

## F7: Low-Voltage Analog Amplifier Design for Filtering and A/D Conversion

**Organizer/Chair:** Peter Kinget, *Columbia University, New York, NY*

**Committee:** **Andrea Baschiroto**, *University of Lecce, Lecce, Italy*  
**JoAnn Close**, *Analog Devices, San Jose, CA*  
**Axel Thomsen**, *Silicon Laboratories, Austin, TX*

Analog designers are forced to deal with continuously decreasing supply voltages. Continued process scaling is reducing device dimensions including the gate oxide thickness and, as a result, the breakdown voltage and maximum supply voltage decrease for each process generation. Additionally, the increased use of battery-powered devices motivates the push toward lower supply voltages in mobile applications. While threshold voltages are not significantly lower, the net usable voltage range for signal swing, biasing, and device stacking is substantially reduced. As a result, amplifier performance (e.g., speed, gain and noise) is compromised, which then requires adjustments in the systems where they are applied.

This forum addresses the basic design issues for low-voltage amplifier circuits in the context of the applications and systems they operate in. A panel of researchers from academia and industry will review low-voltage amplifier design techniques, amplifier performance degradation due to low-voltage operation, as well as filter and A/D converter architecture solutions to mitigate the amplifier design challenges. The presented techniques will range from product-proven established techniques to more recently developed techniques for aggressive supply voltage scaling.

**Andrea Baschiroto** (U Lecce) will discuss active RC filter design solutions that incorporate limited opamp gain and bandwidth in the filter design process. **Peter Kinget's** (Columbia U) talk addresses circuit-level techniques that allow amplifiers to operate at extremely low supplies in filters and converters by utilizing techniques such as bulk biasing or bulk inputs, common-mode level shifting and switch elimination techniques. **Un-Ku Moon** (Oregon State U) will cover low-voltage, switched-circuit techniques for switched-capacitor and filter applications. **Willy Sansen** (KU Leuven) will address the issue of noise optimization in headroom-constrained amplifiers. In low supply environments, high-gain amplifiers need to be implemented as multistage amplifiers and **Johan Huijsing** (TU Delft) will present class-AB techniques as well as compensation techniques that stabilize amplifiers with up to 4 stages. **Jieh-Tsorng Wu** (National Chiao-Tung U) addresses the performance limitations that amplifiers cause in A/D converters and digital calibration techniques to overcome the amplifier imperfections. The final two presentations focus on how the constraints of low-voltage amplifier design result in engineering decisions. Battery-powered hearing aid IC designs require both low-voltage and low power and **Alexander Heubi** (AMIS) will discuss a design using low-voltage circuits in some areas while choosing to boost the supply voltage in others. **Corey Petersen** (Analog Devices) will review the trade-offs in low-voltage design for performance driven applications and discuss under what conditions low-voltage design is really beneficial.

The forum will conclude with a panel discussion where the attendees have the opportunity to ask questions and share their views.

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**Forum Agenda**

<b><u>Time</u></b>	<b><u>Topic</u></b>
08:00	Continental Breakfast
08:30	<b>Welcome and Introduction</b> <b>Peter Kinget</b> , <i>Columbia University, New York, NY</i>
08:40	<b>Critical Opamp Design Aspects for Low-Voltage Active RC Filters</b> <b>Andrea Baschiroto</b> , <i>University of Lecce, Lecce, Italy</i>
09:20	<b>True Low-Voltage OTAs for 0.5V Active Filters, THAs and CT <math>\Delta\Sigma</math> Converters</b> <b>Peter Kinget</b> , <i>Columbia University, New York, NY</i>
10:00	<b>Switched-R applications of Low-Voltage Amplifiers</b> <b>Un-Ku Moon</b> , <i>Oregon State University, Corvallis, OR</i>
10:40	Break
11:00	<b>Low-noise Optimization for Low-Voltage Amplifiers</b> <b>Willy Sansen</b> , <i>Katholieke Universiteit Leuven, Leuven, Belgium</i>
11:40	<b>Low Voltage Multi-Stage Amplifiers</b> <b>Johan Huijsing</b> , <i>Technische Universiteit Delft, The Netherlands</i>
12:20	Lunch
01:40	<b>Calibration techniques for Low-Voltage Amplifier Non-Idealities in Pipelined ADCs</b> <b>Jieh-Tsorng Wu</b> , <i>National Chiao-Tung University, Taiwan</i>
02:20	<b>Low-Voltage Analog Front End for Digital Hearing Aids</b> <b>Alexander Heubi</b> , <i>AMIS, Switzerland</i>
03:00	<b>Performance Motivated Low-Voltage Analog Circuit Design</b> <b>Corey Petersen</b> , <i>Analog Devices</i>
03:40	Break
04:00	Panel Discussion
05:00	Conclusion