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Design & Simulation of 8-Shape Slotted Microstrip Patch Antenna

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Abstract: This paper presents an 8-shape slotted microstrip patch antenna. The antenna is fed by microstrip transmission line. The proposed antenna is simulated with the help of commercially available GEMS software based on the parallel FDTD algorithm. The antenna is designed by FR4 substrate and ground plane with an area 50mm×40mm×1.60 mm. The designed antenna generates three resonant modes at 2.12 GHz, 6.98 GHz and 13.84 GHz respectively. The bandwidths of the antenna (-10 dB) of the three frequencies are 25.75%, 6.13% and 20.63% respectively. The return loss (S_{11}) characteristics for the three bands are -41.95 dB, -22.68 dB and -23.15 dB respectively. The 3D radiation patterns of the proposed antenna are provided in the paper.

Key words: FR4 Substrate · 8-Shape Slotted patch · Microstrip Patch Antenna · Wireless Communication · GEMS Software

INTRODUCTION

The definition of terms of Antennas or Aerial according to IEEE standard (IEEE Std. 145-1983) defined as, "A means for radiating or receiving radio waves" [1] [2]. Generally, the transitional structure between free space and a guiding device is known as Antenna [3]. There are various types of antennas such as [4]:

- Wire antennas,
- Aperture antennas,
- Microstrip antennas,
- Reflector Antennas,
- Lens antennas etc.

Among all of them, Microstrip antennas became very much popular, particularly for spacebourne applications [5]. Microstrip patch antenna consists of a dielectric substrate with a ground conducting plane on the other side [6]. It consists of a metallic patch on a grounded substrate [7]. The configuration of patch may differ upon the applications and operating frequencies. The proposed antenna consists of the rectangular patch. The dimension of the patch is defined by the patch length (L) and width (W). The choice of substrate is also very important. The essential factors like: temperature, humanity and environmental ranges of operation should be considered. The thickness of the substrate (h) plays a significant role on the resonant frequency (f_r) and bandwidth of the antenna.

The desirable advantages of Microstrip patch antenna makes them useful in many wireless communication applications. They have low profile, light weight, low volume, low profile planer configuration, easy fabrication with low cost, supports both linear and circular polarization, easily integrated with microwave integrated circuits, capable of dual and triple frequency operations, mechanically robust [8]. They are well suited for applications like: wireless communication system, cellular phones, pagers, radars systems and satellite communication systems [9]. The most important advantage is the design of Microstrip patch antenna using Microstrip transmission line feeding technique is so much easy to fabricate and easy to match them by inset position control and to model [10]. However, narrow bandwidth, low efficiency, large ohmic loss, capability of handle low RF power & low gain in Microstrip patch antenna are considered as the main disadvantages. The bandwidth of the Microstrip patch antenna can be increased by increasing the thickness of the substrate (h), but, within certain permissible limits, on the other hand, the antenna may stop resonating [11].

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In this paper, an 8-shapped slot Microstrip patch antenna is designed. It is simulated using GEMS software and applicable for various wireless communication applications with overall dimensions 50mm×40mm and height of 1.60 mm. The simulation results are presented in this paper is based on the commercially available GEMS Software (General Electromagnetic Simulator Software, Version: 7.71.03), which is based on the parallel FDTD algorithm.

The paper is divided into the following ways: the section-2 describes several literatures review related to this research; the section-3 demonstrates the design of structures and configurations of antenna; the section-4 consists of the simulated results using GEMS software & the section-5 includes the conclusion of the entire research.

Literature Review: Microstrip patch and its development are going on rapidly with the help of many researchers over the world due to its low profile, low weight and easy fabrication processes. It has narrow bandwidth, low efficiency and low gain. The researchers are trying to overcome the drawbacks of Microstrip patch antenna. Recently, 8-shaped Microstrip patch antenna has been reported by some researchers.

- An 8-shaped dual feed Microstrip patch antenna has been reported for 2.499 GHz (BW= 64.19%) and 4.937 GHz (BW= 11.83%) [12].
- Another, 8-shaped Microstrip PIFA antenna has been proposed having two frequency bands from 2 GHz to 3 GHz and from 4 GHz to 7 GHz. The novel PIFA antenna is designed and optimized using Genetic Algorithm (GA) and then it is implemented on FR4 substrate [13].

Antenna Design and Specifications: The design specifications for the proposed antenna are noted as follows:

- The antenna is designed with a ground plane with an area 50mm×40mm×1.60 mm.
- The dielectric material which is selected for proposed antenna design is FR4.
- The dielectric constant of the material is 4.40.
- The height of the substrate of the proposed antenna is 1.40 mm.

Fig. 1: Eight-Shaped Microstrip patch antenna fed by Transmission line

Table 1: Details dimensions of the proposed antenna (Unit: mm)

W1	40 mm
L1	50 mm
W2	20 mm
L2	30 mm
W3	10 mm
L3	09 mm
W4	10 mm
L4	09 mm
W5	02 mm
L5	10 mm

The designed antenna is fed by 50Ω microstrip transmission line. The advantages of using transmission line feeding technique have mentioned earlier. The antenna configuration is shown in the Figure 1.

The details dimension of the proposed antenna is shown in Figure 2 with the help of mesh view of antenna. The dimension of the antenna is illustrated numerically in the Table 1. The overall dimension of the proposed antenna is 50mm×40mm×1.60 mm. The 8-shaped slot patch has incorporated in order to increase the overall impedance bandwidth of the antenna. The commercially available GEMS software is used to obtain the return loss curve & the radiation pattern of the antenna.

After modeling and designing the structures of the proposed antenna, it is simulated and optimized for improved results using the GEMS software. The next section provides the simulation results with required figures.

Results of Simulation: The S-parameter curve of the proposed antenna is shown in Figure 3. It shows that, the antenna resonates at three different points with satisfactory return loss and impedance bandwidth. The three center frequencies of the antenna from the return loss curve are at 2.12 GHz, 6.98 GHz and 13.84 GHz respectively.

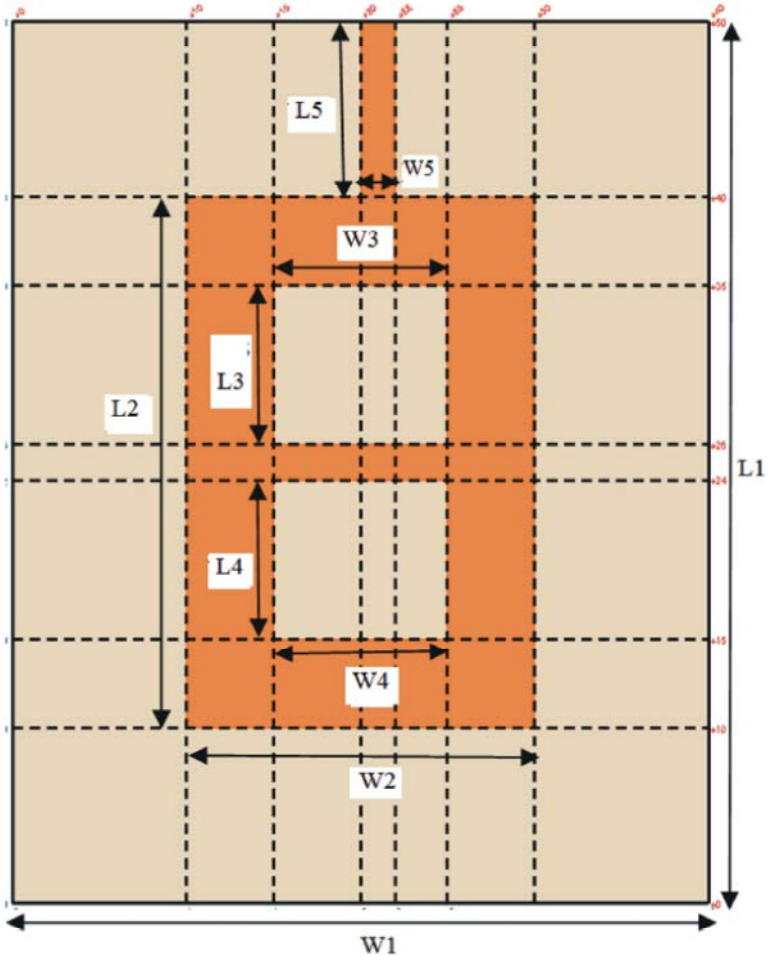

Fig. 2: Geometry & dimensions of the proposed antenna

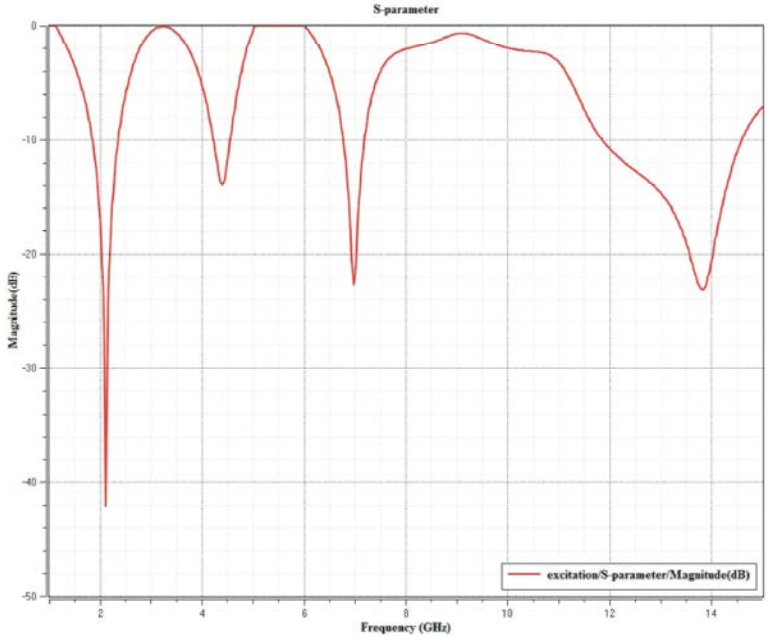

Fig. 3: The simulation result of 8-shaped slot antenna (Return loss and impedance bandwidth)

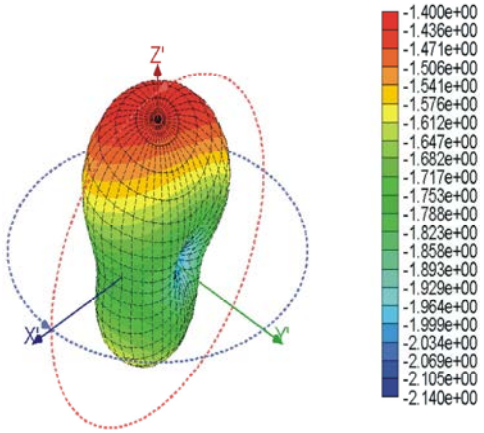

Fig. 4: 3D Radiation Pattern at 2.12 GHz

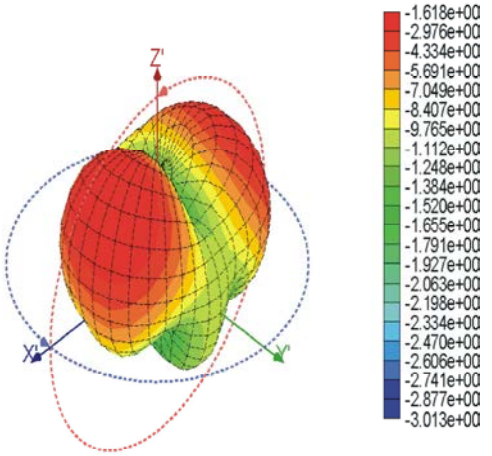

Fig. 5: 3D Radiation Pattern at 6.98 GHz

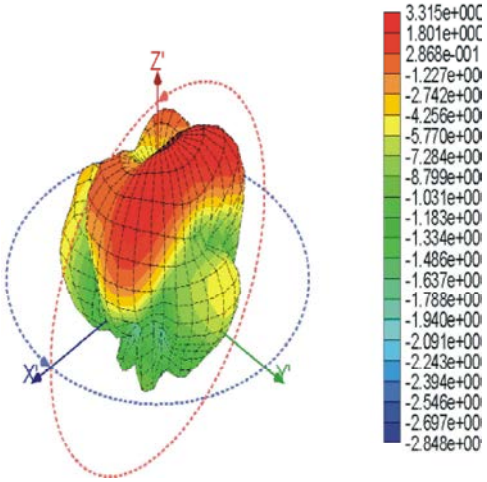

Fig. 6: 3D Radiation Pattern at 13.84 GHz

The frequency bands at lower frequency band is from 1.837 Ghz to 2.38 Ghz, at middle frequency band is from 6.788 GHz to 7.217 GHz & at upper frequency band is from 11.87 GHz to 14.60 GHz with -10 dB return loss. Hence, the bandwidths of the antenna (at -10 dB) of the three frequencies are 25.75%, 6.13% and 20.63% respectively. The return loss (S_{11}) characteristics for the three bands are -41.95 dB, -22.68 dB and -23.15 dB respectively. These are shown in Figure 3.

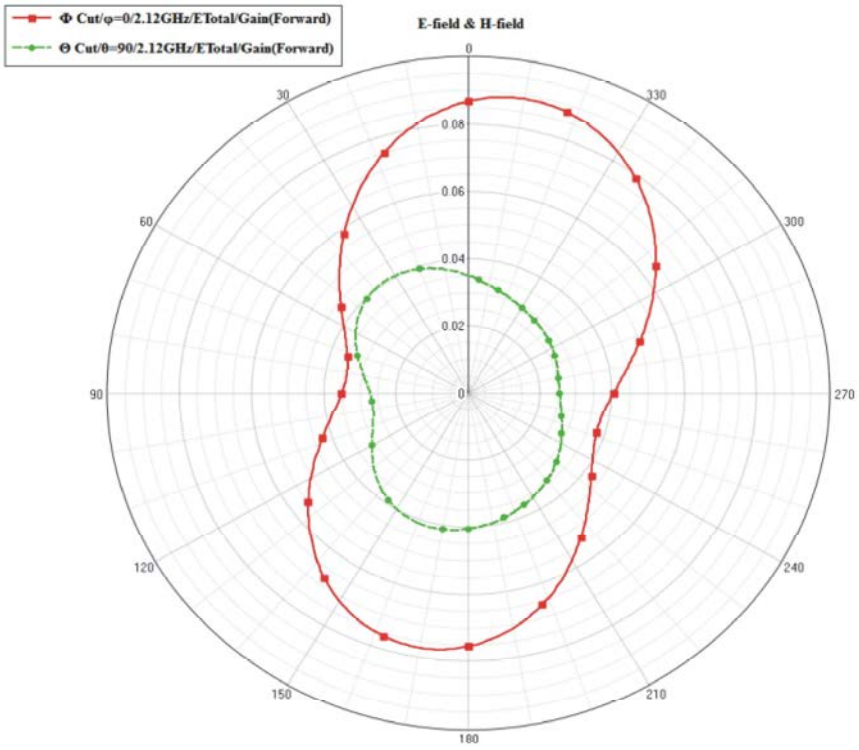

Fig. 7: E-plane and H-plane radiation pattern at 2.12 GHz

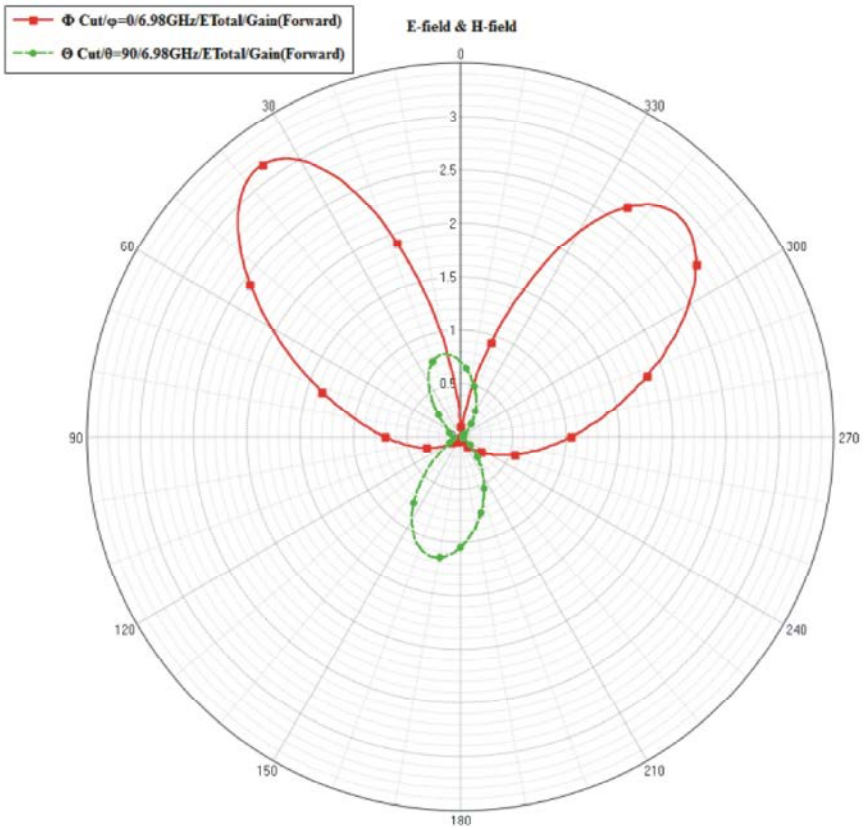

Fig. 8: E-plane and H-plane radiation pattern at 6.98 GHz

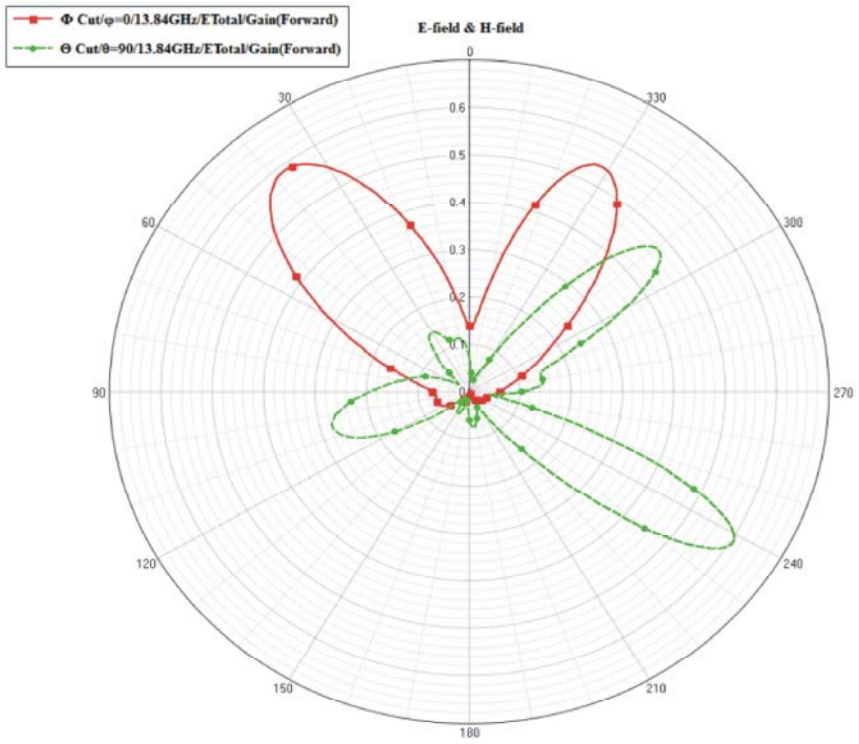

Fig. 9: E-plane and H-plane radiation pattern at 13.84 GHz

The 3D radiation pattern of the designed antenna at the three center frequencies 2.12 GHz, 6.98 GHz and 13.84 GHz respectively are shown in from Figure 4 to Figure 6.

The E-plane and H-plane radiation pattern of the designed antenna at the three center frequencies 2.12 GHz, 6.98 GHz and 13.84 GHz respectively are shown in from Figure 7 to Figure 9.

Hence, we have investigated the designed antenna based on simulation results. The bandwidth from the simulation results is satisfactory, since microstrip patch antenna provides low bandwidth; we have generated significant and acceptable one for different wireless application.

CONCLUSION

This paper presented the design and simulation of an 8-shaped slot microstrip patch antenna. The triple band operation of the antenna is achieved at 2.12 GHz, 6.98 GHz & 13.84 GHz respectively. The impedance bandwidth of the designed antenna is satisfactory having values (at -10 dB) are 25.75%, 6.13% and 20.63% respectively which are generally standards for various wireless applications. The return losses of the antenna at three frequency bands are bands are -41.95 dB, -22.68 dB and -23.15 dB respectively. The antenna characteristics and radiation patterns are applicable for many wireless applications.

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