2012-2013 LONG SIGNATURE SHEET

UNC CHARLOTTE

Proposal Number: ECE 9-17-12

Proposal Title: Establishment of MSEE graduate concentration in Power and Energy Systems

Originating Department: Electrical and Computer Engineering

TYPE OF PROPOSAL: UNDERGRADUATE_____ GRADUATE ✓ UNDERGRADUATE & GRADUATE____
(Separate proposals sent to UCCC and Grad. Council)

DATE RECEIVED	DATE CONSIDERED	DATE FORWARDED	ACTION	SIGNATURES
9/17/12	9/17/12	9/17/12	*Approved*	DEPARTMENT CHAIR [signature] [print name here:] Ian Ferguson
9/28/12	10/3/12	~~10/3/12~~ 10/5/12	*Approved*	COLLEGE CURRICULUM COMMITTEE CHAIR [signature] [print name here:] ASIS NASIPURI
10/11/12	10/15/12	10/15/12	*Approved*	COLLEGE FACULTY CHAIR (if applicable) [signature] [print name here:] Jeff Kimble
10/18/12	10/18/12	10/18/12	*Approved*	COLLEGE DEAN [signature] [print name here:]
			Approved	GENERAL EDUCATION (if applicable; for General Education courses) [print name here:]
			Approved	UNDERGRADUATE COURSE & CURRICULUM COMMITTEE CHAIR (for undergraduate courses only)
1-14-13	2-5-13	2-18-13	*Approved*	GRADUATE COUNCIL CHAIR (for graduate courses only) Rob Roy McGregor
				FACULTY GOVERNANCE ASSISTANT (Faculty Council approval on Consent Calendar)
				FACULTY EXECUTIVE COMMITTEE (if decision is appealed)

Revised 08/10/12
OAA/lz

LONG FORM
COURSE AND CURRICULUM PROPOSAL

*To: Chair of the Graduate Council

From: Asis Nasipuri, ECE

Date: September 17, 2012

Re: Proposal for establishment of MSEE graduate concentration in Power and Energy Systems

The Long Form is used for major curriculum changes. Examples of major changes can include: creation of a new major, creation of a new minor, creation of a new area of concentration, or significant changes (more than 50%) to an existing program (Note: changing the name of an academic department does not automatically change the name(s) of the degree(s). The requests must be approved separately by the Board of Governors.)

Submission of this Long Form indicates review and assessment of the proposed curriculum changes at the department and collegiate level either separately or as part of ongoing assessment efforts.

University of North Carolina at Charlotte

Revised Graduate Course and Curriculum Proposal from: Department of Electrical and Computer Engineering

Proposal Number ECE 9-17-12

Title: Establishment of MSEE graduate concentration in Power and Energy Systems.

A. Proposal Summary and Catalog Copy

1. Summary

The Department of Electrical and Computer Engineering proposes to create a graduate concentration on Power and Energy System in the Master of Science in Electrical Engineering (MSEE) program. The proposed graduate concentration requires taking a prescribed set of core and elective courses on the sub-discipline.

This proposal also includes the addition of the following new graduate courses, which are included in the proposed Graduate Concentration in Power and Energy Systems:

- ECGR 5144: Power Electronics
- ECGR 6144/8144: Electric Power Distribution Systems-I
- ECGR 6145/8145: Electric Power Distribution Systems-II
- ECGR 6146/8146: Smart Grid: Characteristics, Design and Analysis
- ECGR 6147/8147: Power System Stability and Control
- ECGR 6197/8197: Power Electronics II
- ECGR 6198/8198: Design of Renewable Energy Electromagnetic Devices
- ECGR 6199/8199: Dynamics and Control of AC Drives

2. Proposed Catalog Copy

The following text is to be added to the end of the MSEE section of the graduate catalog:

Graduate Concentration in Power and Energy Systems

The Electrical and Computer Engineering department offers a Graduate Concentration in Power and Energy Systems, which requires taking a set of core and elective courses as described below. Students who elect to pursue the Graduate Concentration in Power and Energy Systems towards their MSEE degree will primarily take course work in modern power and energy systems, devices modeling, analysis, protection and control. This concentration prepares students for jobs with power utilities, power and energy devices manufacturing companies, national and regional laboratories, or for continued academic training in power and energy fields. The graduate concentration will be reflected in the student's transcript upon successful completion of the MSEE program. Students interested in earning their MSEE degree with the graduate concentration must indicate their interest in this option in their Plan of Study that must be submitted within their second semester into the MSEE program. The MSEE degree can also be earned without specifying a concentration, where the student has greater flexibility in selecting their courses.

There are two course tracks for the Graduate Concentration in Power and Energy Systems: (a) the Power Systems track, and (b) the Power Electronics and Machines track. In order to earn an MSEE degree with a graduate concentration in Power and Energy Systems, a student must take the four core courses from one of these course tracks and a minimum of three courses from the list of elective courses as described below.

Core courses in the Power Systems track:
ECGR 5142: Power Generation Operation and Control
ECGR 5104: Computational Methods in Power Systems
ECGR 5194: Power System Analysis II
ECGR 6144: Electric Power Distribution Systems-I

Note: students who opt to take the Power Systems course track are expected to have taken the following courses or their equivalents before entering the Master's program: ECGR4141: Power System Analysis I, ECGR4143: Electric Machinery, ECGR4144: Power Electronics-I. If a student has not taken these courses or their equivalents, the student must take their graduate equivalents as elective courses for the graduate concentration or obtain permission from their advisor.

Core courses in the Power Electronics and Machines track:
ECGR 5144: Power Electronics
ECGR 5195: Electric Machinery
ECGR 6197: Power Electronics II
ECGR 6199: Dynamics and Control of AC Drives

Note: students who opt to take the Power Electronics and Machines course track are required to have taken ECGR4141: Power System Analysis or its equivalent, before entering the Master's program. If a student has not taken this course or its equivalent, the student must take its graduate equivalent as an elective course for the graduate concentration or obtain permission from their advisor.

Elective Courses that can be taken for both tracks:
ECGR 5104: Computational Methods in Power Systems
ECGR 5112: Nonlinear Analysis
ECGR 5142: Power Generation Operation and Control
ECGR 5188: Modeling and Analysis of Dynamic Systems
ECGR 5194: Power System Analysis II
ECGR 5411: Control Systems Theory I
ECGR 5412: Control System Theory II
ECGR 6141: Power System Protection
ECGR 6144: Electrics Power Distribution Systems-I
ECGR 6147: Power System Stability and Control
ECGR 6146: Smart Grid: Characteristics, Design and Analysis
ECGR 6198: Design of Renewable Energy Electromagnetic Devices
ECGR 6145: Electric Power Distribution Systems-II
ECGR 6111: Linear Systems
ECGR 6115: Optimal Control Theory I
ECGR 6116: Optimal Control Theory II
ECGR 6117: Multivariable Controls

With written permission from their advisor a student may request to take one course outside of the listed course electives.

Students are advised to review the ECE graduate program web pages for updates and additions to the list of electives.

In addition to the seven courses from the above lists, students seeking a graduate concentration must also complete the general requirements for the MSEE degree for their chosen option. This involves taking 9 credits of thesis, if taking the thesis option; three credits of individualized studies and projects plus two additional courses as approved by the advisor, if taking the project option; and three additional courses approved by the advisor and pass the comprehensive examinations, if taking the comprehensive examinations option.

B. Justification

The Charlotte region as well as the nation is going through an unprecedented resurgence of interest on power and energy systems. This is primarily initiated by the emerging need for high quality trained professionals in the power and energy industry, but is also due to the global need for development of technologies for a higher capacity and more efficient power infrastructure. Consequently, the ECE department is experiencing increasing interest from incoming graduate students towards a concentration in power and energy systems. To foster the growth in this sub-discipline, the ECE department has initiated a number of activities for expanding its education and training functions in this area that includes development of new courses and laboratories. In addition, the department proposes to offer a graduate concentration in power and energy systems that will improve the scope and quality of the Master of Science in Electrical Engineering program in two ways:

a) First, the graduate concentration will allow students to formally define their specialization in the corresponding sub-discipline, i.e. Power and Energy Systems. This will allow students to maintain their focus on relevant core and elective courses and strengthen their knowledge base based on the concentration curriculum.

b) The department can ensure that core courses are offered frequently and will have a larger number of students committed to taking these courses.

The proposed concentration will allow electrical engineers to sequentially take fundamental and advanced courses. Students interested to specialize in this sub-discipline can align their plan of study right from undergraduate level. The proposed concentration also formalizes existing courses and provides pathways for students to seamlessly integrate the undergraduate curriculum with a concentration in power and energy systems. There is significant need for advancing education and technical training in this area of concentration, particularly in the Charlotte region.

All graduate students enrolled in the MSEE program will be eligible for the graduate concentration in power and energy systems. The graduate concentration will not have any additional admission requirements other than those for admission to the MSEE program.

The graduate concentration includes the addition of seven graduate level courses at the 6000 and 8000 levels, which are consistent with course numbering at the Master’s and PhD levels, and one graduate course at the 5000 level that is cross-listed with an equivalent undergraduate course at the 4000 level. These course numberings are consistent with that of similar courses at the corresponding levels. Individual long-form proposals for each of these courses are attached at the end of this proposal.

C. Impact

The graduate concentration in Power and Energy Systems will be available to graduate students in the MSEE program. It will not affect any other graduate program directly. Based on current enrollments of graduate students in similar courses, it is anticipated that approximately 10 – 15 students will opt for the graduate concentration each year. The expected number of students in the proposed graduate courses would be 15 – 20 for the core courses and 10 – 15 for the electives. Since this concentration will serve only those students who are interested to specialize in power and energy systems, it will not affect the enrollments in other graduate courses.

The proposed graduate concentration will prepare students for jobs in power and energy systems with power utilities, power and energy devices manufacturing companies, national and regional laboratories, or for continued academic training in power and energy fields. There is a growing need for trained professionals on power and energy systems, and hence, this concentration will have a significant impact in the Charlotte region, the state of North of Carolina, and beyond.

D. Resources Required to Support Proposal

1. Personnel: No additional resources required
2. Physical facility: No additional resources required
3. Equipment and Supplies: No additional resources required
4. Computer: No additional resources required
5. Audio-visual: No additional resources required

E. Consultation with the Library and Other Departments or Units

Library consultation forms for the proposed graduate courses are attached at the end of each of course proposal. Since this proposal for the graduate concentration does not affect any other program, consultation with other departments is not required.

F. Initiation and Consideration of the Proposal

1. This proposal was initiated by the Energy and Power Systems TTG (Technical Thrust Group) within the Electrical and Computer Engineering department.
2. The faculty of Electrical and Computer Engineering has reviewed the proposal and has approved this proposal on 4/13/2012.
3. The appropriate faculty committee has reviewed the attached course outlines/syllabi and has determined that the assignments are sufficient to meet the University definition of a credit hour.

G. Attachments

1. ATTACHMENT-1: Proposed catalog copy for graduate programs in Electrical Engineering, which includes the proposed description of the graduate concentration, marked in blue.
2. ATTACHMENT-2: Proposal for new graduate courses on (a) ECGR 5144: Power Electronics-I, and (b) ECGR 6197/8197 Power Electronics II
3. ATTACHMENT-3: Proposal for new graduate courses on (a) ECGR 6144/8144: Electric Power Distribution Systems-I, and (b) ECGR 6145/8145: Electric Power Distribution Systems-I
4. ATTACHMENT-4: Proposal for new graduate courses on ECGR 6146/8146: Smart Grid: Characteristics, Design and Analysis
5. ATTACHMENT-5: Proposal for new graduate courses on ECGR 6147/8147: Power System Stability and Control
6. ATTACHMENT-6: Proposal for new graduate courses on ECGR 6198/8198: Design of Renewable Energy Electromagnetic Devices
7. ATTACHMENT-7: Proposal for new graduate courses on ECGR 6199/8199: Dynamics and Control of AC Drives
8. ATTACHMENT-8: Graduate Student Learning Outcomes for MSEE. The proposed graduate courses will all support SLO#1. However, no changes in the SLOs or assessment for the degree program are necessary.

ATTACHMENT-1:

Proposed catalog copy for graduate programs in Electrical Engineering, which includes the proposed description of the graduate concentration, marked in blue.

Electrical Engineering

- **Ph.D. in Electrical Engineering**
- **M.S. in Electrical Engineering (MSEE)**
- **M.S. in Engineering (MSE)**

Department of Electrical and Computer Engineering

246 Woodward Hall
(704) 687-8593
http://ece.uncc.edu

Graduate Programs Director

Dr. Asis Nasipuri

Graduate Faculty

Ian Ferguson, Professor and Chair
Ryan Adams, Assistant Professor
David Binkley, Professor
Jonathan Bird, Assistant Professor
Steve Bobbio, Professor
Lee Casperson, Emeritus
Valentina Cecchi, Assistant Professor
James Conrad, Associate Professor
Robert Cox, Assistant Professor
Kasra Daneshvar, Professor
Abasifreke Ebong, Professor
Johan Enslin, Professor
Michael Fiddy, Professor
Mohamed-Ali Hasan, Associate Professor
Ivan Howitt, Associate Professor
Eric Johnson, Professor
Bharat Joshi, Associate Professor
Aravind Kailas, Assistant Professor
Yogendra P. Kakad, Professor
Sukumar Kamalasadan, Associate Professor
Vasilije Lukic, Professor
Mehdi Miri, Associate Professor
Arindam Mukherjee, Associate Professor
Asis Nasipuri, Associate Professor
Arun Ravindran, Associate Professor
Zia Salami, Associate Professor
Ronald Sass, Associate Professor
Edward B. Stokes, Professor
Farid Tranjan, Professor
Raphael Tsu, Distinguished Professor
Thomas P. Weldon, Associate Professor
Andrew Willis, Associate Professor
Jiang (Linda) Xie, Associate Professor
Yong Zhang, Bissell Distinguished Professor

The Department of Electrical and Computer Engineering offers programs leading to M.S. and Ph.D. degrees in Electrical Engineering. The department provides unsurpassed education to its students, preparing them for careers in high-tech industries or academia. The Ph.D. program is focused on providing research expertise, and is designed to impart the aptitude and confidence for generating new knowledge and practices in a chosen research area. The Master's degree can be earned by successfully completing 30 credits of approved graduate coursework, which can be completed either under the thesis or non-thesis options. Our students are provided with both breadth of knowledge in Electrical and Computer Engineering and related areas and depth of knowledge in the chosen research specialty. The department is staffed with a prestigious faculty conducting research in a number of areas that include circuits and electronics, communications and signal processing, computer engineering, control systems, microelectronics, optics and optoelectronics, power and energy systems. A full range of state-of-the-art laboratories is available enabling faculty and students to conduct research at the cutting edge of technology.

PH.D. IN ELECTRICAL ENGINEERING

The Ph.D. program is designed to provide the students with research-level expertise in a focus area within electrical and computer engineering and breadth of knowledge in areas related to the focus area. In addition to taking a set of courses in a chosen area of concentration, a key aspect of the doctoral degree is the student's research dissertation. Each dissertation is expected to be a significant original contribution on research on a chosen subject, which usually leads to one or more archival publications. Successful doctoral candidates learn how to acquire advanced knowledge from published research articles, identify research problems, formulate plausible approaches to solve them, analyze and evaluate proposed solutions, and present technical material orally and in writing.

Additional Admission Requirements

In addition to the general requirements for admission to the Graduate School, the Electrical and Computer Engineering department seeks the following from applicants to the Ph.D. program in Electrical Engineering:

1) A master's degree in electrical and/or computer engineering or a closely allied field, demonstrating strong academic background for performing research in a chosen area of interest. Exceptional students with only a baccalaureate degree who are motivated to pursue a Ph.D. may also be considered for direct admission to the Ph.D. program.
2) The applicant must receive satisfactory scores on the quantitative and verbal sections of the Graduate Record Examinations General Test.
3) The statement of purpose, written by the applicant, must specify the applicant's research interests within Electrical and Computer Engineering.

Degree Requirements

The following is a chronologically ordered set of requirements for the Ph.D. degree in Electrical Engineering:

1) Appointment of a Ph.D. advisor and formation of an advisory committee.
2) Development of a Ph.D. Plan of Study detailing all course and examination requirements.
3) Successful completion of the qualifying examinations.
4) Presentation of a proposal for Ph.D. research and admission to candidacy.
5) Successful defense of the Ph.D. Dissertation.

Within the first semester of being admitted into a Ph.D. program, the student should choose a Ph.D. advisor and form an advisory committee. In conjunction with the Ph.D. advisor and this advisory committee, the student will develop a Plan of Study to meet the Ph.D. program requirements of coursework and examinations and prepare to undertake original research leading to a doctoral dissertation. Normally, a student would be expected to have at least one archival publication on the research performed for the dissertation.

Plan of Study

The Plan of Study must be submitted to the Director of Graduate Programs for review and approval within the second semester of enrollment in the Ph.D. program. The Plan of Study must show a minimum of 72 hours of credit beyond the Baccalaureate degree, including 18 hours of doctoral dissertation credits. At least 12 hours of coursework must be taken after admission to the Ph.D. program. The specific course requirements will be set by the student's Advisory Committee. Doctoral students should take 8000-level courses when they are available. 6000 and 5000 level graduate courses that do not have 8000-level counterparts may also be counted towards the doctoral degree if approved by the Advisory Committee. For students who do not possess bachelor's and/or master's degrees in appropriate fields of study, additional coursework may be required. Courses taken without the approval of the advisory committee may not be counted toward the degree.

Grades

A student must have a GPA of at least a 3.0 in order to graduate. The dissertation is graded on a Pass/Unsatisfactory basis and, therefore, will not be included in the cumulative GPA. An accumulation of more than two marginal (C) grades will result in suspension of the student's enrollment in the graduate program. If a student makes a grade of U on any course, enrollment will be suspended. A graduate student whose enrollment has been suspended because of grades is ineligible to attend any semester or summer session unless properly readmitted to the graduate program. Readmission to the program requires approval of the Dean of the Graduate School upon the recommendation of the student's major department.

Residence

A student may satisfy the residency requirement for the program by completing 18 hours, either coursework or research credits, by study-in-residence during the academic year and during the summer terms, as long as the study is continuous. Study-in-residence is deemed to be continuous if the student is enrolled in one or more courses (including research/dissertation credit) in successive semesters until eighteen hours of credit are earned.

Qualifying Examination

In addition to demonstrating a high level of competence in coursework, the student must pass the Ph.D. qualifying examinations. The qualifying examination should be taken before completion of 24 hours beyond the master's degree but must be passed no later than four semesters after initial enrollment in the program. Failure to pass the qualifying examination after two attempts will result in the termination of the student's enrollment in the Ph.D. program.

The qualifying examination is divided into two test sessions. The first session comprises of a written examination on the breadth areas of electrical and computer engineering, and the second session is a research aptitude test that comprises of a technical presentation. . For a detailed description of the procedures for the Ph.D. qualifying examinations in electrical and computer engineering please contact the ECE department or visit ece.uncc.edu.

Dissertation Proposal and Admission to Candidacy

Because the Ph.D. program is heavily based on independent research, each student must write a proposal describing his/her proposed dissertation research following the technical guidelines established by the department. The proposal must be presented to and orally defended before the student's advisory committee. The proposal must be presented within one year after the qualifying examination is passed. Upon approval of the student's dissertation proposal, the advisory committee will recommend the student's admission to candidacy subject to the approval of the Engineering Doctoral Graduate Committee and the Dean of the Graduate School. It is the responsibility of the student to file the Admission to Candidacy form to the Graduate School by the filing date specified in the University Academic Calendar.

Dissertation

Evidence of a high degree of competence in scholarship, written exposition, independent inquiry and the ability to organize and apply knowledge must be demonstrated by the student in the dissertation. The student will make a public defense of the dissertation at which time the dissertation, as well as the student's knowledge of the field, will be appropriate matter for examination by the student's advisory committee. Although questions may be asked by the general audience, evaluation of the dissertation defense is the sole responsibility of the advisory committee. The dissertation will be graded on a Pass/Unsatisfactory basis.

Application for Degree

Students preparing to graduate must submit an online Application for Degree by the filing date specified in the University Academic Calendar. If a student does not graduate in the semester identified on the Application for Degree, then the student must update his/her Admission to Candidacy and submit a new Application for Degree for graduation in a subsequent semester.

Time Limit

Students are allowed a maximum of eight (8) calendar years from formal admission to the Ph.D. program to complete the program successfully.

Assistantships

There are two forms of assistantships that are offered by the ECE Department. These are Teaching Assistantships (TAs) and Research Assistantships (RAs). RAs are controlled by faculty members with research grants, and the faculty members make the decisions in selecting students for RAs. Therefore, for RAs, students should contact individual faculty members directly. TAs are given to students to help faculty members with classroom teaching or laboratory instruction and these allocations are related to the ECE department needs and available resources. In all cases, the TAs and RAs are awarded to exceptional students. Application forms are available online at ece.uncc.edu.

Tuition Waivers

For exceptionally qualified candidates who are awarded TAs or RAs, a limited number of tuition awards are available on a competitive basis.

MASTER'S PROGRAMS IN ELECTRICAL ENGINEERING

The Master's programs are designed to provide technical expertise in a specific area of electrical and computer engineering as well as breadth of knowledge in supporting areas. The thesis option provides the students the opportunity to work on a research project that culminates in the publishing of a thesis. The non-thesis option is designed to provide additional breadth in areas that support the chosen focus area. It is also the goal of the program to graduate engineers with effective problem solving and communication skills.

Additional Admission Requirements

In addition to the general requirements for admission to the Graduate School, the Department of Electrical and Computer Engineering seeks the following from applicants to the Master's programs in Electrical Engineering:

Applicants should have baccalaureate degrees in electrical and/or computer engineering with a GPA of at least 3.0 out of 4.0. Applicants must have satisfactory scores in the quantitative and verbal sections of the Graduate Record Examinations general test.

Applicants with baccalaureate degrees in fields closely related to electrical and computer engineering (e.g., electronics, computer science, mathematics, physics, etc.) may also be considered. However, satisfactory evidence on the aptitude to pursue graduate studies in electrical and computer engineering must be demonstrated. If additional preparatory courses are required, such courses should be taken before applying for the MSEE.

Admission is based on the overall background, motivation, and potential, as determined by the department.

Early Entry to the Graduate School

Exceptional undergraduate students of UNC Charlotte may be accepted into the graduate program and begin work towards a graduate degree before completion of their baccalaureate degree. An early entry student may take up to six hours of graduate coursework that will be counted towards his/her undergraduate hours and also towards his/her graduate degree, i.e., up to six credits of graduate coursework may be "double counted" for both baccalaureate and graduate degrees.

An applicant may be accepted at any time after completion of 75 or more hours, although it is expected that close to 90 hours will have been earned by the time the first graduate course is taken. To be accepted into this program, an undergraduate student must have an overall GPA of at least 3.2 and have earned satisfactory scores in the Graduate Record Examinations general tests. If any early-entry student does not meet the normal admission requirements of a 3.0 ~~2.75~~ overall undergraduate GPA ~~and a 3.0 junior-senior GPA~~ at the end of his/her baccalaureate degree, he/she will be dismissed from the graduate program.

M.S.E.E. Degree Requirements

The M.S.E.E degree is awarded to those students who complete the M.S. program of the Department of Electrical and Computer Engineering. Students admitted to the M.S. program who do not have a B.S. degree in electrical or computer engineering or related field, may need to take undergraduate preparatory courses in order to succeed in their graduate studies.

Thesis and Non-Thesis Options

Students may pursue either the thesis or non-thesis option for a Master's degree in Electrical Engineering. In the thesis option, the student must complete 9 hours of thesis research. Alternatively, the student may complete the requirements of a Master's degree under the non-thesis option by taking 30 credits of coursework only, or by taking 27 credits of coursework along with three credits of individualized project work.

Degree Requirements for the Thesis Option

1) Plan of Study - the student must meet with his/her advisor to formulate a plan of study and get the committee's approval. The plan of study must be submitted after completing at least 9 but no more than 18 semester credits.
2) Satisfactory completion of 30 hours of approved graduate credits in major or related area of study including 9 hours of thesis.
3) Not more than 6 credits may be taken from outside the electrical and computer engineering department.

4) Admission to candidacy - the Admission to Candidacy form must be completed prior to the thesis defense. The student should consult the schedule of classes for deadlines on submitting this form for fall or spring graduation.
5) Thesis Defense - a copy of the thesis should be distributed to each member of the program committee at least two weeks prior to the defense. The student should make a public announcement of the defense within the department to allow attendance by interested faculty members and students of electrical and computer engineering.

Degree Requirements for the Non-Thesis Option

1) Plan of Study - the student must meet with his/her advisor to formulate a plan of study and get the committee's approval. The plan of study must be submitted after completing at least 9 but no more than 18 semester credits.
2) Satisfactory completion of 30 hours of approved graduate credits. At least 21 hours of courses must be in the ECE department.
3) A student may take up to three credits of individualized project that will require a written report and an oral presentation. Alternately, the student may take all 30 credits of coursework.
4) Admission to candidacy - the admission to candidacy form must be completed prior to the oral exam. The student should consult the schedule of classes for deadlines on submitting this form for fall or spring graduation.
5) The student must pass a written exam (for coursework only) or an oral exam/presentation (for project) that will be administered by the program advisory committee.

Program Committee

For the thesis and non-thesis project options, the student must select a program committee that is composed of at least 3 members of the graduate faculty, the majority of whom must be members of the Electrical and Computer Engineering department. The graduate program advisor generally serves as the chairman of the committee. For the non-thesis coursework only option, the advisor alone plays the roles of the committee (i.e., no other members are required).

Admission to Candidacy Requirements

Each student must file an Admission to Candidacy Form to the Graduate School by the filing date specified in the University Academic Calendar.

Application for Degree

Students preparing to graduate must submit an online Application for Degree by the filing date specified in the University Calendar. If a student does not graduate in the semester identified on the Application for Degree, then the student must update his/her Admission to Candidacy and submit a new Application for Degree for graduation in a subsequent semester.

Graduate Concentration in Power and Energy Systems

The Electrical and Computer Engineering department offers a Graduate Concentration in Power and Energy Systems, which requires taking a set of core and elective courses as described below. Students who elect to pursue the Graduate Concentration in Power and Energy Systems towards their MSEE degree will primarily take course work in modern power and energy systems, devices modeling, analysis, protection and control. This concentration prepares students for jobs with power utilities, power and energy devices manufacturing companies, national and regional laboratories, or for continued academic training in power and energy fields. The graduate concentration will be reflected in the student's transcript upon successful completion of the MSEE program. Students interested in earning their MSEE degree with the graduate concentration must indicate their interest in this option in their Plan of Study that must be submitted within their second semester into the MSEE program. The MSEE degree can also be earned without specifying a concentration, where the student has greater flexibility in selecting their courses.

There are two course tracks for the Graduate Concentration in Power and Energy Systems: (a) the Power Systems track, and (b) the Power Electronics and Machines track. In order to earn an MSEE degree with a graduate concentration in Power and Energy Systems, a student must take the four core courses from one of these course tracks and a minimum of three courses from the list of elective courses as described below.

Core courses in the Power Systems track:
ECGR 5142: Power Generation Operation and Control
ECGR 5104: Computational Methods in Power Systems
ECGR 5194: Power System Analysis II
ECGR 6144: Electric Power Distribution Systems-I

Note: students who opt to take the Power Systems course track are expected to have taken the following courses or their equivalents before entering the Master's program: ECGR4141: Power System Analysis I, ECGR4143: Electric Machinery, ECGR4144: Power Electronics-I. If a student has not taken these courses or their equivalents, the student must take their graduate equivalents as elective courses for the graduate concentration or obtain permission from their advisor.

Core courses in the Power Electronics and Machines track:
ECGR 5144: Power Electronics
ECGR 5195: Electric Machinery
ECGR 6197: Power Electronics II
ECGR 6199: Dynamics and Control of AC Drives

Note: students who opt to take the Power Electronics and Machines course track are required to have taken ECGR4141: Power System Analysis or its equivalent, before entering the Master's program. If a student has not taken this course or its equivalent, the student must take its graduate equivalent as an elective course for the graduate concentration or obtain permission from their advisor.

Elective Courses that can be taken for both tracks:
ECGR 5104: Computational Methods in Power Systems
ECGR 5112: Nonlinear Analysis
ECGR 5142: Power Generation Operation and Control
ECGR 5188: Modeling and Analysis of Dynamic Systems
ECGR 5194: Power System Analysis II
ECGR 5411: Control Systems Theory I
ECGR 5412: Control System Theory II
ECGR 6141: Power System Protection
ECGR 6144: Electrics Power Distribution Systems-I
ECGR 6147: Power System Stability and Control
ECGR 6146: Smart Grid: Characteristics, Design and Analysis
ECGR 6198: Design of Renewable Energy Electromagnetic Devices
ECGR 6145: Electric Power Distribution Systems-II
ECGR 6111: Linear Systems
ECGR 6115: Optimal Control Theory I
ECGR 6116: Optimal Control Theory II
ECGR 6117: Multivariable Controls

With written permission from their advisor a student may request to take one course outside of the listed course electives.

Students are advised to review the ECE graduate program web pages for updates and additions to the list of electives.

In addition to the seven courses from the above lists, students seeking a graduate concentration must also complete the general requirements for the MSEE degree for their chosen option. This involves taking 9 credits of thesis, if taking the thesis option; three credits of individualized studies and projects plus two additional courses as approved by the advisor, if taking the project option; and three additional courses approved by the advisor and pass the comprehensive examinations, if taking the comprehensive examinations option.

ATTACHMENT-2:

Proposal for new graduate courses on (a) ECGR 5144: Power Electronics-I, and (b) ECGR 6197/8197 Power Electronics II

University of North Carolina at Charlotte

Proposal for New Graduate Course

Course and Curriculum Proposal from: Department of Electrical and Computer Engineering

Title: *New Graduate Two-Course Sequence on Power Electronics*

A. PROPOSAL SUMMARY AND CATALOG COPY

1. **SUMMARY:** The Electrical and Computer Engineering Department proposes to add two new elective courses to the graduate curriculum:
   - ECGR 5144: Power Electronics I
   - ECGR 6197/8197: Power Electronics II

2. **PROPOSED CATALOG COPY: ECGR 5144. Power Electronics I (3).** Prerequisite: Graduate standing and knowledge of fundamentals of electric circuit analysis and electronics, or permission from the department. High power solid state circuits. Topics include power transfer, DC/DC converters, DC/AC inverters for use in resonant converters and motor drives, AC/DC rectifiers, gate-drive circuits for linear and switching amplifiers, pulse-width modulators, introduction to power supply design correction Credit will not be given for ECGR 5144 where credit has been given for ECGR 4144. (*Spring*).

   PROPOSED CATALOG COPY: ECGR 6197. Power Electronics II (3). Prerequisite: Graduate standing, knowledge of fundamentals of power electronics and basics of semiconductor physics, and ECGR 5144, or permission from the department. This course focuses on more advanced topics in power electronics. Topics include converter modeling and control, advanced concepts in magnetic circuit design, gate and base drives, switching losses, resonant converters, zero-voltage and zero-current switching, utility-interfaced applications including FACTS, maximum power-point tracking, and power factor correction Credit will not be given for ECGR 6197 where credit has been given for ECGR 8197. (*Fall*)

   PROPOSED CATALOG COPY: ECGR 8197. Power Electronics II (3). See ECGR 6197 for Course Description. Credit will not be given for ECGR 8197 where credit has been given for ECGR 6197.

B. JUSTIFICATION

1. Identify the need addressed by the proposal and explain how the proposed action meets the need: In recent years, there has been a tremendous growth in the field of power electronics. There are several reasons for this. First, the drive for increased energy efficiency in many applications and power electronics can deliver this efficiency in lighting and motor applications. Second, power electronics are required to interface distributed generation resources and energy-storage sources such as photovoltaics, wind turbines, and batteries into the AC power grid. Power electronics are thus identified as one of the key enabling technologies for the Smart Grid. For this latter reason, it is essential that even students with an emphasis on power systems become familiar with power electronics.

   For these reasons, the two-course sequence is proposed to introduce electrical engineering graduate students to formal studies in power electronics. Specific goals are for the students to:
   - understand basic power electronic circuit topologies, including DC/DC, AC/DC, DC/AC, and AC/AC converters
   - understand and design magnetic components,
   - understand and design basic power supplies,
   - understand the issues affecting the efficiency of power conversion,
   - gain familiarity with key power-electronic applications

2. Discuss prerequisites/corequisites for course(s) including class-standing: ECGR 5144 – Prerequisite: Graduate standing and knowledge of fundamentals of electric circuit analysis and electronics, or permission from the department. ECGR 6197/8197– Prerequisites: Graduate standing, knowledge of fundamentals of power electronics and basic semiconductor physics, and ECGR 5144, or permission from the department.

   ECGR 5144 is cross-listed with ECGR 4144. Students in the graduate-level course will be expected to have a more thorough understanding of circuit analysis and electronics consistent with a student that has completed a BS in Electrical Engineering.

3. Demonstrate that course numbering is consistent with the level of academic advancement of students for whom it is intended: The course numberings ECGR 5144 and ECGR 6197/8197 are consistent with the level of academic advancement of graduate students, for whom these courses are intended.

   ECGR 5144 is cross-listed with ECGR 4144. Students in the graduate-level course will attend the same lectures, but will be given additional problems on each assignment. The most important distinction comes in the final project. At the end of the semester, students in 4144 complete a design project in which they proceed from specifications to complete a paper design of a power supply. This power supply is then simulated in software. ECGR 5144 students, on the other hand, must physically construct their power supply and verify that it meets the required specifications. This activity is significantly more challenging for several reasons. Most importantly, all power supplies suffer from a number of practical problems, including thermal-management issues and problems associated with start-up. The simulations performed by the undergraduates are forgiving on these points. The graduate students have two additional lectures on these issues, and they must understand how to overcome them. The graduate student outcome is thus different – a graduate student must demonstrate an understanding of how to reduce a design to practice. An undergraduate student, on the other hand, must only demonstrate an understanding of the concepts involved in design. An undergraduate should have knowledge sufficient to move forward into practical design issues in graduate school.

4. In general, how will this proposal improve the scope, quality and/or efficiency of programs and/or instruction: Presently, there are no graduate courses in the area of power electronics in the ECE Department at UNCC. Most ECE and EE programs throughout the country, however, do have such courses. The proposed two-course sequence will fit our current Departmental needs and complement existing offerings in the areas of power systems and electronics. These courses will be important components in the graduate curriculum for the Power Systems concentration in the ECE Department. These courses can effectively educate students to be the next-generation workforce in a variety of industries, including Smart Grid and renewable energy integration companies, and prepare them for advanced research in the field of power electronics and power systems.

C. IMPACT

1. What group(s) of students will be served by this proposal? This two-course sequence will serve graduate students in electrical and computer engineering with interest in power engineering and power and energy systems. This course will also serve students with an interest in analog circuit design, although they are not necessarily the primary audience.

2. What effect will this proposal have on existing courses and curricula? The proposed course will complement the existing courses on power systems and electric machines in the ECE Department and effectively prepare graduate students for further studies in advanced graduate courses in power and energy systems.

- **a.** When and how often will added course(s) be taught? According to the current demand and scheduling of courses, ECGR 5144 will be taught each Spring and ECGR 6197/8197 will be taught on demand in the Fall of alternating years.
- **b.** How will the content and/or frequency of offering of other courses be affected? None expected.
- **c.** What is the anticipated enrollment in course(s) added (for credit and auditors)? Typical enrollment expected to be 8-18 students for each course. This is consistent with current offerings of the equivalent Special Topics courses.

d. How will enrollment in other courses be affected? None expected. How did you determine this? Graduate students in electrical and computer engineering routinely express interest to cover power electronics in the curriculum. Because of this interest, ECGR 5144 has been offered as a special topics course each Spring since 2007 and ECGR 6197/8197 was offered as a special topics course in Fall 2010. Both courses were able to adequately able to fill the void in the curriculum.

e. If course(s) has been offered previously under special topics numbers, give details of experience including number of times taught and enrollment figures. The proposed two-course sequence is a modified form of two special topic courses that were taught in the following semesters with enrollments as shown:

- Power Electronics:
  - Spring 2007, Enrollment: 10 (10 M.S.)
  - Spring 2008, Enrollment: 10 (8 M.S., 2 Ph.D.)
  - Spring 2009, Enrollment: 6 (6 M.S.)
  - Spring 2010, Enrollment: 10 (10 M.S.)
  - Spring 2012, Enrollment: 6 (2 M.S., 4 Ph.D)
- Power Electronics II – Fall 2012, Enrollment: 15 (10 M.S., 5 Ph.D.)

f. Identify other areas of catalog copy that would be affected, e.g., curriculum outlines, requirements for the degree, etc. Cross-listing ECGR 5144 with ECGR 4144 (Note: ECGR 4144 is currently ECGR 3134 but the short form paper work for the corresponding change has been passed through the Department and is waiting for approval). Cross-listing ECGR 6197 with ECGR 8197 in the graduate catalog.

D. RESOURCES REQUIRED To Support PROPOSAL

1. Personnel

a. Specify requirements for new faculty, part-time teaching, student assistant and/or increased load on present faculty: None. The course sequence will be taught by one faculty member at no required increased teaching load and with no teaching assistant.

b. List by name qualified faculty members interested in teaching the course(s): Dr. Robert Cox and Dr. Jonathan Bird are among the qualified faculty members interested in teaching these courses.

2. Physical Facility: None

3. Equipment and Supplies: None

4. Computer: None

5. Audio-Visual: None

6. Other Resources: None

7. Indicate source(s) of funding for new/additional resources required to support this proposal: None required

E. CONSULTATION WITH THE LIBRARY AND OTHER DEPARTMENTS OR UNITS

1. Library Consultation
   Indicate written consultation with the Library Reference Staff at the departmental level to insure that library holdings are adequate to support the proposal prior to its leaving the department. (Attach copy of ***Consultation on Library Holdings***).

2. Consultation with other departments or units
   N/A

F. INITIATION AND CONSIDERATION OF THE PROPOSAL

1. Originating Unit
   Approved per attached signatures

2. Other Considering Units
   N/A

G. ATTACHMENTS

ECGR 5144 Syllabus

1. Course Number & Title: **ECGR 5144. Power Electronics**

2. Course Description (Catalog Description)**:**
   ECGR 5144. Power Electronics (3). Prerequisite: Graduate standing and knowledge of fundamentals of electric circuit analysis and electronics, or permission from the department. High power solid state circuits. Topics include power transfer, DC/DC converters, DC/AC inverters for use in resonant converters and motor drives, AC/DC rectifiers, gate-drive circuits for linear and switching amplifiers, pulse-width modulators, introduction to power supply design (*Spring*).

3. Prerequisites:
   Prerequisite: Graduate standing and knowledge of fundamentals of electric circuit analysis and electronics, or permission from the department.

4. Course Objectives:
   Broadly speaking, this subject refers to the conversion and processing of electrical energy so that it is efficiently provided to various loads. Numerous examples of power-electronic systems can be found in society, including power supplies, motor drives, lighting systems, high voltage DC transmission systems, and renewable energy systems. Power-electronic systems are one of the key enablers of the new Smart Grid.

   Specific topics include:

   - DC/DC Converters
   - AC/DC Converters
   - AC/AC Converters
   - DC/AC Converters
   - Magnetics Design
   - Introductory Control
   - Introductory thermal management
   - Introductory gate and base drives and pulse-width modulation
   - Applications

5. Instructional Method:
   The course is in lecture format. Problem sets will be issued on an approximately weekly basis, and will be due one week after issue unless otherwise specified. Several of the homework assignments will feature in-lab assignments, and several others will involve computer simulations. Late problem sets will not be accepted unless previously arranged with the instructor. You may consult your colleagues, but you must indicate this on your assignment.

6. Evaluation:

Grades will be based on the student's performance on homework assignments, two exams, and one project. Final grade for the course will be based on the following point spread:

Homework and Projects	35%
Exam 1	25%
Exam 2	30%
Final Project	10%

Although both graduate and undergraduate students will be graded based on the above point spread, graduate students will be required to solve additional problems in homework assignments and perform hardware implementation in the design project, which is not required from undergraduate students.

7. Policies that apply to this course**:**

The course has theory and practical content:

- Students should be comfortable with Matlab programming as select homework assignments require algorithm coding in Matlab.
- Students should be comfortable in the laboratory as they are working on a final project with a design/build component
- Guidelines, information, and sample code (where applicable) will be provided through the course web site for presentations and projects.

8. Probable Textbooks:

The probable prescribed textbook for this course will be:

Title:	Principles of Power Electronics
Author:	John G. Kassakian, Martin F. Schlecht, and George C. Verghese
Publisher & Edition:	Addison-Wesley
ISBN-13:	978-0201096897

Moreover, the following textbooks may be useful, although not required:

- N. Mohan, T. Undeland, and W. Robbins, "Power Electronics", John Wiley and Sons, Hoboken, NJ, Third Edition, 2003.
- R. Erickson and D. Maksimovic, "Fundamentals of Power Electronics," Kluwer, Norwell, MA, Second Edition, 2001.

9. Topical Outline:

The course will cover the following topics:

- Review of time-domain circuit analysis (i.e. ordinary differential equations and Taylor-Series approximations)
- DC/DC Converters
- AC/DC Converters
- AC/AC Converters
- DC/AC Converters

- Introductory Magnetics Design
- Introductory Gate and drives and pulse-width modulation
- Introductory thermal management
- Introductory converter modeling
- Applications

ECGR 6197/8197 Syllabus

1. Course Number & Title: **ECGR 6197/8197. Power Electronics II**

2. Course Description (Catalog Description)**:**

ECGR 6197. Power Electronics II (3). Prerequisite: Graduate standing, knowledge of fundamentals of power electronics and basics of semiconductor physics, and ECGR 5144, or permission from the department. This course focuses on more advanced topics in power electronics. Topics include converter modeling and control, advanced concepts in magnetic circuit design, gate and base drives, switching losses, resonant converters, zero-voltage and zero-current switching, utility-interfaced applications including FACTS, maximum power-point tracking, and power factor correction Credit will not be given for ECGR 6197 where credit has been given for ECGR 8197. (*Fall*)

PROPOSED CATALOG COPY: **ECGR 8197. Power Electronics II (3).** See ECGR 6197 for Course Description. Credit will not be given for ECGR 8197 where credit has been given for ECGR 6197.

3. Prerequisites:
   Prerequisite: Graduate standing, knowledge of fundamentals of power electronics and basics of semiconductor physics, and ECGR 5144, or permission from the department.

4. Course Objectives:
   This class addresses more advanced concepts in power electronics. Specific goals are to:

   - understand the design of DC/DC, AC/DC, DC/AC, and AC/AC converters
   - understand advanced topics in magnetic circuits, including frequency-dependent losses
   - understand converter modeling as well as voltage-mode and current-mode controls
   - develop an understanding of IGBTs and other power-semiconductor devices
   - develop a solid understanding of ancillary issues, including EMI and filtering, thermal management, switching losses, gate and base drive design, and zero-voltage/zero-current switching strategies
   - understand utility-interfaced applications such as FACTS and power-factor correction

5. Instructional Method:
   The course is in lecture format. Software simulations experiments will be assigned as homework.

6. Evaluation:
   Grades will be based on the student's performance on homework assignments, two exams, and one final project. The project is laboratory-based and intensive. Final grade for the course will be based on following point spread:

Homework	30%
Exam 1	25%
Exam 2	25%
Project	20%

7. Policies that apply to this course**:**
The course has theory and practical content. In addition, students will be learning to search and read papers and to learn design through practical applications.

- Various papers will be cited as reading material on different topics, and these will be required for problem solving
- Students should be comfortable with Matlab programming as select homework assignments require algorithm coding in Matlab.
- Students will gain familiarity with Matlab Simulink as they will be asked to perform software simulation projects, each of which relates to a specific application
- Student should be comfortable in the laboratory as they are working on a final project with a design/build component
- Guidelines, information, and sample code (where applicable) will be provided through the course web site for presentations and projects.

8. Probable Textbooks:
In addition to various assigned research papers, the following textbooks are likely to be required:

The probable prescribed textbook for this course will be:

Title:	Principles of Power Electronics
Author:	John G. Kassakian, Martin F. Schlecht, and George C. Verghese
Publisher & Edition:	Addison-Wesley
ISBN-13:	978-0201096897

Title:	Fundamentals of Power Electronics
Author:	Robert Erickson and Dragan Maksimovic
Publisher & Edition:	Kluwer
ISBN-13:	978-0792372707

The following textbook may be useful, although not required:

- N. Mohan, T. Undeland, and W. Robbins, “Power Electronics”, John Wiley and Sons, Hoboken, NJ, Third Edition, 2003.

9. Topical Outline:
The course will cover the following topics:

- Review of converter topologies
- Converter modeling:
  - State-space averaging
  - Circuit averaging

    - Generalized state-space averaging
- Converter control:
    - Voltage-mode
    - Current-mode
    - Inner/outer loop controls
    - Basic geometric controls
- Resonant converters
- Power semiconductors:
    - MOSFETs
    - IGBTs
    - Schottky Diodes
- Gate and base drives
- EMI and filtering
- Switching losses
- Snubber design
- Advanced magnetics:
    - Frequency-dependent losses
    - Frequency-dependent inductance (i.e. crowding)
- Zero-voltage and zero-current switching
- Thermal management
- Applications:
    - FACTS
    - Renewable interface
    - Active power-factor correction

UNC CHARLOTTE

J. Murrey Atkins Library

Consultation on Library Holdings

To: Robert Cox

From: Alison Bradley

Date: 5/7/12

Subject: ECGR 5144 and 6197/8197: Power Electronics I & II

Summary of Librarian's Evaluation of Holdings:

Evaluator: Alison Bradley **Date: 5/7/12**

Check One:
1. Holdings are superior ______
2. Holdings are adequate __x__
3. Holdings are adequate only if Dept. purchases additional items. ______
4. Holdings are inadequate ______

Comments:
Library holdings should be adequate to support student research in the proposed course. Students will have access to monographs collections in relevant subject areas (see holdings data below), as well as electronic resources including IEEE Xplore, ASTM Digital Library, Compendex, and Electronics and Communications Abstracts among other resources. Students will also be able to access material from outside of the library collections via the Interlibrary Loan service.

LC Subject Heading	Total items
Power Electronics	134
Semiconductors	952
Solid state electronics	69
Electric Circuits	185

Alison Bradley

Evaluator's Signature

5/7/12

Date

ATTACHMENT-3:

Proposal for new graduate courses on (a) ECGR 6144/8144: Electric Power Distribution Systems-I, and (b) ECGR 6145/8145: Electric Power Distribution Systems-I

ECGR 04-24-12

University of North Carolina at Charlotte

Proposal for New Graduate Course

Course and Curriculum Proposal from: Department of Electrical and Computer Engineering

Title: *New Graduate Two-Course Sequence on Electric Power Distribution Systems*

A. PROPOSAL SUMMARY AND CATALOG COPY

1. **SUMMARY:** The Electrical and Computer Engineering Department proposes to add two new elective courses to the graduate curriculum:
   - ECGR 6144/8144: Electric Power Distribution Systems I
   - ECGR 6145/8145: Electric Power Distribution Systems II

2. **PROPOSED CATALOG COPY: ECGR 6144. Electric Power Distribution Systems I (3).** Prerequisite: Graduate standing and knowledge of fundamentals of power systems, or permission from the department. This course will provide the fundamental principles of the electric power delivery system with emphasis on distribution systems. The course will go over three-phase unbalanced system and component models, distribution power flow analysis, and radial power flow techniques. Credit will not be given for ECGR 6144 where credit has been given for ECGR 8144. (*Fall*)

   PROPOSED CATALOG COPY: ECGR 8144. Electric Power Distribution Systems I (3). See ECGR 6144 for Course Description. Credit will not be given for ECGR 8144 where credit has been given for ECGR 6144.

   PROPOSED CATALOG COPY: ECGR 6145. Electric Power Distribution Systems II (3). Prerequisite: Graduate standing, knowledge of fundamentals of power systems, and ECGR 6144/8144, or permission from the department. This course will focus on distribution automation and optimization methods applied to distribution systems operation and planning. Credit will not be given for ECGR 6145 where credit has been given for ECGR 8145. (*Spring*)

   PROPOSED CATALOG COPY: ECGR 8145. Electric Power Distribution Systems II (3). See ECGR 6145 for Course Description. Credit will not be given for ECGR 8145 where credit has been given for ECGR 6145.

B. JUSTIFICATION

1. Identify the need addressed by the proposal and explain how the proposed action meets the need: Traditionally, the majority of power engineering education has focused on high-voltage, transmission systems. In recent years, the interest in electric power distribution systems is resurgent for a number of reasons. First, deregulation and the subsequent restructuring of the electric utilities have brought new operating and planning pressures for distribution energy suppliers. Second, economics and profit margins have driven commercial industries to demand uninterruptable, high-quality power for their manufacturing processes. Third, military goals for reduced manpower are requiring the re-design and upgrading of electric distribution systems for ships, submarines and all-electric vehicles such as tanks and airplanes. Last, but not least, the advent of the Smart Grid, and the need for the distribution system to accommodate the increasing number of distributed renewable energy resources.

   For these reasons, the two-course sequence is proposed to introduce electrical engineering graduate students to formal studies in electric power distribution systems and to deepen students' knowledge of electric power systems in general. Specific goals are for the students to:

   - understand the similarities and differences between electric power transmission and distribution systems,
   - be able to model unbalanced systems and components,
   - perform unbalanced power flow analysis,
   - gain familiarity with distribution automation techniques, including service restoration, network reconfiguration, and capacitor placement,
   - apply optimization techniques to power systems, and specifically to solve operation and planning problems.

2. Discuss prerequisites/corequisites for course(s) including class-standing: ECGR 6144/8144 – Prerequisites: Graduate standing and knowledge of fundamentals of power systems, or permission from the department. ECGR 6145/8145 – Prerequisites: Graduate standing, knowledge of fundamentals of power systems, and ECGR 6144/8144, or permission from the department.

3. Demonstrate that course numbering is consistent with the level of academic advancement of students for whom it is intended: The course numberings ECGR 6144/8144 and ECGR 6145/8145 are consistent with the level of academic advancement of graduate students, for whom these courses are intended.

4. In general, how will this proposal improve the scope, quality and/or efficiency of programs and/or instruction: Presently, several advanced graduate courses in power systems exist. These courses focus on the transmission and generation sides of a power system, including modeling, dynamics and control. However, no existing graduate course systematically covers electric power distribution systems, whose inherent differences from transmission systems (e.g. lower-voltage, multi-phase, unbalanced) require stand-alone courses. The proposed two-course sequence therefore

complements the existing courses in power systems, electric machines and power electronics, and will embody an important component of the graduate curriculum for the Power Systems concentration in the Electrical and Computer Engineering (ECE) Department. These courses can effectively educate students to be the next-generation workforce in a variety of industries, including utilities, Smart Grid and renewable energy integration companies, and prepare them for advanced research in the field of power systems.

C. IMPACT

1. What group(s) of students will be served by this proposal? This two-course sequence will serve graduate students in electrical and computer engineering with interest in power engineering and power and energy systems.

2. What effect will this proposal have on existing courses and curricula? The proposed course will complement the existing courses on power systems, electric machines and power electronics in the ECE department and effectively prepare graduate students for further studies in advanced graduate courses in power.

- **a.** When and how often will added course(s) be taught? According to the current demand and scheduling of courses, the course sequence will be offered on demand, tentatively in alternate years: Electric Power Distribution Systems I in the Fall semester, and Electric Power Distribution Systems II in the Spring.
- **b.** How will the content and/or frequency of offering of other courses be affected? No effect expected.
- **c.** What is the anticipated enrollment in course(s) added (for credit and auditors)? Typical enrollment expected to be 8-18 students for each course.
- **d.** How will enrollment in other courses be affected? None expected. How did you determine this? Graduate students in electrical and computer engineering routinely express interest to cover distribution systems in the curriculum. Because of this interest, the courses were offered as special topics courses in 2011-2012 academic year, when it served to fill this void adequately.
- **e.** If course(s) has been offered previously under special topics numbers, give details of experience including number of times taught and enrollment figures. The proposed two-course sequence is a modified form of two special topic courses that were taught in the following semesters with enrollments as shown:
  - Distribution Systems I – Fall 2011, Enrollment: 14 (12 M.S., 2 Ph.D.)
  - Transmission & Distribution Systems II – Spring 2012, Enrollment: 8 (6 M.S., 2 Ph.D.)
- **f.** Identify other areas of catalog copy that would be affected, e.g., curriculum outlines, requirements for the degree, etc. Crosslisting ECGR 6144 with ECGR 8144 and ECGR 6145 with ECGR 8145 in the graduate catalog.

D. RESOURCES REQUIRED To Support PROPOSAL

1. Personnel
   a. Specify requirements for new faculty, part-time teaching, student assistant and/or increased load on present faculty: None. The course sequence will be taught by one faculty member at no required increased teaching load and with no teaching assistant.
   b. List by name qualified faculty members interested in teaching the course(s): Dr. Valentina Cecchi, Dr. Sukumar Kamalasadan, and Dr. Zia Salami are among the qualified faculty members interested in teaching these courses.

2. Physical Facility: None

3. Equipment and Supplies: None

4. Computer: None

5. Audio-Visual: None

6. Other Resources: None

7. Indicate source(s) of funding for new/additional resources required to support this proposal: None required

E. CONSULTATION WITH THE LIBRARY AND OTHER DEPARTMENTS OR UNITS

1. Library Consultation
   Indicate written consultation with the Library Reference Staff at the departmental level to insure that library holdings are adequate to support the proposal prior to its leaving the department. (Attach copy of ***Consultation on Library Holdings***).

2. Consultation with other departments or units
   N/A

F. INITIATION AND CONSIDERATION OF THE PROPOSAL

1. Originating Unit
   Approved per attached signatures

2. Other Considering Units
   N/A

G. ATTACHMENTS

Course Syllabi

ECGR 6144/8144 Syllabus

1. Course Number & Title: **ECGR 6144/8144. Electric Power Distribution Systems I**

2. Course Description (Catalog Description)**:**
   ECGR 6144. Electric Power Distribution Systems I (3). Prerequisite: Graduate standing and knowledge of fundamentals of power systems, or permission from the department. This course will provide the fundamental principles of the electric power delivery system with emphasis on distribution systems. The course will go over three-phase unbalanced system and component models, distribution power flow analysis, and radial power flow techniques. Credit will not be given for ECGR 6144 where credit has been given for ECGR 8144. (*Fall*)
   ECGR 8144. Electric Power Distribution Systems I (3). See ECGR 6144 for Course Description. Credit will not be given for ECGR 8144 where credit has been given for ECGR 6144.

3. Prerequisites:
   Prerequisite: Graduate standing and knowledge of fundamentals of power systems, or permission from the department.

4. Course Objectives:
   The purpose of this course is to deepen students' knowledge of electric power delivery systems and to introduce them to formal studies in electric power distribution systems. Specific goals are:
   - to understand the similarities and differences between transmission and distribution systems,
   - to understand unbalanced system and component models,
   - to perform unbalanced power flow analysis,
   - to introduce concepts in distribution automation.

5. Instructional Method:
   The course is in lecture format. Software simulations experiments will be assigned as homework.

6. Evaluation:
   Grades will be based on the student's performance on homework assignments, one midterm and one final examination, and one research project with in-class presentation. Presentation and research topics must be approved by instructor. Final grade for the course will be based on following point spread:

Homework and Projects	25%
Midterm	35%
Final	40%

7. Policies that apply to this course**:**

The course has theory and practical content. In addition, students will be learning to search and read papers, critique them, and present their ideas.

- Various papers will be cited as reading material on different topics, and presentation of literature review to the rest of the class will be assigned.
- Students should be comfortable with Matlab programming as select homework assignments require algorithm coding in Matlab.
- Presentations on research material and research projects will be done in groups, each student will have an independent component in it. This has to be made clear by each group while planning the presentation or research project.
- Guidelines, information, and sample code (where applicable) will be provided through the course web site for presentations and projects.

8. Probable Textbooks:

The probable prescribed textbook for this course will be:

Title:	Distribution System Modeling and Analysis
Author:	William H. Kersting
Publisher & Edition:	CRC Press, 2nd Edition
ISBN-13:	978-0849358067

Moreover, the following textbooks may be useful, although not required:

- J. Grainger and W. Stevenson, "Power System Analysis", McGraw Hill, New York NY, 1994.
- R. Bergen, "Power Systems Analysis," Prentice Hall, Englewood Cliffs NJ, 1986.
- T. Gonen, "Electric Power Distribution System Engineering," McGraw Hill, New York NY, 1986.

9. Topical Outline:

The course will cover the following topics:

- Intro to Power Delivery Systems. Intro/Review of Transmission and Distribution Main Concepts
- Intro to Power Distribution Systems: Description, Equipment, Connections, Topics of Distribution Automation, Planning and Operating Concerns
- Review: Basic network analysis techniques, symmetrical components and phase transformations
- Nature of the Loads and Overview of Approximate Methods of Analysis
- Modeling: Distribution Lines
- Modeling: Transformers
- Modeling: Loads, Capacitors, Co-generators
- Distribution Power Flow: Network Topology, Problem Statement
- Radial Distribution Power Flow and General Structure Distribution Power Flow
- Application of Power Flow in Distribution Automation, Planning and Operation
- Overview of Load Capability Studies and Voltage Control Methods
- Distributed Generation
- Introduction to Distribution Automation

ECGR 6145/8145 Syllabus

1. Course Number & Title: **ECGR 6145/8145. Electric Power Distribution Systems II**

2. Course Description (Catalog Description)**:**
   ECGR 6145. Electric Power Distribution Systems II (3). Prerequisite: Graduate standing, knowledge of fundamentals of power systems, and ECGR 6144/8144, or permission from the department. This course will focus on distribution automation and optimization methods applied to power system operation and planning. Credit will not be given for ECGR 6145 where credit has been given for ECGR 8145. (*Spring*)
   ECGR 8145. Electric Power Distribution Systems II (3). See ECGR 6145 for Course Description. Credit will not be given for ECGR 8145 where credit has been given for ECGR 6145.

3. Prerequisites:
   Prerequisite: Graduate standing, knowledge of fundamentals of power systems, and ECGR 6144/8144, or permission from the department.

4. Course Objectives:
   The purpose of this course is to deepen students' knowledge of electric power distribution systems, and to introduce them to Distribution Automation techniques and advanced emerging topics in distribution. Specific goals are:
   - to present Distribution Automation and load capability studies in distribution,
   - to understand several applications of Distribution Automation, such as network reconfiguration, capacitor placement and control, and service restoration,
   - to be able to formulate distribution operation and planning problems as optimization problems,
   - to gain familiarity with several optimization solution methodologies and intelligent system techniques, such as genetic algorithm, simulated annealing,
   - to apply intelligent system techniques to solve for distribution automation problems,
   - to learn distribution state estimation and bad data detection..

5. Instructional Method:
   The course is in lecture format. Software simulations experiments will be assigned as homework.

6. Evaluation:
   Grades will be based on the student's performance on homework assignments, one midterm and one final examination, and one research project with in-class presentation. Presentation and research topics must be approved by instructor. Final grade for the course will be based on following point spread:

Homework and Projects	30%
Midterm	30%
Final	40%

7. Policies that apply to this course**:**

The course has theory and practical content. In addition, students will be learning to search and read papers, critique them, and present their ideas.

- Various papers will be cited as reading material on different topics, and presentation of literature review to the rest of the class will be assigned.
- Students should be comfortable with Matlab programming as select homework assignments require algorithm coding in Matlab.
- Students will gain familiarity with Matlab Simulink as they will be asked to perform four software simulation projects, each of which relates to a specific application of distribution automation.
- Presentations on research material and research projects will be done at the end of the course in groups, each student will have an independent component in it.
- Guidelines, information, and sample code (where applicable) will be provided through the course web site for presentations and projects.

8. Probable Textbooks:

There is no prescribed textbook for the course. Course material will consist of research papers as cited by the instructor. The following textbooks may be useful, although not required:

- W. Kersting, "Distribution System Modeling and Analysis", CRC Press, 2nd Ed..
- J. Grainger and W. Stevenson, "Power System Analysis", McGraw Hill, New York NY, 1994.
- R. Bergen, "Power Systems Analysis," Prentice Hall, Englewood Cliffs NJ, 1986.
- T. Gonen, "Electric Power Distribution System Engineering," McGraw Hill, New York NY, 1986.
- D. Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Addison-Wesley Publishing Co. Inc., Reading MA, 1980.

9. Topical Outline:

The course will cover the following topics:

- Distribution Automation, planning and operation, and load capability studies
- **Simulation Lab 1**: Multi-Phase Radial Power Flow
- Network Reconfiguration: basic graph theory techniques and heuristics, Simulated Annealing, other intelligent system techniques
- **Simulation Lab 2**: Network Reconfiguration
- Capacitor Placement, Replacement & Control: Heuristic Methods and Genetic Algorithm
- **Simulation Lab 3**: Capacitor Placement
- Voltage Control Methods – Transformer Tap Settings
- Monitoring and data management issues, Intro to State Estimation
- State Estimation (cont.): Norms & Approximation Functions, Least Squares
- Service Restoration, Reliability Assessment, and Service Quality Measurements
- **Simulation Lab 4**: Service Restoration
- Intro to Power Quality & DSP concepts: e.g. wavelet transform
- Meter Placement Problem

UNC CHARLOTTE

J. Murrey Atkins Library

Consultation on Library Holdings

To: **Sukumar Kamalasadan**

From: **Alison Bradley**

Date: **5/7/12**

Subject: **ECGR 6144/8144-6145/8145, Electric Power Distribution Systems I&II**

Summary of Librarian's Evaluation of Holdings:

Evaluator: Alison Bradley **Date: 5/7/12**

Check One:
1. Holdings are superior ______
2. Holdings are adequate __x__
3. Holdings are adequate only if Dept. purchases additional items. ______
4. Holdings are inadequate ______

Comments:
Library holdings should be adequate to support student research in the proposed course. Students will have access to monographs collections in relevant subject areas (see holdings data below), as well as electronic resources including IEEE Xplore, ASTM Digital Library, Compendex, and Electronics and Communications Abstracts among other resources. Students will also be able to access material from outside of the library collections via the Interlibrary Loan service.

LC Subject Heading	Total items
Electric power distribution	206
Electric power transmission	120

Alison Bradley

Evaluator's Signature

5/7/12

Date

ATTACHMENT-4:

Proposal for new graduate courses on ECGR 6146/8146: Smart Grid: Characteristics, Design and Analysis

University of North Carolina at Charlotte

Proposal for New Graduate Course

Course and Curriculum Proposal from: Department of Electrical and Computer Engineering

Title: ***Smart Grid: Characteristics, Design and Analysis***

A. PROPOSAL SUMMARY AND CATALOG COPY

1. **SUMMARY:** The Electrical and Computer Engineering Department proposes to add one new elective courses to the graduate curriculum:
   - ECGR 6146/8146: Smart Grid: Characteristics, Design and Analysis
2. **PROPOSED CATALOG COPY: ECGR 6146. Smart Grid: Characteristics, Design and Analysis (3).** Prerequisite: Graduate standing and knowledge of fundamentals of power systems, or permission from the department. This course will provide the fundamental principles of the Smart Grid with emphasis on Grid modernization Analysis and design. The course will go over with design and integration of renewable energy resources to power grid, the impact of power system analysis in the context of smart grid, smart grid observability and controllability, Wide Area Monitoring and Control, Self-Healing network. Credit will not be given for ECGR 6146 where credit has been given for ECGR 8146. (*Spring*)

   PROPOSED CATALOG COPY: ECGR 8146. Smart Grid: Characteristics, Design and Analysis (3). See ECGR 8146 for Course Description. Credit will not be given for ECGR 8146 where credit has been given for ECGR 6146.

B. JUSTIFICATION

1. Identify the need addressed by the proposal and explain how the proposed action meets the need: Traditionally, the majority of power engineering education has focused on conventional power system analysis and design. In recent years, the interest in integration of digitized devices and renewable energy based distributed energy resources have evolved into a new domain of electric power system: Smart Grid. The design and analysis of the modern power grid is extremely critical mainly due to the following reasons. First, development and integration of renewable energy resources has brought a new dimension for the power grid. The impact of integrating these energy resources into transmission and distribution system needs to be analyzed in detail. Second, real-time sensors such as Phasor Measurement Units (PMU's) and smart meters have provided a new method of grid monitoring. The method of extracting data from these sensors and using it for modern power grid analysis is a

new challenge. Third, due to the advent of integrating smarter electrical devices and two way power flow, power system operation and control needs to be changed drastically. Power System analysis has thus become extremely challenging and need to be re-evaluated.

For these reasons, the course on smart grid is proposed to introduce electrical engineering graduate students to formal studies in grid modernization and to deepen students' knowledge of modern electric power systems in general. Specific goals are for the students to:

- understand the similarities and differences between conventional power grid and modern power grid,
- be able to model power grid with renewable energy resources, real-time sensors, digital devices and unbalanced systems and components,
- Perform power flow analysis, short circuit studies, optimal power flow and continuation power flow with renewable energy resources and two way real-power transactions.
- gain familiarity with real-time sensors, Advance Meter Infrastructure (AMI), digital devices,
- apply optimal power flow, stability analysis using continuation power flow and analyze the effect of renewable energy integration to modern power grid.
- Design a modern power grid with sensors and understand characteristic such as self-healing network, interoperability, Wide Area Monitoring and Control

2. Discuss prerequisites/corequisites for course(s) including class-standing: ECGR 6146/8146 – Prerequisites: Graduate standing and knowledge of fundamentals of power systems, or permission from the department.

3. Demonstrate that course numbering is consistent with the level of academic advancement of students for whom it is intended: The course numberings ECGR 6146/8146 are consistent with the level of academic advancement of graduate students, for whom these courses are intended.

4. In general, how will this proposal improve the scope, quality and/or efficiency of programs and/or instruction: Presently, several advanced graduate courses in power systems exist. These courses focus on the transmission and generation sides of a power system, including modeling, dynamics and control. However, no existing graduate course covers the characteristics of modern power system: The Smart Grid. This course systematically covers characteristics and design of the modern power grid. Such a course is extremely important as the existing courses do not cover the grid modernization methods, design, analysis and operational issues. In this course, first design of renewable energy based distributed energy resources is illustrated. Then the integration of these resources to power grid is evaluated. Further, the analysis of power grid with renewable energy resources is discussed. Then the impact of digital devices to modern power grid and the control and reorganization of the grid is evaluated. Thus, this proposed course therefore complements the existing courses in power systems, electric machines and power electronics, and will embody an important component of the graduate curriculum for the Power Systems concentration in the Electrical and Computer Engineering (ECE) Department. This course can effectively educate students to be the next-generation workforce in a variety of industries, including utilities, Smart Grid and renewable energy integration companies, and prepare them for advanced research in the field of power systems.

C. IMPACT

1. What group(s) of students will be served by this proposal? This course will serve graduate students in electrical and computer engineering with interest in power engineering and power and energy systems.

2. What effect will this proposal have on existing courses and curricula? The proposed course will complement the existing courses on power systems, electric machines and power electronics in the ECE department and effectively prepare graduate students for further studies in advanced graduate courses in power.

- **a.** When and how often will added course(s) be taught? According to the current demand and scheduling of courses, the course sequence will be offered on demand, tentatively in alternate Spring Semester.
- **b.** How will the content and/or frequency of offering of other courses be affected? No effect expected.
- **c.** What is the anticipated enrollment in course(s) added (for credit and auditors)? Typical enrollment expected to be 8-18 students for each course.
- **d.** How will enrollment in other courses be affected? None expected. How did you determine this? Graduate students in electrical and computer engineering routinely express interest to cover Smart Grid in the curriculum. Because of this interest, this course was offered as special topics courses in 2011-2012 academic year, when it served to fill this void adequately.
- **e.** If course(s) has been offered previously under special topics numbers, give details of experience including number of times taught and enrollment figures. The proposed course is a modified form of a special topic courses that were taught in the following semesters with enrollments as shown:
    - Smart Grid: Characteristics, Design and Analysis – Spring 2012, Enrollment: 16 (12 M.S., 4 Ph.D.)
- **f.** Identify other areas of catalog copy that would be affected, e.g., curriculum outlines, requirements for the degree, etc. Crosslisting ECGR 6146 with ECGR 8146 in the graduate catalog.

D. RESOURCES REQUIRED To Support PROPOSAL

1. Personnel

a. Specify requirements for new faculty, part-time teaching, student assistant and/or increased load on present faculty: None. The course sequence will be taught by one faculty member at no required increased teaching load and with no teaching assistant.

b. List by name qualified faculty members interested in teaching the course(s): Dr. Valentina Cecchi, Dr. Sukumar Kamalasadan, and Dr. Zia Salami are among the qualified faculty members interested in teaching these courses.

2. Physical Facility: None

3. Equipment and Supplies: None

4. Computer: None

5. Audio-Visual: None

6. Other Resources: None

7. Indicate source(s) of funding for new/additional resources required to support this proposal: None required

E. CONSULTATION WITH THE LIBRARY AND OTHER DEPARTMENTS OR UNITS

1. Library Consultation
Indicate written consultation with the Library Reference Staff at the departmental level to insure that library holdings are adequate to support the proposal prior to its leaving the department. (Attach copy of ***Consultation on Library Holdings***).

2. Consultation with other departments or units
N/A

F. INITIATION AND CONSIDERATION OF THE PROPOSAL

1. Originating Unit
Approved per attached signatures

2. Other Considering Units
N/A

G. ATTACHMENTS

ECGR 6146/8146 – <u>Smart Grid: Characteristics, Design and Analysis</u>

Course	ECGR 6090/8090
Course Description	Smart Grid- Characteristics, Design and Analysis (3)
Catalog Data	Characteristics of smart grid and grid modernization aspects, Important metrics, Key technology areas, Current and Future state, Challenges, Main implementation areas. Modeling modern power grid with distributed energy resources, sensors, analyzing the operation and control of smart power grid
References	1. Design of Smart Power Grid Renewable Energy Systems, Ali Keyhani 2. Smart Grid Government Series 3. Lecture notes and Research Papers
Goals	**Course Objective:** The objective of this course is to prepare students for gaining fundamental knowledge on characterizes of smart grid, modern power grid with distributed generation and storage capabilities, operational aspects of power grid with real-time sensors. **Goals:** 1. Acquaint engineering students with modernizing power systems, its operation and their control 2) Introduce students to the characteristics and metrics of smart grid. 3) Introduce modeling and control aspects of smart grid 4) Introduce smart grid design with and without renewable energy resources and storage 5)Introduce key technology areas and current and future state 6) Introducing the impact of smart grid component integrating with power system operation 7) Evaluate the impact of smart grid operation on power system reliability and resiliency
Prerequisite	ECGR 4141, ECGR 4142or ECGR 5142 and/or Instructors Approval
Class Topics	1) Smart grid scope and characteristics 2) Smart grid metrics and key technology areas 3) Current and future state of each technology areas 4) Key benefits of implementation and barriers to deployment 5) Possible solutions 6) Design of smart power grid System 7) Operating principles and models of smart gird components 8) Modeling and analysis of distribution system with automation and self-healing capabilities 9) Modeling and Control of power electronics in smart grid 10) Modeling and control of renewable energy system (Wind, Solar) and storage in smart grid 11) Analysis of smart power grid with sensors such as a) Phase Measurement Units and communication standards such as IEC 61850 Standards
Outcomes	• Explain the roles of distributed generation technologies, communication infrastructures, sensing and measurements, advanced control methods, and demand management in smart grid operation • Discuss operating principles and develop simplified models of smart grid components • Perform power system analysis with and without distributed energy sources • Analyze the impact of smart grid component integration on power system operation • Evaluate the impact of smart grid operation on power system reliability and

resiliency

Computer Usage	Students are using computers for simulation and design assignments. Computers are used in the class for demonstrations.
Laboratory	Students use computer laboratories for all computer simulations assigned in homework and in the design project.
Design Content	The emphasis throughout this course is to design, model and analyze modern power grid in the contest of smart grid functions. This include designing and modeling generators, loads, renewable energy resources, sensors, analyzing the grid operation with and without supply and demand side management, and evaluating operational aspects of modern power grid.
Grading*	There are frequent homework assignments (mostly one in each week), two exams/project, and a comprehensive final exam, as indicated in the course outline. The weight of each item in determining the final grade is as follows: Homework 10% Test1/Project 1 20% Test2/Project 2 20% Course Project 25% Final Exam/Simulation Project 25% Grades are assigned on an absolute scale, The established ranges are: A 90% and up B 80% to 89% C 70% to 79% D 60% to 69% F Below 60%
Follow-up Courses	Other special research topics.
Academic Integrity	Students have the responsibility to know and observe the requirements of the The Code of Student Academic Integrity . This code forbids cheating, fabrication or falsification of information, multiple submission of academic work, plagiarism, abuse of academic materials, and complicity in academic dishonesty.
Notes	A course outline listing the course topics, and grading pattern will be provided to the students on the first day of class. The course outline is subject to date changes as may occur due to professor travel and other events. During professor travel, a graduate teaching assistant presents prepared lectures to maintain continuity with the course outline.
Coordinator	Sukumar Kamalasadan, Associate Professor of Electrical & Computer Engineering
Prepared by	Sukumar Kamalasadan, January 8th, 2012

* Grading Policy may be modified by the instructor for each section of the course.

NOTE: This syllabus is a guide and is subject to change. Changes will be announced in class. Your attendance in class is expected. You are responsible for material covered in class (obtain information missed when you are absent from class from other students). You should contact the professor under such circumstances.

DISABILITY: If you have a disability that qualifies you for academic accommodations, please provide a letter of accommodation from the Office of Disability Services in the beginning of the semester. For more information regarding accommodations, please contact the Office of Disability Services at 704-687-4355 or stop by their office in 230 Fretwell.

UNC CHARLOTTE

J. Murrey Atkins Library

Consultation on Library Holdings

To: Sukumar Kamalasadan

From: Alison Bradley

Date: 5/7/12

Subject: ECGR 6146/8146. Smart Grid: Characteristics, Design and Analysis

---

Summary of Librarian's Evaluation of Holdings:

Evaluator: Alison Bradley **Date: 5/7/12**

Check One:

1. Holdings are superior ______
2. Holdings are adequate __x__
3. Holdings are adequate only if Dept. purchases additional items. ______
4. Holdings are inadequate ______

Comments:
Library holdings should be adequate to support student research in the proposed course. Students will have access to monographs collections in relevant subject areas (see holdings data below), as well as electronic resources including IEEE Xplore, ASTM Digital Library, Compendex, and Electronics and Communications Abstracts among other resources. Students will also be able to access material from outside of the library collections via the Interlibrary Loan service.

LC Subject Heading	Total items
Renewable Energy Sources	660
Electric power distribution	206
Electric power transmission	120
Network analysis planning	54
Photovoltaic power systems	54

Alison Bradley
____
Evaluator's Signature

5/7/12
____

Date

ATTACHMENT-5:

Proposal for new graduate courses on ECGR 6147/8147: Power System Stability and Control

University of North Carolina at Charlotte

Proposal for New Graduate Course

Course and Curriculum Proposal from: Department of Electrical and Computer Engineering

Title: ***Power System Stability and Control***

A. PROPOSAL SUMMARY AND CATALOG COPY

1. **SUMMARY:** The Electrical and Computer Engineering Department proposes to add one new elective courses to the graduate curriculum:
   - ECGR 6147/8147: Power System Stability and Control
2. **ROPOSED CATALOG COPY: ECGR 6147. Power System Stability and Control (3).** Prerequisite: Graduate standing and knowledge of fundamentals of power systems, or permission from the department. This course will provide the fundamental principles of power system stability with emphasis on modern power grid. The course will go over with various power system stability analyses starting from small signal stability, transient stability, voltage stability, frequency stability. Then the system dynamics based on various stability conditions and controller design will be discussed. Credit will not be given for ECGR 6147 where credit has been given for ECGR 8147. (*Spring*)

   PROPOSED CATALOG COPY: ECGR 8147. Power System Stability and Control (3). See ECGR 6147 for Course Description. Credit will not be given for ECGR 8147 where credit has been given for ECGR 6147.

B. JUSTIFICATION

1. Identify the need addressed by the proposal and explain how the proposed action meets the need: Traditionally, the majority of power engineering education has focused on conventional power system analysis and design. Over the last 50 years there have been major blackouts in the US power grid. Moreover, in recent years, the interest in integration of digitized devices and renewable energy based distributed energy resources have evolved into a new domain of electric power system: Smart Grid. Due to these integration and deregulation in power grid, several new stability phenomena occur in modern power grid that results in new blackouts due to the following reasons. First, development and integration of renewable energy resources has initiated new power flow solutions but at the same time made the grid more vulnerable. Second, stability studies based on real-time sensors has brought a new dimension as more accurate stability margins can be designed. Third, new methods of

controls can be introduced in modern power grid and thus analysis of various power system stability margins is extremely critical. For these reasons, the course on smart grid is proposed to introduce electrical engineering graduate students to formal studies in power system stability and to deepen students' knowledge of modern electric power systems in general. Specific goals are for the students to:

> This course will provide insight into physical aspect of different categories of stability phenomena as well as how to operate power system in secure and stable way. Students will learn about factors causing stability phenomena and the techniques used to analyze and mitigate them. Course will provide answers to questions such as – what is angular stability. What is transient Stability? Why online security assessment is necessary? How to ensure secure and stable system operation? The course will provide a perspective on today's power system structure and train the students to look at maintaining system stability in a deregulated utility environment as power system are operated with a greater degree of uncertainty and a lower level of conservation than in the past.

2. <u>Discuss prerequisites/corequisites for course(s) including class-standing</u>: ECGR 6147/8147 – Prerequisites: Graduate standing and knowledge of fundamentals of power systems, ECGR 5142 and/or permission from the department.

3. <u>Demonstrate that course numbering is consistent with the level of academic advancement of students for whom it is intended</u>: The course numberings ECGR 6147/8147 are consistent with the level of academic advancement of graduate students, for whom these courses are intended.

4. <u>In general, how will this proposal improve the scope, quality and/or efficiency of programs and/or instruction</u>: Presently, several advanced graduate courses in power systems exist. These courses focus on the transmission and generation sides of a power system, including modeling, dynamics and control. However, no existing graduate course covers the power stability analysis with characteristics of modern power system. This course systematically covers characteristics and design of the modern power grid based power system stability analysis. Such a course is extremely important as the existing courses do not cover the grid modernization based power system stability and control analysis. In this course, first various power system stability issues are discussed. Then, method of stability analysis is evaluated. Further, modern power grid based stability and control methods are illustrated. Thus, this proposed course therefore complements the existing courses in power systems, electric machines and power electronics, and will embody an important component of the graduate curriculum for the Power Systems concentration in the Electrical and Computer Engineering (ECE) Department. This course can effectively educate students to be the next-generation workforce in a variety of industries, including utilities, Smart Grid and renewable energy integration companies, and prepare them for advanced research in the field of power systems.

C. IMPACT

1. What group(s) of students will be served by this proposal? This course will serve graduate students in electrical and computer engineering with interest in power engineering and power and energy systems.

2. What effect will this proposal have on existing courses and curricula? The proposed course will complement the existing courses on power systems, electric machines and power electronics in the ECE department and effectively prepare graduate students for further studies in advanced graduate courses in power.
   - **a.** When and how often will added course(s) be taught? According to the current demand and scheduling of courses, the course sequence will be offered on demand, tentatively in alternate Spring Semester.
   - **b.** How will the content and/or frequency of offering of other courses be affected? No effect expected.
   - **c.** What is the anticipated enrollment in course(s) added (for credit and auditors)? Typical enrollment expected to be 8-18 students for each course.
   - **d.** How will enrollment in other courses be affected? None expected. How did you determine this? Graduate students in electrical and computer engineering routinely express interest to cover Modern Power System Stability and Control in the curriculum. Because of this interest, this course was offered as special topics courses in 2011-2012 academic years, when it served to fill this void adequately.
   - **e.** If course(s) has been offered previously under special topics numbers, give details of experience including number of times taught and enrollment figures. The proposed course is a modified form of a special topic courses that were taught in the following semesters with enrollments as shown:
     - Power System Stability and Control – Fall 2011, Enrollment: 9(6 M.S., 3 Ph.D.)
   - **f.** Identify other areas of catalog copy that would be affected, e.g., curriculum outlines, requirements for the degree, etc. Crosslisting ECGR 6147 with ECGR 8147 in the graduate catalog.

D. RESOURCES REQUIRED To Support PROPOSAL

1. Personnel
   - **a.** Specify requirements for new faculty, part-time teaching, student assistant and/or increased load on present faculty: None. The course sequence will be taught by one faculty member at no required increased teaching load and with no teaching assistant.
   - **b.** List by name qualified faculty members interested in teaching the course(s): Dr. Valentina Cecchi, Dr. Sukumar Kamalasadan, and Dr. Zia Salami are among the qualified faculty members interested in teaching these courses.

2. Physical Facility: None

3. Equipment and Supplies: None

4. Computer: None

5. Audio-Visual: None

6. Other Resources: None

7. Indicate source(s) of funding for new/additional resources required to support this proposal: None required

E. CONSULTATION WITH THE LIBRARY AND OTHER DEPARTMENTS OR UNITS

1. Library Consultation
   Indicate written consultation with the Library Reference Staff at the departmental level to insure that library holdings are adequate to support the proposal prior to its leaving the department. (Attach copy of ***Consultation on Library Holdings***).

2. Consultation with other departments or units
   N/A

F. INITIATION AND CONSIDERATION OF THE PROPOSAL

1. Originating Unit
   Approved per attached signatures

2. Other Considering Units
   N/A

G. ATTACHMENTS

ECGR 6090 – Power System Stability and Control

Course	ECGR 6147/8147
Course Description	Power System Stability and Control (3)
Catalog Data	Introduction to Power System Stability, Review of Equipment Characteristics and Modeling, Control of Active Power and Frequency, Transient (angle) Stability, Small-Signal (rotor angle) Stability, Sub-synchronous Oscillations, Voltage Stability,

	Frequency Stability
References	P Kundur, Power System Stability and Control, 1994, EPRI/ McGraw-Hill A. J. Woods and B. F. Wollenberg, Power Generation, Operation, and Control, 2nd ed., John Wiley & Sons, 1996. Selected papers from the IEEE and other journal publications and conference proceedings. Selected web information and class notes.
Goals	Course Objective: The objective of this course is to prepare students for gaining introductory knowledge in power system and control. Goals: This course will provide insight into physical aspect of different categories of stability phenomena as well as how to operate power system in secure and stable way. Students will learn about factors causing stability phenomena and the techniques used to analyze and mitigate them. Course will provide answers to questions such as – what is angular stability. What is transient Stability? Why online security assessment is necessary? How to ensure secure and stable system operation? The course will provide a perspective on today's power system structure and train the students to look at maintaining system stability in a deregulated utility environment as power system are operated with a greater degree of uncertainty and a lower level of conservation than in the past.
Prerequisite	1. Graduate student standing for ECGR 5142 and ECGR 4141/4142 2. Have a working knowledge of analyzing three-phase power circuit
Class Topics	Introduction to power system stability, security, vulnerability problem Small Signal Stability Transient Stability Voltage Stability Sub synchronous oscillations Mid-term and long term stability Methods of improving stability Power system security Power system vulnerability
Outcomes	At the conclusion of the course, students should have the following competencies: 1) Knowledge on mathematical aspect and modeling of power system stability and small signal and transient analysis 2) power system voltage and angular stability 3) Mathematical analysis of power system mid-term and long term stability 4) methods to improve stability and 4) Oscillations in power system.
Computer Usage	Students are using computers for simulation and design assignments. Computers are used in the class for demonstrations.
Laboratory	Students use computer laboratories for all computer simulations assigned in homework and in the design project.
Design Content	The emphasis throughout the course is to understand and analyze the economic operation of power system without compromising quality, security, reliability and stability of the power grid.
Grading*	There are frequent homework assignments, two exams, and a comprehensive final exam, as indicated in the course outline. The weight of each item in determining the final grade is as follows:

Homework 10%
Test1 20%
Test2 20%
Term paper/Project 30%
Final Exam 20%

Grades are assigned on an absolute scale, The established ranges are:
A 90% and up
B 80% to 89%
C 70% to 79%
D 60% to 69%
F Below 60%

Follow-up Courses	None.
Academic Integrity	Students have the responsibility to know and observe the requirements of the The Code of Student Academic Integrity . This code forbids cheating, fabrication or falsification of information, multiple submission of academic work, plagiarism, abuse of academic materials, and complicity in academic dishonesty.
Notes	A Course Outline listing the course topics, two tests, and final exam, will be provided to the students on the first day of class. The Course Outline is subject to date changes as may occur due to professor travel and other events. During professor travel, a graduate teaching assistant presents prepared lectures to maintain continuity with the Course Outline.
Coordinator	Sukumar Kamalasadan, Associate Professor of Electrical & Computer Engineering
Prepared by	Sukumar Kamalasadan, August 23, 2011

* Grading Policy may be modified by the instructor for each section of the course.

NOTE: This syllabus is a guide and is subject to change. Changes will be announced in class. Your attendance in class is expected. You are responsible for material covered in class (obtain information missed when you are absent from class from other students). You should contact the professor under such circumstances.

DISABILITY: If you have a disability that qualifies you for academic accommodations, please provide a letter of accommodation from the Office of Disability Services in the beginning of the semester. For more information regarding accommodations, please contact the Office of Disability Services at 704-687-4355 or stop by their office in 230 Fretwell.

UNC CHARLOTTE

J. Murrey Atkins Library

Consultation on Library Holdings

To: Sukumar Kamalasadan

From: Alison Bradley

Date: 5/7/12

Subject: ECGR 6147/8147. Power System Stability and Control

Summary of Librarian's Evaluation of Holdings:

Evaluator: Alison Bradley **Date: 5/7/12**

Check One:

1. Holdings are superior ______
2. Holdings are adequate __x__
3. Holdings are adequate only if Dept. purchases additional items. ______
4. Holdings are inadequate ______

Comments:
Library holdings should be adequate to support student research in the proposed course. Students will have access to monographs collections in relevant subject areas (see holdings data below), as well as electronic resources including IEEE Xplore, ASTM Digital Library, Compendex, and Electronics and Communications Abstracts among other resources. Students will also be able to access material from outside of the library collections via the Interlibrary Loan service.

LC Subject Heading	Total items
Electric power system stability	39
Electric power distribution	206
Electric power transmission	120
Electric power systems Control	25
Electric controllers	27

Alison Bradley

____
Evaluator's Signature

5/7/12

____
Date

ATTACHMENT-6:

Proposal for new graduate courses on ECGR 6198/8198: Design of Renewable Energy Electromagnetic Devices

University of North Carolina at Charlotte

New Graduate

Course and Curriculum Proposal from: Electrical and Computer Engineering

Title: Add New Graduate Power Course for the ECE Program

A. PROPOSAL SUMMARY AND CATALOG COPY

1. **SUMMARY**.
   The Department of Electrical and Computer Engineering proposes to add a new elective course to the graduate curriculum: ECGR 6198, Design of Renewable Energy Electromagnetic Devices

2. **PROPOSED CATALOG COPY: ECGR 6198 Design of Renewable Energy Electromagnetic Devices (3)**.
   Prerequisite: Graduate standing and knowledge of (a) electric machines, (b) electromagnetic, and (c) programming, or permission from the department. This course will introduce students to the modern and classical methods used by engineers to design renewable energy electromagnetic devices, specifically electromagnetic machines. The course will be separated into two main sections. The first section of the course will review electromagnetic field theory and introduce the theory behind the finite element method. The second section will review the theory behind magnetic circuit modeling of electric machines. The emphasis will be placed on permanent magnet and induction machine design. *(on demand)*

3. **PROPOSED CATALOG COPY: ECGR 8198 Design of Renewable Energy Electromagnetic Devices (3)**. See ECGR 6198 for Course Description. Credit will not be given for ECGR 6198 where credit has been given for ECGR 8198.

B. JUSTIFICATION

1. Identify the need addressed by the proposal and explain how the proposed action meets the need: Renewable energy and distributed generation devices such as wind turbines, wave generators and microturbines as well as hybrid vehicles and electric ships and aircraft all rely on electric machines. In order to be able to design new electric machines for renewable energy devices (such as wind and ocean generators) a detailed understanding of the electromagnetic design methods of rotary machines is required. This course will teach students how utilize electromagnetic finite element analysis software to design electric machines as well as teach analytic based design approaches.

2. Discuss prerequisites/corequisites for course(s) including class-standing:
Prerequisites: Graduate standing and prior knowledge of (a) electric machines (b) electromagnetics and (c) programming (particularly matlab and/or simulink).

3. Demonstrate that course numbering is consistent with the level of academic advancement of students for whom it is intended: The course numbering ECGR 6198/8198 is consistent with the level of academic advancement of graduate students, for whom it is intended.

4. In general, how will this proposal improve the scope, quality and/or efficiency of programs and/or instruction: Presently, several advanced graduate courses in power systems exist these course focus on the interaction of different motors and generators. However, no existing graduate course systematically covers the fundamentals of electric machine design. In fact few course still exist in the country that teach this topic. There is a growing need for more engineers that can design electric machines for renewable energy applications. The proposed course complements the existing courses in power systems, electric machines and power electronics. The proposed course will be an important component of the graduate curriculum for the Power Systems concentration in the ECE department. This course can effectively motivate students' interest in further studies of advanced graduate courses in electric machines and power electronics and prepare graduate students to be effective in the workforce in premier companies and for research in the field of power generation, electric machine control and design.

C. IMPACT.

1. What group(s) of students will be served by this proposal? This course will interest graduate students in electrical and computer engineering with interest in electric machines and power electronics. Typically, graduate students in their second semester or later will take this course, after they have taken some fundamental courses on electric machines and power electronics.

2. What effect will this proposal have on existing courses and curricula? The proposed course will complement the existing courses on power systems, electric machines and power electronics in the in Electrical and Computer Engineering department and effectively prepare graduate students for further studies in advanced graduate courses in power

a. When and how often will added course(s) be taught? It will be offered on demand. According to the current demand and scheduling of courses, it will be offered in alternate years.

b. How will the content and/or frequency of offering of other courses be affected? No effect expected.

c. What is the anticipated enrollment in course(s) added (for credit and auditors)? Typical enrollment expected to be 5-15 students.

d. How will enrollment in other courses be affected? None expected.
How did you determine this? The graduate course will be scheduled so that it will not interfere with other courses in the power area.

d. If course(s) has been offered previously under special topics numbers, give details of experience including number of times taught and enrollment figures.
The proposed course is a modified form of a special topic course that was taught in the following semesters with enrollments as shown:
Spring 2012, Enrollment: 4 (3 M.S., 1 Ph.D.)

f. Identify other areas of catalog copy that would be affected, e.g., curriculum outlines, requirements for the degree, etc. Crosslisting ECGR 6198 and ECGR 8198 in the graduate catalog.

D. RESOURCES REQUIRED TO SUPPORT PROPOSAL.

When added resources are not required, indicate “none”. For items which require “none” explain how this determination was made.

1. Personnel
   a. Specify requirements for new faculty, part-time teaching, student assistant and/or increased load on present faculty: None.
   b. List by name qualified faculty members interested in teaching the course(s): Jonathan Bird,

2. Physical Facility: None
3. Equipment and Supplies: None
4. Computer: Windows or Apple PCs are required. Student owned personal computers or laboratory desktops, such as those available in the Electrical and Computer Engineering department will meet this need. No additional computer resources are needed.
5. Audio-Visual: None
6. Other Resources: None
7. Indicate source(s) of funding for new/additional resources required to support this proposal: None required

E. Consultation with the Library and Other Departments or Units

1. Library Consultation
Indicate written consultation with the Library Reference Staff at the departmental level to insure that library holdings are adequate to support the proposal prior to its leaving the department. (Attach copy of ***Consultation on Library Holdings***).
2. Consultation with other departments or units: none

F. Initiation and Consideration of the Proposal

1. Originating Unit
Briefly summarize action on the proposal in the originating unit including information on voting and dissenting options.
Approved per attached signatures
2. Other Considering Units
Briefly summarize action on the proposal by each considering unit including information on voting and dissenting options. N/A

G. Attachments

Course Description

This course will introduce students to the modern and classical methods used by engineers to design renewable energy electromagnetic devices, specifically electromagnetic machines. The course will be separated into two main sections. The first section of the course will review electromagnetic field theory and introduce the theory behind the finite element method. The second section will review the theory behind magnetic circuit modeling of electric machines. The emphasis will be placed on permanent magnet and induction machine design.

Recommended Course Prerequisite

ECGR 4143 Electric Machines
ECGR 3121 Introduction to Electromagnetic Fields
ECGR 3183 Computer Organization and Programming Languages (programming skills)

Course Textbook

Boldea I. *Variable Speed Generators*, CRC Press, 2005
Gieras J. F., *Permanent Magnet Motor Technology Design and Applications*, 3rd Edition, CRC Press 2010.
Krishnan R., *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Press 2010
Sadiku M. N. O. *Numerical Techniques in Electromagnetics,* 2nd Edition, 2001 CRC Press
Bastos J. P. A., Sadowski N. *Electromagnetic Modeling by Finite Element Methods*, Marcel Dekker, 2003
Tomczuk B. Z . *Linear Synchronous Motors, Transportation and Automation Systems*, 2nd Ed., CRC Press 2011
All books available free from: http://www.crcnetbase.com/page/engineering_ebooks

Class Topics

Field Modeling Methods for Electromagnetic Devices

- Classification of PDE's, Boundary conditions,
- Review of electromagnetic theory: magnetostatics, quasi statics, magnetic scalar potential, magnetic charge
- Variational Method: calculus of variations, solving variational problems, PDE's expressed as a variational problem, Ritz's method, weighted-residual methods, point-collocation method, least-squared method, Galerkin method.
- Finite Element Method: illustrated example, shape functions, step-by-step solution procedure

Magnetic Circuit Based Modeling of Electromagnetic Devices

- Permanent magnet material
- Modeling using permanent magnet material, analytic approach, graphical approach
- PM rotor types
- Hybrid PM machines
- Double Fed Induction Generators
- Winding of machines
- Carter's coefficient
- Eddy current loss in conductors
- Core loss

Grading

The final grade will be determined as follows:

Homework	40%
Projects	50%
Presentations	10%

UNC CHARLOTTE

J. Murrey Atkins Library

Consultation on Library Holdings

To: Jonathan Bird

From: Alison Bradley

Date: 4/27/12

Subject: ECGR6198/8198 Design of Renewable Energy Electromagnetic Devices

---

Summary of Librarian's Evaluation of Holdings:

Evaluator: Alison Bradley **Date: 4/27/12**

Check One:
1. Holdings are superior ______
2. Holdings are adequate __x__
3. Holdings are adequate only if Dept. purchases additional items. ______
4. Holdings are inadequate ______

Comments:
Library holdings should be adequate to support student research in the proposed course. Students will have access to monographs collections in relevant subject areas (see holdings data below), as well as electronic resources including IEEE Xplore, ASTM Digital Library, Compendex, and Electronics and Communications Abstracts among other resources. Students will also be able to access material from outside of the library collections via the Interlibrary Loan service.

LC Subject Heading	Current holdings
Electric machinery	50
Electromagnetic theory.	101
Electromagnetism	175
Finite element method	318

Alison Bradley

Evaluator's Signature

4/27/12

Date

ATTACHMENT-7:

Proposal for new graduate courses on ECGR 6199/8199: Dynamics and Control of AC Drives

University of North Carolina at Charlotte

New Graduate

Course and Curriculum Proposal from: Electrical and Computer Engineering

Title: Add New Graduate Power Course for the ECE Program

A. PROPOSAL SUMMARY AND CATALOG COPY

1. SUMMARY.
The Department of Electrical and Computer Engineering proposes to add a new elective course to the graduate curriculum: ECGR 6199, Dynamics and Control of AC Drives

2. PROPOSED CATALOG COPY: **ECGR 6199 Dynamics and Control of AC Drives (3)**.
Prerequisite: Graduate standing and knowledge of (a) electric machines, (b) power electronics, and (c) programming, or permission from the department. This advanced course will focus on studying the theory behind the control of ac drive systems. Topics studied will include: coupled circuit modeling of ac machines, dynamic modeling of induction machines, power converter and converter modeling, the simulation of electric machines and drives, electric drive system control, steady state analysis with non-conventional sources, small signal dynamic response and doubly salient electric machines. *(on demand)*

PROPOSED CATALOG COPY: **ECGR 8199 Dynamics and Control of AC Drives (3)**. See ECGR 6199 for Course Description. Credit will not be given for ECGR 6199 where credit has been given for ECGR 8199.

B. JUSTIFICATION

1. Identify the need addressed by the proposal and explain how the proposed action meets the need: Renewable energy and distributed generation devices such as wind turbines, wave generators and microturbines as well as hybrid vehicles and electric ships and aircraft all rely on ac drive system in order to transmit and control the power that they generate and consume. Motor drives are an indispensable key component of almost any renewable energy system. This course will teach students how to harness and understand the performance and control of these drives.

2. Discuss prerequisites/corequisites for course(s) including class-standing:
Prerequisites: Graduate standing and prior knowledge of (a) electric machines (b) power electronics and (c) programming (particularly matlab and/or simulink).

3. Demonstrate that course numbering is consistent with the level of academic advancement of students for whom it is intended: The course numbering ECGR 6199/8199 is consistent with the level of academic advancement of graduate students, for whom it is intended.

4. In general, how will this proposal improve the scope, quality and/or efficiency of programs and/or instruction: Presently, several advanced graduate courses in power systems exist these course focus on the interaction of different motors and generators. However, no existing graduate course systematically covers the fundamentals of

Motor drives and their control specifically. The proposed course complements the existing courses in power systems, electric machines and power electronics. The proposed course will be an important component of the graduate curriculum for the Power Systems concentration in the ECE Department. This course can effectively motivate students' interest in further studies of advanced graduate courses in electric machines and power electronics and prepare graduate students to be effective in the workforce in premier companies and for research in the field of power generation, electric machine control and design.

C. IMPACT.

1. What group(s) of students will be served by this proposal? This course will interest graduate students in electrical and computer engineering with interest in electric machines and power electronics. Typically, graduate students in their second semester or later will take this course, after they have taken some fundamental courses on electric machines and power electronics.

2. What effect will this proposal have on existing courses and curricula? The proposed course will complement the existing courses on power systems, electric machines and power electronics in the in Electrical and Computer Engineering department and effectively prepare graduate students for further studies in advanced graduate courses in power

a. When and how often will added course(s) be taught? It will be offered on demand. According to the current demand and scheduling of courses, it will be offered in alternate years.

b. How will the content and/or frequency of offering of other courses be affected? No effect expected.

c. What is the anticipated enrollment in course(s) added (for credit and auditors)? Typical enrollment expected to be 5-15 students.

d. How will enrollment in other courses be affected? None expected.
How did you determine this? The graduate course will be scheduled so that it will not interfere

d. If course(s) has been offered previously under special topics numbers, give details of experience including number of times taught and enrollment figures.
The proposed course is a modified form of a special topic course that was taught in the following semesters with enrollments as shown:
Spring 2010, Enrollment: 8 (8 M.S., 1 Ph.D.)
Fall 2011, Enrollment: 9 (6 M.S., 3 Ph.D.)

f. Identify other areas of catalog copy that would be affected, e.g., curriculum outlines, requirements for the degree, etc. Crosslisting ECGR 6199 and ECGR 8199 in the graduate catalog.

D. RESOURCES REQUIRED TO SUPPORT PROPOSAL.

When added resources are not required, indicate "none". For items which require "none" explain how this determination was made.

1. Personnel
- **a.** Specify requirements for new faculty, part-time teaching, student assistant and/or increased load on present faculty: None.
- **b.** List by name qualified faculty members interested in teaching the course(s): Jonathan Bird, Robert Cox

2. Physical Facility: None
3. Equipment and Supplies: None
4. Computer: Windows or Apple PCs are required. Student owned personal computers or laboratory desktops, such as those available in the Electrical and Computer Engineering department will meet this need. No additional computer resources are needed.
5. Audio-Visual: None

6. Other Resources: None
7. Indicate source(s) of funding for new/additional resources required to support this proposal: None required

E. CONSULTATION WITH THE LIBRARY AND OTHER DEPARTMENTS OR UNITS

1. Library Consultation
   Indicate written consultation with the Library Reference Staff at the departmental level to insure that library holdings are adequate to support the proposal prior to its leaving the department. (Attach copy of ***Consultation on Library Holdings***).
2. Consultation with other departments or units: none

F. INITIATION AND CONSIDERATION OF THE PROPOSAL

1. Originating Unit
   Briefly summarize action on the proposal in the originating unit including information on voting and dissenting options.
   Approved per attached signatures
2. Other Considering Units
   Briefly summarize action on the proposal by each considering unit including information on voting and dissenting options. N/A

G. ATTACHMENTS

Course Description – Dynamics and Control of AC Drives

Renewable energy and distributed generation devices such as wind turbines, wave generators and microturbines as well as hybrid vehicles and electric ships and aircraft all rely on ac drive system in order to transmit and control the power that they generate and consume. Motor drives are an indispensable key component of almost any renewable energy system. Learn how to harness and understand the performance and control of these drives. This advanced course will focus on studying the theory behind the control of ac drive systems. Topics studied will include: coupled circuit modeling of ac machines, dynamic modeling of induction machines, power converter and converter modeling, the simulation of electric machines and drives, electric drive system control, steady state analysis with non-conventional sources, small signal dynamic response and doubly salient electric machines.

Course Objective

The purpose of this course is to introduce students to practical dynamic modeling of electric machines and drives.

Suggested Course Prerequisites

ECGR 3121 Introduction to Electromagnetic Fields
ECGR 3122 Electromagnetic Waves
ECGR 3134 Industrial Electronics
ECGR 5195 Electrical Machinery
ECGR 3183. Computer Organization and Programming Languages (programming skills)

Course Textbook

D. W. Novotny, T. A. Lipo, *Vector Control and Dynamics of AC Drives*, Oxford University Press, USA, Sept. 1996.

Reference Textbooks

M. Ehsani, Y. Gao, S. E. Gay, A. Emadi, *Modern Electric, Hybrid Electric, and Fuel cell Vehicles, Fundamentals, Theory and Design*, CRC Press, 2005*****
P. C. Krause, O. Wasynczuk, S. D. Sudhoff, *Analysis of Electric Machinery and Drive Systems*, 2nd Edn, Wiley – IEEE Press.

* Available free through campus network at: www.engnetbase.com

Class Topics

- Coupled Circuit Modeling of AC Machines: Winding functions, three phase machine models, d-q analysis, rotational transformations, inverse transformations
- Complex Variable Analysis of Induction Machines Steady-state sinusoidal voltage in d-q variables, constant speed electrical transients, transient equivalent circuit modeling
- Simulation of Electric Machines and Drives Flux linkage as a state variable, inertia parameters, per-unit normalization methods, magnetic saturation effects
- Power Converters and Converter Modeling, VSI and CSI inverter models, model switching constraints, synchronous frame modeling, current regulated inverters

Grading

Homeworks	50%
Midterm and Final Exam	50 %

UNC CHARLOTTE

J. Murrey Atkins Library

Consultation on Library Holdings

To: Jonathan Bird

From: Alison Bradley

Date: 4/27/12

Subject: ECGR6199/8199 Dynamics and Control of AC Drives

Summary of Librarian's Evaluation of Holdings:

Evaluator: Alison Bradley **Date: 4/27/12**

Check One:

1. Holdings are superior ______
2. Holdings are adequate __x__
3. Holdings are adequate only if Dept. purchases additional items. ______
4. Holdings are inadequate ______

Comments:
Library holdings should be adequate to support student research in the proposed course. Students will have access to monographs collections in relevant subject areas (see holdings data below), as well as electronic resources including IEEE Xplore, ASTM Digital Library, Compendex, and Electronics and Communications Abstracts among other resources. Students will also be able to access material from outside of the library collections via the Interlibrary Loan service.

LC Subject Heading	Current holdings
Electric Driving	49
Electric controllers	27
Electric machinery	50
Electric vehicles	84
Power electronics	134

____
Evaluator's Signature

4/27/12
____
Date

ATTACHMENT-8:

Graduate Student Learning Outcomes for MSEE.

THE WILLIAM STATES LEE COLLEGE OF ENGINEERING

Mapping MS and PhD Graduate Student Learning Outcomes and Effectiveness Measures

Rev. 10/24/11

SLO #1: Students analyze and evaluate advanced topics in engineering.

Effectiveness Measures:
MS: Project or Thesis Written Report (WR), Project or Thesis Oral Presentation (OP), and/or Exam (EX)
PhD: Doctoral Dissertation Written Report (WR) and/or Oral Presentation (OP), and/or Exam (EX)

Performance Targets:
Reports and Presentations: 90% of the students meet or exceed requirements (≥ 26/36 or 72%)
Exams: 90% of students pass the exam with a grade of 80 or higher (17/21 or 81%)

For MS and PhD candidates:

- WR1a/OP1a: Describes the scope and context of the defined problem
- WR1b/OP1b: Demonstrates existing knowledge and emerging research on the topic
- WR1c/OP1c: Compares and contrasts relevant aspects of the topic
- WR1d/OP1d: Evaluates scope of analytical methods/tools and selects the most appropriate one(s)
- WR1e/OP1e: Identifies assumptions and constraints relevant to the analytical method/tool selected
- WR1f/OP1f: Develops an appropriate model for analysis
- WR1g/OP1g: Analyzes topic beyond the previous level of coursework
- WR1h/OP1h: Evaluates topic beyond the previous level of coursework
- WR1i/OP1i: Interprets results within the scope and context of the defined problem
- WR1j/OP1j: Makes appropriate recommendations and/or identifies next steps

For MS comprehensive examinations and Ph.D. qualifying examinations:

- EX1a: Represents the problem schematically, graphically, or figuratively
- EX1b: Identifies appropriate assumptions and constraints
- EX1c: Identifies appropriate governing equation(s)
- EX1d: Develops an appropriate model for analysis

SLO #2: Students effectively communicate technical information.

Effectiveness Measures:
MS: Project or Thesis Written Report (WR) and/or Oral Presentation (OP), and/or Exam (EX)
PhD: Doctoral Dissertation Written Report (WR) and/or Oral Presentation (OP), and/or Exam (EX)
Performance Target:
Reports and Presentations: 100% of students meet or exceed requirements (= 6/6 or 100%)
Exams: 90% of students pass the exam with a grade of 80 or higher

For MS and PhD candidates:

- WR2a: Document conforms to format specified by the Graduate School (style, font size and type, margins, spacing, pagination, numbering, and organization)
- WR2b: Referencing format confirms to discipline standards
- WR2c: Quality of content, organization, and coherence of writing is at a level expected of professional publications

- OP2a: Delivery follows a logical sequence
- OP2b: Delivery is appropriately paced
- OP2c: Delivery presents a convincing argument

For MS comprehensive examinations and Ph.D. qualifying examinations:

- EX2a: Evaluates scope of analytical methods/tools and selects the most appropriate one(s)
- EX2b: Analyzes the topic beyond the BS level
- EX2c: Correctly solves the problem

SLO #3 (for Ph.D. Students Only): Students discover and create new knowledge

Effectiveness Measure: **# of accepted publications upon graduation**
Performance Target: **90% of students have at least one accepted publication upon graduation**