Fundamentals of Electric Motor Design
Course Outline

I. Magnetics

A. Maxwell's Equations
B. Ampere's Law
C. Faraday's Law
D. Gauss' Law for Magnetic Fields

II. Magnetic Circuits

A. Flux
B. Magneto Motive Force (MMF)
C. Reluctance
D. Permeance
E. Permeability
F. Inductances
G. Leakage
H. Steel Selection
I. Core Loss
J. Magnetization Curves
K. Magnet Characteristics and Selection
L. Permanent Magnet Characteristics
M. Magnet Arc Manufacture
N. Magnet Load Characteristics
O. Demagnetization

III. Electromagnetic Forces

A. Forces on Conductors
B. Electromagnetic Torque
C. Motor Action
D. Energy Approach (courtesy of Earl Richards, Ph.D.)

IV. Mechanics of Motors

A. Ball Bearings
B. ABEC Grades
C. Sleeve Bearings
D. Shafts and Shaft materials
E. Shafts and Bearings
F. Stator Cores
G. Stack In Die Cores
H. Welded Cores
I. Bonded cores
J. Cleated Cores
K. Outer Rotor BLDC or Armature Cores
L. Housings
M. Motor Assembly
N. Magnet Wire

O. Insulation
P. Stator and Coil Assemblies
Q. Windings
R. Sinusoidal Winding Distribution
S. Lap Windings and Concentric Windings
T. Wave Windings
U. Rotor Assemblies
V. Thermal Protection Electrical Spacing
I. Bonded cores

V. Selecting the Proper Motor Type

A. Motor Types
B. Principle of Induction
C. Polyphase Induction Motor
D. NEMA Design Types
E. Single Phase Induction Motors
F. Split Phase Induction Motor
G. Capacitor Start Induction Motor
H. Permanent Split Capacitor (PSC) Motor
I. Shaded Pole Motor
J. Permanent Magnet DC Motor
K. Brushless DC Motor
L. Universal (Series Wound) Motor
M. Switched Reluctance Motor (SRM)
N. Summary

VI. Performance Equations

A. PMDC Motors

1. PMDC Design Analysis Procedure
2. Predicting Air Gap Flux
3. Magnet Permeances
4. Armature Calculations
5. Armature Magnetic Paths
6. Armature Conductors and Resistance
7. Armature Inertia
8. Solving the Magnetic Circuit
9. Armature Reaction and Brush Shift
10. Commutation
11. Output Equations
12. Current Densities
13. Motor Constants

B. BLDC Design Example

1. Specification
2. Computer Simulated Results
3. Mmf Drops vs. Supplied Mmf

C. Induction Motors

1. Pitch and Distribution Factors
2. Calculation of Magnetizing Current
3. Leakage Reactance
4. Performance Calculations
5.Calculations of Starting Conditions

D. Universal (Series Wound) Motors

1. Construction
2. Armature Lamination Calculations
3. Armature Conductors
4. Armature Inertia
5. Field (Stator) Calculations
6. Field Conductors
7. Magnetic Circuit Calculations
8. Reactances
9.Commutation
10.Armature Reaction and Brush Shift
11. Output Equations

E. Switched Reluctance Design Example

1. Customer Specifications
2. Calculations
3. Verifications with FEA or BEA

Instructor: William H. Yeadon, P.E.
Yeadon Energy Systems Inc.

William H. Yeadon, P.E., Yeadon Energy Systems., Iron River, Mich., has over 40 years experience in the electric motor industry including work in design and development, production, quality assurance and engineering management. Prior to starting his consulting firm in 1993, he worked at A.O. Smith, Warner Electric and Barber-Colman Co., Motor Div.