A frequency-selective tunable power amplifier for broadband phased array transmitters

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Wideband phased antenna array technology covering multiple octave bandwidths are predicted to provide unprecedented functionality such as simultaneous beams at different carrier frequencies, larger signal bandwidths, and shorter latencies. One of the many challenges in implementing such an array is the inherent low efficiency of the power amplifier (PA) and high noise figure of the low-noise amplifier (LNA) in the broadband front end. Adaptive impedance matching combined with adaptive filtering is needed to improve the efficiency of the PA/switch/antenna component and the noise figure of the antenna/switch/LNA component.

Recent research efforts in this area have primarily focused on the design of tunable matching networks as variable output/input loads of PAs with the purpose of achieving flat gain and efficiency. Such an example is reported in (A. Wiens et al., EuMC 2014), though it does not take into consideration frequency-band selectivity. In another approach, tunable filters are used as frequency selective output matching networks of PAs in order to functionalize an enhanced-isolation bandpass filtering response with reduced number of components (K. Chen, T. C. Lee and D. Peroulis, IEEE Microwave and Wireless Components Letters, 23, 12, Dec. 2013). This RF co-design techniques results in higher gain and efficiency as opposed to a conventional RF design technique of in-series cascaded RF blocks (in this case, the PA, matching network, and filter). These implementations have thus far been limited in maintaining a wide tuning range.

This paper addresses frequency-selective bandpass matching networks for transistor amplifiers with gain optimized over an octave bandwidth. A continuously tunable second-order band-pass matching network topology is investigated through the design of a 2-4GHz gain-optimized class-A amplifier based on a packaged GaN device (Qorvo TGF2977-SM HEMT). The transistor capabilities are analyzed in NI/AWR MWO using load-pull in harmonic balance nonlinear simulations from 2 to 4 GHz in 500MHz steps with a static broad-band source matching network in place. The load network is then designed to cover a sub-band within the octave. For example, preliminary simulations of a 4GHz narrowband power amplifier, designed on a 30-mil Rogers4350B substrate using a mechanically tunable capacitor (Murata TZB4Z100BA10R00), show the load network return loss varies from 18 to 35 dB with tuning, with a gain of 11dB, output power of 4.54W, 3dB-bandwidth of 600MHz and a PAE of 45%. Similar values can be obtained in all sub-bands of operation in the 2-4GHz octave band. Details of the designs and experimental results that verify this performance will be discussed.