Subject Description Form

Subject Code	EIE4125
Subject Title	Power Conversion Technology for Energy Harvesting
Credit Value	3
Level	4
Pre-requisite / Co-requisite / Exclusion	Pre-requisite: EIE2110 Basic Circuit Analysis and Electronics **AND** EIE3123 Dynamic Electronic Systems
Objectives	**To enable students to gain knowledge and understanding in the following aspects:** 1. Fundamentals of different types of energy transducers. 2. Basic power conversion circuits for energy harvesting. 3. Fundamentals of different energy storage technologies for energy harvesting. 4. Design and implementation of practical energy harvesting systems. Internet-of-Things (IoT) is a fast developing field which has already found many useful applications in our daily lives. However, powering IoT devices remains as one of the greatest challenges towards large-scale deployment of IoT devices. This subject aims to equip students with the fundamental knowledge on the main components of practical energy harvesting systems that are aimed to ensure continuous power supply to IoT devices.
Intended Subject Learning Outcomes	**Upon completion of the subject, students will be able to:** Category A: Professional/academic knowledge and skills 1. Understand the fundamentals of the main components of practical energy harvesting systems. 2. Design practical energy harvesting systems to meet given specifications and constraints. 3. Use appropriate engineering tools to analyse, design, and build hardware prototype of practical energy harvesting systems. 4. Understand the importance of energy harvesting technologies to the sustainable development of IoT and related smart technologies. Category B: Attributes for all-roundedness 5. Communicate effectively. 6. Assimilate new technological developments in energy harvesting technologies.
Subject Synopsis/ Indicative Syllabus	**Syllabus:** 1. Overview of Energy Harvesting Systems for IoT Devices Energy sources. Energy transducers. Power converters. Power management unit. Energy storages. Load devices. 2. Energy Transducers Piezoelectric transducers. Electromagnetic transducers. Electrostatic transducers. Thermoelectric transducers. Solar cells. Wind turbines. RF antenna. 3. Components of Power Converters Power semiconductor devices. Magnetic design. Voltage and current sensors. Power management IC. Feedback controller design. 4. Power Converter Topologies DC-DC converters (linear regulators, non-isolated/isolated switching converters, switched-capacitor converters). AC-DC converters (voltage

	doubler, rectifier with voltage doubler, direct discharge circuit). Computer simulation of power converters. 5. Energy Storages Fuel cells. Electrochemical batteries. Supercapacitors. 6. Power Management Single-source systems. Multi-source systems. Load matching. Maximum power point tracking. Power saving design. 7. Applications of Energy Harvesting Systems for IoT Devices Building automation. Environmental monitoring. Condition monitoring. Structural health monitoring. Automotive. Logistics. Consumer electronics.
Teaching/ Learning Methodology	See table below

Teaching and Learning Method	**Intended Subject Learning Outcome**	**Remarks**
Lectures, supplemented with interactive questions and answers, and short quizzes.	1, 2, 3, 4, 5, 6	In lectures, students are introduced to the *knowledge* of the subject, and *comprehension* is strengthened with interactive Q&A and short quizzes. They will be able to *explain* and *generalize* knowledge in the design of energy harvesting systems.
Tutorials where design problems are discussed, and are given to students for them to solve.	1, 2, 3, 4, 5, 6	In tutorials, students *apply* what they have learnt in analyzing the cases and solving the problems given by the tutor. They will *analyze* the given information, *compare* and *contrast* different scenarios and propose solutions or alternatives.
Laboratory sessions, where students will complete a mini-project by systematic computer simulation and experimental prototyping. They are required to write a report on the mini-project.	1, 2, 3, 4, 5, 6	Students *acquire* hands-on experience in using computer-aided design (CAD) tools in energy harvesting system design, and *apply* what they have learnt in lectures/tutorials to complete a mini-project on the design of an energy harvesting system to meet given specifications and constraints.

Assessment Methods in Alignment with Intended Learning Outcomes								
	Specific Assessment Methods/Tasks	**% Weighting**	**Intended Subject Learning Outcomes to be Assessed (Please tick as appropriate)**					
			1	**2**	**3**	**4**	**5**	**6**
	1. Continuous Assessment (total 60%)							
	• Quizzes	10%	✓	✓	✓	✓	✓	
	• Mini-project	30%	✓	✓	✓	✓	✓	✓
	• Mid-semester test	20%	✓	✓	✓	✓	✓	
	2. Final Examination	40%	✓	✓	✓	✓	✓	
	Total	100 %						

The continuous assessment consists of quizzes, one mini-project, one mid-semester test, and one final examination.

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

Specific Assessment Methods/Tasks	**Remark**
Quizzes	Quizzes are given to students to assess their competence level of *knowledge* and *comprehension*, ability to *analyze* given information, ability to *apply* knowledge and skills in new situation, ability to *synthesize* structure, and ability to evaluate given data to make judgment. Feedback about their performance will be given promptly to students to help them improvement their learning.
Mini-project and report	Students will be required to perform a mini-project and submit a report. The emphasis is on assessing their ability to *use* CAD tools effectively to perform *energy harvesting system design* and *hands-on skills* on hardware design and prototyping. Expectation and grading criteria will be given as in the case of assignment/homework.
Mid-semester test	There will be a mid-semester test to evaluate students' achievement of all the learning outcomes and give feedback to them for prompt improvement. Expectation and grading criteria will be given as in the case of assignment/homework.
Final examination	There will be an end-of-semester examination to assess students' achievement of all the learning outcomes. These are mainly summative in nature. Expectation and grading criteria will be given as in the case of assignment/homework.

Student Study Effort Expected	**Class contact (time-tabled):**	
	• Lecture	26 Hours
	• Tutorial/Laboratory/Practical Classes	13 Hours
	Other student study effort:	
	• Lecture: preview/review of notes; preparation for test/quizzes/examination	39 Hours
	• Tutorial/Laboratory/Practical Classes: preview of materials, revision and/or reports writing	30 Hours
	Total student study effort:	**108 Hours**
Reading List and References	**Reference Books:** 1. P. Spies, L. Mateu, and M. Pollak, *Handbook of Energy Harvesting Power Supplies and Applications*, Jenny Stanford Publishing, 2015. 2. M. Di Paolo Emilio, *Microelectronic Circuit Design for Energy Harvesting Systems*, Springer, 2016. 3. S. Priya and D. J. Inman, T. Morey, *Energy Harvesting Technologies*, Springer, 2010. 4. M. Alhawari, B. Mohammad, H. Saleh, and M. Ismail, *Energy Harvesting for Self-Powered Wearable Devices*, Springer, 2017. 5. N. Bizon, N. Mahdavi Tabatabaei, F. Blaabjerg, and E. Kurt, *Energy Harvesting and Energy Efficiency: Technology, Methods, and Applications*, Springer, 2017. 6. Y. K. Tan, *Energy Harvesting Autonomous Sensor Systems: Design, Analysis, and Practical Implementation*, CRC Press, 2013.	
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