Measurements and Models of a Power Amplifier Suitable for 802.16.1

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Purpose:

This is a response to Document IEEE 802.16.1p-00/09r1, which requested input regarding parameters of typical power amplifiers for use in 802.16.1 systems.

Measurements & Models of a Power Amplifier Suitable for 802.16.1

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- Measurement & Modeling Approach
- Application to Example PA
- Frequency Dependency Issues

Behavioral Modeling Approach

Measure AM-AM & AM-PM responses
(single tone)

↓

Fit to Saleh model
(gain & phase as functions of signal amplitude)

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Use Bessel series expansions of G and φ to compute envelope transfer function h

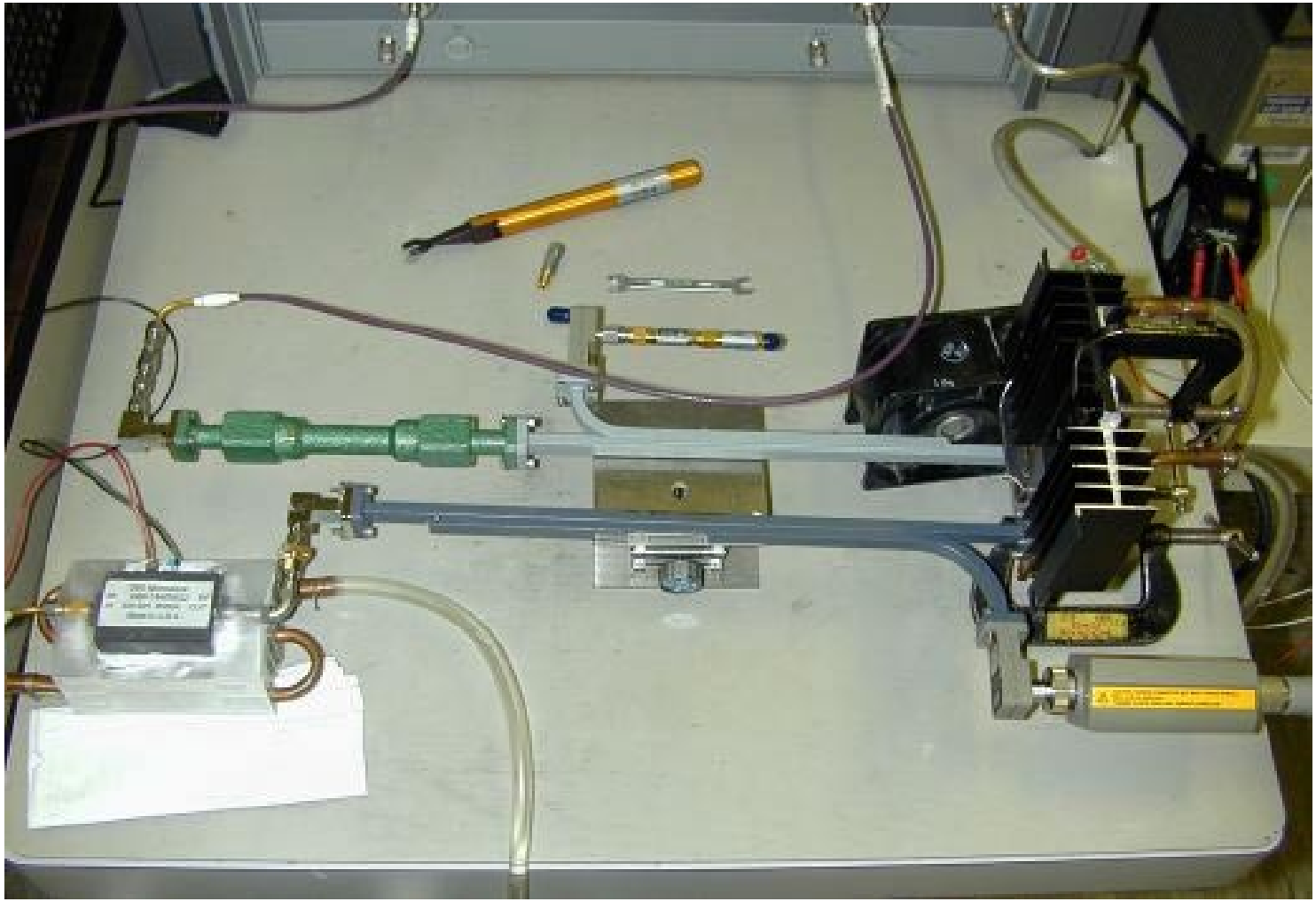
↓

Compute ACPR & EVM from $y(t) = h(x(t))$

Example PA Parameters

Frequency range of measurements	28-29 GHz
Gain (1)	29.3 dB
$P_{1dB\ out}$ (2)	29 dBm

Measurement Set-Up

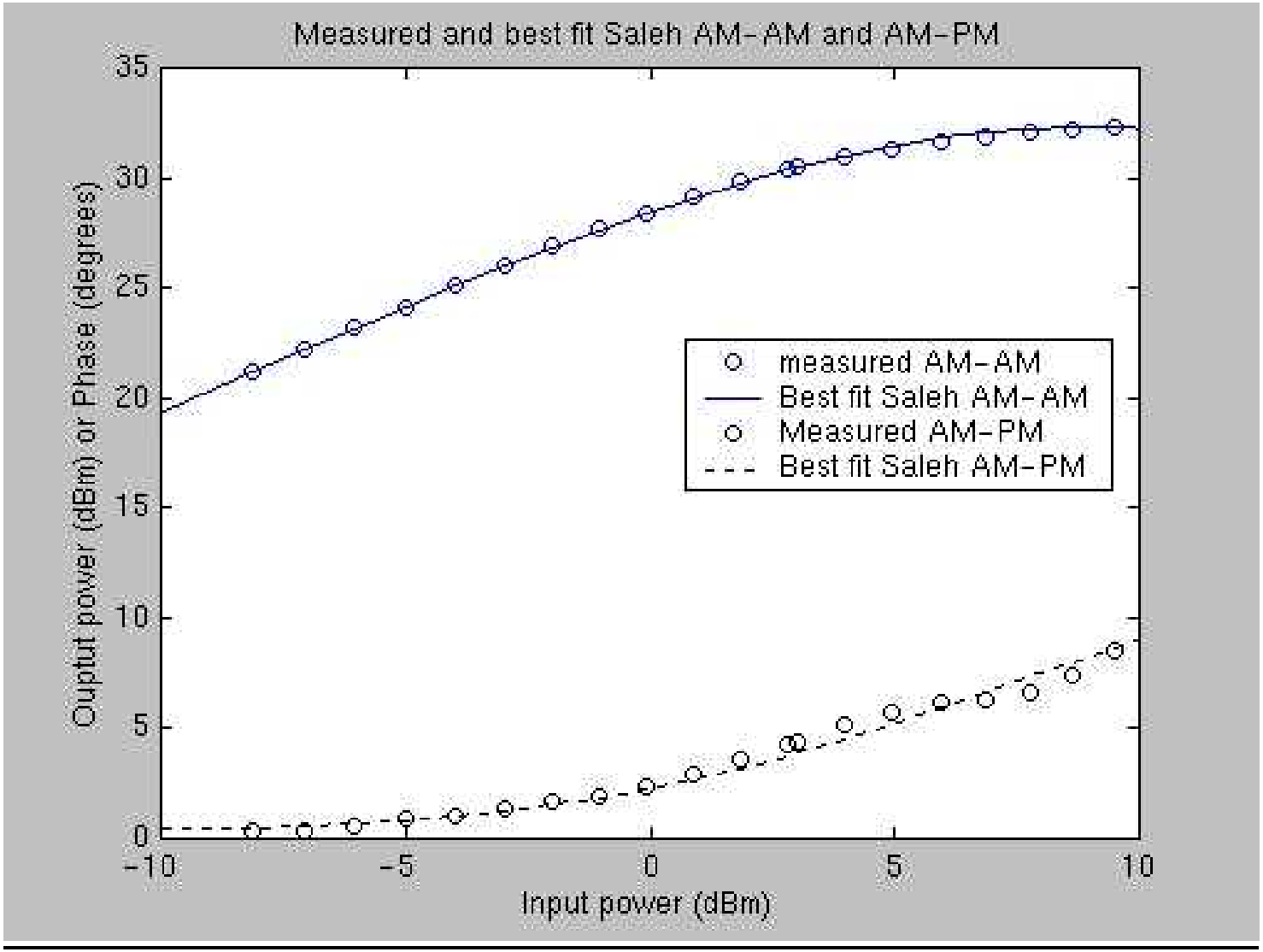


Saleh Model

$$G(r) = \frac{\alpha_1 * r}{1 + \beta_1 * r^2}$$

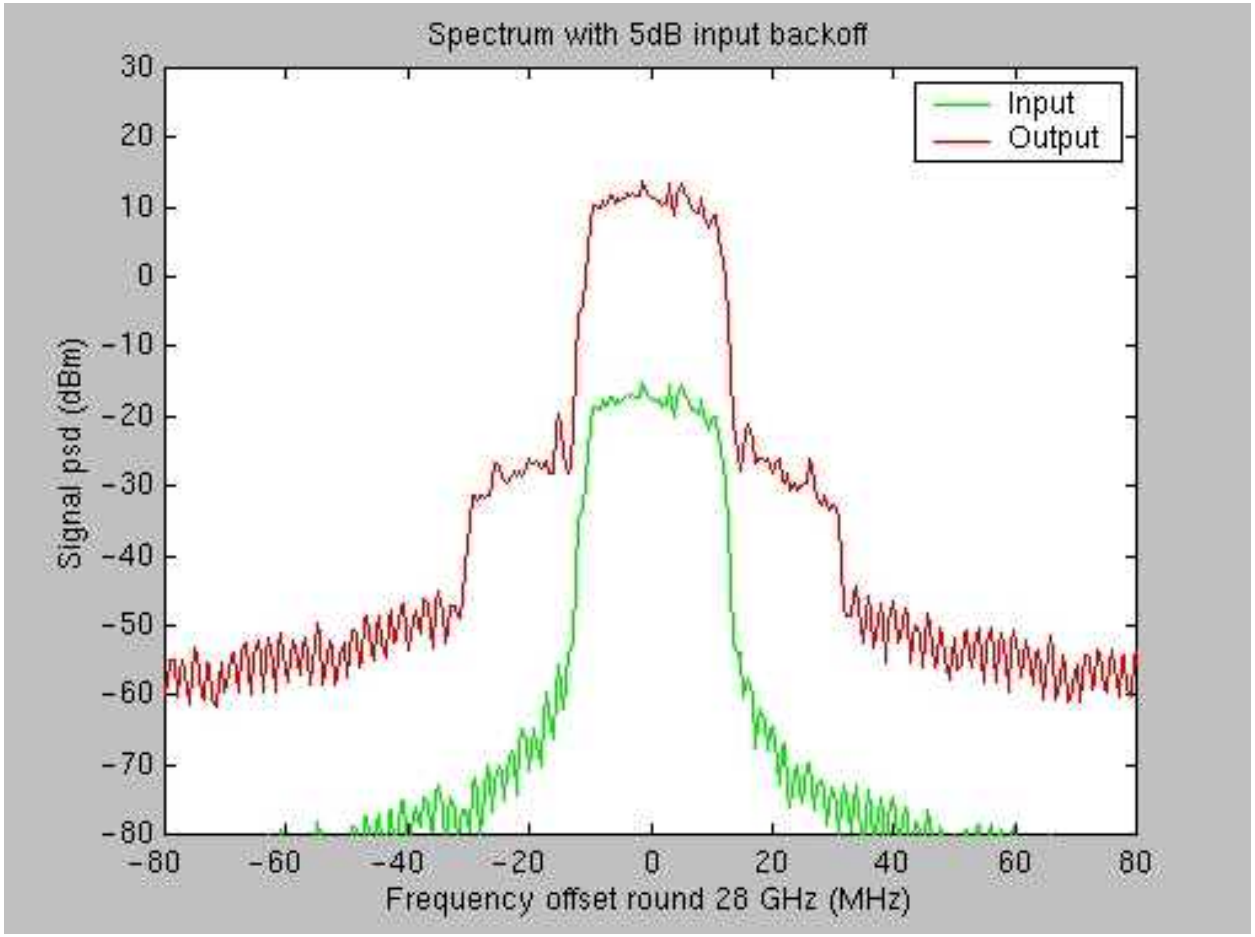
$$\varphi(r) = \frac{\alpha_2 * r^2}{1 + \beta_2 * r^2}$$

Fit to Saleh Model



ACPR & EVM Predictions

$$h(A) = v(A)\mathrm{e}^{\mathrm{j}\varphi(A)}$$



ACPR & EVM Simulations for QPSK

Roll off factor	Input Back off (dB)	Output Back off (dB)	ACPR (dB)	EVM (%)
0.15	3.01	2.95	-30.64	11.74
0.25	3	2.91	-32.8	11.47
0.35	2.97	2.89	-33.82	11.24

Table 2: QPSK, $r_{max} = 0.8$ V

ACPR & EVM Simulations for 16 QAM

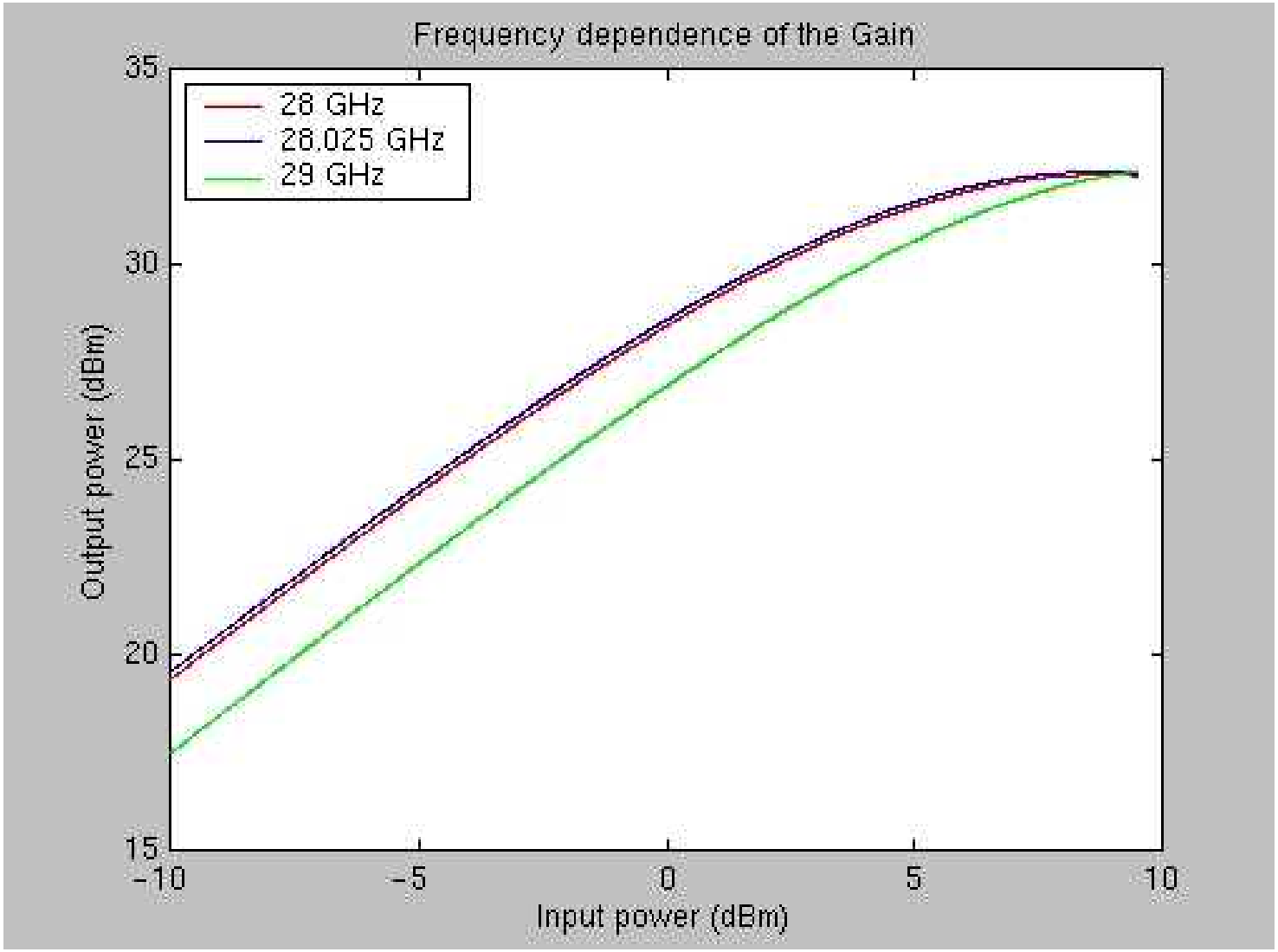
Roll off factor	Input Back off (dB)	Output Back off (dB)	ACPR(dB)	EVM (%)
0.15	5.12	4.81	-31	12.22
0.25	5.11	4.79	-33.84	11.23
0.35	5.1	4.79	-34.23	10.91

Table 3: 16 QAM, $r_{max} = 0.8$ V

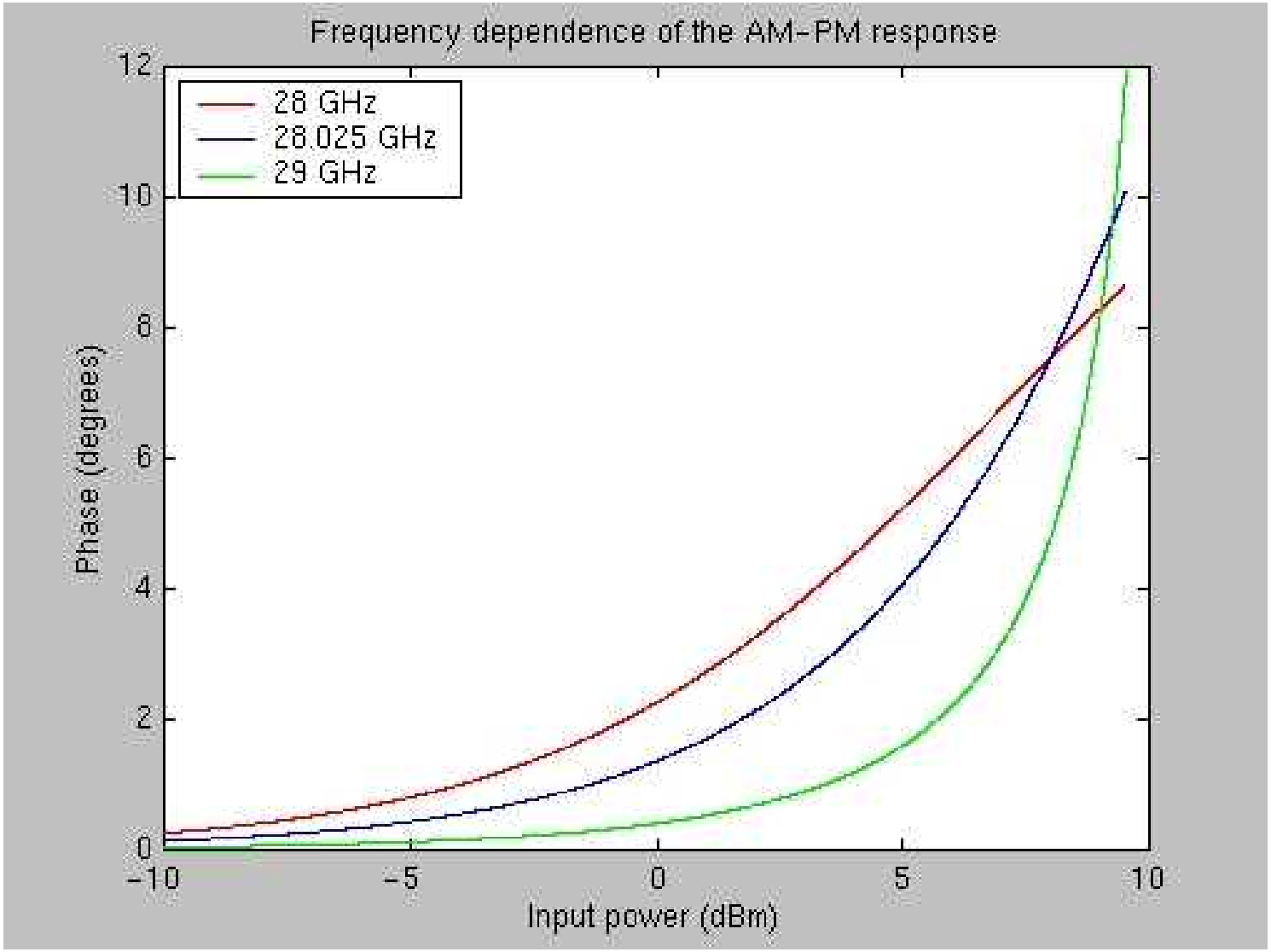
Frequency Dependency Issues

- Broadband amplifiers may not have flat gain and phase responses over 500 - 1000 MHz bands
- Envelope transfer function *h* is calculated using signal tone stimulus, but may depend on input waveform due to memory effects
- Simple frequency response corrections may not work

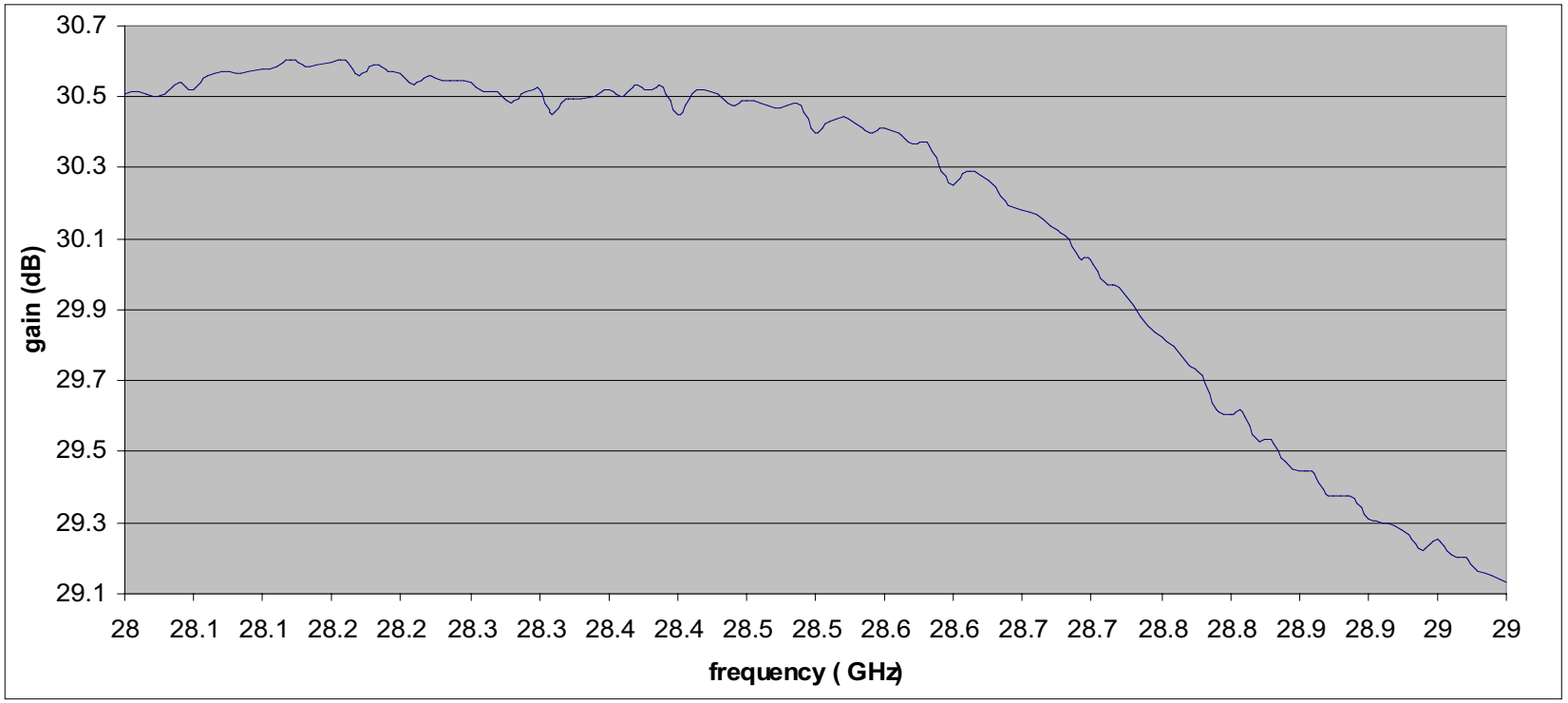
Frequency Dependence in AM-AM



Frequency Dependence in AM-PM

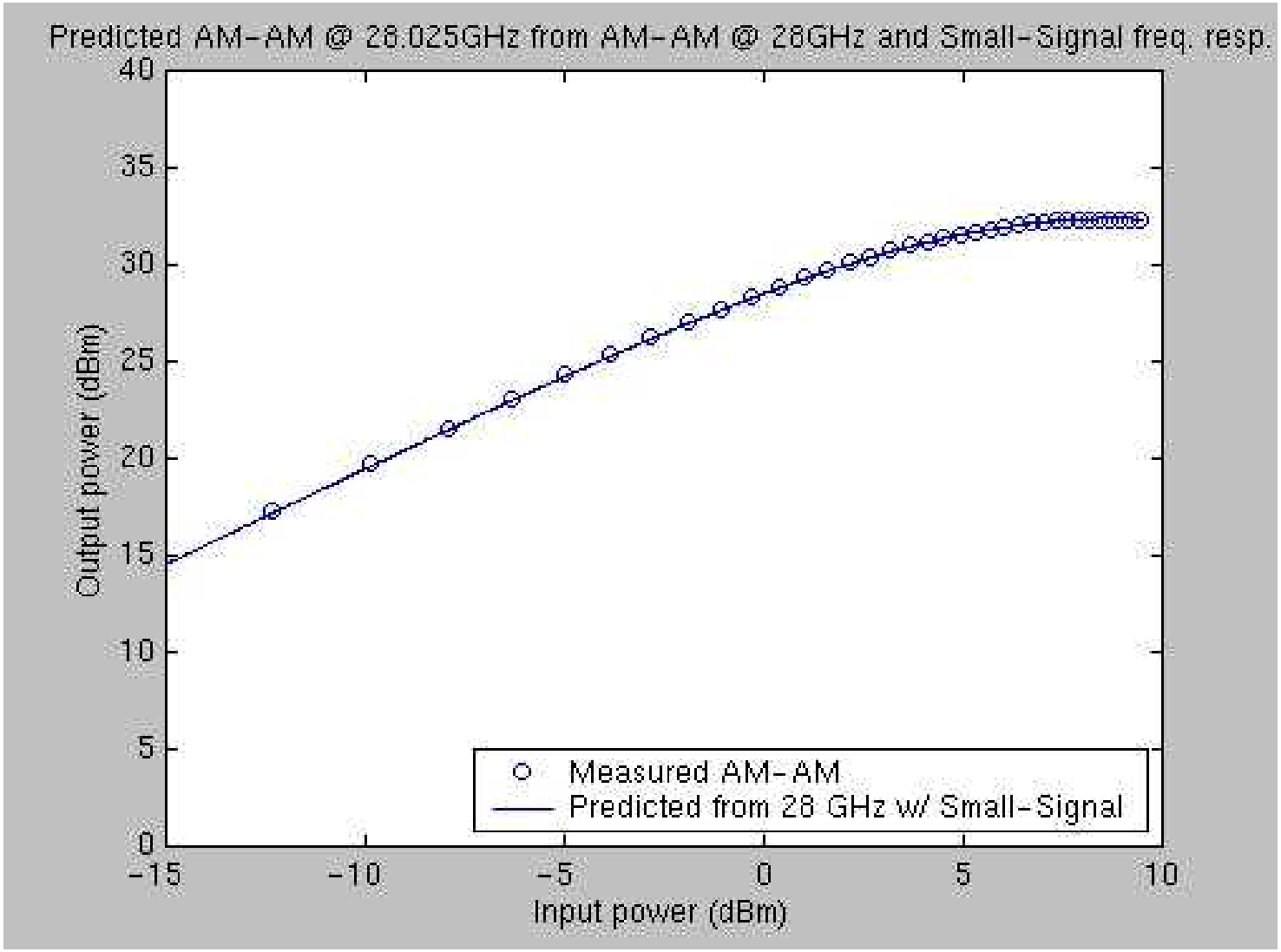


Small Signal Gain & Simple Correction

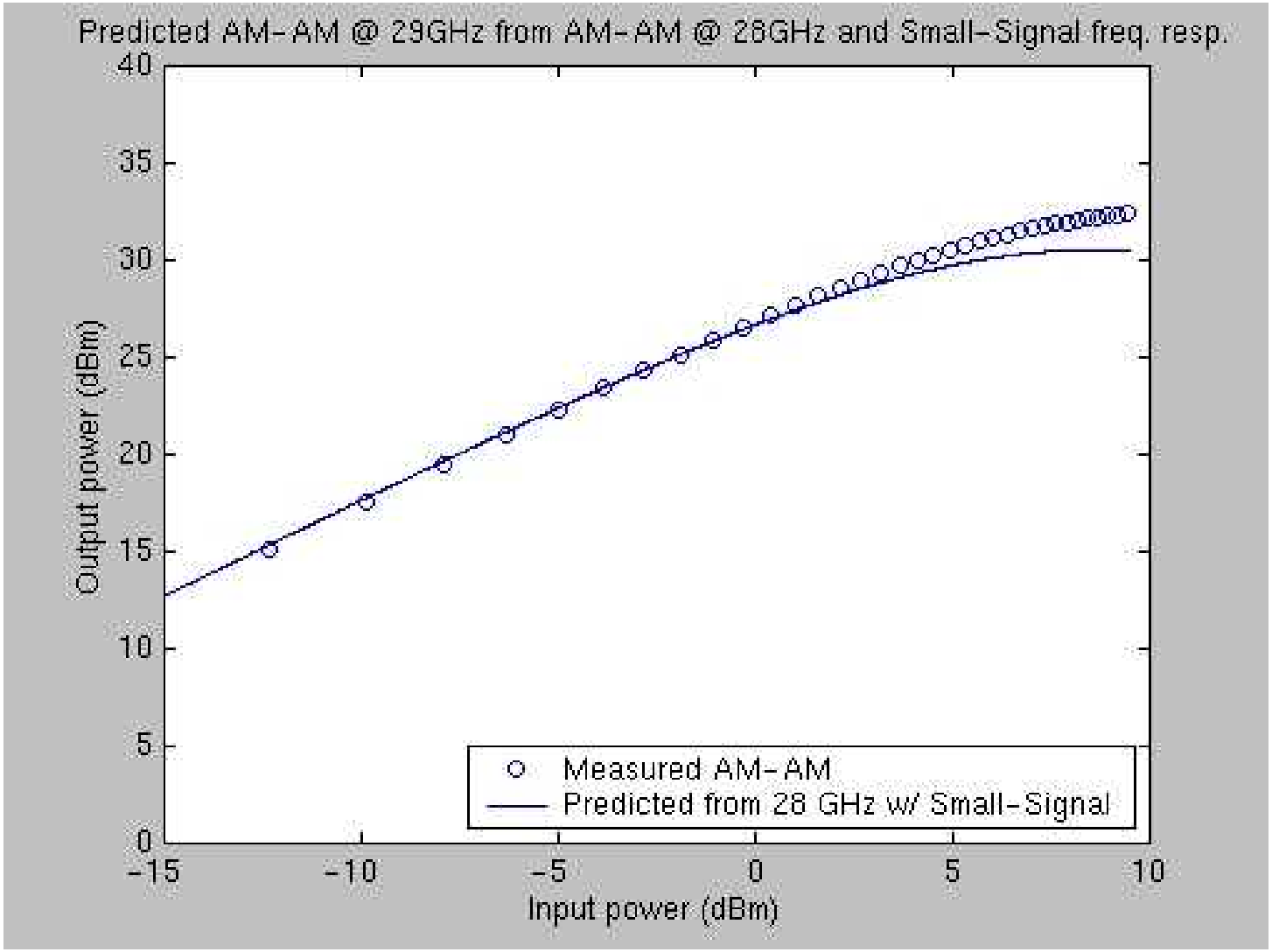


$$G(f) = G(f_0)\frac{g(f)}{g(f_0)}$$

AM-AM Prediction to 28.025 GHz



AM-AM Prediction to 29.0 GHz



Summary

- Measured PA behavior (AM-AM & AM-PM) can be used in modeling effort.
- Saleh model provides independent gain and phase functions that has been used to compute output waveform for given input stimulus.
- Approach does not include memory effects (single tone measurements) and cannot fully correct for frequency dependence within band.
- ACPR and EVM predictions still need to be validated with measurements.