SYSTEMATIC PROCEDURE FOR OPERATING-MODE SELECTION IN CONVENTIONAL AND COAXIAL-CAVITY GYROTRONS*

K. A. Avramides[1], *C. T. Iatrou*[2], *J. L. Vomvoridis*[1]

[1]School of Electrical and Computer Engineering, National Technical University of Athens, Zographou GR-15773, Greece

[2]Thales Electronic Systems, 48 Konstantinoupoleos Str., Koropi GR-19400, Greece

e-mail: koavr@central.ntua.gr

Gyrotrons are millimeter-wave sources that play a major role in ECRH and ECCD in contemporary fusion experiments [1]. In a high-power (~ MW) gyrotron, a high-order TE_{mp} mode (operating mode) must be excited by the electron beam in a cylindrical resonator and single-mode operation must be achieved, despite the presence of various competing modes. In comparison with conventional gyrotrons employing hollow resonators, gyrotrons with coaxial resonators are advantageous regarding the suppression of the competing modes and exhibit smaller depression of the electron-beam voltage due to the beam space charge. As a result they are capable of efficient, continuous-wave (CW), multi-megawatt operation [2].

To design a gyrotron, a pool of suitable candidate operating modes must be specified first. We have developed a standard procedure for the determination of such a pool and of the pertinent operating parameters at the initial step of gyrotron design. The procedure is oriented towards optimization of the efficiency and takes into account the most important physical and technological constraints [3], [4]. It is very general and it applies both to conventional and to coaxial gyrotrons. Moreover, it applies either to pulsed or CW operation, and also to operation either at the fundamental cyclotron frequency or at its harmonics.

To initiate the procedure, the specification of the operating frequency and output power are required, together with estimated values of the electron velocity ratio and of the tilt angle of the emitting surface at the cathode. Suitable expressions have been obtained, describing the constraints related to the electron gun (limitations on the emitter current density, on the electric field at the emitter surface etc), to the resonator (limitations on the ohmic wall loading and losses etc), and to voltage depression. Consequently, constraint-relevant contours on the plane of the TE_{mp} modes (*m-p* plane) determine the region of the candidate operating modes, which satisfy the requirements and all the limitations. Each mode is accompanied by the appropriate set of operating parameters (beam voltage, beam current etc).

References

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