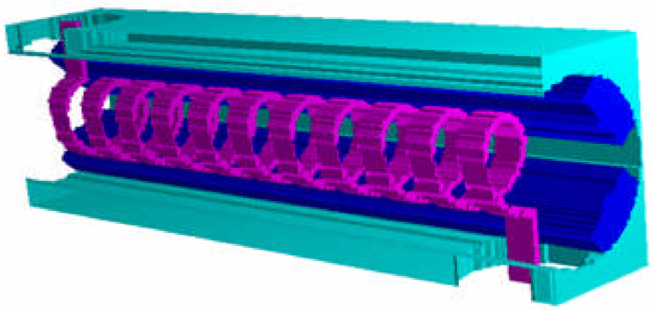
Accurate Time-Dependent Traveling-Wave Tube Model Developed for Computational Bit-Error-Rate Testing



Cutaway of several turns of the helical slow-wave circuit with input/output couplers.

The phenomenal growth of the satellite communications industry has created a large demand for traveling-wave tubes (TWT's) operating with unprecedented specifications requiring the design and production of many novel devices in record time. To achieve this, the TWT industry heavily relies on computational modeling. However, the TWT industry's computational modeling capabilities need to be improved because there are often discrepancies between measured TWT data and that predicted by conventional two-dimensional helical TWT interaction codes. This limits the analysis and design of novel devices or TWT's with parameters differing from what is conventionally manufactured. In addition, the inaccuracy of current computational tools limits achievable TWT performance because optimized designs require highly accurate models.

To address these concerns, a fully three-dimensional, time-dependent, helical TWT interaction model was developed using the electromagnetic particle-in-cell code MAFIA (Solution of MAxwell's equations by the Finite-Integration-Algorithm) (refs. 1 and 2). The model includes a short section of helical slow-wave circuit with excitation fed by radiofrequency input/output couplers, and an electron beam contained by periodic permanent magnet focusing. A cutaway view of several turns of the three-dimensional helical slow-wave circuit with input/output couplers is shown in the figure. This has been shown to be more accurate than conventionally used two-dimensional models (ref. 3).

The growth of the communications industry has also imposed a demand for increased data rates for the transmission of large volumes of data. To achieve increased data rates, complex modulation and multiple access techniques are employed requiring minimum distortion of the signal as it is passed through the TWT. Thus, intersymbol interference (ISI) becomes a major consideration, as well as suspected causes such as reflections within the TWT. To experimentally investigate effects of the physical TWT on ISI would be prohibitively expensive, as it would require manufacturing numerous amplifiers, in addition to acquiring the required digital hardware. As an alternative, the time-domain TWT interaction model developed here provides the capability to establish a computational test bench where ISI or bit error rate can be simulated as a function of TWT operating parameters and component geometries. Intermodulation products, harmonic generation, and backward waves can also be monitored with the model for similar correlations.

The advancements in computational capabilities and corresponding potential improvements in TWT performance may prove to be the enabling technologies for realizing unprecedented data rates for near real time transmission of the increasingly larger volumes of data demanded by planned commercial and Government satellite communications applications.

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Find out more about this research at http://ctd.grc.nasa.gov/5620/5620.html.

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