DIFFRACTION OF EM RADIATION ON HELICOPTER

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Problem of impact of helicopter fuselage on establishing radio connection at low altitude is based on flying in real conditions, when loss of radio contact occurs during helicopter landing. This loss of connection can be caused mainly by diffraction of communication signal on tail of the helicopter, or by system of same band antennas used on single helicopter fuselage. This article is oriented on possibility of signal loss caused by diffraction of electromagnetic radiation on helicopter tail boom.

K e y w o r d s: helicopter, tail, model, diffraction, coupling

1 INTRODUCTION

Wide range of phenomena that cannot be addressed by geometrical optics are diffraction phenomena. Diffraction is bending or change of direction of radiation propagation due to obstacles caused by the wave nature of light.

Diffraction occurs with all waves, including sound waves, waves on the water surface and the electromagnetic waves such as visible light, ultraviolet light, and radio waves.

Since we are working in the field of radio waves, we pay attention to diffraction in this area. In the propagation of radio waves we are interested primarily into wave diffraction on cylinder, because it has approximate shape of real helicopter tail boom.

2 DIFFRACTION ON CYLINDER

We will now follow a simple case of plane wave diffraction on an infinitely long cylinder.

Let's have a circular cylinder with radius „a", with its axis parallel to the „z" axis and in the „+x" axis is the spreading plane wave, ie. the wave fronts are parallel to the plane „yz". May the field vectors of this (primary) wave have E_z and H_y components, then we can write the following exponential forms:

$$E_z = E_m . e^{-jk_o x} \tag{1}$$

$$H_y = -\frac{E_m}{\sqrt{\frac{\mu_0}{\varepsilon_0}}} . e^{-jk_0 x} \tag{2}$$

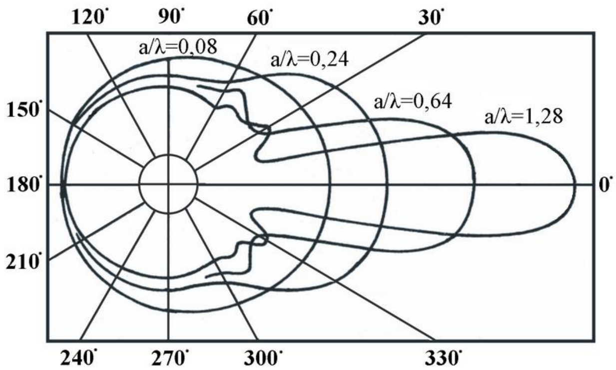
After some modifications, as seen in [1], we can write this formula for intensity of electric field far away from cylinder ($r >> \lambda , r >> a$) as:

$$E_z^{(von)} = -E_m \sqrt{\frac{2}{\pi k_0 r}} e^{-j\left(k_0 r - \frac{\pi}{4}\right)} \sum_{n=-\infty}^{+\infty} \frac{J_n(k_0 a)}{H_n^{(2)}(k_0 a)} e^{jn\varphi} \tag{3}$$

By inserting this formula into equation:

$$F(\varphi) = \frac{E^{(von)}}{E_{\max}^{(von)}} \tag{4}$$

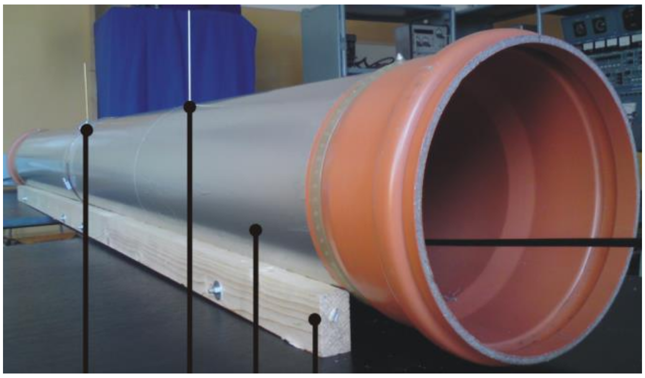
we get graphical representation of this dependence in polar coordinates, Picture 1. From this dependence it is clear that with increasing radius ratio and wavelength (a/λ) the maximum field strength in the shadow increases. On the other hand, while reducing the ratio, the ratios are approaching more to the conditions of geometrical optics.



Picture 1: Secondary field of infinitely long, perfectly conducting cylinder excited by a plane wave

3 MEASURED MODEL

A model of helicopter tail boom was constructed. It was designed as scaled-down cylinder of dimensions 2 meters in length and 0,2 meters in diameter. This cylinder was constructed of two plastic tubes, 1 meter in length each, which were coated by aluminium foil. These two tubes were conductively connected, with contact resistance of 0,02 ohm. This model was placed for measurements onto a wooden stand, see Picture 2.



Picture 2: Model of helicopter tail boom

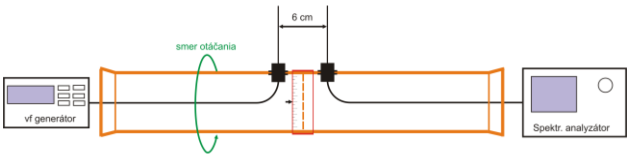
Operational frequencies were chosen to be in aviation VHF frequency spectrum. Because the model is scaled down approximately four times in comparison to the real helicopter tail boom, the frequency used for measurements had to be increased appropriately.

Antennas were designed as monopoles of 5mm diameter and 15,6cm in length, with N connector.

High frequency generator HM8135 and spectral analyser HM5530 were used for measurements.

3.1 Measurements with constant antenna distance

Distance between antennas was 6cm, output power of hf generator was 4dBm, with starting frequency 450MHz.

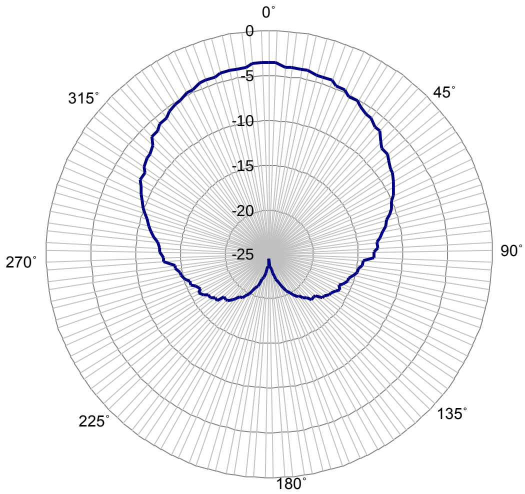


Picture 3: Measurements of diffraction at a constant distance between antennas, different frequencies

Rotatory part of model was rotated from 0 degrees to 180 degrees during measurements, with 5 degree step. 180 degree range of measurements is satisfactory, because of symmetry of the cylinder.

Picture 4: Physical realization

Measured values from spectral analyser were recorded and from these values a diffractional diagram was made, see Picture 5 for diffractional diagram at frequency of 450MHz.



Picture 5: Diffraction on cylinder surface at 450MHz

CONCLUSION

This article described practical measurements made on scaled down model of helicopter tail boom in order to find out how transmitted power through antenna diffracts on this tail boom and how this diffraction can cause signal loss. From made measurements can be seen, that diffraction is significant phenomena in propagation of electromagnetic radiation.

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