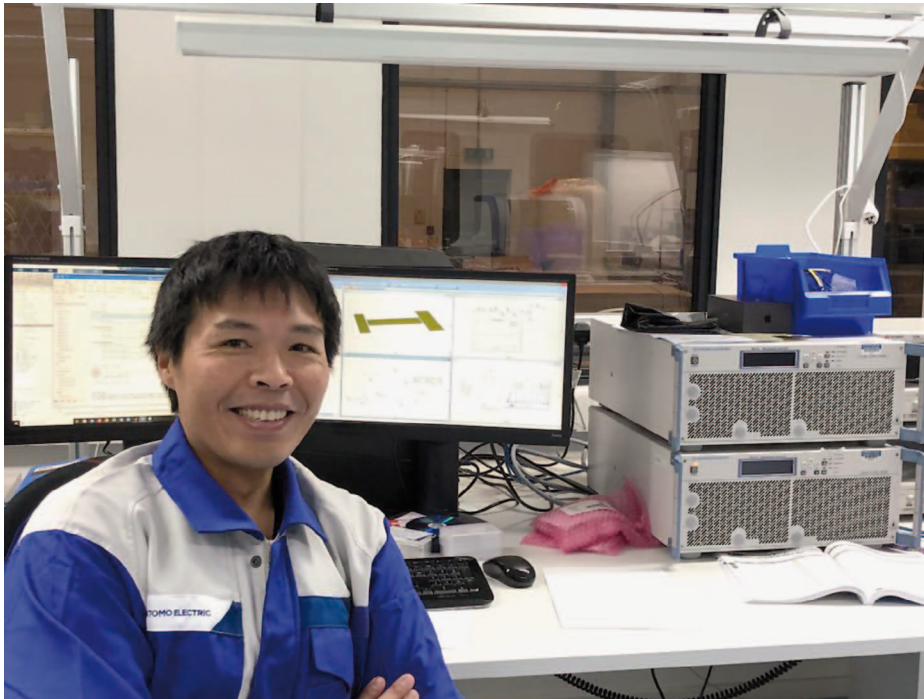


Design of a Compact GaN HEMT Doherty Amplifier



James Wong, RF Specialist, Sumitomo

Sumitomo designers were tasked with developing an innovative high-power, wideband Doherty amplifier covering nearly 1 GHz of operation bandwidth at 2.25 GHz. They used NI AWR Software for best results.

Sumitomo Electric Industries, where the design was done, operates in five business fields: automotive, information and communications, electronics, environment and energy, and industrial materials, and is developing life sciences and materials and resources businesses.

The company focuses on developing new products and is the leading manufacturer of

composite semiconductors in gallium arsenide (GaAs), gallium nitride (GaN), and indium phosphide (InP), which are widely used in semiconductor lasers, LEDs, and mobile telecommunications devices.

Next-generation 4G/5G telecommunication systems require power amplifiers (PAs) to operate with high efficiency over a wide frequency range in order to provide multiband and multi-standard concurrent operation. In these systems with increased bandwidth and high data rates, the transmitting signal is characterized by high peak-to-average power ratio (PAPR) due to wide and rapid variations of the instantaneous transmitting power. Therefore, it is important to provide high efficiency at maximum output power and at lower power levels over a wide frequency bandwidth.

Compactness was of Critical Importance

Sumitomo designers were tasked with developing an innovative high-power, wideband Doherty amplifier covering nearly 1 GHz of operation bandwidth at 2.25 GHz. The compactness of the design was of critical importance. In addition, low impedance levels from the transistor die to the packaged device gate terminal were required for circuit matching (Figure 1). Figure 2 shows its input return loss performance and Figure 3 shows the layout of the low-impedance transform network and related results.

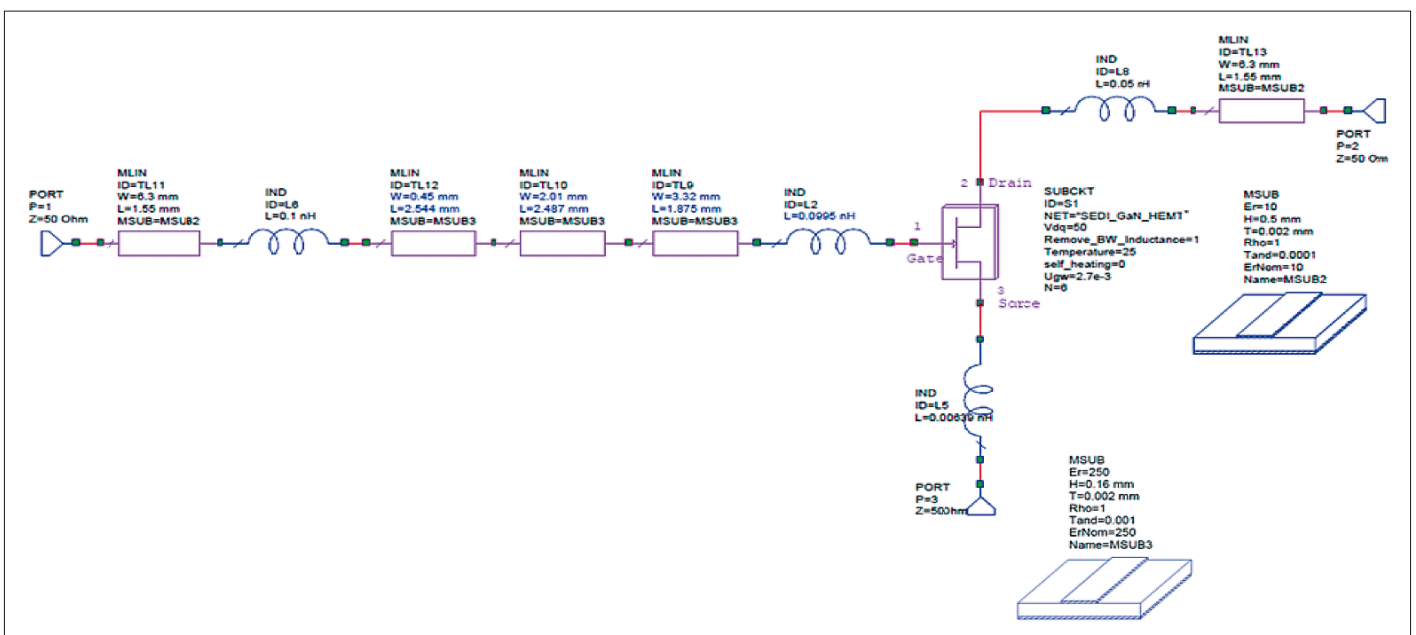


Figure 1: Equivalent circuit of packaged devices.

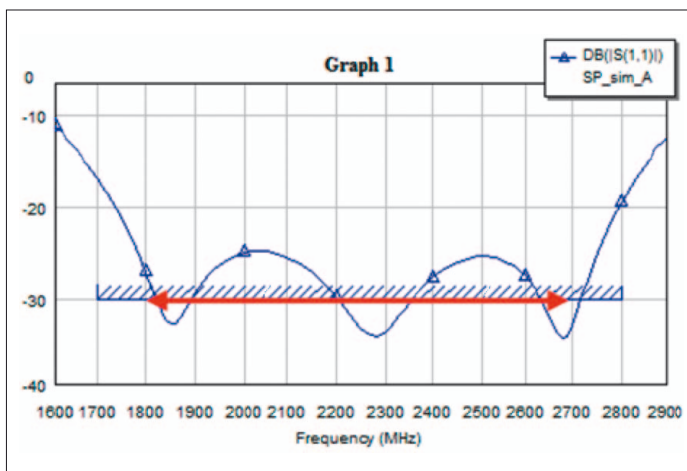


Figure 2: Return loss (dB[S(1,1)]).

The Solution

The designers chose the NI AWR Design Environment platform, specifically Microwave Office circuit design software and AXIEM planar electromagnetic (EM) simulator, for this PA design, because of the software's high rate of first-pass design success. The fast and accurate AXIEM EM

analysis helped overcome the challenge of using different high dielectric materials. The device achieved average efficiencies of 50-60 percent for output powers up to 100 W and significantly reduced the cost, size, and power consumption of the transmitters.

Figure 4 shows the measured power gain and drain efficiency of the transmission-line GaN HEMT inverted Doherty ampli-

fier across the entire frequency bandwidth for five frequencies. In this case, a power gain of more than 9 dB was achieved in a frequency range of 1.8...2.7 GHz.

At the same time, the drain efficiencies of more than 55 percent at saturation power P3dB and around 50 percent at 7 dB backoff output powers were measured across the entire frequency bandwidth, with maximum drain efficiency of more than 70 percent at lower bandwidth frequencies below 1.95 GHz and peak efficiency points at maximum backoff output powers of around 6 dB over the entire frequency range.

Conclusion

Sumitomo designers highlighted the simplicity and accuracy of the simulations, the intuitive user interface, simulation speed, and excellent support services as benefits that helped them achieve success with this novel design. They said, as an example, that a simple matching network designed in NI AWR software is different from other legacy software. When practically verified on hardware using the same device and built with different networks, the legacy software required tuning whereas NI AWR software was spot on.

Special thanks to James Wong, RF Specialist, Sumitomo, Osaka, Japan.

■ National Instruments
www.ni.com/aw

At-A-Glance

Software: NI AWR Design Environment, Microwave Office, Axiem

Benefits: Ease of use, Speed of simulations, High accuracy, Proficient support services

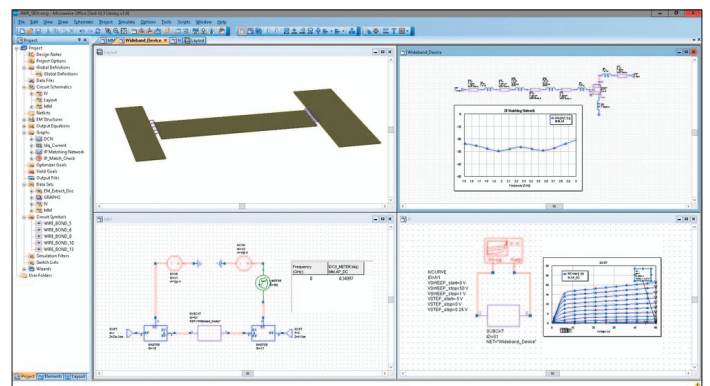


Figure 3: Microwave Office software display of the layout (upper left) of the low-impedance transform network, the impedance-matched power transistor (lower left), full-circuit schematic and input return loss (upper right), and the DC IV curves (lower right).

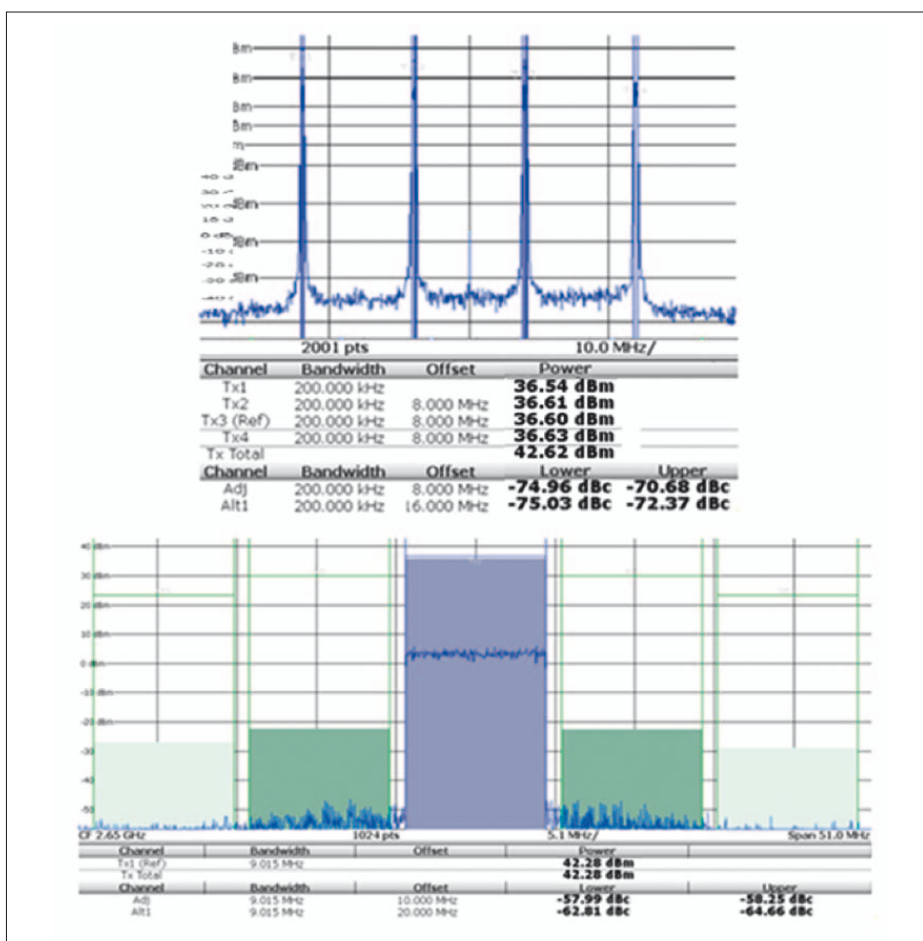


Figure 4. Dual-band DPD linearization of broadband two-stage inverted Doherty amplifier: a) 4 carrier GSM signal and b) 10 MHz LTE signal.