A Macom Design

Ka-Band MMIC Power Amplifier

Ka-band technology addressing 26.5 to 40 GHz frequencies is becoming more and more popular for both military radar and commercial communication systems, driving the need for compact, efficient power amplifiers to boost those signals.

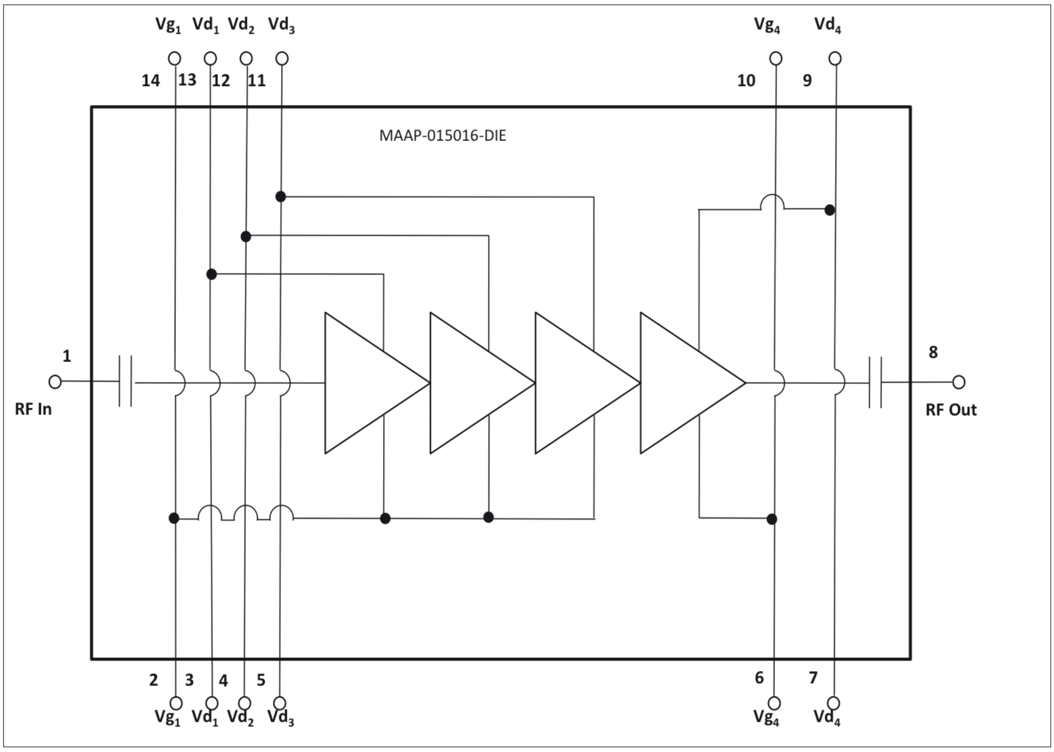

Figure 1: Block diagram of the MMIC

The practical use of load-pull tuners and electromagnetic (EM) simulation software enabled Macom engineers to design a high-frequency, four-stage, MMIC (Figure1) that required extensive EM simulation at a relatively early stage in the design process. The characterization included S-parameter and load-pull measurements taken over wide temperature ranges using load-pull impedance tuners from Maury Microwave Corp. Measured and simulated load-pull data from NI AWR Design Environment simulation software was used to determine the optimum input and output impedances for the MMIC PA.

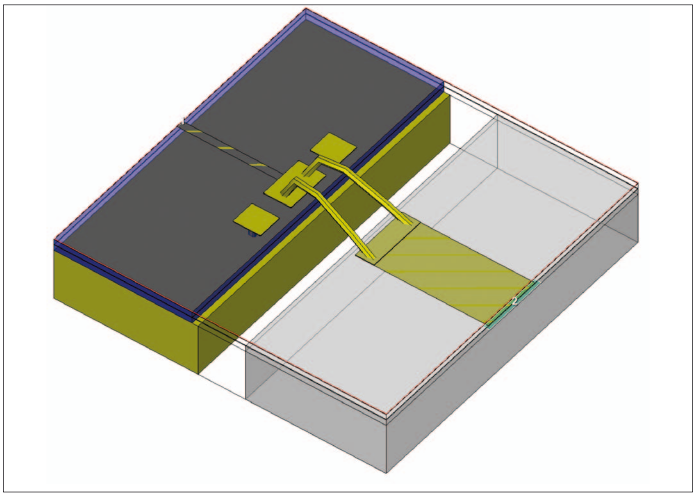

Figure 2: 3D Analyst layout view showing bond wires

Large-signal simulation

A large-signal simulation of an extensive array of saturated transistor cells with good convergence in a reasonable time was called for. In particular, a 3D EM simulation of the RF

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bond wire transition was needed (Figure 2), as well as a 2.5D (3D planar) EM simulation of the IC elements and a full large-signal simulation and optimization of the PA. Foundry models available for the 0.15 µm GaAs process were used for the initial idealized design. Specific design requirements included a competitive size with frequency range of 32 to 38 GHz, Pout greater than 4 W, 18 dB gain fully matched to 50 ohms, continuous wave (CW) and pulsed operation, and on-chip decoupling and electrostatic discharge protection.

Macom designers used NI AWR Design Environment software, inclusive of Microwave Office circuit design software, AXIEM 3D planar EM simulator, Analyst 3D FEM EM simulator, and APLAC harmonic balance (HB) simulator. The software enabled them to successfully design and simulate the 4 W Ka-band PA using a 2-mil thick 0.15 µm GaAs pseudomorphic high-electron mobility transistor (pHEMT) process. Figure 3 is a photograph of the circuit, as well as the corresponding 3D meshed layout view in AXIEM simulator for the output matching section (green traces in photo).

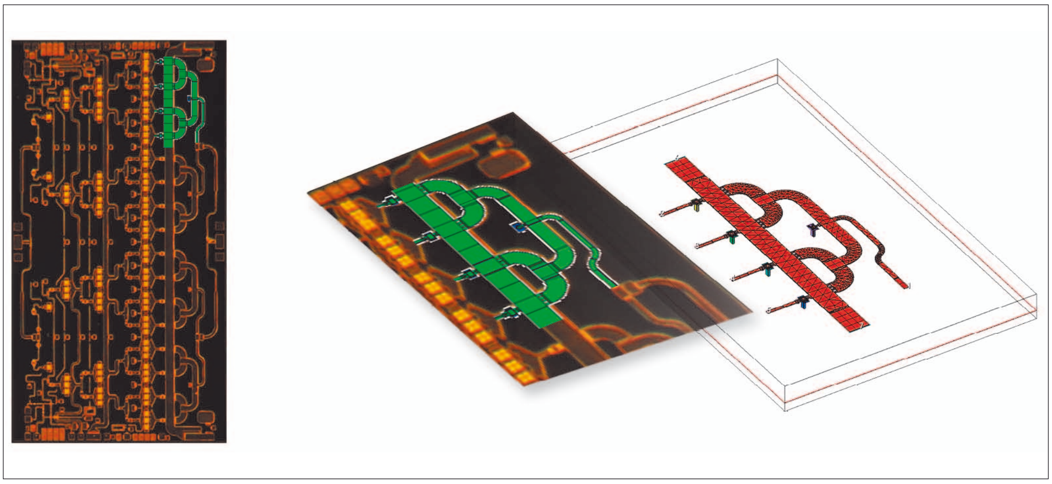

Figure 3: Photograph of the circuit as well as corresponding 3D meshed layout view of AXIEM EM simulator for the output matching section (green traces in photo)

The designers achieved saturated output power in excess of 4 W over the full 32...38 GHz bandwidth, with gain of 19 dB and PAE in the region of 23%. A comparison of measured results with simulated performance as predicted with NI AWR Design Environment software (Figure 4) shows good correlation that validates the design process. As is typical, output power performance measured slightly lower than simulation, while measured PAE is slightly better than predicted by simulation. Despite the variation in magnitude of these parameters, the similar shape of the response curves indicates that the circuit was accurately characterized in simulation.

Excellent performance was verified under both CW and pulsed conditions. The results justified the design approach in terms of device modeling, circuit design, EM simulation, and even thermal considerations.

Quickly simulations

The design team noted that with AXIEM, EM simulations were quick to set up and it was easy to adjust geometry dimensions for performance tuning. Simulation times were reasonable even when simulating from a laptop. Integration with the layout through NI AWR Design Environment software ensured consistency between EM and layout. The APLAC HB engine was fully capable of handling large transistor array simulations with good convergence across the band. The team was especially impressed with the ease of management of the entire design project from measured cell data, EM designs, layout, and reticle design, through to exporting graphs and graphics for reporting.

The MACOM designers chose NI AWR software because of their familiarity with the tool and its intuitive user interface including high- quality layout. The key benefit was excellent correlation between the simulations and measurements. NI AWR Design Environment delivered higher productivity thanks to its ease of use, integration with third-party tools, and superior technical support. ◄

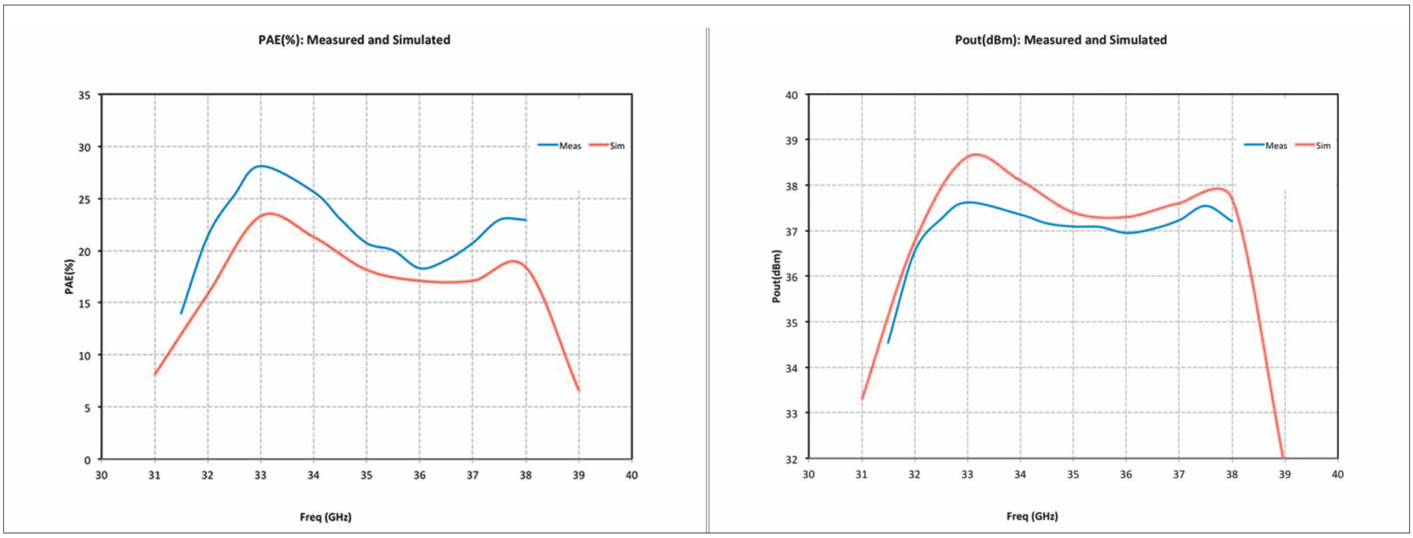

Figure 4: Measured vs. simulated results for PAE and P_{out}