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Research Article

Miniature Magnetic Film Glass Core Helical Antenna Array

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Abstract: This study demonstrates the operation of a miniaturized version of a helical antenna array. Axial mode helical antenna was designed with a magnetic film glass composite core. The usual axial mode air core antennas are usually bulky and consume unnecessary space in the applications. This is overcome by the magnetic film core antenna which is basically smaller compared to the traditional mode. This magnetic film antenna has been designed to operate at a frequency of 2.44 GHz. This version has shown 80% reduction in volume compared to the conventional air-core antenna. This particular antenna is used as 2×2 and 4×4 arrays which show a three-fold gain over the single antenna. Therefore, we have achieved high gain along with the miniaturization of the antenna by using the glass core.

Keywords: Antenna array, axial mode, CPW, miniaturization, return loss, UAV

INTRODUCTION

UAV applications need highly reliable data transmission in the form of audio or video. This application calls mostly for helical antenna because of its various properties which are advantageous over other types. The basic principle of research is to obtain a miniaturized (Bae *et al*., 2010) helical antenna which can be used for mobile applications and also provide a significant gain. The helical antenna has two modes of operation-normal and axial mode. Axial mode shows directional radiation patterns and circular polarization, making it preferable over the normal mode, which has omni directional radiation patterns. The conventional helical antennas operate in normal mode and are very bulky, so miniaturized version is needed. The frequency of 2.44 GHz at which the antenna is to operate limits the diameter D of the helix (Djordjevic *et al*., 2006) in the range of 29 mm $<D<$52 mm. The core size is made small so that it can be applicable for unmanned communication applications. The size reduction is dependent on the magnetic properties of the core material i.e., permittivity (ε_r) and permeability (μ_r) (Nicholas *et al*., year). The magnetic film core provides a better magnetization and current flow. So, these miniaturized antennas provide a very significant gain even with reduced size. This study illustrates the operation and characteristics of a magnetic film glass composite-based helical antenna array and its simulated characteristics.

FABRICATION AND DESIGN

Previous work: The previous work is the conventional helical antenna in the normal mode of operation. This has higher dimensions and not suitable for mobile applications. So, miniaturized antenna in axial mode was designed.

New design: The axial-mode helical antenna has been designed for the particular frequency of 2.44 GHz. The proposed design has been shown in Fig. 1 with its parameters. The design equations before miniaturization are:

Spacing between successive turns of the helix = $\lambda/4$
= 125 mm/4
= 31.25 mm
Spacing of the helix from the ground = $\lambda/8$
= 125 mm/8
= 15.625 mm
Diameter of the helix = $\lambda/3$
= 125 mm/3
= 41.67 mm

The antenna was miniaturized (Guo *et al*., 2009) by a factor of 80%. The magnetic film glass core has a diameter of 8.33 mm, height of 18.75 mm. The antenna has three turns and thus, has a spacing of 6.25 mm between two successive turns. The helical radiator was made by turning a foil of copper of width 1 mm around the glass core.

The core was prepared by wrapping a magnetic film over a hollow glass core. A circular copper plate of

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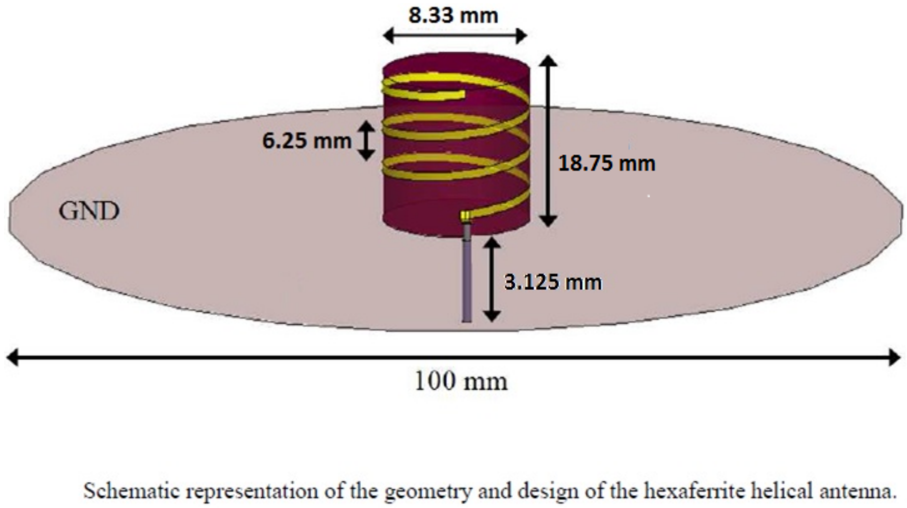

Fig. 1: Miniaturized magnetic film helical antenna

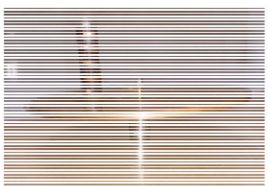

Fig. 2: Single helical antenna

diameter 100 mm has been chosen as the ground reflector. The antenna has been fixed on the ground through a hole in the center of the base and is connected to the probe using coaxial feeding. The spacing of the antenna from the ground plate is 3.125 mm. The input resistance of the feeder (Hui *et al*., 1999) is inversely proportional to the thickness of the ground plate (Balanis, 2005; Lin *et al*., 2011). Thus, maximumthickness is preferred for lower resistance. However, the ground plate thickness is limited to 3 mm because above this, the power coupled to the antenna will be reduced by a notable factor. For the antenna operation, the Coaxial Feeding technique has been

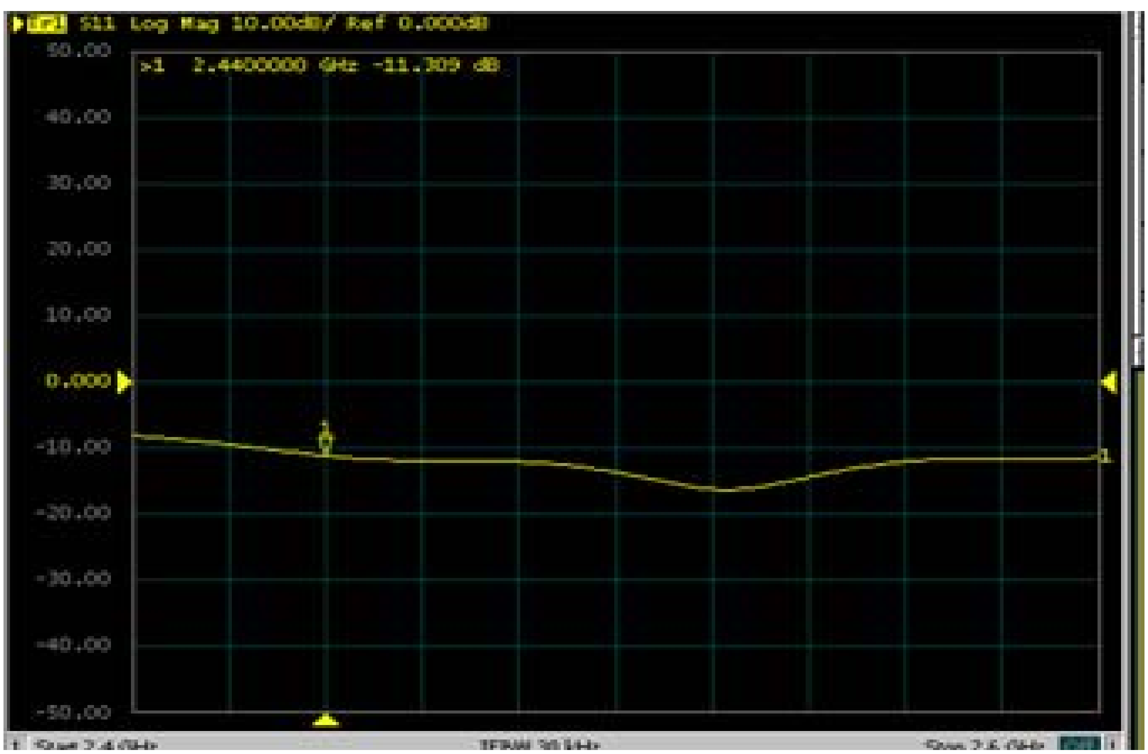

Fig. 3: Return loss of single helical antenna

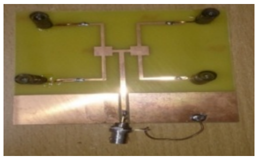

Fig. 4: 2×2 helical antenna array

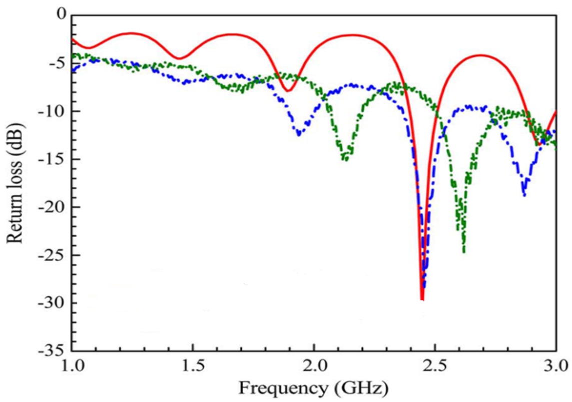

Fig. 5: Simulated return loss vs. frequency

implemented for a single antenna whereas Coplanar Waveguide feeding technique is found advantageous for an array. In an array, all the antennas are fed by using a single feeder.

Single-element helical antenna: Figure 2 shows the single antenna with magnetic film glass core. The base plate length is 100 mm with co-axial feeding.

Figure 3 shows that the return loss of single antenna is approximately -15 dB also called the S_{11}

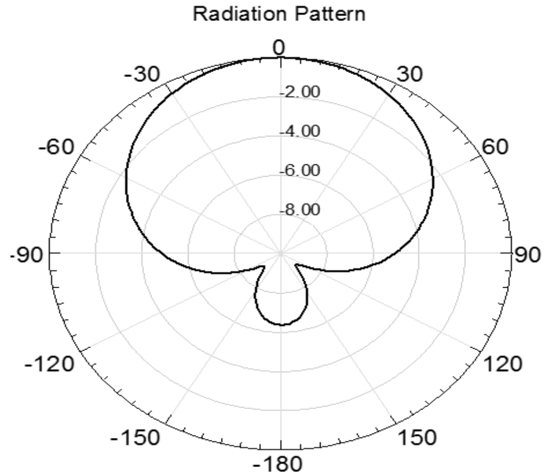

Fig. 6: Simulated radiation pattern of 2×2 antenna array

parameter measured using the vector analyzer. The return loss is very high compared with antenna array. The gain value is also low; hence the Antenna array was proposed to increase the gain.

Four-element helical antenna array: The gain and directivity of the miniaturized antenna was improved by designing a 4-element i.e., 2×2 magnetic film glass core helical antenna arrays. An FR4 substrate in the shape of a square of side 120 mm has been chosen as the substrate for the array. Power dividers, in order to distribute the coupled power to each of the four antennas have been designed by using pure copper sheet of the dimensions shown in the Fig. 4. The

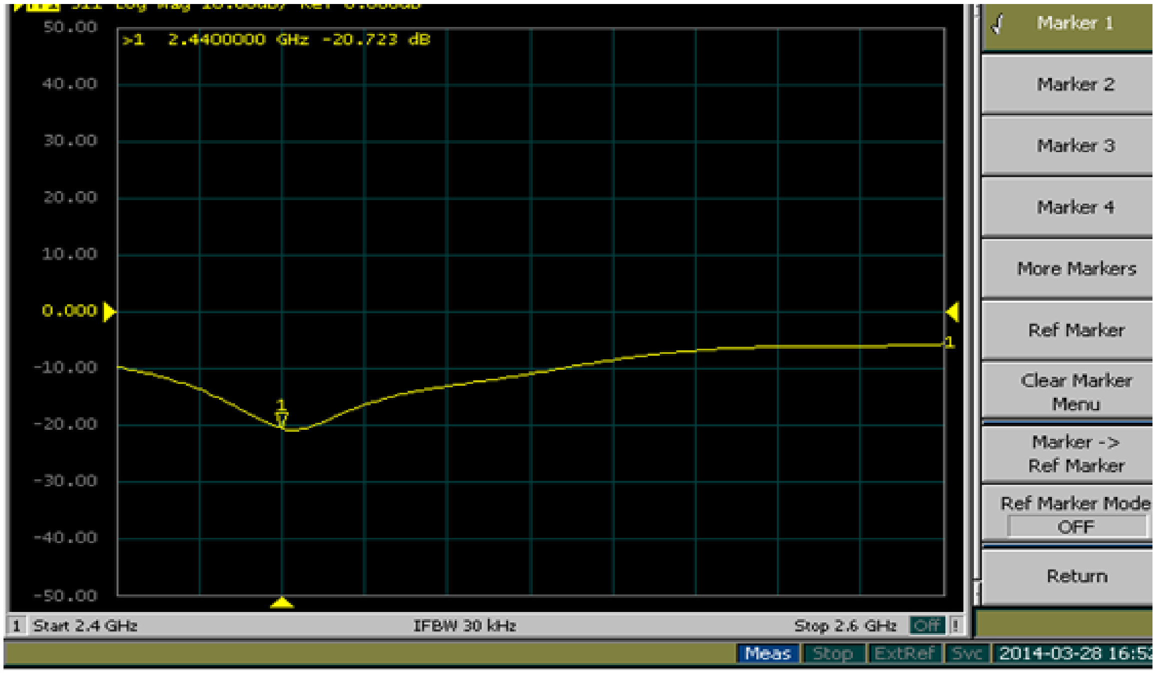

Fig. 7: Return loss for 2×2 array

power dividing circuit is connected to a probe to which is connected the coaxial cable from the vector analyzer which we have used to determine the properties of the array (Lee *et al*., 2011). The feeding technique used was the coplanar waveguide feeding.

SIMULATION RESULTS

The designed antenna array was tested by using the High frequency Simulation Software in order to determine and compare the return loss and gain with the practical results. Figure 5 shows the comparison between the simulated, theoretical and practical return loss for the antenna array. The red curve gives the theoretical return loss. The blue curve gives the simulated return loss while the green curve gives the practical return loss of less than -25 dB which is in close proximity to the fabricated return loss of -21 dB. The following Fig. 6 gives the simulated radiation pattern for the 2×2 magnetic film core helical antenna arrays whose gain was found to be around 0 dB.

Figure 7 shows that the return loss for array is approximately -21 dB also called the S_{11} parameter measured using the vector analyzer. The gain value is thirty percent of the S_{11} parameter. So the gain obtained is around 6 dB practically.

CONCLUSION AND RECOMMENDATIONS

The designed array described in this study has been miniaturized by a factor of 80% as compared to the conventional air-core antenna. The return loss measured at the designed frequency 2.44 GHz has been found to be approximately -21 dB. Hence, the use of magnetic film core played a major role in the miniaturization of the antenna array. The design procedure of the array can be implemented for a bigger array of 4×4. It is expected to increase the gain by three folds.

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