Log-Spiral antenna from 2 to 40 GHz with impedance matching

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Abstract

The designed antenna consists of the logarithmically spiral stripline antenna and wideband transformer from 50 to 150 Ω. This antenna is suitable as a wideband iluminator for a parabolic reflector working in the range 2 to 40 GHz.

INTRODUCTION

The spiral consists of two identical arms which are shifted about 180° with respect to each other. The curves of the arms are described by the function

$$r = r_0\, e^{a(\phi+\varphi)} \tag{1}$$

where r_0 is the distance at $\phi = 0$, a determines the increasing rate of r and ϕ is the angle, see fig. 1. The external curve is designed with $\varphi = 0°$ and internal $\varphi = 90°$.

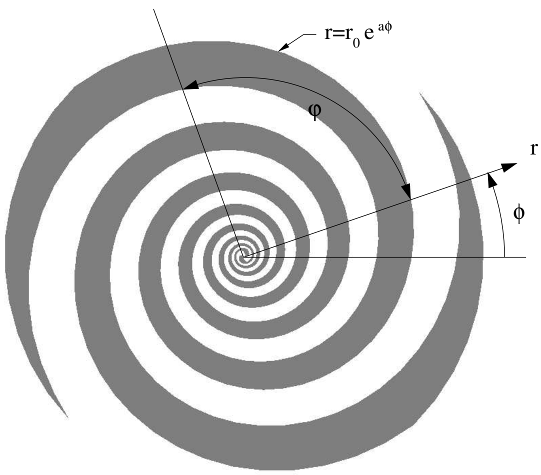

Fig. 1: Geometry of the spiral

It is possible to consider the spiral as a combination of a ***current*** radiator (with the current along its striplines) and a ***slot*** radiator (with the electric field between its striplines). This antenna has a circular polarization to the left in one direction and to the right in the opposite direction. The impedance of the antenna is about 150 Ω feeding symetrically. The gain is between 5 to 6 dBi.
A wideband impedance transformer from 50 to 150 Ω is realized in the microstrip structure. The whole antenna is placed inside a conductive cover which is filled with an absorber to attenuate the cross polarization component. Right circular polarization is absorbed in the cover, whereas the left circular polarization is transmitted in the opposite direction.

MODELING AND MEASUREMENT

The spiral antenna and the impedance transformer are designed separately due to computing demands. They are modeled using IE3D from Zeland Software, Inc. which resolves 2.5D structures using moments method.
The wideband impedance transformer is designed as a microstrip structure. It transforms a nonsymetrical $50\,\Omega$ to a symetrical $62\,\Omega$ and to a symetrical $150\,\Omega$.
The whole design of the spiral antenna and the impedance transformer is placed inside a cover with a polyamid carbon absorber. The measured results of radiation pattern, impedance matching and gain are in fig. 2 to 13.

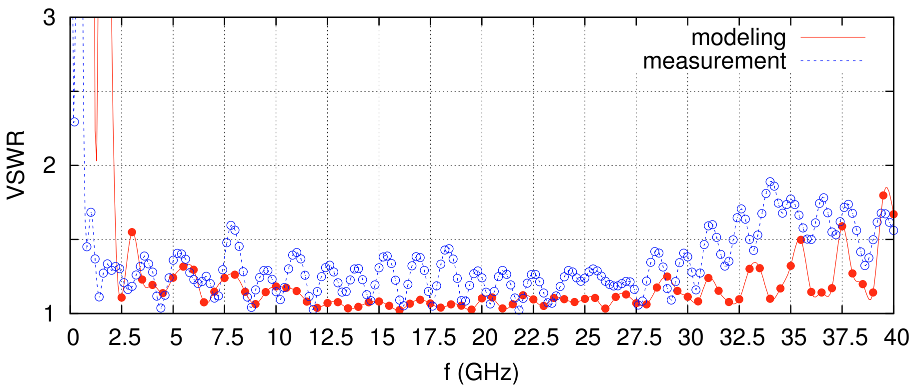

Fig. 2: VSWR of the Log-Spiral antenna

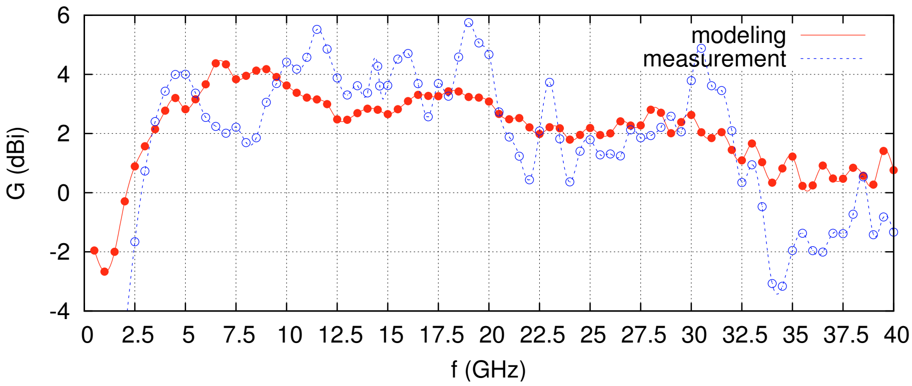

Fig. 3: Gain of the Log-Spiral antenna

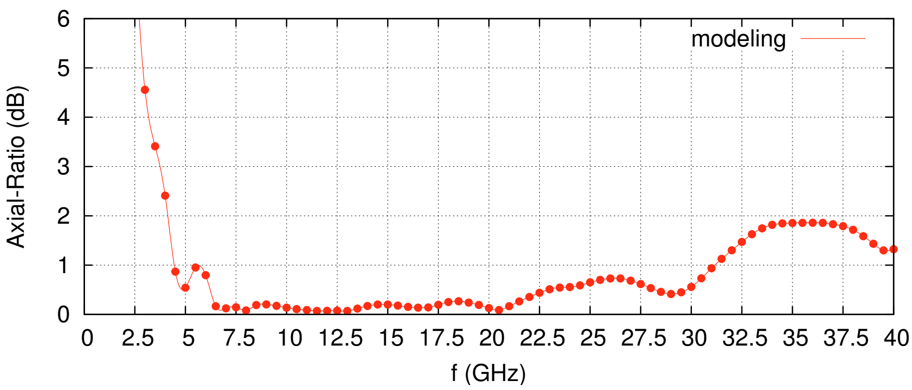

Fig. 4: Axial-Ratio of the Log-Spiral antenna

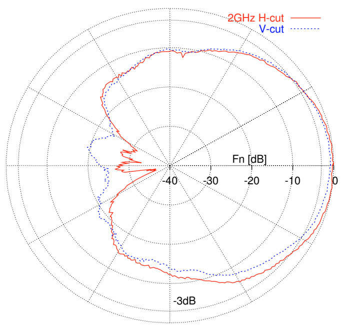

Fig. 5: 2GHz

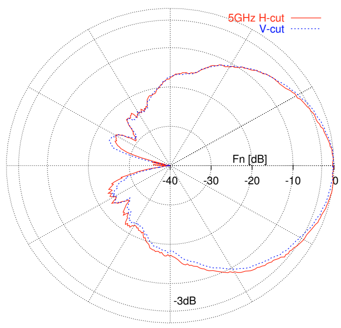

Fig. 6: 5GHz

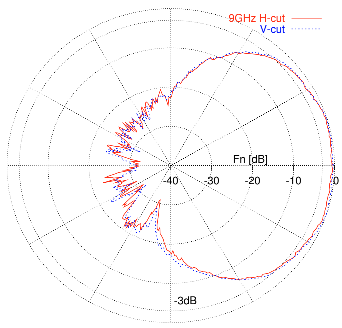

Fig. 7: 9GHz

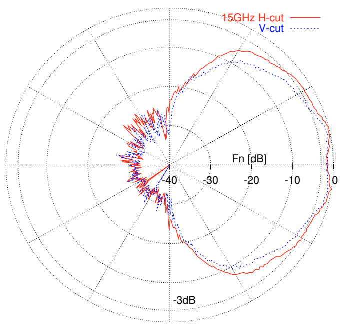

Fig. 8: 15GHz

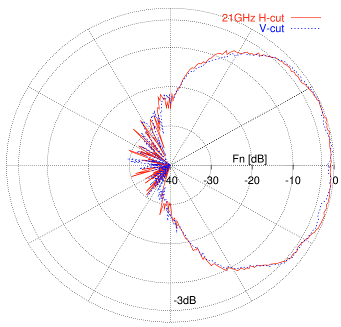

Fig. 9: 21GHz

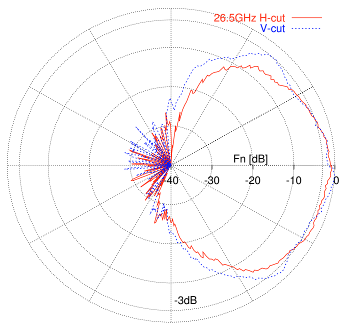

Fig. 10: 26.5GHz

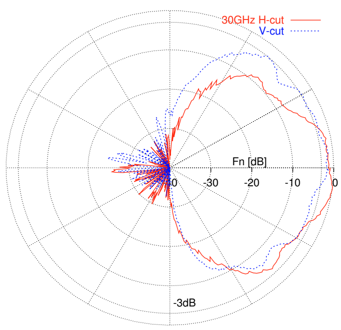

Fig. 11: 30GHz

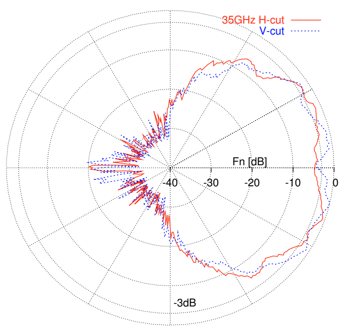

Fig. 12: 35GHz

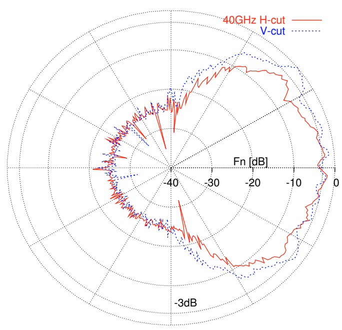

Fig. 13: 40GHz

The profile of the impedance transformer used here is totally new and has never been published before. The profile of the transformer was optimalized in order to reach maximal wideband, minimal losses and dimensions. The length of the transformer is 60 millimeters.

CONCLUSIONS

The Log-Spiral antenna was modeled using the 2.5D electromagnetic field simulator IE3D from Zeland Software, Inc [4]. Antenna was designed and fabricated as a microstrip line structure. The realized antenna was measured [3]. The diferences between modeling and measurement were caused by imperfection etching technology, losses at substrate and reflections at the connectors.

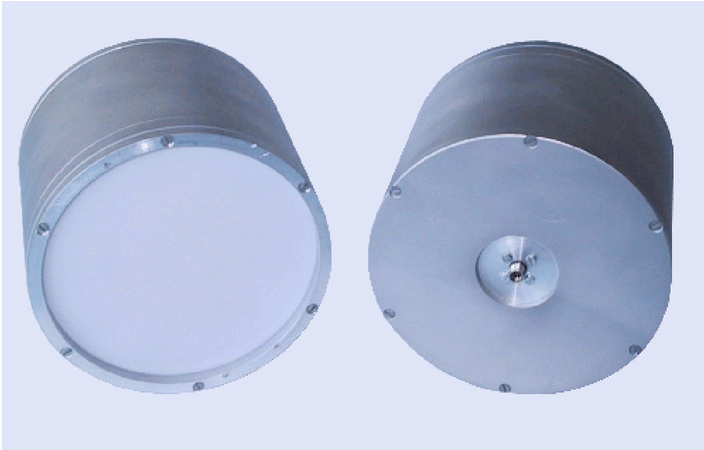

Fig. 14: Front and back views

ACKNOWLEDGMENT

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[2] Wang, Johnson J.H., Tripp, Victor K.: Design of multioctave spiral-mode microstrip antennas. IEEE Trans. Antennas Propagat., vol. 39, pp. 332 - 335, March 1991

[3] http://www.rfspin.cz/anteny/ls33.htm

[4] http://www.zeland.com