IMS2025 Student Design Competition

Allen Katz High Efficiency Power Amplifiers (HEPA) Student Design Competition

Detailed description and rules

Introduction

The twenty-first Allen Katz High Efficiency Power Amplifier (HEPA) Student Design Competition (SDC) will take place at the 2025 IEEE MTT-S International Microwave Symposium (IMS) in San Francisco, CA, on Tuesday, June 17, 2025. This competition is open to all students, both undergraduate and graduate, registered at a recognized educational establishment.

This year's contest will focus on design and demonstration of PAs having both high efficiency and two-tone linearity over a relatively broad frequency band.

Design specifications and rules

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 two-tone 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 two-tone 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.

Additionally, this year, the PA will be tested for linear bandwidth as a check for performance in 5G and beyond telecommunication applications by measuring the ACPR (Adjacent Channel Power Ratio) using a signal bandwidth and operating frequency chosen by the student. ACPR is an important parameter that is used to ensure that a communication system does not interfere with other systems operating in nearby frequency bands. ACPR is defined as a dB ratio of the integrated power transmitted into adjacent frequency channel bandwidths to the integrated power transmitted in the main carrier frequency channel. For the IMS2025 demonstration, linear bandwidth measurements will be performed for the student's HEPA designs operating from 1 up to 6 GHz. This measurement will be performed for demonstration purposes and will not impact scoring for the competition.

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.

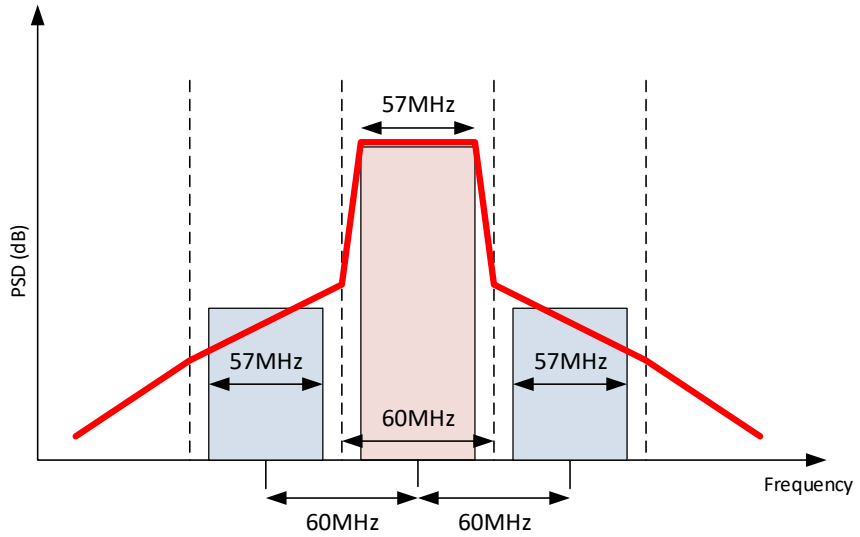
* C/I is based on the ratio expressed in dB between the amplitude of either carrier and the highest intermodulation product. PAE will be measured at the first output power with increasing Pin from 0 dBm where this ratio falls below 30 dB.

** The modulated ACPR measurements will be performed across a channel bandwidth and center frequency chosen by the student and should be between 20 MHz – 100 MHz (using

integer multiples of 5 MHz). The signal will be Additive White Gaussian Noise (AWGN) with a peak-to-average ratio of 9.8 dB at 0.01% and lower probability Complementary Cumulative Distribution Function (CCDF) with an occupied bandwidth 95% of the channel (effectively allowing for filtering bandwidth to not impact the ACPR measurement).

ACPR measurements will be configured centered around the chosen channel and measured in the equal channel bandwidth of the signal. For example, if a team chooses to use a 60MHz channel bandwidth centered at 2GHz, the occupied bandwidth will be 57MHz (95% of 60MHz), and the ACPR (dB) will be measured centered at 2 GHz ± 60 MHz in a 60 MHz integrated bandwidth at three output power levels (the same output power that produced C/I of 30dB, 6dB lower, and 10dB lower). See example spectrum below.

A Q&A Session to review and discuss details of the ACPR measurements is planned. Please email David Runton (drunton@ieee.org) for more information.



Example Spectrum showing ACPR Measurement with a 60MHz Channel Bandwidth

Evaluation process

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. 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 (GHz)^0.25.
10. For demonstration purposes, modulated ACPR linearity (dB) and drain efficiency measurements will be conducted at the same lowest output power level for which the C/I ratio* equals 30 dB, 6dB lower, and 10dB lower. This measurement will not impact the scoring for the competition.
11. The team will be allowed a maximum of 10 minutes to set up their PA and familiarize themselves with the test equipment before testing.
12. The official measurements will be performed by the committee with the chosen device biasing point from the students.
13. The decision of the judges will be final. Awards from IMS and industry will be presented at the Student Awards Luncheon.

Scoring

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 (GHz)^0.25.

How to Participate

Participants must register for the IMS Student Design Competition according to the rules posted on the IMS2025 homepage. At the same time as the registration to IMS2025 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 and David Runton drunton@ieee.org with the subject line "IMS-2025 HEPA-SDC" no later than May 1, 2025 and following the registration instructions for the IMS2025 SDC.

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 IMS2025.

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).

Prizes

1. The team with the winning PA design, as measured at IMS and determined by the judges, will receive a monetary prize as described in the SDC announcement,* and will be invited to submit a paper describing the design for the MTT-S Microwave Magazine.
2. Modelithics will award their high precision PA model software awards to the top three (3) PA teams.
3. Cadence (formerly NI & AWR Corporation) will award 1-year complimentary licenses of its Design Environment software to the top three (3) PA teams.
4. Modelithics and Cadence offer design software assistance to all competitors.
5. 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.

Note: Monetary awards to 3 top PAs are given by the MTT society equally to all SDC.

MTT12 High Power Amplifiers

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Participation estimate

Historical participation has been 5-10 amplifiers being judged

Equipment information

Equipment by Keysight. 2 power supplies 0-100 V, 1 A , VPN network analyzer. 1-100 GHz. 6GHz 40dBm bench top driver PA, Cables to connect to power supplies with banana plugs. MW coaxial cables for high frequencies. Calibration standards.