Ph. D. Degree Assessments and Learning Goals in the Graduate Program in Electrical and Computer Engineering

November 2011/Revised January 2012/Updated June 2015

I. Assessments

Assessments of the Doctoral Graduate Program in Electrical and Computer Engineering are established/obtained using several objective measures that can be placed into six categories presented below.

(1) Placement of Our Doctoral Graduates

We have compiled the placement information of **187 doctoral students out of 190 doctoral students** who received their doctoral degrees from **January 2001 to May 2015.** The corresponding placement table is attached to this document (Table 1). This table shows that **we have placed 19.5% of our doctoral graduates in academic institutions**; 7.9% in national/international research laboratories; 34.2% in telecommunication industries; 13.2% in semiconductor industries; and 23.7% in computer industries. We are in constant contact with our former doctoral students working in academe and we have received very useful feedback from them on how to assess and improve our graduate program and assure that our learning goals are met. We are also in touch with some our former doctoral students who graduated before 2001 and who hold academic positions at very distinguished academic institutions such as Carnegie Mellon, University of Maryland, Texas A&M University, Pennsylvania State University, University of Waterloo (Canada), Korea University (see a partial list after Table 1 of our former doctoral graduates who hold academic positions and who have graduated before January 2001).

(2) Graduate School New Brunswick Exit Poll of Graduating Students

This information very useful for assessing the quality of our graduate program and its learning goals. Based on student recommendations we have completely revised our graduate courses to make them more modern and to cover much broader areas of electrical and computer engineering. In particular, we have revised classes in communications (including wireless communications), control systems, computer engineering, and digital signal processing areas, and introduced new courses in circuits and electronics. Moreover, we have introduced a new concentration in our graduate program, software engineering, and developed new courses in this area. We wish we could get the poll results on a yearly base or at list every other year. The other data from the poll are discussed and presented at the graduate faculty meetings and used to improve our graduate program. Due to the importance of such information, we plan to institute our own exit poll for all ECE doctoral graduates.

(3) Student Evaluations of the ECE Graduate Program Instructors

These evaluations provided to us by the Rutgers University Teaching Excellence Center are reviewed every semester, and a recurring strength of our department has been our full time graduate faculty. Occasionally, we notice problems with our part time lecturers and thanks to these surveys we are able to address them accordingly. We constantly strive to retain the best part time lecturers to teach our graduate and undergraduate classes (please note that we have a very large graduate program of ~350 students with over 250 full- time students). These part time lecturers allow us to offer a large range of graduate classes (~25) spanning both our graduate

programs (Electrical and Computer engineering). Our department consists of 33 full-time faculty members.

(4) Statistical Data about the RU Time Needed to Obtain the ECE Doctoral Degree

Using GRADPORTAL we have compiled statistical data on the time required to obtain an ECE doctoral degree, see Tables 2a and 2b. We noticed that our program from 2008/09 to 2011/12 required a very large amount of RU time for the doctoral degree completion. (7.11 years for 15 doctoral students who graduated in 2009/2010; 6.89 for 18 doctoral students who graduated in 2010/2011; and 7.36 years for 11 students who graduated in 2011/12). In light of these statistics we made an effort to reduce the required time. To that end, we reduced the number of required course credits from 48 to 36. 12 credits consist of either courses or research, which together with 36 mandatory research credits brings the total number of credits needed for the ECE doctoral degree to 72. **This change decreased the average time to receive the doctoral degree in ECE at Rutgers to 5.97 for the period of 2012/13 to 2014/15.** It should be pointed out that our graduate program has also students in solid state electronics whose research is mostly experimental, and thusly requires more time than research in other areas. Finally, we must consider that a third of our graduate student are part time students, and due to their out of school commitments tend to require more time to complete their doctoral degrees.

(5) Additional Statistical Data

We have compiled additional statistical data for assessment of our doctoral program, including data on the number of applicants along with the percentage of those applicants who are admitted (Table 3), number of the graduate students in our program (Table 4), numbers of Ph. D. and M. S. degrees awarded (Table 5), and information about student diversity (Table 6). It can be seen from Table 3 that the number of applicants dramatically increased from 394 in 2010/11 to 546 in 2011/12 and 670 in 2012/13 and that the number remained steady at 600+ over the past three years. Due to an increased number of highly qualified applicants and and acceptance rate of 41-53% over the past seven years, the number of students in the program has increased significantly from the average of 225 students for the period 2008/09-2012/13 up to 323 students in 2013/14 and 350 students in 2014/15. To successfully handle such an increase in the number of graduate students, the ECE Graduate Program will need to significantly increase the number of faculty lines and the number of instructor, part-time lecturer, and teaching assistant lines. We have introduced several new graduate courses, and a new concentration (track) in software engineering. We have also revised and simplified the Ph. D. Qualifying exam to make it more research oriented and increased the GPA core course requirement to 3.75 for doctoral students. Tables 6a and 6c indicate that the number of African American and Hispanic students is very low and that over the past seven years, it has ranged from 1% to 3%. Another alarming statistics is that the number of U.S. students has been decreasing from 28% in 2008/09 to 14% in 2013/14 to only 10% in 2014/15. We are making efforts to recruit more African American, Hispanic, and U. S. students. A bright spot in our enrollment statistics is highlighted in Table 6b that indicates that we have a high percentage of female students (ranging from 21% to 26%), which are excellent numbers for an engineering department.

(6) Academic Assessment Criteria

We measure the quality of our doctoral students by monitoring their grades and their performances on the Ph. D. Qualifying exam. Assessment of their maturity to perform independent doctoral level research is measured by internally administrated Ph. D. Proposal Presentation exam. Assessment of quality of doctoral dissertations is objectively measured by

publications in refereed journals and presentations at national and international conferences. We are very pleased with the quality of students based on these objective measures since almost all of our doctoral students publish several conference and journal papers before graduation.

II. Learning Goals and Assessments

The doctoral program in Electrical and Computer Engineering trains students at the highest level to assume leadership roles in US and world academic institutions and industries in almost all areas of electrical and computer engineering. The learning goals can be summarized in the following three categories.

Learning Goal 1: Attain marked ability, scholarship, research and leadership skills concerning important factors that contribute to the advancement of all aspect of electrical and computer engineering

Role of the program in helping students to achieve Goal 1:

- Close advising to assure that students are being prepared in a coherent and academically rigorous fashion.
- Effective monitoring of student progress:
    - Includes annual reports on research progress from both the student and the student's committee chair.
- Evaluations of teaching effectiveness of instructors in graduate courses:
    - If effectiveness is below expectations, work with instructors to improve effectiveness.
- Periodic review of curricular offerings, degree requirements, and assessment tools
    - By ECE program faculty
    - In consultation with the office of the Dean of the graduate school and/or the office of the School of Engineering Dean.

Learning Goal 2: Engage in and conduct original research

Assessment of graduate student achievement of Goal 2:

- Preparation of and defense of Ph.D. dissertation proposal.
- Assessment of quality of Ph.D. dissertation:
    - Public defense of dissertation.
    - Critical reading of dissertation by committee of graduate faculty members and a committee member from outside of our graduate program.
    - Submission and acceptance of peer-reviewed articles and conference papers.
- Achievement of students as evidenced by professional placements, selection for conference presentations, peer-reviewed publications and individual grant attainment

Role of the graduate program in helping students achieve Goal 2:

- Provide early introduction to research methods and opportunities for research
- Provide opportunities to present research and receive feedback
- Maintain adequate funding levels through the research phase
- Provide comprehensive advising and assist in the identification of mentors

Learning Goal 3: Prepare to be professionals in careers that require training at the highest levels in the areas of electrical and computer engineering.

Assessment of graduate student achievement of Goal 3:

- Review evidence of papers presented, publications and professional networking
- Evaluations of teaching effectiveness of graduate student instructors
- Collection of placement data
- Review by external advisory committees, both inside of and external to the academy.
- Survey alumni/ae

Role of the program in helping students achieve Goal 3:

- Encourage participation in professional development programs in such areas as human subjects research, library use, course management software, interview skills, presentation skills, development of cvs, use of research tools, training in the responsible conduct of research, and proposal writing.
- Host discipline-specific training when appropriate.
- Teach students how to do assessments in their future professional capacities.
- Provide flexible options for students with interdisciplinary interests related to global warming.
- Develop or enhance programs related to job and networking skills, including activity in professional societies and preparation for necessary certifications.
- Acquaint students with non-academic career opportunities.

The leadership of the Electrical and Computer Graduate Program will regularly review the structure and content of the program and the feedback received from assessments and surveys. These reviews will be used to provide the best possible education to students in order to meet the needs for highly trained individuals in the areas of electrical and computer engineering.

Institutions	Number of Students	Universities/Companies
Universities	**37 (19.5%)**	
Assistant Professors	10	University of Maine, Beijing University China Nankai University China, University of Kentucky, Arizona State University, Sonoma State University, CA Prairie View Texas A&M University IIIT New Delhi (2), Tamkang University Taiwan
Associate Professors	8	Lehigh University, Old Dominion University Stevens Inst. of Technology, University of South Carolina, Indiana University/Purdue University Xiamen University, China University of Babes Boilay Romania University of Florida, Gainsville
Professors	3	EAFIT Univ, Columbia, Prairie View Texas A&M Univ. Florida State University
Post-doctoral students	10	University of Virginia Stanford University, Cornell University, CMU (2) Columbia University, Rutgers University (2) Toyota Research Center, Tokyo Southern Illinois University, School of Medicine
Research Associates	4	Harvard University, Rutgers University (2), University of Leicester, UK
Lecturers	2	Old Dominion University, Rutgers University
National/International Research Laboratories and Institutes	**15 (7.9%)**	IBM TJ Watson Research Center (3) NASA, National Institute of Standards, Sarnoff Corp. US Army Research Labs, Navy Research Labs General Motors, GE Research Labs, Ford Motor Co. Institute of Electronic Devices China, Lawrence Livermore National Lab, Schlumberger-Doll, Scientific and Techol. Research Council of Turkey
Telecommunication Industries/Networking	**65 (34.2%)**	Lucent/Alcatel-Lucent (12), Qualcomm (13), AT&T (4) Marvel Technology (2), Telecordia (4), Hitachi (2) Broadcomm (7), UT Star Telecom, Motorola Beijing China, Robertson Technologies, iBiquity Digital Corp. Spirent Communications, Hughes Network Systems, Symbol Technologies, NEC (2), Siemens, Sprint, Juniper Networks, SONY, BBN, Thompson, Aruba Networks (2), Ortiva Network, Terrano Wireless Li Creative Technologies Inc., Hyundai, Akamai
Semiconductor and Car Industries	**25 (13.2%)**	United Silicone Carbide (4), Intermolecular Inc. (2) Charter Semiconductors, Spansion, Photonic IC Vitesse Semiconductor Inc., Traid Trek, Anadigics Marvel Semiconductors, Lattice Semiconductors Velox Semiconductor Inc., EPV Inc, Global Founders, Texas Instruments (2), Cerebrus Coorporation (2) Alpha & Omega Semiconductor CA, Applied Materials Inc. CA (2), SandDisk
Computer Industries	**45 (23.7%)**	
Computer Companies	32	Google (5), Toshiba (2), Xerox, Intel (5), ASK.com Yahoo, Microsof (2), Apple, Hewlett Packard, Inter Digital, Cernuum Corp., Computer Associates CA, Atheros, CA, Aliant, Trano Mets, Altair, Integrated Solutions, SUN Micro Systems, N. Vidia, Nokia Research, Zenefits, Internet Infrastructure Corp., MJ, Aware, MA, Mentor Graphics, OR
Financial Companies	13	Bloomberg (3), HBK Capital, Credit Swiss Boston JP Morgan , Goldman and Sachs, Barclays Capital, MSCI, Two Sigma Investment Morgan Stenley, FlexTrade Systems

Table 1: Placement of ECE January 2001 – May 2015 Doctoral Graduates (**187 out of 190 graduate**

Rutgers ECE Ph. Ds Who Graduated before January 2001 and Who Hold Faculty Positions

(the list is not complete)

1. **Aylin YENER**, Professor, **Pennsylvania State University**, RU **2000**, advisor **R. Yates**.
2. **Sennur ULUKUS**, Professor, **University of Maryland**, RU **1998**, advisor **R. Yates**.
3. **Mohammad SAQUIB**, Professor, **University of Texas at Dallas**, RU **1998**, advisor **R. Yates**.
4. **Jia-Chyi WU**, Associate Professor, National Taiwan Ocean University, RU **1998,** advisor **D. Daut**.
5. **Christi MADSEN,** Professor, **Texas A&M University**, RU **1996**, advisor **J. Zhao**.
6. **Ezhan KARASAN**, Professor **Bilkent University**, Turkey, RU **1995**. Advisor J. **Hui**.
7. **Ching Yao HUANG**, Professor and Associate Dean, **National Chiao Tung University**, Taiwan. RU **1995**. Advisor **R. Yates**.
8. **Myo Taeg LIM**, Professor, **Korea University**, RU **1994**, advisor **N. Puri/Gajic**.
9. **Steven L. GAY** (**GRANT**), Professor, **University of Missouri Rolla**, RU **1994**, advisor **R. Mammone**.
10. **Khaled ASSALEH**, Professor and Graduate Director, **American University of Sharjah**, RU **1993**, advisor **R. Mammone**.
11. **David R. KAELI**, Professor, **Northeastern University**, RU **1992**, advisor **H. Freeman**.
12. **Lawrence A. HORNAK**, Professor & NSF Program Director, **West Virginia University**, RU **1991**, advisor **B. Lalevic**.
13. **John DOHERTY**, Professor, **Pennsylvania State University**, RU **1990**, advisor **R. Mammone**.
14. **Ozan TONGUZ**, Professor, **Carnegie Mellon University**, RU **1990**, advisor **D. Daut**.
15. ***Dongming ZHAO***, Professor, University of Michigan Dearborn. Oct. **1990**, advisor **D. Daut**.
16. **Xuemin SHEN**, Professor, **University of Waterloo**, Canada, RU **1990**, advisor **Z. Gajic**.
17. **Byung Moo MOON**, Professor, **Korea University**, RU **1990**, advisor **B. Lalevic**.
18. **Weng Poo KANG**, Professor, **Vanderbilt University**, RU **1988**, advisor **B. Lalevic**.
19. **Steven CHIN,** Professor & Associate Dean, **Rowan University**, RU **1987**, advisor **D. Daut**.

	Ph. D. 2008/09	Ph. D. 2009/10	**Ph.D. 2010/11**
October	4	7	**7**
January	4	2	**7**
May	5	6	**4**
Total	**13**	**15**	**18**
RU time to ECE PhD Average		**99.5 years/14 = 7.11 years**	**124 years/18 = 6.89 years**

Table 2a: Number of Doctoral Degrees Awarded and RU Time to the Rutgers University ECE PhD (Full-Time and Part-Time Students combined) for the period 2008/09-2010/10

School Year	Number of Students	RU Years 1 year = 2 semesters
2011/12	**11**	**7.36**
2012/13	**9**	**6.05**
2013/14	**14**	**6.00**
2014/15	**9**	**5.83**
Average 2011/12-2014/15	**10.75**	**6.32**
Average 2012/13-2014/15	**10.67**	**5.97**

Table 2b: Number of Doctoral Degrees Awarded and RU Time to the Rutgers University ECE PhD (Full-Time and Part-Time Students combined) for the period 2011/12-2014/15

ADMISSIONS	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	**2014/2015**
Applicants	367	427	394	546	670	651	**586 + 32***
Accepted Acceptance Rate	190 (51.8%)	201 (47.1%)	186 (47.2%)	258 (47.3%)	355 (53.0%)	276 (42.4%)	**218 + 22*** **(41.07%)**
Admitted/Coming % of admitted	64 33.7%	74 36.8%	48 25.8%	91 35.3%	146 41.1%	110 39.9%	
NONDEGREE Admitted	7	3	3	7	2	2	**2**

- 22 new students from China UESTC 3+2 Program out of 32 who applied

Table 3: Admission Data

	2008/09	**2009/10**	**2010/11**	**2011/12**
Total	**235**	**249**	**255**	**210**
Ph D postq.	**40**	**36**	**31**	**26**
Ph D preq.	**46**	**49**	**55**	**56**
Masters	145	159	165	125
Nondegree	4	5	4	3

	2012/13	**2013/14**	**2014/15**	
Total	**230**	**323**	**350**	
PhD postq.	**34**	**29**	**26**	
PhD preq.	**59**	**72**	**68**	
Masters	134	220	255	
Nondegree	3	2	1	

Table 4: Number of Students in the ECE Graduate Program

	Ph. D. 2008/09	Ph. D. 2009/10	Ph.D. 2010/11	Ph. D. 2011/12	Ph. D. 2012/13	Ph.D. 2013/14	**Ph. D. 2014/15**
Oct.	4	7	7	5	4	8	**5**
Jan.	4	2	7	2	1	3	**3**
May	5	6	4	4	4	3	**1**
Total	**13**	**15**	**18**	**11**	**9**	**14**	**9**

Table 5a: Number of Doctoral Degrees Awarded

	M. S. 2008/09	M.S. 2009/10	M.S. 2010/11	M.S. 2011/12	M.S. 2012/13	M.S. 2013/14	**M.S. 2014/15**
Oct.	20	16 (9)	24 (18)	20 (10)	14 (6)	7 (4)	**11 (4)**
Jan.	9	6 (1)	18 (6)	16 (4)	10 (1)	19 (2)	**14 (3)**
May	8	18 (8)	34 (12)	31 (2)	21 (7)	40 (8)	**57 (7)**
Total 3+2 M.S. theses	**37 (15) - (15)**	**40 (18) - (18)**	**76 (36) - (36)**	**67** (16) **- (16)**	**45 (14) - (14)**	**66 (14) - (14)**	**82** (14) **4 (14)**

** all time high

Table 5b: Number of M. S. Degrees Awarded

School Year	Fall	Spring
2014/15	3/348 (0.9%)	3/343 (0.9%)
2013/14	4/323 (1.2%)	4/306 (1.3%)
2012/13	7/230 (3.0%)	6/226 (2.7%)
2011/12	6/214 (2.8%)	6/203 (3.0%)
2010/11	4/257 (1.6%)	4/223 (1.8%)
2009/10	4/252 (1.6%)	4/241 (1.7%)
2008/09	3/225 (1.3%)	3/214 (1.4%)

Table 6a: African American and Hispanic Students/Number of Students

School Year	Fall	Spring
2014/15	84/348 (24.1%)	87/343 (25.6%)
2013/14	68/323 (21.1%)	63/306 (20.6%)
2012/13	49/230 (21.3%)	48/226 (21.2%)
2011/12	53/214 (24.8%)	52/203 (25.6%)
2010/11	57/257 (22.2%)	51/223 (22.9%)
2009/10	52/252 (20.6%)	46/241 (19.1%)
2008/09	50/225 (22.2%)	49/214 (22.9%)

Table 6b: Female Students/Number of Students

School Year	Fall	Spring
2014/15	36/348 (10.3%)	22/343(14.7%)
2013/14	45/323 (13.9%)	45/306 (14.7%)
2012/13	49/230 (21.0%)	45/226 (19.1%)
2011/12	57/214 (26.6%)	54/203 (26.5%)
2010/11	76/257 (29.6%)	57/223 (25.6%)
2009/10	66/252 (26.2%)	58/241 (24.1%)
2008/09	64/225 (28.4%)	57/214 (26.6%)

Table 6c: US Students/Total Number of Students