OBJECTIVE: Develop electronically steerable radio frequency (RF) transmitters over multi-octave bandwidth yet with optimum power efficiency to achieve simultaneous multi-octave bandwidth high-efficiency performance.

DESCRIPTION: Electronically steerable RF transmitters are highly demanded in battlefield communication and electronic warfare systems. Traditional approaches are mostly based on phased arrays in which phase shifters are used to steer the antenna beam and power amplifiers are used to provide the transmitted power. Such architectures, however, suffer in several aspects when multi-octave operations are needed. The grating lobes of antenna array may appear at the higher end of the operating band and destroy the aperture efficiency while the mutual coupling between the antenna elements in the lower end of the band may negatively affect the antenna to transmitter impedance match and thus the radiation efficiency. On the other hand, the trade-off between bandwidth and efficiency in any RF transmitter often must be made according to the famous Bode-Fano limit, which indicates that a good impedance match to a high-Q load cannot be achieved over a wide bandwidth. For this reason, multi-octave RF power amplifiers (PA) are usually not efficient as the existence of transistor parasitics limits the impedance match bandwidth unless a sub-optimal impedance matching condition is used. Similarly, in antenna systems, the form factor constraints often require high-Q, narrow band antenna elements rather than broadband antennas. Multi-octave impedance match to a single antenna is usually impossible. A conventional Ultra-Wide Band (UWB), electronically steerable RF transmitter can thus not be efficient for the above reasons, which in turn limits its maximum operating power for a fixed design of heat dissipation. Tunable components that may tune the matching between antenna and power amplifier to adapt to its operating frequency have been proposed. These components are mostly in the form of switches or variable capacitors made of microelectromechanical systems (MEMS) or phase change material, which may suffer limited power handling and add additional power loss caused by the tuning mechanisms.

Develop a novel, power-efficient, multi-octave electronic steering antenna array architecture that integrate power amplifier and antennas simultaneously for both bandwidth and efficiency while using a power amplifier network to generate a phase slope required for electronic scanning.

PHASE I: Design, develop, and demonstrate an efficient transmitter and antenna array architecture that allows efficient transmission of RF signal with more than 40 dBm power and with the overall system power efficiencies over 50% from 2GHz to at least 4GHz, preferably 8GHz, while being electronically steerable over at least +/-45 degrees. Identification of the appropriate electronics technologies and antenna design must be made during this phase, with feasibility demonstrated through simulation results. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Further develop and perform hardware demonstration of the Phase I concept and the predicted performance in a small scale, with aperture size equivalent to four to eight element phased array. Ensure that the minimum antenna gain will be no less than the ideal aperture gain by 3dB. Prepare the metrics of evaluation that include a chart of power efficiency as a function of both frequency and scanning angle.
PHASE III DUAL-USE APPLICATIONS: Integrate Phase II designs to test installed on an aircraft platform with a goal of maintaining RF performance from Phase II in an installed aircraft environment. Successful technology development would benefit airborne- and ground-based radar systems, aviation, and large communication base stations.

REFERENCES:

KEYWORDS: High-Bandwidth; High-Efficiency Antenna Array; Multi-Octave Transmitter; Integrated Antenna Array With Power Amplifiers