Learn the fundamentals of PM machine design and how to effectively use them on the job.

**Permanent Magnet Machine Design Boot Camp—**

**Internal PM, Surface PM, and Brushless DC**

November 11–14, 2014
Madison, Wisconsin

Essential information on various types of PM machines used in:

- Traction motors
- Industrial motors
- Aerospace motors
- Appliance motors
- Generator designs

Please share this brochure with colleagues who may benefit from attending this course.
Advance Your Knowledge

Permanent magnet (PM) electrical machine design is one of the most important skill sets needed to stay competitive in the motors and generators industry. Its many applications include industrial, electric vehicle, appliance, aerospace, and naval. This intensive course covers the design of several types of PM machines, including internal PM, surface PM, and brushless DC machines. Participants will be able to effectively use knowledge gained from this course to develop new products or refine existing designs.

This course offers you a special opportunity to advance your knowledge in this important field. Our experienced instructors are from both academia and industry, and over the three-and-a-half intensive days, they will focus on sound engineering knowledge with an emphasis on the fundamentals.

Achieve Valuable Objectives

This course will make you more effective in your engineering work. During this course you will:

- Learn detailed design equations for surface PM, internal PM, brushless DC, and PM-assisted synchronous machines
- Review PM machine applications and tear down studies
- Learn finite elements of PM machines
- Review cooling, vibration, and manufacturing of PM machines
- Learn types and characteristics of permanent magnets
- Understand recent advancements and trends in permanent magnet technology
- Compare pros and cons of each permanent magnet type for PM machines
- Study equivalent circuit for permanent magnets
- Review special topics on axial-flux PM machines and PM flux switching machines
- Understand PM machine design for loss minimization and self-sensing

Join Us and Benefit

This course will be valuable to you if your job requires PM machine design knowledge, especially engineers involved in the design, specification, and integration of components and systems.

Audience

This course will be very beneficial for those working in designing, developing, specifying, and testing electric machines, including:

- Electrical engineers
- Mechanical design engineers
- Project engineers, program managers
- Technical managers, supervisors
- System integrators

Course Faculty

Tim Burress is the Electric Machines Team Leader at Oak Ridge National Laboratory in Oak Ridge, Tennessee. Burress has led the development of motor controls and drives as well as comprehensive dynamometer evaluations for over 10 years. He also leads novel machine design projects for transportation applications.

Dan M. Ionel is Chief Engineer at the Regal Beloit Corp., Visiting Professor at UW–Milwaukee, and an IEEE Fellow. He has worked in industrial research and development for Fortune 1000 and FTSE 100 Companies in the U.S. and U.K. His experience includes electric machines and drives with power ratings between 0.002hp and 10,000hp.

Thomas M. Jahns is Grainger Professor of Power Electronics and Electrical Machines, Department of Electrical and Computer Engineering at the UW–Madison. Before joining UW–Madison, he spent 15 years with GE Corporate Research and Development and MIT. His research interests are electric machines, drive system analysis and control, power electronics integration, and renewable energy.

Robert D. Lorenz is the Mead Witter Foundation Consolidated Papers Professor of Controls Engineering in the Department of Mechanical Engineering at UW–Madison. He spent 10 years with Gleason Works, Rochester, New York, where he was the research and development 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 controls and self-sensing in electrical machines, power converters, and drive system applications.

Donald W. Novotny is Professor Emeritus in the Department of Electrical and Computer Engineering at UW–Madison. 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. His research interests include variable frequency inverter drive systems and the control of AC machines.

Gianmario Pellegrino is Associate Professor at the Politecnico di Torino (Polytechnic University of Turin). He received his PhD degree in electrical engineering from the same institution. His research interests include the design of electrical machines and control of electrical drives. He has 24 journal papers and one patent. He was a guest researcher at Aalborg University, Denmark, a visiting fellow at Nottingham University, UK, and an honorary fellow at the UW-Madison.

Bulent Sarlioglu is Assistant Professor at UW–Madison and Associate Director of the Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC). Previously, he spent 11 years at Honeywell International Inc.’s aerospace division, most recently as a staff systems engineer. He earned Honeywell’s technical achievement award in 2003 and an outstanding engineer award in 2011. He is the inventor or co-inventor of 15 U.S. patents and many other international patents.

Aaron Williams is Project Manager in Machine Applications at Arnold Magnetic Technologies. He started in the magnetics industry upon graduation from the Rochester Institute of Technology in 2008. He is an active participant in the Motor and Motion Association (SMMA) and is currently continuing education through the Simon School of Business at the University of Rochester.
Course Outline

1. Introduction to PM Machine Design
   • Surface PM
   • Internal PM
   • Brushless DC
   • PM assisted

2. PM Machine Terminology and Important Definitions

3. PM and PM Machine Modeling
   • Review of Br, Hc, and energy density of magnet types
   • Equivalent circuits for PMs
   • PM machine modeling

4. PM Machine Power and Torque Equations
   • PM torque and reluctance torque components
   • Equivalent circuits
   • Vector diagrams

5. Permanent Magnet Fundamentals and Trends
   • Energy density, remnant flux, and coercive force
   • Temperature effect
   • Losses
   • Price trends
   • Pros and cons of each magnet type for machine design

6. Advances in Magnetic Materials Technology

7. Sizing Equations for PM machines
   • Electric loading
   • Magnetic loading
   • Shear stress

8. Surface PM Machines
   • Design and analysis

9. Brushless DC Machines
   • Design and analysis

10. Internal PM Machines
    • Design and analysis of interior PM machines
    • Flux weakening and fault-tolerant design of PM machines
    • Distributed vs. concentrated windings in PM machines
    • Computer-based design optimization of PM machines

11. Thermal Analysis – Cooling and Ventilation Systems
    • Conduction, convection, and radiation
    • FEA, CFD, lumped-parameters equivalent-networks
    • Fan ventilation, liquid cooling

12. Noise, Vibration, Structural Issues of PM Machines

13. Manufacturing of PM Machines
    • Laminations, cores, windings, frames, assemblies
    • Material and manufacturing tolerances

14. Finite Element Analysis of PM Machines
    • Fundamentals
    • Examples

15. Examples of PM Machines for Traction Drives
    • Tear down examples from Oak Ridge National Lab

16. Design Considerations for the Realization of PM Motors

17. PM Machine Design for Loss Minimization Control

18. PM Machine Design for Self-Sensing Control

19. PM Assisted Synchronous Machines
    • Design
    • Finite element
    • Optimization

20. Special Topics
    • Axial flux PM machines
    • PM flux switching machines

Please note: This course will stress fundamentals and some advanced subjects while highlighting recent developments in PM electric machine design. You should have a bachelor’s degree in engineering or a related science or the equivalent amount of industrial experience.

Course Schedule

Registration and course will be held at
1415 Engineering Dr.
Room 1610 Engineering Hall
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 2-3
8:00 a.m. to 5:00 p.m. Class

Day 4
8:00 a.m. to 12:00 p.m. Class

Midmorning and midafternoon refreshment breaks and noon lunch will be provided all four days.

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

Take your skills to the highest level when you earn your University of Wisconsin Master’s of Science in Electrical and Computer Engineering (Power Electronics). This world-class program, delivered at a distance via online lectures, CDs, or DVDs, allows you to complete courses from anywhere and makes it easy for busy engineers to follow the semester schedule.

For more information, contact Marty Gustafson, Program Director, at 608-262-8819 or magustafson@engr.wisc.edu, or visit 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 an annual review meeting to maximize interaction between students, faculty, and sponsors.

For more information contact:
Professor Robert D. Lorenz
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or
Professor Thomas M. Jahns
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ENROLL ONLINE TODAY! Or visit our website.
Course Information

Please enroll me in Permanent Magnet Machine Design Boot Camp—
Internal PM, Surface PM, and Brushless DC

☐ Course #P723 November 11–14, 2014 in Madison, Wisconsin
   Fee: $1795
☐ Course #P723 November 11–14, 2014 in Madison, Wisconsin
   WEMPEC Discount Member Fee: $1595.
☐ I cannot attend at this time. Please send me brochures for courses.

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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
- AC Machine Design Fundamentals
- 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
- 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, contact Bulent Sarlioglu, PhD, at 800-462-0876 or 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@engr.wisc.edu
608-263-7428

General Information

WEMPEC Discount
WEMPEC member companies will receive a $200 discount.

Fee Covers
Course notebook, break refreshments, three 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. 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.

Accommodations
We have reserved a block of guest rooms (rates starting at $130, including parking and wi-fi) at The Wisconsin Union Hotel, 1308 West Dayton Street, Madison, WI. Reserve a room online at epd.engr.wisc.edu/lodgingP723 or call 608-263-2600 and indicate that you will be attending this course under group code P723/Permanent Magnet. Room requests after October 9 will be subject to availability. Other fees and restrictions may apply.

Earn Continuing Education Credit
By participating in this course, you will earn 25 Professional Development Hours (PDH) or 2.5 Continuing Education Units (CEU).