GENERATION UWB SIGNAL AT ENERGIZATION OF A HELICAL ANTENNA HIGH-CURRENT REB

V.A. Balakirev, A.M. Gorban', A.M. Egorov, A.V. Kantemirov, Yu.F. Lonin, A.G. Ponomarev, N.I. Onishenko, V.T. Uvarov, V.I. Chumakov, D.A. Shevtusev, V.V. Sherney
NSC KIPT, Kharkov, Ukraine

In operation the possibility of generation of UWB signal was researched at excitement of a helical antenna by a high-current relativistic bundle of nanosecond duration. The experiments were conducted on a high-current relativistic accelerator REB "Темр-A" with parameters: E_b ~ 0,5…1,0 MeV, I_b ~ 5…10 кA, duration of a ~15 nc., at the value of a leading edge ~ 1…2 nc. The calculation data of a helical antenna and parameters of a generated UWB signal are reduced.

*PACS:*29.27.-a

INTRODUCTION

Generation and reception nonsinusoidal ultrawidthband (UWB) of pulsing signals – actual problem of a modern relativistic electronics engineering. Such impulses discover broad application in modern systems of a radiolocation and radio communication. They can be used for underground exploration, of learning of effect potent UWB of electromagnetic impulses on different objects of a natural and synthetic parentage and for a number of other applications [1].

The methods of generation potent regular shortimpulsive UHF of waves decimeter and millimeter-wave based on the traditional schemes of con-version of energy of intensive relativistic beam couplings in energy electromagnetic of fields of micro-wave-radiation have sufficient low efficiency [2-4]. In middle of 80-years in operations [5], and later in [6-7], the contributors showed possibility of enough effective energization of energy of a TEM-wave at the expense of energy reserved in the Marx-generator and direct conversion of energy IREB in energy of a TEM-wave. The purpose of the given operation – experimental learning of possibility of generation (UWB) impulse o signals at energization isolated conic helical antenna shortimpulsive IREB, without its previous modulation.

EXPERIMENTAL PART

For this purpose the theoretical calculation was conducted and numerical analysis of a helical antenna [8], with a fitting condition of her inlet with parameters of a high-current relativistic electron beam of the accelerator of "ТЕМП-А", and output with a wide berth 8. Band, which is capable to radiate the given antenna lied in limits from 0,5 GHz up to 10 GHz. т.е. (λl_{min} =60 см, and λ_{max}=3см). Thus radiating antenna was correlated on inlet with the impedance of a beam, and on outlet – with the resistance of free space. The receiving antenna was similar radiating.

The main specifications of a helical antenna had such values:

$2a_{min}$ =0, 2 l_{min} and $2a_{max}$=0,4 l_{max} small and major radiuses of an antenna;

Θ=20°– aperture angle, (α) =18° – corner of winding of a spiral, where l_{min} and l_{max} minimum and maximal length of waves of radiation.

The form and construction isolated однозаходной of a conic helical antenna of a direct wave is shown in a Fig.1

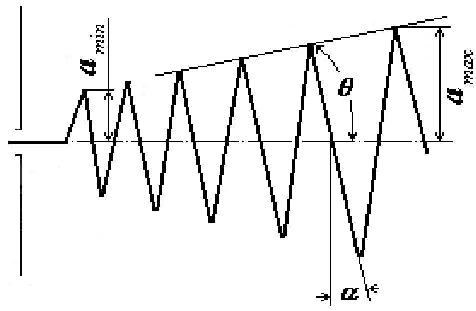

Fig.1. The construction of the isolated conic helical antenna of a direct wave

The equivalent network of a helical antenna we shall present as a shunt circuit excited by a feeding device *I(t)* (Fig.2). Here is marked: *L*-inductance of an antenna, *C* – antenna capacitance

$$G_k = \frac{R_n}{LC} = \frac{1}{\rho Q},$$

resonant conductivity expressed through parameters of an outline.

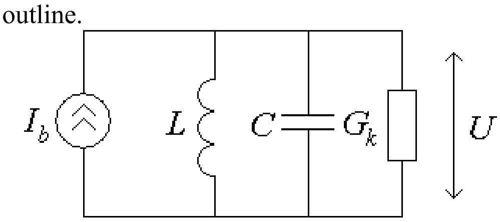

Fig.2. The equivalent network of an antenna as a shunt circuit

According to [8] the resistance of losses can be equated to a resistance of radiation $\boldsymbol{R_n=R_\Sigma}$; the relative frequency range, in which the helical antenna of a direct wave is characterized by provisional persistence of an input resistance, makes $\boldsymbol{f_b/f_n=3}$. Thus the equivalent goodness of circuit will be peer

$$Q = 2\frac{f_в - f_н}{f_в + f_н} = 1 \qquad (1)$$

The edge stress is defined by expression [9]

$$u(t) = \int_0^t i'(t - x)h(x)dx, \qquad (2)$$

where ***i′(.)*** – rate of change of a function of a current of a beam coupling, energizing an antenna, ***h(t)*** – surge characteristic of an outline, which with the registration (1) can be represented as

$$h(t) = \rho e^{-\frac{\pi t}{T}} \sin\left(\sqrt{3}\pi \frac{t}{T}\right). \quad (3)$$

Here $\rho = T/\sqrt{3}\pi C$ – characteristic resistance of an outline, $T = 2\pi\sqrt{LC}$

Let's consider some cases:

1) Let field current is characterized by the function with linearly increasing front by duration τf:

$$i(t) = \begin{cases} I_0/\tau_f, & 0 \le t \le \tau_f \\ I_0, & t > \tau_f \end{cases}. \quad (4)$$

Then the edge stress is gained equal.

$$u(t) = A\left\{\sqrt{3} - e^{-\frac{\pi t}{T}}\left[\sin\left(\sqrt{3}\frac{\pi t}{T}\right) + \sqrt{3}\cos\left(\sqrt{3}\frac{\pi t}{T}\right)\right]\right\} -$$

$$- A\left\{\sqrt{3} - e^{-\frac{\pi(t-\tau_f)}{T}}\left[\sin\left(\sqrt{3}\frac{\pi(t-\tau_f)}{T}\right) + \sqrt{3}\cos\left(\sqrt{3}\frac{\pi(t-\tau_f)}{T}\right)\right]\right\} 1(t-\tau_f), \quad (5)$$

where, $A = \frac{I_0 \rho T}{4\pi \tau_f}$ **1(.)** – single function Хевисайда.

Graphics obtained by results of calculation (5), are reduced in a Fig.3.

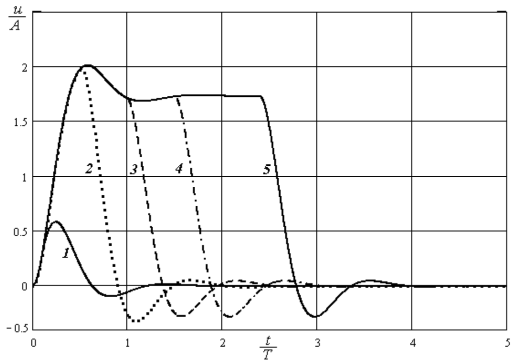

Fig.3. Edge stress at an antenna excitation by a current with linearly increasing front:
1 – τ/T=0,1; 2 – τ/T=0,5; 3 – τ/T=1,0; 4 – τ/T=1,5; 5 – τ/T=2,5

2) For a field current with Gauss's by increase of a leading edge

$$i(t) = I_0\left(\frac{1}{2} + \frac{1}{\sqrt{2\pi}\,\sigma}\int_{-\infty}^{t} e^{-\frac{(x-3\sigma)^2}{2\sigma^2}}dx\right), \quad (6)$$

where σ^2 – dispersions Gauss's of distribution, time dependence of an edge stress are gained with the help (2) substitution in this expression of the formulas (3) and (6). The outcomes of calculation are reduced on the graphs of a Fig.4.

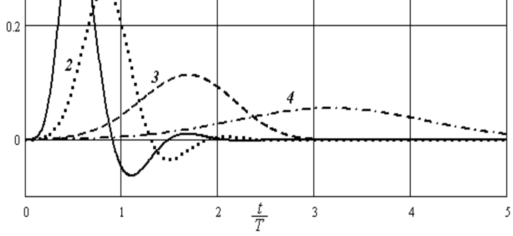

Fig.4.Dependence of power on time

The experimental researches of generation potent UWB of electromagnetic impulses by direct energization of the isolated conic helical antenna impulse REB were fulfilled on the high-current accelerator of "ТЕМП-А" is like [10].

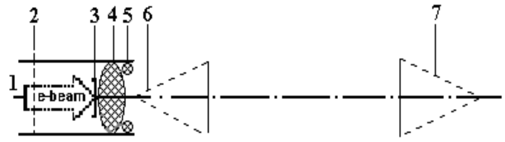

Fig.5. The circuit (scheme) of carrying out of experiment. The 1 – cathode; 2 - anode; 3 - manifold; 4 – insulator; 5 - Rogovsky coil; 6 - a radiating antenna; 7 - receiving antennas

The energization of the isolated conic helical antenna occurs by an electron beam, formed in the cathode – anode interval of the accelerator (pos. 1-2, Fig.5), and which bound hits on a collector (3), with a radiating conic helical antenna (6). The current of a beam was measured by Rogovsky coil (5).

The waveform of power taken out with a voltage divider on a radiating antenna is reduced in a Fig.6.

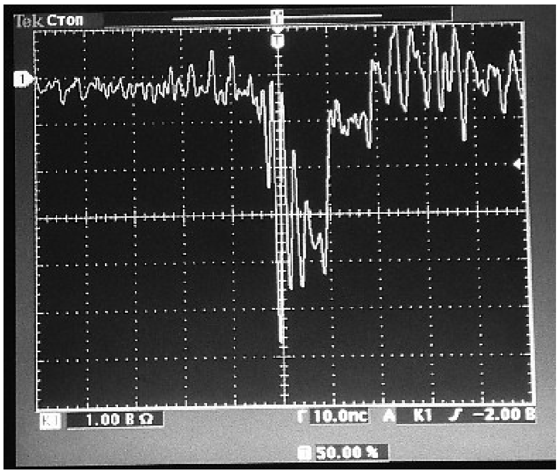

Fig.6. An oscillogram of power on a radiating helical antenna

It is necessary to mark, that the potential distribution on time practically precisely transmits the form of a current of a bundle and is in good correspondence with designed (Fig.4, curve 1). The typical parameters of a bundle thus are those:

E_b~ 0,7…0,8 MeB, I_b~ 7 кА,

duration of a bundle ~15 ns., at the value of a leading edge ~ 1…2 ns.

REFERENCES

1. H.F. Harmut. Nonsinusoidal *Wave for Radar and Radio Communi cations.* N.Y.: "Academic Press", 1981.
2. A.S. Sulakshin // *Zh. Techn. Fis.* 1983, v.53, №.11, p.56 (in Russian).
3. A.N. Didenko, Yu.G. Yushkov, *Powerful microwaves -impulses nanosecond of duration.* M.: "Energoatomizdat".1984, p.112 (in Russian).
4. N.P. Gadetskij, I.I. Magda, S.I. Naisteter et al. // *Plasma Phys. Rep.* 1994, v.19, p.273.

5. M. Friedman, J. Krall, J.J. Lau, V. Serlin // *Rev. Sci. Instr.* 1990, v.61. №1, p.171.
6. K.P.,Grachov et al. // *Radio engineering and electronics*. 1994, №12, p.2044-2049 (in Russian).
7. Ch. Gilman, S.K. Lam, J.T. Naff et al. Proc. Of the 12-th IEEE International Pulsed Power Conference. 1999, v.2, p.1437.
8. N.I. Gaponenko et al. // *Plasma Phys. Rep*. 2000, v.26, №4, p.387-389.
9. O.A. Yur'ev, A.V. Runov, A.N. Kazarin. *Helical antennas.* M.: "Sovetskoe radio", 1974, p.224 (in Russian).

ГЕНЕРАЦИЯ СШП-СИГНАЛА ПРИ ВОЗБУЖДЕНИИ СПИРАЛЬНОЙ АНТЕННЫ СИЛЬНОТОЧНЫМ РЭП

В.А. Балакирев, А.М. Горбань, А.М. Егоров, А.В. Кантемиров, Ю.Ф. Лонин, А.Г. Пономарев, И.Н. Онищенко, В.Т. Уваров, В.И. Чумаков, Д.А. Шевтусев, В.В. Черный

Исследовалась возможность генерации СШП-сигнала при возбуждении изолированной спиральной антенны сильноточным релятивистским пучком наносекундной длительности. Эксперименты проводились на сильноточном релятивистском ускорителе РЭП «Темп-А» с параметрами: E_b~ 0,5…1,0 МэВ, I_b~ 5…10 кА, длительность пучка ~15 нс, при величине переднего фронта ~ 1…2 нс. Приведены расчетные данные спиральной антенны и параметры генерируемого СШП-сигнала.

ГЕНЕРАЦІЯ НШС-СИГНАЛУ ПРИ ЗБУДЖЕННІ СПІРАЛЬНОЇ АНТЕНИ ПОТУЖНОСТРУМОВИМ РЕП

В.А. Балакірев, А.М. Горбань, О.М. Єгоров, А.В. Кантеміров, Ю.Ф. Лонін, А.Г. Пономарьов, І.М. Оніщенко, В.Т. Уваров, В.І. Чумаков, Д.А. Шевтусев, В.В. Черний

Досліджувалася можливість генерації НШС-сигналу при збудженні спіральної антени потужнострумовим релятивістським пучком наносекундної тривалості. Експерименти проводилися на потужнострумовому релятивістському прискорювачі РЕП «Темп-А» з параметрами: E_b~ 0,5…1,0 МеВ, I_b~ 5…10 кА, тривалість пучка ~15 нс, при величині переднього фронту ~ 1…2 нс. Приведено розрахункові дані спіральної антени і параметри генеруємого НШС-сигналу.