Dynamics and Control of AC Drives
August 12–15, 2014
Madison, Wisconsin

Advance your knowledge of solid-state drive systems for AC machines...

- Information on design, modeling, and control of modern AC drives
- Advanced techniques for designing high-performance drives

Please route this brochure to colleagues who would also benefit by attending.
Advance Your Knowledge
This comprehensive course offers you a special opportunity to advance your knowledge in the design, modeling, and dynamic performance of solid-state drive systems for AC machines. Our experienced faculty will focus on both the principles and the practice of AC drives. The learning format will consist of lecture, laboratory, and computer demonstrations. Be sure to come prepared to meet and exchange ideas with fellow electrical engineers from across the country—a certain highlight of your learning experience.

Join Us and Benefit
This course will be valuable to you if you are an engineer involved in the design and development of AC drive systems or a design/development engineer incorporating AC motors and drives into other products and equipment.

An Advanced Course
Expect to apply your fundamental knowledge of power conversion and AC machine theory.

Achieve Valuable Objectives
This course will make you more effective in your engineering work by helping you:

- Understand the principles of modern AC drives, including PM, induction, and reluctance machines
- Understand the modes of interaction between AC motors and power conversion systems, including dynamic stability issues
- Learn how to control AC machines, including the principles of field orientation and direct torque control
- Learn how to model and simulate AC motor/drive systems
- Learn how to use modern control theory to design controllers that minimize or eliminate dynamic interactions in drive systems
- Understand the performance of sensorless control methods for AC drives
- Understand the causes and mitigation of drive-induced machine bearing currents and insulation stress
- Learn about operation and control of regenerative drives and converters

Past Participants Say…

"BEST COURSE I'VE EVER HAD OVER A NEARLY 30-YEAR CAREER. I WISH I'D HAD THESE PROFESSORS WHEN I WAS IN COLLEGE. THEY ARE ALL EXCEPTIONAL."
Allen Davidson, Sr. Project Engineer, Northrop-Grumman Shipbuilding, Newport News, Virginia

"VERY THOROUGH AND COMPLETE COVERAGE OF THE PRESENTED TOPICS."
Jason Johnson, Northrop-Grumman Shipbuilding, Newport News, Virginia

"AWESOME! NICE TO GET THE LATEST INFO IN A CONCISE AND WELL-EXPLAINED FORMAT. LOTS OF GOOD INFO."
John Neely, Eaton Aerospace, Grand Rapids, Michigan

"VERY GOOD PRESENTATION; QUITE INSIGHTFUL."
DeWayne Speer, Manager of Electrical Engineering, Helmerich & Payne IDC, Tulsa, Oklahoma

Course Faculty
Vladimir Blasko holds a PhD degree in electrical engineering and has more than 30 years of industrial experience in the field of power electronics and electrical drives. Presently he holds the position of a Senior Fellow at the United Technologies Research Center. Previously he worked at Otis Elevators and Rockwell Automation—Allen Bradley Companies. During the academic year 1988–1989 he was with the University of Wisconsin—Madison as a Postdoctoral Fellow. His primary areas of interest and expertise are AC drives, intelligent power management, power electronics, applied modern control theory, and technology.

Thomas M. Jahns, PhD, Professor, Department of Electrical and Computer Engineering, University of Wisconsin—Madison. Previously with GE Corporate R&D and Massachusetts Institute of Technology, Jahns has research interests in electric machines, drive system analysis and control, and power electronic modules.

Russell J. Kerkman is Distinguished Engineering Fellow with Rockwell Automation. His career spans 30 years in power electronics and adjustable speed drives. His current interests include adaptive control applied to field-oriented induction machines, design of AC motors for adjustable speed applications, and EMI from PWM inverters.

Robert D. Lorenz, PhD, Professor, Department of Electrical and Computer Engineering and Department of Mechanical Engineering, University of Wisconsin—Madison. Lorenz spent 10 years with Gleason Works, Rochester, New York, where he was R&D staff group leader in product development and automation systems. His research interests include high-precision and high-performance real-time controls, drive system design, and advanced sensor technologies.

Donald W. Novotny, PhD, Professor Emeritus, Department of Electrical and Computer Engineering, University of Wisconsin—Madison. Novotny’s research interests include variable frequency inverter drive systems and the control of induction machines. He has been a visiting professor at the Eindhoven Technical University in the Netherlands and a Fulbright lecturer at the State University of Ghent, Belgium.

Bulent Sarlioglu, PhD, Assistant Professor, UW–Madison, and Associate Director, Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC). He previously worked at Honeywell International Inc.’s aerospace division for 11 years, most recently as a staff systems engineer, earning Honeywell’s technical achievement award in 2003 and an outstanding engineer award in 2011. He is the inventor or co-inventor of 16 U.S. patents and many other international patents.
Dynamics and Control of AC Drives
August 12–15, 2014 in Madison, Wisconsin

Course Outline

Review of Basic Induction Motor Theory
• Equivalent circuit model
• Variable frequency operation
• Non-sinusoidal excitation

Review of Synchronous Machine Theory
• Physical structure and principle of operation
• Equivalent circuit model
• Torque angle and phasor diagram
• Influence of saliency
• Variable frequency operation
• Permanent magnet machines

Converters for AC Drives
• Functional requirements of converters
• Types of converters in use today
• Operating features
• Performance capabilities

Adjustable Speed Drive Types
• Power semiconductor types
• Power converter classifications
• Induction machine drive configurations—VSI, CSI, Static Scheinbus
• Synchronous machine drive configurations—VSI, CSI, Current Regulating

Induction Motor Model
• Coupled circuit model of AC machines
• d-q reference frame representation
• Vector representation of machines
• Effects of saliency

Vector Analysis of Induction Machines
• Steady state equivalent circuits
• Electrical transients at constant speed
• Transient equivalent circuits

Current Regulation in Power Converters
• Proportional and “P-I” Control Basics
• Command Feedforward (CFF)
• Disturbance Input Decoupling (DID)
• Decoupling State Feedback (DSFbk)
• Extension to VSI and AC Motor Current Control

Simulation of AC Machines and Drives
• Flux linkage machine models
• Survey of simulation programs
• Simulation using MATLAB/SIMULINK
• Converter modeling
• Demonstration of converter-machine simulation

Complex Modeling for Control Design and Analysis
• Vector and scalar models of machines
• Synchronous vs. stationary frame vector models
• Asymmetric root locations and frequency response functions
• Controller design using vector models

Field Orientation (FO)—Induction Machines
• Steady state induction machine FO
• Dynamics of induction machine FO
• Indirect controllers for induction machines FO
• Direct controllers for induction machine FO

Field Weakening
• Flux level selection
• Inverter imposed voltage and current limits
• Torque capability in field weakening
• Control system implementation

Flux Observers and Direct Field Orientation (DFO)
• Field orientation from a controls perspective
• Industry standard indirect Field Orientation
• Existing methods for DFO
• Observer-based flux estimation
• Observer-based DFO

Field Orientation Control of Synchronous Machines
• Requirements for high-performance torque control
• Self-synchronous control
• Maximum torque-per-amp operation
• Dynamic response characteristics
• “Brushless” DC machines

Permanent Magnet Synchronous Machine Drives
• Permanent magnet machine discussion
• Vector control of permanent magnet synchronous machines
• Flux weakening operation

Direct Torque Control
• Stator flux and electromagnetic torque control
• Implementation alternatives

Sensorless Control
• Exciting and tracking saliencies
• Observers and performance metrics
• Implementation

Simulation of Field-Oriented Drives
• Motor model
• PWM inverter model
• Speed and current regulators
• Slip gain calculation

Practical Aspects of Drive Control
• Current feedback
• Speed feedback
• PWM

Inverter Effects—Bearing Currents
• Short voltage rise times
• Voltage reflection
• Filters
• Influence of motors and cables

Operation and Control of Regenerative Drives and Converters
• Motivation for regeneration
• Regenerative converters as front-ends of regenerative drives
• Principle of operation
• Phase-lock loop systems for synchronization with single and three-phase systems
• DC Bus voltage control

Parameter Estimation and Adaptation
• Basic estimation principles
• Formulation of accurate methodology
• Forming induction machine models
• Selecting excitation models

Fault Protection for AC Drives
• Asymmetrical systems
• Fault model development
• Fault signature identification

Course Schedule

Registration and course will be held at
Engineering Hall, Room 1610
1415 Engineering Drive
Madison, WI

Day 1
8:00 a.m. to 8:30 a.m.  Registration
8:30 a.m. to 5:00 p.m.  Class

Day 2 and 3
8:00 a.m. to 5:00 p.m.  Class

Day 4
8:00 a.m. to 3:30 p.m.  Class

An optional laboratory demonstration session will be held on evening of Day 2; there is no additional cost for this demonstration.

The daily schedule includes morning and afternoon refreshment breaks and lunch at noon.

Earn Your Master’s Degree in Power Electronics While Working Full Time

Earn your UW–Madison Master of Science in Electrical and Computer Engineering (Power Electronics) degree without traveling to campus. This world-class program, delivered at a distance via online pre-recorded lectures allows you to complete courses from anywhere and makes it easy for you to follow along with classes on a regular semester schedule.

For more information, call:
Program Director: Marty Gustafson
mseeapply@epd.engr.wisc.edu
608-262-8819
distancedegrees.engr.wisc.edu/MSEE
Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC)

WEMPEC is a consortium of more than 80 sponsoring companies and organizations that supports pre-competitive research in the fields of electric machines, power electronics, controls, and their applications. The consortium organizes seminars, campus technology roadmapping visits, student internships, and annual review meetings to maximize interaction between students, faculty, and sponsors.

For more information contact:
Professor Robert D. Lorenz
608-262-5343
lorenz@engr.wisc.edu
or
Professor Thomas M. Jahns
608-262-5702
jahns@engr.wisc.edu

University of Wisconsin
College of Engineering
1415 Engineering Drive
Madison, WI 53706
www.wempec.wisc.edu

Other Course Opportunities

The Department of Engineering Professional Development conducts a variety of courses that provide current, practical information and approaches. Other courses in the power electronics and electrical machinery series include:

- Introduction to Power Electronics
- Design of Magnetic Components for Power Electronic Circuits
- Permanent Magnet Machines and Drives: Principles, Design, and Applications
- Dynamics and Control of AC Drives
- Introduction to Electrical Energy Storage Devices and Systems
- Introduction to Electrical Machines and Drives
- Introduction to EMI/EMC and Best Practices

We also have the following courses available for on-site education:

- Introduction to Power Electronics
- Introduction to Electrical Machines and Drives
- Electromagnetic and Electromechanical Engineering Principles

For information about these courses or to make a suggestion for a course we do not presently offer, call Bulent Sarlioglu, PhD at 800-462-0876 or e-mail: bulent@engr.wisc.edu

Need to Know More?

Call toll free 800-462-0876 and ask for
Program Director: Bulent Sarlioglu, PhD
bulent@engr.wisc.edu
(608) 262-2703

Program Associate: Debbie Benell
benell@epd.engr.wisc.edu
(608) 263-7428

Or e-mail custserv@epd.engr.wisc.edu

General Information

Fee Covers Notebook, course materials, break refreshments, lunches, and certificate and registration of Continuing Education Units (CEU).

Cancellation If you cannot attend please notify us at least seven days prior to the course start, and we will refund your fee.

Cancellations received after that date and no-shows are subject to a $150 administrative fee per course. You may enroll a substitute at any time before the course starts.

Location The course will be held in Room 1610, Engineering Hall, 1415 Engineering Drive, Madison, WI.

Phone messages: 608-263-3163.

Accommodations We have reserved a block of guest rooms (rates starting at $130, including parking) at The Wisconsin Union Hotel, 1308 West Dayton Street, Madison, WI. Reserve a room online at
epd.engr.wisc.edu/lodgingP657 or call 608-263-2600 and indicate that you will be attending this course under group code P657 Dynamics and Control. Room requests after July 10 will be subject to availability. Other fees and restrictions may apply.

We have reserved a second block of guest rooms (rates starting at $120, including shuttle) at The Madison Concourse Hotel and Governor’s Club, One West Dayton Street, Madison, WI. Reserve a room online at
epd.engr.wisc.edu/lodgingP657 or call 800-356-8293 or 608-257-6000 and indicate that you will be attending this course under group code 392519. Room requests after July 15 will be subject to availability. Other fees and restrictions may apply.