Multistage Depressed Collector Design Studies for High Power Gyrotrons Based on the E×B Drift Concept

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Single-stage depressed collectors have been successfully used in gyrotrons. It is possible to increase the overall electrical efficiency to above 50 % with a collector efficiency of about 60 %. To further increase the overall tube efficiency, it is necessary to use a multistage depressed collector (MDC) system. The design of an MDC system for gyrotrons is not trivial due to the fact that the spent electron beam is confined by a relatively strong magnetic field in the collector region. Therefore, the electrostatic sorting used in TWT and klystron MDCs is not applicable to the spent electron beam in gyrotrons. The sorting of the spent beam electrons according to their initial kinetic energy is essential for an efficient collection to increase the collector efficiency and decrease the thermal loading on the collector wall. The separation of the spent beam electrons of a high power gyrotron based on the E×B drift concept was proposed in 2008 [1]. In that work, a design approach for a cylindrical coaxial collector was presented in the limiting case of an infinite number of stages.

In the present work, a variety of designs with a finite number of stages is numerically investigated with a full three-dimensional simulation tool. Collector designs with two, three and four stages are studied in relation to the influence of the depression voltages, the inner and outer radii of the coaxial collector structure, the distance between the stages, as well as, the intensity of the applied drift to the electrons. The influences of space charge, secondary electron emission and the power loading on the collector wall are investigated. Furthermore, the possibility of a decrease in size and an alternative design approach with a simplified coil structure are presented. A high collector efficiency is demonstrated for numerous designs of the E×B MDC. Maximal simulated collector efficiencies of 81.9 %, 83.2 % and 87.4 % are achieved for the cylindrical coaxial collectors with two, three and four stages, respectively. These collector efficiencies correspond to total gyrotron efficiencies of 67.4 %, 68.6 % and 72.9 %.

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