Rev. 2016-10-27

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-9 DIGITAL SIGNAL PROCESSING
MTT-11 MICROWAVE MEASUREMENTS

The title of Student Design Competition:

Power Amplifier Linearization through Digital Pre-distortion (DPD)
Check the competition details at: http://dpdcompetition.com/sdc/

Submission Deadline: Friday, 31 March 2017

Sponsors:

MTT-9 Digital Signal Processing
MTT-11 Microwave Measurements

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

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A short abstract or summary describing the competition:

New nonlinear characterization instruments associated with advanced digital signal processing algorithms turned digital pre-distortion, DPD, into the distortion cancellation method of choice to relax the linearity-efficiency compromise of wireless sys-

tems. Soon after its dawn, about some 15 years ago, it became both a well-established practical technique and a typical example of the incorporation of signal processing algorithms for RF impairment mitigation in the present and future microwave and wireless systems.

The goal for the fourth edition of this Student Design Competition (SDC) is to maximize the output power of an envelope tracking (ET) power amplifier (PA) under specific linearity constraints and realistic waveform operation.

Following the three previous editions of the DPD Student Design Competition, a remote-controlled measurement setup (WebLab) consisting of the PA to be linearized and proper instrumentation will be made available for the competitors prior to IMS. Measurements can then be performed remotely using this virtual laboratory setup in order for the competitors to develop and tune their DPD algorithms.

Design Specification/Rules:

DPD-Competition Description

The objective of this SDC is to design a DPD algorithm appropriate to the linearization of a given PA with dynamic supply. The complete transmitter chain to be linearized comprises the following devices and instrumentation:

- PA designed to allow dynamic supply.
- Commercial envelope modulator.
- Wideband direct RF/uW arbitrary waveform generator (AWG) or Wideband I/Q AWG and modulator (depending on the specific instrumentation made available by the equipment sponsor).
- Signal analyzer.

The participants will be able to remotely (via the web) upload 1) the predistorted envelope signals (baseband I/Q signals) and 2) supply wave to the corresponding signal generators (taking into account of the necessary delay compensation between both I/Q and supply signals). The PA response (also, the baseband envelope signal) will be retrieved by the signal analyzer. The scoring results will be also provided. The participants' DPD algorithms will be run off-line, similarly to the earlier editions of the DPD-Competition, and a realization of the target input signal used in the competition will be made available to the participating teams. A realistic orthogonal frequency division multiplex (OFDM) telecommunications signal will be used as input, which will cover a significant part of the PA's available bandwidth.

Through a dedicated web site, the participating students will be able to test and essay their algorithms with the hardware setup, by remotely uploading the input predistorted signals and supply waves, and capturing the respective output signals. Both the web site and the input signal format to be considered in the DPD-Competition will be made available well in advance to the competition.

In the DPD-Competition, to be held in the IMS2017, the same hardware test setup (or other samples of the same devices) will be made available to the participating students, where they will be able to tune their DPD algorithms and upload their predistorted and supply signals. Each team will have a period of 15 minutes to tune its DPD model. When ready (or at the end of that 15 minutes period) the target input signal will be given to the team and its DPD will generate the predistorted and bias supply signals, which will be uploaded to the signal generator and supply modulator. At that moment, the jury will measure (and register) the performance metrics used to compute the overall score achieved by the team.

Scoring the DPD-Competition Teams

The DPD-Competition goal is to maximize a numerical score, which is used to rank each participating students' team. It will be calculated by a formula, defined long before the competition (and made available to the teams), which increases with the PA output power, although restricted to a specific spectral emission mask and weighted normalized mean square error (NMSE). The computational efficiency of the DPD algorithm will also be measured in terms of minimum number of required resources, for example particularizing in the number of coefficients used by the DPD algorithm. Hence, the ranking score will depend on the following performance metrics:

- The RMS output power level constitutes the desired optimization target, provided that the other linearity constraints are met. It will thus positively contribute to the score.
- The out-of-channel distortion mitigation will be assessed according to an appropriately defined spectral emission mask set following real communication scenarios of the specified signal format. The amount of power violating this mask will negatively contribute to the score.
- The overall signal error will be measured using the NMSE between the (scaled and time-aligned) output signal and the input signal. This NMSE will be weighted so that the errors in distinct signal amplitudes will be weighted differently. The amount of

violation of the limit NMSE (which is also provided ahead) will negatively contribute to the score.

- The computational complexity will be measured in terms of number of resources used by the DPD algorithm. For example, assuming a parameter-based DPD, a high number of required coefficients will have a negative impact on the final score.

The exact score formula will be designed and adjusted based on our assessment of the device to be linearized (if found adequate, the metrics above described will be adjusted).

A MATLAB script will calculate the score based on the defined performance metrics. This same script will provide the scoring values in the remote access web site (before the IMS2017 competition) and during the IMS2017 competition. The script will be available in the web site for downloading by the participants.

Participation Rules

The DPD-Competition is open to teams of undergraduate and/or graduate students that are registered at a university or other educational institution. The maximum number of participants per team is three. Participants cannot be associated with more than one team. Students currently affiliated with the Universitat Politècnica de Catalunya, UPC- Barcelona Tech., Spain, cannot participate in the competition.

At least one member from each team must be present at the competition held during the IMS2017. After the registration period ends, a time-table for the competition day will be made available, with the schedule of the 15 minutes slots of the participating teams. If no team member is present at the competition site within its slot, then the team may be considered as absent.

The MATLAB scripts required by each team to implement and tune their DPD algorithm at the competition must be brought on a USB memory stick. At the IMS2017 competition, the hardware setup will be controlled by a PC to which the teams will have access during their 15 minutes time slot. It will not be possible for participants to connect their own computers to the hardware setup during the competition. The scripts and files brought by the teams will not be stored, but deleted from the PC after the participation of each team.

Participants must register to the IMS Student Design Competition according to the rules posted on the IMS2017 homepage. At the same time as the registration to IMS2017 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 plgilabert@tsc.upc.edu and to gabriel.montoro@upc.edu with the subject line “IMS SDC: Registration DPD-linearization competition” no later than the official deadline announced on the IMS2017 SDC homepage.

In accordance with IMS general rules, it is required that the designed algorithms are principally the work of the students.

Please also see the general IMS student design competition rules on the IMS2017 SDC homepage.

Prizes:

Prizes: 1st team gets $1200 and 2nd team $800.

Undergraduate and graduate students’ DPD algorithms will not be separately judged under two distinct contest levels, but combined.