Development of a Wideband class-E Power Amplifier with High Efficiency

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High power high efficiency power amplifiers are needed for modern communication systems. However, it is challenging to achieve high efficiency across a broad band. The design should consider operation on a switching mode and account for higher order harmonics, as well, to improve the PA performance. Previous designs like "H. Xu et al, high efficiency class-E GaN HEMT power amplifier at 1.9 GHz, Microwave and Wireless Components Letters, IEEE, vol.16, no. 1, 2006", only considered the fundamental frequency which led to a relatively low efficiency (57%-62%) over a relatively wide frequency range (1.8 GHz to 2.43 GHz) with 5-7 W output power. Meanwhile, D. Wu, et al.,"Design of a broadband and highly efficient 45 W GaN power amplifier via simplified real frequency technique," IEEE MTT-S, 2010", achieved 56-65% efficiency with an output power of 20-50W over a wider frequency 1.9 GHz to 4.3 GHz. Here, we present our design of a class-E power amplifier to achieve high efficiency > 63% over 1 GHz across the L-band with an output power exceeding 12W.

To achieve such wideband high performance, we accounted for the first and second harmonics in our design. Our initial design was based on a recently published class E-PA efficiency equations given by Keysight Corp. kit released in 2015 (https://edaapps.software.keysight.com) to estimate various matching parameters like the series inductor and shunt capacitor, and load resistor required to sustain the design goals. Subsequently, we utilized these lumped elements for the output matching networks and using the nonlinear model of a GaN HEMT transistor represented as a switch (CGH40025F, Cree); where parasitic effects were included in the Advanced Design Systems (ADS) model. The circuit was optimized over 1 GHz to 2 GHz frequency range to obtain a class-E operation. Lumped element design was subsequently replaced by microstrip-distributed elements. Two RF chock were used to bias the drain and gate of the PA. The drain-source voltage of the PA was tuned across L-band to get maximum efficiency, but gate voltage was constant and selected to be -4V for the GaN HEMT transistor. The simulation results showed 66%-89% power efficiency, 12-30W output power across the L-band.

The design was fabricated and the circuit was tested. Measured results show 63-87.9% power efficiency, 12-30 W output power over 1 to 2 GHz frequency band, which are in close agreement with the simulated results.