6-12 GHz Transmit Phased Array Efficiency with Stepped Static Supply Modulation for Beam Shaping

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Transmit phased arrays have been used since the ’60s for military and space applications, and more recenty their use has expanded to other fields such as MIMO communications. Electronically scanned phased arrays with independent RF front-end circuit in each radiating element bring advantages of flexible beam-shaping and scalable effective isotropic radiated power (EIRP). Active circuits present size, weight, power, cost, and cooling (SWaPC2) trade-offs, so circuit miniaturization and simplification is desired. This work presents a study of side-lobe level control of transmit octave-bandwidth phased arrays using static supply modulation of the power-amplifier (PAs) stage of beamforming networks. The PA gain and efficiency is affected by the drain voltage, which can be used to both increase EIRP and taper the array pattern sidelobes. The solution brings a potential advantage of avoiding variable gain amplifiers (VGA), thus decreasing the size of beamforming network bias and control circuits, as well as dissipated power. The analysis is performed by co-simulation between Ansoft HFSS and Cadence AWR, first combining broadband beamforming network nonlinear performance twith passive antenna array coupling in the circuit simulator. This results in a set of excitations for each element that depend on frequency, input power, and drain voltage, which are fed back into HFSS for radiation pattern calculation. In the example presented here, the beamforming network design is composed of a multi-section Wilkinson corporate feed network, cascaded with ideal phase-shifters and Qorvo QPA2598 GaN MMIC PA X-parameters. The PA X-parameters are defined for drain voltages varying from 10-24V. The passive antenna array is composed of 4 small broadband horns in a linear array as in Fig.1 (left). A secondary analysis is done by observing power added efficiency (PAE) and overall beamformer performance degradation with active scan impedance.

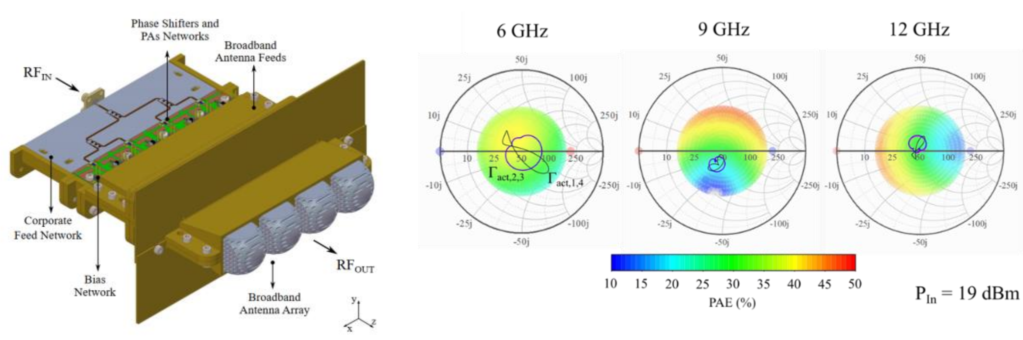

Figure: Left: Linear 4-element transmit antenna array . Right: PAE of power amplifiers in the array for Pin = 19 dBm, shown together with active scanning impedance at 6,9 and 12 GHz.