Session Number 2233

Planning for a Power Engineering Institute

Frank W. Pietryga, Gregory M. Dick, Jerry W. Samples

University of Pittsburgh at Johnstown

Abstract

Anecdotal evidence suggests that emphasis on power engineering education has decreased during the past decade. As the demand for electrical power increases in the future, our power grid will become more complex and proper training of recent graduates and experienced power engineers will be essential for our survival. The recent electrical blackout of the North Eastern region of the United States reminds us that power generation, transmission, and distribution are critical to the nation's security. The EET program at the University of Pittsburgh at Johnstown (UPJ) continues to maintain a strong curriculum in electrical power engineering. The centerpiece of this program is a $300,000 Power System Simulator [1], one of only a few in the country. The simulator is a small power system consisting of scaled generators, transmission systems, substations, various loads, circuit breakers, relaying, and instrumentation. A supervisory mode PC enables the real time supervisory control and data acquisition (SCADA) functions of the Power System Simulator. UPJ plans to expand its contributions to power engineering by establishing a Power Engineering Institute to better service the needs of the electrical power industry. The purpose of the Power Engineering Institute is to provide basic and advanced continuing education to power systems and electrical utility engineers as well as further strengthen the undergraduate program in electrical power engineering at UPJ. The institute project is now in the planning stage that includes:

- Assessing the state of power engineering education in the region
- Assessing the requirements of the electrical power utility industry
- Exploring cooperative opportunities with other educational/training organizations and electrical utilities
- Developing a program which completely utilizes the capabilities of the Power System Simulator for both training and research

The purpose of this paper is to summarize the current state of the project, to describe the planning for the next stage of development for the Power Engineering Institute at UPJ, and to solicit cooperating partners.

Verifying the Need

UPJ is planning to survey regional universities to confirm or deny preliminary conclusions that Power Engineering education is declining. Also, regional power utilities and industries that rely on expertise in power engineering will be surveyed. Preliminary conversations with local power utility companies and power engineering consultants have been very encouraging.

Seeking External Support

The creation of the Power Engineering Institute at UPJ will be a major project requiring considerable effort. There are plans to seek support from the Electric Power Research Institute (EPRI), the National Science Foundation (NSF), the Department of Homeland Security, and the Power Engineering Society (PES) of the Institute of Electrical and Electronics Engineers (IEEE).

Power System Simulator Description

The Power System Simulator consists of seven unique sections which model a complete "mini utility" network. The sections include: Generating Station 1, Generating Station 2, Residential Distribution, Industrial Distribution, Commercial Distribution, Substations, and Interconnection and Sectionalizing.

Section 1 Generating Station 1

This section of the simulator contains the equipment necessary for the control of power generation and the interconnection and synchronization of two or more systems. All of the controls and instrumentation required to control 2 three phase alternators and their respective drive motors are provided. The bus system arrangement is configured using circuit breakers and disconnect switches.

Section 2 Generating Station 2

This section of the simulator contains the equipment necessary for the control of power generation and transmission, the metering of substations, and the monitoring of grounding and protective relaying. All of the controls and instrumentation required to control an additional three phase alternator and its drive motor are provided. Agricultural resistive loading is also simulated. This section is depicted in Figure 1

Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition

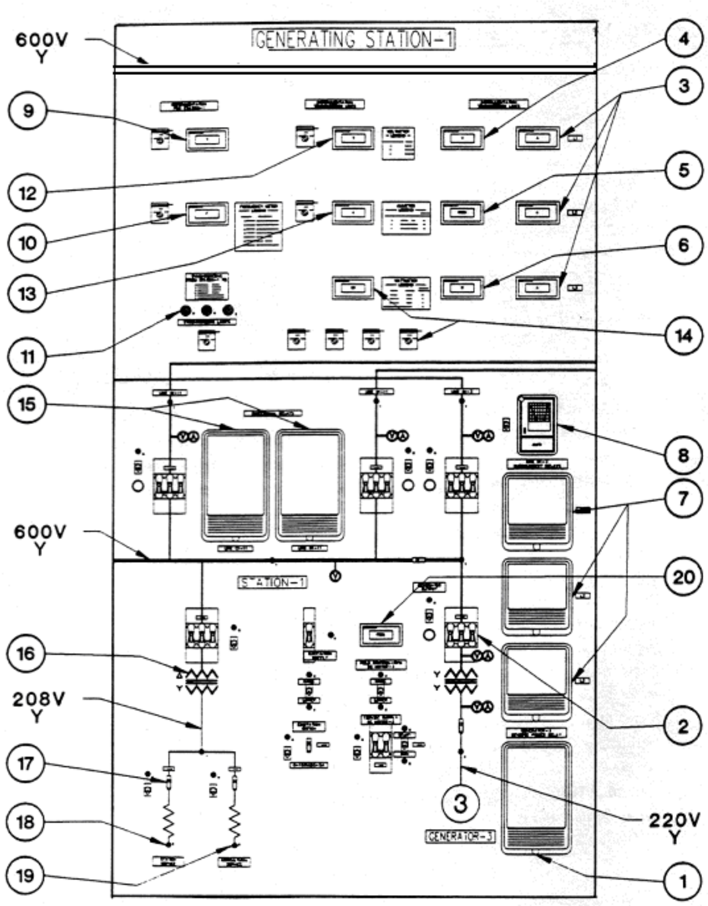

FIGURE 1
Generating Station 2 Front Panel
Generating Station 2 Front Panel Device Identification

1	Generator Reverse Power Relay	11	System Synchronization Lamps/Selector SW
2	Shunt Trip Circuit Breaker/Test PB	12	Transmission Line Voltmeter/Selector SW
3	Generator Line Ammeters	13	Transmission Line Ammeter/Selector SW
4	Generator Line Voltmeter/Selector SW	14	System Wattmeter/Selector SW
5	Generator Power Factor Meter	15	Line Directional Overcurrent Relays
6	Generator Wattmeter	16	Local Load Step Down Transformer
7	Line Overcurrent Relays	17	Local Load Switch
8	Line Current Strip Chart Recorder	18	Station Service Load and Status Light
9	Station 1 Line Voltmeter/Selector SW	19	Agricultural Service Load and Status Light
10	System Frequency Meter/Selector SW	20	Generator Frequency Meter

Section 3 Residential Distribution

This section of the simulator contains the equipment needed for residential loading, power consumption measurements, temperature monitoring, substation distribution, transformer testing, and ground fault interruption. With this section, it is possible to simulate a 24 hour cycle of residential loading into 2 real-time hours.

Section 4 Industrial Distribution

This section of the simulator contains the equipment necessary for industrial loading, power consumption measurements, emergency single phase power, power factor correction, voltage regulation, and lightening voltage protection. With this section, it is possible to simulate a 24 hour cycle of industrial loading into 2 real-time hours.

Section 5 & 6 Commercial Distribution and Substations

These sections of the simulator contain the equipment needed for commercial distribution and substation operation. A 2 bus system, main and auxiliary, is utilized along with the appropriate disconnect switches and circuit breakers. These sections have provisions for simulating faults on several electrical buses.

Section 7 Interconnect and Sectionalizing

This section of the simulator contains the equipment necessary for interconnection to a second system, simulation of peak load and emergency generation, station distribution, and the main power circuit breaker. With this section, the possibility exists to study transmission line faults.

Also included with the Power System Simulator are a PC and a graphics printer. The PC is equipped with an analog to digital converter board and a digital I/O board. The ADC board is used to monitor voltages, currents, and powers in the various Power System Simulator sections. The digital I/O board controls a limited number of discrete channels which enable the simulator to be controlled in a dispatched manner. The PC system is capable of performing real-time supervisory control and data acquisition in an open-loop operator assisted format. The graphics provided to the user are the same as those found on major utility dispatching systems in the United States, Canada, and Europe. With the combination of the Power System Simulator and the computer system, the student may be come familiar with all aspects of real world power system operation and control in a laboratory environment. The UPJ Power System Simulator with remote supervisory and data acquisition system is depicted in Figure 2.

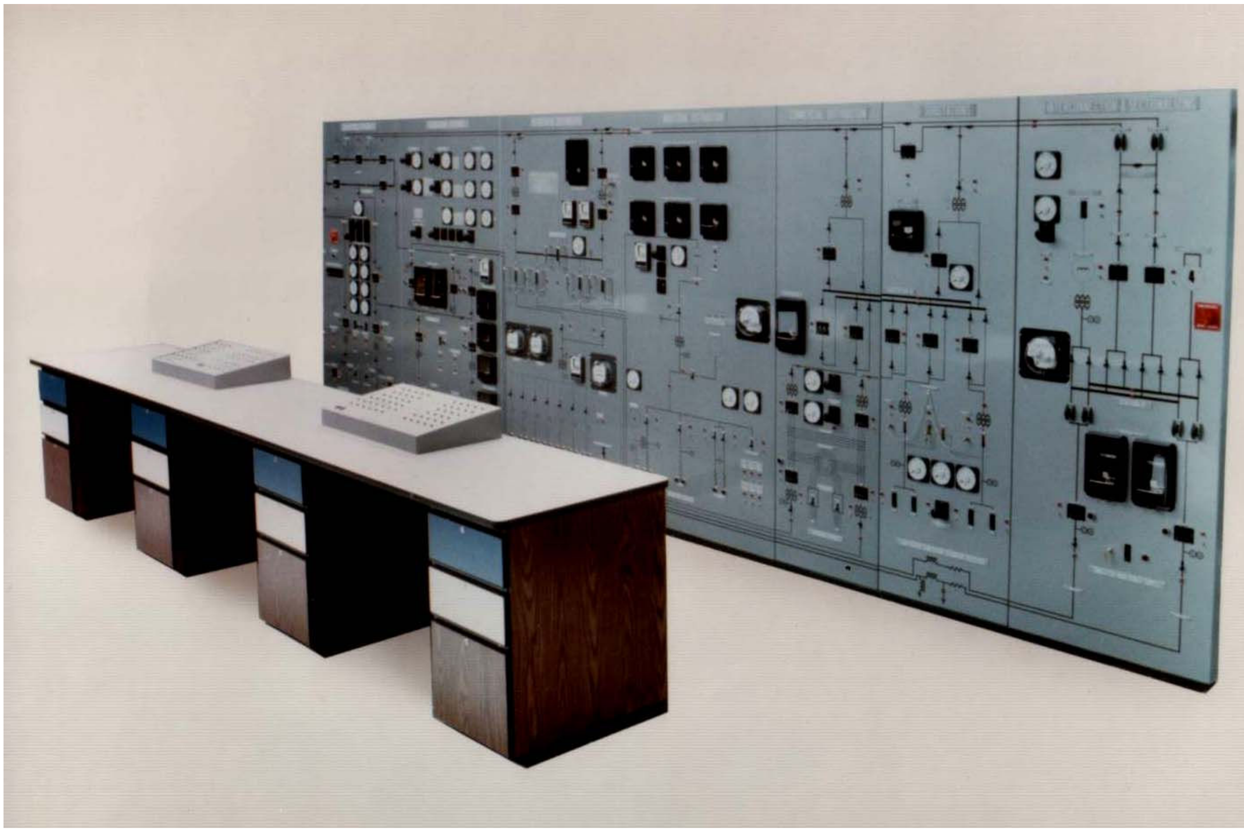

FIGURE 2
Hampden Model 180 Power System Simulator

An example of the one-line diagram graphics display on the remote SCADA system for the Power System Simulator is depicted in Figure 3.

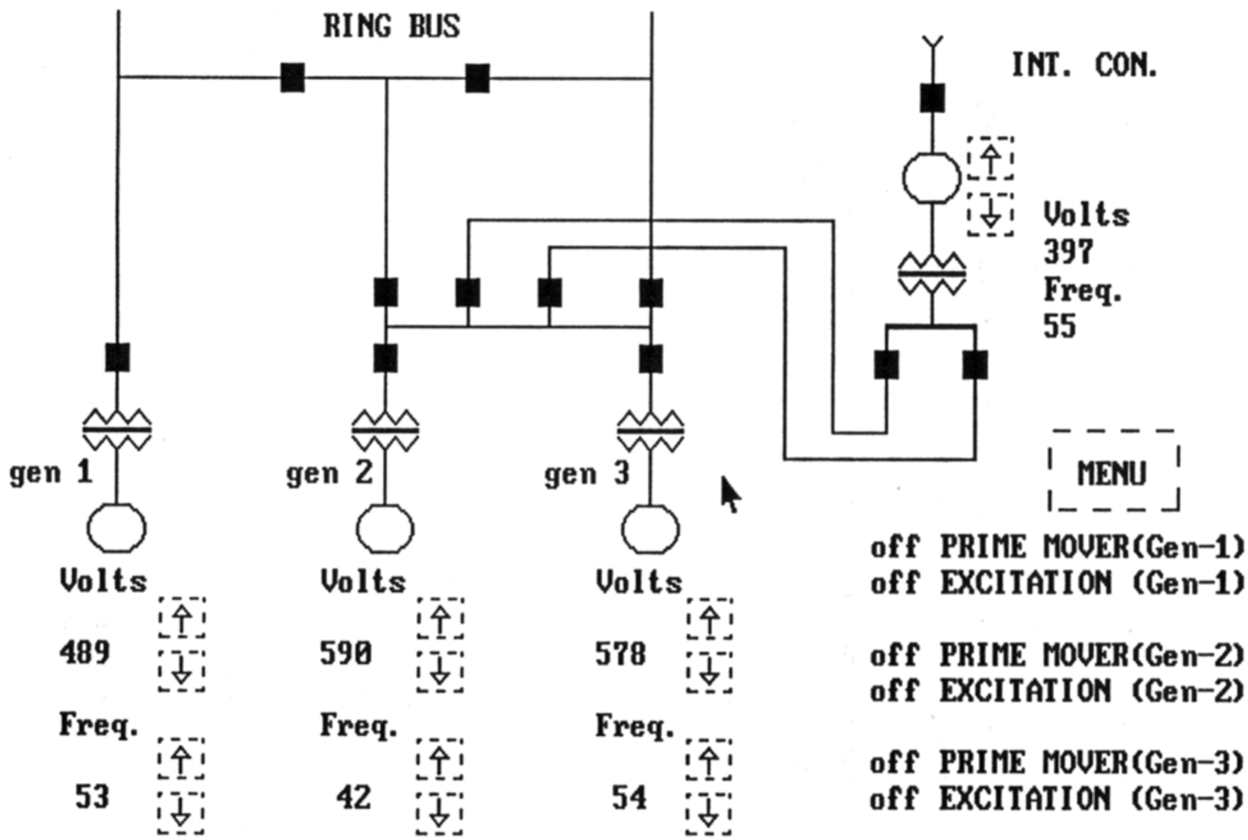

FIGURE 3
Remote SCADA System One-Line Diagram Example

Undergraduate Program

Presently, the Power Systems Simulator is being re-integrated into the laboratory section of an undergraduate course, Power Systems Analysis 1, at UPJ. Initially, the simulator will be used as a demonstration tool to reinforce the theoretical material studied in the lecture portion of the course. As the students become more familiar with the equipment, they will actually complete a set of laboratory assignments that have been designed for use with the simulator. An outline of the various laboratory assignments by topic is as follows:

INTRODUCTION

- A) Power Safety
- B) Familiarization of Equipment
- C) Grounding

GENERATION

A) Characteristics of Polyphase Alternators
B) Parallel Operation of Alternators
C) Power System Operation Costs
D) Frequency Regulation
E) Power Sources and Load Factors

TRANSMISSION

A) Transmission Lines – General
B) Overhead Transmission Lines
C) Parallel Transmission Lines
D) Underground Transmission Lines

DISTRIBUTION

A) Familiarization with distribution systems

SUBSTATIONS

A) Voltage Regulation
B) Transformers

PROTECTIVE RELAYING

A) Overcurrent Relays
B) Directional Overcurrent Relays
C) Differential Relays
D) Reverse Phase Relays
E) Reverse Power Relays
F) Network Reverse Power Relays

To further exploit the capabilities of the Power System Simulator, a sequence of courses will be redesigned to better utilize the simulator and to give the student a more advanced understanding of power system engineering concepts. The proposed courses and a brief description of each are as follows:

Power System Analysis 1

This course will introduce the student to the analysis of power generation, transmission and distribution systems. Topics will include the one-line diagram, per unit calculations, system modeling, three-phase fault calculations, and system protective devices.

Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition

Power System Analysis 2

This course will present more advanced topics in power system design and analysis. Topics will include load flow, unbalanced faults (utilizing symmetrical components), economic dispatch, and power system stability. There will be extensive use of the digital computer in these analyses.

Power System Analysis 3

Short-circuit current calculations are expanded to include unsymmetrical faults using symmetrical components. Economic design and operation of electrical utility power systems is introduced.

Power System Analysis 4

WATT/VAR control and load-flow studies utilizing numerical methods and the digital computer are introduced. Power system stability is considered with emphasis on transient stability and computer solutions.

Industrial Power Systems

This course is designed for ET students who desire to learn the essential parts and operation of a power system but with much less detail than the previously described courses. The course will describe industrial power system representation, per unit calculations, fault calculation and analysis, system circuit arrangements, voltage selection, low-voltage protective devices, system and equipment grounding, system over-voltages, voltage spread, power factor improvement, and industrial relaying.

Continuing Education & Graduate Program

Once the undergraduate program has been updated, the need exists to expand the program. A series of power engineering workshops will be designed. These workshops will provide recent EE graduates, who have graduated from colleges or universities not offering "power" in their curriculum, the opportunity to gain a basic understanding of power system operation and control. With this knowledge, recent graduates could pursue job opportunities in the electric utility industry.

In order to fulfill the requirements of a graduate program in power engineering, collaboration with other universities having similar power engineering curriculums would be necessary. With the Power Engineering Institute, UPJ would like to provide other schools offering advanced degrees in power engineering, the opportunity to utilize the Power System Simulator in their curriculums. UPJ has recently contacted the Pennsylvania State University regarding their Advanced School in Power Engineering [2]. Their program covers all aspects of modern electric utility and industrial power systems. The curriculum includes lectures, workshops, and visits to manufacturing, research, and electric utility facilities. In the near future, UPJ may become involved with this program for the purpose of providing "hands on" experiences with the Power System Simulator.

Electric Utility Industry

Regarding the electric utility industries, UPJ is presently contacting the electric utility companies in the local area to determine the needs and requirements for training newly hired power engineers. The plan is to establish a curriculum consisting of a variety of short courses. The short courses will cover the suggested topics recommended by the electrical utility companies. The faculty would consist of highly qualified engineers from electric utility companies, consultants, and power engineering professors. The duration of the program would be for either 1 or 2 weeks. The Power System Simulator would be an integral part of the curriculum. Living accommodations for the attendees could be provided by the university.

Summary/Conclusion

The Power System Simulator is a unique and expensive resource. The plan is to increase its usage in undergraduate education and make it available to a larger audience as a service to the electrical power industry. Preliminary work has been completed towards the establishment of a Power Engineering Institute at the University of Pittsburgh, Johnstown Campus. UPJ will continue efforts to verify the need for power engineering education and will seek support for the institute. The results of the research data will be utilized to establish the exact nature of the Power Engineering Institute. UPJ will also seek cooperative partners both educational and industrial in this enterprise.

In conclusion, there will always be a need for properly trained engineers in the field of electrical power generation, transmission, and distribution. The Power Engineering Institute and the Power System Simulator will prove to be valuable assets for the electrical power utilities in the future.

Bibliography

1. Hampden Model 180 Power System Simulator designed and manufactured by Hampden Engineering Corporation, East Longmeadow, Massachusetts.

2. "Advanced School in Power Engineering", established by The Pennsylvania State University, College of Engineering, Monroeville, Pennsylvania. http://www.engr.psu.edu/powerengineering

Biography

FRANK W. PIETRYGA is an Assistant Professor at the University of Pittsburgh at Johnstown. He graduated from UPJ in 1983 with a BSEET degree and completed his MSEE degree in 1993 at the University of Pittsburgh, main campus. His interests include power system engineering, AC/DC machinery, power electronics, and motor drive systems. Mr. Pietryga is also a registered professional engineer in the Commonwealth of Pennsylvania.

GREGORY M. DICK is an Associate Professor and Department Head of Electrical Engineering Technology at the University of Pittsburgh at Johnstown. Dr. Dick holds degrees from the University of Pittsburgh, Stanford, and the Pennsylvania State University and is licensed in the Commonwealth of Pennsylvania. He has taught at Pitt-Johnstown for 28 years. His areas of interest include Computing, Systems and Controls, Digital Signal Processing and the interface between technology and society.

JERRY W. SAMPLES holds a B.S. Ch.E. from Clarkson College, M.S. and Ph.D.in ME from Oklahoma State University. Dr. Samples served at the United States Military Academy twelve years before assuming the position of Director of the Engineering Technology Division at the University of Pittsburgh at Johnstown in 1996. He is currently serving as the Vice President for Academic and Student Affairs at the University of Pittsburgh at Johnstown.