Subject Description Form

Subject Code	EIE567
Subject Title	Wireless Power Transfer Technologies
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	The student is expected to have knowledge in basic electricity, electronics, circuits, and ability to analyze problems using computer tools.
Objectives	From mobile, cable-free re-charging of portable devices, notebooks and electric vehicles to delivering power to lighting systems, wireless power transfer (WPT) technologies offer convenient power supply solutions to consumer products and large infrastructures. This course explains the fundamental principles and latest advances in WPT and illustrates key applications of this emergent technology. The key objectives are to introduce: 1. The fundamental principles of WPT for cable-free transfer of power. 2. Theories for near-field (inductive) wireless power transfer (NF-WPT) based on the coupled inductor model and circuit compensation. 3. Theories for far-field wireless power transfer (FF-WPT) based on the transmitting antennas and receiving rectennas. 4. Specific converter topologies for battery charging applications. 5. Technology trends in the adoption of WPT for key consumer applications.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: **(1) Professional/academic knowledge and skills** 1. Understand the characteristics of power transfer through coupled inductors (NF-WPT) and antennas/rectennas (FF-WPT) 2. Understand the analysis and design approaches of appropriate compensation circuits and efficient power converters for WPT applications 3. Understand technical requirements for applications involving solid-state loads and battery loads using WPT technologies 4. Understand the appreciation of the factors affecting adoption of WPT in consumer applications including charging of smartphones and electric vehicles. **(2) Attributes for all-roundedness** 5. Communicate effectively 6. Think critically and creatively
Subject Synopsis/ Indicative Syllabus	**Syllabus:** 1. <u>Basic Circuit and Electromagnetics Theory</u> Review of transformers. Leakage inductance. Circuit compensation principles. Low-order compensations; series and parallel compensations. Resonance frequency. Efficiency equation. Fundamentals of Electromagnetics and Antennas. 2. <u>Power Converters Fundamentals</u> DC-DC converters. AC-DC converters and inverters. PWM and soft switching principles. Basic topologies with transformers. Input, output and transfer characteristics of power converters. Control methods.

3. <u>Compensation Configurations</u>
   Types of compensation for inductor power transfer. Characteristics for various termination requirements. Design for load-independence output voltage and output current. Efficiency optimization.

4. <u>Applications</u>
   Circuit requirements for various loading conditions. Characteristics of LED loads, resistors and battery loads. Appropriate compensation design. Battery charging profiles. Electric vehicle charging. Energy efficiency metric for charging.

5. <u>Technology Trends</u>
   Demand for safe power transfer and durable operation. Portable and smart devices. Mobile communication devices. IoT devices and systems. Sensors. Solid- state lighting development. Battery technologies. Electric vehicle development. Renewable source integration trends. Future trends and demand for wireless power transfer.

Teaching/Learning Methodology

This course emphasizes fundamental understanding of the principles and design procedure of wireless power transfer systems as well as the various parameters involved in the optimization of wireless power transfer systems. Selected examples will help students learn the salient aspects of the technologies and the key design constraints. Lab activity will provide hands-on experiences for students to build up real WPT circuits. Case studies of specific consumer applications will reinforce understanding of the basic principles and inspire thoughts on future applications.

Teaching/Learning Methodology	Intended Subject Learning Outcomes					
	1	2	3	4	5	6
Lecture	✓	✓	✓			
Tutorial	✓	✓			✓	✓
Lab	✓	✓	✓			✓
Case Study			✓	✓	✓	✓

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. Assignments	40%	✓	✓	✓			
2. Test	30%	✓	✓	✓			
3. Lab	10%	✓	✓	✓			✓
4. Project report & viva examination	20%	✓		✓	✓	✓	✓
Total	100%						

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

Assignments allow students to reinforce their understanding of the basic theories and design principles. Since MSc students are mostly mature technical personnel, engineers and managers, the course must be relevant to their needs. Each student has different background and career needs. Hard memorization of a fixed set of theories and facts is not useful. It is important that students are able to extract useful contents

	relevant to their profession, and being mature students, they know best what are relevant and useful for them. Thus, instead of taking a written exam, students are given the opportunity to define and formulate their case studies under the guidance of the instructor and to pursue a detailed study and analysis of a topic that is strongly relevant to their experience and needs. The nature of case study may range from deep technology survey, innovative system design, to detailed circuit analysis at research level, catering individual needs. The case study project requires students to do further reading, search for information, keep abreast of current development, develop a proposal for specific application, give a presentation and write a complete report.	
Student Study Effort Required	Class contact:	
	▪ Lecture/Tutorial	24 Hours
	▪ Lab	3 Hours
	▪ Case study – presentations and discussions	9 Hours
	▪ Test	3 Hours
	Other student study effort:	
	▪ Lecture: further reading, doing homework/ assignment	42 Hours
	▪ Tutorial/Project: design, writing a report	30 Hours
	Total student study effort	111 Hours
Reading List and References	Text books: 1. C. T. Rim and C. Mi, *Wireless Power Transfer for Electric Vehicles and Mobile Devices*, New York: IEEE Press-Wiley, 2017. 2. J. I. Agbinya, *Wireless Power Transfer*, River Publishers, 2015. References: 1. Z. Huang, S. C. Wong, and C. K. Tse, "Design of a single-stage inductive-power-transfer converter for efficient EV battery charging," *IEEE Transactions on Vehicular Technology,* vol. 66, no. 7, pp. 5808-5821, July 2017. 2. L. Xu, Q. Chen, X. Ren, S. C. Wong, and C. K. Tse, "Self-oscillating resonant converter with contactless power transfer and integrated current sensing transformer," *IEEE Transactions on Power Electronics,* vol. 32, no. 6, pp. 4839-4851, June 2017. 3. W. Zhang, S. C. Wong, C. K. Tse, and Q. Chen, "Load-independent duality of current and voltage outputs of a series or parallel compensated inductive power transfer converter with optimized efficiency," *IEEE Journal of Emerging and Selected Topics in Power Electronics,* vol. 3, no. 1, pp. 137-146, March 2015. 4. J. Hou, Q. Chen, S. C. Wong, C. K. Tse, and X. Ruan, "Analysis and control of series/series-parallel compensated resonant converters for contactless power transfer," *IEEE Journal of Emerging and Selected Topics in Power Electronics,* vol. 3, no. 1, pp. 124-136, March 2015. 5. W. Lin and R. W. Ziolkowski, "High performance electrically small Huygens rectennas enable wirelessly powered Internet of Things sensing applications: A review," *Engineering*, vol. 11, pp. 42-59, 2022. 6. W. Lin and R. W. Ziolkowski, "Theoretical analysis of beam-steerable, broadside-radiating Huygens dipole antenna arrays and experimental verification of an ultrathin prototype for wirelessly powered IoT applications," *IEEE Open Journal of Antennas and Propagation*, vol. 2, pp. 954–967, Sep. 2021.	