ADVANCED MOTORTECH LLC
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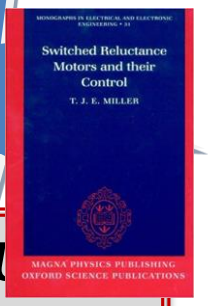
Includes Book!



August 21st, 22nd, & 23rd 2019 in Columbus, Ohio U

Design of Reluctance Machines

Switched Reluctance (SwR) Motors & Generators and Synchronous Reluctance (SynR) Motors & Generators

Much New Material!

Learn practical Reluctance Machine Design and Drive Requirements by applying key motor principles, academic theory and practical manufacturing experience. Presented by experienced experts in the field.

Early Registration Discount!

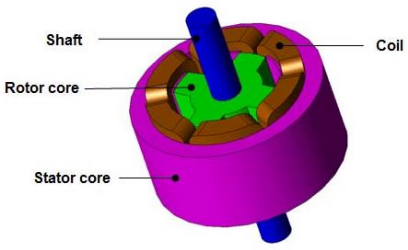
- *Reluctance Motor Operation Principles*
- *SwR & SynR Drive Topologies & Operation*
- *Geometry and Control Details for Low Torque Ripple, Low Noise*
- *Reluctance Motor Design for Traction and High Speed*
- *Reluctance Motor Design Tools, Practical Guidelines, Design Examples*
- *Realistic Possibilities and Limitations for Motor Design*

Objectives and Benefits:

The principles of the Reluctance Machines, both Switched Reluctance and Synchronous Reluctance topologies are simple, but their design is difficult because of non-linear effects and sensitivity to key dimensions. They are usually designed for specific applications, and produced using unique manufacturing methods, which make the design decisions even more difficult.

This revised course will use established motor principles and electromagnetic fundamentals to increase your understanding of machine design in the context of Switched Reluctance and Synchronous Reluctance machines. Academic theory will be reduced to practical results with examples and calculation 'how-to', taking realistic manufacturing constraints, especially magnetic saturation, into account. Special emphasis will be on design of application-specific motors, drive requirements, practical design for low-cost manufacturing, and how to achieve specifications such as torque, power density, speed, low noise, etc. The similarities and differences of induction machines, BLDC machines and IPM machines are in almost all topics. Most applications will be motors, with explanation of extending the ideas for generator mode of operation.

The primary goal of this course will be to use a foundation of machine and magnetic concepts to learn Switched Reluctance and Synchronous Reluctance machine design to achieve performance specifications based on the electrical, magnetic, mechanical, and thermal interactions



Those who will benefit:

- **Motor design engineers, Traction drive engineers**
- **Application engineers**
- **Motor manufacturers, Suppliers to motor manufacturers**
- **Control engineers, Drives engineers, System engineers**
- **Engineering managers, Inventors**
- **Others who design, manufacture, test, use or service Reluctance machines, including technical students**

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

Course Schedule

SynR=Synchronous Reluctance SwR=Switched Reluctance;

Day 1:

08:00-08:30 Registration
08:30 Session Begins

Overview of Reluctance Motors & Drives (LX)
☑ What is a reluctance machine?
☑ Feature comparison: SwR & SynR
☑ SynR is an AC synchronous machine
☑ SwR is a pulsed DC machine (= AC?)
☑ Where they fit in the motor family
☑ Drive circuits & control basics

Magnetic Analysis (LX)
☑ Magnetic circuits & analysis
☑ Magnetization & loss curves: mfr data
☑ Magnetization & loss curves: testing
☑ Analysis needs for SwR & SynR
☑ Analytic design vs. Finite-Elements
☑ Finite-elements: Overview, 2D vs. 3D
☑ Co-simulation with Simulink

Materials & Mfg. (KK)
☑ Magnetic material data
☑ Effect of magnet pricing & availability
☑ Losses, heat, efficiency, loss minimization
☑ High speed issues, limits
☑ Reference Data
☑ Modular & Automated Mfg.

Sizing & Scaling Principles (KK)
☑ Figures of merit, usual values
☑ Principles of scaling laws
☑ General scale factors, sensitivity
☑ Practical limits to scaling

SynR Fundamentals (LX)
☑ Machine configurations; brief history
☑ The phasor diagram in dq axes
☑ The saliency ratio: how big should it be and how do we maximize it?
☑ Current Waveform
☑ Torque vs. speed and position
☑ Volt-ampere requirement; power-factor
☑ Generating mode

16:30 Session Ends

Daily schedule includes
- **Mid-morning break (10:30-10:45)**
- **Lunch (12:00-13:00)**
- **Afternoon break (15:00-15:15)**

Day 2:

08:30 Session Begins

SynR Motor Design (LX)
☑ Design process; key trade-offs
☑ No. of poles, slots, and phases
☑ Rotor geometry: flux-barriers, gap
☑ Key dimensions and proportions
☑ Mechanical limits and manufacturing
☑ Designing for High efficiency

SynR — Manual sizing (KK)
☑ Overall sizing; air-gap shear stress
☑ Rough proportioning rules
☑ Calculating the turns and wire size

☑ ***In-Class Design Example:***
High efficiency integral-kW—better than induction motor?

SynR — Detailed design (KK)
☑ Practical windings, slot fill
☑ Practical multi-barrier rotor design
☑ Other configurations, geometries
☑ Frame, noise, stress, dynamics

SynR — Drive and Control(LX)
☑ Control strategy, Space vectors
☑ Controlling the current waveform
☑ Torque vs. speed
☑ Sensitivity to measurement errors

SwR Fundamentals (LX)
☑ Machine configurations; brief history
☑ The energy conversion diagram
☑ Static magnetization curves
☑ Current waveform
☑ Torque vs. speed and position
☑ Energy flow; volt-ampere requirement
☑ Generating mode

SwR Motor Design (KK)
☑ Design process; key trade-offs
☑ Choosing poles & phases
☑ Rotor geometry: tooth shape, gap
☑ Key dimensions and proportions
☑ Mechanical limits and design for manufacturing

16:30 Session Ends

Day 2, 17:30
Special Extra:
FEA Demonstration,
Including Refreshments

Day 3:

08:30 Session Begins

SwR — Manual sizing (KK)x
☑ Overall sizing; air gap shear stress
☑ Drive voltage and current
☑ Rough proportioning rules

SwR — Detailed design (KK)
☑ Practical windings, slot fill
☑ Practical stator & rotor cores
☑ Frame, noise, stress, dynamics
☑ ***In-Class Design Example:***
High speed Fractional kW

SwR — Drive and Control (LX)
☑ Torque vs. speed and position
☑ Controlling the current waveform
☑ Over-running and generating
☑ Sensitivity to measurement errors
☑ Testing for performance

SwR — Detailed design (LX)
☑ ***In-Class Design Example:***
Traction Motor—better than HEV IPM?

Design improvement(KK)
☑ How to get more torque
☑ How to get low torque ripple,
☑ How to get low noise
☑ How to get higher efficiency

Thermal & Structural (KK)
☑ Thermal & structural modeling
☑ Material data
☑ Losses, heat, temperature
☑ Forces & noise
☑ Typical parameter values
☑ Practical expectation, limits

☑ 15:00 Adjourn

Related topics (as time allows)
- PM-assisted SynR--Might we want to add magnets?
- SwR machines with magnets
- Flux-switching machines
- Axial-flux reluctance machines
- Linear reluctance machines
- Sensor requirements (current, position)
- More on Torque vs. speed
- More on Control strategy
- Cross-saturation between phases

***Note: Course content is subject to change. Entire agenda may not be covered, depending on time used for questions and extended discussion.**

YOUR INSTRUCTORS:

Dr. Keith W. Klontz is President and Founder of Advanced MotorTech LLC, a computer-aided engineering (CAE) services company with emphasis on advanced electric machine and magnetic component design and analysis. He holds BS & MS degrees in Electrical Engineering from the University of Illinois, and a PhD in Electrical Engineering from the University of Wisconsin. Dr. Klontz is a world-recognized expert in electric machine design and has over 40 years hands-on experience with electric machine design engineering, from concept to performance to failure analysis. He has been involved in the research, development, prototype manufacture and testing of very high performance machines from 10 Watts to 8 MW. He has also developed and presented motor training classes to well over 1000 motor engineers and technicians. Recent work includes implementing CAE tools and developing design techniques for the design of alternators and motors for high efficiency, high power density and cost effectiveness.

Dr. Longya Xu is a Professor at The Ohio State University and Director of the Center for High Performance Power Electronics. He received his M.S. and Ph.D. degrees in Electrical Engineering from the University of Wisconsin. Dr. Xu is a well-recognized expert in Switched Reluctance and Synchronous Reluctance machines, and the power electronics used to control them. His experience and research interests include design and control of novel electric machines, advanced concepts in power electronics, and digital technology for electrified transportation and renewable energy systems. Dr. Xu is an IEEE Fellow, and he has received several prestigious IEEE awards, including the 2014 Outstanding Achievement Award and the 2018 IEEE Nikola Tesla Award for outstanding contributions to the generation and utilization of electric power. He is author or co-author of over 200 technical papers, and has served as the chairperson of Electric Machine Committee of IEEE/IAS, and as an Associate Editor of IEEE Transactions on Power Electronics over the past two decades.

General Information

Tuition Fees Includes:

- ☑ Extensive Training Manual (Full Color)
- ☑ Book "Switched Reluctance Motors and Their Controls" by TJE Miller
- ☑ Mid-Morning Break & Afternoon Break, Each Day
- ☑ Lunch, Each Day
- ☑ Signed Certificate of Course Completion

Host Hotel:

Columbus Airport Marriott – Phone: 614-383-3687
1375 North Cassady Ave.
Columbus, Ohio 43219 USA

Accommodations:

A block of rooms has been reserved at the beautiful ***Columbus Airport Marriott*** in Columbus, Ohio. Reservations should be made **before July 31, 2019** to receive the reduced rate. Identify yourself as a participant of the **Advanced MotorTech** group.

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Enrollment:

☐ Yes! Please enroll me in **Course No. SRM-1908 'Design of Reluctance Machines', August 21-23, 2019**
Fee: $1875 USD*
Early Registration Fee: $1775.00 (USD only); Payment received by July 20, 2019
(We reserve the right to not enroll anyone considered to be a competitor, at our sole discretion.)

Payment: ☐MasterCard ☐Visa ☐Amex **(*Deadline: payment must be received before start of course)**

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

☐ Check enclosed (payable to Advanced MotorTech, LLC)*
☐ Bill my company* ☐ Purchase Order*

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Title _____

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Address _____

City _____ State _____Zip _____

Phone ( ) _____ Email_____

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* 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 less than 7 days before the course starts are subject to the full fee, but all course materials will be shipped to you.