Laser driven ultra-wideband microwave pulse generator numerical simulation

Brendel V. M., Bukin V. V., Garnov S. V., Dolmatov T. V., Loza O. T., Sadovskiy S. P., Chijov P. A.

Tarakanov V. P.
Prokhorov General Physics Institute, Russian Academy of Sciences
Moscow, Russia
brendel.vadim@gmail.com

Abstract—Results of numerical simulation of flat laser driven UWB microwave pulse generator using PIC code KARAT are presented. Calculation results compared with analytical estimations.

Keywords—microwave, particle-in-cell, short laser pulses

I. Introduction

Papers [1-3] proposed Cherenkov radiation source of centimeter range wavelengths. Such generator irradiates directional Cherenkov electromagnetic pulse, with electrical field strength proportional to the charge extracted from the cathode and accelerating voltage in the gap. We made numerical model of such Cherenkov source by use of PIC code KARAT. Problem is posed in 2D formulation. The obtained simulation results are in good agreement with the analytical estimation.

II. Calculations and results

The system is a plate capacitor with cathode and mesh anode spaced with 5mm gap, cathode-anode accelerating voltage fixed by 100kV. Short laser pulse (15ps) with flat wave front falls at an angle of 45 degrees relative to the normal of cathode surface. Cathode emits electrons with uniform energy distribution from 0 to 0.5eV, velocity vectors are collinear with cathode normal.

Set of such histories at different current densities (as part of maximum current density calculated above) were obtained. Peak value of electric field strength of EMI pulse was analyzed. Fig.1. shows Ez(k) dependence, peak value of electrical field strength 2.5*10^5 V/cm achieved at saturation current.

Analytical solutions for pulse duration represented in [3]:

\[ T_A \approx \frac{d}{c} \sqrt{\frac{\gamma+1}{\gamma-1}}, \]

\[ \gamma = 1 + \frac{e \cdot U_{C-A}}{m_e \cdot c^2}, \]

where \( d \) - gap distance, \( c \) - speed of light, \( e \) - electron charge, \( U_{C-A} \) - accelerating voltage, \( m_e \) - electron mass.

In our case \( T_A \approx 55\, \text{ps} \). Estimation gained from numerical simulations is in good agreement \( T_N \approx 45\, \text{ps} \) FWHM, that gives an error 10% for analytical and numerical solutions. Numerical simulations acknowledge potential performance of laser driven EMP source, consistent with analytical solution help to understand physics of such generator.

References