A special three-day course to advance your knowledge of the performance, design, and application of permanent magnet AC machines and their associated drives.

**Permanent Magnet Machines and Drives: Principles, Design, and Applications**

August 4–6, 2015
Madison, Wisconsin

A results-oriented course with:

- Information on design, modeling, and analysis of permanent magnet AC machines
- Machine-drive interactions and advanced control and sensing techniques
- Applications, practical considerations, and future trends

Please share this brochure with colleagues who may benefit from attending this course.
Advance Your Knowledge
Advance your knowledge of the design, modeling, and application of permanent magnet machines and their associated drives and controls. Our experienced faculty will focus on the principles and the practice of PM machines. A thorough introduction to the fundamentals and advanced concepts will be our objective during three intensive days.

The market for permanent magnet AC machines has grown rapidly in recent years because of the availability of affordable high-energy-product magnet materials, continuing improvements in power electronics technology, and major advances in the design and control of permanent magnet ac machines. This potent combination of technology advances is providing opportunities for improved product performance, reduced system costs, and the introduction of features not previously feasible. Be sure to come prepared to meet and exchange ideas with fellow engineers from across the country—a valuable highlight of your learning experience.

Join Us and Benefit
Permanent magnet AC machines, operating as motors or generators, can achieve very high power density, fast dynamics, high operating efficiency, and robust control characteristics. This course will be valuable if your work includes the design, development, or application of systems utilizing PM machines as motors or generators.

Please Note: This is an advanced course. Attendees are expected to have a basic knowledge of magnetics, synchronous machines, and drives. A brief review of these fundamentals will be included in the course. You should have a bachelor's degree in engineering or a related field, or the equivalent amount of industrial experience.

Who Will Benefit
Engineers involved in:
- Electric machine design
- Electric vehicles (land, sea, air)
- Wind and renewable power generation
- High-performance motion control
- Elevators and cranes
- HVAC equipment
- Aerospace applications

Achieve Valuable Objectives
During this course you will:
- Learn about the current applications and future trends of permanent magnet AC machines
- Review the principles of permanent magnet AC machines, including the basics and the major topologies
- Examine the techniques and tools for designing permanent magnet AC machines, including thermal and structural considerations
- Learn how to control permanent magnet machines, including the principles of field orientation, direct torque control, current regulators, and flux-weakening
- Study the performance of self-sensing control methods for permanent magnet AC machines
- Learn how to model and simulate the machine/drive system with examples in MATLAB/Simulink
- Learn about the fault modes of permanent magnet AC machines and techniques for minimizing their impact on drive performance

Course Faculty
Dan M. Ionel, PhD, FIEEE, Chief Engineer, Regal Beloit Corp., and Visiting Professor, UW–Milwaukee. He worked in industrial R&D for Fortune 1000 and FTSE 100 Companies in the US and the UK. His experience includes electric machines and drives with power ratings between 0.002hp and 10,000hp.

Thomas M. Jahns, Grainger Professor of Power Electronics and Electrical Machines, Department of Electrical and Computer Engineering, UW–Madison. Before UW, he spent 15 years with GE Corporate R&D and MIT. He has research interests in electric machines, drive system analysis and control, power electronics integration, and renewable energy.

Robert D. Lorenz, Mead Witter Foundation, Consolidated Papers Professor of Controls Engineering, Department of Mechanical Engineering, UW–Madison. He spent 10 years with Gleason Works, Rochester, New York, where he was R&D staff group leader in precision motion control, power control, and integrated sensing. His research interests include high-precision and high-performance real-time controls and advanced integration of control and self-sensing in electrical machines, power converters, and drive system applications.

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 US patents and many other international patents.
Course Outline

Applications and Technology Trends
- Review of PM machine applications
- Suitability for direct-drive applications
- High-power-density and high-efficiency applications
- Trends toward higher speed and higher power
- Trends toward higher motor-converter integration

Fundamentals of Synchronous Machines
- Equivalent circuit models
- d-q modeling for salient pole machine
- Magnetic circuit model
- Introduction to magnetic materials properties

Major PM Machine Topologies
- Features and comparative overview, attributes for selection
- Stator and rotor configurations, including radial and axial

PM Machine Design and Analysis, Tools, and Methods
- Electromagnetic
- Thermal and structural
- Parameter measurement
- Design for self-sensing

Drive System Issues for PM Motors and Generators
- Drive configurations and topologies
- Torque-speed characteristics

PM Drive Control
- Current regulators
- Vector control and direct torque control (DTC)
- Sensors, observers, and self-sensing control

Flux-Weakening Control
- Alternative control algorithms
- Interactions between machine design and control

Drive System Simulation
- Matlab/Simulink
- Rapid prototyping

Fault-Mode Operation
- Open-circuit and short-circuit faults
- Uncontrolled generator operation
- Demagnetization
- Fault-tolerant machine design

Course Schedule

Registration and course will be held at:
Room 1610 Engineering Hall
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
8:00 a.m. to 5:00 p.m.  Class
5:00 p.m. to 6:00 p.m.  Optional laboratory demonstration

Day 3
8:00 a.m. to 3:30 p.m. Class
Midmorning and midafternoon refreshment breaks and noon lunch will be provided all three days.

Past Participants Say…

“All the presenters were very articulate, easy to understand, and seem to want you to understand.”
Fred Wirth, Principal Engineer, Magnetek, Menomonee Falls, Wisconsin

“I’ve gained a deeper understanding about the characteristics and issues of PM machines and especially of PM drives.”
Adriana Urda, Elec. Machine Design Engineer, Sauer-Danfoss, Denmark

“The instructors and the presentations are top notch. The course logistics and food were excellent.”
Jerhod Smithback, Electrical Engineer, Kato Engineering, North Mankato, Minnesota

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 an annual review meeting 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
wempec.wisc.edu

ENROLL ONLINE TODAY! Or visit our website.
Course Information

- Please enroll me in *Permanent Magnet Machines and Drives: Principles, Design, and Applications*
  - Course #R293 August 4–6, 2015 in Madison, Wisconsin Fee: $1695
- WEMPEC Members save $200
  - Course #R293 August 4–6, 2015 in Madison, Wisconsin Fee: $1495
- I cannot attend at this time. Please send me brochures on future courses.

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- Company ____________________________
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- City/State/Zip ____________________________
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Additional Enrollees

- Name ____________________________
- Title ____________________________
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Need to Know More?

Call toll free 800-462-0876 and ask for

**Program Director:**
Bulent Sarlioglu, PhD, Assistant Professor sarlioglu@wisc.edu or 608-262-2703

**Program Associate:**
Debbie Benell debbie.benell@wisc.edu or 608-263-7428
Or e-mail custserv@epd.engr.wisc.edu

General Information

**Fee Covers:** Course materials, break refreshments, lunches, and certificate and registration of Continuing Education Units (CEU). WEMPEC member companies save $200.

**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:** This course will be held in Room 1610, Engineering Hall, 1415 Engineering Drive, Madison, WI. Phone messages: 608-263-3163.

**Earn Continuing Education Credit:** By participating in this course, you will earn 21 Professional Development Hours (PDH) or 2.1 Continuing Education Units (CEU).

Accommodations

We have reserved a block of guest rooms (rates starting at $135) at the Wisconsin Union Hotel, 1308 West Dayton Street, Madison, WI. To reserve a room call 608-263-2600 and indicate that you will be attending this course under group code R293 Permanent Magnet Machines. Room requests after July 4 will be subject to availability.

We have reserved a second block of guest rooms (rates starting at $159) at HotelRED, 1501 Monroe Street, Madison, WI. Reserve a room online at epd.engr.wisc.edu/lodgingR293 or call 608-819-8228 and indicate that you will be attending this course under group code Permanent Magnetic Machines. Room requests after July 4 will be subject to availability. Other fees and restrictions may apply.

**Parking:** Limited parking is available for $12/day in Lot 17 adjacent to Engineering Hall.