

## **AC 2009-1328: A NEW ELECTRICAL ENGINEERING LABORATORY FACILITY COMBINES TRADITIONAL LABORATORY EXPERIMENTS, COMPUTER-BASED LAB EXERCISES, AND LABS TAUGHT VIA DISTANCE**

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# **New Electrical Engineering Laboratory Facility Combines Traditional Laboratory Experiments, Computer-Based Lab Exercises, and Labs Taught via Distance**

## **Introduction**

On August 21, 2006 Missouri Governor Matt Blunt, along with the Curators of the University of Missouri, the Chancellor of Missouri University of Science and Technology (Missouri S&T), and the President of Missouri State University (MSU) signed a Memorandum of Understanding that allowed Missouri S&T to offer bachelor's degrees in Civil and Electrical Engineering on the MSU campus. The primary motive behind the signing of this agreement was an increased demand for Civil and Electrical Engineering graduates in southwest Missouri. A more detailed description of the conditions leading to the signing of the Memorandum of Understanding and specific details of the agreement are presented elsewhere<sup>1</sup>. This focus of this paper is on the development and implementation of an appropriate Electrical Engineering laboratory facility on the MSU campus so that Electrical Engineering Laboratory courses in the Missouri S&T Electrical Engineering program can be offered on the MSU campus in Springfield.

## **Initial Implementation Steps**

Following the signing of the Memorandum of Understanding, the Missouri legislature provided a set of both one-time and ongoing funds for the development and ongoing support of the collaborative program. Faculty and administrators from both institutions started to meet regularly to map out the details of how the Memorandum of Understanding would be implemented. The goal at MSU was to offer all of the courses in the Missouri S&T Electrical Engineering curriculum on the MSU campus, including laboratory classes. The Electrical Engineering program at Missouri S&T has a total of 17 required or elective laboratory courses that cover the major areas of electrical engineering including circuits, electronics, digital systems, linear systems, communications, signal processing, transmission lines and electromagnetics, energy conversion, and power systems.

MSU thus began to develop an Electrical Engineering laboratory facility on the MSU campus to allow all the required Missouri S&T Electrical Engineering laboratory courses and most, if not all, of the Missouri S&T elective Electrical Engineering laboratory courses to be taught directly on the MSU campus.

Most laboratory courses in the Missouri S&T Electrical Engineering program involve traditional laboratory experiment type activities, such as wiring circuits or devices and making measurements with electronic test equipment. Some other labs in the program were actually done using simulation software on a computer. In addition, the lab for the Missouri S&T Electrical Engineering course, El Eng 235, "Controllers for Factory Automation" involved the control of a simulated factory process from a remote location. Since the students enrolled in this

laboratory at Missouri S&T control the simulated factory from a location some distance away from the factory, it was determined that it would be best if this laboratory were to be taught at MSU via distance from Missouri S&T, rather than attempting to duplicate such a laboratory on the MSU campus.

Thus, in order to successfully replicate the Missouri S&T laboratory courses at MSU, MSU needed to develop a laboratory facility that would allow the conventional Electrical Engineering laboratory experiments to be conducted but also have the computer capability for simulation type labs and finally also allow for distance-type laboratory exercises, such as the El Eng 235 course at Missouri S&T. At the time the Memorandum of Understanding was signed, no electrical engineering laboratory facilities were in place on the MSU campus, although laboratories in the MSU Physics Department were equipped for experiments in electricity, magnetism, and some aspects of electronics.

It was decided to remodel an existing MSU Physics laboratory room and develop a new room for a dedicated Electrical Engineering laboratory facility for all Electrical Engineering laboratory classes held on the MSU campus. Working with the Electrical Engineering Department at Missouri S & T, MSU purchased lab equipment that was similar or identical to that used in the labs of the Missouri S&T Electrical Engineering program on the Rolla campus. This ensured that the laboratory classes in the Electrical Engineering program at Rolla and Springfield would be as similar as possible. In addition, MSU purchased new computers and software for those Missouri S&T laboratory courses that involved primarily computer-based experiments. Finally, for courses such as El Eng 225, a distance learning system was installed which allowed students at MSU to perform laboratory experiments via distance using the equipment in the Electrical Engineering labs on the Missouri S&T campus.

### **Description of the new Laboratory Facility**

The end result was an Electrical Engineering laboratory room that was approximately 35 feet long and 25 feet wide. The view looking toward the front of the room is shown in Figure 1. A view looking to the back of the room is shown in Figure 2.



**Figure 1. Electrical Engineering Laboratory room viewed from the back**



**Figure 2. Electrical Engineering Laboratory room viewed from the front**

A photograph of one of the stations in the laboratory room is shown in Figure 3.



**Figure 3. Close up view of one Electrical Engineering laboratory station**

The room contains six (6) laboratory stations each complete with a lab bench and stools. As per laboratory policy in the EE program at Missouri S&T, the lab was designed so that student lab groups would be two students per group, with an occasional group of three students in the event that an odd number of students enrolled in a particular lab class.

In addition to the laboratory benches, a set of tables and chairs was placed in the center of the room. This allows students to sit and take notes from the lab instructor as he or she goes over the experiment to be conducted during that lab session. The tables and chairs also allow the room to be used as a regular classroom when lab classes are not meeting.

A list of the initial laboratory equipment supplied for each lab station is given in Table 1. This equipment was selected in consultation with faculty in the Electrical Engineering program at Missouri S&T. Efforts were made to ensure that all lab equipment purchased was the same or equivalent to lab the equipment used in the undergraduate laboratory classes at Missouri S&T. Additional lab equipment will be purchased as the program progresses.

**TABLE 1. LABORATORY EQUIPMENT PURCHASED FOR THE  
ELECTRICAL ENGINEERING LABORATORY FACILITY MISSOURI STATE  
UNIVERSITY**

<b>ITEM</b>	<b>MAKE AND MODEL</b>	<b>UNIT COST \$</b>	<b>QUANTITY REQUIRED</b>	<b>TOTAL COST \$</b>
oscilloscopes	Agilent Technologies, Inc. Model DSO5012A	4,070.00	7 – 1 for each station plus 1 spare	28,490.00
computer oscilloscopes	Agilent Technologies, Inc. Model MSO6012A	6,774.00	7– 1 for each station plus 1 spare	47,418.00
power supplies	Tenma Model 72-6615	500.00	7– 1 for each station plus 1 spare	3,500.00
signal generators	Tenma Model 72-6644	503.00	7– 1 for each station plus 1 spare	3,521.00
digital multimeters	Agilent Technologies, Inc. Model 34405A	749.00	7– 1 for each station plus 1 spare	5,243.00
analog multimeters	Simpson Model 01260-8P	279.00	7– 1 for each station plus 1 spare	1,953.00
1 GHz counter	Agilent Technologies, Inc. Model 53181A with Option 015	2,447.00	2	4,894.00
curve tracer	Tectronix Model	4,000.00	2	8,000.00

	577/D1/177(used)	(estimate)		
LCR meter	BK Precision Model 878A or Tenma Model 72-960	209.00	7- 1 for each station plus 1 spare	1,463.00
1.3 GHz frequency counter	Precision Mastech Enterprises, Co. Model MS6100 HQ	135.00	2	270.00
computer board	Altera Model DE2-BRD-2C35/U-0A	269.00	7- 1 for each station plus 1 spare	1,883.00
Electric machinery laboratory	Lab-Volt Systems, Inc., EMS Training System, LVDAM Model 8006-Discount	22,028.25	6 - 1 for each station	132,169.50
	Mobile Console Model 8110-20 black shipping	2,375.90		14,255.40
	Total	150.00	6 - 1 for each station	900.00
			6 - 1 for each station	141,324.90
power system analysis software	PowerWorld Corp. Simulator 13	4,570.00	1	4,570.00
electronic circuit	PSPICE Version	2,000.00	1	2,000.00

analysis software	9.1			
mathematical modeling software	The MathWorks MATLAB Version 7.6	5,000 (estimate for site license, if not already on campus)	1	5,000.00
Decade resistance box	Elenco Electronics, Inc. Model RS-500	30.00	14 – 2 for each station plus 2 spares	420.00
<b>TOTAL</b>				259,949.90

This combination of laboratory equipment and laboratory space was believed to be the most effective cost and space combination that will provide students with a quality laboratory experience within the allotted cost and space constraints of the program.

### **Laboratory Experiments**

Copies of all of the laboratory experiments performed in each laboratory course in the Electrical Engineering program at Missouri S&T have been obtained. Students in the collaborative Electrical Engineering program at MSU will run the same set of laboratory exercises in the facility at MSU as is done at Missouri S&T. These experiments have been developed over time by the faculty in the Electrical Engineering Department at Missouri S&T. Faculty in the program at Missouri S&T and MSU will regularly communicate to ensure that any changes, deletions, or additions to the laboratory experiments planned for a particular electrical Engineering lab class are noted at both locations.

Laboratory reports for the laboratory classes held on the MSU campus will be the same at those required in the equivalent lab class at Missouri S & T.

### **Progress to Date**

The signing of the Memorandum of Understanding in August, 2006 was followed by another year of planning, procurement of equipment, development of classroom and laboratory space, and recruitment of program faculty. The plans were to start the program with only the freshman level courses the first year. Then, sophomore level courses would be added in year two, junior level classes in year three, and senior level classes in year four. The complete program would be in place after four years. With this timetable in mind, the first freshman level engineering classes

were held on the MSU campus in the fall semester of 2008. It is anticipated that a sufficient number of students will have completed the required prerequisite courses by the fall semester of 2009 to be able to enroll in the first Electrical Engineering laboratory classes, and the first laboratory classes will formally begin at that time.

### **Preliminary Assessment**

The first formal use of the new laboratory room will be in the fall semester of 2009. In the spring of 2009, one student who met the prerequisites, agreed to enroll and go through the laboratory experiments used in the lab that accompanies the introductory circuit analysis course. This student was able to successfully complete all the laboratory exercises required in the course and reported that he was generally pleased with the quality of the laboratory room and the laboratory equipment he used in the experiments. This “dry run” proved invaluable. In the process of doing the experiments, the student discovered several additional items of lab equipment that were still needed in order to complete the experiments. The missing items were purchased and added to the list given in Table 1, above. This student also made several helpful suggestions about the general layout of the laboratory and the arrangement of the lab equipment.

### **Summary**

At the present, the Electrical Engineering laboratory facility on the MSU campus is approximately 90% complete and, with the likely acquisition of some additional lab equipment, is expected to be ready for use in fall 2009. The equipment for the distance education component of the lab facility has been installed and tested. The distance course is scheduled to be taught for the first time in 2011.

### **References**

1. Egbert, Robert I., “Starting from Scratch” – A Summary of Experiences in the First Year of the Collaborative Electrical Engineering Program between Missouri University of Science and Technology and Missouri State University, submitted to the 116<sup>th</sup> Annual American Society for Engineering Education (ASEE) Conference and Exposition, Austin, TX, June 14-17, 2009.