Graduate Degree Addition

Master of Science in Electrical and Computer Engineering (MSEE)

Weisberg Division of Engineering

Marshall University

Proposed Implementation Date: Fall 2017

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Brief Program Description:

The Master's of Science in Electrical and Computer Engineering degree (MSEE) is developed by the Weisberg Division of Engineering at the College of Information Technology and Engineering (CITE) to graduate electrical and computer engineers for meeting West Virginia's increasing technological demands. Graduates with this Degree will contribute to West Virginia's economic development, advance its competitive edge globally and contribute to improvement in the quality of life.

A master's degree in electrical and computer engineering (MSEE) provides additional breadth and depth of knowledge, positioning graduates for technical leadership and specialization in industry. Candidates develop skills such as analysis, resourcefulness, ingenuity, responsibility and perseverance through research activities. The proposed MSEE will significantly increase graduate students' enrollment at Marshall University from local, national and international sources. The INTO program recruiters in China and India have indicated that they can recruit large number of students to study MSEE at Marshall University once the program is in place. The MSEE will enable the introduction of an Accelerated Master's Degree (AMD or 4+1) program in BSEE. AMD allows outstanding undergraduate students to complete a traditional four-year Bachelor's degree in Electrical and Computer Engineering and then, with one additional year, earn a Master's degree. AMD will help attract more highly motivated undergraduate students to Marshall University. MSEE degree program is essential to attract and retain qualified faculty members in EE. Also, research is an integral part of a faculty member's career to stay abreast in a rapidly evolving field such as EE. MSEE program is critical to helping faculty members stay current and also contributes to keeping the BSEE program current and relevant.

This proposed MSEE program is to be established on the foundation of the currently under-review BSEE program. Therefore, both programs are to share the same resources. The program will cost approximately $1.12 million during its first five years, of which about $150,000 will be used to develop needed laboratories. The program is expected to generate $1.85-2.49 million in revenues during the first five years. Enrollment is expected to increase over this period; it is expected that, after the first five years, 35 students will have graduated with a MSEE degree and approximately 46 students will be actively pursuing a MSEE degree at MU.

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1. Rationale for the New Degree Program

1.1 Market Demand

The Master's of Science in Electrical and Computer Engineering degree (MSEE) is developed by the Weisberg Division of Engineering at the College of Information Technology and Engineering to prepare electrical and computer engineers for meeting the increasing technological demands for West Virginia and the surrounding region. Graduates of this Program will contribute to the region's economic development, advance its competitive edge globally and contribute to improvement in the quality of life.

Electrical engineering is a field of engineering that generally deals with the study and application of electricity, electronics, and electromagnetism. The fields of electrical and computer engineering cover a wide range of subfields including electronics, power engineering, telecommunications, control systems, radio-frequency engineering, signal processing, instrumentation, microelectronics, digital systems including hardware, software, compilers and operating systems, coding, cryptography, network, mobile and distributed computing system, and cyber physical systems and security. As such, the MSEE program at Marshall University (MU) will prepare graduates with a MSEE with two areas of emphasis: general electrical engineering, and computer engineering. It will, also, emphasize service, systems-based knowledge, and sustainability with an eye toward the interface of traditional electrical and computer engineering with new and emerging fields.

The U.S. Department of Labor, Bureau of Statistics, reported that nationwide, the number of electrical and computer engineers and closely related jobs grew by 11 % between 2006 and 2014 (from 216,000 to 240,000); and it is expected to grow to about 290,000 in year 2022. The U.S. Census Bureau (Field of Bachelor's Degree in the US: 2009; Issued February 2012) reported that there are 4.452 million engineers of 25 years and over in the USA; with 1.410 million in the age bracket of 25-39 and 2.252 million in the age bracket of 40-64. Therefore; the overall job opportunities in engineering are expected to be good because the number of engineering graduates should be in rough balance with the number of job openings between 2010 and 2020. In addition to openings from job growth, many openings will be created by the need to replace current engineers who retire or transfer to management, sales, or other occupations; or leave engineering for other reasons. Therefore, in the next 20-25 years US academic institutions are expected to graduate, on average, about 125,000 engineers per year to keep up with

demands. The American Society of Engineering Education (ASEE), in its annual report (Engineering by the Number-2011; www. asee.org/colleges) reported that in 2010-2011, all US Institutions graduated only 83, 001 engineers of which 6.7% were nonresident aliens.

Employment of engineers is expected to grow about as fast as the average for all occupations over the next decade, but growth will vary by specialty. Electrical and computer engineers are projected to have about 20 percent employment growth over the projected decade, slower than the average for all occupations. But, some new job opportunities will be created due to emerging technologies in biotechnology, smart grid, power systems, cyber systems and security, and mobile technologies. Additional opportunities outside of electrical and computer engineering will exist because the skills acquired through earning a degree in electrical/computer engineering often can be applied in other engineering specialties.

Competitive pressures and advancing technology will force companies to improve and update product designs and to optimize their manufacturing processes. Employers will rely on engineers to increase productivity and expand output of goods and services. New technologies continue to improve the design process, enabling engineers to produce and analyze various product designs much more rapidly than in the past. Unlike some other occupations, however, technological advances are not expected to substantially limit employment opportunities in engineering because engineers will continue to develop new products and processes that increase productivity.

In West Virginia, as reported by many industrial leaders, a substantial percentage of all engineering jobs in the state are filled by graduates of out-of-state or foreign institutions. There are more than thirty large businesses in the Tri-State region that employ electrical or computer engineers. In recent years, many of these companies have had difficulty hiring qualified engineers and also had difficulty retaining them longer than five years. Local leaders assert that a substantial problem for them is the absence of a MSEE in this region of the State to support local industries.

A Master's degree is often necessary to land certain jobs or for career advancement within certain disciplines of electrical and computer engineering. Many careers that require a master's degrees are typically found in sectors such as research and product development. Electrical or computer engineers with a Master's degree often benefit from higher pay and increased job responsibilities. While the technical abilities are essential, employers value Master’s holders for their organization, independence,

problem solving, fast learning, commitment, flexibility, leadership, and communication skills.

A Master's degree in electrical or computer engineering provides additional breadth and depth of knowledge, positioning graduates for technical leadership and specialization in industry. Candidates develop skills such as analysis, resourcefulness, ingenuity, responsibility and perseverance through research activities. These skills make employees more successful and give them a greater opportunity to work on more interesting projects. In the longer term, these skills are more important than the specialty, and the better skills of Master's degree holders will serve them well. U.S. data (across all areas of engineering) show that the unemployment rate for Bachelor's degree holders is 4.5% and for Master's degree holders is 3.0%.

The economy of the future will be driven by innovation and knowledge. R&D to fuel innovation is largely conducted by graduate degree holders, yet USA in general and West Virginia in particular lags seriously in producing them. USA ranks 14th in the world for the fraction of its population graduating with a graduate degree (behind almost every other industrialized country a relatively smaller fraction is in engineering than is typical of peer nations). The need to take action for maintaining technological leadership of the United States is progressively becoming more urgent. Developing cutting-edge technology through cultivating innovation is critically important in the global competitive environment. Engineering education is one of the most important aspects of this innovation-cultivating process. Many states are now recognizing a shortage of engineers and are taking actions to address this urgent problem. Enrollment in engineering related Master's degrees grew to about 113,000 in 2013, representing a 6 percent increase above the previous year. In the 2012-13 academic year, there were 19,452 students enrolled in MSEE programs and related fields nationwide (engineering enrollment 2012-13, www.asee.org/college) at a rate of 66 per million capita. The total enrollment in state supported MSEE programs in West Virginia was estimated to be 102 students in Fall 2013 at a rate of 53 per million capita—13 per million lower than the national average.

1.2 Strategic Importance

Given the above backdrop and especially the opportunities presented by renewable energy, distributed power systems, telecommunications, controls, and computers and cyber security, introducing a MSEE degree at Marshall University is of strategic importance for the following reasons:

- There is only one Electrical and Computer Engineering Master's Degree program in the state of West Virginia, which is located at the West Virginia University. Given the high demand for Electrical and Computer Engineering (EE) graduate education and excellent job opportunities, there is a need for an additional master's programs to serve southern West Virginia and the Tri-State region.
- Marshall University Bachelor of Science in Engineering (BSE) recent graduates have gone to other institutions such as the Ohio State University, University of Michigan, Purdue University, and others to pursue graduate studies in engineering. Once West Virginia students leave the state to pursue graduate engineering degrees elsewhere, they are less likely to come back to the state after graduation. The MU MSEE program will help keep more West Virginia EE students in the state and potentially attract outside students to the state.
- Given the rapid advances in the electrical and computer engineering (EE) disciplines, a MSEE degree program is essential for providing BSEE students an educational experience that reflects current advances and practices in the field. MSEE program provides a research-oriented academic environment that helps to attract more students into the BSEE program.
- MSEE will enable the introduction of an Accelerated Master's Degree (AMD or 4+1) program in BSEE. AMD allows outstanding undergraduate students to complete a traditional four-year Bachelor's degree in Electrical and Computer Engineering and then, with one additional year, earn a Master's degree. AMD will help attract more highly motivated undergraduate students to Marshall University.
- MSEE degree will significantly increase graduate student enrollment at Marshall University through both direct and INTO program channels. The INTO program recruiters in China and India have indicated that they can recruit large number of students to study MSEE at Marshall University once the program is in place. This is not surprising given the current and future EE job growth rates in the US and globally.
- MSEE degree program is essential to attract and retain qualified faculty members in EE. Research is an integral part of a faculty member's career to stay abreast in a rapidly evolving field such as EE. MSEE program is critical to helping faculty members stay current and also contributes to keeping the BSEE program current and relevant. MSEE students will be able to serve as research assistants and work on research being conducted by faculty members.

- Even at the current research activity level at Marshall University, MSEE graduate students will be able to help advance collaborative research opportunities for MU faculty by effectively utilizing advanced computational and analytical research tools. Especially faculty of School of Medicine and bio-medical fields. MSEE program will contribute to interdisciplinary research at Marshall University.
- With shrinking state financial support to Marshall University, it is critical that academic departments acquire advanced and specialized laboratory instruments to support instruction through external funding. MSEE degree program will help make proposals more competitive.

1.3 Five-Year Enrollment Projection

Assuming Fall, 2017 start date, the Tables 1 and 2 show the projected MSEE program enrollment growth during the first five years. This is a very conservative estimate. Furthermore, by design, enrollment will be capped at the levels shown in the table so that the program can be offered without additional faculty resources.

Under a typical scenario, it will take four semesters to fulfill the MSEE degree requirements. Students will complete 9 hours of course work during each of the first two semesters, 6 hours of course work and initial thesis work during the third semester, and dedicate the fourth semester to completing thesis research. Students completing the Design Project option would take 9 hours of course work during each of the first three semesters, and complete the Design project during the fourth semester.

In steady state, the program requires offering 9 courses per academic year and maximum enrollment per section will be capped at 24. The lab fee generated through the courses will be used to fund graduate teaching assistants who will help the professors in grading assignments and exams.

If the US Bureau of Labor Statistics projections were to hold true, the program can easily grow to a level where 15-25 students graduate every year. Offering 9 graduate courses per academic year requires 1.25 FTE faculty. The goal is to kick-start the program with only minimal additional faculty resources and providing the university administration the option to grow the program with additional faculty resources.

Table 1. MSEE Program Five-Year Enrollment Projection

	New Students	Attrition	Graduation	Cumulative Head Count	Cumulative FTE
1St year 2017-18	12	0	0	12	12
2nd Year 2018-19	18	3	0	27	27
3rd Year 2019-20	20	5	9	33	33
4th Year 2020-21	25	5	12	40	40
5th Year 2021-22	25	5	14	46	46

Table 2: Five-Year Projection of Program Size^

	First Year 2017	Second Year 2018	Third Year 2019	Fourth Year 2020	Fifth Year 2021
Number of Students Served through Course Offerings of the Program:					
Headcount	12	27	33	40	46
FTE	14	31.50	38.50	46.67	53.68
Number of student Credit hours generated by Courses within the program (entire academic year):	252	567	693	840	966
Number of Majors:					
Headcount	12	27	33	40	46
FTE majors	14	31.50	38.50	46.67	53.68
Number of student Credit hours generated by majors in the program (entire academic year):	252	567	693	840	966
Number of degrees To be granted (annual total):	0	0	9	12	14
^ The average student load is 21 Cr/Academic Year. Graduate FTE is 18 CH/ Academic Year.					

1.4 Expenses and Revenue Projection

No additional faculty will be needed to support this program. The proposed MSEE program as well as the existing BSEE program will share faculty and resources and students as well (in case of the accelerated BSEE/MSEE program). It is neither practical nor possible to accurately assess the financial impact of the MSEE program in the absence of the BSEE program. The listed table shows the MSEE portion:

Table 3: Five-Year Projection of Total Operating Resources

	First Year 2017	Second Year 2018	Third Year 2019	Fourth Year 2020	Fifth Year 2021
A. FTE POSITIONS					
1. Administrators	0.125	0.125	0.125	0.125	0.125
2. Full-time Faculty	0.75	1.25	1.25	1.25	1.25
3. Adjunct Faculty	0	0	0	0	0
4. Graduate Assistants	0	1	2	2	0
5. Other Personnel:					
a. Clerical Workers	0.0	0.0	0.0	0.0	00
b. Professionals	0.0	0.0	0.0	0.0	0.0
B. OPERATING COSTS (Appropriated Funds Only)					
1. Personal Services:					
a. Administrators	$ 19,050	$ 19,622	$ 20,210	$ 20,863	$21,441
b. Full-time Faculty	$88,900	$150,431	$ 154,944	$159,594	$164,381
c. Adjunct Faculty	$0.0	$0.0	$0.0	$0.0	$0.0
d. Graduate Assistants	$0.0	$15,000	$30,000	$30,000	$0.0
e. Non-Academic Personnel:					
Clerical Workers	$0.0	$0.0	$0.0	$0.0	$0.0
Professionals	$0.0	$0.0	$0.0	$0.0	$0.0
Total Salaries	$107,950	$185,053	$205,155	$210,409	$185,822
2. Current Expenses (Recurring)	$14,000	$14,500	$14,500	$14,500	$19,750
3. Repairs and Alterations	$0.0	$0.0	$0.0	$0.0	$0.0
4. Equipment:					
Educational Equip.	$0.0	$25,000	$25,000	$25,000	$5,000
Library Books	$5,000	$5,000	$5,000	$5,500	$6,000
5. Nonrecurring Expenses: See the attached spreadsheet	$12,000	$6,000	$6,000	$5,500	$5,500
Total Costs	$138,950	$235,553	$255,655	$260,909	$222,072
C. Sources					

1. General Fund Appropriations (Based on 50% non-res. Students @ $1042.50/C.R)	$189,000	$425,250	$519,750	$630,000	$724,500
[1] General Fund Appropriations (Based on Pro-forma Attached in Appendix C)	$125,429	$290,921	$382,118	$478,954	$576,497
D. Net Revenue ([1]- total Cost)	**($13,521)**	**$55,368**	**$126,463**	**$218,045**	**$354,425**

2. Additional Resource Requirements

The proposed MSEE program is to be established on the foundation of the currently under-review BSEE program. Therefore, both programs are to share the same resources. However, the MSEE degree program will require some additional resources due to the nature and scope of the proposed program. These additional resources fall into four primary categories: physical infrastructure, research support, student support, and faculty.

2.1 Physical Infrastructure

The approach for building MSEE program has been to leverage MU resources and complement engineering programs of other organizations to meet the State's needs for practicing engineers. All needed space will be accommodated in the Weisberg Family Applied Engineering Complex (WAEC), the Weisberg Engineering Lab (WL), and Gullickson Hall (GH). Adequate resources exist for laboratory and support services. No new needs are anticipated. Space for classrooms is adequate. The proposed program will not require the addition of new space or facilities or the remodeling or renovation of existing space.

2.2 Research & Students Support

The Division has ten laboratories that are associated with the existing engineering program. Most of these facilities can be utilized as associated electrical and computer engineering laboratories with the proper equipment complement. All needed space will be accommodated in the Weisberg Family Applied Engineering Complex, Weisberg Engineering Lab and Gullickson Hall.

The total projected, therefore, for the research labs is $150,000. About $45,000 of the required funds will be in form of start-up support for the new faculty (new faculty member usually receives about $30,000 as start-up fund).

During the infancy phase, the MSEE program requires financial support in terms of graduate assistantships to attract over-achieving students. These assistantships should come in the form of tuition benefits and stipends (20 hours/ Week). Therefore, it is anticipated that the program will be awarded a total of three full graduate assistantships per year for the first three years of the program. The estimated cost of such support is about $29,000 per year.

2.3 Faculty Resources and Teaching Load Mapping

As it was mentioned earlier, this proposed MSEE program is to be established on the foundation of the existing BSEE program. Therefore, no additional faculty will be needed to support this program. The following table shows a typical faculty course load when the program is fully staffed and implanted. While, Table 5 shows the annual course schedule to meet the MSEE requirements.

Table 4. MSEE Core and Support Faculty

Name of Core Faculty and Faculty Rank	Highest Degree	% of time assigned to the Program
Salem, Asad * [Primary responsibility for administering the program]	Ph.D. in Mechanical Engineering	12.5
Boker, Muataz	Ph.D. in Electrical Engineering	25
Hajjar, Salam	Ph.D. in Computer/Electrical Engineering	25
New Faculty (2) in Year 2017-18	PhD in Electrical/ Computer Engineering	25
New Faculty (3) in Year 2017-18	PhD in Electrical Engineering	25
New Faculty (4) in Year 2018-19	PhD in Electrical Engineering	25
New Faculty (5) in Year 2018-19	PhD in Electrical/Computer Engineering	25

The listed tables to provide information about Core and Support faculty. An asterisk (*) indicates the individual who will have direct administrative responsibilities for the program.

Table 5. Annual Course Schedule to Meet MSEE Requirements

	Fall	Spring
Year I	EE- 602 EE- 606 EE-608 Two Elective Courses	EE-607 EE-608 Three Elective Courses
Year II	EE- 602 EE-606 EE-608 Two Elective Courses EE-698** EE- 699**	EE-607 EE-608 Three Elective Courses EE- 698** EE-699**
**EE 698 (Design Project) & EE 699 (Thesis) will be offered based on need and faculty and student interests.		

3. Non-Duplication

The proposed MSEE degree is new. It does not duplicate any existing graduate degree.

4 New Catalog Description

4.1 Program Description

The Master of Science in Electrical and Computer Engineering (MSEE) degree is designed to provide students with the knowledge, skill, and professional practices needed to develop and design electrical or computer engineering related systems. The program also prepares students who desire to pursue further graduate work leading to a Ph.D. degree.

4.2 Admission Requirements

Applicants should follow the admissions process described in this catalog or at the Graduate Admissions website: http://www.marshall.edu/graduate/admissionsrequirements.asp. Each applicant for admission to the M.S. in Electrical and Computer Engineering degree program must have an undergraduate engineering degree from either an accredited ABET curriculum or an internationally recognized program and meet *one* of the following (A, B, or C) admission requirement options:

A. Pass the PE exam, or

B. Have an undergraduate cumulative GPA of 3.00 or greater, or

C. Have an undergraduate cumulative GPA of 2.50 or greater, and satisfy at least two of the following:

(1) Pass the FE exam,

(2) verbal GRE score at least 145,

(3) quantitative GRE score at least 150, and/or

(4) analytical writing GRE score at least 3.0.

Additionally, to be considered for admission, international students must have an iBT TOEFL score of at least 85, or a Paper-Based TOEFL score of at least 527.

Students who do not meet admission requirement options A, B, or C are welcome to apply, and their applications will be considered for admission on a case by case basis. The program admission recommendation will be decided by the MSEE degree program coordinator based on a combination of GRE scores and level of performance in undergraduate engineering coursework.

Applicants who do not meet the above criteria but have an undergraduate engineering degree are welcome to apply as non-degree seeking students and take classes toward their MSEE degree. If the student has a minimum cumulative graduate GPA of 3.30 in his or her first 9 credit hours of CITE MSEE courses, that student may re-apply to the university to be considered for admission to the MSEE degree program.

Eligibility to take the PE exam is based primarily on completion of an ABET accredited undergraduate engineering degree in most states. Completion of a MSEE graduate degree at an institution with an ABET-accredited undergraduate degree does not fulfill that requirement to take the PE exam.

4.3 Degree Requirements

The Master of Science in Electrical and Computer Engineering (MSEE) degree is designed to provide students with the knowledge, skill, and professional practices needed to develop and design electrical and computer engineering related systems. The program also prepares students who desire to pursue further graduate work leading to a Ph.D. degree.

Each degree candidate is required to complete at least 30-33 graduate credit hours, depending on the "option" chosen below (thesis, or coursework only), with a cumulative Grade Point Average of 3.0 for the courses included in the student's Plan of Study. At least one-half of the minimum required hours for the degree must be earned in classes numbered 600 or above.

Each degree-seeking student must file an approved "Plan of Study," developed with a faculty advisor, before the student registers for the 12th credit hour. The Academic Regulations portion of the Graduate Catalog may be consulted for additional information. The Plan of Study should define a Focus Area for the individual student that is related to the student's technical and professional development interests. Examples of focus areas include power, signal processing, control and embedded systems, communications, and integrated systems, computer architecture, computer vision and machine intelligence, and network and security. At least three of the Elective Courses (9 CR) must be within the student's Focus Area at the 600-level.

Students may choose to complete either the "thesis option," or the "coursework only option" after consultation with their academic advisor.

4.3.1 Core Courses (12 CR):

All graduate students in the MSEE program are required to complete four required core courses:

1. EE-606 Electrical Engineering Analysis
2. EE-602 Random Signals and Noise
3. EE-607 Adv. Electrical Engineering Analysis
4. EE-608 Research Methods (another 600-level EE course approved by the advisor and department head can be substituted for the coursework-only option).

4.3.2 Focus Courses (9 CR):

All graduate students in the MSEE program must develop a graduate focus area of study, with prior approval from their adviser and the department head. The focus area should consist of at least 9 CR of graduate study in electrical and computer engineering (EE 600 or higher) and be related to the student's technical and professional development interests. Examples of focus areas include power, signal

processing, control and embedded systems, communications, and integrated systems, computer architecture, computer vision and machine intelligence, and network and security

4.3.3 Elective Course (3 – 12 CR):

Graduate students pursuing the Thesis Option must complete a minimum of 3 CR of elective courses. Graduate students pursuing the Design Project Option must complete a minimum of 6 CR of elective courses. Graduate students pursuing the Coursework Only Option must complete a minimum of 12 CR of elective courses. The elective courses must be approved by the advisor.

4.3.4 Comprehensive Assessment (3-6 CR)

Thesis Option (6 CR): Prior to completing 12 semester credit hours of graduate work, students should prepare and present a formal thesis proposal to their faculty advisor. An acceptable proposal (including a statement of work, extensive literature search, and proposed timeline), signed by the student and approved by their faculty advisor and department head, is required prior to registering for thesis credits. Students must form a graduate thesis committee in coordination with their advisor and present their proposal to their committee for review and approval during the first semester in which they have registered for thesis credit. Students are required to deliver a successful written and oral presentation of their thesis

4.3.5 Coursework Only Option (NC): The Master of Science degree may be completed without the preparation of a formal research thesis or report. Instead, a student may be permitted to enrol in a no thesis/no report (coursework only) program which involves additional course work. The student must complete at least thirty-three graduate credits of approved courses. During the first semester of the MS program; the student should select an advisor. Each student will have an individual Program of Courses approved by the student's assigned advisor and the division's chair by the end of the first semester of the program. For this option only, the student must satisfactorily complete the comprehensive examination prior to graduation.

4.4 Plan of Study

Students are required to complete a **Plan of Study** form in consultation with their academic advisors by the end of first semester in the program.

Approved Elective Courses

Any ME (Mechanical Engineering) course approved in advance by the student's advisor

Any EM (Engineering Management) course approved in advance by the student's advisor

Any ENGR (Engineering) course approved in advance by the student's advisor

Any CS (Computer Science) course approved in advance by the student's advisor

5. Summary of Courses in MSEE Degree

New Courses (proposals submitted concurrently)

The following course additions have been submitted to the Graduate Council for Approval:

1. EE 602 Random Signals & Noise
2. EE 606 Electrical Engineering Analysis
3. EE 607 Advanced Electrical Engineering Analysis
4. EE 608 Research Methods
5. EE 611 Digital Design
6. EE 615 Real Time Systems
7. EE 618 Data and Communication Networks
8. EE 624 Wireless Communications
9. EE 630 Robust Control
10. EE 631 Optimal Control
11. EE 636 Power Systems Operation
12. EE 638 Nonlinear Systems and Control
13. EE 639 Distributed Power Systems
14. EE 650-653 Special Topics
15. EE 685-688 Independent Study
16. EE 699 Thesis