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IOT USE AS A POWER SOURCE FOR A LINEAR ACCELERATING STRUCTURE

E. Savin, S. Matsievskiy, N. Sobenin, I. Sokolov, NRNU MEPhI, Moscow, Russia
A. Zavadtsev, LLC « Nano Invest », Moscow, Russia

Abstract

Nowadays the interest of using compact and high efficiency power sources called Inductive Output Tubes (IOT) [1] for feeding accelerating structures with the required pulsed power around 1MW is increasing. In this article results of the beam dynamics and geometry calculations for the L-band IOT S-band IOT and accelerator-generator hybrid module are presented. Different concepts of the cavity have been proposed, but the most efficient has been chosen. The layout of the generator cell with biperiodic buncher cells has been investigated. The hybrid structure composed from the generator cell and the compact SW accelerating section is proposed.

THE GOAL

The goal of the research is to find optimal geometry of the generator cells, output and injection systems for different types of the linear accelerators.

L-BAND PROTON LINEAR ACCELERATOR HYBRID STRUCTURE

Accelerating section consists from washers-diaphragms accelerating structure working on TH_{020} mode at 991 MHz frequency [2]. The idea is to create TH_{020} cavity designed for the same purpose as a klystron output cavity with six beam tubes (Fig. 1). Together with accelerating section they create the hybrid structure working on quasi $\pi/2$ mode [3] where connecting waveguide is a coupling cavity (Fig. 2).

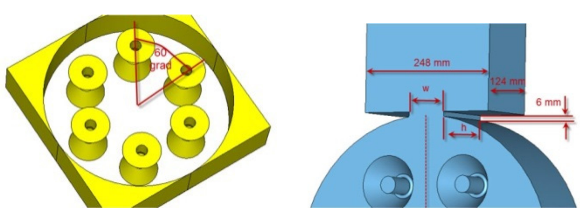

Figure 1: Generator cell geometry.

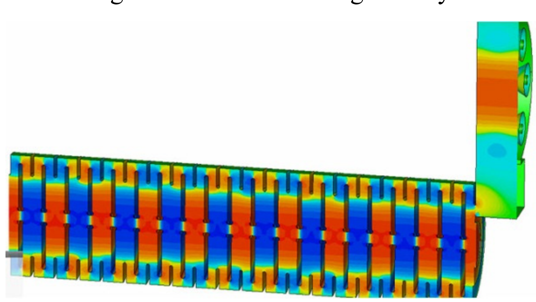

Figure 2: Generator-accelerator hybrid structure.

IOT DESIGN

Next geometries are designed on 2856 MHz working frequency regarding for the uncovered researches for the S-band IOTs. Geometry parameters were varied to achieve maximum output power [4] from the generator cell while inputting there six 5A (pulse) modulated electron beams (Fig. 3).

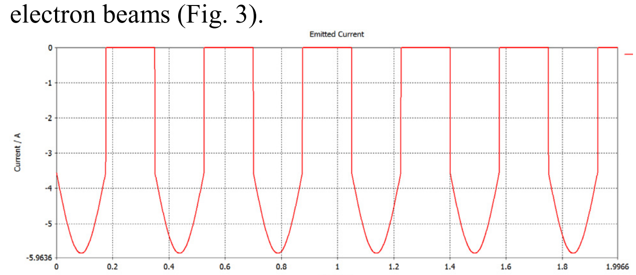

Figure 3: Emitted current from the one cathode.

TH_{020} Pillbox Cavity

TH_{020} wave type consists from two electric field maximums – one in the middle of the cavity and other one (radial) on the perimeter, thus we can put beam pipes in this maximum (Fig. 4).

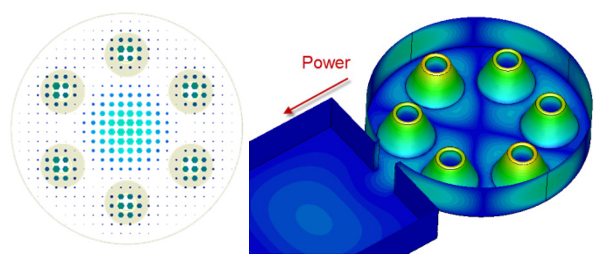

Figure 4: TH_{020} wave in resonator and the power output waveguide.

Maximum power level was reached by varying the beam gap and over coupling between generator cell and the output design by changing the window width w (Fig. 5). In every geometry variations the operating frequency was tuned to 2856 to match with injected beam frequency.

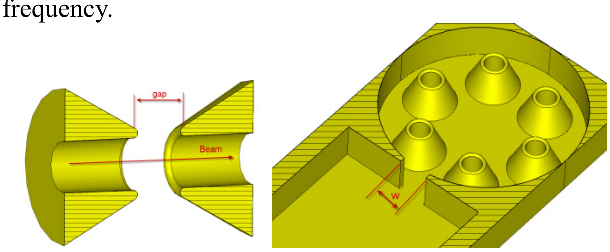

Figure 5: Generator parameters to adjust.

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The dependence of the output power from these parameters is shown on Fig. 6 and the tuned output signal is shown on Fig. 7. In Table 1 are presented the IOT parameters for different input beam currents. Electric beam are injected in the generator cavity with the energy of 100 KeV.

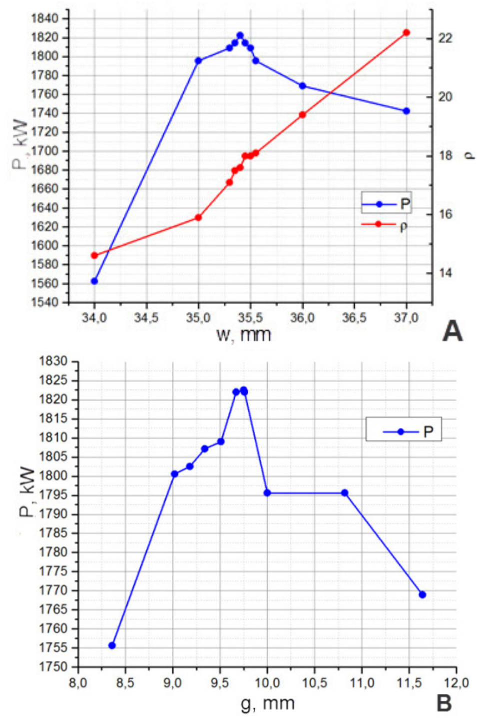

Figure 6: A. Power and VSWR dependence from the window width; B. Power dependence from the gap size.

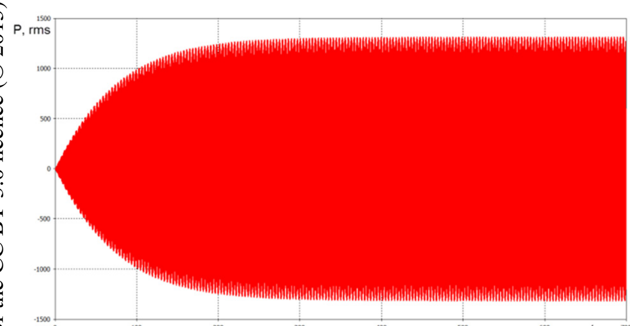

Figure 7: Output signal time dependence in the tuned cavity.

Table 1: IOT Parameters

I (pulsed), A	P out, MW	Efficiency, %
5*6=30	1.8	60
3*6=18	1.02	57
1*6=6	0.23	38

TH_{010} Coaxial Cavity

In order to obtain TH_{010} to avoid the useless peak field in the centre of the cell it is possible to upgrade the cell geometry co the coaxial cavity (Fig. 8). The calculations of optimal geometry are still carrying out.

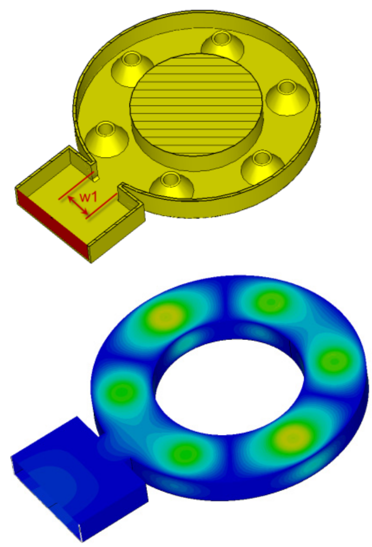

Figure 8: Coaxial IOT geometry and field distribution.

GENERATOR – ACCELERATOR COMBINED MODULES

Biperiodic Accelerating Structure and Coaxial Generator Cavity Combining in the One Hybrid Module

For the example two structures has been designed and connected: coaxial generator cavity tuned to the critical coupling with waveguide on the 2856 MHz frequency and four – cells biperiodic accelerating structure tuned the same way (Fig. 9).

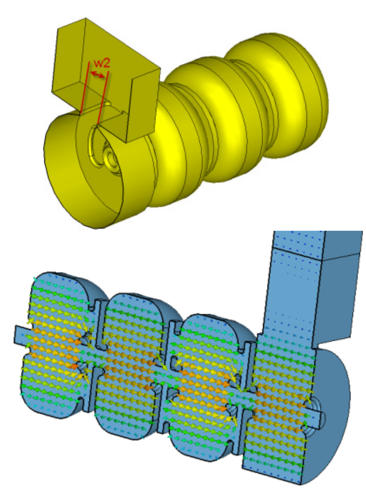

Figure 9: Tuned biperiodic accelerating structureAfter the connection these two structures together the connecting waveguide length (Fig. 10) was varied till resonant frequency (Fig. 11) stopped to depend from it.

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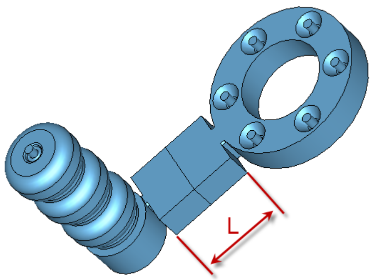

Figure 10: Hybrid structure.

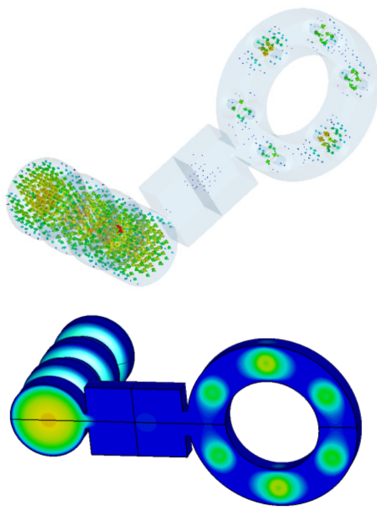

Figure 11: Operating mode obtained in the eigen mode solver.

As a power input to simulate measurements of this test geometry the 50 Ohm coaxial cable is proposed (Fig. 12). Field results, obtained in his simulation (Fig. 13) well matched with eigen mode results.

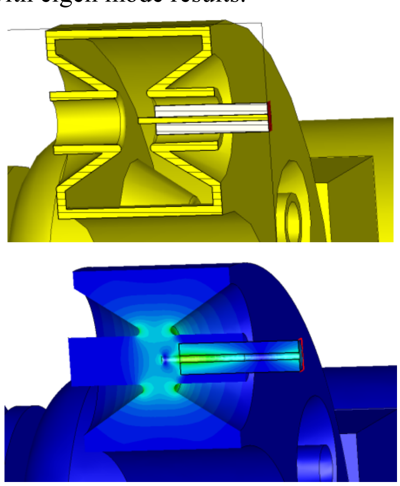

Figure 12: Antenna field excitement.

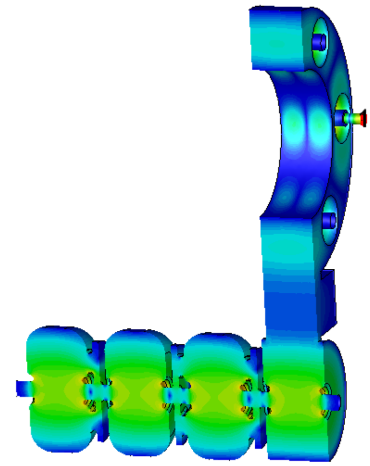

Figure 13: Field in the hybrid structure.

On-axis Biperiodic Accelerating Structure and Generator Cavity as a Hybrid Structure

The idea is to minimise the size of the structure by placing an accelerating structure in the middle of coaxial generator cavity (Fig. 14). This is a topic for the further researches.

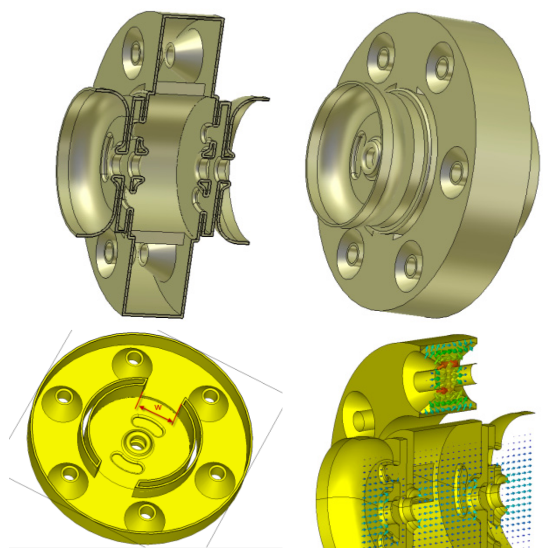

Figure 14: On-axis hybrid module.

REFERENCES

[1] Morten Jensen, High Power IOTs, Proceedings FCC'15, Washington, 2015.

[2] E. Savin et al., "Multi-Bunch Generator Cavity", proceedings, IPAC'14, Dresden, Germany (2014).

[3] N. Sobenin, B. Zverev, "Electrodynamic Characteristics of Accelerating Cavities", Foundation for International Scientific and Education Cooperation, Gordon and Breach Science Publishers S.A. 1999.

[4] A. Baikov et. al., "Development of klystrons with ultimately high – 90% RF power production efficiency", Proceedings FCC'15, Washington, 2015.