International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 14 (2017) pp. 4741-4746

Helical Antenna Design for Image Transfer

Stanislav Kovar[1,*], Hana Urbancokova[2], Jan Valouch[3], Milan Adamek[4] and Vaclav Mach[5]

[1-5]Tomas Bata University in Zlín, Faculty of Applied Informatics, Nad Stráněmi 4511, 760 05 Zlín, Czech Republic.
**Corresponding author's*

[1]Orcid: 0000-0001-7264-150X

Abstract

Nowadays, there are high demands on the transmission of visual information between devices. It is expected that the image will be transmitted at high speed and if it is possible at all times. The helical antenna designed in this paper works at the frequency of 5.820GHz for which are suggested standards for signal transmission. It is assumed to insert the product into Unmanned Aerial Vehicles as quadcopters. The experiment is tested by using simulating tools called CST Microwave Studio. The purpose of this paper is to design a small circularly polarized antenna for image transfer.

Keywords: CST Studio, helical antenna, electromagnetic radiation, circularly polarized antenna

INTRODUCTION

Nowadays, there are some serious problems during image transmission between control ground workplaces and Unmanned Aerial Vehicles as quadcopters. Conventional antennas might not be the best choice for this purpose, therefore, these antennas are changed for circularly polarized antennas as a helical antenna. In comparison with other types of antennas for circularly polarized waves is a crucial advantage of the helical antenna a directivity that allowed high-quality signal reception over a distance substantially greater than would be the case using other antennas.

An antenna is defined by the IEEE Standard Definition of Terms for Antennas as the part of a transmitting or receiving system for radiation or reception of electromagnetic waves. [1] According to [1], an antenna is defined as "a transmitting antenna converts oscillating electric current into electromagnetic radiation, while a receiving antenna converts electromagnetic radiation into a time harmonic current." Helical antenna is specific due to beam width up to 40°, the relatively good gain in the range from 8 to 15dB and it is suitable for air platforms. [2] It is necessary to pay attention to all components of the developed devices, to achieve acceptable electromagnetic interference level. [3]

The paper is inspired by other projects [1], [4], where the authors simulated and calculated results of their own designed antennas. This paper describes and analyses helical antenna designed for image transmission from Unmanned Aerial Vehicles.

ANTENNA DESIGN

As mentioned above, the antenna selected for this experiment is circularly polarized antenna, characterized by excellent suppression of reflected waves and high axial gain. The antenna consists of a coiled conductor in a spiral of N turns and it is supplemented by the reflector at the point of connection to the antenna lead. The helical antenna work at the frequency 5.820GHz, it means that wavelength is equal approximately 51.55mm. Circumferencescrew-thread should be near to wavelength and the distance between turns should be equal approximately quarter wavelength. For simplicity, in this case, the circumference turn has the same value as wavelength and distance between turns is λ/4. According to this values is possible to calculate other information. The formulas for calculations is available in the publication [5], which is the really interesting source of information. The authors of the publication described the issue understandably.

Distance between turn is:

$$S = C \cdot \tan\alpha = 12.853mm \tag{1}$$

For a number of turns equals to 6, the length of antenna wire should be following:

$$L = N \cdot 1.118 \cdot \lambda = 6 \cdot 1.118 \cdot 51.55 = 345.8mm \tag{2}$$

The length of central helix spindle and its diameter are following:

$$H = N \cdot S = 6 \cdot 12.853 = 77.118mm \tag{3}$$

$$D = \frac{\lambda}{\pi} = 16.41mm \tag{4}$$

The angle of the turns pitch is:

$$\alpha = \tan^{-1}\left(\frac{1}{4}\right) = 14^\circ \tag{5}$$

Reflector diameter is dependent on wavelength. A minimum dimension of the disc is equal of wavelength.

$$R = \lambda = 51.55mm \tag{6}$$

This value is not usual, in many cases, the reflector diameter is higher than the wavelength; therefore, the authors proposed to enlargement of the disc diameter on the value of 56.7mm.

Ideal wire diameter should be in the range of 0.04lambda to 0.09lambda; however, in this case, the diameter lies in the lowest point of the range. Because there are important dimensions of the antenna, it is the logical choice; moreover, the thin wire may be more suitable for higher frequency. As a material of wire was chosen copper, for its shaping properties.

The last important value for purpose of simulation is an input impedance. It is possible to calculate according to the following formula.

$$R = 140 \cdot \left(\frac{C}{\lambda}\right) = 140 \cdot \left(\frac{51.55}{51.55}\right) = 140\Omega \tag{7}$$

The resulting value is high because the coaxial cable is dimensioned for the impedance of 50Ohm; however, antenna impedance should be improved by using of impedance compensator.

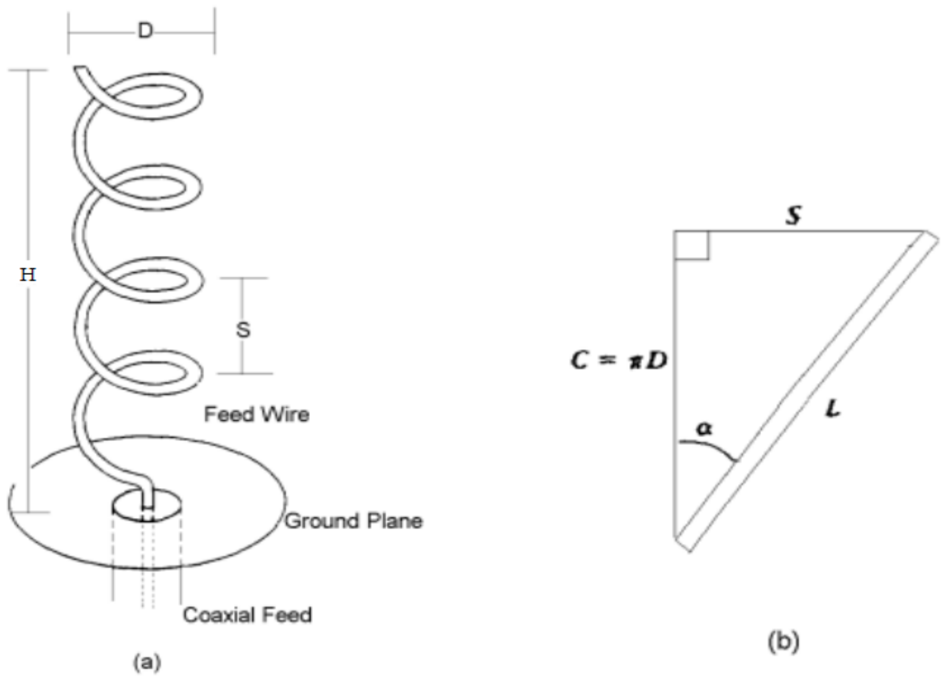

Figure 1. a) Geometry of antenna; b) Unrolled turn of antenna [5]

Table 1. Parameters of the Antenna

Parameter	Value	Unit
Frequency	5.820	GHz
Wavelength	51.55	mm
Number of turns	6	-
Length of antenna wire	345.8	mm
Length of central helix spindle	77.118	mm
Angle of the turns pitch	14	°
Reflector diameter	56.70	mm
Wire diameter	1.6	mm
Impedance	140	Ω

CALCULATED RESULTS

In this section, there are described the result of the calculation performed via CST Microwave Studio. The helical antenna was created according to the parameters shown in Table 1. The final result is available for viewing in Fig. 1.

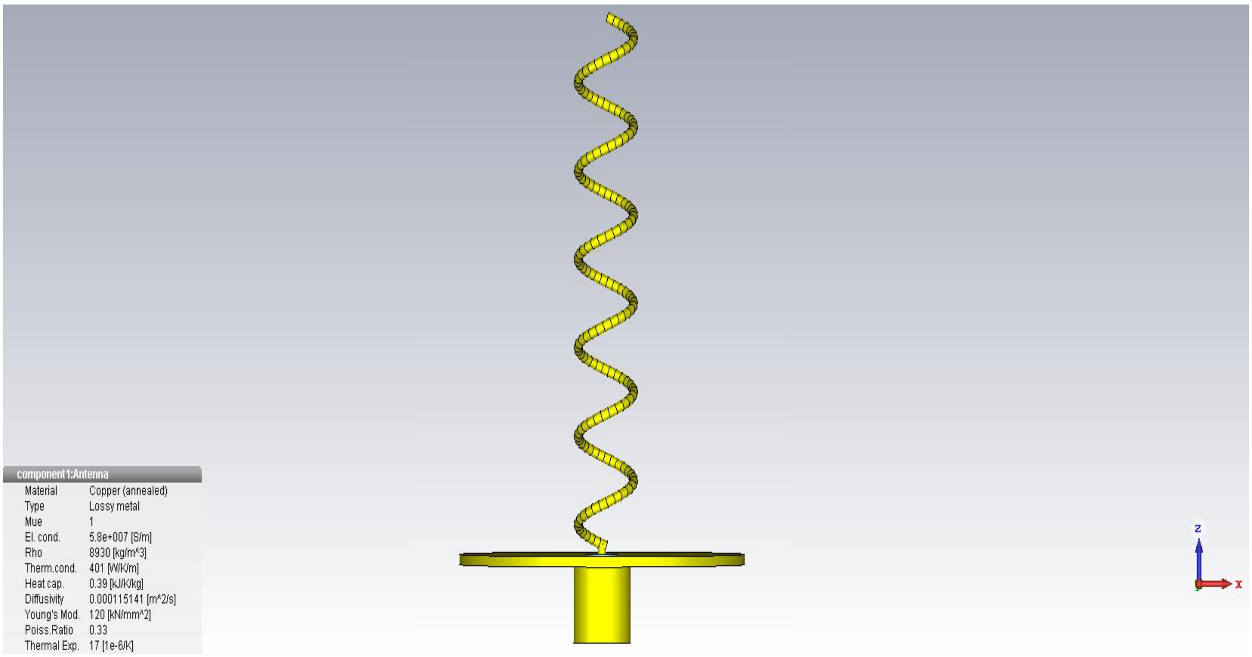

Figure 2. Helical antenna

a) *S-Parameter*

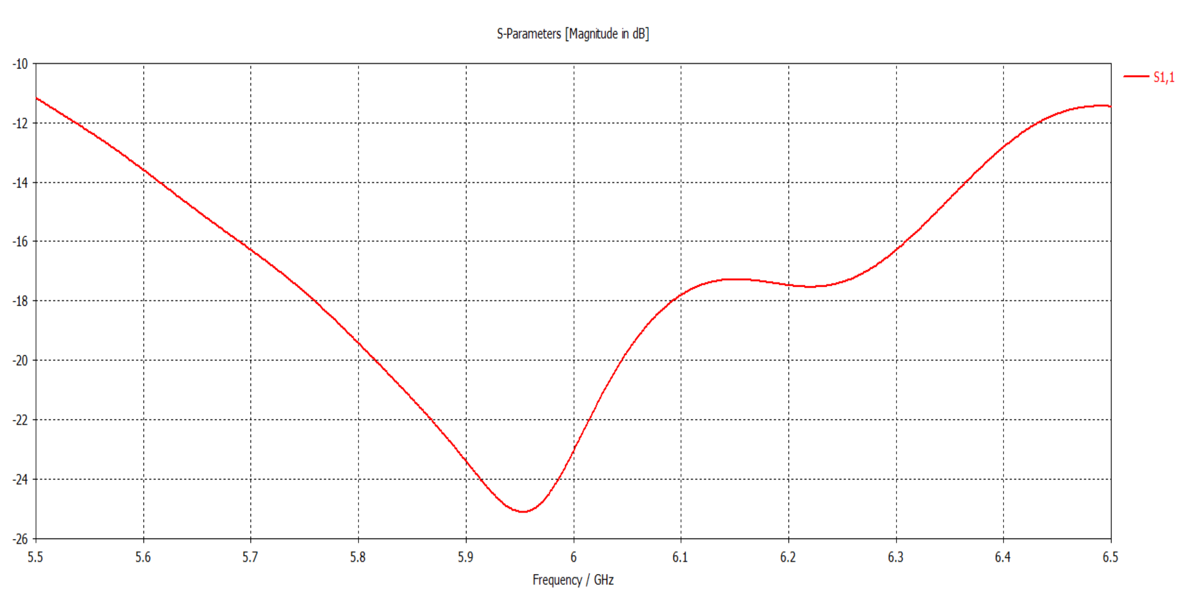

Figure 3. S-Parameter

As can be seen in Fig. 3, the antenna is best matched at 5.95 GHz. There is possible to execute several optimization tasks to improve properties of designed antenna.

b) Smith Chart

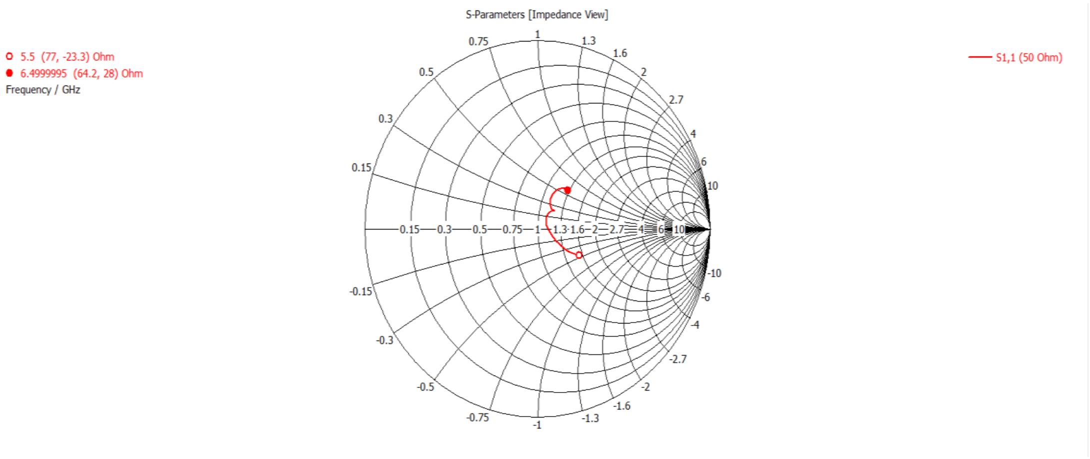

Figure 4. Curves describing Antenna Characteristic Impedance

c) Electric Field

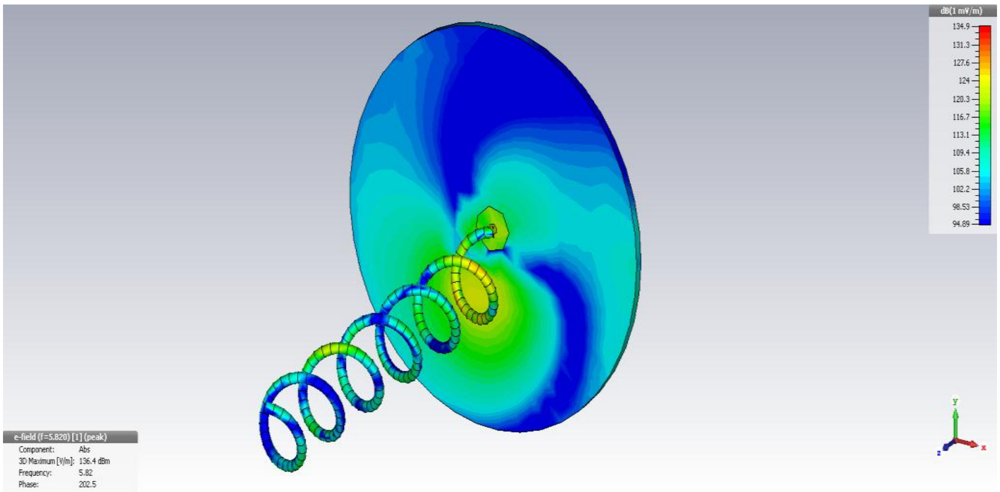

Figure 5. Electrical Field

d) Magnetic Field

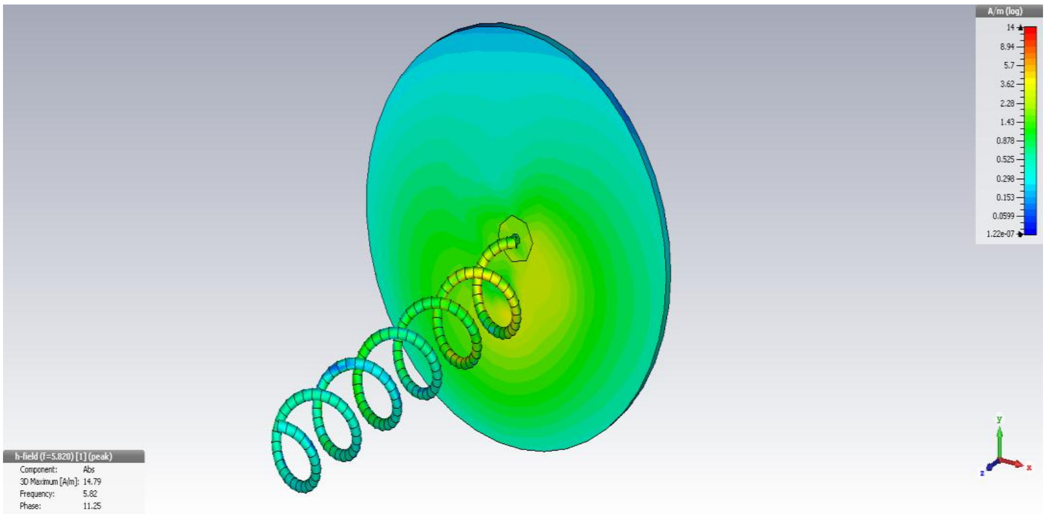

Figure 6. Magnetic Field

e) Far-field

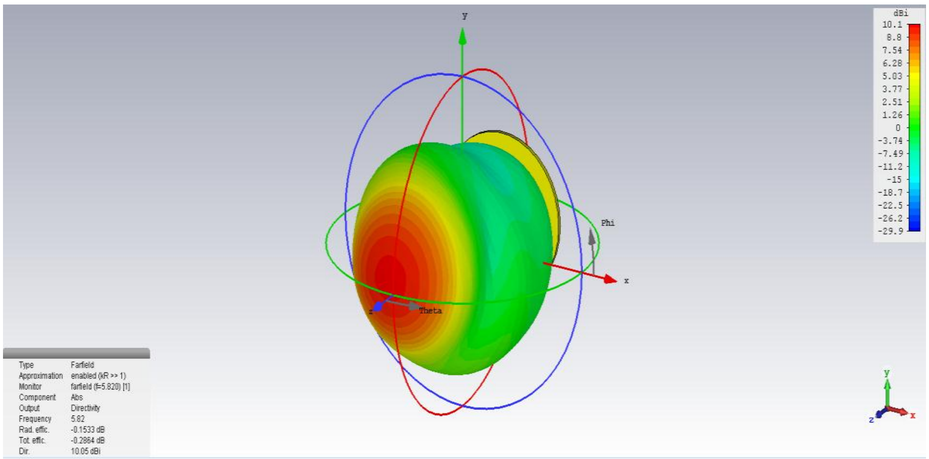

Figure 7. Radiation of Helical Antenna in Far-Field – Directivity

f) Polar Plot

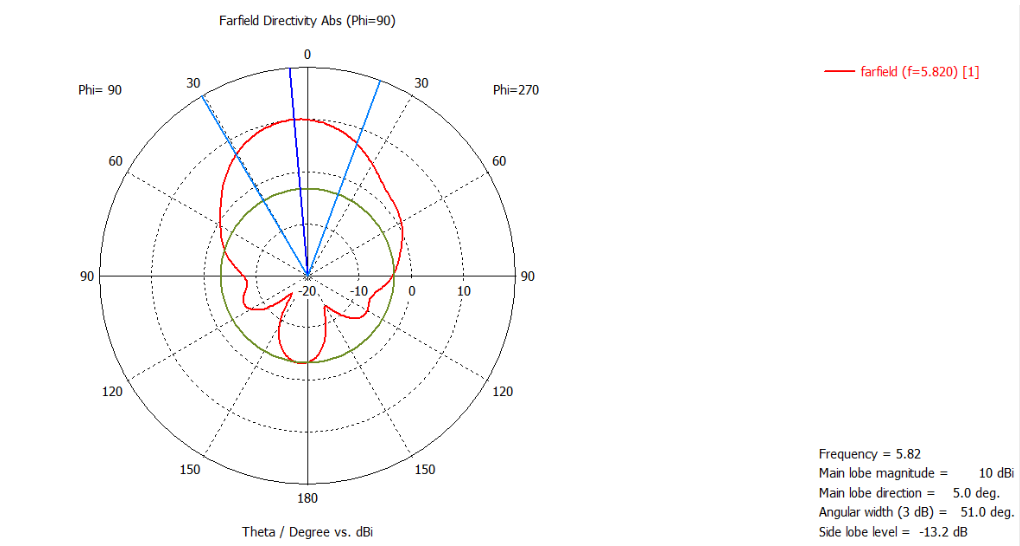

Figure 8. Polar Plot - Directivity

CONCLUSION

The aim of this study is to summarize and analyze the issue of helical antennas for transmitting image information. It is necessary to remind that the transmission of the video signal from Unmanned Aerial Vehicles to ground station is not a simple matter. Because, classical antennas, which are not a circularly polarized antenna, are not able to send information at any time, for example owing to a different polarization of transmitted and received antenna. As can be seen in figures shown in section of Calculated Results, the antenna achieves the best results at the frequency of 5.95 GHz. However, the standard for transmitting video signal is not intended for this frequency. Despite of this fact, results of 3D simulation look interesting, according to calculation, the antenna meets the requirements for using in normal conditions. Nevertheless, it is necessary to emphasize, that there must be performed improvement, especially, at the frequency of 5.82 GHz, for it, the antenna is designed. It should be the aim of future research.

ACKNOWLEDGMENTS

This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic within the National Sustainability Programme project No. LO1303 (MSMT-7778/2014) and also by the European Regional Development Fund under the project CEBIA-Tech No. CZ.1.05/2.1.00/03.0089 and by the Internal Grant Agency of Tomas Bata University under the project No. IGA/CebiaTech/2017/006.

REFERENCES

[1] YOUNG, Mike. Design and testing of helical antennas for a RF test facility. 2012. PhD Thesis. University of Missouri--Columbia.

[2] MAYES, J.R., M.G. MAYES, W.C. NUNNALLY a C.W. HATFIELD. Helical antennas for high powered RF. In: 2009 IEEE Pulsed Power Conference [online]. IEEE, 2009, s. 484-488 [cit. 2017-01-03]. DOI: 10.1109/PPC.2009.5386324. ISBN 978-1-4244-4064-1. Available at: http://ieeexplore.ieee.org/document/5386324/.

[3] KOVÁŘ, Stanislav, Jan VALOUCH, Hana URBANČOKOVÁ and Milan ADÁMEK. Impact of Security Cameras on Electromagnetic Environment in Far and Near-Field. In: International Conference on Information and Digital Technologies 2016. Poland, Rzeszów, 2016. pp. 156-159. ISBN 978-1-4673-8860-3. 4 p.

[4] TANG, Xihui, Yejun HE a Botao FENG. Design of a Wideband Circularly Polarized Strip-Helical Antenna With a Parasitic Patch. IEEE Access [online]. 2016, 4, 7728-7735 [cit. 2017-01-03]. DOI: 10.1109/ACCESS.2016.2628044. ISSN 2169-3536. Available at: http://ieeexplore.ieee.org/document/7742322/

[5] SINGH, Parminder, Manju a Manpreet KAUR. Single Band Helical Antenna in Axial Mode. International Journal of Electronics Communication and Computer Technology (IJECCT) [online]. 2012, 2(6), 3 [cit. 2017-02-10]. ISSN 2249-7838. Available at: http://www.ijecct.org/v2n6/(256-258)0206M35.pdf

[6] KRAUS, J.D. The Helical Antenna. Proceedings of the IRE [online]. 1949, 37(3), 263-272 [cit. 2017-01-03]. DOI: 10.1109/JRPROC.1949.231279. ISSN 0096-8390. Available at: http://ieeexplore.ieee.org/document/1697976/

[7] VALOUCH, Jan. Electromagnetic Compatibility of CCTV.Alarm Focus. Issue. No 2, 2/2013. Brandýs nad Labem: Orsec, 2013, p. 22- 23. ISSN 1805-9007. (in Czech)