High Efficiency X-Band MMIC GaN Power Amplifiers

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The design and measured performance of X-band power amplifier MMICs for supply modulated transmitter architectures are presented. Under continuous wave operating conditions, 2-stage MMICs fabricated on a 0.15µm GaN on SiC process demonstrate peak power added efficiencies (PAE) above 60% and output powers above 10W as shown in the figure. The layout of the 2.3x4mm MMIC is shown in the figure below, which has 3.6mm of gate periphery on the output stage.

Modern communication signals have increasingly high peak-to-average power ratio (PAR) and bandwidth signals. However, high PAR signals are difficult to amplify with high efficiency because the average power is much less than the optimal saturated output power. Typical high efficiency power amplifier modes (class F and E) are not efficient under back off. Additionally, high efficiency modes are highly non-linear requiring the transmitter to have large amounts of digital pre-distortion (DPD), and as such, are not suited for communication transmitters. Drain modulation mitigates some of the efficiency loss by moving the optimal saturated output power dynamically with the input envelope.

The power amplifiers presented here are designed to work across a range of drain bias voltages to achieve high efficiency at lower output powers (S. Schafer *et al.* "X-Band MMIC GaN Power Amplifiers Designed for High-Efficiency Supply-Modulated Transmitters," IEEE MTT-S International 2013). Design methodology and performance under back off is investigated. For use in a transmitter, there are various methods to implement drain modulation (also known as a trajectory), including vector split or polar modulation, envelope elimination and restoration, and partial supply/drive modulation among others. Various trajectories are simulated to allow for high PAE and/or linearity. Implications and requirements for the supply modulator are discussed.