Dual-Loop Joint Circuit and Waveform Optimization Technique for Ambiguity Function, Spectral Performance, and Power Efficiency

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This presentation describes results of a dual-loop joint circuit and waveform optimization algorithm that will allow tuning of a reconfigurable transmitter circuit in real-time to meet changing operating frequency, spectral constraints, and ambiguity function objectives. This capability will be needed for transmitters to operate in a dynamic spectrum allocation environment. The optimization attempts to maximize the power-added efficiency (PAE) while meeting ambiguity function objectives and spectral constraints. Woodward's ambiguity function is defined as at time displacement τ and frequency displacement u from the time and frequency of the actual target. The ambiguity function is defined as

$$\chi(\tau, u) = \int_{-\infty}^{\infty} x(t)x^{*}(t-\tau)e^{-j2\pi ut}dt,$$

where τ is the time displacement from the actual time delay to the target, u is the frequency displacement from the actual Doppler frequency of the target, and $x(t)$ is defined as the radar's waveform.

Standard approaches often focus on separate optimization of the waveform and circuit, but for a general nonlinear power amplifier, this is not expected to give the optimum joint solution. In joint optimization, the input waveform to the amplifier and the power amplifier load matching network are optimized in parallel. The objective of this approach is to find the best combination of circuit and waveform to maximize the PAE while minimizing the error in the ambiguity function and maintaining spectral compliance.

The optimal ambiguity function is calculated using a variation of projection onto convex sets, where each set includes a different requirement. When an optimal waveform is chosen by the ambiguity function algorithm, the best performing waveform is updated into the ongoing circuit optimization, which adjusts the load impedance to optimize the PAE, while maintaining the spectral compliance. These two operations continue simultaneously, allowing simultaneous tuning of the waveform and circuit for high-efficiency performance with desired ambiguity properties while meeting spectral constraints.