The Revision of Power Courses into Industrial Automation and Communications Courses

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Abstract

One of the concerns facing educators in electric power programs is the lack of interest expressed by incoming students in the subject matter. This conflicts with the strong demand for graduates with knowledge in industrial power systems. A topical survey of industrial manufacturers in Maine revealed that a strong need exists for graduates with knowledge of three-phase power, electric machines, electric drives, and industrial automation.

As part of University of Maine’s continuous improvement process, this input served as a driver to revise traditional coursework in power systems analysis to courses introducing state of the art technology in industrial automation, controls and communications. This paper will discuss the course content covered in the new “power” courses and will also discuss the laboratory improvements made to support this effort.

Previous Courses

Historically, the Electrical Engineering Technology program at the University of Maine has provided excellent training for students interested in careers in electric utilities and manufacturing. Firms such as General Electric, Rockwell Automation, ABB and regional electrical utilities have hired a significant percentage of each graduating class. This strong client base has served actively on the program’s Industrial Advisory Committee and helped shape a three-course, power sequence in the program.

The first course in the sequence was EET 321 – Power Systems I. That course covered Three Phase Power, Magnetics, Per Unit Calculations, Transformers, DC Motors, DC Generators, and an introduction to Programmable Logic Controllers. The second course was EET 422, which covered AC Induction Motors, AC Synchronous Motors and Generators, Admittance and Impedance Matrix Calculations, and Transmission Lines. The final course was EET 423, which covered Power Flow Analysis, Symmetrical Components, Sequence Networks, Three Phase Faults and Shunt Faults.

During the last five years, the hiring of power equipment manufacturers have changed while utilities needs have dropped off. Manufacturers have requested additional coursework in electric drives, and digital communications. To address these concerns, we have revised our power courses.
2. New Course Descriptions

The first power course is now, “EET 321 - Industrial Power and Sequential Automation”. This course retained the traditional topics of three-phase power, transformers and DC machines. We spend two weeks on three-phase power, three weeks on transformers and two weeks on DC machines.

It differs in that we now spend seven weeks on programmable logic controllers, DC drives and industrial communications. To do this, we had to select a commercial vendor and base our assignments on their systems. We chose Rockwell Automation based upon their market strength in the United States and their willingness to partner with our institution in developing a state of the art training facility.

Students now learn how to program and operate PLCs using RS Logix and RS Linx software on Rockwell’s Enhanced PLC 5 platform. We use LogixPro software for PLC simulation and homework assignments. LogixPro was developed by Bill Simpson and provides an excellent simulation that is tied to a PLC ladder. Students view a split screen that displays their ladder on one side and the process simulation on the other side. It shows students the results of faulty logic without the associated equipment damage.

Once students master basic programming skills, they progress to an actual production line. Lanco Assembly Systems in Westbrook, Maine was generous enough to loan a parts assembly system to the University of Maine. The system consists of four cells with primary control provided by a Rockwell PLC. It features a variety of sensors and pneumatic controls as well as electric controls. The system assembles parts that are utilized as electrical harnesses for Ford Aerostar vans. Class lecture time on PLCs alone is limited to three weeks, but laboratory assignments cover four to five weeks. Figure 1 demonstrates an assembly station.

![Figure 1 - Lanco Assembly System - Station 1](image)

Once students have mastered the basics of PLCs, we move on to DC machines. As mentioned previously, we spend approximately two weeks covering DC machine theory. Then we transition to power electronic devices used in DC machine control. We spend three weeks on power electronics concepts and drive basics. In the laboratory, students communicate with Rockwell 1397 drives after setting up a Scanport communications module. We have used
RSView32 to create a nice PC interface so that the students can monitor drive and machine performance. Figure 2 illustrates a 1397 drive. Figure 3 illustrates a typical motor-generator set.

![1397 Drive](image1.png) ![Motor-Generator Set](image2.png)

Figure 2 - 1397 Drive  Figure 3 - Motor-Generator Set

Finally, we devote the last four weeks of class to data communications across several platforms. Students learn about point-to-point information using Remote I/O. They gather packet information using DeviceNet. We also have some input sensors that are set up for DeviceNet so that they can contrast the data provided by DeviceNet with data from Remote I/O. We discuss appropriate applications for each network. We learn about ControlNet and talk over that network as well. Finally, we discuss ControlLogix programming and we use a rack as a gateway to all three networks.

While there are drawbacks to focusing on one vendor’s software, the benefits greatly outweigh them. Since students take this course in their sixth semester, they are well prepared to serve in summer internships with a wide range of manufacturers as well as consulting engineering firms. We believe their knowledge of this platform will also greatly reduce any training requirements associated with other vendor's PLC and industrial communications software.

The second course in the revised power sequence is now “EET 422 – Electrical Machines and Power Electronics. In this course, students still learn AC machine basics but now they learn how to control them for industrial applications. They learn the basic power electronic concepts currently used in AC drives. Basic operational parameters that are common to many AC drives are covered. Topics such as pulse width modulation and vector control concepts are introduced.

We spend six weeks developing AC induction and synchronous machine theory. Students learn basic machine design and traditional calculations. We then spend four weeks on AC drive theory and applications. We control the AC induction motors in the laboratory using Rockwell 1336 AC drives. We examine system efficiency for an air handling system using controlled louvers with a full speed motor as compared to using the same motor that is controlled by an AC drive.

Finally, we spend the last four weeks covering basic fault calculations and system protection concepts. We cover symmetrical components and solve shunt fault problems. We discuss coordination for fuses and circuit breakers.

We have selected a single textbook to be used for both courses. The text is Electrical
Machinery and Power System Fundamentals, by Stephen Chapman. While the text adequately covers the machinery and power system topics, it does not offer any coverage on power electronics. Thus, supplementary readings are required from Chapman’s other text titled Electric Machine Fundamentals, and Ned Mohan’s text titled, Electric Drives.

3. The Role of the Laboratory

A weekly laboratory experiment is required in both courses. We believe the laboratory experience is a key part of the course. EET students are very “hands on” learners and the laboratory exercises are integral to the presentation of material.

Our laboratory was developed in partnership with Rockwell Automation and Rittal Corporation. We have a single motor control center which houses an enhanced PLC 5 with all communication hardware, (6) DC drives, (4) AC drives, (6) motor starters, PowerMonitor II blocks mounted in motor carts and a ControlLogix gateway.

We have four student stations and each consist of, a table and chairs, personal computer, connections for DeviceNet, ControlNet, and Data Highway. Depending upon the experiment, we have six, portable, 19” Rittal cabinets that each house an enhanced PLC5, AC I/O cards, DC I/O cards, analog I/O cards, communication cards and a Panelmate human-machine interface. All connections are wired to banana connectors in the front door.

For motor and generator experiments, we have six, portable, Rittal carts that each has a coupled AC/DC motor combination mounted on top complete with an end tachometer. Rockwell Automation manufactured all the motors. Inside each cabinet is a Rockwell PowerMonitor II block. All wiring leads to Hampden connector points on the side of each cart. (See Figure 3)

Each laboratory experiment requires direct supervision by a faculty member. The laboratory equipment is far too costly to repair if it is damaged and its operational voltage of 480 volts creates a safety issue. While this causes concern, it also creates a realistic experience on actual industrial equipment. Students develop a healthy respect for safety issues and they learn to be certain of all connections before applying power to a circuit.

Laboratory experiments require students to communicate across all four communications networks. They learn how to pull necessary information from vendor’s instruction manuals with assistance from faculty when necessary. By communicating with the power monitoring blocks and the drive’s software, they capture voltage and current waveforms that are inserted in their formal reports. They also learn about the safety interlocks built into all equipment that serve to protect individuals while operating the equipment.

4. Expected Outcomes

We expect that the changes in these courses will better prepare our students for a wide array of positions in industry. We want our students to gain a fundamental understanding of electric machines, drives, power and sequential automation. This practical experience coupled with theoretical concepts, should give our graduates a competitive edge.

Historically, our graduates have scored near the top of training classes offered as entry-level training for original equipment manufacturers. While we certainly believe they will be well prepared on vendor-specific equipment, we also believe that knowledge will translate to different vendor’s platforms. We will survey employers in 2004.

5. Conclusions and Recommendations
One of the toughest challenges for engineering technology educators is to ensure that coursework reflects current technology trends in industry. Overall curriculum revisions requiring the deletion or additional of technical classes needs to be carefully examined to fit long term career placement trends. Topic changes within existing courses needs to occur yearly to keep up with new technology trends.

The changes presented in this paper represent both curriculum revisions and topical revisions. The curriculum revision reflects the changes in job opportunities available to our students. We are deleting material that is not deemed necessary from the current employers of our graduates.

The topical revisions in the course material reflect a shift in focus from typical machine theory to motor system applications. We have decided to spend less time teaching students how to build machines and more time how to communicate with them and control them. This is in direct response to needs expressed by our Industrial Advisory Committee.

As educators, we are often conflicted when balancing theoretical concepts with practical applications. We want to ensure that we cover sound basics and not just train students to operate specific equipment. Our new laboratory experiments require a fair amount of training to demonstrate theoretical principles. This tradeoff is necessary to familiarize students with typical equipment applications and communications protocols. We believe these course changes and topic changes offer a key balance between necessary theory and application experience.

Bibliography

1 Simpson, W., LogixPro Software
4 Mohan, Ned, Electric Drives, MNPERE, 2001

Biography

Scott C. Dunning in Associate Professor and Department Coordinator for Electrical Engineering Technology at the University of Maine, in Orono, Maine. He teaches undergraduate courses in electrical machinery and power systems. He received a Ph.D. in Electrical Engineering from the University of Maine. He is a licensed professional engineer in the state of Maine. He is a Senior Member of the Institute of Electrical and Electronics Engineers in Maine (IEEE) and a Member of the American Society for Engineering Education (ASEE).