BENCHMARK OF CAD VENDORS

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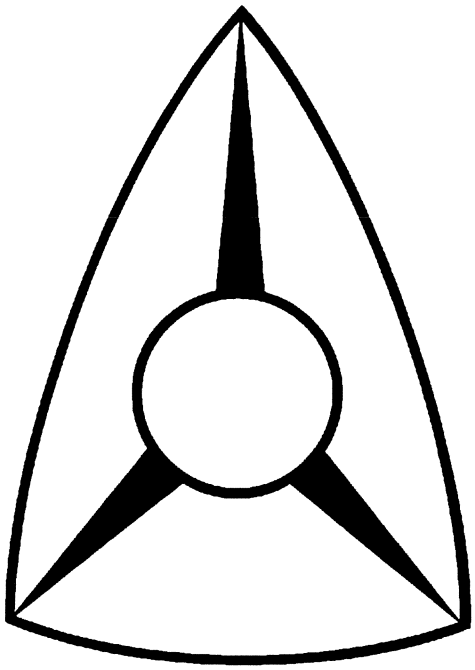


Benchmark of CAD Vendors

nonlinear CAD benchmark by Microwave Engineering Europe of software vendors with products significantly beyond the entry level (November, 1993)

nonlinear simulation of a bipolar transistor power amplifier originally designed by R. Jennings and P. Perry at University College Dublin, Ireland, for communication applications around 2 GHz

the amplifier worked well in practice but proved very difficult to simulate using nonlinear harmonic balance simulators

OSA, Hewlett Packard, EEsof and Compact Software participated

Circuit Structure and Characteristics

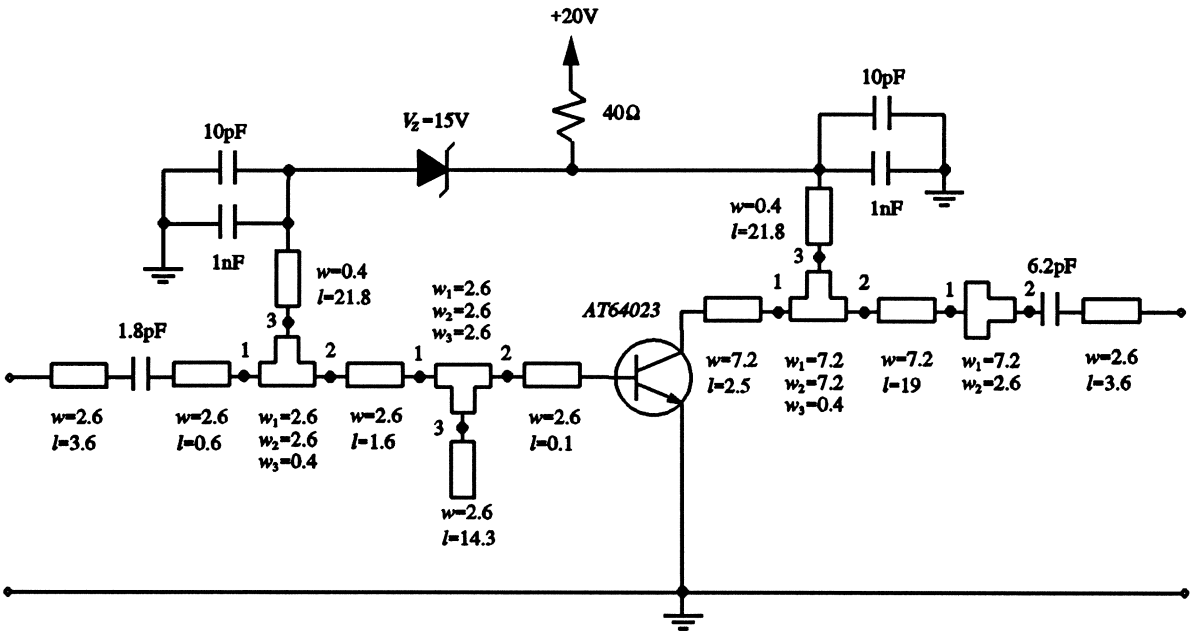
a single bipolar transistor (the Avantek AT64023) biased for a constant collector current (100 mA) and a constant collector emitter voltage (16 V)

distributed elements for input and output matching circuits realized in microstrip on standard 1.5 mm FR4 board

a high power driver to saturate other high power devices being tested under nonlinear operation

a very narrow band response centered at 2 GHz with the power characteristics having been somewhat sacrificed in favour of good impedance and gain characteristics

Circuit Schematic



units: mm
substrate thickness 1.5 mm
relative dielectric constant 4.75
metallization: 35 μm thick copper

Device Model for the Bipolar Transistor

SPICE type nonlinear model including the package provided by Avantek

some discrepancies noticed between the model provided by Avantek and the measured *S*-parameter data also provided by Avantek

model refinement for a better *S*-parameter fit using the parameter extraction capabilities of OSA90/hope

Small- and Large-Signal Simulation

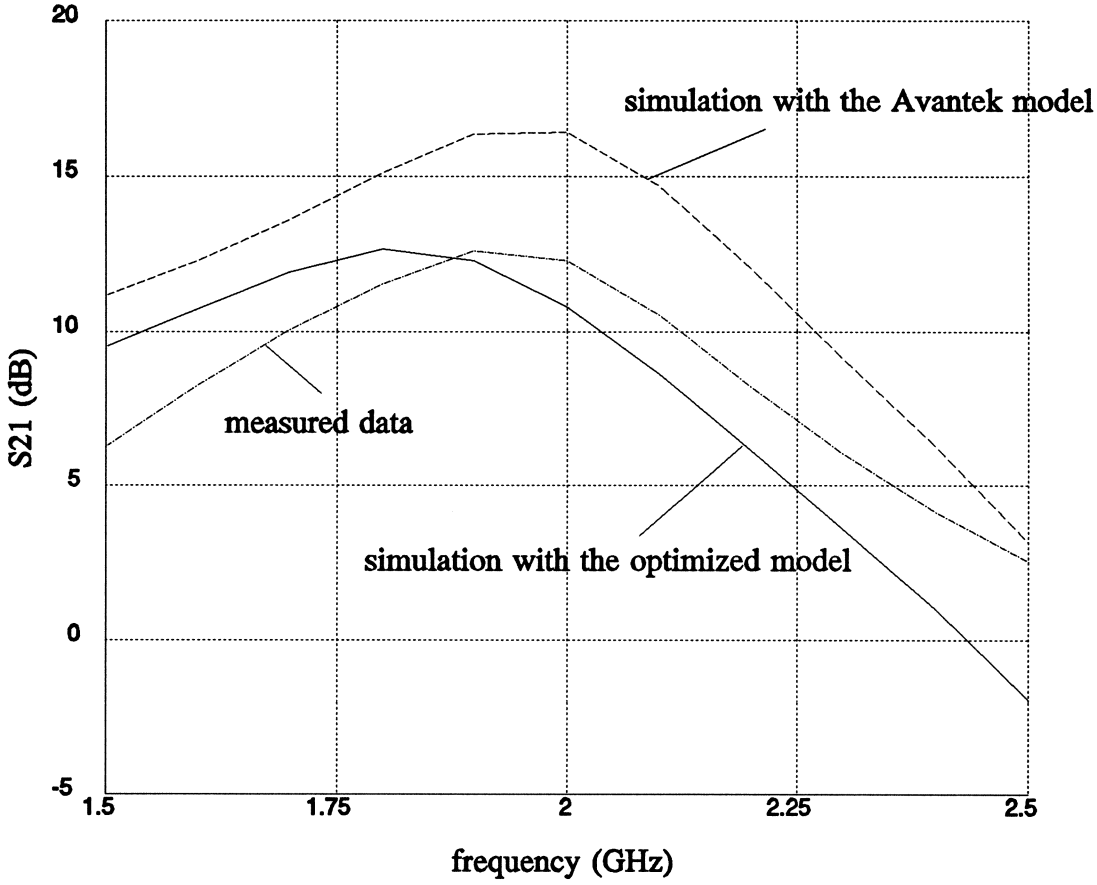
small-signal linear and large-signal nonlinear HB simulation of the amplifier using OSA90/hope

16.35 dB small-signal gain and 26.6 dBm output power at 1 dB gain compression at 2 GHz obtained using the model provided by Avantek

10.74 dB small-signal gain and 23.43 dBm output power at 1 dB gain compression at 2 GHz obtained using the optimized model extracted from the measured *S* parameters given by Avantek

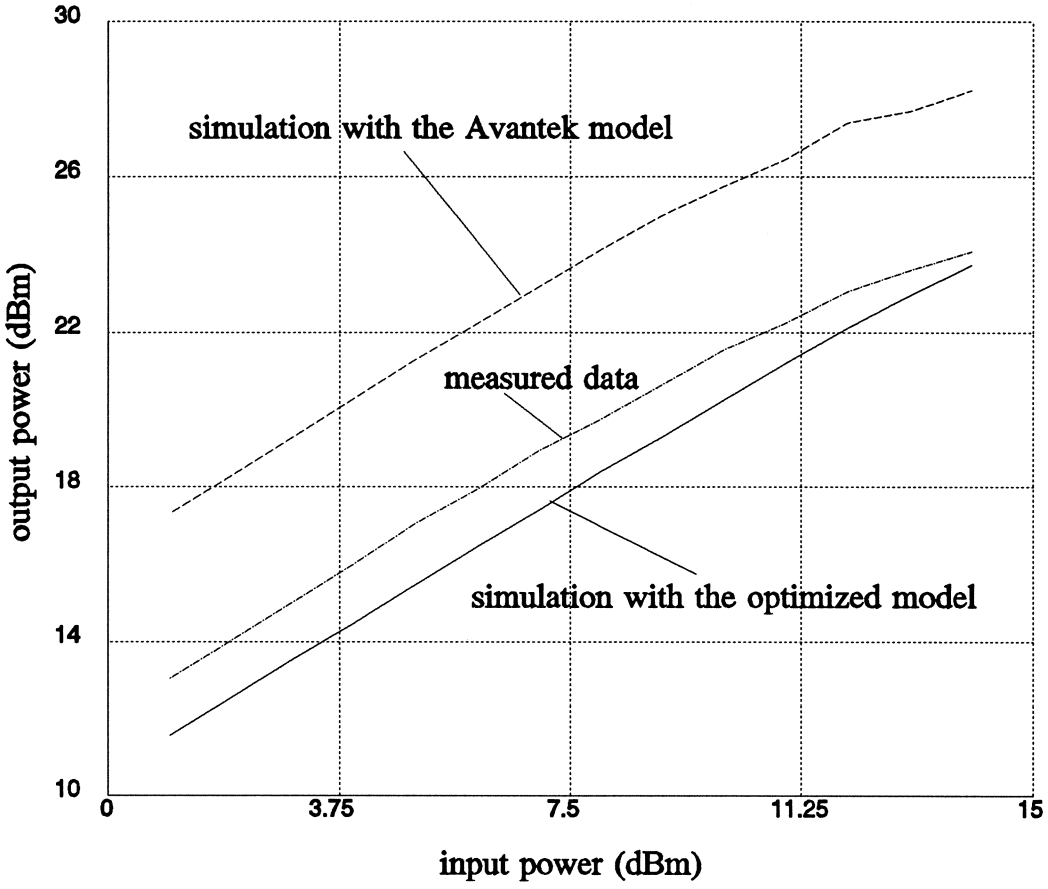
12.2 dB small-signal gain and 23.0 dBm output power at 1 dB gain compression at 2 GHz measured for the actual circuit

Small-Signal Gain of the Amplifier



measured data not supplied to participants

Output Power vs. Input Power of the Amplifier



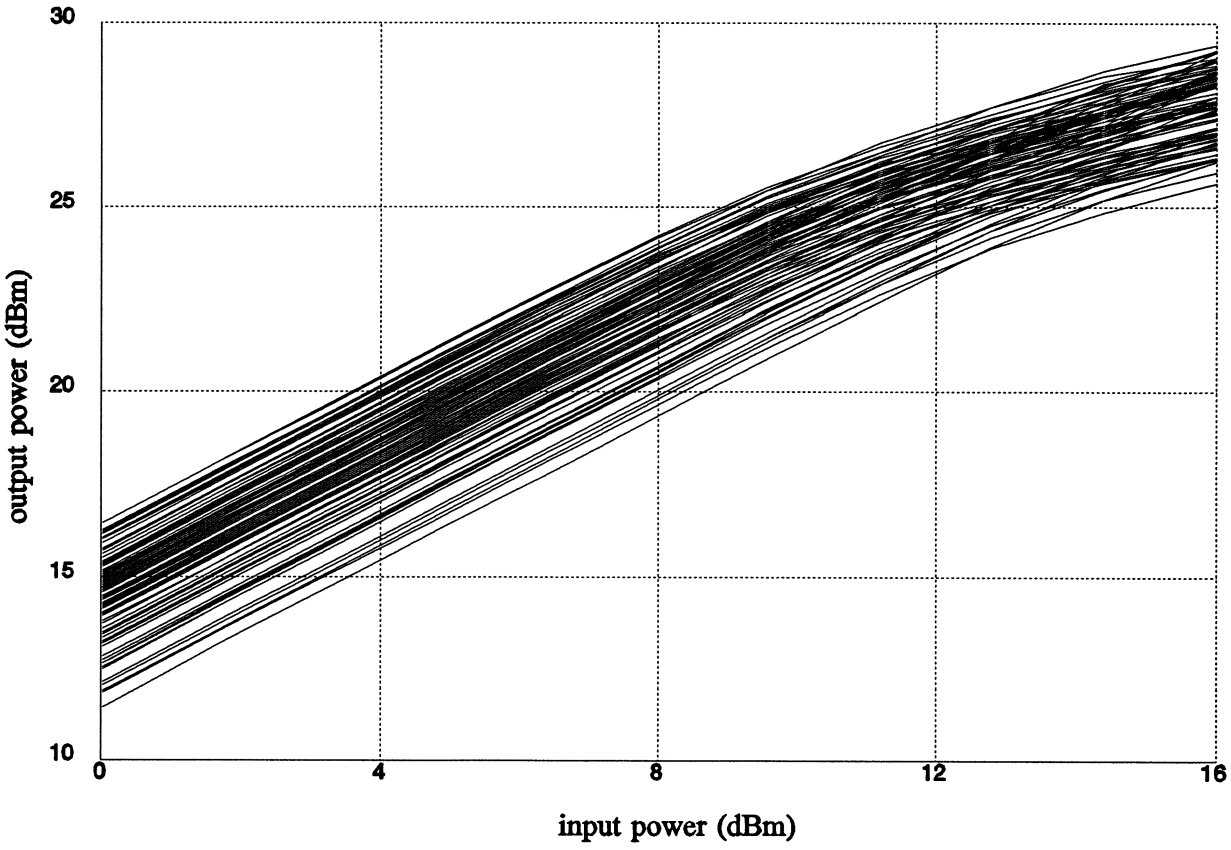
measured data not supplied to participants

Statistical Analysis

investigation of the effects of parameter tolerances of the transistor model on the output power

Monte Carlo simulation using 100 outcomes by assigning tolerances to the model parameters

Monte Carlo Sweep of Output Power vs. Input Power



Sensitivity Analysis

sensitivity analysis of the output power at 1 dB gain compression w.r.t. the elements in the matching circuits

the response is more sensitive to the length of the open stub in the input matching circuits and the lengths of the microstrip lines in the output matching circuits than any other parameters in the circuits