Measurement of an upgraded input coupling system for W-band gyro-TWA

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Abstract—**A gyrotron traveling-wave amplifier (gyro-TWA) operating at W-band has been upgraded and experimentally measured. In this paper, the design and measurement of the upgraded input coupling system for the gyro-TWA is presented. In the measurement, the transmission coefficient of the coupler is at an optimal level of about -1 dB.**

Keywords—input coupler; gyrotron traveling-wave amplifier; microwave window;

I. INTRODUCTION

The gyro-devices have the capability to generate high power radiation in the millimeter and sub-millimeter range. They can be used in applications such as high resolution radar, plasma diagnostics and deep space communication. Following the success of a gyro-BWO operating over 88–102.5 GHz [1], a W-band gyro-TWA has been experimentally studied at Strathclyde University. The gyro-TWA was designed to be driven by a 40 kV, 1.5 A annular shaped large-orbit electron beam. The simulated output power is about 5 kW.

A schematic drawing of the gyro-TWA is shown in Fig. 1. The whole system includes magnetic coils (1 and 6), a cusp electron gun (2), an input coupling system (3 and 4), an elliptical converter (5), an helically corrugated interaction region (HCIR) (7) and an output system (8) [2-7]. The input coupling system plays an important role in the operation of the gyro-TWA. The lower power microwave seed signal is coupled into the vacuum electronic device through an in-band pillbox window (4) and then the waveguide bends. Then the linearly polarized wave is converted into a circularly polarization wave. The eigenwave in the HCIR is used to resonantly interact with the axis encircling electron beam to amplify the input microwave signal. The amplified microwave radiation is coupled out by the output system, which is composed by a smoothly profiled horn and a multiple-layer microwave window.

The input coupler is required to have good a transmission coefficient and sufficient bandwidth for the operation of the gyro-TWA [7, 8]. In this paper, the design and measurement of the upgraded input coupling system is presented.

II. THE INPUT COUPLER

The input coupling system includes a microwave window, 90 degree waveguide bends, a side-wall coupler and a broadband reflector [9]. A pillbox window was used because it has relatively broad bandwidth, and it is easy to connect with the standard WR-10 waveguide. The dimensions of the pillbox window can be quickly optimized by using the mode-matching method.

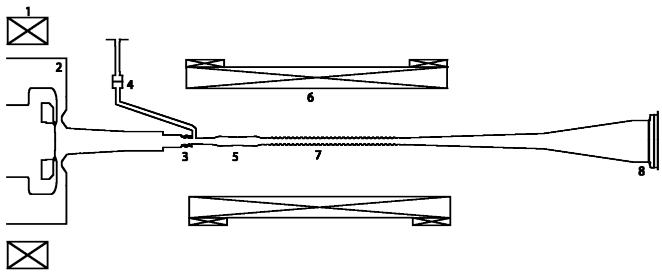

Fig. 1. The schematic of the gyro-TWA. (1, 6) solenoids, (2) cusp electron gun, (3) input coupler, (4) pillbox window, (5) polarizer, (7) HCIR, (8) horn and multiple-layer window.

The T-junction was used to convert the TE_{10} mode in rectangular waveguide into the TE_{11} mode in circular waveguide. However, as shown in Fig. 2(a), the port 1 and 3 are symmetric, the maximum transmission coefficient from port 2 to 3 is -3 dB. To enhance the coupling coefficient from port 2 to port 3, a broadband reflector was applied to port 1. Normally, a cutoff waveguide is more easy to achieve good reflection over a broad bandwidth. However, it has a small aperture, which increases the difficulty of electron beam transportation within the beam tunnel. A Bragg reflector with bigger aperture was therefore designed. To reduce the machining difficulty and allow fast calculation by using the mode-matching method, the Bragg reflector was made from of a number of short circular waveguides with the same length but different aperture sizes. The period of the corrugations and the radius of each section were optimized for the reflection coefficient and the bandwidth, as shown in Fig. 2(b). The performance of the T-junction with the Bragg reflector was measured by a W-band vector network analyzer (VNA) and an average -1.0 dB transmission coefficient was measured as shown in Fig. 2(c).

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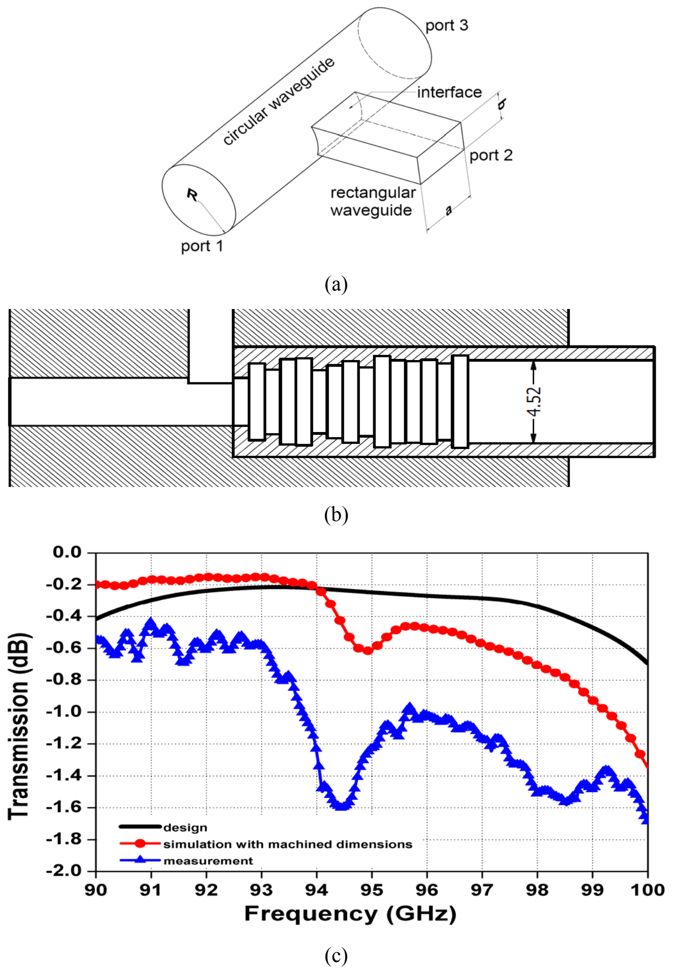

Fig. 2. The structure of the side-wall coupler. (a) T-junction, (b) T-junction with broadband reflector, and (c) the measured transmission coefficient.

III. The Input Coupling System

The T-junction was brazed together with a waveguide bend and a beam tube, which was used to house the elliptical converter, HCIR and waveguide tapers. The broadband reflector and the pillbox window were then assembled to form the complete input system.

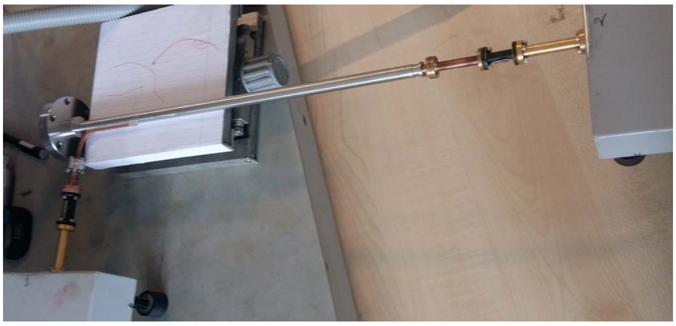

Fig. 3. Measurement setup of the whole system includes input coupling system.

Fig. 3 shows the photo of the beam tube. Its microwave properties were then measured using a W-band Vector Network Analyser. To achieve the optimal results, the position of the broadband reflector can be slightly adjusted. Fig. 4 shows the final measured results. The overall transmission loss of the whole setup was about -4.5 to -6 dB, which includes a -0.6 dB loss from the pillbox window; -0.4 dB loss from the rectangular waveguide bends; -1.5 dB loss from 2 polarizers; -1.0 dB from the input coupler; -1.5 dB loss from the HCIR; -0.6 dB loss from a long smooth circular waveguide after the HCIR, and a -0.3 dB loss from a rectangular-to-circular convertor.

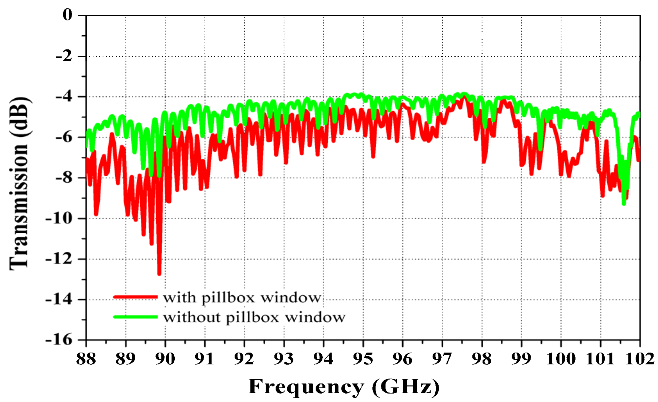

Fig. 4. The measured performance of the whole system including input coupling system for the W-band gyro-TWA.

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