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CHANGE OF A MONOPOLE ANTENNA’S RADIATION DUE TO FINITE DIMENSIONS OF ITS GROUND PLANE

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Summary. The presented paper deals with variation of a monopole antenna’s radiation in terms of its peak angular direction from the ground plane. This variation is caused by the finite size of the antenna’s ground plane. The mentioned effect is analysed by computer simulation and the results of the simulation are verified by measurements. All results are evaluated in the vertical plane.

Keywords: monopole antenna, ground plane, radiation pattern, peak lift

1. INTRODUCTION

During measurements of the radiation pattern of a monopole antenna placed on the surface of an aircraft model [1], a phenomenon of radiation pattern’s lift from the aircraft surface was observed. As this lift ultimately changes the quality of a radio connection of an aircraft, it is desirable to examine this phenomenon. In order to evaluate it, the research described in this article was carried out.

2. THEORETICAL BACKGROUND

A typical simple monopole antenna consists of a single straight conductor mounted perpendicularly over a conductive surface, the ground plane. The ground plane acts like a mirror and so it creates an image of the straight conductor, resulting in a dipole-like antenna, see Figure 1. This is also referred to as the image theory [2].

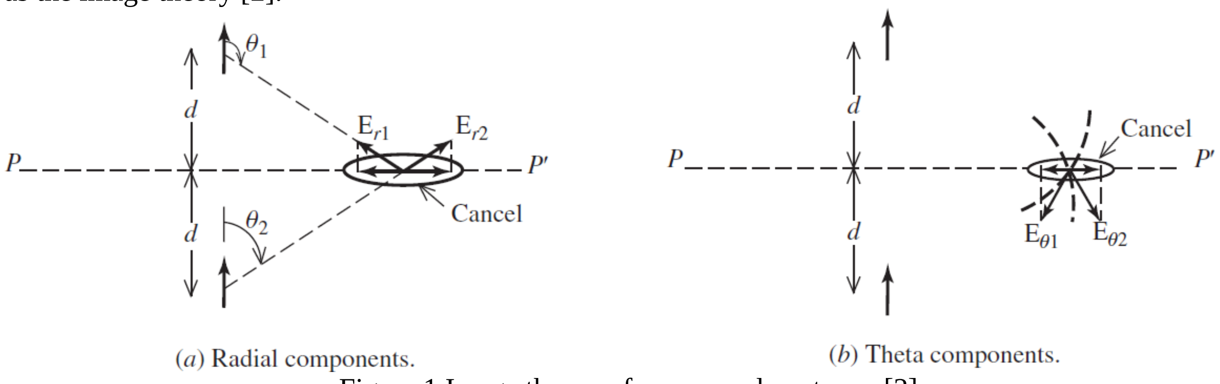

Figure 1 Image theory of a monopole antenna [2]

As can be seen from the Figure 1, the resulting electrical field is created by summing the individual wave reflections from the antenna’s ground plane, summing them together with the direct waves. Combination of all the direct waves and waves reflected by infinite ground plane creates a radiation pattern identical to of a dipole antenna. However, in case of a finite ground plane, some of the reflections are not present and resulting radiation pattern is, in comparison to the ideal pattern created by monopole antenna with infinite ground plane, altered. This alteration usually manifests itself as an angular lift of the radiation peak [2] [3] [4].

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3. MEASUREMENT DESCRIPTION

In aim to have the results of measurement symmetrical and therefore easily readable, a circular shape of the ground plane was chosen. Radius of this ground plane was changed in such way, that the difference between two subsequent measurements was small enough and that it covered all the peak direction variations present in the spectrum of ground plane’s electrical size ranging from 1/10 wavelength to 5 wavelengths.

The simulations were performed in the FEKO software, having it set to a constant frequency 3GHz and the ground plane’s radius was parametrised. Solution method was set to the Method of Moments, with default Fine mesh.

To have the results of measurement relevant to the aviation industry, which in this case means to have them approximately correspond to a real aircraft and its comm antennas, the circular ground plane for measurement in anechoic chamber, used also as a verification of the simulation results, was defined to have electrical radius ranging from 1/4 wavelength to 2 wavelengths.

The radius of the constructed ground plane was 10cm, therefore the frequencies of measurement were ranging from 750MHz to 6GHz. Totally 8 measurements were made. Radiation pattern was measured in vertical plane, with angle being varied from 0 to 90 degrees by 1 degree. To cover the whole frequency spectrum needed for the measurement, multiple monopole antennas were used, all in shape of a rod with radius 4mm and of a suitable length for given measurement frequency.

Constructed circular ground plane, together with the mounted active element, is shown in Figure 2.

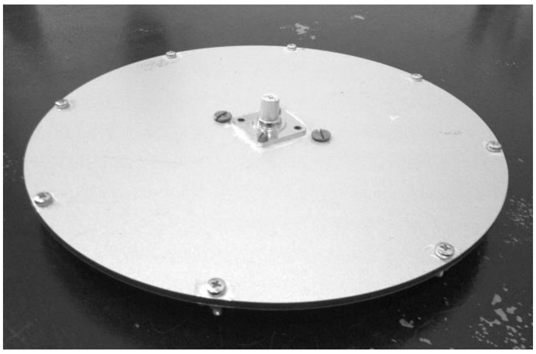

Figure 2 Constructed ground plane with active element

4. RESULTS OF MEASUREMENT

The collected data from both simulation and measurements were analysed and the angular position of the radiation peak was recorded. A sample 3D radiation pattern, which can be used to clarify the connection of angular data and peak direction relative to the ground plane, is displayed in Figure 3.

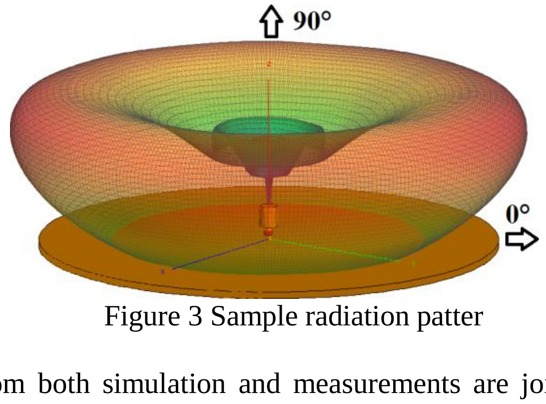

Figure 3 Sample radiation patter

The obtained results from both simulation and measurements are jointly presented in graphical form in Figure 4.

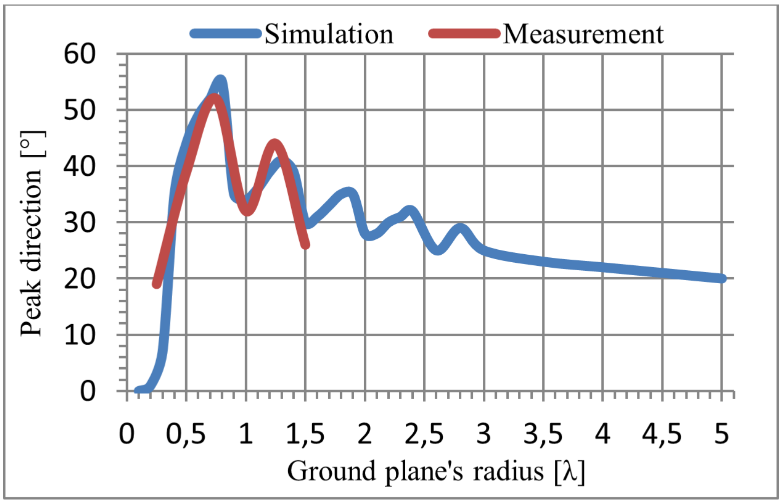

Figure 4 Results of peak direction variation

Obtained results show quite good match between measurement and simulation, which verifies the simulation results. The differences between results are probably caused by design of the used ground plane, which has several screws protruding from the constructed ground plane, see Figure 2, affecting the reflected electromagnetic waves. For the resulting radiation patterns in polar diagrams, which show this effect in detail, see [1]. The overall trend seems to converge to the theoretical 0° in case of infinite ground plane's radius.

5. CONCLUSION

It can be concluded, based on the results presented in this paper, that the finite size of the ground plane has lifting effect on the angular direction of the radiation pattern's peak. When the radius of the circular ground plane is equal to 1/4 wavelength of the desired frequency, then the radiation pattern is very similar to the radiation pattern of the infinite ground plane, with the radiation peak in plane with the ground plane. Increasing dimensions of the ground plane somewhat above 1/4 of the wavelength causes rapid lift of the radiation pattern. Further increase of the ground plane's dimensions causes theradiation pattern's peak to decline closer to the plane of the ground plane.

This resulting knowledge can be used in fast determination of the radiation pattern lift by the rule of thumb, and can be helpful in precise analysis of radiation pattern behaviour of mounted aircraft monopole antennas.

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