Design and construction of a frequency-replaceable ferroelectric cathode gyrotron for Ka-band

Eviatar Avraham, Roey Ben-Moshe, Moritz Pilossof, Moshe Einat

Dept. of Electrical and Electronic Engineering, Faculty of Engineering, Ariel University, ISRAEL

Abstract

A modular, mid power, Ka-band frequency (27-40 GHz) gyrotron is reported. The gyrotron is known as a dominant tube for the millimeter waves, but once fabricated its frequency changing is limited. In this research a gyrotron with a replaceable resonator was designed and built. By rather simple action of resonator replacement, the operating frequency of the gyrotron can be replaced. The use of a ferroelectric cathode supports a quick opening and closing of the tube for the resonator replacement in less than an hour. With the view of covering a wide range of frequencies, a wide range magnetic field pulsed copper solenoid was designed, supporting the gyrotron operation on either the fundamental or second harmonic of the electron cyclotron frequency. The gyrotron design is based on a ferroelectric electron gun designed and built to provide the appropriate radius beam, and is flexible for adapting the electron beam properties to a wide variety of resonators operating at the fundamental or at the second harmonic.

Design and experimental setup

The FE cathode enable fast replacement of the operating frequency! This gun operate at modest vacuum $10^{-3}$Torr. Replacement of cavities is done in an hour.

Figure 1. up- the shape of the magnetic field supporting Homogeneous area that cover the Ka-band.
Down- CST simulation of the electron beam trajectory

Figure 2. the cathode schematic, design and built.

Figure 3. experimental setup.

Frequency replaceable

Figure 4. CST- 27GHz dimensions and mode operation.
Figure 5. CST- 39GHz dimensions and mode operation.
Figure 6. 27GHz and 39GHz cavities and the replacement operation.

27GHz Experimental result and System stability in high PRF

Figure 7. Left- operation at accelerating beam voltage of 35kV and a beam current of ~1.7A, an output power of ~6kW was obtained at ~5us macro-pulse and ~200ns micro-pulse with ~20% duty-cycle. System stability has been tested and output power of ~500W/500ns pulse was repeated every five seconds for half an hour with high stability. Right- parameters result on TE11 mode dispersion graph demonstrate TWT-Gyro.

Figure 8. accumulation of ~500W/500ns pulses repeated every five seconds for half an hour with high stability.

Conclusion

In this experiment the gyrotron has been constructed and tested in the TE11 mode at 27GHz. With an accelerating beam voltage of 35kV and a beam current of ~1.7A, an output power of ~6kW was obtained at ~5us macro-pulse and ~200ns micro-pulse with ~20% duty-cycle. System stability has been tested and output power of ~500W/500ns pulse was repeated every five seconds for half an hour with high stability. In addition, a resonator for the gyrotron operation at 39GHz in TE01 mode has been designed to demonstrate the behavior for the entire Ka-band. The resonator for this frequency is now under fabrication.

Corresponding Author: einatm@ariel.ac.il