IMPROVING TRAVELING-WAVE TUBES FOR MODULATED OPERATION IN BACK-OFF

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ABSTRACT

Traveling-wave tubes (TWTs) are high-power high-efficiency vacuum electronic amplifiers, predominantly used in satellite communications. Here, modern applications shift the modulation schemes from simple ones (like constant-envelope QPSK) to more involved amplitude- and phase-modulated signals. The TWT's nonlinearity near saturation introduces distortions according to the signal envelope. To avoid these distortions, the amplifiers are typically operated far in the linear back-off region. While this diminishes nonlinearity-induced modulation errors, it severely reduces the overall efficiency, as the beam efficiency decreases quickly. As more complex schemes typically need more linearity, this issue requires increased attention [1].

For optimizing TWTs at their actual operating conditions, one therefore needs to consider both linearity in terms of introduced distortions and total efficiency in back-off. For this, one can imagine adjustments to the interaction region, i.e., the delay line taper, and the collector. A simple approach is to tune the collector potentials, such that the continuous-wave collector efficiency at the designated operating point increases. While this leads to an improved total efficiency at that point, it could possibly diminish the performance at saturation and it is unclear how well such an adaption would perform considering amplitude-modulated signals. Instead, it is beneficial to consider realistic modulations or generalized distributions to tune the collector to a robust optimum. This can also be considered in a delay line optimization [3], where the beam energy distribution is altered for better collectability of the electron beam in back-off. Additionally, we investigate the idea of dynamic collector biasing, which has been proposed in [4].

These adjustments require sophisticated simulation procedures that can accurately predict the multi-tone transmission behavior. Envelope-based models [2] enable hybrid time- and frequency-domain simulation and can therefore be used to enhance the design for modulated operation.

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