Study on Oscillation Characteristics of G-band Gyrotron Traveling Wave Tubes with a Tapered Interaction Circuit

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***Abstract*— The oscillation characteristics of G-band gyrotron traveling wave tube (gyro-TWT) are analyzed and verified. The contours of oscillation threshold with the changes of the magnetic field, beam current and pitch ratio are plotted. It is found that a tapered circuit with small angle can effectively improve oscillation threshold.**

***Keywords*— G-band, gyro-TWT, interaction circuit, oscillation threshold**

I. INTRODUCTION

The gyro-TWT is a fast-wave device featuring high power, high frequency and broad bandwidth for advanced radar and communication applications in millimeter-wave and terahertz wave band. A major obstacle to the development of gyro-TWT has been its susceptibility to oscillations caused by the absolute instability [1]. This paper examines the oscillation characteristics of G-band gyro-TWT, a slowly tapered circuit that can improve oscillation threshold is demonstrated.

II. RESULTS

A. Theoretical Oscillation Threshold

According to the linear theory of gyro-TWTs [2], the oscillation threshold of both the operating mode and backward-wave modes are calculated. Main parameters of the interaction circuit are the beam voltage of 60 kV, the waveguide radius of 0.9 mm and the interaction circuit length of 10 mm, respectively.

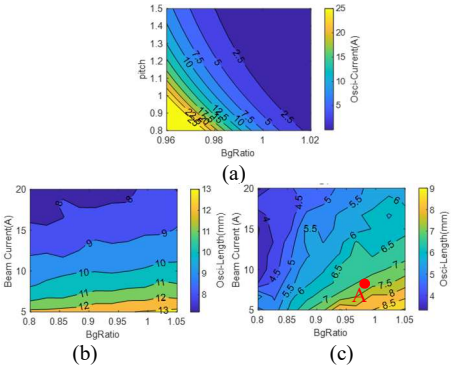

Fig.1. (a) Oscillation current contour of TE_{01} mode with magnetic field and velocity pitch ratio. (b) Oscillation length contour of TE_{11} mode with magnetic field and beam current. (c) Oscillation length contour of TE_{21} mode with magnetic field and beam current.

B. PIC Simulation of Uniform Circuits

In order to verify the theoretical results, point A where the B_gRatio is 0.97 and the beam current is 8 A in the Fig. 1(c) is chosen for simulation verification. According to Fig. 2, the cut-off frequency of TE_{01} mode is 203.1 GHz and the backward intersection frequencies with TE_{11} and TE_{21} mode are 154.6 GHz and 172.2 GHz respectively. As in Fig. 1, the oscillation current of the TE_{01} mode is 9.406 A, the oscillation lengths of the TE_{11} and TE_{21} mode are 10.88 mm and 7.06 mm respectively. In this case, only the TE_{21} mode will oscillate by predicting.

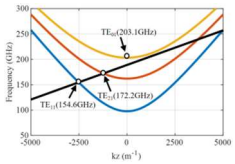

Fig.2 Dispersion diagram of G-band gyro-TWT.

As shown in Fig. 3, clear signal of TE_{21} mode with an oscillation frequency of 175.66 GHz at the output port is observed. No oscillation of the TE_{01} and TE_{11} mode is observed. The theoretical prediction and PIC simulation results show a good agreement.

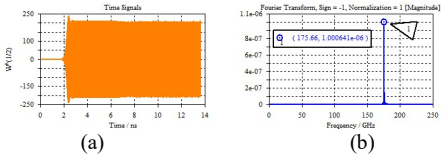

Fig.3. TE_{21} mode (a) input port signal. (b) input port spectrum.

C. PIC Simulation of Tapered Circuits

To decrease the effective interaction length within the whole beam-wave interaction process, a tapered circuit is employed to change the intersection frequency with different circuit positions, in this way the oscillation threshold can get improved. A tapered circuit with small angle is introduced to alleviate the oscillation for design verification with above simulation parameters. As shown in Fig. 4, the oscillation of the TE_{21} mode is suppressed. In addition, no clear oscillation signal is observed for the TE_{01} and TE_{11} mode. It can be seen that a tapered circuit with small angle is beneficial to improve the oscillation threshold.

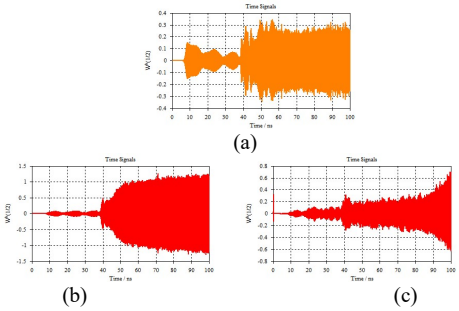

Fig.4. (b) TE_{11} mode input port signal. (c) TE_{01} mode output port signal.

. (a) TE_{11} mode input port signal.

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