# Peculiarities of Poklington Equation Application to Carbon Nanotube Antennas Analysis

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*Abstract* – **The possibility and singularities of using the Poklington integral equation (IE) for analysis of the antennas and scatterers, consisting of carbon nanotubes (CNT). It is shown that the results of simulation with the Poklington integral equation are in complete agreement with the results known from the literature.**

*Keywords* - **carbon nanotubes, antennas, integral equation, nanoantennas, analysis.**

## I. Introduction

At present a considerable study is being given to the possibilities of using various structures, consisting of the carbon nanotubes (CNT) in electronics, power engineering, promising composite materials creation. Unusual electric properties of nanotubes make them one of the main materials in nanoelectronics; progress in its development is rather significant. The use of the CNT as the antenna systems in different fields, namely, for communication between nanodevices, fiber optic communication devices as well as their use for connection between nanoelectronic and microscopic devices is very promising. Such antenna systems feature a diversity of peculiarities distinguishing them from the traditional antenna systems [1].

Moreover, the composite materials based on the CNT can be used in the microwave range devices, for instance, as frequency-selective surfaces [2]. A wide introduction of such devices into practice is impossible without knowledge of their electrodynamics characteristics. At present a considerable body of work is devoted to their investigation (see, for example, references in [3]). In this case either individual oscillators in the form of the rectilinear CNT, or periodic arrays consisting of such vibrators are considered in them, and the mathematical model is built on the basis of the Hallen integral equations [4].

But on frequent occasions investigation into the structures representing totality of the arbitrary oriented CNT is required and, moreover, these CNTs can have arbitrary configuration [2]. In the given case, as it is shown in [6], it is more expedient to use Poklington equation for construction of the mathematical model.

## II. Main Part

The results of the mathematical model, algorithm and program complex (PC) development for calculation of radiation and scattering characteristics of the CNT-based structures, are presented in the report.

Poklington integral equations for the structures, consisting of a finite number of the CNT of an arbitrary configuration oriented in space arbitrarily, are derived. In this case it was assumed, that the boundary conditions of the type

$$\mathbf{n}\times\mathbf{E}(\mathbf{r},\omega)=Z_S\left[\mathbf{n}\times\left[\mathbf{n}\times\mathbf{H}(\mathbf{r},\omega)\right]\right],$$

were met on the CNT surface, where $\mathbf{E}(\mathbf{r},\omega)$ and $\mathbf{H}(\mathbf{r},\omega)$ were vectors of the electric field and magnetic field intensities at the point **r** on the CNT surface; **n** – was the normal to the surface at the same point; $Z_S$ was the operator, describing the properties of the CNT surface impedance.

Being solved numerically the derived integral equation system was brought to the system of the linear algebraic equations using Galerkin method and Richmond basic functions. Results of individual nanovibrators simulation with the use of the developed package of programs were given. Comparison of obtained results with those ones known from the literature has confirmed adequacy of the offered model and correctness of the developed program complex.

## III. Conclusion

The results given in the report show that an effective program package based on Pocklington's integral equations can be developed. These programs are used to analyse electrodynamic characteristics both single nanoantennas of complicated configuration and antenna systems consisting of such elements. It allows to increase the category of analysed nanostructures essentially.

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