Ongoing Development of a Helical-Type Gyro-TWT for 263 GHz DNP-NMR at IHM

Max Vöhringer[1], Alexander Marek[2], Stefan Illy[1], Gerd Gantenbein[1], Manfred Thumm[1,3], Chuanren Wu[1] and John Jelonnek[1,3]
[1]IHM, [3]IHE, Karlsruhe Institute of Technology (KIT), Kaiserstr. 12, 76131 Karlsruhe, Germany
[2]Fraunhofer FHR, Fraunhoferstraße 20, 53343 Wachtberg, Germany

ABSTRACT

In the age of semiconductors and integrated circuits, vacuum tubes are filling important technical niches. In particular, gyro-devices are used to generate highest levels of output power of millimeter and sub-millimeter waves, that are not achievable otherwise. That allows for a wide variety of use cases for gyro-devices, e.g., electron cyclotron resonance heating of plasma fusion devices, radar, and spectroscopy. Especially the last two applications mentioned benefit from a special type of gyro-device, the gyro-traveling wave tube (TWT) with a helically corrugated interaction region (HCIR), a so-called helical gyro-TWT [1]. By utilizing the weakly relativistic electron cyclotron maser interaction principle [2], this device can amplify a broadband input signal. For that, however, it requires a high-quality axis-encircling large-orbit electron beam (LOB) with low velocity spreads and a small guiding center radius. Such a beam is generated in a so-called CUSP-type electron gun [3-6] by a non-adiabatic reversal of the magnetic field (cusp). In addition to the high-quality electron beam, a well-designed and manufactured HCIR is needed to facilitate ideal energy transfer from beam to sub-millimeter waves.
In this work, the ongoing development of a helical gyro-TWT for Dynamic Nuclear Polarization (DNP)-Nuclear Magnetic Resonance (NMR) spectroscopy at 263 GHz (400 MHz NMR) with an output power of up to 1 kW is presented. This includes an overview of the amplifier system and a closer investigation of the superconducting magnet, CUSP-type electron gun, as well as the HCIR.
The resulting CUSP-type electron gun, in combination with the superconducting magnet, are designed to produce high-quality LOBs at multiple frequencies, including 94 GHz and 140 GHz, in addition to the target frequency of 263 GHz [7]. The ensuing electron beam parameters are then used to design the appropriate HCIR for 263 GHz with an output power of up to 1 kW.

References

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