Memory Effects Measure for Improved Digital Predistortion Tuning

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Understanding the impact of memory effects is key for an RF engineer designing amplifiers for use with baseband digital predistortion linearization. Qualitative measures of "memory effects" have been previously proposed which attempt to capture the essence, describe the causes of memory, and relate the impact to digital predistortion linearizability. [1-3] In this paper an approach is presented, using a "measure" to characterize memory effects, which will assist designers in achieving improved tuning for digital predistortion performance. This paper will demonstrate that this "measure" of memory effects shows significant statistical correlation to the linearity performance of the power amplifier device, and will be demonstrated for amplifiers that can be used for 3G and WiMAX basestations.

Both engineers and test equipment suppliers have demonstrated the value of measuring modulated AM/AM and AM/PM of an amplifier. [Figure 1a, 1b] Typically, a designer would consider the visual spread (variation) of the data in the plots to qualitatively represent the memory effects of the amplifier. To further enhance this, the proposed measure is a calculated standard deviation of the modulated AM/PM of the amplifier, tested using the appropriate modulation standard, and measured at the desired average power point for which the amplifier must operate.[Figure 2] The proposed measure has been termed "Average Power Phase Dispersion" (APPD). By having a-priori knowledge of the test signal and capturing the IQ of the signal at the output of the amplifier, the APPD can be calculated. APPD then becomes a numeric measure representing memory effects for the specific amplifier. By minimizing APPD, the amplifier designer will improve the linearity of the amplifier under test.

In basic terms, digital predistortion allows an amplifier to achieve an improved linearity when the device is pushed further into compression. The fact that the amplifier is more compressed also provides a boost in efficiency. A typical measure of compression that PA designers use is peak to average ratio (PAR), which is often times calculated using the CCDF of the received signal and choosing the 0.01% point. PAR by itself does not guarantee a specific linearity for a device. From the parts measured thus far, APPD has a higher statistical significance than PAR compression in correlating device linearity to digital linearized performance. [Table 1]

Though this is not the "Holy Grail" of figure of merits which could both predict the exact amount of "improvement" of an amplifier using digital predistortion, and give all the reasons for memory effects demonstrated in an amplifier, it has statistically been proven to be useful in improving the tuning/building of amplifiers. Future efforts include continuing to refine APPD measurements, set APPD limits, and further correlate other amplifier technologies and topologies to actual linearized performance, all of which will help designers improve amplifier design capability.

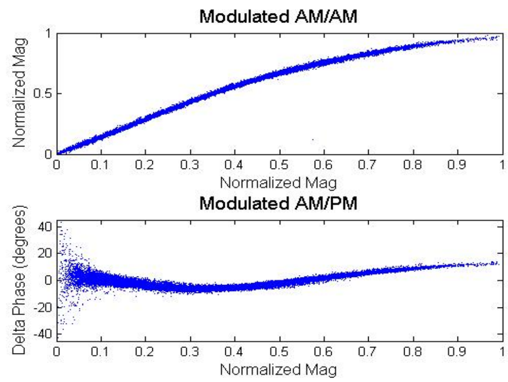

Figure 1: Modulated AM/AM and AM/PM

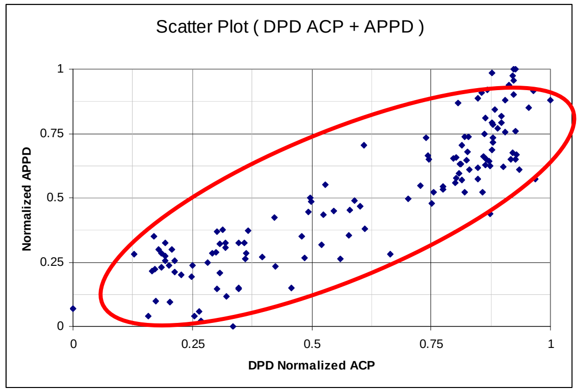

Figure 3: Scatter Graph of APPD to DPD Linearity

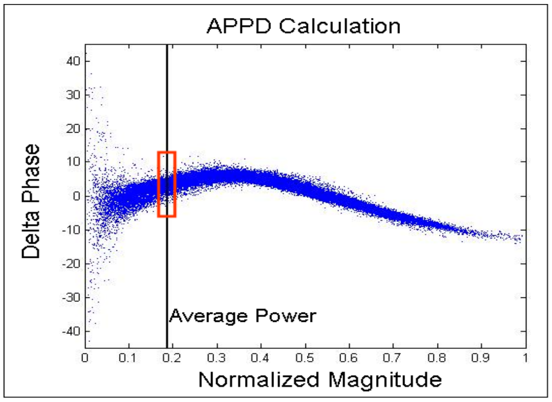

Figure 2: Calculation of APPD

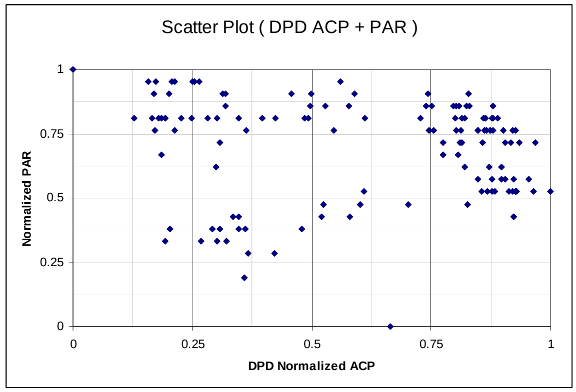

Figure 4: Scatter Graph of PAR to DPD Linearity

Table 1: Correlation Values

(44 amplifiers tested at 3 frequencies Pearson Correlation Coefficient)

	APPD	PAR
DPD ACP	0.8865	-0.0996
EFF	0.3134	-0.7814
Gain	-0.6814	-0.1645

Bibliography:

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3. Ku, Hyunchul, McKinely Michael, Kenney, J. "Quantifiying Memory Effects in RF Power Amplifiers", IEEE Transactions MTT, Vol. 50, No. 12, Dec. 2002