ADVANCED MOTORTECH LLC
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Practical design concepts you can't get from books or software training

Updated! (again!)

Permanent Magnet AC Machine Design

-Taking Theory to Practice

Includes BLDC, IPM and SMPM motors and generators

Join Us in Los Angeles, CA!

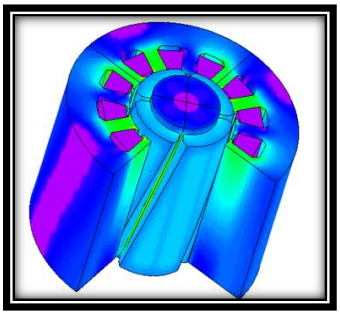
July 23rd - 24th - 25th, 2019 (Tues-Wed-Thurs)

At the Sheraton Gateway Los Angeles (next to LAX)

Early Registration Discount!

Learn Design Methods of PMAC Motors and Generators: SMPM, BLDC, IPM, and PM Generators by applying practical experience, academic theory, material characteristics & manufacturing practices and costs:

- ☑ **Permanent Magnet AC Machine Design Methods**
- ☑ **Practical Magnetic Analysis Techniques for Motors**
- ☑ **Selecting Materials, Poles, Slots, Turns, Shapes**
- ☑ **Putting Magnets & Coils to Work, Concentrated Coils**
- ☑ **Performance & Loss Calculations That Work**
- ☑ **Realistic Practice & Expectation; In-Class Design**
- ☑ **How to Calculate & Test for Parameters & Performance**



Objectives & Benefits:

Get the "How-to" for state-of-the-art, application-oriented design of sinusoidal Surface Mounted PM (SMPM) machines, trapezoidal Brushless DC (BLDC) motors, Interior Permanent Magnet (IPM) motors & PM generators. Learn solid foundations of PMAC machine design techniques based on academic theory and years of practical experience, taking manufacturing and costs into account.

You will learn about the latest PMAC motor design trends, including:

- Rare Earth Magnets Versus Low Cost Ferrite magnets
- New Analysis Techniques, Computer-Aided Engineering, Quick Approximations & Scaling Size
- Trade-offs for Achieving Efficiency, Power Density, Torque-Per-Ampere, Constant Power Speed Range
- Design for Flexible Manufacturing, Low Cost, and New Manufacturing Methods

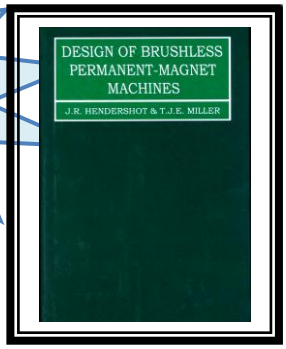
Material in this course is engineering you can't find in a book, & you can't get from software training! Presentations include specification requirements, design steps, balancing cost and performance, good rules of thumb, analysis approaches & test methods. Applications include industrial, hybrid electric drives, traction, wind turbine generators, home appliances, and aerospace.

The updated material in this course is a combination of the latest machine design concepts & computer techniques, with a heavy dose of experience. You will also understand the major similarities & differences of PMAC machines, compared to induction machines, wound-field synchronous machines, brushed dc motors, reluctance motors.

Those who will benefit:

- **Motor & Generator Design Engineers**
- **Drive & Control Engineers**
- **Application Engineers, for Industrial, EV, HEV, UAV, Wind Energy, High Efficiency, Aerospace**
- **Suppliers to Motor Manufacturers**
- **Engineering & R&D Managers**
- **Others Who Specify, Design, or Manufacture SMPM, BLDC or IPM Machines**
- **Electric Machine Professors & Graduate Students**

Includes 882 pg Book!
Design of Brushless Permanent Magnet Machines
by Hendershot & Miller



You should know electric motor and generator principles, operation & construction such as an undergraduate engineering course in electric machines & drives. Understanding of basic magnetic circuits is needed, but advanced motor theory & control is not essential.

Course Schedule

Day 1:

7:45-8:15 Registration

8:15 Session Begins

Fundamentals of PMAC Machines
- ☑ PMAC: BLDC vs. IPM vs. SMPM
- ☑ PM Rotor Configurations, & Why
- ☑ Torque Production in PMAC Machines
- ☑ Equivalent Circuit of PMAC, & Options
- ☑ Predict Performance, Sine vs BLDC Model
- ☑ PM Machine Design Steps, Using CAE

Control of PMAC Motors
- ☑ Constant Torque Control, Base Speed
- ☑ Speed & Torque Limits
- ☑ Drives, 6-step, PWM, Vector Control
- ☑ Traction: Field-Weakening & Peak Torque
- ☑ Control Issues Impacting Machine Design
- ☑ Machine Issues Impacting Control Design
- ☑ Current & Position Sensing, Sensorless

PM Material
- ☑ Permanent Magnet BH Loops
- ☑ PM Parameters, Understanding the Data
- ☑ PM Material Options, Trade-offs
- ☑ Demagnetization Effects
- ☑ Temperature, Aging
- ☑ Change Rare Earth to Ferrite, Costs

Steel Core Material
- ☑ Core Steel for PMAC, Key Cost Issues
- ☑ Understanding Mfr. Data for PM Fields
- ☑ Coatings, Punching & Heat Treatment
- ☑ Segmented & Hinged Laminations, CCW
- ☑ Soft Magnetic Composites for PMAC?
- ☑ Sources of Good Data

Magnetic Circuit Analysis
- ☑ Magnetic Circuits & Analysis with PMAC
- ☑ Airgap Flux, EMF; Sine or Square?
- ☑ Slot Leakage, Saturation, Inductances
- ☑ Reluctance Torque & dq Model
- ☑ Intro to Motor Design Software & FEA
- ☑ PMAC Machine Performance Calculation

SMPM, BLDC and IPM Rotor Design
- ☑ Construction, Principles
- ☑ Physics of Rotor Magnetization
- ☑ Effect of Changing Number of Poles
- ☑ Magnet Shape, Choices, Trade-offs
- ☑ Barriers: Number, Shape, Options
- ☑ Base design to use for Benchmark
- ☑ Some New Variations, Practical Tips

16:45 Session Ends

Day 2:

8:15 Session Begins

Practical Windings for PMAC
- ☑ Coils, Phases, Slots, Pole Shape
- ☑ Series, Parallel Circuits, Wye vs. Delta
- ☑ Winding Pattern Choices, Effect on Cost
- ☑ Winding MMF & Harmonics
- ☑ Distributed vs. Concentrated Windings
- ☑ Single/Double Layer, Fractional Slot

Sizing & Scaling Laws
- ☑ Key Sizing Factors, Figures of Merit
- ☑ Current Density & Electric Loading
- ☑ Flux Density, MMF Drop
- ☑ Ke, Kt, Maxwell Shear Stress for PMAC
- ☑ Scaling: Varying Diameter, Axial Length

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

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

How to Design an IPM Motor
- ☑ IPM Machine Topologies
- ☑ Practical Motor Sizing & Key Ratios
- ☑ Equivalent Circuit Parameter Analysis
- ☑ Designing Barriers, Saturated Bridges
- ☑ Reducing Cogging Torque
- ☑ Design Example: Rare Earth vs. Ferrite

Modeling & Simulation
- ☑ Analytic vs. Finite-Element Methods
- ☑ Motor Design Software & Books
- ☑ FEA Software, Proper Role
- ☑ Linked CAE Simulation
- ☑ Design Optimization Methods

16:45 Session Ends

Day 3:

8:15 Session Begins

Thermal & Mechanical Design
- ☑ Mechanical Design, Fits, Tolerances for PM
- ☑ Losses, Heat, Cooling, Temperature
- ☑ Cooling Tradeoffs – Self-Cool, Fan, Liquid
- ☑ Forces & Noise; Tips to Lower Noise
- ☑ Transients During Peak Torque
- ☑ Thermal, Mechanical Structural Data
- ☑ Magnet Retention--Banding, Core Bridges
- ☑ Practical Expectation, Limits

Testing: Losses & Model Parameters
- ☑ Electrical: R, L, Volts, Amps, PF
- ☑ Mechanical: Torque, RPM, Heat
- ☑ Back-EMF, Open-Circuit Losses
- ☑ d,q Inductances, Design for Inductance
- ☑ Core Loss, Bearings, Fan
- ☑ Cogging Torque & Short-Circuit Losses
- ☑ Inverter Operation Testing

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

Design for Traction
- ☑ EV & HEV Applications
- ☑ Toyota Prius IPM Motor
- ☑ Honda Insight SMPM Motor
- ☑ Other HEV Examples
- ☑ HEV Example Design

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

The real stuff for real engineering!

15:00 Closing & Adjourn

We will keep you nourished!
Daily schedule includes:
Mid-morning break (10:00)
Lunch (12:00-13:00)
Afternoon break (15:00)

Day 2 – PM Special Extra
FEA Motor Design Demo
+ Reception

**Course content is subject to change. All listed or issued material may not be covered contingent on time used for Questions & Answers.*

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 and instructor in electric machine design and has over 50 years of hands-on experience with electric machine applications and design engineering, from concept to performance to repair and failure analysis. He has been involved in the research, development, prototyping, testing and/or training of very high performance machines from 5 Watts to 1150 MW, with speeds ranging from angle positioning torque-motors to 120,000 rpm machines. Recent work includes design of extremely high efficiency PM and induction motors, very high power density machines, permanent magnet alternators, brushless d.c. traction motors, brush d.c. motors, universal ac/dc motors, and low cost manufacturing.

Tuition Fees Include:

- ☑ Extensive Training Manual (Full Color)
- ☑ Hardcover Book, "Design of Brushless Permanent Magnet Machines" by Hendershot & Miller (2010, "the Green Book")
- ☑ Mid-Morning & Afternoon Breaks w/ Refreshments
- ☑ Lunch Each Day
- ☑ Reception with hors d'oeuvres and refreshments (2nd day, PM)
- ☑ Signed Certificate of Course Completion

Host Hotel Location:

Sheraton Gateway Los Angeles Hotel
6101 W Century Boulevard
Los Angeles CA 90045 USA
Phone: (310) 642-1111, or toll free (888) 855-7741

Accommodations:

A block of rooms at an excellent rate has been reserved at the beautiful Sheraton Gateway Los Angeles Hotel, next to LAX airport. Reservations **should be made before July 2, 2019**. Please identify yourself as a participant of the Advanced MotorTech **PMAC Motor Design Course** to reserve a room of our block.

Enrollment:

☐ Yes! Please enroll me in **Course No. PMAC-1907**

PMAC Machine Design, July 23-25, 2019
Early Registration Fee: $1775.00 (USD only); Payment must be received by July 2, 2019
Regular Fee: $1875.00 (USD only)

Payment: (*Deadline: Payment must be received prior to start of course)

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How did you hear about us?

☐ Email/Constant Contact ☐ Electrical Apparatus Magazine
☐ Social Media (Facebook/Twitter/LinkedIn) ☐ Other (Please Specify) _____

* Cancellations received earlier than 14 days before the course are subject to a 15% late cancellation fee. Cancellations made within 7- 13 days before the course starts are subject to a 50% cancellation fee. Cancellations made 6 or less days before the course starts are subject to the full fee.

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