# DESIGN OF RADIATION OF THE DIPOL ELECTRON-BEAM ANTENNA

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Actuality of problem of generation and radiation of ultra-wideband (UWB) signal makes experimenting with new methods of excitation of the radiating systems. For forming of radiations of high intensity the high-currents accelerating of electrons is used lately quite often. Theoretical and experimental researches show possibility of generation of impulses with a relatively wide spectrum which is determined by variation of energy of electrons at the front front of bunch. The results of design of dipole electronic beams of antenna (EBA) at excitation by the impulses of current of different form are resulted in the real work.

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## 1. INTRODUCTION

The actuality of the problem of generation and radiation of nonsinusoidal ultrawideband (UWB) signals forces to experiment with new methods of excitation of the radiating systems. To generate radiation of high intensity recently often used high-current electron accelerators (HCEA). Studies of the generation processes and the formation of the pulsed electromagnetic radiation using the technique of HCEA led to the development of electron-beam antenna (EBA), in which the radiating structure connected to the collector of the accelerator, is excited directly by an electron beam [1,2]. The TEM antenna was experimentally investigated and the possibility of obtaining of UWB radiation with high field intensity in far-field region was shown. In this paper we present the simulation results of the dipole EBA when excitating by pulses of different shapes.

## 2. MAIN PART

Experimental study of excitation of TEM-antenna high-current relativistic electron beam confirmed the possibility of generating UWB signals by this method. Scheme of the experiments is given in Fig. 1.

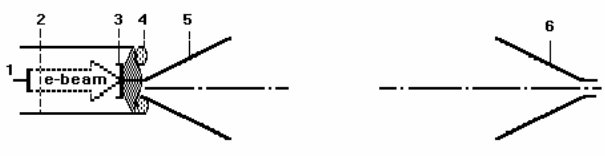



*Fig. 1. Scheme of the experiments: 1 – cathode, 2 – e-beam, 3 – anode-collector, 4 – Rogovsky coil, 5, 6 – sending and pickup antennas*

In order to make a comparative analysis of the TEM antenna dipole was designed consisting of two elongated plates, the dimensions of which changed in length from 100 to 300 mm and in width from 10 to 100 mm. The specified range of values was divided into 5 equal intervals. A solution was founding for all combinations of geometric parameters of the dipole by sequential scan. In each solution was done a sample of maximum and minimum values of field intensities. Radiation pattern of the electric dipole at the frequency of 2.5 GHz at exciting by trapezoidal current pulse is shown in Fig. 2.

Fig. 3 shows amplitude time dependencies (ATD) field in the direction of maximum Radiation pattern (RP). As can be seen, with the excitation pulse of trapezoidal ATD though receiving scarred containing emissions, but the antenna operating in pulsed radiation, but not oscillatory, that is a fundamental difference of spiral antennas.

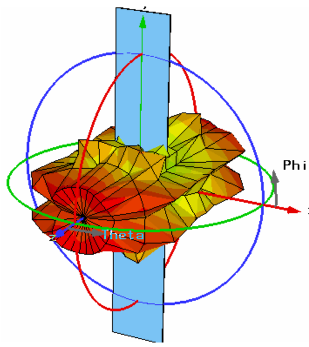
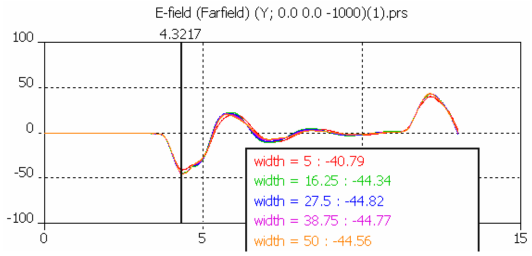



*Fig. 2. RP of flat electric dipole at the frequency 2.5 GHz when exciting trapezoidal current pulse*

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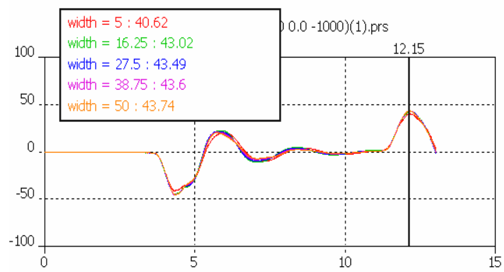


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*Fig. 3. ATD of field versus dipole geometry: a) versus width, b) versus length*

According to the sample data dependencies of peak field values on the length and width of the electric dipole arm were constructed (Figs. 4, 5). The amplitude of the field strength increases with the width and length dipole, but the value of the maximum field with increasing in plate width grows faster than with increasing in plate length. The current amplitude maximum of the rapid processes in the flat conductors is observed at the edges of the conductors. Expanding the radiating plate, we remove the edges from the observation point, located near the center of the radiating plate and, thereby, creating a sort of antenna array of two dipoles, which leads to a narrowing of the RP and increase the field strength in the far region (see Figs. 4, 5).

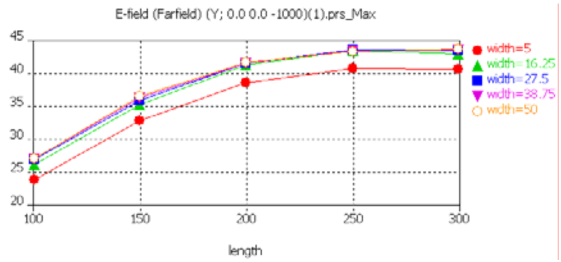



*Fig. 4. Amplitude values of field maximum versus dipole length for different values of slab plate width*

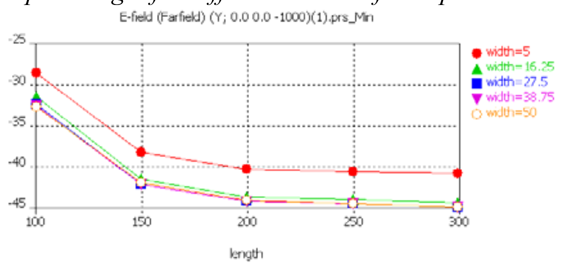



*Fig. 5. Amplitude values of field minimum versus dipole length for different values of slab plate width*

In paper [7] for the effective radiation of UWB signals, a model of the cross plane electric dipole is proposed. To analyze the effectivity of its radiation and to compare the results with the results of simulation of a flat electric dipole computer model of the Phillips antenna has been designed and calculated (Fig. 6). The model consisted of two flat dipole (identical to Fig. 2) arranged crosswise, each of which was supplied half the value of the current amplitude. It was done to keep radiating energy supplied to the system at the same level as in the previous model. Figs. 7-10 show the results of computations.

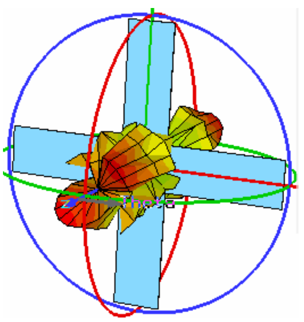
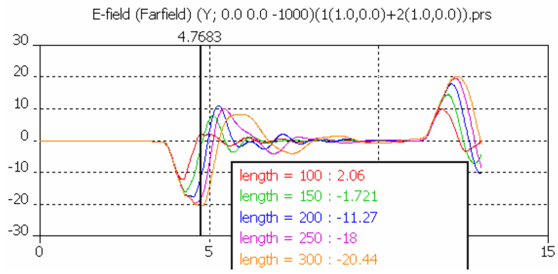


*Fig. 6. Numerical model of the Phillips antenna at frequency 2.5 GHz when exciting trapezoidal current pulse*

The sources of electromagnetic fields are known [8], electric charge, moving with a positive or negative acceleration. Moreover, this acceleration can be not only absolute but relative, i.e., radiation can occur as a result of acceleration occurring when changing the trajectory of motion of a charged particle. In paper [5] the radiation of the UWB pulsed electromagnetic fields of high current Hartmut antennas has been theoretically and experimentally investigated. The antenna was a magnetic frame excited by short curren pulses. In particular, it was shown that the bendings of the frame are the areas of the radiator, in which concentrated charges are. They behave similarly to the excitation region of the rod antenna end and are areas of radiator from which comes the maximum radiation. Emitted electromagnetic field is formed due to interference of the fields coming from all four bendings and the excitation region of the radiator.

Based on the results obtained in ref. [5], the authors proposed a method for improving the radiation effectivity of the plane electric dipole by way of the corrugating of elements of its design. Radiation pattern calculated for the frequency of 2.5 GHz is shown in Fig. 10. Comparative analysis of field ATD in far field region shows that the amplitude of the electromagnetic field generated by an electric dipole with a flat corrugated arm is higher than the peak value of the field produced by electric dipole of flat electric dipole having a straight arm. Moreover, the gain is about 4.5%. Thus, the results of calculations confirm the possibility of increasing the radiation effectivity due to a corrugating of structure elements of the radiator.

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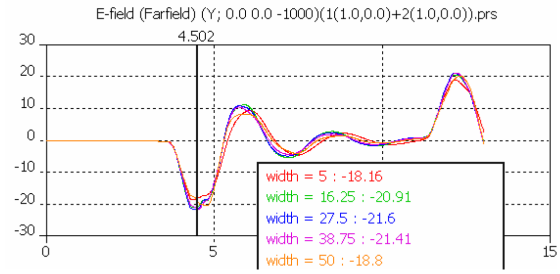


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*Fig. 7. Far field ATD of flat electric dipole when exciting flat electric dipole by trapezoidal current pulse, shown for different dipole geometry parameters*

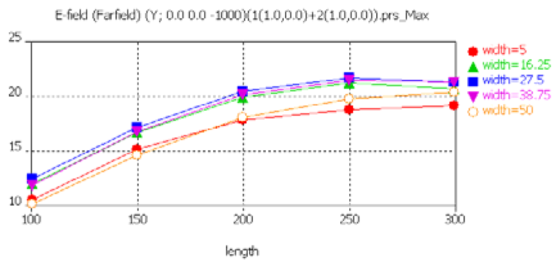


*Fig. 8. Amplitude of field maximum versus dipole length for different values of slab width*

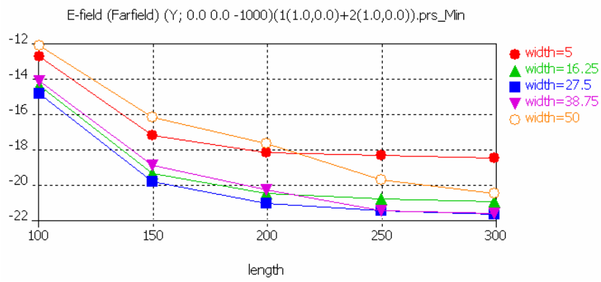


*Fig. 9. Amplitude of field minimum versus dipole length for different values of slab width*

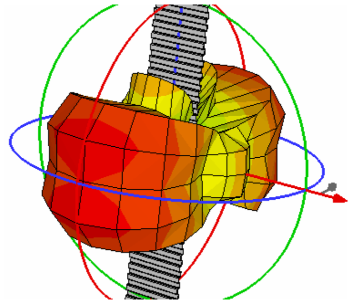

*Fig. 10. RP of flat electric dipole having corrugated arm at the frequency 2.5 GHz when exciting trapezoidal current pulse*

## 3. CONCLUSIONS

1. Using finite difference time domain allows you to simulate the processes of excitation and radiation of UWB pulses with acceptable reliability. The simulation results are in good agreement with experimental results. Using computer modeling allows the preparation for experimental work in a shorter time and with lower material costs, an opportunity to become more informed approach to the choice of parameters and the detail in the production model or a prototype.
2. The analysis of simulation results of a flat electric dipole showed it to a higher radiativity in comparison with spiral antennas. On the basis of realized example of geometric parameterization dipole, offers advice on selecting the size of structural elements, for maximum energy transfer to the pump pulse energy in the electromagnetic field of UWB pulse. An option of increasing the efficiency of the radiating capacity of a flat electric dipole due to the introduction of corrugated plates, forming his shoulder. The calculation results of increasing the field strength in the DMZ through the introduction of corrugation.

## REFERENCES


1. N.I. Gaponenko, V.I. Kurilko, S.M. Latinsky, Yu.F. Lonin, I.F. Kharchenko. Excitation of isolateds rode antenna by high-current electron beam // *Problems of Atomic Science and Technology. Ser. "Nuclear-physics Investigations".* 1997, N 4, 5 (31, 32), p. 151-153.
2. V.A. Balakirev, N.I. Gaponenko, A.M. Gorban, D.V. Gorozhanin, A.M. Egorov, V.V. Ermolenko, Yu.F. Lonin, I.N. Onishchenko. Excitation of TEM-horn antenna by pulse relativistic electron beam // *PAST. Ser. "Plasma Physics" (5).* 2000, N 3, p. 118-119.
3. B. Scheers. Ultra-Wideband Ground Penetrating Radar, with Application to the Detection of Anti Personnel Landmines: Ph.D. thesis / Université Catholique de Louvain, Laboratoire D'Hyperfréquences. Louvain-la-Neuve (Belgium), March 2001, 277 p.
4. E.G. Farr and C.E. Baum. Time Domain Characterization of Antennas with TEM Feeds // *Sensor and Simulation Notes.* 1998, Note 426.
5. G.P. Pochanin. UWB radiation of pulse electromagnetic fields by high current Kharmut antenna // *PhD thesis.* Kharkov: Usikov IRE of NANU. 2002.
6. G.S. Smith, T.W. Hertel. On the transient radiation of energy from simple current distributions and linear antennas // *IEEE Antennas and Propagation Magazine.* 2001, v. 43, № 3, p.49–62.
7. N.N. Gorobets, A.N. Dumin, O.A. Dumina. About radiation of short pulses by wire antenna of finite length // *The First International Workshop "Ultra Wideband and Ultra Short Impulse Signals".* Kharkov (Ukraine). 2002. Proceedings of the conference on CD.
8. H.F. Harmut. *Nonsinusoidal Wave for Radar and Radio Communications.* NewYork - London - Toronto - Sydney - San-Francisco: "Academic Press", 1981.


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## МОДЕЛИРОВАНИЕ ИЗЛУЧЕНИЯ ДИПОЛЬНОЙ ЭЛЕКТРОННО-ПУЧКОВОЙ АНТЕННЫ

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Актуальность проблемы генерирования и излучения сверхширокополосных (СШП) сигналов заставляет экспериментировать с новыми методами возбуждения излучающих систем. Для формирования излучений высокой интенсивности в последнее время нередко применяются сильноточные ускорители электронов (СУЭ). Теоретические и экспериментальные исследования показывают возможность генерирования импульсов с относительно широким спектром, который определяется разбросом энергии электронов на переднем фронте пучка. В работе приведены результаты моделирования дипольной электронно-пучковой антенны при возбуждении импульсами тока различной формы.

## МОДЕЛЮВАННЯ ВИПРОМІНЮВАННЯ ДІПОЛЬНОЇ ЕЛЕКТРОНО-ПУЧКОВОЇ АНТЕНИ

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Актуальність проблеми генерування та випромінювання надширокосмугових (НШС) сигналів примушує експериментувати з новими методами збудження випромінюючих систем. Для формування випромінювань високої інтенсивності останнім часом застосовуються сильноточні прискорювачі електронів (СПЕ). Теоретичні і експериментальні дослідження показують можливість генерування імпульсів з відносно широким спектром, який визначається розкидом енергії електронів на передньому фронті пучка. У роботі приведено результати моделювання діпольної електронно-пучкової антени при збудженні імпульсами струму різної форми.