ECE 412 – Hybrid Electric Vehicle Drives

Credits: 4, **Contact Hours:** Two 75-minute lecture sessions per week, one 160-minute laboratory session per week.

Coordinator: M. Krishnamurthy, Associate Professor of ECE

Textbook: Principles of Electric Machines and Power Electronics, 3rd Edition, P. C. Sen, Wiley Press, ISBN-10: 9781118078877

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Fundamentals of drivetrains for electric vehicles and hybrid electric vehicle drives are studied with a brief introduction to different machine topologies. Applications of semiconductor switching circuits to adjustable speed drives, robotics, and traction applications are explored. Selection of motors and drives, calculating the ratings, speed control, position control, starting, and braking are also covered. Simulation mini-projects and lab experiments are based on the lectures given.

Prerequisites or co-requisites by topic: ECE 308, ECE 311, ECE 319

Enrollment: Senior Level Elective

Specific outcomes of instruction:

After completing this course, the student should be able to do the following things correctly.

1. Show an understanding of electrified transportation. Demonstrate a practical understanding of implementation details the implementation of EV drivetrains, including power electronics, electric machines & drives and energy storage.
2. Given an electromechanical system including an electric machine and a mechanical load with different torque-speed characteristics, find torque, acceleration, speed, position, and power.
3. Given an energy conversion system, using fundamentals of electromagnetism, draw and analyze the equivalent electric circuit.
4. Derive and apply the relevant equations of electric DC machines: motors and generators, separately-excited, shunt, series, and compound machines as well as universal motors.
5. Derive and apply the relevant equations of three-phase induction machines: motors and generators. Analyze the fundamental operation and starting of single-phase induction motors.
6. Derive and apply the relevant equations of multi-phase permanent-magnet synchronous motors and three-phase synchronous generators.
7. Given an electric power source, a DC motor, and a mechanical load, design power electronic drivers using phase-controlled AC/DC rectifiers as well as DC/DC converters and analyze all operating modes.
8. Given an electric power source, a three-phase induction motor, and a mechanical load, design power electronic drivers using phase-controlled AC/AC converters as well as DC/AC inverters and analyze all operating modes.
9. Derive and apply the fundamental equations of special motor drives: switched reluctance, stepper, brush-less DC, and electronic motor drives.
10. Carry out an independent project using simulation tools, identifying context of the problem, approach chosen, projected timeline and tools used.
11. Develop a time-constrained presentation based on independent term project and present it to an audience. Highlight all lessons learned from the project and explain any deviations.

Relationship of ECE 412 specific outcomes of instruction to student outcomes:

	Student Outcomes	**Course Goals**
1	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	1,2,3,4,5,6, 7,8
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	10, 11
3	An ability to communicate effectively with a range of audiences	11
4	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	11
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	1,2,3,4,5,6, 7,8
6	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	10
7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	10

Topics:

- Electric and Hybrid Electric Vehicles (1.5 week)
- Electromagnetic energy conversion and magnetic circuits and introduction to Electric machines (1 week)
- Brushed DC Motors for auxiliary loads in automotives (2.5 weeks)
- Automotive Power Electronics (1 week)
- Induction motor modeling and control (3.5 weeks)
- Brushless Permanent magnet synchronous motor modeling and control (1.5 weeks)
- Switched Reluctance Machines: Fundamentals and converters (0.5 week)
- Practical Design Considerations in EV traction motors (0.5 week)
- Health Monitoring and Fault-Tolerant Operation of Traction Motors (0.5 weeks)
- Fundamentals of energy storage (0.5 week)
- Practical design and analysis of EV drivetrains (2.5 weeks)

Prepared by: M. Krishnamurthy **Date:** February 28, 2020