Semi-Circular Micro Strip Patch Antenna for Multi-Frequency Application

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Abstract
A Semicircular Microstrip patch antenna is simulated. Three different bands of operation are achieved. All the bands of operation are independent to each other. All the bands have good Return Loss, VSWR and Radiation resistance. The outer dimensions of the patch are designed so that the antenna resonates at the lower resonant frequency. The dimensions of the slots are designed to control the upper resonant frequency and the bandwidth. Some other circular and semi circular antenna are also simulated for a thorough characterization of the antenna.

Keywords
Single Band, Dual Band, Multi Band, Waveport, Microstrip Patch Antenna

I. Introduction

Modern day communication devices are required to smaller in size and should be able to perform various functionalities. The antenna used in these communication systems should possess multi frequency capabilities but should be compact and less bulky. The most common antenna used for this purpose is the microstrip patch antenna because of their less bulkiness, low cost and easy to fabricate.

It is observed that the superstrate permittivity has significant effect on the resonant frequency and half power bandwidth. This effect is dominant when the superstrate permittivity is higher as compared to the substrate material [1]. In order to achieve higher order of miniaturization, shape modification process was used which drastically reduced the antenna efficiency, without any significant effect on the directivity. On the other hand, if relative permittivity is varied with a principal patch shape, directivity remains unchanged as well. (Principal patch shape and relative permittivity has no effect on directivity). If other parameters of antenna are to be varied then the combination of shape modification and high permittivity substrates is a primary technique rather than using then either alone [2]. For cellular communication system dual band antennas were designed which can be made to work with a single input port by electrically shorting the radiating element, which proved to have good decoupling between two radiating element due to the reduction of electric field by three to four times of the non resonant element than that of resonant one [3]. Further developments in the design of circular microstrip antenna which was when feeded from an open ended coplanar waveguide proved that the parameters of the antenna are similar to rectangular microstrip antenna [4]. Wide investigation on the circular patch microstrip antennas have proved them to be light weight, small dimension and can be easily manufactured compared to the parabolic ones. The gain of these antennas can be increased by increasing the number of elements and also by changing parameters like substrate thickness, tangent loss and dielectric constant [5]. Apart from circular patch antenna, research is ongoing towards the semi circular feeding structures with multilayer structure showing improved impedance bandwidth and also reduced effect of ground plane [6]. For multi frequency applications antenna with inner semi circle and a number of external semi circular rings have been developed with the advantage of generation of new excitation modes which can be used in radiation, due to which the radiation efficiency of the antenna is improved [7].

II. Proposed Work

In this paper a semicircular antenna with three semi circular rings has been simulated. In order to achieve similar parameters as that of rectangular microstrip antenna, microstrip waveport feeding has been used. By using waveport feeding the connection of shunt or series components are on the same side of a substrate which eliminates the requirement of holes in the substrate resulting in low leakage radiation [4]. The substrate available for fabrication in the market is of 50mm × 50mm size. In future, the hardware implementation can be easily done using the same available substrate. The simulations were carried out using HFSS 11 environment. The antenna resonates at three different frequencies of 1.71 GHz, 1.96 GHz and 2.41 GHz which can be used for various wireless communication systems.

III. Simulated Examples

A. Circular Patch Antenna

First of all, a basic circular microstrip antenna is presented. This is a single band antenna with a radius of 10 mm. Waveport feeding is used for the excitation of the antenna. The substrate dimensions are 50 mm x 50 mm x 1.6 mm. The relative permittivity of the substrate is 4.4 and resonant frequency of the antenna is 1.65 GHz as shown in the Fig. 1 (a), (b), (c) and (d).

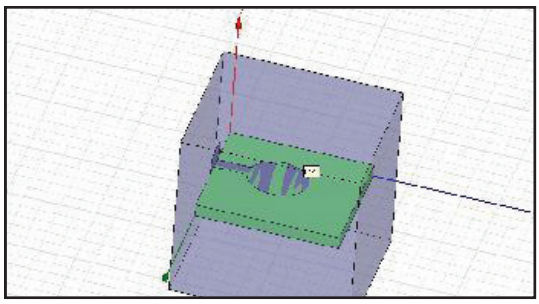

Fig. 1(a): Circular Patch Antenna.

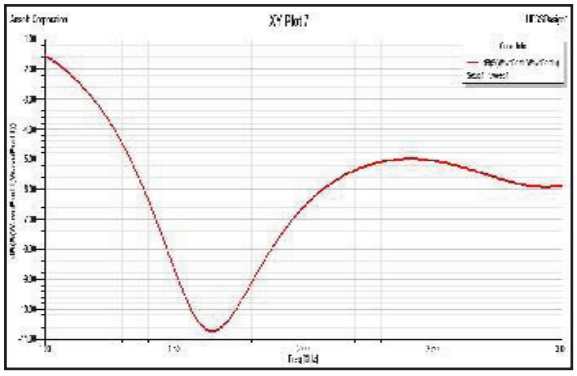

Fig. 1(b): Return Loss parameter V/s Frequency

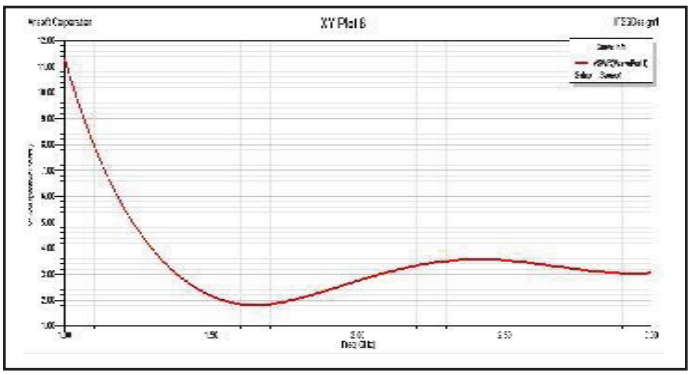

Fig. 1(c): VSWR V/s Frequency.

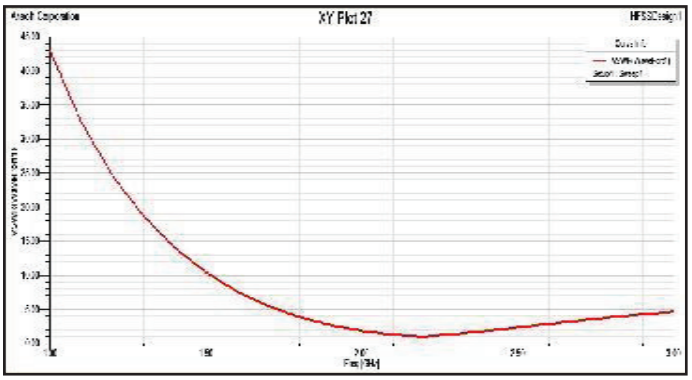

Fig. 2(c): VSWR V/s Frequency

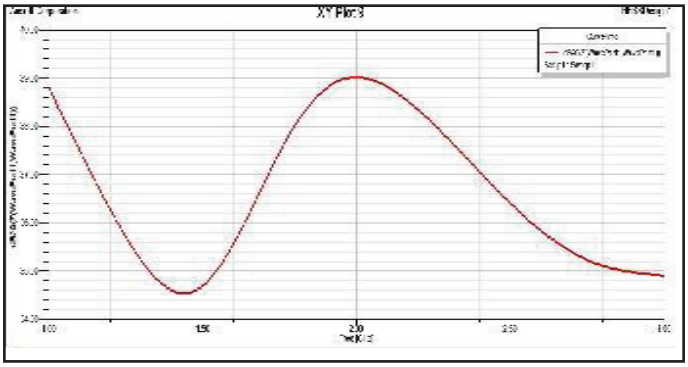

Fig. 1(d): Impedance V/s Frequency.

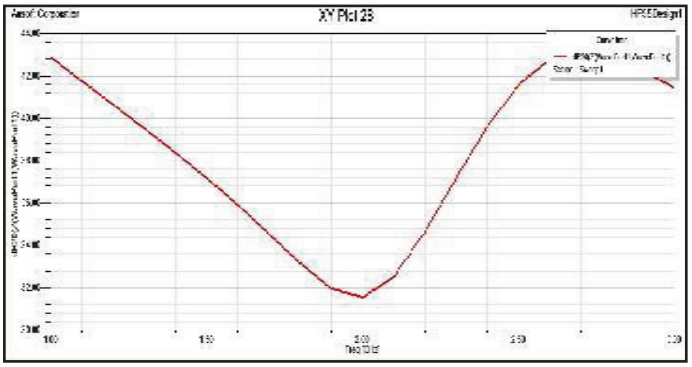

Fig. 2(d): Impedance V/s Frequency.

B. Semi circular Patch Antenna

To reduce the size of the antenna a semi circular antenna is presented. This is also a single band antenna with a radius of 20 mm. Waveport feeding is used for the excitation of the antenna. The substrate dimensions are 50 mm x 50 mm x 1.6 mm. The relative permittivity of the substrate is 4.4 and the resonant frequency of the antenna is 2.2 GHz as shown in the Fig 2 (a), (b), (c) and (d).

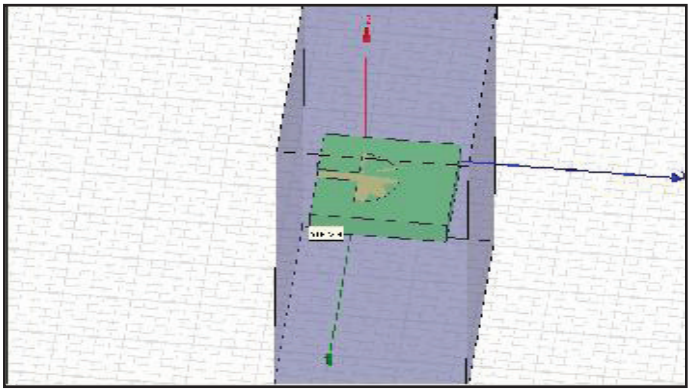

Fig. 2(a): Semi Circular Patch Antenna

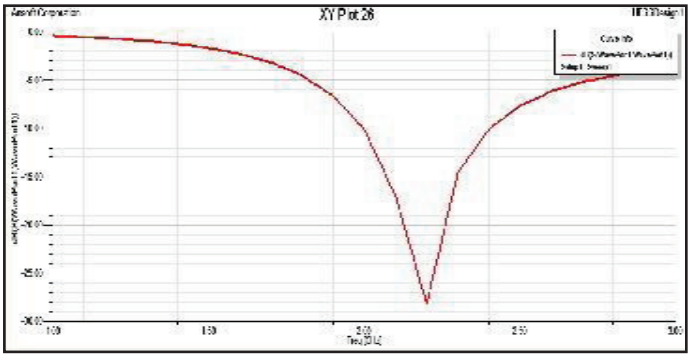

Fig. 2(b): Return Loss parameter V/s Frequency.

C. Semi circular Patch Antenna With One Semi Circular Ring

To introduce dual band properties a semi circular arc is introduced in the semicircular antenna. This is a dual band antenna with a radius of 20 mm and the semicircular arc has a radius of 19 mm with a gap of 1 mm. Waveport feeding is used for the excitation of the antenna. The substrate dimensions are 50 mm x 50 mm x 1.6 mm. The relative permittivity of the substrate is 4.4 and the resonant frequencies of the antenna are 2.1 GHz and 2.6 GHz as shown in the Fig. 3 (a), (b), (c) and (d).

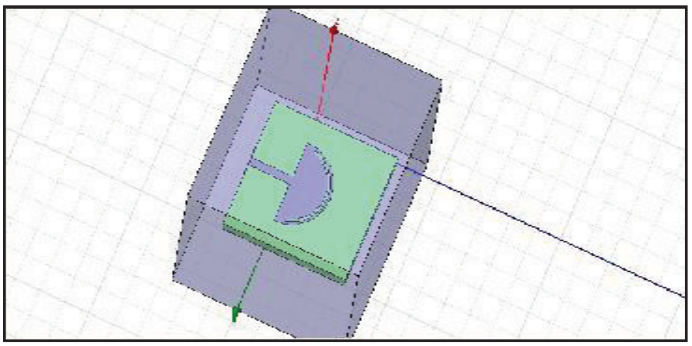

Fig. 3(a): Semi Circular Patch Antenna with one semi circular ring.

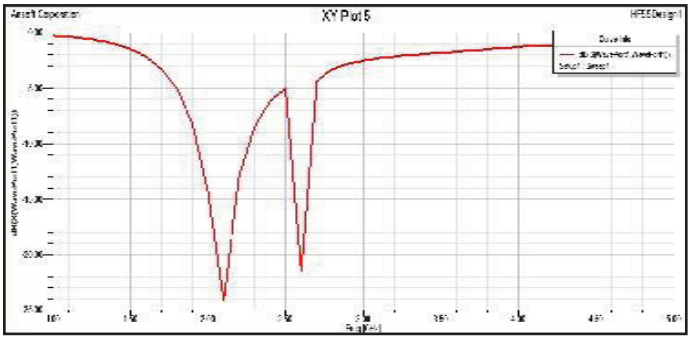

Fig. 3(b): Return Loss parameter V/s Frequency

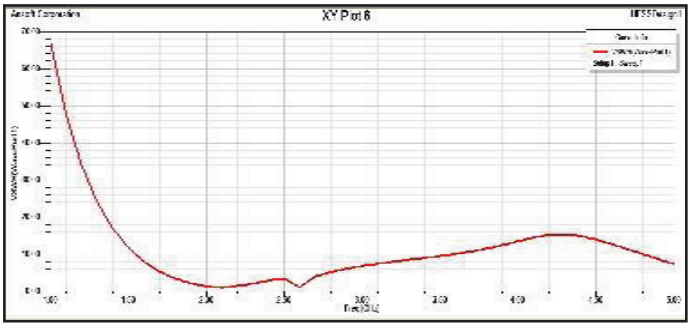

Fig. 3(c): VSWR V/s Frequency.

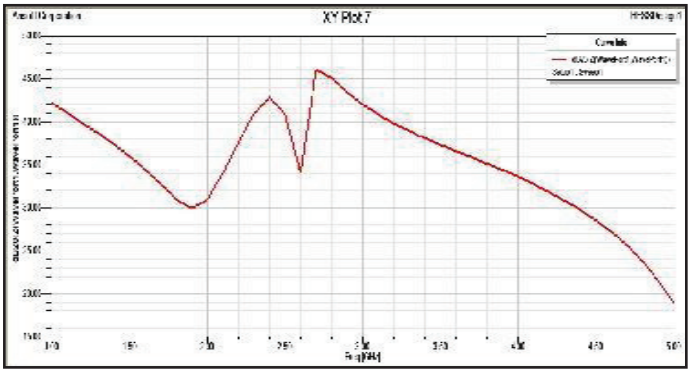

Fig. 3(d): Impedance V/s Frequency.

D. Semi Circular Patch Antenna Eith Two Semi Circular Rings

To introduce more prominent dips one more semi circular arc is introduced in the semicircular antenna. This is a dual band antenna with a radius of 20 mm and the semicircular arc has a radius of 19 mm and 17 mm with a gap of 1 mm each. Waveport feeding is used for the excitation of the antenna. The substrate dimensions are 50 mm x 50 mm x 1.6 mm. The relative permittivity of the substrate is 4.4 and the resonant frequencies of the antenna are 1.86 GHz and 2.13 GHz as shown in the Fig. 4 (a), (b), (c) and (d).

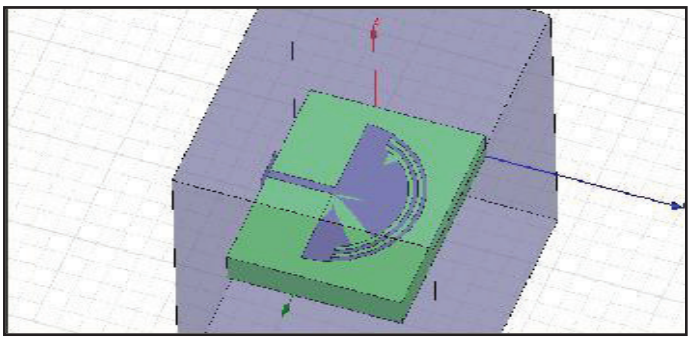

Fig. 4(a): Semi Circular Patch Antenna with two semi circular ring.

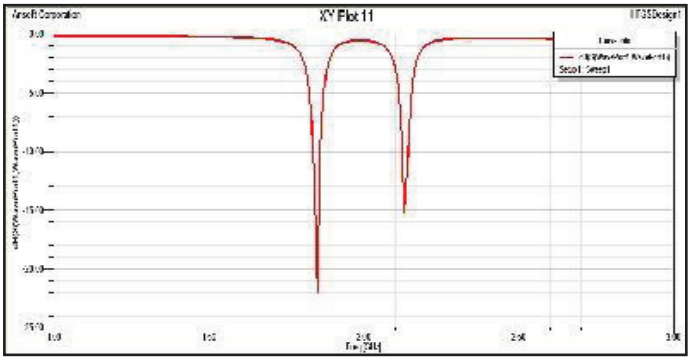

Fig. 4(b): Return Loss parameter V/s Frequency.

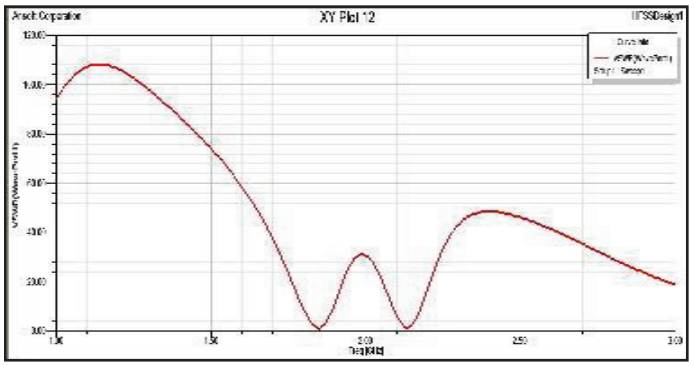

Fig. 4(c): VSWR V/s Frequency

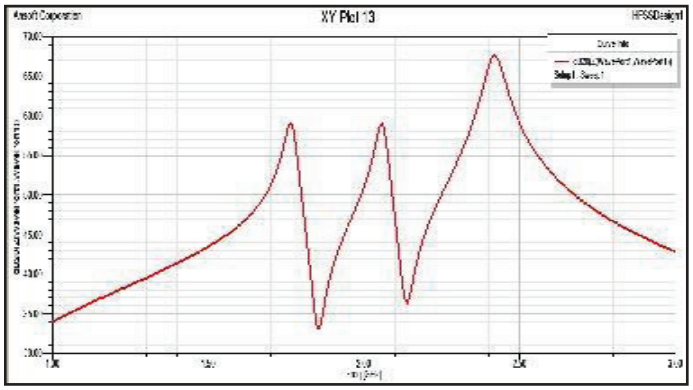

Fig. 4 (d) Impedance V/s Frequency.

E. Semi circular Patch Antenna with three semi circular rings

To introduce triple band of operation one more semi circular arc is introduced in the semicircular antenna. Now there are all total three arcs in the antenna. This is a triple band antenna with a radius of 20 mm and the semicircular arc has a radius of 19 mm, 17 mm and 15 mm with a gap of 1 mm each. Waveport feeding is used for the excitation of the antenna. The substrate dimensions are 50 mm x 50 mm x 1.6 mm. The relative permittivity of the substrate is 4.4 and the resonant frequencies of the antenna are 1.71 GHz, 1.96 GHz and 2.41 GHz as shown in the Fig. 5 (a), (b), (c) and (d).

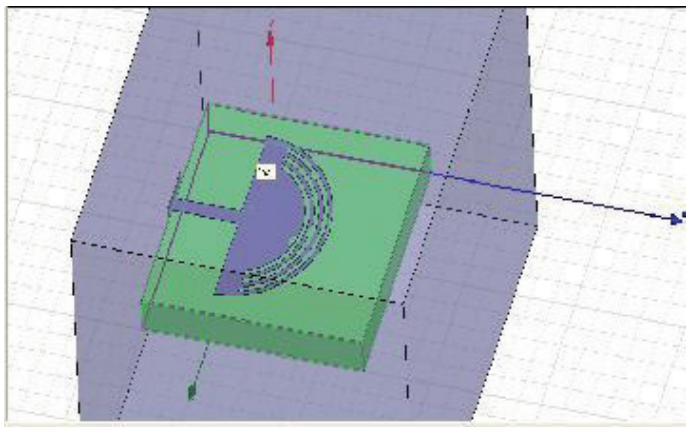

Fig. 5(a): Semi Circular Patch Antenna with two semi circular ring.

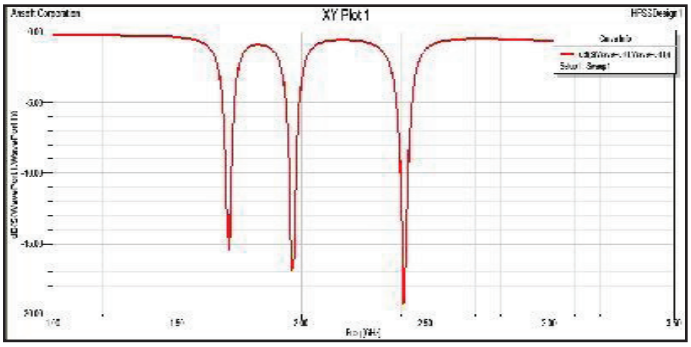

Fig. 5(b): Return Loss parameter V/s Frequency

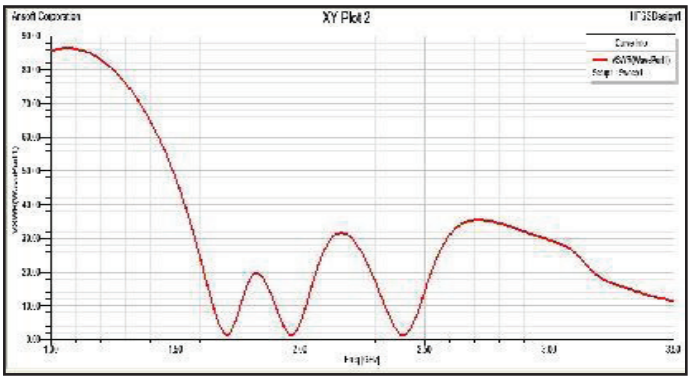

Fig. 5(c): VSWR V/s Frequency

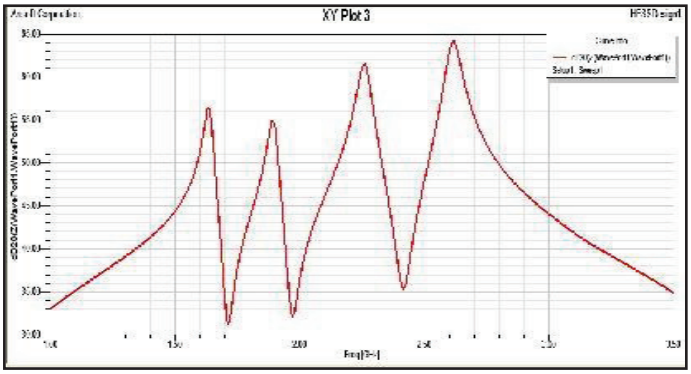

Fig. 5(d): Impedance V/s Frequency.

IV. Conclusion

A compact semicircular microstrip antenna is presented in this paper which is capable of producing triple band of operation depending on the application. The antenna has multiple semi circular arcs to produce dual and triple band of operation. Five different antennas have been simulated. The first was a circular antenna with single band operation. The second was a semi circular antenna with single band operation. The third was a semicircular antenna with a semicircular arc with a dual band operation. The forth was a semicircular antenna with two semicircular arcs with more prominent dual band operation. And the last was a semicircular antenna with three semicircular arcs with triple band of operation. These five examples were studied with simulations in terms of return loss, VSWR and impedance with waveport feeding technique.

V. Acknowledgment

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