Development of real life power systems learning facilities at CQUniversity

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Abstract

This paper discusses about the development of real life power system learning facilities at CQUniversity. Single Wire Earth Return (SWER) model is being built. Research and planning have been started to also develop Supervisory Control and Data Acquisition (SCADA) laboratory. These purpose built real-life power system facilities will provide a unique learning opportunity to researchers, practicing engineers, students and faculty members to conduct experimental work and perform various real life power system researches. It will also operate as a training centre for utilities to train their staff prior to starting their work.

Keywords: *Real life power system facilites, Single Wire Earth Return (SWER)***,** *Supervisory Control And Data Acquisition (SCADA)*

INTRODUCTION

The electric power industry enters the new century, powerful driving forces, uncertainties and new services are compelling electric utilities to make dramatic changes in the power system information infrastructure design. With these changes and development, the future power system engineers must be well trained and knowledgeable with the current technological advancement in power system and its communication infrastructure. Therefore, the best place for electrical power engineers to get hand-on experience is while studying in their respective learning environment (Amanullah, et al., 2005 a).

Real life SWER model and Real-life power system SCADA laboratory (PSSL) in CQUniversity will provide a unique learning opportunity to researchers, practicing engineers, students and faculty members to conduct experimental work and perform various real life power system researches. These facilities will be used for undergraduate laboratories facilities. It will also play a practical role in PBL scheme providing opportunity to students to visualize the real life power system. The successful completion of these facilities will take CQUniversity into the leading edge in power system education. This paper discusses the development of SWER and SCADA laboratories in CQUniversity learning environment.

DEVELOPMENT OF SWER MODEL

A few countries around the world, including Australia, have implemented Single Wire Earth Return (SWER) systems to supply power to rural communities and areas with small load densities. This method of transmission currently provides the most cost effective means of power transmission over large areas, although suffers from a number of issues that currently limit its use and development. Future testing opportunities using a physical system model will allow for further testing and analysis and provide possible means of system evolution and development. CQUniversity undertakes ample research into this particular field alongside Ergon Energy, and has recently completed a study showing how a SWER system can be modeled using software applications.

Comprehensive research, analysis and design have been made to build a physical SWER system that allows the user to vary load and load densities. This gives a realistic test bench from which system response can be physically tested and examined. The project consists of two major components, systems design and analysis, and construction and testing. The SWER distribution system which is being built will be a scaled replica based on the three phase supply voltages (415VL-L).

The system consists of various reactive and resistive elements used to emulate a typical transmission line length. Two winding transformers are used to step down voltage off the 3 phase backbone, as well as for distribution transformers. Furthermore, the physical system will be run with various loads, and used to support typical theoretical principles of operation, in order to ensure characteristic system response.

For the past decade, researchers at Central Queensland University have been looking at different ways to model SWER power distribution systems. During this time, a number of software models have been successfully implemented using software such as MATLAB, DINIS and PSCAD. These models have been used to demonstrate prominent and often undesired characteristics of SWER distribution, such as voltage regulation and transient response. In each of these cases however, there are a number of limitations to modeling such a system, and one piece of software cannot currently analyze all of the desired circuit responses. As a result, CQUniversity has proposed that a scaled SWER system be built for research and academic purposes.

The system is being installed in the Electric Drives Laboratory at CQUniversity, and will be used as a physical test bench for both research and academic purposes. The end product contains all of the elements that characterize an earth return system, to enable the system to react in the same way as a typical high voltage line.

This will allow for future testing with varying loads, transmission line impedances, distribution lengths, and voltage regulators such as fixed shunt reactors. A final distribution voltage of 240 volts will also allow for easier recording and analysis of results using the existing LABVOLT equipment and telemetry systems. A typical schematic diagram of SWER model is shown in Figure 1.

DEVELOPMENT OF SCADA SYSTEM LABORATORY

Modern power system fully employs SCADA system to monitor and control field devices and substations (Oza & Brahma, 2005). It is therefore vital to train future engineers in the university learning environment and be familiar with the industry systems such as SCADA. The purpose build will consist of several elements of power system. The SCADA facilities will be integrated with the SWER model so as to represent a total power system environment at the CQUniversity. This laboratory facility will consist of SWER as power system hardware, Remote terminal Devices (RTU), Communication facilities and control centre. A typical power system is shown in Figure 2. Power system data will be sent from control centre to RTU devices. The control signal can also be sent from RTU devices with control Centre. SCADA will be employed to monitor, protect and control the system.

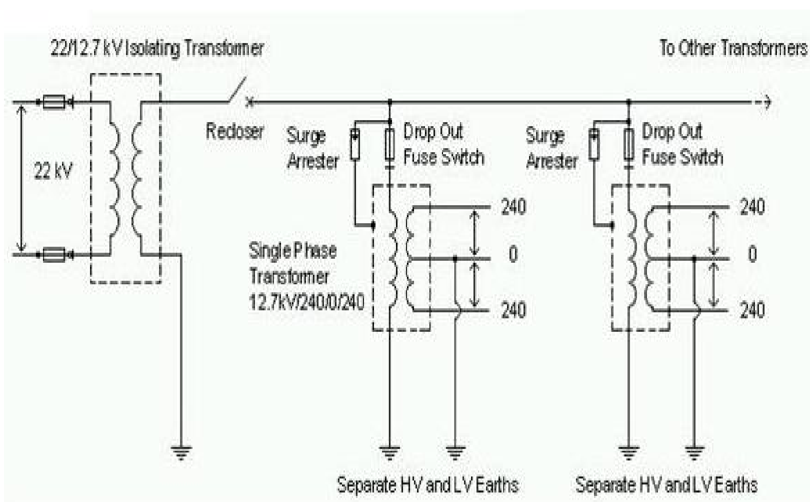

Figure 1: Typical schematic diagram of SWER model.

ENERGY MANAGEMENT SYSTEM

The EMS emulator consists of a computer embedded SCADA system, remote terminal devices (RTUs) and power system equipment.

Remote terminal unit

RTU device collects information from the field device as well as communicates with SCADA system. RTU devices are programmed such that it Synchronization with this three phase utility grid needs a lot of technical issues to be considered. Earthing arrangements, backup protection, power quality and stable current flow are some of the considerations that need to be taken on to account before synchronization. Frequency and voltage level matching can provide required instruction to the field device.

Modern power system communication protocol such as Distributed Network Protocol (DNP3) will be used to establish communication between RTU devices and control centre.

Master Station

The master station will be created with high speed computer embedded with CitectSCADA software. This is the centre point of the laboratory setup. Master Station is connected with RTU and other power system devices.

CitectSCADA allows user to input any command that will perform the expected task at the RTU and display the action on the graphic window. The primary function of SCADA is to collect information (data) and provide an interface to control specific equipment such as RTUs and intelligent Electronic Devices (IEDs). CietectSCADA had all the required powerful features and configuration tools to communicate with RTUs and IEDs.

Upon successful completion laboratory facility, future students will be able to understand about the following aspects of SCADA (Amanullah, et al., 2005 b):

- Control of IDEs or RTU from master terminal unit (MTU) using clear, concise, resizable graphics pages (screens),
- Techniques to perform single or multiple tasks using graphical control buttons to the graphic pages,
- Sophisticated animations designing to display the operating status and performance of the power system
- The way to show the status of a process or the state of an alarm by displaying text messages and graphics.
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- Configuring the CitectSCADA project in one language and displaying it in other language for overseas student,
- Specifying keyboard commands that operate universally (for all pages) or just for individual pages,
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- Specifying keyboard commands that operate universally (for all pages) or just for individual pages,
- The method to monitor, control, log, and display (in various formats) all alarms,
- Providing historical and real-time millisecond trending in graphical format,
- How to produce periodic and event-driven reports in Rich Text Format (RTF),
- The steps involved in monitoring product quality with Statistical Process Control (SPC) facilities,
- Developing a multi-layered security system that allows personnel access to the area or areas of the plant within their control,
- Exchanging plant-floor data with other applications for data analysis and post processing, or to control the power system.
- Other features such as templates, Genies, wizards, RAD Graphics, and automatic color

Communication with other devices is essential to show the file sharing capability of CitectSCADA. Live values of the some of the devices will be stored directly to MSExcel which will be running on another computer. This process allows users to monitor live data of the equipment of the power system from the server computer through MTU. Everyone can use these values for other purpose. This communication was done with the help of Microsoft Windows 2000 Dynamic Data Exchange (DDE) opportunities. In this project the communication with another computer was essential to show the file sharing capability of CitectSCADA. Live values of the some of the devices were stored directly to MSExcel which is running on another computer.

The Master Station will be deigned to serve as a platform from which students and users can perform various experiments in order to gain experience on the operation and control of power systems. The Master Station laboratory applications will enhance the students' perception of electrical power systems and their performance by graphically modeling the active control elements of the power system on a color computer screen as seen in Figure 2 (CITECT SCADA User Manual, 2006).

Figure 2: Typical SCADA display.

The SCADA laboratory facility with the integration of SWER model is shown in Figure 3.

CONCLUSION

The complete setup of power system facilities will provide power engineering system problems up front (design, experimentation and analysis), promote student teamwork and put engineering in a real-life context. It is hoped that this laboratory will help break down the conventional "barriers" between power systems and provide the students a clearer sense and more realistic picture of what the future holds for electrical power engineers. More specifically, it is desired that this laboratory setup will help students visualize power system phenomena in terms of the EMS equipment used by power system operators. The final completion of these facilities will also provide future opportunities for researchers and can be used as a training centre for utilities, faculty members, engineers and students. Upon successful implementation of this project, similar power system laboratory such as power system protection laboratory can be easily set up and implemented in other learning environments.

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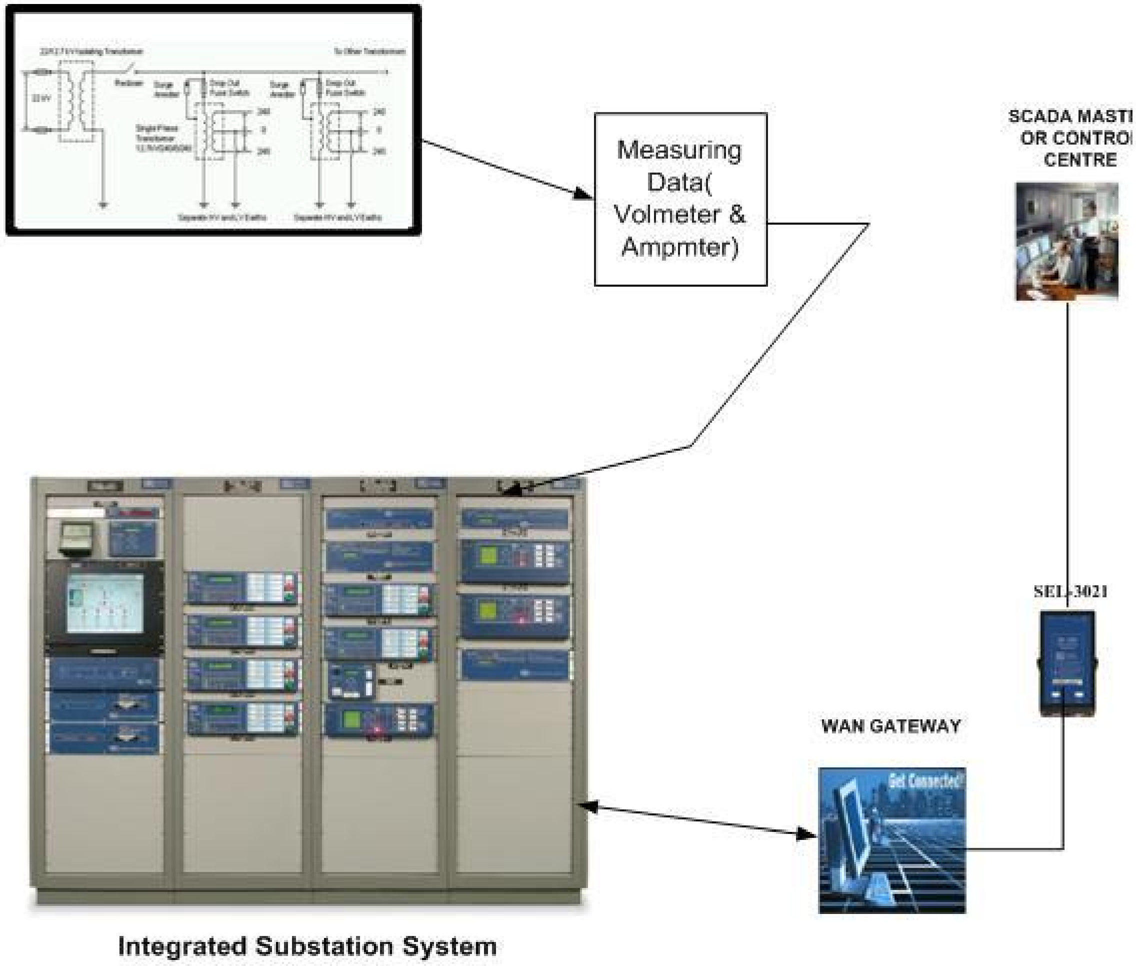

Figure 3: SCADA system laboratory setup.