Appendix A:
Description of Electrical Engineering Graduate Program Track Areas

Graduate Program in Electrical Engineering: Signal Processing Track

Track Summary

Signal Processing is a broad field that encompasses:

- the acquisition of data from the world around us,
- manipulating or processing that data into a useful form,
- the extraction of information from that data, and
- the interpretation of that information.

The breadth and power of signal processing is what makes it one of the key enabling technologies of the information age.

Academic Background

Students entering the program should have the following background:

1. Calculus including differential equations
2. Circuits, Signals, and Systems (discrete and continuous)
3. Programming Languages
3. Probability
4. Linear Algebra

Any student requesting admission without this background will be required to take undergraduate courses to make up for these deficiencies.

Course Requirements:

	Master of Science Plan I		Master of Engineering Plan II		Master of Engineering Plan III		Doctoral Program (proposed)	
Core courses	2-3 courses	6-9 crs	2-3 courses	6-9 crs	2-3 courses	6-9 crs	2-3 courses	6-9 crs
Major courses	3-4 courses	9-12 crs	3-5 courses	9-15 crs	6-8 courses	12-24 crs	5-6 courses	15-18 crs
Elective courses	2-3 courses	6-9 crs	2-3 courses	6-9 crs	2-3 courses	6-9 crs	2 courses	6 crs
Thesis		6 crs						12 crs
Doctoral Seminar								1 cr
Advanced Mathematics							2 courses	6 crs
Project				3-6 crs				
Total		30 crs		30 crs		36 crs		49 crs

The course requirement distribution for each plan of studies for the MS, ME, and PhD degrees are shown in the table above. There are 6-9 credits of core courses. If you did not take INEL 5309 or its equivalent at the undergraduate level, you have to take it as part of your graduate

program. If you had INEL 5309 you can take an additional elective (major or outside the major). Students in MS Plan I or II need to work on thesis or or project. Students in the doctoral program need to complete a doctoral dissertation, and pass the comprehensive and qualifying exams.

Students in MS Plan III will need to take a comprehensive exam after finishing the course requirement. Students in Plan III can register in INTD 6015 Preparation for the Comprehensive exam if they finished the course requirement for the ME program and have not approved the comprehensive exam to maintain active student status.

Any course not listed in the core or major courses can count as a course outside the area of specialization even if they are from INEL or ICOM. The list of core courses, major courses and a typical course sequence are shown next. The arrows indicate pre-requisite requirements.

Core Courses:

INEL 5309 Digital Signal Processing[1]
INEL 6076 Adaptive and Optimal Signal Processing
INEL 6078 Estimation, Detection and Stochastic Processes

Major Courses:

INEL 6007 Introduction to Remote Sensing
INEL 6049 Multidimensional Signal Processing
INEL 6050 Advanced Digital Signal Processing Algorithms
INEL 6087 Computer Vision
INEL 6995 Special Topics (with emphasis in Signal Processing)

INEL 5046 Pattern Recognition
INEL 5315 Communication Theory II
INEL 5326 Communication System Design: Signal Processing
INEL 5327 Image Processing
INEL 5505 Linear Systems Theory

Recommended Elective Courses:

MATE 5150 Linear Algebra
MATE 6025 Numerical Linear Algebra
MATE 6045 Optimization Theory
MATE 6677 Elementary Partial Differential Equations
ESMA 6600 Probability Theory
ESMA 6661 Theory of Statistics I
ESMA 6662 Theory of Statistics II
ESMA 6788 Advanced Probability Theory
ESMA 6789 Stochastic Processes

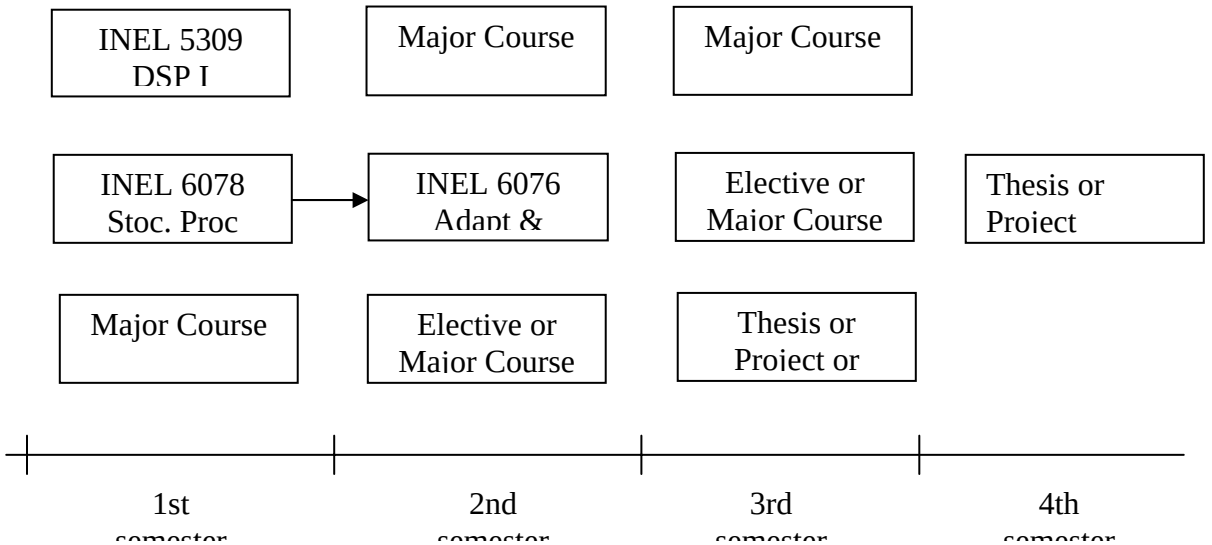
and other courses selected by the student graduate committee.

[1] If equivalent not taken previously.

Course Programming for the Signal Processing Track

Cursos	2006-2007		2007-2008		2008-2009		2009-2010	
	1er	2do						
INEL 5046 Pattern Recognition	X		X		X		X	
INEL 5309 Digital Signal Processing	X	X	X	X	X	X	X	X
INEL 5326 Communication System Design: Signal Processing	X	X	X	X	X	X	X	X
INEL 5327 Image Processing		X		X		X		X
INEL 6007 Remote Sensing		X		X		X		X
INEL 6049 Multidimentional Signal Processing	X		X		X		X	
INEL 6050 Advanced SP Algorithms		X		X		X		X
INEL 6078 Detection, Estimation and Stochastic Processes	X		X		X		X	
INEL 6076 Adaptive and Optimal Systems		X		X		X		X

Suggested Schedule for a student in MS Plan I or II



Suggested Schedule for a student in MS Plan III

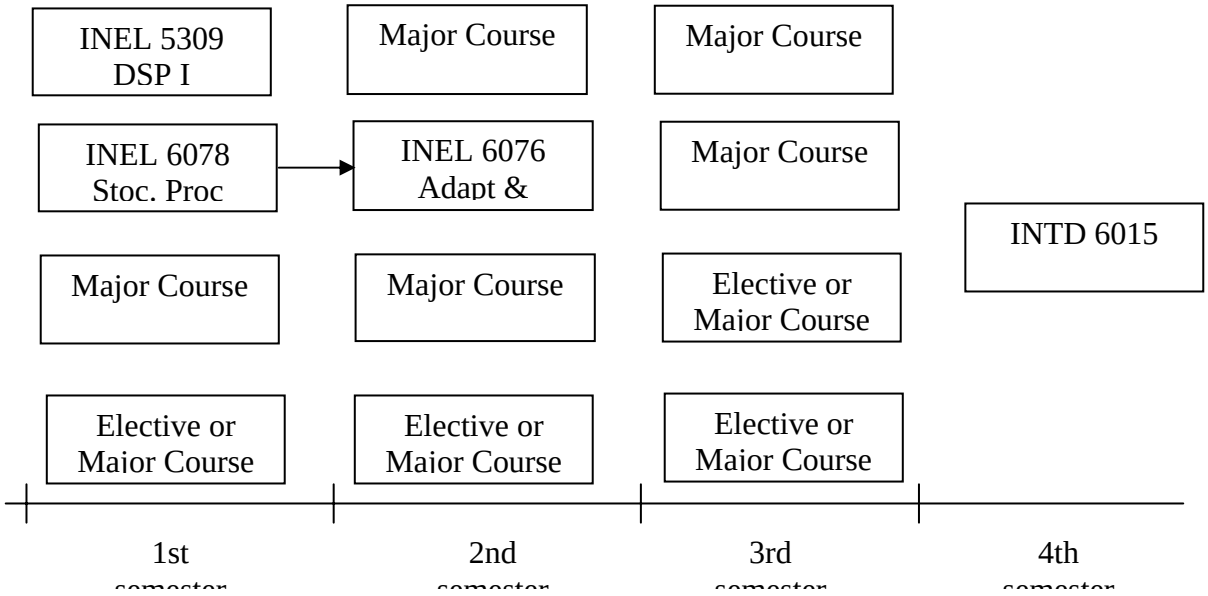


Table 1: Summary of faculty in the Signal Processing Track

Name	Rank	Degree - Year	Institution	Research Area
SHAWN HUNT	Professor	Ph.D. 1992	Michigan State University	Digital Signal Processing, Non-linear Dynamic Systems
LUIS O. JIMENEZ RODRIGUEZ	Professor	Ph.D. 1996	Purdue University	Remote Sensing, Pattern Recognition, Image Processing
VIDYA MANIAN	Assistant Professor	Ph.D. 2005	University of Puerto Rico at Mayagüez	Image Processing, Hyperspectral Image Classification, Computer Vision, Pattern Recogntion and Algorithm Analysis
HAMED PARSIANI	Professor	Ph.D. 1979	Texas A&M University	Multispectral Image Processing and Compression
DOMINGO A. RODRIGUEZ	Professor	Ph.D. 1988	City University of New York	Information Theory, Computational Signal Processing
RAMON E. VASQUEZ ESPINOSA	Professor	Ph.D. 1984	Louisiana State University	Remote Sensing, Geographic Information Systems, Image Processing, Artificial Intelligence
JOSE FERNANDO VEGA	Associate Professor	Ph.D. 1989	Syracuse University	Digital Publishing, Semantic Web and Knowledge-Based
MIGUEL VELEZ REYES	Professor	Ph.D. 1992	Massachusetts Institute of Technology	Model-based signal processing, inverse problems, imaging spectrometry, remote sensing
JAMES GOODMAN	Adjunct Professor	Ph.D. 2003	University of California at Davis	Remote Sensing of Coastal Environments

Graduate Option in Applied Electromagnetics
Department of Electrical and Computer Engineering
University of Puerto Rico at Mayagüez

Introduction

This document defines the Applied Electromagnetics Option in the Electrical Engineering Graduate Program at UPRM. The purpose of the document is to provide a description of the option and its associated research and to guide the graduate students in the preparation of their programs of study.

Description of the Area and Research Facilities

The Applied Electromagnetics area deals with the generation, transmission, propagation, scattering and reception of electromagnetic waves, applied to telecommunications and remote sensing. Telecommunications applications include r.f., microwave and millimeter-wave systems and circuits, antenna theory and design, and electromagnetic wave propagation and scattering. Remote sensing applications include the design and use of passive and active sensors to gather information on the physical properties of natural and man-made media, as well as the interaction of the electromagnetic waves with such objects. Research areas under the Applied Electromagnetics option include microwave circuits and systems, microwave and millimeter-wave antennas and arrays, microwave remote sensing and radiowave propagation.

There are two main laboratories that serve the Applied Electromagnetics area, the Radiation Laboratory and the Cloud Microwave Measurements of Atmospheric Events (CLiMMATE) Laboratory. In addition, the Applied Electromagnetics Laboratory is used for instructional purposes.

The Radiation Laboratory is a research laboratory sponsored by NSF through a Major Research Instrumentation Grant, the Collaborative and Adaptive Sensing of the Atmosphere (CASA) Engineering Research Center, and a CAREER award, and by NASA through the Tropical Center for Earth and Space Science (TCESS). This state of the art laboratory houses microwave instrumentation for network testing from 45 MHz to 50 GHz, a near-field antenna measurement facility with a frequency range of 2 to 40 GHz, a milling machine for the fabrication of prototypes at microwave frequencies and several computer workstations for the simulation and modeling of microwave and millimeter-wave circuits and antennas. The CLiMMATE Laboratory has several computer workstations for the analysis of atmospheric phenomena and the development of models for atmospheric absorption of electromagnetic energy. The Applied Electromagnetics Laboratory is primarily an instructional facility, with microwave instrumentation up to 3 GHz. This laboratory is used for demonstrations and laboratory practices for undergraduate and graduate courses.

Academic Background

Students entering the program must have the following background:

1. Integral, differential and vector calculus, including differential equations
2. Plane-wave propagation in lossless and lossy media
3. Plane-wave reflection and transmission at normal and oblique incidence
4. Two-port networks
5. Transmission lines
6. Smith Chart
7. Basic radiation concepts and antenna theory
8. Fourier Transforms
9. Basic Electronics

Students requesting admission without this background will be required to take INEL 4152 (Engineering Electromagnetics II), INEL 4301 (Communication Theory), INEL 4201 (Electronics I) and the necessary math courses to make up for their deficiencies.

Core Courses and Area Courses:

Core Course

INEL 6216, Advanced Electromagnetics, is the core course in the Applied Electromagnetics option. All students in the option must approve this course.

Area Courses

The Applied Electromagnetics Area Courses include the courses listed below. These can be used to satisfy the option requirements (M.S.; M.E. Plan II - Project; M.E. Plan III - Courses; Ph.D.)

INEL 5029: Telecommunication Electronics
INEL 5305: Antenna Theory and Design
INEL 5306: Microwave Engineering
INEL 5316: Radiowave Propagation in Wireless Communications
INEL 6068: Microwave Antenna Engineering
INEL 6069: Microwave Remote Sensing
INEL 6105: Active Remote Sensing Techniques
INEL 6106: Introduction to Radar Systems
INEL 6115: Active Microwave Circuits

Doctoral Courses

INEL 8396: Advanced Topics in Applied Electromagnetics

Recommended Courses

The following courses are not required but can help students to get a better background in areas related to the remote sensing aspects of applied electromagnetics. This is not a comprehensive list; students must consult their graduate committee to add these or any courses to their programs of study. In addition, these courses can be used to satisfy the option requirements for students in

M.E. Plan III.

INEL 6007: Introduction to Remote Sensing
INEL 6078: Estimation, Detection and Stochastic Processes

Guidelines for Programs of Study

Students following the Applied Electromagnetics option must approve INEL 6216, Advanced Electromagnetics; this is the core course for the option. Master students in Electrical Engineering must approve 30 credits for Plan I (M.S., Thesis) and Plan II (M.E., Project), and 36 credits for Plan III (courses only). Students seeking a Master of Science (M.S.) degree must approve 6 credits of Master Thesis (INEL 6046) and pass an oral examination on their thesis; students seeking a Master of Engineering (M.E.) degree (Plan II) must approve 3-6 credits of Engineering Project (INEL 6045) and pass an oral examination on their project.

Ph.D. students in Electrical Engineering must approve 43 credits beyond their B.S. work. They must approve six (6) credits in Advanced Topics in Applied Electromagnetics (INEL 8396), six (6) credits in graduate (5000 and above) math courses, and 12 credits in Doctoral Dissertation (INEL 8999). In addition, students must register for INEL 8998, Doctoral Seminar, every semester, pass the Qualifying Exam and the Comprehensive Exam, and successfully defend their dissertation.

Students are allowed to take up to nine (9) credits in 5000 level courses. Any course not listed as core or area course can count as an elective course outside the option. Table 1. summarizes the degree requirements for the different graduate programs.

1. Degree Requirements for the Applied Electromagnetics Option

Degree	Ph.D.	Master of Science	Master of Engineering	
		Plan I	Plan II	Plan III
Course Type	Total Credits	Total Credits	Total Credits	Total Credits
Core course (INEL 6216)	3	3	3	3
Area courses	15	15	15-18	24-27
Out-of-Area courses	6	6	6	6-9
Advanced math courses	6	0	0	0
Doctoral course (INEL 8396)	6	0	0	0
Doctoral seminar	1	0	0	0
Thesis or project	12	6	3-6	0
Total	43	30	30	36

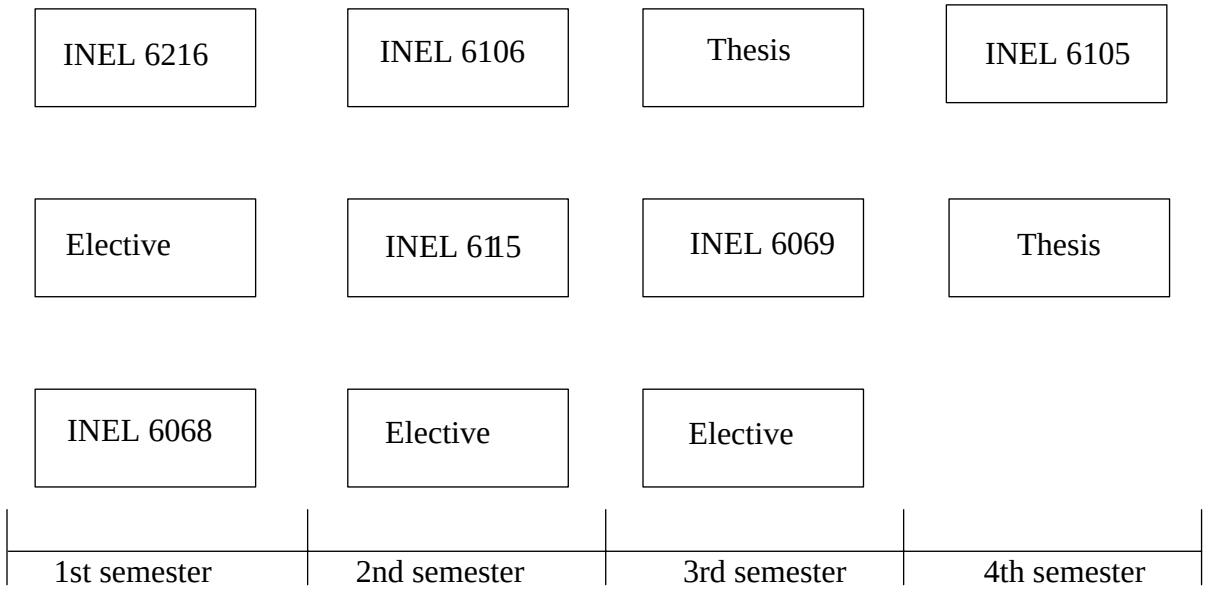
Table 2 shows the Applied Electromagnetics course schedule

Table 1: Course Schedule

	07-08		08-09		09-10		10-11		11-12	
Course	1	2	1	2	1	2	1	2	1	2
INEL 5029		X		X		X		X		X
INEL 5305		X		X		X		X		X
INEL 5306	X		X		X		X		X	
INEL 5316	X		X		X		X		X	
INEL 6068	X				X				X	
INEL 6069			X				X			
INEL 6105				X				X		
INEL 6106		X		X		X		X		X
INEL 6115		X				X				X
INEL 6216	X		X		X		X		X	
INEL 8396		X		X		X		X		X

Two sample course sequences for M.S. students and the course sequence for a Ph. D. student admitted with a B.S. are shown next for illustration purposes. Please note that the student program of study is flexible and is designed taking into account the student interests, the project or research requirements and the guidance from the student graduate advisor.

A student with background in microwave and antennas could follow the course sequence shown below.



A sample course sequence for a student without background in microwave and antennas is shown below

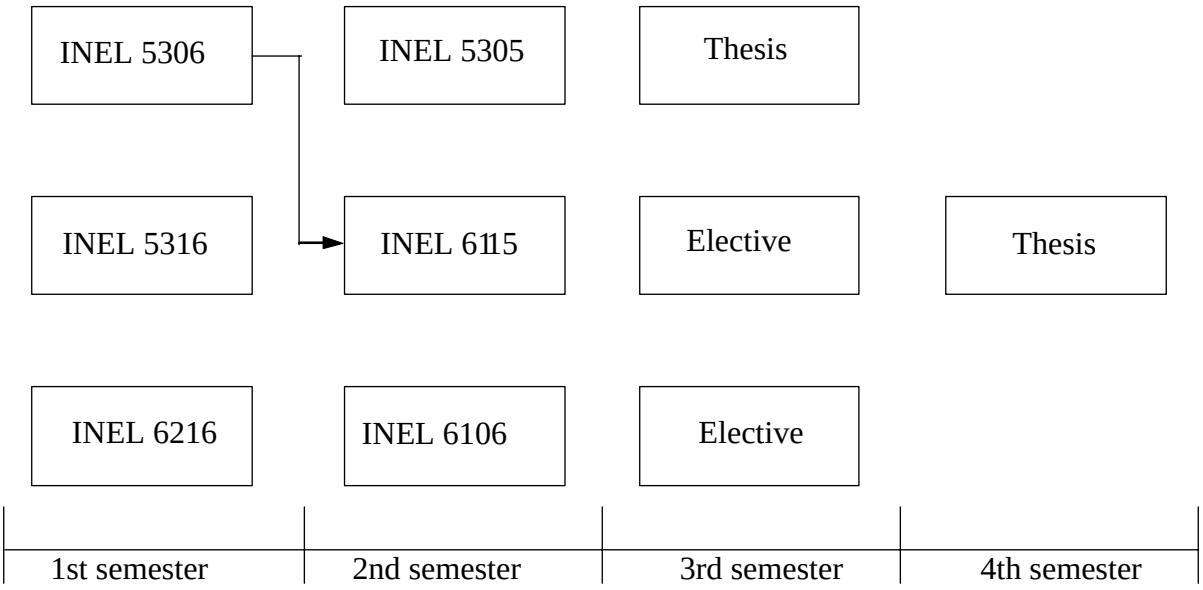


Table 1: Ph. D. Course Sequence for a Student Admitted with a BS in Electrical Engineering

First Semester		
Course		Credits
INEL 6216	Advanced Electromagnetics	3
INEL AXXX	Elective in Applied Electromagnetics	3
INEL AXXX	Elective in Applied Electromagnetics	3
INEL 8998	Doctoral Seminar	0
	Total	9
Second Semester		
INEL AXXX	Elective in Applied Electromagnetics	3
INEL AXXX	Elective in Applied Electromagnetics	3
MATE AXXX	Elective in Advanced Math	3
INEL 8998	Doctoral Seminar	0
	Total	9
Third Semester		
INEL 8396	Advanced Topics in Applied Electromagnetics	3
INEL AXXX	Elective in Applied Electromagnetics	3
MATE AXXX	Elective in Advanced Math	3
INEL 8998	Doctoral Seminar	0
	Total	9
Fourth Semester		

INEL 8396	Advanced Topics in Applied Electromagnetics	3
----------	Elective Course	3
----------	Elective Course	3
INEL 8998	Doctoral Seminar	0
	Total	9
Qualifying Exam		
Fifth Semester		
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	0
	Total	3
Sixth Semester		
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	0
	Total	3
Comprehensive Exam		
Seventh Semester		
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	0
	Total	3
Eighth Semester		
INEL 8999	Doctoral Dissertation	3
INEL 8998	Doctoral Seminar	1
	Total	4

All graduate students must submit a program of study before registering for a second semester. Also, note that *students **must** present their dissertation, thesis or project proposal before registering on Doctoral Dissertation, Master Thesis or Master Project for a second time*.

Students entering the doctoral program with a B.S. degree must take the qualifying exam by the end of their second year; those entering the program with a M.S. degree must take the qualifying exam by the end of their first year.

Research

The Applied Electromagnetics faculty is very active in research and has received more than $3.85 million in research grants since 2000 and is participating in the NSF Engineering Research Center for Collaborative and Adaptive Sensing of the Atmosphere (CASA). Current research projects include the study of microwave atmospheric absorption in clean air and in the presence of clouds and rain, the development of microwave transceiver modules for phased arrays, the characterization and development of tunable microwave circuits and antennas using electroceramic materials, the validation of rain-rate measurements using NEXRAD data and rain gauges, the modeling of wireless communication channels, the characterization and development of novel slot-like antennas and the development of phased array antennas. Research is conducted mainly at the CLiMMATE Laboratory and the Radiation Laboratory facilities. Most of the

research faculty are members of the Laboratory for Remote Sensing and Image Processing (LARSIP), the Tropical Center for Earth and Space Studies (TCESS), a NASA research center, the Center for Subsurface Sensing and Imaging Systems (CenSSIS) and CASA NSF Engineering Research Centers. In addition, the Applied Electromagnetics group has strong research ties with the National Astronomy and Ionosphere Center, the University of Massachusetts at Amherst, the Georgia Institute of Technology and the University of Colorado at Boulder.

Faculty

Table 1: Applied EM Faculty

Name and Rank	Degree	Research Interests
JOSE G. COLOM USTÁRIZ colom@ece.uprm.edu Professor	Ph.D. (1998) Penn State University	Microwave Circuits, Microwave Remote Sensing Systems, Numerical Methods in Electromagnetics
SANDRA CRUZ POL SandraCruzPol@ieee.org Professor	Ph.D. (1998) Penn State University	Microwave Remote Sensing using Radiometric and Altimeter data, Microwave Atmospheric Absorption and Sea Surface Emissivity, Microphysical properties of Clouds; cirrus, stratus, and precipitation.
HENRICK M. IERKIC ierkic@ece.uprm.edu Professor	Ph.D. (1980) Cornell University	Communications and Information Theory, Mobile Communications, Radar Techniques, Plasma Theory.
SAMUEL R. IRIZARRY MILÁN irizarry@ece.uprm.edu Professor	Ph.D. (1974) University of Michigan	Electromagnetic Theory
HECTOR MONROY AYALA hmonroy@ece.uprm.edu Professor	MSEE (1971) Ohio State University	Ionospheric Studies, Communication Systems, Microwaves and Antennas
RAFAEL A. RODRÍGUEZ SOLÍS rarsolis@ieee.org Professor	Ph.D. (1997), Penn State University	Broadband Microwave and Millimeter-wave Antennas and Phased Arrays, Tunable Antennas, Broadband Micro-wave Circuits, Numerical Methods in Electromagnetics
JOSÉ ROSADO ROMÁN jrosado@ece.uprm.edu Associate Professor	Ph.D. (1999) Cornell University	Electromagnetics, Plasma Physics

Graduate Program in Control Systems Engineering

Electrical and Computer Engineering Department
University of Puerto Rico-Mayagüez

1. Introduction

This document describes the Control Systems option within the graduate program in Electrical and Computer Engineering at the University of Puerto Rico-Mayagüez (UPRM). Information regarding courses, graduation requirements, research areas, facilities and faculty is provided. The information contained in this document is useful for both prospective students who are considering applying to the Control Systems graduate option, and to graduate students currently enrolled at UPRM.

2. Academics

The Department of Electrical and Computer Engineering at UPRM offers the following advanced undergraduate and graduate courses in control systems engineering:

Advanced Undergraduate Courses

INEL 5505 Linear Systems Analysis (Spring)
INEL 5506 Process Instrumentation and Control Engineering (Spring)
INEL 5508 Digital Control Systems (Fall)
INEL 5516 Automation and Robotics (Fall)

Graduate Courses

INEL 6000 Introduction to Nonlinear Control Systems (Fall)
INEL 6001 Feedback Control Systems I ** (Fall)
INEL 6002 Feedback Control Systems II (Spring of Odd Years)
INEL 6047 Advanced Control System Theory (Spring of Even Years)
INEL 6059 Intelligent Systems (Spring)
INEL 6995 Special Topics in Electrical Engineering (Announced when Offered)

** Core Course

Plan of Study

Graduate students should submit a plan of study before the end of the first semester. This plan of study will be prepared by the student with the guidance of his/her thesis advisor and the rest of the student's graduate committee. To obtain the Master of Science degree, the student must complete at least 30 credit hours of graduate work. These 30 credit hours are divided in 24 credit hours of coursework and 6 credit hours of thesis work. The student is allowed to take at most 9 credit hours in 5000-level courses. The following table serves as a guideline when preparing a plan of study.

Table1. Guidelines for programs of study in Control Systems Engineering:

Thesis Option	Description	Credits
Core Course	INEL 6001 Feedback Control Systems I	3
Area Courses	Courses with INEL codification	18-12
Out-of-Area Courses	Courses outside the ECE department	6-9
Thesis		6
TOTAL CREDITS		30

3. Research

All faculty members within the control systems area are actively involved in research, which results in a diverse number of research topics available for new graduate students to work on. Some of these areas include: Fuzzy Logic Based Systems, Biomedical Engineering, Non-Linear Dynamic Systems, Computer Vision, Intelligent Systems, and System Identification.

4. Facilities

The ECE department has numerous facilities dedicated to educational and research activities in control systems. These include:

- **Process Control and Instrumentation Engineering Laboratory**
- **Automation and Robotics Laboratory**
- **Biomedical Engineering Research Laboratory**

5. Control Systems Engineering Faculty at UPRM

Dr. Gerson Beauchamp*, Professor*

Office: S-203
Phone: (787) 832-4040 Ext. 2502
E-Mail: gerson@ece.uprm.edu

Research Interests:

- Automatic Control

- Fuzzy Logic Based Systems

***Dr. Eduardo J. Juan**, Assistant Professor*

Office: T-215
Phone: (787) 832-4040 Ext. 3205
E-Mail: ejuan@ece.uprm.edu

Research Interests:
- Biomedical Acoustics
- Medical Instrumentation and Devices
- Functional Electrical Stimulation
- Biosensors

***Dr. Shawn Hunt**, Professor*

Office: S-412
Phone: (787) 832-4040 Ext. 3654
E-Mail: shawn@ece.uprm.edu

Research Interests:
- Digital Signal Processing
- Non-Linear Dynamic Systems

***Dr. Raul Torres**, Assistant Professor*

Office: T-213
Phone: (787) 832-4040 Ext. 2191
E-Mail: rtorres@ece.uprm.edu

Research Interests:
- Neural Networks
- Robotics
- Intelligent Systems
- Virtual Reality
- Computer Vision
- Manufacturing

***Dr. Miguel Vélez**, Professor*

Office: S-404
Phone: (787) 832-4040 Ext. 2888
E-Mail: mvelez@ece.uprm.edu

Research Interests:
- Parameter Estimation and System Identification
- Model-based Signal Processing

GRADUATE PROGRAM IN POWER ENGINEERING
ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT
UNIVERSITY OF PUERTO RICO-MAYAGÜEZ

1. INTRODUCTION

This document defines the graduate options within the Power Engineering Program at the University of Puerto Rico-Mayagüez (UPRM). Courses within each option are identified. The purpose of this document is to facilitate the admissions process by clearly stating which are the minimum requirements for power engineering. The information in this document is also useful to graduate students preparing their programs of study.

2. DEFINITION OF THE AREA

Power Engineering deals with the efficient generation, transmission, distribution and utilization of energy. Recent technological advances in semiconductor technology have made possible the application of power electronics in all areas of power systems. Thus, our Power Engineering Graduate Program combines these two areas and offers students two options: Power Systems and Power Electronics. Research areas include power electronic converters, modeling and control of electric drives, power quality, alternate energy sources, energy storage, atmospheric studies, electromagnetics applied to power engineering, commercial and industrial design, transient phenomena and insulation coordination, system protection (fault & short circuit), energy management, stability and dynamics, device and load modeling, power system analysis

An electric machines laboratory and a power electronics laboratory support teaching and research in energy conversion. The energy systems computational laboratory supports research focused on modeling and simulation. The use of computers is integrated to all courses to enhance the theory presented in class. Research in power engineering is also supported by the Center for Power Electronics (CPES) at UPRM. This is an NSF Research Center that focuses on power electronics research, industrial collaboration, education and technology transfer. UPRM is a member of CPES. Other members include Virginia Tech, RPI, University of Wisconsin-Madison and North Carolina A & T. Appendix I presents a detailed description of CPES.

3. DEFINITION OF OPTIONS

The Power Engineering Graduate Program has two options: Power Systems and Power Electronics. When a person applies to the Power Engineering program, he/she must identify one area of interest within the program. If the person is admitted to the program, he/she must meet the minimum requirement for the selected option. These requirements are:

Power Systems:	INEL 4415 Power System Analysis or equivalent
Power Electronics:	Basic knowledge of polyphase circuits and electromechanical energy conversion

These requirements can be met if the student has taken such courses or their equivalent in their previous degree, through continuing education programs or relevant work experience (proof required). Otherwise, students must take such courses during their first year at UPRM. If a student wants to take courses in an option in power engineering different to the one for which he/she was admitted, it will be that student's responsibility to meet the requirements for the second option in power engineering.

These options are meant as guides, not as strict rules, or cages. All students will be considered Power Engineering students, some specializing in power system topics, others in power electronics applications. Students are encouraged to attend courses in both options. This will give a better understanding of power engineering and would prepare students for the challenges of working in industry or continue Graduate School. Further guidelines are given in Section 4.

4. CORE COURSES AND AREA COURSES

Each option has three core courses, all students must attend and pass at least two of these core courses within an option. These are:

For Power Systems (2 out of 3):
- INEL 6026 Computational Methods for Power System Analysis
- INEL 6027 Power System Dynamics and Control
- INEL 6028 Economic Operation of Power Systems

For Power Electronics (2 out of 3):
- INEL 6058 High Frequency Power Converters
- INEL 6066 Electric Drive Systems
- INEL 6085 Advanced Power Electronics

There are seven other courses in power systems and three other courses in power electronics. Graduate students can take up to 9 credits in 5000-level courses (Senior undergraduate courses). The course in Power Quality belongs to both areas. The courses (other than the core courses) within each area are:

Power Systems
INEL 5406 Transmission and Distribution
INEL 5407 Computer Aided Power System Design
INEL 5415 Power System Protection Design
INEL 5495 Design Course in Power Systems
INEL 6025 Advanced Energy Conversion
INEL 6077 Surge Phenomena
INEL 6096 Power Quality

Power Electronics
INEL 5408 Motor Control
INEL 5496 Design Course in Power Electronics
INEL 6096 Power Quality

5. PROGRAMS OF STUDY

The purpose of this section is to GUIDE students in the process of creating their programs of study (POS). Students and their Faculty mentors have room to accommodate the professional goals of the student as well as the needs of their research projects. During this process it is important that the student consults with his/her Graduate Committee for further guidance.

There are ECE courses from other areas (e.g., Controls) that can be considered area courses in power engineering. Special permission from the student's Graduate Committee is required to include up to 2 of these courses as "area courses" in a POS. A maximum of three out-of-area courses may be selected from any UPRM department as long as they are approved by the Student's Graduate Committee (these three courses do not include the two courses a student may use as "area courses"). A maximum of three 5000-level and up to two special topics courses may appear in a student's POS. ***Students must file a POS before registering for their second semester.***

Guidelines for programs of study in Power Engineering:

Thesis option:

5 or 6 courses in-area:	15-18 credits
3 or 2 out-of-area courses:	9 - 6 credits
Thesis:	6 credits
Total:	30 credits

Project option:

5 to 7 courses in-area:	15 - 21 credits
3 or 2 out-of-area courses:	9 - 6 credits
Project	6 - 3 credits
Total:	30 credits

6. COURSE SEQUENCE

Course	2003 – 2004		2004 – 2005		2005 – 2006		2006 – 2007	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
INEL 5406 Transmission and Distribution	PS	PS	PS	PS	PS	PS	PS	PS
INEL 5407 Computer Aided Power System Design	PS	PS	PS		PS		PS	
INEL 5408 Motor Control	PE		PE		PE		PE	
INEL 5415 Power System Protection Design				PS		PS		PS
INEL 5495 Design Projects in Power Systems (capstone)	PS	PS	PS	PS	PS	PS	PS	PS
INEL 5496 Design Projects in Power Electronics (capstone)		PE		PE		PE		PE
INEL 6025 Advanced Energy Conversion			PS/PE				PS/PE	
INEL 6026 Computational Methods For Power System Analysis		PS		PS				PS

INEL 6027 Power System Dynamics and Control		PS		PS		PS		PS
INEL 6028 Economic Operation of Power Systems	PS		PS		PS		PS	
INEL 6058 High Frequency Power Converters – (CPES distance course)								
INEL 6066 Electric Drive Systems		PE		PE		PE		PE
INEL 6077 Surge Phenomena	PS				PS			
INEL 6085 Advanced Power Electronics	PE		PE		PE		PE	
INEL 6096 Power Quality		PS/PE				PS/ PE		

PE: Power Electronics

PS: Power Systems

The following tables show offerings in each option. In each semester there are 3 courses per option, thus in a year a student may complete the required 18 credits for the power engineering option. Other combinations of courses are possible, including courses from other areas that may be counted as "in-area" courses as recommended by the student's Graduate Advisory Committee.

Power Systems

First Semester	Second Semester
6025/6077 (alternate each year)	6026/6096 (alternate each year)
6028	6027
6085 (suggested)	5495

Power Electronics

First Semester	Second Semester
5408	5995
6058/CPES/6025	6066
6085	5496

7. POWER ENGINEERING FACULTY AT UPRM

NAME AND RANK	TERMINAL DEGREE	AREAS OF SPECIALIZATION
Erick E. Aponte	PhD (2006), Rensselaer Polytechnic Institute	Power System Analysis, Power Electronics
Juan R. Caro Moreno Professor	MSNE (1971), University of Puerto Rico	Power System Analysis, Electric Machines
J. Ricardo Cedeño Assistant Professor	PhD (2002), Ohio State University	Operation and Control of Power Systems, Applications of Artificial Intelligence in Power Systems
Agustín A. Irizarry-Rivera Associate Professor	PhD (1996) Iowa State University	Power Systems Dynamics and Operation, Renewable Energy Sources and Energy Storage Systems
Baldomero Lloréns-Ortiz Professor and Director of ECE	MSEE, EE (1976) Massachusetts Institute of Technology	Modern Control Systems, Automation, Power System Analysis
Seyed M. Madani	PhD (1999), Eindhoven University, The Netherlands.	Electric machines, power electronics, hybrid vehicles, protection systems.
Efraín O'Neill-Carrillo Associate Professor	PhD (1999), Arizona State University	Power Quality, Power Distribution Systems, Distributed Generation, Engineering Education, Social Implications of Technology
Lionel Orama Associate Professor	PhD (1997) Rensselaer Polytechnic Institute	Power System Transients and Protection, Switching Devices, Switchgear technology, Arc Discharges in Vacuum and gases, EMTP & Finite Element Modeling of Power Devices
Roberto Pérez-Colón Professor	MSEE (1979), University of Puerto Rico	Illumination Systems, Energy Conservation and Management, Industrial/commercial design

NAME AND RANK	TERMINAL DEGREE	AREAS OF SPECIALIZATION
Alberto Ramírez-Orquín	PhD (2002), University of Texas, Arlington.	Power system operation and control, power systems dynamics and stability, power system transients and protection, deregulation, power markets, congestion management.
Julio A. Santiago-Pérez Professor	MSEE (1970), Rensselaer Polytechnic Institute	Electric Power Engineering, Computer Applications to Power Systems, Atmospheric Sciences, Induced Voltages in Transmission Lines, Industrial/commercial design
Miguel Vélez-Reyes Professor	PhD (1992), Massachusetts Institute of Technology	Parameter Estimation and System Identification, Model-based Signal Processing, Algorithms for the Solution of Inverse Problems in Remote sensing and for Parameter Estimation in Electrical Energy Processing Systems, Analysis and Design of Nonlinear Control Systems, Modeling, Design, and Control of Electric Drive Systems
Krishnaswami Venkatesan Professor	PhD (1974), University of Roorkee	Power Electronic Circuits, Electric drives, Stability and Control of Power Systems, Electric Machines, Switching Power Supplies

Graduate Studies in Electrical Engineering
with Emphasis in Electronics

Introduction

The last twenty years have witnessed what could be called a revolution in electronics. The fast pace of advances in solid-state technology, fabrication processes, and circuit techniques have triggered enormous developments, which in turn have expanded human capabilities in many areas of knowledge.

The Electrical Engineering graduate program at the UPRM offers a graduate-level specialization in the area of electronics. This specialty area encompasses course offerings and research that embrace contemporary topics in solid state electronics, analog and digital systems design, and computer-aided electronic design. Modern laboratories and computer equipment are available to support both teaching and research activities in these areas, preparing master's candidates for design and development activities at either the academic or industrial level.

Requirements

To be admitted to the electronics area applicants must minimally have undergraduate courses in the following areas:

- Microprocessors
- Combinational and Sequential Logic Design
- Microelectronics
- Programming Languages
- Differential Equations
- Probability and Statistics

Applicants without the proper preparation in any of these areas will be recommended by the Department's Graduate Committee to take appropriate remedial courses.

Coursework

The coursework in the electronics area is divided into two sets: core and elective courses. Graduate students are required to complete between 12 and 18 credits in their area of specialization. From these, at least 3 credits must be in core courses. A list of the course offering is provided below.

Core Courses

Core courses in electronics include the following offerings:

- INEL 6009 Computer Systems Architecture
- INEL 6055 Solid State Electronics
- INEL 6080 VLSI Systems Design
- INEL 6085 Analysis and Design of Power Semiconductor Circuits

Elective Courses

Additional courses in the electronics area include advanced undergraduate-level classes as well as other graduate-level courses offered on demand.
The list of advanced undergraduate courses include:

- INEL 5205 Instrumentation
- INEL 5206 Digital Systems Design
- INEL 5207 Design with OpAmps and Analog ICs
- INEL 5065 Analog Integrated Circuit Design

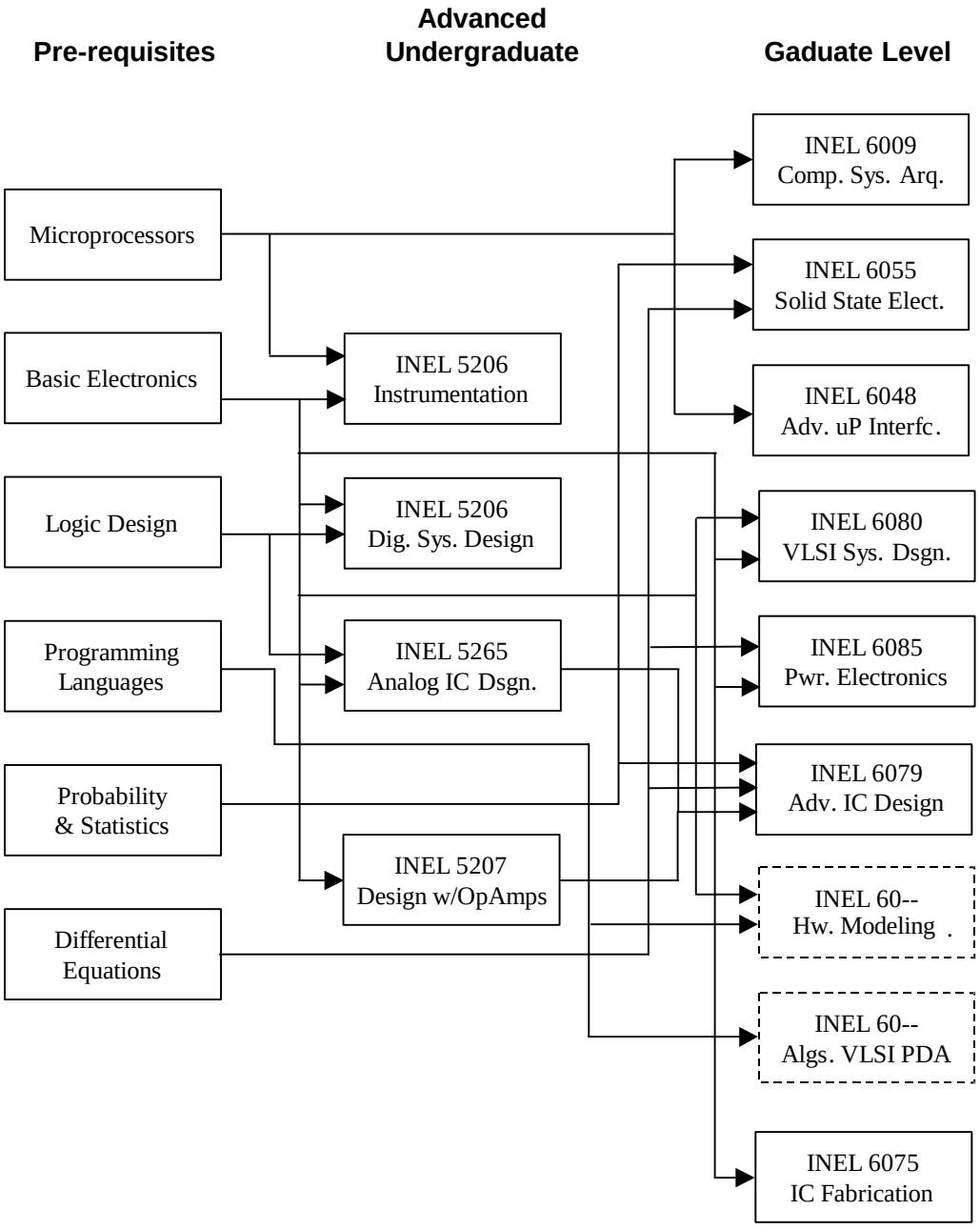
At the graduate level, the list of additional course offerings include:

- INEL 6005 Integrated Circuits Analysis and Design
- INEL 6048 Advanced Microprocessor Interfacing
- INEL 6075 Integrated Circuit Fabrication
- INEL 6995 Special Topics in Electrical Engineering
- INEL 6079 Advanced IC Design Techniques
- INEL 60XX Hardware Modeling in Circuits and System*
- INEL 60XX VLSI Physical Design Automation*

The sequence of classes and their association with their pre-requisite areas are graphically illustrated in the next section.

* New courses to be added on demand.

Course Flowchart



Research Areas

The research interests of the ECE Department electronics faculty fall into diverse areas, many of them corresponding to interdisciplinary categories. Examples of this diversity include Biometrics Systems, Electronic Design Automation, Embedded Systems, Electro-optics, and Advanced Computer Architectures, among others. In addition to this rich diversity of contemporary topics, several faculty members are also active in more classical areas in electronics such as analog and digital VLSI, and circuits and systems. The list below includes the names, contact information, and research interests of electronics professors in the ECE Department.

***Dr. Gerson Beauchamp**, Professor*

Office: S-203
Phone: (787)832-4040 Ext. 2502
Email: gerson@ece.uprm.edu
Home Page: http://ece.uprm.edu/~gerson

Research Interests

- Instrumentation Systems

***Dr. José Luis Cruz**, Associate Professor*

Office: S-502
Phone: (787)832-4040 Ext. 3121
Email: jcruz@ece.uprm.edu
Home Page: http://ece.uprm.edu/~jcruz

Research Interests

- Optoelectronic Computing
- Biometric Systems
- Medical Image Processing

***Dr. Manuel Jiménez**, Associate Professor*

Office: S-222B
Phone: (787)832-4040 Ext. 3780
Email: mjimenez@ece.uprm.edu
Home Page: http://ece.uprm.edu/~mjimenez

Research Interests:

- Low-power Digital Circuit Design
- CAD Tools for VLSI Physical Design Automation
- Microprocessors & Embedded Systems
- Rapid System Prototyping

***Dr. Jorge Ortíz**, Professor*

Office: S-402
Phone: (787)832-4040 Ext. 3624
Email: jortiz@ece.uprm.edu
Home Page: http://ece.uprm.edu/~jortiz

Research Interests:

- Microprocessor Systems

***Dr. José Rivera Cartagena**, Professor*

Office: SA-204
Phone: (787)832-4040 Ext. 3539
Email: joser@ece.uprm.edu
Home Page: http://ece.uprm.edu/~joser

Research Interests:

- Image and Voice Coding

***Dr. Rogelio Palomera**, Professor*

Office: S-414
Phone: (787)832-4040 Ext. 3098
Email: palomera@ece.uprm.edu
Home Page: http://ece.uprm.edu/~palomera

Research Interests:

- Analog VLSI
- Linear and Non-linear Electronic Circuits
- Fuzzy Systems

***Dr. Nestor Rodriguez**, Professor*

Office: S-408
Phone: (787)832-4040 Ext. 3463
Email: nestor@ece.uprm.edu
Home Page: http://ece.uprm.edu/njr/nestor.html

Research Interests:

- Digital VLSI Systems
- Advanced Computer Architectures

***Dr. Manuel Toledo**, Assistant Professor*

Office: T-214
Phone: (787)832-4040 Ext. 3097
Email: mtoledo@ece.uprm.edu
Home Page: http://ece.uprm.edu/~mtoledo

Research Interests:

- Computer vision applications
- Embedded systems and instrumentation
- Adaptive optics

***Dr. Ramón Vasquez**, Professor*

Office: S-224
Phone: (787)832-4040 Ext. 3824
Email: reve@ece.uprm.edu
Home Page: http://ece.uprm.edu/~reve

Research Interests:

- Artificial Vision Systems

***Dr. Miguel Vélez-Reyes**, Professor*

Office: S-404
Phone: (787)832-4040 Ext. 2888
Email: mvelez@ece.uprm.edu
Home Page: http://ece.uprm.edu/~mvelez

Research Interests:

- Modeling, simulation and control of power electronic systems.

***Dr. Krishnaswamy Venkatesan**, Professor*

Office: S-409
Phone: (787)832-4040 Ext. 3217
Email: venka@ece.uprm.edu
Home Page: http://ece.uprm.edu/~venka

Research Interests:

- Power Electronics

Facilities

The ECE Department has numerous facilities for instructional and research activities in the electronics area. These include:

- Integrated Circuit Design Laboratory (ICDL)
- Rapid Systems Prototyping Laboratory (RASP)
- Control and Instrumentation Laboratory
- Instructional Computer Aided Design Laboratory (INCADEL)
- Microprocessor Development Systems Laboratory (MDS)
- Power Electronics Laboratory
- Electric Energy Processing Systems Laboratory

These facilities are available in addition to the general purpose computing facilities available for the student body of the ECE Department, which includes several PC and Unix clusters.

Recent Work

Some examples of research projects currently under development or recently completed in the electronics area include:

- Macromodeling of Sigma-Delata Modulators in Oversampled Converters
- 3D Scalability Analysis of Floating-Point Arithmetic Hardware
- Scalable Digital Fuzzy Controller on Reconfigurable Platforms
- Software Power Reduction in Embedded Systems Applications
- Automatic Layout Techniques for Power Electronics PCBs
- Wireless Smart Sensors
- Intelligent Traffic Systems
- Biomedical Devices for the Handicap
- Design of Communication Circuits Using BiCMOS Technology
- Electro Thermal Modeling of Power Electronic Modules