Application of LabView as real time SCADA in power system transmission line

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Abstract
This study presents the application of LabView in real time monitoring and control of transmission line. National Instrument Compact Reconfigurable i/o (cRIO) devices interfaced with computer can act as SCADA in the system. The cRIO can perform acquisition of voltage and current data with input modules and at the same time can transmit, process and display data and as well as retrieve historical data for studying. With recent technology advances the measurement and protection of power system has become much simpler and convenient.

Keywords: LabView, transmission line, cRIO

Introduction
Earlier data acquisition was carried out manually, recording data from multimeter or other instrument. This method is become cumbersome for handling large number of data and not acceptable where recording are necessary. Modern power systems are normally complex network consisting of huge data volume. (Zhang et al., 2010) stated that demand for electrical energy has been increasing sharply which in turn demand for smart grid with inbuilt communication and information technologies. With introduction of new technology/methodology in power system it has become necessary to examine the interactions of system dynamics. Laboratory Virtual Instrument Engineering Workbench (LabView) is a powerful and flexible instrumentation and analysis software application tool which was developed in 1986 by the National Instruments (National Instruments, 2002). (Pecen et al., 2004) has stated that LabView has become a very important and promising tool in today’s growing technologies. LabView is used in academic, industry, and government organization for data acquisition, controlling and analysis software. (French, 1998; Bishop, 2001; Hennessey, 2001; Ertugrul, 2002; Franz, 2003;) explained in detail the basic, virtual instruments, programming of Lab View Software as well as testing, acquisition, measurement, control, protection of data using Lab View software. LabView became widely used in data acquisition across varied industries which significantly resulted in arousing the interest of and researchers to research and explore on the application of Lab view further. Reliability in the form of precision of data acquisition method used has become very significant in technological research work as the selected data acquisition method can cause major impacts on the outcomes and Lab View software is gaining increasing significance in research work in the area of data acquisition due to its reputation of precision in data acquisition.

Faults in power system cannot be avoided. Fault may occur in transmission lines as a result of natural events or accidents. (Glover, 2007) stated that in order to ensure stability and continuity of service, the faulty area of the circuit should be isolated within minimum time delay. This paper is an attempt to discuss and present conception real time monitoring and controlling of transmission line. Various methods of fault detection, classification and isolation can be implemented on the test bed set up in Fig 2. This study will give a platform to explore real-time operational analysis and real life challenges in power system.

Architecture of the Test-Bed
The test bed considered in this study is a 3-phase transmission line module of 360 km of π-model. The test bed system consists of power supply unit, transformer, transmission line model panel, power analyzer panel. The three-phase power
from the power supply unit is given to the transmission line module through transformer. To begin with, the hardware systems setup was connected properly. The data acquisition system NI cRIO-9067 devices based on LabView was setup. The single line diagram of the hardware test bed system is given in Figure 1. An image of the test bed hardware setup is shown in Figure 2. Table 1 represent data of test bed. Figure 3 presents the schematic of Programmable Automation and Control technology of test-bed. The users write programs for National Instrument Compact Reconfigurable i/o (cRIO) with LabView through Host PC. Also Host PC provides user interface and control of the executed program of cRIO. We have used National Instruments Controller with 667 Mhz Dual-Core ARM Cortex-A9 processor running in the NI Linux Real-Time, also integrated Chassis has Artix-7 FPGA. LabVIEW 14 Version was used for programming and implementation of logics. For the compilation process LabVIEW uses Xilinx Vivado 2013.4 as Compilation Tool.

Table 1: Data of the test-bed

<table>
<thead>
<tr>
<th>Scale factor</th>
<th>Voltage</th>
<th>380V:380KV=1:1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>1A:1000A=1:1000</td>
<td></td>
</tr>
<tr>
<td>Line parameters</td>
<td>resistance</td>
<td>R_L=13Ω</td>
</tr>
<tr>
<td></td>
<td>inductance</td>
<td>L_L=290mH</td>
</tr>
<tr>
<td></td>
<td>mutual capacitance</td>
<td>C_L=0.5µF</td>
</tr>
<tr>
<td></td>
<td>earth capacitance</td>
<td>C_E=1 µF</td>
</tr>
<tr>
<td>Earth return parameter resistance</td>
<td>R_E=11Ω</td>
<td></td>
</tr>
<tr>
<td>Natural Load</td>
<td>600MW</td>
<td></td>
</tr>
<tr>
<td>Characteristic impedance</td>
<td>340Ω</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Single line diagram of two bus system

Figure 2: Image of hardware setup system.

Figure 3: Programmable Automation and Control technology of test-bed

National Instrument Labview

LabView is a system design graphical programming environment based on the concept of data flow programming. LabView is extremely flexible and commonly used for data acquisition, instrument control, data processing and industrial automation. LabView library includes program development, signal generation, digital signal processing (DSP), linear algebra, measurement, numerical methods, instrument control, control systems, neural network and fuzzy logic. Since LabView is based on graphical programming, users can setup instrumentation called virtual instruments (VIs) using software objects. Using proper hardware, these VIs can be used for data acquisition, design, analysis and distributed control. The built-in library of LabView has a number of VIs that can be used to develop and design any system. LabView can be used to inscribe the needs of various courses in a technology and science curriculum. LabView can give command to the DAQ boards to read analogue input signals (A/D conversion), generate analogue signals output (D/A conversion), read and write digital signals, and manipulate the on-board counters. The voltage and current data goes through the plug-in DAQ board in the computer, which sends data into a host computer memory for storage, processing, or other monitoring.

The traditional LabVIEW applications are classified into two portions: one portions is front panel, which is the graphical user interface (GUI), on which the parameters necessary to examine and how to improve the performance of transmission line represented. These parameters consist of Voltage and current characteristics of the transmission line. Figure 4 shows the front panel of the LabView GUI created. It may be observed that front panel show all the necessary parameters
instantly. The other portion is the block diagram which is the heart of the whole software. The code is developed in flow chart-style with the functional blocks (VIs).

Figure 4: Front panel of the LabVIEW GUI

Real Time Monitoring

National Instrument Compact Reconfigurable i/o (cRIO) is reconfigurable Embedded Design Platform that permit users to promptly develop embedded control or acquisition systems [6]. The LabView 14.01 and cRIO devices were set up to acquire data from the test bed. The cRIO devices, cRIO 9067 reconfigurable control and acquisition systems has been implemented to monitor real time parameters of the hardware set-up. NI cRIO-9067 combines a dual-core processor, a reconfigurable FPGA, and eight slots of C Series I/O modules within one chassis. Featuring a 667 MHz dual-core ARM Cortex-A9 processor running the NI Linux Real-Time OS and an Artix-7 FPGA, this system is well-suited for advanced embedded control and monitoring applications. The device features 512 MB of DDR3 memory for embedded operation, 1 GB of nonvolatile memory for data logging, and a wide range of connectivity options including Gigabit Ethernet, USB device, USB host, and serial ports. The cRIO systems consist of a real time processor running Real Time Operating System (RTOS) and also a Field Programmable Gate array (FPGA) backplane for accessing the I/O s with the RTOS and FPGA working together to ensure real time performance. The c series I/O modules used for the study are-NI 9244 and NI 9227. The NI 9244 module has 3 single-ended channels, 50 kS/s per channel simultaneous sample rate with 400 Vrms L-N, 800 Vrms L-L measurement range & 24-bit resolution and NI 9227 C Series current input module was designed to measure 5 Arms nominal and up to 14 A peak on each channel with channel-to-channel isolation with 50 kS/s/ch simultaneous sample rate. The real time data acquisition ensures precise control within specified time limit. The monitoring and control methods are implemented using the LabView RT and FPGA Modules on a Host PC. The program is downloaded to the cRIO controller and FPGA for compilation and execution. The LabView Virtual Instruments (VIs) are used to monitor and control (if desired) the RT System and Controller simulation. The National Instruments data acquisition modules are hot swappable input and output analogue and digital modules which are also used to pass signals between the cRIO controller and the RT power system simulation. The inputs and outputs of the NI c series I/O modules were mapped in LabView VIs in the host PC. Then the data acquisition settings for the I/O modules such as the number of channels, data type, data buffer length, and sampling rate programmed in VIs. This ensures that the data monitored by the current and voltage monitor modules are correct and matching with the other measuring systems output.

The LabView program is developed in two parts. The first part is the FPGA program which is used to access the Digital and Analog Input/Outputs. Figure 5 shows the FPGA program where the Analog Data read from module 7 of the cRIO and sent to the RT using a FIFO. This program runs continually and serves data to RT based on need basis. The next part of the program is the RT program which is shown in Figure 6. The RT program first establishes a connection with the FPGA program. It then starts acquiring the data coming from the FPGA using FIFO. This FIFO uses DMA method reducing the RT processor usage and the acquired data can be logged to the files. For further study the acquired data may be processed for analysis of power quality, voltage management and load management. The NI 9482 module which consist of 4-channel, single-pole single throw (SPST) sourcing digital output module can be implemented to control the protection switch. And logic can be developed to identify and classify the types of fault occurring in the system.

The transmission line of the test-bed is kept in no-load condition. The voltage waveform acquired is shown in Figure 7. L1-Ground fault is introduced at the end of 360Km transmission line. Figure 8 and Figure 9 shows voltage waveform and current waveform for the transmission line when L1-Ground fault occurs in the system. It is observed in Figure 8 that when fault occurs L1 voltage reduces and when L1-Ground fault occursL1 and neutral current increases as shown in Figure 9.

Figure 5: LabView Block diagram of FPGA program
National Instrument Compact Reconfigurable i/o (cRIO) devices were realized as SCADA using Programmable Automation and Control (PAC) technology. LabView software and cRIO interfaced with computer can be used to monitor the transmission line. The NI cRIO FPGA are reconfigurable if in case design problem is detected at testing stage the chip can be reprogrammed after certain changes are made in the design. The test-bed can be exploited to study new protection methodology and their performance.

**Conclusion**

**References**


