Introduction to Electric Machines and Drives

March 24–26, 2015
Madison, Wisconsin

A special three-day course on the theory, design, and application of electric machines and drives

- Principles of rotating electrical machines
- Power electronics converter basics
- Drives and the fundamentals of their controls
- In-class demonstrations and hands-on lab session
Increase Your Knowledge

Industry relies critically on the ability to move systems and control power. The conversion of electrical energy to torque and motion has been the purview of motors for more than a century. In the last 30 years, the introduction of power electronic drives with motors has led to new design opportunities; indeed, the increased integration of drives and machines in recent years has created a quantum leap in productivity, efficiency, and system performance.

During this course, you will learn from recognized machines and drives experts. You will gain a solid introduction to the rapidly expanding field with well-founded fundamentals, practical application examples, and in-class demonstrations.

Who Should Attend

Anyone new to the field of electrical rotating machines and drives and those desiring a refresher from the perspective of actual designs from actual practitioners will benefit by attending this state-of-the-art course. You will find this course valuable if you work in the fields of:

- Appliance drives
- Cranes and elevators
- Precision motion control
- Renewable/alternative energy
- Electric/hybrid-electric vehicles
- Autonomous vehicle control
- Aerospace, marine, and military vehicles

Networking Opportunity

As an additional benefit, this course will feature a social hour following class on the first day. This will allow time to discuss your interests with the course faculty and other attendees.

Course Faculty

**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.

**Robert D. Lorenz, PhD**, professor, 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.

**Michael Ryan, PhD**, president, Ryan Consulting, Los Angeles, California. Ryan is involved in the application of power electronics and controls, particularly for alternative energy systems. He has had a wide range of industrial experience with positions at Capstone Turbine, General Electric Corporate R&D and Defense Systems Divisions, Automated Dynamics, Otis Elevator, and Hamilton Standard.

**Michael Harke, PhD**, staff engineer, UTC Aerospace Systems, Rockford, Illinois. Harke has worked on research and product development in the applications of aerospace, automotive, and industrial drives. His experience includes Danfoss Power Electronics, Whirlpool, Ford Motor Company, Schneider Electric, and International Rectifier.

**Phillip Kollmeyer, PhD candidate**, Department of Mechanical Engineering, University of Wisconsin–Madison. Kollmeyer has focused his studies and research on electric machines, power electronics and controls, specifically as related to energy storage and vehicles. He has built a research oriented electric truck to help improve modeling and design.

Wisconsin Electric Machines and Power Electronics Consortium

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 an annual review meeting to maximize interaction between students, faculty, and sponsors.

For more information contact:

Professor Thomas M. Jahns
608-262-5702
jahns@engr.wisc.edu

Professor Robert D. Lorenz
608-262-5343
lorenz@engr.wisc.edu

Or visit wempec.wisc.edu

ENROLL ONLINE TODAY! Or visit our website.
Course Outline

Introduction
- Welcoming remarks
- What you can expect to learn

Review: AC Systems and Three-Phase Circuits
- AC voltages and currents
- Effective or RMS values
- Complex numbers and phasor concepts
- Why three-phase?
- Harmonics
- Per-unit system

Review: Electromagnetics and Energy Conversion
- Magnetic fields, flux, and force
- Faraday’s Law of Induction
- Ferromagnetic materials
- Inductors and transformers
- The DC machine

Basics of AC Machines
- Elementary AC machines
  - air-gap MMF
  - flux
  - voltage waveforms
  - Distributed stator windings
  - Elementary rotor-stator coupling
- Three-phase operation

Induction Motors: Steady State
- Induction machine types
  - wound rotor
  - “squirrel cage” rotor
- Circuit models
- Concept of slip
- Torque-speed curves

Synchronous Machines: Steady State
- Synchronous machine types
  - wound rotor
  - permanent magnet
- Circuit models and vector diagrams
- Capability curves

Converter Power Electronics: Basic Theory, Devices
- Review of circuit fundamentals
- Basic converters
- Conversion stages
- Device characteristics and capabilities

AC Inverter Basics: VSI, CSI, Modulation
- Basic inverter system
- Voltage source inverter (VSI)
- Current source inverter (CSI)
- Modulation techniques
- Pulse width modulation (PWM)
- Practical considerations

Adjustable Speed Drives: Basics
- Basic adjustable speed drive systems
- Review: DC machine speed control
- Varying voltage
- Varying frequency
- Motor and drive selection

Adjustable Speed Drives: Volts/Hz Control
- Concepts of constant flux and torque
- Operation at constant torque or power
- Low speed operation
- Basic Volts-per-Hertz system
- Drive limitations

Adjustable Torque Drives: Basics
- Ideal adjustable torque systems
- Review: DC machine torque control
- Key elements of torque control
- Synchronous machine torque
- Induction machine torque-slip control

Induction Motor Field Orientation
- Review machine forces: Lorentz and reluctance
- Rotating vectors: stator and rotor currents
- Lorentz force control = vector control
- AC current regulation
- IM slip and torque production

Application-Specific Selection of Machine-and-Drive Systems
- Load types and characteristics
- Specific drives to suit application
- Practical issues of machine and drive selection
- PM versus IM
- Installation considerations

Hands-on Electric Machines Lab Session
- Machines tested
  - induction machine
  - wound-field synchronous
  - permanent magnet
  - concepts explored
  - line starting
  - efficiency
  - Volts/Hertz control
  - iron saturation and hysteresis
  - back EMF
  - field weakening
  - flux and torque control

Earn Continuing Education Credit
By participating in this course, you will earn 20 Professional Development Hours (PDH) or 2.0 Continuing Education Units (CEU).

Course Schedule

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

Day 1
8:00 a.m. to 8:30 a.m. Registration
8:30 a.m. to 4:30 p.m. Class
4:30 Social Hour

Day 2
8:00 a.m. to 4:30 p.m. Class

Day 3
8:00 a.m. to 3:00 p.m. Class
Refreshments prior to the start of the course, midmorning and midafternoon refreshment breaks, and lunch will be provided all three days.

Past Participants Say…

“GOOD STUFF — BUILT UP VERY LOGICALLY. I REALLY ENJOYED DIVING INTO THE MOTOR MODEL.”
Paul Avery, Engineer, Yaskawa America Inc., Waukegan, Illinois

“I REALLY LIKED THE LAB AND VISUAL DEMONSTRATIONS. IT HELPED ME UNDERSTAND IM CONTROL PRACTICES.”
Jon Kuehnemund, Software Design Engineer, John Deere Electronic Solutions, Fargo, North Dakota

“I LOVED THE CONTENT AND PRESENTATIONS. WHEN IT COMES TO DRIVE APPLICATIONS, I WILL USE THIS.”
Scott Young, Electrical Power Engineer, Chevron Corporation, Houston, Texas

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 Marty Gustafson, program director, at 608-262-8819, e-mail mseeapply@epd.engr.wisc.edu or visit distancedegrees.engr.wisc.edu/MSEE.

ENROLL ONLINE TODAY! Or visit our website.
Course Information

☑ Please enroll me in Introduction to Electric Machines and Drives
Course #P932 March 24–26, 2015 in Madison, Wisconsin Fee: $1695
☑ Team Discount: $1495 each when three of more people from the same organization enroll in this course
☑ WEMPEC Discount: $1495 each for members of WEMPEC Sponsor Companies

These discounts cannot be combined.

☑ I cannot attend at this time. Please send me brochures on future courses.

Personal Information (Please print clearly.)

Name ____________________________________________________________
Title ____________________________________________________________
Company _________________________________________________________
Address __________________________________________________________
City/State/Zip _____________________________________________________
Phone (_______) ____________________ Fax (_______) ____________________
E-mail ____________________________________________________________

Additional Enrollees

Name ____________________________________________________________
Title ____________________________________________________________
E-mail ____________________________________________________________
Name ____________________________________________________________
Title ____________________________________________________________
E-mail ____________________________________________________________

Billing Information

☑ Bill my company ☑ P.O. or check enclosed (Payable in U.S. funds to UW – Madison)

Cardholder's Name ____________________________________________
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Need to Know More?

Call toll free 800-462-0876 and ask for
Program Director: Mitch Bradt, PE
bradt@wisc.edu
608-263-1085
Program Associate: Maren Muñoz
munoz@epd.engr.wisc.edu
608-262-3748
Or e-mail: kustserv@epd.engr.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:

- Permanent Magnet Machines and Drives
- Dynamics and Control of AC Drives
- Introduction to Power Electronics
- AC Machine Design Fundamentals

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

- Introduction to Power Electronics
- Introduction to Electric 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 program director Mitch Bradt at 800-462-0876 or e-mail bradt@wisc.edu.

General Information

Fee Covers Course materials, textbook, break refreshments, lunches, and certificate.

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 may be left for you with the program director, Mitch Bradt, at 608-263-1085.

Parking Limited pay-as-you-go parking is available at Lot 17 adjacent to Engineering Hall. We recommend making your room reservation at one of the hotels providing shuttle service.

Accommodations We have reserved a block of guest rooms (rates starting at $120, including shuttle) at Madison Concourse Hotel and Governor’s Club, One West Dayton Street, Madison, WI. Reserve a room online at epd.engr.wisc.edu/lodgingP932 or call 800-356-8293 or 608-257-6000 and indicate that you will be attending this course under group code 412956. Room requests after March 3 will be subject to availability. Other fees and restrictions may apply.