



Proposal for a Doctoral Program in Electrical Engineering

Presented by:

**The Department of Electrical and Computer
Engineering**

**University of Puerto Rico
Mayagüez Campus**

September 7, 2007

Table of Contents

Introduction..... 5

 1.1 Program Title and Degree..... 5

 1.2 Program Duration..... 5

 1.3 Program Summary 5

 1.4 Beginning Date 6

2 Justification..... 6

 2.1 Program’s relation to UPR and UPRM’s mission and objectives 6

 2.1.1 Academic reasons for establishing the program 6

 2.1.2 Program..... 8

3 Program’s Alignment with the University Strategic Plan..... 13

4 Relation to Other Programs 15

 4.1 Within the Mayagüez Campus..... 15

 4.2 In Other UPR Campuses..... 15

 4.3 In other Institutions of Higher Learning in Puerto Rico..... 15

5 Proposed Program Description 16

 5.1 Mission and Vision 16

 5.2 Goals 16

 5.3 Specific Objectives 16

 5.4 Graduate Profile 17

 5.5 Program’s Components..... 17

 5.5.1 Course Descriptions 18

 5.5.2 Proposed Program Course Sequences..... 25

 5.5.3 Course sequence for a student admitted with an MS in Electrical Engineering... 27

 5.6 Educational Method and Institutional Strategies 28

 5.7 Catalogue and Promotion..... 30

6 Admission and Registration..... 31

 6.1 Admission Requirements 31

 6.2 Graduation Requirements 31

 6.3 Registration Projections 32

7 Academic Requirements for conferring the grade 32

 7.1 Total Credit-Hour requirement 32

 7.2 Minimal Academic Index Requirements 33

 7.3 Maximum Number of Transfer Credits to be allowed..... 33

 7.4 Residency 33

 7.5 Seminar 33

 7.6 Qualifying Exam..... 33

 7.7 Comprehensive Exam 34

 7.8 Dissertation 34

 7.9 Language Requirements..... 34

 7.10 Time Limit for Program Completion..... 34

8 Available Faculty 34

 8.1 Program Faculty Credentials..... 34

 8.1.1 Publications..... 38

 8.1.2 Research..... 38

 8.1.3 Honors and Distinctions..... 42

8.2	Faculty Projections for the Next Five Years.....	43
8.3	Faculty Training Plan.....	44
9	Learning Resources.....	44
9.1	Existing Learning Resources Inventory.....	44
9.2	Plan for the Improvement of Existing Resources	44
9.2.1	Acquisition of Bibliographical and Audio Visual Resources	44
9.2.2	Acquisition of Serial Publications	45
9.2.3	Electronic Database Access	45
9.3	Acquisition of Other Resources	45
10	Physical Installation and Equipment.....	45
10.1	Inventory of Available Facilities	45
10.2	Program’s Impact On Existing Physical Installations	46
10.3	Demand for and Availability of Computer Facilities for the New Program.....	47
10.4	Copies of Applicable Licenses Required for the Utilization of Physical Installations.....	47
11	Accreditation and Program Licensing	47
11.1	Professional Accreditation	47
11.2	Accreditation by Council of Higher Education	47
12	New Program Administration	47
13	Student Economic Aid.....	49
14	Fiscal Resources: Budget.....	49
14.1	Recurrent Expenses.....	49
14.2	Non-Recurrent Expenses	50
15	Funding.....	51
16	Evaluation	51
Appendix A: Description of Track Areas in Electrical Engineering		A-1
Appendix B: Applications for New Courses		B-1
Appendix C: Faculty Resumes		C-1
Appendix D: List of Publications: 1999-2005		D-1
Appendix E: Description of Facilities		E-1
Appendix F: Sample Program of Studies for the Different Tracks		F-1
Appendix G: Syllabuses for Existing Courses in the ECE Graduate Program		G-1

Introduction

1.1 Program Title and Degree

The proposed program title is Doctoral Program in Electrical Engineering and the degree to be conferred will be Doctor of Philosophy in Electrical Engineering.

1.2 Program Duration

According to the academic requirements described in this proposal, the doctoral program will have a normal duration of four to five years for students who begin with a bachelor's degree and three to four years for students starting with a master's degree.

The maximum time limit allotted for a student to complete the degree will be the same as that specified in the existing UPRM Graduate School Norms which at the time of writing this proposal are:

- Ten years, if the student begins with a Bachelor's degree when starting the program, even if the student has transferred from another graduate program or has temporarily postponed studies.
- Eight years, if the student begins with a Master's degree at the initiation of the program, even if the student has transferred from another graduate program or has temporarily postponed studies.

1.3 Program Summary

The proposed program will provide the most advanced education in electrical engineering in Puerto Rico. Graduates of this program will utilize their knowledge and training to think critically and creatively to significantly contribute to the social and economic development of Puerto Rico and its hemisphere in the areas of research, development, and education. The proposed program emerges from the natural evolution of research and graduate studies at the Master level in the Department of Electrical and Computer Engineering. The proposed doctoral program addresses the need for advanced study and research in electrical engineering, according to the description in "Proyecto Manos Tecnológicas"(Technological Hands Project) and "Proyecto Puerriqueño para el Siglo 21"(Puerto Rican Project for the Twenty-first Century) both sponsored by the government of the Commonwealth of Puerto Rico for the economic development of the country.

The program will neither include specialty nor concentration areas. Instead, it will utilize internal areas of emphasis in order to guide students in their curriculum and research. This is done in order to maintain a flexible structure which will allow the program to adapt itself to the rapid technological changes while permitting the development of non-traditional interdisciplinary research areas that do not fit into the traditional electrical engineering mold. The doctoral program will have an initial orientation towards the areas of power systems, power electronics, applied electromagnetic, signal processing, control systems, and electronics. Detailed descriptions of each area are included in Appendix A.

The proposed academic program will consist of a minimum of forty-nine credits, from which a minimum of twenty-four will be taken in one of the areas previously described. Of the forty-nine required credits, a minimum of six credits will be taken in advanced graduate or undergraduate level mathematics courses, of which at least three credits will be at the 6000 or higher level. The objective behind this requirement is to strengthen essential analytical skills required for state of the art research in electrical engineering. In addition, six credits in electives outside the area of emphasis will be required. Each doctoral candidate will be required to participate in the doctoral seminar each semester for which he will receive one credit at the conclusion of his dissertation. Besides, students will be required to pass a qualifying exam and a comprehensive exam as part of the process of evaluating their ability to engage in doctoral level research. Finally, students will be required to pass 12 dissertation credits.

The dissertation will measure the scope of acquired knowledge and it will evidence the student's degree of creativity. It will require an original contribution to the existing scientific and/or technological body of knowledge in the field of electrical engineering.

1.4 *Beginning Date*

The program will begin as soon as it is approved by the corresponding authorities. It is tentatively set to begin during the first semester of the 2007-2008 academic year.

2 Justification

2.1 *Program's relation to UPR and UPRM's mission and objectives*

2.1.1 Academic reasons for establishing the program

The traditional notion of electrical engineering tells us that it is mainly concerned with information systems and electrical energy systems. The former utilizes electrical means in order to transmit, store, and process information; while the latter transmits energy from one place to another or converts energy from one form to another. In the twenty-first century, the scope of electrical engineering will extend far beyond traditional areas. This may be confirmed by studying the publications of the Institute of Electrical and Electronic Engineers (IEEE), the largest professional society in the world with over 320,00 members in more than forty countries. IEEE publications are classified in the following categories:

- Devices
- Circuits
- Electronics
- Computers
- Systems
- Power
- Interdisciplinary Areas

Interdisciplinary areas include among others:

- Bioengineering
- Biotechnology
- Manufacturing

- Mechatronics
- Reliability
- Robotics
- Material Science

The Department of Electrical and Computer Engineering has offered graduate programs for over thirty-five years. During this time, programs have been in constant evolution. Since its inception, in 1967, with fewer than 10 students and approximately 20 professors, the electrical engineering Master's degree program emphasized the traditional areas of Power, Electronics and Controls. Throughout the years, the department has grown including the creation of a master's degree program in computer engineering. At present, the department consists of more than a hundred graduate students, over fifty professors and includes multiple areas of specialization such as: Power Systems, Electronics, Control Systems, Digital Signal Processing, and Applied Electromagnetics. The degree of maturity, relevance, and magnitude of Department of Engineering's involvement in research projects has reached levels where the depth of exploration, dedication to scientific endeavors and formulated expectations cannot be sustained by the existing graduate master's degree program. Figure 1.1 shows the distribution of faculty by area.

The proposed doctoral program will assist in the development of engineering professionals at the doctoral level through preparation and formation in the previously described areas while providing the means for developing existing graduate and research endeavors in electrical engineering. Furthermore, it will become a key instrument in strengthening interdisciplinary research projects such as collaborations with Marine Sciences, Geology, Chemical Engineering, Mechanical Engineering, Industrial Engineering and Computer and Information Science and Engineering.

As reported by the Research and Development Center, the Department of Electrical and Computer Engineering averages above four million dollars a year, for the past five years, in external research funding. This department has a highly competitive faculty with which to establish a PhD degree. The department has five NSF CAREER awardees, one Presidential Early Career Awardee (PECASE) under President Clinton in 1997, and one NASA Faculty Award for Research (NASA FAR). This is particularly noteworthy given that this campus has received only six total Careers awards, one PECASE, and one NASA FAR. The department includes two research centers, and 17 laboratories with the equipment and facilities to support advanced level courses and state of the art research. In addition, the department has been successful in establishing intercollegiate graduate research programs through collaboration with the Center for Power Electronics Systems (CPES), the Center for Imaging Sensing and Creation Systems (CenSSIS) and the Center for Adaptive and Collaborative Atmospheric Measurement (CASA), established in collaboration with universities in the United States. These joint ventures have increased our academic offerings by taking advantage of distance education and exchange programs. Besides, these collaborations provide our developing faculty with guidance and mentoring opportunities in their development as researchers.

This analysis concludes that the Doctoral Program in Electrical Engineering represents, from the academic perspective, a natural evolution of the master's degree program in Electrical and Computer Engineering at UPRM. Academic and research experience, faculty competencies, the de-

veloped infrastructure, and the country's needs have established the basis for establishing a doctoral program in electrical engineering at the University of Puerto Rico at Mayagüez.

2.1.2 Program

Since 1983, Puerto Rico has envisioned transforming the economy of the country from one based primarily on manufacture and services to one based on research and development of new products, and more recently, one based on the creation and handling of knowledge in the areas of science and technology. The first efforts in this direction were during the years 1985-1987, when the highest official in Fomento Economico, Antonio Colorado, develops the following initiatives:

- Establish the Economic Development Bank to provide funds to high risk, high potential companies.
- Passing laws providing tax exemption for commercial enterprises in research and development.
- Creating venture capital funds for start up companies.
- Passing the venture capital law designed to bring this type of company to the island by means of tax credits.

In 1991, high tech again becomes relevant with the explosion of internet companies. As a result, the Governor creates the Science and Technology Board to evaluate research and development proposals to be funded by the government. This effort comes to fruition and in 1994 the Science and Technology Counsel is created to design the public policy for science and technology. It is not until 1997, after the hiring of the Arthur D. Little company that the policy is started. Its most important points are summarized below:

- **Goal:** increase the gross national product related to science and technology from 5% to 34% by the year 2010.
- **Strategy:** promote the synergy between academia, government, industry and the financial sector.
- **Science and Technology areas to be supported:** pharmaceuticals, global competitive manufacturing, health, communications and informatics, and biotechnology.

To begin implementing this policy of Science and Technology, the government of the Commonwealth of Puerto Rico created the technology corridor on the west end of the island. This technology corridor was based on technology parks elsewhere, such as the North Carolina Research Triangle Park, Silicon Valley and the Singapore Science Park. The proposed Western Technology Corridor envisioned establishing centers of excellence in scientific and engineering research, in addition to incubators and high technology companies dedicated to developing and commercializing new ideas and advances in the above mentioned areas.

The technology corridor was established in the west, from Aguadilla to Lajas, due to the fact that many successful research parks were linked to universities. As such it was decided that the best place would be close to the University of Puerto Rico at Mayagüez, who in its tradition of excellence and dedication to the development of Puerto Rico, had the desired characteristics to become the academic axis of the corridor.

In the 2000 elections, the two main candidates to governorship promised to back science and technology in Puerto Rico. The Popular Democratic Party, the winner of these elections, supported the initiatives in science and technology with a project entitled “Operación Manos Tecnológicas”, (Operation Technological Hands). From this plan we highlight the following points that we believe support the creation of the proposed program:

- Establish a Unit for Technological and Informatics development which will promote high viability projects in technology and informatics, introducing at the same time tax incentives to stimulate investment, to attract scientists, researchers and development companies.
- Tax incentives to propose Puerto Rico as a center for research, technology and specialized manufacturing. Incentives to industry (combined rate of 5%), to their shareholders, (combined rate of 5%), and essential personnel within these industries (combined rate of 10%).
- Develop an incentive plan to allow the reversal of the brain drain in business, science and technology. Create the environment to attract this talent to Puerto Rico to nurture the growth of new industry and promote the economic development of Puerto Rico.
- Develop human resources to improve the productivity and competitiveness of these firms on the island. Educational proposals will take into account curricular revision and educational development in the areas of informatics, both at a university as well as at the primary and secondary school levels. Establish ties and personnel and technology exchange with academia in the United States and Europe.
- Establish a grid of industry incubators in collaboration with universities and elements of the private sector to nurture the development of start-ups in the high tech and electronics industries.
- Co-finance, with the help of federal funds and with close ties to academia, the formation of research and development institutes in the strategic niche areas in manufacturing and services in Puerto Rico.
- Strengthen technology transfer with mechanisms that protect and commercialize intellectual property of local inventors and the research and development work at universities, and which will permit technology transfer to start-up and multinational companies.

The Operation Technological Hands plan was given to the Science and Technology Office at PRIDCO to establish the public policy to be adopted. As part of this effort, it was decided that the policy to be developed would be an instrument for:

- Focusing the abilities of the government, private industry and academia, toward more effective measures that would lead Puerto Rico to bettering the areas of Science and Technology, developing in this was the nations competitiveness.
- Assure that necessary resources would be assigned and used to maximize the science and technology capacity in Puerto Rico.
- Attract to Puerto Rico research and development and industry based on research and development, and the promotion of local high tech start-ups.

The policy developed by the Science and Technology Office was supported with wide participation from members of industry, government and academia, calling themselves the “Puerto Rico Science and Technology Alliance”. The developed policy was designed to change Puerto Rico into a world class business competitor in science and technology. Among the main objectives and strategies are the following:

- New culture of science and technology
- Solid infrastructure in science and technology
- Innovation capital
- Strong component in research, development and education.
- Competitive community in science and technology

Among the metrics used determine the success of the new policy, and among which the proposed program would have major impact are:

- Size and strength of the science and technology community
- Growth in the available science and technology infrastructure

To accelerate the policy implementation, the Puerto Rico Science and Technology Alliance commissioned a study by the firm McKinsey & Co. In this study McKinsey & Co. suggest that the policy implementation should be in the communication and information technology area. In terms of the most attractive opportunities for Puerto Rico, McKinsey & Co. identified the following:

- **Computer and electronics manufacturing (including design):** Computers and peripherals, communication equipment, audio and video equipment, optical and magnetic communication media, applications. Focus: a good position in the area of medical devices manufacturing and application for defense.
- **Information services:** Geophysical research (e.g. remote sensing), software, internet, telecom, business with technology access (e.g. e-commerce). Focus: Software development and information technologies related to health.
- **Consumer Services:** Telephonic help centers, repair and maintenance of electronic equipment, facility administration. Focus: Contact centers for hispanic markets, centers for shared services.
- **Remote Service:** Information services, consumer services. Focus: Off-shore bank and insurance processing and outsourcing of pharmaceutical processes.

At present, the Science and Technology Office is in the process of developing operational plans to facilitate implementing the recommendations make by McKinsey & Co.

To meet the new challenges for the economic and social development of Puerto Rico, evidenced by the new initiatives described above, will require a critical mass of scientists and engineers with the capacity to be leaders in the different areas of science and technology. To produce this critical mass in researchers to permit the evolution of the island from manufacture to research and development, it is essential to have advanced technological degrees and research at the University of Puerto Rico.

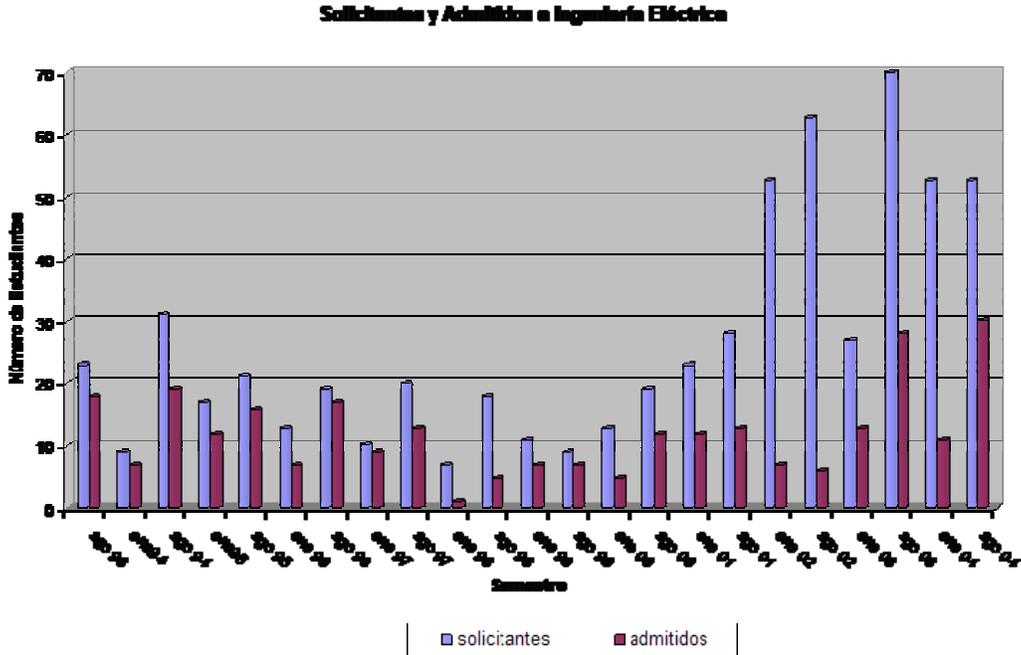


Figure 2.1: Applications and Admissions to the Electrical Engineering Masters Program.

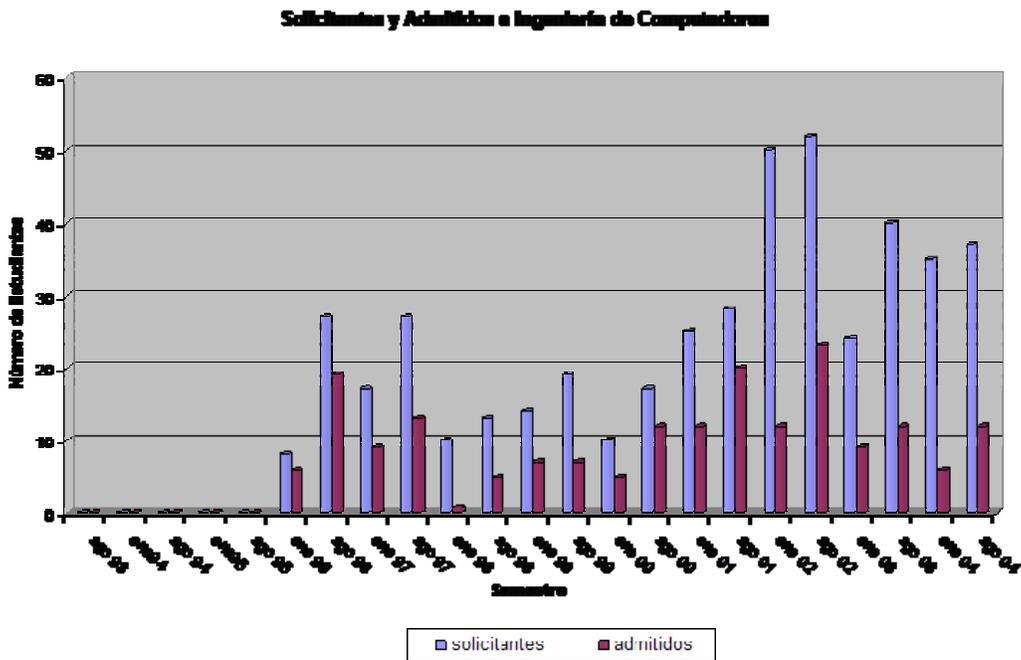


Figure 2.2: Applications and Admissions to the Computer Engineering Masters Program.

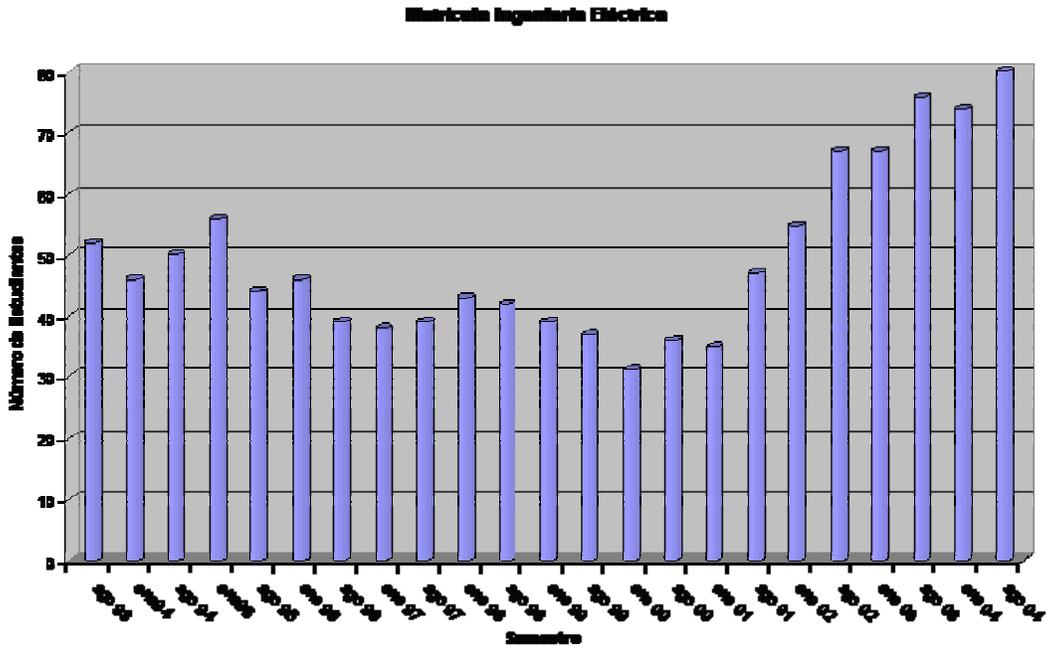


Figure 2.3: Students Registered in the Electrical Engineering Masters Program.

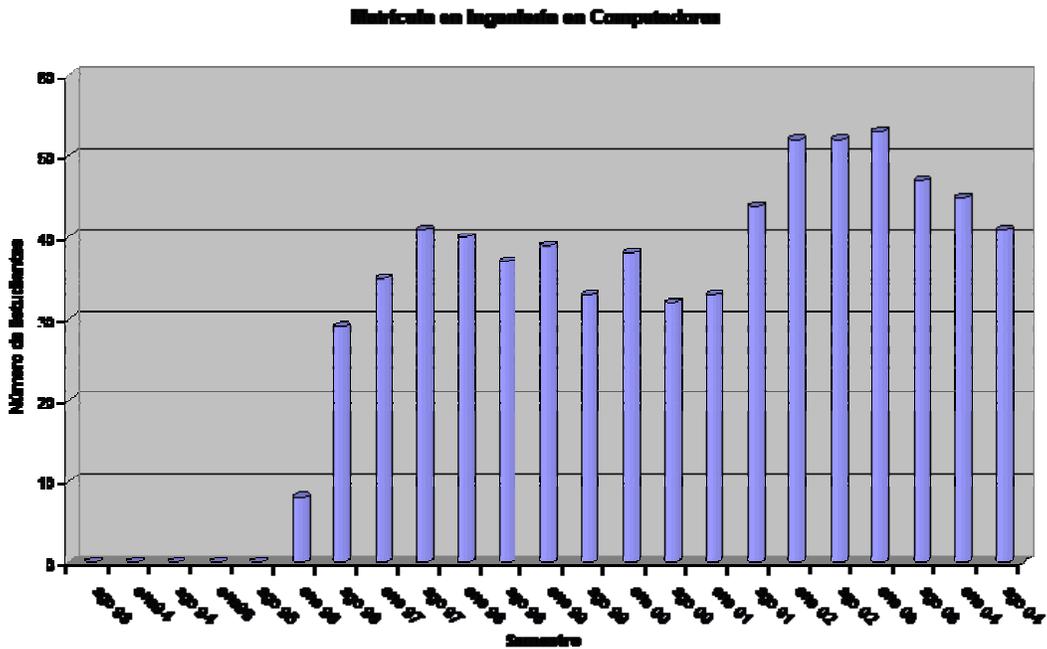


Figure 2.4: Students Registered in the Computer Engineering Masters Program.

The proposed Doctoral program in Electrical Engineering will be instrumental in developing the personnel with the necessary preparation and will strengthen the research environment in the communication and information areas described by McKinsey & Co. The doctoral program will

permit the development of research at the highest level in electrical engineering and the training of future leaders who will contribute to the technological development of Puerto Rico and this hemisphere.

2.1.2.1 Proposed Program's Demand

Based on the number of applications vs. the number of admissions during the last five years for the Electrical and Computer Engineering master degrees, shown in Figures 2.1 and 2.2, we anticipate that the demand for a doctoral program will be significant. During the last five years, the number of applications to the department graduate programs has tripled. These come primarily from Puerto Rico and Latin America. For example, of the 30 students admitted to the Electrical Engineering masters program, 18 were from Puerto Rico, 9 from Colombia, one from Peru, one from Cuba and one from the Dominican Republic. Of the 11 admitted to the Computer Engineering masters program, 8 were from Puerto Rico and USA, 3 from Colombia, and one from Bolivia.

Figures 2.3 and 2.4 show the enrollment in the Electrical and Computer Engineering masters programs for the last 10 years. Our experience shows that a large number of these students would continue doctoral studies toward a PhD in Electrical Engineering if it were available.

In Puerto Rico, in addition to our students, students from the undergraduate and graduate programs from Universidad Politécnica, Universidad Interamericana at Bayamón and Universidad del Turabo would be potential candidates for the proposed program. The program will be promoted in Puerto Rico, in the United States, and in Latin America in order to attract qualified candidates.

2.1.2.2 Employment Opportunities for Program Graduates

The program intends to develop professional engineers capable of contributing to the development of electrical engineering infrastructure in Puerto Rico, to industrial development and research, to academic research and to college education. This broad spectrum of possibilities provides all program graduates with concrete and diverse employment options in Puerto Rico, the United States and Latin America.

According to existing statistics provided by the National Science Foundation, the job market for engineers with doctoral degrees in science and engineering for the past five years is a very healthy one with less than 1.5% unemployment rate. Of those electrical engineering PhD's polled by NSF, approximately 70% had industry-related jobs, 21% were employed by academia and 6% by government agencies. With the creation of new industry dedicated to research and development, this following the plans of the Government of Puerto Rico for economic transformation, the job market for engineers with Doctoral degrees in Puerto Rico is expected to be similar to the statistics quoted above. In addition, program graduates have the opportunity to join the electrical engineering faculties of the Polytechnic, Turabo, and Interamerican Universities.

3 Program's Alignment with the University Strategic Plan

The proposed program will provide state of the art education in electrical engineering. The program's graduates will utilize acquired knowledge and skills to think critically and creatively while contributing significantly to the economic and social development of Puerto Rico and its

hemisphere. This program is the a natural evolution of research and graduate programs at the master's degree level in Electrical and Computer Engineering and responds to Puerto Rico's need for the development of advanced graduate studies and research in areas where electrical engineering can have far reaching results in the social and economic development of Puerto Rico.

The proposed program addresses several critical areas of the Strategic Plan of the University of Puerto Rico such as:

- More and improved quality research endeavors.
- Academic and professional offerings of known quality in electrical engineering.

The proposed program will help increase the level of research and creative activities by:

- Improving institutional conditions and climate necessary for the increase of research and creative activity in Electrical Engineering
- Stimulating the application of acquired knowledge, generated by research and creative activity, to Puerto Rico's development through the creation of an industrial affiliates program supporting graduate-level research.
- Continue developing, through proactive activity and practical experiences, creative professional engineers, who are innovative and skilled in the application of research for solving problems in Puerto Rican society.
- Strengthen inter and intra collegiate collaborative efforts, as well as industrial, commercial and governmental collaborative efforts in Puerto Rico and abroad. The creation of this doctoral program is an institutional commitment made in intercollegiate research center in which our department participates.
- Strengthen the institutional infrastructure to continue promoting the search for additional sources of external funding for research by allowing our researchers to become involved in advanced research endeavors.

The program will improve the quality of graduate academic offerings in the Department of Electrical and Computer Engineering by:

- Broadening and improving specialized resources required by existing graduate program within the department.
- Promoting intercollegiate coordination between our department and other universities in order to strengthen offerings and educational experiences among our students and faculty while building upon the foundation of existing collaborations in engineering research centers sponsored by the National Science Foundation.
- Continuing to improve existing departmental resources and facilities used in graduate and undergraduate research programs with the hope of increasing external funding resources in order to reach a higher level of research.

4 Relation to Other Programs

4.1 Within the Mayagüez Campus

The proposed doctoral program intends to be directly related to the existing master's degree program in Electrical Engineering. Most of the courses presently offered in this program form part of the courses that will be offered in the doctoral program. Qualified graduates of the master's degree program may be admitted into the doctoral program and may transfer all earned credits (except those obtained for thesis or project work) toward the doctoral program.

The proposed program is related to the Master's Degree Program in Computer Engineering (with options in electronics, hardware systems and signal processing) and the Ph.D. program in Computational Science and Engineering (Computer Science and Engineering option). Some of the courses in these programs are part of the courses included in the Signal Processing and Electronic Areas of the proposed program. Qualified students or graduates from these programs may be admitted to the new program with minor deficiencies.

The proposed program is related to the baccalaureate degree programs in Electrical Engineering and Computer Engineering at UPRM. Some advanced undergraduate courses from these programs are included in the proposed program. Any qualified student who has graduated from either program may be admitted directly into the doctoral program.

No other program in UPRM is directly related to the new program. Nevertheless, graduates from other qualified engineering, science, and mathematics programs might be considered for admission into the electrical engineering Ph.D. program. Depending on the applicant's academic background, deficiency courses may be assigned and admission granted, or a master's degree in electrical or computer engineering may be recommended prior to consideration for admission into the doctoral program.

4.2 In Other UPR Campuses

The proposed program will be the only doctoral program of its type offered within the UPR System and has no direct relation to any other graduate or undergraduate program in the University of Puerto Rico system.

4.3 In Other Institutions of Higher Learning in Puerto Rico

The proposed program will be the only doctoral program of its kind offered in Puerto Rico. Nevertheless, there are master's and BA degree programs in other institutions of higher learning which are related to this one. The new program provides qualified graduates of those programs with the opportunity to pursue a doctoral degree in electrical engineering.

The proposed program is related to the Master's Degree program in Electrical Engineering offered at Universidad Politécnica. Graduate students from this program may seek admission into the Doctoral program and may transfer some course credits, provided these credits meet UPRM residency criteria and approval of the Departmental Graduate Committee.

The proposed program is related to the baccalaureate programs in Electrical Engineering at Universidad Politécnica, Universidad Interamericana at Bayamón and Universidad del Turabo. The new program offers students the opportunity to continue graduate studies and obtain a doctoral degree in Electrical Engineering. Additionally, members of those faculties who do not possess a doctoral degree will have the opportunity to complete doctoral studies in Puerto Rico and re-join their respective faculties.

5 Proposed Program Description

5.1 *Mission and Vision*

The mission and vision of the doctoral program are:

- **Mission:** Be a program of excellence in research and in the training of doctors in Electrical Engineering.
- **Vision:** Establish a doctoral program in Electrical Engineering which contributes significantly to the technological, scientific and economic development of Puerto Rico and its hemisphere.

5.2 *Goals*

The doctoral program's goals are as follows:

- Serve as the top education and research center of Electrical Engineering in Puerto Rico.
- Prepare the professional engineers at the highest level capable of contributing to the social and economic development of Puerto Rico and its hemisphere in the areas of government, industry, and academia.
- Develop close ties with industry in order to support research relevant to the economic development of Puerto Rico and facilitate technology transfer.

5.3 *Specific Objectives*

The specific objectives of the doctoral program are:

- To be able to award a minimum of 15 PhD's during the first ten years of the program.
- To increase departmental external funding by 50% percent during the first five years of the program's initiation.
- Establish a system for the distribution of publications and technical reports providing public access to research work performed by the department.
- Increase the number of peer reviewed articles by research professors to two (or more) per year which is the average publication rate in the United States.
- Establish recruitment programs in Puerto Rico, United States, and Latin America.
- Establish mechanisms for the continual improvement of laboratory infrastructure, equipment, library, and collaborations supporting the doctoral program.
- Double the number of IEEE "Senior Members" in our department and at least one IEEE "Fellow Member" in the next ten years.

5.4 Graduate Profile

Among the general skills of the professional profile for the graduates of the Doctoral Program in Electrical Engineering the following are the most outstanding:

1. Profound knowledge in an area of expertise. Knowledgeable of state of the art language, topics, and research problems in this area.
2. Capable of active participation in scientific research and application to their area of expertise.
3. Ample knowledge in electrical engineering which allow for significant contributions to the academic milieu in institutions of higher learning.
4. Ability to creatively apply and integrate this knowledge to the development of scientific research, problem solution and design, evaluation and maintenance of electrical systems.
5. Ability for oral and written communication in both Spanish and English.
6. Ability to clearly formulate short term, medium-range and long term objectives and to communicate ideas and results adequately with colleagues.
7. Ability to communicate effectively the essential aspects of a problem and its solution to the general public.
8. Ability to develop research proposals for public and private funding agencies.
9. Ability to present results in written form in professional journals and orally in conferences in the field.
10. Ability to evolve, due to the changing nature of the discipline.
11. Awareness of an individual's professional impact on society's quality of life including a clear understanding and respect for the legal, ethical, social and cultural issues pertinent to the profession.
12. Appreciation of the relationship between theory and practice. The Ph.D. graduate should appreciate both the value of good design as well as the theoretical framework on which it is based. That is, he should understand the value of the relation between theory, experiment and results while being able to utilize this understanding effectively in his professional practice.

5.5 Program's Components

The program will aid in the development of engineering professionals with appropriate training at the doctoral level in the aforementioned areas, and at the same time, will provide the means for the development of existing graduate and research programs in electrical engineering. In addition to this, it will become a key instrument in strengthening interdisciplinary research projects such as collaborations with Marine Sciences, Geology, Chemical Engineering, Mechanical Engineering, Industrial Engineering and Computational Sciences and Engineering.

The proposed academic program will consist of a total of at least forty-nine credits. It is required that students approve a minimum of 49 credits distributed in the following manner: 18 credits in graduate or advanced undergraduate level courses within a particular area of specialization

- 6 credits in advanced level courses (8000 or higher) in the area of specialization
- 6 credits in mathematics at a graduate level
- 6 credits in elective courses outside the area of specialization
- 1 credit in doctoral seminar
- 12 credits in doctoral dissertation

No more than nine credits in advanced undergraduate courses (5000 level) may be used to complete the PhD course requirements. Additionally, the student must take a qualifying and a comprehensive exam, and must present and defend a dissertation which shows an original work in their emphasis area.

5.5.1 Course Descriptions

The following courses will comprise the academic offerings of the Doctoral Program in Electrical Engineering.

5.5.1.1 Existing Courses

INEL 5029 TELECOMMUNICATION ELECTRONICS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4301, INEL 4201 and INEL 4152. Study of the operation theory of radio frequency and microwave devices and components and foundations of the design techniques for RF systems with the purpose of understanding the operation of the different components of a telecommunication system.

INEL 5046 PATTERN RECOGNITION. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4301 and ININ 4010. This course is an introduction to the basic concepts, topics and methods in Pattern Recognition. The first part of the course is a review of the basic concepts and skills in probability and linear algebra. The second part of the course is related with classification algorithms, its application and methods for easier implementations. It includes sections on Statistical Decision Theory, Non-Parametric Methods and Neural Networks. The third part of this course will introduce the student to application such as image analysis, and computer vision. The emphasis of this course will be in theory and application as well.

INEL 5205 INSTRUMENTATION. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4206 and INEL 4202. Signals from transducers; signal conditioning, data conversion and transmission; effects of noise. Data storage and display; use of microprocessors in instrumentation.

INEL 5206 DIGITAL SYSTEMS DESIGN. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4207. Design methods in combinational and sequential systems. Use of programmable logic devices in digital systems design. Analysis and design of system controllers.

INEL 5265 ANALOG INTEGRATED CIRCUITS DESIGN. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4205 and INEL 4201. Design and analysis of analog and mixed-signal (digital-analog) circuits using advanced analytical design techniques and advanced computer aided design tools. Discussion of topics about physical design and development of functional testing of analog integrated circuits.

INEL 5305 ANTENNA THEORY AND DESIGN. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4152 and INEL 4301. Radiation mechanism. Types of antennas; impedance; radiation patterns; arrays. Antenna measurements.

INEL 5306 MICROWAVE ENGINEERING. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4152. Rectangular and circular wave guides; passive components; tubes, and solid-state devices used in microwave systems.

INEL 5307 OPTICAL COMMUNICATIONS. Three credit hours. Three hours of lecture per week. Prerequisites: INEL 4301 and INEL 4152. Optical communication principles; transmitter and receiver design; fiber optic channels.

INEL 5309 DIGITAL SIGNAL PROCESSING. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4301. Signal classification; Z-transform and discrete Fourier transform; matrix representation of digital filters and digital systems; digital filter design; discrete Fourier transform algorithms.

INEL 5315 THEORY OF COMMUNICATIONS II. Three credit hours. Three hours of lecture per week. Prerequisite: (INEL 4011 or ININ 4010) and INEL 4301. Information theory; coding theory; signal design; noise and probability of error.

INEL 5316 WIRELESS COMMUNICATIONS. Three credit hours. Three hours of lecture per week. Introduction to The Study of Cellular and Wireless Personal Communications. The Communications Channel Is Characterized By Describing Large-scale Path Loss and Small-scale Fading and Multipath Interference Properties. Development of Modulation and Diversity Methods to Facilitate Signal Transmission and to Improve Quality of Reception, Respectively. Study of Multiple Access Techniques for The Efficient use of The Radio Spectrum. Introduction to Wide Area Wireless Communication Systems. Description of Some Wireless Systems and Standards.

INEL 5325 COMMUNICATION SYSTEM DESIGN: CIRCUITS AND ANTENNAS. Three credit hours. One hour of lecture and two two-hour laboratories per week. Prerequisite: INEL 5305 or INEL 5306. Design of communication circuits and antennas. Several design projects including: specification, evaluation and selection of alternatives and implementation. Written reports and computer use required.

INEL 5326 COMMUNICATION SYSTEM DESIGN: SIGNAL PROCESSING. Three credit hours. One hour of lecture and two two-hour laboratories per week. Prerequisite: INEL 5309. Block diagram design and simulation of communication systems. Design projects including: specification, evaluation and selection of alternatives, and implementation. Computer and laboratory work and written reports required.

INEL 5327 IMAGE PROCESSING Three credit hours. Three hours of lecture per week. Prerequisite: INEL 5309. Mathematical representation of 2-D digital signals. 2-D filter design. Image coding standards. Image filtering, enhancement and compression.

INEL 5406 DESIGN OF TRANSMISSION AND DISTRIBUTION SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4415. Design of electric power distribution systems with emphasis on distribution transformer connections and energy tariffs. Trans-

mission line design with emphasis on conductor selection, and mechanical considerations. Review of transmission line parameters.

INEL 5408 ELECTRICAL MOTORS CONTROL. Three credit hours. Three hours of lecture per week. Prerequisites: INEL 4405, INEL 4416 and INEL 4505. Characteristics and selection criteria of alternating current (A.C.) and direct current (D.C.) motors; design and control of solid state drive systems; braking methods; heating and duty cycle calculations. Performance calculations and design of closed loop controllers.

INEL 5415 ELECTRICAL SYSTEMS PROTECTION DESIGN. Three credit hours. Three hours of lecture per week. Prerequisites: INEL 4415. Design and selection protective devices used in electric energy generation, transmission and distribution systems: relays, fuses, breakers, reclosers, arresters among others. Selection of system components such as sectionalizers and throwovers. Insulation coordination.

INEL 5505 LINEAR SYSTEM ANALYSIS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4505. Linear spaces and matrices; state variables representations for linear continuous and discrete systems; the Z-transform and its application; controllability and observability; state estimators; stability.

INEL 5506 PROCESS INSTRUMENTATION AND CONTROL ENGINEERING. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4206 and INEL 4505. Design of process instrumentation and control systems, based on analog and digital instruments and mini or microcomputers. Standards and practical considerations emphasized.

INEL 5508 DIGITAL CONTROL SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4505. Analysis and design of digital control systems; stability, controllability and observability of discrete systems. Practical considerations when implementing a digital control system.

INEL 5516 AUTOMATION AND ROBOTICS. Three credit hours. Three hours of lecture per week. Prerequisites: INEL 4206 or ININ 4057. Analysis and design of automated pneumatic systems using programmable controllers. Programming of industrial robots.

INEL 5995 SPECIAL PROBLEMS. One to six credit hours. Investigations and special problems in Electrical Engineering or related fields. Open to outstanding Electrical Engineering students.

INEL 6000 INTRODUCTION TO NONLINEAR CONTROL SYSTEMS. Three credit hours. Three hours of lecture per week. Analysis and synthesis of nonlinear control systems; phase plane and describing function techniques; Lyapunov's second method and its application in the design and stability determination of nonlinear systems.

INEL 6001 FEEDBACK CONTROL SYSTEMS I. Three credit hours. Three hours of lecture per week. The Z-transform and its application to sampled-data control systems; analysis of automatic control systems, using state variable concepts; stability criteria; introduction to parameter optimization techniques.

INEL 6007 INTRODUCTION TO REMOTE SENSING. Three credit hours. Three hours of lecture per week. History, principles, and applications of remote sensing. Electromagnetic radiation; aerial photography; image interpretation; land observation satellite systems; image resolution; preprocessing and classification of images; geographic information systems.

INEL 6009 COMPUTER SYSTEM ARCHITECTURE. Three credit hours. Three hours of lecture per week. Fundamentals of the architecture and organization of computers. Concepts of high-level languages. Architectural support to the compilation process and to operating systems.

INEL 6025 ADVANCED ENERGY CONVERSION. Three credit hours. Three hours of lecture per week. Theory and design of processes for direct energy conversion. Thermoelectric, thermionic, and photovoltaic conversion. Fuel cells. Introduction to irreversible thermodynamics and its application to describe operations. MHD equations and generators. Conversion efficiency and electrical losses.

INEL 6026 COMPUTATIONAL METHODS FOR POWER SYSTEMS ANALYSIS II. Three credit hours. Three lectures per week. Prerequisite: INEL 5027. Application of numerical techniques and computer methods to the solution of a variety of problems related to the planning, design and operation of large interconnected electric power systems.

INEL 6027 DYNAMICS AND CONTROL OF INTEGRATED POWER SYSTEMS. Three credit hours. Three hours of lecture per week. Discussion of a variety of transient and control problems associated with interconnected power systems, and techniques for their analysis and solution. Methods for dynamic analysis of large systems are stressed.

INEL 6028 OPTIMIZATION AND ECONOMIC OPERATION OF INTEGRATED POWER SYSTEMS. Three credit hours. Three hours of lecture per week. Theory of optimization under equality and inequality constraints; computational methods and application to generation scheduling in integrated power systems.

INEL 6048 ADVANCED MICROPROCESSOR INTERFACING. Three credit hours. Three hours of lecture per week. Architecture of 8, 16, and 32 bits microprocessors; bus, input/output and memory interfacing; parallel processing architecture; configuration and interfacing of multiprocessors; applications of the multiprocessor system.

INEL 6049 MULTIDIMENSIONAL DIGITAL SIGNAL PROCESSING. Three credit hours. Three hours of lecture per week. Representation of multidimensional signals and systems; Fourier analysis of multidimensional signals; design and implementation of twodimensional digital filters; applications of digital filtering techniques to beam forming and image analysis.

INEL 6050 ADVANCED DIGITAL SIGNAL PROCESSING ALGORITHMS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 5309. Theoretical foundations, fast algorithms for the Discrete Fourier Transform. Fast convolution algorithms, multidimensional techniques, fast filtering computations, architecture of filters and transforms, fast algorithms in VLSI. Application studies in transmission error controlling codes, sonar, radar, speech, image

processing, and other engineering areas. Study of software implementations on vector and parallel architectures. Algorithms and symbolic computation.

INEL 6055 SOLID STATE ELECTRONICS. Three credit hours. Three hours of lecture per week. Introduction to the study of the properties and functionality of solid state devices. Structure of crystal and metal solids. Electronic emission semiconductors, dielectrics and magnetic devices.

INEL 6058 HIGH FREQUENCY POWER CONVERTERS. Three credit hours. Three hours of lecture per week. Analysis, simulation, design and control of high frequency power converters. Pulse width modulated and resonant converter topologies. Applications such as power direct current sources, uninterruptible power sources, and superconducting electromagnetic energy storage.

INEL 6059 INTELLIGENT SYSTEMS AND CONTROLS. Three credit hours. Three hours of lecture per week. Engineered intelligent systems and their application to complex decision, modeling, and control processes.

INEL 6066 CONTROL OF ELECTRIC DRIVE SYSTEMS. Three credit hours. Three hours of lecture per week. Theory and operation of phase and chopper controlled direct current (d.c.) drives, closed loop d.c. drives and their analysis, phase locked loop d.c. drives; design of controllers for optimal performance. Speed control and control schemes for induction and synchronous motors; inverters and cycloconverters; closed loop alternating current (a.c.) drives; stability and performance analysis.

INEL 6068 MICROWAVE ANTENNA ENGINEERING. Three credit hours. Three hours of lecture per week. Analysis and design of microwave and millimeterwave antennas.

INEL 6069 MICROWAVE REMOTE SENSING. Three credit hours. Three conference hours per week. The interaction of electromagnetic waves with natural (i.e. clouds, rain, snow) and artificial targets. It provides with an introduction to radiometry (Planck's Law) and to operation principles of active(radars) and passive(radiometers) instrumentation used in remote sensing, with emphasis on passive systems.

INEL 6076 ADAPTIVE AND OPTIMAL SIGNAL PROCESSING. Three credit hours. Three hours of lecture per week Signal and system modeling, spectrum estimation, linear optimum filtering, linear and nonlinear adaptive filtering.

INEL 6077. SURGE PHENOMENA IN POWER SYSTEMS. Three credit hours. Three hours of lecture per week. Transient surge phenomena in electric power systems: generation, propagation, analysis, modeling, and protection.

INEL 6078. ESTIMATION, DETECTION AND STOCHASTIC PROCESSES. Three credit hours. Three hours of lecture per week. Fundamentals of detection, estimation, and random process theory for signal processing, communications, and control. Random processes and sequences. Linear systems driven by random processes. Bayesian and nonrandom parameter esti-

mation. Signal detection and estimation from waveform observations Wiener and Kalman filtering.

INEL 6079 INTEGRATED CIRCUIT ADVANCED DESIGN TECHNIQUES. Three credit-hours. Three conference contact hours per week. Prerequisites INEL 4202 or INEL 5265. The course studies novel design techniques geared to the design of Low-Power Low-Voltage Analog and Digital Integrated Circuit Design. This course also focuses on optimization of speed and signal to noise ratio of integrated circuits.

INEL 6080 VLSI SYSTEM DESIGN. Three credit-hours. Three conference contact hours per week. Design, Implementation and fabrication of very high level integrated systems(VLSI). system analysis and design using MOSFETS (Metal Oxide Semiconductor Field Effect Transistors). The course focuses on synchronization and physical implementation of various computational systems.

INEL 6085 ANALYSIS AND DESIGN OF POWER SEMICONDUCTOR CIRCUITS. Three credit hours. Three hours of lecture per week. Analysis and design of single phase and three phase controlled rectifiers, dual converters, A.C. voltage controllers, PWM converters, for power supplies, four quadrant choppers, voltage and current source inverters with modulation techniques, A.C. to A.C. converters.

INEL 6088 COMPUTER VISION. Three credit hours. Three hours of lecture per week. Introduction to computer vision. Computer vision systems. Biological vision system and biological signal processing; early image processing; boundary detection; region growing; texture and shape analysis.

INEL 6096 ELECTRIC POWER QUALITY Three credit hours. Three hours of lecture per week. Prerequisites: INEL 4103 o equivalente e INEL 4201 o equivalente. Analysis, modeling and mitigation of the difficulties related to the distortion of voltages and currents in power systems. Special emphasis on harmonics and sources of power quality problems. Voltage sags and swells, impulses and other transient events.

INEL 6105 ACTIVE REMOTE SENSING TECHNIQUES. Three credit hours. Three hours of lecture per week. This course presents the theory behind radar and ladar techniques. Topics discussed include wave propagation and polarization, transversal section of objects, coupled filters, ambiguity function, radar coded signals, processing and interpretation of radar and ladar echo signals. Typical applications discussed include weather radar, synthetic aperture radar, and lidar.

INEL 6106 INTRODUCTION TO RADAR SYSTEMS. Three credit hours. The course aims to develop the basic theory underlying the radar system, focusing in the hardware. The students will learn basic radar concepts including the radar equation for different applications; different types of radars such as Fm, Fm-cw, Pulse, etc., are discussed; strengths and weaknesses are addressed, as well as applications for different types of radars. Calibration and detection of signals in noise techniques are also discussed. Typical radar transmitters and receivers are studied.

INEL 6115 MICROWAVE ACTIVE CIRCUITS. Three credit hours. Three hours of lecture per week. This course studies the theory and analysis of the design of microwave transistor amplifiers and oscillators. Parameters such as noise, bandwidth, gain and power are considered for the design of the amplifiers. Different transistor amplifiers such as broadband, low noise, and power amplifiers are discussed. The course also covers the design of microwave oscillators using dielectric resonators.

INEL 6216 ADVANCED ELECTROMAGNETICS. Three credit hours. Three hours of lecture per week. Advanced study of Maxwell equations, electric properties of the matter, wave propagation, polarization, reflection, and transmission and the techniques and theory for the analysis of electromagnetic systems, use of Green functions.

INEL 6995 SPECIAL TOPICS IN ELECTRICAL ENGINEERING. One to six credit hours. One to six hours of lecture per week. Study of selected topics in Electrical Engineering.

5.5.1.2 New Courses

The suggested course numbering follows those currently used to distinguish different areas, special topics, and theses. The course creation forms are presented in Appendix B.

INEL 8XXX ADVANCED TOPICS IN APPLIED ELECTROMAGNETICS One to six credits. One to six contact hours per week. Study of selected topics in applied electromagnetics or related fields.

INEL 8XXX ADVANCED TOPICS IN ELECTRONICS. One to six credits. One to six contact hours per week. Study of selected topics in electronics or related fields.

INEL 8XXX ADVANCED TOPICS IN SIGNAL PROCESSING One to six credits. One to six contact hours per week. Study of selected topics in signal processing or related fields.

INEL 8XXX ADVANCED TOPICS IN APPLIED ELECTROMAGNETICS One to six credits. One to six contact hours per week. Study of selected topics in applied electromagnetics or related fields.

INEL 8XXX ADVANCED TOPICS IN COMMUNICATION SYSTEMS. One to six credits. One to six contact hours per week. Study of selected topics in communication systems or related fields.

INEL 8XXX ADVANCED TOPICS IN ELECTRIC POWER ENGINEERING. One to six credits. One to six contact hours per week. Study of selected topics in electric power engineering or related fields.

INEL 8XXX ADVANCED TOPICS IN POWER ELECTRONICS. One to six credits. One to six contact hours per week. Study of selected topics in power electronics or related fields.

INEL 8XXX ADVANCED TOPICS IN CONTROL SYSTEMS. One to six credits. One to six contact hours per week. Study of selected topics in control systems or related fields.

INEL 8XXX ADVANCED TOPICS. One to six credits. One to six contact hours per week. Study of selected topics in electrical engineering or related fields.

INEL 8XXX ADVANCED TOPICS IN COMPUTER ENGINEERING. One to six credits. One to six contact hours per week. Study of selected topics in computer engineering or related fields.

INEL 8XXX INDEPENDENT STUDIES. One to three credits. Independent student research in electrical engineering and related fields.

INEL 8XXX DOCTORAL SEMINAR. Zero to one credit. Oral presentation on a research topic in electrical engineering.

INEL 8XXX DOCTORAL DISSERTATION. Zero to twelve credits.

Development, preparation and defense of a dissertation based on an original research project in electrical engineering that represents a significant contribution in the area of specialization.

5.5.2 Proposed Program Course Sequences

The curriculum will be administered by the ECE Graduate Committee in Coordination with the Thrust Coordinators and the ECE Associate Chair for Graduate Studies and Research. The Ph.D. program is a research oriented program and as such we decided to have a general structure but leave enough freedom to develop study programs that meet student interest and research opportunities. Students will have an advisor who will, in conjunction with the student graduate committee, decide which of the available tracks to follow and which courses to take to meet student interest and research project needs. Information about the existing tracks is given in Appendix A. Examples of programs of study for each track are given in Appendix F. New tracks in biomedical engineering and networking are being considered as future expansions.

The open structure also give the opportunity to develop programs of study that will meet multi-disciplinary research opportunities not satisfied by a single track.

5.5.2.1 Course sequence for a student admitted with a BS in Electrical Engineering.

<i>Course</i>	<i>First Semester</i>	<i>Credits</i>
INEL Axxx	Course in Electrical Engineering	3
INEL Axxx	Course in Electrical Engineering	3
INEL Axxx	Course in Electrical Engineering	3
INEL 8998	Doctoral Seminar	0
	Total	9

<i>Course</i>	<i>Second Semester</i>	<i>Credits</i>
INEL Axxx	Course in Electrical Engineering	3
INEL Axxx	Course in Electrical Engineering	3
MATE Axxx	Graduate or Adv. Undergraduate Mathematics Course	3
INEL 8998	Doctoral Seminar	0
	Total	9

<i>Course</i>	<i>Third Semester</i>	<i>Credits</i>
INEL Axxx	Course in Electrical Engineering	3
INEL Axxx	Course in Electrical Engineering	3
MATE Axxx	Graduate or Adv. Undergraduate Mathematics Course	3
INEL 8998	Doctoral Seminar	0
	Total	9

<i>Course</i>	<i>Fourth Semester</i>	<i>Credits</i>
INEL Axxx	Course in Electrical Engineering	3
-----	Elective Course	3
-----	Elective Course	3
INEL 8998	Doctoral Seminar	0
	Total	9

Qualifying Exam

<i>Course</i>	<i>Fifth Semester</i>	<i>Credits</i>
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	0
	Total	3

<i>Course</i>	<i>Sixth Semester</i>	<i>Credits</i>
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	0
	Total	3

Comprehensive Exam

<i>Course</i>	<i>Seventh Semester</i>	<i>Credits</i>
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	0
	Total	3

<i>Course</i>	<i>Eighth Semester</i>	<i>Credits</i>
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	1
	Total	4

5.5.3 Course sequence for a student admitted with an MS in Electrical Engineering

<i>Course</i>	<i>First Semester</i>	<i>Credits</i>
INEL Axxx	Course in Electrical Engineering	3
INEL Axxx	Course in Electrical Engineering	3
MATE Axxx	Graduate or Adv. Undergraduate Mathematics Course	3
INEL 8998	Doctoral Seminar	0
	Total	9

<i>Course</i>	<i>Second Semester</i>	<i>Credits</i>
INEL Axxx	Course in Electrical Engineering	3
INEL Axxx	Course in Electrical Engineering	3
MATE Axxx	Graduate or Adv. Undergraduate Mathematics Course	3
INEL 8998	Doctoral Seminar	0
	Total	9

Qualifying Exam

<i>Course</i>	<i>Third Semester</i>	<i>Credits</i>
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	0
	Total	3

<i>Course</i>	<i>Fourth Semester</i>	<i>Credits</i>
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	0
	Total	3

Comprehensive Exam

<i>Course</i>	<i>Fifth Semester</i>	<i>Credits</i>
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	0
	Total	3

<i>Course</i>	<i>Sixth Semester</i>	<i>Credits</i>
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	1
	Total	4

Table: 5.1: Summary of Credit Distribution for a student admitted with a BS degree

Table 5.2: Summary of Credit Distribution for a student admitted with a MS degree

Semester	Credits			
	Courses	Seminar	Thesis	Total
1	9	0	-	9
2	9	0	-	9
3	9	0	-	9
4	9	0	-	9
5	-	0	3	3
6	-	0	3	3
7	-	0	3	3
8	-	1	3	4
Total	36	1	12	49

Semester	Credits			
	Courses	Seminar	Thesis	Total
1	9	0	-	9
2	9	0	-	9
3	-	0	3	3
4	-	0	3	3
5	-	0	3	3
6	-	1	3	4
Total	18	1	12	31

5.6 Educational Method and Institutional Strategies

The educational methods to be employed in the proposed academic program will seek to to develop and strengthen the skills described in the student profile. Skills 1,3,4 and 12 in the student profile will be addressed by means of course work. The mapping between courses and skills is summarized in Table 5.3. The educational strategies employed will consist of independent work, cooperative learning, team work, and research experiences. Independent work skills will be developed through course assignments and the preparation of technical reports in some courses. The ability for teamwork and cooperative learning will be promoted and evaluated by means of projects that will require complex designs and effective collaboration among students in the process of finding a common solution.

Skills 5,6,7,8,9,10 and 11 of the student profile will be gained through the doctoral seminar. Through seminars, students will be trained for independent work and research, to prepare research proposals and write technical articles, and to prepare effective technical presentations. Additionally, the seminars will serve to guide students as to the different career paths for Ph.D. graduates in academia, goverment, and private industry, as well as the creation of research and development oriented businesses.

Skills 2,4,5,6,8,10 and 12 in the student profile will be gained through the preparation of the thesis proposal and dissertation. Through the preparation of a doctoral dissertation and the publica-

tion of articles in conferences and refereed professional journals, students will develop high quality research skills and the ability to effectively disseminate them.

Table 5.3 Relation between Courses and Student Profile.

Course	Skills											
	1	2	3	4	5	6	7	8	9	10	11	12
INEL 5029.	x		x	x	x							x
INEL 5046.	x		x	x	x							x
INEL 5205.	x		x	x	x							x
INEL 5206.	x		x	x	x							x
INEL 5207	x		x	x	x							x
INEL 5265	x		x	x	x							x
INEL 5305.	x		x	x	x							x
INEL 5306.	x		x	x	x							x
INEL 5307.	x		x	x	x							x
INEL 5309.	x		x	x	x							x
INEL 5315	X		X	X	X							X
INEL 5316.	x		x	x	x							x
INEL 5325.	x		x	x	x							x
INEL 5326.	x		x	x	x							x
INEL 5327.	x		x	x	x							x
INEL 5406.	x		x	x	x							x
INEL 5408.	x		x	x	x							x
INEL 5415	x		x	x	x							x
INEL 5505.	x		x	x	x							x
INEL 5506.	x		x	x	x							x
INEL 5508.	x		x	x	x							x
INEL 5516.	x		x	x	x							x
INEL 5995.	x		x	x	x							x
INEL 6000.	x		x	x	x							x
INEL 6001.	x		x	x	x							x
INEL 6007.	x		x	x	x							x
INEL 6009.	x		x	x	x							x
INEL 6025.	x		x	x	x							x
INEL 6026.	x		x	x	x							x
INEL 6027.	x		x	x	x							x
INEL 6028.	x		x	x	x							x
INEL 6048	X		X	X	X							X
INEL 6049.	x		x	x	x							x
INEL 6050.	x		x	x	x							x
INEL 6055.	x		x	x	x							x
INEL 6058.	x		x	x	x							x
INEL 6059.	x		x	x	x							x
INEL 6066.	x		x	x	x							x
INEL 6068.	x		x	x	x							x
INEL 6069	x		x	x	x							x
INEL 6076.	x		x	x	x							x
INEL 6077.	x		x	x	x							x
INEL 6078.	x		x	x	x							x
INEL 6079.	x		x	x	x							x
INEL 6080.	x		x	x	x							x

Course	Skills											
	1	2	3	4	5	6	7	8	9	10	11	12
INEL 6085.	x		x	x	x							x
INEL 6088.	x		x	x	x							x
INEL 6096	x		x	x	x							x
INEL 6105	x		x	x	x							x
INEL 6106	X		X	X	X							X
INEL 6115	x		x	x	x							x
INEL 6215.	x		x	x	x							x
INEL 6995.	x		x	x	x							x
INEL 8IEL	x		x	x	x							x
INEL 8EMA	x		x	x	x							x
INEL 8CON	x		x	x	x							x
INEL 8ICP	x		x	x	x							x
INEL 8POT	x		x	x	x							x
INEL 8DSP	x		x	x	x							x
INEL 8ELC	x		x	x	x							x
INEL 8COM	x		x	x	x							x
INEL 8IND	x	x	x	x	x							x
INEL 8SEM					x	x	x	x	x	x	x	
INEL 8DIS	x	x		x	x	x			x			x

5.7 Catalogue and Promotion

The program’s description will be included within the Department of Electrical and Computer Engineering section in UPRM’s graduate catalogue. The particular textual description appears below.

Doctoral Program in Electrical Engineering

The department offers the degree of Doctor of Philosophy in Electrical Engineering. General requirements for the PHD are described in the REGULATIONS THAT RULE GRADUATE PROGRAMS AT UPRM and in this catalogue. The specific requirements for the doctoral program in Electric Engineering are described below.

Students in the doctoral program in Electric Engineering are required to develop a program of graduate studies and research in one of the following areas: Power Systems, Electronics, Power Electronics, , Signal Processing, Control Systems, and Applied Electromagnetics. The curriculum will consist of at least 37 credits in courses to be distributed as follows:

- 18 credits in graduate or advanced undergraduate courses within the area of specialization
- 6 credits en advanced courses (8000 or higher) in the area of specialization
- 6 credits in mathematics courses at the graduate or advanced undergraduate level. At least one course must be at the graduate level.
- 6 credits in elective courses outside the area of specialization.
- 1 credit in the doctoral seminar.

A maximum of 9 credits in advanced undergraduate courses (5000 level) may be utilized to complete course requirements for the doctoral degree. In addition to the courses, a student must take a qualifying exam, a comprehensive exam, and twelve (12) thesis credits to determine his potential for original and advanced electrical engineering research. The student must complete independent research that is a significant advancement of knowledge in the field of electrical engineering, prepare a dissertation, and pass an oral defense of his doctoral dissertation.

After the program is approved, an informative program brochure will be prepared, as well as other printed material, a web page that will serve as promotion tool. In addition, program representatives will participate in conferences such as those sponsored by SHPE and SACNAS, and in graduate school promotional fairs in the United States and in Puerto Rico.

6 Admission and Registration

6.1 Admission Requirements

General requirements necessary for admission into the graduate program appear in the section titled NORMS WHICH REGULATE GRADUATE STUDIES AT UPRM which at the moment of writing this proposal are established in Certifications 97-21 and 97-55 issued by the UPRM Academic Senate. Specific program requirements are as follows:

- Bachelor Degree or Master's Degree in Electrical Engineering, Computer Engineering or their equivalents from an accredited institution of higher learning. The graduate departmental committee will evaluate each applicant's qualifications and the reputation of their graduating institution to determine if the applicant fulfills admission requirements of the doctoral program and decide on the type of admission to be awarded.
- Applicants with a bachelor degree or a master's degree in other types of engineering, in science, in mathematics or in related areas may be considered for direct admission into the electrical engineering doctoral program. Depending on the applicant's academic background, admission may be granted with deficiency courses or a master degree in Electrical or Computer Engineering may be recommended before admission into the doctoral program.
- A general grade point average of 3.3/4.0 or its equivalent if the applicant holds a BS degree
- A general grade point average of 3.3/4.0 GPA or its equivalent if the applicant holds an MS degree or a higher degree.
- Mastery of both English and Spanish skills that may allow understanding of printed publications in the areas of electrical and computer engineering and related areas, and to write technical documents in both languages.

The same norms established by the Office of Graduate Studies as well as all previously described admission guidelines to the doctoral program are applicable to transfer students.

6.2 Graduation Requirements

The proposed academic program will consist of a minimum of forty-nine credits, from which a minimum of twenty-four will be taken in one of the areas of emphasis. Of the forty-nine required credits, a minimum of six credits will be taken in advanced graduate or undergraduate

level mathematics courses, of which at least three credits will be at the 6000 or higher level. The objective behind this requirement is to strengthen essential analytical skills required for state of the art research in electrical engineering. In addition, six credits in electives outside the area of emphasis will be required. Each doctoral candidate will be required to participate in the doctoral seminar each semester for which he will receive one credit at the conclusion of his dissertation. Besides, students will be required to pass a qualifying exam and a comprehensive exam as part of the process of evaluating their ability to engage in doctoral level research.

Students will be required 12 credits in dissertation. The dissertation will measure the scope of acquired knowledge and it will evidence the student's degree of creativity. It will require an original contribution to the existing scientific and/or technological body of knowledge in the field of electrical engineering.

6.3 Enrollment Projections

It is estimated that at least five students will be admitted to the program annually during the initial five years. At present, the department has the required physical infrastructure to accommodate these students.

Having these doctoral candidates will strengthen research endeavors within the department by increasing external funding given to the same and contributing to the improvement and development of physical facilities. Furthermore, a stronger research program will attract applicants to all existing graduate programs in the department. This has already been evidenced by graduate programs such as the Master's degree program in Electrical Engineering and Computer Engineering, where admissions have tripled from 1998-1999 through 2002-2003 as evidenced on Figure 2.1.

7 Academic Requirements for Conferring the Degree

The general academic requirements for conferring the doctoral degree are specified in the "Norms that regulate graduate studies at UPRM". Specific requirements for the doctoral program in Electrical Engineering are described below.

7.1 Total Credit-Hour Requirement

Students are required to approve a minimum of 49 credits distributed in the following manner:

- 18 credits in graduate or advanced undergraduate level courses within a particular area of specialization
- 6 credits in advanced courses (8000 or higher) within the area of specialization
- 6 credits in graduate level mathematics courses
- credits in elective courses outside the area of specialization
- 1 credit in doctoral seminar
- 12 credits in doctoral dissertation

No more than 9 credits at the advanced undergraduate level can be used to complete doctoral degree requirements.

7.2 Minimal Academic Index Requirements

In order to obtain a doctoral degree, each student must approve a minimum of 49 credits (according to specifications stated in Section 7.1) with a 3.0 or higher GPA. Students enrolled in the doctoral program may repeat a course with an earned grade of C or lower only once. Courses with a final grade of A or B cannot be repeated.

7.3 Maximum Number of Transfer Credits to be Allowed

Courses taken at UPRM in fulfillment of requirements of another graduate program may be utilized to fulfill the requirements of the doctoral program. Courses taken at other institutions of higher learning may be utilized to fulfill doctoral program requirements but are subject to residency requirements specified in “Norms that Regulate Graduate Studies at UPRM” which at the moment of writing this proposal require that 60% of the courses are taken at UPRM. The departmental graduate committee will determine in all cases the number of transfer credits. All transfer courses must have been approved with a minimum grade of B. Under no condition may thesis credits be transferred.

7.4 Residency

Residency requirements are those established by Norms that Regulate Graduate Studies at UPRM which at the time of this proposal read as follows:

“Residency requirements at the Doctoral level - a minimum of four semesters for students entering with a Bachelors degree, and a minimum of two semesters for students entering with a Masters degree. In both cases the student will complete at least sixty percent of the course work for the program at UPRM.”

7.5 Seminar

The seminars are a method to integrate in a coherent manner various research areas linked to the program. Doctoral candidates will be required to register for the Doctoral Seminar in INEL for the duration of their doctoral program and will be awarded one credit the semester their dissertation is turned in.

7.6 Qualifying Exam

All students will be required to take a Qualifying Exam. This exam will serve to evaluate a candidate’s competency in areas related to Electrical Engineering. The exam will be prepared by the department Graduate Committee. This committee will determine the minimum competencies required to pass the exam. Students admitted to the program with a Masters degree must take the exam at the end of the first year of studies. Those admitted with a Bachelors degree must take the exam at the end of the second year of studies. Students must have passed the qualifying exam in order to register for the doctoral dissertation course. In accordance with the “Norms that Regulate Graduate Studies at UPRM”, doctoral candidates who fail this exam will be allowed to repeat the exam only once, and will be suspended after failing twice. Once the qualifying exam is passed, the student becomes a doctoral candidate.

7.7 Comprehensive Exam

After passing the Qualifying Exam, the student must prepare a research thesis proposal and submit it to his Graduate Committee for approval. After receiving approval, the student will request the Comprehensive Exam. This application must be done the semester following the submission of the proposal at the latest.

The student will present his research proposal during this exam and can be evaluated on any topics related to his area of emphasis or research. The comprehensive exam will be prepared and administered by the members of the student's graduate committee and one representative of the departmental graduate committee appointed by the Associate Director for Graduate Studies. They will decide whether the student passes or fails the exam and will submit a report to the department. Doctoral students may repeat the comprehensive exam only once in case of failure.

7.8 Dissertation

All Ph.D. candidates must undertake an independent research project that is a significant contribution to the advancement of knowledge in the area of specialization. All doctoral candidates must pass the oral exam in defense of his dissertation. Students must have passed the qualifying examination in order to register for the doctoral dissertation course, and have passed the comprehensive exam before defending the thesis.

7.9 Language Requirements

This program has no language requirements

7.10 Time Limit for Program Completion

The time limit to complete the degree will be determined by the existing "Norms that Regulate Graduate Studies at UPRM" which at the time of the publication of this proposal is as follows:

- Ten years if the student initiates the program with a Bachelor's degree, even if the student is a transfer from another graduate program or if the student had temporarily suspended studies.
- Eight years if the student initiates the program with a Master's degree, even if the student is a transfer from another graduate program or if the student had temporarily suspended studies.

8 Available Faculty

8.1 Program Faculty Credentials

The Department includes the necessary faculty members to initiate this program. At present, the department has 54 professors, of which, 30 have pledged support to the proposed program. The department has five professors on study leave who are pursuing PhD's in universities in the United States. These professors should become active participants in the proposed program once they complete their PhD's. Table 8.1 summarizes the faculty's academic background and their possible course offerings. All program professors have either a tenure-track or tenure status. Individual biosketches of participating professors with information about their academic and industrial experience, publications, and research grants and contracts appear on Appendix C.

Table 8.1: Summary of available faculty

Name	Type of Position	Rank	Degree - Year	Institution	Specialty Area	Courses to teach	Expected Academic load in credits	Expected Number of Preparations
ERIC E. APONTE	Tenure Track	Assistant Professor	Ph.D. 2006	Rensselaer Polytechnic Institute	Power Systems	INEL 6025, INEL 6027, INEL 6028, NEL 8XXX	6	2
JAVIER ARROYO	Permanent	Associate Professor	Ph.D. 1997	University of Florida	Computer Engineering	NEL 8XXX	12	2
GERSON BEAUCHAMP	Permanent	Professor	Ph.D. 1990	Georgia Institute of Technology	Control	INEL 6001, NEL 8XXX	9	2
JOSE R. CEDEÑO MALDONADO	Permanent	Assistant Professor	Ph.D. 2000	Ohio State University	Power Systems	INEL 6026, INEL 6028, NEL 8XXX	Assoc. Dir 3	1
JOSE COLOM USTARIZ	Permanent	Associate Professor	Ph.D. 1998	Pennsylvania State University	Electromagnetics	INEL 5306, INEL5325, INEL 6115, INEL6105, NEL 8XXX	6	2
ISIDORO COUVERTIER	Permanent	Professor	Ph.D. 1996	Louisiana State University	Computer Engineering	INEL 6009, NEL 8XXX	Director 3	1
SANDRA CRUZ POL	Permanent	Professor	Ph.D. 1998	Pennsylvania State University	Electromagnetics	INEL 5305, INEL 5306, INEL 6069, NEL 8XXX	3	1
JOSE L. CRUZ RIVERA	Permanent	Professor	Ph.D. 1996	Georgia Institute of Technology	Electronics	INEL 6009, NEL 8XXX	UPRM VP	N/A
CARLOS CUADROS	Tenure Track	Assistant Professor	Ph.D. 2004	Virginia Polytechnic Institute	Power Electronics	INEL 6085, INEL 6066, INEL 6058, NEL 8XXX	9	2
GLADYS O. DOCOUDRAY	Tenure Track	Assistant Professor	Ph.D. 2003	New Mexico State University	Electronics	INEL 5207, INEL 5265, INEL 6075, INEL 6079, INEL 8295, NEL 8XXX	6	2
ANDRE M. DOS SANTOS	Tenure Track	Associate Professor	Ph.D. 2002	University of California at Santa Barbara	Computer Engineering	NEL 8XXX	6	2
SHAWN HUNT	Permanent	Professor	Ph.D. 1992	Michigan State University	Signal Processing	INEL 5309, INEL 5326, INEL 6000, INEL 6049, INEL 6076, INEL 6078, NEL 8XXX	9	2
HENRICK M. IERKIC VIDMAR	Permanent	Professor	Ph.D. 1980	Cornell University	Electromagnetics	INEL 6078, INEL 6105, INEL 6106, INEL 5316, NEL 8XXX	12	2
AGUSTIN A. IRIZARRY RIVERA	Permanent	Professor	Ph.D. 1996	Iowa State University	Power	INEL 6025, INEL 6027, INEL 6028, NEL 8XXX	6	2
MANUEL JIMENEZ CEDEÑO	Permanent	Professor	Ph.D. 1999	Michigan State University	Electronics	INEL 5265, INEL6055, INEL 6075, INEL 6080, NEL 8XXX	6	2

PROPOSAL FOR A DOCTORAL PROGRAM IN ELECTRICAL ENGINEERING (September 7, 2007)

Name	Type of Position	Rank	Degree - Year	Institution	Specialty Area	Courses to teach	Expected Academic load in credits	Expected Number of Preparations
LUIS O. JIMENEZ RODRIGUEZ	Permanent	Professor	Ph.D. 1996	Purdue University	Signal Processing	INEL 5046, INEL 6007, INEL 6078, NEL 8XXX	6	2
EDUARDO J. JUAN GARCIA	Permanent	Assistant Professor	Ph.D. 2001	Purdue University	Control	INEL 5506, INEL 5205, INEL 5505, INEL 5508, NEL 8XXX	6	2
KEJIE LU	Tenure Track	Assistant Professor	Ph.D. 2003	University of Texas at Dallas	Electronics	INEL 6076, INEL 6078, NEL 8XXX	6	2
VIDYA MANIAN	Tenure Track	Assistant Professor	Ph.D. 2004	University of Puerto Rico at Mayaguez	Signal Processing	INEL 5046, INEL 6007, NEL 8XXX	6	2
JUAN MARTINEZ-VELASCO	Tenure Track	Professor	Ph.D. 1982	Universitat Politecnica de Catalunya – Spain	Power Systems	NEL 8XXX	6	2
EFRAIN O'NEILL CARRILLO	Permanent	Professor	Ph.D. 1999	Arizona State University	Power Systems	INEL 6025, INEL 6096, NEL 8XXX	6	2
LIONEL ORAMA	Permanent	Professor	Ph.D. 1997	Rensselaer Polytechnic Institute	Power Systems	INEL 6077, NEL 8XXX	9	2
EDUARDO ORTIZ	Tenure Track	Assistant Professor	Ph.D. 2006	Michigan State University	Control Systems and Power Electronics	INEL5505, INEL 6000, INEL 6085, NEL 8XXX	6	2
ROGELIO PALOMERA	Permanent	Professor	Sc.D. 1979	Swiss Federal Polytechnical Institute	Electronics	INEL 5265, INEL6055, INEL 6075, INEL 6080, NEL 8XXX	12	2
HAMED PARSIANI	Permanent	Professor	Ph.D. 1979	Texas A&M University	Signal Processing	INEL 5327, INEL 6078, INEL 5327, INEL 5307, NEL 8XXX	6	2
DOMINGO A. RODRIGUEZ	Permanent	Professor	Ph.D. 1988	City University of New York	Signal Processing	INEL 5309, INEL 5326, INEL 6048, INEL 6050, NEL 8XXX	6	2
MANUEL RODRIGUEZ	Permanet	Associate Professor	Ph.D. 2001	University of Maryland at College Park	Computer Engineering	NEL 8XXX	6	2
NESTOR RODRÍGUEZ	Permanent	Professor	Ph.D. 1990	University of Wisconsin – Madison	Computer Engineering	INEL 6009, NEL 8XXX	6	2
RAFAEL RODRIGUEZ SOLIS	Permanent	Professor	Ph.D. 1997	Pennsylvania State University	Electromagnetics	INEL 5305, INEL 5306, INEL 5325, INEL 6068, INEL 6105, NEL 8XXX	6	2
JOSE ROSADO	Permanent	Associate Professor	Ph.D. 1999	Cornell University	Electromagnetics	INEL 6216, NEL 8XXX	12	2
NAYDA SANTIAGO	Tenure Track	Assistant Professor	Ph.D. 2003	Michigan State Unive-risyt	Electronics	INEL 6009, NEL 8XXX	6	2
JAIME SEGUEL	Permanent	Professor	Ph.D. 1987	City University of New York	Computer Engineering	NEL 8XXX		

Name	Type of Position	Rank	Degree - Year	Institution	Specialty Area	Courses to teach	Expected Academic load in credits	Expected Number of Preparations
NELSON SEPULVEDA	Tenure Track	Assistant Professor	Ph.D. 2005	Michigan State University	Electronics	INEL 5209, INEL 6055, NEL 8XXX	6	2
GUILLERMO SERRANO	Tenure Track	Assistant Professor	2007	Georgia Institute of Electronica	Electronics	NEL 8XXX	6	2
RAUL TORRES MUÑIZ	Permanent	Associate Professor	Ph.D. 1998	University of Virginia	Control Systems	INEL 5516, INEL 6059, INEL 6088, NEL 8XXX	6	2
RAMON E. VASQUEZ ESPINOSA	Permanent	Professor	Ph.D. 1984	Louisiana State University	Signal Processing	INEL 6007, INEL 6088, INEL 6215, NEL 8XXX	Dean	N/A
JOSÉ F. VEGA	Permanent	Professor	Ph.D. 1989	Syracuse University	Signal Processing	INEL 5046, INEL 6215	6	2
MIGUEL VELEZ REYES	Permanent	Professor	Ph.D. 1992	MIT	Control Systems and Signal Processing	INEL 6000, INEL 6001, INEL 6007, INEL 6076, INEL 6078, NEL 8XXX	3	1
KRISHNASWAMY VENKATESSAN	Permanent	Professor	Ph.D. 1974	University of Roorkee	Power Electronics	INEL 5408, INEL 6085, INEL 6066, INEL 8XXX	9	2

8.1.1 Publications

The available faculty for the proposed program is very active in their area of research as evidenced by the number of publications and the amount of external funding received by the Department in past years. All together, during the last five years, they have published over 200 peer reviewed articles in their respective research areas. Appendix D lists publications of the last five years.

8.1.2 Research

The Department of Electrical and Computer Engineering is one of the leaders in research in the UPR system. Its faculty has become very effective in obtaining external research funding during the last five years. During the last years, external funding secured by professors for the department averages over \$4 million annually. The department's faculty bring in close to one-fifth of the total external funding awarded to UPRM. A sample of active projects, and participating faculty are shown in Table 8.2. The following are various statistics associated with research taken from the 2003-04 academic year supporting the claims above. All statistics were provided by the Center for Research and Development (CID, by its Spanish initials) at UPRM.

- The department submitted 22 proposals through the CID. This represents 16% of all proposals submitted by the College of Engineering and 10% of the total submitted by all academic departments at UPRM.
- The department obtained \$4.36 M in external funding, making it the department with the most external funding this year. This represents 41% of all funding obtained by the College of Engineering and 15% of the total obtained by all departments at UPRM.
- The department awarded a total of 167 graduate-teaching assistantships, the second largest of all departments at UPRM (171 in Marine Sciences). The department was responsible for 20% of all graduate-teaching assistantships awarded at UPRM and of 21% of all funding awarded for this purpose.
- The department awarded 178 undergraduate assistantships, the highest of any department at UPRM. The department was responsible for granting 33% of all undergraduate assistantships offered at UPRM and of 27% of all funding utilized for such purposes. These assistantships were awarded with external funds.
- The department awarded 114 additional compensations for research and support personnel at UPRM, making it the department with the highest number in UPRM.

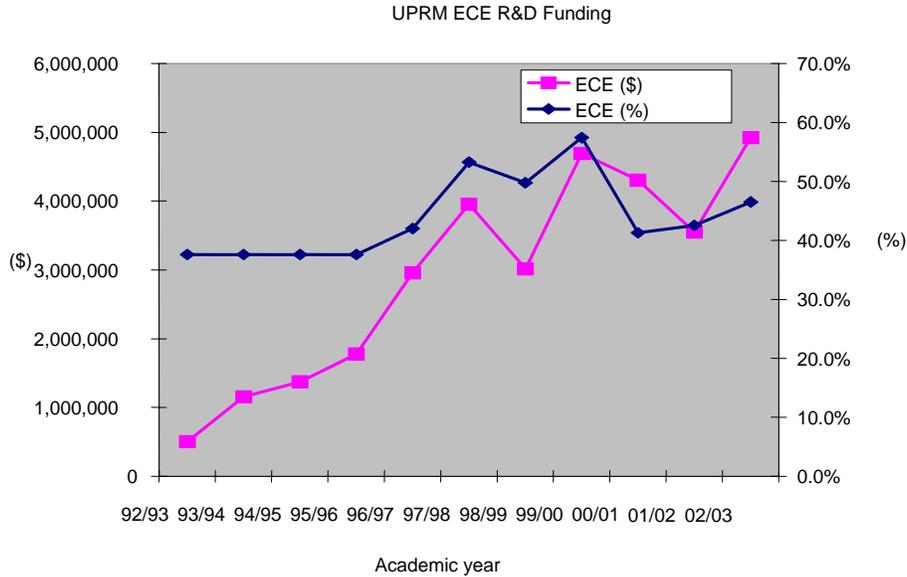


Figure 8.1 Total Research dollars for ECE and percentage of ECE research dollars within the School of Engineering

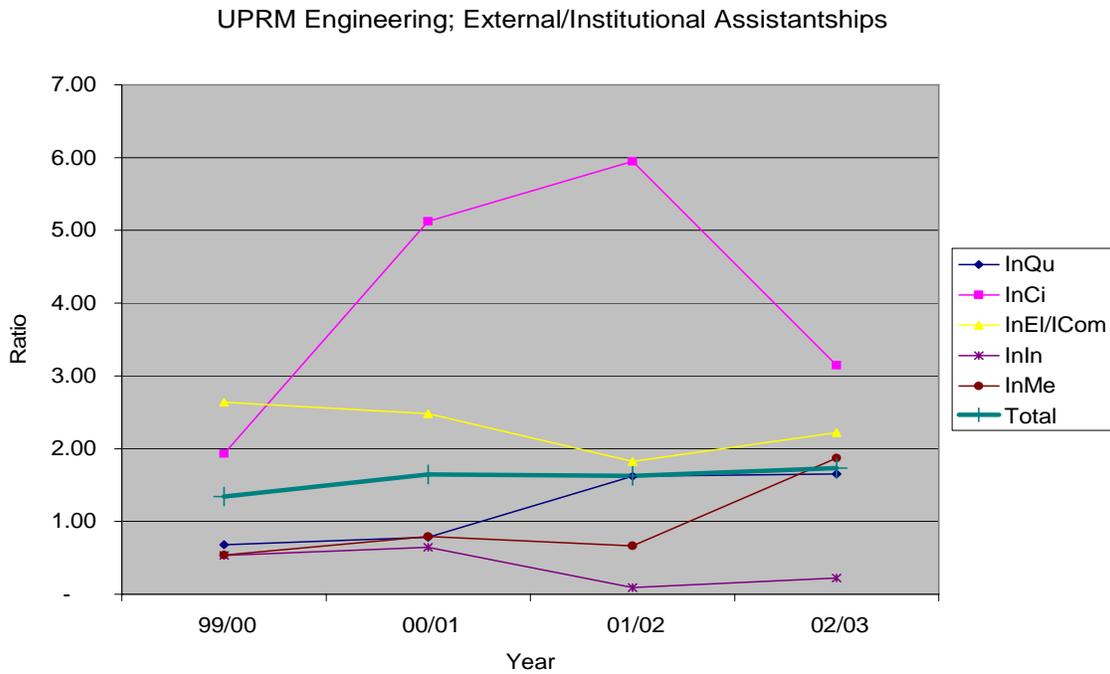


Figure 8.2 Ratio of External to Institutional Assistantships for different departments within the School of Engineering

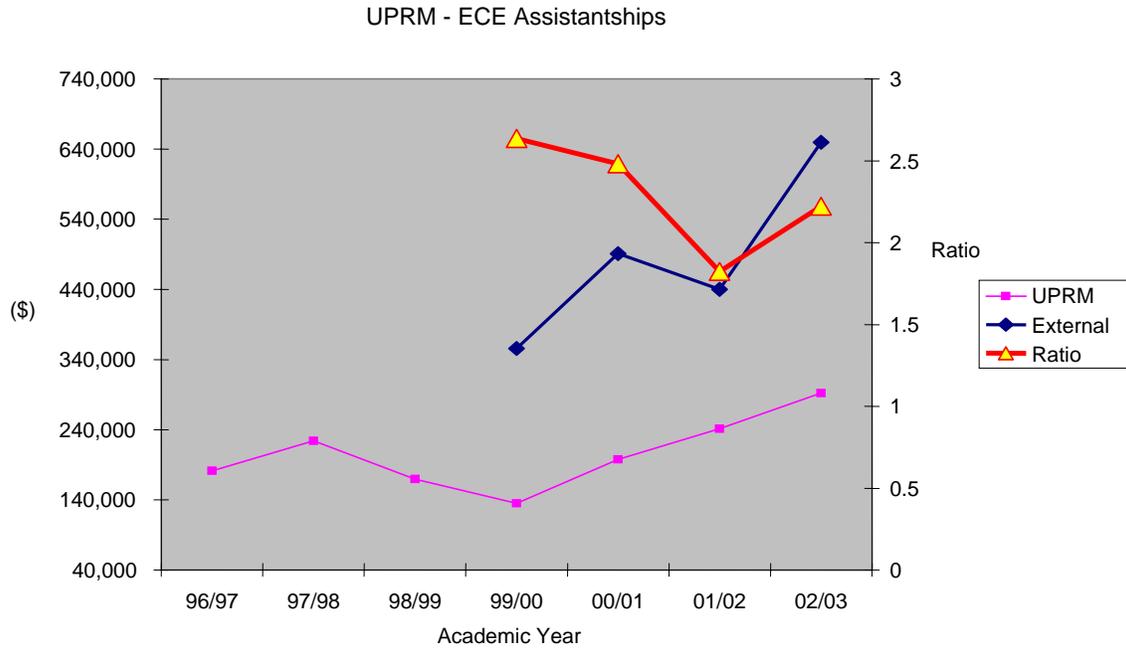


Figure 8.3 Funding Distribution for Graduate Assistantships in ECE

Table 8.2: Summary of Active Research Projects in ECE

Project Title	Funding Agency	Award	Duration	ECE Faculty Involved
A Novel Medium Access Framework for Emerging Wireless Mesh Networks: Protocol Design, Theoretical Analysis, and Prototype Development	EPSCOR	\$200,000	Agosto 2005-Julio 2007	Kejie Lu
Center for Power Electronic Systems	NSF/ERC	1,450,000* *at UPRM	2003-08	Miguel Vélez, Efraín Oneill, Ricardo Cedeño, Manuel Jiménez, Carlos Cuadros
Center for Subsurface Sensing and Imaging Systems	NSF/ERC	3,700,000* *at UPRM	2000-05	Miguel Vélez, Luis Jiménez, Shawn Hunt, Raúl Torres, Wilson Rivera, José L. Cruz, Rafael Rodríguez, Sandra Cruz, José Colom
Collaborative Adaptive Sensing of the Atmosphere Engineering Research Center	NSF/ERC	3,113,000* *at UPRM	2003-08	Sandra Cruz, José Colom, Rafael Rodríguez, Lionel Orama, Shawn Hunt, Mario Ierkic
PRECISE	NSF	1,500,000	1999-04	Domingo Rodríguez, Ramón Vásquez, Jaime Seguel, Wilson Rivera, Néstor Rodríguez, José Borges
Tropical Center for Earth and Space Studies	NASA University Research Centers Program	8,500,000	2000-05	Miguel Vélez, Rafael Fernández, Shawn Hunt, Luis Jiménez, Ramón Vásquez, Hamed Parsiani, Rafael Rodríguez, Sandra Cruz
EPNES: Intelligent Power Routers for Distributed Coordination in Electric Energy Processing Networks	NSF	500,000	2002-05	Agustín Irizarry, Efraín Oneill, Ricardo Cedeño, Manuel Rodríguez, Bienvenido Vélez
Acoustical Guidance of Liquid Filled Tubes and Catheters	NIH	78,000	2003-07	Eduardo Juan
E-Government	NSF	750,000	2003-06	Bienvenido Vélez, Manuel Rodríguez, Wilson Rivera
TI Analog, Digital and Mixed Signal Program	Texas Instruments	\$777,000	1999-04	Manuel Jiménez, Rogelio Palomera, Isidoro Couvertier
Tera-Scale Facility	IBM	\$100,000	2003	Manuel Rodríguez, Bienvenido Vélez, Jaime Seguel, Wilson Rivera, Pedro Rivera
Parameter Estimation of Ill Conditioned Systems with Applications to Electric Drives and Power Systems	NSF PECASE	677,000	1997-03	Miguel Vélez
Advanced Technology Platforms	HP			Wilson Rivera
Wideband Slot-like Antennas	NSF CAREER	584,000	2001-06	Rafael Rodríguez
Power Quality Research and Education	NSF CAREER	530,000	2002-07	Efraín O'neill
Acquisition of Instrumentation for the Electric Energy Processing Systems Laboratory	NSF MRI	210,848	2002-03	Efraín Oneill, Miguel Vélez, Lionel Orama, Ricardo Cedeño
Integrating Laboratory Practices and Undergraduate Research to the Power Engineering Curriculum at UPRM	NSF CCLI	2001-2003	162,902	Efraín Oneill, Miguel Vélez
Iterative Algorithms for Unmixing Hyperspectral Data	Mission Research Co	\$10,000	2003	Miguel Vélez
Development of a Compact, Air Cooled Solar Air Conditioning System	NSF STTR	\$500,000		Gerson Beauchamp
Microwave Remote Sensing of Clouds	NASA FAR	\$300,000	2002-05	Sandra Cruz
Modeling of MMIC Passive Structures for mm-waves	Raytheon	\$51,000	2000-03	José Colom
PR Wind Resource Assessment	AAE	\$32,000	2003	Agustín Irizarry

Project Title	Funding Agency	Award	Duration	ECE Faculty Involved
Development of Technologies for the Manufacture of Cardiac Pacing and Defibrillation Leads	Medtronics	\$45,863	2003	Eduardo Juan, Manuel Toledo, Raúl Torres, Rogelio Palomera, Rafael Fernández
Faliure Probablity and Parameter Estimation for Condition Based Maintenance of Synchronous Generators	NSF	\$100,000	2003-2005	Agustín Irizarry, Miguel Vélez, Efraín O'Neill
Center of Remote Sensing Technology	NOAA CREST	1,200,000	2001-04	Ramón Vásquez, Hamed Parsiani

8.1.3 Honors and Distinctions

Besides research accomplishments, the caliber of the departmental faculty is evidenced by the high number of awards that have been conferred on them for their numerous contributions to education and research. Among the most outstanding awards are the following:

- Presidential Early Career Award for Scientists and Engineers:** Each year federal agencies nominate 60 of the top researchers in the United States to the “Presidential Early Career Award for Scientists and Engineers (PECASE)”. PECASE gives recognition to outstanding scientists and engineers who early in their careers demonstrate exceptional potential for leadership in the quest for knowledge. This is the highest Presidential Award conferred by the government of the United States of America to scientists and engineers who initiate their careers independently. Dr. Miguel Veléz Reyes was distinguished with a PECASE in 1997 by the White House Office of Science and Technology.
- NSF CAREER Award Recipients:** The “Early Career Development Program” is a program supported by all NSF directorates, and is the most prestigious award the Foundation has for new faculty members. The “CAREER” program acknowledges and supports professional development activities of those teaching –professors who will probably become the academic leaders of the 21st century. Those awarded with the CAREERS distinction are selected on the basis of their creative professional development endeavors in effectively integrating research and education within the mission of the institution. These plans must build a solid foundation for lifelong integrated contributions in research and education. Five members of our department have been distinguished with “CAREER” awards. Four of them are presently available to participate in the proposed doctoral program: Dr. José Luis Cruz (1997), Dr. Rafael Rodríguez Solís (2001), and Dr. Efraín O’Neill (2002) and Dr. Manuel Rodríguez Martínez (2005).
- NASA FAR Award Recipient:** The “NASA Faculty Award for Research” provides research funds to universities for basic and applied research in support of NASA’s entrepreneurial strategies. FAR’s goal is to assist in fulfillment of NASA’s mission and at the same time improve cultural diversity among research communities sponsored through NASA. Dr. Sandra Cruz Pol was honored with a NASA FAR Award in 2002.
- IEEE Walter Fee Outstanding Young Engineer Award:** This award was established in order to recognize engineers younger than 36 years old for outstanding contributions in leading local or international technical activities of the IEEE Power Engineering Society, including community and humanitarian activities and outstanding engineering accomplishments. Dr. Miguel Veléz Reyes received this award in 1998 and Dr. Efraín O’Neill in 2005.

Finally, it is important to distinguish those members of our departmental faculty who have been actively involved in professional association such as Colegio de Ingenieros y Arquitectos de Puerto Rico, The American Society of Engineering Educators (ASEE) and the Institute of Electrical and Electronics Engineers (IEEE). Multiple symposia, conferences, and national and international workshops have been organized in Puerto Rico. Those hosted most recently include:

- IEEE Workshop on Computers in Power Electronics, June 2002
- Caribbean Colloquium in Power Quality, June 2003
- Parallel and Distributing Computer Workshop, November 2003
- IEEE Midwest Symposium on Circuits and Systems, San Juan, Puerto Rico, August 6 - 9, 2006.
- IEEE 9th Specialist Meeting on Microwave Radiometry and Remote Sensing Applications, San Juan, Puerto Rico, Feb. 28 to March 3, 2006

By awarding the distinction of “Senior Members” to nine of our professors, the IEEE has acknowledged professional contributions by our faculty:

1. Dr. Thomas L. Noack
2. Dr. Ramón Vásquez Espinosa
3. Dr. José L. Cruz
4. Dr. Miguel Vélez Reyes
5. Dr. K. Venkatesan
6. Dr. Alberto Ramírez
7. Dr. Sandra Cruz-Pol
8. Dr. Efrain O’Neill-Carrillo
9. Dr. Isidoro Couvertier

This distinction is awarded to only 7% of the association’s membership -the largest professional association in the world.

It is clear that the faculty available for the proposed doctoral program is highly qualified and brings a large diversity in research endeavors and interests.

8.2 Faculty Projections for the Next Five Years

Of those professors listed as available in Section 8.1, none will retire in the next five years. Professors who will retire in the next five years have opted not to participate in the program. It is hoped that the new professors hired for their replacement will participate in the doctoral program.

Presently, the department sponsors several professors on study leave. Their names and corresponding universities appear on Table 8.3. At the conclusion of their doctoral studies, these professors will become active participants in the program.

Table 8.3: Faculty Members on Study Leave

Name	Area	Institution
Miguel A. Figueroa	Signal Processing	Michigan State University
Sandra Soto Cabán	Applied Electromagnetics	Michigan State University
Lizdabel Morales	Communication Systems	Virginia Tech
Eladio Rodríguez	Signal Processing	Boston University
Juan E. Suris	Networking	Virginia Tech
Dalimar Vélez	Signal Processing	Michigan State University

8.3 Faculty Training Plan

The program's faculty does not require special training. Nevertheless, it is expected that professors will keep up to date in their particular fields of expertise through research and in teaching by participating in training workshops and effective teaching strategies offered at UPRM.

9 Learning Resources

9.1 Existing Learning Resources

UPRM's General Library holds 217,114 volumes, 6,704 serial periodicals, 1,576 CD-ROM, 2,476 thesis dissertations, and 488,527 microfiche, 17,683 microfilms, 86,218 microcards, 583,155 documents and 3,203 videocassettes. In addition, the library has access to 25,000 periodicals and 46 databases through Internet subscriptions through Ebscohost, Proquest, H.W. Wilson, Web of Science, Science Direct, Gale, Engineering Information Village2 and the electronic library for IEEE/IEE (IEEE Explorer). Detailed information regarding Internet services at UPRM may be obtained at <http://www.uprm.edu/library/>.

The IEEE Explorer provides Internet access to the entire collection of publication (magazines, conference proceedings, and standards) of the Institute for Electrical and Electronic Engineers (IEEE) and the Institution of Electrical Engineers (IEE). This is one of the most complete collections of electrical and computer engineering literature. The EBSCO system provides access to 3,200 academic periodicals ranging from social sciences, humanities, language, linguistic, arts, literature, medical sciences and ethnic studies.

In addition to these resources, the library participates in an interlibrary loan program which allows access to books and other publications unavailable at UPRM.

9.2 Plan for the Improvement of Existing Resources

What follows is a five-year plan aimed at continually improving existing library resources with the objective of addressing the proposed program's needs during the next five years. The plan is divided in four principal parts: book acquisition, serial publication acquisition, audiovisual resources acquisition, and increased electronic access to documentation and databases.

9.2.1 Acquisition of Bibliographical and Audio Visual Resources

This proposal requests, from university administration, that \$20,000 per year be assigned to the library to purchase bibliographical and audiovisual resources to support the doctoral program. A list of bibliographical and audiovisual resources for use by departmental students and faculty will be sent to the library. Once the funds are allocated to the program they will be transferred to the

library. This will be coordinated by the departmental representative to the Library Committee of the Faculty of Engineering.

9.2.2 Acquisition of Serial Publications

At the time of writing this proposal, we understand that the electronic subscriptions to Ebscohost, Web of Science, Science Direct, Engineering Information Village2 and the electronic library for IEEE/IEE (IEEE Explorer) provide appropriate access to most technical serial publications (journals and conference proceedings) in electrical and computer engineering and related areas that are needed to support research in the proposed doctoral program.

The departmental representative to the Faculty of Engineering Library Committee will periodically consult the departmental faculty regarding the need to review existing serial subscriptions and publications. Recommendations will be forwarded to the library.

9.2.3 Electronic Database Access

UPRM General Library has developed an infrastructure for electronic documentation and databases access through the local electronic campus web. Periodic evaluations of this infrastructure will guarantee appropriate support to the doctoral program. These evaluations will be coordinated through the Departmental Representative at the Faculty of Engineering Library Committee.

9.3 Acquisition of Other Resources

UPRM General Library has access to an interlibrary loan program in order to secure access to books and articles unavailable at UPRM. Additionally, the Internet provides students with access to a host of publications and scientific information. UPRM web facilitates student access to these Internet resources.

10 Physical Installation and Equipment

10.1 Inventory of Available Facilities

The department has approximately 58,600 square feet of classroom, office and laboratory space, which are distributed between Stefani Building and the UPRM Research and Development Center. The space devoted to research and teaching laboratories that will provide direct support to the doctoral program consists of approximately 8,639 square feet. Research laboratories include instrumentation and computer equipment that serve to support the type of research which typically characterizes a doctoral program in Electrical Engineering. This infrastructure has been achieved through a series of proposals submitted to NSF, NASA, the Department of Defense, and private companies such as Intel, IBM, Raytheon, Kodak, and Hewlett Packard. During the past five years, over two million dollars has been employed to improve the Department of Electrical and Computer Engineering's infrastructure.

The facilities include seven laboratories that support undergraduate courses, and courses at the advanced and graduate levels. A list of these laboratories is included below:

- Control Laboratory
- Communication and Signal Processing Laboratory
- Applied Electromagnetic Group Laboratory

Energy Systems Instrumentation Laboratory
Automation and Robotics Laboratory
Microprocessor Interfacing Laboratory
Integrated Circuit Design Laboratory

Besides the aforementioned laboratories, the department houses ten laboratories mainly devoted to research that will provide key support to the proposed doctoral program in Electrical Engineering. A list follows.

Laboratory for Applied Remote Sensing and Image Processing
Laboratory for Energy Processing Systems
Space Information Laboratory
Power Quality Laboratory
Power Electronics Laboratory
CLIMMATE
Radiation Laboratory
Atmospheric Phenomena Laboratory
Rapid Prototyping Laboratory
Bioengineering Instrumentation Laboratory

A more detailed explanation of the equipment available in each of these laboratory facilities may be found in Appendix E as well as in the Internet at this address:

http://ece.uprm.edu/engineering/inelicom/pages/resources/computational_resources.htm

10.2 Program's Impact on Existing Physical Installations

The proposal requests funds to remodel laboratory and a cubicle space for students in the doctoral program. The existing laboratory infrastructure is adequate to provide the necessary resources at the start of the program. It is our hope that the doctoral program will serve as a catalyst for obtaining resources that will contribute to the improvement and development of research laboratories. In addition, the construction of a new building to house the Department of Electrical and Computer Engineering as well as the proposed Department of Computer Sciences and Engineering will provide improved long-term facilities.

10.3 Demand for and Availability of Computer Facilities for the New Program

The ECE Department is host to excellent information systems laboratories. The department net consists of over 500 computers connected to the Web and distributed throughout diverse teaching and research laboratories previously described. In addition to the existing facilities, additional computer facilities will be provided in the new areas to be remodeled.

10.4 Copies of Applicable Licenses Required for the Utilization of Physical Installations

All licenses for the use of facilities are available from the UPRM Dean of Administration.

11 Accreditation and Program Licensing

11.1 Professional Accreditation

The proposed program does not require professional accreditation.

11.2 Accreditation by Council of Higher Education

Once approved by the corresponding bodies of the University of Puerto Rico, the proposed program will require approval by the Council of Higher Education (Consejo de Educación Superior).

12 Program Administration

Departmental Graduate programs are administered by the Department Graduate Committee in coordination with the Associate Department Director for Research and Industry Relations. The Department created the position of 'Oficial de Asuntos Estudiantiles II' (Student Affairs Officer II) and Ms. Sandra Montalvo has been the academic advisor for graduate students in the MS programs and will do a similar work for Ph.D. students. Clerical support will be given by departmental secretaries.

The following describes the tasks of each of the administrative components of the departmental graduate programs.

The Departmental Graduate Committee is responsible for the elaboration of academic regulations applicable to the departmental graduate program. In addition, in accordance with Certification 97-21 Norms for Graduate Studies at UPRM, it has the following responsibilities:

- Evaluate admission, readmission, and transfer applications and submit recommendations to the Faculty Dean for a final decision.
- Award credit-equivalencies for courses taken and approved at other universities.
- Award credit equivalencies for courses approved prior to admission.
- Determine the procedure for the elaboration, administration and evaluation of qualifying and graduate exams, as defined by departmental programs.
- Promote the Graduate Program as well as currently developed in departmental research projects.

- Periodic evaluations of the Graduate Program's progress and rate of success through activities such as, and including, the evaluation of program graduates.

Administrative oversight to all graduate programs in the department is offered by the Associate Director in charge of research and industry relations. In relation to the graduate programs, his responsibilities are:

- Coordinate graduate course offerings in collaboration with the departmental director or his representative.
- Coordinate student registration in collaboration with the departmental director.
- Process student admission applications or transfer requests in coordination with the departmental graduate committee.
- Provide student orientation regarding academic, research and administrative affairs, as well as information regarding economic aid.
- Coordinate the development of industry affiliate program and sustain an active partnership with industrial, governmental, community and higher learning institutions which may contribute to fulfill the program's objectives.
- Supervise the program's development and render an annual progress report.
- Coordinate, along with the graduate committee the periodic evaluation of the graduate program progress and success.
- Supervise the program development and generate an annual report.

The Associate Director will be designated by the Department Director in consultation with the Department's Graduate Committee.

The department has an 'Oficial de Asuntos Estudiantiles II' (Student Affairs Officer II), which will has the following duties:

- Assist the director in calculating the demand and offerings, establishing capacity and schedules of graduate courses for regular and summer semesters.
- Coordinate preregistration and registration for graduate students. Register graduate students in collaboration with the Associate Director and work on adjustments to these as required. In coordination with the Associate Director, prepare and publish for use on university bulletin boards information and registration instructions. Serve the graduate students during registration and the adjustment periods.
- Work on orientation about the graduate program for graduate students and visitors, including program offerings, admission requirements and academic regulations.
- Counsel graduate students on their programs of study and academic regulations.
- Collaborate with the graduate committee on admission application evaluation and processing. Prepare the applicant profile and in area GPA. Maintain a digital database of applicants for report statistics. Communicate with admitted students to offer information about their admissions, assistantships and registration processes.
- Assist the Associate Director and laboratory coordinators in assigning teaching assistantships and graders.
- Maintain a digital database of departmental graduate students for statistical reports and monitor their academic progress.

- Assist in the orientation of new graduate students.
- Assist the Associate Director and area coordinators in the preparing class schedules for newly admitted students and their registration.
- Prepare documents and statistical reports. Provide the projected assistantship budget to the Director. Provide information and statistical reports to the Director as required.
- Assist the Associate Director in preparing and publishing the projected five year graduate course offerings.
- Coordinate the preparation of promotional material and participate in activities which promote the programs as required by the Director.
- Collaborate with the Director and Graduate Committee in activities related to the departmental graduate programs.

13 Student Economic Aid

At present, the Department of Electrical Engineering and Computers has been able to provide a considerable number of graduate teaching assistantships. These aides fall into two categories: teaching assistantships and research assistantships. Funding for research assistantships stems primarily from external funds which have been allocated for research, while funding for teaching assistantships come from the general fund of the University of Puerto Rico. The department grants approximately 33% of all assistantships awarded to graduate and undergraduate students on campus. During the 2004-2005 academic year, including summer 2004, the department awarded \$1,097,263 (40% of the assistantships in the school of engineering) in teaching assistantships of which \$849,667 came from external funding sources.

The establishment of the new program will serve as the means to increase investigative efforts. It is our hope that this increase in research activity will serve, in turn, to increase external funding which, among other things, will result in our providing a higher number of assistantships for graduate students. Nevertheless, in order to facilitate research for newly hired professors, it is essential to provide seed money to fund, among other things, one graduate assistantship for the first two years. This is included in the proposal budget.

14 Fiscal Resources: Budget

The doctoral program can be initiated with the existing departmental financial and physical infrastructure resources. Additional funding is requested to strengthen library resources, to remodel space, and for research assistantships in support of junior faculty in the department. The requested budget is described on Table 14.1.

14.1 Recurrent Expenses

The proposed program requires adding new bibliographical resources to those in the UPRM general library, and the acquisition of audiovisual resources as necessary. An annual figure of \$20,000 has been budgeted for this purpose which will be transferred to the UPRM Library.

Table 14.1: Proposed Program Budget

Description	Yr1	Yr2	Yr3	Yr4	Yr5	Total
Recurrent Costs						
Library Resources	\$ 20,000	\$ 20,000	\$ 20,000	\$ 20,000	\$ 20,000	\$ 100,000
Total Recurrent Costs	\$ 20,000	\$ 20,000	\$ 20,000	\$ 20,000	\$ 20,000	\$ 100,000
Non Recurrent Costs						
Remodeling (\$150/sq.ft.)	\$ 225,000					\$ 225,000
Assistantships (\$13k/student)	\$ 18,340	\$ 39,480	\$ 42,280	\$ 42,280	\$ 42,280	\$ 184,660
Advisory Committee	\$ 8,000		\$ 8,000		\$ 8,000	\$ 24,000
Total Non recurrent costs	\$ 251,340	\$ 39,480	\$ 50,280	\$ 42,280	\$ 50,280	\$ 433,660
Total Cost	\$ 271,340	\$ 59,480	\$ 70,280	\$ 62,280	\$ 70,280	\$ 533,660

14.2 Non-Recurrent Expenses

Funding is requested to remodel administrative space and different area to have cubicles for doctoral students to work. We estimate that 1,500 square feet of existing space will be remodeled for this purpose at a cost of approximately \$150 per square foot for a total of \$225,000.

We have tentatively identified Stefani S-215 as a potential place to establish the office for the graduate programs in the ECE department.

Laboratory areas to be remodeled include laboratory space in the R&D Center and Stefani Building. In the Stefani Building, funds will be used to relocate the Radiation Laboratory and the Electromagnetics Laboratory to S-105D. The Radiation Laboratory provides support to the CASA NSF ERC Center. S-202 currently occupied by the Electromagnetics Lab will be re-furnished to provide office space for Ph.D. students working in laboratories in the Stefani Building since most of the laboratories in this building are too small to have space inside for student offices. These laboratories include Robotics (S-102), Control Systems (S-212-213), Biomedical Engineering (S-214), and Power Electronics (S-101). ECE has research facilities in the Reactor Building at the R&D Center. Some of the funding will be used to re-furnish rooms F-217 in the Electric Energy Processing Systems Laboratory, F-218 and F-219 in the Laboratory for Applied Remote Sensing and Image Processing, and F-220 and F-222 Power Quality Laboratory.

As part of the program assessment during the first five years, an external Advisory Committee is proposed. The members will come from academia, industry and government, and will meet bi-annually to evaluate the progress toward meeting the program objectives. A budget of \$8000 per meeting has been assigned for this committee in years 1, 3, and 5.

In year 1, \$18,340 are allocated for 2 student research assistantships. In years 2 to 5, funding for 4 assistantships per year has been allocated. This funding will be primarily directed towards junior faculty who are in the beginning of their academic careers and do not have funding to support graduate students.

15 Funding

At present, the exact amount of external funds available for the proposed program cannot be determined. Nevertheless, based on previous experience, it is expected that external funding for the program will be significant. The Department of Electrical Engineering and Computers has brought in an annual average of over \$4,000,000 during recent years for research and development projects which constitutes over 20% of the total external funding received by UPRM. It is our understanding that the Department has the capability to maintain and increase the amount of external funds to be received during the next five years.

16 Evaluation

The Department of Electrical Engineering and Computers will establish a permanent committee to be named Committee for the Evaluation of Graduate Programs (CEPG), that will be in charge of the evaluation of graduate programs in the department, including the proposed Doctoral Program in Electrical Engineering. This committee will be composed of three members of the Graduate Committee, the departmental Associate Director for Research and Industry Relations, and the Student Affairs Officer II. The evaluation process to be utilized in the program will be based on the best assessment practices as defined by the Accreditation Board of Engineering and Technology (www.abet.org) and the Middle States Association Council for Higher Education (www.msache.org).

In terms of the proposed doctoral program in electrical engineering, the CEPG will establish a periodic evaluation plan for the program. This plan will implement qualitative and quantitative strategies to determine the department's work, efforts made in reaching goals and specific objectives related to the program's mission and vision and in forming professional engineers with characteristics defined in the graduate profile, as shown in Section 5. This information will be analyzed in order to refocus the strategies and thus improve departmental outcomes in the areas of teaching, physical infrastructure, planning, budgeting, etc.

The CEPG will utilize internal and external methods to realize periodic evaluations of the proposed Doctoral Program in Electrical Engineering. The following is a preliminary list of the methods to be utilized by CEPG:

- Internal Methods: (a) to evaluate student academic performance by utilizing academic transcripts; (b) to evaluate the availability of student assistantships and scholarships for student support and strengthening recruitment, (c) to evaluate job success rates and incomes obtained by program graduates, (d) to evaluate the quality and prestige of those companies registered at UPRM Placement Office which have expressed interest in hiring doctoral program graduates; (e) to evaluate the quality and prestige of those companies which hire doctoral program graduates; (f) to evaluate the results of a poll to determine the satisfaction and accomplishment levels among students who apply for the program's qualifying exams; (g) to evaluate student performance in the qualifying exam, the comprehensive exam and in the thesis dissertation defense; (h) to evaluate student academic portfolios (such as those including: qualifying exam, publications, and presentations) throughout various stages of doctoral studies.

- External methods: (a) to evaluate results of a survey that will determine student levels of satisfaction and development after completing program requirements; (b) to evaluate the results of a survey that will determine student degree of satisfaction and development three years after graduation (graduate survey).

In order to initiate the first evaluation cycle of the proposed doctoral program , the CEPG will establish mechanisms (internal and external methods, as previously defined) to be used to measure the program's success rate in fulfilling its vision and mission, in reaching its goals, specific objectives and in the formation of a professional engineer with the qualities defined in the graduate profile.

Results, success measurement criteria and measurement mechanisms (logically stemming from criteria) relative to the program's specific objectives were specified in Section 5.3. Once the CEPG is constituted, it will proceed to define results, criteria and mechanisms for mission, vision and goal measurement and the graduating student profile. As an example, the following is a list to be used by the CEPG as a starting point for the definition of outcomes and measurement mechanisms associated with determining if the program meets its vision of "Being a program of excellence in research and in the training of doctors in electrical engineering"

- **Result #1:** Students must be able to perform high quality doctoral level research. Assessment method and success criteria: A minimum of 90% of the graduating students must have published at least one peer-reviewed article based on their doctoral work within two years of receiving their degree.
- **Result #2:** Graduates gain employment within one year after receiving their degree. Assessment method and success criteria: A minimum of 80% of the graduates have employment or employment offers in areas related to their grade within one year after receiving their degree.
- **Result #3:** Graduates are satisfied with the academic program and their research experience in the Doctoral Program in Electrical Engineering. Assessment method and success criteria: A minimum of 80% of the graduates polled during the first three years after obtaining their degree indicate they are satisfied with the academic program and recommend it to other students. Comments about the strengths and deficiencies of the program will be requested and analyzed.
- **Result #4:** Increase research funding in the Electrical and Computer Engineering Department. Assessment method and success criteria: Increase external funding by 50% after five years of establishing the program.
- **Result #5:** Increase the number of peer reviewed publications in the Department. Assessment method and success criteria: The participating faculty will average two peer-reviewed publications per year.

In addition, during the first five years of the program, there will be an external advisory board (EAB) of four persons, composed of scientists and engineers from academia, industry and gov-

ernment who will assess the program based on visits every two years and statistical reports. The committee will produce a report and submit it to the Department. The graduate committee, along with the Associate Director, will have 90 days to respond to the report and establish a plan to solve any weakness o threats found by the committee. Funds have been requested for visits in years 1, 3 and 5.

