# Design for w-band folded waveguide traveling-wave tube

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**Abstract:** This paper designs a folded waveguide traveling wave tube which works in 97 *GHz*-99 *GHz*. The interaction efficiency of the whole working band is about 3%, and the output power is up to 57 *w*, therefore the whole tube gain is more than 37 *dB*. The high-frequency characteristics of the slow wave structure and the amplification performance of the TWT have been investigated.

**Keywords:** W-band, Folded waveguide, Traveling wave tube.

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## 1. Introduction

The folded waveguide (FWG) is a promising type of slow-wave structure (SWS) for millimeter-wave and terahertz-wave devices. This new type of slow-wave structure has been made of metal structure, so it is good at heat dissipation and with high coupling impedance. Besides,it is also simple to process. Previously, an FWG traveling-wave tube (TWT) operating at 43.5-45.5 *GHz* with more than 190-*W* peak output power at midband was made by our laboratory [8]. Recently, most of the FWG TWT research has concentrated on W-band millimeter-wave and terahertz-wave devices [6, 7]. This paper has designed a medium-power folded waveguide TWT which works in W-band, and its output power is less than 100 *w*. In our design, we have made an analysis of the nonlinear large signal theory, and completed a one-dimensional nonlinear large signal simulation with MATLAB reference for the further optimization. In order to achieve better results, we have designed a suitable new input and output structure and the attenuator. By using HFSS for optimization, their voltage standing wave ratio can be less than about 1.2. Finally, we have simulated a group of interaction parameters with TAU which meets the design requirements.

## 2. High-frequency Characteristics

Figure 1 shows the folded waveguide model. The equivalent circuit method has been used to optimize the electrical parameters of the slow wave structure, including propagation constant, on-axis impedance and its physical dimensions. The optimized results are shown in Figure 1. As can be seen, when the frequency is varied, the wave velocity changes slowly, which will result in a very wide operating bandwidth. The on-axis impedance of this structure is bigger than 1.8 *Ω* at the W band from about 97 *GHz* to 99 *GHz*, which means much stronger beam-wave interaction.

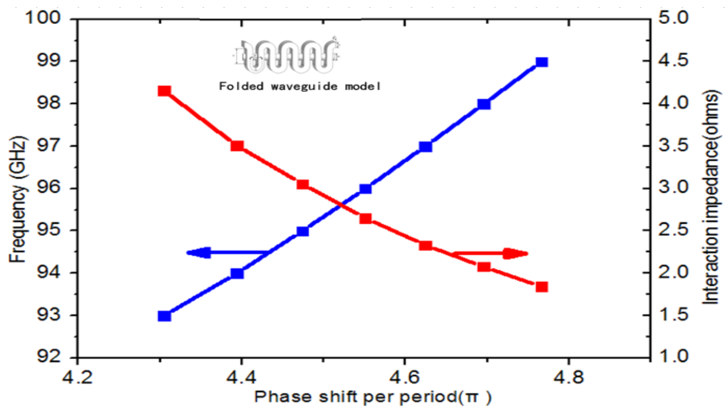


Fig. 1 Dispersion relation and interaction impedance of folded waveguide

## 3. Design of input and output structure and attenuator

A hyperbolic arc gradient structure has been adopted for input-output structure after the reference of researchers of the electric vacuum laboratory at UESTC. The reflection coefficient is very small from the results. An attenuator used E surface wedge gradient structure meets the design requirements after the help of the above researchers. The structure material is carburizing beryllium oxide. The optimized results are shown in Figure 2 and 3.

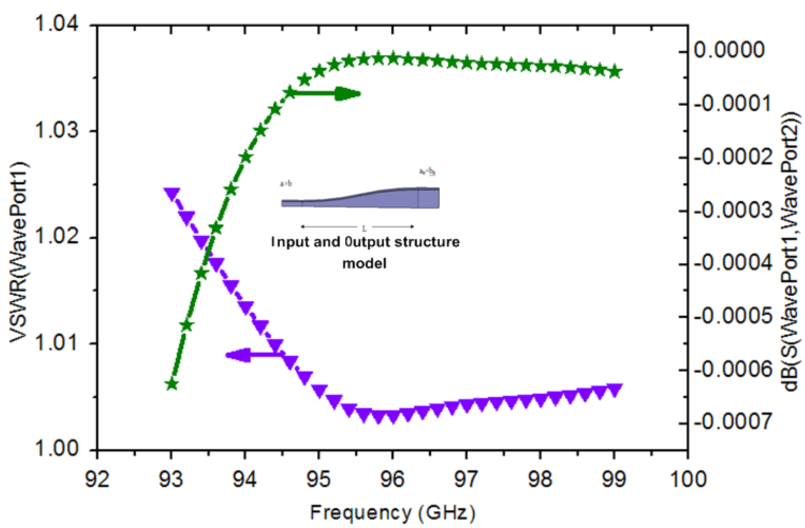


Fig. 2 Simulated VSWR and S-parameter of input and output structure.

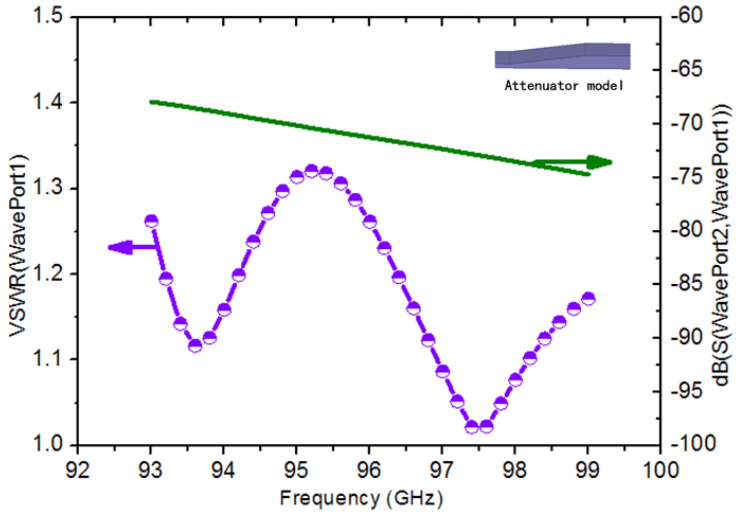


Fig. 3 Simulated VSWR and S-parameter of attenuator.

## 4. Beam-wave interaction simulation

In this section, the TAU is utilized to predict the output power of the folded waveguide traveling wave tube. The operating voltage is set at 19.0 *kV* and the beam current is set at 100 *mA*, respectively. The optimized results are shown in Figure 4. It is shown that the peak power is up to 57 *W* in the frequency ranging from 97 *GHz* to 99 *GHz*. The power gain of the whole working band is more than 37 *dB*.

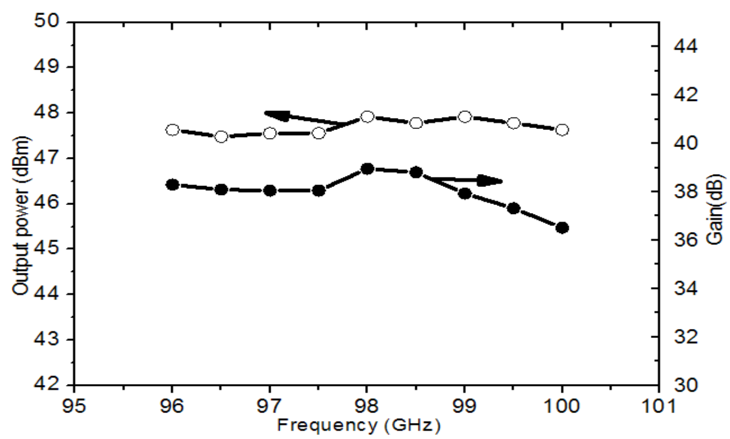


Fig. 4 Simulated output power and gain of folded waveguide TWT.

In our design, we have assembled one TWT working at the W-band, which is shown in Fig.5. The complete testing of the TWT will be developed during the next phase of this design.

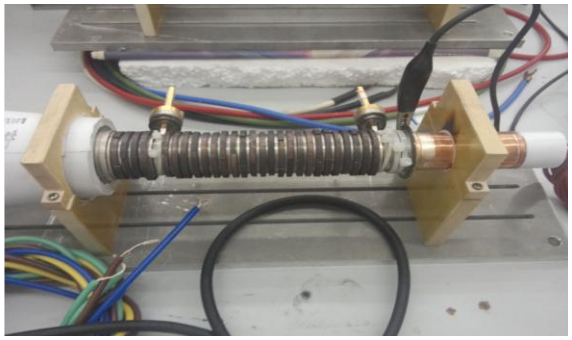

Fig. 5 W-Band folded waveguide TWT under testing.

The future work will be concentrated on the improvement of the output power and efficiency of folded waveguide TWT by optimizing each structure dimension parameter and utilizing new design technology.

## 5. Conclusion

A folded waveguide traveling wave tube was designed in this paper. This amplifier was predicted to have output power of 57 *W* and interaction efficiency of 3%, which can be used as a high efficiency, high-power short millimeter or Terahertz radiation source.


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