ESE 352: Electromechanical Energy Converters

Fall 2023

Course Description:

An introduction to the conversion of mechanical power to electric power (generators) and the conversion of electric power to mechanical power (motors). Analysis of the interaction of magnetic fields with electric current and moving conductors to produce electromagnetic force and induced voltage. Energy converters studied include three phase AC synchronous generators and motors, AC induction motors, DC linear and rotating machines, and single phase AC motors. An introduction to inverter-based renewable energy generations in power systems.

Course Designation: Elective

Text Book: Electric Machinery Fundamentals (5th ed. McGraw Hill) Chapman (ISBN 978-07-352954-0)

Prerequisites: ESE 273

Instructor: Yifan Zhou (Yifan.zhou.1@stonybrook.edu)
Office Hours: Tuesday and Wednesday 8:30 am-10:30 am (Online)

Class/laboratory Schedule: 3 lecture hours per week

Goals:

Teach analysis and design techniques associated with the conversion of mechanical energy to electrical energy (generators) and the conversion of electrical energy to mechanical energy (motors).

Course Learning Outcomes:

Upon completion of this course, students will demonstrate an understanding of:

1. The interaction of magnetic fields with electric current and moving conductors in the production of electromagnetic induced force and voltage.
2. The design and application of three phase AC synchronous generators, induction machines and synchronous motors.
3. The design and application of DC generators and motors.
4. The design and application of single-phase AC machines.
5. Fundamental knowledge of power converters and the application of inverter-based resources (IBRs) in power systems

Topics Covered:

Week 1.	Overview of electromechanical energy converter fundamentals: rotational motion, power, magnetic fields and circuits, induced force and voltage, linear DC machine, real, reactive, and apparent power flow in AC circuits, Faraday's Law.
Week 2.	Transformers including: ideal transformers, equivalent circuit, efficiency, voltage regulation, three-phase transformers.
Week 3.	Fundamentals of AC machines: rotating loop in magnetic field, induced voltage in AC machines, induced torque, machine power flow, losses.
Week 4.	Synchronous generators including the following: construction, relationship between rotor mechanical speed and electrical frequency, internal generator voltage, equivalent circuit, phasor diagram representation, power and torque, operation, and ratings.
Week 5.	Synchronous motors including: rotating magnetic field, equivalent circuit, steady-state operation, starting issues, phasor diagrams, ratings.
Week 6.	Review sessions 1 through 5.
Week 7.	Mid-term exam
Week 8.	Review mid-term exam. Induction machines including: construction, slip and frequency, equivalent circuit, torque, torque-speed characteristics, induction motor design, starting challenges, speed control, induction generators, and induction machine ratings.
Week 9.	DC machinery fundamentals including: rotating coil between magnetic poles, commutation, induced voltage and torque, machine construction, power flow, losses.
Week 10.	DC motors and generators including: equivalent circuits for separately excited, shunt, permanent magnet, series and compound machines; starting circuits, and machine efficiency.
Week 11.	Single phase motors including: universal motor, single phase induction motor, starting challenges, equivalent circuits. Special-purpose motors including: split phase, capacitor start, capacitor start/capacitor run, shaded pole, and stepper motors.
Week 12.	Fundamentals of power converters. Inverter-based resources (IBRs) in Photovoltaics (PV) systems including: PV array modeling, maximum power point tracking (MPPT), grid-connected PV system. IBRs in wind generation systems including: fundamentals for wind turbine, wind generation systems, Type I-IV wind turbines.

Week 13.	Fundamentals for IBR control: grid connection of inverters, double-loop control of IBRs, primary control, secondary control, distributed control.
Week 14.	Review for final exam.
Week 15.	Final exam

Notes:

- Homework assignments are due as specified in Brightspace.
- The weekly quiz will cover material discussed during the previous session.
- Final grade will be determined as follows:

Homework, Weekly Quiz, Participation	34%
Mid-term Exam	33%
Final Exam	33%
	100

	Student Outcomes	Contribution*
1	an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	3
2	an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	1
3	an ability to communicate effectively with a range of audiences.	
4	an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in a global, economic, environmental, and societal contexts.	1
5	an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	1
6	an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions.	
7	an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	

* **3**-Strongly Supported**;** **2**-Supported**;** **1**-Minimally Supported

University Policies:

The University Senate Undergraduate and Graduate Councils have authorized that the following required statements appear in all teaching syllabi (graduate and undergraduate courses) on the Stony Brook Campus:

Student Accessibility Support Center Statement

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Professions, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.