Graduate Program Review  
Department of Electrical & Computer Engineering  

Introduction  

The 6-year review for graduate programs in the Department of Electrical & Computer Engineering (hereafter, simply "ECE") was conducted during spring of 2011. An internal Texas Tech committee consisting of three faculty members outside ECE was constituted. The members are:  

- Philip Gipson, Department of Natural Resources Management  
- Ram Iyer, Department of Mathematics and Statistics  
- Sanjaya Senadheera, Department of Civil & Environmental Engineering  

In addition, an outside reviewer participated:  

- Dr. Khalid Sayood, Henson Professor of Engineering, Department of Electrical Engineering, University of Nebraska-Lincoln  

Dr. Sayood and the internal committee met with ECE faculty, graduate students, and support staff on Friday, April 1, 2011.  

All members of the Review Committee received copies of the ECE graduate program self-review. The committee also contacted research universities in Texas, including the two flagship universities and other peer universities competing for support from the National Research University Fund, to supplement the information provided by the ECE self review. This report contains our conclusions based on materials provided by ECE and interviews during the one-day review process, and on the report of the external reviewer.  

Overview of Report and Recommendations  

ECE is a critical component of the Whitacre College of Engineering (WCOE) at Texas Tech University. It is one of the largest departments in the WCOE with 25 tenure track faculty and about 167 graduate students. The faculty and graduate students are engaged in diverse and well-funded research activities. The Centers for Pulsed Power Electronics and Nanophotonics are recognized internationally as outstanding and other prominent ECE research groups have achieved widespread recognition in their respective discipline areas. The department has also been recognized for quality teaching and service to the scientific community.  

ECE research and teaching programs support the goal of Texas Tech University to achieve Tier-One status. It has consistently attracted a high-level of national level research funds. Several of its research programs are led and staffed by outstanding faculty who can continue to make this an outstanding department in the future. However, our committee has identified areas that should be strengthened to assure the continued top rankings that ECE has achieved. One such area is to provide greater diversity in Ph.D. student training, especially for students that may seek careers in academia and public service positions. One of our recommendations is for the university to
provide resources to help ECE implement suggested changes without compromising their outstanding programs that are already performing at exceptional levels.

The following grading scale was used to evaluate each of the five stated dimensions of performance in delivering graduate education:

A = Excellent  
B = Acceptable  
C = Acceptable with Concern  
D = Deficient  
F = Unacceptable

Grades assigned by our committee are presented in the following table. Analysis of our assigned grades and recommendations is provided later in this report.

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**Recommendations:**

The Review Committee makes the following recommendations:

1. *Program Overview and Vision.* A new strategic plan is needed to articulate the current goals of ECE. The plan should emphasize achieving Tier-One status for the university, benefitting from opportunities under the Responsibility Center Management (RCM) System, and developing research programs in cutting-edge research and in education.

A re-organization of the administration of the graduate program will be very beneficial. An additional full-time staff position should be created to help separate supervision of graduate studies from routine graduate advising. A Director of Graduate Studies, who is a member of the faculty, should be entrusted with growing the graduate program, recommending program updates, and provide direction to a Graduate Advisor, who is a member of the staff. The Graduate Advisor should counsel students about the availability of classes and other curricular issues.
2. **Faculty Productivity.** ECE should move toward a teaching load of three courses per academic year per tenure-track faculty member. Additional funds for this purpose will help the University achieve Tier-One status.

ECE should offer opportunities for interested Ph.D. students to learn more about teaching and to gain teaching experience that would allow them to teach an undergraduate course. Experienced faculty members could be assigned to mentor Ph.D. students when they teach. This suggestion will increase faculty productivity as they will have additional time to create special topics courses for graduate students.

3. **Quality and Quantity of Graduate Students and Graduates.** Revise the doctoral student admission requirements and expectations to be on par with other ECE departments in major research universities. There is a need for a comprehensive examination to replace the currently used Fundamentals of Engineering (FE) exam that will allow ECE to more effectively identify and recruit exceptional students for the doctoral program.

The department website should be updated to provide easy access to key information for both prospective and current students. A graduate student manual that clearly outlines academic expectations and key milestones required to complete the degrees should be developed.

4. **Curriculum and Programs of Study.** The department should evaluate the extent to which it cross-lists undergraduate and graduate courses and expand the list of graduate-only courses.

In order to expand the list of graduate-only classes, ECE should allow students to take more courses in other departments that closely relate to the subject matter. For example, the departments of Mechanical Engineering and Mathematics and Statistics co-offer courses on control theory that could be a good fit for a doctoral student degree plan.

5. **Facilities and Resources.** Assignment of office space for graduate students in laboratories should be reviewed to prevent overcrowding and ensure compliance with University health and safety requirements and to prevent overcrowding.

ECE is in need of additional technical staff to maintain its computer systems which are integral to effective management and operation of the Department.

**Program Overview and Vision**

ECE has taken important strategic initiatives to introduce new research programs and to hire outstanding faculty in areas of cutting-edge research such as Nanophotonics and Bioengineering. The department has also strengthened existing programs including Pulsed Power, by recruiting new faculty who have been highly successful in obtaining major grants that advance Texas Tech’s pursuit of Tier-One status.

The review committee was impressed with some of the progress in the department. Connections with industry and other universities have been developed and nurtured, and more such
collaborations are being planned. This has benefited the students. However, we believe there is a problem with strategic planning. The strategic plan of the department does not appear to have been updated for the past seven or eight years. The latest strategic plan on the ECE website lists goals that the department seems to have consistently met since 2004. An update of the strategic plan is needed to reflect the department’s growth and renew its focus on helping the university achieve Tier-One status, benefit from opportunities under the Responsibility Center Management (RCM) system, and developing research programs in cutting-edge research and in teaching.

The committee felt that a reorganization of the administration of the graduate program will benefit the students and the department. Instead of one faculty member serving as both the Director of Graduate Studies and as the Graduate Advisor, it will be beneficial to have two positions: a faculty member serving as the Director of Graduate Studies, who will be responsible for growing the program and establishing collaborations, and a staff Graduate Advisor who will be available for day to day advising of the students. Such an organizational structure can be found in our university in some other departments (Dept. of Mathematics and Statistics for example), and at the ECE departments of Texas A & M University and University of Texas at Austin.

Two other important points for strengthening the graduate program are (i) have uniform and consistent high standards for admitting students into the graduate program, including the administration of a preliminary exam to admit students into the doctoral program, and (ii) develop a graduate student manual which communicates the different programs and program requirements to the students.

**Faculty Productivity**

ECE has some of the most productive faculty members at Texas Tech, including two Paul Whitfield Horn professors, four endowed chairs and one endowed professor. There are 11 research centers in the department where graduate students conduct research for their M.S. theses and Ph.D. dissertations. The Center for Pulsed Power and Power Electronics and the Center for Nanophotonics are recognized internationally for their quality research. Several others of the 11 centers are also widely recognized for their quality research and graduate training programs. It should also be noted that several individual faculty members are making commendable contributions to the department and the university through their research, teaching and service.

External funding to the department for the last seven years has averaged almost $6,000,000 per year. Funding obtained by ECE faculty during the last six years has increased from $3,408,254 in the 2004/05 academic year to $11,286,321 in the 2009/10 academic year. Forty-nine awards were reported for the current year totaling $12,089,112 for an average of $246,716 per award. The average amount of funding obtained per faculty member, for 24 faculty listed, was $503,713.

There has been considerable turnover of faculty during the last six years, with nine of the 25 tenure-track faculty hired since 2004. The department and the university identified and recruited several key senior faculty members with funding from the state of Texas and a special university initiative.
All of the faculty are members of the graduate faculty and typically teach two classes per semester. This is a demanding teaching load for faculty members who also conduct research, advise graduate students and provide professional service. An effort is being made to reduce the teaching load to three courses per academic year (spring and fall semesters). Our committee supports this proposed reduction in courses taught by each faculty member and recommends the university help provide funds to hire additional teachers.

The ECE self-review indicated that the department carries one of the highest faculty teaching loads in the WCOE. The reported faculty workload for ECE ranged from 10.59 to 13.00 for the period 2004-2009, while the numbers reported for the WCOE during the same period ranged from 14.35 to 15.79. Our committee noted that the ECE faculty carry high research loads and this, coupled with the high teaching loads reported in the program self assessment, appears to be inconsistent with workload numbers reported. The department should address this inconsistency in the workload assessments.

In ECE, only faculty members teach courses while graduate students funded through Teaching Assistantships (TAs) help to teach laboratories, grade exams and homework, and help students that are having difficulty with assignments. Our committee contacted ECE departments at the University of Texas at Austin, Texas A&M University in College Station and the University of Houston to determine how their TAs are utilized. The TAs at these universities perform tasks similar to those in TTU ECE -- TAs do not teach classes. However, there are major differences between the relatively high numbers of ECE faculty members at these universities and the relatively low number at TTU. The larger number of tenured/tenure-track faculty in these schools enable them to have a low number of cross-listed undergraduate/graduate (UG/G) courses. In order for ECE at TTU to (i) decrease the number of cross-listed courses, (ii) provide Ph.D. students an opportunity to gain teaching experience, and (iii) to allow the faculty to develop graduate-only courses in their areas of specialty, the committee recommends allowing qualified Ph.D. students to teach some undergraduate courses.

As noted later in this report, a number of Ph.D. students in ECE indicated to the Review Committee that they would like to get training to help them become college teachers. In particular, they wished to get some experience in teaching an undergraduate course. This committee believes that ECE should offer opportunities for their graduate students to gain teaching experience to make them more marketable for faculty positions and free-up time for faculty members to develop new graduate courses. Another possibility to increase graduate course offerings would be to employ more post-doctorial scientists and Visiting Assistant Professors who would work mostly on research, but also help develop and teach new advanced courses exclusively for graduate students.

Qualified Ph.D. students could be assigned to teach an undergraduate course and an experienced faculty member could mentor these students when they teach. This will free-up time for faculty members to conduct research and develop specialty courses. Possibly a faculty member’s teaching load could be reduced to two or three courses per year when they serve as a mentor to two Ph.D. students that teach undergraduate courses. According to the current graduate advisor
of the ECE department at Texas A & M University (TAMU), they used this approach to expand graduate course offerings before they increased their faculty numbers through new hires.

The review committee was not provided data needed to evaluate faculty productivity in terms of numbers and quality of peer reviewed publications or numbers of M.S. and Ph.D. students advised. Adequate data were presented in resumes of 22 of the 24 current faculty members to examine when their most significant research was conducted. Of those faculty members listing publications of their most significant research, 10 (45 percent) listed the date of their most recent significant publication as 2006 or earlier. This suggests that even though faculty members are generally successful in obtaining research grants, a significant part of the faculty may not be working in areas that they believe will result in the greatest contributions to Electrical and Computer Engineering. The faculty of ECE should seek support for scholarly research to advance engineering and to provide the best possible training for graduate students.

Quality and Quantity of Graduate Students and Graduates:
The Graduate Student Experience

Graduate students in ECE seem in general to be content and take pride in the quality of their department and the reputation of the faculty. Several ECE research programs have good reputations at national and international levels. Almost all graduates in the department appear to be employed by industry upon graduation, even though there is interest among students in pursuing academic careers. Many Ph.D. graduates, particularly in the Pulsed-Power area, go to work for national research laboratories and the department seems to maintain good relationships with them upon graduation.

ECE appears to be well-positioned to build on its strong relationship with research laboratories and high technology industry groups to enhance its stature as a premier doctoral program in the country. Based on the latest (2009) data provided in the department self-assessment report, there were 167 graduate students enrolled in the graduate program. This was comprised of 121 M.S. and 46 Ph.D. students giving a Ph.D. student percentage of approximately 28 percent of the total number of graduate students. The enrolled MS and total graduate student numbers have steadily increased from a low of 78 MS and 105 total students, respectively, in 2006. The number of Ph.D. students increased significantly from 30 in 2008 to 46 in 2009.

The strategic plan of the department does not appear to have been updated for the past seven or eight years. The latest strategic plan on the ECE website lists goals that the department seemed to have met as far back as 2004. This includes the number of enrolled graduate students, the number of Ph.D. students per faculty member and the GRE quantitative score for admitted students. The current ratio of Ph.D. students per faculty member is just below two.

Student Admissions and Recruitment: ECE receives a large number of applications from prospective graduate students each year. The review committee was advised that screening of the applicants is done in two stages. During Stage 1, each applicant’s GRE quantitative score, GPA and the reputation of their undergraduate institution are considered. Stage 2 screening is based on the student’s statement of purpose and letters of recommendation. There is also a significant amount of internal recruiting from the undergraduate student pool in the department.
The process of selecting students for graduate programs from the Texas Tech ECE undergraduate pool was not clear, especially for the five–year program that enables students to complete both an undergraduate degree and a MS degree in five years.

The review committee concluded that more information is needed in order to fully understand and evaluate the recruiting practices for students entering M.S. and Ph.D. programs, particularly those students who were recruited directly from the ECE undergraduate program compared to students applying from other institutions. There is a perception that some students with relatively low GPAs from Texas Tech may be admitted into graduate programs in ECE while students applying from other institutions are being held to higher standards in order to be accepted. The committee believes that all graduate student applicants should be held to a high and consistent standard.

ECE uses the Fundamentals of Engineering (FE) exam as the preliminary exam for Ph.D. students. The committee agrees that having an FE requirement for students is worthwhile, particularly considering the number of students who are recruited to the graduate program with non-engineering bachelor’s degrees. However, using an exam that tests the basic undergraduate knowledge to screen potential Ph.D. students is questionable and could damage the reputation of the department as a respected doctorate granting program. Peer institutions and other similar institutions in the state place emphasis on a departmental preliminary examination to ensure that only students with outstanding scholarly potential are accepted to the doctoral program.

ECE attracts applications from a large number of students from other countries. Having a strong internet presence is critical to get the attention of the best students. An update of the graduate student portion of the website could benefit the Department at a minimal cost. Many graduate students indicated to the review committee that it is difficult to obtain information on the website that is useful to them. They also suggested that a graduate student manual with necessary information to ensure timely progress in their studies and in their employment as TAs/RAs is needed.

**Funding for students:** ECE appears to have access to substantial monetary resources to support its graduate students. Based on the information collected during the site visit by the committee, more than 80 percent of the graduate students receive funding from the department. The department could have even more success in recruiting outstanding doctoral students by offering higher stipends, particularly in the present environment where stipends have to be competitive to attract students who can earn good money working in industry with a master’s or bachelor’s degree. The department has access to a $4 million endowment for student support, some of which is dedicated to undergraduate students. There is also a successful industry-sponsored program that brings in about $250,000 per year that supports approximately 20 students. Students supported by this program get internship opportunities that pay approximately a beginning engineer’s salary. About 80 percent of the students who are supported by this program go to work for the sponsoring company when they graduate. The department has a need for, and is looking at other similar funding opportunities. We noted that the current workload of the current Graduate Advisor Dr. Richard Gale with the support of only a part-time staff member makes it difficult to pursue additional outside funding sources for graduate students. Hiring a full-time staff Graduate Advisor would provide more time for the faculty Director of Graduate
Studies to pursue additional funding and grow the graduate program, and also improve the quality of student advisement.

There appears to be some concern among graduate students about the high degree of variability in support for graduate students. The department has access to about $50,000 in course fee funds annually that supports scholarships of approximately $1,000 to about 50 students who are admitted, but otherwise unfunded. Recipients of these scholarships are eligible for in-state tuition. The monthly stipends paid to research assistants are typically around $1500, which seems to be on par with other departments in the WCOE, while research assistants in the Pulsed Power group are paid between $2100 and $2600 per month.

The number of TA positions available within the department and the tasks assigned to TAs do not appear attractive to outstanding prospective students, particularly when compared to other institutions that are similar in size or larger than the Texas Tech program. Additional TA positions could allow more outstanding Ph.D. students to join the program and explore research opportunities and provide teaching experience to those who aspire to be academics in the future.

The committee was pleased to learn that the department has several collaborative ventures with other universities both within the United States and overseas with graduate students studying in Denmark, France, Spain, and Mexico. Students from Mexico are also studying in the TTU ECE Department through an exchange program called International Association for the Exchange of Students for Technical Experience. We also noted that some students participate in technical competitions and some are exposed to intellectual property applications and regulations.

Curriculum and Programs of Study

ECE offers a Master of Science (M.S.) degree with thesis or non-thesis options in Electrical Engineering and a M.S. in the Program for Semiconductor Product Engineering (M.S. PSPE) degree program which is sponsored by Texas Instruments (TI). The M.S degree with thesis option requires 24 semester hours of graduate coursework, of which 18 semester hours is required to be in Electrical Engineering (EE). Of the 18 semester hours in EE, at most three hours can be an individual studies course. The non-thesis M.S. option requires 36 semester hours of graduate coursework, of which 27 semester hours is required to be in EE. Of the 27 semester hours in EE, at most six hours may be individual study. Students in the MS PSPE program take courses at TTU during the first two semesters, complete an internship during the summer terms, and complete an internship during the next long semester at TI offices in Tucson or Dallas.

A Doctor of Philosophy degree is offered in EE. The Ph.D. degree requires 60 hours of graduate coursework beyond the Bachelors degree exclusive of the dissertation. The department requires 45 of the 60 hours to be graduate coursework in EE. No more than 18 hours of the 60 may be individual study courses.

The FE exam serves as the preliminary or comprehensive exam and only those students who can find a Ph.D. advisor are allowed into the Ph.D. program. Once they are in the Ph.D. program the students have to defend their dissertation proposal in order to become candidates. Ph.D. students
are encouraged to publish at least one article a year and usually have two publications by the time they graduate. There is a need for a departmental preliminary exam along the lines of other research universities in Texas to maintain a consistent standard for admission into the Ph.D. program.

No courses are required for the graduate students except for EE 5371 for M.S. students. M.S. students are required to take at least six hours in EE that are outside their area of specialization. There are nine areas of specialization in the ECE graduate program:

1. Instrumentation, control and network analysis
2. Digital/computer hardware/software
3. Antennas and microwaves
4. Signal processing and communications
5. Analog electronics and devices
6. Power, power electronics and pulsed power
7. Image processing and pattern recognition
8. Semiconductor product engineering and MEMS
9. Optics and Lasers

Typically, graduate students take 10 credit hours during each long semester of which one credit hour is a graduate seminar class. During each seminar, three students give a 15 minute presentation on their research. It seems that during some semesters, the students in the Pulsed Power specialty group have their own separate seminar class. According to the self-study report, students who come from other disciplines such as Physics are required to take EE 5363 (Linear Systems Analysis and Design) and EE 5301 (General Electrical Engineering). Recently, the department has started offering distance learning courses - two courses were taught in each of Spring 2010 and Spring 2011 semesters.

Since the 2004-2005 academic year, three courses (EE 5301, EE 5328, EE 5363) have been dropped from the catalog, while five new courses (EE 5350, EE 5351, EE 5352, EE 5355, EE 5356) have been added.

Our examination of courses offered in the department shows that all senior level undergraduate courses, except for individual study (ECE 4331), topics (ECE 4332), and project lab (ECE 4333, 4334), have a corresponding 5000 level graduate course listed in the catalog. Additionally, except for three out of the 24 senior level courses, the descriptions in the university catalog for the corresponding undergraduate/graduate courses are identical and class times for the 4000 level courses were identical to the 5000 level courses for the last three semesters and is identical for the upcoming Fall 2011 semester. Below is a table that shows the senior level and graduate level courses offered for the last three long semesters (Spring 2010, Fall 2010, Spring 2011) and the forthcoming Fall 2011 semester( individual study courses and project lab courses are not included).
Table 1. Number of 4000- and 5000-level courses offered

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<th>Spring 2010</th>
<th>Fall 2010</th>
<th>Spring 2011</th>
<th>Fall 2011</th>
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<tr>
<td>4000+ UG courses</td>
<td>14</td>
<td>13</td>
<td>11</td>
<td>15</td>
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<tr>
<td>5000+ G courses</td>
<td>22</td>
<td>22</td>
<td>18</td>
<td>24</td>
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<tr>
<td>Cross-listed courses</td>
<td>14</td>
<td>13</td>
<td>11</td>
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Approximately 66 percent of courses offered by the Texas Tech ECE each semester at the graduate level are cross-listed with senior level undergraduate courses. For comparison, the ECE department at Texas A&M University offered 31 graduate courses and 30 undergraduate courses during the spring 2011 semester and only four of the courses were cross-listed (13 percent). The proportion of cross-listed courses by the ECE department at the University of Houston is between 10 and 15 percent.

The review committee has identified several concerns about cross-listing undergraduate and graduate level courses that should be addressed:

1. Is the same faculty member teaching both the 5000 level course and the 4000 level equivalent, and if so, is the faculty member given credit for teaching two courses that may be perceived as effectively only one course?

2. Since a large percentage of graduate students (between 15 percent and 20 percent in our estimate) are in the 150 hour combined B.S.-M.S. program, the cross-listing of all senior level undergraduate courses with graduate courses raises the problem of providing these students with meaningful courses. The problem is exacerbated in the Pulsed Power group where nearly 100 percent of the students are from the undergraduate program at TTU. One student in our review indicated that they had taken the same course at the undergraduate and graduate levels, but this practice did not seem to be the norm.

3. According to the faculty that we interviewed, graduate students in cross-listed courses are given different assignments and exams than those given to undergraduates. However, students in the 150 hour program take graduate level courses in lieu of their senior level courses. Therefore, they have the same background in these courses when compared with their fellow students who are not in the 150 hour program.

It is clear that the large number of cross-listed courses is hurting the graduate program. The State of Texas Higher Education Coordinating Board requirements for Bachelor’s degrees are the same for universities across Texas, and the number of undergraduate courses taught per semester in the major universities in Texas are roughly the same. For the Spring 2011 semester, the number of UG courses taught by TAMU was roughly the same as Texas Tech (30 versus 28 respectively). Both TAMU and TTU use only faculty to teach the undergraduate courses that are not lab-oriented. This implies that approximately the same number of faculty at TAMU and TTU will be needed to teach the UG courses. As TAMU has roughly three times the number of faculty
that TTU has (25 versus 73), it is clear that TAMU has the ability to teach a lot more graduate-only courses than TTU.

Perhaps, TTU is following the TAMU and UTA model closely with regard to teaching UG courses, which has contributed to the problem. According to the TAMU graduate advisor, TAMU used to employ Ph.D. candidates to teach lower level ECE classes until they increased their graduate faculty through hires. Since hiring faculty at TTU in the current situation is very difficult, we recommend the use of Ph.D. candidates or instructors to teach lower level EE courses to free-up faculty to teach graduate-only courses. Another possibility is to use Visiting Assistant Professors to teach advanced undergraduate and graduate courses. The long term solution that will take Texas Tech ECE closer to the level of ECE departments in Tier-One universities in Texas is the hiring of more faculty.

If it is not possible in the immediate future to offer mostly graduate-only courses, then another option is to allow graduate students to take more courses outside ECE. For example, the ME department and the Math and Statistics department co-offer courses on control theory and it would be beneficial to EE students to take those courses.

The review committee’s concern about the lack of teaching opportunities and courses that address academic career issues for Ph.D. students has been noted above, but we also find that the present lack of emphasis on training for academic careers is in conflict with the stated policy of ECE. In section II of the report prepared by ECE, we find the statement: “The principal goal of the Ph.D. is to train research oriented electrical engineers for university teaching and research, governmental, and industrial employment.” The lack of significant advanced coursework for Ph.D. students beyond the Bachelor’s degree and the lack of teaching opportunities affect their subsequent employment. Except for two alumni that the faculty could recall, all other Ph.D. graduates have taken jobs in industry and government laboratories. The recent lack of placement of PhD graduates in academic positions is surprising as several alumni from the early 1990’s and before have prominent academic positions. For example, the University of Missouri has several Ph.D. and MS graduates from TTU on their faculty – all from the Pulsed Power area.

Graduate students expressed concerns about the organization of the graduate seminar. There have been two sections each semester with a disproportionate number of students in each. During some semesters, the second seminar section was labeled PSPE. The actual enrollment for the last four semesters is shown in the following table.

| Table 2. Enrolment in the Graduate Seminar Class |
|-------------------------------|-------------|-------------|-------------|-------------|
|                               | Fall 2009   | Spring 2010 | Fall 2010   | Spring 2011 |
| EE 5120 001                  | 124         | 141         | 132         | 128         |
| EE 5120 002                  | 20          | 21          | 18          | 18          |

During the fall semesters, the class duration of the second section was 80 minutes while the first section was for 50 minutes. In the spring semesters, both sections were scheduled for 50 minutes. According to faculty interviewed, three students typically presented a talk for 15 minutes in each seminar. But, since each seminar was only scheduled once a week, and a semester has 14 weeks,
only 42 students had an opportunity to make a presentation in section 1. The majority of students enrolled in section 1 could not make a presentation for the entire year, while in section 2, each student could present twice a semester.

Several students expressed concern that some students who did poorly at the FE exam were given an alternate (“mock FE”) exam. Most students were not aware of this alternate exam, and when they became aware of it during our meeting, they felt that this was unfair. We recommend a uniform policy for all the students. Our committee believes that graduating weak students from ECE will do more harm to the carefully built image of the department than perceived benefits that they might bring by boosting graduation numbers.

Facilities and Resources

The Department is housed in a three-story building with a 40,000-square-foot, two-story annex, which contains specialized laboratories for radio science, optical sciences, plasmas, pulsed power and power semiconductors. These laboratories are equipped with all conventionally required and considerable state-of-the-art apparatus.

The number of enrolled graduate students grew by 33% in the period 2004-2009 (126 in 2004 versus 167 in 2009). This has led to a strain on office space for graduate students. All of the laboratories visited by the Review Committee doubled as office space for the students. In some of the labs, floor space was almost entirely occupied by laboratory equipment with cubicles for graduate students squeezed into corners and small areas between equipment. The Pulsed-Power Laboratory in particular, seemed to have reached its limit in terms of space for new equipment and students. The students were using any unutilized space for their cubicles. In some instances, the desks for students were adjacent to high voltage equipment and some students shared cubicles. The close proximity of the cubicles to the laboratory equipment is of great concern. It seemed to the review committee that it will be very difficult to grow the graduate program further – in particular, in the pulsed-power area, unless additional office space is made available to the students.

ECE course schedules show that courses for freshmen (ECE1304) through the most basic junior course (ECE 3301) are typically large - between 30 and 70 students, mostly the latter. From ECE 3302 onwards, junior level classes have between 30 and 45 students. All senior level courses - which are typically paired with graduate courses – have enrollment between 15 and 30 students. The graduate-only courses can have between 5 and 30 students with lower numbers being the norm. The capacity of classrooms in ECE is 50, which implies that most of the lower level classes have to be taught elsewhere. The ECE self-review indicated that the department had four small classrooms and two large lecture halls with the large lecture halls taken over by the university for other purposes than for teaching ECE classes. The graduate seminar with typical enrollment of between 125 and 140 meets in the ECE auditorium which may have a capacity to seat 150 people.

ECE is operating at its peak efficiency and in some specific cases such as the pulsed-power laboratory is over the peak, with regard to utilization of space. Even a small increase in the
number of graduate students can only lead to over-crowding of already crowded laboratories which could put students at safety risk – it simply is not safe to have numerous students working and studying in rooms next to high voltage electrical lines and laser research equipment.

**Computing and Technical Resources:** ECE has one computer laboratory and two project laboratories. The technical staff includes one staff member and an undergraduate assistant to manage all the computers and servers in the department. The two project laboratories are managed by a Ph.D. student. The staff member also serves as the webmaster. In the absence of the staff member in charge of IT, the Review Committee was able to speak with his student assistant. This undergraduate student assistant manages the ECE computers in the Nanotech Center and in the ECE building. This student is employed between 12 and 15 hours each week. The UG assistant who was interviewed was unaware of how the Pulsed-power laboratory computers are being maintained. The UG assistant mentioned that theft of computer equipment, printing paper, and other material like microcontroller/FPGA boards is a concern. The UG assistant was also unaware of an inventory of the computing items in the department.

ECE uses several different types of operating systems – the server uses Linux, other computers use Apple and Windows 2000 through Windows 7. The Windows systems are maintained individually and not through the use of ghosting programs unless end-of-the-semester maintenance is being performed on laboratory computers. Replacement of old computers is done every two to three years which is adequate.

ECE is in need of additional technical staff to maintain its existing computers. There is a need for one more staff person for such a large department since computing is the backbone of almost everything that goes on in the department. In addition, the use of ghosting programs to keep all the Windows computers up-to-date probably should be implemented by the department.

**Support personnel for the graduate program:** The current faculty Graduate Advisor Dr. Richard Gale has a staff assistant who does the job of filing paperwork, assisting in preparing the admissions folders, and other clerical tasks.

For a department with 167 graduate students – among them, a number of non-thesis students – it is simply not practical for one faculty member to be asked to advise all the students, teach classes, run a productive research program, and grow the graduate program. There is a pressing need to separate the Director of Graduate Studies and the Graduate Advisor duties – as is done at TAMU, UT and UH. The Graduate Advisor could be a staff person whose primary job will be to deal with the graduate students and advise them on curricular issues, while the Director of Graduate Studies will be a member of the faculty whose job it is to grow the graduate program. It will be important to reduce the teaching load of the faculty member performing this important duty.
Texas Tech Electrical Engineering Graduate Program Review

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The Department of Electrical and Computer Engineering at Texas Tech University has a growing and dynamic graduate program. In the last five years the number of graduate students has grown from 126 to 167. The number of doctoral students has increased from 35 to 46 (after a dip to 27 doctoral students in 2007). Unlike their peer institutions the graduate enrollment at Texas Tech is biased towards the MS program. The ratio of PhD students to MS students is approximately 1:3 at TTU while it is 3:2 for ISU and 2:1 for UNL. The graduate program in the department is administered by the Chair of the Graduate Studies Committee with support from one staff person and an admissions committee of seven faculty members.

The students can work with professors in several centers including

1. Center for Pulsed Power and Power Electronics (7 ECE faculty members)
2. Nano Tech Center (4 ECE faculty members)
3. Computer Vision and Image Analysis Laboratory (4 ECE faculty members)
4. Applied Vision Laboratory (1 ECE faculty member)
5. Wireless Communication Systems Laboratory (1 ECE faculty member)
6. Advanced Vehicular Engineering Laboratory (1 ECE faculty member)
7. Neuroimaging, Cognition, and Engineering Laboratory (1 ECE faculty member)
8. Microwave and Antenna Laboratory (2 ECE faculty members)
9. Program for Semiconductor Product Engineering (1 ECE faculty member)
10. Advanced Electronic Systems Engineering Program (1 ECE faculty member)
11. Nanophotonics (2 ECE faculty members)

\(^1\)numbers based on the department website
Of these groups, the Center for Pulsed Power and Power Electronics is by far the largest. Because of its size this center has a significant influence on many aspects, both obvious and subtle, of the graduate program. In light of its significance we will review its effect on the doctoral program in a separate section. As is the case for most US institutions the majority of doctoral students are foreign nationals. However, because the funding sponsors of the Center for Pulsed Power and Power Electronics require that students working on Center projects be US citizens, the overall population is less heavily biased to international students than is the case in their peer departments. In the overall graduate population the number of non-residents is 109 out of 167 students. There are only five Hispanic students among the 167 students. In a region where there is a large (almost 37 percent) population of Hispanics this seems to be a very low participation. This is especially striking given that the there is a significant (albeit small - about 16%) number of Hispanic undergraduate students in the department.

Students awarded Research Assistantships are assigned to an advisor at the time of their admission. The rest are initially supervised by the graduate advisor. While there have been very few occasions where a student has changed an advisor, where it has happened the change has happened smoothly and without rancor. This indicates a cordial relationship among the faculty and a genuine concern on the part of the faculty for the well being of the graduate students. Students on research projects are encouraged to write papers and present their work at conferences. While there is no travel support from the department, the faculty are willing to commit sufficient funds from their various research programs to allow student travel. Depending on the particular program, students are also encouraged to take part in the proposal preparation process.

The department also has an Industrial Masters program, funded by Texas Instruments, which is currently supporting twenty students. While the program is focused on MS students it also provides a valuable source of prospective PhD students.

There are very few students on teaching assistantships within the department. The teaching assistants are not provided with any training to develop their teaching skills. This may be because, except for the TA’s assigned to the project labs, the teaching assistants mainly grade. They are required to have office hours but these do not seem to be utilized by the undergraduates. If they have not already done so, the department may consider setting up a Resource Room where graduate TA’s would spend a certain number of hours per week helping undergraduates with their classes. This would provide the graduate students some teaching experience while also helping the undergraduates. None of the doctoral students we met were interested in a teaching career after graduation. A reason for this may be the absence of teaching experience for doctoral students.

The department has an excellent level of research funding with about two thirds of the funding obtained by faculty in the Pulsed Power group. The department generated close to two million dollars in overhead return in 2010, of which 20% went to the principal investigators. This rate of return is generous when compared to many institutions and represents a significant resource to sustain and grow the graduate program.
The normal faculty teaching load is two courses per semester. New faculty teach one course per semester in the first year. It is understood that there is an effort underway to reduce the teaching load to three per year for faculty involved in research. This is a very necessary effort as it is difficult to envision growth in the doctoral program when faculty are teaching two courses per semester.

In summary, the department has an excellent graduate program with devoted faculty, conscientious administration and enthusiastic students. Given the very heavy load that the department and its faculty labor under it is difficult to see how they can further improve their national and international standing without infusion of fresh resources. However, if resources were to be made available the department is in an excellent position to take advantage of them. In the following we try to provide some suggestions for further improvements to the program.

1 Administration

The graduate program is administered by a Graduate Chair, Professor Richard Gale, with one support staff. The admission process involves review of application files by up to seven faculty members. The graduate chair runs the admission process, serves as the advisor for the approximately 75 students in the non-thesis option and is the advisor for all students who have not yet selected a research mentor. He is also responsible for developing plans to improve the program. This duty is in addition to teaching two courses per semester and directing the industrial MS program. While Professor Gale deserves a great deal of credit for doing a difficult job very well - much better than can reasonably be expected - the situation is not tenable. During the last year the department reviewed more than five hundred applications with the graduate student population currently standing at 167. In order for Professor Gale to devote attention to what should be one of the most important tasks facing the graduate program - planning for the future - an effort has to be made to reduce his other duties. A few possible ways this could happen would be the following:

- The obvious thing to do is to provide more staff support for the graduate program. It is not clear that the staff person supporting the graduate program is only responsible for the graduate program. The graduate program requires significant attention and it is important that this person be responsible only for the graduate program. If this support person also has responsibilities outside of the graduate program then it might be wise to hire another person with sole responsibility towards the graduate program.

- The graduate school could provide some much needed support during the application process. It is my understanding that the current process does not permit recommendations to be provided on line. This can easily be remedied and will provide some relief in terms of book keeping. Another possibility would be for the graduate school to provide summary information about the applications. A spreadsheet listing the
students’ test scores, undergraduate institution etc. would allow the department to streamline their review process.

• The incoming graduate students who do not have a faculty mentor should be provided a temporary mentor from among the faculty. While in our meeting several students expressed their appreciation for Professor Gale’s willingness to spend whatever time with them that was required, it was also clear that many of the students did not even consider the option of asking faculty for advice.

• The teaching load of the Graduate chair needs to be reduced or he should be provided some summer support. At Nebraska the Graduate chair gets one course relief per year, along with dedicated staff support.

It is necessary that some of the administrative pressure be relieved so that the Graduate Chair can spend more time, with assistance from the graduate committee, to develop a strategic vision for the program. Much as exercises in developing strategic visions are maligned, without some level of formal planning the program cannot move beyond its current level.

There is also a need for a better communication protocol between the department and the graduate students. The use of the web is a double edged sword when communicating information. Because the information is available on the web the department assumes that the graduate students are aware of the information. However, because many of the graduate students do not know where this information is available they never access it. This engenders frustration on the part of the department who feel that the information necessary has been provided, and befuddlement on the part of the graduate students who are simply not aware of essential information. This kind of miscommunication can lead to unpleasant consequences with each side blaming the other. Printed handouts given to the graduate students when they first enter the program which highlight essential information and the responsibilities of the students would be a very useful supplement to the current efforts of the department. Another option could be to set aside a fifteen minute time slot once every semester in the graduate seminar class for dissemination of information.

2 Recruitment

The department has done an excellent job of recruiting its own undergraduate students. The 150 credit hour combined BS/MS program seems to be very successful in helping the department encourage capable students to stay on for an MS, and possibly a PhD degree. It has also used the Industrial MS program to good effect, even recruiting students from Monterey Tech in Mexico. The department also conducts outreach to encourage especially promising applicants to come to Texas Tech. Despite these successes this is one area in which the department, given additional resources, could do much more.

2 for an extreme fictional case see D. Adams, A hitchhikers guide to the galaxy
Rather than simply focusing on students who self identify as being interested in Tech by filling out an application there should be an effort to get students to apply to Texas Tech. This could be especially promising with respect to foreign students. There are a significant number of foreign born faculty in the department who possibly still have connections with universities and colleagues in their countries of origin. Resources could be made available to these faculty to go on recruiting trips to highly ranked Universities in their countries of origin.

The department may be passing up opportunities to get outstanding students from institutions which may not be in the top tier but are still outstanding. This is especially true for students from populous countries like India and China. The graduate school could help the department to identify such schools in a number of ways. The graduate school probably has its own information networks which could identify particular institutions as being the source of high quality students. The graduate school could also develop a database of students coming to Texas Tech from various institutions along with a record of their success in the program at Texas Tech. I am sure the department currently does focus more attention on schools from which it has received outstanding students. However, their net is not as wide as the one available to the graduate school - institutions which graduate top notch mechanical engineering students would, with high probability, also graduate top notch electrical engineering students. The information they provide can be very useful to the department in its recruitment efforts.

Finally, for whatever reason the department has not been very successful in recruiting underrepresented minorities to the graduate program. The lack of any significant Hispanic component in a state which is more than third Hispanic is both a problem and an opportunity. A similar case can be made for the underrepresentation of women in the graduate population. The seeming lack of women and Hispanics among the students in the 150 hour combined BS/MS program was especially striking. This is one area where a departmental focus on recruitment would be highly productive on many levels.

3 Training

Graduate students on the whole are well trained by the faculty. One glaring omission in their training is the lack of opportunity for students to take graduate-only courses. It is understandable for the department to cross-list the vast majority of the graduate courses to permit undergraduate students to take the classes. It allows for greater enrollment in the classes which in turn allows more classes to “make.” However, the lack of graduate-only classes deprives the students of the type of interaction with the instructor that is only available when the instructor does not have to “dumb down” the material in order to accommodate the undergraduates in the class. One student in our meeting described how the instructor in a graduate power systems course spent time explaining the elementary undergraduate concept of a transformer turns ratio. I understand that there is a requirement that the graduate students in a cross-listed class be required to perform at a higher
level that the undergraduates. However, according to the students, this rarely entails more than an additional question on the exam for the graduate students. There is an issue of resource involved here as well. Given that the faculty are already teaching a full load (in my opinion, more than a full load) making some of these classes graduate-only will reduce the options available to the undergraduate students. However, this is an issue that has to be addressed if the department is to advance along its chosen path. In particular graduate only classes are excellent recruiting tools for the doctoral program. If the doctoral program is to grow the department will have to be given the resources necessary to develop graduate-only classes.

4 Pulsed Power

The Center for Pulsed Power and Power Electronics is the largest and best funded research group in the department. Based on the numbers provided by the department, the Center is responsible for two thirds of the research funding in 2010. Due to its size and productivity the Center exerts a great deal of influence on the doctoral program. For the most part the influence of the Center is positive. The funding allows the Center to support a significant number of graduate students. The active participation of the graduate students in the Center’s research and publishing activities sets a benchmark for other students. The involvement of the faculty with the graduate students also provides a standard for the interactions of other groups. The post-docs actively interact with the graduate students providing valuable training for the students. However, the Center also poses some possible problems for the future of the graduate program.

By the nature of its funding, the Center is restricted to hiring US citizens. Also by the requirements of the funding sources much of the research conducted by the Center is in labs not accessible to other graduate students. This restricts the students in the Center from interacting with the graduate student population of the department as a whole, and hinders their learning from their peers. In an increasingly globalized world, exposure to interaction with a diverse population is a significant aspect of graduate training and is the hallmark of top tier research universities. The students in the Center are deprived of this aspect of a graduate education. It is important that the faculty and department be aware of this and develop strategies to ameliorate the effects of this segregation. This could be attempted by providing other venues for collaboration and interaction between all students in the program such as seminars and common classes. The Center could also try and provide some diversity by intensifying its efforts to recruit female students and students of Hispanic origin - neither category seems to be represented in any number in the Center’s graduate population.

The Center also exerts a major pull on the undergraduates. From what could be seen almost all the combined BS/MS students were part of the center. If the rest of the faculty see the combined program as simply a feeder for the Center for Pulsed Power and Power Electronics their commitment to the program will degrade over time. This is not good for
the program or the department. In our short visit it was not possible to reliably identify the reason for this though one assumes the higher level of assistantship support provided by the Center plays a role. Whatever the reason, this is an issue the department should monitor in order to head off any untoward effects.

5 Conclusion

Of the options available currently I would rate the program as Very Good. The strengths of the department include committed faculty, well funded research, conscientious administrators and an enthusiastic student body. Possible weaknesses include an overburdened management structure, a restricted recruitment strategy, and a paucity of graduate-only classes. Each of these weakness is also an opportunity which if exploited can pave the way for an excellent graduate program.