Real-Time Amplifier Impedance Optimization Using a Nonlinear Tunable Varactor Matching Network with Power-Dependent Characterization

Sarvin Rezayat[*(1)], Zach Hays[(1)], Christopher Kappelmann[(1)], Matthew Fellows[(1)], Charles Baylis, Ed Viveiros[(2)], Abigail Hedden[(2)], John Penn[(2)], Ali Darwish[(2)], and Robert J. Marks II[(1)]

(1) Wireless and Microwave Circuits and Systems Program, Department of Electrical & Computer Engineering, Baylor University, Waco, TX, USA
(2) Army Research Laboratory, Adelphi, MD, USA

Dynamic spectrum allocation is being proposed as a method to more effectively share the radio spectrum. Reconfigurability allows circuitry to operate with high efficiency while meeting changing operating-frequency and spectral mask requirements. This presentation demonstrates the practical implementation of a real-time circuit optimization using a tunable-varactor matching network as the amplifier load matching network. Because the power amplifier is one of the most important and largest consumers of power in a transmission chain, the power added efficiency (PAE) of an amplifier is crucial in the efficiency of a transmitter. A fast algorithm is implemented for real-time adjustment of the varactor tuning network to maximize the amplifier PAE while maintaining acceptable adjacent-channel power ratio (ACPR). This tunable network is characterized by recording the resulting reflection coefficient at different combinations of the control voltage. Data is presented that shows the effects of varactor network nonlinearities on the characterization. As such, the varactor network must be characterized over a range of input power levels that span the range of expected transistor output power values. Characterization results are combined into a power-dependent characterization look-up table. This power-dependent characterization provides more accurate measurement results because it takes into considerations the changes in the S-parameters of the matching network as it becomes nonlinear.

To use the power-dependent characterization, the algorithm estimates the transistor output power and locates this power value's characterization in the look-up table for each measured reflection-coefficient state. The ability of the power-dependent characterization to accurately tune the adaptive tunable-varactor network is demonstrated by presenting fast tuning algorithm results and load-pull data from the tunable varactor network. Load-pull results for the varactor tuner are compared with measurements from a traditional mechanical load-pull tuner. The power-dependent characterization is shown to result in more accurate measurement assessment of load-pull contours than using only a traditional, single-power characterization performed at small-signal power levels. In the fast search to maximize PAE under ACPR constraints, results show that using the power-dependent characterization results in quicker convergence for the algorithm and more accurate identification of the optimum. The characterization and optimization demonstrated in this work is expected to find application in reconfigurable radar and communication transmitter power amplifiers.