Join Us in Dallas, Texas!
November 18th, 19th, & 20th
At the Hilton Garden Inn – DFW Airport South

**UPDATED MATERIAL** – Learn BLDC & IPM Motor & Generator Design by applying practical experience, PM characteristics, academic theory & manufacturing practices:

- BLDC & IPM Machine Design Methods
  - Practical Magnetic Analysis Techniques
  - Putting Magnets & Windings to Work
  - Selecting Materials, Poles, Slots, Turns
  - Performance & Loss Calculations That Work
  - Realistic Practice & Expectation
  - How to Test for Parameters & Performance

**Objectives & Benefits:**

Get the “How-to” for state-of-the-art, application-oriented design of BLDC & IPM motors & PM generators. Learn solid foundations of Brushless DC & IPM machine design techniques based on academic theory and years of practical experience, taking manufacturing limits and costs into account.

You will learn about the latest BLDC/IPM motor design trends, including:

- Rare Earth Magnets Versus Low Cost Ferrite magnets
- New Analysis Techniques, Computer-Aided Engineering, Approximations
- Trade-offs for Achieving Efficiency, Power Density, Torque-Per-Ampere
- Design for Flexible Manufacturing 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 hybrid electric drives, all-electric traction, wind turbine generators, home appliances, aerospace, industrial applications.

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 BLDC/IPM machines, compared to induction machines & wound-field synchronous machines.

**Those who will benefit:**

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

You should have some background in electric machine principles, operation & construction such as the equivalent of a B.S. degree in engineering. Understanding of basic magnetic circuits is needed, but advanced motor theory & control techniques are not essential.
Day 1: Tues, November 18
7:30-8:00 Registration
8:15 Session Begins

Fundamentals of PMAC Machines
- BLDC vs. IPM vs. SMPM
- PM Motor 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 BLDC/IPM 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 BLDC/IPM, Key Cost Issues
- Understanding Mfr. Data for PM Fields
- Coatings, Punching & Heat Treatment
- Segmented & Hinged Laminations, CCW
- Soft Magnetic Composites for BLDC, IPM?
- 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

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

Day 2: Wed, November 19
8:15 Session Begins

Practical Windings for BLDC & IPM
- 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 Relationships, Figures of Merit
- Current Density & Electric Loading
- Flux Density, MMF Drop
- Ke, Ki, Maxwell Shear Stress for PMAC
- Scaling: Varying Diameter, Axial Length

Loss Calculations & Segregation
- BLDC & IPM 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

Day 3: Thurs, November 20
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 Renetration--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 PMAC Motor
- Honda Insight PMAC Motor
- Other HEV Examples
- HEV Example Design

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

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, very high power density machines, and low cost manufacturing.

We will keep you nourished!
Daily schedule includes:
Mid-morning break (10:00)
Lunch (12:00-13:15)
Afternoon break (15:30)

16:45 Session Ends

16:45 Session Ends

15:00 Closing & Adjourn

*Course content is subject to change. All issued material may not be covered contingent on time used for Questions & Answers.
Tuition Fees Include:
- Extensive Training Manual (Full Color)
- Hard Cover Book “Design of Rotating Electrical Machines” by Juha Pyrthonen
- Mid-Morning & Afternoon Break w/ Refreshments Each Day
- Lunch Each Day
- Signed Certificate of Course Completion

Host Hotel Location:
Hilton Garden Inn
DFW Airport South
2001 Valley View Lane
Irving, Texas 75061
(972) 313-2800
(Free Airport Shuttle)

Accommodations:
A block of rooms has been reserved at the beautiful Hilton Garden Inn, DFW Airport South in Irving, Texas. Reservations should be made before November 4, 2014. Identify yourself as a participant of the Advanced MotorTech group to reserve a room at the reduced rate. *Additional directions & information will be sent with your enrollment confirmation.

Enrollment:
- Yes! Please enroll me in Course No. BLDC-IPM-1114
  BLDC/IPM Machine Design, November 18-20, 2014
  Fee: $1725.00 (USD only)

Payment: (Deadline: *must be received before November 18th)
- MasterCard
- VISA
- AMEX
  Cardholder Name ___________________________________________
  Card No. ___________________________________________________
  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.
  Name ____________________________________________________
  Title ___________________________________________________
  Company __________________________________________________
  Address ___________________________________________________
  City ___________________ State _______ Zip ____________
  Phone (____) __________ Email _____________________________

* Cancellations received later than 14 days before the course are subject to a 15% late cancellation fee. Cancellations made 13 – 7 days before the course starts are subject to a 50% cancellation fee. Cancellations made after the course starts are subject to the full fee.

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