# Design of Coaxial Resonator in TE$_{28, 8}$ Mode Generator

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**Abstract:** *In this paper, a three-stage coaxial cavity mode generator for the cold measurement of gyrotron is studied in detail, which uses the mode selection characteristics of the coaxial cavity to convert the input 140 GHz Gaussian mode into the high purity TE$_{28,8}$ mode. Based on the first-order transmission line equation and its boundary conditions, we describe the design the structural parameters of the coaxial cavity and verify it by simulation. The TE$_{28,8}$ mode generator consists of a Gaussian horn, a convex lens, a quasi-parabolic cylindrical lens, and a coaxial cavity. After numerical programming, the diffraction quality factor of the resonator is 872, and the mode purity is 93.2%.*

**Keywords:** TE$_{28,8}$ mode generator, coaxial cavity, mode purity

## Introduction

The gyrotron is one of microwave vacuum tubes, which are devices for generating or amplifying microwaves [1,2]. The high-order mode of direct output from the gyrotron is not suitable for transmission. It must be converted to TEM$_{00}$ or HE$_{11}$ mode utilizing the mode converter [3]. Mode converter must be tested and ensured to function properly before being installed in the gyrotron. Generally, the working mode generated by the mode exciter is used as the input of the mode converter, and then the performance of the mode converter is measured.

There are several different methods to produce high-order rotating gyrotron modes. However, as the frequency increases and the order of the mode increases, the quasi-optical mode excitation method becomes the mainstream method. The 140GHz TE$_{28,8}$ source described in this paper was designed and constructed. The quasi-optical generator method was proposed by N L Aleksandrov in 1992. The design of this source uses the method: quasi-optical generator of a translucent-wall cylindrical cavity [4]. If modes exist with similar spatial structure to the desired mode and with a resonant frequency near that of the desired mode, these nearby modes can be excited.

This paper analyzes the field in the resonant cavity. In order to solve the mode competition problem, a coaxial cavity suppression method is proposed. The coaxial cavity achieves separation of similar modes, improves the purity of the mode, and reduces processing difficulties. Design of coaxial cavity structure is the crucial point of the mode actuator. The higher-order operating mode requires a higher cavity selection [5].

## Design of Coaxial Cavity

It can be seen from the Fig.1 that this structure is a classic three-section coaxial cavity.This cavity consists of three segments. The first segment is cut-off segment with the length of L1 to cut off the working mode and form a reflection [6]. The cut-off section can improve the starting current and reduce the diffraction quality factor of the miscellaneous mode, achieving the purpose of suppressing the low-order mode.The second segment is resonant segment with length of L2 to store energy and couple it out of the required mode. This section is very important, and its structure will directly affect the operating frequency and diffraction quality factor of the resonator. The third segment is called the radiant segment with the length of L3 in order to suppress the higher order mode than the working mode and make the working mode reach the full traveling wave output.

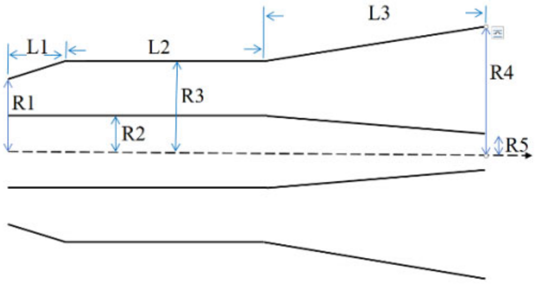

**Fig.1** Schematic diagram of a three-stage coaxial resonator structure

Fig.2 (a) shows the distribution of the normalized electric field amplitude along the z-axis of the TE$_{28,8}$ mode. Fig.2 (b) is the phase distribution of the TE$_{28,8}$ mode along the z-axis. As can be seen from Fig.8, a traveling wave is formed at the output port of the cavity. Moreover, the interaction point is in the second section of the cavity, indicating that the cavity structure satisfies the requirements.

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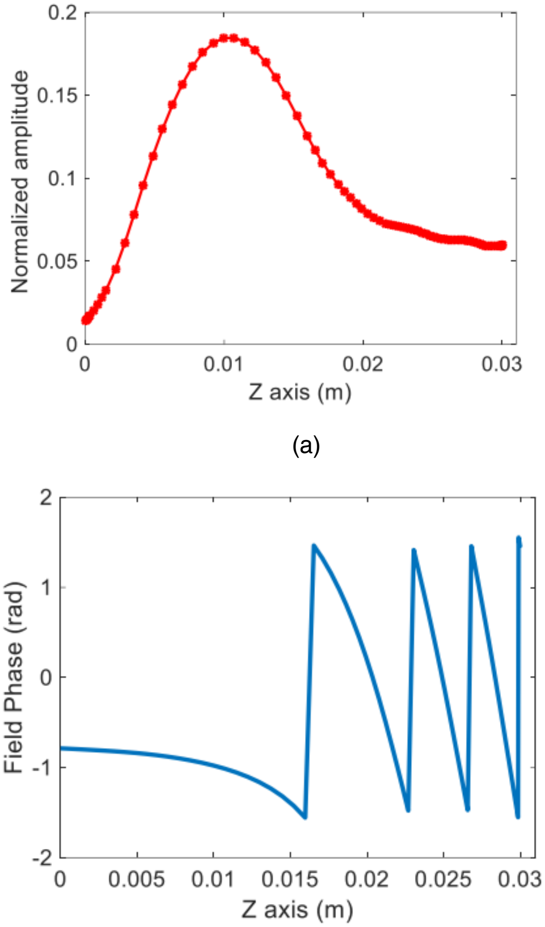


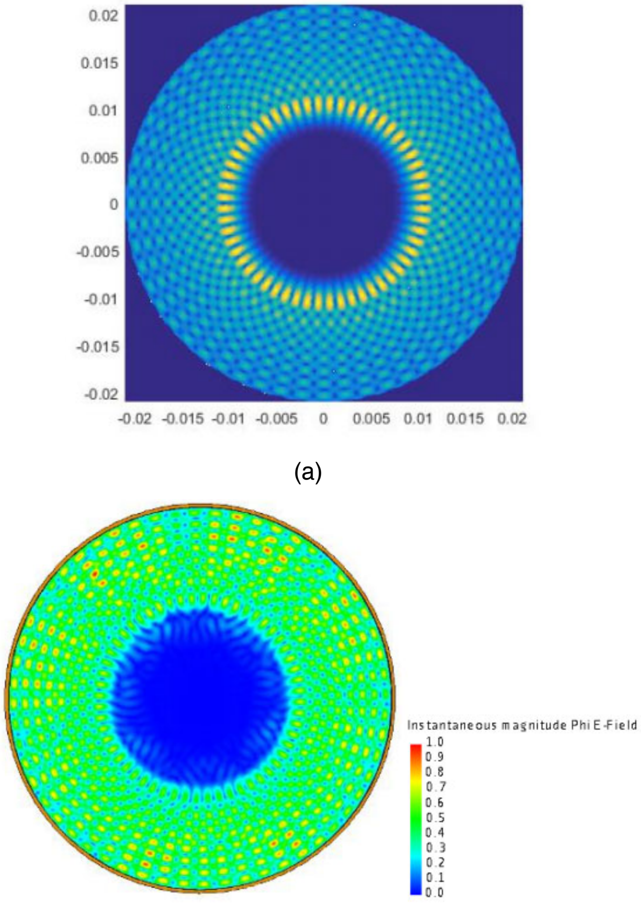
(a)

(b)

**Fig.2** (a) the distribution of the normalized electric field amplitude along the z-axis of the $TE_{28,8}$ mode (b) the phase distribution of the $TE_{28,8}$ mode along the z-axis.

## Simulation Results

The operating frequency of the cavity and the purity of the output mode can be determined by the electromagnetic simulation software FEKO. The optimal output of $TE_{28,8}$ mode is obtained when the operating frequency is 140 GHz. The calculated numerical field distribution and Electromagnetic simulation results are shown in Fig.3(a)(b). The FEKO electromagnetic simulation results are highly consistent with the numerical results. the MATLAB numerical simulation results. The purity of the $TE_{28,8}$ mode was 93.2% by numerical calculation.The final optimization results in operating frequency of 140 GHz with a quality factor of 872.



(a)

(b)

**Fig.3** (a) Theoretical electromagnetic field (b) Simulation result of electric field amplitude

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