

Success Story

Wavice Research Engineer Designs S-Band IMFET Using NI AWR Software



“The NI AWR software user interface is intuitive and simple, which reduced my design time while delivering high accuracy. In particular, the tuning and optimization features are advantageous for assigning variables to view performance trends.”

Kwanjin Oh, Wavice Inc.

Company

Wavice Inc is a leading defense company in South Korea and equipped with an internal fab that provides a durable RF gallium nitride (GaN) process that has been bolstered by the recent opening of its 0.4 μm foundry service. Wavice is expanding its presence as an integrated device manufacturer within South Korea to the global market with its high reliability and high efficiency products.

Challenge

GaN high-electron mobility transistor (HEMT) devices have been widely adopted as a core technology of choice for many military and commercial RF applications such as long-distance radar, mobile base stations, satellite communications, and more. GaN HEMT high-power amplifiers (HPAs) provide very high efficiency, excellent power handling capabilities, and exceptional tolerance of operational temperature in a wide frequency range.

Long-range radar systems with solid-state PAs often require very high-power output with a very small device size because there is limited installation space. Monolithic microwave integrated circuits (MMICs) are considered the best solution for reducing the size of HPAs, however, the development cost of MMICs can be extremely high when used in low- to medium-volume applications. Internally matching field-effect transistors (IMFETs), a block diagram of which is shown in Figure 1, include impedance-matching circuits that reduce the size of HPAs more than 10 times, while keeping the manufacturing cost comparable to designs with unmatched discrete transistors. In addition, IMFETs keep manufacturing costs lower compared to SMT-based matching networks by reducing the bill of materials.

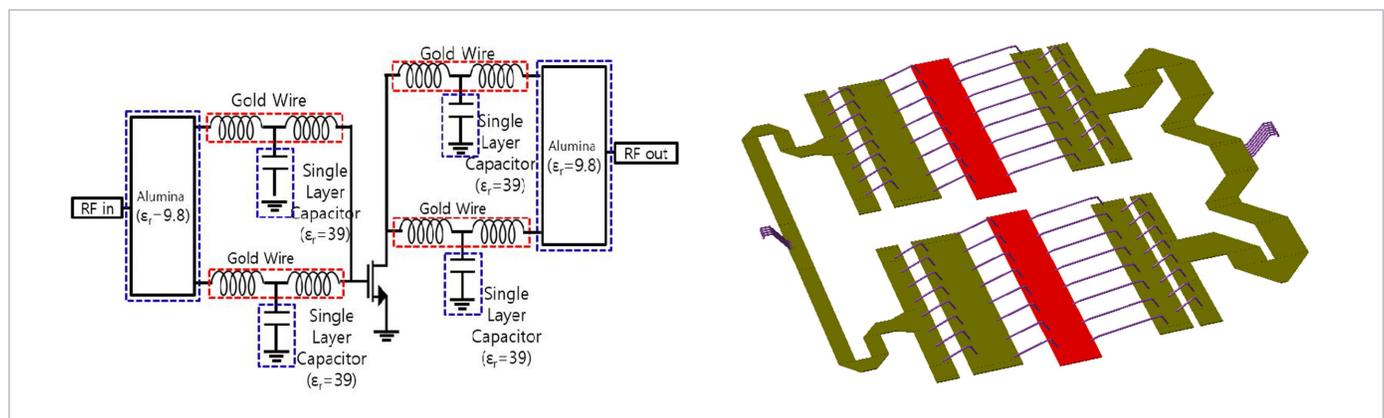


Figure 1: Block diagram and 3D layout of IMFET.

At-A-Glance

Application

- Amplifier

Software

- [NI AWR Design Environment](#)
- [Microwave Office](#)
- [AXIEM](#)

Benefits

- Ease of use
- Reduction in design time
- High accuracy
- User productivity

Solution

The designer chose the Microwave Office circuit simulator within NI AWR software for the IMFET design and used the large-signal model and manufacturer information for the GaN HEMT devices. Load-pull simulation was done at 48-dBm input power (P_{in}), -2.75-V gate voltage (V_g), 50-V drain voltage (V_d), and 1-A drain current (I_d) at 3.4 GHz, which was the center frequency of the target frequency range of 3.2 ~ 3.6 GHz. The matching circuit was designed based on the load-pull simulation results. Figure 2 provides the IMFET simulation results at 48-dBm P_{in} for a 3.1 ~ 3.7-GHz frequency range. The P_{out} and the gain show excellent flatness across the 3.2~3.6-GHz range and the PAE is over 50% for 3.2 ~ 3.6-GHz range.

Figure 3 shows P_{out} (top) and PAE (bottom) as a function of P_{in} for various frequencies. For 3.2 ~ 3.6 GHz frequency range, the P_{out} , PAE, and power gain of over 57.8 dBm, 45.5%, and 9.8 dB were measured, respectively, with 48 dBm P_{in} . The size of the IMFET was 24 mm x 17.4 mm and the P_{out} per unit area of the package was record high as 1.74 W/mm². The P_{out} , gain, and PAE were measured over 55.8 dBm, 9.8 dB, and 57.82% respectively. Figure 4 shows the comparison of simulated and measured data of P_{out} and PAE from a typical IMFET. The measured and simulated P_{out} and PAE are reasonably well matched.

Conclusion

Matching the source and drain impedances using Microwave Office software was straightforward and the load-pull analysis, tuning, and optimization features significantly reduced design time. In addition, the simulation of gold wire (Figure 1), which is important for IMFETs, was easily performed and allowed the designers to optimize the IMFET performance based on wire bond length.

Key benefits of using NI AWR software were ease of use, simulation speed and accuracy, and availability of models, all of which increased the designer's productivity. Of special note were the superiority of the optimization and tuning features, which saved significant design time. AXIEM simulations were accurate and the analysis time fast and efficient.



Special thanks to Kwanjin Oh for his contributions to this success story.

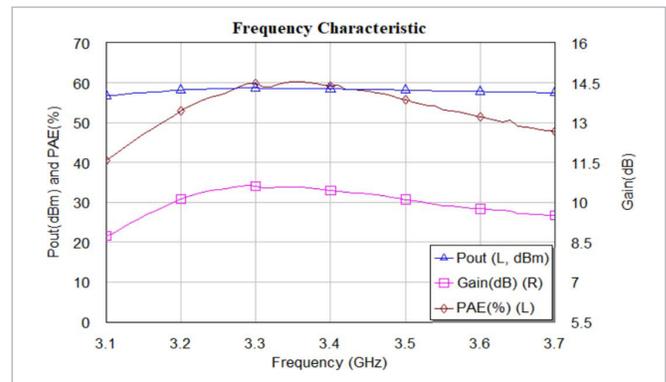


Figure 2: IMFET simulation results.

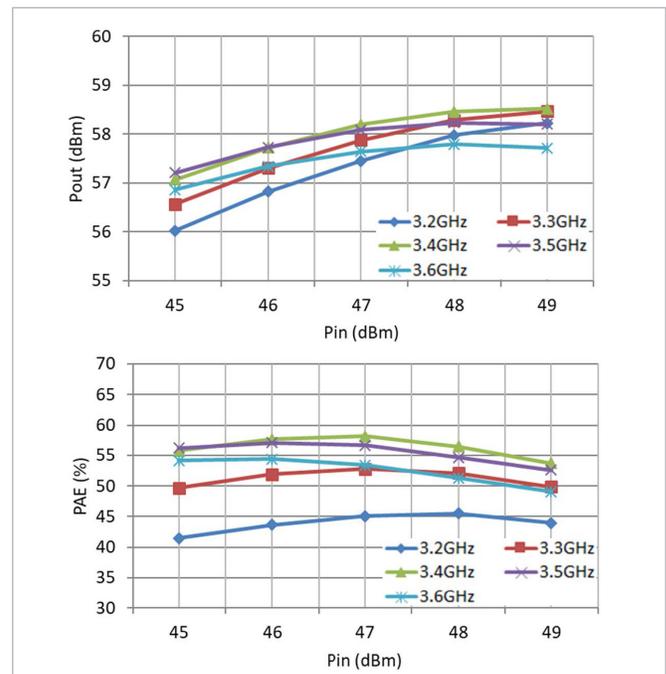


Figure 3: Measured RF performance of the IMFET for P_{out} (top) and PAE (bottom) as a function of P_{in} for various frequency values.

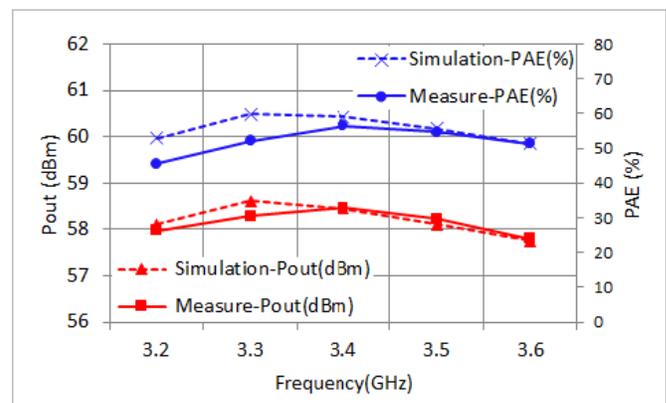


Figure 4: Comparison of simulated and measured data of P_{out} and PAE of IMFET for 3.2 ~ 3.6 GHz.