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## Resonant O-type millimeter wave oscillators with the inclined focusing field

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### ABSTRACT

This report investigates the influence of inclined focusing magnetic field (MF) on the starting current and efficiency of the resonant O-type oscillators (orotron, laddertron, resonant BWO). Analysis is carried out within a two-dimensional model in which the finite transverse dimensions of the electron beam and interception of electrons by grating are taken into account. The numerical calculation results bear significant effect of the MF incline angle on the oscillators operatoin characteristics.

### 1.THEORETICAL MODEL

A sheet electron beam passes over a reflecting diffraction grating, which is imbedded in a mirror which, along with another mirror, forms an open resonator. Self-consistent nonlinear equations set is used for theoretical investigation of this system. It is assumed that the focusing MF is intense enough so that the electron beam boundaries ripples can be neglected. Electrons are propagating at the incline angle  $\chi$  to the diffraction grating plane. To describe the oscillator starting regime we are used the small-signal approximation of the basic equations (linear theory)<sup>1</sup>.

Three kinds of the longitudinal rf field amplitude distribution in the interaction space are considered. Gauss function corresponds to the orotron

$$f(y) = (w\sqrt{\pi/2})^{-1/2} \exp\left[-((y-0.5L)/w)^2\right] \quad (1)$$

Next two functions correspond to laddertron and resonant BWO respectively

$$f(y) = \sqrt{2} \cos(\pi y/L) \quad (2)$$

$$f(y) = \sqrt{2} \cos(\pi y/2L) \quad (3)$$

where  $y$  - longitudinal coordinate;  $L$  - interaction space length;  $w$  - rf field spot radius on the lower mirror of the open resonator.

### 2.DISCUSSION

The characteristics of oscillators operation, as calculated from linear theory, are shown in Fig.1. The normalized starting current for the three types of the rf field distribution are given as a function of the incline angle  $\chi$ . The solid curve gives the starting current of the orotron (Eq.1). The dashed curve corresponds to the rf field dist-

tribution of the laddertron (Eq.2) and dotted curve gives the starting current of the resonant BWO (Eq.3). The negative angle  $\chi$  indicates that electron trajectories are inclined to the grating surface. The MF incline is obvious to results in decrease of the starting current for all kinds of the function  $f(y)$ . Calculations show that the electron beam fraction is striking the grating when incline angle value corresponds to the minimum starting current. In this case the beam fraction strikes the grating between the collector and rf field spot edge. The further increase of the incline angle results in beam striking the grating in the area where rf field is intense. Thus, the interaction region length decreases and starting current increases (Fig.1).

The electron efficiency  $\eta$  for these oscillators is plotted in Fig.2 as a function of the incline angle  $\chi$ . Numerical calculations based on the governing equations were performed for fixed ratio  $I/I_0$ . Here  $I$  is the dc beam current,  $I_0$  is the minimum starting current. All curves in Fig.2 are plotted in the range of the incline angle values where starting current is lower than in case  $\chi=0$ . For example we consider the orotron. If the angle  $\chi$  increases from zero to  $(-42')$  then an efficiency of the oscillator enhances from 17% to 25%. It is clear from Fig.1 that starting currents are equal at  $\chi=0$  and  $\chi=-42'$ . Thus efficiency enhancement due to dc beam current increase is expected. It should be noted that higher (compared to case  $\chi=0$ ) efficiency can be obtained for the lower beam current since the ratio  $I/I_0$  is fixed.

It is seen that we are obtained different dependences of the efficiency for different kinds of the function  $f(y)$ . Each kind of the devices being considered has its own optimal incline angle. It should be noted that optimal incline angles in the linear and nonlinear theories are not equal.

### 3. REFERENCES

1. E.N.Odarenko and A.A.Shmat'ko, "Self-excitation of oscillations in the prolonged-interaction O-type generators with inclined dc magnetic field", Radiotekhnica i Electronica, V.37, N2, pp.303-310, 1992.
2. E.N.Odarenko and A.A.Shmat'ko, "Nonlinear theory of the resonant generators with inclined dc magnetic field", Radiotekhnica i Electronica, V.38, N9, pp.1690-1695, 1993.

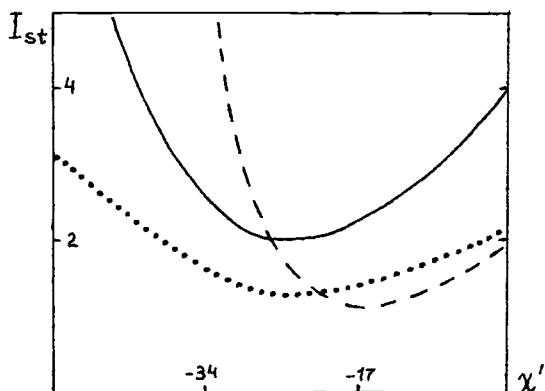


Fig.1. Starting current vs incline angle.

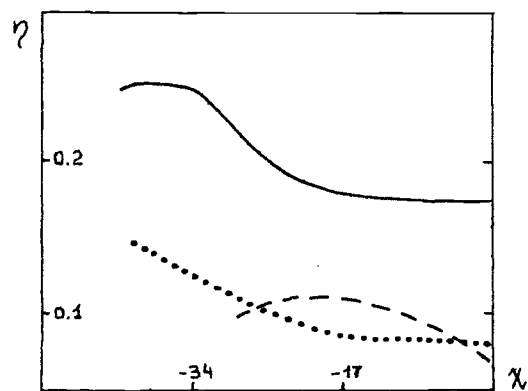


Fig.2. Electron efficiency vs incline angle.