Simulation of heat conduction in the helicon isolator

Yory V. Vountesmery

1 National Technical University of Ukraine “Kiev Polytechnic Institute”, e-mail: youry@vountesmery.org.ua

Abstract – In this paper there are considered a stationary regime of heat transfer inside the structure of helicon isolator. A proposed one-dimensional model allows to evaluate the temperature distribution along the helicon isolator depending on the magnitude of power dissipation.

Keywords – helicon isolator, power dissipation, heat conduction.

I. INTRODUCTION

Helicon isolators are nonreciprocal passive microwave devices based on the effects of dimensional resonance of circularly polarized helicon waves in the magnetized semiconductor [1]. Helicon isolator is a decoupling device, so its essential characteristic is the maximum dissipation power. Dissipation power is limited mainly due to the temperature dependence of the helicon resonator parameters [2]. The aim of this work is to simulate the temperature in the helicon isolator dependence on the power dissipation, the estimation of maximum permissible power dissipation and to find ways to improve it.

II. MAIN PART

Construction of the helicon isolator is shown in fig.1. Helicon resonator is the parallel plate of semiconductor (mostly it n-InSb), inductors are wound with the copper varnished wire. Emptiness is filled with winding heat conductive silicone paste KPT8. Pole tips and the case of the magnetic system is made of steel. Between them are permanent magnets. The gap between poles of the magnetic system is also filled with KPT8.

Outside ends of the magnetic system combined with massive heat sinks, such that the further consideration of their temperature will be constant. Heat from inside the helicon resonator will be conducted mainly along its axis. If we ignore the heat transfer in the transverse direction, then the problem can be reduced to one-dimensional approximation of thermal problem for a layered medium with distributed heat sources. Let the x-axis is directed across the layers from the center of resonator. Stationary heat equation for resonator layer can be written as:

$$\lambda_0 \frac{\partial^2 T(x)}{\partial x^2} + f(x) = 0, f(x) = \frac{2P}{\pi S^2 \cos^2 \left(\frac{\pi}{2d}\right)}$$

Here $P$ - dissipation power, $S$ - square of resonator, $x = -d...d$ - thickness of resonator. Solving this equation with the boundary conditions leads to the expression:

$$T(x) = \begin{cases} T_0 - \frac{2P}{\lambda_0 \pi S^2} \left(1 - \frac{k}{\pi} \sin \left(\frac{\pi}{2d}\right) \right) \frac{d^2}{\pi^2} \sum_{N=1}^{M} \frac{1}{k_N} & x = 0...d \\ T_0 + \frac{P}{\lambda_0 \pi S^2} \frac{h_i}{x_d} & x = d + h_i, \quad N = 1...M \end{cases}$$

Here $h_i$ and $\lambda_i$ - thickness and heat conductivity of layers from resonator to outside, $T_0$ - temperature of isolator without dissipation power. Simulated temperature distribution along the axis of isolator is shown in fig.2.

Fig.2 Simulated temperature distribution along the helicon isolator with various power dissipated.

III. CONCLUSION

In this paper we consider a stationary regime of heat transfer inside the helicon isolator. Proposed one-dimensional model allows to evaluate the temperature distribution along the isolator as a function of power dissipation. Further development will be introducing into account the power dissipation in a general model of nonreciprocal helicon transformer and devices based on it. Also promising is the study of nonstationary heat transfer in the isolator in pulse mode.

REFERENCES