On the new prospects of high power wideband TWT creation

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Abstract. A new design of a slow - wave structure of a "crossed staircase" type for a powerful broadband multi-beam X-band TWT has been considered. The use of dense packing of beams and diaphragms with bushings allows to increase the interaction impedance to 4-7 Ohm and the dispersion correction makes it possible to expand the band up to 18% using a special form of coupling slots. The calculation of electronics demonstrates a possibility of obtaining the power of 24 kW, gain of 17 dB and efficiency of 28% in the TWT with such a slow-wave structure. The design of the permanent magnet system with an interpole gap of 119 mm was developed which provides 100% transportation of the electron beam to the collector.

1 Introduction

The operating frequency band of a radar is a valuable resource that determines the capabilities of the station and therefore the expansion of the band is one of the main tasks in the development of radars. Klystrons and coupled-cavity TWTs usually provide a frequency band of no more than 5-6% [1-4]. We are considering a possibility of creating a TWT that covers 16% of the operating band with the output power of about 30 kW.

The most important node of the broadband TWT is a slow-wave structure (SWS). It is known that a "helix" SWS and a "looping waveguide" allow to provide a wide band, however, the first system has limitations in heat dissipation (and therefore, in output power), and the second one has a low interaction impedance in the operating band. Thus, broadband SWSs with high interaction impedance are in demand.

2 The design of TWT

For a higher power TWT with an amplification band of at least 16% a "crossed staircase" type of SWS design is proposed, which is a waveguide periodically blocked by diaphragms with coupling slots of a certain shape with fourteen transit channels (fig.1) [5].

To increase the interaction impedance the transit channels are packed as tightly as possible, which minimizes the working gap area. To reduce the steepness of the dispersion curve, additional protrusions and inductive elements were introduced into the design. (fig.2).

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The interaction of the electron beam is carried out on a spatial harmonic of mode 2 (fig.2). The operating voltage of the beam is 22 kV.

Figure 3 shows a graph of the interaction impedance. The average value of the interaction impedance in all channels was (4.8-7.5) Ohm. Such a high coupling resistance at the highest type is due to the fact that bushings were introduced into the SWS design. Using the second mode allowed to increase the period and make the diaphragms massive enough for good heat removal.

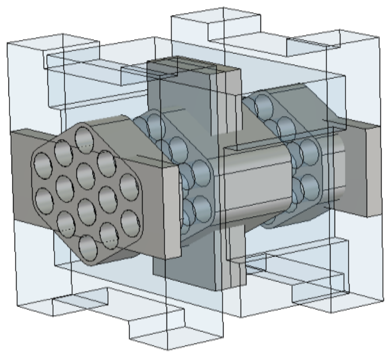

Fig. 1. A model of modernized SWS period.

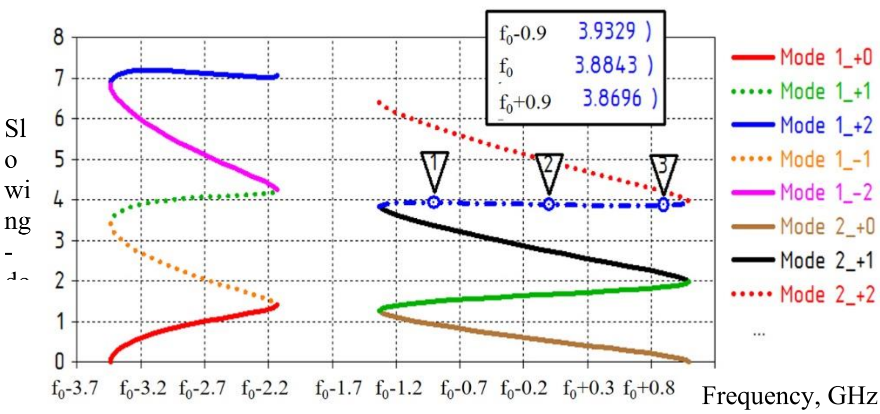

Fig. 2. Slowing-down factor versus frequency.

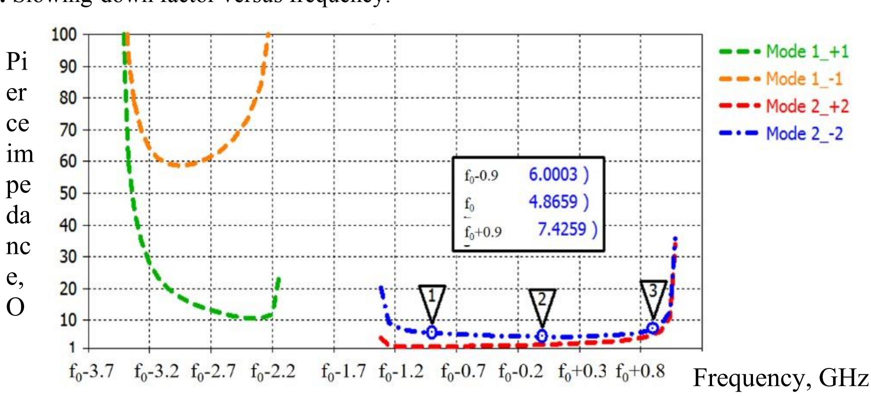

Fig. 3. Frequency response of interaction impedance.

The electron-optical system has the following parameters: total current 4.2 A, supply voltage 22 kV, filling at the input to SWS – 0.3. The electron flows focusing in channels with a radius of 0.75 mm is conducted by a constant magnetic field with an amplitude of 0.17 T, (fig. 4) and the magnetic gap of 119 mm. Figure 5 shows the design of a magnetic system weighing 7.4 kg for a multi-beam TWT.

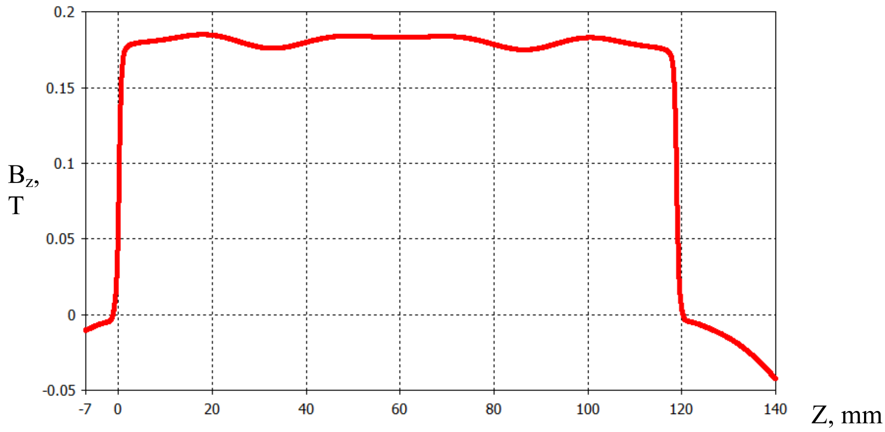

Fig. 4. The distribution of magnetic field on the MFS gap axis in the transit channels.

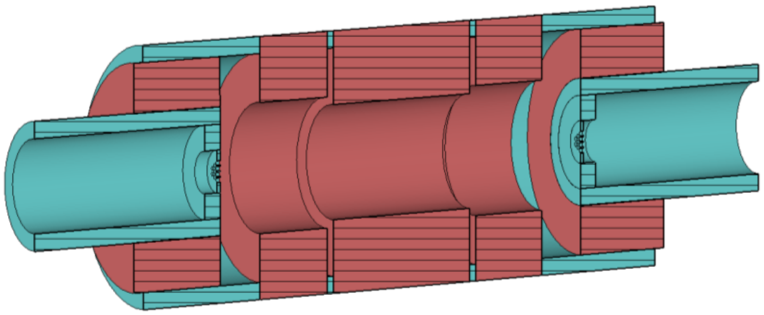

Fig. 5. The design of magnetic system in permanent magnets.

To achieve uniform distribution of the longitudinal component of magnetic field in the working gap, three longitudinally magnetized ring magnets providing pulsations not more than 5.4 % are introduced into the structure. This is enough so that the transverse components of magnetic field do not have a strong effect when transporting the electron beam in peripheral channels.

The paper considers a "transparent" TWT without an absorber. The interaction of the beam with the microwave field of the traveling wave was calculated using a two-dimensional model in a single-beam approximation. The particle trajectories of the beam in the saturation mode are shown in Figure 6.

3 Conclusion

The investigated SWS possesses high electrodynamic characteristics, mechanical strength and heat dissipation ability and ensures stable TWT operation in 18% band. The design of a focusing magnetic system that creates a magnetic field of 0.17 T in a working gap of 119 mm and has a weight of ~ 7.4 kg was developed and investigated.

The work continues on the design of microwave energy input/output in a wide frequency band, a collector with a single-stage recuperation and a device cooling system.

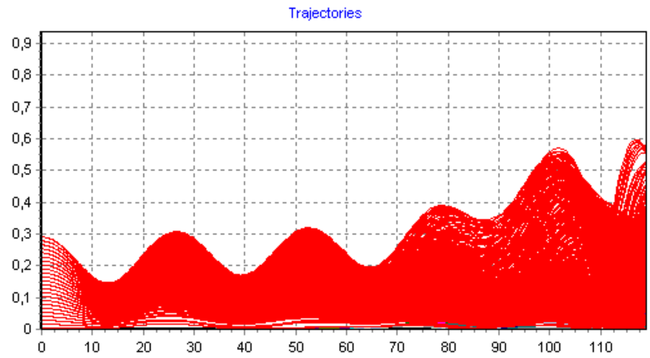

Fig. 6. Electron beam trajectories in the large-signal mode in a single-beam approximation.

It can be seen from the calculation that the electron beam passes without total current fall. The TWT output parameters were calculated in a single-beam approximation, and the total tube power was 24 kW, a gain -17 dB and an efficiency – 28 %.

References

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