

Priority Based Switching of Loads Using PLC and SCADA

Khadka Vikram Thapa Magar, Aviral Kandel, Deepak Neupane, Dipak Rijal

Abstract— PLC is a medium between electrical systems and personal computers for SCADA to take input and output bits. SCADA and PLC communication systems make it possible to integrate protection control and monitor electrical parameters together for maximum benefit. The idea is to provide continuous power supply to the load, based on the priority by switching the loads. In case any one of the sources is absent i.e., source 1, source 2 and source 3, then automatically the least priority load cuts-off and first priority load gets supply continuously. This paper presents a real time prototype design and implementation of automatic control system for supply of load using Programmable Logic Controller (PLC). This analyzes the basics of ladder logics to code a program that works based on switching by priority. The communication between PLC and SCADA is developed and presented on hardware to control and supervise the loads.

Index Terms— Automatic, Faults, Ladder Logic, Programmable Logic Controller, Priority Loads, Supervisory Data Acquisition,

1 INTRODUCTION

Continuous supply of power in many sectors is the main requirement on these days. The very short period of power interruption or cut off is also a big and serious problem in the case of hospitals and other industries that produce daily consuming products. Fulfilling the energy demand by increasing the generation is expensive and difficult too. By using proper energy management techniques could help to cover increased demand to some extent. However, proper management and control of energy DG is the biggest challenge nowadays but there are many ways of doing it. The energy shifting technique is one of them where we shift the energy by shifting where uninterruptible loads are connected like hospitals areas and other main industrial areas during the case of failure and the whole switching process is automatic.[1]

The lack of proper knowledge on management and control of the distribution system may lead towards huge loss of energy as well as creates serious issues. Therefore, the latest need in the energy system is not only the generation part but also includes the management part too. To help in the energy distribution system this project is introducing the smart grid system that involves automatic switching using PLC (Programmable Logic Control) and SCADA (Supervisory Control and Data Acquisition) [2].

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In Nepal, there is a high risk of power system failure and interruption due to complex geographical structure, different natural causes, improper distribution system, and bad settlement of grid and other causes. Sudden failure in electricity may cause big problems in the areas such as hospitals, educational sectors, medicine-manufacturing industries and other crucial industries as well as for commercial users. There are many questions regarding the safety of patients in the hospital and workers in the industries and is somehow related to electricity. If we are able to provide uninterruptible power supply to these sectors, this could solve many problems. The control and switching using older technology are costly and the whole system is more complex. More maintenance time, frequent replacement, complex systems and partial automation are drawbacks of older systems.

2 SYSTEM OVERVIEW

2.1 Microcontroller Vs PLC

Microcontroller vs PLCs can be compared on the basic of following:

1) Architecture
2) Interface

3) Performance and Reliability
4) Required skill level
5) Programming

PLCS architecture:
1) High Level microcontroller
2) Easy interface (USB, Ethernet or RS 232) along with communication network
3) Processor Module, the power supply ,I/O module
Microcontroller architecture:
1) Implemented everything in a single chip from CPU to I/O ports and interface.
PLCs Interface:
1) PLCs are standard designed to interface with industrial grade
sensor, actuators, and communication module and are thus given current and voltage ratings which are often incompatible with microcontrollers without extra hardware [5].
2) PLCs devices capable of transmitting data over wireless
communication
3) Usually designed to handle processing of only a few 100 IOs.

4) Able to withstand several adverse conditions associated with environment, extreme temperature ranges, electrical noises, rough handling and high amount of vibration
5) Real time operation due to fast operation of plc
Microcontroller's interface:
1) Microcontrollers as well have sensors, actuators, and modules designed to meet their specific needs, which might be difficult to interface with a PLC. They are however usually designed to handle processing of only a few 100 IOs [3]. While several techniques can be explored to increase the IOs of the microcontroller, this is still possible with PLCs and is thus not unique to the microcontrollers, aside from the fact that it increases the entire project budget.
Performance, Sturdiness and Reliability:
1) PLC can be able to withstand several adverse conditions associated with that environment like, extreme temperature ranges, electrical noise, rough handling and high amount of vibration. PLCs are also a good example of a real time operating system due to their ability to produce outputs within the shortest time possible after evaluating an input [5].
2) Microcontrollers however are less sturdy. By design, they were not designed to serve as standalone devices like PLCs. They were designed to be embedded in a system.

Skill Requirement for Use:

1) One of the key attributes of the PLC is the low technical knowledge required for programming, and generally operating it. The PLC was designed to be used by both the highly skilled automation experts and factory technicians who have little or no formal training.
2) Microcontrollers on the other hand however, require skillful handling**.** Designers need to have a good knowledge of electrical engineering principles and programming to be able to design complementary circuits for the microcontroller.

Programming:

1) Ladder logic programming is simple and easy to understand in case of PLC programming.
2) Microcontrollers on the other hand are programmed using low level languages like assembly or high level languages like C and C++.

2.2 PLC

A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of typically industrial electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures[9]. PLCs are used in many machines, in many industries. PLCs are designed for multiple arrangements of digital and analog inputs and outputs, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a "hard" real-time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result[7]. Some use machine vision. (Gruenemeyer,1991)[1] on the actuator side, PLCs operate electric motors, pneumatic or hydraulic cylinders, magnetic relays, solenoids, or analog outputs.

2.3 SCADA

As the name implies SCADA system supervises, acquires and controls data received from a distant data source from the control center. SCADA system is located in the control center and is operated in the scanning mode, communicating between the CONTROL CENTER and the REMOTE STATION by means of two-way communication channels [8]. Such a supervisory control and data acquisition system is intended to facilitate the work of operators by acquiring and compiling information as well as locating, identifying and reporting faults[7].Based on information received, the operator makes necessary decisions via the control system he can then perform different control operations in power stations or influence the processing of the information acquired [4]. The main task of a modern-day power system is to ensure quality and reliable power at an economic rate. In order to do that, the system has to update data at a very fast rate (real time mode/management), which helps to control the complex system effectively without any loss of time.

2.4 Flowchart

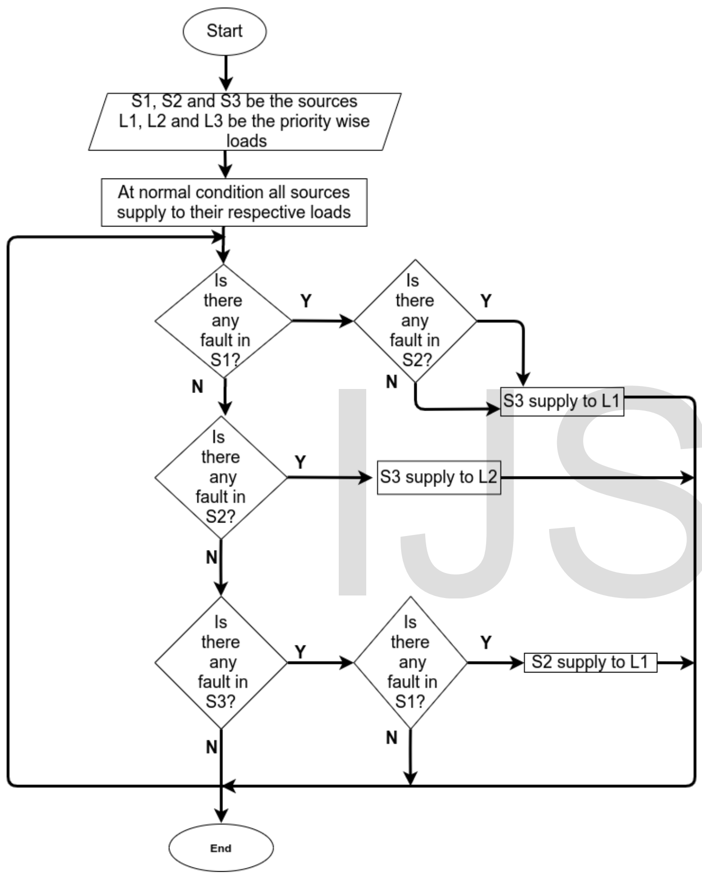

Fig: Flowchart of Ladder logic in PLC

3 SYSTEM DESIGN

3.1 Ladder Logic

Load connected across depends upon the output of the PLC, which in turn depends upon the ladder logic developed inside the controller. In fig 2, ladder logic is generated based on the requirement of the output.

This ladder logic consists of four main rungs. There are various branches depending upon the logics required. We can adjust as many branches as required in each rung.

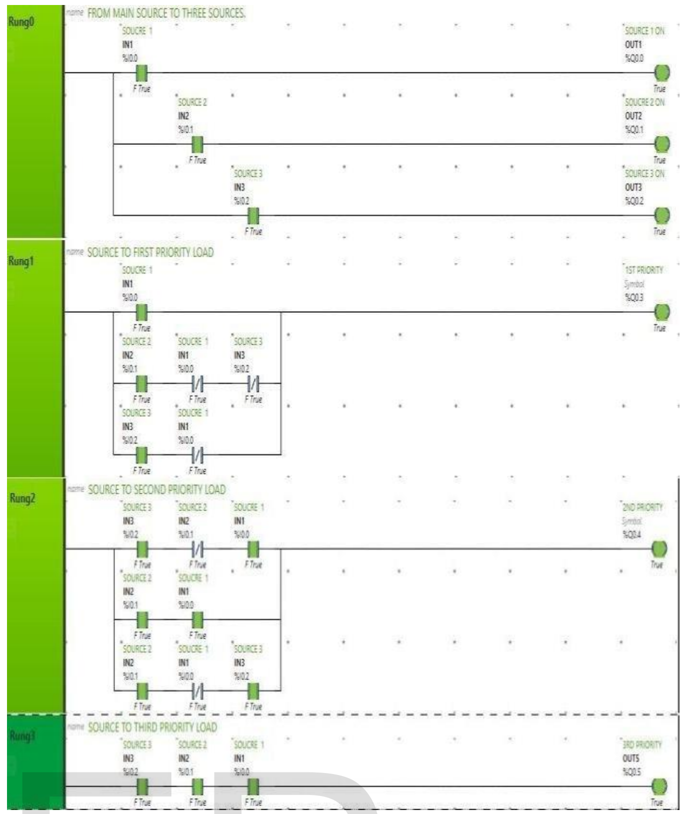

Fig. 2. Ladder logic

The function of each rung is briefly described below:

a. First rung simply denotes whether or not each source has supplied its load.

b. Second rung denotes our top priority load. It consists of three branches. The main motive of this paper is to provide continuous supply to the top priority load. Therefore, supply has to be provided to this load in any case. During normal condition, signal simply passes through the first branch while on faulty condition signal may pass through other branches.

c. Similarly, the third rung denotes our second priority load. In case of any faulty condition, it gets second priority for load fulfillment. If there is no power in source 3, then source has to cut its load out and supply to the top priority load.

d. It represents the last and final rung, which is the least priority load. The least priority load only operates when there is no faulty condition. If fault arises in any of the above sources(first or second), then it has to cut its load out and supply to the higher priorities loads.

3.2 Connection Diagram

This paper presents the switching of loads on the basis of their priority. The project simulation is done in Automation studio 5.0 before implementation in hardware. The simulated circuit is shown in fig: 3. Here, we have used three motors M1, M2 and M3 as three different loads in respective priority order.

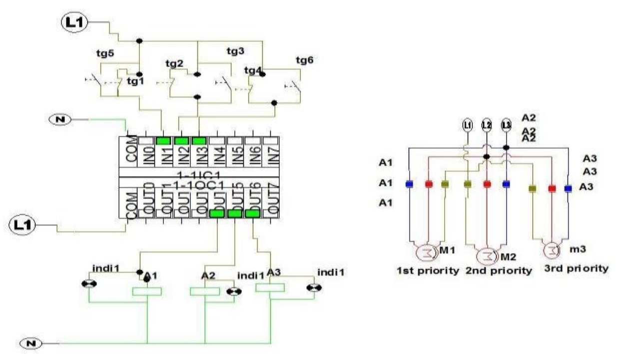

Fig. 3. Simulation in Automation Studio 5.0

The ladder logic developed is installed in the PLC as shown above. According to the logic, PLC provides signals to operate motors. A1, A2 and A3 represent contactors. The coil of the contactor energizes if and only if it receives signal from PLC. Loads followed by the contactor only operate if the coil is energized.

3.3 Hardware Implementation

In figure 4, coils of the contactors are energized with the output of PLC. The digital bits are used for the operation of loads. The coils of contactors are energized if the address bit of the PLC is 1, else coils are de-energized.

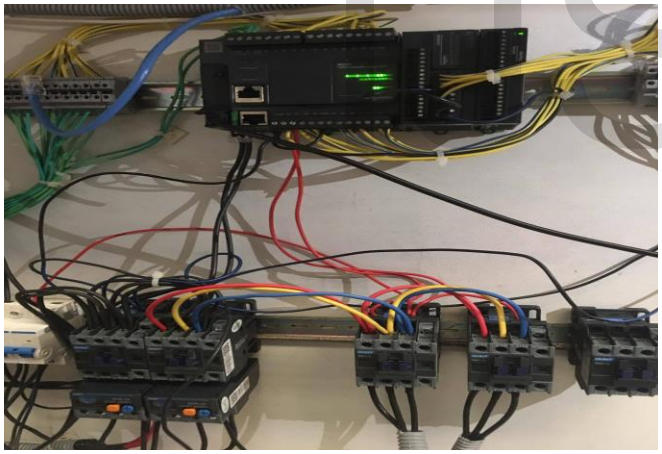

Fig.4. Connection diagram showing PLC and contactors

Schneider Electric Modicon TM221 Series is used. This series consists of two modules which are specified below:

i. Module 1: TM3DM24R/G

ii. Module 2: TM3AM6/G

Fig. 5. Hardware implementation

The overview of our project is well represented in figure 5. Two motors with each of 1 h.p.(0.746 kW) ratings are used for the demonstration of loads while indicator is used to represent the least priority load. The panel is well covered to show its aesthetic beauty. It consists of nine indicators and pushbuttons however, just three are operated for our project. The built-up computer along the panel is placed for the control and visualization of the operation through VTScada software.

3 RESULT AND DISCUSSION

The ladder logic program is implemented in the PLC hardware. Here we have used the VTScada software for user interface. The results for different cases can be visualized by using the VTScada interface.

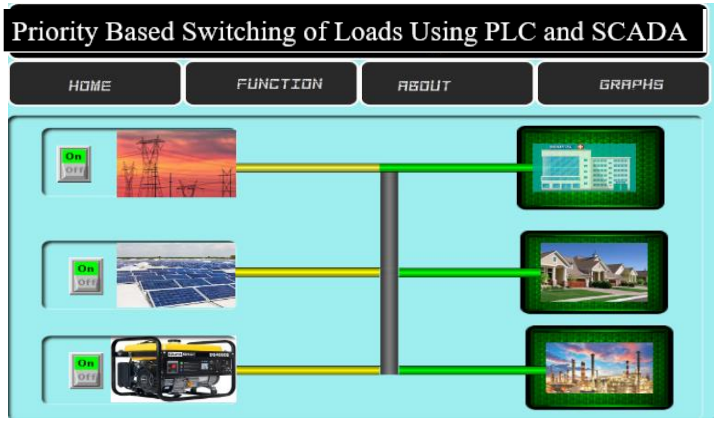

Fig. 6. Control and supervision through SCADA

4 CONCLUSION

This paper demonstrates the steps for designing and implementing an automatic transfer based on its priorities using a programmable logic controller (PLC) with SCADA (Supervisory Control and Data Acquisition). It provides management with real-time data on production operations, implements more efficient control paradigms, improves plant and personal safety along with reduction on cost of operation[8]. Here, PLC based control systems combine with the SCADA for automating the whole system. We have used ladder logic programming to automate the system. The PLC and SCADA along with other hardware is used to supply the continuous power to the loads based on their priorities even if there is an occurrence of fault [6].

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