Tutorials PCIM 2004 at a Glance

Tutorial 1 **Sunday, May 23**

High Efficiency Rectification

Instructor: Ionel Dan Jitaru,
Delta Energy Systems, USA

Tutorial 2 **Sunday, May 23**

Design with Power Semiconductors – Part I – Basics

Instructors: Pierre Aloisi, Jean-Marie Peter, FRANCE

Tutorial 3 **Monday, May 24**

Design with Power Semiconductors – Part II – Power Semiconductors in the Field

Instructors: Pierre Aloisi, Jean-Marie Peter, FRANCE

Tutorial 4 **Sunday, May 23**

Design Considerations for High Frequency Linear Magnetics

Instructor: Bruce Carsten,
Bruce Carsten Associates, USA

Tutorial 5 **Monday, May 24**

High Frequency Conductor Losses in Switchmode Magnetics

Instructor: Bruce Carsten,
Bruce Carsten Associates, USA

Tutorial 6 **Sunday, May 23**

DC-DC Converters for Power Management Applications

Instructor: Dr. Richard Redl, ELFI, SWITZERLAND

Tutorial 7 **Monday, May 24**

Control, Modelling and Feedback Loop Design of DC-DC Converters

Instructor: Dr. Richard Redl, ELFI, SWITZERLAND

Tutorial 8 **Sunday, May 23**

Electromagnetic Compatibility within Power Electronics – Part I – Fundamentals

Instructor: Jaques Laeuffer, PSA Peugeot Citroën, FRANCE

Tutorial 9 **Monday, May 24**

Electromagnetic Compatibility within Power Electronics – Part II – Advanced

Instructors: Jaques Laeuffer, PSA Peugeot Citroën, Jean-Marie Peter, FRANCE

Tutorial 10 **Monday, May 24**

Design with MOSFET and IGBT Power Modules

Instructors: Prof. Josef Lutz, Chemnitz University of Technology, GERMANY, Dr. Tobias Reimann, ISLE, Ilmenau, GERMANY

Tutorial 11 **Monday, May 24**

A Comprehensive Review of the Basic Design Elements of the Switched and Synchronous Reluctance Motors and Drives and their Use in World Markets

Instructor: Dan Jones, Incremotion Associates, USA

Tutorial 12 **Monday, May 24**

Advanced Technologies for Robust and Reliable Controller Design

Instructor: Dr. Alexandru Forrai,
Mitsubishi Electric, JAPAN

Tutorial 13 **Monday, May 24**

Fundamentals of Power Management with Integrated Circuits

Instructor: Paul Greenland,
National Semiconductor, USA

Tutorial 14 **Monday, May 24**

Advanced Techniques in Power Factor Correction

Instructors: Prof. Dr. Javier Sebastian, Prof. Arturo Fernández, University of Oviedo, SPAIN

Tutorial 15 **Monday, May 24**

UPS Topologies, Standards, Performances and Features: Technical Considerations for defining the UPS Topologies, Systems Configurations and Evaluating their Performances

Instructor: Jean-Francois Christin, MGE UPS Systems, FRANCE

Tutorial 16 **Monday, May 24**

Fundamentals of Power Quality Monitoring

Instructor: Dr. Alexander Kuznietsov,
ZES Zimmer, GERMANY

High Efficiency Rectification

Instructor

Ionel Dan Jitaru,
Delta Energy Systems, USA

About the Instructor

Ionel Dan Jitaru is the founder of Rompower Inc., an international recognized engineering firm in the field of power conversion, later Ascom Rompower Inc. and Delta Energy Systems (Arizona) Inc. Presently he is the president of Delta Energy Systems (Arizona) Inc., the advanced development group of Delta Energy Systems, the world's largest Power Supply Company.

He has published 28 papers and held 24 professional seminars professional at different International Conferences in the power conversion field, wherein several of them have received the best paper award.

Mr. Jitaru has pioneered several trends in power conversion technologies such as "Soft frequency", "Full integrated multilayer PCB packaging concept", "Synchronized rectification". Some of these technologies have been covered by 22 intellectual properties and thirteen granted patents.

Contents

The seminar will present a comprehensive overview of the rectification techniques for low and high voltage application. A full section is dedicated to the synchronized rectification a major step forward in the quest for higher efficiency. There will be presented different methods of drive and control for synchronized rectifiers. The seminar will also show some future trends in improving the efficiency of the synchronized rectification.

Another key chapter is dedicated to high efficiency rectification wherein the limiting factor is the reverse recovery of the rectifiers. A focal point will be the soft commutation technology applied to the rectifiers with applications not only in high voltage but also in low voltage, using synchronized rectification and higher frequency of operation.

- **High Efficiency Rectification for Low Output Voltage Application**
  - An overview of synchronized rectification
  - Self-driven synchronized rectification
  - Driven Synchronized rectification
  - Timing challenges to avoid the cross conduction and body diode conduction
  - Back flow prevention
  - Synchronized rectification in different topologies
  - Future trends
- **High Efficiency Rectification for High Output Voltage Applications**
  - Loss mechanism due to reverse recovery of the rectifiers
  - Low loss snubbing methods
  - Circuit techniques to reduce the reverse recovery loss
  - Soft switching across the rectifiers

The presentation will be highlighted with design guidance, design example and experimental results showing efficiency reaching 97%.

Who should attend

This course is designed for power conversion engineers and technical managers who are involved in state-of-art power conversion. The participants will get familiar with the latest advancement in power conversion technologies aimed to increase the performance and reduce the total cost.

Start: 9.00 a.m. **End: 6.00 p.m.**

Design with Power Semiconductors - Part I - Basics

Instructors

Pierre Aloisi, Jean-Marie Peter, France

About the Instructors

Pierre Aloisi, Formerly Principal Staff Application Engineer in Motorola semiconductors, Toulouse, France. Specialist of power semiconductors, mainly working in power applications like motor control, power supplies, telecom, appliance, lighting and automotive. Author of more than 100 papers in various international conferences and magazines. He has written four books on semiconductors. Today power electronic professor in different French universities.

Jean-Marie Peter started as R&D Engineer with Thomson in the field of Servo-mechanisms and Magnetic Amplifiers. He developed the first solid state motor drives in France operating in the market at the beginning of 1960. After he worked in the design of High Power Electronic Converters. Later with SGS THOMSON he was responsible of power applications and finally director of the strategic industrial market. He is now PCIM Technical Conference Director.

Contents

1.1 Basics about Power Semiconductors in Switching Mode

Essentials about silicon for power applications

Bipolar components: Diode - Bipolar transistor - Thyristor - GTO - IGCT - Fast rectifier

MOS Components: MOSFET - IGBT - MCT

Max ratings definitions - Junction temperature - Influence of the rated voltage - Safe operating area - Drive

Power Integration. What is specific from power - Monolithic and hybrid technologies - System or improved component - Smartpower-limits - What can be integrated, what cannot be integrated today - Examples - Power modules - IMPs - Advantages and disadvantages of power integration

1.2 Data Sheets

Max ratings - Characteristics - Typical and maximal values

1.3 Losses

Conduction losses - Switching losses

Examples of losses calculation; (Diodes - MOSFET - IGBT - GTO) Typical and maximum values

1.4 Thermal Resistance and Impedance

Component - Heatsink

1.5 Examples of Thermal Calculations

Case without and with heatsink - MOSFET for SMPS - IGBT for motor drives

1.6 Packaging and Reliability

Who should attend

This first part of the course is designed for all engineers (Designers - Quality responsibles - Component engineers - System engineers and technical managers) who want to refresh their knowledges in the state-of-the-art about power silicon components.

Start: 9.00 a.m. **End: 6.00 p.m.**

Design with Power Semiconductors - Part II - Power Semiconductors in the Field

Instructors
Pierre Aloisi, Jean-Marie Peter, France

About the Instructors
see Tutorial 2

Contents

2.1 Component Comparison

Choice - Data Sheets - Typical and maximum values - second source - Reliability and safety margin

2.2 Drive

MOSFETs and IGBTs, GTO and IGCT

2.3 The fast Recovery Rectifier in the Field

Turn-off behavior - Consequences, losses, overvoltages, noise current spikes. The circuit has an influence. The designer´s job.

2.4 Overvoltage Protection

Analysis of overvoltages - Passive components - Active protection Snubbers: Switch aid networks and clamping circuits

2.5 Overcurrent Protection

Active short circuit protection MOSFETs and IGBTs. GTOs and IGCTs

2.6 Simulation

2.7 How to Minimize the Losses

Switching losses: Hard and soft switching component behavior in zero-voltage switch and in zero current switch. Conduction losses

3.1 The Power Electronics World Changes

Power electronics evolution and main requirements. From “high tech” to - “heavy industry” - Progresses and improvements

3.2 Power Semiconductors Evolutions and Trends

Discrete and integrated devices - New devices? Or new control methods? MOSFET and IGBT trends - The competition: MOSFET vs IGBT - IGBT vs IGCT - What could be the successor of the IGBT? The fast rectifier always the week point?

3.3 Consequences for the Design

The challenge of power integration - Consequences for the design

Who should attend
Engineers involved in power electronics and interested in:

- Converter design
- Choice of components and component policy
- Component reliability

For this part II course it is not necessary to have followed the first part of the course. Some background about basics of power component is desirable.

This course is focused on:

The concrete aspects of the components in the field, from low to high power. The components evolution and the major future trends.

Start: 9.00 a.m. **End: 6.00 p.m.**

Design Considerations for High Frequency Linear Magnetics

Instructor
Bruce Carsten,
Bruce Carsten Associates, USA

About the Instructor

Bruce Carsten has 33 years of design and development experience in high frequency and switchmode magnetics, at power levels from 100 mW to 10 KW and frequencies from KHz to MHz. The focus of his two magnetics design seminars is on an inutitive but detailed understanding of how transformers and inductors work at high frequencies. This understanding will aid the practicing design engineer in the synthesis of suitable power magnetics without extensive time spent in 'cut and try' design cycles, as opposed to heavily analytical approaches which often provide little practical guidance in design. Formulas are provided for quantification of effects whenever possible, but math is largely kept to a minimum.

Contents

This updated and revised seminar discusses many of the important aspects of transformer and inductor design that are not included in the text books. Although some of the fundamentals are reviewed, a basic understanding of magnetics design is assumed. The relative merits of various low profile geometries are explored at medium and high frequencies, illustrating that most magnetics designs would be more efficient with 'more core and less copper'. Topics include:

* Ferromagnetic Materials
* Core Losses in Magnetic Materials
* Inductance and Energy Storage in the Magnetic Field
* Maximizing Inductor Energy Storage
* Transformer Leakage Inductance, What it Is and Is Not
* Common Mistakes in Measuring Leakage Inductance
* Calculation and Measurement of Winding Capacitances
* Magnetics Design in the Low, Medium and High Power-Frequency Domains
* Faraday Shields and Flux Bands for Reduced EMI
* Scaling Laws Beyond the Area Product; Effects of Magnetics Size
* Optimizing the Shape of Conventional and Low Profile Magnetics
* Thermal Considerations, and Thermal Management Alternatives
* Magnetics Design Guidelines:
  – Power Transformers (& Rectifier Influence)
  – High Ripple 'Main' Filter Inductors
  – Second Stage and Normal Mode EMI Inductors
  – Common Mode EMI Inductors
  – Pulse Current Transformers
  – Gate Drive Transformers
  – Transformer Design Myths

Who should attend

Switchmode Converter and Inverter design engineers, Magnetics Designers

Start: 9.00 a.m. **End: 6.00 p.m.**

High Frequency Conductor Losses in Switchmode Magnetics

Instructor
Bruce Carsten,
Bruce Carsten Associates, USA

About the Instructor
see Tutorial 4

Contents

This course provides and intuitive understanding of ac Skin and Proximity Effect losses in transformer and inductor windings. Formulas and approaches are provided for calculation of ac winding losses with arbitrary current waveforms. Methods for winding ac resistance measurement are discussed, with cautions on invalid measurements. Myths and misunderstandings are discussed, including: "'Skin Effect' is the current distribution in an isolated conductor"; "Foil and Litz wire conductors reduce loss because they have more 'skin' area", and "Losses are always reduced by replacing a solid conductor with an insulated, stranded conductor". Loss mechanisms unique to planar windings will be presented. Topics Include:

- Several Approaches to the Understanding of Eddy Currents
- Common Misconceptions about Skin Effect
- Single Conductor Proximity Effects
- Proximity Effects with Two Parallel Conductors
- Single Layer Proximity Effects in a Solenoidal Winding
- Proximity Effects with Multiple Winding Layers
- Calculating AC Winding Losses, with Sinusoidal and Non-sinusoidal Current
- Presentation of the "Equivalent Frequency" Concept, and Applicability.
- Conductor Options for Minimizing AC Losses, including Foil and Litz Wire
- Winding Options for Minimizing Loss (Interleaving Windings, AC and DC Windings...)
- The Inductor-Transformer Similarity (equivalence of Core Air Gap and a Secondary)
- Reducing Winding Losses due to an Inductor Core Air Gap
- Eddy Current Losses in Transformer Shields
- Measuring Winding Resistances; Cautions and Techniques
- Excess Losses in Conventional "Non-Ideal" Planar Windings
- Losses in Flyback Transformer Windings

Who should attend

Switchmode converter design engineers, Magnetics designers, DC-AC Inverter and Motor Drive designers

Start: 9.00 a.m. **End: 6.00 p.m.**

DC-DC Converters for Power Management Applications

Instructor

Dr. Richard Redl,
ELFI, Switzerland

About the Instructor

Dr. Redl is the director of ELFI S.A., an electronics consulting company in Switzerland, specializing in power supplies and other power-conversion equipment, electronic ballasts, and integrated circuits for power management. He holds sixteen patents, has written over hundred technical papers, and co-authored a book on the dynamic analysis of power converters. Dr. Redl is an associate editor of the Transactions on Industry Applications and a Senior Member of the IEEE.

Contents

This seminar reviews and critically evaluates the most important DC-DC converters, with special emphasis on power management applications. After a discussion of the basic converter types and their derivatives, the seminar addresses the topics of synchronous rectification, multi-phase converters, and multi-output converters. The seminar concludes with an overview of the isolated converters.

I. Basic converters and their derivatives

A. Basic converter topologies (buck, boost, buck-boost)
B. Characteristic waveforms and steady-state analyses
C. Converters with tapped inductors
D. Two-inductor/two-capacitor converters
E. Converters with coupled inductors
F. Cascaded and quadratic converters
G. Which converter for what application?

II. The synchronous rectifier

A. Loss analysis of the buck converter without and with synchronous rectification
B. Application examples
C. Diode emulation for reduced loss at light load; emulation techniques
D. Control considerations

III. Multi-phase converters

A. Examples and characteristics
B. Input and output ripple currents
C. Multi-phase converters for powering CPUs and DSPs

IV. Multi-output converters

A. Auxiliary winding on the inductor
B. Combining converters for multiple outputs
C. Implementing multiple outputs with a one-winding inductor and bidirectional switches

V. Isolated converters

A. Buck-derived isolated converters
B. Buck-boost-derived isolated converters
C. Clamp/reset techniques and charge-pump converters
D. Cascaded and combined converters
E. Synchronous rectifiers in isolated converters (self-driven, driven)
F. Multi-output converters and post-regulation techniques

Who should attend

This seminar is targeted towards power-supply design engineers, power-management IC designers, system designers, managers, engineering students and other professionals interested in DC/DC power conversion and power management.

Start: 9.00 a.m. **End: 6.00 p.m.**

Control, Modeling, and Feedback Loop Design of DC-DC Converters

Instructor
Dr. Richard Redl,
ELFI, Switzerland

About the Instructor
see Tutorial 6

Contents
The first part of this seminar reviews the various control techniques for DC/DC converters, including the most-important single-loop and multi-loop controls, as well as some of the auxiliary control functions (control for ensuring high efficiency over wide load range, current sensing, overload protection, and current sharing). The second part reviews the various modeling approaches, and presents theoretical and practical foundation for feedback loop design, including design for optimal load transient response. The following topics will be presented:

I. Single-loop control techniques

A. PWM (constant-frequency, constant-off-time, constant-on-time)
B. Variable-frequency with constant duty ratio
C. Regulation without error amplifier (hysteretic, peak-voltage control, valley-voltage control)

II. Multi-loop control techniques

A. Current-mode control (peak, valley, hysteretic, PWM-conductance, average)
B. Current control without the dc component (capacitor, inductor-voltage integral, Vsquare)
C. Charge control
D. Feedforward control (input-voltage, load-current, power-equalizing)

III. Auxiliary control functions

A. Loss reduction for high efficiency over wide load range (frequency slowdown at reduced load, burst control, phase shedding in multi-phase converters)
B. Overload protection (current-sensing techniques, pulse-by-pulse current limiting, effects of initial spike and stabilizing ramp, current-limit foldback, average current limiting)
C. Current sharing solutions for paralleled converters

IV. Small-signal modeling of basic square-wave converters

A. State-space averaging
B. Circuit averaging
C. Method of injected/absorbed currents
D. Model representations (equivalent-circuit, transfer-function block)
E. Transfer functions of basic converters (voltage-mode control, current-mode control)

V. Feedback loop design

A. Fundamentals of stability analysis
B. Error amplifiers
C. Feedback loop design for phase/ gain margin using the K factor (both theory and practical examples)
D. Feedback loop design for load transient response

Who should attend
This seminar is targeted towards power-supply design engineers, power-management IC designers, system designers, managers, engineering students and other professionals interested in control, modeling and feedback-loop design of switching power supplies and DC-DC converters.

Start: 9.00 a.m. **End: 6.00 p.m.**

Electromagnetic Compatibility within Power Electronics – Part I – Fundamentals

Instructor

Jacques Laeuffer,
PSA Peugeot Citroën, France

About the Instructor

Jacques Laeuffer has a 20 years experience in the field of Power Electronics for different applications including inverters for radar servo controls, high frequency resonant converters and high voltage transformers for X-Ray generators, and automotive drive systems for hybrid vehicles. He has written 50 technical papers, and is inventor of 20 patents. Together with his activity for PSA Peugeot Citroën, he is a teacher of E.M.C. at Conservatoire des Arts et Métiers, an Engineering University in Paris.

Scope and Benefits

Power Electronics are hundred times more powerful sources of electromagnetic interferences (E.M.I.) than digital control electronics. The scope of this seminar is to focus on what is specific with Power Electronics for E.M.C., from 100W up to 100KW, to avoid uncontrolled extra costs and delays during converters developments and in the field. Seminar's benefits include:

- Physical understanding of how interferences occur.
- Developed quantitative calculations from origins to effects, according regulations.
- Calculation of optimized and cost effective power designs and protections.

Contents

Introduction

- Issues take source in power transistors and diodes sudden commutations.
- Differential Mode interferences occurs when perturbation flows through active circuits, while Common Mode occurs when perturbation flows through parasitic capacitors, cases, grounds, etc.

Differential Mode Conducted Disturbances (example of a forward)

- Switching supply operating sequence.
- Input filtering capacitor resistance. Disturbance calculation.
- Disturbance measurement according regulations.
- Line diodes recovery. Line inductance effect.
- Differential mode filter components calculation.

Common Mode Conducted Disturbances (example of resonance)

- Parasitic capacitance trough heat sinks. Disturbance calculation.
- Disturbance measurement according regulations.
- Parasitic capacitance trough transformers; screens, electric machines windings.
- Common mode filter components calculation.

Gate Drive Through Galvanic Barrier

- Optocouplers and optic fibers receptors susceptibility. Pulse transformer resonances.

Who should attend

- Power electronics design engineers, intelligent motion, systems integration, field service, and E.M.C. specialists intended to design and / or integrate E.M.C compliant power electronics and / or drive systems, with optimized global cost and reliability.
- Technical managers interested in major trends of power electronics.

Start: 9.00 a.m. **End: 6.00 p.m.**

Electromagnetic Compatibility within Power Electronics – Part II – Advanced

Instructors

Jacques Laeuffer,
PSA Peugeot Citroën; Jean-Marie Peter, France

About the Instructors

Jacques Laeuffer: see Tutorial 8, Jean-Marie Peter: see Tutorial 2

Scope and Benefits

Over about 1MHz, conventional circuit theories with localized constants like "parasitic capacitances" or "stray inductances" need to be improved with a physical understanding of the electro-magnetic propagation in and around power circuit. Seminar's benefits include:

- How to choose and design E.M.C. optimized power designs (from 100W up to 100KW).
- Avoid expensive shielding. Reliability improvement.

Contents

Issues to be Solved

- High frequency (H.F.) parasitic resonances occur just after semi-conductors commutation, i.e. between MOS capacitance and transformer stray inductance.
- This H.F. is radiated and envelop detected by control semiconductors, and by antennas.
- Magnetic field radiations are very expensive to shield.
- Inductances reduction leads to capacitances increase, and vice versa.

Electromagnetic Power Propagation

- Propagation in coaxial lines: Poynting theorem. Electric and magnetic energy storage; electromagnetic power flow. Waves impedance and speed.
- Energy flow trough a transformer.
- To avoid resonances, the switch commutation time should be greater than circuits time constants:
  3 ways:

1. **Semicinductors DI/DT and DV/DT Control**
   - Smoothing di/dt and dv/dt front edges by gate drives. Control for MOS and IGBTs.
   - Drawback: increased commutation times and losses.
2. **Reduce Passive Components Time Constants**
   - Reduction of capacitors' inductance and inductors' capacitance. Transformers calculation and PCB layout. Snubbers, damping, grounding, shielding, etc.
   - Drawback: increased size of passive com-ponents.
3. **Topology Choice**
   - When power is increased, topology change (from forward to half bridge, or to resonance) reduces the above mentioned drawbacks. ZVS and ZCS resonance.
   - DRIVES: cables magnetic shielding between inverter and motor. Damping.

Radiations Reduction

- Cables, PCBs, transformers emission reduction.
- Easy magnetic field measurement. Scope probes use

Who should attend

- Power electronics design engineers, intelligent motion, systems integration, field service, and E.M.C. specialists intended to design and / or integrate E.M.C. compliant power electronics and / or drive systems, with optimized global cost and reliability.
- Technical managers interested in major trends of power electronics.

Start: 9.00 a.m. **End: 6.00 p.m.**

Design with MOSFET and IGBT Power Modules

Instructors
Prof. Josef Lutz, Chemnitz University of Technology, Germany,

Dr. Tobias Reimann, ISLE, Ilmenau, Germany

About the Instructors

Prof. Dr. Josef Lutz joined Semikron Electronics, Nuremberg, Germany in 1983. First he worked in the development of GTO Thyristors, then in the field of fast recovery diodes. He introduced the Controlled Axial Lifetime (CAL) diode, is holder of several patents regarding fast diodes, and has published 60 papers and conference contributions. Since August 2001 he is Professor for Power Electronics and Electromagnetic Compatibility at the Technical University of Chemnitz, Germany.

Dr. Tobias Reimann received 1994 his PhD from the Ilmenau Technical University in the field of power semiconductor applications for hard and soft switching converters. He works as scientific assistant in the Department of Power Electronics of the TUI. His special fields are power electronic circuits and power semiconductor applications. In 1994 he was one of the founders of the ISLE company which is engaged in system development for power electronics and electrical drives.

Contents

Switching Modes in Power Conversion
Switching – Commutation – Switching Modes

Power Module: Transistor - Freewheeling Diode Interaction
Forward and Reverse Recovery Characteristics - State of the Art – New Developments

Thermal-Mechanical Aspects of Power Modules
Power Loss and Junction Temperature Calculation - Module Standard Solutions - Materials – Thermal Resistance and Impedance – Thermal Mismatch – Power Cycling Capability – Design and Reliability

Topology-dependent Power Losses
DC/DC-Converters - DC/AC-Converters - Load Cycles

Drive and Protection
Technical Realisations – Failure Modes –Failure Detection – Protection – Special Problems Related to New Device Technologies – Active Clamping - Avalanche

Paralleling and Series Connection of Power Modules
Drive – Protection – Layout – Loop Current Problems

Special Effects in ZVS / ZCS Topologies with New Devices
Basics – Typical Waveforms – Power Loss Reduction – Special Problems Related to New Device Technologies

Device Induced Electromagnetic Disturbance
Parasitics -Oscillations in Power modules Oszillations in Commutation Loops

Who should attend

Engineers designing converters with IGBT- and MOSFET power modules having basic knowledge in power devices, or who have joined the Tutorial No. 2 (J.M. Peter) before.

Start: 9.00 a.m. **End: 6.00 p.m.**

A Comprehensive Review of the Basic Design Elements of the Switched and Synchronous Reluctance Motors and Drives and their Use in World Markets

Instructor
Dan Jones,
Incremotion Associates, USA

About the Instructor

Dan Jones received is BSEE degree and MS Mathematics. He has 40+ years experience in the design of precision servo and step motors. He has held engineering design and marketing management positions at various of companies. He has written over 170 technical articles and papers and held seminars in 11 countries. He is the Past President of AIME, past member of the Board of Directors of SMMA and Vice-President of EMERF.

Contents

This seminar combines marketing and engineering design information together in a presentation about the switched and synchronous reluctance (SR) motors and drives from around the world. The evolution of the SR motor and drive is chronicled from the early 1970's through its current activities. The basic design approach for SR motors is presented using SPEED simulation programs. The all important link to the drive is developed. Today's applications are presented along with a look at future SR applications.

1. **A Motor in Search of a Market**
   The Promise of SR Technology
   Earliest SR Design and Patent Activities
   European Developments in the 70's and 80's
   U.S. Development in the 80's
2. **SR Motor and Drive Developments**
   Emerging High Volume Applications in the 90's and 00's
   European Developments Through the 1990's
   U.S. Developments in the 90's
   Advantages and Disadvantages of SR Technology
   Market Barriers to the SR Motor and Drive
3. **The Other SR Motor**
   Early History
   Basic Definition and Construction
   Performance Characteristics
   Differences between 2 SR Motor Types
4. **Basic Design Choices for the SR Motor**
   Phase and Pole Combinations
   Computer Aided Design Techniques and Design Tradeoffs
   Performance Characteristics
   Differences between PM BLDC and SR Motors
   Magnetization (Flux Linkage) Curves and Co-Energy Equations
5. **Mechanical Design Issues**
   Air Gap Length Selection
   Tolerances and Concentricity Requirements
   Minimize Mechanical Losses
   Designing the SR Motor for Lower Noise Characteristics
6. **Winding and Thermal Design**
   Basic Winding Patterns
   Thermal Characteristics
7. **Basics of Drive Electronics for Both SR Motors**
   Basic Drive System Outline
   Power Circuit Topologies
   General Conduction Modes
   Early Drive Circuits
   Optimized Control Strategies
8. **Applications – Present and Future**
   Transportation
   Appliances
   Factory Floor
   HVAC, Others

Who should attend

Both technical and marketing manager and executives with responsibility for planning their company's future motion control products. Design engineers involved in design of other motor types who want both design and application information or who wish to update their knowledge.

Start: 9.00 a.m. **End: 6.00 p.m.**

Advanced Technologies for Robust and Reliable Controller Design

Instructor

Dr. Alexandru Forrai,
Mitsubishi Electric, JAPAN

About the Instructor

Dr. A.Forrai obtained his Ph.D. degree in Applied Computer Science from TU of Cluj-Napoca, Romania, 1998. He was Assistant Professor at TU of Cluj-Napoca, Faculty of Electrical Engineering, and in 1998 joined to Computer and Automation Research Institute, Hungary as Senior Research Fellow. From 2000 he was Post-doctoral Research Fellow at Utsunomiya University Japan and in 2002 joined to Mitsubishi Electric Corp. Japan as Research Fellow. His present research interests include: system identification and robust control, nonlinear control, motion control and intelligent machines, active vibration suppression control.

Contents

Robust controller design has been an active research area in the past decades and currently in on the main focus of the industry, where higher performance and robustness is required for lower price in order to keep the competitiveness. Therefore, the main objective is to present an unified approach for robust control system design with main focus on motion control systems. Suitable system identification techniques and robust controller design procedures are presented in order to meet the design requirements in presence of model uncertainties. For a better understanding of each design phase, practical examples are considered which are illustrated by experimental results. The considered examples are: a tracking control problem (speed control of a vector controlled brushless d.c. drive), as well as a disturbance rejection problem (active vibration suppression control of flexible structures).

1. **Basic concepts – introduction to robust and reliable controller design**
   Mathematical models and control system's characteristics
   Performance specifications of control systems
   Controller design for deadbeat response
   Robust and reliable controller design – a practical approach
2. **Short review of classical controller design techniques**
   Systems with time delays – Smith predictor
   Disturbance observers and notch filters
   Controller design using the root locus technique - examples
3. **Control objectives – robustness and performance**
   Internal stability and asymptotic tracking - strong and simultaneous stabilization
   Robust performance of control systems - robust controller synthesis problem
   Practical examples - tracking and disturbance rejection control problems
4. **System identification and model order reduction**
   Design of system identification experiments for linear-time-invariant systems
   Model order reduction methods and model validation
   Practical examples - system identification of a vector controlled drives and flexible structures
5. **Robust controller design - mixed sensitivity approach**
   Plant uncertainties and robustness criteria
   Design for robust performance
   Practical examples - tracking control and disturbance rejection control problems
6. **Robust controller design with constraint on the control signal**
   Robust controller design with hard constraint on the control signal
   Robust gain-scheduled control and robust stability analysis
   Practical examples - tracking control and disturbance rejection problems

7. Concluding remarks, future trends

Who should attend

R&D engineers, managers and academics, who work in the field of high precision motion control systems, and are interested in advanced system identification and robust control systems. No priori knowledge in the field of system identification or robust control techniques is required.

Start: 9.00 a.m. **End: 6.00 p.m.**

Fundamentals of Power Management with Integrated Circuits

Instructor

Paul Greenland,
National Semiconductor, USA

About the Instructor

Paul Greenland is a veteran of the power supply industry with over twenty years experience in the design of power converters and specification of power management integrated circuits. Currently Marketing Director for National Semiconductor Corporations Power Management product line, Paul brings many years of hard-won practical experience to this complex field. Previous PCIM seminars on quasi-resonant & multi-resonant converters concentrated on creating deep understanding and a "toolbox" to design with the topologies, this seminar will emphasis real-world considerations also.

Contents

This seminar is back to basics, with an emphasis on practical techniques for power management with Integrated circuits. All the basic regulator topologies, magnetic and charge-pump are presented with insight into circuit operation and device selection. Control techniques and phase compensation issues are reviewed in detail. Where appropriate, passive component selection, scaling and construction are discussed, together with layout/PCB design considerations. Particular attention is placed on the IC technology and the limitations and characteristics of integrated devices.

Subject Material includes:

Basic integrated regulator topology review:
- Buck
- Boost
- Buck-boost
- Cuk

Charge-pump techniques

Isolated topologies
- Flyback
- Forward
- Half-bridge

Passive component selection
- Filter inductor
- Filter capacitor
- Transformer

Synchronous vs. Conventional rectification

MOSFET driver considerations
- Ground-referenced
- Half-bridge

Current sensing techniques
- Shunt resistor
- Current transformer
- Current mirror cell
- Inductor Rdc
- MOSFET Rds(on)

Phase compensation techniques
- Transconductance vs. conventional error amplifiers
- Type 1, 2 & 3 Compensators
- Current vs. voltage mode control

Integrated circuit specifics
- Process technology
- Failure modes & protection
- Packaging & thermal aspects
- PCB Layout considerations

Who should attend

This seminar is appropriate for all disciplines from novice to experienced engineers wishing to refresh broad knowledge of the subject.

Start: 9.00 a.m. **End: 6.00 p.m.**

Advanced Techniques in Power Factor Correction (PFC)

Instructors

Prof. Dr. Javier Sebastian,
Prof. Arturo Fernández,
Universidad de Oviedo, Spain

About the Instructors

Javier Sebastián was born in Madrid, Spain, in 1958. He received the M.Sc. degree from the Polytechnic University of Madrid, and the Ph.D. degree from the University of Oviedo, Spain, in 1981 and 1985, respectively. He was an Assistant Professor an Associate Professor at both the Polytechnic University of Madrid and at the University of Oviedo, in Spain. Since 1992, he has been with the University of Oviedo, where he is currently a Professor. His research interests are switching-mode power supplies, modelling of DC/DC converters, low output voltage DC/DC converters and high power factor rectifiers.

Arturo Fernández.
He received the M.Sc. degree, and the Ph.D. degree in Electrical Engineering from the University of Oviedo, Spain, in 1997 and 2000, respectively. In 1998 he joined the University of Oviedo as an Assistant Professor and since 2003 he is an Associate Professor at the same university. He has been involved in around 20 power electronics research and development projects since 1997 and he has published over 50 technical papers. His research interests are switching-mode power supplies, low output voltage, converter modelling, and high power factor rectifiers.
Regarding Power Factor Correction issues, he has been involved in the development of high power factor rectifiers for Alcatel and Chloride Power Protection.
He cooperates regularly with the IEEE and currently he is the Development Chair of the IEEE-PELS Spanish Chapter.

Contents

The IEC 61000-3-2 regulations applied to Switching-Mode Power Supplies

Line inductors and LC filters to comply with the IEC 61000-3-2 regulations in Class A and in Class D.

How to use a simple resistor to comply with the IEC 61000-3-2 regulations in Class A.

Exploring the use of isolated PFCs (like flyback) as the only conversion stage for medium-speed response applications.

Very simple single-stage PFCs.

High efficiency post-regulators used to improve the transient response of PFCs.

Very simple current shaping techniques for very low-cost applications.

Who should attend

The course is focused for people working in the design of Switching-Mode Power Supply Systems for applications from low power (about 100W) to medium power (about 1kW). This power range includes many very widely used pieces of equipment such as personal computers, battery chargers, etc.

Start: 9.00 a.m. **End: 6.00 p.m.**

UPS Topologies, Standards, Performances and Features:

Technical Considerations for defining the UPS Topologies, Systems Configurations and Evaluating their Performances

Instructor

Jean-Francois Christin,
MGE UPS Systems, France

About the Instructor

Jean-Francois CHRISTIN received his B.S Degree in 1990 from Winthrop University (S.C. / USA) and joined Schneider that same year. He spent most of his time through the technical and sales support department, to come up with innovative solutions in the UPS field, everywhere from Europe to Asia. He now heads the technical marketing department of MGE UPS SYSTEMS for Europe, Middle East, Africa.

Contents

Processes and applications require higher power availability, and need to be protected from power outages and disturbances. This seminar will provide all necessary explanations in order to design a "resilient" electrical installation, and to understand the UPS, a key element of that installation. The engineer will have all the information to make rational comparison of UPS. He will have an overview of the major risks that may disrupt the power, and of the solutions to mitigate those risks.

1 - UPS topologies

Power disturbances: types, causes and consequences
UPS standards
UPS topologies
Recommended solutions according to applications
Static and rotary UPS

2- Power Quality & UPS performances

Key performances and features
Frequency regulation
Voltage regulation
Voltage distortion
Efficiency
PWM technology
Reliability
Operation/maintenance
Harmonic rejection
Compatibility with generator set
Energy storage technologies
Recommended selection criteria

3 - UPS configuration and high availability architectures

Availability
MTTR
MTBF
Parallel and redundant configuration,
Architecture comparison

Who should attend

Electrical engineers, consultants in electrical engineering, Power quality engineers, Facility managers, managers responsible for an electrical infrastructure.

Start: 9.00 a.m. **End: 6.00 p.m.**

Fundamentals of Power Quality Monitoring

Instructor

Dr. Alexander Kuznietsov,
ZES Zimmer, Germany

About the Instructor

Dr.-Ing. habil. Alexander Kuznietsov was born in Kiev, Ukraine on October 16, 1967. He received the M.E. and Ph.D. degrees in measuring science from Technical University Kiev in 1992 and 1996 respectively. In 1996 he joined the Technical University of Ilmenau, Germany, where he worked as a guest researcher and dealt with a modelling and measurement of power quality factors in electrical supply networks. Since 2000 he has been with the ZES ZIMMER Company in Germany and deals with development of measuring instruments for power electronics and power quality. 2003 he received his habilitation degree from Technical University of Ilmenau.

Dr. Kuznietsov is member of IEEE Instrumentation and Measurement Society

Contents

The seminar presents the following topics:

1. **The importance and recent development of power quality monitoring tools**
2. **Origins, mathematical models and characterisation ways of the power quality factors**
   - Harmonics and Interharmonics;
   - Unbalance
   - Flicker
   - Dips and Swells
   - Transients
3. **Measuring tools and operations to analyse the power quality factors**
   - Structure of the measuring instrument
   - Analogue transformations, sampling and quantisation of measured data with an analysis of uncertainties and pitfalls
   - Digital processing of measured data (r.m.s. and half wave r.m.s. values, symmetrical components, Fourier transformation)
   - Supported measurement of currents and power components
4. **Advanced algorithms of data-processing**
   - Measurement of emission of harmonics and flicker
   - Defining the origins of voltage dips
   - Data visualisation
   - Reduction of measured data
   - Regression analysis to find out the origin of distortions
   - Clustering of measured data to detect typical operational situations
   - Estimation of the impact of power quality factors to the operation on electrical equipment
   - Using the monitoring results for future-oriented planning
5. **Organisation of power quality monitoring**
   - Main objectives of power quality monitoring
   - Correct choice of monitoring equipment
   - Monitoring places and duration
   - Presentation of results

Who should attend

Electrical engineers who develop the electrical appliances and equipment. Operation personnel and quality assurance departments of large industrial plants. Operator of wind farms. Consulting engineers and power quality experts.

Start: 9.00 a.m. **End: 6.00 p.m.**