ABDULLAH GÜL UNIVERSITY
GRADUATE SCHOOL OF ENGINEERING & SCIENCE
ELECTRICAL AND COMPUTER ENGINEERING PROGRAM
COURSE DESCRIPTION AND SYLLABUS

Course Title	Code	Semester	T+L Hours	Credit	ECTS
ADVANCED THEORY of ELECTRICAL MACHINES	ECE 555	FALL	3 + 0	3	10

Prerequisite Courses	EE 308 Electrical Machines and Drives

Type	Selective
Language	English
Coordinator	Prof. Irfan Alan
Instructor	Prof. Irfan Alan
Adjunt	None
Aim	Modeling and analysis of dc and induction machines, detailed analysis of various supply cases and control methods and usage of a programming language during the course of these analysis.
Learning Outcomes	• learn the DC motor control loop design principles • learn the derivation of various frequency based equivalent circuits of induction machine and how to use them in the steady state analysis of induction machine • learn the derivation of equivalent circuit used in the field oriented control of induction machine and how to use it in the steady state analysis of induction machine • learn the steady state analysis technique of induction machine in per-unit system • learn to determine the first response of an induction machine in transient while operating at steady state by means of an equivalent circuit used in transient analysis • learn the steady state analysis of induction machine for unbalanced supply cases • learn the steady state analysis of induction machine for non-sinusoidal supply cases
Course Content	• DC motor transient and steady state equations, • Derivation of transfer functions of DC motor, • Controller design for dc motor control, • Review of induction machine theory, • Derivation of equivalent circuits of induction machine, • Derivation of equivalent circuit used in the field oriented controlled induction machine, • Analysis of induction machine in per-unit system, • Equivalent circuit of induction machine used in the transients • Analysis of induction machine for unbalanced cases with symmetrical components, • Analysis of induction machine for non-sinusoidal supply cases by means of harmonic equivalent circuit

WEEKLY TOPICS AND PRELIMINARY STUDY

Week	Topic	Preliminary Study
1	DC motor transient and steady state equations: Electrical side and mechanical side equations for separately excited, series excited machines; torque, current, speed characteristics	The relevant book chapters and materials from the literature
2	Derivation of transfer functions of DC motor: Derivation of Speed/Input-Voltage transfer functions in separately excited machines with and without load torque disturbance	The relevant book chapters and materials from the literature
3	Controller design for dc motor control: Type zero, one, two and three systems; steady state errors, controller design to eliminate steady state errors	The relevant book chapters and materials from the literature
4	Controller design for dc motor with current and speed feedback: Transfer functions for current feedback and current regulated control, ideal current regulator, external speed feedback speed regulated and internal current regulated controller design	The relevant book chapters and materials from the literature
5	Review of induction machine theory: Rotating field theory in ac machines, operating principles of induction machines, stator and rotor flux current, voltage relationships and equations	The relevant book chapters and materials from the literature
6	Derivation of equivalent circuits of induction machine: Derivation of steady state equivalent circuit from the stator and rotor flux, current, voltage relationships and related equations	The relevant book chapters and materials from the literature

7	Derivation of equivalent circuits of induction machine: Derivation of stator frequency, rotor frequency and slip frequency based equivalent circuits, derivation of arbitrary referral ratio equivalent circuit	The relevant book chapters and materials from the literature
8	Derivation of equivalent circuit used in the field oriented controlled induction machine: Basics of Field Orientation Control (FOC) of Induction Machine (IM), derivation of equivalent circuit used in FOC IM, Steady state analysis of IM by this equivalent circuit	The relevant book chapters and materials from the literature
9	Analysis of induction machine in per-unit system: First and second degree base quantities for IM per unit system, derivation of steady state per-unit quantities, approximate critical quantities in per-unit	The relevant book chapters and materials from the literature
10	Steady state and transient response analysis of induction machine in per-unit system: Thevenin equivalent circuit of voltage Fed IM, Norton equivalent circuit of current fed IM, steady state analysis with per-unit quantities, derivation of equivalent circuit that will be used in transients while operating at steady state, first transient response analysis	The relevant book chapters and materials from the literature
11	MIDTERM EXAM	
12	Analysis of induction machine for unbalanced cases with symmetrical components: Review of symmetrical components, usage of symmetrical components in unbalanced fed IM	The relevant book chapters and materials from the literature
13	Analysis of induction machine for unbalanced cases with symmetrical components: Derivation of balanced positive and negative sequence voltage components of IM for a defined unbalanced voltage fed case	The relevant book chapters and materials from the literature
14	Analysis of induction machine for unbalanced cases with symmetrical components: Analysis of IM with the balanced set of positive and negative sequence voltages, usage of superposition theorem to find net statedy state solution for IM quantities	The relevant book chapters and materials from the literature
15	Analysis of induction machine for non-sinusoidal supply case: Derivation and evaluation of harmonic equivalent circuit of IM used in non-sinusoidal supply cases, calculations of slip, current, torque, power for harmonics, usage of superposition theorem to find net steady state quantities for non-sinusoidal supply cases	The relevant book chapters and materials from the literature
16	FINAL EXAM	

SOURCES	
Lecture Notes	Lecture notes and slides
Other Sources	**Course Textbook:** "University of Wisconsin-Madison ECE 411 Course Notes" **Additional Materials:** 1. "Electrical Machinery", Fitzgerald, 5th Edition, 1992, McGraw Hill Int. Lmtd . 2. Advanced Continuous Simulation Language (ACSL) Program User Manual

COURSE MATERIALS SHARING	
Documents	Lecture notes and slides
Homeworks	Students will be given at least total of 7 analytical or simulation homeworks
Exams	1 Midterm and 1 Final Exam

EVALUATION SYSTEM		
SEMESTER STUDY	**NUMBER**	**CONTRIBUTION**
MIDTERM EXAM	1	30
Homeworks	7	35
FINAL EXAM	1	35
TOTAL		100

Course Category	
Sciences and Mathematics	50%
Engineering	50%
Social Sciences	0%

RELATIONSHIPS BETWEEN LEARNING OUTCOMES AND PROGRAM QUALIFICATIONS							
No	Program Qualifications	Contribution Level				
		1	2	3	4	5
1	Skills of using Mathematical, Science and Engineering Knowledge in Advanced Research					**x**
2	Skills of analyzing, designing and/or implementing an original system which will solve an Engineering Problem					**x**
3	Skills of using software, hardware and modern measurement instruments for advanced research in one's field of expertise					**x**
4	Skills of planning, detailing and doing independent research					**x**
5	Skills of following literature, making and/or listening technical presentation, writing academic level article				**x**	
6	Skills of finding original ways by means of innovative thinking and questioning					**x**

*Increasing from 1 to 5.

ECTS / WORK LOAD TABLE			
Activities	Number	Duration (Hours)	Total Work Load
Course Length (includes exam weeks: 16x total course hours)	16	3	48
Out-of-class Study Time (Pre-study, practice)	16	5	90
Internet search, library work, literature search	16	3	48
Homework	7	13	91
Midterm	1	15	15
Final Exam	1	20	20
Total Work Load			312
Total Work Load / 30			312/30
Course ECTS Credit			10