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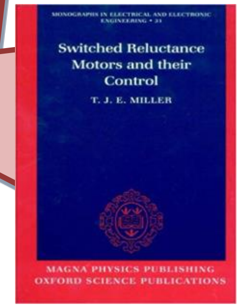
Includes Book by TJE Millier



Reluctance Motor Design

-Taking Theory to Practice

Switched Reluctance (SwR) Machines and Synchronous Reluctance (SynR) Machines

Join Us LIVE, On-Line: November 16-17-18, 2020

Learn practical Reluctance Machine Design and Drive Requirements by applying key motor principles, academic theory and practical manufacturing experience. Both Switched Reluctance (SwR) Machines and Synchronous Reluctance (SynRel) Machines are discussed in detail. Presented by experienced experts in the field.

- *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:

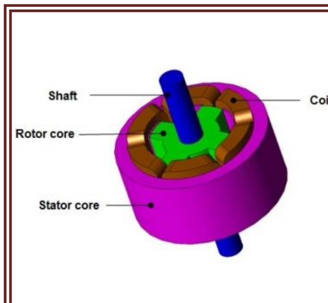
The principles of the Reluctance Machines, both Switched Reluctance and Synchronous Reluctance topologies are simple, but their design is difficult because of non-linear effects and sensitivity to key dimensions. They are usually designed for specific applications, and produced using unique manufacturing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



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 (*All times are Eastern Time Zone, USA*)*

SynR=Synchronous Reluctance SwR=Switched Reluctance;

Day 1:

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

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

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*
- *Session breaks will not be coincident with topic breaks*

Day 2:

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

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

18:00 Session Ends

Day 2 PM
Special Extra:
FEA Motor Design Demonstration

Day 3:

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

SwR — Manual sizing (KK)

☑ 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

16:00 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.**

YOUR INSTRUCTORS:

Dr. Keith W. Klontz is President of Advanced MotorTech LLC, a computer-aided engineering (CAE) services company with emphasis on advanced electric machine 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 up to 8 MW.

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, and he is author or co-author of over 200 technical papers.

Enrollment Fees Includes:

- ☑ Extensive Training Manual (Full Color)
- ☑ Live HD Broadcast, with two-way interaction capability
- ☑ Book "Switched Reluctance Motors and Their Controls" by TJE Miller
- ☑ Signed Certificate of Course Completion
- ☑ WEBEX Link and Entry credentials

Broadcast Information:

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

To Attend This Course:

- **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: RMD–2011

Reluctance Motor Design, November 16-17-18, 2020

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

Early Enrollment 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 Enrollment Discount!
Payment by October 1, 2020

Payment (USD$ only):

(Payment Deadline: Payment must be received 2 weeks before the course; Early Enrollment payment must be received by August 15, 2020, no exceptions; †Invoiced and †PO payments not eligible for early discount)

☐ MasterCard ☐ VISA ☐ AMEX

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

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

Name ______________________________Title ______________________________

Company ______________________________

Shipping Address ______________________________

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***By enrolling 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 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.