INSTABILITIES IN HELIX TRAVELING-WAVE TUBES

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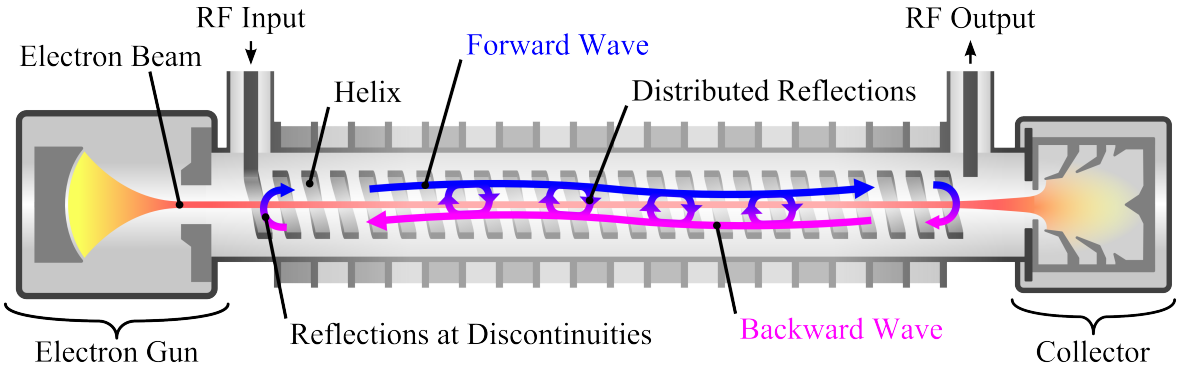
ABSTRACT

Helix traveling-wave tubes (TWTs) are RF power-amplifiers that are mainly used in satellite communications. Due to the increasing demand for higher data rates and bandwidth, the involved components need to be improved and adapted as well. As a consequence, the amplifier performance needs to be enhanced, which increases the risk of instabilities, as they may occur in any active device. The prediction of instabilities during the design process is thus of high interest to avoid malfunctioning prototypes. As an overview, an introduction to instabilities in helix TWTs, including brief explanations on their physical background, is presented.

The figure shows a schematic helix TWT with its main components. Additionally, some of the subsequent effects which may lead to instabilities of the amplifier are depicted. The most straightforward instability is caused by multi-reflections of the propagating RF waves, where local reflections due to mismatched discontinuities create an internal feedback loop. If the loop gain exceeds the value of one, the TWT starts oscillating.

In helix TWTs, an inherent feedback path is provided by the forward-traveling electron beam and backward-traveling RF waves. Due to the periodicity of the helical delay-line, the backward RF wave contains parts that can interact with the forward-traveling electron beam. As a consequence, a backward-wave oscillation will arise from noise if the beam current exceeds a certain threshold.

Additional feedback paths are caused by distributed reflections or an asymmetric electron beam. The former is caused by asymmetries in the helix while the latter results for instance from a misaligned electron gun. Both imperfections can cause instabilities as well and even lower the oscillation threshold compared to backward-wave oscillations in some cases. While mismatch-induced oscillations and so called π-mode oscillations occur without any excitation of the amplifier, drive-induced oscillations arise in the case of large-signal operation close to saturation of the TWT.



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