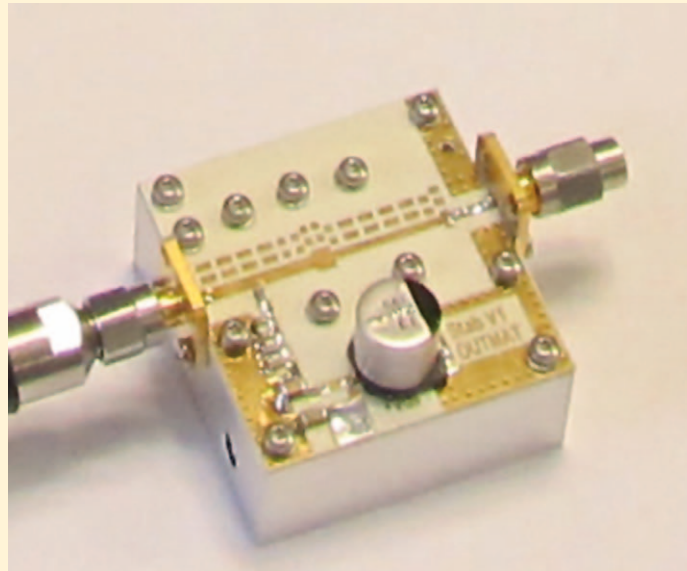## Design

SARAS Technology designs broadband and efficient RF Power Amplifiers using NI AWR Software

The Design Challenge

Demand for multiple 5 - 10 W linear-coded orthogonal frequency-division multiplexing (COFDM) power amplifiers covering the frequency range 1.5 - 2.8 GHz inspired designers at SARAS Technology to develop an approach for designing broadband and efficient RF power amplifiers (RFPAs) using optimal impedances and matching networks. An important parameter of these designs was to provide a typical linearity >25 dBc whilst maintaining the highest efficiency possible in output back-off mode.

Moreover, in an increasingly competitive market, amplifier products must be delivered in a short timeframe and therefore a right-the-first-time-design is becoming the norm rather than the exception. Coupled with time-to-market pressures is the need for the amplifier design to

deliver performance based on customers' original expectations.

The Solution

SARAS Technology designers chose NI AWR Design Environment, specifically Microwave Office circuit design software,

which greatly enhanced the design process and provided an accurate model of final amplifier performance, enabling the company to deliver its RFPA products to market quickly without compromising on performance. The design flow began with a

thorough device selection and delineation process. This allowed an accurate identification of a "best candidate" device/technology prior to commencing the detailed design activities such as load pull, matching network synthesis, EM analysis, and layout.

After selecting a device and obtaining its nonlinear model, the initial device stability and operating point was determined. Following this, load- and source-pull simulation was used to accurately evaluate parameters such as P_{max}, Eff_{max} and G_{max} (Figure 1).

Microwave Office's comprehensive load-pull measurements provided a very quick way to define and analyze tradeoffs and target optimal impedance regions. Also useful was the index marker feature that allowed the designers to observe these parameters over the band of interest.
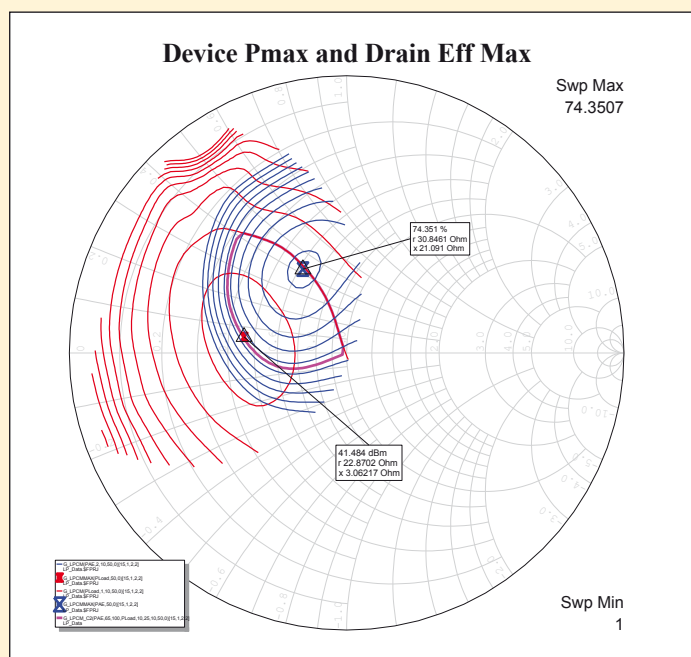

Figure 1: Load-pull analysis shows the maximum power and maximum power-added efficiency at the fundamental frequency
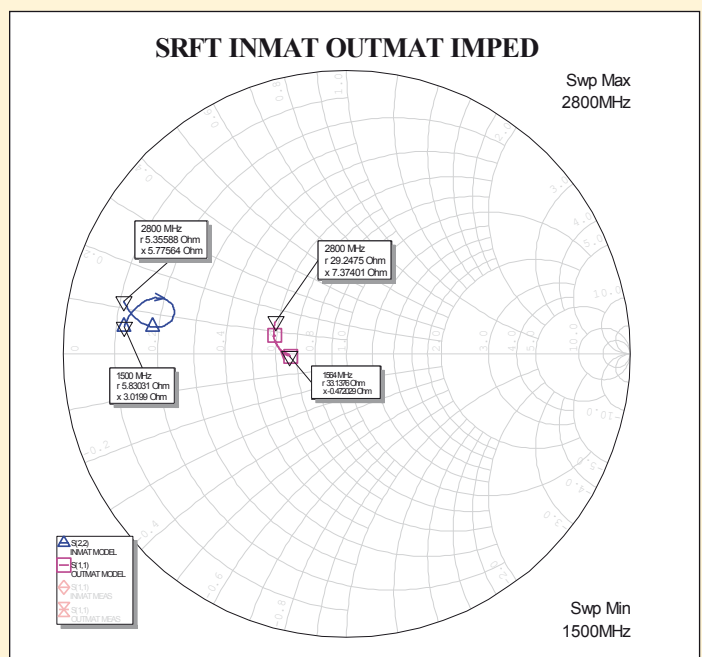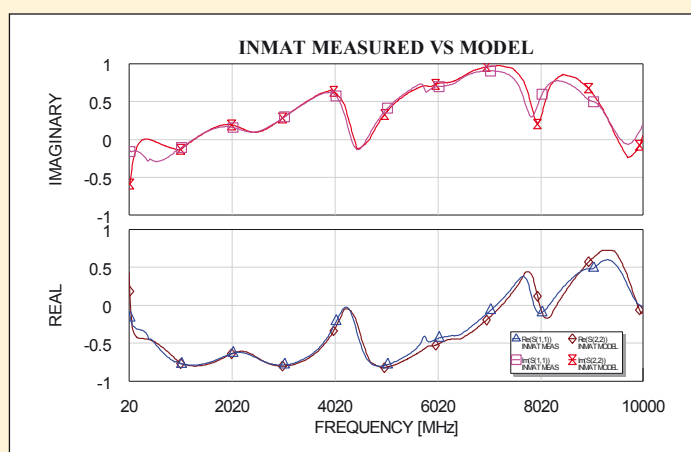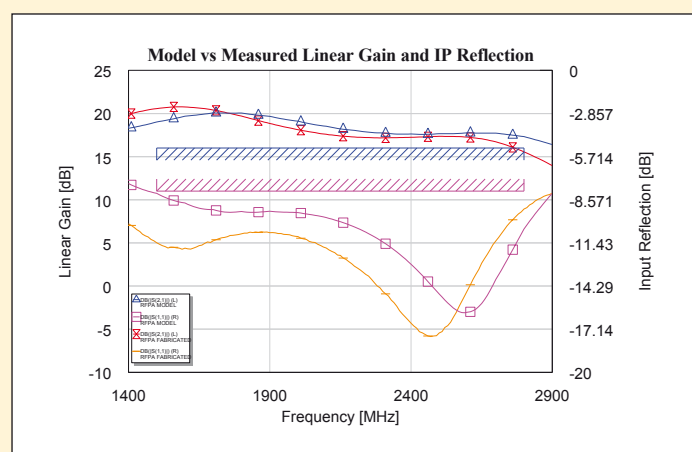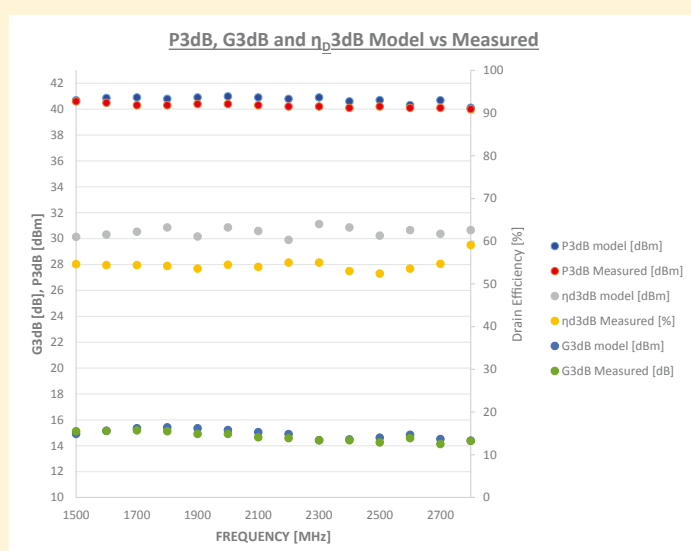

Figure 2: Impedances from both INMAT and OUTMAT networks showing non-dispersive nature over a wide bandwidth

Figure 3: Excellent agreement of modeled versus measured of the input matching network up to 0 - 10 GHz

Figure 4: Modeled vs. fabricated small-signal gain and input reflection

Figure 5: Modeled vs. measured power performance of the RFPA

Having decided on performance tradeoffs for the device, the target impedances were defined. A real-frequency technique was employed to design and synthesize the INMAT and OUTMAT networks that controlled the impedances over the broad operating bandwidth whilst maintaining low insertion loss (Figure 2).

Next, the networks were realized as distributed networks using the X-models and then the extraction feature was used for EM simulation in EMSight, which enabled network geometries to be actively altered against a design goal for fine tuning. In this design, the drain bias feed insertion point was also included

for direct attachment to the high-impedance bias choke inductor external to the subcircuit. The impedances were then mapped on a Smith chart and compared to those defined by the load-pull exercise.

The complete RFPA was then simulated using both the linear engine for small-signal gain and match, as well as the nonlinear engine for power simulations. Finally, the complete RFPA was laid out using the Microwave Office layout feature and a reference circuit was fabricated. To properly evaluate the accuracy of the design methodology, measured data was then compared to modeled data. This was done by measuring both the INMAT

(Figure 3) and OUTMAT on test jigs and then measuring the final complete RFPA performance.

The measured impedances of the fabricated INMAT and OUTMAT showed a very high degree of correlation between measured and modeled, even over a broader bandwidth than what was required by the RFPA design goal. The complete RFPA was then biased accordingly to measure small-signal gain and match. Again, a high degree of correlation was observed between the two datasets (Figure 4).

The final stage of the evaluation was to assess power performance of the RFPA and compare the measured versus modeled datasets (Figure 5). Comparisons were carried at the 3-dB compression point of the amplifier. It is worth noting that the amplifier delivered 10 W right down to 1300 MHz and up to 2900 MHz. In addition to continuous wave (CW) measurements, when evaluated in output back-off mode at 34 dBm using a 2.5 MHz CHBW COFDM modulation test waveform (PAPR = 9 dB), the RFPA achieved >25 dBc intermodulation sidebands with >34 percent drain efficiency at 2.25 GHz.

Why NI AWR Design Environment

NI AWR Design Environment enabled the design team at SARAS to develop a very streamlined, holistic approach to

power amplifier design in what they believe to be the most user-friendly, accurate design suite available. They found the software to have a very good availability of nonlinear device models from semiconductor manufacturers that, used in tandem with the nonlinear engine features such as load pull and EM analysis, delivered repeatable and accurate designs. The proven design flow covered above has significantly reduced the design and evaluation phase of SARAS Technology RFPAs in comparison to the use of traditional methods.

Jack Brunning, Microwave Design Engineer at SARAS Technology Ltd commented: "The FPA design flow we developed requires the use of an integrated RF/Microwave software package that incorporates load pull, circuit design, EM simulation and layout. Microwave Office provides this complete, integrated flow in an easy-to-use, powerful, and productive software environment."

SARAS Technology Ltd, based in the UK, is a world-class designer and manufacturer of a broad range of custom RF/microwave components and subsystems used in a range of market sectors, including defense, broadcast, and wireless communications.

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