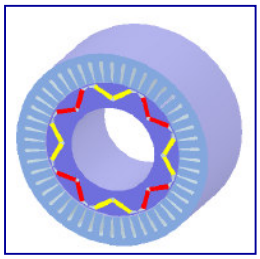
ADVANCED MOTORTECH LLC
4951 71ST AVENUE NORTH
PINELLAS PARK, FL 33781-4428 USA
NEW ADDRESS: PLEASE UPDATE YOUR RECORDS!

Next Offering of Our Most Popular Course!

Design of Interior Permanent Magnet and Brushless DC Machines – Taking Theory to Practice

Learn practical IPM and BLDC Machine Design by applying motor characteristics, academic theory and manufacturing practices

April 11-13, 2012 Middleton, WI (Madison Area)



- ***IPM & BLDC Machine Design Methods***
- ***Practical Magnetic Analysis Techniques***
- ***Putting Magnets & Windings to Work***
- ***Performance & Loss Calculations***
- ***Realistic Practice & Expectation***
- ***How to Test for Parameters & Performance***

Objectives and Benefits

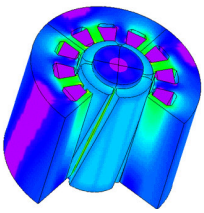
This How-To course addresses the key state-of-the-art application-oriented design issues for IPM & BLDC machines. We will use basic motor principles to increase understanding of integrating permanent magnets into any IPM or BLDC machine design. Academic theory will be reduced to practical results with calculation 'how-to', taking manufacturing constraints into account. Special emphasis will be on design differences and new trends in IPM/BLDC motors, including new analysis techniques and design options to achieve cost, efficiency, power density, and torque per amp requirements. The similarities and differences of IPM/BLDC machines, compared to induction machines and wound-field synchronous machines are discussed.

The material in this course is the engineering material you can't find in a book, and you can't get from software training. It is presented using a combination of modern machine design concepts and computer techniques with a heavy dose of many years of experience. The specification requirements, design steps, analysis approaches and test methods are discussed for motors and drive systems for a variety of applications such as hybrid vehicles, all-electric traction, wind turbine generators, home appliances, aerospace, and industrial.

The primary goal of this course is to provide an up-to-date, practical foundation of IPM and Brushless DC machine design techniques to produce accurate and realistic design results based on the electrical, magnetic, mechanical, and thermal interactions.

Those who will benefit:

- **Motor and generator design engineers**
- **Application engineers, especially for EV, HEV, UAV, Wind Energy, high efficiency**
- **Suppliers to motor manufacturers**
- **Control engineers**
- **Engineering and R&D managers**
- **Others who specify, design, analyze, manufacture or service IPM or BLDC machines**



You should have some background in electric machine principles, operation and construction such as the equivalent of a B.S. degree in engineering. Understanding of basic magnetic circuits is needed, but advanced motor theory and control techniques are not essential.

Course Schedule

Day 1: Wednesday April 11

7:30-8:00 Registration

8:15 Session Begins

Fundamentals of PM Machines
- ☑ BLDC vs. IPM vs. SMPM
- ☑ PM Rotor Configurations, & Why
- ☑ Rotating Fields, Current Waveform
- ☑ Torque Production in PM Machines
- ☑ Reluctance Torque, Options
- ☑ Machine Design Steps, Using CAE
- ☑ Using Models to Predict Performance
- ☑ d-q Equivalent Circuit

PM Material
- ☑ Permanent Magnet BH Loops
- ☑ PM Parameters
- ☑ PM Material Options, Trade-offs
- ☑ Demagnetization Effects
- ☑ Temperature, Aging

Steel Core Material
- ☑ Electrical Steels for IPM/BLDC
- ☑ Coatings & Heat Treatment
- ☑ Understanding Mfr. Core Loss Data
- ☑ Segmented & Hinged Laminations
- ☑ Soft Magnetic Composites
- ☑ Sources of Good Data

Magnetic Analysis
- ☑ Magnetic Circuits, Modeling and Analysis
- ☑ Analytical and Finite-Element Methods
- ☑ Airgap Flux, EMF Waveform
- ☑ Output Torque, Inductance, Losses
- ☑ Reluctance Torque & dq Model
- ☑ Effect of Changing Number of Poles
- ☑ PM Machine Performance Calculation

Loss Calculations & Segregation
- ☑ Loss Components, Thermal Balance
- ☑ Problem of Core Loss Prediction
- ☑ Core Loss Calculations & Modeling
- ☑ Eddy Current Loss, Segmenting Magnets
- ☑ Efficiency Calculation
- ☑ Practical Ways to Reduce Losses

Control of IPM/BLDC Motors
- ☑ PWM, 6-step, Vector Control
- ☑ Current and Position Sensing
- ☑ Sensorless Control Introduction
- ☑ Field-Weakening Control
- ☑ PM vs. Induction Comparison

4:45 Session Ends

Day 2: Thursday, April 12

8:15 Session Begins

Sizing & Scaling Laws
- ☑ Principles of Sizing & Scaling
- ☑ Key Relationships, Figures of Merit
- ☑ Ke, Kt, Shear Stress, current and flux density, MMF drop, Electric Loading
- ☑ Scaling Laws: varying diameter, axial length, turns etc.

Practical Design Windings
- ☑ Coils, Phases, Circuits, Slots, Poles
- ☑ Series, Parallel Circuits, Wye vs. Delta
- ☑ Winding Pattern Choices
- ☑ Winding MMF & Harmonics
- ☑ Manufacturing Considerations
- ☑ Some Practical Tricks of the Trade

Concentrated Winding Designs
- ☑ Distributed vs. Concentrated Windings
- ☑ Single/Double Layer, Fractional Slot
- ☑ Selection of Slot/Pole Combinations

How to Design a BLDC Motor
- ☑ Specification, Materials, Cooling
- ☑ Choosing Poles, Slots, Frequency
- ☑ Designing Rotor PM Configuration
- ☑ Designing Stator Slots & Winding
- ☑ Efficiency vs. Power Density
- ☑ Design Example

How to Design an IPM Motor
- ☑ Example Specification Design Process
- ☑ IPM Machine Topologies
- ☑ Motor Sizing and Key Ratios
- ☑ Design Optimization Methods
- ☑ Equivalent Circuit Parameter Analysis
- ☑ Shear Stress, Magnetic / Electric Loading
- ☑ Key Dimensional Ratios
- ☑ Reducing Cogging Torque

Testing for Losses and Model Parameters
- ☑ Measurements: T, ω, electrical quantities
- ☑ Resistance, d,q Inductances
- ☑ Back-EMF, Open-Circuit Losses
- ☑ Cogging Torque and Short-Circuit Losses
- ☑ Inverter Operation Testing

Modeling & Simulation
- ☑ Motor Design Software & Books
- ☑ FEA Software
- ☑ Linked CAE Simulation
- ☑ Hardware in Loop Simulation

4:45 Session Ends

PM: Optional Extra: FEA Demo

Day 3: Friday, April 13

8:15 Session Begins

Thermal & Structural Analysis
- ☑ Thermal & Structural Modeling
- ☑ Material Data
- ☑ Losses, Heat, Temperature
- ☑ Forces & Noise
- ☑ Typical Parameter Values
- ☑ Practical Expectation, Limits

Design for Wind Energy
- ☑ Wind Energy Conversion System Configurations
- ☑ Small, Medium, Large Examples
- ☑ Design Example

Design for Traction
- ☑ EV and HEV Applications
- ☑ Toyota Prius PM Motor
- ☑ Honda Insight PM Motor
- ☑ Other HEV Examples
- ☑ HEV Example Design

Small Motor Design
- ☑ Baseline Conventional Machine
- ☑ Soft Magnetic Composite PM Design
- ☑ Performance Comparison

Realistic Manufacturing Tolerances
- ☑ Important Key Parameters
- ☑ Issues with Core Steels, Magnets
- ☑ Issues with Cooling, Noise
- ☑ High speed Practice & Limits
- ☑ Issues with Frames & Shaft

New Trends & Technologies – What, Why, When
- ☑ Status of Chinese Magnet Market
- ☑ Axial Flux PM Machines
- ☑ Transverse Flux & Toroidal Winding Machines
- ☑ New Materials
- ☑ Modular & Automated Mfg.

3:00 Closing & Adjourn

Future Courses:

To receive brochures on upcoming courses, please tell us your interests:

- □ Induction Machine Design
- □ Design of Magnetic Components for Power Electronic Circuits
- □ Switched Reluctance Machines
- □ Traction Motor Design and Drives
- □ Focused motor type or issue: _____
- □ Other_____

Instructor:

Dr. Keith W. Klontz is President and CEO of Advanced MotorTech LLC, an engineering services company with emphasis on electric machine design. He holds BS & MS degrees in Electrical Engineering from the University of Illinois, Champaign-Urbana, and a PhD in Electrical Engineering from the University of Wisconsin-Madison. Dr. Klontz is a world-recognized expert in electric machine design and has over 40 years hands-on experience with electric machine applications and design engineering, from concept to performance to failure analysis. He has been involved in the research, development, testing and training of very high performance machines from 10 Watts to 50 MW, with speeds ranging from angle positioning torque-motors to 60,000 rpm machines. Recent work includes design of permanent magnet alternators, brushless d.c. motors, brush d.c. motors, high efficiency induction motors, and very high power density machines.

Attention International Engineers: **This course will also be offered:** June 2012: Frankfurt, Germany
Oct/Nov 2012: Shanghai, China

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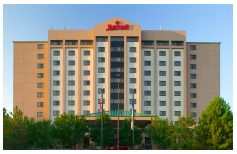
General Information

Fee Includes: Training Manual (full color), hard cover book by Duane Hanselman, break refreshments, lunch, and certificate.

Cancellation: Kindly notify us at least seven days before the course starts for 100% refund. Cancellations received later than seven days before the course are subject to a 15% late cancellation fee. Cancellations made after the course starts are subject to the full course fee

Course Location: Wisconsin Trade Center
8401 Greenway Blvd., Suite 210
Middleton, Wisconsin 53562

Hotel Location: Marriott West
(3 blocks from WI Trade Center)
1313 John Q Hammons Drive
Middleton, Wisconsin 53562
Phone: 608-824-2717



Accommodations: A **reduced-rate block** of rooms has been reserved at the beautiful Marriott West for reservations made **before Mar 28th**. Identify yourself as a participant in this course to reserve a room at the reduced rate. Additional directions and information will be sent with your enrollment confirmation. Please make your own reservations.

Includes Book!
"Brushless Permanent Magnet Motor Design"
by Duane Hanselman

☐ Yes! Please enroll me in **Course No. IPM-BLDC-0412**
IPM/BLDC Machine Design, April 11-13, 2012
Fee: $1575.00 (USD only)

PAYMENT: (Deadline: must be received before start of course)

☐ MasterCard ☐ VISA ☐ Amex

- Cardholder Name _____
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- Exp ___/___/___ Billing Zip_____ Security Code: _____

□ Check enclosed (payable to Advanced MotorTech, LLC) *
□ Bill my company* □ Purchase Order*
* Please note payment deadline above; no exceptions; subject to approved credit.

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Title _____

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Address _____

City _____ State _____Zip _____

Phone ( ) _____ email_____

To Enroll: Phone: (727) 412-8200 Fax: (727) 412-8299
Email: Training@AdvancedMotorTech.com
Mail: 4951 71st Ave. North, Pinellas Park, FL 33781

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