“Square-spiral antenna with unbalanced-excitation”

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***Abstract*— A new spiral square architecture antenna with unbalanced excitation was designed. Spiral antenna is formed by two arms, a ragged arousal in which one of the arms is powered by an inner conductor and the other is short-circuited with a ground plane by means of a cavity. The proposed antenna is able to generate a wide range of frequencies for transmission and reception of signals UWB to VSWR 2:1 without the need for adjustments to its parameters.**

***Index Terms*— Independent-frequency; Unbalanced excitement; Square spiral antenna.**

I. Introduction

Frequency-independent antennas are used in applications that require greater bandwidths [1] [2]. Bi-conical spirals antennas, and log-periodic antennas are often classified as independent of frequency, since the spiral antennas can be built as planares structures in accordance with the principle of staggered Rumsey that defines the classes of antennas characterizing them as a single angle and so not showing an intrinsic scale length: e.g. spiral antennas, in plan [4].

Several authors have proposed microstrip square spirals antennas and circular to operate with wide bandwidth and be known as independent of frequency antennas.

In [1] the authors developed a new printed square spiral antenna, consisting of two strips in three laps, surface (80 x 80) mm², capable of operating over a wide frequency range, these antennas simulated the results were compared with results an Archimedean spiral antenna in terms of frequency dependency.

In [2] the authors proposed a spiral antenna having two arms and an unbalanced excitation where the radiation is circularly polarized within the analysis frequency range. The unbalanced-excitation spiral exhibits a frequency response for the gain i.e. similar to that of the balanced-excitation spiral.

The proposed spiral antenna has the purpose of add and continue the work defined by the authors in [1] and [2]. The proposed project measured and simulated exhibit functions miniaturization techniques. The ground plane placed diagonally and short-circuited with the feed line of the antenna is to increase its electrical length; specific assignments are attached to the proposed project.

Three spiral antennas of three rounds, turns five and seven turns were simulated and analyzed as shown in Figure 1 for the choice of planar spiral antenna proposed. In this project the proposed spiral antenna present two- arms symmetric with respect to the center point of the spiral,, square patch and unbalanced-excitation. Features including return loss, VSWR, input impedance and polarization are analyzed and discussed.

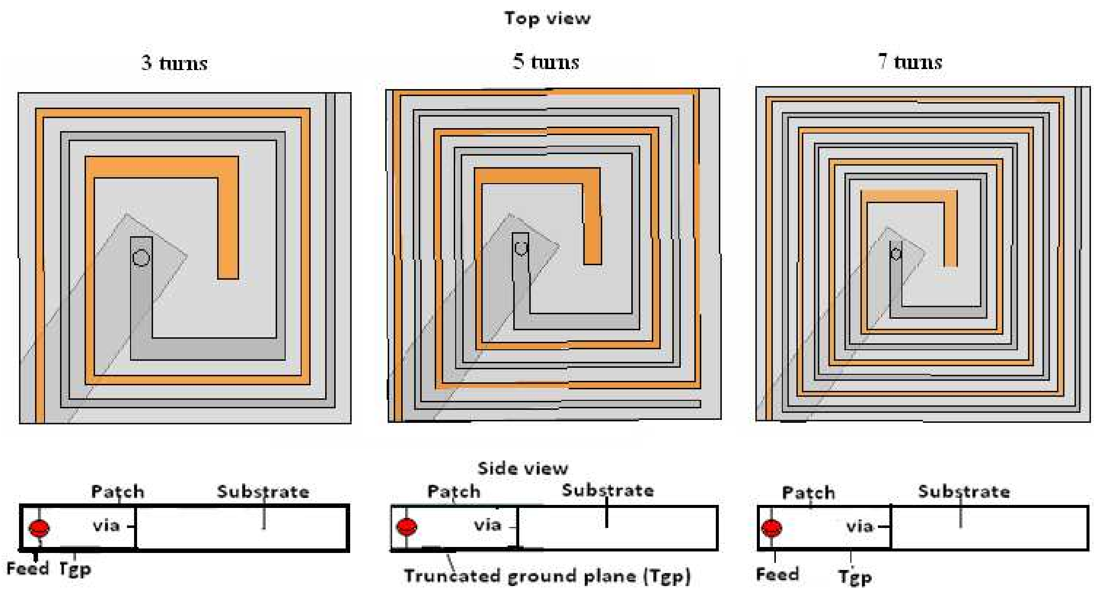

Figura 1. Optimization in the simulation of spiral antennas

Balanced spiral antennas present: the number of arms is chosen to be two, and the excitation is balanced, i.e. the same amplitude and a 180-degree phase difference between arms. With a balanced excitation, the spiral radiates a circularly polarized (CP) wave in the direction normal to the antenna plane.

The commercial program Ansoft High Frequency Structure Simulator (HFSS) [9] based on finite element method was used to analyze the behavior of proposed antenna and to determine suitable values of parameters. The experiments were performed using a vector network analyzer from Rhode and Schwarz model ZVB 14.

II. STRUCTURE AND THEORETICAL FORMULATION

Substrate of FR4, thickness of 1.8 mm, relative permittivity of 4.4, loss tangent of 0.02, measuring (65 x 65) mm²; ground plane truncated diagonally to the feed point measuring (9x45) mm² Feed made by SMA connector which in essence is a coplanar waveguide traditional, as the loss tangent of the substrate of FR4 is large, the insertion loss simulated is of 1.7 dB at 5 GHz and the measured loss is 2.9 dB at 5.0 GHz; width of the strips spirals d1 = 1mm, d2= 2.5mm and width of spirals spacing c = 2mm as shown in Figure 2. The radiation field of the spiral E_{rad} was calculated using the equivalence principle, where the electric current is given as:

$$J_e = n \ x \ FH(r,t) \quad (1)$$

and magnetic current:

$$J_m = n \ x \ FE(r,t) \quad (2)$$

on an radiating surface of the spiral.

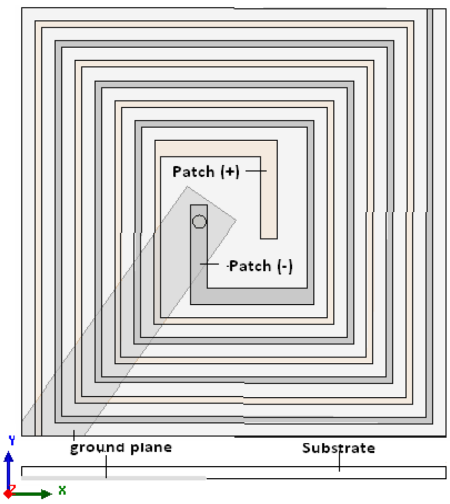

Figura 2. Antenna design proposed

III. ANALYSIS OF THE PROJECT

The first analysis was done with the simulations presented in the graphs as show the Figure 3. During the process there was separation of an active region due to studies on the incidence of resonant frequencies in a 2:1 VSWR and for definition of a proposed spiral antenna. With results of return loss versus frequencies It turns out that the greater the number of turns of the spiral, therefore, greater bandwidth and increased the size of the antenna as well defining the choice of proposed antenna.

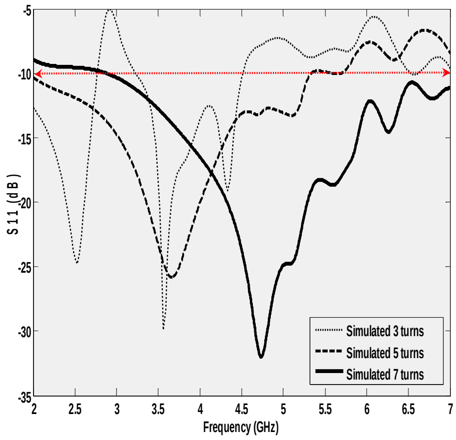

Figura 3. Return loss of simulated spirals antennas

The square spiral antenna with seven turns has the preference in the simulation process between antennas in analyzes, by presenting a graphic better in the frequency low region, a good marriage of impedance for resonant frequency in (4.75 GHz, - 32dB) and excellent amplitude (bandwidth with approximately 7.0 GHz for transmission and reception of signals UWB to VSWR 2:1) as show the Figure 4.

The proposed spiral antenna has a truncated ground plane, short-circuited through a via in diagonal with the patch with aiming to facilitate the form of power supply, the type of polarization and creating of a virtual arm of the dipole that consequently increases the electrical length of the antenna, in agreement with theory of the image.

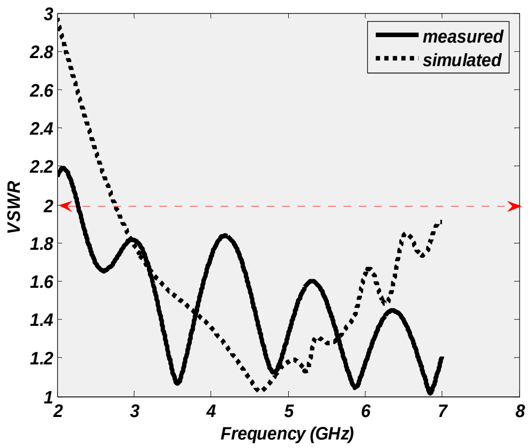

Figura 4. VSWR simulated and measured comparison

The new square spiral antenna has two arms which are symmetrical in relation to the center of the spiral with phase difference in 180 degrees; is excited by an unbalanced supply line so that there is no need of balun circuit and without bandwidth limitation [3] [4]. A microstrip line excites a spiral arm and the other behaves like a parasitic element. Square spiral antennas have advantages when in the operation of the same performance at lower frequencies, defined in [1].

The Archimedean spiral antenna radiates from a region where the circumference of spiral is equivalent to a wavelength where the lowest operating frequency of the antenna is determined theory by external strip. The second analysis is conducted by comparison between the measured and simulated signals from proposed spiral antenna as show the Figure 5. It is observed that there is a correlation between the signals below minus ten decibels, i.e. approximately (2 to 7) GHz, which corresponds to a reflected signal loss, minimum acceptable in 10%, in the active in the region determined by the process of analysis of the simulations. Was found a measured signal resonant at 4 GHz with return loss of -35 dB setting a good impedance marriage, as also correlation between the measured and simulated signal in the resonance frequency of 4.75 GHz.

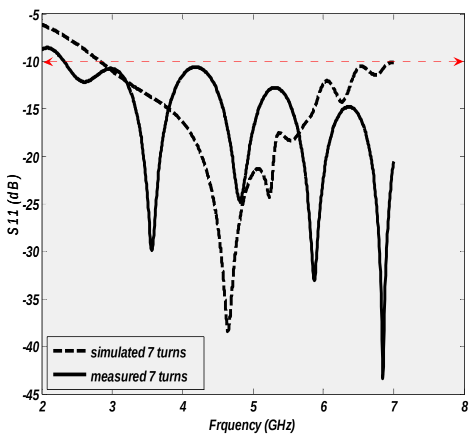

Figura 5. S11 simulated and measured comparison

The graph of return loss versus frequency of the proposed spiral antenna starts to answer at 2.85 GHz and ends on defining a bandwidth of approximately 6.25 GHz with acceptable standards to operation. When the direction is not specified, the power gain is generally calculated in the direction of maximum radiation [3].

IV. CONCLUSIONS

A planar square spiral antenna with unbalanced excitation, as shown in Figure 2 and Figure 8 has been investigated and constructed. Presents a performance good of omni-directional radiation in the horizontal plane. Experimental results indicate that the project has advantages of low profile, easy PCB fabrication, low cost, performance-bandwidth and circular polarization.

The procedures performed in obtain this polarization were studied and analyzed as authors in [2]. Proposed spiral antenna presents one of the arms fed by a microstrip line and the other arm acting as a parasitic element. It is emphasized that the Unbalanced-Excitation Spiral Antenna does not have a balun circuit, which is required for a conventional spiral antenna fed by an unbalanced feed.

The construction of the proposed antenna has been duly studied and elaborated with return loss analyzed. Features of square spiral antenna as unbalanced excitation and miniaturized size were attached. The new proposed antenna was compared with the spiral antennas in [1] and [2] in terms of frequencies and dependencies of the parameters of fundamental antennas, such as, gain, radiation pattern and axial ratio as show the Figure 6 and Figure 7.

The proposed antenna is also compared with a geometry more complex obtained by increasing the numbers of turns in spirals. In these comparisons with antennas presented, are observed reductions of (80 × 80) mm ² to (65 × 65) mm ². This represents a reduction of 35% of the total area that makes the antenna be more suitable for applications in mobile and / or portable devices.

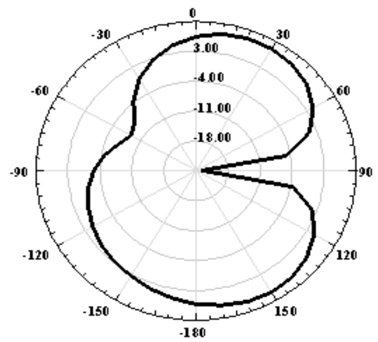

Figura 6. Radiation Pattern – Polarization Ratio L3X

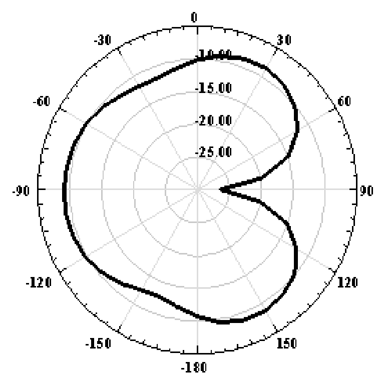

Figura 7. Radiation Pattern - Gain total (dB)

REFERENCES

[1] "A Novel Square-Spiral Strip Antenna" Ugur Saynak*1 and Alp Kustepeli2 Izmir Institute of Technology, Dept. of Electrical and Electronics Eng. Gulbahce Koyu, 35430 Izmir, Turkey.

[2] "Unbalanced-Excitation Spiral Antenna" H. Nakano, T. Igarashi, R. Suzuki, and J. Yamauchi College of Engineering, Hosei University, Koganei, Tokyo, Japan 184-8584

[3] V. H. Rumsey, "Frequency Independent Antenna" (Academic Press, New York and London, 1966). 84 R. G. Hohlfeld & N. Cohen

[4] "Self-Similarity and the Geometric Requirements for Frequency Independence in Antenna" – ROBERT G. HOHLFELD Center for Computational Science, Boston University, 3 Cummington St., Boston MA 02215, USA / Received December 20, 1998; Accepted January 17, 1999

[5] "Planar Spiral Resonators for Compact Antenna Applications" P. Sundaralingam(1), T. Brabetz(1), A. Schuchinsky(1), F. Capolino(2) March-2008 Queens University Belfast, ECIT Institute, Queen's Road, Queen's Island, Belfast, BT3 9DT

[6] J Parron, J M Gonzalez-Arbesu, F Fortuny, J M Rius, G Junkin, R Villarino and J Romeu, "Artificial Magnetic Reflector Based on Spiral Resonators", Proc. EuCAP2006, Nice, France, 6–10 Nov.2006.

[7] H. Zhao and T. J. Cui, "A double-spiral resonator structure to realize lefthanded material with lower resonant frequency", Microwave and OpticalTechnology Letters , vol. 48, no. 5, pp. 923-926, May 2006.

[8] J. Joubert, "Spiral microstrip resonators for narrow-stopband filters," Proc. IEE — Microwave, Antennas, Propag., vol. 150, no. 6, pp. 493–496, Dec. 2003.

Figura 8. Square-spiral antenna with unbalanced-excitation