

**REQUEST FOR AUTHORIZATION TO IMPLEMENT A
DOCTOR OF PHILOSOPHY IN ELECTRICAL
ENGINEERING
AT UNIVERSITY OF WISCONSIN (UW-MILWAUKEE)
PREPARED BY UW-MILWAUKEE**

ABSTRACT

The University of Wisconsin-Milwaukee proposes to establish a Doctor of Philosophy in Electrical Engineering (Ph.D. EE). The undergraduate electrical engineering program at UWM has been present (with some early changes in name) since the inception of the College of Engineering in the 1960s. At the graduate level, currently there is a long-standing, college-wide doctoral program, Ph.D. in Engineering, with tracks in six engineering disciplines and computer science. Each track functions, essentially, as its own individual program. This request is to separate the EE track of the college-wide Ph.D. program into its own program. The need for this program primarily stems from a desire to make the program more attractive to prospective students and enhance graduate placement (the generic Ph.D. in Engineering makes the graduates in the individual tracks less competitive in the job market). The proposed Ph.D. program in Electrical Engineering will essentially be the same as the EE track of the existing college-wide Ph.D. program. Curricular areas will be unchanged, covering typical graduate-level electrical engineering content. No new courses are needed, and no new faculty/staff are needed for this program. There are no planned changes in research foci – current areas of strength include power systems and components, bio-optical imaging, and nanotechnology.

PROGRAM IDENTIFICATION

Institution Name

University of Wisconsin-Milwaukee

Title of Proposed Program

Electrical Engineering

Degree/Major Designations

Doctor of Philosophy

Mode of Delivery Single institution Face-to-face

Projected Enrollments and Graduates by Year Five

The Ph.D. enrollment in the EE portion of the current college-wide Ph.D. program for years 2015-2018 was 38, 43, 44, and 40, for an average of 41 Ph.D. students in the EE portion of the program. Approximately 80% of these students are full-time. We do not expect any significant changes in that number after the EE Ph.D. program becomes a stand-alone program.

Table 1: Five-Year Academic Program Enrollment Projections

Students/Year	Year 1	Year 2	Year 3	Year 4	Year 5
New Students	8	8	8	8	8
Continuing Students	33	33	33	33	33
Total Enrollment	41	41	41	41	41
Graduating Students	8	8	8	8	8

There is some attrition in the program due to, e.g., students failing the Ph.D. Qualifying Exam, poor academic performance, visa or funding issues, etc., but the numbers are quite small.

Tuition Structure

Standard tuition and fee rates will apply. For full-time enrollment, a resident student will pay a tuition of \$5,271.28 per semester and segregated fees of \$753.65 for a total of \$6,024.93 per semester. For students enrolling part-time, one-semester resident tuition is \$658.91 per credit and segregated fees are based on the number of credits enrolled. For three-credit enrollment, the resident tuition and segregated fees are a total of \$2,666.52 and for six-credit enrollment the total is \$4681.59. The corresponding nonresident tuition and segregated fees are \$12,641.17 for full-time enrollment, \$5,147.61 for three-credit enrollment, and \$9,643.77 for six-credit enrollment. Segregated fees for non-resident students are the same as the resident rate. There are separate rates for Minnesota w/ Reciprocity and Midwest Student Exchange, which fall between the resident and non-resident rates. Credits taken in the College Engineering and Applied Science are assessed an additional “differential tuition” which is currently \$21.63 per credit. The majority of PhD students in Engineering are graduate assistants and have their tuition remitted.

Department or Functional Equivalent

Department of Electrical Engineering and Computer Science

College, School, or Functional Equivalent

College of Engineering and Applied Science

Proposed Date of Implementation

August 2020

DESCRIPTION OF PROGRAM

Overview of the Program

The program will be comprised of 66 graduate credits beyond the Bachelor’s degree with minimum credit distribution as follows:

- 21 credits in electrical engineering topics
- 9 credits in an approved minor area (within or outside of EE)
- 6 credits in mathematics and/or quantitative methods
- 9 credits of approved electives
- 3 credits of CEAS Graduate Seminar (Ethics and Engineering Communication, EE700)

- A minimum of 26 credits, excluding dissertation, must be at the 700 level or higher
- 18 credits of doctoral thesis
- A minimum of 33 credits (including thesis) must be completed in the Ph.D. program at UWM.

A maximum of 33 credits may be considered for transfer from prior graduate work, including a Master's degree earned at UWM or elsewhere provided the course work taken falls within the appropriate areas and has earned a grade of "B" or better. Students entering the program without an applicable Master's degree are limited to a maximum transfer of 9 credits for courses taken elsewhere.

Student Learning Outcomes and Program Objectives

Learning Outcomes of the EE Ph.D. Program (same as the current college-wide Ph.D. Program):

- a. Apply advanced knowledge of mathematics, science, and engineering to solve complex problems.
- b. Use modern tools or techniques to solve complex problems, conduct research, and analyze and interpret data.
- c. Demonstrate proficiency and competency in the area of specialization.
- d. Identify, formulate, and solve complex problems with an original and/or significant contribution to the field.
- e. Demonstrate a familiarity with research in a related or complementary discipline.
- f. Use quantitative methods appropriate to the field of research.
- g. Understand academic, professional and ethical responsibility.
- h. Communicate effectively via technical writing and oral presentations.

Assessment of Outcomes

Outcome (a) is assessed through achievement of the Ph.D. Qualifying Examination.

Outcome (b) is assessed through the dissertation proposal hearing.

Outcome (c) is assessed through the Qualifying Examination and achieving a grade of B or higher in program of study.

Outcome (d) is assessed in the preliminary examination (identify and formulate), in the thesis (solve) and in any published results.

Outcome (e) is assessed through achieving required B or higher average in selected course work (9 minor credits) and in the preliminary examination.

Outcome (f) is assessed in the program of study's inclusion of appropriate course work with a grade of B or higher.

Outcome (g) is assessed in the required ethics and communication course(s) being developed with a grade of B or higher.

Outcome (h) is assessed in the Dissertation Proposal hearing and the Dissertation Defense.

Program Requirements and Curriculum

This proposed program is housed within the College of Engineering and Applied Science (CEAS). It will follow the College's **existing Ph.D. admission requirements**, which are:

- Bachelor's or Master's degree in electrical engineering.
- If you have BS or MS degrees outside of electrical engineering, you may be admitted with no more than two course deficiencies.

- Minimum GPA of 3.0 in the highest degree granted based on a 4.0 scale.
- A brief statement describing your professional goals (i.e., Statement of Purpose, SoP) and two letters of reference.
- The Graduate Record Examination (GRE) is required for all international and domestic applicants.
- International students require proof of English language proficiency.

Credits

The electrical engineering doctoral program consists of 66 graduate credits beyond the Bachelor's degree, as described above. Courses are chosen by the student in consultation with her/his advisors. The number of credits and scope of the course work is comparable to other institutions (UW-Madison EE doctoral program requires 51 credits, whereas Univ. of Minnesota EE doctoral program requires 64 credits).

Course format

In general, courses will be offered face-to-face; however, a few courses are delivered online.

Graduate Course List

ELECENG 410G Digital Signal Processing
ELECENG 420G Random Signals and Systems
ELECENG 421G Communication Systems
ELECENG 430G Energy Modeling
ELECENG 436G Introduction to Medical Instrumentation
ELECENG 437G Introduction to Biomedical Imaging
ELECENG 439G Introduction to Biomedical Optics
ELECENG 451G Introduction to VLSI Design
ELECENG 457G Digital Logic Laboratory
ELECENG 458G Computer Architecture
ELECENG 461G Microwave Engineering
ELECENG 462G Antenna Theory
ELECENG 464G Fundamentals of Photonics
ELECENG 465G Broadband Optical Networks
ELECENG 471G Electric Power Systems
ELECENG 472G Introduction to Wind Energy
ELECENG 474G Introduction to Control Systems
ELECENG 481G Electronic Materials
ELECENG 482G Introduction to Nanoelectronics
ELECENG 490G Topics in Electrical Engineering:
ELECENG 541G Integrated Circuits and Systems
ELECENG 545G FPGA Embedded CPUs & Firmware Development
ELECENG 562G Telecommunication Circuits
ELECENG 565G Optical Communication
ELECENG 568G Applications of Digital Signal Processing
ELECENG 572G Power Electronics
ELECENG 574G Intermediate Control Systems
ELECENG 575G Analysis of Electric Machines and Motor Drives
ELECENG 588G Fundamentals of Nanotechnology
ELECENG 699G Independent Study
ELECENG 700 CEAS Graduate Seminar
ELECENG 701 Advanced Linear System Analysis
ELECENG 710 Artificial Intelligence
ELECENG 711 Introduction to Machine Learning

ELECENG 712 Image Processing
ELECENG 713 Computer Vision
ELECENG 716 Tomography: Imaging and Image Reconstruction
ELECENG 717 Tomography: Image Quality and Artifact Correction
ELECENG 718 Nonlinear Control Systems
ELECENG 721 Digital Communications
ELECENG 733 Sensors and Systems
ELECENG 737 Medical Imaging Signals and Systems
ELECENG 741 Electromagnetic Fields and Waves
ELECENG 742 Electromagnetic Wave Theory
ELECENG 755 Information and Coding Theory
ELECENG 758 Advanced Computer Architecture
ELECENG 760 Computer Systems Performance Evaluation
ELECENG 762 Fault-Tolerant Computing
ELECENG 765 Introduction to Fourier Optics and Optical Signal Processing
ELECENG 766 Introduction to Nonlinear Optics
ELECENG 781 Advanced Synchronous Machinery
ELECENG 810 Advanced Digital Signal Processing
ELECENG 816 Optimal Control Theory
ELECENG 819 Adaptive Control Theory
ELECENG 872 Computer Analysis of Electric Power Systems
ELECENG 880 Bioengineering Seminar
ELECENG 888 Candidate for Degree
ELECENG 890 Special Topics:
ELECENG 990 Masters Thesis
ELECENG 998 Doctoral Thesis
ELECENG 999 Advanced Independent Study

Program Requirements (the following are UWM Graduate School requirements)

Major Professor as Advisor

The Graduate School requires that the student must have a major professor to advise, supervise, and approve the program of study before registering for courses. The GPSC or its delegates will assign the incoming student to an initial Program Advisor at the time of admission. Prior to the completion of 12 credits (9 credits for part-time students), the student must select a major professor who will be the student's thesis advisor. The student, in consultation with the major professor, develops a proposed program of studies which is submitted to the Graduate Program Subcommittee for approval. For subsequent changes, the student must file a revised program of study for approval.

Foreign Language

There is no foreign language requirement for the degree.

Residence

The program residence requirement is satisfied either by completing 8 or more graduate credits in each of two consecutive semesters, inclusive of summer sessions, or by completing 6 or more graduate credits in each of three consecutive semesters, exclusive of summer sessions.

Qualifying Examination

Each student in the program must take and pass a Qualifying Examination to demonstrate that the student is qualified for doctoral-level work. The Qualifying Examination is a written exam and is structured in two parts: Part 1 and Part 2. The examination is offered twice a year during the regular academic year. The content of the examination varies among the major areas of the PhD in Engineering program.

Students entering with only a bachelor's degree or with a master's degree in an area unrelated to their major area may take the Qualifying Examination for the first time after earning 12 credits of graduate work at UWM and must successfully pass the exam before earning 30 credits of graduate work at UWM.

Students admitted after completing an appropriate master's degree must take this examination no later than the semester immediately after 18 credits of graduate work have been earned at UWM.

A student may take the Qualifying Examination twice. On the first attempt, the student must attempt both Part 1 and Part 2 of the examination.

- If the student passes both parts, then the student has passed the entire examination and will be permitted to proceed toward the Doctor of Philosophy degree.
- If the student fails both parts, then the student must take the entire exam again at its next offering.
- If a student passes only one of the two parts, then the student must take the examination again at its next offering, but may choose to take only the part of the examination that was not passed on the first attempt.
- If a passing grade is not obtained on the second attempt of the Qualifying Examination, the student will not be permitted to proceed toward the Doctor of Philosophy degree.

A student who fails the qualifying exam twice is subject to dismissal from the PhD in Engineering program. A student may appeal the failure and dismissal within 30 days of being notified of the failure. If the student does not appeal or the appeal is not granted, the College will recommend to the Graduate School that the student be dismissed. A student who is dismissed from the PhD in Engineering program because of failing the qualifying exam may not be enrolled in the PhD in Engineering program for a complete calendar year. This does not preclude the student from being enrolled in any other degree program offered by the University. A student who wishes to re-enroll in the program after a calendar year has passed must apply as any other student would, including payment of fees. A student readmitted after having failed the qualifying exam twice must take the qualifying exam in the first semester of matriculation and this will count as the student's first attempt at the exam. The student may appeal this requirement prior to the first scheduled day of classes. If the student fails the qualifying exam on this first attempt, the student is permitted the customary second attempt as described above. All appeals must be in writing and directed to the CEAS Associate Dean for Academic Affairs.

Doctoral Program Committee

The Doctoral Program Committee is proposed by the major professor in consultation with the student and the department. The Committee must include at least five graduate faculty (three from major area, one from minor area, and one from any area, including the major and minor areas). The last member may be a person from outside the University (such as another university, a research laboratory, or a relevant industrial partner), provided that person meets Graduate School requirements. The Committee

may have more than five members, provided that the majority of the Committee members are from the student's major field. The Major Professor is generally a faculty member from the EECS department who has Graduate Faculty status.

Doctoral Preliminary Examination

A student is admitted to candidacy only after successful completion of the doctoral preliminary examination conducted by the Doctoral Program Committee. This examination, which normally is oral, must be taken before the completion of 48 credits of graduate work toward the Doctor of Philosophy degree in Engineering and should be taken within the first five years in the program. Prior to the examination, the student must present a proposal for a doctoral dissertation project. The examination may cover both graduate course material and items related to the proposed dissertation project.

Dissertation and Dissertator Status

The student must carry out a creative effort in the major area under the supervision of the major professor and report the results in an acceptable dissertation. The effort of the student and the major professor to produce the dissertation is reflected in the PhD in Engineering program requirement that the student complete at least 18 credits of doctoral thesis.

After the student has successfully completed all degree requirements except the dissertation, the student may apply for Dissertator Status. Achieving Dissertator Status requires successful completion of the Doctoral Preliminary Examination and prior approval of the student's advisor, the Doctoral Program Committee, and the GPSC of a dissertation proposal that outlines the scope of the project, the research method, and the goals to be achieved. Any proposal that may involve a financial commitment by the University also must be approved by the Office of the Dean. After having achieved Dissertator Status, the student must continue to register for 3 credits of doctoral thesis per semester during the academic year until the dissertation is completed.

Dissertation Defense

The final examination, which is oral, consists of a defense of the dissertation project. The doctoral defense examination may only be taken after all coursework and other requirements have been completed. The student must have Dissertator Status at the time of the defense.

Time Limit

All degree requirements must be completed within ten years from the date of initial enrollment in the doctoral program.

Diversity

According to the American Society for Engineering Education (ASEE), in 2018, 14.2% of earned Ph.Ds. in Electrical Engineering in the United States were awarded to women and 17.7% were awarded to persons from ethnic or racial minority groups^[1]. By comparison, currently, in the EE part of the common CEAS Ph.D. program, there are currently 10 female and 28 male students (i.e., 36% female). One

of the male students is African American.

Internal and external efforts to maintain diversity in the graduate ranks in this and other STEM related programs have been proposed. The UW-Milwaukee STEM-Inspire, Wisconsin Alliance for Minority Participation, and McNair initiatives seek to improve retention and persistence in science, technology, engineering, and mathematics (STEM) fields of students from underrepresented backgrounds. The proposed EE doctoral program is very supportive of these initiatives, and we plan on continuing our strong support for female and under-represented groups.

Collaborative Nature of the Program

Subject to department approval, the program allows for a faculty member outside of Electrical Engineering to serve as Major Professor. Typically, these are faculty members in Physics, or in another engineering discipline who has an affiliate appointment who has been granted Graduate Faculty status by their home unit, or a member of the UWM Category B Research Academic Staff with the Scientist title (any prefix), as well as other stipulations as described in Faculty Doc. F3134/GFC Doc. 1173.

In addition, doctoral students are required to take courses in a minor area, which typically encompasses other engineering disciplines, physical sciences, or mathematics.

Projected Time to Degree

A full-time student with a completed master's degree would typically complete the Ph.D. in 3-4 years. For a student entering with a baccalaureate degree, the time to complete the degree would typically be 4-5 years.

Program Review

According to established UWM policy, the program will be reviewed once after five years, and then every ten years henceforth.

JUSTIFICATION

Rationale and Relation to Mission

The current umbrella Ph.D. program, being focused on research and advanced education, clearly serves the broad UW-Milwaukee mission for discovery, research, and education, and supports the generation of new knowledge for the development and betterment of society. The new, split-off EE program will serve the same purpose.

As discussed above, at present there is a college-wide Ph.D. program in Engineering and Applied Science. The electrical engineering portion of that program has approximately 100 graduate students, divided roughly in half between Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) students. The proposed program is simply to split off the electrical engineering portion of that existing program, to become a Ph.D. in Electrical Engineering. Department faculty feel that this is an appropriate move for several reasons. First, there is some student reluctance to have a Ph.D. degree that is, officially, in Engineering, rather than in Electrical Engineering. We feel that a more specific degree name would aid in attracting top Ph.D. student candidates to the program. Second, department faculty would like more autonomy in administering the program, including scheduling and evaluation of the Ph.D. Qualifying Exam. Third, having a combined college-wide program makes it difficult to collect data on our (EE) students and graduates, as all Ph.D. students in the college are, officially, in Engineering rather than Electrical Engineering. Related to data collection for our own internal purposes, the

presence of a college-wide Ph.D. program adversely affects us in rankings, such as US News and World Reports and similar venues. We do not appear in these rankings of electrical engineering Ph.D. programs simply because we do not have a Ph.D. in electrical engineering (despite the fact that we, essentially, do have such a program of longstanding nature).

Institutional Program Array

As this is really just a continuation of the existing (EE track) of the Engineering Ph.D., there will be no impact on the program array of the institution.

Other Programs in the University of Wisconsin System

In Wisconsin, UW-Madison and UW-Milwaukee are the only two Ph.D. granting institutions. We do not expect that this program will have any effect on the EE Ph.D. program in Madison. Our student pool is largely drawn from two groups. One is engineers working in industry in Milwaukee. They choose UWM because it is convenient, and for them, Madison is too far to commute. The creation of a stand-alone EE Ph.D. program will not affect these students. The other main group is foreign students, but our program and the program at Madison have different admission criteria (which is the current situation, and which will not change in the proposed program). As such, it is clear that the proposed program will neither produce unnecessary duplication within the UW System, nor impact the program at Madison.

Need as Suggested by Current Student and Market Demand

Having had an average of 41 Ph.D. students in the EE portion of the program in recent years (a number which has been relatively stable for a considerable time), there seems to be a clear need for the program.

As a representative example, in the 2017-2019 span, there were 16 Ph.D. graduates in the EE portion of the Engineering Ph.D. program, for an average of approximately five per year. The following lists what they did immediately upon graduation:

Eight graduates went to work in industry (Johnson Controls, Rockwell Automation, Marshfield Clinic, Milwaukee Tool, Eaton Corporation, ASML HMI, Qlarant, Alta Devices). Four graduates became Post-Docs (Cornell, University of Calgary, University of Illinois at Urbana-Champaign, UW Madison). Two graduates went to the Global Energy Interconnection Research Institute (GEIRI). One graduate went to work for Minnesota State University, Mankato, and one graduate went to work at Indiana University (as a Senior Electronics Engineer).

Thus, there is clearly a market demand for UWM EE Ph.D. graduates.

ADDITIONAL DOCUMENTATION TO BE SUBMITTED:

Three additional documents must be submitted along with the Request for Authorization to Implement a Degree narrative to apei@uwsa.edu. These additional documents are:

- Cost and Revenue Projections Spreadsheet (Excel format)
- Cost and Revenue Projections Narrative (Word format)
- Institutional Letter of Commitment (PDF format)

These documents will be combined into one PDF document for the Board of Regents' packet later.

Cost and Revenue Projections Spreadsheet – Additional Document #1 (Excel format)

Cost and Revenue Projections Narrative – Additional Document #2 (Word format)

Institutional Letter of Commitment – Additional Document #3 (PDF format)

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