A Coaxially Loaded Helical Slow-wave Structure for TWTs

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Abstract

Helix traveling wave tubes (TWTs) are widely employed in communications and other related applications where ultra high bandwidths are required in microwave frequency regime since they offer a multi-octave bandwidth at higher frequencies [1]. Because of this major feature of wide bandwidth capability, they are often preferred when compared with other devices for wide band applications. This main feature kept it ahead of its counter parts. But these otherwise wide band interaction structures are limited to low power operation only owing to their power handling capability. This paved the way for the helix derived structures, which will offer higher powers at relatively larger band operation.

With this back ground, it will be interesting to see and analyze the behaviour of coaxial type of wide band helical interaction structures in conventional slow-wave regime since the coaxial versions of interaction structures are widely used in fast wave devices [2] for high power and high frequency applications. In this paper, we present the analysis of a new type of helical slow-wave structure with a coaxial insertion for a possible employment in TWTs in conventional slow-wave regime. By making use of the field theory and equivalent circuit analysis approaches, the dispersion relation and the equivalent circuit parameters, namely, capacitance per unit length, inductance per unit length, and characteristic impedance of the cold interaction structure are deduced.

The schematic diagram of the proposed interaction structure is shown in Fig. 1. In this structure, the outer side of the helix is supported by dielectric material housed in a metal envelope and a metal rod with dielectric lining is inserted inside the helix. The radial thickness of the helix is simulated as given in [3]. The following assumptions are taken into account for the analysis purpose.

(i) A sheath helix model is assumed.
(ii) The field is varying as $e^{j(\omega t-\beta z)}$ where ω is angular frequency and β the axial phase constant.
(iii) Hybrid helix modes in the conventional slow-wave regime are considered for analysis.

Following the field theory and equivalent circuit analysis methods [1], the dispersion relation and equivalent circuit parameters for the given structure are deduced. A typical set of dispersion and impedance plots is shown in Fig.2. This is a first hand assessment of the problem only. Work is in progress to deduce the wall loading factor and interaction impedance calculations, which are helpful to assess this proposed interaction structure for

use in helix TWTs. By making use of these parameters, one can make a realistic assessment of the interaction structure for broad band and high power applications.

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References

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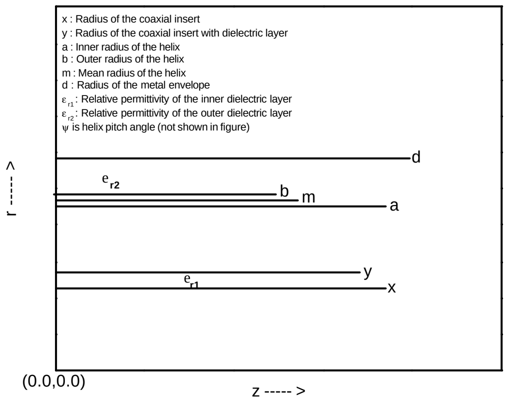

Fig.1 Schematic layout of the structure considered for analysis.

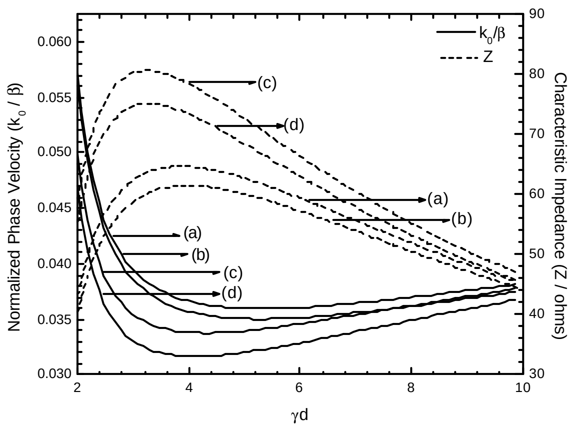

Fig.2. Plots of normalized phase velocity and characteristic impedance versus γd, which is proportional to frequency of the structure (γ is the radial propagation constant, β axial phase constant, k_0 free space wave number). Here, $\cot\psi$=20.0, a/d = 0.75, b/d = 0.80, ε_{r1} = 1.0, ε_{r2} = 9.0, x/d = 0.6, y/d = 0.6, (b) ε_{r1} = ε_{r2} = 9.0, x/d = 0.6, y/d = 0.6, (c) ε_{r1} = 1.0, ε_{r2} = 9.0, and (d) ε_{r1} = 9.0, ε_{r2} = 9.0, y/d = 0.6.