

Sierpienski fractal Slotted Hexagonal Microstrip Patch Antenna Using transmission feeding technique

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Abstract—There are various types of microstrip antenna that can be used for number of applications in wireless communication. In this paper, the design of Sierpienski fractal Slotted Hexagonal Microstrip Patch Antenna with FR4 glass epoxy substrate having dielectric constant, E_r of 4.4, and thickness 1.6mm has been presented. It is instigated using stripline feeding. These antennas are compact, conformal to both the surfaces- planar & non-planar, simple, inexpensive, rugged, compatible with MMIC designs. Microstrip antenna is made up of a very thin metallic strip (patch) i.e, placed over a small fraction of a wavelength above a ground plane. The simulated results indicate that the antenna is suitable for RADAR (all types), GPS carriers, WLANs, Wimax, Satellite communication, navigation. The design is simulated using IE3D software and result is obtained in terms of smith chart, VSWR, return loss.

Keywords—Antenna theory, Return Loss, VSWR, Feeds, Microstrip Patch Antenna.

I. INTRODUCTION

The microstrip patch antenna plays a substantial role in the modern wireless communication due to its light weight, small size and low cost. In ISM band, aforesaid antennas can be used in Satellite communication, near field communication (NFC), Bluetooth devices and Cell phones [3]. The microstrip patch antenna has a radiating patch above the dielectric substrate with ground plane on other side. The copper or gold material can be used for the patch. Fabrication techniques are used to fabricate the microstrip antennas [3]. The instigation of patch antennas can be done by using two feeding techniques i.e, stripline feed and coaxial feed. The design is simulated using IE3D Software [14] for parameters like return loss, VSWR, smith chart, Radiation pattern and the comparison of these results is reported.

II. THEORY OF PATCH ANTENNA

The microstrip patch antenna consisted of a dielectric substrate intermeditated between two conducting metals [1]. It can be designed in different shapes like square [9], rectangular [2], triangular, [4], circular [10], E shaped [7]. However, rectangular shape is preferred over other shapes to design microstrip antenna. The fringing field formed between the patch edge and ground plane is responsible for antenna radiation. The dimensions of patch are- length L [12], width W [11], and thickness t over the dielectric substrate of height h supported by ground plane as in Fig.1[1].

Microstrip Feed

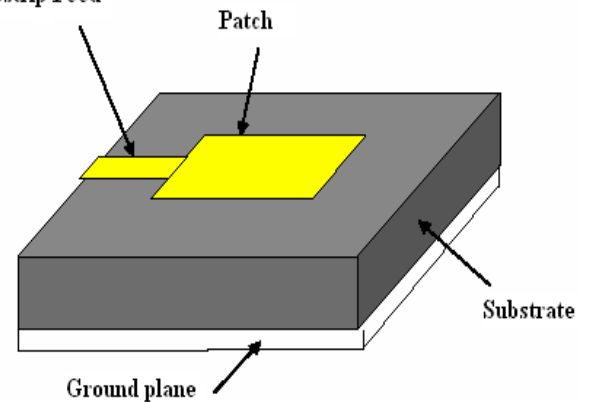


Fig.1: Geometry of Rectangular microstrip patch antenna.

The transmission line model is used to examine the microstrip patch antenna [6]. The fringing field are affected by the dielectric constant. Value of dielectric constant reduces the fringing field. They are formed not only in dielectric substrate but are also spread in air as shown in Fig.2

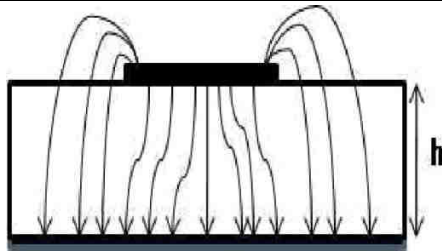


Fig.2: Electric field lines

Plays a vital role in impedance matching. The position of feed also affects the input resistance of microstrip antenna [2]. Different types of feeding methods are transmission line, probe, aperture coupling and proximity coupling. The designs of microstrip patch antennas can be simulated by using IE3D software [14].

Width of the patch

$$W = \frac{c}{f_r \sqrt{\epsilon_r + 1}} \sqrt{2} \tag{1}$$

Where , c is the speed of light
 f_r is the resonant frequency

Effective dielectric constant:

$$\epsilon_{\text{reff}} = (\epsilon_r + 1)/2 + (\epsilon_r - 1) / \sqrt{2 \sqrt{1 + 12 h/w}} \tag{2}$$

Where, ϵ_{reff} is the effective dielectric constant

ϵ_r is the dielectric constant

h is the height of the substrate

W is the width of the patch

Taking into account the fringing effect:

The fringing fields along the width of the structure are taken as radiating slots and the patch antenna is electrically seen to be a bit larger than its physical size.

$$\Delta L = 0.412h \frac{(\epsilon_{\text{reff}} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{\text{reff}} + 0.258) \left(\frac{W}{h} + 0.8 \right)} \tag{3}$$

Calculating the effective length of the patch

$$L_{\text{eff}} = \frac{c}{2f_r \sqrt{\epsilon_r}} \tag{4}$$

Calculating the actual length of the patch

$$L = L_{\text{eff}} - 2 \Delta L \tag{5}$$

Thus by using resonance frequency of 3.54 GHz with stripline feed ,dielectric material FR4 With $\epsilon_r = 4.4$

height of substrate 1.6mm, the width of patch and length of patch of propounded antenna was calculated by using equations 1, 2, 3, 4. Similarly, results are obtained using probe feed. These parameters are presented in Table I.

Table 1

Feeding Techniques	Resonant Frequency (Ghz)	BW (%)	VSWR	Return Loss (db)
Transmission line feed	3.54	8.75	1.75	11.34

A. Feeding Methods

The instigation of patch antenna can be done using various feeding techniques like transmission line, coaxial, aperture coupling and proximity coupling. Transmission line and coaxial feeding methods are mainly used in present communications. The transmission line feed method has a conducting strip with comparatively smaller width to the patch. It is easier to fabricate. Impedance matching is performed by choosing a particular position at the edge of the patch. Furthermore, in coaxial feeding the inner conductor of SMA is enlarged through dielectric and is connected to the conducting patch by soldering while outer conductor is soldered to the ground plane.

III. RESULTS AND DISCUSSION

The propounded rectangular microstrip antenna is designed; particular location of feed position for stripline and coaxial feeding is enhanced and the various parameters of antenna are instigated using IE3D software.

B. Location of Feed Point

The location of stripline and coaxial feed is at point, where input impedance is 50Ω at a determined resonant frequency. For both feeding technique the location of feed point is decided in such way that the return loss is more negative at resonant frequency at that point. Thus in stripline feeding, the feed point is varied along width of patch noticing the return loss at resonant frequency. Additionally, in coaxial feeding the feed point is varied in the plane of rectangular patch. Hence, the position of feed point was changed and the value of return loss for number of times was perceived by trial and error method [13].

The designed Sierpienski fractal Slotted Hexagonal Microstrip Patch Antenna of width 20 mm and length 20 mm with proper feed position for stripline is presented in Fig.3.

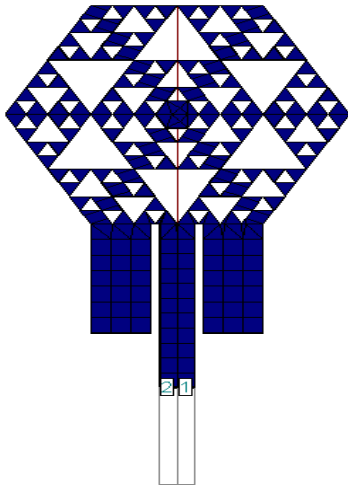


Fig.3: Geometry of the designed microstrip patch antenna

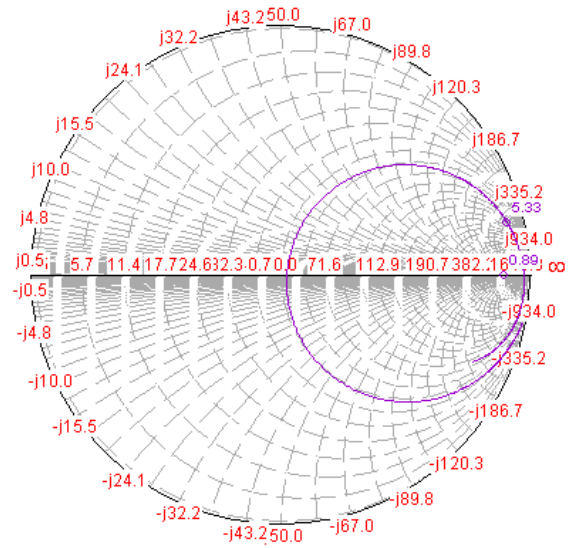


Fig.6: Smith chart

The simulated results were obtained in the frequency range of 0 GHz to 8 GHz for stripline feed . The variation of return loss with frequency for stripline feed is shown in Fig 4. The corresponding resonant frequency is inspected to be 3.54 GHz for stripline feeding . It can be noticed that the resonant frequency for stripline feeding is very close to conjectural frequency for coaxial feeding. The return loss is -11.34 dB at 3.54 GHz for stripline feeding, the return loss is not more negative for coaxial feeding than for transmission line feeding.

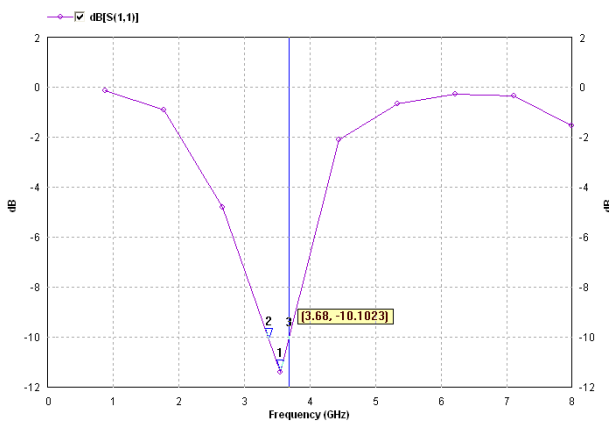


Fig.4: Variation of return loss with frequency

Fig.5 shows the variation of VSWR with frequency. The VSWR to be 1.75 for stripline feeding at resonance frequency.

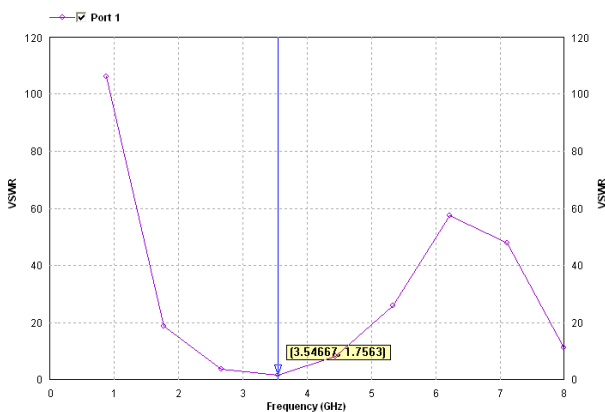


Fig.5: VSWR with frequency

Fig.6 shows the input impedance loci using the smith chart.

IV. CONCLUSION

Design is simulated and the results of the propounded antenna is obtained using transmission feed methods. The main advantages of propounded method are: simple and easy design, low profile, maintained radiation pattern. The transmission fed Sierpienski fractal Slotted Hexagonal Microstrip Patch Antenna at 3.54 GHz, designed on FR4 substrate with 4.4 dielectric is studied by IE3D software. The simulated results indicate that the antenna is suitable for RADAR (all types), GPS carriers, WLANs, Wimax, Satellite communication, navigation.

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