OPERATION LIMITS OF A 236 GHZ HOLLOW-CAVITY GYROTRON FOR DEMO

Parth C. Kalaria[1], Konstantinos A. Avramidis[1], Joachim Franck[1], Gerd Gantenbein[1], Stefan Illy[1], Ioannis Gr. Pagonakis[1], Manfred Thumm[1], and John Jelonnek[1,2]
[1]Institute for Pulsed Power and Microwave Technology (IHM),
[2]Institute of High Frequency Techniques and Electronics (IHE),
Karlsruhe Institute of Technology (KIT), Kaiserstr. 12, 76131 Karlsruhe

ABSTRACT

Gyrotrons are used as efficient, high-frequency RF sources for Electron Cyclotron Resonance Heating and Current Drive (ECRH&CD) in fusion plasma experiments. Following the development of 140 GHz, 1 MW gyrotron for the Wendelstein 7-X (W7-X) stellarator and 170 GHz, 1 MW gyrotron for the ITER tokamak, the conceptual design of a 240 GHz gyrotron for the DEMOnstration Power Plant (DEMO) is ongoing at IHM, KIT. Along with a 237.5 GHz (2 MW) coaxial-cavity gyrotron design, a 236 GHz (1 MW) hollow-cavity gyrotron design is under investigation for DEMO as per EUROfusion baseline 2012 (aspect ratio 4.0) [1]. The operating mode has been selected considering multi-frequency gyrotron operation at 170 GHz / 203 GHz / 236 GHz and 269 GHz for multi-purpose application [2]. Considering realistic electron beam parameters in the cavity (RMS velocity spread: 6%, radial width: $\lambda/4$) and a realistic conductivity of the anticipated cavity material Glidcop, the designed cavity suggests stable output power of 920 kW with an interaction efficiency of 36% with the co-rotating operating mode $TE_{-43,15}$ (eigenvalue ~103) [3].

To increase the output power per tube, it is necessary to operate gyrotrons with even higher order modes, which permits a larger cavity radius and thus higher power handling capacity, until mode competition hampers stable operation. Knowledge of this eigenvalue limit allow us to select suitable modes for high output power with controlled mode competition for a particular frequency [4]. At eigenvalues around 105,125 and 145, the output power and efficiency limits have been also estimated with the help of parametric analysis of the cavity.

In this talk, the generic methods to find eigenvalue limits will be presented in detail. All these methods suggest an eigenvalue limit of 125 for 236 GHz gyrotrons with normal diode start-up, corresponding to the output power of 1.5 MW and the eigenvalue limit of 145 using triode start-up corresponding to the output power of 1.8 MW.

Acknowledgment
This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

References

[1] M. Schmid et al., 2015 *Fus. Eng. Des.*, **96–97**, 589-592. (DOI:10.1016/j.fusengdes.2015.03.003)
[2] M. Thumm *et al* 2015 *International Journal of Terahertz Science and Technology* **8** 85-128. (DOI: 10.11906 /TST.085-100.2015.09.09)
[3] P. C. Kalaria *et al* 2015 *IEEE International Vacuum Electronics Conference* (Beijing, China) (DOI: 10.1109/ IVEC.2015.7223769)
[4] P. Kalaria, 2016 *IEEE International Vacuum Electronics Conference* (Monterey, USA), P4.15.