COMPRESSION ANALYSIS
OF A HIGH POWER AMPLIFIER

OSA-93-OS-15-R

September 28, 1993

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We use OSA90/hope to estimate the 1dB compression point of a high power amplifier originally designed by R. Jennings and P. Perry at University College Dublin, Ireland. This problem was obtained by fax from the Editor, *Microwave Engineering Europe* on September 13, 1993.

A. Transistor Model

First, we used the model provided by Avantek for the AT64023 bipolar transistor as given in the data book (also provided by the Editor, *Microwave Engineering Europe*, September 20, 1993).

B. Simulation Results Using the Model Provided by Avantek

Using OSA90/hope, we performed both small-signal and large-signal (harmonic balance) simulation of the amplifier. The small-signal gain at 2GHz is 16.35dB. At 1dB compression at 2GHz, the output power is 26.6dBm, the input power is 11.25dBm and the power gain is 15.35dB.

C. Parameter Extraction from S Parameters

We have noticed some discrepancies between the model provided by Avantek and the measured S-parameter data, also provided by Avantek in the data book.

If we assume the S-parameter measurements to be more trustworthy than the model provided by Avantek, how would it affect the simulation results? To answer that question, we performed model refinement for a better S-parameter fit using the parameter extraction capabilities of OSA90/hope.

Fig. 1 shows the match between the measured S parameters and the simulated S parameters using the model provided by Avantek. Fig. 2 shows the much improved match using the optimized model.

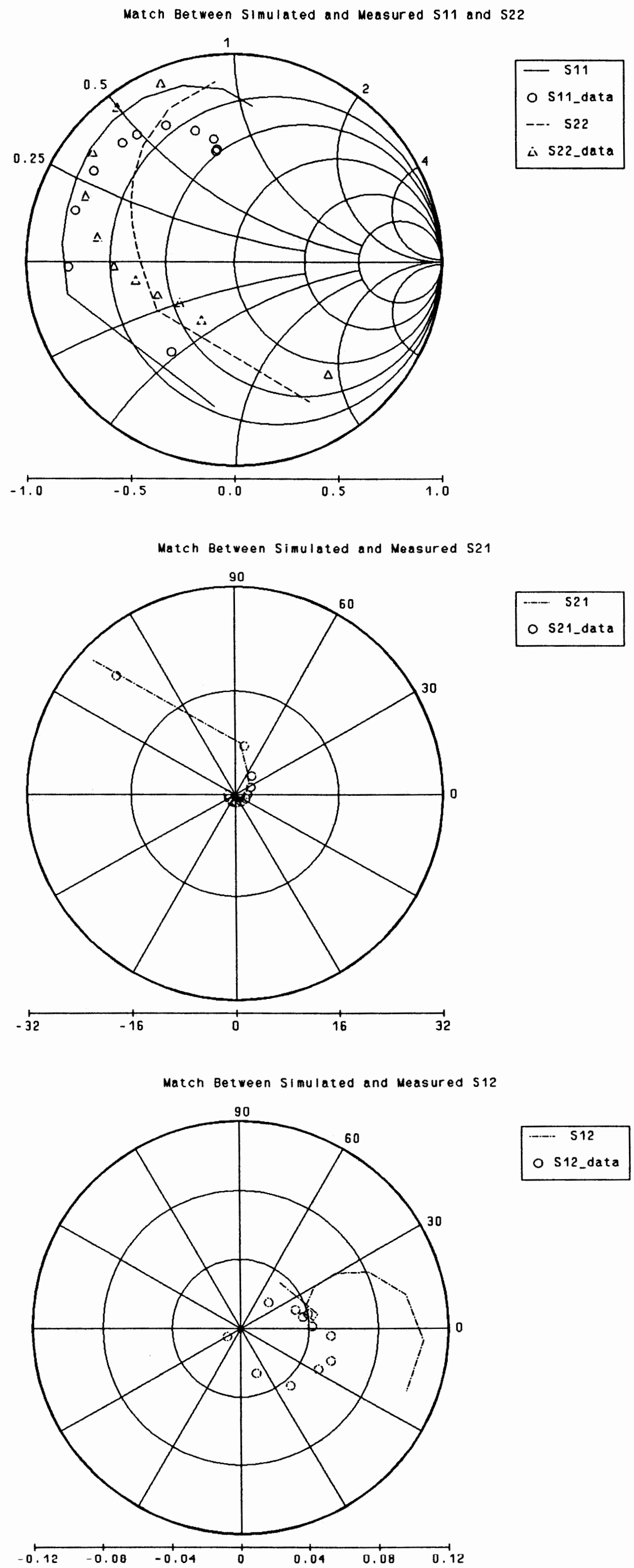

Fig. 1 S-parameter match using the model provided by Avantek. The solid and dashed lines are the simulated S parameters. The o and Δ are the measured S parameters.

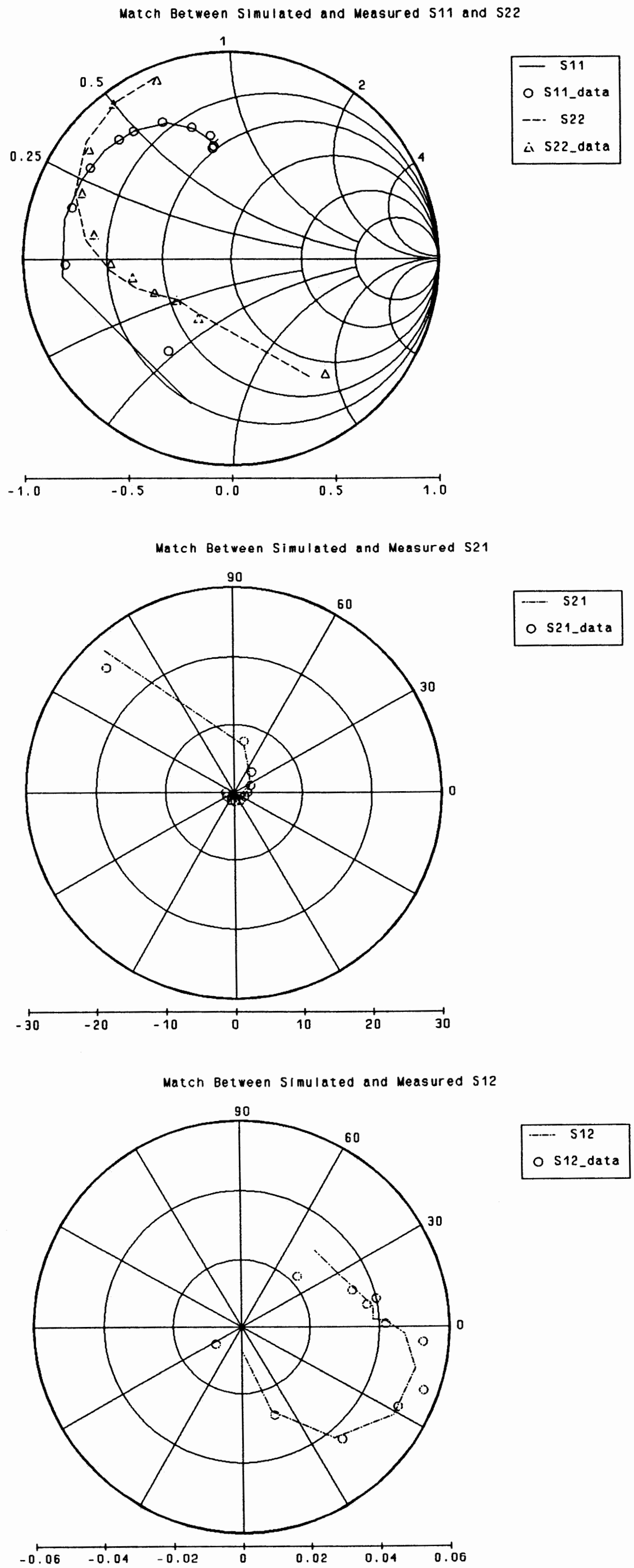

Fig. 2 *S*-parameter match using the optimized model. The solid and dashed lines are the simulated *S* parameters. The o and Δ are the measured *S* parameters.

D. Simulation Results Using the Optimized Model

We repeated small-signal and large-signal (harmonic balance) simulation of the amplifier using the model extracted from the *S* parameters. Fig. 3 shows the small-signal gain of the amplifier.

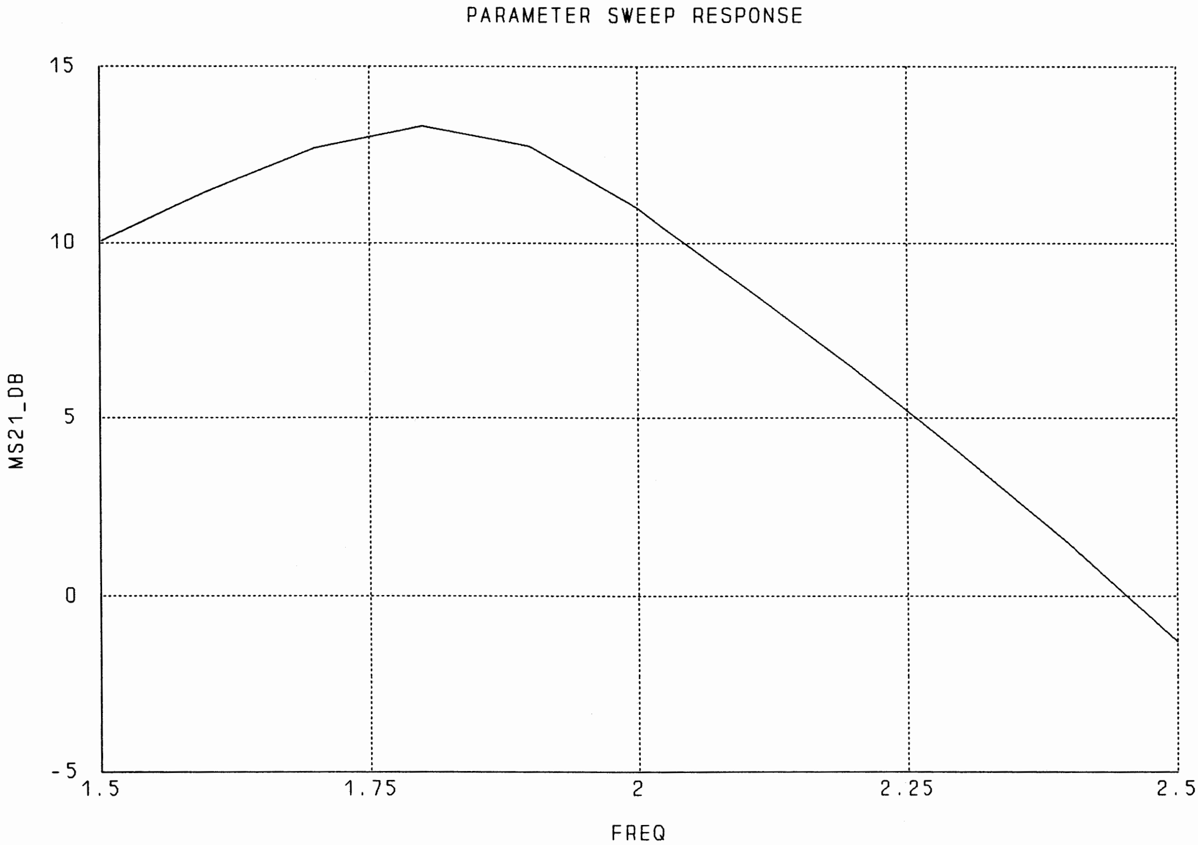

Fig. 3 Small-signal gain of the amplifier with the optimized model.

The amplifier gain is lower than that obtained with the model provided by Avantek, indicating that the matching circuits were probably originally designed by R. Jennings and P. Perry w.r.t. the model provided by Avantek. Fig. 4 shows the output power at 1dB gain compression versus frequency. The output power at 1dB compression at 2GHz is 25.5dBm. Note that due to the smaller gain, a higher input drive level will be required. This can be improved by fine tuning the matching circuits.

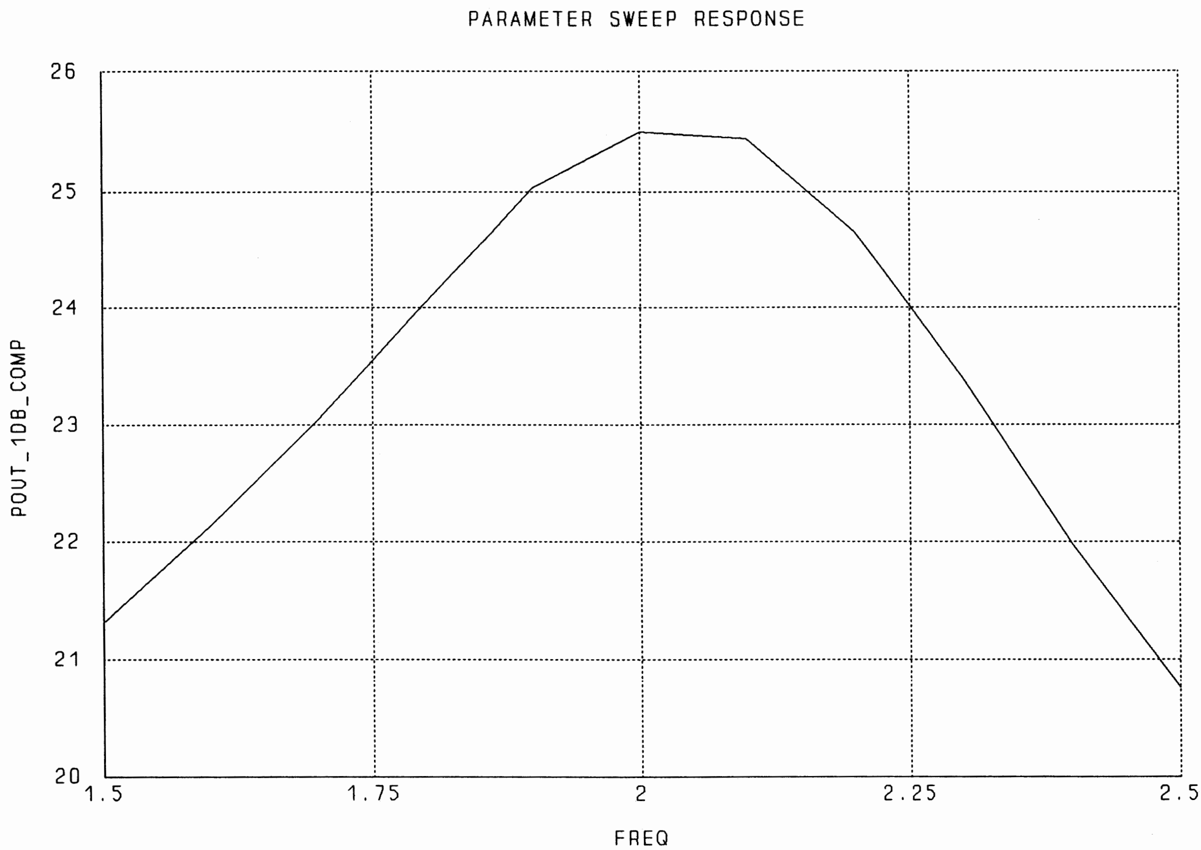

Fig. 4 Output power at 1dB gain compression using the optimized model.

E. Statistical Analysis

The differences between the model provided by Avantek and the model obtained from the *S* parameters reveal the uncertainties associated with the device model. For an engineer to be confident with the design, a single simulation based on a single model may not be sufficient.

This motivated us to conduct statistical analysis of the amplifier to investigate the effect of parameter tolerances of the transistor model on the output power. The nominal parameter values were chosen as the average of the values provided by Avantek and the values of the optimized model. Tolerances were assigned to the model parameters according to the differences between the models. Monte Carlo simulation was carried out using 100 outcomes. The output power versus input power at 2GHz is shown in Fig. 5.

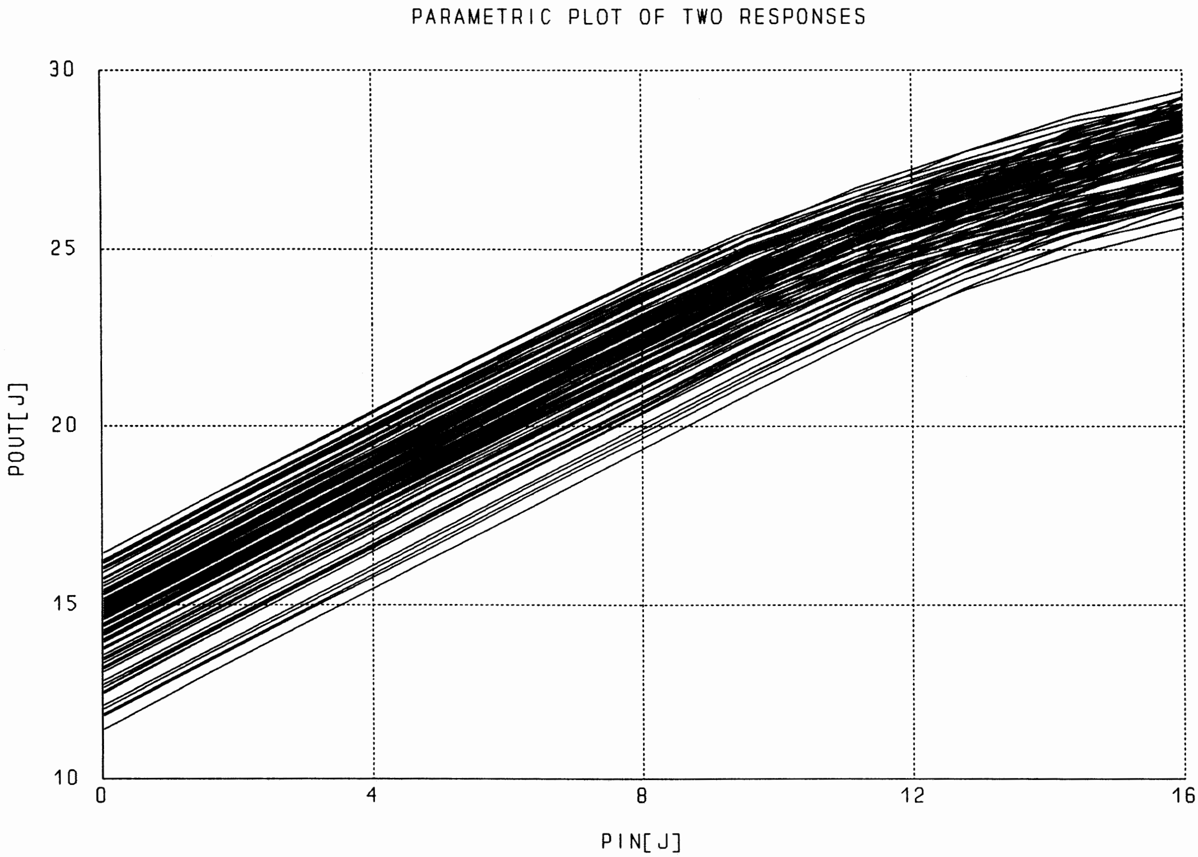

Fig. 5 Monte Carlo sweep of output power (dBm) versus input power (dBm) at 2GHz.

The values of output power at 1dB gain compression at 2GHz are spread between 23.2dBm and 27.2dBm. This reflects the uncertainty of the model and is illustrated by the histogram shown in Fig. 6.

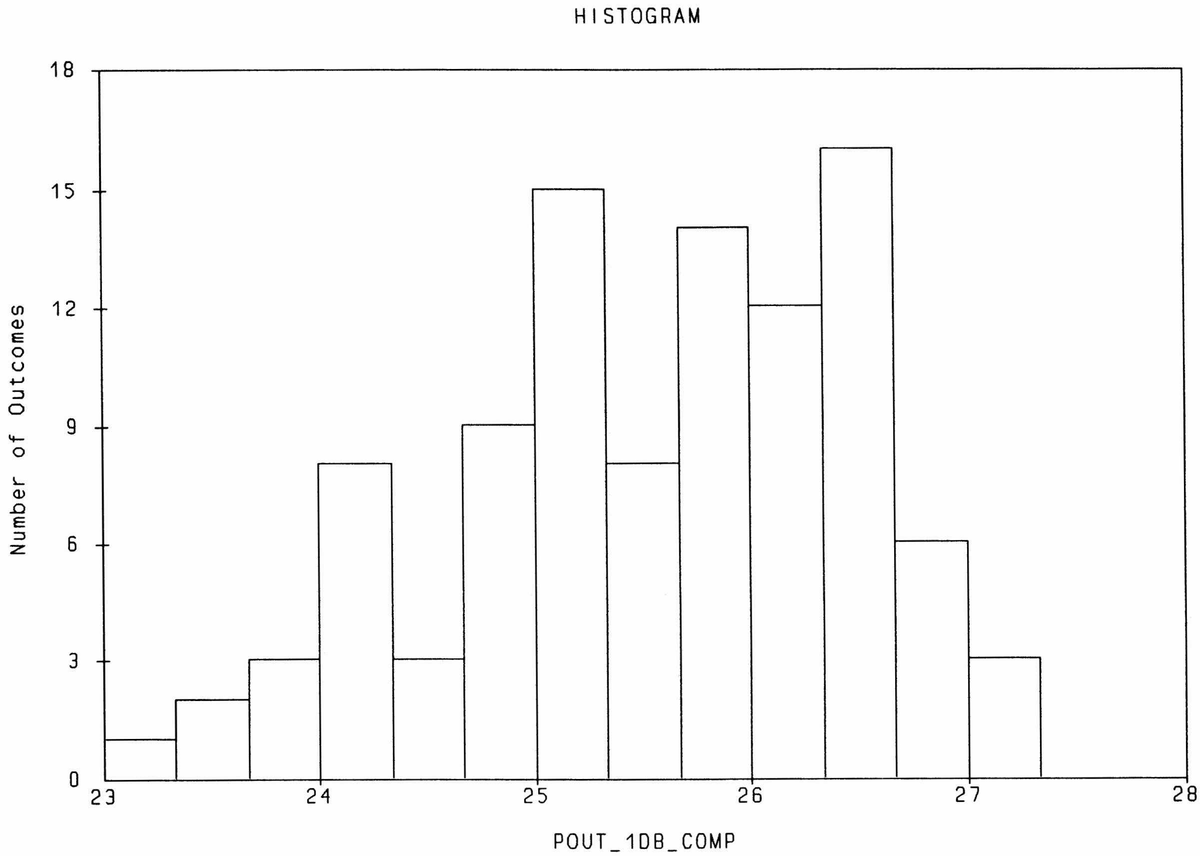

Fig. 6 Histogram of output power (dBm) at 1dB gain compression at 2GHz for assumed model uncertainty.

F. Sensitivity Analysis

We have further investigated the sensitivity of the output power at 1dB gain compression at 2GHz w.r.t. the elements in the input and output matching circuits on a minimax design basis. The result shows that the response is more sensitive to the following parameters: the length of the open stub in the input matching circuit, the widths and lengths of the microstrip lines in the output matching circuits, than to the other parameters in the circuits.