A MICROSTRIP PATCH ANTENNA EXPLOITING H AND T-SLOT INTENDED FOR WIRELESS COMMUNICATION

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Abstract- The antennas utilized for communicating have shrunken size dramatically for diverse applications recently, although their flexibility has improved. Among them, microstrip patch antennas contribute a vital part in the field of mobile communication due to its feasible nature as well as compact size. The main drawback of the existing microstrip antenna types are narrow bandwidth and efficiency. The design of T as well as H slotted microstrip patch antenna is presented here which offers wide range of operating bandwidth with improved efficiency. Various parameters for the design and its influences are analyzed utilizing HFSS software in various operating frequencies and maximum return loss bandwidth is obtained. The results demonstrates that the antenna designed with T-slot as well as H-slot generates radiation patterns which are steady in nature and has the ability to wrap frequencies required by applications for wireless communication.
Keywords: Microstrip antenna, T-slot, H-slot, HFSS, VSWR.

1 INTRODUCTION

An antenna with frequency and polarisation agility is becoming increasingly desirable as modern smart systems evolve. As a result, reconfigurable antennas have recently received increased attention and effort, especially in microstrip technology [1]. Microstrip patch antennas possess the benefits of being minimal-cost, minimal-profile, as well as simple to manufacture [2]. The majority of these antennas were built with directional radiation in mind and a small number of patch antennas for omnidirectional radiation have recently been created. Microstrip patch antennas, which have a monopole-like radiation pattern, can be used in place of traditional monopole antennas when low profile antennas are needed [3-5].A resonant cavity can be made out of a microstrip antenna. In other words, it can store electromagnetic energy from a plane wave that has been irradiated [6]. The antenna is located close or even combined with the front-end in recent frameworks for communicating as well as radar purposes. It is utilized in these systems because it is combined along a variety of circuits which are active as well as passive [7]. The primary structure of a microstrip antenna produces a radiation pattern of broadside, and the structure is ideal for circumstance where electronic applications are dispersed inside a specific region [8].

Antenna array problems typically have wide variable attributes, including element lengths, array spacings, position and feed shape, tapering of excitation for amplitudes or phases, and so on. Numerical optimization becomes critical in this situation for systematic antenna array design. Even a single simulation for practical antenna array models is computationally costly when accurate. The use of traditional numerical optimization gradient-based routines, which usually require multiple simulations of the array model, prohibitive in terms of computational cost [9]. Metaheuristic-based approaches, such as genetic algorithms [10,11], particle swarm optimizers [12,13] have shown to be effective in dealing with specific issues in the synthesis of array pattern, such as existence of locally placed optima. On the other hand, metaheuristics typically require thousands of feature tests, infeasible in nature.

Although the microstrip patch antenna is common because of its minimal size, low profile, , unidirectional, and symmetry radiation, their property of narrow bandwidth, makes them uncommon in ultra wide-band applications [14]. Many excellent methods for the the operating bandwidth are suggested. To begin, parasitic elements are utilized for increasing the bandwidth of the impedance. The utization of these elements on the other hand, have a complicated structure and a high profile [15]. Parasitic elements are positioned as the radiating portion in the similar plane [16]. Even though the antennas possess improved broad band efficiency, a minimal gain of less than 6.5 dBi is noticed. Because of its low profile, the traditional microstrip patch antenna is a decent option, but it has the drawback of having a narrow bandwidth. Since a traditional patch antenna's resonant length is around half a wavelength, the size of the patch is big for low microwave frequency usage [17]. Another commonly used approach to improve the microstrip patch antenna bandwidth is to connect the patch radiators with parasitic patches for gap-coupling [18-22]. Another issue is the mirror effect typically produced by metal field, which is seen in the lower part of the microstrip antenna. The endfire path is offset by the surface current as well as the mirror current. [23]. The zero-order loop antenna which is planar as well as the Alford loop antenna which is square-shaped, and combines patterns of directional as well as omnidirectional, are also realised to simplify the antenna structure. However, since those antennas are rigid, they can only be used in deployable and morphing systems [24].

Henceforth, an efficient microstrip patch antenna is deigned with the contributions given as,

- Utilization of T-slot as well as H-slot design with small microstrip line feed.
- High Frequency Simulator Structure (HFSS) for various operating frequencies obtaining maximal return loss bandwidth.
- Generation of steady radiation patterns.

The arrangement of paper is: Section 2 elucidates the relevant works. Proposed framework is detailed in section 3. Results as well as discussion are explained in section 4. Finally, work summary is given in section 5.

2 RELATED WORKS

Sohini et al [25] described a novel method for the analysis of a microstrip antenna which is linear as well as series-fed. It accounted for the mutual coupling within the components and permitted a model which possessed an amplitude of arbitrary nature as well as phase related to the phase currents that radiate. The coefficients utilized for formulating were estimated by the simulation of full-wave.

Ian et al [26] presented a patch antenna which is mechanically reconfigurable composing of a stationary feed on the substrate layer at bottom and a truncated cornered patch on the substrate layer at top. The frequency at the resonance was altered by interchanging the patch with other one possessing various dimensions. The design of the antenna was described together with measured outputs revealing excellent values.

Ya-Hui et al [27] proposed a novel microstrip antenna of single feed possessing polarization agility. The efficient permittivity in resonant mode is varied and the radiation of circular polarization was attained. It also illustrated the measurement as well as fabrication of prototype antenna.

Xiumei et al [28] introduced a microstrip antenna which is miniaturized with two elements. These elements of the microstrip antenna were located with closer proximity. The radiation features of these elements were preserved in the electromagnetic bandgap structure. The proposed design was potentially applied in terminals of mobile.

Fu-Chang et al [29] codesigned a novel approach for the necessities of efficacious integration as well as simpler fabrication. The microstrip patch antennas were utilized for illustrating the fusion of antenna array which was bandpass filtered. With the control of coupling strength within resonators, a power dividing network either uniform or non-uniform was be obtained.

Shuai et al [30] proposed a minimal-profile microstrip antenna which possessed the stacking of double band. The impedance bandwidth was widened by the loading of coupled annular ring as well as group of conductive vias. For verifying the proposed antenna's performance, fabrication as well as measurement of a protype which is fully functional was performed.

3 PROPOSED METHODOLOGY

Figure 1 denotes a microstrip patch antenna composed of a radiating patch as well as a ground plane which is dielectric in nature. The patch is usually composed of conductive element like copper or gold and is made into any form. On the dielectric substrate, the normal photo etching of the radiating patch as well as feed lines are performed.

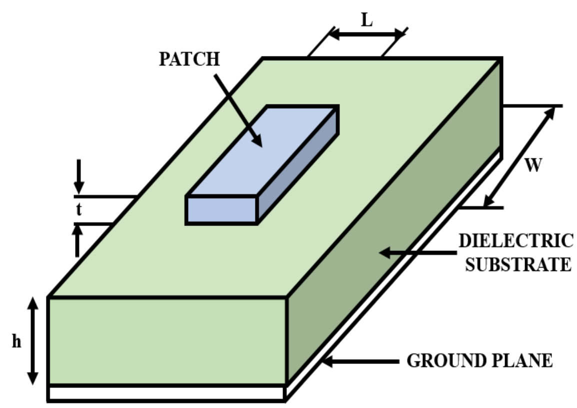

Figure 1 Microstrip patch antenna

The radiation in antennas occur due to fringed fields within the patch edge as well as the ground plane. A dielectric substrate which is thickened along a minimal dielectric constant is preferable for improved performance of the antenna since it offers good power, a larger bandwidth, as well as high radiation. However, this setup necessitates the use of a larger antenna. Dielectric constants which are higher shows minimal efficiency as well as generate restricted bandwidth, are needed to build a compact microstrip patch antenna. However, such a setup necessitates the use of a larger antenna. As a result, a balance between antenna dimensions and antenna efficiency must be found.

3.1 Feeding Approaches

The various feeding approaches regarding the microstrip patch antenna are given below.

3.1.1 Microstrip Line Feed

The microstrip patch edge is attached with a strip which conducts. This strip is narrower when compared to the path, and possess the merit of allowing the feed to be in the substrate which is similar as the path, resulting in a planar form. As a result, this is a simple feeding scheme, as it allows for fast fabrication and modelling, as well as impedance matching.

3.1.2 Coaxial Feed

It is also known as probe feeding, is a popular method for the feed purposes. The coaxial connector's conductor present inwards passes across the dielectric and soldering is performed, the outside conductor is linked with ground plane. Key benefit of this feed scheme is its ability to be mounted within the patch to match its input impedance. It is simple to build and emits no spurious radiation.

3.1.3 Aperture Coupled Feed

The radiating patch is isolated from the microstrip feed line which is linked with the patch and a slot present in ground plane. The coupled aperture is normally located beneath the patch, resulting in minimal cross-polarization. The lower substrate is usually composed of a dense dielectric substance with increased dielectric constant. To optimise radiation from the patch, the top substrate is made of a material with a low dielectric constant.

3.1.4 Proximity Coupled Feed

This type of approach for feeding is also known as the electromagnetic coupling strategy. Owing to total improvement in the microstrip patch antenna density, its key significance is the removal of pretended radiation feed as well as offering extremely improved bandwidth. This scheme also gives you the option of choosing within different dielectric material. For optimising the functioning, one for the patch as well as another for the feed line were developed.

3.2 Design of Microstrip Patch Antenna

The design of H and T-slotted microstrip patch antennas require the parameters like dielectric constant, height as well as frequency.
The patch width is given by,

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

Here ε_r → dielectric constant
f_0 → resonating frequency

The microstrip antenna's effective dielectric constant is given by,

$$\varepsilon_{ref} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2}\left[1 + 12\frac{h}{w}\right]^{-0.5} \quad (2)$$

Here ε_{ref} → effective dielectric constant
h → substrate height
w → width

The effective length is determined by,

$$L_{ef} = \frac{c}{2f_0\sqrt{\varepsilon_{ref}}} \quad (3)$$

The extension of length is given by,

$$\Delta L = 0.41h\frac{(\varepsilon_{ref}+0.3)(0.26+\frac{w}{h})}{(\varepsilon_{ref}-0.25)(0.8+\frac{w}{h})} \quad (4)$$

The patch length is,

$$L = L_{ef} - 2\Delta L \quad (5)$$

3.2.1 Design of T-Slot Antenna

The microstrip patch antenna is configured and designed utilizing High Frequency Structure Simulator (HFSS). The main objective is designing of antenna with appropriate microstrip line feed.

Figure 2 indicates the T-slot antenna in which a,b,c as well as d indicate T-slot dimensions. L denotes length as well as W denotes width of radiating patch which is further mounted in a substrate. To prevent higher order modes being excited, the patch width should be less than the wavelength in the dielectric substrate material. This excitation can also be avoided by using several feeds.

Table 1 Dimensions of T-Slot Antenna

Parameter	Size (mm)
Substrate	22*31*2.6
Infinite ground	22*31
Patch	16*23*2.6
Corner cut	2*3
Air	22*31*2.6
Feed	3*2
T-slot 1 & 2	10*1.5, 1.5*15

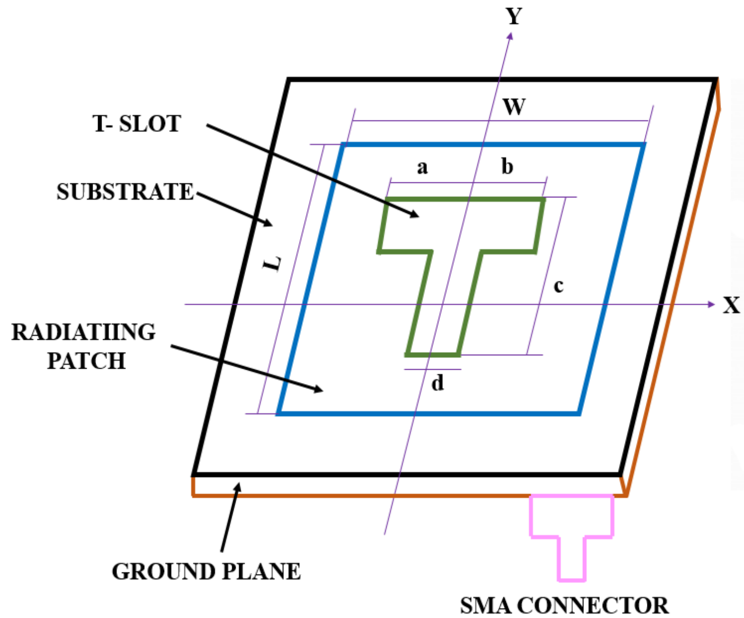

Figure 2 Design of the T-slot antenna

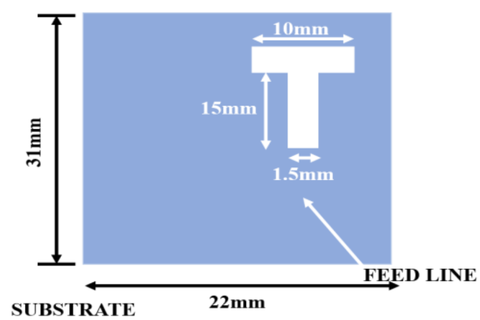

Figure 3 T slot geometry

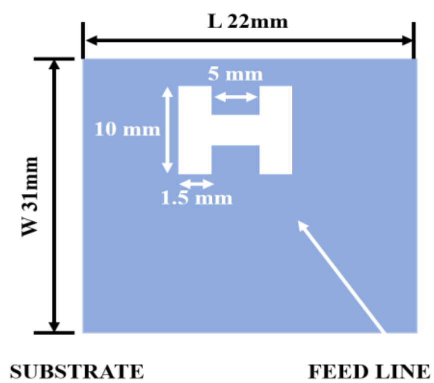

Figure 4 H slot geomet

The dimensions utilized for the designing of T-slot antenna are illustrated in table 1 and corresponding design of T-slot antenna is given in figure 3.

3.2.2 Design of H-Slot Antenna

The H-slot antenna comprises of a dielectric substrate at the lower as well as upper region along with a parasitic patch. A ground plane is present on the upper area with microstrip lines which are required for feeding these slots in the metal plane which is grounded. This coupling slot feeds radiating patch at the top improving the bandwidth and minimizing the reflection loss. This further increases the antenna's coupling efficiency.

Since, a ground plane is intermediately present, the feed's effect over radiating elements is minimized.

Table 2 Dimensions of H-Slot Antenna

Parameter	Size(mm)
Substrate	22*31*2.6
Infinite ground	22*31
Patch	16*23*2.6
Corner cut	2*3
Air	22*31*2.6
Feed	3*2
H-slot 1, 2,3	10*1.5,10*1.5&1.5*5

The dimensions utilized for the designing of H-slot antenna are given in table 2 as well as the corresponding design of H-slot antenna is given in figure 4.

3.3 Antenna Parameters

The various parameters of the antenna are given below.

3.3.1 Directivity

Directivity denotes ratio of intensity of radiation to the average intensity of radiation in all direction.

$$D = \frac{4\pi U}{P_{rd}} \quad (6)$$

3.3.2 Gain

Gain denotes ratio of antenna's radiation intensity in a specific direction to the overall fed input power.

$$G = 4\pi \frac{radiation\ intensity}{total\ input\ power} \quad (7)$$

3.3.3 Bandwidth

It is defined as the operating frequency of the antenna. It lies on both sides of the centre frequency. Generally, narrow as well as broad are the two categories of the bandwidth.

$$BW = f_2 - f_1 \quad (8)$$

Where f_2→ upper frequency
f_1→ lower frequency

3.3.4 Return Loss

It reflects the signal power due to the device insertion and is measured in dB.

$$RL = 10 \log \frac{P_r}{P_i} \quad (9)$$

Where P_r→ reflected signal power
P_i→ incident signal power

4 RESULTS AND DISCUSSION

The intoduced antenna design is analyzed utilizing HFSS software. It is a full-wave electromagnetic (EM) field simulator performing in a improved manner that uses Microsoft Windows graphical user interface to model 3D passive components. It combines simulating, visualisation, solid modelling, as well as automating in user friendly environment to provide fast and accurate solutions to 3D EM problems. A soft HFSS uses the finite element method (FEM), stunning graphics as well as adaptive meshing for providing unmatched results. The S-parameter, resonant, frequency, and fields can all be calculated using a soft HFSS.

4.1 Gain

It considers the antenna efficiency along with its capability regarding direction.

After simulation in the HFSS simulator the gain of the T-Slot is generated. The gain obtained for the designed antenna is 5.4533 as given in figure 5.

After simulation in the HFSS simulator the gain of the H-Slot is generated. The gain obtained for the designed antenna is 3.93 as given in figure 6.

4.2 Directivity

It estimates the concentration degree of the emitted radiation in a specific direction.

After simulation in the HFSS simulator the directivity of the T-Slot is generated. The directivity obtained for the designed antenna is 2.7766 as given in figure7.

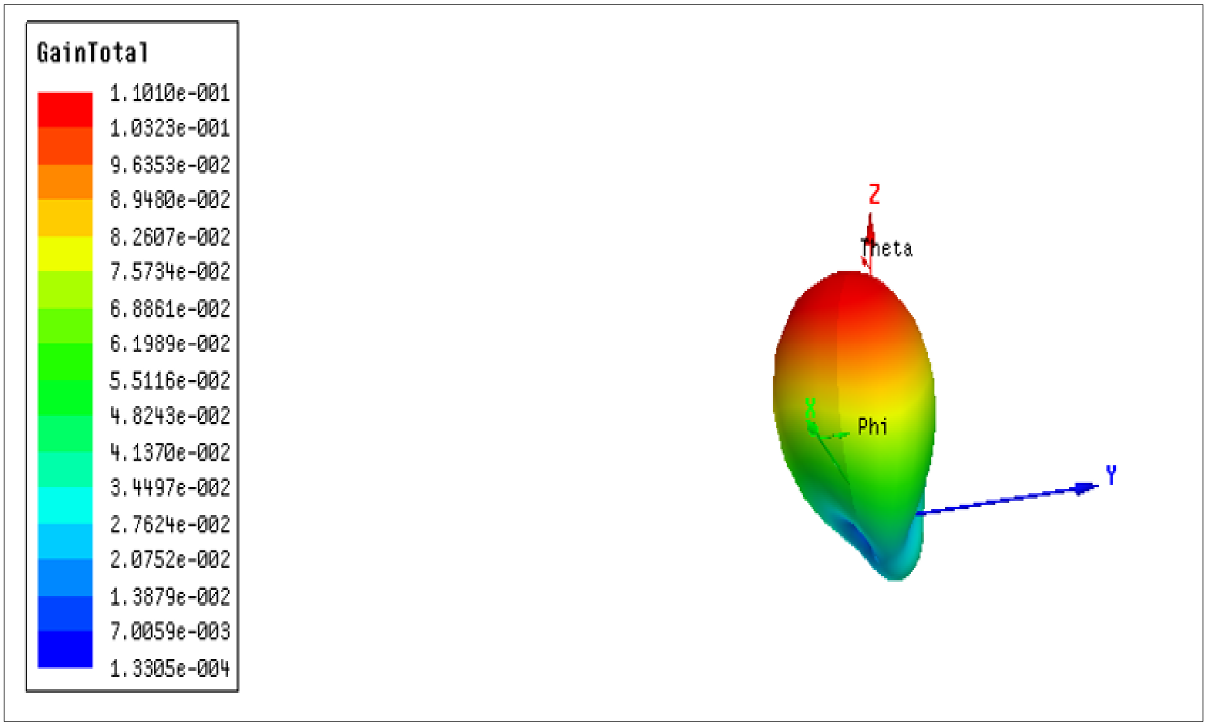

Figure 5 3-D Plot Gain for T-Slot

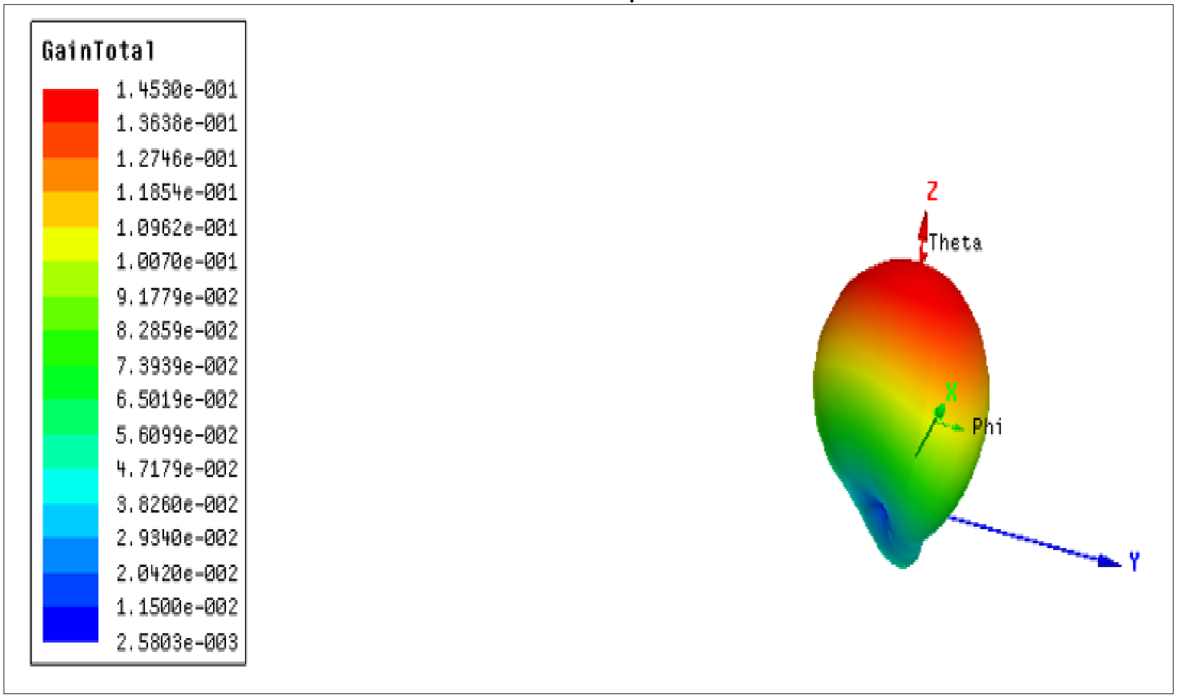

Figure 6 3-D Plot Gain for H-Slot

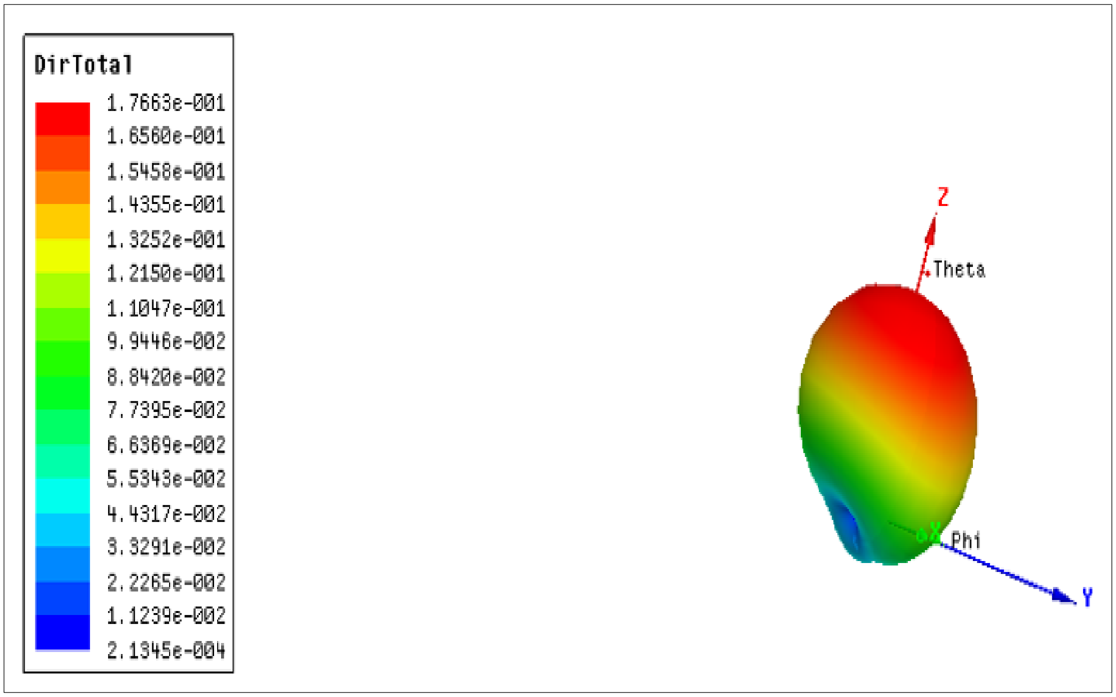

Figure 7 3-D Plot Directivity for T-Slot

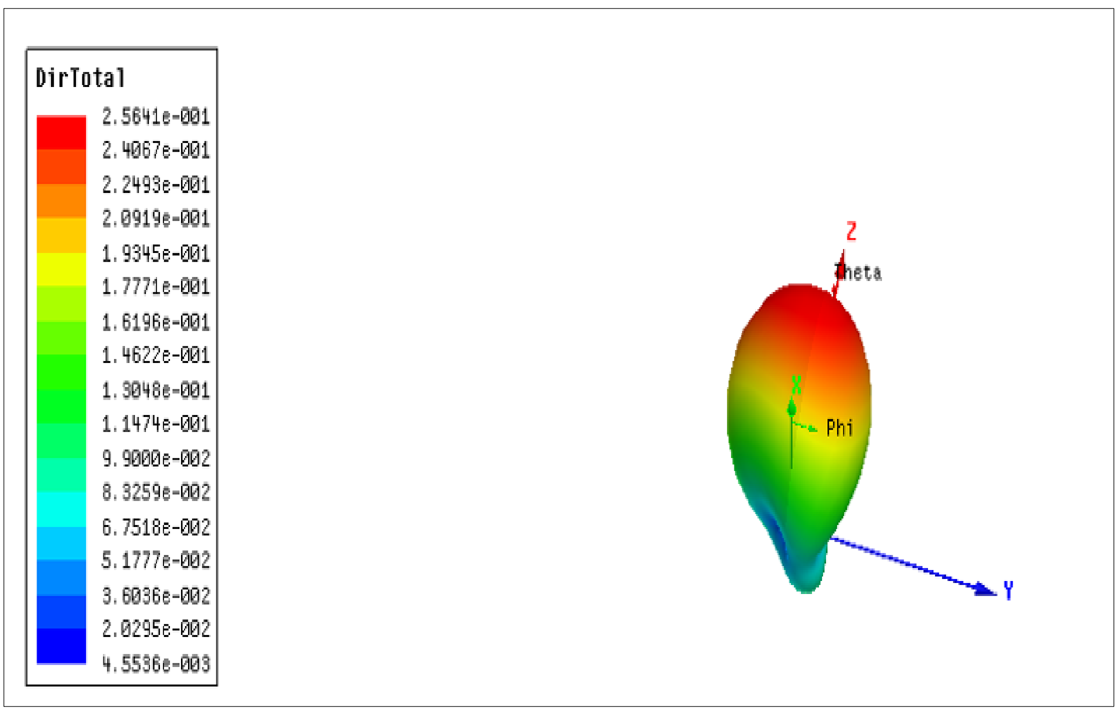

Figure 8 3-D Plot Directivity for H-Slot

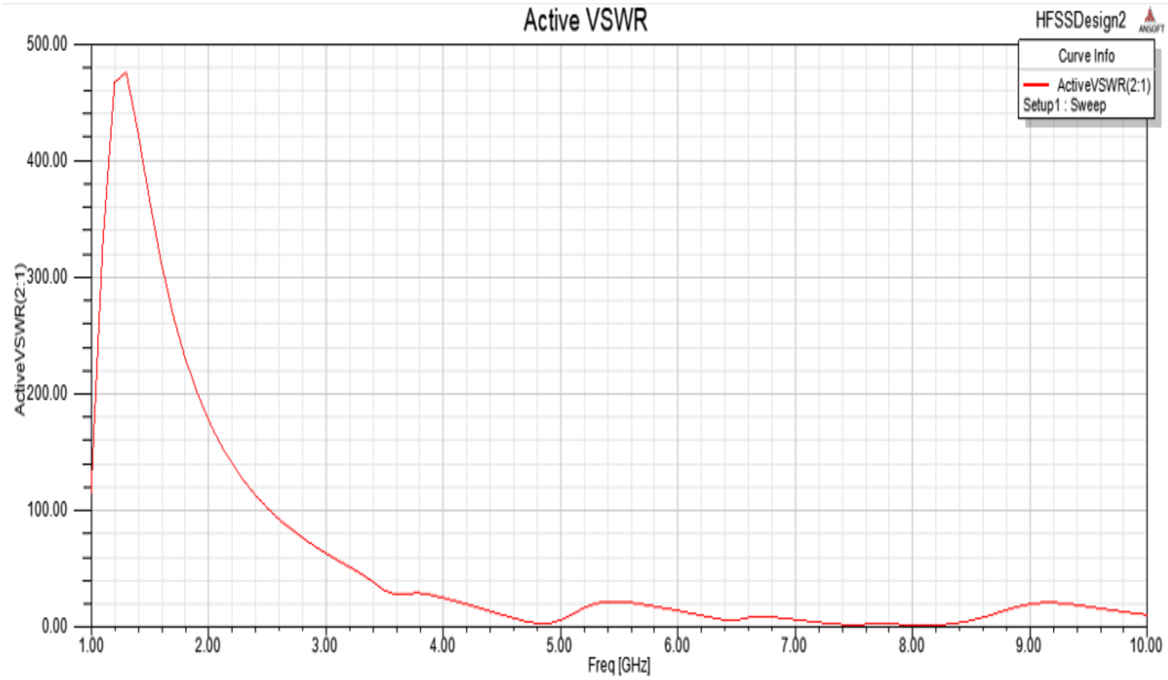

Figure 9 VSWR for T-Slot

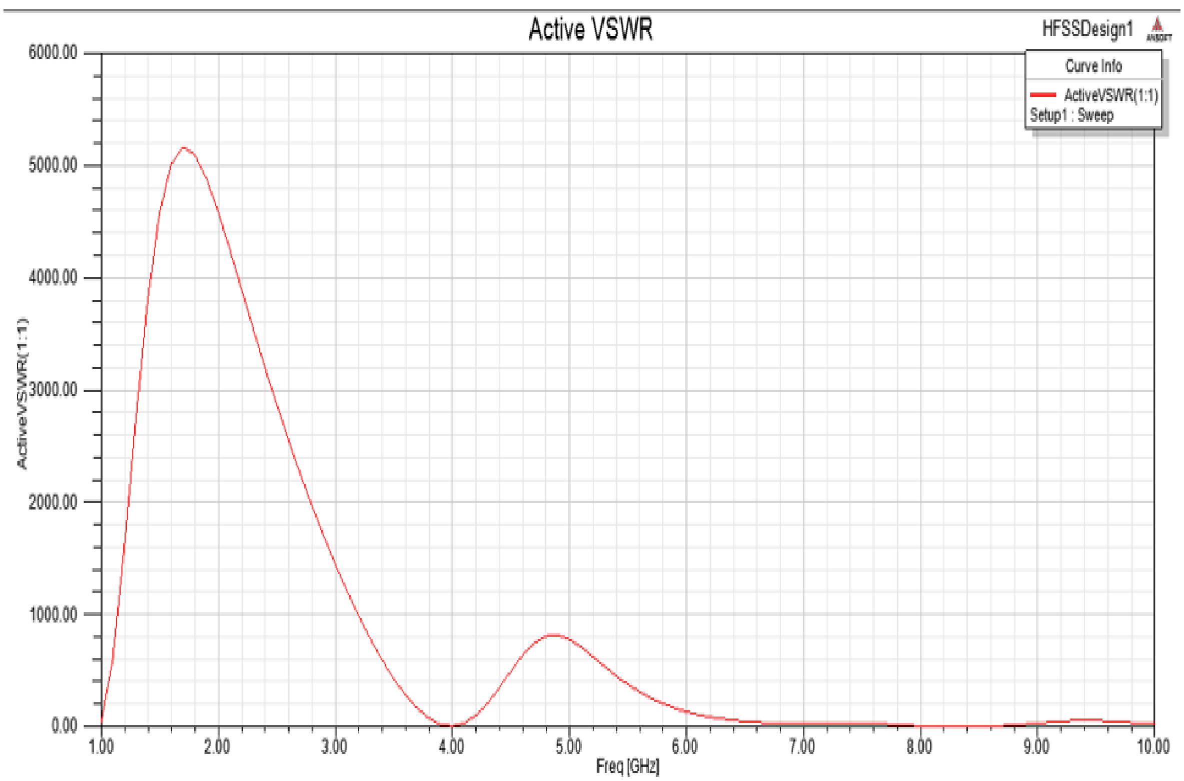

Figure 10 VSWR for H-Slot

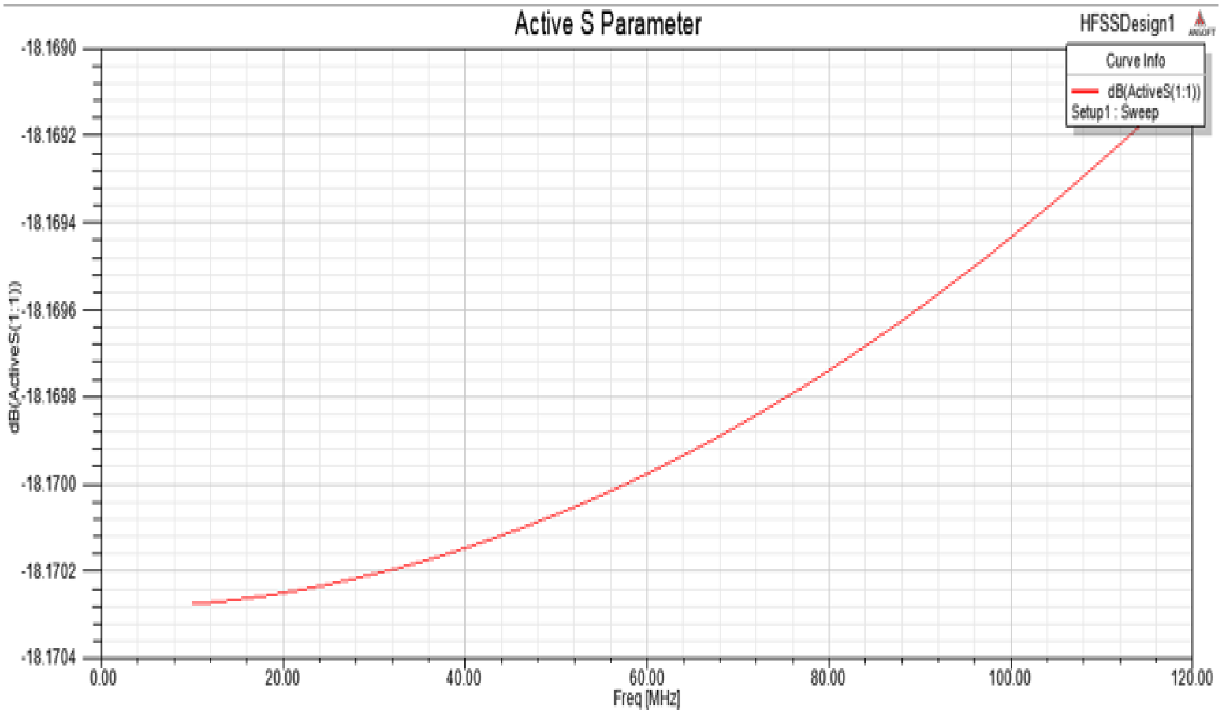

Figure 11 S Parameter for T-Slot

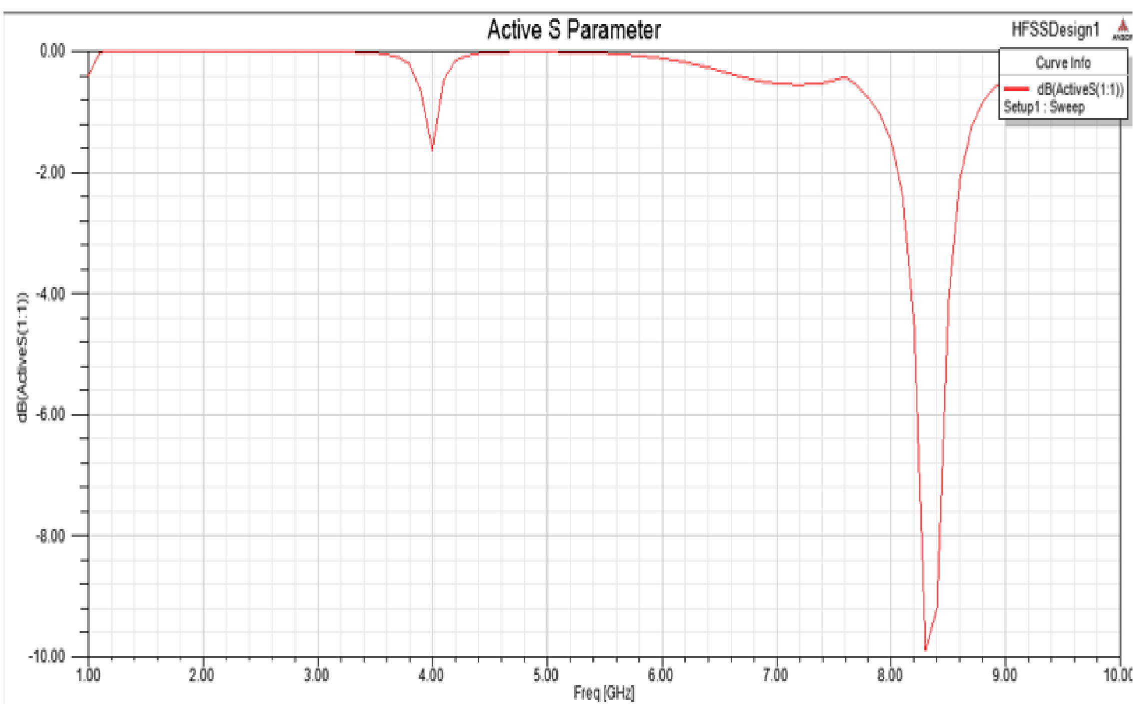

Figure 12 S Parameter for H-Slot

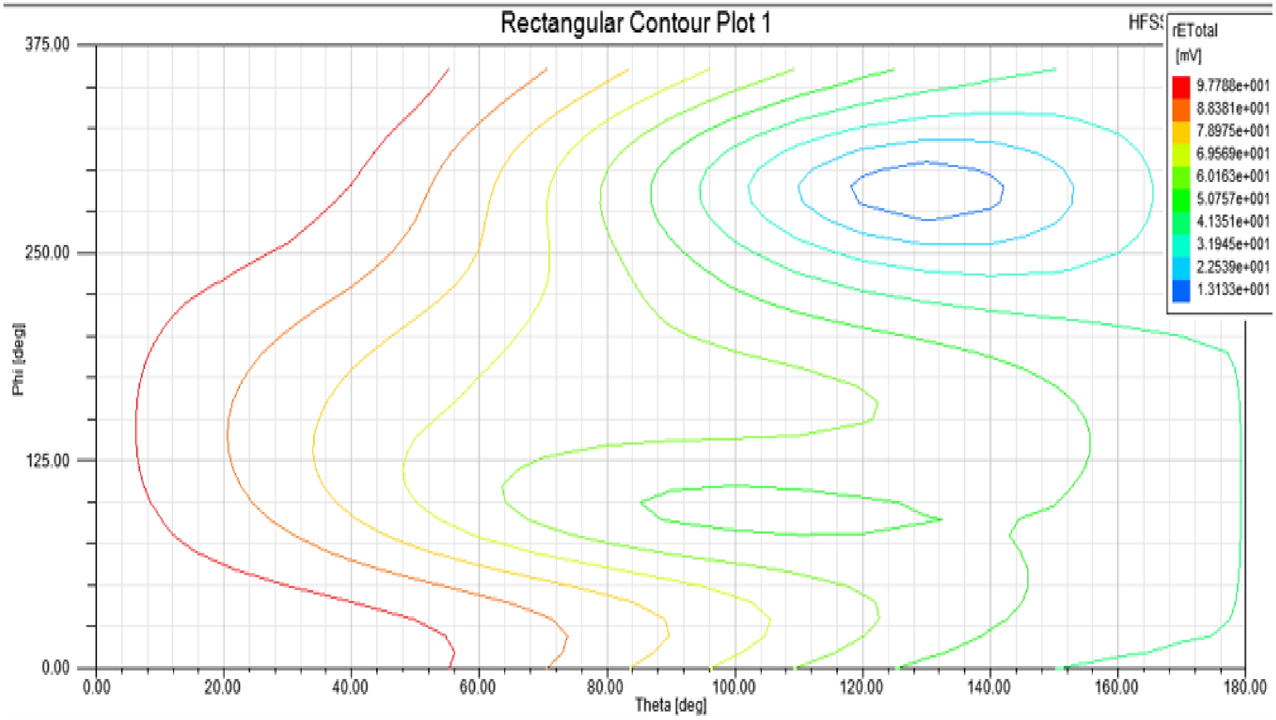

Figure 13 Rectangular Counter Plot for T-Slot

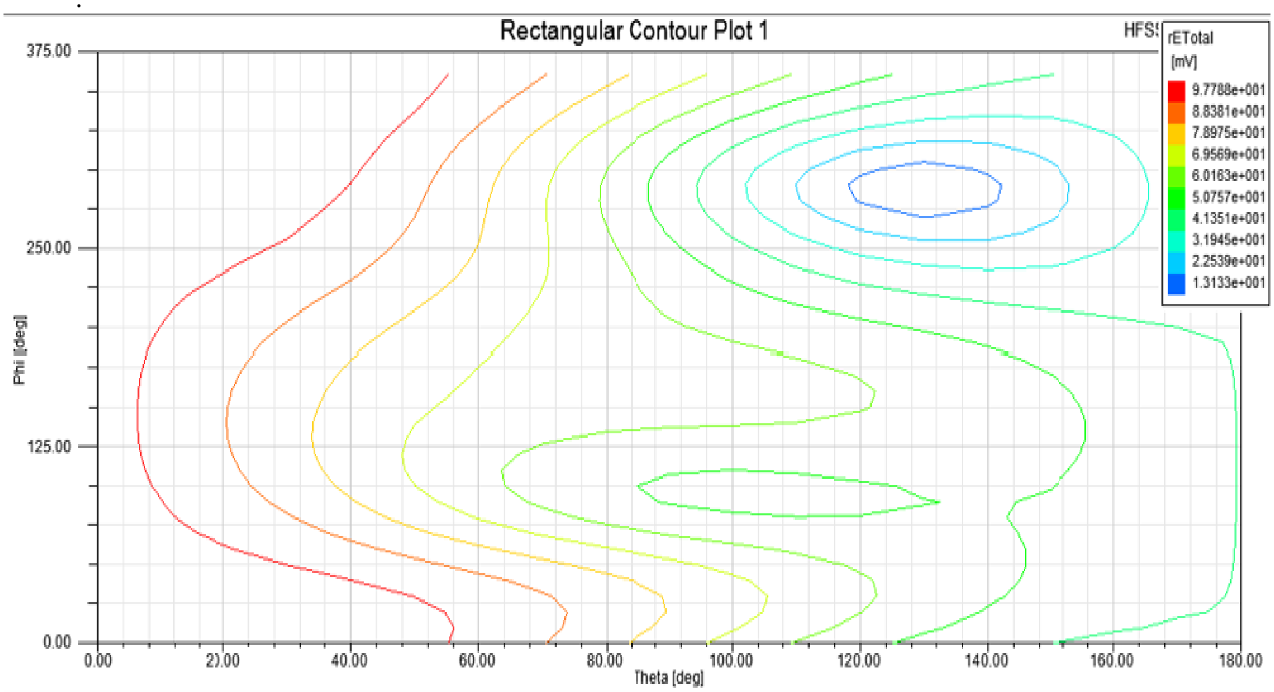

Figure 14 Rectangular Counter Plot for H-Slot

4.3 VSWR

VSWR estimates the efficiency transmission from a power source, along a transmission line, to the load. The VSWR happens because of the standing waves formation in the transmission medium.

After simulation in the HFSS simulator the VSWR of the T-Slot is generated as shown in figure 9.

After simulation in the HFSS simulator the VSWR of the H-Slot is generated as shown in figure 10.

4.4 S Parameter

Scattering parameter illustrates electrical functioning of linear networks during diverse stimuli of steady state because of electrical signals.

After simulation in the HFSS simulator the S parameter of the T-Slot is generated as shown in figure 11.

After simulation in the HFSS simulator the S parameter of the H-Slot is generated as shown in figure 12.

4.5 Rectangular Counter Plot

Rectangular counter plots indicate three-dimensional plane, with two variables XY on the y-axis as well as response variable Z as counter. Where counter line indicates elevations.

After simulation in the HFSS simulator the rectangular counter plot of the T-Slot is generated as shown in figure 13

After simulation in the HFSS simulator the rectangular counter plot of the H-Slot is generated as shown in figure 14.

After simulation in the HFSS simulator the directivity of the H-Slot is generated. The directivity obtained for the simulated antenna is 1.7633 as shown in figure 8.

5 CONCLUSION

The antenna has been designed for multiple frequency bands to be utilized for different applications. The patch antenna is designed with different structures like T-Slot as well as H-Slot. The operating frequencies are 1.675GHz, 3.97GHz, and 7.93GHz, minimum return loss up to -28.1171dB and maximum gain of 5.4533dB. These can be used to design arrays in future for increasing gain as well as bandwidth. Major applications of designed antenna are Wi-Fi satellite, Radio, Microwave relay and RADAR.

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