Curriculum Vitae of Paolo Maffezzoni

Personal data

Address:

Dipartimento di Elettronica, Informazione e Bioingegneria
Politecnico di Milano
Piazza Leonardo da Vinci 32, Milano, Italy, I-20133
Phone: +39-2399-3679
Fax: +39-2399-3412
E-mail: paolo.maffezzoni@polimi.it

Date and place of birth: June 15th 1966, Cremona, Italy
Nationality: italian

Academic Position

- *2018-to date* Full Professor of Electrical Engineering (Professore Ordinario di Ruolo in Elettrotecnica). Dipartimento di Elettronica, Informazione e Bioingegneria (DEIB), Politecnico di Milano.

- *2004-2017* Associate Professor of Electrical Engineering, DEIB, Politecnico di Milano.

- *1998-2003* Assistant Professor in Electrical Engineering (Elettrotecnica), scientific disciplinary sector: ING-IND/31, Dipartimento di Elettronica e Informazione (DEI), Politecnico di Milano.

- *1996-1998* Postdoctoral Research Assistant (Assistente post-doc) in Electrical Engineering (Elettrotecnica), Dipartimento di Elettronica e Informazione, Politecnico di Milano. Tutor as an expert in the area of Electronic Design Automation at Research Center CEFRIEL, Milano, for the Master in Information technology, IX and X Editions.

Education

- *1993-1996* Ph.D. degree in Electronic Instrumentation Engineering. Università degli Studi di Brescia. Thesis: "*Elaborazione dei segnali provenienti da sensori di misura con tecniche di calcolo neurale*".

- *1992-93* Civil service (Servizio Civile) at Caritas italiana.

- *1991* National qualification for the Engineering Licence at Politecnico di Milano.

- *1991* "Laurea" degree (five years) in Electronic Engineering (Ingegneria Elettronica) at Politecnico di Milano. Thesis: "*Simulazione di circuiti non lineari in regime periodico nel dominio delle frequenze*," mark 100/100 e Lode.

Scientific Research Activity

The research activity addresses the *methodological and computational tools* that are at the basis of modeling, simulation, analysis and design of nonlinear dynamical circuits and systems. The research has been multi-disciplinary with several scientific areas involved, among which: nonlinear circuits and systems, electronic design automation (EDA), analog and digital electronics, numerical analysis and computing algorithms, electrical simulation, signal processing, electromagnetics, thermodynamics, fluid-dynamics, stochastic processes and statistics. The activity has been driven by some relevant applications, which include *Analog and Mixed-signal (AMS)* RF electronics, *Renewable Photovoltaic systems* and *Unconventional Computing Machines*. The research has been performed in part in collaboration with national and international teams that are recognized leaders in their area, among which:

- ***Computational Prototyping Group*** at Research Electronic Laboratory, *Massachusetts Institute of Technology (MIT),* Cambridge, MA, USA (Ref. Prof. Luca Daniel)
- ***University College Cork (UCC) and Tyndall National Institute***, Cork, Ireland (Ref. Prof. Michael Peter Kennedy)
- ***Microelectronics Group***, *Politecnico di Milano*, Milan, Italy (Ref. Prof. Salvatore Levantino)
- ***Physics Lab at Pennsylvania State University***, University Park, PA, USA (Ref. Prof. Suman Datta)
- ***Georgia Institute of Technology***, Atlanta, GA, USA (Ref. Prof. Arijit Raychowdhury)

The main research activities include what follows:

1 - Advanced computational methods for the analysis and design of nonlinear circuits and systems with applications to AMS electronics

This research activity has been driven in part by applications to the field of Radio Frequency (RF) Analog and Mixed-signal (AMS) circuits. The challenging features of AMS circuits that have been addressed include: a) ***Complexity.*** AMS circuits are made of thousands of nonlinear components and functional blocks having very different electrical behaviors. Fundamental building blocks are autonomous oscillators, strongly nonlinear devices such as comparators and phase detectors, digital logics and power devices. Detailed transistor-level simulations of such analog-digital complex system are prohibitively time consuming. b) ***Lack of a standard/modular design flow.*** Mature electronic design automation (EDA) techniques for AMS are still missing with analog design largely relying on designers experience and repeated time-consuming fabrication taping. c) ***Noise, non-ideal effects, parameter variability.*** With scaled technology nodes (< 32nm), and new manufacturing materials (MEMS oscillators) non-ideality effects such as noise effects, parameter variability, nonlinearities have become extremely relevant. As a result, noise analysis, uncertainty quantification, yield analysis have entered among the key figures of merit of the design flow. Specific tools for performing these new types of analysis are required. To overcome the above-reported issues, the research has being focused on developing an innovative *hierarchical analysis/simulation methodology* that allows breaking the system in simpler functional blocks. The blocks are described, at different levels of abstraction, via compact behavioral models that can include noise and variability. In this way, complex system-level analyses are made possible. In this context, the following research contributions have been provided.

1.1 Development of advanced numerical methods for the simulation of AMS circuits and systems blocks

Several advanced numerical methods and algorithms have been developed for simulating the critical functional blocks of AMS circuits, at detailed transistor-level, and have been used for extracting compact behavioral models. In this activity, some commercially-available tools, such as SpectreRF of Cadence or Eldo of Mentor Graphics, have also been used. However, many extraction and macro-modeling techniques require an "intrusive" approach, i.e. the direct access to internal data structures of the simulation code (such as the Jacobian matrix or the State Transition matrix) that are not available in commercial tools. For these reasons, a novel Spice-like simulation code, written in Matlab/C language and referred to as Simulation LABoratory (S-LAB), has been developed and used as the computational tool for prototyping new simulation algorithms. Such algorithms include an innovative simulation technique for the time-domain analysis of both autonomous circuits, i.e. oscillators, and non-autonomous circuits such as injected oscillators, phase-locked loops, and power converters. The proposed technique combines a highly accurate implicit Runge–Kutta (RK) integration method with an efficient Envelope Following Method (EFM) [6, 18, 23, 27-28, 35, 79, 81-82, 110]. Runge-Kutta integration methods have rarely been adopted in circuit simulation before of this research since the majority of them do not fit well with the computational flow of a circuit simulator. One of the crucial contribution of this research has just been that of identifying the proper sub-set of RK formulas that can be implemented effectively in spice-like circuit simulators [28]. The proposed method allows handling in an efficient way the critical cases of high-Q oscillators and circuits with multi-scale time constants [1, 35]. Other specific techniques, based on an event-driven analysis, have been developed to deal with the case of circuits containing harsh nonlinear devices, e.g. switches and comparators [27].

1.2 Behavioral modeling of autonomous (Oscillators) and non-autonomous dynamical nonlinear circuits

A general technique for modeling the variations of the transient and steady-state response of nonlinear dynamical circuits due to injected perturbations and parameter changes has been developed. The method relies on linear-time-varying approximations of the system dynamics along the trajectory or orbit [25, 31, 32, 46, 53, 58, 120, 123]. Particular importance has been given to the modeling of autonomous oscillators. Oscillators are in fact at the heart of AMS circuits where they are employed in a myriad of applications which include frequency synthesis, clock generation and system synchronization. For a wide class of autonomous oscillators, a macro-modeling technique has been provided that is based on the Floquet Theory of linear-periodically-varying circuits and on the concept of phase-domain response and Perturbation Projection Vector (PPV). It has been proved for the first time that the same system of equations used to formalize parameter-sensitivity problem can also be exploited to calculate the phase response to injected perturbations [31]. The phase-domain compact modeling has been extended as to include the effects due to oscillation amplitude modulations [53-58]. The extended compact model has been applied to the analysis of deterministic jitter in crystal oscillators due to electromagnetic interferences (EMI), crosstalk or power supply line. We have highlighted how the deterministic jitter is the result of a complex interference mechanism that involves both phase modulation (PM) and amplitude modulation (AM) of the oscillator response [58]. The proposed macro-modeling methodology has been applied to other functional blocks such as the delta-sigma converters and amplifiers [45, 29].

This research activity has been developed in collaboration with the **Computational Prototyping Group at Massachusetts Institute of Technology (MIT)**. It was supported in part by the **Progetto Roberto Rocca Travel Grant and Seed Fund** *"Development of macro-modeling and simulation techniques for uncertainty quantification and noise analysis in oscillatory devices"* [55, 58, 124].

1.3 System-level analysis including noise and variability

Experimental measurements, transistor-level noise analyses (e.g. pnoise of SpectreRF) as well as phase-domain stochastic simulations have been extensively employed to study the effect of intrinsic noise sources in the main AMS blocks with oscillators analysis emphasis [30, 41-42]. Both white thermal noise and colored noise sources, e.g. flicker noise in MOS transistor, have been investigated. The research activity has shed new light on several important theoretical issues connected to oscillator noise, such as the correct calculation of the phase-noise diffusion coefficient and the correct evaluation of the noise spectrum near the fundamental harmonic component. Furthermore, these investigations have allowed us to devise an effective and realistic method for including the effects of phase noise in the compact macro-model of oscillators. Such a noise-aware compact model has been exploited in the system-level analysis of complex AMS such as frequency synthesizers, all-digital phase-locked loops or multi-phase oscillator arrays. A relevant result has been achieved in the design of charge-pump phase-locked-loops (PLLs) where it has shown for the first time that the phase noise due to the Voltage-Controlled-Oscillator is subject to a spectrum folding effect that results in an in band spectrum deterioration [44, 48]. Such an unwanted effect, that is unpredicted by conventional PLL linear theory and difficult to verify though conventional simulations, has been fully confirmed by experimental evidences. A second relevant application has been achieved in the emerging field of digital phase-locked loops (DPLL) that employ a single-bit (i.e. bang-bang) phase detectors [51-54, 57]. The harsh nonlinear behavior of DPLLs and the coarse quantization of phase error make their design challenging in terms of signal purity. In fact such systems are prone to the generation of limit cycles appearing as unwanted spurs in the spectrum. It has been proved for the first time how the phase noise of embedded oscillator can be exploited to reduce or completely remove such unwanted spurs thanks to a fascinating phenomenon referred to as "Stochastic Resonance" [54]. The research has highlighted how stochastic resonance occurs for a proper selection of the PLL loop parameters, corresponding to an optimal design condition, and leads to maximum system performance in terms of quality of the output response. The proposed analysis and optimization have been validated experimentally on digital bang-bang PLLs fabricated in CMOS process. This research activity has been developed in part in collaboration with the **Microelectronics Group, Politecnico di Milano**, and its laboratory [54, 58, 117-123].

2 - Synchronization effects in oscillators and systems of oscillators, new paradigms for parallel computing

This second research activity has been focused on the theoretical investigation of the nonlinear dynamical phenomenon of synchronization in self-sustaining oscillating devices and its exploitation in several engineering applications. In the field of communication electronics, it has been studied how oscillator synchronization can be employed in the implementation of innovative techniques for frequency synthesis, for generating multiple signals with finely tuned phase separations and in noise reduction methods. From a different point of view, the research activity has highlighted how oscillator synchronization with unwanted small interferences injected by neighbor devices can compromise the reliability of communication electronics.
RF transmitter/receiver circuits are in fact formed by many analog blocks, among which are amplifiers, oscillators, and mixers, all integrated over the same substrate and thus subject to reciprocal interactions. The power amplifier output, for instance, can contain large spectral components in the vicinity of the free-running oscillator frequency, and the signal leaking through the substrate or through the packaging can interact with the oscillator causing frequency perturbations referred to as frequency pulling.
Finally, visionary applications of the synchronization effects to the realization of non-Boolean computational machines are currently under investigation. Synchronization of large arrays of coupled oscillators is emerging as a promising way for implementing new paradigms for massively-parallel computing tasks, such as big data analysis and pattern recognition. In this context, the main achievements are described in the following points.

2.1 **Injection locking and lock range estimation**

An innovative method has been provided that allows predicting the lock range, i.e. the range of frequency where the correct synchronization occurs, for oscillators injected by weak signals whose frequency is close to a multiple of that of the oscillator [32, 38, 40, 46, 47]. Before of this research, no universal formula existed which was able to predict the lock range independently of the oscillator topology and for any possible injection point. Our achievement is based on the exploitation of a proper phase-domain model of the oscillator dynamical response and on a set of closed-form expressions for the lock range that are valid under the hypothesis of weak injection. The analysis has been extended to the case of mutual synchronization among two or more oscillators. For chain arrays of mutually coupled oscillators, it has been assessed how synchronization can be exploited to generate multi-phase signals with prescribed phase differences [60, 64]. The proposed theory and simulation tools have been employed in the design of innovative AMS circuit solutions for frequency synthesis among which Injection-Locked Frequency Dividers. This last activity has been developed in **collaboration with the University**

College Cork (UCC) and Tyndall National Institute, Cork, Ireland and has been **supported in part by Science Foundation of Ireland under Grant 06/RFP/ENE009 and Grant 08/IN.1/I854 (2010-2011)** on the research subject: "*Optimizing the Design of Injection-Locked Frequency Dividers by Means of Nonlinear Analysis*" [39, 116].

2.2 **Injection pulling, Interferences and noise**

In order to evaluate unwanted synchronization effects due to spurious interferences, a set of closed-form expressions for a fast and efficient evaluation of injection pulling in several RF oscillator topologies have be provided for the first time. It has been highlighted how weak, and apparently innocuous, injected signals can have dramatic consequences on the oscillator response. This depends on the oscillator topology and on the node at which injection takes place. Several design guidelines can be derived to mitigate interference effects and increase the system resilience. By combining the developed phase-domain models for oscillators and the compact representation of intrinsic noise through equivalent noise sources, the interacting mechanism between noise and synchronization has been investigated. It has been shown with simulations and experiments how the injection of a small stable reference can improve the oscillator noise performance. Several types of noise mitigation techniques have been studied which include pulse injection locking (Pulse-injection Locked Oscillators) and mutual coupling in arrays of multi-phase oscillators [33, 41, 43, 49, 51, 56, 59, 64, 122, 133].

2.3 **New paradigms for parallel computing**

This research activity has targeted the realization of novel computational machines based on arrays of weakly coupled oscillating devices for massively-parallel computational tasks, such as associative memory and pattern recognition. A significant step forward towards the real implementation of oscillator arrays for associative memory has been provided by solving some fundamental open issues. A first contribution has been the identification of proper topologies of arrays of mutually coupled resonant oscillators that allow controlling the array response in terms of relative phase differences [61]. Such phase differences can be used to encode the information in the associative memory. A second crucial contribution has been the development of a robust design methodology for such complex system [65]. This second challenge is solved through a hierarchical simulation approach and behavioral macro-modeling. Thanks to such contributions, we were able to verify the achievable associative memory capability of the array as well as to identify some relevant implementation factors and design parameters that can deteriorate the memory performance. In particular, we highlighted the importance of frequency matching among oscillators. A switched-interconnected architecture was proposed in order to mitigate the implementation complexity of a fully-interconnected array. Oscillator arrays implementations in emerging More than Moore technologies have been also evaluated which include new family of two-terminal devices fabricated with Vanadium Dioxide material and piezoelectric Resonant Body Oscillators [63]. In the first case, the Vanadium Dioxide Oscillators (VDO) exhibit a hysteretic switching-like behavior with large and abrupt change in electrical conductivity that can be triggered by the applied electrical voltage. The research activity provided several advancements, which include a new driving-point equivalent model for the two-terminal device, theoretical and numerical tools for the design of stable VDO and first realization of voltage-controlled oscillators and of small oscillator arrays. This research activity was carried out in collaboration with a **network of universities and research centers that include Massachusetts Institute of Technology (MIT), Pennsylvania State University, and Georgia Institute of Technology.** The activity was **supported in part by the National Science Foundation (U.S.) (NEEDS Program 2015) Award #1227020**, *"Network for Computational Nanotechnology"* - NEEDS Node [58, 60, 61, 62, 63, 64, 65].

3 - Multi-physics simulation, thermal analysis, photovoltaic energy

This research activity has provided significant advancements in the field of modeling and simulation of some multi-physics distributed phenomenon associated to the electrical and electronics circuits. This includes the analysis of thermal and conjugate electro-thermal effects in micro/nano electronics integrated circuits and in power electronics, the extraction of capacitance parasitic in on-chip interconnections of digital electronics, as well as the analysis and design of novel distributed photovoltaic arrays for renewable energy generation. The common features of such different applications are: a) the interaction of physical phenomenon of different nature, e.g. electrical, optical and thermal, and that are represented with both lumped and distributed models; b) the complexity of such distributed models; c) the long computational times required by multi-physic simulations.

3.1 Thermal and Electro-thermal analysis

A first research activity has focused on some relevant issues that emerge in the electro-thermal analysis of electrical systems and that are related to the distributed nature of the thermal problem. A first issue is connected to the definition of the device junction temperature used in device electro-thermal model. In the distributed thermal problem in fact the device occupies a finite space of the domain and thus it is described by many temperature values, i.e. a given temperature distribution. In this research it has been shown how the abstract concept of lumped junction temperature can be linked to that of temperature distribution and how this concept results in a port-like representation of the thermal problem through an equivalent thermal network [16]. An important achievement of the research has been that of providing a proper definition of junction temperature for which the thermal network preserves the reciprocity and passivity properties. This guarantees the stability of the thermal network used in electro-thermal simulations. A second important achievement of the research have been a suite of innovative techniques for reducing the complexity of the thermal network. This includes an Arnoldi-type algorithm implemented [17] with multipoint moment matching approximation of the discretized thermal network and a Truncated-Balanced-Realization (TBR) method with vector alternate-direction-implicit (ADI) approximation [16]. Several benchmark examples, including electro-thermal analysis of power amplifiers and vertical MOS devices, have been used to confirm the accuracy and robustness of the proposed compact-modeling technique [3, 8, 9, 12, 15-17, 26, 77-80, 85-105, 111-115].

3.2 Compact modeling of on-chip interconnect, parasitic capacitance extraction

This research activity has targeted the precise estimation of the signal delays and propagation skews in on-chip interconnects embedded in complex industrial layouts. Such propagation effects are dominated by the parasitic capacitance effects that arise among the micro-strip lines and the underneath substrate whose determination results extremely challenging due to the geometry complexity. This research has provided a significant contribution by combining an efficient statistical technique for capacitance extraction with an algorithm that directly supplies the reduced-order RC model of the interconnection, ready for delay evaluation. The parasitic capacitance extraction problem has been efficiently accomplished by means of an extend version of the statistical floating random walk (FRW) while model order reduction has been achieved through an innovative Monte Carlo integration of the interconnect equations. It has been proved how the proposed method is able to deal with very complicated 3D geometries in an efficient way and needs neither fracturing the original layout into sub-regions nor discretization of the interconnects. This results in higher robustness and accuracy compared to techniques available in the literature based on geometry simplifications. The accuracy of the proposed interconnects modeling technique has been verified on several industrial layouts. Such a research has been developed in part in collaboration with the Central Research and Development of STMicroelectronics that has provided the industrial layouts and measurements [4, 5, 7, 11, 13, 19, 20, 24, 76, 84, 90].

3.3 Multi-physics analysis of photovoltaic arrays.

The multi-physics modeling and simulation activity has supported the realization of prototype solar panels for the hybrid generation of electric energy and heat in remote areas. One of such solution includes a solar concentrator, a string of series-connected PV cells, and a water cooling system having heat-recovery capability. Light concentration leads to a significant saving of the active material but unavoidably implies also a much higher power density over the cell surface and, thus, a great increase of the local temperature. This imposes the adoption of a proper cooling system to remove a portion of the generated heat and to limit the temperature rise. The presence of a cooling interface improves the electrical efficiency of the solar cells and, in addition, increases the life-time of the system. A further advantage of such a solution is that a significant portion of the solar energy which would be wasted in the PV process is actually rescued in terms of fluid heating, thus increasing the overall conversion efficiency. Light concentration and cooling through a cold fluid that flows into one or more pipes connected to the back of the panel produce temperature gradients over the panel and non-uniform thermal conditions over the solar cells. The research activity has been focused on the determination of compact electro-thermal macro-model of the hybrid photovoltaic module able to properly incorporate fluid cooling effect and temperature gradients along the cells. The proposed model has been exploited in the design of the prototype panels to predict the temperature profile along the cells, the current and voltage levels that can be sustained by the solar panel and the maximum achievable power as a function of the cooling strategy. This research has been developed in collaboration with the universities of Firenze, Salerno, and Bologna. The activity has been **supported in part by the Italian Ministry of University and Research Grant, PRIN2006,** *``Study, design and optimization of a modular photovoltaic system with concentration, integrated with a heat recovery and related conversion interface"* [34, 37, 113-115].

Grants and Funded Activities Coordinator

Paolo Maffezzoni has been the **Coordinator** of the following Grants and Funded activities:

- **Progetto Roberto Rocca Travel Grant and Seed Fund**, from 2013 to 2015, between Massachusetts Institute of Technology (MIT) and Politecnico di Milano (PoliMI). **Grant coordinator** for Politecnico di Milano, (MIT coordinator Prof. Luca Daniel). Title: *"Development of macro-modeling and simulation techniques for uncertainty quantification and noise analysis in oscillatory devices"* . The project was granted on the basis of a selection procedure by the Global Seed Funds Advisory Committee of MIT.

- **Italian Ministry of University and Research Grant,** from 2007 to 2008 (PRIN2006). **Node coordinator** for Politecnico di Milano of a research network with the universities of Firenze, Salerno, Bologna. Title: *``Study, design and optimization of a modular photovoltaic system with concentration, integrated with a heat recovery and related conversion interface".* The project was granted on the basis of a selection procedure with anonymous expert reviewers.

- **IEEE Circuits and Systems Society (CASS) Outreach Activity Grant**, years 2014, 2015 and 2017. **Coordinator** at Politecnico di Milano. Title: *"Developing Inter-disciplinary Education in Circuits and Systems Community".* The project was granted on the basis of a selection procedure by a committee formed by the Vice-President of Financial Activity and Board of Governors members of the IEEE CAS Society.

Paolo Maffezzoni has participated or collaborated to several funded international research projects, among which: a) **National Science Foundation (U.S.)** (NEEDS Program 2015) Award #1227020, *"Network for Computational Nanotechnology"* - NEEDS Node. b) **Science Foundation of Ireland** under Grant 06/RFP/ENE009 and Grant 08/IN.1/I854 (2010-2011) on the research subject: *"Optimizing the Design of Injection-Locked Frequency Dividers by Means of Nonlinear Analysis".* c) **Progetto Roberto Rocca** Seed Fund (2014). *"Development of Efficient Stochastic Simulation and Modeling Techniques for Photonic Design Automation, Bioelectrical Engineering and Computer Science",* Coordinator at Politecnico di Milano, Prof. Andrea Melloni. d) **Progetto Roberto Rocca** Seed Fund (2017). *"Disorder-aware Engineering of Metasurfaces for Advanced Photonics",* Coordinator at Politecnico di Milano, Prof. Giuseppe della Valle.

National and international reputation and professional activity for the scientific community

- **Participation to the Editorial Boards of International Journals:**

  - Member of the Editorial Board of the ***IEEE Transactions on Circuits and Systems-I: Regular Papers (TCAS-I)***, for the term 2016-2017 and renewed for the term 2018-2019, in the role of **Associate Editor**.

  - Member of the Editorial Board of the ***IEEE Transactions on Computer-Aided-Design of Integrated Circuits and Systems (TCAD)***, from January 2013 to February 2016, in the role of **Associate Editor** and as a Member the TCAD **Advisory Committee** for special issues and keynote papers selection.

- **Service as a Reviewer**

  He has served as a Reviewer for several Journals and Conferences. In what follows, only the main ones are reported.

  - **Journals:**
    IEEE Transactions on Circuits and Systems-I and II,
    IEEE Transactions on Computer-Aided-Design of Integrated Circuits and Systems,
    IEEE Transactions on Industrial Electronics,
    IEEE Journal of Solid State Circuits,
    IEEE Transactions on Microwave Theory and Techniques,
    IET Electronics Letters,
    International Journal of Circuit Theory and Applications,
    Microelectronics Journal.

  - **International Conferences:**
    IEEE International Symposium on Circuits and Systems (ISCAS),
    IEEE/ACM International Conference on Computer-Aided Design (ICCAD),
    IEEE-ACM Design Automation Conference (DAC),
    IEEE European Conference on Circuit Theory and Design (ECCTD),
    IEEE International Conference on Electronics, Circuits, and Systems (ICECS).

- **Memberships and awards/recognitions:**

  - **Senior Member of the IEEE** since 2015.

  - **Member** of the IEEE Circuits and Systems Society, the IEEE Council of Electron Device Automation (CEDA) and of the IEEE Industrial Electronics Society.

  - **TCAS-I Guillemin-Cauer Best Paper Award Nomination** for the paper:

P. Maffezzoni e S. Levantino,``Analysis of VCO Phase Noise in Charge-Pump Phase-Locked Loops," *IEEE Trans. Circuits and Systems I: Regular Papers* , vol. 59, no. 10, pp. 2165-2175, Oct. 2012.

- **Best Invited paper Nomination**: Z. Zhang, X. Yang, G. Marucci, P. Maffezzoni, I. M. Elfadel, G. Karniadakis and L. Daniel, ``Stochastic testing simulator for integrated circuits and MEMS: Hierarchical and sparse techniques," *IEEE Custom Integrated Circuits Conf. (CICC)*, 8 pages, San Jose, CA., Sept. 2014.

- **Participation to Recent International Conferences as invited speaker, and to Committees of International Conferences:**

  - Member of the **Technical Program Committee** of the **IEEE-ACM Design Automation Conference** (DAC), Feb. 2015.

  - **Invited Lecture.** Title: "Phase-domain modeling of oscillators: theory and applications" in the ***Advanced Topics In Microelectronic Engineering ATIME 2015/01*** (sponsored by the **IEEE CASS 2015 Outreach Initiative**), Limerick, Ireland, June 2015.

  - **Invited Paper**: Z. Zhang, X. Yang, G. Marucci, **P. Maffezzoni**, I. M. Elfadel, G. Karniadakis and L. Daniel, ``*Stochastic testing simulator for integrated circuits and MEMS: Hierarchical and sparse techniques,"* at the **IEEE Custom Integrated Circuits Conference (CICC)**, San Jose, CA., Sept. 2014.

  - **Session Chair at IEEE-ACM Design Automation Conference** (DAC). Session Title: Analog: Simulate, Check and Go !, San Francisco, CA, USA, June 2014.

  - **Invited Lecture.** Title: "Phase-domain Macro-modeling of Oscillators for the analysis of Noise, Interferences and Synchronization Effects". **Tutorial Sponsored by Progetto Roberto Rocca**, Massachusetts Institute of Technology (MIT), Cambridge, MA, USA. Sep. 2013.

  - **Invited Tutorial.** Title: "The Phase Sensitivity Function: what it is and how to calculate it using a frequency-domain method", **Workshop sponsored by IEEE Solid State Circuits Society**, University College Cork, Cork, Ireland. Nov. 2012.

  - **Session Chair at IEEE International Symposium on Circuits and Systems** (ISCAS) 2010. Section Title: Nonlinear Circuits and Systems, Paris, France, May 2010.

  - **Invited Keynote Lecture**. Title: "Hybrid Numerical-Analytical Approach to the Analysis of Oscillators" at **IEEE international conference PRIME 2009**, Cork, Ireland, July 2009.

- **Participation to recent National Conferences/Meetings as invited speaker:**

  - **Invited speaker** to the educational event ***10th anniversary of Progetto Rocca***, (invitation by Prof. Donatella Sciuto), Politecnico di Milano, Italy, June 2015.

  - **Invited Talk**, Title: "Analysis and Design of Multi-phase oscillators" at ***Riunone Annuale Gruppo Nazionale Elettrotecnica,*** (invitation by Prof. Mauro Parodi), Genova, Italy, June 2015.

  - **Invited speaker** to the educational ***MIT-Rocca day***, (invitation by Prof. Serenella Sferza, Political Science Dept MIT), Politecnico di Milano, Italy, October 2013.

  - **Invited Talk**. Title: "Modeling noise in oscillators embedded in analog mixed-signal electronics" (invitation by Prof. Marco Storace), ***Riunone Annuale Gruppo Nazionale Elettrotecnica,*** Padova, Italy, June 2013.

Service to University

- **Member** of the "Commissione Verifica della Regolarità del Consiglio della V Facoltà di Ingegneria del Politecnico di Milano" (from 2002 to 2010).

- **Member** of the "Collegio di dottorato in Ingegneria dell'Informazione" del politecnico di Milano code number: DOT0316899 (years 2008-2012), DOT1316508 (years 2013-2015).

- Member of the "Commissione di selezione per gli incarichi di didattica integrative" for the Section of Electronics, DEIB, for the years 2014/15 and 2015/2016.

- **Member** of the "Commissione di concorso ad un posto di ricercatore universitario presso l'università di Siena" SSD ING-IND/31 (Elettrotecnica), nomina Gazzetta Ufficiale n. 39 del 17-5-2002.

- **Member** of the "Commissione di conferma per professore associato, SSD ING-IND/31 (Elettrotecnica) Ministero dell'Istruzione, dell'Università e della Ricerca, nomina del 19-05-2008, prot. n. 1788

- **Referee MIU**R for the selection of PRIN projects (year 2008)

- **Referee MIUR** for the preselection of "Scientific Independence of young Researchers" SIR projects (year 2014)

- **Referee MIUR** for the VQR 2011-2014 (year 2016/17)

Teaching and PhD students activity

- **Course Responsibility:** Paolo Maffezzoni has had the responsibility of the "Basic Circuit Theory" courses at Politecnico di Milano since 2000-2001, as it is reported in the detailed description that follows. In all the editions, from 2000-2001 to date, the courses have always been rated as "High" (in a scale of values "Low", "Average", "High") by the official evaluation given by the students.
  - *Seven years*, from 2010-2011 to date, of **formal responsibility** of the course ***"Basic Circuit Theory"*** (Elettrotecnica, S.S.D. ING-IND/31, ordinamento D.M. 270/04), 10 Credits, for the Bachelor's Degree (Laurea di primo livello) in Information Engineering (Ingegneria Informatica) at Politecnico di Milano. About 240 students per year.
  - *Nine years*, from 2000-2001 to 2009/2010, of **formal responsibility** of the course ***"Basic Circuit Theory"*** (Elettrotecnica, S.S.D. ING-IND/31, ordinamento D.M. 509/99), 7.5 Credits, for the Bachelor's Degree (Laurea di primo livello) in Information Engineering (Ingegneria Informatica) at Politecnico di Milano. About 200 students per year.
  - *Two years*, from 2008-2009 to 2009-2010, of **formal responsibility** of the course ***"Basic Circuit Theory"*** (Elettrotecnica, S.S.D. ING-IND/31, ordinamento D.M. 270/04), 10 Credits, for the Bachelor's Degree (Laurea di primo livello) in Information Engineering (Ingegneria Informatica) and Management Engineering (Ingegneria Gestionale) at Politecnico di Milano, branch of Cremona. About 120 students per year.
  - *Seven years*, from 2001-2002 to 2007/2008, of **formal responsibility** of the course ***"Basic Circuit Theory"*** (Elettrotecnica, S.S.D. ING-IND/31, ordinamento D.M. 509/99), 7.5 Credits, for the Bachelor's Degree (Laurea di primo livello) in Information Engineering (Ingegneria Informatica) at Politecnico di Milano, branch of Cremona. About 100 students per year.

- **Activity with Postgraduate and PhD students**
  - *Eight years*, from 2008 to 2015, **member of the board** of the ***PhD track in Information Technology (ICT)*** at Politecnico di Milano, code number: DOT0316899 (2008-2012), DOT1316508 (2013-2015). The activity included the participation to the yearly and midterm commissions for the Examination of the PhD students (about 20 students per year) and the participation to the steering PhD committee for course selections.

- *Three years*, from 2013-14 to 2015-16, ***organizer and teaching assistant*** for the ***PhD class "Introduction to Simulation and Modeling of Complex Dynamical Systems"*** (ID code 0999261, 5 Credits), PhD School of the Politecnico di Milano, held by Prof. Luca Daniel (MIT). The activity included tutoring the students during the development of their projects and participation to the final examinations.

- *Two years*, from 2014-2015, **organizer of several educational** seminars/tutorials for the PhD students at Politecnico di Milano granted by the ***IEEE Circuits and Systems Society (CASS).***

- **Advisor or Tutor** of the following PhD students at Politecnico di Milano:

  Nadia Spennagallo, 1 joint publications in Journals and 3 in conferences, [36, 98, 104, 105]
  Federico Pepe, 2 joint publications in Journals and 3 in conferences, [50, 53, 119, 122, 123]
  Giovanni Marucci , 3 joint publications in Journals and 3 in conferences, Intership at MIT, [52, 54, 57, 120, 121, 124]

- **External cotutoring** of the following PhD students in foreign Universities:

  Said Daneshgar, University College Cork, 1 joint publication in Journals and 1 in conferences, [39, 116]
  Nikhil Shukla, Pennsylvania State University, 2 joint publications in Journals, [62, 63]
  Bichoy Bahr, Massachusetts Institute of Technology, 4 joint publications in Journals, [60, 61, 64, 65]
  Zheng Zhang, Massachusetts Institute of Technology, 6 joint publications in Journals and 1 in conferences, Intership at PoliMI, [55, 58, 60, 61, 64, 65, 124].

- **Tutor** at Politecnico di Milano for two postgraduate students of the **Alta Scuola Politecnica**, (between Politecnico di Milano e Politecnico di Torino) under the Project: *"Enhances: Energy Harvesting from Noise in Circuits & Systems"* (2015-2016).

- **Educational Node coordinator** for the Politecnico di Milano of the Young Investigator Training Program (YITP) sponsored by the *IEEE Workshop on Signal and Power Integrity* (2017).

Publications and Impact on the Scientific Community

Currently, Paolo Maffezzoni has published:

- **68 papers** in ISI Journals **(**62 of such papers have been published in IEEE Journals), among which 11 as the **single author**,
- **62 papers** presented in international conferences with peer-review,
- **1** educational **book**.

Currently, Paolo Maffezzoni has **Hirsch's h-index**: 22 according to Google Scholar and 18 according to Scopus.

Selected Recent Publications

Analog-Mixed-Signal (AMS) Simulation/Design

- P. Maffezzoni, B. Bahr, Z. Zhang, and L. Daniel, "Reducing Phase Noise in Multi-Phase Oscillators", *IEEE Trans. Circuits and Systems I: Regular Papers* , vol. 63, no. 3, pp. 379-388, Mar. 2016.

- P. Maffezzoni, S. Levantino, "Phase Noise of Pulse Injection-Locked Oscillators," *IEEE Trans. Circuits and Systems I: Regular Papers* , vol. 61, no. 10, pp. 2912-2919 , Oct. 2014.

- G. Marucci, S. Levantino, **P. Maffezzoni**, C. Samori, "Analysis and Design of Low-Jitter Digital Bang-Bang Phase-Locked Loops," *IEEE Trans. Circuits and Systems I: Regular Papers*, vol. 61, no. 1, pp. 26-36, Jan. 2014.

- P. Maffezzoni, Z. Zhang, L. Daniel, "A Study of Deterministic Jitter in Crystal Oscillators," *IEEE Trans. Circuits and Systems I: Regular Papers* , vol. 61, no. 4, pp. 1044-1054, April 2014.

Synchronization/Unconventional Computing

- P. Maffezzoni, L. Daniel, "Exploiting Oscillator Arrays as Randomness Sources for Cryptographic Applications," *IEEE Trans. on Computer-Aided Design of Integrated Circuits and Systems,* vol. PP, no. 99, pp. 1-9, 2017.

- P. Maffezzoni, B. Bahr, Z. Zhang, and L. Daniel, "Analysis and Design of Boolean Associative Memories Made of Resonant Oscillator Arrays", *IEEE Trans. Circuits and Systems I: Regular Papers* , vol. 63, no. 11, pp. 1964-1973, Nov. 2016.

- P. Maffezzoni, L. Daniel, N. Shukla, S. Datta, and A. Raychowdhury, "Modeling and Simulation of Vanadium dioxide Relaxation Oscillators", *IEEE Trans. Circuits and Systems I: Regular Papers* , vol. 62, no. 9, pp. 2207-2215, Sep. 2015.

- P. Maffezzoni, B. Bahr, Z. Zhang, and L. Daniel, "Oscillator Array Models for Associative Memory and Pattern Recognition", *IEEE Trans. Circuits and Systems I: Regular Papers* , vol 62, no. 6, pp. 1591-1598, June 2015.

- P. Maffezzoni, B. Bahr, Z. Zhang, and L. Daniel, "Analysis and Design of Weakly Coupled Oscillator Arrays Based on Phase-Domain Macromodels", *IEEE Trans. Computer-Aided-Design of Integrated Circuits and Systems* , vol. 34, no. 1, pp. 77-85, Jan. 2015.

Energy Systems/Photovoltaic

- A. Bernardini, **P. Maffezzoni**, L. Daniel, A. Sarti, "Wave-Based Analysis of Large Nonlinear Photovoltaic Arrays," *IEEE Trans. Circuits and Systems I: Regular Papers,* vol. PP, no. 99, pp. 1-13, 2017.

- M. Longo, **P. Maffezzoni**, D. Zaninelli, N. Lutz, L. Daniel, "A predictive model to support the widespread diffusion of electric mobility", *Proceedings of IEEE International Conference on Models and Technologies for Intelligent Transportation Systems*, June 2017, Naples, Italy, n. pp. 6.

- G. Gruosso, R. Silva Netto, **P. Maffezzoni**, Z. Zhang, L. Daniel, "Low voltage electrical distribution network analysis under load variation*," IEEE Intl. Conf. Industrial Tech. (ICIT 2018),* Lyon, France, Feb. 2018, pp.1-6.

- Bernardini, A. Sarti, **P. Maffezzoni** and L. Daniel, "Wave Digital-Based Variability Analysis of Electrical mismatch in Photovoltaic Arrays", *IEEE International Symposium on Circuits and Systems (ISCAS2018),* Florence, Italy, May 2018, pp. 1-4.