

W-band MMIC Power Amplifiers using 90-nm GaN-on-SiC Technology

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This paper presents the design and performance of two W-band power amplifier (PA) in single-ended and balanced amplifier configuration. The W-band MMICs presented here are designed in Qorvo's 90-nm gamma-gate GaN-on-SiC HEMT research process, with passives in the Qorvo 3MI 3-metal interconnect layer process that provides TaN resistors and various capacitor configurations. The EEHEMT nonlinear models of the $4 \times 40 \mu\text{m}$ devices are validated by measurements.

A 4-stage, 4-way power combined MMIC PA with 1:1 drive staging is chosen for a single-ended PA design. The output stage $4 \times 40 \mu\text{m}$ devices provide a total periphery of $640 \mu\text{m}$. Four stages are chosen to increase the overall saturated gain and provide adequate compression of the output stage, and the total chip size is 3.49 by 1.91 mm^2 . All four stages are biased at 200 mA/mm . The output 4-way power combiner is optimized to achieve maximum output power by matching the transistors to the simulated load-pull impedance. One more level of power combining with Lange couplers in a balanced configuration increases the output power and improves input/output return loss for a second MMIC PA with a footprint of 3.98 by 3.76 mm^2 (Figure 1). The simulated performance of the balanced amplifier in Figure 2 shows a frequency response of $76.6 - 92.7 \text{ GHz}$ and peak output power densities of 1.36 W/mm^2 . This performance demonstrates close power densities to state-of-the-art power densities at W-band (J. M. Schellenberg, IEEE T-MTT, vol. 63, no. 9, pp. 2833-2840, Sept. 2015).

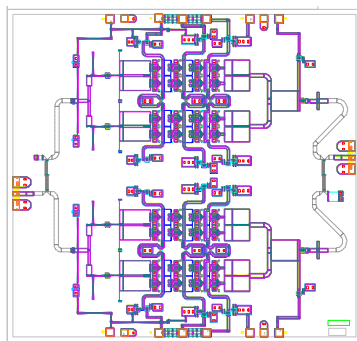


Figure 1. Layout of W-band balanced PA with total output periphery of $1280 \mu\text{m}$ and layout footprint of 3.98 by 3.76 mm^2 .

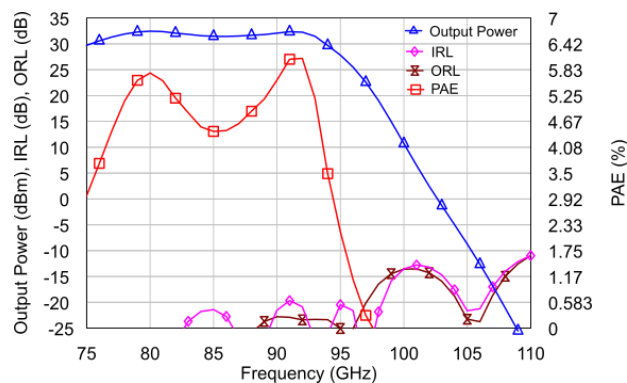


Figure 2. Simulated frequency response for the balanced MMIC amplifier with $+21 \text{ dBm}$ RF input power at $(V_{\text{DD}}, I_{\text{DS}}) = (18 \text{ V}, 200 \text{ mA/mm})$ for the $4 \times 40 \mu\text{m}$ transistors.