Technique for measuring parameters of ultra-wideband microwave radiation

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New type of ultra-wideband (UWB) microwave radiation source was developed. Operating principle of this source is based on amplification of relativistic electron beam noise. Microwave excitation is the result of interactions between electron beam and plasma waves. In UWB source of this type middle frequency of microwave signal determined only by plasma density and does not depend on relativistic electron beam (REB) pulse duration. That allows us to receive UWB 2Δf / (fmin + fmax) = 0.55 > 0.2 microwave signals with durations about 200-300 ns and turn the middle frequency from one REB current pulse to another. The middle frequency could be turn in interval from 2.2 to 3.8 GHz.

Problem of comparison of plasma UWB amplifier effective potential with the same value for other known UWB sources [1] was solved. Effective potential is defined as the product of electric intensity in the given point in the far field and the distance z between this point and emitting antenna. To measure this value in the far field we had to reduce emitting horn diameter D to 16 cm. In this case we can consider area disposed z = 40–80 cm from emitting horn as far field region. Obtained effective potential value is about 400 kV for signals with the middle frequency of 3 GHz, that is comparable with the same value of other UWB sources.

Another problem to be solved was microwave pulse energy measurement. When D ~ λ, microwave beam is characterized with a large divergence. To measure energy in microwave signal one have to place calorimeter with the diameter of 50 cm close to emitting horn. The reflection coefficient is about 10% in the case of normal incidence plane electromagnetic wave. However, if D ~ λ then electric field on emitting horn aperture have large longitudinal component, that leads to significant increase of reflection coefficient from calorimeter surface. Results of numerical simulation, accuracy of which was verified in [2], showed that energy value of 3 J measured in far field (z = 70 cm) corresponds to whole signal energy of 15 J. To confirm this statement between emitting horn and calorimeter (z = 70 m) additional horn with the diameter D = 44 cm placed. Energy value obtained in experiment with additional horn was about 13 J for signals with middle frequency 3 GHz. Thus, it has been proven that a plasma ultra-wideband source makes it possible to create microwave pulses with a duration of 200–300 ns with an energy of ~15 J.

To register spectrum of UWB signal one have to use receiving antenna with wide band pass. During model measurements, which consist in irradiating receiving antenna with monochromatic microwaves with frequencies 2.62–3.9 GHz. Numerical simulations with the code KARAT confirm that optimal length of receiving antenna obtained in experiment and calculated one is the same.

It was shown that signal spectrum is determined by spectrum of cathode current oscillations and amplification band of plasma UWB amplifier. This statement follows from the analysis of the autocorrelation functions of microwave signals recorded in vacuum and in plasma.

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References

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