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Design and Study of Pentagonal, Square Slotted Patch Antenna for Wireless Applications

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ABSTRACT: **This paper presents design and study of Pentagonal, Square Slotted Patch Antenna (PSSPA) with stripline-feed for wireless communication based applications. Multi bands with better VSWR are obtained for respective resonant frequencies. The impedance bandwidth of PSSPA is improved from 2.06% to 15.2 % with better return loss characteristics by etching square shape slot inside pentagon shape slot embedded with circular patch. The proposed antenna consists of a single substrate layer on one side with ground plane on other side. The characteristics features of antenna are investigated on Mentor Graphics IE3D EM simulation software. The design procedure and practical results are presented and discussed in detail.**

Keywords: Pentagon, Patch, VSWR, Return loss, radiation, software.

I. INTRODUCTION

Due to their many attractive features, microstrip antenna has drawn the attention of researchers over the past work [1-3]. Microstrip antennas are used in an increasing number of applications, ranging from biomedical diagnosis to wireless communications [4]. These wide ranges of applications, coupled with the fact that microstrip patch structures are relatively easy to manufacture, have turned microstrip analysis into an extensive research problem. Research on microstrip antenna in the 21st century aims at size reduction, increasing gain, wide bandwidth, multiple functionality and system-level integration. Significant research work has been reported on increasing the gain and bandwidth of microstrip antennas. Many techniques have been suggested for achieving wide bandwidth [5-6].

There are numerous and well-known methods to increase the bandwidth, gain of antennas, including decrease of the substrate thickness, feeding techniques and with the use of different optimization techniques [7-8]. There are many types of feeding methods used but they are bit complex, e.g. aperture coupled feeding, L-probe feeding, non contact feeding, which can also be used to enhance the bandwidth. In this work, antenna feeding is done by microstrip line feed method with different slots cut on the patch surface with ground plane on the other side. This kind of design work is studied and investigated on Mentor Graphics IE3D EM simulation software with optimized dimensions.

II. DESIGN OF ANTENNA & RESULTS

Fig. 1 show the proposed geometry of Pentagonal, Square Slotted Patch Antenna (PSSPA) with stripline-feed. As shown in Figure 1, the patch antenna is fabricated on a substrate with relative dielectric constant of ϵr = 4.4 and thickness of h = 1.6 mm. After the selection of a suitable substrate material, the other characteristics parameters of the antenna are determined by using the design methods available in the literature [1].The length and the width of the patch are calculated by using below equations. The patch width W shown in Fig. 1 is given by,

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

The length of patch is given by,

$$L = \frac{c}{2f_r\sqrt{\varepsilon_r}} - 2\Delta l \quad (2)$$

where, $$\Delta l = 0.412h\frac{\left(\varepsilon_e + 0.3\right) + \left(\frac{w}{h} + 0.264\right)}{\left(\varepsilon_e + 0.258\right)\left(\frac{w}{h} + 0.8\right)} \quad (3)$$

$$\varepsilon_e = \left(\frac{\varepsilon_r + 1}{2}\right) + \left(\frac{\varepsilon_r - 1}{2}\right)\sqrt{1 + \frac{12h}{w}} \quad (4)$$

The Pentagonal, Square Slotted Patch Antenna (PSSPA) is designed for the resonant frequency (f_r) of 3.5 GHz using the basic equations available in literature [9-13]. The length and width (L x W) of the patch is (18.99 x 26.92 mm). The length and width of quaterwave transformer ($L_t x\ W_t$) is (10.18 x 0.66 mm). The length and width of feedline (L_f x W_f) is (10.19 x 3.35 mm). The horizontal and circular slots is etched on the patch plane of as shown in Fig. 2. The dimension of the slot is taken in terms of λ_0, where λ_0 is the free space wavelength corresponding to the designed frequency of conventional RPA.

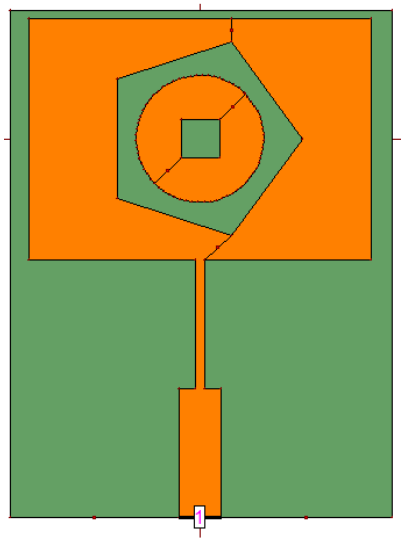

Fig. 1. Structure of PSSPA.

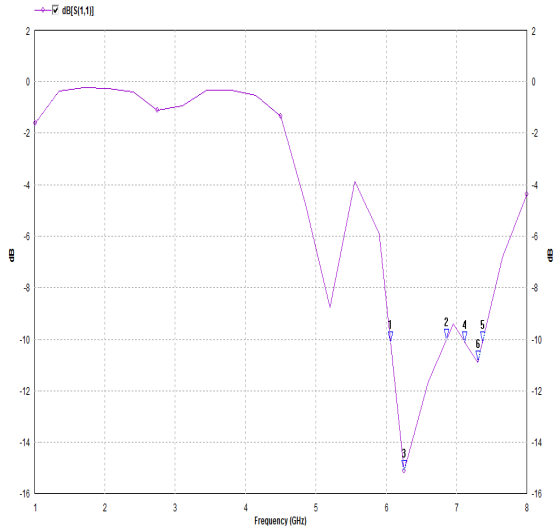

Fig. 2. RL Characteristics of PSSPA.

Fig. 2 shows the return loss in dB for (Pentagonal, Square Slotted Patch Antenna) PSSPA with line feed with optimization. The actual dimensions are used, which have calculated by geometrical formulas.

After optimized dimensions, the return loss decreases to -15 dB at 6.25 GHz as primary frequency and secondary frequency resonates at 7.3 GHz (-11.2dB) which further improved BW1=15.2 % BW2=8 % for respective resonant frequencies. With this novel different shape slot loading technique Improvement in bandwidth is achieved (15.2 %) compared to conventional microstrip antenna.

Figure 3 shows the average current density distribution plot of a PSSPA. It shows the average strength of the time-harmonic current density distribution at a specific frequency. The colour represents the average strength of the current density at a specific point. For the default continuous tone display, the blue colour means strong current density. The green colour means excitation current density.

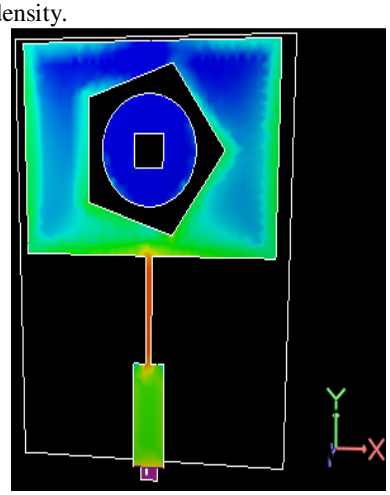

Fig. 3. Current Distribution Display for PSSPA.

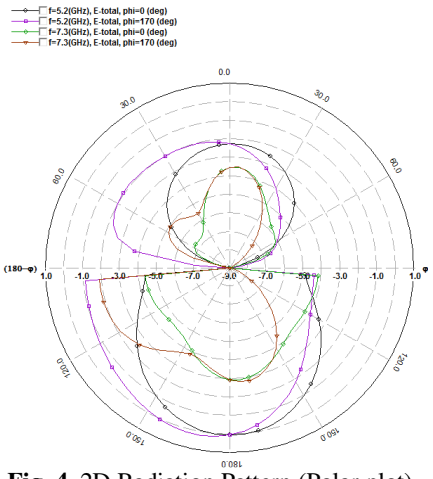

Fig. 4. 2D Radiation Pattern (Polar plot).

The 2D polar plot of PSSPA is as shown in figure 4 for respective resonant frequencies 6.25 GHz and 7.3 GHz. Figure 5 shows the radiation pattern in the actual 3D space. The size of the pattern from the origin represents how strong the field at a specific (theta, phi) angle.

Figure 6 shows the VSWR characteristics showing the VSWR values are quite well below 2 representing the low value of losses better matching.

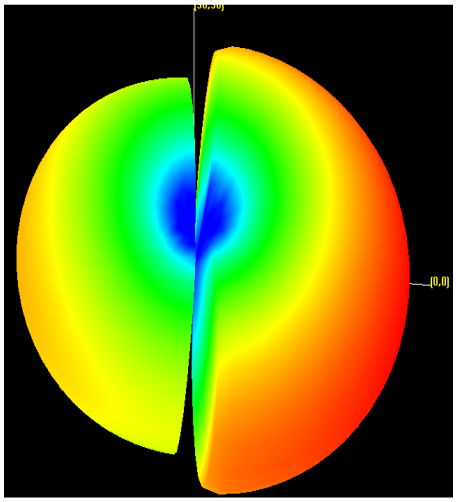

Fig. 5. True 3D Radiation Pattern.

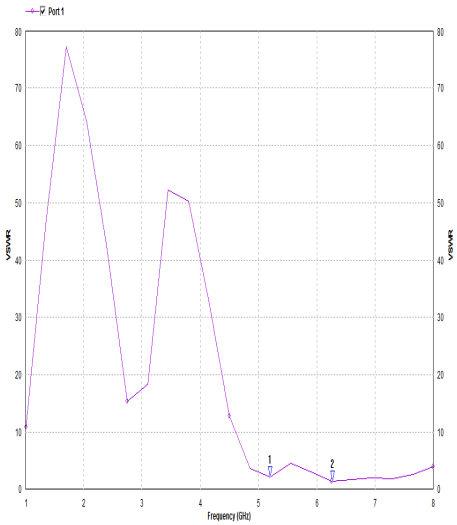

Fig. 6. Plot of VSWR for PSSPA.

III. CONCLUSIONS

In this work, with the help of IE3D simulation software tool, the study and design of Pentagonal, Square Slotted Patch Antenna id carried out. The results obtained from IE3D shows almost 15.25 Improvement in bandwidth compared to conventional microstrip antenna. Significantly better radiation patters with low values of VSWR are also achieved which is suitable for wireless communication based applications.

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