

## Multi-transmission-line-beam interactive system

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We construct here a Lagrangian field formulation for a system consisting of an electron beam interacting with a slow-wave structure modeled by a possibly non-uniform multiple transmission line (MTL). In the case of a single line we recover the linear model of a traveling wave tube due to J. R. Pierce. Since a properly chosen MTL can approximate a real waveguide structure with any desired accuracy, the proposed model can be used in particular for design optimization. Furthermore, the Lagrangian formulation provides: (i) a clear identification of the mathematical source of amplification, (ii) exact expressions for the conserved energy and its flux distributions obtained from the Noether theorem. In the case of uniform MTLs we carry out an exhaustive analysis of eigenmodes and find sharp conditions on the parameters of the system to provide for amplifying regimes. © 2013 AIP Publishing LLC. [<http://dx.doi.org/10.1063/1.4832486>]