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OWF WORKING EXAMPLE: CLASS J AMPLIFIER

The example that follows uses Mesuro's MB20 measurement system, set up for three- harmonic active load pull, to produce a Cardiff Model for a 10-W Cree CGH40010 GaN transistor. The model was then used in simulations with AWR's Microwave Office design suite. The new approach used here is currently being evaluated at several multinational companies around the world.

A Class J mode of operation was chosen to enable a broadband and efficient PA design. In all modes of operation the device is well defined by its current and voltage waveforms from which a template is based that closely maps the measured waveforms to utilise the full theoretical potential of a Class J PA. From this, the initial design goal is set for a 50% bandwidth amplifier with a centre frequency of 1.8GHz and at least 60% drain efficiency over the entire bandwidth.

A new measurement approach, coined 'waveform engineering', is used to obtain the Class J waveforms, which are mapped from the calibrated package-plane to the output current generator plane and compared with theoretical waveform templates. The difference between the waveforms is then used to adjust the setting of the three harmonic output terminations. Figure 2 illustrates the achieved waveforms with the harmonic content listed in Table 1. The bias point implemented here is deep Class AB (Idq≈5% of Idss).

Based on the results of waveform engineering, power sweeps are conducted using the identified optimum harmonic terminations, which are also generated using the same active harmonic load-pull setup shown in Figure 2. Peak drain efficiency of 83% is measured in this state – with just below 10W device output power and approximately 3.5dB of gain compression. Note that even at the 6dB power back-off point, the measured drain efficiency is still in excess of 60%. These measurements are carried out at several frequencies between 1.5 and 2.3GHz in order to begin the design stage of the broadband Class J PA.

Based on these results, a matching network is synthesised using the identified optimum harmonic terminations over the measured frequency range as a target. The measured data is then imported into AWR's Microwave Office software to accurately replicate the DUT performance during subsequent nonlinear simulations, i.e., embed it with the rest of the PA circuit and simulate the full design. The resulting matching circuit architecture is depicted in Figure 4.

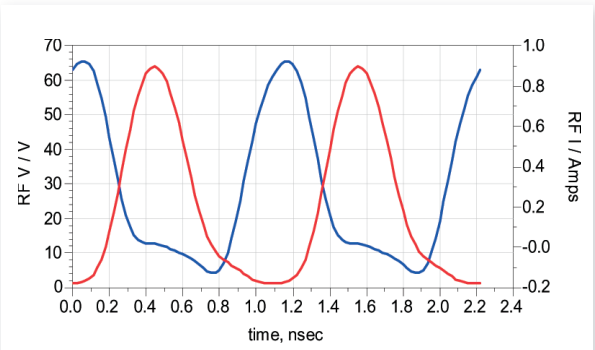

Figure 2. Measured Class J waveforms on a 10W GaN HEMT.

Frequency	I_{gen}-Plane Load Impedance
f_0	43.8 + j45.2 Ω
$2f_0$	1.6 – j52.0 Ω
$3f_0$	2.4 – j49.7 Ω

Table 1. Class J Igen (current generator) plane load terminations.

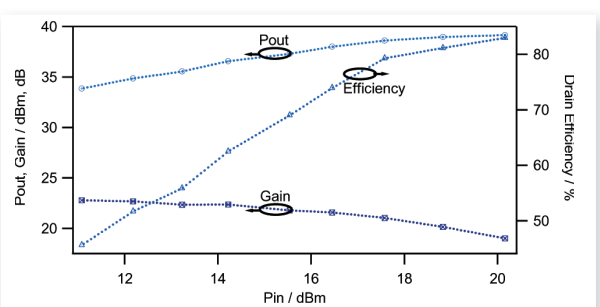

Figure 3. Power sweep showing very-high-efficiency Class J operation at 1.8GHz.

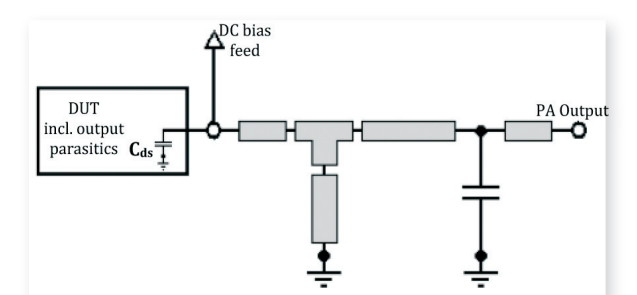

Figure 4. Load matching network schematic.

First realized design iteration of the Class J amplifier is shown in Figure 5. Power sweeps over a 12dB range were carried out on the PA across a frequency range of 1.2 to 2.5GHz. Results of this sweep are shown in Figures 6 and 7 and demonstrate very good agreement with the measurement predictions.

The measured P2dB drain efficiency for the realized Class J amplifier is at a level of 60 to 70% between 1.35GHz and 2.25GHz; a 50% bandwidth centered at frequency of 1.8GHz. Within this bandwidth, corresponding output power from the PA is between 9 and 11.5W. A comparison between the realized PA results and simulated efficiency from the non-linear device model, set in the same impedance environment, is also shown in Figure 6.

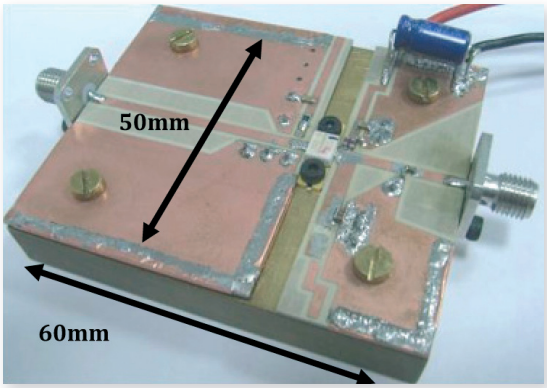

Figure 5. Realized Class J amplifier - output matched only.

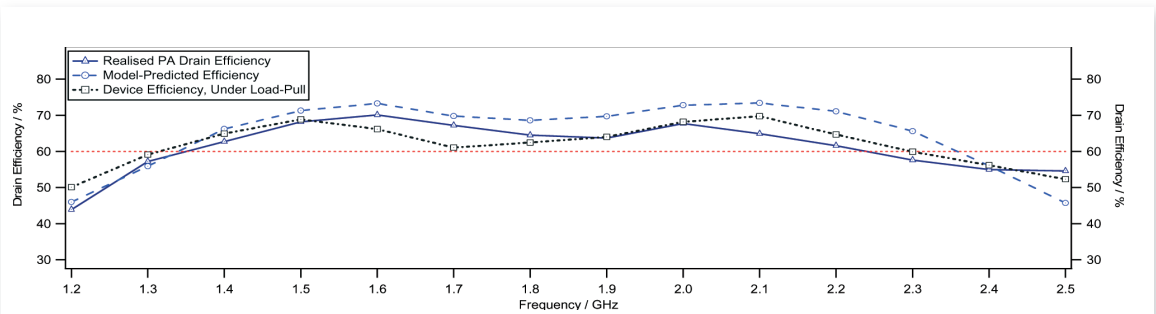

Figure 6. P2dB drain efficiency for device under load-pull, device-model simulation and for the realized Class J PA across a bandwidth of 1.2 to 2.5GHz.

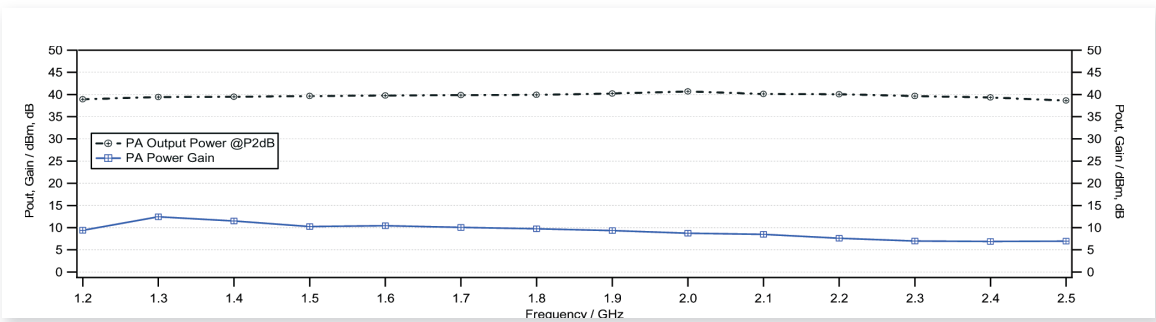

Figure 7. Realized Class J PA output power and gain at P2dB across bandwidth of 1.2 to 2.5GHz

Note: All the measurements used in this example were measured by Tektronix equipment.

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