1. Embedded Systems Design (6 CFU)

Docente: Alessandro Bertacchini

Contenuti:

1. Introduction on Embedded Systems: Definitions and main features of embedded systems, examples of embedded systems in real scenarios.
2. Hardware/Software Co-design: HW/SW co-design methodologies; Platform-based design concepts; System architecture and evaluation of design alternatives; criteria of HW/SW partitioning.
3. Design Specifications & Model Based Design: Design methodologies, design flow, models, metrics; requirements and approaches for specifying embedded systems. Requirements of dependability;
4. Notes on Hardware Design: Fundamentals on main sensors for industrial applications, Calibration, Analog vs. Digital Signals, Signal Conditioning, A/D Converters & D/A Converters, Power Supply Topologies, Basics of "energy-aware" design
5. Fundamentals of Embedded Systems Communications: on-board serial protocols (e.g. SPI, I2C), board-to-everything (e.g. 4-20mA Loop, UART and RS232 interface). Fundamentals of CAN (network and node architecture)
6. Fundamentals of Fault-Tolerant Design
7. General Architecture of Microcontrollers and Basics of Firmware Development

Obiettivi

The course is intended to provide the tools needed to deal with all the development phases of an embedded system, from the specs definition of the application to the realization and test of the prototype.

With reference to the Dublin descriptors, the objectives of the course can be summarized as in the following:

Acquiring knowledge and understanding: acquisition of the basic concepts of HW / SW Co-design; design methodologies and specs definition of an embedded system; main hardware components; main methods of communication; fundamentals of fault-tolerant design.

Applying knowledge and understanding: using analytical techniques, appropriate design methodologies, circuit simulators and specific development environments, the student acquires the ability to analyze and design the functional specifications of an embedded system; the ability to analyze, design and realize analog and digital circuits, communication systems, fault-tolerant systems; the ability to develop firmware for microcontrollers.

Making informed judgments and choices Ability to perform independently and according to their own experience design choices even in case of incomplete specifications, Ability to organize the development phases of a project (even complex).

Communicating knowledge and understanding: Ability to work in a team, Ability to present projects (even complex) to both specialist and non-specialist people.

Capacities to continue learning: Ability to refine an effective individual/team study methodology allowing solving complex problems.

Prerequisiti

Electronics, Industrial Electronics, Analog Design, Fundamentals of Informatics, Fundamentals of Automatic Controls, Static Conversion of Energy, Fundamentals of Machines and Electrical Drives.

Metodi Didattici

Course teaching consists of theoretical lectures and laboratory activities aiming at the design and realization of embedded system prototypes from both hardware and software points of view.

During the course, the student uses both analytical techniques and computer-aided techniques concerning both software/firmware programming for microcontrollers and PCB design.

Verifica Apprendimento

During the course, the students divide their self into working groups comprised of 4-5 people each with the scope to design and realize a working prototype of embedded system for an application of their own choice or assigned by the teacher.

Learning assessment is based on 3 components:

Evaluation of a group report to evaluate the skills in making informed judgments and choices and the skills in communicating knowledge and understanding.

One oral presentation per group with a technical discussion of the proposed project and a live demo of the realized prototype (max 20 minutes). During the presentation each group member presents a part of the whole project to the scope of evaluating his skills in making informed judgments and choices, in communicating knowledge and understanding.

Individual oral examination

For each student, the final grade results from the sum of the common grade obtained by his group in part 1 (up to 25/30), and of the individual grade obtained in part 2 (up to ±2/30) and in part 3 (up to ±4/30).

E.g. : Part 1 23/30; Part 2 -1/30; Part 3 +3/30 -> Final grade = 23-1+3= 25/30

Risultati di apprendimento attesi

See "Objectives".

Testi

The following textbooks are suggested in addition to the course handouts, reference manuals and datasheets of the microcontrollers and any other design tool used during the lab activities:

- Embedded System Design; Peter Marwedel, Ed. Springer, 2011, ISBN-10: 9400702566, ISBN-13: 978-9400702561.
- SISTEMI EMBEDDED - sviluppo hardware e software per sistemi dedicati; C. Brandolese, W. Fornaciari, Ed. Paerson - Prentice Hall, 2007, ISBN-10: 8871923421, ISBN-13: 978-8871923420.
- R. Aarenstrup, «Managing Model Based Designs», Published by The MathWorks, Inc., ISBN-13: 978-1512036138, ISBN-10: 1512036137, FREE DOWNLOAD
- P. Schaumont, «A Practical Introduction to Hardware/Software Codesign» , Springer, 2013, ISBN 978-1-4614-3736-9 ISBN 978-1-4614-3737-6
- J. Fraden, «Handbook of Modern Sensors – Physics, Design and Applications» 4th Ed., Springer, 2010,
  ISBN 978-1-4419-6465-6 e-ISBN 978-1-4419-6466-3
- G. Meijer, M. Pertijs, K. Makinwa, «SMART SENSOR SYSTEMS: EMERGING TECHNOLOGIES AND APPLICATIONS», John Wiley & Sons Ltd, 2014, ISBN 978-0-470-68600-3
- W. Bolton, «Mechatronics: Electronic control systems in mechanical and electrical engineering», 6th ed., Pearson, 2015, ISBN 978-1-292-07668-3
- R. Isermann, «Fault-Diagnosis Applications», Springer, 2011, ISBN 978-3-642-12766-3
- E. Dubrova, «Fault-Tolerant Design», Springer, 2013, ISBN 978-1-4614-2112-2
- J. Beningo, «Reusable Firmware Development: A Practical Approach to APIs, HALs and Drivers», APress, 2017, ISBN 978-1-4842-3296-5

2. Analog and Mixed Signal Circuit Design (9 CFU)

Docente: Borgarino Mattia

Obiettivi:

Aim of the course is to provide the knowledge required to understand how the main building blocks of an electronic system work and to provide the required design methodologies.

Contenuti:

Course content can be divided into three main topics:
Switched capacitor circuits: basic topologies, integrators, amplifiers, filters.
Radiofrequency Electronics: architectures and spec's of the transceivers. Basic building blocks: low noise amplifier, mixer, oscillator, VCO, frequency divider, PLL.

Analog-to-Digital Converter and and Digital-to-Analog-Converter: signal sampling and quantization, Figure-of-Merits of converters, converter architectures.

Testi:

B.Leung, VLSI for Wireless Communication, Ed. Prentice Hall, 2002
R.Ludwig, P.Bretchko, RF Circuit Design, Ed. Prentice Hall, 2000
T.C.Carusone, D.Johns, K.Martin, Analog Integrated Circuit Design, Ed. John Wiley & Sons, 2013

B.Razavi, "Design of Analog CMOS Integrated Circuits", Ed. McGrawHill, 2001
F.Maloberti, "Design of CMOS Analog Integrated Circuits" Kluwer Academic Publisher, 2001

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3. High Performance Electric Drives and Laboratory (12 CFU)

Docente: Davide Barater

Obiettivi:

L'insegnamento ha l'obiettivo di fornire conoscenze avanzate relative al funzionamento, al controllo e all'impiego dei diversi tipi di azionamenti elettrici:
macchine in corrente continua, brushless DC e AC, macchine asincrone e sincrone a riluttanza.
Al termine del corso lo studente dovrà conoscere, per ogni tipologia di azionamenti: i dettagli costruttivi, i principi di funzionamento, i sensori applicabili per la misura di corrente, posizione, velocità, i principali schemi e algoritmi di controllo, le possibili applicazioni (industriale, autotrazione, elettrodomestici, ecc.) e il funzionamento dei principali circuiti impiegati per il pilotaggio delle macchine elettriche.

Contenuti:

- Principio di funzionamento, circuito equivalente e schema di controllo delle diverse tipologie di azionamenti.
- Trasformazioni di Clarke e Park, modello dinamico della macchina su assi rotanti.
- Controllo vettoriale e pilotaggio della macchine IPM e SynREL con traiettorie di MTPA e MTPV
- Principali componenti delle catene di regolazione dei convertitori e tecniche di modulazione dei convertitori, SPWM, SVM.
- Realizzazione del controllo: regolatori standard e ad alta dinamica, sistemi sensored e sensorless.
- Introduzione al controllo digitale degli azionamenti elettrici.
- Introduzione alla programmazione embedded, sviluppo di algoritmi di controllo su processori a virgola fissa.

Testi:

Shaahin Filizadeh. Electric Machines and Drives: Principles, control, modelling and simulation. CRC Press.
W. Bolton, "Mechatronics - electronic control systems in mechanical and electrical engineering", 4th ed., Pearson Educational, ISBN 978-0-13- 240763-2.
M. Rashid, "Power electronics", 3rd ed., Prentice-Hall, ISBN 0-13-122815- 3

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4. Nanoelectronics and Bioelectronics (6 CFU)

Docenti: Puglisi Francesco e Pavan Paolo

Obiettivi:

Contenuti:

Testi:

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5. Modeling and Control of Electromechanical Systems (6 CFU)

Docente: Zanasi Roberto

Obiettivi:

Il corso fornisce gli strumenti base per modellare, simulare e controllare sistemi elettromeccanici. In particolare, verrà presentata e discussa la tecnica modellistica Power-Oriented Graphs (POG). Nel corso verranno presentati molti esempi applicativi, sua lineari che non lineari. Gli esempi applicativi verranno sviluppati, prevalentemente, in ambiente Matlab/Simulink.

Contenuti:

1. Modellistica dinamica di sistemi fisici;
2. Tecnica modellistica Power-Oriented Graphs (POG);
3. Simulazione di sistemi fisici in ambiente Matlab/Simulink;
4. Motori elettrici ed azionamenti: concetti base;
5. Dinamica diretta e inversa di sistemi elettromeccanici e sistemi robotici;
6. Esempi applicativi in ambito industriale e Automotive: Sistemi meccanici con un grado di libertà, Sistemi robotici; Cambio marcia automatizzato, Sospensioni attive, CVT, Veicoli ibridi, KERS, Conversione di potenza.

Testi:

Fotocopie dei lucidi utilizzati a lezione dal docente.

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6. Advanced Photonics (6 CFU)

Docente: Vincetti Luca

Obiettivi:

The course aim is to provide knowledge and design skills-set of the most popular optical and photonics components such as couplers, gratings, interferometers, optical amplifiers, and specialty fibers used both in fiber and integrated photonic technologies.

Contenuti:

- Fiber Optics Transmission Systems: overview
- Coupled mode theory
- Directional coupler and examples of applications: controlled photonic switch, filter, sensor
- Gratings: Bragg, Transmission and Reflection and examples of applications: monochromatic mirror, multiplexer-demultiplexer, spectrometer
- Interferometers and Resonators and examples of applications: photonic modulators, controlled photonic switch, sensors, multiplexer-demultiplexer
- Optical amplifiers: technologies, main figures of merit
- Erbium Doped Fiber Amplifiers: high power amplifier configuration, low noise amplifier configuration
- Specialty Fibers: Photonics Crystal Fibers, Hollow Core Fibers
- Nonlinear Optics and Plasmonics

Testi:

S. Selleri, L. Vincetti, A. Cucinotta, "Optical and Photonic Components", Esculapio (2nd ed. 2015) ISBN: 9788874889242O

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7. Networked Control Systems (6 CFU)

Docente: Giarré Laura

Obiettivi:

The course deals with advanced filtering and control of networked systems. . Such networks are of great interest in a wide range of areas in science and engineering, including: mobile sensor networks, distributed robotics such as formation flying and swarming, quantum networks, networked economics, biological synchronization, and social networks. Considering the stochastic framework and the networked tools, such as the graph theory, it will present the classic and more recent control and estimation algorithms, when the system to be controlled are interconnected and partial information is known and shared among agents.

Contenuti:

1) Stochastic systems: state space and ARMA models
2) Graph theory and networked systems
3) Consensus algorithms
4) Estimation Theory
5) Kalman Filtering
7) Distributed Kalman Filtering
9) Model Identification
10) Networked Identification

11) LQG
12) Model Predictive Control

Testi:

You can download slides and material (lecture notes) at https://giarre.wordpress.com/sc/
Books
M. A. Dahleh https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-435- system-identification-spring-2005/lecture-notes/ I
Ljung, Lennart. System Identification: A Theory for the User. 2nd ed Prentice Hall, 1998. ISBN: 0136566952. I T.
S. Soderstrom, P. G. Stoica. System Identification, 1989.
A. Bemporad, M. Morari, V. Dua, and E.N. Pistikopoulos, The explicit linear quadratic regulator for constrained systems, Automatica, vol. 38, no. 1, pp. 3–20, 2002
A. Bemporad, A multiparametric quadratic programming algorithm with polyhedral computations based on nonnegative least squares, IEEE Trans. Automatic Control, vol. 60, no. 11, pp. 2892–2903, 2015.
Mehran Mesbahi (Author), Magnus Egerstedt (Author) Graph Theoretic Methods in Multiagent Networks (Princeton Series in Applied Mathematics)

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8. Reliability and Safety for Industrial applications (6 CFU)

Docenti: Cattini Stefano e Ciani Lorenzo

Obiettivi:

The compliance with safety and reliability standards is nowadays mandatory in all areas of industrial production ranging from automotive to industrial installations, chemical plants, oil and gas up to biomedical. The overall objective of the course is to provide the students with the basis for understanding and analyzing the reliability of systems and components with particular focus on electronic systems and components. Then it will be discussed how to develop a risk and hazard Assessment by using the most important Methods and techniques present in literature and in the international standard. Finally, the course covers the Functional Safety for electrical/electronic/programmable electronic safety-related systems.

Contenuti:

- Reliability Concepts
- Reliability data analysis
- Reliability tests, physical acceleration models and accelerated tests
- Reliability of Systems with Complex Structure
- Risk assessment
- Functional safety

Testi:

1) P.A. Tobias and D.C. Trindade, Applied reliability, 2nd or 3ed edition, Chapman & Hall/CRC
2) A. Birolini, Reliability Engineering, 7th edition, Springer 2014

3) J. W. McPherson, Reliability Physics and Engineering Time-to-Failure Modeling, Second Edition, 2013
4) Marvin Rausand, System Reliability Theory: Models, Statistical Methods, and Applications, 2nd Edition, 2004

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9. Learning Algorithms for Smart Connected Systems (6 CFU)

Docente: ??

Obiettivi:

Contenuti:

Testi: