ADVANCED MOTORTECH LLC
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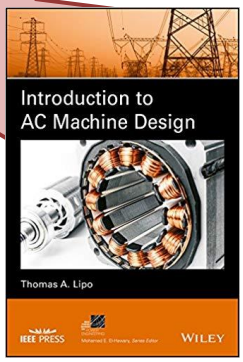
Includes Book!
Introduction to AC Machine Design
By Thomas A. Lipo



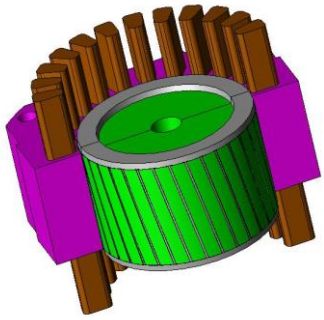
INDUCTION MOTOR DESIGN

--TAKING THEORY TO PRACTICE

Join Us LIVE, On-Line: October 27-28-29, 2020

Learn practical Induction Machine Design by applying motor characteristics, academic theory and manufacturing practices:

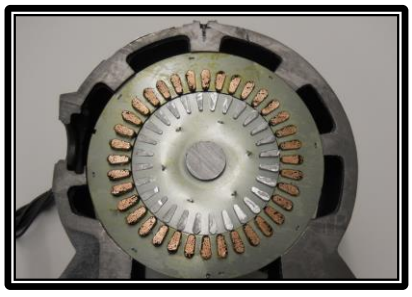
- **Induction Machine Design Methods, Unique Issues to IM's.**
- **Understand the Difference Between Analysis and Design**
- **Practical Non-Linear Magnetic Analysis Techniques**
- **Putting Flux & Windings to Work, Limitations**
- **Performance & Loss Calculations**
- **Realistic Practice & Expectations, Effect of Manufacturing**
- **How to Test for Parameters & Performance**



Objectives and Benefits:

This course provides practical, application-oriented design engineering methods for Induction Machines. Key motor principles are used to understand and choose options for Induction Machine design. Academic theory and practical experience is transformed to practical results with calculation 'How-to', considering manufacturing constraints. Emphasis is on quick decisions, performance differences, and new trends in induction motors. Included are new analysis techniques and new design options to achieve low cost, high efficiency, high power density, and maximum torque per amp. Similarities and differences of induction machines, compared to the latest PM machines, reluctance machines, and wound-field synchronous machines, is a common theme.

We specialize in engineering material that you can't find in a book, and you can't get from software training! It is presented using our acclaimed combination of motor design concepts and computer technology, with a heavy dose of many years of experience. Specifications, design steps, analysis approaches, useful rules of thumb and test methods are discussed for motors and drives for applications such as industrial systems, commercial HVAC, hybrid and electric vehicles, wind turbine generators, and home appliances. Most of the course focuses on three-phase squirrel-cage machines, both NEMA and non-NEMA types.



Those who will benefit:

- **Induction Motor & Generator Design Engineers**
- **Motor Engineering and R&D Managers, Professors & Grad Students**
- **Suppliers to Motor Manufacturers**
- **Control Engineers, Drive Systems Engineers**
- **Application Engineers, Sales Engineers**
- **Those Who Specify, Manufacture, Use or Service Induction Machines**

You should have some background in electric machine 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 (*All times are Eastern Time Zone, USA*) ***

Day 1:

9:45-10:10 On-Line Entry; AV check
10:15 Sessions Begin

1. Fundamentals of Induction Machines
- ☑ Comparison of Motor Types
- ☑ Rotor Configurations, & Why
- ☑ Create Torque in Induction Machines
- ☑ Equivalent Circuit of IM, DQ Model
- ☑ IM Models to Predict Performance
- ☑ IM Machine Design Steps, Using CAE

2. Control of Induction Motors
- ☑ Speed, Current, Torque, Loss Control
- ☑ VFD, 6-step, PWM, SVM, Vector Control
- ☑ Control for Torque/Amp or Efficiency
- ☑ Traction: Field Weakening, Peak Torque
- ☑ Peak Torque vs. High Speed, New Concepts
- ☑ Sensors for Control, Limits, Sensorless

3. Steel Core for Induction Machine
- ☑ Electrical Steels for IM, Making Lams
- ☑ Understanding Loss Data for Small Gap
- ☑ Coatings, Punching & Heat Treatment
- ☑ Segmented, Hinged Laminations for IM?
- ☑ Soft Magnetic Composites for IM?
- ☑ Sources of Good Data

4. Magnetic Analysis for IMs
- ☑ Non-linear Magnetic Circuits, MMF, Gap
- ☑ Air gap Flux, EMF Waveform
- ☑ Slot Leakage, Saturation, Inductances
- ☑ Intro to Motor Design Software & FEA
- ☑ Rules of Thumb, Good Practices

5. Squirrel Cage IM Rotor Design
- ☑ Materials, Construction, Principles
- ☑ Physics of Rotor Magnetization, Poles
- ☑ Rotor/Stator Slot Choice, Trade-offs
- ☑ Rotor Bar-shape, Options, Trade-offs
- ☑ Bar Shape for Peak Torque (Traction)
- ☑ Copper vs. Aluminum Cage

18:00 Session Ends

Please Note:
Daily schedule includes:
- *Three AM & Three PM sessions, approximately 1 hour, each*
- *10 minute breaks between sessions*
- *30 minute Lunch Break*

Day 2:

9:45-10:10 On-Line Entry; AV check
10:15 Sessions Begin

6. Winding Design Choices for IMs
- ☑ Coils, Poles, Slots, Phases
- ☑ Series, Parallel Circuits, Wye vs. Delta
- ☑ Lap vs. Concentric Winding
- ☑ Consequent Poles, Fractional Slots / Pole
- ☑ Design with Concentrated Coils
- ☑ Traction & Large Machine Coils
- ☑ Some Practical Info & Tricks of the Trade

7. Sizing & Scaling Laws
- ☑ Key Sizing Factors, Figures of Merit
- ☑ Current and Flux Density, MMF Drop
- ☑ Torque/Ampere, Maxwell Shear Stress
- ☑ Scaling: Vary Diameter, Vary Axial Length

8. Loss Calculations & Segregation
- ☑ Loss Components, Thermal Balance
- ☑ Causes, Core Loss, Prediction
- ☑ How to Determine Loss Coefficients
- ☑ Conductor & Eddy Current Losses
- ☑ Loss Segregation, Efficiency Map

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

10. Harmonics
- ☑ Winding MMF – Analysis, Models
- ☑ Winding Harmonics – Causes & Fixes
- ☑ Slot Harmonics, Minimizing the Effect
- ☑ Current Harmonics, Inverter Effect
- ☑ Effect of Rotor Design

11. Modeling & Simulation
- ☑ Analytic vs. Finite-Element Analysis
- ☑ Motor Design Software & Books
- ☑ FEA Software, Practical Perspective
- ☑ Linked CAE Simulation
- ☑ Ideas for Software & Hardware

18:00 Session Ends

Day 2 – PM
Special Extra
FEA Motor Design Demo

Day 3:

9:45-10:10 On-Line Entry; AV check
10:15 Sessions Begin

12. Thermal & Mechanical Design
- ☑ Mechanical Design, Fits, Tolerances, gap
- ☑ Losses, Heat, Cooling, Temperature, Rotor
- ☑ Cooling Tradeoffs – Self-Cool, Fan, Liquid
- ☑ Forces & Noise; Tips to Lower Noise
- ☑ Transients During Peak Torque
- ☑ Thermal, Mechanical Structural Data
- ☑ Practical Expectation, Limits

13. Testing: Losses & Model Parameters
- ☑ Electrical: R, L, Volts, Amps, PF
- ☑ Mechanical: Torque, RPM, Heat
- ☑ Locked Rotor, No-Load Tests, Equivalent Circuit Parameters
- ☑ Speed - Torque Curve
- ☑ Dynamometer Recommendations
- ☑ Test for Current Ripple, Ld, Lq
- ☑ Loss Tests, Efficiency Calculation

14. Efficiency for Industrial/HVAC
- ☑ Principles & Myths of Energy Savings
- ☑ Understanding Application Options
- ☑ Conversion System Configurations
- ☑ Design Example,: Copper Rotor

15. Power Density for Traction
- ☑ EV & HEV Applications
- ☑ Toyota Prius PM Motor
- ☑ Tesla Induction Motor
- ☑ Rail Traction Motor
- ☑ Design Example: Max Torque/AMP

16. New Trends & Technologies – What, Why, When
- ☑ Cast Copper Rotors
- ☑ Axial Flux IM Machines
- ☑ High Speed IM Machines
- ☑ New Materials
- ☑ Modular & Automated Mfg.
- ☑ PM Supply Uncertainty, Effect on IM

16:00 Closing & Adjourn

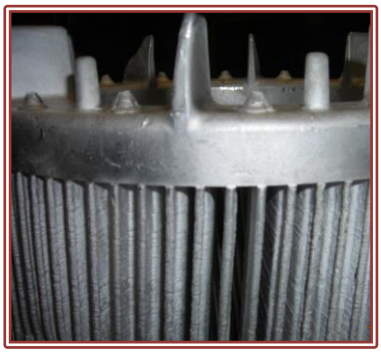
- *Session breaks will not be coincident with topic breaks*
- *Course content and schedule is subject to change.*
- *All listed material may not be covered in the course.*

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 training of very high performance machines from 5 Watts to 50 MW, with speeds ranging from angle positioning torque-motors to 90,000 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, and design for low cost

Registration Fee Includes:

- ☑ Extensive 400+ page Training Manual (Full Color), materials shipped about 2-3 weeks before the course starts
- ☑ Access to the Live HD Broadcast, with two-way interaction capability
- ☑ Hard Cover Book "**Introduction to AC Machine Design**" by Thomas A. Lipo
- ☑ Signed Certificate of Course Completion



Broadcast Information:

Hours: Live 9:45am to 18:15pm, Eastern Time Zone USA
Type: Classroom Setting; Live Instructor at Large-View Screen *(Not voice-over-slides)*
(Just like a live classroom, session recordings will not be available for later viewing)
Platform: Custom 1080p WEBEX; Entry Credentials with Password Required

To Attend This Course:

- **We will send a WEBEX Link and Entry credentials; please confirm receipt**
- **Recommended connection & bandwidth: Ethernet, 50MBs download** (5 MBs minimum); Wireless quality is not assured
- **Recommended viewing: 15 inch or larger monitor;** (1280 × 800 minimum**;** viewing ability, streaming quality, and compatibility with mobile devices, smaller screens and lower resolution, cannot be assured**)**
- **For now, we can accept only attendees located in: North America, UK/Europe, Japan, Korea, Australia, New Zealand** *(Exceptions are not likely, but possible, on a case by-case only, at our sole discretion).*

*Enrollment: ☐ Yes! Please enroll me in the 3-day course: Course ID: IMD–2010

Induction Motor Design, October 27-28-29, 2020

Fee: $2125.00 for USA shipping address
$2325.00 for all International shipping addresses

Early Registration Fee†: $1975.00 for USA shipping address
$2175.00 for International shipping addresses

(We reserve the right to not enroll anyone, for any reason, at our sole discretion.)

Early Registration Discount!
Payment by September 15, 2020

PAYMENT (USD$ only): *(Payment Deadline: Payment must be received 2 weeks before the course; Early Registration payment must be received by September 15, 2020, no exceptions; †Invoiced and †PO payments not eligible for early discount)*

☐ MasterCard ☐ VISA ☐ AMEX

- Cardholder Name _____
- Card No. _____
- Exp ____/____ Billing Zip_____ Security Code: _____

☐ Check (payable **to Advanced MotorTech, LLC**); ☐ †Invoice me; ☐ †Purchase Order; *Subject to approved credit.*

Name _____Title _____

Company _____

Shipping Address _____

City _____ State _____Zip _____

Phone ( ) _____ Email_____

Our Specialty: Theory Reduced to Practical How-to

*By registering for our course, you agree:

(1) To provide us a verifiable address with this enrollment for trackable shipment of training materials
Sorry, a PO Box is not acceptable for this. Delivery without signature required will be used
(2) To not allow any unpaid individuals to view any of the training content with intent to learn from our broadcast
(3) To screen-capture only handwritten white-board/flipchart writing, and visual samples shown.
(4) With exception of (3) screen-captures, to not allow any recording of the broadcast without permission in writing and prior payment of a recording fee. All training material and broadcast content is copyright protected.
(5) To not hold us responsible for poor connection, poor audio, or poor visual quality due to issues with your hardware, software, ISP, or facility. (*If in doubt, please contact us in advance for an Audio/Visual check.*)
(6) Cancellations made more than 14 days before the course starts AND BEFORE shipment of the training materials, are subject to a 15% cancellation fee.
Cancellations made 14 days or less before the course starts, OR AFTER shipment of training materials are subject to a 50% cancellation fee.

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