Non-Foster Impedance Matching of a Monopole Array

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Antenna arrays enable various beamforming and multiple-input multiple output (MIMO) schemes. However, implementing these techniques on compact mobile platforms is challenging because the space required for the customary $\lambda/4$ to $\lambda/2$ (λ is the wavelength) element size and spacing is often not available, especially below 1 GHz. When the spacing is less than $\lambda/4$, beamforming becomes superdirective—which leads to high quality factor (Q) and its associated tradeoff between bandwidth and efficiency when using passive matching techniques—and MIMO becomes problematic due to mutual coupling. Decoupling networks transform arrays with mutual coupling into arrays with independent beams (e.g. Volmer *et al.*, *IEEE AWPL*, 7, 613-616, 2008), enabling compact MIMO and adaptive beamforming with port impedances that are not a function of the beam. However, passive decoupling networks do not solve the problem of the high Q of superdirective patterns.

Non-Foster matching, on the other hand, significantly improves the Q and wideband realized gain of electrically-small antennas. The authors have proposed a non-Foster matching network for a 2-element monopole array comprising 3 negative capacitors that cancel both the self and mutual reactance (White, *IEEE APS Symp. Proc.*, 2012). The impedance and transducer gain were evaluated by decomposing the array into even and odd modes; it was shown that while employing non-Foster circuits (NFCs) in series with the antennas cancels the odd mode reactance, attempting to cancel the even-mode reactance in this manner leads to instability. Fortunately, employing a third NFC connected between the two antennas solves the stability problem, enabling the even mode to be matched. In fact, the three NFCs enable simultaneous reactance cancellation of both even and odd modes.

The proposed non-Foster monopole array has been realized with all NFCs implemented in a single 1.6 x 1.6 mm^2 die using the IBM 8HP SiGe BiCMOS process. In addition, two reference antennas were realized: a passive un-matched array and an array with only the series NFCs. The measured input impedance matrices, radiation patterns, and stability observations will be presented. It will be shown that the measured data validates the predictions of the prior work.