Input coupling systems for mm-wave amplifiers

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***Abstract*—Input couplers for mm-wave gyrotron traveling wave amplifiers (gyro-TWAs) were designed. A W-band input coupler composed of a T-junction and a broadband reflector was constructed and measured in W-band. It achieved a transmission coefficient of -2.2 dB including the pillbox window and a waveguide bend. A multiple-hole coupler was designed and simulated at 372 GHz. Without considering the Ohmic loss, in simulations the 372GHz coupler achieved a transmission coefficient of -0.5 dB.**

Keywords—gyrotron traveling wave amplifier, Input coupler, side-wall coupler, multiple-hole coupler

I. Introduction

Gyrotron travelling wave amplifiers (gyro-TWAs) [1-3] are coherent microwave radiation sources based on the cyclotron resonance mater instability. They have promising applications in telecommunication, RADAR, plasma diagnostics, electron paramagnetic resonance (EPR) and so on due to its high power and broadband capabilities. Gyro-TWAs operating at mm-wavelengths are under development at the University of Strathclyde. A gyro-TWA operating at 90 to 100 GHz was predicted to achieve about 40 dB gain, when it was driven by a 40 keV, 1.5 A axial-encircling large-orbit electron beam, and with a helically corrugated interaction region [4, 5]. Another gyro-TWA operating at the higher centre frequency of 372 GHz, was modelled using CST Particle Studio. In simulations ~500 W output power and a bandwidth of 5% were predicted.

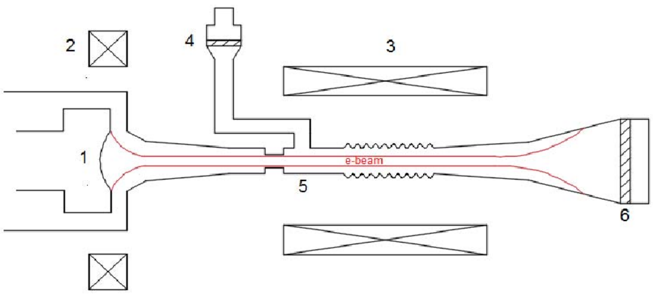
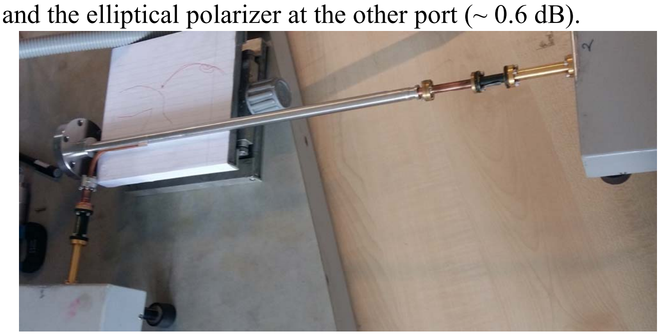


Fig. 1. The schematic of a gyro-TWA. (1) electron gun, (2, 3) coil system, (4) pillbow window, (5) input coupler, (6) output window.

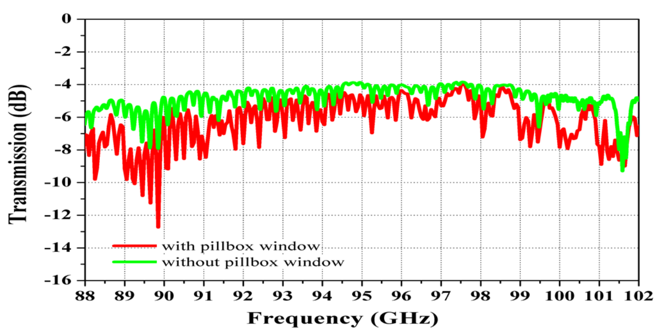
A schematic drawing of the gyro-TWA is shown in Fig. 1. It includes the electron gun (1), solenoid systems (2, 3), input coupling system (4, 5) and the output launcher (6) [6-8]. The input coupling system enables the lower power input microwave signal to be coupled into the interaction region. It plays an important role in the whole system because it not only separates the atmosphere from the ultra-high vacuum inside the gyro-TWA, but it also ensures efficient mode coupling between the input mode from the TE_{10} mode in rectangular waveguide to the TE_{11} mode in the circular waveguide.

The whole input coupling system will include a microwave window, waveguide bends, and a microwave coupler. Each component can be designed and optimized separately and then brazed together.

An input coupler for the W-band gyro-TWA has been designed and measured [9]. It contains a pillbox-type microwave window and a T-junction side-wall coupler. To enhance the transmission coefficient, a broadband reflector was used which also helps stop the input microwave signal being transported to the electron gun region. The input coupler was measured using an Anritsu ME7808B vector network analyser (VNA) and the setup is shown in Fig. 2. The side-wall coupler achieved a transmission coefficient of -1.0 dB and the transmission coefficient of the whole input coupling system was about -2.2 dB, which also includes the loss from the pillbox window and the waveguide bends, but does not include the loss of the helically corrugated waveguide (~ 2 dB) and the elliptical polarizer at the other port (~ 0.6 dB).



(a)



(b)

Fig. 2. (a) The measurement setup of the input coupler system at W-and and (b) the meaurement results.

At higher frequency, the dimensions of the microwave components becomes smaller. The machining tolerance and loss are two major challenges that need to be overcome. To avoid the machining difficulty of the broadband reflector, a multiple-hole input coupler was designed [10, 11]. The multiple-hole coupler is a 4-port waveguide component. By carefully choosing the dimensions, it is able to achieve high coupling between the desired modes. The multiple-hole coupler also has the advantage of a high directivity which will help to stop the microwave signal traveling back to the electron gun region.

By increasing the number of the holes, the performance, such as the bandwidth and the directivity, can be improved, however, the loss will also increase. The final designed multiple-coupler at a center frequency of 372GHz contained 12 identical holes, as shown in Fig. 3. In the simulation, it was able to achieve a transmission coefficient of -0.5 dB without considering the Ohmic loss, as show in Fig. 4.

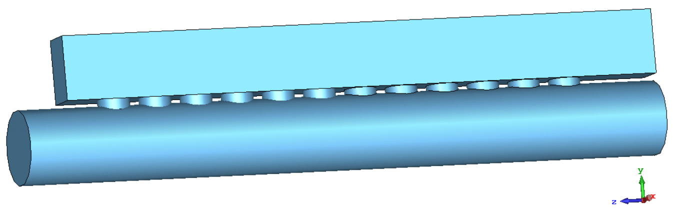


Fig. 3. The schematic of the multiple hole coupler.

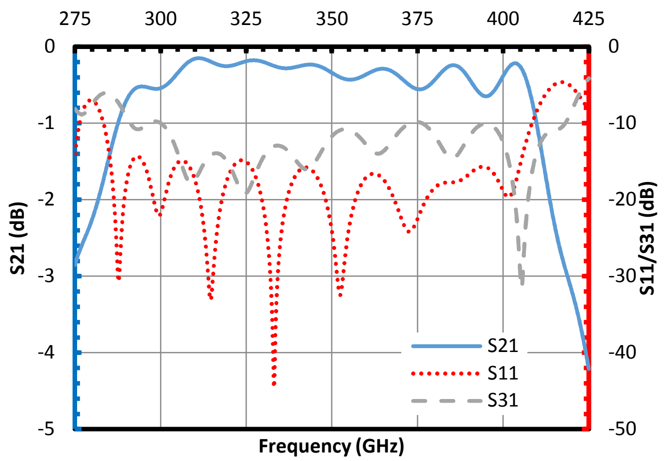


Fig. 4. the transmission and reflection of the high frequency multiple hole coupler with 12 holes.

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