Gain insight into actual design challenges and solutions from the perspective of practitioners with real-world as well as leading-edge research experience.

**Introduction to Power Electronics**

April 23–25, 2014
Madison, Wisconsin

“VERY THOROUGH. EASY TO ASK QUESTIONS. EXCELLENT.”
Past participant in this course.

- Gain a solid introduction to this emerging and rapidly growing field
- Learn with a building-block approach filled with applications-specific examples
- Engage with hands-on demonstrations and a simulation lab
- Gain a solid introduction to this emerging and rapidly growing field
- Please route this brochure to colleagues who would also benefit by attending.
Introduction to Power Electronics
April 23–25, 2014 in Madison, Wisconsin

Information You Need Today
Power electronics is the application of solid-state electronics for the control and conversion of electric power. It connects four subfields: electronics, magnetics, energy conversion, and control systems. Power electronics is central to the conversion of energy for use in all manner of equipment:
- Power supplies
- Cranes and elevators
- Precision motion control
- Renewable/alternative energy
- Electric/hybrid-electric vehicles
- Autonomous vehicle control
- Smart distribution systems
- Flexible AC Transmission Systems (FACTS)

The implementation of power electronics is expanding rapidly as companies pursue Energy Star, NEMA Gold, and other efficiency standards, enabling them to achieve a competitive advantage in the marketplace.

During this course, you will receive a solid introduction to this emerging and rapidly growing field. Using a building-block approach filled with applications-specific examples and hands-on demonstrations, this course will bring you up to speed on the basics and nuances of the field of power electronics. You will master the fundamentals of power electronics while examining application-specific examples.

Who Should Attend
This course was created in response to a need to train people who are new to the power electronics field. If you are just starting your career or transitioning to this growing field from another engineering discipline, you will benefit by attending this course. The course will also serve as a refresher course for practicing professionals. You will gain insight into actual design challenges and solutions.

Learn from Experienced Professionals
Your instructors each have more than 20 years of experience in product development and design. Each has made significant contributions to the field’s body of research and has authored a number of papers in the field of power electronics.

Marc Thompson, PhD
President, Thompson Consulting, Inc., Harvard, Massachusetts

Dr. Thompson conducts research and prototype development specializing in power electronics, control systems, magnetic design, advance analog design, and magnetic levitation. Previously he was an advanced engineer at Polaroid Corporation. He received his PhD, MS, and BS degrees in electrical engineering from The Massachusetts Institute of Technology.

Michael Ryan, PhD
President, Ryan Consulting
Los Angeles, California

Dr. 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 Raytheon Space and Airborne Systems, Capstone Turbine, General Electric Corporate R&D and Defense Systems Divisions, Automated Dynamics, Otis Elevator, and Hamilton Standard.

He received his PhD degree from the University of Wisconsin–Madison, his MS degree from Rensselaer Polytechnic Institute, and his BS degree from the University of Connecticut—all in electrical engineering.

Special Course Features
This course will include hardware demos, with real-time oscillographic displays of fundamental and non-ideal circuit operation and characteristics. This course also will include an introduction to simulation strategies and tools for analysis and design of power electronic circuits. You’ll spend one afternoon learning to use a demonstration version of a power electronics software tool.

Please plan to bring your laptop to the course for the software segment. We will ask you to install the demonstration software and will provide circuit files to learn with. This software requires Win XP, Vista, or 7. If you would like to use an on-site laptop, please indicate that when you register.

Learn How…
You will master the fundamentals of:
- Basic electrical concepts
- Basic magnetic concepts
- Review of switches and device realization

You will then focus on:
- Basic converters
- Diode rectifiers
- Phase-controlled rectifiers and inverters
- DC/DC converters and isolated converters
- Inverters and modulation strategy
- Single- and three-phase inverters

You will receive detailed instruction on:
- Magnetic design issues
- Gate drive design
- Sensor integration
- Cooling and layout
- DC bus design
- Real-world design considerations
- Electromagnetic Interference (EMI)
- Applications

Enroll online today! epd.engr.wisc.edu/webP311
Explore Key Topics…

Introduction to Power Electronics
- Scope of power electronics
- Disciplines encompassed
- Example applications and projects

Basic Electrical Concepts
- Resonance and damping
- Single- and three-phase power
- Real/reactive/apparent power and power factor
- Root-mean square quantities

Basic Magnetic Concepts and Design Issues
- Review of Maxwell’s equations
- Inductance and energy
- Magnetic circuit model
- Magnetic core materials
- Basic inductor and transformer design

Review of Switches
- Properties of the ideal switch
- Diodes
- Thyristors/SCRs
- MOSFETs
- IGBTs
- Comparisons of switches in the design space

Diode Rectifiers
- Half- and full-wave rectifiers with resistive load
- Rectifiers with RC filter—ripple and PF
- Commutation
- Three-phase rectifiers (6 and 12 pulse)

Phase-controlled Rectifiers and Inverters
- Review of thyristor operation
- Thyristor rectifier with resistive load
- Full bridge rectifier with LR and current source load
- Inverter mode of operation

Basic Converters
- Converters and associated circuit fundamentals
- Pulse Width Modulation (PWM)
- Introduction to the switching leg
- H-bridge converter
- Conversion stages

Basic DC/DC Converters
- Block diagrams of basic systems
- Buck converter
- Boost converter
- Buck/boost converter
- SEPIC converter
- Cuk converter

Isolated DC/DC Converters
- Motivation for using isolation
- Flyback converter
- Forward converter
- Other isolated converters

Real World DC-DC Converter Issues
- Efficiency
- Input filter selection
- Choice of core material
- Real-world capacitors and inductors
- Off-the-shelf ICs for control design

Converter Hardware Demo
- DC-DC buck converter
- Isolated DC-DC converter
- PWM signals for DC-DC and DC-AC
- Demos—operating waveforms
- Demos—non-ideal characteristics

Simulation Workshop
- Motivation and methods
- Challenges and pitfalls
- Introduction to the software
- Sample circuits

Single-Phase Inverters and Modulation
- Half-bridge inverters
- Square wave, PWM, and harmonics
- Over-modulation
- Full-bridge inverters
- Phase-shift control
- Bipolar vs. unipolar PWM
- Inverter energy storage example
- Output ripple and other practical considerations

Three-Phase Inverters and Modulation
- Basic three-phase inverter
- Three-phase VSI inverter
- Six step and PWM
- Ripple current
- Harmonic elimination
- Increased bus voltage utilization
- Third harmonic injection
- Bus clamping
- VSI voltage vectors

Gate Drives and Sensors
- Device control
- BJT base drives
- MOSFET/IGBT gate drives
- Thyristor and GTO gate drives
- Gate resistance and dead time
- Isolation and protection
- Voltage and current sensing

Cooling, Layout, and EMI Considerations
- Device thermal limits
- Cooling approaches
- Thermal modeling
- Heat flux
- Circuit layout techniques
- EMI mitigation

DC Bus Design Considerations
- DC bus function
- Converter ripple current
- Capacitor characteristics and types
- Harmonics and capacitor ESR
- Converter design examples
- Aluminum electrolytic capacitor wear-out

What Past Participants Have Said…

“ALL OF THIS WILL BE APPLICABLE IN THE FUTURE FOR MY JOB.”
Benjamin Shover, General Motors Power Train-Hybrid, Pontiac, Michigan

“I REALLY LIKED THE REAL-WORLD EXAMPLES. THEY REALLY TIED IN PREVIOUS SCHOOLING WITH PRACTICAL REAL-WORLD EXAMPLES. GREAT SIMULATION AND DESIGN EXPLANATIONS.”
Chris Heilman, Engineer, ASC Capacitors, Ogallala, Nebraska

“VERY GOOD EXPLANATIONS AND MODELING OF POWER ELECTRONICS.”
Jesse Marek, Hamilton Sunstrand, Rockford, Illinois

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
8:00 a.m. to 5:00 p.m. Class

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

The daily schedule will include refreshments prior to the start of the course, morning and afternoon refreshment breaks, and lunch served at noon.

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

Internet: epd.engr.wisc.edu/webP311

Phone: 800-462-0876 or 608-262-1299 (TDD 265-2370)

Mail to: The Pyle Center
Attn: Engineering Registration
702 Langdon Street
Madison, Wisconsin 53706

Fax: 800-442-4214 or 608-265-3448

Course Information

☐ Please enroll me in Introduction to Power Electronics
Course #P311 April 23–25, 2014 in Madison, Wisconsin Fee: $1595
☐ Team Discount: $1395 each when three or more enroll from the same organization.
☐ Please reserve an on-site laptop for my use during the Simulation Workshop Rental Fee: $50
☐ 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 __________________

Billing Information

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

Cardholder’s Name __________________________ __________________________
Card No. __________________________ __________________________
Card Type: □ MC □ VISA □ □
Expiration __________________________ __________________________
Please check the box if you are a person with a disability and desire special accommodations. A customer service representative will contact you. Requests will be kept confidential.

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
distedegrees.engr.wisc.edu/MSEE

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 custserv@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:

• Dynamics and Control of AC Drives
• Introduction to Electric Machines and Drives
• Introduction to Electromagnetic Interference and Compatibility (EMI/EMC) and Best Practices
• Permanent Magnet Machines and Drives: Principles, Design, and Application

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 Notebook, CD of trial version of simulation software with sample network files, break refreshments, lunches, certificate, continuing education credits (PDH/CEU), and rosters.

Cancellation If you cannot attend please notify us at least seven days in advance of the course, 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 Engineering Hall, Room 1610, 1415 Engineering Drive, Madison, WI, on the University of Wisconsin–Madison campus. If you must be contacted during the course, phone messages may be left for you with the program director, Mitch Bradt, at 608-263-1085.

Accommodations We have reserved a block of guest rooms (rates starting at $118, 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/lodgingP311 or call 800-356-8293 or 608-257-6000 and indicate that you will be attending this course under group code 345936. Room requests after April 2 will be subject to availability. Other fees and restrictions may apply.

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