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Power System Hands-on Skill Enhancement through Senior Design Project

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Abstract

With the growing demand of electrical energy, skilled engineers in power engineering are also desired. Current curriculum in power system courses do not offer students much opportunity to have some hands-on experience with industrial power systems due to the availability and danger of high power. A senior design project cooperated with a local company involved voltage as high as 2.3 kV is described to enhance their experience with industrial level power systems. All of the Students working in the project got a taste of what a power engineer deals with every day. These skills will be advantageous in the job market and prepare them to be successful in their future working field.

1. Introduction

A power system is a network of electrical components used to generate, transmit, distribute and consume electric power. The growing demand of electrical energy from sustainable sources requires an ever increasing skilled workforce. In a recent survey conducted in 2015 by the Center for Energy Workforce Development, analysis indicates that 38% of engineers (including positions in nuclear) may need to be replaced due to potential retirement or attrition from 2015 to 2019 [1]. All these facts lead to the development and teaching of courses in power engineering to fill the shortage of skilled engineers.

Sergeyev and Alaraje described an industry-driven power curriculum in an electrical and computer engineering technology program. The primary outcome of their project was to educate a large number of qualified engineering technologist graduates with skills and knowledge that are current and relevant [2]. Inside Electrical and Computer Engineering Department Heads Association, Mousavinezhad *et al.* started a workshop series for developing educational and research programs in a critical area of power and energy systems with the support of the National Science Foundation [3]. Many recent efforts have been devoted to improve the teaching through simulation [4-7]; nevertheless, few have been devoted to enhance hands-on skills. Recently Farhadi

and Mohammed designed a Laboratory-Scale Hybrid DC power System to address that issue[8]. However, it requires tremendous effort from the instructors and a great amount of source funding, which is hard to duplicate in most of the schools. In addition, the DC power system is sparsely used in power industry as the AC power system is still dominant due to the easy transformation between low and high voltage. Besides, laboratory-scale power levels are much lower than industry levels, so graduates will still need to get trained in the high voltage field after stepping into the industry. This paper describes how a senior design project with a local paper mill corporation increased the students' exposure and skills related to power systems.

2. Hands-on Skill in Power engineering

Power engineering is a very important sub-discipline of electrical/electronic engineering technology (EET). Students graduated from the EET department usually have a high placement rate due to their hands-on experience and skills. EET focuses more on application, applied design and implementation; while traditional electrical engineering (EE) focuses more on theory and conceptual design [9]. EET graduates can work in the field with minimum training compared to EE graduates; thus saving cost and time for the employer.

Most of the courses offered by the EET department are accompanied by a lab. So students learn knowledge not only from the lecture in the class, but also from the lab by exposure to current equipment and technology. Typically graduates from EET have outstanding hands-on skills and experience; thanks to the labs offered for each course. However, the power system course deals with voltage from 120 volts up to hundreds and thousands of volts; it is dangerous and economically unfeasible to have a lab on campus dealing with such high voltage. Therefore, students in the power system sub-discipline of EET do not have enough exposure to current equipment and technology like other sub-disciplines do. Their hands-on experience and skills are not so prominent in that aspect, thus hindering employers from hiring such EET students for co-ops, internships or full time jobs.

3. Senior Design Project Topic

Verso Paper Corporation is a leading North America producer of printing papers, specialty papers and pulp. These paper products are primarily used in media and marketing applications. The

local branch (Quinnesec mill in Michigan) of Verso paper uses one million gallons of water per day from Menominee River for paper production. The water is then treated and sent through a foam breaker before returning to the river. The foam breaker was the cause and focus of this senior design project. The original electrical feeder at the foam breaker location was not adequately sized to allow for temporary loads. The original site also utilized a bare conductor and pole-mounted transformer system, as shown in Figure 1. A pole-mounted system can pose potential safety concerns in a high traffic area. The bare conductor system can further be subjected to reliability issues if a tree or wildlife were to contact the 2300V wire. In addition, the 480V breaker panel design (as shown in Figure 2) was outdated and accessible to unauthorized personnel, creating another potential hazard. Last, there was lack of lighting at the site which needed to be improved.

Figure 1: Original Pole-Mounted Transformers

Figure 2: Original 480V Breaker Panel

The senior design team was tasked with designing a completely new electrical system which included two pad-mounted transformers: one 2300V/480V transformer for the foam breaker power and another 480V/120V transformer for lighting and maintenance equipment. The team was responsible for providing one-line drawings, elementary drawings, panel schedules, a bill of materials, a cable schedule, a conduit plan, a lighting plan and a construction package. The team was also responsible for assembling two electrical panels and shipping them to the mill.

4. Implementation

In the process of completing this project for Verso, the team gained a great deal of real world experience. During the design phase, the team went through a training class for the National Electrical Code (NEC). The NEC is developed by the National Fire Protection Association (NFPA) as a regionally adoptable standard for the safe design, installation and inspection of electrical wiring and equipment to protect people and property from electrical hazards in the United States. The NEC is an extremely important guideline necessary for an electrical engineer to design and work in the field. Nevertheless, these design guidelines are rarely included in any four year program power engineering curriculum. In order for students to get familiar with electrical codes and obtain crucial hands-on experience, Azizur in Grand Valley State University proposed a short NEC course which has been offered since winter 2008 [10]. It was found that this short course was very beneficial to student's lab, course project and senior design project work.

Under the guidance of the NEC, the team used the entire first semester to design the new system and place orders for equipment and components. The required general design specifications included:

- a 2300V to 480V step-down transformer
- a 480V to 120V step-down transformer
- temporary power receptacles for welders, drills, etc.
- protection of all electrical components
- lighting the area with LED floodlights

Some of the design drawings that were provided to the paper mill are shown in Figures 3 and 4.

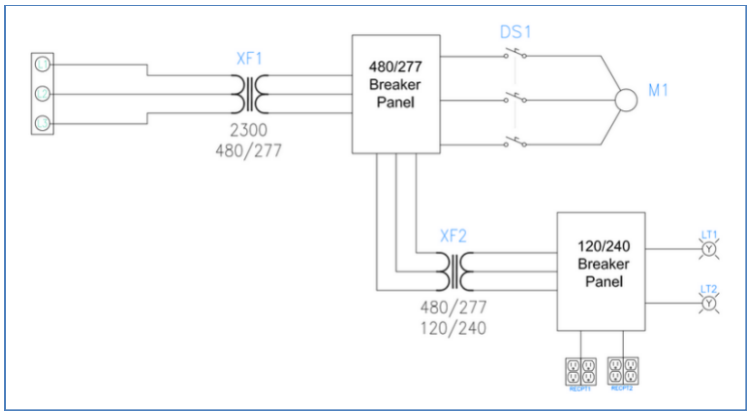

Figure 3: One-Line diagram of System

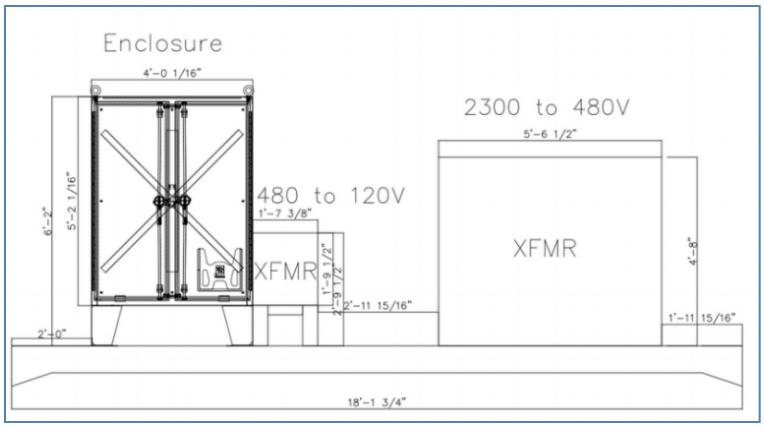

Figure 4: Equipment Layout of System

The team maintained contact with an engineer at the paper mill through weekly conference calls to insure that the design would meet their needs. After a couple of trips to their facility, it was time to order equipment and hire contractors. The process of ordering, tracking and expediting equipment was found to be a difficult process, but also a useful skill required in most industries.

5. Results and Conclusions

After all the equipment and components arrived, some assembly was done at the University. When it came time for the final installation at the paper mill, a pre-scheduled shut-down was initiated. The final removal of the old pole-mounted transformer is shown in Figure 5 and the installation of the new pad-mount transformer is shown in Figure 6.

Figure 5: Old Transformer Removal

Figure 6: Wiring New Transformer

Upon successful completion of the project, the following final deliverables were submitted to the paper mill:

- Scope of Work
- Scheduled Shut-Down
- Bill of Materials
- Budget
- One-line Drawings
- Electrical & Installation Plan (E&I)
- Panel Schedules
- Concrete Schedule
- CAD Drawings
- Procurement List
- All Equipment

Verso graciously granted a fund of $17,500 for the project. Because of the money-saving design and various equipment purchases made by Verso, the project was successfully accomplished with a budget surplus of over $4,000. From this remaining budget, a set of 11 wireless headphones was ordered that will assist in field trips within the noisy environment of the paper mill. The paper mill was very satisfied with the result.

All of the Students involved in the project received some level of hands-on experience working in the power industry and a taste of what a power engineer deals with every day. These skills will be advantageous in the job market and prepare them to be successful in a future job. A similar project will be pursued in the near future to enhance the experience.

6. Acknowledgements

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