antenna is its profile which deals with height and width of antenna. It is significantly high in conventional antennas like monopoles [1] which can radiate with linear polarization and maximum radiation at endfires. While microstrip antennas have significantly low height and width and also parallel polarization and broadside radiation [2]. This low profile property makes them suitable for critical applications.Some designs also employ circular patch to achieve monopolar radiation but results in low gains. So this situation introduces certain trade-offs like size and compactness vs. broadside radiating nature [3][4], profile vs. bandwidth [5], and omnidirectional radiating nature vs. gain. The long rectangular microstrip with single feed can have bandwidth of nearly 4% [3]. This statistics can be improved by several percent by employing thicker substrates. But the resulting antennas may not give us satisfactorily low profile which is mandatory in some applications allowing low profile space and thus vertical polarization.

The main aspect of this antennadesign is introduction of shorting-vias along the width and length of stem. There are two main purposes of introducing shorting pins in any design. First is, shorting pins partly suppress the excitation to the patch and thus radiation in particular directions. So if we have to suppress radiation in any specific directions and thus modify resulting radiation pattern, we can introduce shorting pins at particular places and vary the location of co-axial feeding. Another purpose of shorting pins is it can give multi-frequency radiation.

So, in this paper, a microstrip antenna is discussed which is having low profile and thus allowing linear polarization at endfires.Also the antenna gives nearly 3 dB higher gain than that of monopolar circular patch[1].

II. ANTENNA DESIGN

This antenna is designed in two parts.

A. Design for single radiating frequency:

In this step the shorting-vias are added along the width of the antenna only. The design schematic of this antenna is shown in fig. 1(a). The design specifications are as follows. The length of patch L(the distance between two columns of shorting-vias) = 62.4 mm, width of patch W = 30.4 mm. The antenna is designed on FR4_epoxy substrate which has relative permittivity ε_r= 4.4. The thickness of substrate i.e. the height of antenna h = 1.59 mm. Thedimensionsofshorting-vias' are d = 0.6 mm, period $p1$ = 3 mm. For feeding of antenna, there are several methods such as strip-line feeding, microwave feeding, and co-axial feeding. But as this antenna has shorting pins around its circumference, so we have chosen co-axial feeding technique. Antenna is fed at center with 50Ω co-axial probe. Fig. 1 (b) shows longitudinal equivalent circuit for the same antenna. The antenna works as resonant circuit in longitudinal direction because of the shorting columns at the ends of patch. The antenna works in TM_{12} mode along with respect to z-direction.

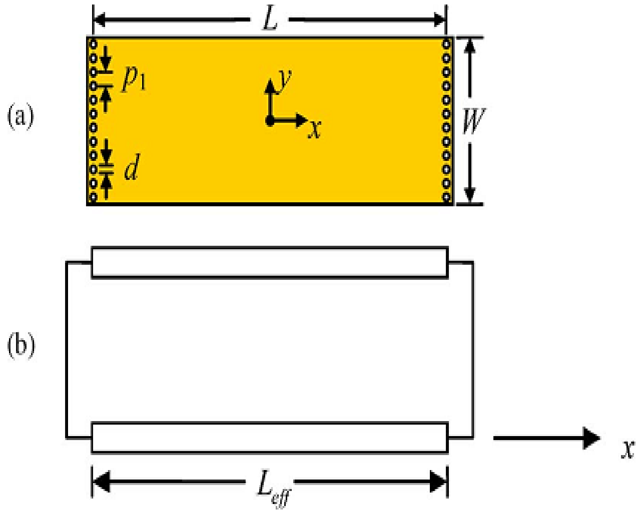

Fig. 1.(a) Design of rectangular patch antenna with shorting-vias at both ends (b)Longitudinal equivalent circuit

B. Design for Dual radiating frequency:

In second part of designing, additional shorting-vias are added along the longitudinal direction of stem. The complete schematic of design is as shown in fig 2. It also shows side view of the antenna design. Additional measurements in the design are s = 16.8 mm, period p = 7.8 mm while all other measurements are kept unchanged. These longitudinal shorting pins actually provide the additional gain and multi-frequency behaviorto the existing design of part I. The additional columns of shorting pins are added at $y = \pm s/2$. This gives another resonant mode TM_{10} along with the existing TM_{12} mode of previous design. So, by adjusting the period p we can adjust the resonant frequency for TM_{10} mode which will give the improvement in antenna gain.

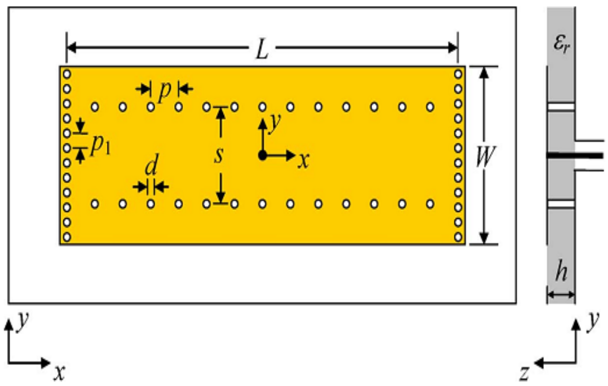

Fig. 2. Full geometry of antenna with shorting columns along the lengths

Fig. 3 shows the design of antenna in HFSS. The design has 20 shorting-vias along the width and two columns along the patch length with 8 shorting-vias in each. All of them are arranged symmetrical with respect to origin.

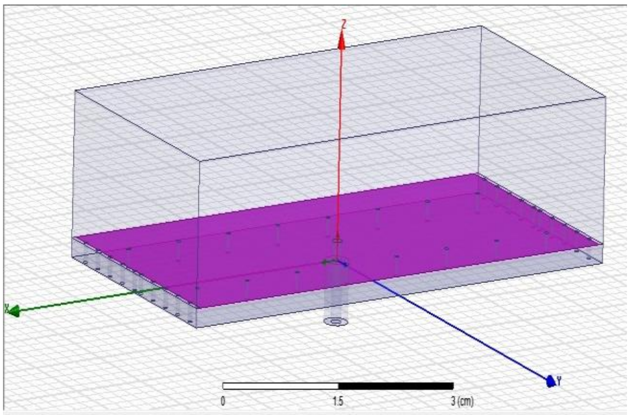

Fig. 3. Design of antenna in HFSS

III. SIMULATION RESULTS AND DISCUSSIONS

The design of antenna is performed and simulated inAnsoft HFSS (High Frequency Structure Simulator) software. As discussed earlier, the antenna has been simulated in two different steps, so that we can compare the results produced by these designs. For design results of A i.e. the graph of S_{11}parameter and VSWR are shown in fig.4 and fig.5 respectively.

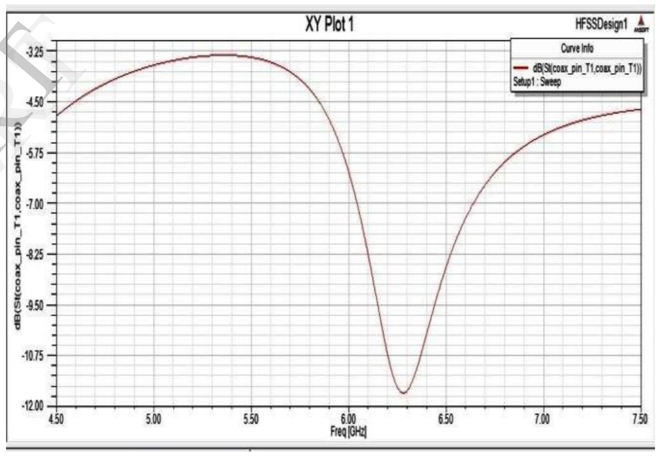

Fig. 4. S_{11} parameter graph for one radiating mode design

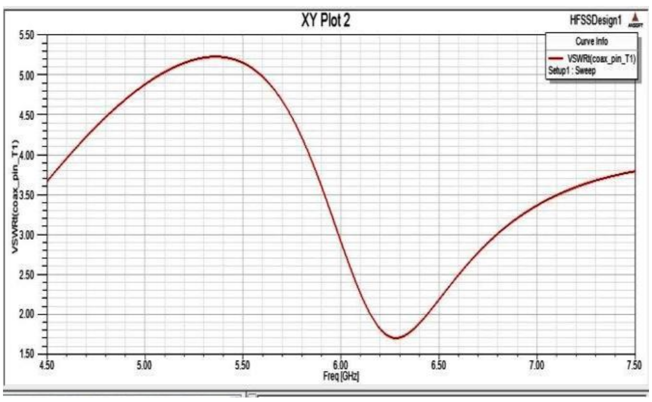

Fig. 5.VSWR graph for one radiating mode design

The graph of S_{11} parameter shows return loss for TM_{12} radiating mode. The design gives S_{11}parameter below -10 dB for frequency 6.26 GHz. The value of VSWR for the same frequency is 1.69. Fig.6 shows radiation pattern of this configuration.

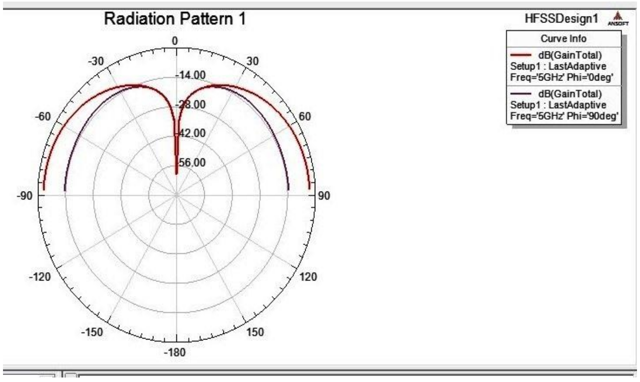

fig. 6. Radiation pattern for one radiating mode design

All these parameters are also found out for part B configuration.

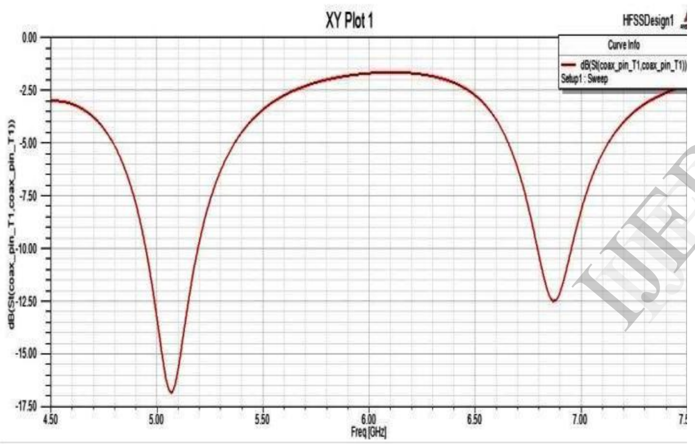

Fig. 7.S_{11} parameter graph for two radiating modes design

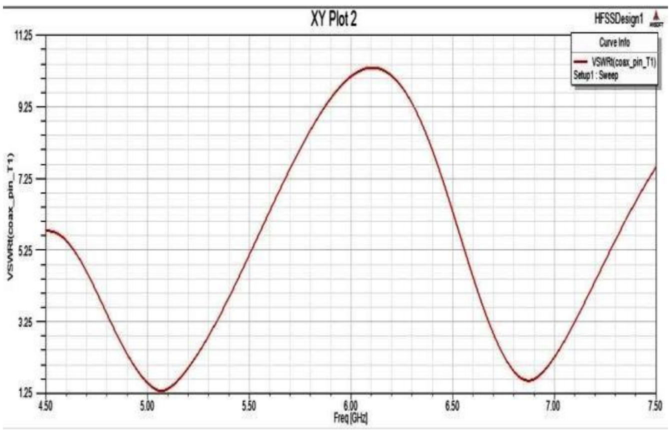

Fig. 8. VSWR graph for two radiating modes design

Fig. 7 and fig. 8 respectively show S_{11} parameter and VSWR for two radiating modes configuration. As shown in graph, value of S_{11} parameter drops down to -13dB at 6.86GHz. Also more importantly, we get another frequency 5.10 GHz where the value of S_{11} parameter is observed to be -17 dB. Also we get VSWR equal to 1.25 for this another radiating frequency with TM_{10} mode. This additional frequency band is added due to incorporation of shorting-vias along the longitudinal direction of antenna. Also we get more stabilized values of S_{11} parameter and VSWR for TM_{12} mode

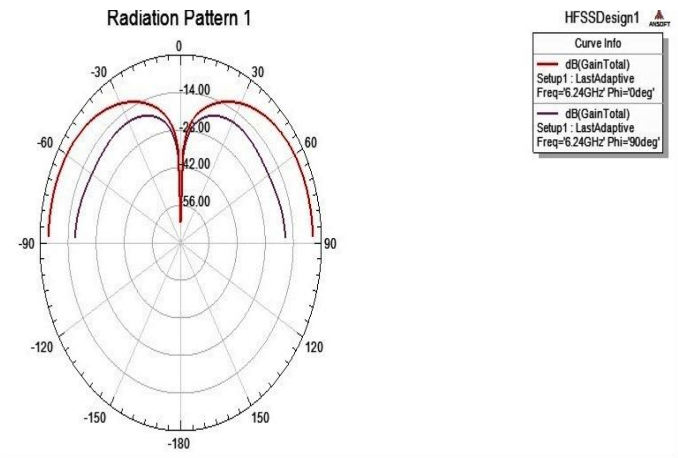

Fig. 9. Radiation pattern for two radiating modes design

Radiation pattern for configuration with two radiating modes is shown in fig. 9. To elaborate the difference between gains of both configurations, we consider following graphs in fig. 10.

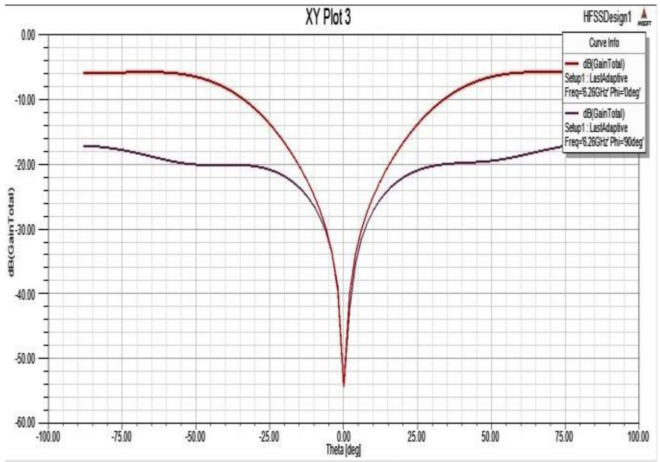

Fig. 10. (a) Gain plot for one radiating mode configuration

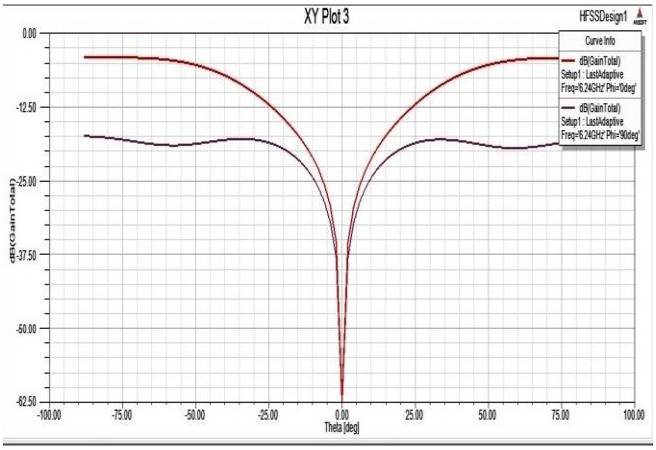

Fig. 10. (b) Gain plot for two radiating mode configuration

By comparing both the graphs, we understand that, the gain has been improvised by nearly 8.5 dB at θ = 0°. Also thereafter, gain of antenna is improvised by nearly 2-3 dB.

IV. CONCLUSIONS

In this paper, a rectangular patch antenna with shorting-vias and dual radiating modes is studied. The antenna is designed for two stepwise configurations. For shorting-vias along only width of antenna which gives only one radiating frequency i.e. 6.26 GHz. But after addition of shorting-vias in longitudinal direction, it is observed that first frequency is shifted to 6.86 GHz and we get second radiating frequency at 5.1 GHz. The antenna finds its applications in weather monitoring systems, RADAR communication, Wi-Fi devices etc. The gain of antenna is improvised by nearly 2dB- 8.5 dB.These parameters are discussed based on the simulation results created using HFSS tool.

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