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Microstrip Patch Antenna

Jamini Sharma[1], Archana Sharma[2], Mehak Rathore[3], Neha Mahajan[4], Pooja Gupta[5]
[1-5]Department of ECE, MIET, Jammu, India
Email address: [2]asharma1003@gmail.com, [3]rathore.mehak@gmail.com, [4]neha.btechece@gmail.com, [5]poojag981@gmail.com

Abstract**—**Microstrip antennas (MSA) received considerable attention in the 1970's, although the first designs and theoretical models appeared in the 1950's. They are suitable for many mobile applications: handheld devices, aircraft, satellite, missile, etc. The MSA are low profile, mechanically robust, inexpensive to manufacture, relatively light and compact. Micro strip antennas are used in a wide range of applications because of their advantageous features in terms of low profile, low cost, light weight and easy fabrication. However two major disadvantages are low gain and narrow bandwidth when high dielectric constant material is used for fabrication of the microstrip antenna.

Keywords**—** E-shaped antenna; far field domain; feeding point; H-shaped antenna; L-shaped antenna; microstrip patch antenna; triangular shaped antenna.

I. Introduction

Wireless communication has been developed widely and rapidly in the modern world especially during the last two decades. The future development of the personal communication devices will aim to provide image, speech and data communications at any time, and anywhere around the world. This indicates that the future communication terminal antennas must meet the requirements of multi-band or wideband operations to sufficiently cover the possible operating bands. One of the recent technological advance in antennas is microstrip patch antenna. A microstrip patch antenna (MPA) consists of a conducting patch of any planar or non planar geometry on one side of a dielectric substrate with a ground plane on other side. Compared with conventional antennas, microstrip patch antennas have more advantages and better prospects. They are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity.

This article introduces some of the basic concepts of patch antennas. The main focus will be on explaining the general properties of patch antennas by using the simple rectangular probefed patch. It will cover topics including: principles of operation, impedance matching, radiation pattern and related aspects, bandwidth, and efficiency.

II. A Parametric Study of Patch Antennas

This section describes some important antenna parameters can be calculated by the transmission line method [7].

A. Patch Width

Numerically, the width of the microstrip patch can be calculated using the equation as

$$W=\frac{c}{2f_0\sqrt{(\varepsilon_r+1)/2}} \quad (1)$$

where *c* is the velocity of light in free space, f_0 is the re-sonant frequency and ε_r is the dielectric constant of the substrate.

B. Patch Length

The length of the patch can be calculated only if the effective dielectric constant is known , and the effective dielectric constant can be calculated as

$$E_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+\frac{12h}{w}\right]^{1/2} \quad (2)$$

where E_{reff} is the effective dielectric constant, ε_r is the dielectric constant of the substrate, *h* is the height of dielectric substrate and *w* is the is the width of the patch. The dimensions of the patch is extended on each end by a distance ΔL and is calculated by

$$\Delta L = 0.412h\,\frac{(E_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(E_{reff}-0.258)\left(\frac{w}{h}+0.8\right)} \quad (3)$$

The actual length L of the patch is given as

$$L = \lambda_0/2 = 2\Delta L \quad (4)$$

C. Ground Dimensions

For practical design, it is necessary to have some finite ground plane. For optimum design of small patch antenna, it is required that the ground plane should be greater than the patch dimensions by approximately six times the substrate thickness all around the fringe. Hence, the ground plane dimensions would be given as

$$L_g = 6h + l \quad (5)$$

$$W_g = 6h + w \quad (6)$$

III. Feeding Methods

A. Microstrip Feed Line

The feed line to the patch antenna is in its origin a transmission line and is therefore often referred to as the transmission line feed. The feed line width is smaller than the patch and is etched directly to the edge of the patch so that power is transferred from the source through a coaxial cable, into the feed line and then to the patch. The purpose of the feed line is to match the impedance from the patch without any additional matching component, however because the feed line is a patch itself it can cause radiation interfering with the patch which will decrease the bandwidth of the antenna.

B. Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Fig 1, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating

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patch, while the outer conductor is connected to the ground plane.

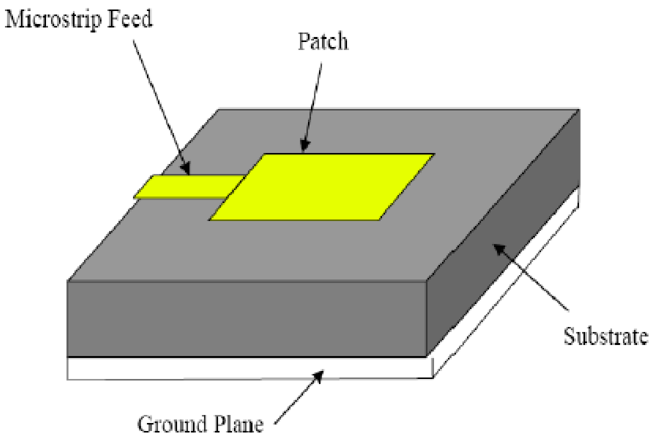

Fig. 1. Microstrip feed.

IV. Proposed Antenna Design

The proposed model is designed and simulated using Roger RTduroid 5880 substrate with thickness h= 2mm, relative permittivity ε_r = 2.2 and ground plane and excited through Coplanar waveguide. A rectangle radiator is fed by a 50 ohm CPW transmission line. Since both the antenna and the feeding are implemented on the same plane, only one layer of substrate with single-side metallization of copper is used. Starting from a rectangle and modified the shape so we have obtained the required geometry. The analysis will be performed between 0-35 GHZ. Therefore the minimum distance between the air volume wall and the radiating aperture should be one quarter wavelength at respective lowest frequency of the respective band.

SHAPE	DIMENSIONS (L=Total substrate length W=Total substrate width, H= Total substrate height)
H-SHAPE	L=34mm, W=64mm, H=2mm
L-SHAPE	L=200mm, W=200mm, H=.32mm
TRIANGULAR	L=75mm, W=75mm, H=1.6mm
E-SHAPE	L=34mm, W=64mm, H=2mm

V. Geometry of The Proposed Antenna

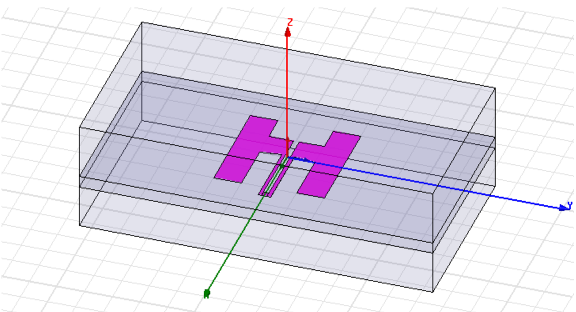

Fig. 2. Geometry of the proposed H shaped antenna.

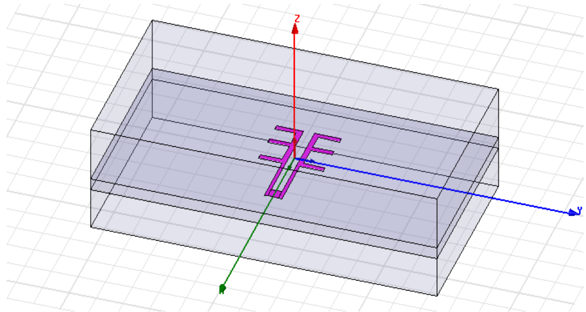

Fig. 3. Geometry of the proposed E shaped antenna.

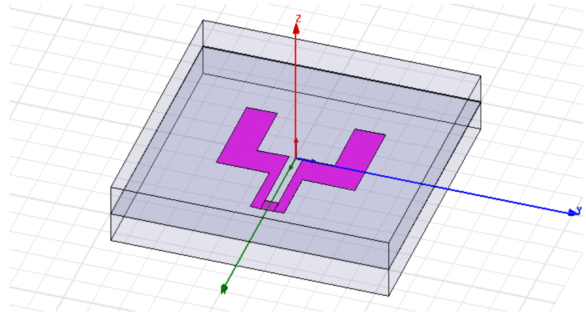

Fig. 4. Geometry of the proposed L shaped antenna.

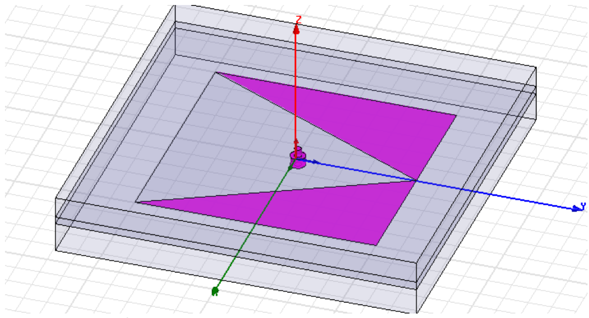

Fig. 5. Geometry of the proposed Triangular shaped antenna.

VI. Results

Some simulations have been carried out for finding out the sharp bandwidth in all the antennas. S-parameter plots have been taken for the bands- K-band, X-band, Ku band, L&S band. From the plots, we have found the working frequency as dictated in the table below.

Table I. Frequency bands.

Shapes	Working frequency
E shaped antenna	Band- Ku band Frequency- 15 GHz
L shaped antenna	Band- L and S band (dual) Frequency-1GHz and 2GHz
Triangular shaped antenna	Band- K band Frequency- 22GHz
H shaped antenna	Band- X band Frequency- 8GHz

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A. *E-shaped antenna*

a) S parameter

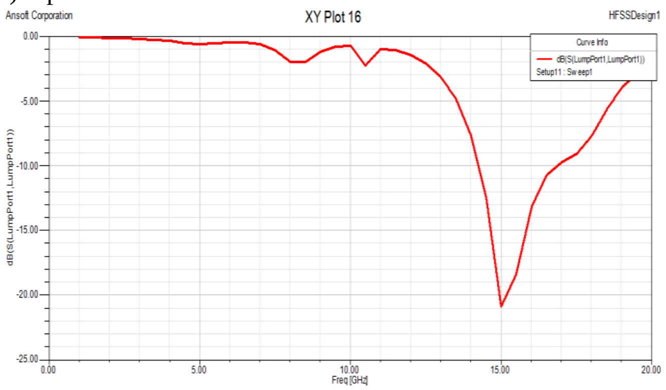

Fig. 6. S parameter for E shaped antenna.

This figure shows the return losses of this antenna .It has very less return losses of about -21db. This also shows working frequency of an antenna which is 15 GHz. It has pass bandwidth of 3 GHz.

b) 2D radiation pattern

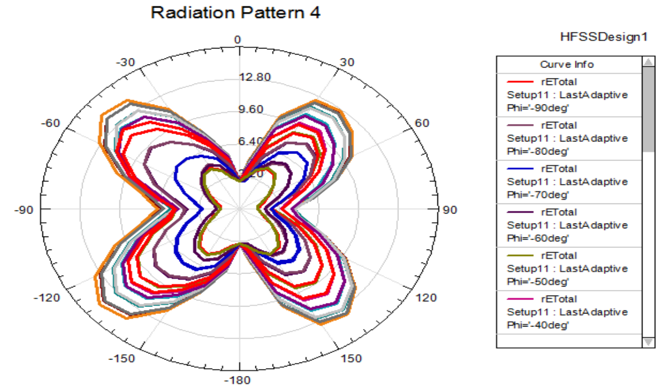

Fig. 7. 2D radiation pattern of E shaped antenna.

The graphical representation of radiation of an antenna as a function of direction is known as radiation pattern of an antenna. In this radiation pattern there are 4 major lobes .Major lobe is also known as main beam and is defined as the radiation lobe containing the direction of maximum radiation. One major lobe has peak value at 40degrees. Other three lobes have peak value at -130degrees, 140 degrees,-40 degrees respectively. This antenna is bi directional. The antenna will have maximum field strength in the direction of major lobes.

c) 3D polar plot for radiation pattern

A complete radiation pattern is a three dimensional solid figure and gives the radiation for all angles of the θ and φ. This figure shows the 3D plot for radiation pattern in X, Y and Z axis. This shows in reference with theta and phi where theta is the elevation angle and phi is the azimuthal angle. This plot allows to visualize where the antenna transmits or receives power. This is directional antenna which means it does not have the symmetry in radiation pattern.

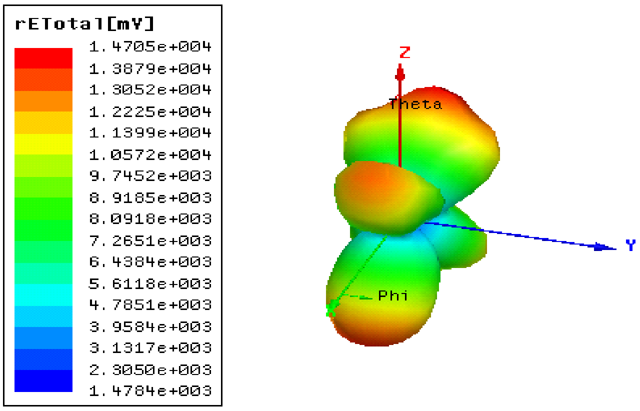

Fig. 8. 3D polar plot of radiation pattern of E shaped antenna.

B. *Triangular shaped antenna*

1) S parameter

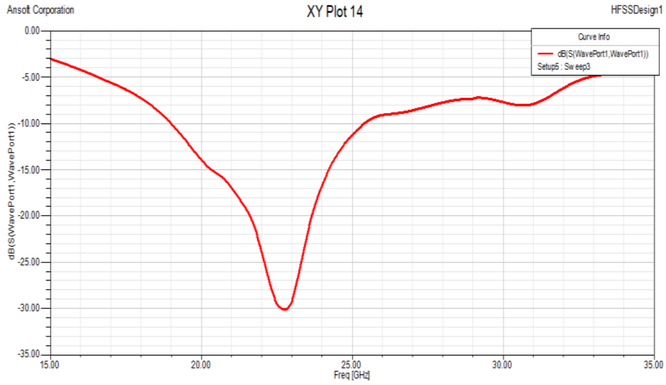

Fig. 9. S parameter of triangular shaped antenna.

This plot shows the working frequency of antenna 22GHz. It has a pass bandwidth of 4GHz. This shows that the return losses are very less -30dB.

2) 2D radiation pattern

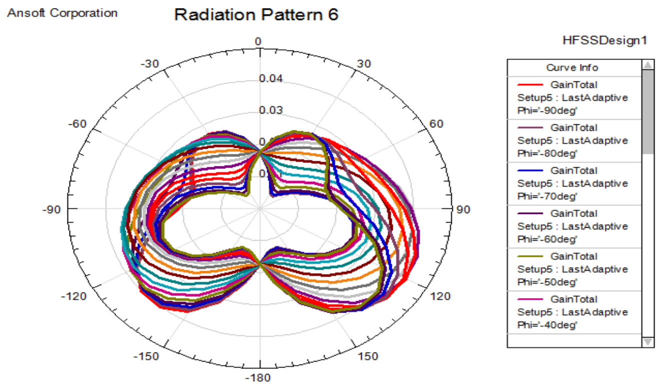

Fig. 10. 2D radiation pattern for triangular shaped antenna.

The figure above shows the graphical representation of radiation of an antenna. This pattern shows bidirectional behavior of this antenna .This shows major lobes at

100degrees, -100degrees. The antenna will have maximum field strength in the direction of major lobes.

3) 3D polar plots for radiation pattern

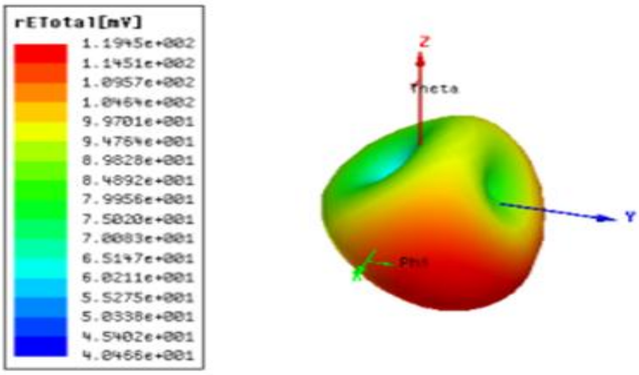

Fig. 11. 3D polar plots of radiation pattern of triangular shaped antenna.

The figure above shows the 3D plots of radiation pattern in X, Y, Z axis. This is shown with reference to theta and phi. where theta is the elevation angle and phi is the azimuthal angle. This plot allows to visualize where the antenna transmits or receives power. This is directional antenna which means it does not have the symmetry in radiation pattern.

C. L shaped antenna

1) S parameter

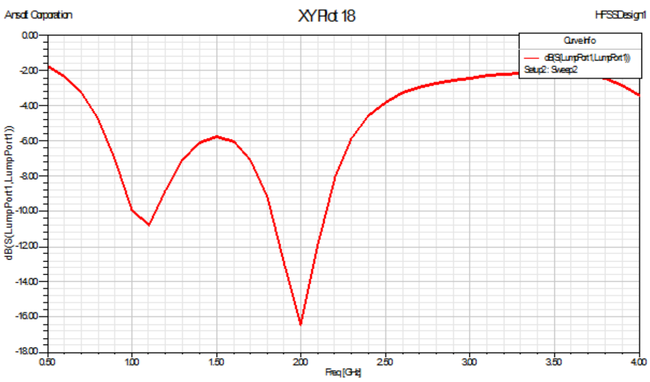

Fig. 12. S parameters for L shaped antenna.

This figure shows that this antenna works at two frequency i.e. it has dual band 1.2GHz and 2GHz. It has very less losses about-17db. It has two pass bandwidth .2GHz and 1GHz.

2) 2D radiation pattern

Figure 13 shows the bidirectional behavior of the antenna . It has two major lobes at 10 degrees, -170 degrees. It shows the graphical representation of radiation of an antenna as a function of direction. It is a measure of field strength at a point.

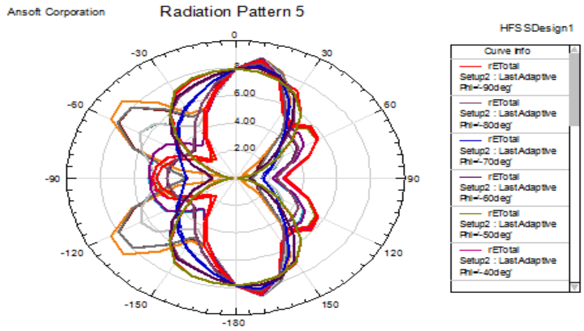

Fig. 13. 2D radiation pattern for L shaped antenna.

3) 3D radiation pattern

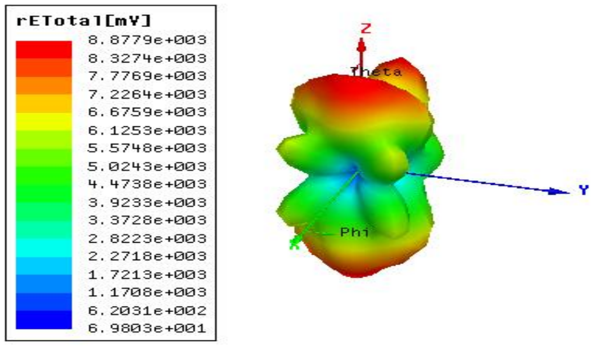

Fig. 14. 3D polar plots of radiation pattern.

This shows 3d plots of radiation pattern in X,Y,Z axis. This is shown with reference to theta and phi where theta is the elevation angle and phi is the azimuthal angle. This plot allows to visualize where the antenna transmits or receives power. This is directional antenna which means it does not have the symmetry in radiation pattern.

D. H-shaped antenna

1) S parameters

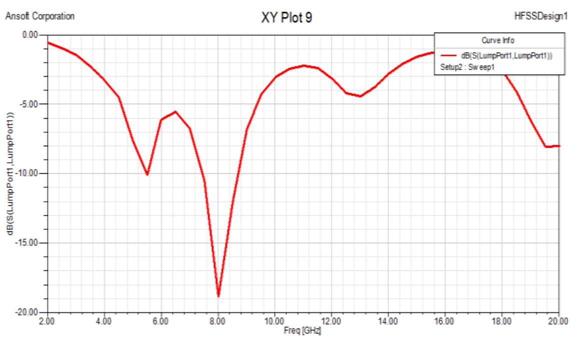

Fig. 15. S parameters for H shaped antenna.

The figure above shows that the working frequency of this antenna as 8 GHz. It has very less return losses which can be depicted by the dip which is at –19GHz. The pass bandwidth is 2GHz.

2) 2D radiation pattern

The figure above shows that the respective antenna is bidirectional in nature. it has major lobes at 0degree,

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180degrees. This shows maximum radiation in different directions. It is the graphical representation of radiation of an antenna with respect to direction.

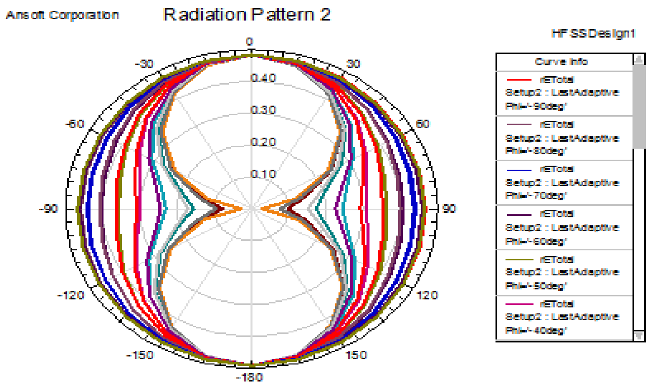

Fig. 16. 2D radiation pattern for H shaped antenna.

c) 3D polar plot of radiation pattern

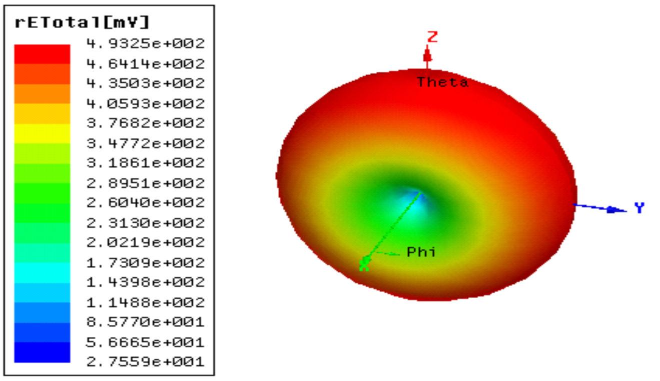

Fig. 17. 3D polar plots of radiation pattern.

This shows 3d plots for radiation pattern in X, Y, Z. this is shown with reference to theta and phi where theta is the elevation angle and phi is the azimuthal angle. This plot allows to visualize where the antenna transmits or receives power. This is directional antenna which means it does not have the symmetry in radiation pattern.

VII. Conclusion and Future Scope

This paper proposes four different microstrip patch antenna designs that are modest and economical for mobile communication applications. The designs have been simulated for obtaining far-field radiations, polar plots and the insertions losses and the characteristics of four different microstrip patch antennas. The paper shows the results of different antennas in terms of radiation pattern, far field domain and the resonant frequency obtained from the return loss for different microstrip patch antennas working in different frequency bands.

A microstrip or patch antenna is a low profile antenna that has a number of advantages over other antennas it is lightweight, inexpensive, and easy to integrate with accompanying electronics.

Future work implies the enhancement techniques for the bandwidth and radiation patterns of these antennas. Designs using different substrate and structure can be taken into consideration for the future research. Different patches, dimensions and feeding techniques may also affect the performance of the antennas.

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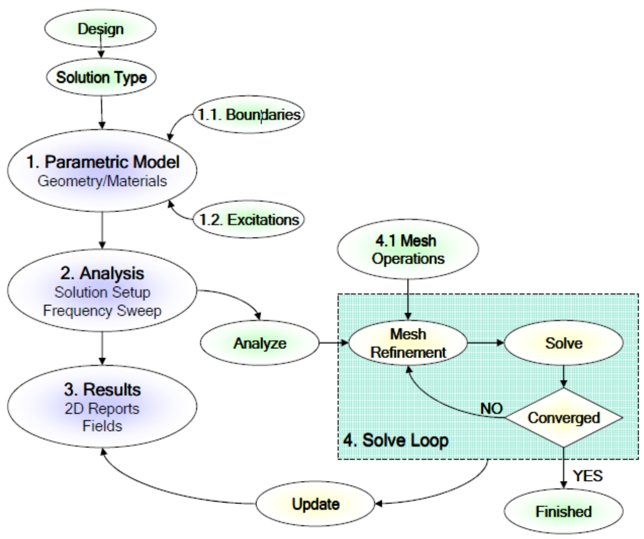
Appendix

A. *HFSS*

HFSS is a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modeling, and automation in an easy-to-learn environment where solutions to your 3D EM problems are quickly and accurately obtained.

HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. HFSS can be used to calculate parameters such as S Parameters, Resonant Frequency, and Fields.

B. *Modelling and Desinging*



The modelling and simulation is shown with the help of flow chart. The following flow chart shows the simulation process in brief.

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