
Rev. 2016-10-26

# IMS2017 Student Design Competition Rules

As part of the technical program, the Student Design Competition (SDC) is one of the most energetic parts of IMS. The SDCs have proven to be very successful events in the past 12 years, as evidenced by the ever increasing student participation and the support it has enjoyed from the organizers, both logistically and financially. The IMS2017 in Honolulu will continue the legendary tradition of enthusiasm with a very strong SDC program.

**TC number and name:**

MTT-6 MICROWAVE AND MILLIMETER-WAVE INTEGRATED CIRCUITS

**The title of Student Design Competition:**

5G Mobile Com Receiver Module

**Submission Deadline:** Saturday, 1 April 2017

**Sponsors**

MTT-6 (Microwave and Millimeter-Wave Integrated Circuits)
MTT-14 (Microwave Low-Noise Techniques)
MTT-16 (Microwave Systems)
MTT-20 (Wireless Communications)
Rohde & Schwarz, NoiseCom, Fraunhofer

**Primary contact name(s), email address, and phone number (of host or competition leader(s)):**


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|---|---|---|
| Rüdiger Quay | (Ruediger.quay@ieee.org) | Fraunhofer IAF, Freiburg, Germany |
| Nils Pohl | (nils.pohl@rub.de), | Ruhr Universität Bochum, Germany |
| Roger Kaul | (rogerieeemtt@gmail.com) | Army Research Lab. (ret.), USA |


**A short abstract or summary describing the competition:**

This project will introduce students to multiband and multistandard wireless technology envisioned for 5G mobile com in the frequency range from 2 GHz to 6 GHz. Linear and rugged low-noise amplifiers are needed in any operational communication

system to achieve fast and reliable information transfer while maintaining good ruggedness and linearity even in harsh environments over a wide frequency range from 2 GHz and 6 GHz through MOBCOM, WIFI, and Bluetooth. The students are to design a broadband device which, other than in previous years, will have to answer the challenge of providing very broad services. The devices will be collected at the beginning of the competition. Two frequencies from the range (2 GHz, 3 GHz, 4 GHz, 5 GHz, 6 GHz) will be selected by throwing a dice (with the result leading to 2 = 2 GHz, 3= 3 GHz, etc.) at the beginning of the competition for the whole competition and all participants. At these two frequencies a figure of merit will be measured for the submitted modules and a FOM calculated. The amplifiers must be ready to answer any of these frequencies without further adjustments. This approach shall provide an insight into the upcoming statistical and parallel use approach to the spectrum usage. Further, harsh environments may be your daily life with your cell phone, e.g., once you try to achieve a maximum data rate communication while traveling in your car or the train. Broadband low-noise operation is needed in a multi-standard environment which we all require with our advanced cell phones. The competition is meant to raise your awareness about the complexity and the non-deterministic nature of the topic and the connections on the receiver end for multistandard and multiband applications.

Please contact Rüdiger Quay for more information on this competition.

**Number of Previous Contestants:**

- IMS 2011: 7 groups
- IMS 2012: 11 groups
- IMS 2013: 5 groups
- IMS 2014: 4 groups
- IMS 2015: 2 groups
- IMS 2016: 7 groups

**Eligibility:**

1. Enrollment in a university or colleges
2. It is open to both undergraduate and graduate students
3. Groups of up to four members are admitted

**Design Specification:**

1. Competitors are required to design, construct, measure, and demonstrate **ONE** broadband high linearity, low-noise amplifier module evaluated at two out of six frequencies. There can be no exchanges of the device.
2. The two frequencies of evaluation will be determined with all participants attending at the beginning of the competition.
3. The devices will be collected at the beginning of the competition before the frequencies are selected. NO CHANGES on the devices are allowed after the frequencies of measurements have been determined by throwing the dice. There can be no modification on the broadband LNA of any kind (mechanical, electrical).
4. The students can attend the measurements of their individual device.
5. The amplifier may use any technology. Use of commercial amplifier subsystems and passive components is allowed.
6. The amplifier shall allow for internal inspection of the circuitry.
7. The amplifier shall be capable of amplifying a signal with a minimum 13-dB of small-signal gain from 2 GHz to 6 GHz over the band with a 50-ohm source and load impedance.
8. The noise figure must be lower than 1.5 dB at both f1 GHz and f2 GHz
9. The P1dB (1dB compressed, single tone) output power should be greater than 0 dBm for both f1 and f2 GHz.
10. The amplifier must have no DC voltage at its input and output ports.
11. The amplifier must be operated at room temperature.
12. The amplifier must utilize 3.5 mm SMA (female at the input, male at the output) jacks on both the input and output. The prime power shall use two wires with banana plugs at least 0.5 meter in length and it must be shielded. The hot connector must be in red with ground in black. **The device must be ruggedized and shielded to work in a noisy environment. This is a central requirement as in the past unshielded devices could not be measured in the noisy environment of an exhibition hall at IMS due to electromagnetic interference (EMI).** The LNA module enclosure should be shielded completely with a metallic top cover lid. RF absorber material may be used on the inside surface of the top cover lid if required.
13. The prime DC power shall be totally derived from a single supply with a voltage of up to +5 Volts DC **or** –5 Volts DC employing two wires. A metered power supply will be provided at IMS2017 by the organizers.
14. No internal batteries may be used.
15. No changes are allowed on the device during the measurements.

**Evaluation Criteria:**

1. The performance of the amplifier is based on the output third-order intercept parameters and noise figure at f1 and f2 measured with a signal analyzer using a noise diode source. Two isolated signal generators (e.g., Rohde&Schwarz model SMA, SMB, or equivalent) will provide the two signals for the third-order measurements. The third-order intercept measurement will be performed using two -20 dBm input signals around f1 and f2 GHz with a tone spacing of 20 MHz.
2. The amplifier circuit with the highest LNA figure of merit shall be declared the winner.
3. **The overall LNA figure of merit** (LNAFOM) is determined by the following relationship based on the two frequencies f1 and f2.

   LNAFOM= (LNAFOM_up+ LNAFOM_low)/2

   LNAFOM_low=(OIP3_low/Pdc)/NFdB_low (at frequency 1)

   LNAFOM_up=(OIP3_up/Pdc)/NFdB_up (at frequency 2)

   (NFdB_up, NFdB_down is set to 1.5 dB for all contestants after the go/no go decision

   where:

   LNAFOM_up, LNAFOM_low = LNA figure of Merit at frequency 1 and 2

   OIP3_low = Output third order intercept point IP3 of LNA in milliwatts for the lower tone (based on a two-tone measurement with tones at f1-10 MHz and f1+10MHz with 20 MHz spacing and taking the lower IP3 around f1)

   OIP3_up = Output third order intercept point IP3 of LNA in milliwatts for the upper tone (based on a two-tone measurement with tones at f2-10 MHz and f2+10 MHz with 20 MHz spacing and taking the upper IP3 around f2)

   Pdc = DC power drawn by power supply in milliwatts

   NFdB_low, NFdB_up = LNA noise figure in dB = 1.5 dB set for all those passing the test at f1 and f2.

   OIP3dBm_low= Po_low + 0.5 (Po_low - P3rd_low)

   OIP3dBm_up  = Po_up + 0.5 (Po_up - P3rd_up)

   Po_low, Po_up = Output power of the f1-10 MHz and f2+10 MHz signal in dBm

P3rd_low, P3rd_up = Output power of the third order products around f1 and f2 in dBm

OIP3_low = 10^(OIP3dBm_low/10) in milliwatts for the lower tone.

OIP3_up = 10^(OIP3dBm_up/10) in milliwatts for the upper tone.

4. In the case that 6 GHz is chosen as a center frequency, the center frequency will be moved 20 MHz downwards to stay within the maximum measurement equipment range of 6 GHz also with the intermodulation products.
5. In the unlikely situation of contestants with the same LNA figure of merit, the one with the lowest DC power will be selected.
6. Due to the broadband operation and the variety of frequencies, that might be chosen, the asymmetry of the intermodulation powers will not be considered.

**How to Participate:**

1. Submit an entry form to both Rüdiger Quay and the Student Design Competition chair by Saturday, 1 April 2017 giving names, affiliations.
2. Provide a support letter by your professor stating that you are working on this project and that at least one person will be able to join IMS2017.
3. Sponsoring professors are encouraged to introduce this competition as a course project for their students in order to acquaint them to system and circuit level design

**State what materials the student teams need to submit prior to IMS:**

1. A short description of the modules is to be provided. A schematic of the circuit shall be brought to the IMS
2. The module shall be accessible to inspection on-site.

**Prizes:**

The winner(s) will receive a prize of $2,000 (USD) and will be invited to submit a paper describing his/her project to the IEEE Microwave Magazine.

**Important Dates:**

Saturday, 1 April 2017: Last day to submit entry forms

June 2017: Competition at IMS 2017 (not at the beach !)

**Space:**

Two regular tables with multiple power cords to enable parallel measurements

The set-ups for this SDC should be located as remote as possible from the SDCs doing high power microwave in free space, e.g. radar and harvesting in order to minimize EMI.

**Equipment:**

Rohde and Schwarz Signal Analyzer (SMA, SMB for intermod measurements). The organisers will arrange contacts, as in the previous years.

Noise diode from NoiseCom as in the previous years.

Noise diode and noise analyser included in the R&S signal analyzer

Good contacts are available to **R&S** and **NoiseCom** from the previous competitions

RF-Cables etc. will be provided by the organizers