Theory and New Amplification Regime in Periodic Multimodal Slow Wave Structures With Degeneracy Interacting With an Electron Beam

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***Abstract*— We present the theory of a new amplification regime in traveling wave tubes (TWTs) composed of a slow wave periodic structure that supports multiple electromagnetic modes that can all be synchronized with the electron beam. The interaction between the multimodal slow wave structure and the electron beam is quantified using a multi-transmission line (MTL) approach based on a generalized Pierce model and transfer matrix analysis, leading to the identification of modes with complex Bloch wavenumber. In particular, we address a new possible operation condition for TWTs based on the supersynchronism between an electron beam and four modes exhibiting a degeneracy condition near a band edge of the periodic slow wave MTL. We show a phenomenological change in the band structure of a periodic MTL, where we observe at least two growing modal cooperating solutions as opposed to a uniform MTL, interacting with an electron beam where there is rigorously only one growing modal solution. We discuss the advantage of using such a degeneracy condition in TWTs that leads to larger gain conditions in amplifier regimes and also to very low starting beam current in high-power oscillators.**

***Index Terms*— Degenerate band edge (DBE), electromagnetic bandgap, high-power microwave (HPM), slow wave structures (SWSs), transmission line (TL) theory, traveling wave tubes (TWTs).**