Study and Simulation of Wide Band Spiral Microstrip Antenna

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ABSTRACT: *The expanding use of wireless devices has prompted the need of larger bandwidths by these devices. This need is a result of larger bit-rates or the use of different standards using different frequency bands. In this work, Ultra Wide Band (UWB) 2-14GHz with its matching circuit is presented. The antenna responses, input impedance radiation pattern, currant distribution and VSWR at various frequencies are studied and compared to that of a commercial antennas . The viability of this antenna is tested using the simulator of CST-2010 tool.*

Keywords: 2 to 14 GHz Band, Spiral Antenna, Wideband Antenna, Balun

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1. Introduction

As the demand for spread spectrum and multi functions RF systems increases, antennas that are capable of wide band operation are becoming more desirable in recent years. As well as the increasing demands for high-quality wireless communication system, circularly polarized antennas have attracted significant attention, since they can suppress multipath interference and require no polarization tracking. Spiral antennas have low profiles, light weight and are easy to fabricate and integrate. So the spiral antennas meet the requirements for automotive , Radar, and pulse transmitting and receiving applications. Therefore it is noted that designing and fabricating a wideband antenna with balloon has been an issue for antenna engineers. The first very wide-band antenna using spiral topology was invented by Ed Turner in 1950 [1]. There are several types of antennas that exhibit large bandwidths, such as: Bow-Tie, Equiangular Spiral, Log-Periodic and Archimedes spiral [2] [3]. These can be easily constructed using inexpensive PCB technology and exhibit constant input impedance throughout the band. Furthermore, the designing a wideband balloon circuit has been an issue for antenna engineers[4] [5].

In this work, a wideband spiral antenna is studied, designed and simulated to obtain covering frequency band from 2GHz to 14GHz. In addition, a wideband balloon circuit is inserted between the feed line and antenna, in order to retain the inherent wideband characteristics of the spiral. The spiral has 3 turns on a substrate thickness 0.3 cm and the balun is vertically connected to the spiral as shown in figure 1.

3. Theoretical Study

Figure 2 shows the configuration and coordinate system of the proposed two-arm Archimedean spiral antenna. The arms of the spiral are described by the following equations: [6] [7]

$\rho 1(\varphi) = a.\ \varphi + b$

$\rho 2(\varphi) = a.(\varphi - \pi) + b$

Where ρ and φ are polar coordinates, a and b are constants. With as 3 turns, the radiation pattern of the antenna displays two broad lobes whose maxima are normal to the plane of the antenna. This antenna is made of two micro strip lines printed on a dielectric substrate.

The spacing between the conductors ($\Delta\rho$) is chosen to be the same of the line width (Δ). Accordingly to the principles of frequency independent antennas [1], the spiral antenna exhibits automatic cut-off of radiating currents. It consists in the fact that the currents in the spiral arms are attenuated as they go through one turn of the spiral, normally equal in perimeter to one wavelength. The geometric characteristics of the antenna are chosen by the following rules; the lower limit of the frequency span is determined by the perimeter of the last turn of the antenna, which is equal to the wavelength of the lower frequency. The upper limit is set by fact that the wavelength must be equal to the perimeter of the region where the antenna is feed.

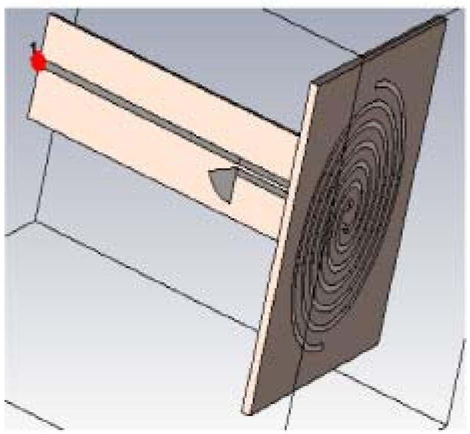

Figure 1. Spiral Antenna from With Balun

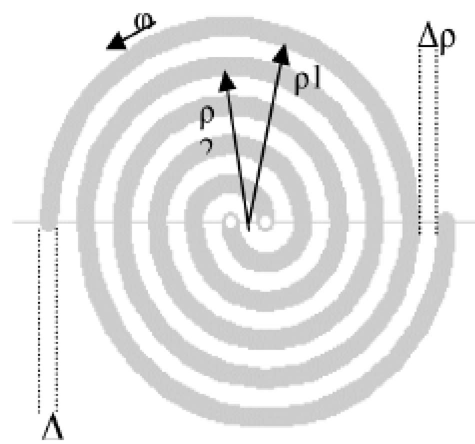

Figure 2. Configuration of spiral antenna

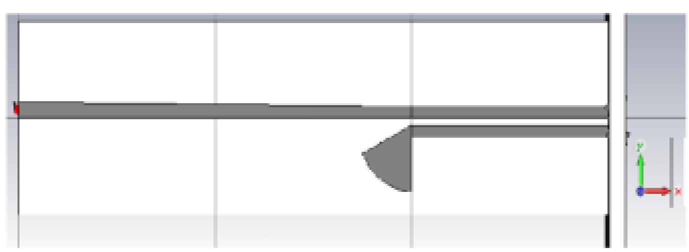

Figure 3. Balun form that is vertically to spiral plane

2. Design of the Spiral Microstrip Antenna

The Spiral antennas, such as Equiangular and Archimedean [6], are particularly known for their ability to produce very wideband, almost perfectly circularly-polarized radiation over their full coverage area. Spirals have nearly constant input impedance, radiate to both sides of the spiral plane, and are suited for low-gain systems.

In this section we investigate the antenna characteristics operating in the frequency range of 2 GHz to 14 GHz. In manner to operate the spiral as a complementary-antenna, we choose the parameters as follows: space between the conductors = 0.5 mm; line width = 0.5 mm; number of turns = 3 on substrate (FR4, εr = 4.3, and height = 1.54mm). With these parameters, the antenna has an outside diameter of (λ = 0.15 m) operating at the lower frequency, and a inside diameter of (λ = 0.0214 m) at the frequency of 14 GHz. This design was analyzed using the simulator cst-2010 [9]. The balun is required to change from unbalanced source to balanced, also to obtain the entire frequency of spiral strip. The balun is similar to [8], was developed to be vertically to the

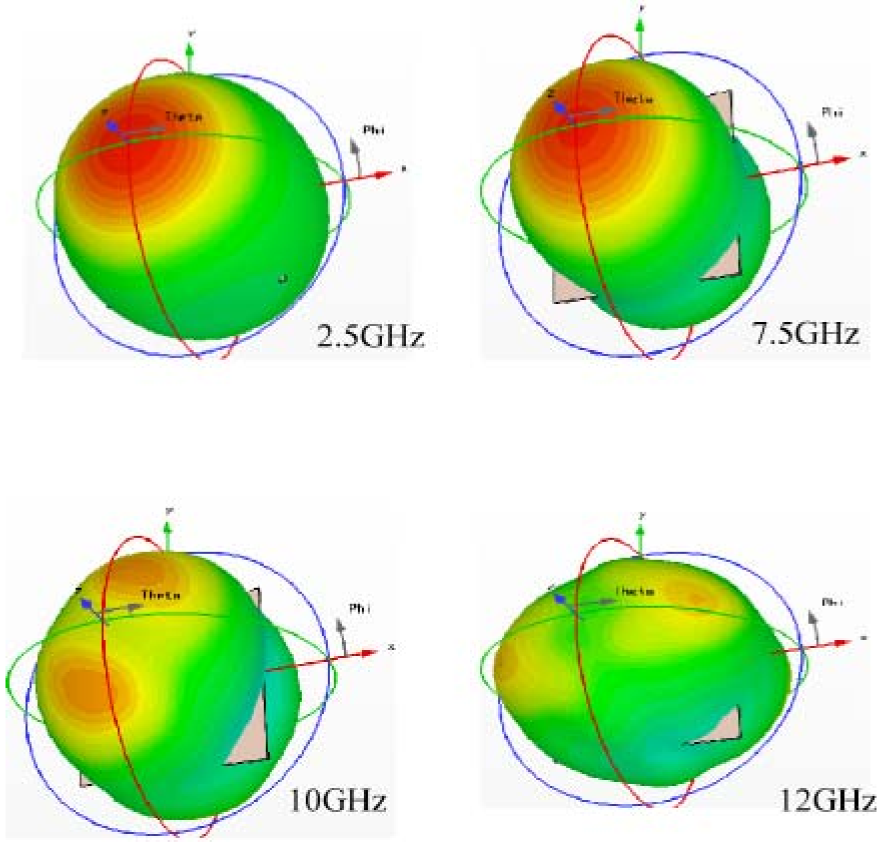

Figure 4. Radiation pattern for different frequencies

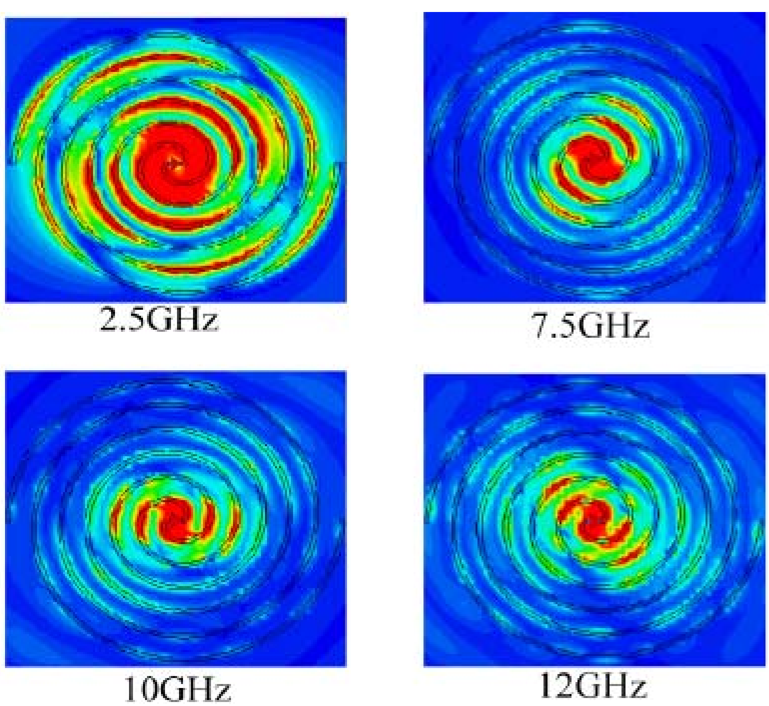

Figure 5. Current distribution form

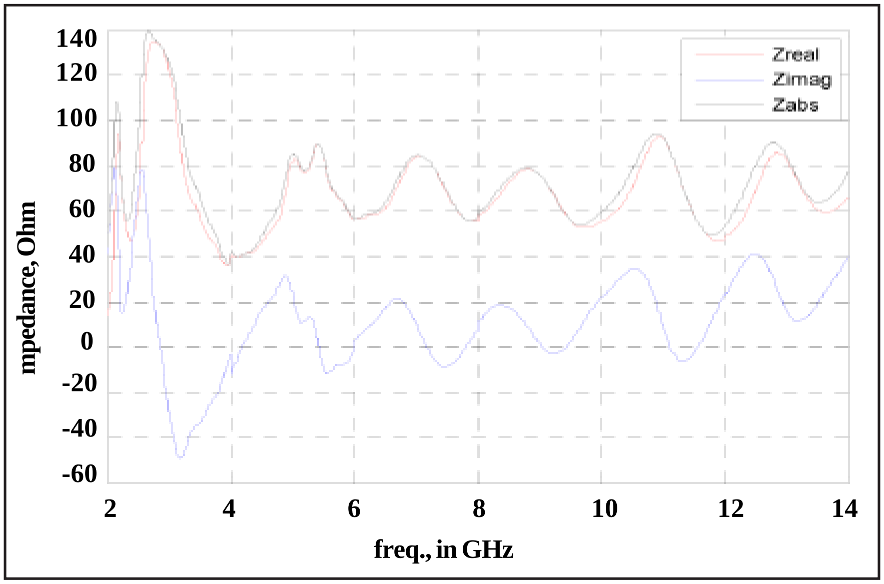

Figure 6. Input impedance over freq. range

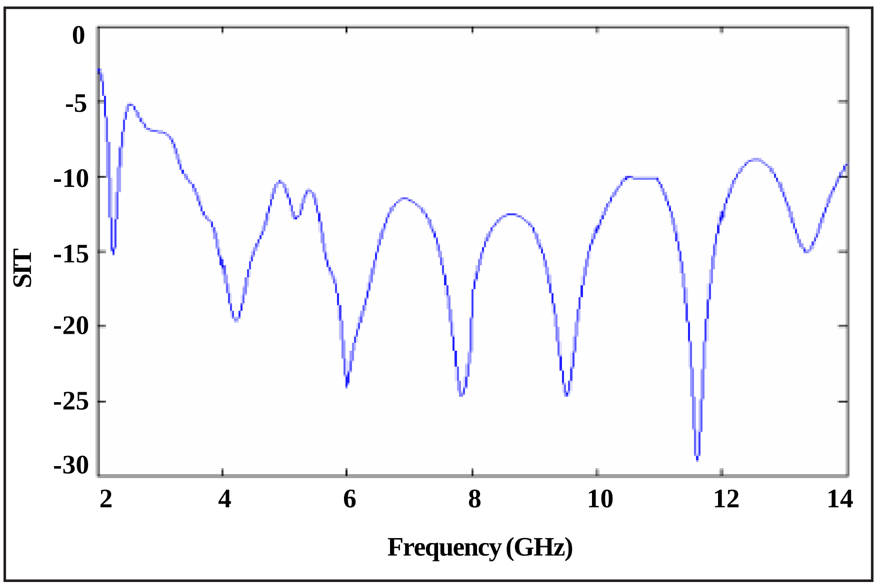

Figure 7. Simulated S11 as a function of frequency

plane of spiral. As seen in Figure 3, with εr =2.17 Taconic TLY-5A (lossy).

4. Simulation Results

Figure 4 illustrate the EΘ far-field (ϕ = 0) radiation pattern of the spiral antenna for the operation frequencies of 2.5 GHz, 7.5 GHz, 10 GHz, and 12 GHz. From Figure 4 it can be observed that there are a few issues with the radiation patterns:

1. There are ripples at high frequencies.

2. The radiation pattern is not symmetric at high frequencies (>10GHz) and the pattern remain bi bidirectional in the entire frequency band from 2GHz to 14 GHz.

Examination of the radiation patterns reveals insignificant changes with the variation of the frequency in terms of radiation fields. Figures 5 shows the distribution of the current along the arms of the spiral. Note that for 12 GHz only the first turn of the antenna is excited due the automatic cut-off principle. But at 12 GHz, the current distribution is extended to the end of spiral antenna strip line.

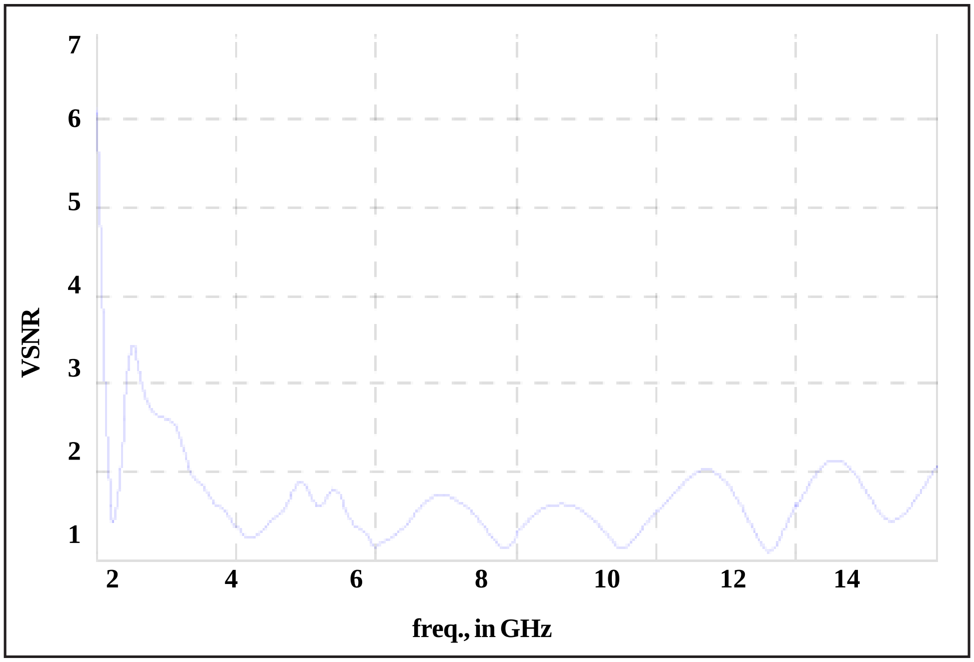

Figure 8. Simulated VSWR as a function of frequency

The input impedance is nearly constant over all the bandwidth as shown in the graph of figure 6. Also it is evident that the antenna has good impedance matching. The real part of the input impedance is around 50Ω in the operating frequency. On the other hand the imaginary part is mainly inductive over the operating band.

The return loss of the antenna is exhibited in Figure 7. From the curve it is apparent that the antenna achieved -10 dB return loss bandwidth 12GHz, ranging from 2GHz to 14GHz. Also, From Figure 8, it can be seen that this antenna has a VSWR of less than 2 over most of the frequency range from 2-14 GHz.

5. Conclusions

In this work, it was presented the design and simulation of a wide-band equiangular spiral antenna with matching circuit. This antenna cover a wide range of frequency band (2GHz -14GHz), also it is can be manufactured using inexpensive PCB . Furthermore, this antenna is compact size. So that this antenna will be competitive and suitable candidate for use in wideband communications systems.

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