

## Mitsubishi Electric

Mitsubishi Electric Develops 28GHz High-Efficiency GaN Doherty PA for mmWave 5G Using AWR Software

### Key Challenges

The Ka band is a popular frequency for millimeter-wave (mmWave) applications for 5G communications. High-efficiency and high-output power amplifiers (PAs) are required to reduce power consumption and increase data transmission distance. However, although gallium nitride (GaN) is widely used for wideband applications, most Ka-band GaN amplifiers have only 10% efficiency at backoff output power due to their Class-AB single-ended configuration.

Mitsubishi Electric engineers were challenged to meet the requirements for a PA with high output power and high efficiency at backoff output power by designing a 28GHz PA monolithic microwave integrated circuit (MMIC) using a high-efficiency Doherty architecture. The PA MMIC was to be fabricated using a 0.15 $\mu$ m GaN process technology with a 50 $\mu$ m silicon carbide (SiC) substrate (Figure 1).

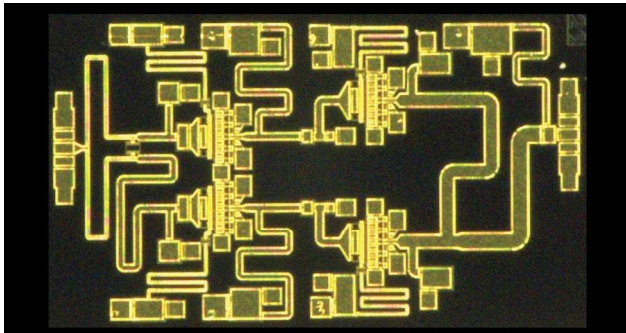


Figure 1: Photograph of the GaN Doherty amplifier MMIC

### Application

- ▶ MMIC Amplifier

### Software

- ▶ Cadence® AWR Design Environment® Software Portfolio, including:
  - Cadence AWR® Microwave Office® Circuit Design Software
  - Cadence AWR AXIEM® Planar Electromagnetic (EM) Simulator

### Benefits

- ▶ Ease of use
- ▶ High accuracy
- ▶ Speed of simulations

## Solution

The design goals for the GaN Doherty PA MMIC were 28GHz operation, 3W saturated output power, and power-added efficiency (PAE) over 20% at 6–8dB backoff output power. The designers chose the AWR Design Environment platform for this exacting design and believe that the resulting Doherty PA device is the state of the art in 5G amplifier devices for the Ka band.

The parameters of the Doherty output combiner, which consisted of microstrip lines and metal-insulator-metal (MIM) capacitors on a 50 $\mu$ m thickness SiC substrate, were calculated using AWR Microwave Office circuit design software. EM simulations were performed on the Doherty output combiner using the AWR AXIEM planar EM simulator. The layout and EM simulation are shown in Figure 2.

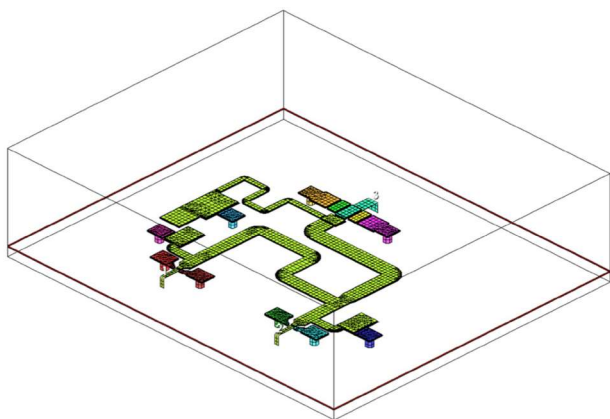


Figure 2: Circuit layout and EM simulation of the Doherty output combiner using AWR AXIEM software

Figure 3 provides the measured and simulated large-signal characteristics of the fabricated GaN Doherty PA MMIC. The fabricated two-stage Doherty PA using a GaN high electron mobility transistor (HEMT) achieved a measured saturation output power of 35.6dBm (3.6W) and peak PAE of 26%. PAE of 23% and 20% was respectively obtained at 6dB and 8dB backoff.

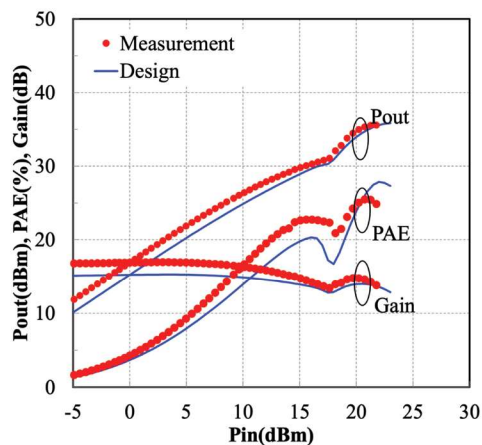


Figure 3: Measured and simulated large-signal characteristics of the GaN Doherty PA MMIC

## Conclusion

Because 5G communications is developing rapidly, early delivery of amplifiers to market is critical. The straightforward, integrated AWR software platform enabled fast development of the GaN PA MMIC while meeting all requirements and the AWR AXIEM simulator reduced analysis time by 50%. In addition, ready access to a design kit for the Mitsubishi Electric GaN enabled the engineers to optimize the development environment.

The design team appreciated that the speed of the circuit and EM simulation was so fast that the AWR AXIEM simulator was able to do the required simulations very quickly and provided highly accurate results. The designers highly recommend AWR software and plan to use it from now on because of its beneficial development environment and simulation speed and accuracy. They were especially appreciative of the design kit support.



*Cadence AWR software provided us with immense benefits for early development of our new 5G power amplifier.*

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