COAXIAL / CIRCULAR HORN ANTENNA FOR 802.11A STANDARD

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Abstract: In this paper, the design, simulation and optimization of the coaxial / circular horn antenna is described. The proposed antenna is excited by the TEM mode of the coaxial line. This mode is further transformed to the TM_{01} mode of a circular waveguide. The coaxial / circular horn antenna was simulated by using CST Microwave Studio. Then, the simulated antenna is optimized according to specified criteria. Obtained results are going to be experimentally verified.

Keywords: Coaxial line, circular waveguide, TM mode, monopole antenna

1. INTRODUCTION

This article describes the design of the coaxial / circular horn antenna for the 802.11a standard (the operating frequency is 5.43 GHz). The antenna transforms the impedance of the coaxial transmission line to the impedance of the open space via the circular waveguide [1]. The described antenna was modeled in CST Microwave Studio 2010. The designed coaxial /circular horn antenna was optimized using the Nelder-Mead simplex algorithm to reach a proper impedance matching in specified frequency bands. Thus, the proposed antenna can be used in situations where demands are placed on the dimensions, especially at the height of the whole structures.

2. ANTENNA CONCEPT

The antenna (Figure 1) combine principles of a circular horn antenna (the top of the structure) and a coaxial transmission line (the bottom of the structure). The structure is feeding by the coaxial line with the characteristic impedance 50 Ω. The outer conductor of the coaxial transmission line is extended to create a horn antenna. The antenna is filled by the dielectrics to reduce the dimensions on one hand, and to match the input impedance of the antenna structure on the other hand [2].

Along the coaxial transmission line, the transversally electromagnetic wave is propagating. The magnetic field intensity is formed to the rings circulating around the inner conductor of a feeder of the radius R_{f1} [3]. The electric filed is of a radial direction. The radius of the outer conductor is widened from R_{f2} to R_1 to match the characteristic impedance of the feeder to the characteristic impedance of the open space. Moreover, a large-enough aperture of the antenna is formed that way [2].

In the distance *L*f from the aperture, the inner conductor of the coaxial feeder is ended to suppress radial components of the electric field intensity on the aperture. Therefore, the rings of the magnetic field intensity are dominant on the aperture. Those rings of the magnetic field intensity simulate a loop of the magnetic current. Considering the duality theorem, the loop of the magnetic current is equivalent to an electric monopole [2], [3].

Resonant frequency of the antenna depends on the electrical radius of the loop kR, where $k = 2\pi / \lambda$, and λ is the wavelength. The antenna can be therefore tuned by changing the radius of the aperture. The frequency response of the magnetic loop antenna can be also influenced by the length of the horn L, the distance of the end of the *buried* monopole from the aperture L_f, and the permittivity of the dielectric filling ε_r.

The described antenna (Figure 1) was numerically modeled with the parameters listed in Table 1. Frequency response of the return loss of the antenna is depicted in Figure 2. Obviously, in the required operating band antenna is not matched.

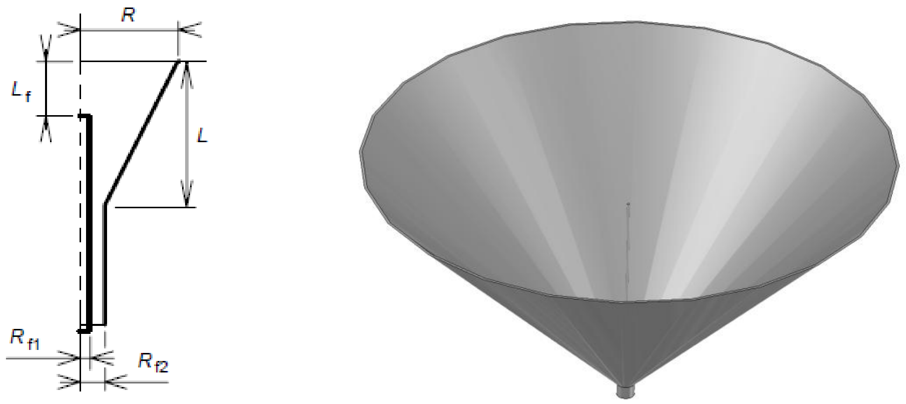

Figure 1: Vertical cut of the antenna (left), modeled antenna (right).

Description	*Variable*	*Unit*	*Value*
Radius of aperture	R	mm	100.00
Radius of inner conductor of coaxial feeder	R_{f1}	mm	0.50
Radius of outer conductor of coaxial feeder	R_{f2}	mm	2.43
Length of horn	L	mm	100.00
Distance of monopole from aperture	L_f	mm	20.00
Permittivity of dielectric filling of horn	ε_{r1}	-	3.60

Table 1: Numeric values of the state variables of the antenna.

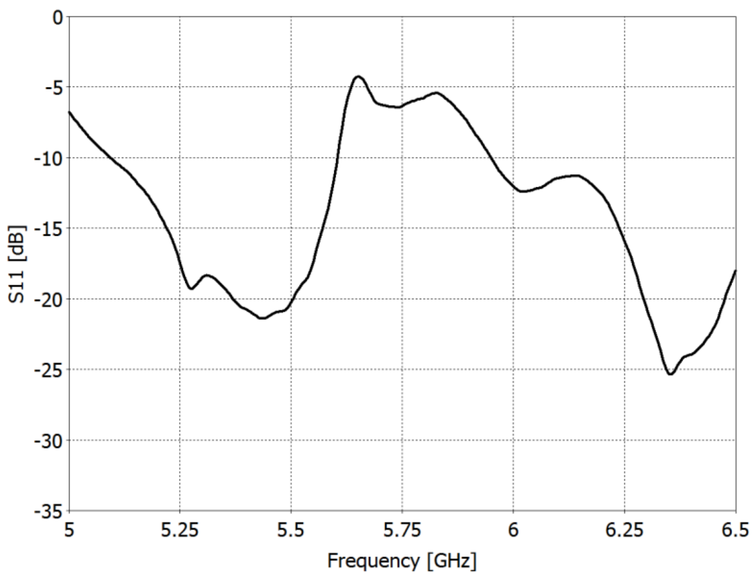

Figure 2: Frequency response of the return loss of the antenna.

3. OPTIMIZATION OF ANTENNA

The concept of the antenna is based on the assumption that the impedance has to change from the characteristic impedance of the coaxial line to the characteristic impedance of the open space. The radius of the inner conductor is widened from R_{f1} to R_{f3} to match the characteristic impedance of the feeder to the characteristic impedance of the open space. The vertical cut of the antenna (one half of the structure) is depicted in Figure 3.

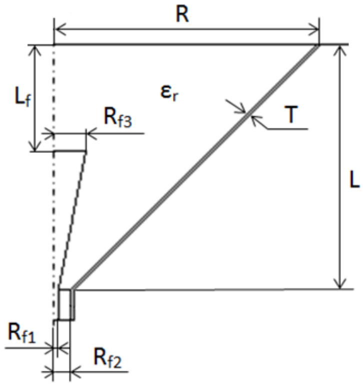

Figure 3: Vertical cut of the antenna.

The antenna was optimized to meet impedance matching conditions in the 802.11a band (5.150 to 5.825 GHz). The return loss was asked to be $|S_{11}| < -10$dB in the operation band. In order to meet this goal, the optimization routine computed the upper radius of the antenna R, the permittivity of the dielectric filling ε_r, the length of the whole structure L and the distance of monopole from the aperture L_f. The optimal parameters are listed in Table 2. The vertical cut of the optimized antenna is depicted in Fig. 4.

Description	*Variable*	*Unit*	*Value*
Radius of aperture	R	mm	27.00
Radius of inner conductor of coaxial feeder	R_{f1}	mm	0.50
Radius of outer conductor of coaxial feeder	R_{f2}	mm	2.60
Radius of extended inner conductor of coaxial feeder	R_{f3}	mm	1.34
Length of horn	L	mm	18.60
Distance of monopole from aperture	L_f	mm	2.20
Permittivity of dielectric filling of horn	ε_r	-	3.91

Table 2: Numeric values of the state variables of the optimized antenna.

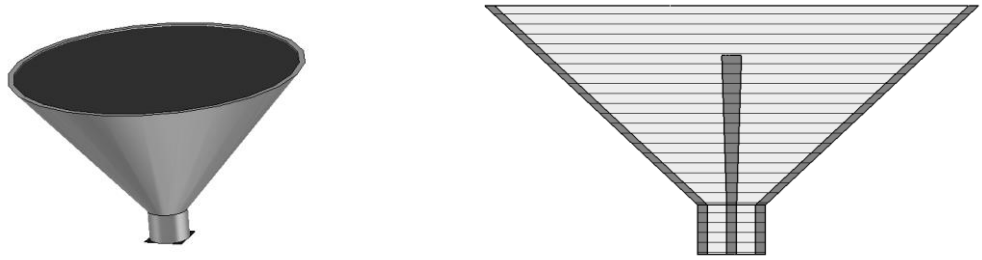

Figure 4: Optimized antenna (left), vertical cut of the optimized antenna (right).

Figure 5 shows the frequency response of the return loss of the optimized antenna. Clearly, the desired impedance matching has been achieved in the operating band. Radiation patterns of the antenna are depicted in Figure 6. Thanks to the symmetry of the antenna, the characteristics are depicted for φ = 90˚ only.

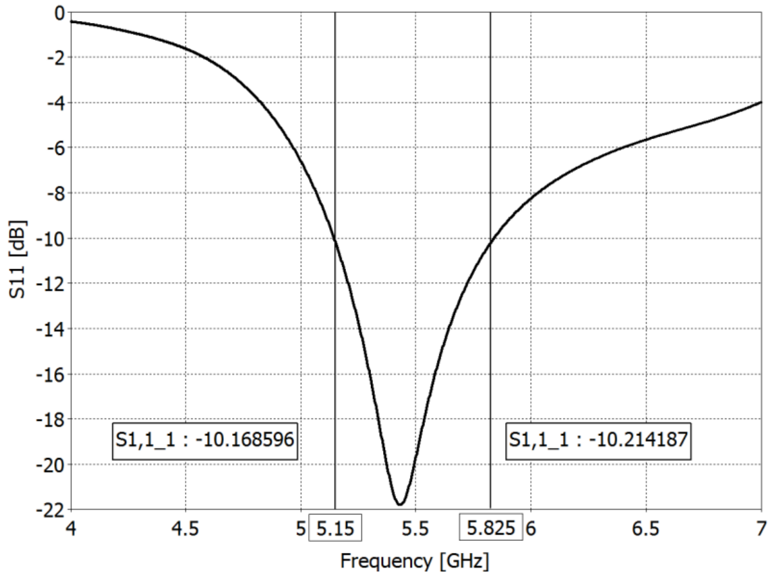

Figure 5: Frequency response of return loss of the optimized antenna.

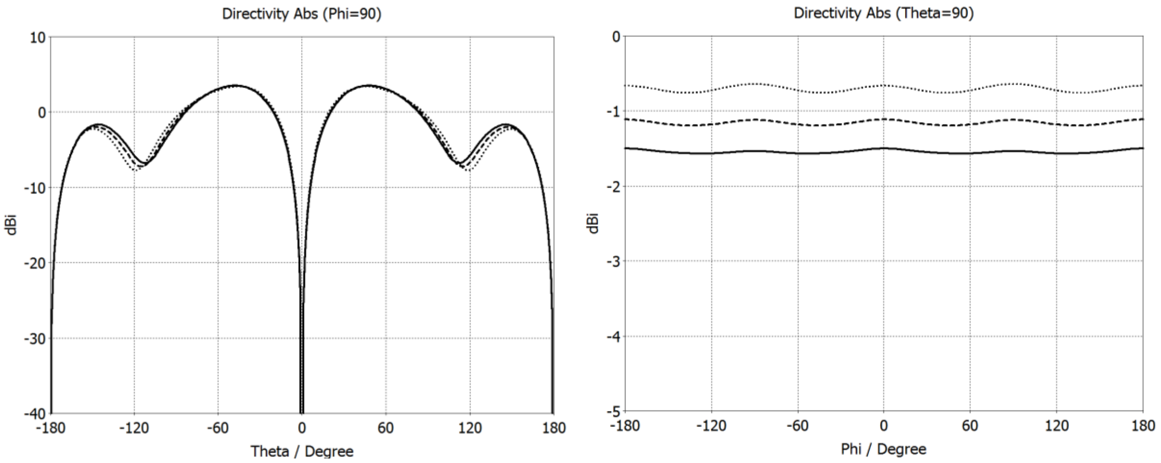

Figure 6: Radiation pattern of the antenna in E plane (left), H plane (right), (5.2GHz – solid, 5.43GHz – dashed, 5.8GHz - dotted).

4. CONCLUSION

The antenna exhibits good impedance matching and good radiation pattern in the operating band. The radiation patterns are shaped as a conventional monopole. The greatest advantages of the antenna are its small size. On the other hand, the manufacturing of the antenna is rather complicated due to the widened inner conductor.

ACKNOWLEDGEMENT

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