POWER QUALITY & RELIABILITY PROJECT

FINAL REPORT

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POWER QUALITY AND RELIABILITY

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ABSTRACT

One area where universities and industry can link is in the area of power systems reliability and quality - key concepts in the commercial, industrial and public sector engineering environments. Prairie View A&M University (PVAMU) has established a collaborative relationship with the University of Texas at Arlington (UTA), NASA/Johnson Space Center (JSC), and EP&C Engineering and Technology Group (EP&C) a small disadvantaged business that specializes in power quality and engineering services. The primary goal of this collaboration is to facilitate the development and implementation of a Strategic Integrated power/Systems Reliability and Curriculum Enhancement Program.

The objectives of first phase of this work are (a) to develop a course in power quality and reliability, (b) to use the campus of Prairie View A&M University as a laboratory for the study of systems reliability and quality issues, (c) to provide students with NASA/EPC shadowing and Internship experience.

In this work, a course, titled "Reliability Analysis of Electrical Facilities" was developed and taught for two semesters. About thirty seven has benefited directly from this course. A laboratory accompanying the course was also developed. Four facilities at Prairie View A&M University were surveyed. Some tests that were performed are (i) earth-ground testing, (ii) voltage, amperage and harmonics of various panels in the buildings, (iii) checking the wire sizes to see if they were the right size for the load that they were carrying, (iv) vibration tests to test the status of the engines or chillers and water pumps, (v) infrared testing to the test arcing or misfiring of electrical or mechanical systems.

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POWER QUALITY AND RELIABILITY

1.0 INTRODUCTION AND OBJECTIVES

Today, engineering education is entering a new era of forced change and strong competition. It needs to cope with rapidly changing technology, a global economy, trade competition, and a sometimes-uncertain employment market. In order to serve local economies, university programs are linking themselves more and more into collaborative relationships. These collaborations link universities, governmental agencies, and industry though student technical training, internship programs, and industrial advisory committees. These formalized contacts often lead to the development of a university in-house technical consultation base offering engineering consulting and research services to industries, governmental agencies, and the small business community, with emphasis on innovations and competitions for economic markets.

One area where universities and industry can link is in the area of power systems reliability and quality - key concepts in the commercial, industrial and public sector engineering environments. Prairie View A&M University (PVAMU) has established a collaborative relationship with the University of Texas at Arlington (UTA), NASA/Johnson Space Center (JSC), and EP&C Engineering and Technology Group (EP&C) a small disadvantaged business that specializes in power quality and engineering services. The primary goal of this collaboration is to facilitate the development and implementation of a Strategic Integrated power/Systems Reliability and Curriculum Enhancement Program. As a group, the collaborators represent a significant pool of highly qualified professionals with a wide range of talent, experience, and skills.

The objectives of first phase of this work are (a) to develop a course in power quality and reliability, (b) to use the campus of Prairie View A&M University as a laboratory for the study of systems reliability and quality issues, (c) to provide students with NASA/EPC shadowing and Internship experience. All the above objectives were achieved. The following describes what was done during the two years this project.

2.0 CURRICULUM DEVELOPMENT

2.1 Course Description

After several consultations among Dr. W. Lee and Dr. J. Attia, Mr. P. Cofie and Mr.W. Ali, the following course description (Sections 1.1 and 1.2) was decided upon for the course, which is the first of its kind in the nation.

Course Title: Reliability Analysis of Electrical Facilities

Course Description ELEG 4283 (2.5-1) Credit 3 semester hours. Overview of reliability and probabilistic theory, Monte Carlo simulations, preventive and

predictive maintenance methodology, computerized maintenance management systems, generation, transmission and distribution networks and loads, field study, and power deregulation. Prerequisites: MATH 3023 and ELEG 4013.

This course uses practical application of fundamental engineering principles to system and component reliability. Designed for the electrical engineering student, the course covers the theories of reliability and reviews the operation & maintenance of electrical Power systems. The essential tools of reliability analysis are presented and demonstrated. Practical problem solving exemplified by field studies solidifies applications. At the completion of the course, the student will be prepared to address reliability issues related to engineering equipment and demonstrate competency in the use of reliability analysis tools.

2.2 Detailed List of Lecture Topics

The course is being offered during the Spring 2000 and 2001 semesters. The Lecture Topics for the course are shown in **Table 1**

Table 1 Lecture Topics

	Lecture Topic	Instructor	Affiliation
Week 1-2	Power System Overview, Generation, Transmission Distribution Networks and Loads	Mr. P. Cofie	PVAMU
Week 3	Power Deregulation	Dr. W. Lee	UTA
Week 4-6	Probabilistic Theory and Application to System Reliability	Mr. P. Cofie	PVAMU
Week 7	Power Quality	Dr. W. Lee	UTA
Week 8	Midsemester Exam	Mr. P. Cofie & Dr. W. Lee	PVAMU & UTA
Week 8	Midsemester Break		
Week 10-13	Maintenance Methods and Management	Mr. P. Cofie	PVAMU
Week 14-15	Field Study	Professionals from Industry	EP & C
Dead week	Review	Mr. P. Cofie	PVAMU
Final week	Final Exam	Mr. P. Cofie	PVAMU

Annotations: PVAMU (Prairie View A&M University)
UTA (University of Texas – Arlington)

2.3 Students

Sixteen students enrolled in the course during the Spring 2000 semester. There are fourteen seniors and two graduate students. Out of the fourteen seniors, one was a Civil Engineering major, and the other thirteen were Electrical Engineering majors. **Table 2** shows the students names, their classification and majors.

Table 2 List of Students Enrolled in the course ELEG 4283 during Spring 2000 Semester

	Name	Classification	Majors
1	ASLAM, MOHAMMAD	Graduate Student	General Engineering
2	CLEMONS, CHRISTOPHER	Senior	Electrical Engineering
3	COLEMAN, KENDALL E.	Senior	Electrical Engineering
4	HANDLEY, ROSH	Senior	Electrical Engineering
5	HASHEM, SHIBLEE	Senior	Electrical Engineering
6	HOUSTON, ROBLYN W.	Senior	Civil Engineering
7	LOVE, JENNIFER	Senior	Electrical Engineering
8	MOHAMMAD, EMAD	Senior	Electrical Engineering
9	MUCKELROY, DARRYL J.	Senior	Electrical Engineering
10	MUHAMMAD, AMJAD	Graduate Student	General Engineering
11	RICHERSON, LAMEIKA D.	Senior	Electrical Engineering
12	SAWYER, JEFFREY	Senior	Electrical Engineering
13	SCOTT, ERIC A.	Senior	Electrical Engineering
14	SEARS, LAWRENCE	Senior	Electrical Engineering
15	TAYLOR, CLARENCE	Senior	Electrical Engineering
16	THOMSON, DEXTER	Senior	Electrical Engineering

During the spring 2001 semester, eleven students enrolled in the course. All the students were seniors. All the students registered in the course had electrical engineering major, with the exception of one student from Computer Science. **Table 3** shows the students names, their classification and majors.

Table 3 List of Students Enrolled in the course ELEG 4283 during Spring 2001 Semester

	Name	Classification	Majors
1	Bibbs, Monica	Senior	General Engineering
2	EVERSON, ROGER D.	Senior	Computer Science
3	FRANCIS, BENITA C	Senior	Electrical Engineering
4	GAMBRELL, TIFFANY L	Senior	Electrical Engineering
5	ISLAM, MOHAMMAD S	Senior	Electrical Engineering
6	JONES, DE'ANDRE M	Senior	Civil Engineering
7	LEWIS, JEREMY L.	Senior	Electrical Engineering
8	ODIMA, EVALYN O.	Senior	Electrical Engineering
9	SOLOMON, TSEGAY	Senior	General Engineering
10	TRAVIS, TASHARA S	Senior	Electrical Engineering
11	WILSON, WELDON E	Senior	Electrical Engineering

2.4 Laboratory Development

A power quality and Reliability laboratory has been developed. Five personal computers have been procured for the Laboratory. Furthermore, a reliability software package, Relex 2 Electro-Mechanical System with 5 User Network Version was purchased. The software program can be used for reliability analysis of electrical systems.

2.5 Partnership Activities

(1) Dr. W. Lee from University of Texas at Arlington gave the following presentations to the students: (i) Power Deregulation and (ii) Power Quality.

(2) Mr. Campbell gave presentations and demonstrations in power quality yesting and assessment.

(3) Mr. Lee Fuller gave presentations and demonstrations on power equipment failure predictions using infra red testing

(4) EP&C performed the facility survey and obtained baseline measurements for the applicable buildings surveyed.

Figures 1 to 5 show some pictures that were taken during the course.

Figure 1 Dr. Lee giving a talk on Power Deregulation

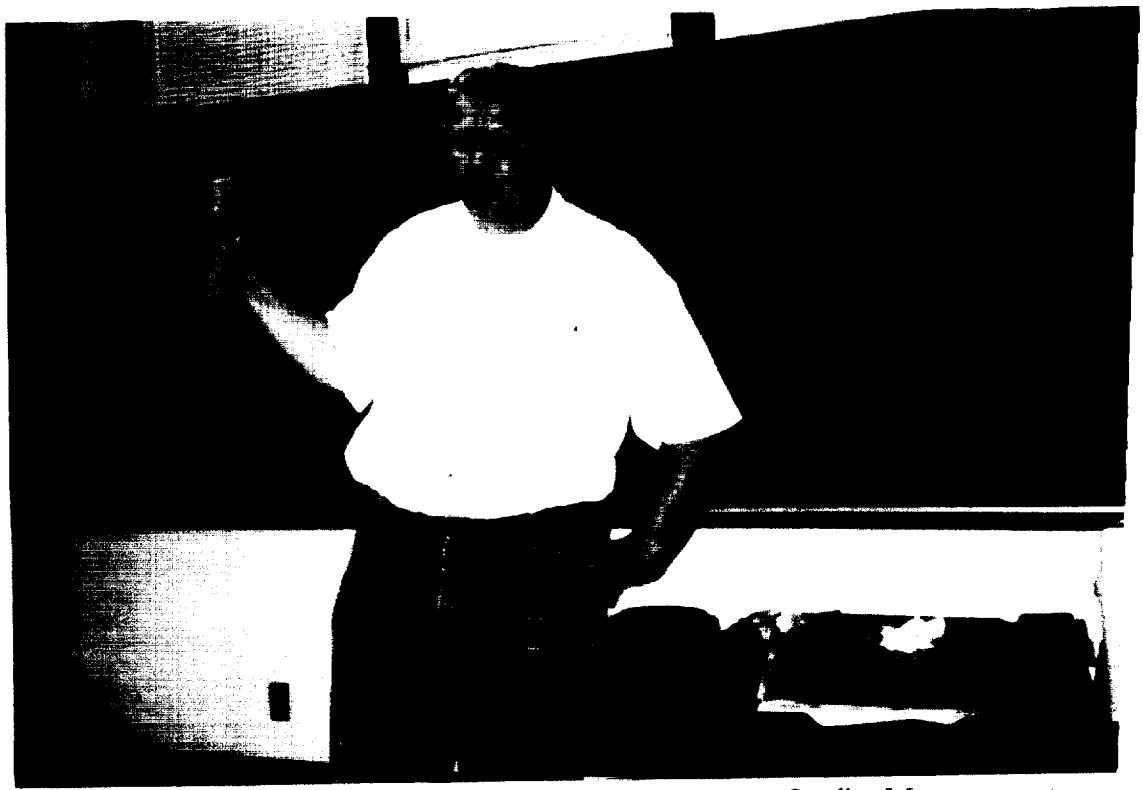

Figure 2 Mr. Campbell Providing Demonstration on Power Quality Measurements

Figure 3 Mr. Campbell with Students in a Class

Figure 4 Mr. Fuller demonstrations to a Class

Figure 5 Mr. Lee Fuller and Mr. David Gibson of Technical Diagnostic Services Posing with a Class after Demonstrations on Electrical Facility Testing

3.0 PRAIRIE VIEW A&M UNIVERSITY AS A LABORATORY – FACILITY SURVEY

Prairie View A&M University, a component of the Texas A&M University System, has a physical plant worth over $180 million. To establish the campus as a laboratory, a comprehensive survey of pre-selected facilities began during the first phase of this work. The survey provided the information needed for facilities modifications required to support planned curriculum enhancements and laboratory facilities upgrade. The survey included Earth ground measurements performed on all of the four buildings. Some other tests that were performed are (i) voltage, amperage and harmonics of various panels in the buildings, (ii) checking the wire sizes to see if they were the right size for the load that they were carrying, (iii) vibration tests to test the status of the engines or chillers and water pumps, (iiii) infrared testing to the test arcing or misfiring of electrical or mechanical systems.

Survey was performed on four buildings at Prairie View A&M University campus: (i) Greaux Chemical Engineering Bldg., (ii) Wilson Engineering Bldg, (iii) J.P. Coleman

Library Bldg., and (iv) Central Utilities Plant Bldg. EP&C Engineering Services, a subcontractor of this project, performed the facility survey. The following is a brief description of the type of tests performed.

3.1 Earth Ground Measurements

A minimal ground relative to the earth resistance of a building is necessary for safety and reliability. It is recommended that any commercial or industrial facility using modern equipment should have ground relative to earth resistance of less than 5 Ohms. For facilities that use computers or other high-tech equipment, the electrical resistance should be less than 1 Ohm.

Earth ground measurements were made for the above mentioned buildings on the campus of Prairie View A&M University using AEMC Ground Resistance Tester, Model 4610. The earth ground resistance of the buildings and the method of measurement are shown in **Table 3**.

Table 3 Earth Ground Measurement Readings

BUILDING	METHOD OF MEASUREMENT	RESISTANCE READING
Greaux Chemical Engineering Bldg.	Fall-of-Potential Method	0.175 Ohms
Wilson Engineering Bldg.	Fall-of-Potential Method	0.85 Ohms
Coleman Library Bldg.	Fall-of-Potential Method	0.2 Ohms
Central Utilities Plant Bldg.	Three-Point Measurement	0.2 Ohms

3.2 Electrical and Mechanical Rooms

The electrical and mechanical rooms of the buildings were also checked. A specific recommendation was made for the Greaux Chemical Engineering building that had corrosion and a residue on an equipment in the building.

3.3 Wire Sizes

The wire sizes were checked. There was one location where the wire size needs to be changed or protection for the wires need to be added.

3.4 Multiple Circuit Breaker

The National Electrical Code (NEC) only allows one wire to be connected to a lug or a screw terminal on a circuit breaker unless the manufacturer for such use rates it. During the survey, five panels with the total of five double-lugged and two triple-lugged connections were found. Corrective actions were recommended.

3.5 Panel Grounding

In electrical facilities, there are cumulative currents from equipment to ground. Whenever, the leakage currents exceed 2% - 3% of the largest phase current, they should be investigated to determine the source so that they can be reduced or eliminated. Excessive ground currents are indication of breakdown in electrical insulation, and/or improperly wired circuits. Ground currents also have potential safety hazards.

For the 22 out of the 42 panel grounding checked had greater than 3% of the largest phase current appearing on the ground conductor. Corrective actions were recommended.

3.6 Harmonics

Harmonics were checked. Four panels had high percentages of harmonic content in the current. However, the percent of the panel capacity was low. Also the voltage harmonics were consistently low (less than 3%) so they were not considered to be a concern at the time of the test.

4.0 INTERNSHIP EXPERIENCE

Mr. Paul Adams, an Electrical Engineering student at Prairie View A&M University, did an internship at NASA Johnson Space Center from June 1st to August 27th, 1999. His supervisor was Mr. Ken Heussner. The latter is with the Plant Engineering Division, the Center Operations Directorate. During his summer internship, the student worked with several individuals as part of his summer job: Mr. Bruce Campbell (Facilities Conservation Consultants (FCC) at Prairie View), Mr. Hozea Chambers (Electric Protection and Control, EP & C), Mr. Wayne Powell (BRSP) and Dell Thompson (BRSP).

The student developed electrical one-line schematic drawings for each of the five power sources (utility company meters) at the Ellington Field Airforce facilities at Houston, Texas. This work will save NASA a lot of time while identifying electric panels and their sources. In addition, the student performed inspection of electrical panel at Ellington Field Airforce Base and at Prairie View A&M University. This inspection involved performing several tests on the electrical facilities at both sites. The tests that were performed are (i) 2-point measurement and the Fall-of-Potential test for ground resistance evaluation. (ii) Voltage, amperage and harmonics of the various panels at the

two sites. (iii) Checking the wire sizes to see if they were the right size for the load they were carrying. (iv) Vibration tests to test the status of engines on chillers and water pumps (v) Infra-red testing to test arcing or misfiring of an electrical or mechanical mechanism. From the result of the test, electrical problems were discovered and non-operational equipment was tagged for repair or replacement.

5. CONCLUSIONS AND FUTURE WORK

In this work, a course was developed and taught for two semesters. About thirty seven has benefited directly from this course. A laboratory accompanying the course was also developed. Four facilities at Prairie View A&M University were surveyed. Some tests that were performed are (i) earth-ground testing, (ii) voltage, amperage and harmonics of various panels in the buildings, (iii) checking the wire sizes to see if they were the right size for the load that they were carrying, (iv) vibration tests to test the status of the engines or chillers and water pumps, (v) infrared testing to test arcing or misfiring of electrical or mechanical systems.

Some future work that might be done are:

(i) Enhance the concept of using PVAMU as a Laboratory
(ii) Survey additional buildings on campus and perform serial measurements on some of the buildings surveyed the previous year
(iii) Train practicing engineers on power quality issues through short courses.
(iv) Establish a course in power quality
(v) Facilitate internship opportunities in power quality for students