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NUMERICAL MODELING OF MULTIBEAM MICROSTRIP ANTENNA ARRAYS FOR TELECOMMUNICATION SYSTEMS USING THE INTEGRAL EQUATION METHOD

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Abstract. Process of numerical modeling of the microstrip antenna array farfield with formation of zero in the interference direction is considered. It is shown that it is possible to apply the method of integral equations in thin-wire approximation to provide the required accuracy of the amplitude-phase distribution calculation for effective interference suppression.

Keywords: antenna array, numerical modeling, method of integral equations

Introduction

In today's interconnected world, reliable communication is essential. With the increasing number of users and devices relying on 5G and other telecommunication systems, managing electromagnetic compatibility becomes challenging. Digital antenna arrays and Digital Beamforming (DBF) technologies offer solutions by dynamically adjusting signal direction and filtering interference [1-3]. However, accurately modeling these antenna arrays is crucial for optimizing performance. Fast and efficient numerical modeling methods are very important for developing reliable telecommunication infrastructures that meet modern connectivity demands [4-5]. In this article, we explore how numerical modeling of antenna arrays helps to overcome existing problems in advanced telecommunication systems.

Numerical modeling of multibeam microstrip antenna arrays

When calculating digital antenna arrays to effectively suppress interference signals, it is necessary to use mathematical models of rafiators that ensure low calculation errors.

Figure 1 shows the calculated radiation patterns of an adaptive multibeam antenna obtained by the geometric optics method.

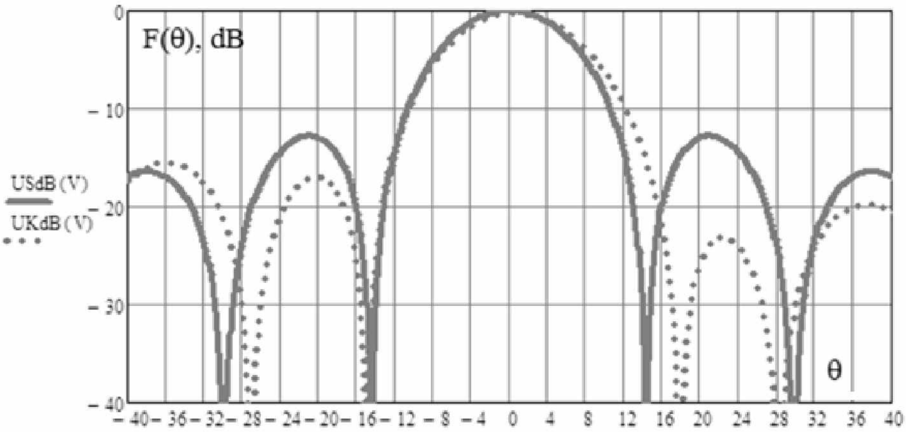

Figure 1. The original radiation pattern of the antenna array and the pattern when forming a zero in the direction of interference

The solid line (*USdB*) shows the antenna pattern in the absence of interference. Dots (*UKdB*) - adaptive antenna pattern in the presence of interference from directions $Vp1 = -27°$ and $Vp2 = 17$ degrees.

From Figure 1 it can be seen that the adaptive antenna pattern in the direction of the received signal ($Vc = 0°$) has remained virtually unchanged. In the presence of interference, the adaptive antenna array formed pattern nulls in the directions of interference. Analysis of the results obtained showed that in order to effectively attenuate interference signals, the error in determining the direction to interference sources should not exceed 1-2 degrees. If the error in determining the direction to the interference is 2 degrees ($Vp1 = -29°$, $Vp2 = 16°$), the suppression of interference signals decreases ($UKdB(-28°) = -24$ dB; $UKdB(15°) = -16$ dB).

Figure 2 shows the results of modeling an antenna array farfield taking into account the failure of one emitter. The solid line (*USdB*) shows the original antenna pattern in the absence of interference, the dots (*UKN1dB*) show the adaptive antenna pattern if present, and the dotted line (*UKKdB*) shows the pattern when one radiator fails.

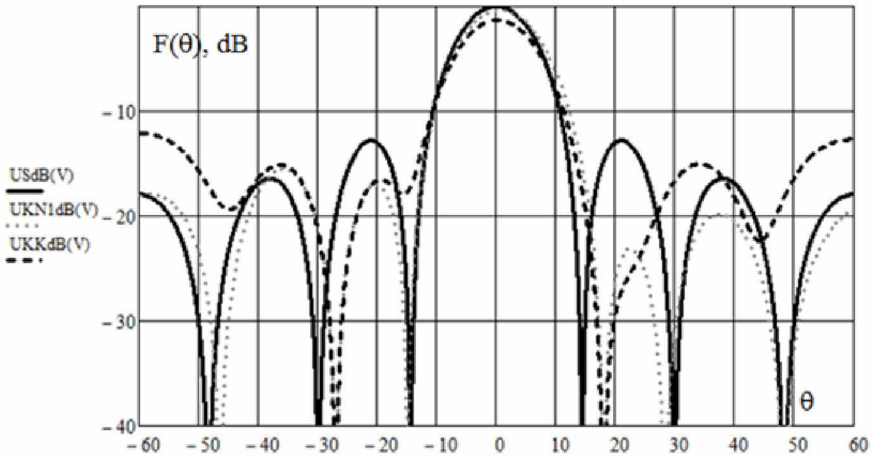

Figure 2. Antenna array farfield when a zero is formed in the direction of interference and one emitter fails

From Figure 2 it can be seen that to ensure effective interference suppression at the output of a multibeam antenna, it is necessary to ensure high accuracy in determining the angular coordinates of interference signals. The use of the geometric optics method does not consider a number of factors affecting the measurement error. To accurately calculate the radiation pattern, one of the well-known electrodynamic modeling packages (CST Studio Suite, NI AWR MWO) can be used. However, these packages require significant hardware and time resources for calculation. To reduce the simulation time and the required amount of RAM, the method described earlier in [6-8] can be used, in which the plates of microstrip emitters are replaced by a system of thin conductors. Additional acceleration of the modeling process can be achieved using CUDA technology.

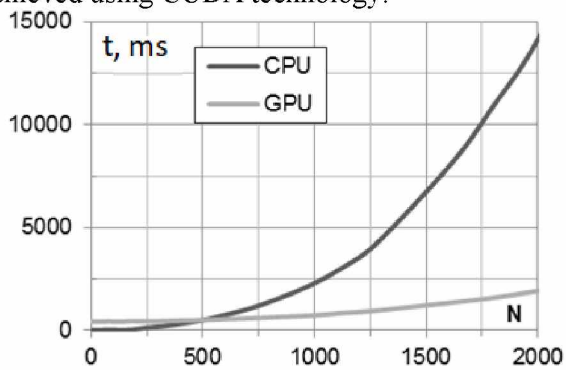

Figure 3. Dependence of the time for calculating the current distribution on the elements of the antenna array on the number N of segments

From Figure 3 it is clear that with small sizes of the problems being solved (the number of segments N is less than 500), the central processor solves the problem faster and it is not advisable to use a graphics processor. As the problem size increases, the GPU begins to outperform the CPU. The

GPU solved the system, compiled for 5120 segments (32×32 vibrator array) 11,03 times faster than the CPU.

Conclusion

The process of modeling the radiation pattern of an antenna array with the formation of a zero in the direction of interference is considered. It is shown that for effective interference suppression, high accuracy is required in the formation of the amplitude-phase distribution. To reduce modeling time, the method of integral equations in the fine-wire approximation and transfer of calculations to a GPU accelerator can be used.

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