# Remedying HPM pulse shortening in plasma relativistic microwave oscillators

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***Abstract*—Numerical modeling of plasma relativistic microwave oscillator revealed reasons for HPM pulse shortening. The proposed method allows to eliminate the cause of this effect and to generate high-power microwave pulses with the duration exceeding 80 ns at power level of 100 MW.**

***Keywords- HPM; microwave; high-power; pulse shortening; plasma***

The main and insuperable reason for microwave pulse shortening in vacuum HPM oscillators is RF breakdown on the walls of slow-wave structure as a result of proximity to the relativistic electron beam (REB). In plasma masers this reason is not significant because REB is screened by plasma and propagates far from walls, but contrary to this fact, the effect of pulse shortening in plasma HPM devices does exist [1].

The reasons for microwave pulse shortening were found in numerical modeling using 2.5-D version of the KARAT code with PIC-method for electrons and ions. The first reason is a gap that appears between the plasma cylinder and collector [2]. This gap decreases plasma wave reflection coefficient from the collector and may violate the condition for self-excitation. Another reason was found to be more significant, it is the reverse electron flux with the current ~ 1 kA induced by the REB through plasma. This flux interacts with plasma at frequencies other than the REB does. The reverse electron flux hinders plasma from modulation corresponding to the interaction with the REB, reduces plasma wave amplification twice or more and is capable to quench HPM oscillations.

Calculations showed that the electron temperature in plasma grows to 20 keV in the course of the pulse. Such rise of the temperature in itself does not affect the Cherenkov gain but it tends to increase the plasma potential and the reverse electron flux trough plasma. Interaction of these electrons with plasma according to the Cherenkov mechanism takes place at frequencies close to the Langmuir frequency, where the group velocity of the plasma wave vanishes. As a result, plasma does not emit energy and the temperature rises.

The drop in the reflection coefficient of the plasma wave and the gain can be compensated by a multiple lengthening of the beam-plasma interaction area, however, this way has obvious drawbacks. Another method to avoid microwave pulse shortening is shown in Fig. 1. The left border of plasma abuts on an additional electrode connected to a source of negative potential approximately equal to that of the collector. This design prevents electron current throughout plasma.

Fig. 2 shows that unlike conventional plasma HPM oscillator [1], the proposed scheme allows to generate HPM radiation which not terminate. Nevertheless, there remain electron fluxes in plasma which spoil the oscillator. Electrons are emitted from negative (~ 40 kV) collector into positively charged (~ 20 kV) plasma and heats it. Concurrently, the hottest electrons leave plasma overcoming the potential barrier. Therefore, HPM power diminishes to 100 MW but not to zero as it was originally.

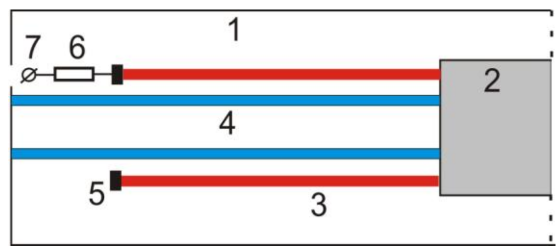


Figure 1. Modified plasma relativistic microwave oscillator: 1 - circular waveguide; 2 – collector; 3 – plasma; 4 – REB; 5 – electrode; 6 – resistor; 7 – source of negative potential.

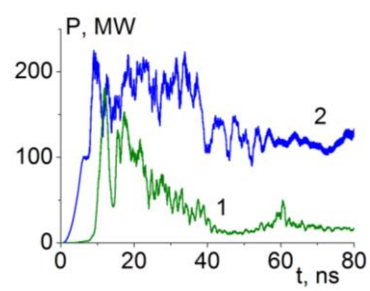


Figure 2. Radiation power vs time: 1 – conventional plasma relativistic microwave oscillator; 2 – modified oscillator.

## REFERENCES

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