# CALL FOR CONTRIBUTIONS ON POWER AMPLIFIER MODEL PARAMETERS

## IEEE 802.16.1 Session #8

### Deadline: 7 July 2000

The IEEE 802.16 Working Group on Broadband Wireless Access is preparing to define the 802.16.1 broadband wireless access air interface specification in accordance the "Development Plan for the 802.16.1 Air Interface Standard" (Document IEEE 802.16-99/05). It has approved a proposal (Document IEEE 802.16.1pc-00/29r1) as the initial draft of the physical layer (PHY).

As the 802.16.1 Task Group revises and finalizes its specification, it is interested in validating its standard through simulation and possibly through measurement. One critical issue in the simulation of the PHY is the behavior of the power amplifier and its nonlinearity. This will require a specific model and a specific set of parameters representing typical power amplifiers (PAs) as might be used in implementations of the 802.16.1 standard.

This Call for Contributions invites contributions suggesting a PA model, along with specific parameter data representing typical base station and subscriber station PAs, for use in the system simulation. In addition, supporting measurements, as detailed below, are requested.

Contributions will be considered non-confidential and will be posted, as soon as possible following receipt, for public access on the 802.16 Web Site <http://ieee802.org/16>.

Contributions will be considered only if submitted using Revision 8 or higher of the 802.16 Document Submission Template <http://ieee802.org/16/docs/802_16_template.doc>. The template requires a cover page and a narrative. In the cover sheet category labeled "Re", please cite not only this document but also the document number of the document(s) you are addressing.

Email your contribution, for receipt by the **deadline of 7 July 2000**, to each of the following:

- 802.16 Chair Roger Marks <mailto:marks@nist.gov>
- 802.16.1 Chair Lou Olsen <mailto:louis.olsen@teligent.com>
- 802.16.1 PHY Chair Jay Klein <mailto:jay@ensemblecom.com>

Late submissions are subject to time constraints that may preclude full evaluation by the committee.

The PAs under consideration should meet the following specifications:

(1) Subscriber Station PA
This will be used with QPSK and a root-raised-cosine (RRC) filter with $\alpha = 0.15$ or 0.25:

| | |
|---|---|
| P1dB out | 24 dBm |
| Gain | >10 dB |
| Center Frequency $f_c$ | 29 GHz |
| Bandwidth | 200 MHz |

(2) Base Station PA
This will be used with modulation ranging from QPSK to 64 QAM and RRC filter with $\alpha = 0.15$ to 0.35:

| | |
|---|---|
| P1dB out | 30 dBm |
| Gain | >10 dB |
| Center Frequency $f_c$ | 29 GHz |
| Bandwidth | 1 GHz |

In both cases, the following parameters should be provided:

| |
|---|
| P1dB out |
| Gain |
| Output SNR |
| Center Frequency $f_c$ |
| Bandwidth |
| Efficiency |

and the following measurement data is requested:

| Parameters | Conditions | Why is it important? |
|---|---|---|
| **Gain** | Small-signal (at $f_c$) | Required for system simulation tools using a polynominal model of the PA [1]. |
| **P1dB** | Input power at 1 dB compression (at $f_c$) | |
| **IP3** | Two-tone result based on **IM3** measurement (submission should specify the two frequencies) | |

| | | |
|---|---|---|
| **AM-AM**<br>**AM-PM** | AM-AM: dBm vs. dBm<br><br>AM-PM: degrees vs. dBm<br><br>Measure at $f_c$; repeat at band edges. | Required for system simulation tools using a behavioral model of the PA [2].<br><br>Could also be used to find a Saleh-like formula that fits the conversion curves [4]; this is suitable for incorporation into common system simulation tools. |

| | | |
|---|---|---|
| **Small signal scattering parameters** | At least 100 frequencies equally spaced across the specified bandwidth | System model can be improved [3] by taking into account the frequency dependence of the gain. |

| | | |
|---|---|---|
| **ACPR** | $ACPR=\frac{\text{power in the upper or lower adjacent channel}}{\text{power in the main channel}}$<br><br>Stimulate with QPSK, 16-QAM and 64-QAM, at Symbol Rate = 10 to 40 Mbaud and RRC filtered w/ ROF = 0.15, 0.25 and 0.35. In submission, specify conditions, including channels. | To validate PA model using AM-AM and AM-PM data.<br><br>ACPR is a good linearity figure-of-merit for digital wireless system. Behavioral models simulate this figure, but measurements are still needed to see how good the model is. |

Contributions that relate experience in simulating systems with the PA and comparing these simulation results with real life behavior are welcomed, as are suggested models and other comments.

## Appendix

A nonlinear Power Amplifier (PA) model for 802.16 simulations should satisfy the following requirements:

- model must determine the signal envelope at the output of the PA given the input signal envelope (such a model could be used to predict, with a given input, the output spectrum, ACPR or other spectral regrowth figures, and EVM)
- model should be capable of taking into account the frequency dependence of the nonlinear response across the bandwidth, if such an effect is non-negligible
- the model parameters, including distortion parameters, must be externally measurable from real PAs.
- the model must not require a large amount of computation.

In order of presumed increasing accuracy, the models available are:

- Polynomial models [1]:

Gain compression is calculated according to a polynomial decomposition. The coefficients of this polynomial are determined by the amplifier linear gain, P1dB, and the third order intercept point (IP3); these parameters are commonly provided on data sheets. In general, since this model does not account for phase distortion in the envelope transfer function, it cannot accurately predict spectral regrowth.

- Behavioral models [2]:

The model parameters are the measured conversion curves, also known as AM-AM and AM-PM conversion.

- Frequency dependent models [3]:

If conversion curves happen to vary across the system's large band of operation, small-signal frequency response of the PA can be taken into account.

## References

[1] Fu-Ling Lin, Shin-Fu Chen, Liang-Fang Chen, and Huey-Ru Chuang, "Computer simulation and measurement of error vector magnitude (EVM) and adjacent-channel power ratio (ACPR) for digital wireless communication RF power amplifiers, " Vehicular Technology Conference, Fall 1999, Volume 4, pp. 2024 -2028.

[2] J.S. Kenney, and A. Leke, "Power Amplifier Spectral Regrowth for Digital Cellular and PCS Applications," *Microwave Journal*, vol. 38, no.10, pp.74-92, October 1995.

[3] M.S. Muha, C.J. Clark, A.A. Moulthrop, and C.P. Silva, "Validation of Power Amplifier Nonlinear Block Models," 1999 IEEE MTT-S International Microwave Symposium, 1999, pp.759-762 vol.2.

[4] D. Falconer, T. Kolze, Y. Leiba, and J. Liebetreu, "Proposed System Impairment Models," IEEE 802.16.1pc-00/15, February 2000.