OSCILLATION STARTING CURRENT APPROXIMATION BY TIME-DOMAIN SIMULATION IN TRAVELING-WAVE TUBES

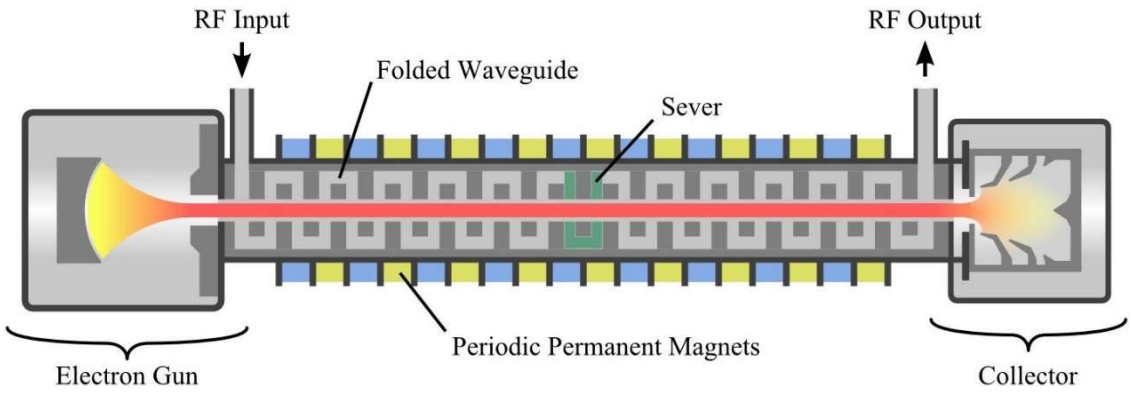
Moritz Hägermann[1], Philip Birtel[2], Arne F. Jacob[1]
[1] Institut für Hochfrequenztechnik, Technische Universität Hamburg-Harburg, Hamburg, Germany
[2] Thales Electronic Systems, Ulm, Germany

ABSTRACT

Traveling-wave tubes (TWTs) are high-power RF amplifiers that are mainly used in satellite communications or radar applications. As in any active device, instabilities may occur and lead to improper operation or damage of the device. The prediction of those effects is of high relevance since it reduces development costs and avoids malfunctioning of prototypes.

The instabilities arise from the coupled system of the RF-fields and the electron beam. Thus, a lower threshold for the beam current exists for the oscillation to start. Instabilities can be simulated by frequency-domain solvers like MVTRAD [1] or time-domain simulation tools like CST Particle Studio [2]. While the first one is a specialized and fast approach, the latter is a general purpose tool, geometry driven and thus inherently includes all appearing effects. Difficulties emerge when determining the threshold current in the time-domain solver. Stability can only be proven by a very long simulation. In this contribution, a fast approach to determine the starting current in time-domain simulation is presented.

The startup of any oscillation is characterized by an exponential growth $\sim e^{\alpha t}$, where α shows a dependence on the beam current in simulation. At or below the oscillation starting current, α has to be zero or negative since no oscillation arises. A model is used to determine the starting current from the simulation of oscillations above the threshold. This approach is applied to an exemplary folded-waveguide TWT section which is forced to oscillate at the 2π-point.



Acknowledgment

The authors wish to acknowledge funding and support of this work by the German Aerospace Center (DLR) on behalf of the German Federal Ministry of Economics and Technology (BMWi) under research contract 50YB1702.

References

[1] P. Waller, "Modélisation numérique de l'interaction et diagnosticexpérimental du faisceau d'électrons dans un tube à ondes progressives spatial" as *Ph.D. dissertation*, Université Paris 7, 1999.
[2] CST Particle Studio, *Computer Simulation Technology GmbH*, 2018