CEI UPM
Centro de Electrónica Industrial

NewsLetter

of CENTRO DE ELECTRÓNICA INDUSTRIAL (CEI)

POLITÉCNICA

July 2010 – June 2011 *"You can't play a symphony alone; it takes an orchestra to play it"* (Navjot Singh Sidhu) **nr. 3**

Thank you for reading this third issue of CEI-UPM Newsletter. Our aim is to continue providing information on our activities, results, news,… and some gossip, which is always welcome ☺.

In this issue of CEI-UPM newsletter, we would like to show our activity during one year, starting on July 2010. We know that we are a bit late on this issue, but time is shorter than we think and our duties are too many!. Our editorial line, is based on the team work. The statement selected for this third number states what is essential in a research environment, the coordinated team work. The three main research lines at CEI-UPM work together in projects, share resources and space. Due to this sinergy, we can face projects that involve two or more fields and we can optimize the use of common resources. Examples like the experience in digital control of power converters, based on FPGAs or DSPs, is difficult to make in an isolated way. Another example is a project related with metering electrical power connected to wireless sensor networks, as a result of the cooperation of the embedded systems group and the power quality researchers.

In this issue you will find an intersting quiz: the electronic sudoku… but you can do it in paper! There is also an interesting article about the use of simulation tools in power electronics, written by our colleague Prof. Roberto Prieto, who has made a number of contributions to this field.

Preparing this Newsletter regularly is not an easy task, but thanks to the contribution of many CEI-UPM members, we are being able to complete our duties.We really appreciate if you send us any suggestion, question or comment to cei@upm.es. Enjoy reading this Newsletter!… and more will come in a few months!

The editorial board

4th Annual Meeting

The 4th edition of the CEI-UPM Annual Meeting took place at ETSII-UPM on March 24th and 25th.

This event is becoming an interesting networking space, a place to learn and to meet your colleagues and partners. This year, 99 people attended the Annual Meeting, with a more International flavour ever, with participants from 17 different companies, 3 international universities and other research groups from Spanish universities.

The structure of the Annual Meeting was based on Thursday afternoon for the keynote conferences and visit to CEI-UPM, and Friday morning for the technical sessions. The contents were the following:

- *Opening session* by Prof. Celina González, Vicedean of Reasearch of ETSII-UPM and Prof. Teresa Riesgo, Director of CEI-UPM
- *Keynote conferences.* The topic selected this year was "Power on chip". The session was chaired by Prof. José A. Cobos and the speakers were and Prof. Marcelino B. Santos, from INESC and Silicon Gate (Portugal), who talked about "Self adaptive drivers for integrated DC-DC converters", and Prof. Cian O'Mathuna from the Tyndal Institute (Ireland), who talked about "Power supplies on chip"
- *Visit to CEI-UPM* and poster session, with the participation of all the CEI-UPM researchers. The current status of our research is presented in an informal way, using posters and demos, and with strong interaction among CEI researchers and visitors.
- *Technical sessions.* This year, the selected topics were:
  - Control Techniques
  - Modelling and Simulation
  - Optimization of Power Circuits
  - Power Topologies
  - Reconfigurability & Evolvable Hardware
  - Wireless Sensor Networks

The documentation of the event is available in our website (http://www.cei.upm.es/Seminario_CEI/cei_Seminario_2010.html

Don't miss the 5th edition of the CEI-UPM **Annual Meeting**, which will take place at ETSII-UPM on **March 8th and 9th, 2012** Mark the dates in your agenda!

Monday Seminars

be aware of CEI-UPM results every two weeks

From November 2010 to March 2011, we have started a dissemination activity that is open to all our members and partners, which consists of organising seminars, given by CEI-UPM researchers to give more visibility to our activities.

These seminars are taking place every fifteen days on Monday. The program of the seminars has been as follows:

- 15 November 9:30 h. *Digital control implementation to reduce the cost and improve the performance of the control stage of an industrial switch-mode power supply* by Daniel Díaz
- 29 November 12:00 h. *Dynamically Reconfigurable Scalable Architectures* by Andrés Otero
- 13 December 12:00 h. *Hardware adaptation strategies based on Evolvable Hardware techniques: application to the design of intelligent signal processing architectures* by Rubén Salvador
- 10 January 12:00 h. *Research on predictive control algorithms, adaptive algorithms or the application of artificial intelligence systems (hardware evolution) to problem solving* by Benoit Duret
- 14 March 12:30 h. *Power consumption optimization for wireless sensor networks.* by Victor Roselló
- 21 March 12:30 h. *Multiphase buck converter with minimum time control strategy for RF envelope modulation* by Pengming Cheng

For the following period we have the participation of the following researchers:

- June 6 10:00 h, *Dual Active Bridge Series Resonant Converter with Pulse Modulation* by Zoran Pavlovic
- July 4 12:00 h, *Single-Stage Grid-Connected Forward Microinverter with Boundary Mode Control* by David Meneses
- July 18 12:00 h. *High Performance Reconfigurable Cookie: HiReCookie* Juan Valverde
- 26 September, 12:00 h. *Extraction of parameters using SIwave* by Carlos A. López
- 8 October 12:00 h. *Stability and Transient Performance Assessment in a COTS-Module-Based DC/DC System* by Sanna Vesti
- 10 October 12:00 h. *Design Planning Tool For Wireless Sensor Networks* by Danping He
- 7 November 12:00 h. *Synchronous BUCK converter with Output Impedance Correction Circuit* by Vladimir Šviković
- 21 November 12:00 h. *RECINTO: A new approach to low level FPGA programming* by Eduardo Lezcano
- 12 December 12:00 h. *Model Predictive Control for Multi-Phase Buck Converter with Variable Output Voltage* by Giuseppe Catalanotto

The seminars are open to the public and they are around one hour, including presentation and Q&A. They run in an informal way, so people are encouraged to participate and to suggest ideas to the researchers. In most of the cases, they are related to ongoing work.

PhD Thesis

Author: Miroslav Vasić
Title: *Wide bandwidth high efficiency power converter for RF amplifiers*
Thesis Supervisors: O. García, J.A.Oliver
Evaluation Committee: J. Uceda, J. Ortega, J. Sebastián, J. Popovic, H.J. Bergveld
Dissertation date: 23rd July, 2010 **Grade:** Apto cum laude

Master Theses

Optimización de la respuesta dinámica en fuentes de alimentación conmutadas:Control Vic y control V2ic by **Miriam del Viejo**
Thesis Supervisors: P. Alou & J.A. Oliver **Date:** 05/10/2010

Analysis and simulation of DC distributed power systems based on behavioral models: analysis guidelines by **Sanna Vesti**
Thesis Supervisors: P. Alou & J.A. Oliver **Date:** 30/11/2010

Estudio de banda de frecuencias sub-GHz para redes de sensores inalámbricas e implementación de plataforma modular by **Mariana Molina**
Thesis Supervisors: T. Riesgo & J. Portilla **Date:** 12/04/2011

Diseño e implementación de un control adaptativo para obtener ZVS en un convertidor trifásico de puente activo para aplicaciones de vehículos eléctricos by **José Mª Molina**
Thesis Supervisors: O. García **Date:** 12/04/2011

Design of envelope amplifier based on multiphase converter with minimum time control by **Pengming Cheng**
Thesis Supervisors O. García **Date:** 12/04/2011

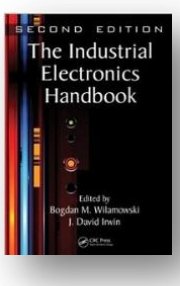
Control en modo corriente gobernado por lazo de tensión eficaz y lazo de offset para inversor monofásico embarcado en aviones adecuando para funcionamiento en paralelo y conexión trifásica by **Pablo Varela**
Thesis Supervisor: O. García **Date**: 12/04/2011

Optimización de devanados paralelos en componentes magnéticos planos by **Fermín Holguín**
Thesis Supervisor: R. Prieto **Date:** 12/04/2011

News Briefs

- CEI-UPM participated in the activities of *Semana de la Ciencia*, coordinated by UPM. Three groups of high-school students visited us, and we hope they enjoyed with us (as we did with them). The young potential-future-researchers were given some hints on how a research center works, what is electronics and how close it is to their daily lives. For 2011, the visit will take place on November 14th, 2011.
- CEI-UPM has ellaborated its **Strategic Plan** 2011-2014. The plan has been very positively evaluated by the National authorities. Now, it's time to make it work!
- During June 2011, there was an specialized course on "Wireless Sensor Networks" taught to engineers and researchers of the company ISDEFE. 40 hours course in 6 days!
- **Congratulations** to our colleague, **Dr. Óscar García**, who became Professor in May.
- **Farewell…** to **Benoit Alexandre**, who went back to France and he is now working at CEA, to **Miriam del Viejo** and **Mariana Molina**, who left us after getting the Master on Industrial Electronics degree. They both are working in the Spanish company Dimetronic.
- **Welcome…** to the new CEI-UPM members who joined us during this period: **Nico H. Hensgens** (from Luxembourg) and **Danping He** (from China) as full-time researchers and PhD students, **Giuseppe Catalanotto** (from Italy), **Gabriel Mujica** (from Venezuela), **Vladimir Šviković** (from Serbia) and **Eduardo Lezcano** (from Spain) as full-time researchers and Master students. We also welcome **Dr. Li Wei** (from China), who came for a 9-month post-doctoral stay, funded by the TAMDEM program (Erasmus Mundus)

Book Chapter



- J.J.Rodríguez-Andina, E. de la Torre, FPGAs and reconfigurable systems (Chapter 24), Fundamentals of Industrial Electronics (Volume 1), *The Industrial Electronics Handbook*, 2nd edition. Eds J.D.Irwin &, B.M.Wilamowski. CRC Press, March 2011

Journals

- F.J. Azcondo, A. de Castro, V.M. López, O. García, "Power Factor Correction Without Current Sensor Based on Digital Current Rebuilding", *IEEE Trans. Power Electronics*, June 2010
- J.G. Mayordomo, A. Carbonero, L.F. Beites, W. Xu, "Decoupled Newton Algorithms in the Harmonic Domain for the Harmonic Interaction of Line Commutated Converters With AC Systems", *IEEE Trans. on Power Delivery*, July 2010.
- Y.E. Krasteva, E. de la Torre, T. Riesgo, "Reconfigurable Networks on Chip. DRNoC Architecture", *Journal of Systems Architecture*, July 2010.
- R. Salvador, F. Moreno, T. Riesgo, and L. Sekanina, "Evolutionary Approach to Improve Wavelet Transforms for Image Compression in Embedded Systems", *EURASIP Journal on Advances in Signal Processing*, July 2010.
- J. Portilla, A. Otero, E. de la Torre, T. Riesgo, O. Stecklina, S. Peter, and P. Langendörfer, "Adaptable Security in Wireless Sensor Networks by Using Reconfigurable ECC Hardware Coprocessors", *International Journal of Distributed Sensor Networks*, November 2010.
- C. Huerta, P. Alou, J.A. Oliver, O. García, J.A. Cobos, A. Abou- Alfotouh, "Non-Linear Control for DC-DC Converters Based on Hysteresis of the COUT Current with a Frequency Loop to Operate at Constant Frequency", *IEEE Trans. on Industrial Electronics*, January 2011.
- A. de Castro, O. García, P. Zumel, T. Riesgo, G. González de Rivera, "Comparison of Phase-shifters for Multiphase Power Converters", *IETE Journal of Research*, February 2011

Trends in the use of simulation tools for the design of power electronic circuits

by R. PRIETO

Unlike the integrated digital circuit designer, who has always rested in the simulation tools as a necessary design procedure, the designer of power electronic circuits has traditionally been based on trial and error procedures for the final stages of the design. However, this trend has changed dramatically over the past 20 years, in which the power of the computers and the CAD tools have evolved tremendously.

Many power electronic circuits include devices that work as switches that switch at high frequency (hundreds of kilohertz). For this reason there have always been several specific difficulties for the simulation of these circuits. One of them is a common problem to all simulation tools, which is the availability of models that provide the expected information of the simulation. It is important that the model is accurate enough to be useful without increasing its complexity more than necessary, since this implies simulation time problems or potential problems of convergence. Another problem associated with these circuits is the fact that they commonly work with waveforms presenting high derivatives and high frequencies. In addition to that, there are several orders of magnitude of difference among the temporal parameters involved in the simulation: the transitions of the voltage and current are commonly in the range of nano-seconds, the switching period is in the order of micro-seconds and the quasi-static evolution of the signals is in the order of mili-seconds. All these facts increase the difficulties in model convergence.

Many of the difficulties discussed above have been solved today in several simulation systems which have large libraries of models and include robust mathematical algorithms solving potential problems of convergence. However, a new challenge has appeared in the current scenario that is the simulation of large electronic systems against the simulation of a single circuit. This new situation makes necessary the development of new models of the components that enable system-level results, eliminating the information with not useful contribution to the analysis. For example, the system designer may be interested in information on the overall performance, power budget, stability or the impact of failures in the system but will not be interested on the current ripples in the devices. Therefore, the models and how to implement them should be different depending on the level of abstraction and the information that is necessary from the analysis.

The Center of Electronics for the Industry (CEI) has worked for over 15 years in the development of models and circuit simulation tools for power electronics. Within the work done in the field of design and modeling of devices it is necessary to emphasize the commercial tool "PExprt" which has been fully developed in the CEI and is marketed worldwide by the American company ANSYS. This tool which has sold more than 300 licenses to over 250 customers, is a reference in creating designs and models of magnetic components for power electronic circuits. In addition, the CEI has developed component libraries as "SMPS Library", which is also being marketed by the same company, brings to the designer of power electronic circuits a collection of component models to simulate these circuits. In the field of system design, the CEI has developed the "SMPS parametrization Tool", which is a tool sold with the "SMPS Library" that provides behavioral "black box" models of DC/DC switch mode power supplies for its use in the simulation of complex power electronics systems.

Conferences

ECCE — Atlanta (USA), September 2010

- M.C.Gonzalez, N.Ferreros, P.Alou, O.García, J.Oliver, J.A.Cobos. H. Visairo, *Core-less Multiphase Converter with Transformer Coupling*
- L. Laguna, R. Prieto, J. A. Oliver, J. A. Cobos, H. Visairo, *Fast architecture generation and evaluation techniques for the design of large power systems,*
- M. del Viejo; P. Alou; J. A. Oliver; O. García; J. A. Cobos, *Fast control technique based on peak current mode control of the output capacitor current*
- M.Vasic, O. García, J.A. Oliver, P. Alou, D. Diaz, J.A. Cobos, A.Gimeno, J.M.Pardo, C.Benavente, F.J.Ortega, *High Efficiency Power Amplifier Based on Envelope Elimination and Restoration Technique*
- S. Vesti, P. Alou, J.A. Oliver, O. García, R. Prieto and J.A. Cobos, *Modeling and Simulation of a Distributed Power System for Avionic Application*
- Z. Pavlovic, J.A. Oliver, P. Alou, O. García, R.Prieto, J.A. Cobos, *Multiple-output Class E Isolated dc-dc Converter*
- R. Prieto, R. Asensi, J.A. Cobos, *Selection of the appropriate winding setup in planar inductors with parallel windings,*

DSD — Lille (France), September 2010

- R. Salvador, F. Moreno, T. Riesgo, L. Sekanina, *High level validation of an optimization algorithm for the implementation of adaptive Wavelet Transforms in FPGAs*
- A. Otero, A. Morales, J. Portilla, E. De la Torre, T. Riesgo, *A Modular Peripheral to Support Self-Reconfiguration in SoCs*
- F. Moreno, I. López, R. Sanz, *A design process for harware/software system co-design and its application to designing a reconfigurable FPGA*

SAEEI — Bilbao (Spain), July 2010

- A.B. Duret, D. Meneses, F. Moreno, O. García, J.A. Oliver, P. Alou, J.A. Cobos, *Implementación digital de un doble lazo de control tensión/corriente para el control de inversores de potencia embarcables en aviones*
- S. Vesti, P. Alou, J.A. Oliver, O. García, R. Prieto and J.A. Cobos, *Modeling, Analysis and Simulation of a DC Distributed Power Architecture for an Airborne Application*
- Z. Pavlovic, J.A. Oliver , P. Alou, O. García , R. Prieto , J.A. Cobos, *Two-output Class E Isolated dc-dc Converter at 5 MHz Switching Frequency*
- M. del Viejo , P. Alou , J.A. Oliver , O. García , J.A. Cobos , *Técnica de control de rápida respuesta dinámica para convertidores DC/DC integrados de alta frecuencia (5MHz)*

DCIS — Lanzarote (Spain), November 2010

- A.B. Duret, F. Moreno, D. Meneses, O. García, J.A. Oliver, P. Alou, J.A. Cobos, *Design and implementation in a DSP of a digital double voltage/current loop for a power inverter for an aircraft application*
- J. Portilla, J. Valverde, T. Riesgo, *Wireless Sensor Network Application for Environmental Impact Analysis and Control*
- R. Pujo, A. Otero, E. de la Torre, T. Riesgo, *Feasibility of HW genetic algorithms for profile selection in reconfigurable autonomous embedded systems*
- R. Salvador, F. Moreno, T. Riesgo, L. Sekanina, *Implementation of bio-inspired adaptive wavelet transforms in FPGAs. Modeling, validation and profiling of the algorithm,*

SPIE Mic. — Prague (Czech Republic), April 2011

- R.Salvador, A.Vidal, F.Moreno, T.Riesgo, L.Sekanina, *Bio-inspired FPGA Architecture for Self-Calibration of an Image Compression Core based on Wavelet Transforms in Embedded Systems*
- A. Otero, M. Llinás, M.L. Lombardo, J. Portilla, E. de la Torre, T. Riesgo, *Cost and energy efficient reconfigurable embedded platform using Spartan-6 FPGAs*
- G. Liang, D. He, E. de la Torre, T .Riesgo, *Low-power, high-speed FFT processor for MB-OFDM UWB application*
- T. Cervero, A. Otero, E. de la Torre, S. López, G.M. Callicó, T. Riesgo, R. Sarmiento, *Scalable 2D architecture for H.264 SVC deblocking filter with reconfiguration capabilities for on-demand adaptation*
- W.He, C.Pizarro, E.de la Torre, J.Portilla, T.Riesgo, *SCA security verification on wireless sensor network node*

APEC — Fort Worth, Texas (USA), March 2011

- Gonzalez, M.C.; Alou, P.; García, O.; Oliver, J.A.; Cobos, J.A.; Visairo, H. *DC-DC transformer multiphase converter with transformer coupling for two-stage architecture*
- Gonzalez, M.C.; Vasic, M.; Alou, P.; García, O.; Oliver, J.A.; Cobos, J.A.; Visairo, H., *Power analog to digital converter for voltage scaling*
- Vasic, M.; García, O.; Oliver, J.A.; Alou, P.; Diaz, D.; Cobos, J.A.; Gimeno, A.; Pardo, J.M.; Benavente, C.; Ortega, F.J., *High efficiency power amplifier for high frequency radio transmitters*
- Vasic, M.; García, O.; Oliver, J.A.; Alou, P.; Diaz, D.; Cobos, J.A. *Switching capacities based envelope amplifier for high efficiency RF amplifiers*
- M. del Viejo, P. Alou, J.A. Oliver, O. García, J.A. Cobos, *V2ic Control: A Novel Control Technique with Very Fast Response under Load and Voltage Steps*
- M.C. González, P. Alou, O. García, J.A. Oliver, J.A. Cobos, *Multiphase transformer-coupled converter: two different strategies for energy conversion*
- P. Cheng, M. Vasić, O. García, J. A. Oliver, P. Alou, J. A. Cobos, *Multiphase Buck Converter with Minimum Time Control Strategy for RF Envelope Modulation*
- M. del Viejo, P. Alou, J.A. Oliver, O. García, J.A. Cobos, *V2IC control: A novel control technique with very fast response under load and voltage steps*

Other

- A. Otero, Y.E.Krasteva, E. de la Torre, T. Riesgo, *Run-time Scalable Systolic Coprocessors for Flexible Multimedia SoPCs*, International Conference Field Programmable Logic and Applications (FPL), September, 2010, Milan (Italy)
- M. del Viejo, P. Alou, J.A. Oliver, O. García, J.A. Cobos, *Output cap reduction thanks to a fast and novel control Output cap reduction thanks to a fast and novel control technique technique: V2IC control*, International Workshop on Power Supply On Chip (PowerSoc), October, 2010, Cork (Ireland)
- Otero, R. Salvador, J. Mora, E.D. Torre, T. Riesgo, L. Sekanina, *A Fast Reconfigurable 2D HW Core Architecture on FPGAs for Evolvable Self- Adaptive Systems*, NASA/ESA Conference on Adaptive Hardware and Systems (AHS), June, 2011, San Diego (California, USA)
- R. Salvador, A. Otero, J. Mora, E. de la Torre, T. Riesgo, L. Sekanina, *Evolvable 2D computing matrix model for intrinsic evolution in commercial FPGAs with native reconfiguration support*, NASA/ESA Conference on Adaptive Hardware and Systems (AHS), June, 2011, San Diego (California, USA)
- T. Cervero, A. Otero, S. Lopez, E. de la Torre, R. Sarmiento, T. Riesgo, G. Callicó, *A Novel Scalable Deblocking-Filter Architecture for H.264/AVC and SVC Video Codecs*, *International* Conference on Multimedia and Expo Barcelona (ICME), July, 2011, Barcelona (Spain)

Research Projects

New projects

- *Consulting services for developing IC power module components* for Simplorer funded by ANSYS from 1/9/10 to 31/12/10
- *Estudio y definición de la funcionalidad de las fuentes de alimentación para la alimentación de imanes superconductores* funded by CIEMAT from 1/12/10 to 30/7/11
- *Reconfigurable Ultra-Autonomous Novel Robots* funded by Eurostars / CDTI from 1/12/10 to 30/11/13
- *Fuentes de alimentación para los imanes superconductores del XFEL europeo* funded by MCInn from 1/12/10 to 30/11/13
- *Fuentes de alimentación con rápida respuesta dinámica para gestión de la energía* funded by MCInn from 1/1/11 to 31/12/13
- *Técnicas de control avanzadas para convertidores CC/CC de muy rápida respuesta dinámica* funded by CM-UPM from 1/1/11 to 31/12/11
- *Modelos rápidos equivalentes para gestión de redes electrónicas de energía* funded by MCInn from 01/1/11 to 31/12/13
- *Reconfigurabilidad Interoperable* funded by CM-UPM from 1/11/1 to 31/12/11
- *Consulting services for developing IC power module components* for Simplorer funded by ANSYS from 4/1/11 to 31/12/11
- *Harmonic Modeling of Three Phase Rectifiers: Continuous Mode* funded by Électricité de France from 01/2/11 to 01/3/12
- *Introduction to a Harmonic Equivalent for Domestic Loads-Programmming* funded by Électricité de France from 01/2/11 to 12/12/11

Running projects

- *Desarrollo e Innovación en pilas de combustible de membrana polimérica y óxido sólido* funded by EADS-CASA from 01/1/07 to 31/12/10
- *Sistemas de gestión y regulación de energía eléctrica* funded by INDRA (CENIT) from 01/10/08 to 30/9/11
- *Magnesium new technological opportunities* funded by FAGOR (CENIT) from 1/11/08 to 31/10/11
- *Reconfigurabilidad dinámica para escalabilidad en redes orientadas a aplicaciones multimedia* funded by MCInn from 1/1/09 to 31/12/11
- *Secure, Mobile visual sensor networks ArchiTecture* funded by Artemis/MICyT from 1/5/09 to 30/4/12
- *28V/500W and 5V/200W D/5/C/DC converter* funded by Cheerful Technologies from 1/7/09 to 31/12/10
- *Power Delivery, distribution and Design Modeling Research* funded by INTEL Corp. from 1/9/09 to 31-aug-11
- *Tecnologías para la movilidad urbana sostenible y accesible* funded by MCInn from 1/10/09 to 30/9/11
- *Tecnologías eficientes e inteligentes orientadas a la salud y al confort en ambientes interiores* funded by MTP (CENIT) from 1/10/09 to 31/12/12
- *Soporte al desarrollo de componentes inductivos y sistemas electrónicos de potencia* funded by PREMO from 1/11/09 to 31/12/11
- *Dispositivos semiconductores avanzados de gap ancho para el uso racional de la energía/Advanced Wide band gap semiconductor devices for rational use of energy* funded by MCInn from 1/11/09 to 31/10/14
- *Amplificadores de envolvente de banda ancha para etapas EER/ET y fabricación de dispositivos de nitruro de galio (GAN)* funded by MCInn from 1/1/10 to 31/12/12
- *Seguridad en Vías Ferroviarias (2010)* funded by AVANZA I+D/MICyT from 1/1/10 to 31/12/10
- *Plataforma tecnológica inteligente para la producción sostenible en industrias agroalimentarias (2010/11)* funded by AVANZA I+D/MICyT from 1/1/10 to 31/12/11
- *PhD work in virtual optimized EMC filter design for power electronic converters under consideration of real components and interconnects* funded by ABB Switzerland from 1/3/10 to 28/2/13
- *Sistema de gestión de energía para alimentación de cargas de continua regenerativas desde un generador trifásico* funded by INDRA (CENIT) from 1/7/10 to 31/3/12

Electronic Sudoku