The Smith Tube: Providing the Foundation for Real-Time, Spectrally Sensitive Circuit Optimizations

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The present shortage of radio spectrum requires new and innovative approaches for radar and communication coexistence. For radar transmitters, the joint optimization of the circuit and waveform in real-time has been proposed as a solution. Real-time circuit optimizations have been demonstrated (Qiao, *IEEE Trans. MTT*, 2005), and our previous work includes algorithms for fast circuit optimizations (Fellows, *Radar, Sonar & Navigation,* 2014 and Martin, *IEEE Trans. MTT*, 2014). The challenge in creating useful optimizations is the simultaneous optimization of multiple parameters from both the circuit and the waveform. The Smith Tube, a cylindrical extension of the well-known Smith Chart shown in Fig. 1(a), provides an optimization space for multiple-parameter optimization. As a vertical extension of the Smith Chart, the Smith Tube allows plotting of desired characteristics versus an additional input parameter, to be placed on the vertical axis. In typical power-amplifier design, designers attempt to optimize bias voltages, input power, and load reflection coefficient (Γ_L) through multiple measurements to obtain desirable power efficiency while obtaining acceptable spectrum performance and delivered power. In addition to bias voltages, input power, and reflection coefficient, radar operators may desire to add input variables and optimization criteria (including radar waveform parameters and metrics).

In this talk, joint optimization of Γ_L and waveform bandwidth using the bandwidth Smith Tube is reviewed. Joint design for Γ_L and input power using the power Smith Tube is also demonstrated through simulation and measurement (Fig. 1(b)). Optimization for multiple output criteria (power-added efficiency, adjacent-channel power ratio, and delivered power) and the concept of multi-dimensional Smith Tubes for simultaneous, multi-input-parameter optimizations are discussed. The talk concludes by looking toward computationally intelligent Smith Tube procedures for real-time, measurement-based optimizations of multiple input parameters for multiple optimization criteria.

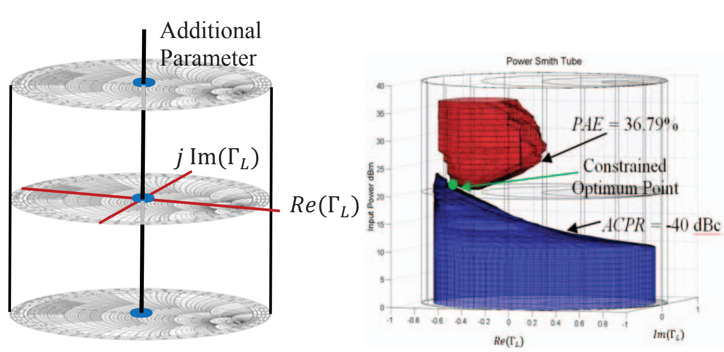

Fig. 1. (a) The Smith Tube. An additional parameter can be plotted on the vertical axis, allowing optimization with multiple input parameters, (b) plot of surfaces from nonlinear device model simulations demonstrating PAE (power-added efficiency) = 36.79% and ACPR (adjacent-channel power ratio) = -40 dBc, in a Smith Tube with power as the vertical axis.