TO: The Faculty of the College of Engineering

FROM: School of Electrical and Computer Engineering of the College of Engineering

RE: New Graduate Course, ECE 61016 Power Electronic Converters & Systems

The faculty of the School of Electrical and Computer Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ECE 61016 Power Electronic Converters & Systems
Sem. 1, Lecture 3, Cr. 3.

Prerequisite: ECE 202 and PHYS 272

Prerequisite by Topic: Basic circuit analysis; elementary electromagnetics; elementary mechanics

Description: The objective of this course is to educate students in the operation, detailed modeling, average-value modeling, and control design of power electronics converters and systems of converters.

Reason: Power electronics is a key discipline within power engineering. It is one of the bases of hybrid electric vehicles, electric vehicles, wind and PV power generation, dc transmission systems, flexible ac transmission systems, electric drive and propulsion systems, and almost all mobile power systems. This course is the primary graduate level course concerning power electronics within the ECE curriculum at Purdue. It is taught from a rigorous mathematical perspective from a graduate level textbook, papers, and supplementary notes. Although the course normally includes midterm and final exams, the assessment for the course is dominated by course projects with a research flavor. The course is not appropriate for undergraduates.

Michael R. Melloch

Michael R. Melloch, Associate Head
School of Electrical and Computer Engineering

Approved for the faculty of the Schools of Engineering by the Engineering Curriculum Committee
ECC Minutes #6 Date 11-15-16
Chairman ECC

Office of the Registrar
FORM 40G REV. 4/13

PURDUE UNIVERSITY
REQUEST FOR ADDITION, EXPIRATION,
OR REVISION OF A GRADUATE COURSE
(50000-60000 LEVEL)

DEPARTMENT: Electrical and Computer Engineering EFFECTIVE SESSION: Spring 2016

INSTRUCTIONS: Please check the items below which describe the purpose of this request.

- [x] 1. New course with supporting documents (complete proposal form)
- [ ] 2. Add existing course offered at another campus
- [ ] 3. Expiration of a course
- [ ] 4. Change in course number
- [ ] 5. Change in course title
- [ ] 6. Change in course credit/type
- [ ] 7. Change in course attributes
- [ ] 8. Change in instructional hours
- [ ] 9. Change in course description
- [ ] 10. Change in course requisites
- [ ] 11. Change in semesters offered
- [ ] 12. Transfer from one department to another

PROPOSED:		EXISTING:	
Subject Abbreviation	ECE	Subject Abbreviation	
Course Number	61016	Course Number	
Long Title	Power Electronic Converters & Systems		
Short Title	Power Electronic Covert & Sys		

Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

TERMS OFFERED (Check All That Apply): [x] Fall [ ] Spring [ ] Summer

CAMPUS(ES) INVOLVED: [ ] Calumet [ ] N. Central [ ] Cont Ed [ ] Tech Statewide [ ] Ft. Wayne [x] W. Lafayette [ ] Indianapolis

CREDIT TYPE

1. Fixed Credit: Cr. Hrs. 3
2. Variable Credit Range: Minimum Cr. Hrs ____ (Check One) To [ ] Or [ ] Maximum Cr. Hrs ____
3. Equivalent Credit: Yes [ ] No [x]
4. Thesis Credit: Yes [ ] No [x]

COURSE ATTRIBUTES: Check All That Apply

1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ] Maximum Repeatable Credit: [ ]
4. Credit by Examination [ ]
5. Fees [ ] Coop [ ] Lab [ ] Rate Request — Include comment to explain fee
6. Registration Approval Type: Department [ ] Instructor [ ]
7. Variable Title [ ]
8. Honors [ ]
9. Full Time Privilege [ ]
10. Off Campus Experience [ ]

Schedule Type	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
Lecture	3	50	16	100
Recitation				
Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):

The objective of this course is to educate students in the operation, detailed modeling, average-value modeling, and control design of power electronics converters and systems of converters.

*COURSE LEARNING OUTCOMES:

a. Understanding of switched circuits (a,c)
b. Understanding of average-value analysis techniques (a,c)
c. Understanding of feedforward/feedback control of power electronic converters (a,c)

Calumet Department Head	Date	Calumet School Dean	Date	Calumet Director of Graduate Studies	Date
Fort Wayne Department Head	Date	Fort Wayne School Dean	Date	Fort Wayne Director of Graduate Studies	Date
Indianapolis Department Head	Date	Indianapolis School Dean	Date	IUPUI Associate Dean for Graduate Education	Date
North Central Department Head	Date	North Central School Dean	Date	North Central Director of Graduate Studies	Date
West Lafayette Department Head	10/28/15	West Lafayette College/School Dean	12/2/15	Date Approved by Graduate Council	Date
Graduate Area Committee Convener	Date	Graduate Dean	Date	Graduate Council Secretary	Date
				West Lafayette Registrar	Date

OFFICE OF THE REGISTRAR

Supporting Document to the Form 40G
for a New Graduate Course

To: Purdue University Graduate Council

From: Faculty Member: Scott Sudhoff

Department: Electrical and Computer Engineering

Campus: West Lafayette

Date:

Subject: Proposal for New Graduate Course

Contact for information if questions arise:
Name: Matt Golden
Phone: 494-3374
Email: goldenm@purdue.edu
Address: EE Building, Room 135

Course Subject Abbreviation and Number: ECE 61016

Course Title: Power Electronic Converters & Systems

Course Description:

The objective of this course is to educate students in the operation, detailed modeling, average-value modeling, and control design of power electronics converters and systems of converters.

Semesters Offered:

For the benefit of graduate student plan of study development, how frequently will this prototype be offered? Which semesters?
Fall Even Years

A. Justification for the Course:

Provide a complete and detailed explanation of the need for the course (e. g., in the preparation of students, in providing new knowledge/training in one or more topics, in meeting degree requirements, etc.), how the course contributes to existing majors and/or concentrations, and how the course relates to other

graduate courses offered by the department, other departments, or interdisciplinary programs.

Justify the level of the proposed graduate course (500- or 600-level) including statements on, but not limited to: (1) the target audience, including the anticipated number of undergraduate and graduate students who will enroll in the course; and (2) the rigor of the course.

Power electronics is a key discipline within power engineering. It is one of the bases of hybrid electric vehicles, electric vehicles, wind and PV power generation, dc transmission systems, flexible ac transmission systems, electric drive and propulsion systems, and almost all mobile power systems. This course is the primary graduate level course concerning power electronics within the ECE curriculum at Purdue. It is taught from a rigorous mathematical perspective from a graduate level textbook, papers, and supplementary notes. Although the course normally includes midterm and final exams, the assessment for the course is dominated by course projects with a research flavor. The course is not appropriate for undergraduates.

Use the following criteria:
Graduate Council policy requires that courses at the 50000 level in the Purdue system should be taught at the graduate level and meet four criteria: a) the use of primary literature in conjunction with advanced secondary sources (i.e., advanced textbooks); b) assessments that demonstrate synthesis of concepts and ideas by students; c) demonstrations that topics are current, and; d) components that emphasize research approaches/methods or discovery efforts in the course content area (reading the research, critiquing articles, proposing research, performing research). Such courses should be taught so that undergraduate students are expected to rise to the level of graduate work and be assessed in the same manner as the graduate students.

- Anticipated enrollment
  - Undergraduate 0
  - Graduate 20-30

B. Learning Outcomes and Method of Evaluation or Assessment:

ECE Graduate Learning Outcomes:

a. Knowledge and Scholarship (thesis/non-thesis)
b. Communication (thesis/non-thesis)
c. Critical Thinking (thesis/non-thesis)
d. Ethical and Responsible Research (thesis) or Professional and Ethical Responsibility (non-thesis)

- List Learning Objectives for this course and map each Learning Objective to one or more of the ECE Learning Outcomes (a-d, listed above):

    a. Understanding of switched circuits (a,c)
    b. Understanding of average-value analysis techniques (a,c)
    c. Understanding of feedforward/feedback control of power electronic converters (a,c)
    d. Understanding of waveform level and average-value simulation techniques for switched systems (a,c)
    e. Understanding of several ac-dc, dc-ac, and dc-dc power conversion topologies (a,c)
    f. Understanding of inverter modulation techniques (a,c)
    g. Understanding of ethical homework and project practices, and implications of failure to adhere to these (d)
    h. Understanding of how to effectively present project results (b)

- Methods of Instruction

    - Lecture

- Will/can this course be offered via Distance Learning?

    This course is offered through Distance Learning.

- Grading Criteria

    Grading criteria (select from checklist); include a statement describing the criteria that will be used to assess students and how the final grade will be determined. Add and delete rows as needed.

        - exams
        - projects

    ▶ Describe the criteria that will be used to assess students and how the final grade will be determined:

    The final grade is dominated by the performance of the projects, which generally accounts for 70% of the final grade. The midterm and final exam are often weighted at 15% each.

C. Prerequisite(s):

List prerequisites and/or experiences/background required. If no prerequisites are indicated, provide an explanation for their absence. Add bullets as needed.

- Graduate Standing or Consent of Instructor
- Prerequisite by Topic: Basic knowledge of ordinary differential equations, solution of ODEs using numerical methods, state-space system representation, basic feedback control design with frequency domain methods, reference frame theory, some knowledge of rotating electric machinery

D. Course Instructor(s):

Provide the name, rank, and department/program affiliation of the instructor(s). Is the instructor currently a member of the Graduate Faculty? (If the answer is no, indicate when it is expected that a request will be submitted.) Add rows as needed.

Name	Rank	Dept.	Graduate Faculty or expected date
Scott Sudhoff	Professor	ECEN	Yes

E. Course Outline:

Provide an outline of topics to be covered and indicate the relative amount of time or emphasis devoted to each topic. If laboratory of field experiences are used to supplement a lecture course, explain the value of the experience(s) to enhance the quality of the course and student learning. For special topics courses, include a sample outline of a course that would be offered under the proposed course. **(This information must be listed and may be copied from syllabus).**

Weeks	Principal Topics
2	**Basic Tools**
	GOSET for Single and Multi-Objective Optimization
	Simulink for Time-Domain Simulation
2	**DC-DC Conversion**
	Buck Converters
	Waveform-Level Modeling
	Average-Value Modeling
	Control Design Case Study
4	**Controlled DC-AC and AC-DC Conversion**
	The Three-Phase Bridge Inverter
	Waveform-Level Modeling
	Average-Value Modeling
	Control Design Case Study: Ship Service Inverter Module
	Review of Permanent Magnet AC Machine
	Control Design Case Study: PMAC DC Generation System
3	**Uncontrolled AC-DC and DC-AC Conversion**
	Line-Commutated Converters (LCCs)
	Operation of LCCs from Ideal Source
	Waveform Level Modeling of LCCs
	Average-Value Modeling of LCCs
	Synchronous Machine LCC Systems
3	**Special Topics (At Discretion of Class/Instructor)**
	Isolating DC/DC Converters
	Multi-level Converters
	Immittance Based Stability Methods
	Soft Switched and Resonant Converters
	Common Mode Effects
1	**Exams**

F. Reading List (including course text):

A primary reading list or bibliography should be limited to material the students will be required to read in order to successfully complete the course. It should not be a compilation of general reference material.

A secondary reading list or bibliography should include material students may use as background information.

- Primary Reading List
    - Krause, Wasynczuk, Sudhoff, Pekarek, *Analysis of Electric Machinery and Drive Systems, Third Edition*, IEEE Press/John Wiley & Sons, 2013, ISBN 978-1-118-02429-4.
- Secondary Reading List
    - S.D. Sudhoff and K.A. Corzine, H.J. Hegner, D.E. Delisle, "Transient and Dynamic Average-Value Modeling of Synchronous Machine Fed Load-Commutated Converters," IEEE Transactions on Energy Conversion, Vol. 11, No. 3, September 1996, pp. 508-514.
    - O. Wasynczuk, S.D. Sudhoff, T.D. Tran, D.H. Clayton, and H.J. Hegner, "A Voltage Control Strategy for Current-Regulated PWM Inverters," IEEE Transactions on Power Electronics,Vo. 11, No. 1, January 1996, pp. 7-15.
    - S.D. Sudhoff, *Immittance Based Stability Analysis of Power Electronic Based Systems*, unpublished monograph.
    - S.H. Zak, *Systems and Control*, Oxford University Press, 2003 (Chapter 4)
    - Chong, Zak, *An Introduction to Optimization*, Wiley InterScience, 2001.
    - Sudhoff, GOSET Manual, Version 2.2

G. Library Resources

Describe any library resources that are currently available or the resources needed to support this proposed course.

H. Course Syllabus

(While not a necessary component of this supporting document, an example of a course syllabus is available, for information, by clicking on the link below, which goes to the *Graduate School's Policies and Procedures Manual for Administering Graduate Student Program.*
See Appendix K.
http://www.purdue.edu/gradschool/faculty/documents/Graduate_School_Policies_and_Procedures_Manual.pdf