A REPORT

ON

Substation Automation System

BY

AYUSH AGRAWAL 2018A8PS0568G

AT

RMJ AUTOMATION SOLUTION & TRAINIG PVT. LTD.

A Practice School - I/II station of

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI

(May, 2020-June, 2020)

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AYUSH AGRAWAL	2018A8PS0568G	ELECTRONICS & INSTRUMENTATION

Prepared in partial fulfilment of the Practice School – I Course Nos.

BITS C221/BITS C231/BITS C241

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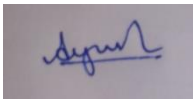
Abstract

Green and sustainable power is the need of the day. With widening supply and demand gap, power management has become one of the most critical areas of concern all over the world. India's energy consumption is increasing at one of the fastest rates in the world. Hence, we require Substation Automation Systems in the present day substations to efficiently control and deliver power .There is demand for a substation automation system that is simple to integrate and provide high performance and flexibility. The increasing installation of Intelligent Electronic Devices (IEDs) provides interoperability and advanced communications capabilities in substation protection, coordination, control, monitoring, metering, and testing. All devices in substation are controlled, protected and monitored by substation automation system (SAS) that collects information from the power equipment (process) and performs actions on it. Communication network is a fundamental element in all automation system and network performances can have a critical impact on the control process.



Signature of Student: **Signature of PS Faculty:**

Table of Contents

Cover……...……..…….1

Title Page……...……2

Acknowledgement……...……..3

Abstract……..4

Table of Content…….....6

About the Organization……..……7

Introduction……8

Substation……..10

Automation……12

-PLC……12

-SCADA……..13

-HMI……14

-Softwares Used……...14

Substation Automation System…….....15

Implementation……...16

Timeline…….....18

Conclusion……..22

References……..23

Glossary……..24

About the Organization

RMJ Automation solution & Training Pvt. Ltd is a Mysore Based company and one of the leading Automation Training provider in Sensors, Actuators, PLC, SCADA, HMI & Drives. RMJ also provides engineering, consultancy and system integration services for Industrial Automation projects to various industries in India. RMJ is committed to provide quality-training services as a bridge between the technical academic institute and industry. RMJ provides generic training on automation products like Sensors, Actuators, PLC, SCADA, HMI and Drives of many companies. Their training comprises of 30% theory and 70% Practical's along with animations to explain students very easily the Core topics. They also provide trained manpower in PLC / SCADA / DCS automation. Their clients include companies like MYPOL, MYSTEEL, UB Group, Vizag Steel Plant and many companies and colleges across Karnataka.

Introduction

Over the years, there has been increasing competition in the industry over the demand for high-quality products and services, along with the perpetual need for increased productivity. Industrial Automation is one of the key parts of the solution to this problem, along with process engineering. Automation is the technology by which a process or procedure is performed with minimal human assistance. Industrial automation is a set of technologies that uses control systems and devices, such as computer software, to control industrial processes and machinery by removing as much labour intervention as possible and replacing dangerous assembly operations with automated ones. Automation covers applications ranging from a household thermostat controlling a boiler, to a large industrial control system with tens of thousands of input measurements and output control signals. In control complexity, it can range from simple on-off control to multi-variable high-level algorithms. Industrial Automation is the replacement with computers and machines to that of human thinking. Doing this not only reduces costs and saves time, but also eliminates the possibility of human error, which facilitates higher quality goods and consistency among these produced goods. Some of the other advantages of automation include - efficient use of raw materials, reduced energy consumption, increased safety, better data collection, and assisted remote monitoring. Industrial automation is closely linked to control engineering.

A substation is a subset of electrical generation system, transmission system, and distribution system. Substations perform several important functions like transforming voltage from high to low, or the reverse. Electric power may flow through a lot of substations at different voltage levels before reaching the consumer from the generating station. A substation may include transformers at the interconnection of two different transmission voltages or to change voltage levels between high transmission voltages and lower distribution voltages.

Demands for better quality electricity and the evolution of the electric generation are the most significant factors for progressing substation automation. Interruption’s cost in electricity supply is increasing and the electricity distribution companies want to reduce it and offer better quality

electricity. Substation automation has critical role for these matters. Changing to automation system is the best way to increase reliability in online conventional substation because the new system can work beside old system as subsidiary system in parallel mode. Substation Automation uses data from IEDs to remotely monitor and control the processes in a substation. It helps in building a smarter, more reliable power grid. The health monitoring of the grid is becoming more and more difficult since the rise of technology. The dynamic real time measurement has come into effect since nobody knows that what is going to happen in the next second and therefore. Substation automation includes processes associated with generation, transmission and delivery of power. Using Substation Automation for monitoring and control of power transmission systems in the substation and on the pole not only reduce the occurrence of outages but also shorten the duration of outages that do occur.

Substation

A substation is a part of an electrical generation, transmission, and distribution system. The electrical substation is the part of a power system in which the voltage is transformed from high to low or low to high for transmission, distribution, transformation and switching. A substation mainly consists of transformers to change voltage levels between high transmission voltages and lower distribution voltages, or at the interconnection of two different transmission voltages. A typical distribution substation consists of mainly transformer, bus-bar, conductor, breaker, isolator, protection devices etc

Types of Substation

A. Transmission Substation - A transmission substation connects two or more transmission lines. A transmission station may have transformers to convert between two transmission voltages that is to step-up or step-down the voltage. It is further divided into three types-:

a. Step-up or Primary Substations – Used to step up the voltage.

b. Primary Grid Substations - Used to lower the voltage which was stepped up by primary substation.

c. Step-down Substations – Used to further step down for primary distribution.

B. Distribution substation - A distribution substation transfers power from the transmission system to the consumers of a particular area where the substation is located. Unless it is a critical consumer or high power consumer, voltage needs to be stepped down to supply to regular customers.

C. Collector Substation - A collector substation is typically located near a distributed generating station such as a wind farm or a solar farm. It is similar to distribution substation but with one main difference, that is the power flows in reverse direction, from wind turbines or solar plates to the transmission grid.

D. Converter Substation - Converter substations are typically associated with HVDC converter plants, traction current or to interconnect non-synchronous networks. They mainly consist of power electronic equipment to alter the frequency of current or else convert from alternating current to direct current (AC to DC conversion) or vice-versa.

E. Switching Station - A switching station operates at a single voltage level and thus lacks transformers. It may be sometimes used as a collector substation. Their main function is to switch the current to back-up lines or parallelize the circuits in case of failure.

F. Industrial Substation - Industrial substation is also known as bulk substation and is a special type of distribution substation. They are built near industries for a specific industry which demands quite a heavy load.

Automation

Automation is controlling the power system through instrumentation and control devices. It uses data from Intelligent Electronic Devices (IEDs) and control commands from remote users to control the power system. It is the process of acquiring or collecting data measured in the form of current and voltage and sent to the operators. Computer processing and personnel monitoring takes place. From the data monitored, operators send command messages to a device to operate power system devices. Every electrical device must be protected from overcurrent conditions. If the origin of overcurrent is within the local area then automatically current is interrupted immediately. And if the origin is outside the local area, then a backup provision interrupts the current after some time delay.

PLC

A programmable logic controller or programmable controller is an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, or robotic devices, or any activity that requires high reliability, ease of programming and process fault diagnosis

Programmable Logic Controller. These are similar to RTUs, but are more often deployed without their own power supply and using wired communications. They are more often found on a plant oor or factory, where controllers are close to the centre of control.

SCADA

Supervisory control and data acquisition (SCADA) is a control system architecture comprising computers, networked data communications and graphical user interfaces (GUI) for high-level process supervisory management, while also comprising other peripheral devices like programmable logic controllers (PLC) and discrete proportional-integral-derivative (PID) controllers to interface with process plant or machinery. Sensing and actuation elements: sensors translate temp, pressure, flow, level, torque, displacement, etc. to convenient electrical or pneumatic forms of info. Signal conditioning element: serves the function of altering the nature of signal generated by sensing element. Signal processing element: Processes signal to remove noise, assesses health of sensor, obtains output which is linearly related with the physical measured, and amplification.

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HMI

Human Machine Interface sometimes called the (Man Machine Interface) MMI or (Human Computer Interface) HCI. These are nodes at which control engineers monitor their plants, factories, pipelines, and field devices. Often found in control rooms, but sometimes dispersed across the plant oor. These are often running a well known operating system and any internet reachability is of particular concern as these nodes are in control of field or plant devices. Anecdotally, changing a display on an HMI can cause an operator to perform a detrimental safety critical action under false pretences, in a similar manner to Phishing attacks on banking customers today.

Softwares Used

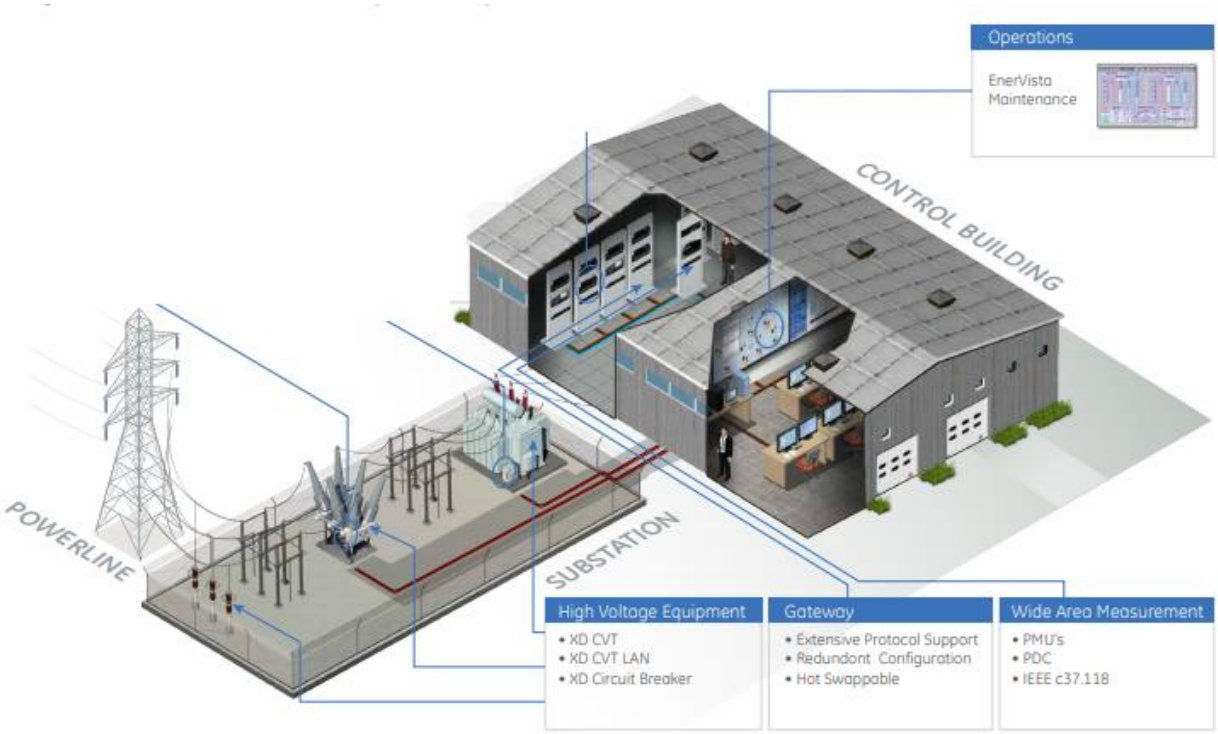
- WPLSoft -WPLSoft is program-editing software made for the Delta DVPPLC series used under WINDOWS. Except for general program planning and other general functions (e.g. cut, paste, copy, multi-windows, etc.) of WINDOWS, WPLSoft, in addition, has provided various Chinese/English commentary-editing and other special functions (e.g. survey and edit the listed register, the setup, the data readout, the file saving, and monitor and set up diagrams of various contacts, etc.).

- Control Expert - EcoStruxure Control Expert (formerly known as Unity Pro) is a unique software platform to increase design productivity and performance. It integrates easily with field devices.

- Citect SCADA – Citect SCADA is a reliable, flexible and high performance Supervisory Control and Data Acquisition (SCADA) software solution for industrial process customers. Helps in developing and deploying any size application.

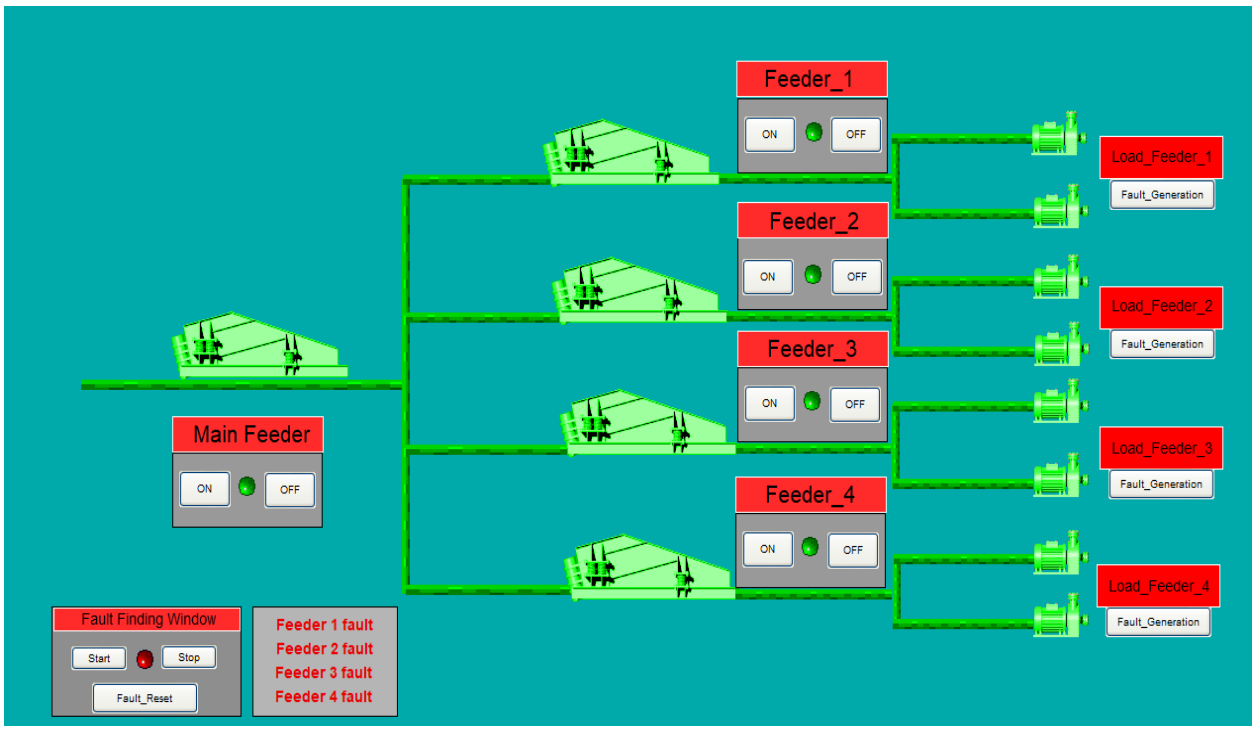
Substation Automation System

Substation integration and automation can be considered a five level process. The lowest level is considered to be the power system equipment, like transformers and circuit breakers. IED implementation, IED integration, and substation automation applications are the middle three levels. IEDs are being implemented in every substation. Integration of the IEDs is the main focus these days. After this is done, what automation applications should run at the substation level will come into focus. Utility enterprise is the highest level. The process of substation to utility enterprise has multiple functional paths.

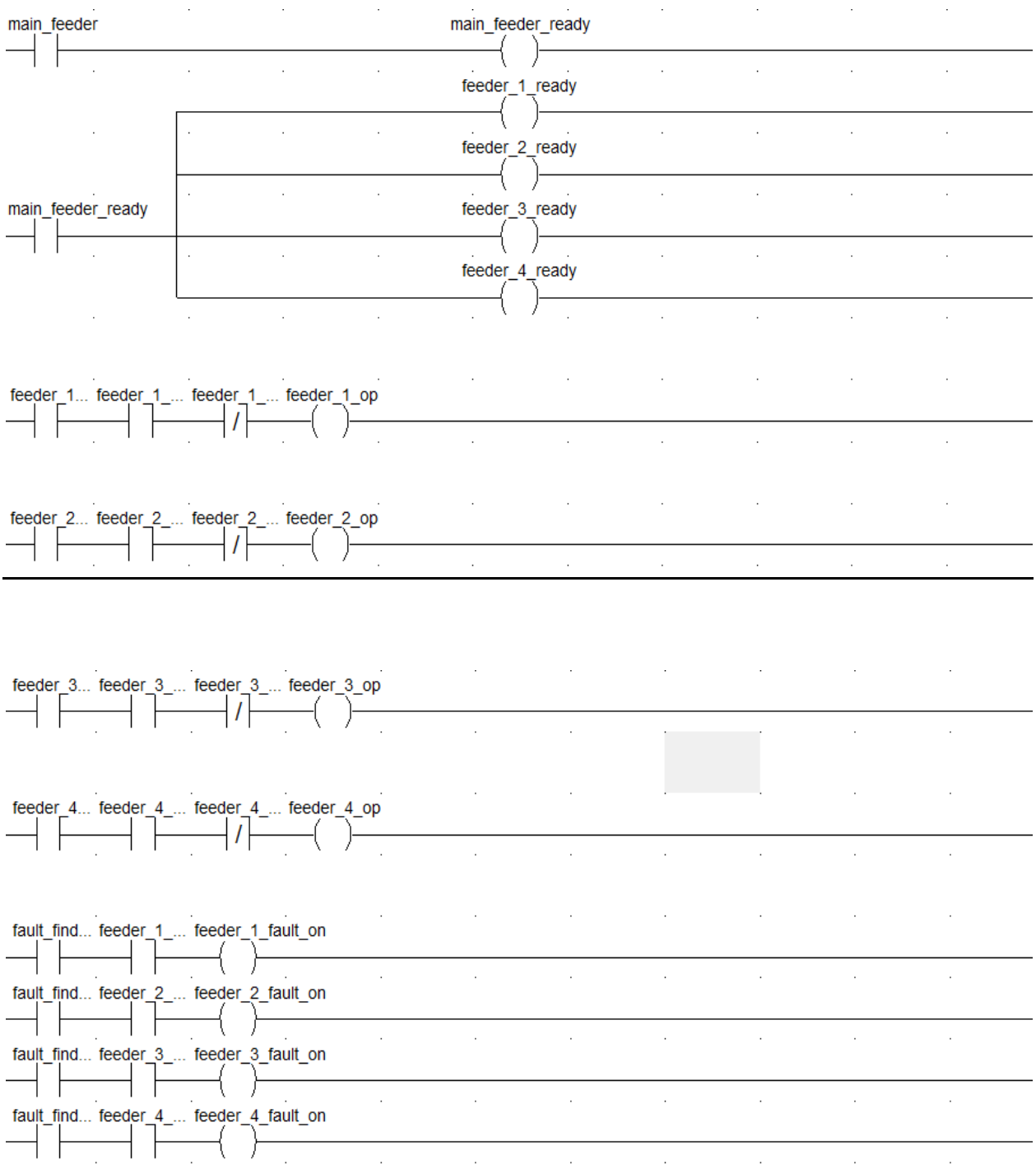


Implementation

For the project we had to develop a demo of a smart substation system. In the system there is a main feeder which powers four other feeders. All the feeders have an on/off button which turns the feeder on/off. If the main feeder is turned off, all the other feeders lose power. There are loads that are attached to the feeders. Whenever there is a fault in any of the feeders the supply to that feeder is cut, preventing main feeder and load from getting harmed. There is a display in the station which displays which feeder has the fault. The logic was implemented in control expert and the simulation screen was developed in Citect SCADA.



SCADA Screen



Logic Implemented using Ladder Logic on Control Expert

TIMELINE

Week 1

18th of May to 24th of May

1. Got to learn about the station and project domain.
2. Interacted with the instructor, the industry mentor and peers at the same station.
3. Learned about:

    • what is a system?

    • what is process control

    • what is a PID controller

    • what is control and automation

    • Control and its types

    • Types of data involved in process control

    • What variables could be manipulated in a process control?

    • How to gauge a system based on its stability, accuracy, reproducibility, resolution and hysteresis.

4. Got to know what a PLC is, and it's advantages.

5. Understood difference between ladder logic and block diagrams used to program a PLC.

6. Understood the role of SCADA in automation industry.

7. How PLCs mediate HMIs and SCADA communication which could be used to remotely operate a plant/or a large-scale industrial process.

8. Understood the role of RMJ Automation Solution and Training in automation industry

9. The major players in the automation industry were introduced

Week 2

25th of May to 31st of May

1. Week two was devoted to acquiring PLC programming skills.

2. Programming was carried out in WPLSoft by Delta Electronics.

3. The following circuits/programs were executed in the software using ladder logic

- Interlock Control Circuit
- Common Latched Circuit
- Conditional Control Circuit
- First in Priority Circuit
- Forward/ Reverse Control for Three Phase Asynchronous Motor
- Selective Program Execution
- Daily Production Record (16-bit counting up latched counter)
- 24 Hour Clock Operation using Counters
- Delay OFF Program
- Delay ON Program
- Delay ON/OFF Program
- Sequential Delay Output (Starting 3 Motors Sequentially)
- Pulse Width Modulation
- Star-Delta Reduced Voltage Starter Control
- Automatic Door Control
- Automatic Coffee Maker
- Automatic Water Sprinkler of a Garden

4. The Project title was decided this week and project groups were created.

Week 3

01st of June to 06th of June

1. This week was devoted to transposing the PLC programming skills gained using WPLSoft to Control Expert by Schneider Electric.

2. Got to learn about the circuit diagram of a PLC.

3. Implemented a program and simulated it in Control Expert.

4. The program implemented in this software had the following constraints

- 3 Valves not to be opened or remain open more than one at a time.
- A fourth valve to be operable only if one of the previous valves is opened
- A pump to be switched on if the water level in the tank is found to be below the set point and the fourth valve is open.

Week 4

07st of June to 14th of June

1. Midsem evaluation was conducted. It consisted of -

- Seminar
- Project Report Submission

Week 5

15st of June to 22th of June

1. This week was devoted to learning simulation in Citect SCADA, software by Schneider Electric.

2. Implemented a program and simulated it in Citect SCADA.

3. The program implemented in this software had the following constraints

- 3 Valves not to be opened or remain open more than one at a time.
- A fourth valve to be operable only if one of the previous valves is opened
- A pump to be switched on if the water level in the tank is found to be below the set point and the fourth valve is open.

Week 6

23st of June to 27th of June

1. This week was devoted to the project. We had to make a demo of a smart substation.

2. Implemented a program and simulated it in Citect SCADA.

3. The project implemented had the following constraints

- There are 4 feeders that draw power from a main feeder.
- Each feeder has 2 loads attached to it.
- Whenever there's a fault in any of the feeder, the supply to the feeder is disconnected preventing loads from any harm.

Conclusion

During the duration of these 6 weeks I got to work with industry experts in automation domain & it gave me an idea how working in industries feels like. I learned about how important automation is and how it affects the industries in a positive way. I did get a lot of hands on experience of the softwares used in the automation industry. I learned about PLC Programming in various languages. I also learned about how SCADA is useful in the automation industry and simulated several examples on SCADA and then completed my project which was designing a demo of smart substation. So overall it was a really nice experience working with the experts and I learned a lot.

References

1. WILP Videos by BITS Pilani Goa Campus

2. Instructional Videos by REAL PARS

3. Study Material provided by RMJ Automation Solution and Training

4. Wikipedia

Glossary

1. Control Systems - A control system is a system, which provides the desired response by controlling the output. ... Traffic lights control system is an example of control system. Here, a sequence of input signal is applied to this control system and the output is one of the three lights that will be on for some duration of time.

2. Automation: Making tasks in a facility to run without human intervention

3. Control: Manipulation of process variables as means to achieve a desired output/ outcome.

4. PLC: A device used to take over automation of a process using programmable logic

5. SCADA: A software used to remotely monitor a process whose data is fed by an intermediary like a PLC gather by an HMI at the site.

6. HMI: A device used by humans to control the process parameters via an integrated GUI

7. MODBUS: Modbus is a communication protocol developed by Modicon systems. It is a method used for transmitting information over serial lines between electronic devices.

8. Master: The device requesting the information is called the modbus Master

9. Slave: The devices supplying information are modbus Slaves

10. PLC: A device used to take over automation of a process using programmable logic.

11. Relay: A switch operating electronically/ electromechanically

12. Relay Sequencer: Logic implemented solely with the hardwired connection of relays

13. PID: A type of control that could be integrated into a functional block of a PLC to offer either proportional, Integral, derivative or all three of these controls together.

14. SCADA: Software used to remotely monitor a process whose data is fed by an intermediary like a PLC gather by an HMI at the site.

15. Slave: The devices supplying information are modbus Slaves

16. Servomechanism: A device used to correct the action of a mechanism using negative feedback

17. Interlocking: An interlock is a feature that makes the state of two mechanisms or functions mutually dependent.

18. Latching: Latching function is a self-maintaining circuit in that, after being energized, it maintains that state until another input is received.