**Linear HPA Design with Behavioral Model**

**Sponsoring MTT-S Technical Committees & Organizations**

Maury Microwave, USA

Anteverta, The Netherlands

AMCAD, France

Wolfspeed, USA

**Coordinators and Contacts**

Osman Ceylan, Ph.D.

Giampiero Esposito, M.S.

Mauro Marchetti, Ph.D.

Steve Dudkiewics, Eng.

Sathya Padmabanhan, M.S.

Please send all communication to Osman Ceylan via “oceylan@maurymw.com”

**Competition Summary**

Modern wireless communication systems use wideband and complex modulation schemes to provide high data rate. Therefore, distortion of the power amplifiers should be considered for a reliable communication, and thus linearity is a significant evaluation criterion in addition to efficiency and output power.

Characterization and modeling of the high power RF transistor is the first and maybe the most important step of designing an advanced and high-performance power amplifier (HPA). Since HPAs operate at large signal condition, the model should support the nonlinear analysis and be reliable in the saturation region. An accurate nonlinear model of a high power RF transistor is the key to the successful first-pass design and high performance.

In this competition, the students are required to design and assemble a narrowband and highly efficient HPA by using behavioral models. The winner PA will be the one revealing the highest average efficiency with the modulated signal. All promising designs will be awarded, as well.

The students will use either the measured data or the nonlinear model prepared by Maury Microwave. A packaged medium power (a few Watts) RF transistor will be used for the competition. All participants will use the same data, model, and transistor. But they are free to use any substrate material, passive components, and design topology.

The measurements will be taken at the IMS’20 with a Maury Microwave load-pull setup.

**Detailed Competition Description and Rules**

The objective of this SDC is to design a highly efficient high power amplifier (HPA) by using either the behavioral model or measured data of the RF power transistor. The participants will receive the measured data and model after the registration by e-mail. The students are free to use only measured data for the design.

After submitting a design report, sample transistors will be sent by the sponsor. The students will fabricate the designed HPA and measure it. A final report should be sent to get an invitation to the competition. If the students use nonlinear model, the report should include circuit schematic, layout, simulated results (PAE, output power, power gain, and S-parameters), and archived project file. If measurement data are used for the design, the report should have circuit schematics, S-parameter data for the input and output stages, layout view, and archived project file.

1. The competition steps:

a) Registration (for receiving the measurement data and model)

b) Design of the high power amplifier

c) Submitting the design report (for receiving the sample transistors)

d) Fabricating the circuit and measurements

e) Submitting the final report (for invitation to competition)

1. The center frequency of the HPA is 3.3 GHz.
2. HPA must have SMA or 3.5 mm female connectors at the input and output.
3. DC blocking capacitors must be included to prevent the flow of DC signals in to the measurement system (Between biasing networks and connectors).
4. Any substrate material can be used.
5. HPA must have only one transistor (single stage PA).
6. The students will prepare the circuit(s) for the measurements during the competition day. The implemented circuits should be reliable for mechanical issues such as cable connection tension. The organization committee does not accept any responsibility in case of physical damages during the competition.
7. A power supply for the gate and drain biasing will be provided by the sponsor. A heatsink with a fan will also be installed. If the participants want ot use their fan and heat sink, there will be another power supply up to 30V and will be ready during the measurements.
8. All measurement tools will be provided by the organizer, such as coaxial cables, attenuators, etc. A Maury Microwave measurement setup will be used for the measurements.
9. All measurements will be carried out with pulsed continuous-wave (CW) signal with 1s measurement period. All measurements will be done automatically with the Maury Microwave setup.
10. The implemented circuit should be suitable for visual inspection. No sealed casing is allowed.
11. Embedded batteries and supercapacitors are not allowed.
12. No changes and modifications are allowed during the measurements.
13. Before the competition day, a detailed report including model, circuit schematic, layout, measured data, and design files (EDA workspace) should be submitted to the organizing committee.
14. The board size should be smaller than 20 × 20 cm².
15. Female banana connectors are recommended for the biasing. Crocodile and banana connector type cables will be provided by the sponsor.
16. Use of additional amplifiers as a driver is not allowed.
17. All measurements are referenced to 50 Ω impedance

**Evaluation Criteria**

The designs will be evaluated by a commission at the IMS’20 based on measurements taken on site. 10 MHz, 10.2 dB PAR LTE signal will be used for the measurements. For the evaluation, average power-added efficiency (PAE) at the Adjacent Channel Power Ratio (ACPR) of – 30 dB will be considered. In case of equal or very close results, the highest power gain at the linear region will define the winner. If there are still equal or very close results, the jury may consider additional criteria such as circuit size, implementation, and effort.

The PAE is defined as follows,



where PRFout is the measured average RF power at the output at 3.3 GHz, PRFin is the measured average signal power at the circuit input.

There will not be pulsed biasing option. CW performance of the HPA will be considered for the evaluation. Using a heatsink and fan is allowed. A wide range power sweep will be done for each measurement with 1 second steps. The measurement will stop automatically when the output signal is compressed 3.5 dB

**How to Participate**

1. Participants must register to the IMS Student Design Competition according to the rules posted on the IMS-2020 homepage. At the same time as the registration to IMS-2020 is completed, the competitors must also register with the organizers of the competition. This is done by sending an e-mail containing the name of the team members and their contact details (e-mail preferred) to oceylan@maurymw.com with the subject line “IMS-2020 SDC7: Registration for the competition” no later than the official deadline announced on the IMS-2020 SDC homepage.
2. Registration e-mail should be sent by the academic advisor or the laboratory coordinator.
3. In the registration e-mail, it should be clearly mentioned that 100% of the modeling and designing activities will be effort of the students. Professional support is not allowed. But students are free to ask any questions to design committee.
4. At least one member from each team must be present at the competition during the IMS-2020.
5. Do not forget the register to IMS-2020 Student Design Competitions. Follow the instructions on the website to submit your student design competition application.
6. It is recommended to register as early as possible by e-mail to receive the data and model to start the design and have enough time for circuit fabrication and tests. IMS official registration can be done later.

**Student Eligibility Criteria**

1. The Design Competition is open to teams of undergraduate and/or graduate students that are registered at a university or other educational institution. Students must show a valid student ID during the competition.
2. Students may enter as individuals or as a team. There may be no more than five students on a team. Each student may be a member of only one team. Each team may submit up to two entries but can receive an award for only one entry.
3. There is no restriction on age.
4. At least one of the students on a team must register for and attend the conference to demonstrate their design for evaluation during the contest day at IMS’20.
5. The students should use the email address issued by their respective institutions for all communication regarding the competitions, rather than their personal emails (e.g., Gmail, Hotmail). regarding the competitions, rather than their personal emails (e.g., Gmail, Hotmail).

**Awards**

There will be two prizes awarded. The first and second place winners will receive $1500 and $1000, respectively. The first-place winner is invited to submit a paper describing the design in the MTT’s Microwave Magazine. All invited participants will receive $100 if their amplifier is able to reveal more than 25% average PAE.