

Interaction Impedance Determination in Ring-Bar Helix

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Abstract: *In this paper we present some contribution to the work of some authors on the study of slow-wave structures for high-power traveling-wave tubes. We present theoretical results for the dispersion and the interaction impedance characteristics of the ring-bar helix as function of the helix radius to period ratio.*

Keywords: ring-bar helix; interaction impedance; slow-wave structure; high-power TWT.

Introduction

Ring-bar helices are very suitable slow-wave structures (SWS) when high-power microwave amplification is needed. Following early works on the determination of the electromagnetic properties of the SWS for traveling-wave tubes (TWT), we present our recent progress in obtaining the dispersion and the interaction impedance characteristics for SWS that use a ring-bar helix. This kind of helix, illustrated in Fig. 1, was introduced by Birdsall & Everhart [1] as a practical solution for the contra-wound helix proposed by Chodorow & Chu [2] in order to reduce the interaction impedance of the backward mode.

The dispersion characteristics of ring-bar helices were investigated by Cain & Grow in [3], where they presented dispersion curves as function of structure parameters such as helix radius, external guide radius, dielectric loading, and ring-to-period thickness ratio.

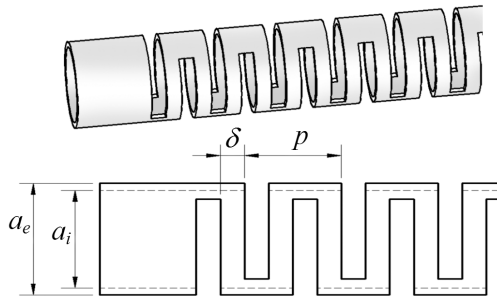


Figure 1. Ring-bar helix illustration. a_e and a_i are the outer and the inner helix radius, respectively. δ is the ring length and p is the helix period.

We followed the analysis derived in [3] and present here the interaction impedance characteristics for the ring-bar helix.

Mathematical Model

Solving the Maxwell equations under suitable boundary conditions for the SWS, we found the field component expressions. Using a variational method applied to the lagrangian for the electromagnetic field, we found a dispersion equation which shape is

$$0 = 2U_0 + \sum_{\ell=1}^{\infty} J_{\ell}^2 (Y_{\ell} + Y_{-\ell}), \quad (1)$$

where J_{ℓ} is the Fourier coefficient of the current density distribution the tape helix. The interaction impedance expression was obtained from the Pierce's definition

$$K_0 = |E_{z,0}(\rho=0)|^2 / 2\beta_0^2 P_T, \quad (2)$$

where P_T is the total power propagated in the SWS obtained from the Poynting's theorem and β is the axial propagation constant. The final expression for P_T can be expressed in the form

$$P_T = 2P_0 + \sum_{\ell=1}^{\infty} (P_{\ell} + P_{-\ell}), \quad (3)$$

where P_0 , P_{ℓ} , U_0 , and Y_{ℓ} functions will be given in a full version of this paper.

Results

We present some curves obtained for the dispersion characteristic for ω - β diagram and the phase velocity and for the interaction impedance. Figure 2 shows the dispersion behaviour for ring-bar helix SWS as function of frequency and $\cot \gamma = 2\pi a / p$. Figure 3 shows the phase velocity behaviour SWS as function of frequency. The interaction impedance behaviour for

ring-bar helix SWS as function of frequency and $\cot\psi$ is shown in Fig. 4. Figure 5 shows the interaction impedance behaviour for the forward \mathcal{K}_0 and the first-backward \mathcal{K}_{-1} modes.

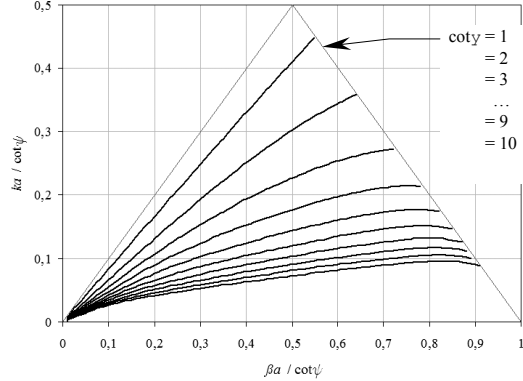


Figure 2. Dispersion behaviour for ring-bar helix SWS as function of frequency and $\cot\psi$.

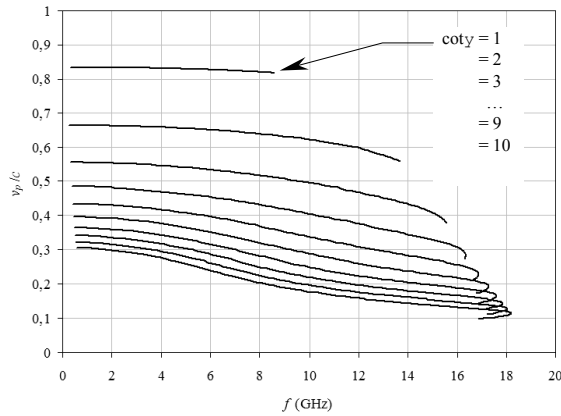


Figure 3. Phase velocity behaviour for ring-bar helix SWS as function of frequency and $\cot\psi$.

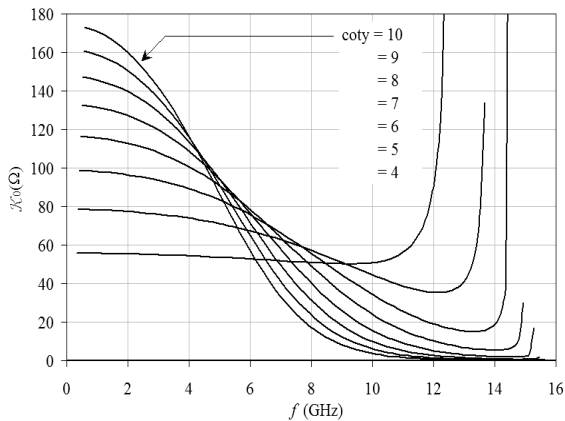


Figure 4. Interaction impedance behaviour for ring-bar helix SWS as function of frequency and $\cot\psi$.

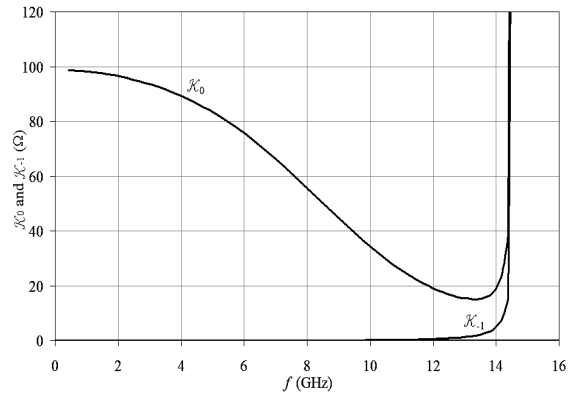


Figure 5. Interaction impedance behaviour for the forward \mathcal{K}_0 and the first-backward \mathcal{K}_{-1} modes.

Conclusion

In this paper we presented some results of our contribution in expanding Cain & Grow work in order to obtain the expression for ring-bar helix interaction impedance. We present some plots for the \mathcal{K}_0 behaviour as function of $\cot\psi$ and the influence of the backward impedance rising at high frequencies.

References

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