Simulation of a Rectangular Spiral Shaped Microstrip Patch Antenna

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Abstract

For some applications it is required to design antennas operating at lower frequencies, have relatively low lateral size and a narrow beam broadside radiation pattern. To that end a new rectangular spiral shaped microstrip antenna is designed and simulated by using of commercial software CST Microwave Studio. The parameters are optimized to have an operation frequency around 1-3.5 GHz, maximum lateral size of 3.5 cm, a minimum directivity of 6 dBi and a HPBW less than 90°. The achieved results are promising and are tunable to specific parameters.

1. Introduction

Subsurface imaging applications and other applications where the penetration depth and resolution are concerned there is a need for directive antennas operating at relatively low frequencies, having smaller lateral size and narrower HPBW. However these requirements are constrained by inverse relationship about the electrical size of the antenna and its operating frequency. In this paper the aim was to design an antenna have a maximum lateral size of 3.5 cm, will be able to operate between 1-3.5 GHz, a minimum directivity of 6 dBi and a HPBW less than 90°. To that end the microstrip antenna is chosen as a template since it has a high performance in many applications due to its lightweight, low profile with conformability and ease of integration in other systems [1].

It is well known that to decrease the operating frequency electrical size of the antenna has to be increased. In addition, to reduce the size of the patch antenna several techniques have been presented in the literature such as using a substrate with high dielectric constant [2], cutting slots in radiating patch [3-4] and by partially filled high permittivity substrate [5]. In this paper we present a rectangular spiral shaped microstrip patch antenna and its simulation results obtained by using of commercial software CST Microwave Studio.

2. Antenna Design Procedure

The geometrical configuration of the discussed rectangular spiral shaped patch antenna consists of 3 turns. In every turn the microstrip increases in length regularly. The total length of the turned microstrip is 24.6 cm. The dielectric constant of the substrate is chosen as 2.2. The spiral shaped patch antenna fed by a coaxial feeding system is in the midpoint of the antenna as it is depicted in Figure 1. The spiral shaped patch antenna introduces the capacitance to allow the use of a thick substrate (~0.1λ_o) and induce a second resonance near the main resonance of the spiral shaped patch. The spiral shaped patch antenna has an average gain of 7 dBi and excellent pattern characteristics.

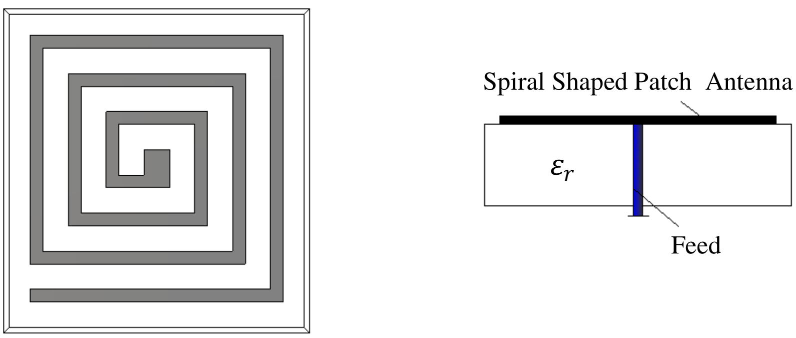

Figure 1. Rectangular spiral shaped microstrip patch antenna top (left) and side (right) view.

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For this design, the substrate electrical parameters, feed line width, and slot size and position can be used to optimize the design [6]. Typically matching is performed by controlling the width of the feed line and the length of the slot. The coupling through the slot can be modeled using the theory of Bethe [7]. The coaxial feed position is determined at the center of the antenna to give optimal matching ~50 ohm (characteristic impedance) at the port.

3. Simulation Results of the Spiral Shaped Patch Antenna

In Figure 2 the return loss of the antenna is depicted between 1-4.5 GHz. S-parameters as a function of frequency resonant at 2.0858, 2.5101, 2.9894 and 3.4745 GHz, where the S11, VSWR and directivity are given in Table 2. In Figure 3-4 the scaled radiation patterns are depicted in terms of directivity in elevation direction for $\phi = 0, 90^{\circ}$.

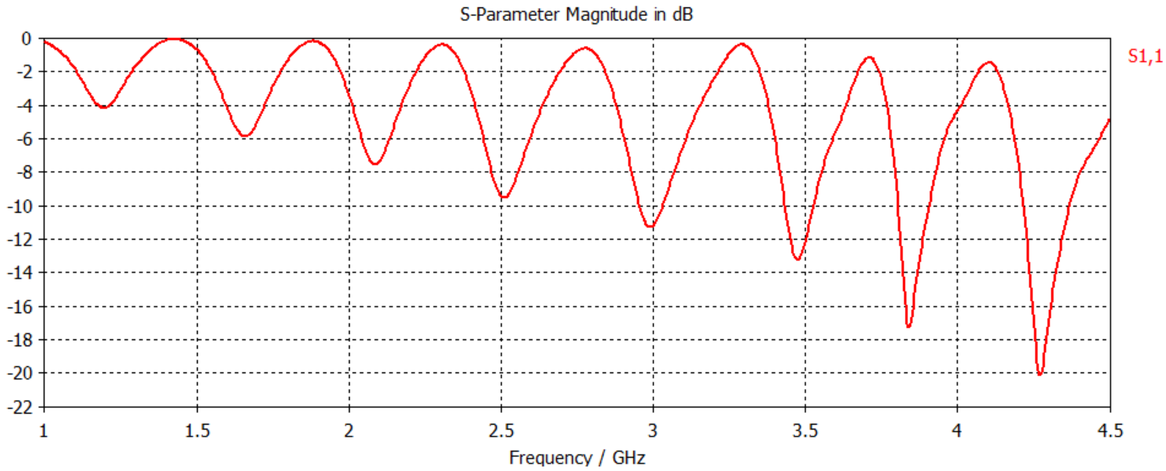


Figure 2. Magnitude of S11 for the spiral shaped patch antenna

Table 2. S11 Parameters, VSWR and directivity results

Resonant Frequency- f [GHz]	S11 Parameters	VSWR	Directivity [dBi]
2.0858	-7.558	2.4	7.029
2.5101	-9.549	1.9	7.708
2.9894	-11.284	1. 7	7.603
3.4745	-13.232	1.5	6.845

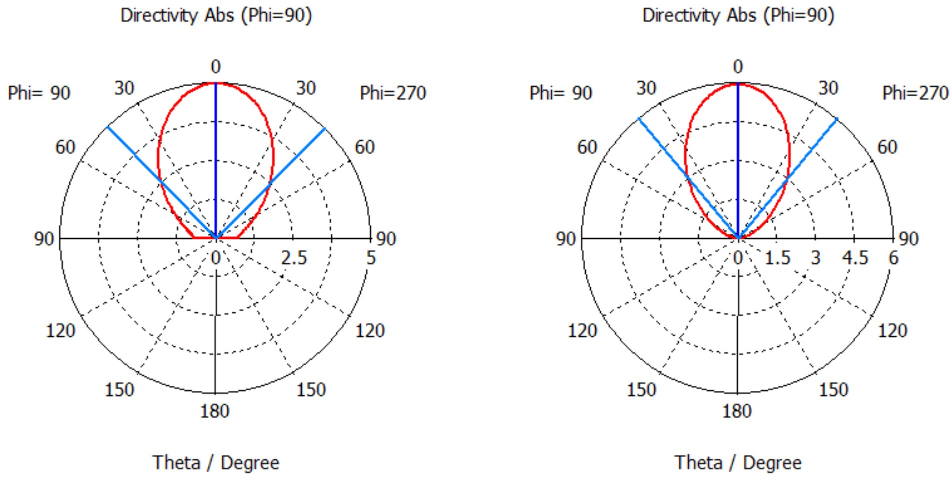
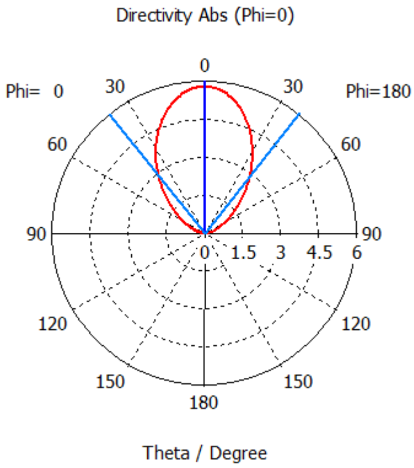


Figure 3. Scaled radiation patterns for $f = 2.0858$ GHz (left) and for $f = 2.5101$ GHz (right)



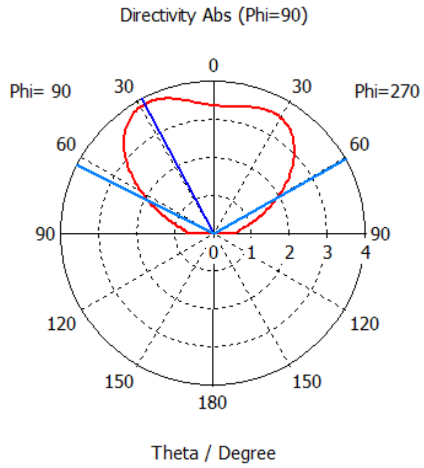


Figure 4. Scaled radiation patterns for $f = 2.9894$ GHz (left) and for $f = 3.4745$ GHz (right)

4. Conclusion

In this paper, the design of a small size multi-band spiral shaped patch antenna has been presented at different resonant frequencies. The obtained results promise to use it in applications for 1-3.5 GHz region requires HPBW less than 90° and a directivity of minimum 7 dBi. The radiation pattern greater than 3 GHz becomes worse and its directivity decreases.

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