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Design and Implementation of SCADA System Based Power Distribution for Primary Substation (Control System)

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Abstract- SCADA stands for Supervisory Control and Data Acquisition. SCADA system is more porpular than other control system in the modern industrial processes. This research describes the automated switch control for SCADA based electrical distribution system of primary substation by using PLC. The objective of this research is to transform the manual control system to automated switch control system in Myanmar. There are four main portions in SCADA based electrical distribution system. They are automated control system, interfacing units, monitoring system and networking system. The automated control system is emphasised in this research. This system can be accomplished by using PLC ladder diagram. This automated distribution system is analyzed to develop a secure, reliabe and convenient management tool which can use remote terminal units (RTUs). The simulations based approach automated system are demonstrated in this research. According to the simulation results, the proposed automated control system using PLC are met with the desired control environment with high performance stage. This system is efficient and reliable for conventional electrical distribution system in Myanmar by using SCADA based technology.

Keywords – Programmable Logic Controller,electrical distribution for primary substation, SCADA.

I. INTRODUCTION

SCADA (supervisory control and data acquisition system) refers to the combination of telemetry and data acquisition. SCADA encompasses the collecting of the information via a RTU (remote terminal unit), transferring it back to the central site, carrying out any necessary analysis and control and then displaying that information on a number of operator screens or displays. A SCADA system gathers data from sensors and instruments located to remote sides.Then, it transmits data at a central site for controller monitoring process. SCADA system consists of one or more field data interface devices (RTUs or PLCs).A communication system such as radio, telephone, cable, satellite, etc.A central host computer sever or severs (also called a SCADA center, or Master Terminal Unit (MTU)). A collection of standard and/or custom software (Human Machine Interface(HMI)). Critical infrastructure systems include critical physical processes. These processes are controlled by automation systems which combine humans, computers, communications, and procedures. Automation systems are used to increase the efficiency of process control by trading off high personnel costs for low computer system costs. They also contribute to improve performance by taking advantage of faster computer control instead of human reaction times. These automation system are often referred to as process control system (PCS) or supervisory control and data acquisition (SCADA) systems, and the widespread use of such systems makes them critical to the safe, reliable, and efficient operation of many physical processes.

II. SCADA BASED AUTOMATED SWITCH CONTROL FOR POWER DISTRIBUTION SYSTEM

A. Scada Based Substation Automation System

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The broad architecture of a SCADA involves physical equipment such as switches, pumps, and other devices able to be controlled by a Remote Telemetry Unit (RTU). The dual roles of the master computers are to provide the information such as meter readings and equipment status to human operators in a digestible form and to allow the operators to control the field equipment in predefined ways. Most SCADA deployments choose to restrict access to the master computers, and interface with the system using operator consoles which communicate with the master computers over a network.

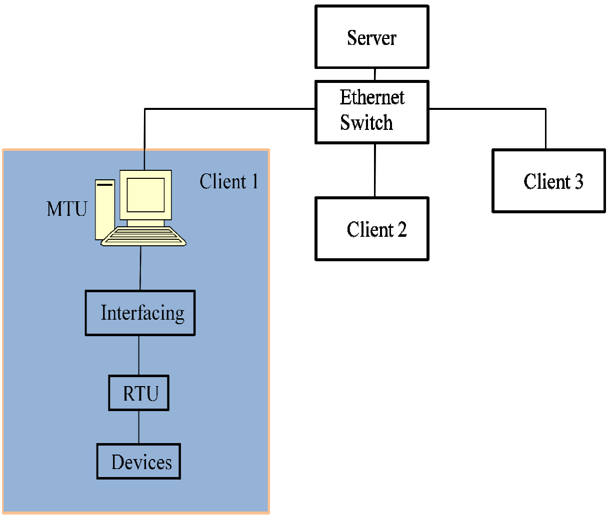

Figure1 : Block Diagram of SCADA System

Master Terminal Unit(MTU) – allows operators to view the state of any part of the plant equipment and drives most operator interaction with the by alarms. It provides displays of process status information, including alarms and other means.

Interfacing – allows communications equipment from different manufacturers to be connected together. The RS-232 or RS-485 interface is designed for the connection of two devices. Two devices called: DTE (Data Terminal Equipment) communicates with a DCE device and transmits data and receives data and DCE (Data Communications Equipment) transmits data between the DTE and a physical data communications link.

Remote Terminal Unit(RTU) – means a microprocessor-controlled electronic device and contains setup software to connect data input streams to data output streams. RTU may include a battery or charger circuitry. It is accomplished by using an isolated voltage or current source. In SCADA system, RTU is a device that collects data, codes the data into a format that is transmittable and transmits the data back to MTU. It also collects information from the master device and implements processes that are directly by the master. RTUs are equipped with input channels for sensing or metering, output channels for control.

Intelligent Electronic Devices (IEDs) - includes electronic meters, relays and controls on specific substation equipment. It has the capabilities to support serial communications to a SCADA sever and reports to modern RTU via communication channels. It performs all functions of protection, control, monitoring, metering and communication.

B. Control Actions for Remote Terminal Unit(RTU)

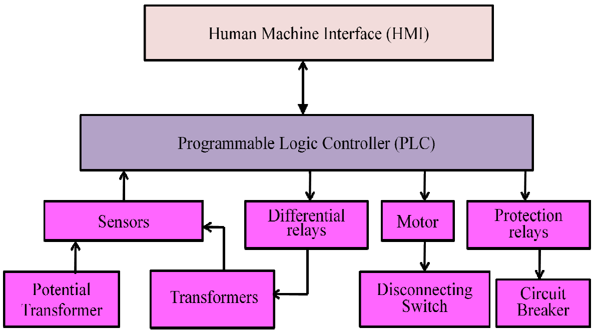

Figure 2: Remote Terminal Unit(RTU)

C. Automation System Model

A distribution substation needs devices such as the following intelligent electronic devices:

- Potential transformers (PT)
- Current transformers (CT)
- Main transformers
- Disconnecting switches (DS)
- Circuit breakers (CB)

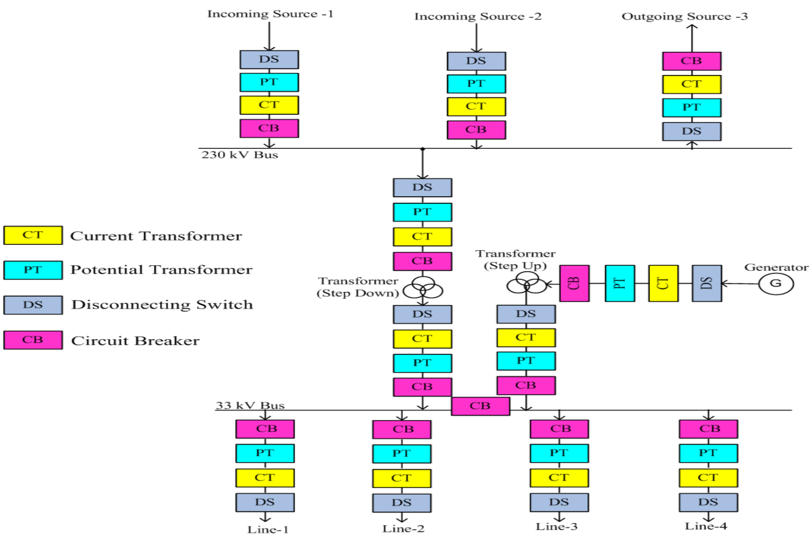

Figure 3: Block Diagram of Distribution Substation

D. Data Assignment of Distribution Substation Project

The external input and output devices connected to the PLC must be determined. The input devices are various switches, and emergency switches etc. The output devices are relays, overload devices, circuit breakers, indicators etc.

Table 1. Assign for I/O devices of primary substation

No.	Tag Names		Types	I/O Devices	Address
1.	Generator source	G-1	Digital	Input device	X-3
2.	Incoming power source-1	S-1	Digital	Input device	X-1
3.	Incoming power source-2	S-2	Digital	Input device	X-2
4.	Disconnecting switch-1	DS	Digital	Input device	X-31
5.	Disconnecting switch-2	DS	Digital	Input device	X-32
6.	Disconnecting switch-3	DS	Digital	Input device	X-33
7.	Disconnecting switch-4	DS	Digital	Input device	X-34
8.	Disconnecting switch-5	DS	Digital	Input device	X-35
9.	Disconnecting switch-6	DS	Digital	Input device	X-36
10.	Disconnecting switch-7	DS	Digital	Input device	X-37
11.	Disconnecting switch-8	DS	Digital	Input device	X-40
12.	Disconnecting switch-9	DS	Digital	Input device	X-41
13.	Disconnecting switch-10	DS	Digital	Input device	X-42
14.	Disconnecting switch-11	DS	Digital	Input device	X-43
15.	Incoming circuit breaker-1	ICB-1	Digital	Output device	Y-0
16.	Incoming circuit breaker-2	ICB-2	Digital	Output device	Y-1
17.	Transformer circuit breaker	TCB	Digital	Output device	Y-2
18.	Outgoing circuit breaker	OCB	Digital	Output device	Y-3
19.	Distribution circuit breaker-1	DCB-1	Digital	Output device	Y-4
20.	Bus-coupling circuit breaker	BCCB	Digital	Output device	Y-5
21.	Feeder circuit breaker-1	FCB-1	Digital	Output device	Y-6
22.	Feeder circuit breaker-2	FCB-2	Digital	Output device	Y-7
23.	Feeder circuit breaker-3	FCB-3	Digital	Output device	Y-10
24.	Feeder circuit breaker-4	FCB-4	Digital	Output device	Y-11
25.	Generator circuit breaker	GCB	Digital	Output device	Y-12
26.	Distribution circuit breaker-2	DCB-2	Digital	Output device	Y-13

E. System Flowchart

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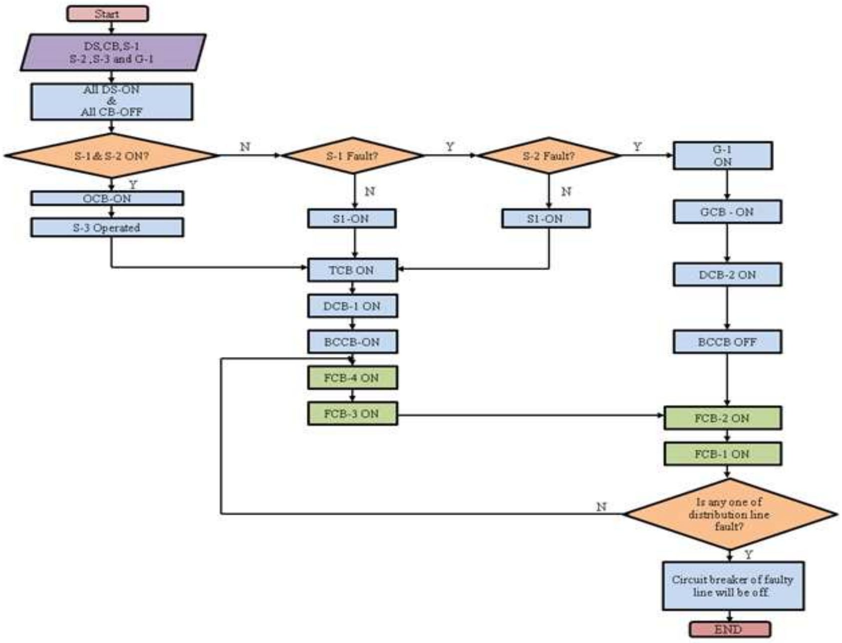
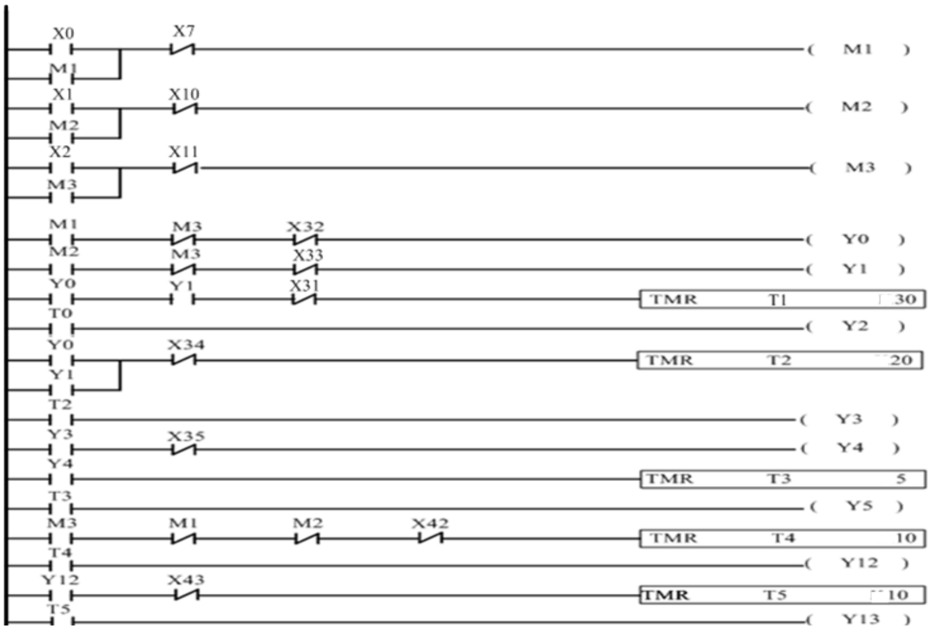


Figure 4: Flowchart illustrates the operation of distribution substation

F. The Analysis Process used PLC Ladder Diagram



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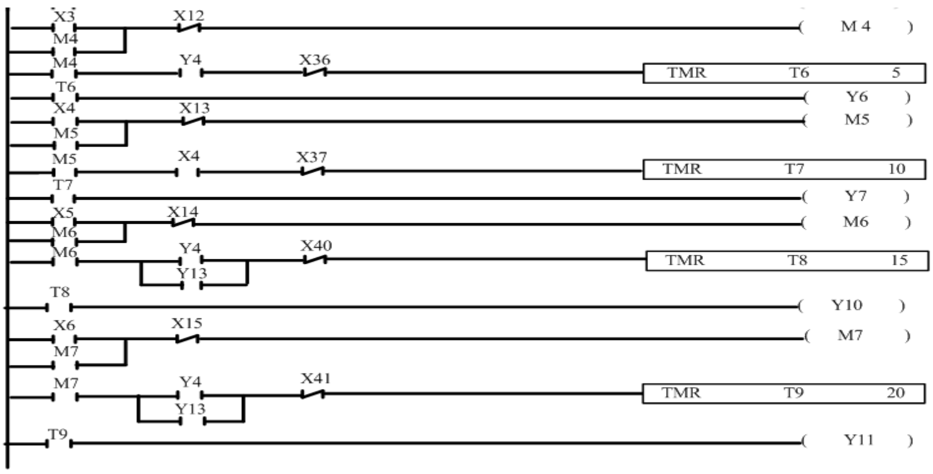
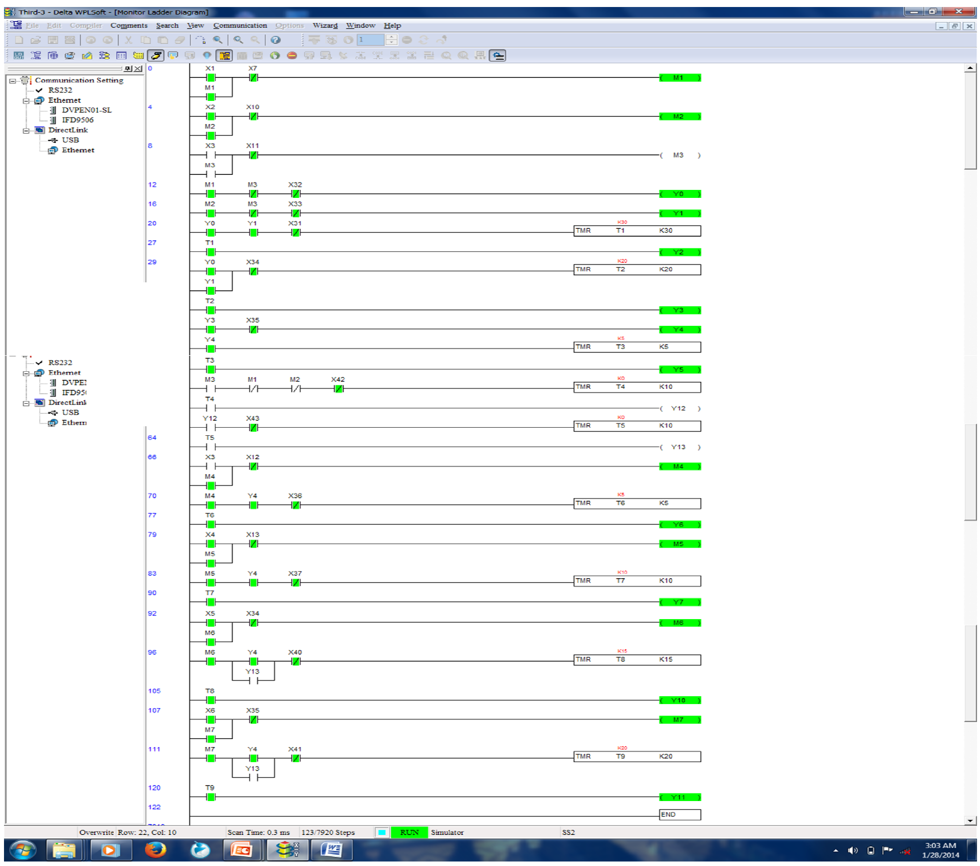


III. SIMULATION RESULTS USING WPL SOFTWARE

A. A Simulation Result when Incoming Power Source-1 and Source-2 are active



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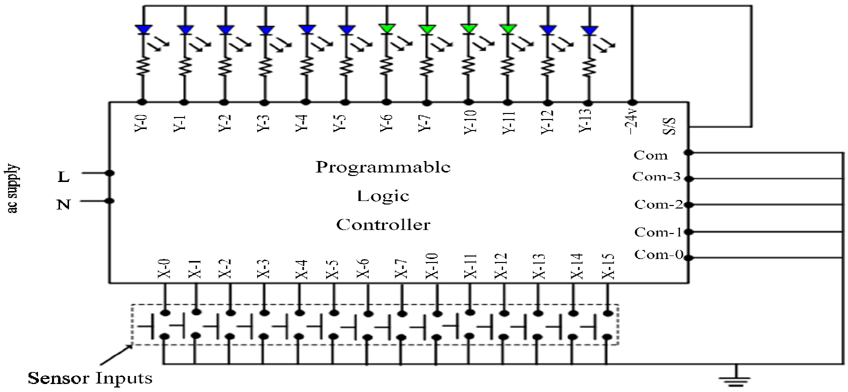
B. Circuit Diagram for Input and Output of PLC using IVC 1-1614 MAR

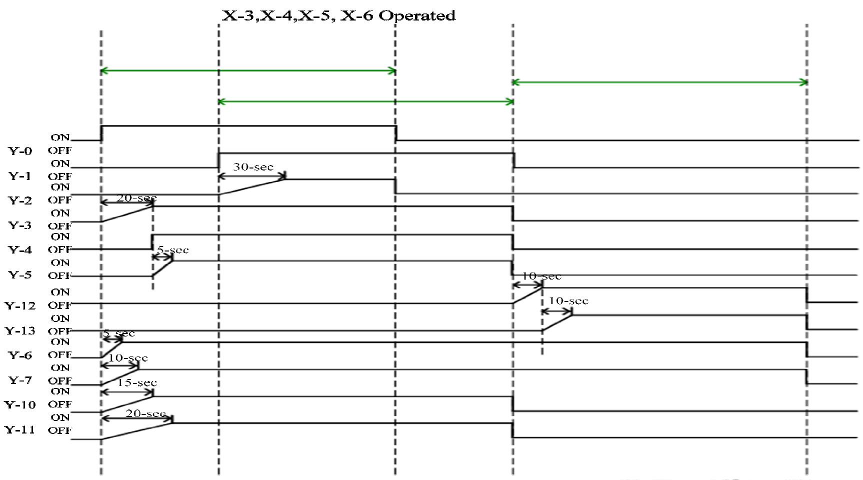


C. Tests and Results by using Auto-Station Software

(a) (b)

Figure 5: Simulation of (a) Both Incoming Power Source-1 and Source-2 are active and (b) generator's operation

D. Timing Diagram



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IV. CONCLUSION

SCADA provides management with real-time data on production operations, implements more efficient control paradigms, improves plant and personnel safety, and reduces costs of operation.The security of SCADA systems depends on the effective application of security principles and technology to the SCADA system. This paper has proposed a model that illuminates the categories of data, functionality, and interdependencies present in a SCADA system. The model serves as a foundation for further research on how to best apply technical security controls to SCADA systems in a way that is consistent with the operation and mission of that system. SCADA system is one of the most important legacy systems of the smart grid systems. PLC based control system to implement the SCADA system for Power Distribution system has been developed. There are four conditions for PLC simulation tests to implement the proposed system. All conditions for switch control stage are mentioned. The overall flowchart for proposed control system is also mentioned. It evolved from independent systems with little connectivity to networked system.

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