

## SDC6 - HEPA-SDC

# High Efficiency Power Amplifier (HEPA) Student Design Competition (SDC)

## Detailed description and rules

### Introduction

Brief introduction to the topic giving the background for better understanding.

**The nineteenth High Efficiency Power Amplifier (HEPA) Student Design Competition (SDC) will take place at the 2023 IEEE MTT-S International Microwave Symposium (IMS) in San Diego, California, on Tuesday, June 13, 2023. This competition is open to all students, both undergraduate and graduate, registered at a recognized educational establishment.**

**This year's contest will focus on PAs having both high efficiency and linearity over a relatively broad frequency band. The competitors are required to design, construct, and measure a highly efficient, linear PA at a frequency of their choice between 1 GHz and 10 GHz. To qualify for the linearity test, the PA must produce an output power of at least 4 watts, but no more than 40 watts, when excited by a single carrier at the frequency of test. All linearity testing will be conducted using two equal amplitude carriers spaced 20 MHz apart. To qualify for the linearity measurement, with 0 dBm per tone input, carrier-to-intermodulation ratio (C/I) must be greater than 30 dB\*.**

**The winner will be the PA that demonstrates the highest power added efficiency (PAE) when producing a two-tone carrier-to-intermodulation ratio (C/I) of 30 dB\* weighted for the frequency of operation.**

**A representative of the design group must be present at the testing to assist with the evaluation. Each team is limited to a maximum of two entries.**

**\* C/I is based on the ratio expressed in dB between the amplitude of either carrier and the highest intermodulation product. PAE will be measured at the first output power with increasing Pin from 0 dBm where this ratio falls below 30 dB.**

## Design specifications and rules

Detailed specification of the goal that students will attempt to achieve with their design. The specification apart of the electrical performance metrics might also include other metrics like size, etc. All the specification parameters must be measurable. Geography-specific metrics like fabrication price, etc. are not allowed.

## Detailed Competition Rules

- 1. The power amplifier (PA) design may use any type of technology, but must be the result of new effort, both in the amplifier design and fabrication.**

2. The PA mechanical design should allow for internal inspection of all relevant components and circuit elements. The RF ports should be SMA female connectors. Bias connections should be banana plugs.
3. The PA should require a maximum of two dc supply voltages for operation.
4. The PA must operate at a frequency in the range of 1 GHz to 10 GHz and have an output power level when excited by a single carrier of at least 4 watts, but no more than 40 watts at the frequency of test.
5. All PAs should require less than 24 dBm of input power to reach the minimum 4 watt output power when excited with a single carrier.
6. Measurements will be made by the judges only. A team representative must be present at testing to provide information on connections, design frequency, and expected output power level.
7. All linearity measurements will be performed under CW two-tone operation with two equal amplitude carriers spaced 20 MHz apart at room ambient conditions into a 50 ohm load. Only the power at the two fundamental carrier frequencies will be included in the measurement of output.
8. Linearity measurements will be conducted with a maximum of 21 dBm input power per tone. The tone power will be swept from 0 dBm to 21 dBm and the C/I ratio measured.
9. The winner will be based on the amplifier's PAE measured during official testing at the lowest power level for which the C/I ratio\* equals 30 dB. If the C/I ratio is better than 30 dB over the entire testing range, the measurement at 21 dBm input power per tone will be used. The figure of merit for scoring will be the PAE multiplied by a frequency weighting factor having the form  $(\text{GHz})^{0.25}$ .
10. The team will be allowed a maximum of 10 minutes to set up their PA and familiarize with the test equipment before testing.
11. The official measurements will be performed by the committee with the chosen device biasing point from the students.
12. The decision of the judges will be final.

## How to Participate

Participants must register to the IMS Student Design Competition according to the rules posted on the IMS-2023 homepage. At the same time as the registration to IMS-2023 is made, 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 Dr. Kiki Ikossi <ikossi@ieee.org> with the subject line "IMS-2023 HEPA-SDC" no later than the official deadline announced on the IMS-2023 SDC homepage and following the below format.

## Student Eligibility Criteria

1. Students may enter as individuals or as a team. There may be no more than four students on a team. Each student may be a member of only one team. A student group may enter a maximum of 2 PAs, but can receive an award for only one PA.
2. To enter a competition, the student(s) must have been full-time student(s) (enrolled for a minimum of nine hours per term as graduate students or twelve hours per term as undergraduates) during the time the work was performed. There is no restriction on age.

3. The student(s) must have a signed statement from their academic advisor that the work is principally the effort of the student(s).
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 IMS2023.
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).

### **Additional non-monetary prizes**

1. Modelithics will award their high precision PA model software awards to the top three (3) PA teams.
2. Cadence (formerly NI & AWR Corporation) will award 1-year complimentary licenses of its Design Environment software to the top three (3) PA teams.
3. Modelithics and Cadence offer design software assistance to all competitors.
4. The measurements are performed at IMS by Keysight engineers using Keysight equipment with the oversight of MTT Judges. Keysight offers measurement guidance to all student participants.

### **Evaluation process**

Step-by-step procedure of evaluating the student design by the jury that will result in obtaining the score for each of the designs.

**Please see above competition rules. 1-12**

### **Scoring**

Please define one numerical value based on which you will evaluate the designs. In case of multi-objective design, add weights to each of the scores to end-up with one scalar quantity.

### **Criteria for judging:**

The winner will be based on the amplifier's PAE measured during official testing at the lowest power level for which the C/I ratio\* equals 30 dB. If the C/I ratio is better than 30 dB over the entire testing range, the measurement at 21 dBm input power per tone will be used. The figure of merit for scoring will be the PAE multiplied by a frequency weighting factor having the form  $(\text{GHz})^{0.25}$ .

Please see detailed rules above.

### **Name and number of supporting MTT-S Technical Committee**

TC-12

## Contact information

**Kiki Ikossi, [ikossi@ieee.org](mailto:ikossi@ieee.org)**

**Anding Zhu, [anding.zhu@ieee.org](mailto:anding.zhu@ieee.org)**

**Pete Zampardi [pete.zampardi@gmail.com](mailto:pete.zampardi@gmail.com)**