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A Peak-Search Algorithm for Combined PAE and ACPR Load-Pull

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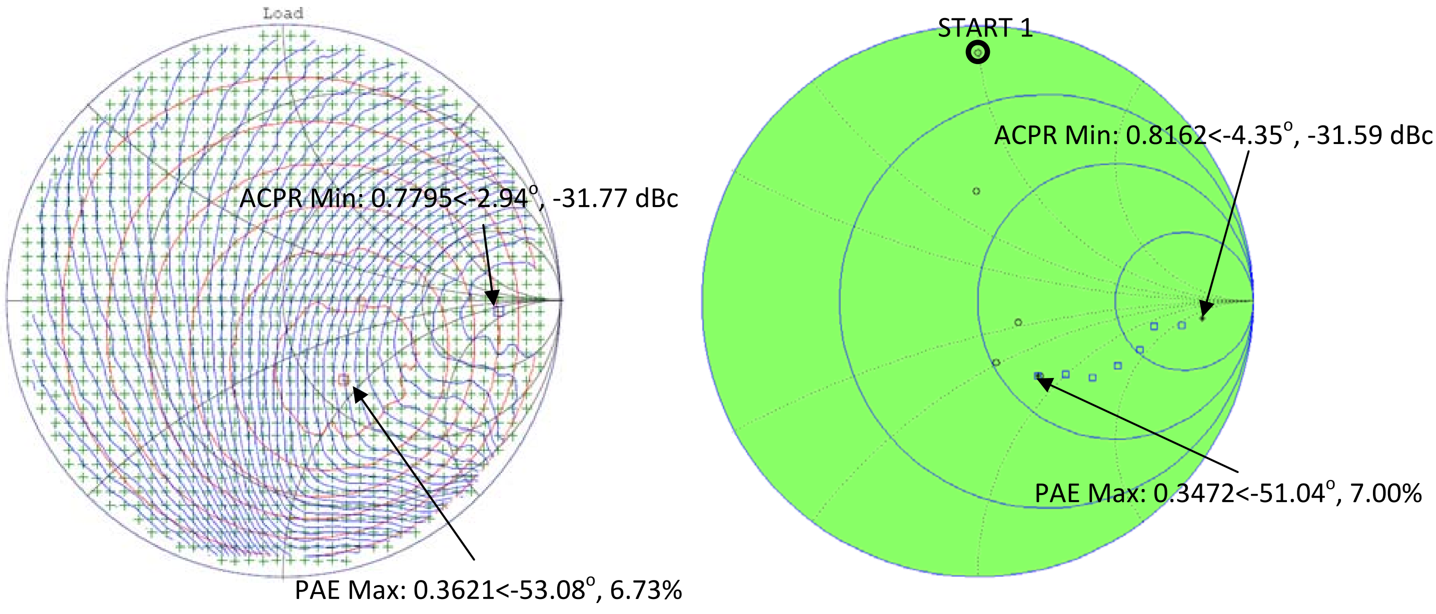
ABSTRACT

Maximizing amplifier PAE and associated output power is critical to preserving the detection capabilities of radar systems. The conflicting criterion for maximizing efficiency is amplifier linearity, which is a well studied tradeoff [1,2]. ACPR shows a measure of linearity by directly quantifying the spectral leakage produced at the amplifier output. Load pull techniques are can be used to measure the PAE and ACPR as a function of load reflection coefficient. PAE and ACPR data can be used by a designer to achieve a desired amplifier output. Temperature dependencies, however, are known to cause changes in the amplifier output over time. Additionally, the recent interest in cognitive systems requires systems to operate under different modulation schemes. These two factors cause the designed amplifier matching network to become less effective under different operating conditions.

The work demonstrated in this paper improves upon the previous test bench in [3] by implementing a real-time ACPR load pull. The steepest ascent algorithm has been suggested in implemented in [4-7] for maximizing unimodal amplifier characteristics on the complex impedance plane. The aim of applying intelligent search methods is to reduce the number of queries required to obtain an optimal tradeoff between linearity and efficiency. The algorithm begins by performing a steepest ascent for a known unimodal set using a large step size, such as PAE. Each iteration of the algorithm requires that three impedance points be measured for PAE, which include the initial and two neighboring impedance points. The distance of these two neighboring impedances from the initial point determines the resolution of the search. The three impedances are use to identify the gradient of ascent for the occupied region. The next candidate point is identified by stepping a set distance in the direction of gradient ascent. The algorithm continues until the candidate point is smaller than the initial point, and results in step size reduction. Candidate points are queried until the step size approaches the distance between the initial point and its neighbors. Once this level of accuracy has been reached, three additional points are measured around the final candidate point and a least squares fit is performed. The extrema of this fit approximates the true PAE maximum. A second steepest ascent for ACPR begins at the maximum of the previous dataset with a step size equal to the neighboring point distance. Using a smaller step size for the second routine allows for the Pareto front between the two datasets to be approximated. The Pareto front contains load-reflection coefficients which provide an optimal tradeoff between PAE and ACPR, which can be utilized in real time to adjust the amplifier circuitry to unknown spectrum demands.

The bi-objective optimization is performed using a radar chirp excitation for six initial load reflection coefficients to demonstrate the system robustness. The convergence of these instantiations is compared to a load-pull standard in Figure 1a. The results of one initial stating point at a normalized reflection coefficient $0.9\angle 90^{\circ}$ are shown in Figure 1b, where the candidate points are indicated along the steepest ascent path. Figure 2 shows the paths for convergence taken by each of the initial six starting locations. The results of the test are tabulated in Table 1. The load pull extrema are identified in the upper portion of Table 1 as a standard for the measurement. The table also shows the results for all initializations for PAE and ACPR as well as the deviation of their mean from the standard. The critical

figure of merit for the accuracy of this test is the magnitude of the complex standard deviation, which describes the magnitude of the complex mean from the standard. This value is shown to be less than 0.1 for both PAE and ACPR, which is accuracy on the order of the exhaustive load pull standard.



(a) (b)

Figure 1: Traditional Load-Pull with 1000 Queries (a) and Sequential Steepest Ascent for PAE (circle) and ACPR (square) with 46 Queries (b)

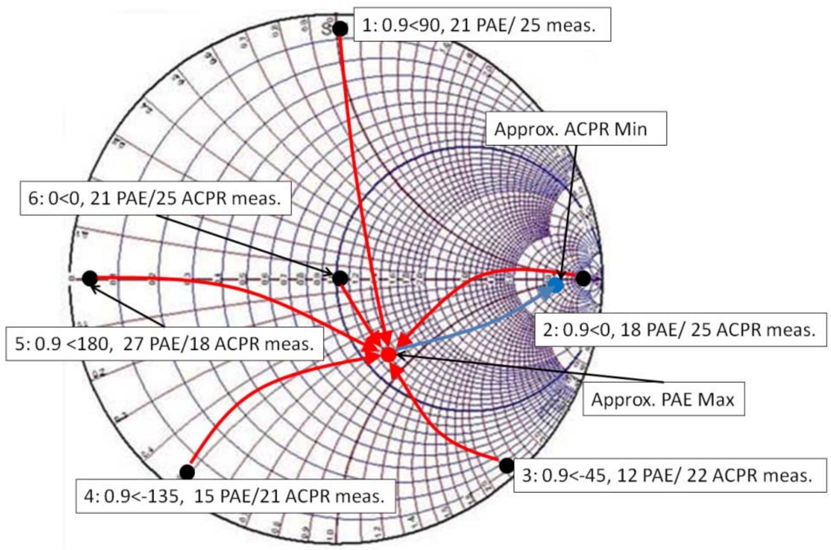


Figure 2: Initial Starting Points and Associated Convergence Paths

PAE Data Analysis			
	Resistance	Reactance	PAE Value
Mean:	1.361180063	-0.7988641	6.971472167
Standard Deviation:	0.124145414	0.16150114	0.08574343
Complex Mean (Rectangular): 0.2405-j0.2564			
Magnitude of Complex Standard Deviation: 0.0223			

ACPR Data Analysis			
	Resistance	Reactance	ACPR Value
Mean:	9.206037952	-2.1641172	-31.55460333
Standard Deviation:	2.915267993	2.32658164	0.078731224
Complex Mean (Rectangular): 0.8081-j0.0338			
Magnitude of Complex Standard Deviation: 0.0329			

Table 1: Comparison Data for Six Steepest Ascent Initializations

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