

Design of Coaxial fed Circular Patch Antenna

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ABSTRACT: The paper is aimed at building a circular patch antenna which is fabricated on FR4 substrate. The antenna works on frequency range of 2.4GHz. Common design equations of a circular patch are used in implementation of antenna. The paper also includes a method for finding a proper feed point for a circular patch. Implementation of a coax feed is also described in the paper along with design of coax SMA connector. The design is simulated in CST Microwave Studio and verified the output. Proper design methodology of circular patch is also mentioned in the paper.

KEYWORDS: Antennas, CST, Patch Antenna, Coaxial Connector, 2.45 GHz

I. INTRODUCTION

A patch antenna is fabricated on FR4 substrate. Other substrates can also be used but FR4 is used widely due to its availability. The patch is fabricated using lossy copper material. A ground plane is also fabricated on the opposite face of the FR4 substrate. The presence of a ground plane improves the gain of the antenna. The ground plane is also fabricated using lossy copper. The dimensions of the patch antenna to be fabricated depends on the frequency of operation of antenna.

II. SOFTWARES USED

- CST Microwave Studio – For simulation
- Python 3 – Implemented a script which calculates the patch radius which is used for accurate calculations

III. DESIGN METHODOLOGY

Parameters for design:

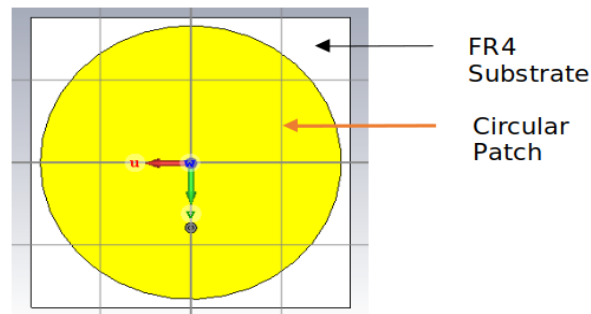
- Operating Frequency (Fr) : 2.4GHz
- Height of FR4 Substrate (h) : 1.6mm
- Dielectric constant(ϵ_r) : 4.4
- Thickness of Copper (Tc) : 0.035

Patch radius calculation:

The physical dimensions are to be calculated before performing simulations. The primary physical dimension of a circular patch is its radius. The radius of circular patch can be calculated using the equation:

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi\epsilon_r F} \left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726 \right] \right\}^{1/2}} \quad \text{Where,} \quad F = \frac{8.791 \times 10^9}{f_r \sqrt{\epsilon_r}}$$

On calculation of the radius of the patch, the design of size of substrate and ground plane is done accordingly. The substrate is chosen in a square shape where the side of substrate is 3mm more than the diameter of patch. This is done to prevent chopping of the patch during fabrication process.



Calculation of Feed Point Position:

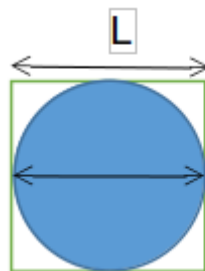
The position of feed point is a key element in the design of a patch antenna. The feed point is the position where signal is supplied into an antenna. It is the position where a coaxial connector is placed to facilitate signal input. An important point to be considered in feed point of a circular patch is that feed point should not be in the center of the patch and not towards the edges. This is due to the high impedance properties. The feed can be given at any point inside the patch. Since there is no appropriate design methodology for feed point of a circular patch antenna, the design methodology of feed point for a rectangular patch antenna is followed for a systematical analysis.

The feed point in a rectangular patch is calculated using the following equation:

$$X_f = \frac{L}{\sqrt[2]{\epsilon_{eff}}}$$

$$Y_f = \frac{w}{2}$$

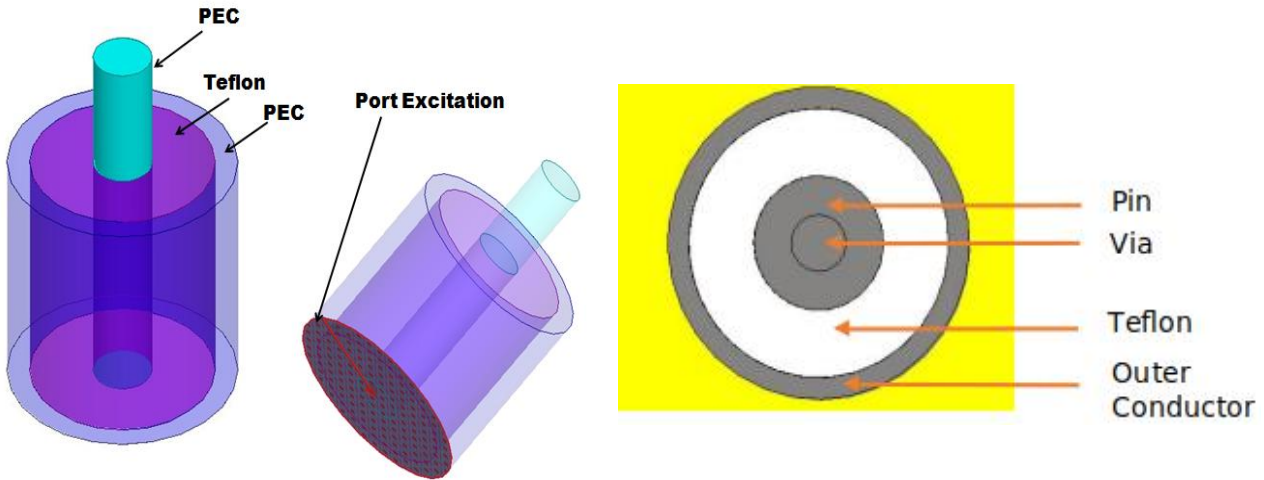
Where X_f is the position on X-axis and Y_f is the position on Y-axis. The circular patch is assumed like a rectangular patch where diameter of the circle becomes length(L) and width(W) of the rectangle. Since it is a circle the rectangle becomes a square.



Coaxial Connector Implementation:

A female coaxial connector also known as SMA connector is fixed at the feed point to provide signal input. The SMA connector consists of 3 conductors. The pin & via are connected to the patch. It is made of PEC. It is insulated by using a Teflon coating(PTFE lossy in CST). The outer conductor is connected to ground. This outer conductor is also made from PEC. The SMA connector is implemented and positioned as shown in figure

The waveguide port is setup on the end of SMA connector. The waveguide port is excited and the antenna design is simulated to obtain far-field results.

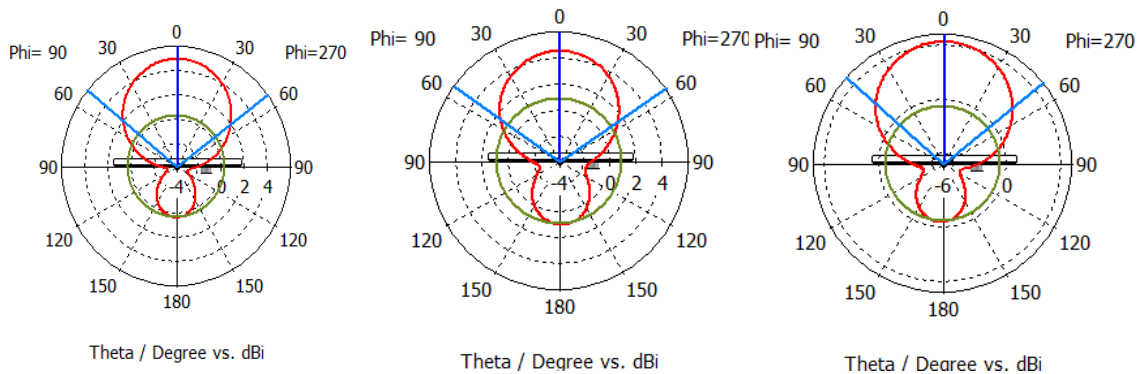


The dimensions of SMA Connector are as follows:

Part	Radius(from centre)
Via	0.265mm
Pin	0.625mm
Teflon	0.925mm
Outer Conductor	1.25mm

IV. EXPERIMENTAL RESULTS

The farfield radiation pattern for the resonating frequency(2.45 GHz) along with minimum threshold frequency (2.3GHz) and maximum threshold frequency(2.6GHz) are obtained after simulation. Other parameters of antenna are also calculated.



The antenna provides the results of its parameters as shown in the table below.

Parameters	Value
Frequency	2.45GHz
Main lobe magnitude	4.94dBi
Main lobe direction	1.0 deg.
Angular width(3 dB)	103.9 deg.
Side lobe level	-4.7 dB

These parameters shows the ideal characteristics of antenna which will be almost similar when fabricated in real irrespective of the machining defects.

V. CONCLUSION

The paper describes a theoretical methodology towards implementation of an antenna design. The design steps are derived from similar patch antenna design methodologies. An example for this is the derivation of feed point location from that used in a rectangular patch feed. These design methodologies are used in design of an antenna to test its functionality. The tests are done by building a circular patch antenna with coaxial feed. The results are verified to define an accurate methodology.

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