Digital calibration of analog, mixed-signal and radio-frequency circuits and systems

February 8, 13:15 – 14:30

Seminar room at second floor of DIET Department

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Abstract

Trends in analog and digital technologies allow system designers to shift more functions from the analog / mixed-signal / radio-frequency sections to the digital section: higher flexibility and modularity of digital solutions, rapidly increasing digital processing power and power efficiency, and growing analog limitations (gain, mismatches…) in advanced CMOS processes allow an increased role for digital processing.

Digital calibration is the use of digital techniques to improve the performance of analog / mixed-signal / radio-frequency systems. Examples of systems whose performance can be improved through digital processing are analog-to-digital converters, power amplifiers, I/Q mixers, whole receivers or transmitters, or entire systems such as direction-finding receivers, beam-formers, etc.

The process of digital calibration can be separated in three steps: modeling the effect of the analog impairments on the system, estimation of the error parameters of the model, correction of the effects of the impairments. In background calibration techniques, estimation is performed online through adaptive filtering techniques; in foreground calibration techniques, parameters are estimated offline and loaded in the correction hardware.

Digital calibration techniques can correct linear errors (component mismatches, finite-gain in OTAs…) which have nonlinear impact on systems such as ADCs and mixers. Alternatively, they can correct nonlinear errors, potentially improving the dynamic range and interferer/jamming robustness of electronic systems.

By its nature, digital calibration requires multiple interdisciplinary skills: circuit and system design, block and system behavioral modeling, statistical estimation theory, system identification, digital signal processing, digital design, adaptive filtering techniques. This technique also poses new trade-offs from an engineering point of view.

Bio

Pietro Monsurrò is research fellow at the DIET Department of the University of Rome Sapienza. He received the BSc magna cum laude in Electronics in 2002, the MSc magna cum laude in 2004, the PhD in 2008 at the University of Rome Sapienza. He has been visiting researcher at the University of Paderborn (Germany) in 2005 and 2014, and at the NTNU of Trondheim (Norway) in 2011. He published 25 journal papers and 40 conference papers. His main research interests are: low-power, low-voltage circuit design; class-AB circuits; analog filter design; behavioral modeling of electronic circuits and systems; modeling and calibration of time-interleaved ADCs; system-level modeling and calibration; asynchronous time-interleaving digitizers.