ABSTRACT

Title of Dissertation: A FIRST STUDY OF A HARMONIC DOUBLING GYRO-TWT

Wenjun Chen, Doctor of Philosophy, 2000

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A frequency doubling, two-stage Ka band gyro-TWT amplifier that is based on the concept of harmonic multiplication has been demonstrated for the first time in an experiment at the University of Maryland. The input waveguide operates at the fundamental cyclotron harmonic in Ku band while the output waveguide operates at the second cyclotron harmonic in Ka band. An output peak power of 126 kW, a 3 dB bandwidth of 3.2 %, a maximum gain of 27 dB and a highest efficiency of 12 %

were achieved when a 50 kV, 22 A beam was employed. The highest achieved output power is 180 kW when a 50 kV, 33 A beam was employed. The operating modes in the input and output waveguides were TE_{02} and TE_{03}, respectively. The achieved gain and bandwidth represent an advance in the state-of-the-art for a gyro-TWT with output at the second harmonic of the electron cyclotron frequency; moreover, the frequency doubling feature and operation in a high order symmetric mode are new features that have practical advantages.

The present dissertation emphasizes the contributions of Wenjun Chen who was part of the team investigating the harmonic multiplying gyro-TWT at the University of Maryland. His major contributions to the analysis, design and execution of the experiment are summarized in the following paragraphs.

It was found during the experiment that the attainable level of the output power of the frequency doubling gyro-TWT was limited because of insufficient power injected into the amplifier due in part to the reflection of the waves by the input coupler. Therefore, a new input coupling structure was proposed and a X-band prototype was fabricated and tested. The reflection measurement of the X-band input coupler prototype showed that 40 % bandwidth was achievable for this new coupler.

A magnetic system that is capable of producing a magnetic field up to 7 kG was designed for the successful operation of the harmonic doubling gyro-TWT. It consisted of two sets of gun coils and four sets of main magnetic coils. It was found that a magnetic field profile that is up-tapered in the input waveguide and down-

tapered in the output waveguide is favorable to the interaction of the harmonic doubling gyro-TWT.

An analytical theory and numerical simulation, which are capable of dealing with the effect of both traveling wave bunching and ballistic bunching of the electron beam, were developed to study frequency multiplying, two-stage gyro-TWT. The simulation code can also take into account the effects of magnetic tapering, waveguide radius tapering as well as velocity spread on the operation of the gyro-TWT.

A formalism, which followed the analytical framework, was developed to estimate the dependence of phase variation of the output signal on the operating parameters such as beam voltage, beam current and applied magnetic field. The simulation results are in agreement with the experiment.