The University Senate of Michigan Technological Universtiy

Proposal 7-17

(Voting Units: Academic)

"A PROPOSAL TO ESTABLISH A CONCENTRATION IN *Electric Power Engineering* as part of the degree BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING"

(Department of Electrical and Computer Engineering)

(1) Date November 3, 2016

(2) Department Proposer: Daniel R. Fuhrmann, Chair, ECE

(3) Interdisciplinary Program Approval– Not Applicable, this concentration is not an interdisciplinary program.

(4) General Description and Program Characteristics

The Department of Electrical and Computer Engineering at Michigan Technological University proposes a new Concentration in Electric Power Engineering to be included with the degree Bachelor of Science in Electrical Engineering. The Concentration is being created in response to Senate Proposal 43-15 to replace the function of the Certificate in Electric Power Engineering for our undergraduate students. We will continue to offer the Certificate in Electric Power Engineering to students who have already earned a Bachelor's degree.

This concentration will provide a tailorable but constrained coursework focus in (a) electric energy systems (both conventional and renewable), (b) power system component, device and machine modeling, (c) steady state electric power system analysis, (d) faulted power system analysis, (e) power system protection, (f) transient analysis of power systems, (g) economic operation of power systems and (h) opportunities to explore expanded graduate-level coursework in power systems.

Learning Goals: The learning goals associated with this concentration would include those defined by ABET program outcomes: a (an ability to apply knowledge of mathematics, science and engineering), b (an ability to design and conduct experiments, as well as to analyze and interpret data), c (the ability to design a system, component, or process to meet desired needs within realistic constraints), e (an ability to identify, formulate and solve engineering problems) and k (the ability to use the techniques, skills, and modern engineering tools necessary for the practice of electrical engineering).

Other goals of this concentration include:

1) Provide a coursework structure that will allow current and prospective students to be aware of the many applications of electrical power engineering in today's marketplace, and the opportunities available to electrical engineers with interests in electric power, and

2) Provide employers with the clear distinction of potential employees with focused studies in the field of electrical power engineering at Michigan Technological University.

(5) Rationale

Electrical engineering and affiliated fields such as computer engineering and computer science are among the technical disciplines which are experiencing the highest demand currently among prospective employers. This is particularly true at Michigan Tech, where our educational approach emphasizing a firm grounding in the fundamentals, individual skills, team-based projects, and hands-on experiences produces graduates which are highly recruited in industry. For example, at the Fall 2015 Career Fair, there were representatives from 377 companies and organizations on campus; 215 were seeking electrical engineers and 118 were seeking computer engineers for co-ops, internships, and full-time positions. Self-reported data from the Michigan Tech EE and CpE graduates in the Class of 2013 indicates a 96% placement rate and an average starting salary in excess of $60,000.

One of the core competencies in the ECE Department is education in electrical power generation, transmission, and distribution. This has been true since the founding of the EE Department in 1928, and it remained true throughout our history, even during the "lean years" of the 1980s and 1990s when electrical

power engineering fell out of favor among many small- and medium-sized ECE Departments due to lack of research funding and lack of innovation and investment in the utility power industry. Today, that situation has completely turned around. Our industry partners tell us of a shortage of engineers in the workforce as many of the current engineering near retirement age. Investment in the power grid infrastructure, the advent of "smart grid" technologies, concern over critical infrastructure cybersecurity, and the broad nationwide interest in renewable sources such as wind and solar, along with emerging energy storage technologies, have all made electric power engineering one of the hottest sub-fields within electrical engineering, for students and recruiters alike.
Michigan Tech has a number of long-standing good relationships with the utility power industry in the upper Midwest. The ECE External Advisory Committee includes representatives from Consumers Energy, DTE Energy, and Systems Control, and the College of Engineering External Advisory Board has a representative from International Transmission Corporation. We have research sponsored by Xcel Energy and agencies within the federal government, most notably the Department of Defense, that have a strong interest in the energy technologies of tomorrow. The Dennis Wiitanen Endowed Professorship in Electric Power Engineering was made possible by contributions from several industry partners and individuals in the industry. Many other companies in the energy field recruit at Michigan Tech, including American Transmission Company, Black & Veatch, Schweitzer Engineering Laboratories, and Wolverine Power. We are proud of our reputation and our contributions to the field and are pleased to see it recognized in so many different ways.

Because of the strong interest by many of our undergraduate students in electric power engineering, and the strong interest among recruiters in those same students, we feel it will be beneficial to both parties to have a formal recognition of specialized training in this area as part of the broader training in electrical engineering. This was true many years ago when the BSEE degree included what were known as "options"; indeed we did have at one time a "power option". Today this recognition is done through the mechanism of Concentrations. Students taking the Concentration in Electric Power Engineering will be directed toward a specific set of courses that will best train them to enter the workforce in the power industry. Similarly, industry recruiters will know which of our students have had that specialized training, and will seek them out for co-ops, internships, and full-time jobs. This Concentration may also serve as a recruiting tool for

prospective undergraduate students, who recognize the value of a Michigan Tech education and have an interest in re-inventing the power grid someday. The proposed concentration is designed to meet all these needs.

(6) Related Programs

There are no other related programs at Michigan Tech.

(7) Student Enrollment

There have been no problems handling demand for the previous Certificate in Electrical Power Engineering with the current faculty and staff within the ECE Department. Therefore, there are no anticipated shortcomings in delivering this proposed concentration.

(8) Scheduling Plans

This concentration can be accommodated in a regular, 4-year electrical engineering student study plan (see (9)).

(9) Curriculum Design

The boundary conditions the proposed concentration must satisfy were established by the University Senate of Michigan Technological University in proposal 15-11. In particular:

"Concentrations (also referred to as options) within a major degree program will be granted to students who have completed the requirements established by the program's home academic unit at Michigan Technological University. Concentrations will be noted on official transcripts and diplomas. The purpose of a concentration is to give recognition that the student has actively and consciously engaged the intellectual issues central to the concentration."

"A concentration does not have any specific credit limitations, except that the total number of credits required by the degree and the major concentration combined may not exceed 128 credits (or 131 credits if 3 credits of free elective are included in the degree requirements). The academic unit offering the concentration determines specific courses fulfilling the requirement. The minimum grade-point average required for the concentration is that of the major degree program."

Currently in the EEE curriculum, there are:

12 Credits General Education Required Courses
12 Credits HASS Distribution Courses
30 Credits Required Math, Physics and Eng Fundamentals

48 Credits in the EE core curriculum

7 Credits Approved (Capstone) Design

15 Credits EE Electives
1 Credits Approved Electives
3 Credits Select Approved Electives

128 Total Credits

To complete the Bachelor of Science Degree in Electrical Engineering with a Concentration in Electric Power Engineering a student **must** include the following 10 credits of coursework:

EE 3120 Electric Energy Systems	3	F/S/Su
EE 4221 Power System Analysis I	3	F
EE 4222 Power System Analysis II	3	S
EE 4226 Power Engineering Laboratory	1	S/Su

And 6 credits or more from:

EE 4219 Intro to Electric Machinery and Drives	3	S
EE 4220 Intro to Electric Machinery and Drives Lab	1	S
EE 4227 Power Electronics	3	F
EE 4227 Power Electronics Lab	1	F
EE 4262 Digital and Non-linear Control	3	S
EE 5200 Advanced Methods in Power Systems	3	F
EE 5230 Power System Operations	3	F
EE 5223 Power System Protection	3	S
EE 5223 Power System Protection Lab	1	S
EE 5240 Computer Modeling of Power Systems	3	F
EE 5250 Distribution Engineering	3	F
EE 5290 Special Topics in Power Systems	3	F/S/Su

The courses listed above are taught regularly (listed as shown in the University catalog) by faculty members within the department of Electrical and Computer Engineering (see http://www.mtu.edu/ece/department/faculty/ for faculty credentials).

It should be noted that the list of electives given above includes several advanced courses in the ECE graduate power program. Waivers to allow appropriately prepared undergraduates into these courses are routinely granted.

The BSEE 4-year plan that includes the proposed Concentration in Electric Power Engineering can be found in the Appendix.

(10) New Course Descriptions

The *Certificate* in Electric Power Engineering currently draws from regularly scheduled ECE courses to satisfy its requirements; therefore no difficulty is anticipated in servicing the student demand for the proposed *Concentration*.

This concentration is based entirely on existing courses at Michigan Tech. No new resources are required.

(11) Schedule

On-campus students who previously would have earned the Certificate In Electric Power Engineering will now be directed to the Concentration in Electric Power Engineering. Students will schedule coursework to complete this concentration as shown in the appended 4-year plan.

(12) Library/Other Resources

No additional library or other non-ECE resources required.

(13) Faculty Resumes

The background and interest/expertise areas of the power area faculty are found on the department webpage: http://www.mtu.edu/ece/department/faculty/

(14) Needed Equipment

There are no additional equipment needs required to implement this concentration.

(15) Program Costs

No additions costs are required to implement this concentration.

(16) Space

There are no additions space requirements to implement this concentration.

(17) Policies, Regulations and Rules

The requirements to earn the Concentration in Electric Power Engineering are presented in (9) above.

(18) Accreditation Requirements

The courses contained in this concentration falls under the same ABET mandated accreditation procedures implemented as part of the ECE department's continuous improvement plan.

(19) Planned Implementation

Implementation of the concentration will begin immediately upon approval.

Bachelor of Science in Electrical Engineering plan
Electric Power Engineering Concentration (16 cr.)

This suggested plan applies to students entering in Academic Year 2016-2017 who are ready for calculus.

Semester 1			**Semester 2**		
CH1150&1151	Univ. Chemistry I & Lab I	4	PH2100	Univ. Physics I - Mechanics	3
CH1153	Prob. Solv. Chem. I :optional	1	ENG1102	Engineering Modeling & Design	3
ENG1101	Engineering Analysis	3	MA2160	Calculus with Technology 2	4
MA1160[1]	Calculus with Technology 1	4	PH1200	Univ. Physics II Lab	1
PH1100	Physics Lab 1	1	EE1110	Essential Math for EE's	1
			EE1111	Intro. to Elec. & Comp. Engg.	1
UN1015	Composition	3	UN1025	Global Issues	3
	Total	***15/16***		Total	***16***
Semester 3			**Semester 4**		
MA2321[2]	Linear Algebra	2	EE*2112*	Electric Circuits II w/lab	4
MA3521[2]	Differential Equations	2	EE3120	Electric Energy Systems	3
EE 2111	Electric Circuits I	3	EE2174	Digital Logic w/ Lab	4
PH2200	Univ. Physics II Elec&Magnetism	3	MA3160	Multi-variable Calculus	4
CS1111	Intro to Programming in C/C++	3			
	Goal 4 Crit/Creat.Thinking course[6]	3		Goal 8 Soc/Eth Reasoning course[6]	3
	Total	***16***		Total	***18***
Semester 5			**Semester 6**		
EE3131	Electronics	4	EE3901	Design Fundamentals	2
EE3140	Electromagnetics	3	EE3180	Probability – Signal Analysis	3
EE3160	Linear Systems	3	EE3261	Control Systems	3
	SELECT Approved Elective[3a]	3	EE3171	Microcontroller Applications	4
	HASS 2nd Comp/Comm. course[6]	3	EE3250	Intro. Communication Theory	3
	Total	***16***		Total	***15***
Semester 7			**Semester 8**		
EE4901[4]	EE Design Project 1 (part 1)	2	EE4910[4]	EE Design Project 2 (part 2)	2
EE4221	Power Analysis I[7]	3	EE4222	Power Analysis II[7]	3
	Power Concentration Elective[7]	3	EE4226	Power Engineering Laboratory	1
	EE Elective[7]	3		Power Concentration Elective[7]	3
	HASS HU/FA elective[6]	3		HASS EC/SS/PSY elective[6] ;HASS	6
	Approved electives[3b]	2		Free electives	1
	Total	***16***		Total	***16***

Total **128** Credits

Students must *add 3 units of co-curricular activities* (Physical Education), usually taken in six .5 units.
Follow pre-requisites and semester offerings. This is a 'suggested' plan which can vary by individual student; shows best route through system to avoid conflicts. Students who begin in a pre-calculus course will take ENG1001 and ENG1100 in place of ENG1101 in first year.

1. MA1160 may be replaced by MA1161
2. MA2320 and MA3520 may replace MA2321 and MA3521
3. SELECT Approved Elective(3a): 3 credits from a "select approved list", topics recommended by industry professionals, plus 2 credits from Approved electives(3b) list: CH1153 may apply. Reduce 3b by 2 cr. with enterprise design option.
4. Approved Engineering Design courses or Enterprise courses may replace EE4901, & EE4910. See department advisor for details.
5. EE Electives: 15 credits of EE courses not listed here and not EE3805, EE4805, EE4901, EE4910.
6. HASS = Humanities, Arts and Social Sciences. Follow university requirements for general education courses.
7. Up to 6 credits "EE" level 4000+ may be double-counted toward the ECE accelerated master's program.