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Validation Studies for CHRISTINE-CC Using a Ka-Band Coupled-Cavity TWT*

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A CW Ka-band coupled cavity TWT, a CPI model VTA-6430A2, is under study at the Naval Research Laboratory, partly for the purpose of validating a large signal coupled-cavity simulation code, CHRISTINE-CC, and an equivalent Block model description, both now under development. The CC-TWT is voltage tunable over the range 28 to 30 GHz, with a rated output power of 500W, and an instantaneous bandwidth of 500 MHz. The simulation code used to model the performance is a coupled cavity version of the CHRISTINE code, originally written to simulate helix TWT's [1]. Briefly, the code employs a 1D disk model representation of the beam, a user-selectable lumped element model of the slow wave circuit, and a user-selectable model of the electric field in the gap. The slow wave circuit model may be chosen to be either that of Curnow [2] or that of Malykhin, Konnov, and Komarov [3], which has some additional flexibility to match the dispersion and impedance characteristics in the cavity and slot bands. The gap field model may be chosen to be either a parabolic shape or a Kosmahl-Branch [4] model. Space charge fields are represented as in the CHRISTINE code for helix TWT's, including an improvement reported in this conference (paper 19-1).

Figure 1 shows a comparison between a drive curve at 29.2 GHz, as computed by CHRISTINE-CC and measured at NRL. It is seen that the small signal gain predicted by CHRISTINE-CC is a little lower, and the simulated drive curve saturates more quickly, than the measurements. The reason for the discrepancy in small signal gain is probably attributable at least in part to reflections known to be present in the input section of this particular tube, before the sever. The disagreement between the simulated and measured values of saturated power may be additionally due to the limitation imposed by the 1D disk model for the beam, in which the beam radius remains fixed throughout the interaction space.

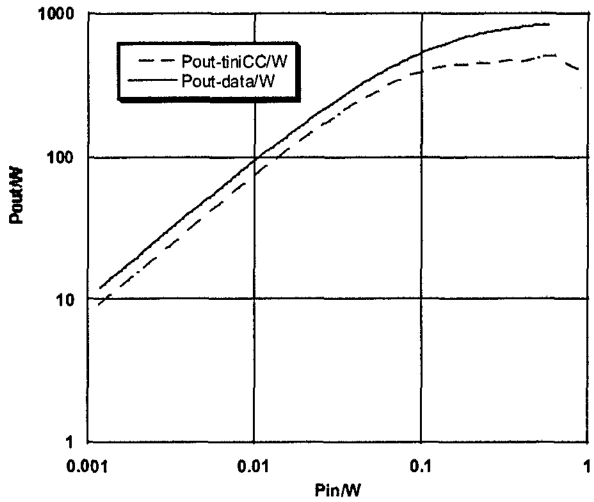

Figure 1: Output vs. input power at 29.2 GHz for the VTA-6430A2 Ka-band CC- TWT at NRL, as measured and as computed by CHRISTINE-CC.

CPI recently announced [5] a modification of the VTA-6430A2, called the VTA-6430A1, which produces 500 W of saturated power in the band 29-30 GHz, and 450 W between 30 and 31 GHz. Results from this tube are also being used in the CHRISTINE-CC validation study. Figure 2 shows a comparison of the measured and computed small signal gain for this tube. Simulation results are shown using (1) nominal tube specifications for cathode voltage and beam radius, (2), same as (1), but with the cathode voltage reduced by 1.8%, and (3), same as (2), but with the beam radius increased by 5.0%. It is seen that quite good agreement between simulations and measurements is obtained in case (3). The reason that the cathode voltage may need to be set lower than the measured value may be due in part to the neglect in the simulation of the additional space charge depression experienced by the beam in the gap regions. The simulation fixes the beam radius at a constant value over the interaction space. It may be that there are ~5% uncertainties in the beam radius over the length of the

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interaction and that a 2D code is required for more accurate results using the specified initial value of beam radius.

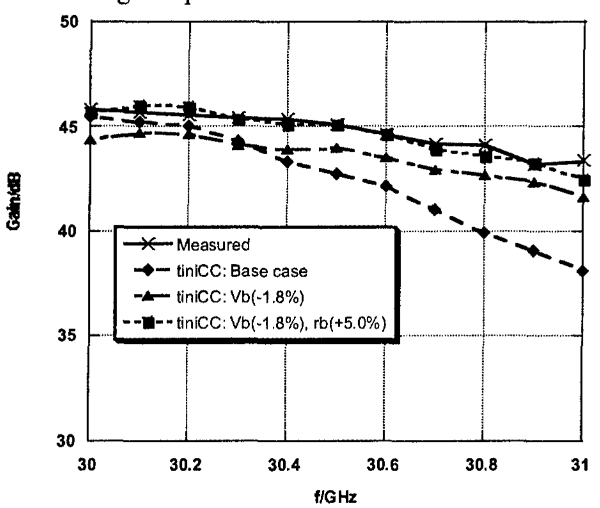

Figure 2: Small signal gain vs. frequency for the VTA-6430A1 Ka-band CC-TWT, as measured and as computed by CHRISTINE-CC.

Using the values from case (3), above, we have computed output power and phase as functions of drive power and compared them to measured values. Results are shown in Figures 3 and 4. Good agreement between measurement and simulation is obtained.

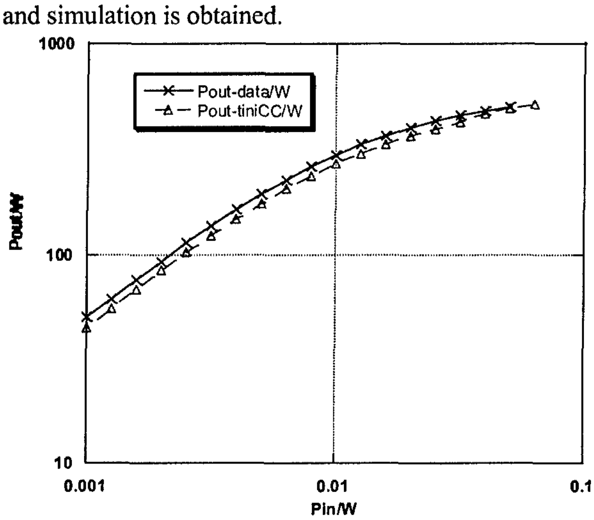

Figure 3: Output power vs. input power at f=30.0 GHz for the VTA-6430A1 Ka-band CC-TWT, as measured and as computed by CHRISTINE-CC.

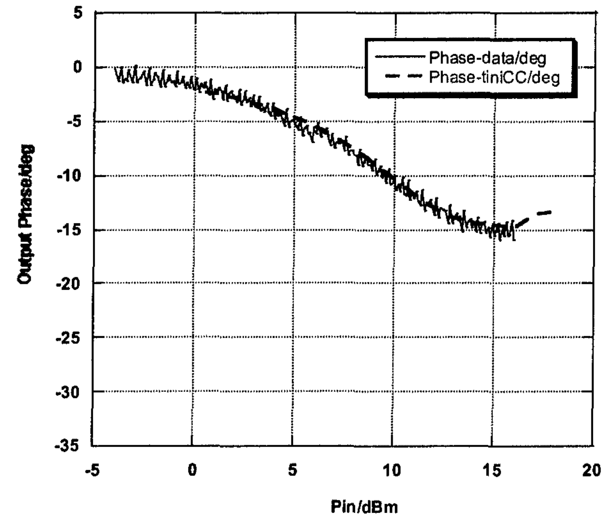

Figure 4: Output phase vs. input power at f=30.0 GHz for the VTA-6430A1 Ka-band CC-TWT, as measured and as computed by CHRISTINE-CC.

Additional comparisons, including a computation and measurement of C3IM amplitudes, will be presented at the Conference.

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