Design Method of Focusing Magnetic Field for Restraining Dynamic Defocusing of High Efficiency TWT

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Abstract: *In order to suppress the dynamic defocusing problem of the electron beam that often occurs in high-efficiency space TWT, this paper provides an effective focusing magnetic field design method and takes a traveling wave tube of a certain band as an example to introduce and explain. Under the premise of not affecting other working indexes, the focusing magnetic field designed by this method effectively suppresses its dynamic defocusing problem.*

Keywords: dynamic defocusing, TWT, focusing magnetic field

INTRUDUCTION

Dynamic defocusing is an important factor which affect the electronic efficiency of TWT. Under the disturbance of the high-frequency field, the radial force on the electrons increases, so the clustering density becomes different, which make the space charge forces on the electrons also become different, and it is easy to generate an interception current. In this paper, a design method of focusing magnetic field which can effectively restrain the dynamic defocusing is proposed, and an example of a certain band TWT is given.

DESIGN AND SIMULATION

First of all, we set the peak value of the magnetic field in the whole helix range in the range of 1.5-2.0 times Brillouin magnetic field, as shown in Figure 1 below. The peak value of the focusing magnetic field presents a uniform distribution firstly, then presents an increasing trend.

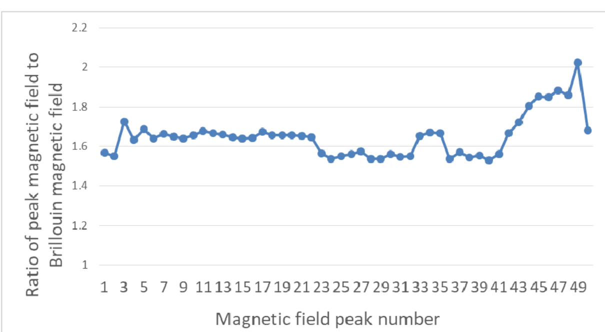

Fig. 1. Magnetic field peak setting distribution

In the vicinity of the input window and the front section of the helix, the peak value is about 1.5-1.6 times of Brillouin magnetic field. In order to ensure that there is no intercepted current in the helix, the peak value of the magnetic field near the output window needs to increase, which is about 1.7-2.0 times of Brillouin magnetic field. From the results at this time, it can be seen that there has no intercepted current in the helix, but in the drift region, dynamic defocus is difficult to control, resulting in a large amount of intercepted current.

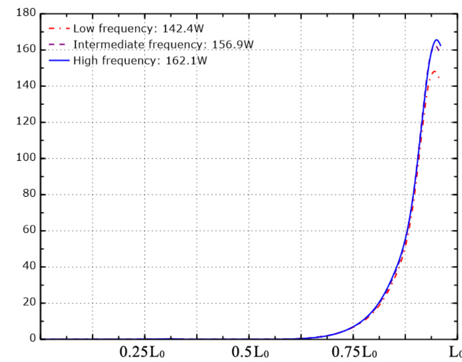

Fig. 2. Output power of initial design

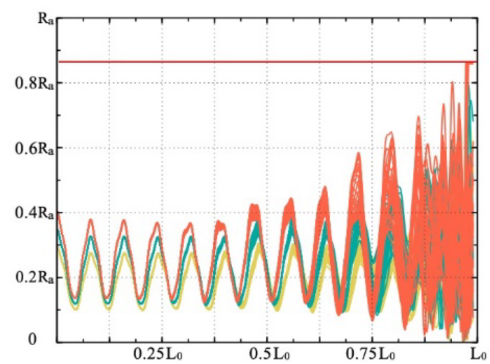

Fig. 3. IF particle trajectory of initial design

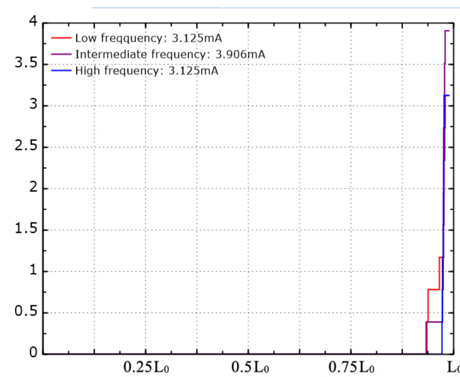

Fig. 4. Intercepted current of initial design

Secondly, on the basis of the initial design, combining the curve shown in Figure 2 and the magnetic field shown in Figure 1, we optimize it as follows: The peak value of the magnetic field distributed in the first half of the helix decreases by 10% - 12% of the Brillouin magnetic field; the magnetic field peak value of the middle part of the helix is kept unchanged, and the magnetic field of the second half in which the output power curve starts to rise obviously decreases with an exponential distribution $y = 0.0725e^{0.0785x}$, as shown in Figure 6. Among them, y is the ratio of the decline range to the Brillouin magnetic field, and x is the serial number of the peak value of the second half of the magnetic field. The smallest decrease is no less than 5%, and the largest decrease is no more than 50%.After optimization, the output power increased and the intercept current is almost zero. Even in the drift area between helix and collector, the electron beam still keeps a good beam type, and the intercept current is greatly reduced.

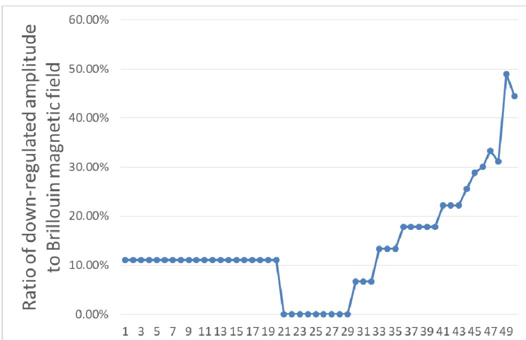

Fig. 5. Magnetic field peak down amplitude setting

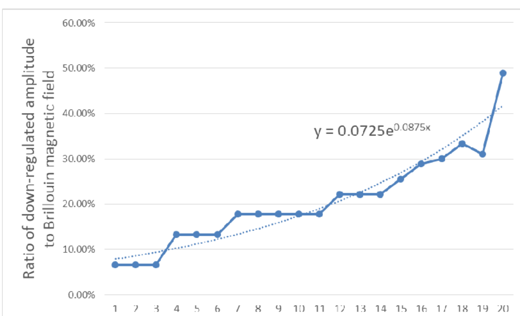

Fig. 6. The decline range distribution and fitting exponential curve of the 20 magnetic steels in front of the output window

RESULT

Aiming at the dynamic defocusing problem occurs in high efficiency Space TWT, this paper presents a design method of focusing magnetic field which can effectively restrain it. As an example, the TWT which is given also has been made into an actual tube, which verifies the feasibility of the method proposed in this paper.

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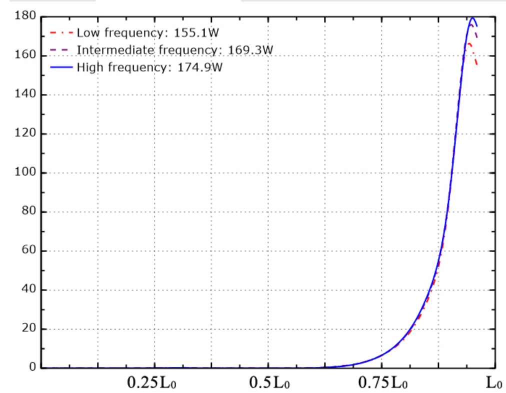

Fig. 7. Optimized output power

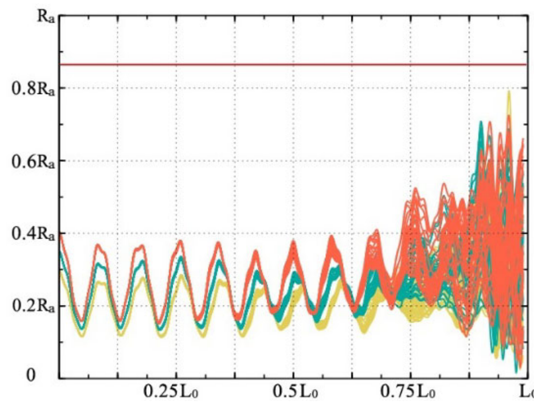

Fig. 8. Optimized IF particle trajectory

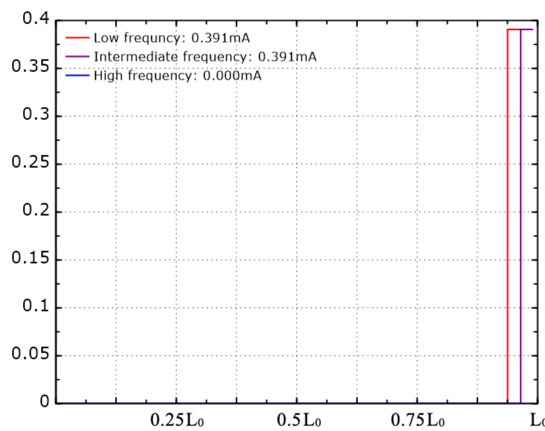

Fig. 9. Optimized intercept current

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