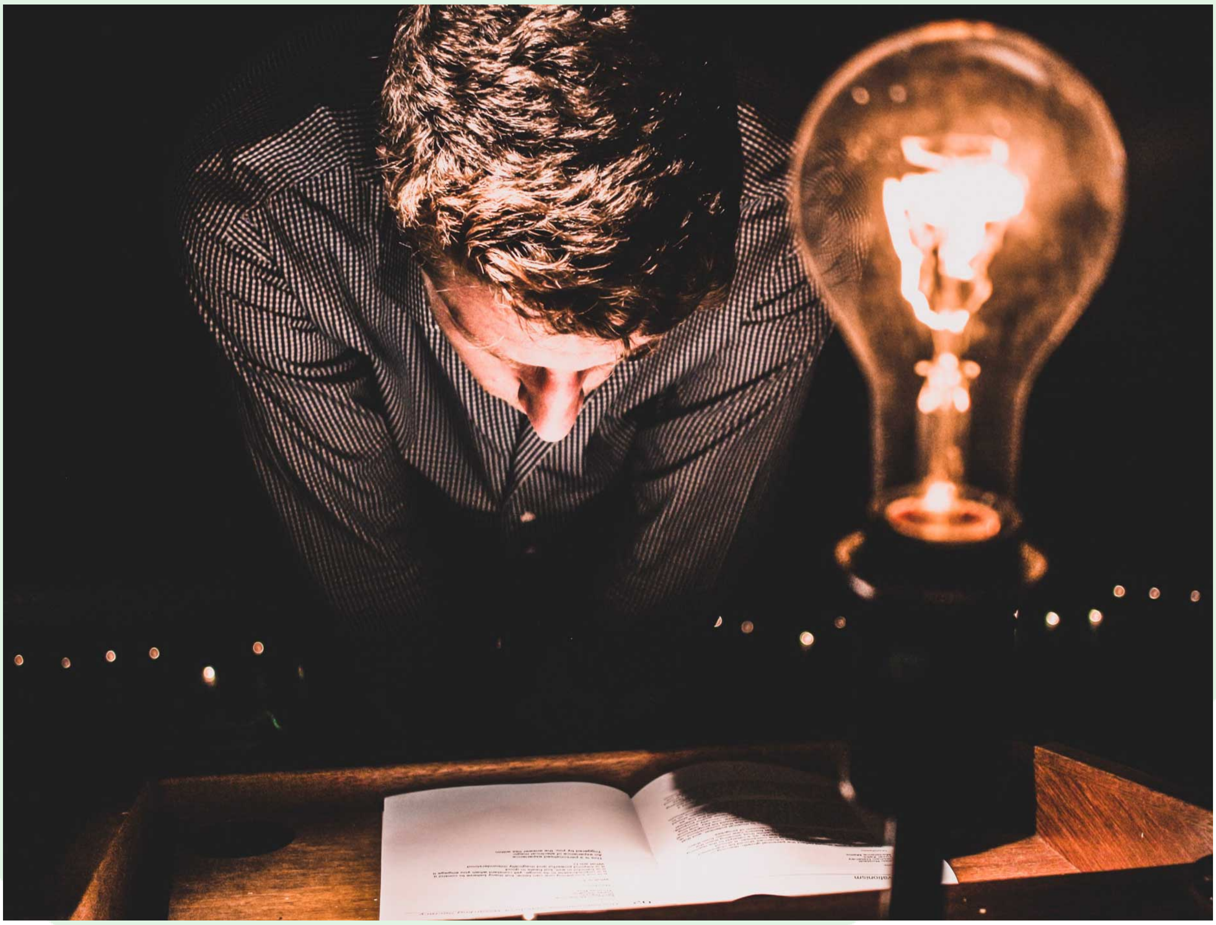
School of Electrical Engineering & Telecommunications

UNSW Engineering

ELEC4613

Electrical Drive Systems

Term 2, 2022



Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
AProf Rukmi Dutta	rukmi.dutta@unsw.edu.au	During office hours	EE 406 , Level 4	+61293857 884

School Contact Information

Consultations: Lecturer consultation times will be advised during the first lecture. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC/TELExxxx in the subject line; otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Student Support Enquiries

For enrolment and progression enquiries please contact Student Services

Web

Electrical Engineering Homepage

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

Course Details

Units of Credit 6

Summary of the Course

Introduction to Electrical Drive Systems. Elements of Drive systems and their requirements for servo and industrial drive applications. Drive representation, quadrant operation, dynamic and regenerative braking. Performance analysis of induction motor drives with variable voltage, variable current and variable frequency supply. Performance analysis of synchronous, brushless DC and reluctance motors with variable voltage, current and variable frequency supply. Computer modeling and design of drive system. Analysis of dynamics of DC, induction and synchronous machines; drive system design .

Course Aims

If you see yourself as the expert driving the 5th industrial revolution that promotes sustainable development and the most sought-after professionals of transport electrification, you have come to the right place. A high level of automation that you see in a self-driving electric car, robotic arms in the industrial process or the wind energy conversion is possible by efficient control of electric motor drives. Electric Drive Systems are an essential part of industrial processes, electric traction systems, wind energy conversion systems, motion control systems, and domestic appliances. Electrically actuated processes and systems deliver high energy efficiency, product quality and highly flexible and high-volume production of items that are in everyday use.

In this course, you will gain knowledge of variable-speed drives and motion control systems used in many industrial processes such as conveyors, machine tools, pumps, compressors, mining drives, electric cars, ship propulsion, all-electric aircraft, servo drives, and automation system. The course stresses the basic understanding of characteristics of machines driven from appropriate power electronic converters and controllers. You will explore the steady state behaviour of drives and the design of high-performance drives. The dynamic issues of drive representation and control system design for the latter will also be covered in this course. You can gain hands-on experience via lab experiments and computer modelling of motor drive systems using simulation platforms such as Matlab-Simulink.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Explain fundamental elements of drive systems and their interactions	PE1.1, PE1.2, PE1.3, PE2.1, PE2.2, PE3.2, PE3.3
2. Analyse steady-state and dynamic performance characteristics of DC, Synchronous and Induction motor drives supplied from appropriate converters	PE1.1, PE1.2, PE1.3, PE2.1, PE2.2, PE3.2, PE3.3, PE3.6
3. Select and develop skills in selecting and designing important elements (e.g., appropriate motor type, controller, converter) of a drive system.	PE1.1, PE1.2, PE1.3, PE1.5, PE2.1, PE2.2, PE3.2, PE3.3, PE3.6

Learning Outcome	EA Stage 1 Competencies
4. Design hierarchical torque, speed and position controllers for converter driven motor drive systems and identify related issues.	PE1.1, PE1.2, PE1.3, PE1.5, PE2.1, PE2.2, PE3.2, PE3.3, PE3.6

Teaching Strategies

Delivery Modes

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Lectures will be delivered online this term. These will provide you with a focus on the core analytical material in the course covered according to the Approximate Lecture Schedule (see below), together with qualitative, alternative explanations to aid your understanding. The lecturer will be available on Microsoft Team/via email during each lecture. Students will be able to contact the lecturer during the formal lecture times for consultation by students.
- Tutorials will be delivered in hybrid mode (i.e. the face-face class and the online session will occur simultaneously). Online student will see the face-face students and vice-versa. The hybrid mode is a pilot project from PVC teaching. Tutorial will discuss exercises in problem-solving and allow time for you to resolve problems in understanding of lecture material.
- The laboratory will consist of 3-hour sessions for each of four experiments, E1 – E4. Laboratory demonstrators will familiarise you with the equipment for the scheduled experiment and will help you perform procedures included in the lab sheets for each experiment during each experiment. Each experiment will support the formal lecture material and provide you with the measurement and analytical skills of an electric drive. Students are encouraged to perform simulation studies on PSIM/Matlab-Simulink platforms, culminating in the analysis of drive systems performance using such platforms.

At the end of each lab session, the lab demonstrator will assess your logbook, which should record all relevant experimental data, graphs, CRO recordings and your findings from the experiment. The demonstrators will also ask each student questions at the end of each lab session in order to ascertain students' in-depth understanding of the experiment performed.

Learning in this course

You are expected to attend all lectures, tutorials, labs in order to maximise learning. You must prepare well for your laboratory classes, and your lab work will be assessed. In addition to the lecture notes/videos, you should also read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending the three modes of course deliveries throughout the course.

Tutorial

You should attempt your problem sheet questions in advance of attending the tutorial classes. The importance of adequate preparation prior to each tutorial cannot be overemphasised, as the effectiveness and usefulness of the tutorial depend largely on this preparation. Group learning is encouraged where possible. The solution to some of the questions set in tutorials will be discussed during the tutorial class. In addition, 1 or 2 new questions, or extensions of existing questions, may be brought in by the tutor for you to try in class. These additional questions and their solutions may not be made available in Moodle, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit.

Laboratory (compulsory)

The laboratory component of this course exposes you to physical motor drives via experiments that are designed to give you hands-on experience of electric drive concepts that are covered in lectures. It is a **compulsory** part of the course and must therefore be completed and passed.

The laboratory for this course consists of four hardware experiments, E1 – E4. There are two laboratory sets for each experiment. A maximum of two students can be accommodated for each set in a face-face session. This term, hybrid mode of laboratory (where online students pair ups with face-face students) are offered only for those who are stuck overseas. All other students must attend lab in face-face mode.

The laboratory will start in week 7. Laboratory sheets will be made available on the course page. The laboratory schedule for each enrolled group will be available via the course web page.

Students are required to read the *School Safety Manual for Laboratory* and *Laboratory Safety Instructions* for this course and submit the signed *Laboratory Safety Declaration* form to the lab supervisor before they start the first laboratory experiment.

Because of the extensive nature of each experiment and the introduction given for each experiment, you must prepare well in advance for your scheduled experiments.

Laboratory experiments:

The following four laboratory experiments have been included. Please see the Lab Schedule in the course webpage for your schedule of lab attendance and experiments to perform.

Experiment E1. Speed control of a DC motor with an inner current loop.

Experiment E2. Induction motor drive with slip-power recovery.

Experiment E3. *V/f* and rotor flux oriented (vector controlled) induction motor drive

Experiment E4. *V/f* and rotor flux oriented (vector controlled) synchronous motor drive

Laboratory Exemption

There is no laboratory exemption for this course. Regardless of whether equivalent labs have been completed in previous courses, all students enrolled in this course must complete all four labs. If, for medical reasons (for which a valid medical certificate must be provided) you are unable to attend a lab session, you will need to discuss with the laboratory demonstrator/lecturer for a catch-up lab during another lab period.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Assignment	10%	08/08/2022 11:59 PM	1, 2, 3, 4
2. Final Examination	50%	Not Applicable	1, 2, 3, 4
3. Mid-term Test	20%	01/07/2022 07:00 PM	1, 2, 3
4. Laboratory	20%	Not Applicable	1, 2

Assessment 1: Assignment

Submission notes: Online submission (pdf file preferable)
Due date: 08/08/2022 11:59 PM

Each student will be required to submit a report/assignment topic on a given project. The report/assignment will allow some self-directed study leading to some further operational aspects of a real-world drive system. The project may require a modelling the steady-state and dynamic responses of the real-world example using a simulation platform (Matlab-Simulink).

Marks will be allocated according to how completely and correctly the problems have been addressed and the understanding of the course material demonstrated by the report. The assignment must be submitted online (details will be provided closer to the date).

Assessment 2: Final Examination

The final exam in this course will consist of a 2-hour written examination online. The examination tests analytical and critical thinking and a general understanding of the course material in a controlled fashion. Questions may be drawn from any aspect of the course (including laboratory). Marks will be assigned according to the correctness of the responses. ***Please note that you must pass the final exam in order to pass the course.***

Hurdle requirement

Must pass the exam to pass the course.

Assessment 3: Mid-term Test

Submission notes: Online Quiz
Due date: 01/07/2022 07:00 PM

The online mid-session test (openbook) will be of 2-hour duration. It will give an indication of your general understanding of the analytical components of the course material covered during the first five weeks. Questions may be drawn from any course material up to the end of week 5. It may contain questions requiring some numerical and analytical work and derivations.

Assessment 4: Laboratory

You are required to maintain a lab book (or logbook) for recording your laboratory experimental data and observations. A lab book is an A4 size notebook containing a mix of plain pages and graph sheets. You should purchase your own lab book. Each student must submit the lab book **individually** to the lab demonstrator at the end of each lab session for marking. The lab demonstrator will mark the lab book according to the student's performance in the laboratory. Please read the online Laboratory Guidelines in the course webpage to find more about conducting your experiments.

It is essential that you complete suggested laboratory preparations before attending each lab session. You are required to write the aim of the experiment and draw the circuit diagram, if any, in your laboratory lab book. This will be verified by your demonstrators during each lab session. You will be recording your observations/readings in your lab book.

Laboratory Assessment marks will be awarded according to your preparation, punctuality, involvement, presentation of the results obtained, how much of the lab you were able to complete, your understanding of the experiments conducted during the lab, the quality of the records entered during your lab work (according to the guidelines given in the lab sheets), and your understanding of the topic covered by the lab.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

The course consists of 2x2 hour of lectures, a 1-hour tutorial, and a 3-hour laboratory session each week. Enrolled students will be required to complete 4 laboratory experiments during the term.

	Day	Time	Location
Lectures	Monday Thursday	4-6 pm 2-4 pm	Ainswth G03/Microsoft Teams
Tutorials	Thursday	2-3 pm	MAT101/Microsoft Teams
Labs	As per Time-Table	As per Time-Table	EE115/Microsoft Teams (MS Teams is only for those stuck overseas)

View class timetable

Timetable

Date	Type	Content
O-Week: 23 May - 27 May	Reading	1. Welcome message from the course convenor sent by email 2. Course outline
Week 1: 30 May - 3 June	Lecture	**Topic 1: Introduction to Electrical Drives** • Basic concepts of rotational systems, • Load couplings, • representation of torque referred to motor and load shafts, • Energy relationship. • Stability in steady-state, • Quadrant operation
	Workshop	**Guest Lecutre** (Compulsory for all, assignment will be based on this lecture contents)
Week 2: 6 June - 10 June	Lecture	**Topic 2: Brushed DC motor drives** • Review of DC motors and characteristics

		• Switched-mode PWM converters. • Single- and three-phase thyristor converter circuits. • Analysis of converter and dc motor circuits.
	Workshop	Topic 1
Week 3: 13 June - 17 June	Lecture	**Topic 3: Brushless DC drives** • BLDC machine fundamentals; • Analysis of machine back emf and torque; • Ideal back-emf and current waveforms,
	Workshop	Topic 2
Week 4: 20 June - 24 June	Lecture	**Topic 4: Synchronous motor drives** • Review of synchronous motors and characteristics • Performance under Voltage Source Inverter (VSI) drive • Performance under Current Source Inverter (CSI) drive
	Workshop	Topic 2
Week 5: 27 June - 1 July	Lecture	**1. Topic 4 Concludes** **2. Topic 5: Induction motor drives begins** • Review of Induction motors and characteristics • Drive characteristics using equivalent circuit representation • Performance with variable-voltage and rotor power • Static Scherbius drive. • Characteristics with VSI-VF inverter and CSI-VF drive
	Workshop	Reveiw for mid-term test
	Assessment	Mid-term Test: Online Quiz
Week 6: 4 July - 8 July		Flexibility week - no lecture, workshop or lab
Week 7: 11 July - 15 July	Lecture	**Topic 5 continues**
	Workshop	Topic 4

	Laboratory	Experiment 1/2/3/4 run in parellel
Week 8: 18 July - 22 July	Lecture	**Topic 6: Dynamics of DC and AC machines** • Representation of DC machine dynamics; • Rotor reference frames • Representation of AC machines in reference frames • Representation of synchronous machine dynamics in the stator and rotor reference frames; • d- and q-axes currents and fluxes; rotor flux oriented control (RFOC). • Representation of induction machine dynamics in the stator and synchronously rotating reference frames; • Condition for alignment of the direct-axis with rotor-flux axis. • Indirect rotor-flux oriented control (RFOC) structure; • effect of rotor time-constant on RFOC.
	Workshop	Topic 5
	Laboratory	Experiment 1/2/3/4 run in parellel
	Assessment	Assignment details release
Week 9: 25 July - 29 July	Lecture	**Topic 6 continues**
	Workshop	Topic 6
	Laboratory	Experiment 1/2/3/4 run in parellel
Week 10: 1 August - 5 August	Lecture	**Topic 7: Controller design for electrical drives** • Role of various control loops in drive systems; • drive system damping; • Sensors for speed, position and current. • Hierarchy of control loops for torque/current, speed and position; • Role of the inner current loop(s); • design considerations for torque, speed and position control loops. • Torque, current, speed and position controller design for specified bandwidth
	Workshop	Topic 7

	Laboratory	Experiment 1/2/3/4 run in parellel
Study Week: 8 August - 11 August	Laboratory	Catch-up lab if required
	Assessment	Assignment: Online submission (pdf file preferable)

Resources

Prescribed Resources

Text Books and References

1. *Electric Drive Systems* – comprehensive lecture notes from previous lecturer Prof. F. Rahman. PDF file will be made available on the course page.

The following books may be consulted for further reading:

Reference books:

1. *Control of Electric Machine Drive Systems* - Seung-Ki Sul, IEEE Press and John Wiley, 2011.
2. *Electric Drives* by Ion Boldea and S. A. Nasar, CRC Press, 3rd edition, 2017.

Online resources

All Lecture Notes, workshop problem sheets and Laboratory sheets for each experiment will be available on the course page in Microsoft Teams.

Academic Honesty and Plagiarism

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see https://student.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Academic Information

COVID19 - Important Health Related Notice

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

Dates to note

Important Dates available at: https://student.unsw.edu.au/dates

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://student.unsw.edu.au/policy), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **15 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both formal classes and *independent, self-directed study*. In periods where you need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You can apply for special consideration when illness or other circumstances beyond your control interfere with an assessment performance. If you need to submit an application for special consideration for an exam or assessment, you must submit the application **prior to the start** of the exam or before the assessment is submitted, except where illness or misadventure prevent you from doing so. Be aware of the "fit to sit/submit" rule which means that if you sit an exam or submit an assignment, you are declaring yourself well enough to do so and cannot later apply for Special Consideration. For more information and how to apply, see https://student.unsw.edu.au/special-consideration.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and UNSW policies:

https://student.unsw.edu.au/guide

https://www.engineering.unsw.edu.au/electrical-engineering/resources

Disclaimer

This Course Outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies:

Image Credit

Synergies in Sound 2016

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering problem solving	✓
PE2.2 Fluent application of engineering techniques, tools and resources	✓
PE2.3 Application of systematic engineering synthesis and design processes	
PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in professional and lay domains	✓
PE3.3 Creative, innovative and pro-active demeanour	✓
PE3.4 Professional use and management of information	
PE3.5 Orderly management of self, and professional conduct	
PE3.6 Effective team membership and team leadership	✓