PLC AND SCADA BASED AUTOMATED SYSTEMS

DISSERTATION

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I, Rajat Kumar Choudhary, Roll No(s). 2K20/C&I/07 student of M.Tech (Control & Instrumentation), hereby declare that the Thesis titled "**PLC AND SCADA BASED AUTOMATED SYSTEMS**" which is submitted by me to the Department of Electrical Engineering, Delhi TechnologicalUniversity, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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CERTIFICATE

It is certified that the Thesis titled "**PLC AND SCADA BASED AUTOMATED SYSTEMS**" submitted by Rajat Kumar Choudhary, 2K20/C&I/07 [Electrical Engineering Department], Delhi Technological University, Delhi in partial fulfillment of the requirement for the award ofthe degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree orDiploma to this University or elsewhere.

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Abstract

The objective of our project is to design, develop and monitor PLC and SCADA based automated systems. PLC and SCADA have great impact on future of industrial as well as commercial control system. This thesis focuses on industrial as well as commercial automation based on PLC and SCADA. The first part of thesis focuses on Industrial based project PLC based diesel generator synchronization, whereas second part of thesis is PLC based water bottle filling station which is a commercial implementation.

Large-scale industries are facing high interruptions in work due to unstable electricity supply. These industries become less efficient and require a continuous power supply. Whenever a power failure is considered, most industries use the generator for a backup power supply. To fully meet the load demand in large-scale industries, many generators are used, and controlling the number of generators manually is not possible. Also, manual synchronization will take more time to switch the load, resulting in power loss. This is overpowered by using various controllers like PLC, PIC microcontroller, Arduino, etc., to change the generators automatically and provide a continuous power supply to the load and ensures fast switching of loads between transformers and diesel generator. This research focused on calculation of ratings of circuit breakers, transformers and diesel generator with interlocking scheme of generators and transformers using a programmable logic controller (PLC). PLC programming is done Tia portal and HMI is designed in Tia portal for monitoring of the system for fast switching of loads between transformers and diesel generator.

Universities have a social responsibility to address environmental issues, and they can play unique role in a sustainable society. Among the various environmental issues plastic waste is one of the biggest problems. The aim of this project is to reduce the use of plastic bottles and to prevent waste water. The designed system provides total water consumption and total value. of stored bottles. The system also monitors individual water use. The filling is based on the user-defined volume in which the user can select the volume of the liquid to be filled. The system is designed using PLC (programmable logic controller), HMI (Human Interface System), Solenoid Valve, Relays, MCB, Indicators and pressure buttons. Filling of water bottle is controlled by PLC using the ladder logic method.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

HMI	Human Machine Interface
SCADA	Supervisory Control and Data Acquisition
PLC	Programmable Logical Controller
DG	Diesel Generator
BC	Bus Coupler
TR	Transformer

CHAPTER 1

INTRODUCTION

1.1 Automation

Industrial automation is used in control systems, such as computers or robots, as well as information technology to manage various processes and equipment in the industry to replace human beings. It is the most valuable step in the field of industrialization.

Previously the goal of automation was to increase productivity (as automated systems can operate 24 hours a day) and to reduce costs associated with human resources (i.e. salaries & benefits). Today, However, now a days the focus of automation has shifted to improvement in quality and flexibility in the production process.

1.2 Advantages of Industrial Automation

High Productivity

Although many companies hire hundreds of production workers for up to two shift to run the industry for maximum possible hours, the workshop still needs to be closed for maintenance and vacations. Industrial automation fulfills the company's mission by allowing the company to run the production 24 hours a day 7 days a week and 365 days a year. This leads to significant improvements in company production.

High Quality

Automation reduces the error associated with the person. Moreover, unlike humans, robots do not engage in any form of fatigue, which results in products of the monotonous quality being produced at different times.

High Flexibility

Adding new work to the assembly line requires training with a co-worker, however, robots can be programmed to perform any task. This makes the production process more flexible.

High Information Accuracy

Adding automated data collection can allow you to gather important production information, improve its data accuracy, and reduce the cost of data collection. This provides you with facts to make the right choice when it comes to reducing waste and improving your processes.

High Safety

Industrial automation can make the production line safer for workers by sending robots to handle difficult working conditions.

1.3 TYPES OF AUTOMATION SYSTEMS

1. Fixed Automation

Fixed automation is also known as hard automation, fixed automation systems perform one set of tasks outside deviation. Due to its function, this type of system will usually be used for a variety of value generation and continuous flow systems. Example of default the system will be an automatic system band designed to amplify efficiency by moving objects from point A to point B without much effort. As and all other components of the automation system, the conveyor belts work automatically consistent and repetitive tasks to achieve high productivity.

Manufacturing processes compatible with this system would be:

• Repetitive production that allows for variability within the production process though limited (eg in food packaging or textile industry)

Adopting a fixed automation system as automatic and inclusive transport belts additional value solutions aimed at reducing both time and labor costs in them setting, reducing the competitive pressure on your business, increases your profitability margin, and keeps you one step ahead of the competition. An example of a value an additional solution would be to use multiple cables in the default transport systems. This not only reduces installation time, but also reduces labor costs and keeps workers safe fence damage during installation.

2. Programmable Automation

As the names suggest, systematic automation is accompanied by a computer-generated command system. This means that the resulting processes may be in contrast to changing the instructions given to the computer by a series of codes. However, as planning efforts are no small feat, so the processes work do not change too much. This type of default is common in mass production settings the same types of products using many similar steps and tools such as paper mills. The production processes associated with this program can be:

• Repetitive production where the same products are produced over a long period of time and in large collections. These types of devices can continue to be handled with very little personal supervision. They are often used in the manufacture of cars and equipment. The initial setup of flexible equipment may require high costs but later with these continuous unchanged processes, often costing less over time.

3. Flexible Automation

Also called soft automation, this type of switch is used in computer-generated flexible production systems and allows for flexible production. Everything machines receive instructions on a personal computer that is tasks can vary greatly by changing the computer-generated code. This type of default will be used extensively in batch processes and in various operating stores of high-quality products and services with low to medium volume, such as textiles production. The production processes associated with this program can be:

Discrete manufacturing which allows for variability within the production process although limited e.g. in food packages or textile industry.

Job shop manufacturing which takes place within designated production areas and requires more workers compared to other types of production. An example would be to make custom machines.

Batch process manufacturing is when raw materials move along the production line with such batches that there is a break between each step as the collection passes (e.g. in the pharmaceutical industry as well in paint production).

Continuous process manufacturing which provides consistent processing as a production process from beginning to end it does not change. This type of production is often used in food and beverage production as well as oil and gas production.

4. Integrated Automation

Integrated automation includes the complete automation of productive plants as they are fully managed computers and control systems with minimal human involvement. Computers can design the necessary parts, test designs, and make parts. Included automation, like dynamic automation, accompanies both batch processes production and continuous process production. Technology that uses this type of default includes:

- Computer-aided process planning
- Computer-supported design and manufacturing
- Computer numerical control machine tools
- Computerized production and scheduling control
- Automatic storage and retrieval systems
- Flexible machine systems
- Automated material handling systems, e.g., robots
- Automated conveyor belts and cranes

1.4 Thesis Organization

This thesis of 6 chapters. Chapter 1 includes introduction of various types of automation system and their advantages. Chapter 2 includes literature review. Chapter 3 covers first part of thesis “PLC BASED D.G SYNCHRONIZATION SYSTEM” along with mathematical equations and basic explanations. This chapter also covers PLC programming in Tia portal software. Chapter 4 includes second part of thesis “PLC Based Water Bottle Re-Filling Station” which covers hardware as well as software specification along with PLC programming and HMI screen.

CHAPTER-2

LITERATURE REVIEW

2.1 Introduction

This chapter consist of literature review of various references used in this thesis. Literature review is divided in two parts. PLC based D.G synchronization system and PLC based water bottle re-filling station.

2.2 PLC based D.G synchronization system

This paper discusses the design and implementation of a remote monitoring and control platform for PLC-based processes via TCP / IP or GSM network. The platform is built using standard PLCs on the shelf industry. Included with each PLC communication processor can be used to connect to a GSM network and modem. The communication processor module (Ethernet module) used in this project, provides a specific industry-specific TCP / IP protocol that achieves the same performance as Profit but at a much higher bandwidth (10/100 Mbps). Additionally, a mobile-based communication system that assists the monitoring and remote control of PLCs using SMS messages has been improved.[1].

This paper introduces the design and implementation of automation switching using a programmable logic controller (PLC). In the event of a power outage, the button automatically turns on the generator and connects the outlet, instead automatically shuts off the generator when the power is restored and returns the load to a higher power with the help of the required distance. parameters can be set by the system. This helps to reduce the time required to change jobs. In this way, the continuation of the supply is maintained [2].

This project describes the operational, control and maintenance features of the Diesel Production Unit and discusses system technologies, implementation and collaborations to facilitate operations using programmable logic control (PLC). All methods of safe start-up, operating time, load storage and load distribution between available diesel-producing units. Prevention of emergency power outages and fuel efficiency of diesel generators are considered in the software. The center develops a PLC-based monitoring learning program for a variety of applications and a control unit for diesel production. Over the years the demand for high quality, highly efficient systems and equipment has increased worldwide. In order to meet these developments and developments it is expected that this project will be regarded as a very successful endeavor. [3].

This paper provides an overview of DPGS frameworks based on fuel cells, photovoltaics, and wind turbines. Additionally, the grid-side converter control properties are introduced, and the possibility of compensation for low-order harmonics is also discussed. In addition, control strategies where grid errors are managed. This paper concludes with a review of synchronization methods and a discussion of their importance in regulation.[4]

Processed plants are active day and night. Any power supply disruption will lead to systematic suspension leading to significant productivity losses and financial losses. In the event of a serious supply failure, the waiting power should reach the finish line without delay for a long time. To meet this need, automatic switching of the generator to the power supply system is required to automatically switch the power supply from electricity to generator.[5].

The project provides an idea of an uninterrupted industrial power supply with automatic switching over the control system via PLC and HMI, which means, when the supply from the transformer is disconnected, then the backup supply will be turned on, i.e., a diesel generator. it begins. by receiving a command signal from the PLC and the continuation of the supply is maintained. When the supply is returned to the transformer, the PLC will supply the command signal to the diesel generator to stop. Then the automatic transmission switch (ATS) will be removed from source-II to the source — that is, the transformer and supporting generator will shut down. In this way the continuation of the supply is maintained without delay for a long time. [6]

The aim of this project is to protect the transformer under congested conditions by sharing the load. Due to the high load on the transformer, the efficiency decreases and the windings become very hot and can become hot. Thus, by sharing the load on the transformer, the transformer is secured. This will be done by connecting another transformer in conjunction with a small controller. The small controller compares the load on the first transformer with the reference value.[7]

1.3 PLC Based Water Bottle Re-Filling Station

This paper introduces a volume measurement system using an automatic Arduino liquid filling machine. Two solenoid valves to control the flow of water between the storage tank to the measuring tank and the measuring tank to the mouth. The combination between the solenoid valve and the ultrasonic sensor is able to work with the cylinder piston and reduce the complexity of the machine.[9]

This paper introduces Computer Image Technology to an automatic liquid filling machine. By analyzing filling requirements, Simulink is used to develop a simulation model of the automatic filling machine control system, to simulate the control system using appropriate simulation breaks, and finally to design a filling machine control system. Test results show that the filling volume has a slight deviation and the control system can be used for stability. It can be noted from this that imaging technology has many advantages to the automatic liquid filling process, which can not only improve the automation degree of filling the machine, but also reduce the incidence of accidents and save labor costs.[10].

The aim of this project is to automate the operation of the transportation system. The operation of the transport system encompasses two important tasks that must be performed. The main task is to start and stop the transport machine using the engine. The second task is to fill the bottles at a certain time (in seconds) to remove excess fluid from all the bottles. A world full of technology requires a high level of productivity, especially in industries where automation is needed. PLC is best known for its real-time systems, so it is used to control a variety of devices and the PLC is a device that is often operated with multiple outputs and outputs and operating in high-risk environments. Therefore, the bulk of the hardware used is PLC. [13]

The aim of our project is to design, develop and monitor the "Automatic bottle filling system using PLC". This function offers many benefits such as low power consumption, low operating costs, minimal adjustment, accuracy and much more. The project is based on Industrial automation and is a major application used in many industries such as dairy industries, chemicals, food, mineral water and many industrial producers. The prototype is designed to model the project. Filling is a mechanical task and this process is widely used in many industries. In this project, bottle filling is controlled using a controller known as PLC which is also the heart of the whole system. In the transport system, the dc motor is selected for better performance and easier operation. A sensor was used to detect the bottle. In our project we have used a small number of programs which is why the total cost has been reduced to some extent. Ladder logic is used for PLC editing, which is the most widely used and widely accepted language in PLC editing. The PLC used in this program is the Siemens S7–1200 which makes the system simpler and easier to operate. [16]

In this paper a bottle filling machine is introduced using a program based on Programmable Logic Controller (PLC) in the automation industry. The main purpose of paper is to design and make a small and simple filling system using PLC. A conveyor belt is used to move the bottle. The dc pump is set in the tank to control the flow of water. The shape of the bottle is detected by an infrared sensor so that the pump can operate at the right time. When the bottle is at the bottom of the tank, the pump is started and the bottle is filled with water. All parts work fine. This filling machine is expensive and can be used in small bottle filling systems such as coffee shops, juice shops and other beverage industries.[17]

1.4 Conclusion

The purpose of this review was to view the trends in industrial automation studies within the past years. It is clear from the research reviewed that PLC plays vital role in automation and it has various applications in industrial as well as commercial automation.

CAPTER-3

PLC BASED D.G SYNCHRONIZATION SYSTEM

3.1 Introduction

With the increase of power failure, industries are becoming less efficient. To overcome this most industry, use standby generators for power supply. Controlling generators manually consumes a lot of time and energy. Large-scale industries use many generators to full fill the load demand, so controlling them manually becomes more difficult. To overcome this problem PLC is used for synchronization between generators. This paper presents the interlocking scheme of generators and transformers using PLC for industrial plant with high load demand. In our project we have Considered that two transformers are coming from the grid each of 1600 KVA, during normal condition load is transferred from transformers. When main supply fails and transformers not supplying load in that condition diesel generators will supply the load. Four diesel generators are connected of rating 500KVA and 640KVA. For protection purpose air circuit breakers are used, which are connected with transformers and diesel generators. Bus bar are used for connection between air circuit breakers. Project vision proposed to reduce diesel consumption by the automatic changeover of the generator based on load conditions. In this world of increasing automation PLC struck our minds. For controlling, monitoring, integrating system with newer technology PLC is a very efficient tool to automate. As PLC has rugged type construction hence it can withstand any situation like vibrations, temperature, humidity, and noise. In industry, the most sensible and important loads are controlled through the PLC. The PLC automation has one of the advantages that it is an easy programing language and which can be easily understood by workers. For handling and controlling PLC there is no need for expertise, as the ordinary worker can also operate it easily. Another advantage of PLC is its fast response, which helps in maintaining the stability of the system. According to the load usage, the generators start automatically by PLC command and if any generator is not working then other generators will provide load. Also, load distribution depends upon the load demand in the bus section.

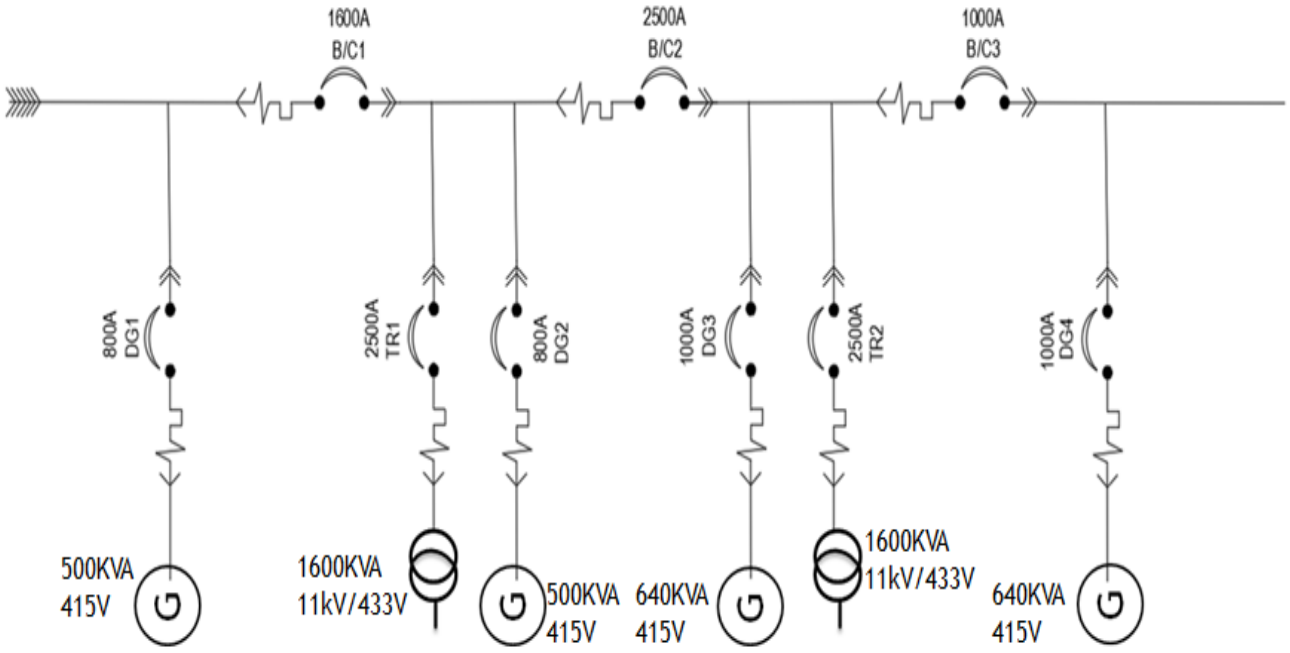


Fig. 3.1: Incoming load system

3.2 D.G Synchronization System Design

Proposed D.G synchronization system consist of transformers, diesel generators, air circuit breakers and bus bar. Since, we are Considering real industrial plant with high load demand, we calculate rating of all components assuming no. of connected loads with high load demand.

A. Transformers Rating Calculation

Considering an industrial plant has connected load of 6000A. So, for 6000A of load we have to select transformer and calculate its rating. For, that we need to calculate actual load of industrial plant.
Formula for calculating Actual load is

$$Actual\ load = \frac{Connected\ load \times load\ factor}{Diversity\ factor} \ldots\ldots\ldots (1)$$

$$load\ factor = \frac{Average\ load}{Maximum\ demand} \ldots\ldots\ldots (2)$$

$$Diversity\ factor = \frac{Sum\ of\ individual\ maximum\ demand}{Maximum\ demand\ on\ power\ station} \ldots\ldots\ldots (3)$$

Taking connected load equal to 6000A, considering average value of load factor between (0.5-0.6) and diversity factor between (1.2-1.4) we get, *Actual load* =3000A. Voltage rating of step-down transformer is taken as 433V due to voltage drop margin of 4 % in transmission lines.

Now using actual load and voltage we can calculate rating of transformer,

$$\boldsymbol{P_t = \frac{\sqrt{3} \times V \times I}{1000}} = \frac{\sqrt{3} \times 433 \times 3000}{1000} = 2250KVA$$

According to the government regulation we can use only 80 % of the load supplied from substations. So, we have to add 20% margin in our rating and 20% margin for reserve capacity, in case if there is increase in load demand in future then reserve capacity can be used. After calculations we get final rating of transformer P_t=3200KVA (approx.). It is preferred to use two transformers rather than one, because if one transformer have some fault then second one can still provide load. So, we have two transformers TR-1 and TR-2 each with the rating of 1600KVA.

B. Diesel Generator Rating Calculation

Diesel generator is used as a substitution of main supply. Generally D.G rating for same load is more than transformer rating, due to power factor lag of 0.8 in alternator of diesel generator. We do load shedding of 30 % according to the load demand and requirement only important machine are operated. Voltage rating of diesel generators is 415V and we calculated actual load equal to 3000A.

Formula for calculating diesel generator rating is

$$\boldsymbol{P_{dg}} = \frac{\sqrt{\mathbf{3}}\times\boldsymbol{V}\times\boldsymbol{I}}{\mathbf{1000}\times\mathbf{0.8}} = \frac{\sqrt{3}\times 415\times 3000}{1000\times 0.8} = 2700\ KVA$$

After load shedding of 30% we get P_{dg}=1890 KVA. For protection of diesel generator wiring, we use only 80 % of load. So, keeping 20% margin in rating we get final rating of diesel rating equals to 2280KVA.

For proper functioning of the system, we divide 2280KVA rating into different smaller rating to match different load demands. We divide diesel generator rating into four smaller ratings. So, we have four diesel generators D.G-1, D.G-2, D.G-3, D.G-4 with the rating of 500KVA,500KVA,640KVA and 640KVA respectively.

C. Air Circuit Breaker Rating Calculation

Air circuit breaker is an electrical device used to provide over current & short circuit protection for electric circuit over 800A to 10kA. It connects & disconnect two bus bars; it is mainly for energizing and cutting off high current. In our project we have connected ACBs along with our incomers, and between the incomers. Rating of air circuit breaker depends on incomer rating; this is done to ensure protection of the whole system. Formula for calculating air circuit breaker rating is

For transformers,

$$\boldsymbol{P_t} = \frac{\sqrt{3}\times V\times I_{ACB}}{1000}$$

Taking V=433V, P_t=1600KVA we can calculate current rating,

$$\boldsymbol{I_{ACB(t)}} = \frac{\mathbf{1000}\times\boldsymbol{P_t}}{\sqrt{\mathbf{3}}\times\boldsymbol{V}} = \frac{1000\times 1600}{\sqrt{3}\times 433} = 2133\text{A}$$

For diesel generator,

$$\boldsymbol{P_{dg}} = \frac{\sqrt{3}\times V\times I_{ACB(dg)}}{1000}$$

Taking V=415V, P_{dg}=500KVA and 640KVA we can calculate current rating,

$$\boldsymbol{I_{ACB(dg1,2)} = \frac{1000\times P_{dg}}{\sqrt{3}\times V} = \frac{1000\times 500}{\sqrt{3}\times 415}}\text{=695A}$$

$$\boldsymbol{I_{ACB(dg3,4)} = \frac{1000\times P_{dg}}{\sqrt{3}\times V} = \frac{1000\times 640}{\sqrt{3}\times 415}}\text{=890A}$$

Since, air circuit breakers come in fixed ratings. We have to select circuit breaker with next higher rating of our calculation. So, air circuit breaker for transformers with 2133A current rating is 2500A. Similarly, for diesel generators 1 &2 with 695A current rating is 800A and for diesel generator 3&4 with 890 A current rating is 1000A.

For calculating ratings of three bus coupler connected between incomers, we have to take average of incomers air circuit breaker rating. Usually, bus coupler rating depends on outgoing load requirement.

Incomers	**Incomer's rating**	**Air Circuit Breaker Rating**
Transformer1	1600KVA	2500A
Transformer2	1600KVA	2500A
Diesel generator1	500KVA	800A
Diesel generator2	500KVA	800A
Diesel generator3	640KVA	1000A
Diesel generator4	640KVA	1000A
Bus Coupler 1	-	1600A
Bus Coupler 1	-	2500A
Bus Coupler 1	-	1000A

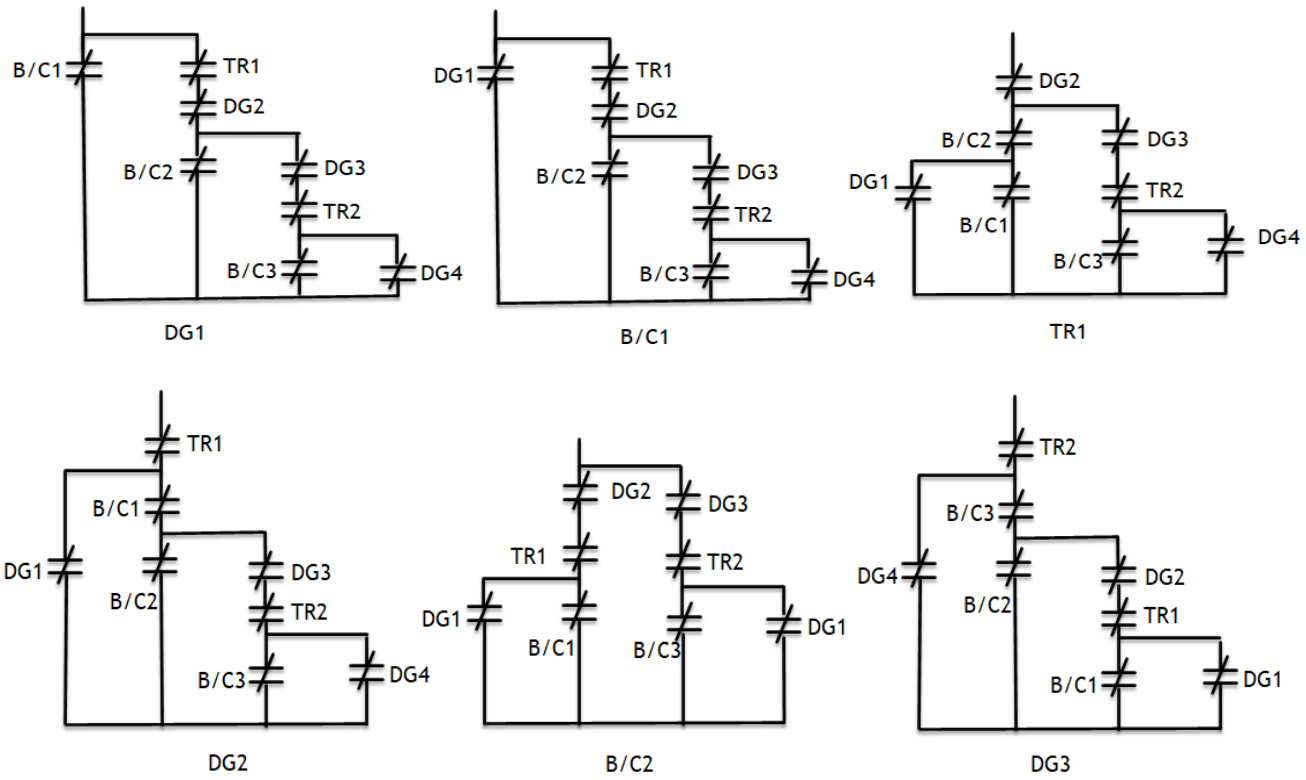
Table. 3.1: Ratings of designed system

3.3 Interlocking Scheme & Operating Conditions of Diesel generators and Transformers

In interlocking scheme two adjacent air circuit breaker should not be turned on at the same time, because of high current it can damage the devices. This is done for protection purpose, moreover it is used for automatic switching between transformer and generator. Interlocking can be done by wiring directly or by using controllers. In our project PLC programming is done on same interlocking scheme. In our project interlocking for all circuit breakers follows same pattern. Fig 3.2. Show all interlocking scheme for all circuit breakers.

For interlocking of DG1 all other circuit breakers are taken in off condition with normally closed connection. Operating conditions for DG1 are:

- B/C1 and TR1 should not be operated at same time.
- B/C1, DG2 and DG3 should not be operated at the same time.
- B/C1, BC2 and TR2 should not be operated at the same time.
- B/C1, BC2, TR2 and DG4 should not be operated at the same time.



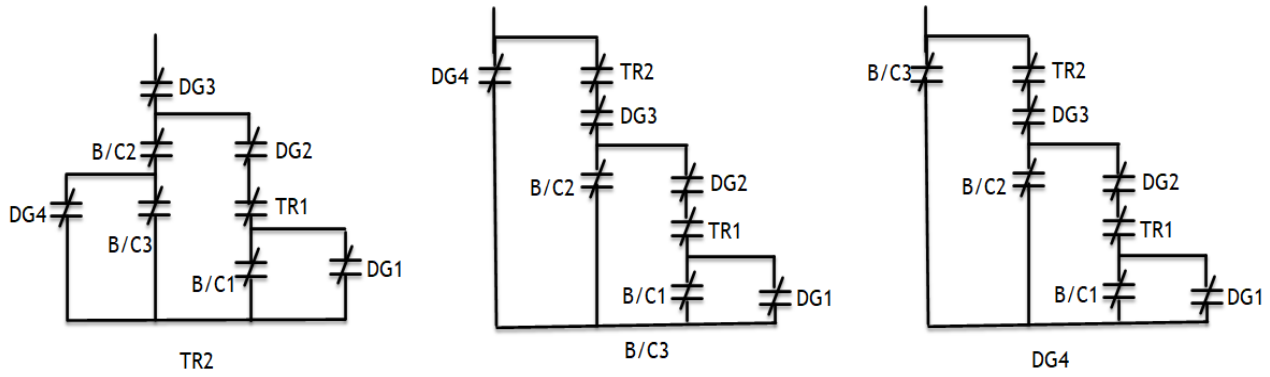


Fig. 3.2: Interlocking scheme

Operating Conditions Of D.G Synchronization System

For continuous supply there should be less time between transformer and generator switching. Fast switching can only be done if system know which generator should be turned ON. So, we define generators as masters if any mains failure takes place, then master will immediately take action and supply the required load. Fig 3.3 shows the configuration of diesel generators

- If main supply fails then load will instantly transfer to master 1 which is diesel generator1.
- If diesel generator1 fails to supply load then load will be transferred to master 2 which is diesel generator2.
- If diesel generator2 fails to supply load then load will be transferred to master3 which is diesel generator3.
- If diesel generator3 fails to supply load then load will be transferred to master4 which is diesel generator4.

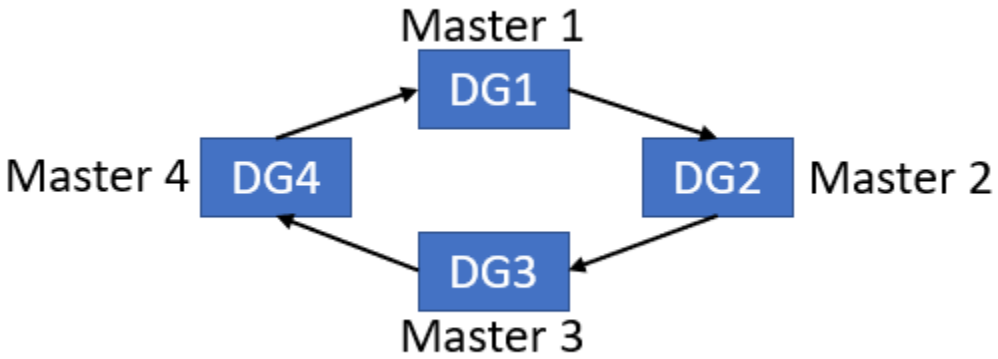


Fig. 3.3: DG master configuration

Under normal conditions substation shall energize the system. It can be continuous or discontinuous depends on the suppliers. During this condition circuit breaker of both transformers will be ON along with bus coupler 1 and bus coupler 3. When main supply fails and maximum demand load is up to 340KW then load is transferred to diesel generator 1. In this condition DG1 circuit breaker will be ON along with bus coupler 1, bus coupler 2 and bus coupler 3. In this case diesel generator1 will supply load to the complete system. When diesel generator 1 fails and maximum demand load is up to 340KW then load is transferred to diesel generator 2. In this condition DG2 circuit breaker will be ON along with bus coupler 1, bus coupler 2 and bus coupler 3. When diesel generator 2 fails and maximum demand load is up to 340KW/435KW then load is transferred to diesel generator 3. In this condition DG3 circuit breaker will be ON along with bus coupler 1, bus coupler 2 and bus coupler 3. When diesel generator 3 fails and maximum demand load is up to 435KW then load is transferred to diesel generator 4. In this condition DG4 circuit breaker will be ON along with bus coupler 1, bus coupler 2 and bus coupler 4. Fig. 3.4 shows generator operating condition when load is limited and single generator load is enough to meet the demand.

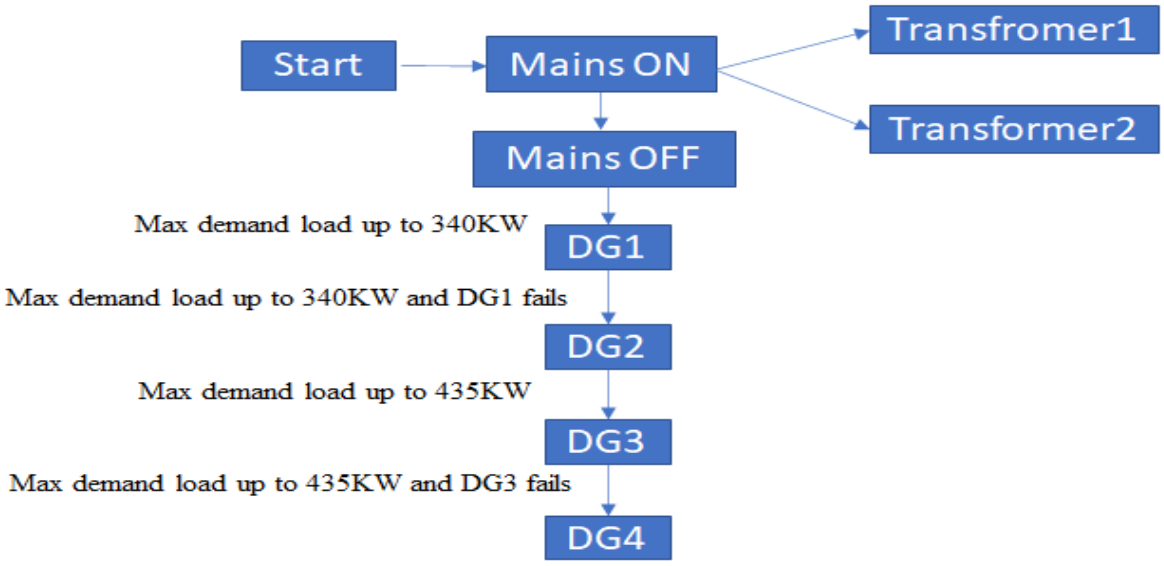


Fig. 3.4: generator operating conditions

When load demand increases and is not fulfilled by single generator in that condition many generators can be operated at the same time which depends on individual bus section load. Bus section defined in our system is shown in fig. 3.5. Bus section is the region between two bus couplers. Each bus section has separate outgoings, so according to the bus section load demand generators are operated.

Fig. 3.5: Bus section region

When combined maximum demand load of bus section 1&2 is up to 340KW then load transferred to diesel generator 1, load of bus section 3 is at diesel generator 3 and load of bus section 4 is at diesel generator 4. If diesel generator1 fails to start then load of bus section 1&2 will be transferred to diesel generator2. When combined maximum demand load of bus section 2&3 is up to 340KW then load transferred to diesel generator 2, load of bus section 1 is at diesel generator 1 and load of bus section 4 is at diesel generator 4. If diesel generator2 fails to start then load of bus section 2&3 will be transferred to diesel generator3. When combined maximum demand load of bus section 2&3 is up to 435KW then load transferred to diesel generator 3, load of bus section 1 is at diesel generator 1 and load of bus section 4 is at diesel generator 4. When combined maximum demand load of bus section 3&4 is up to 435KW then load transferred to diesel generator 3, load of bus section 1 is at diesel generator 1 and load of bus section 4 is at diesel generator 4. If diesel generator3 fails to start then load of bus section 3&4 will be transferred to diesel generator4. Fig. 3.6 shows generator operating condition based on bus section load, when load demand increases and single generator load is enough to fulfill the demand then two generators are operated simultaneously to meet the load demand.

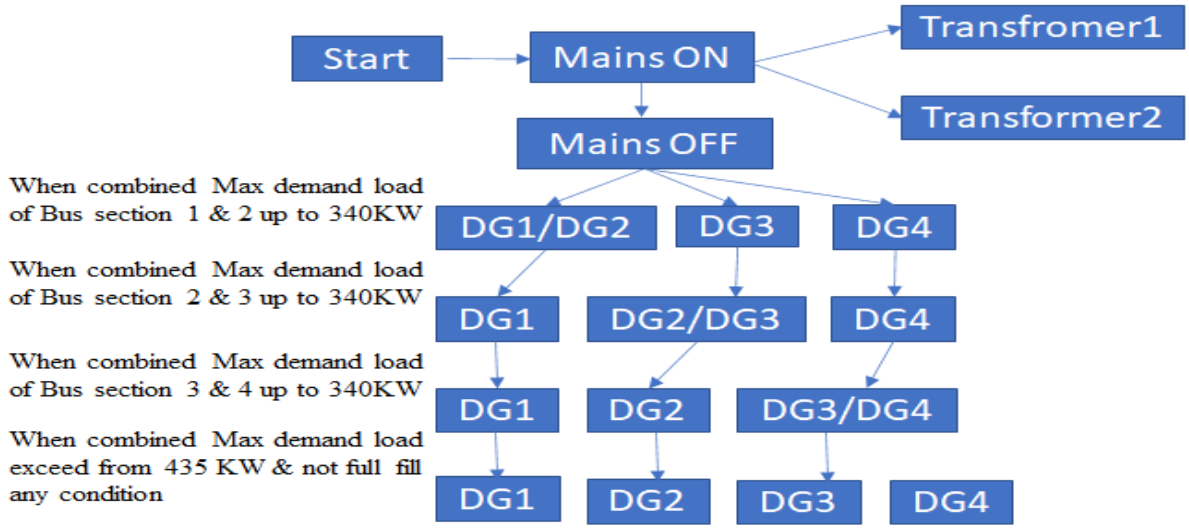


Fig. 3.6: Generator operating conditions based on bus section load

3.4 SCADA Screen Design & PLC programming

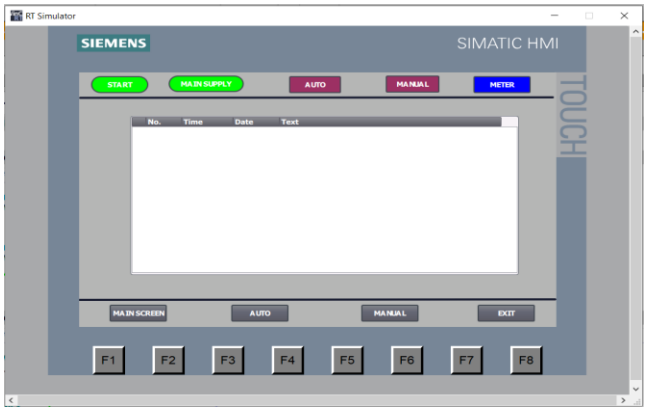
Direct control and data acquisition (SCADA) is a software program with hardware allows industry organizations to:

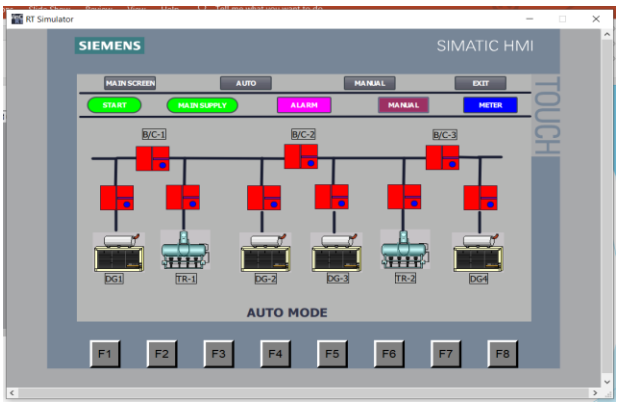
• Monitor, gather, and process real-time data

• Interact directly with devices such as sensors, valves, pumps, motors, etc. with the human machine software (HMI)

• Record events into log file SCADA programs are important for industry organizations as they help maintain efficiency, process data for smart decisions, and communication with system issues to help reduce leisure time.

SCADA screen is designed in Tia portal HMI/Wonderware Intouch. Wonderware InTouch enables users to quickly and easily build and manage usable, and industrial applications; maximizing return on engineering, shortening project times, reducing risk. PLC programming is connected with SCADA system to check and monitor the system. In fig.3.7 (a) main screen is shown, which has main supply notification system with alarm detection system. Different screens are linked by providing buttons in the bottom of the screen. Fig.3.7(c) shows manual mode Screen, it has four button to control generators manually when main supply fails. Providing manual mode in SCADA system helps in cost reduction of overall project and it is easy to control system from single device. Fig3.7(d) shows meter reading screen which gives information about load on each generator. Diesel generators and transformers are connected according to the designed system and rating requirement. Proper working of interlocking scheme is shown with the help of different color indications.





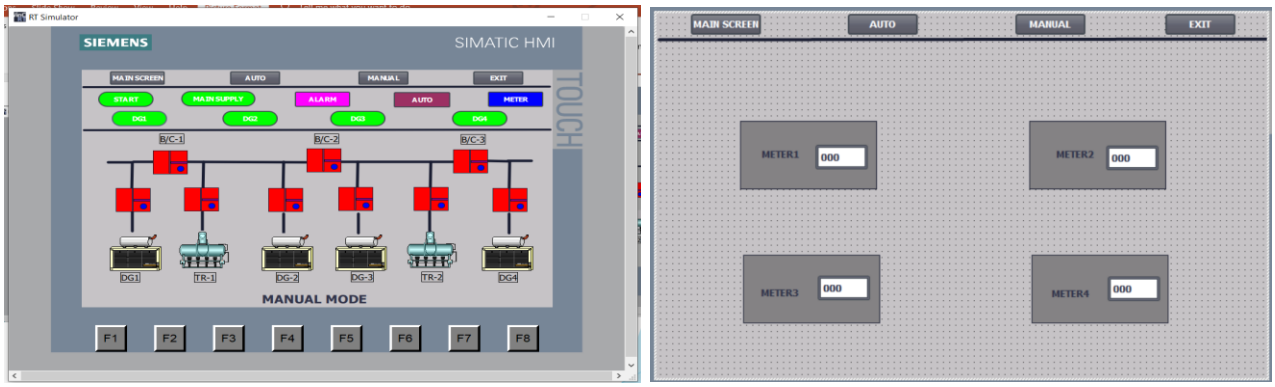


Fig. 3.7: a) MAIN screen b) Auto mode screen c) Manual mode screen d) Meter reading screen

Programmable Logic Controller

Programmable Logic Controller is a mainly used in industry. These controllers can perform all industrial specific automated process, machine function, or entire production line. Systematic logic control (PLC) or a controller is a digital sector computer modified for control production processes, such as integrated lines, or robot equipment, or any such function it requires high reliability, ease of planning and error processing. PLCs can chase small module devices with a wide range of inputs and outputs (I / O) in a critical area housing area. with the processor, on large devices equipped with a rack with this value thousands of I / O, and are often linked to other PLC and SCADA programs. They can be designed for many Digital and analog I / O systems, extended temperatures, noise protection, and vibration resistance.

Siemens Tia portal

Totally Integrated Automation (TIA) Portal is an engineering platform that let users to successfully submit, edit, and test Siemens automation hardware and software, all within one software that allows diagnostics, communication, and more. features. SIMATIC STEP 7 in the TIA Portal is a complete engineering tool for setting up and editing SIMATIC controls, whether they are programmable logical controller or PC-based systems.

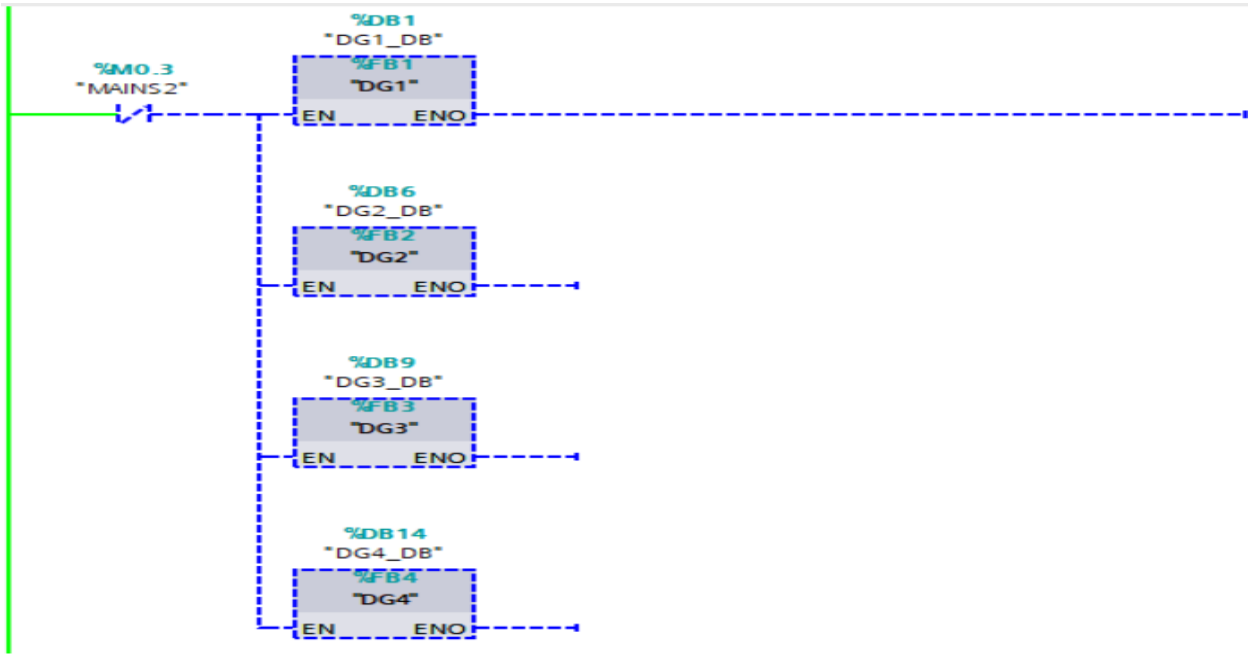


Fig. 3.8: DG function blocks

3.5 Result & Discussion

A. PLC programming results

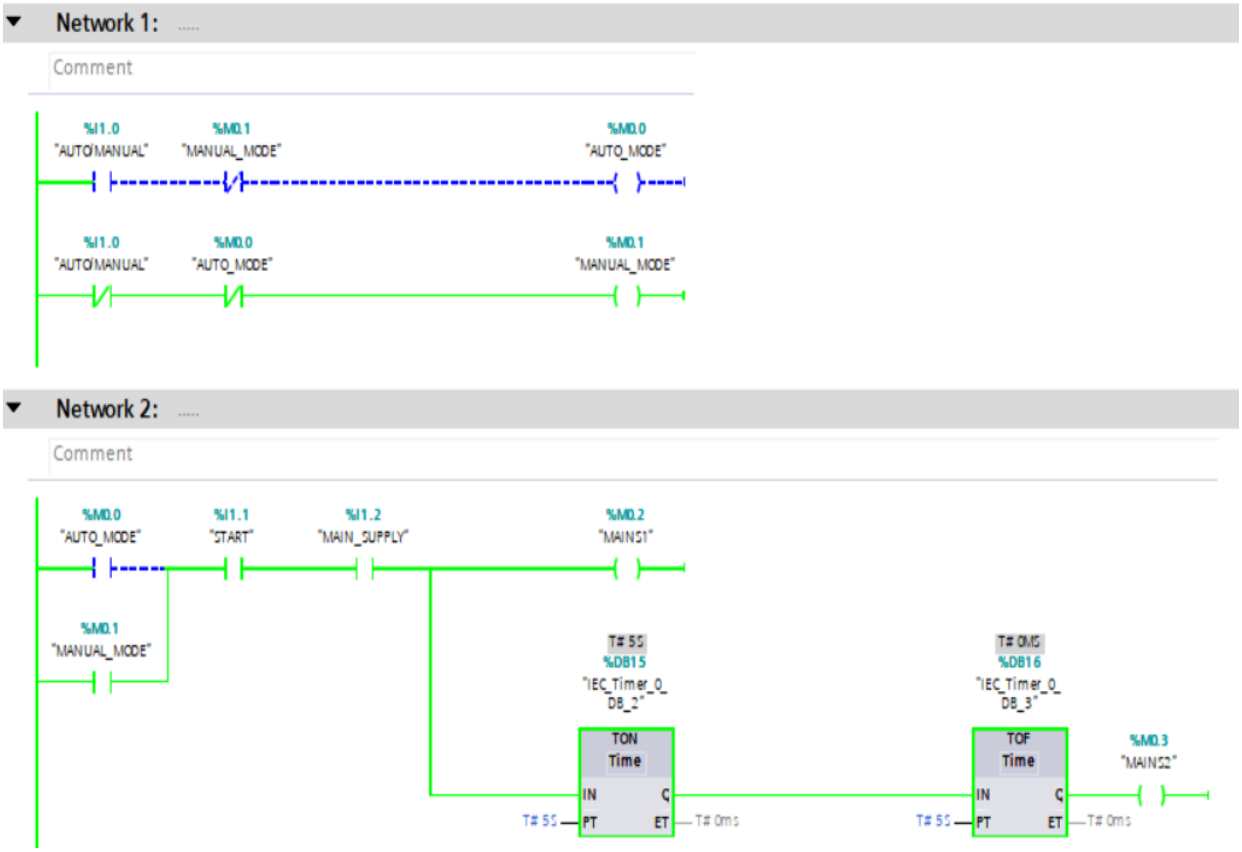


Fig. 3.9: AUTO/MANUAL MODE

Fig 3.9 network 1 is used for controlling system in Auto manual mode, Auto_mode and Manual_Mode tags are defined for operating programming can be controlled by these two tags. when main supply is ON, MAINS2 make sure DGs are OFF. Timers are connected between DG and transformer transition,

To make sure if once generator turned ON it will be ON for next 10s even if mains supply is healthy.

To ensure if main fails again then there will be no need of turning on generator again. It protects the system from extra diesel consumption. Separate function block is defined for each DG for proper functioning. Each DG function block has different condition for bus section 1&2, 2&3, 3&4. Programming is done in such a way that no two bus sections should match same load conditions. All condition can be seen in Fig.3.10.

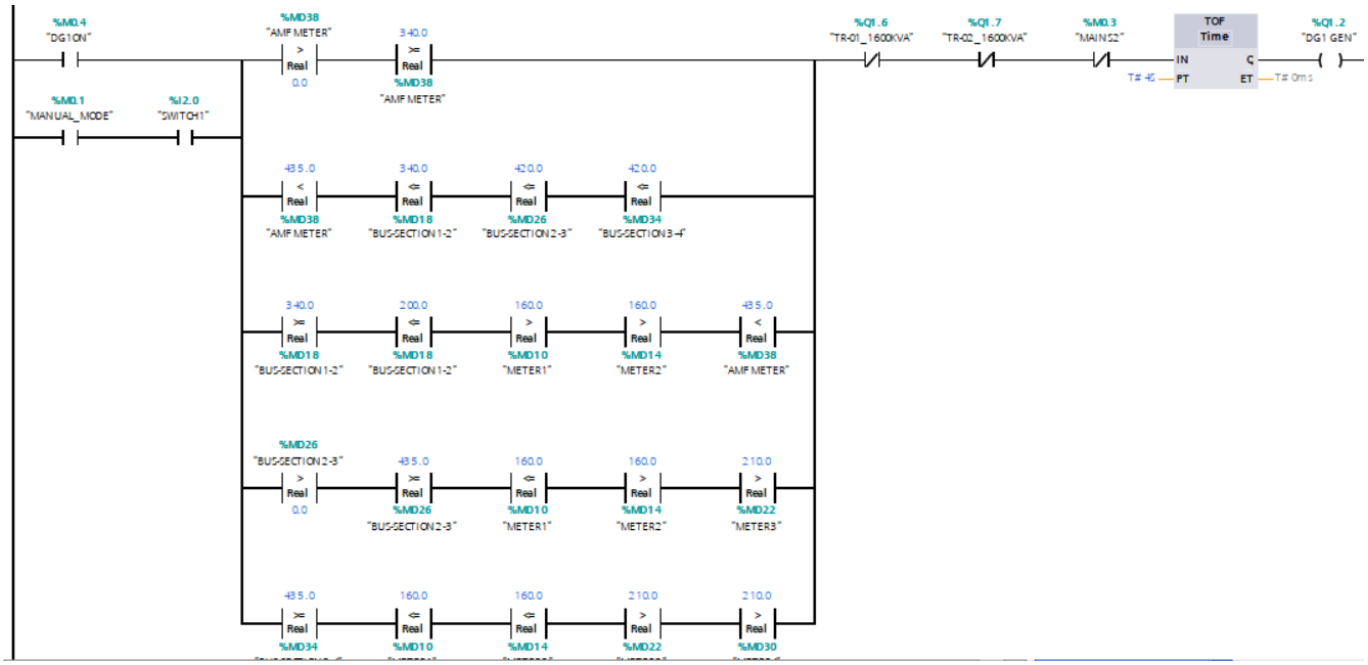


Fig. 3.10: Different conditions are included according to the load demand

Fig 3.11-3.12 show interlocking connections for air circuit breaker. For transformer 1 and 2 interlocking will work only when main is ON, system will know this by defined input tags. If input tag sends positive signal to the controller, it will implement interlocking scheme for transformers and send output signal to turn ON circuit breaker.

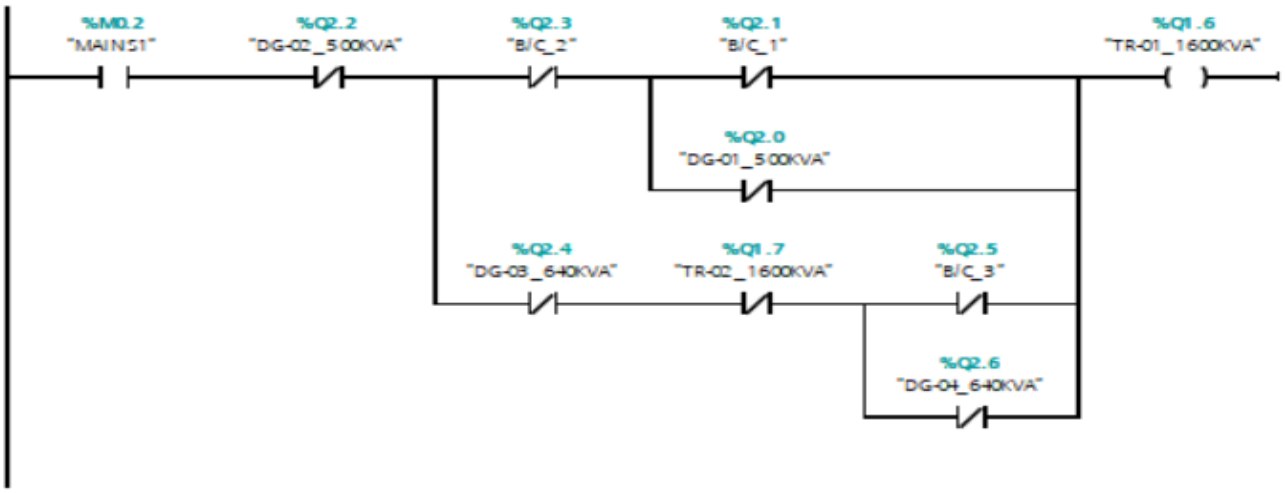


Fig. 3.11: Interlocking for transformer 1 circuit breaker

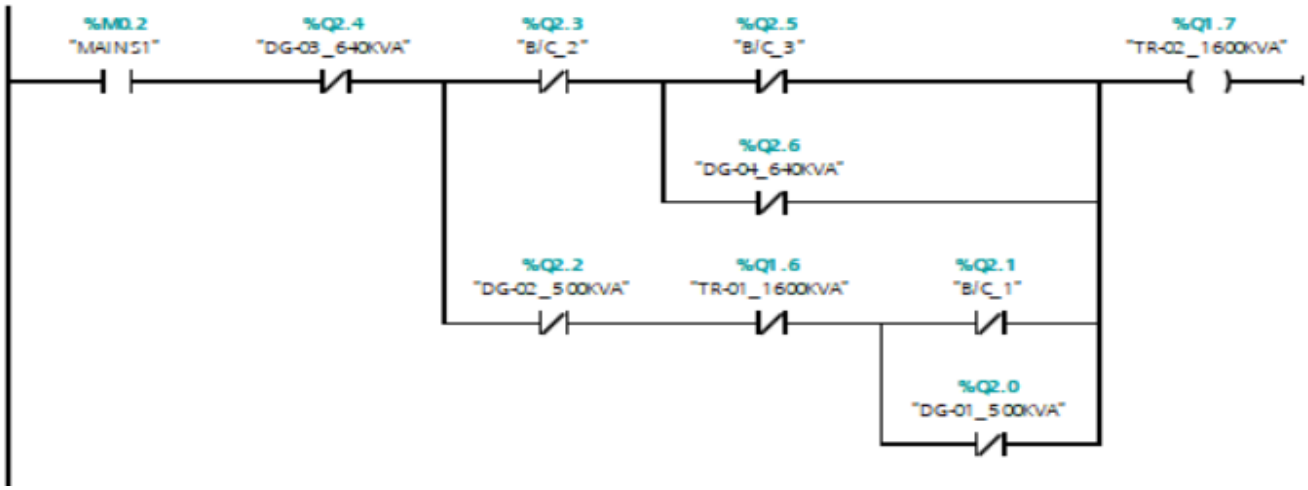


Fig. 3.12: Interlocking for transformer 2 circuit breaker

Fig. 3.13-3.15 shows interlocking connections for air circuit breakers of bus coupler 1, bus coupler 2 and bus coupler 3. All operating condition are implemented according to the bus coupler controls and interlocking is done in similar manner as given in fig.3. Normally open and normally closed connection are done with bus section maximum load demand limits. If maximum load demand limit exceeds then bus coupler will not turn ON. Different operating conditions for bus coupler can be seen in section4 operating conditions for DG synchronization system.

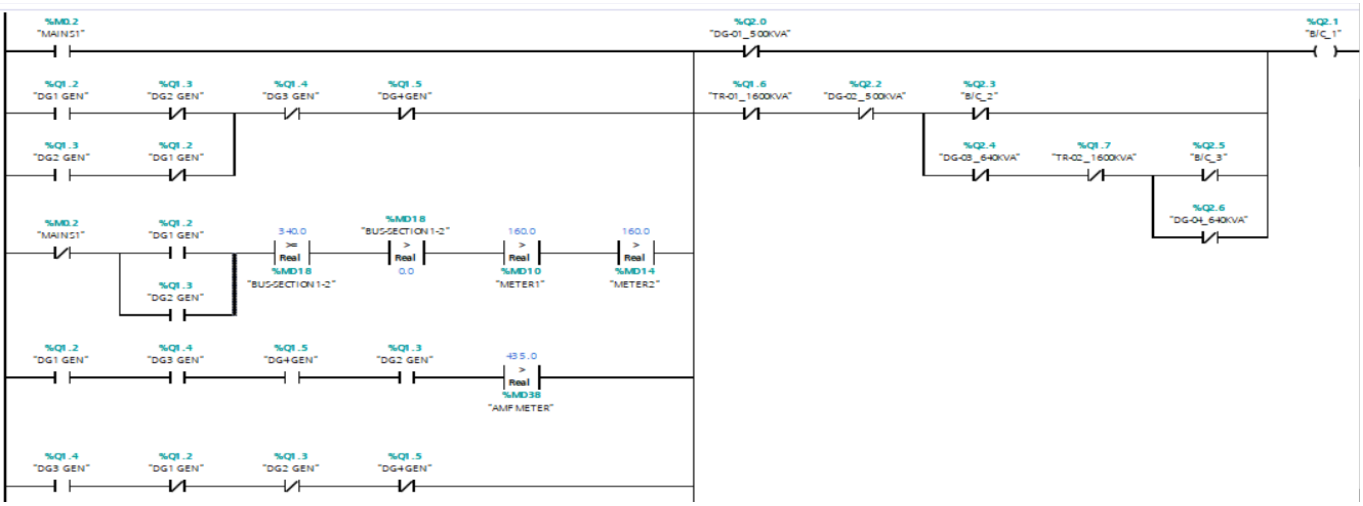


Fig. 3.13: Interlocking with operating conditions for Bus coupler 1

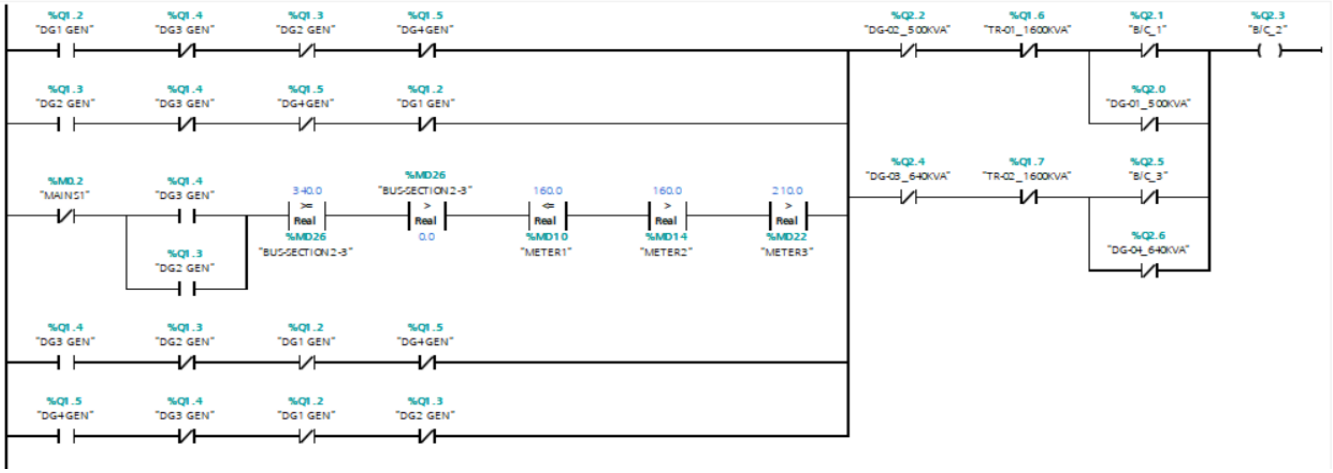


Fig. 3.14: Interlocking with operating conditions for Bus coupler 2

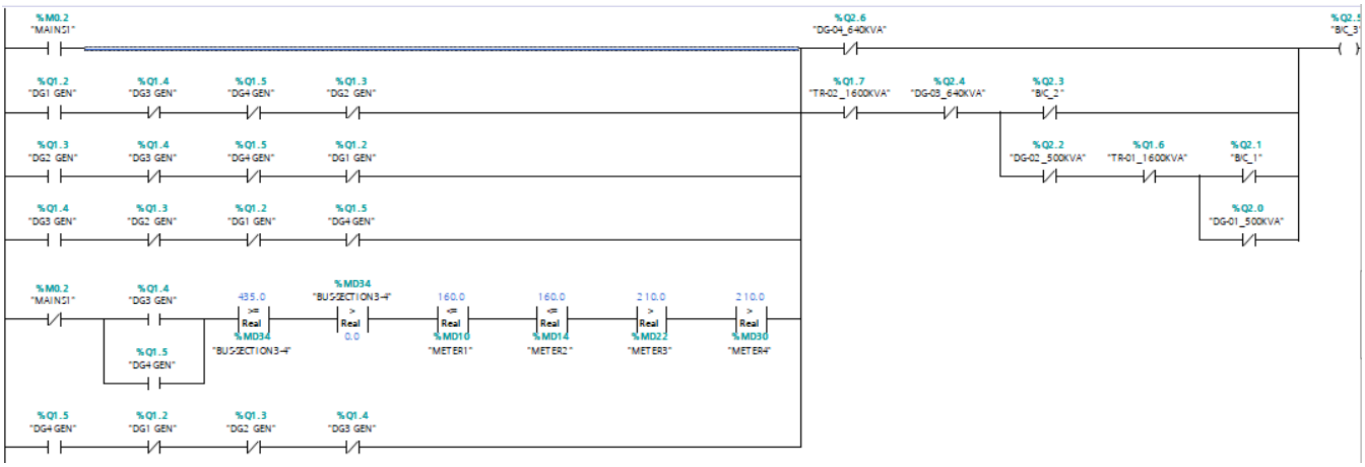


Fig. 3.15: Interlocking with operating conditions for Bus coupler 3

B. **D.G Synchronization System SCADA Screen Results**

SCADA screen is designed in Tia portal and results are obtained. Figure 3.16 shows operation during normal condition, tasnformer1 and transformer 2 are turned ON. Along with transformer1 and transformer2 bus coupler1 and bus coupler2 are also turned ON. Which ensures load supply in whole system. It is seen that similar results are obtained in both auto mode and manual mode which means system works properly in auto mode as well as in manual mode.

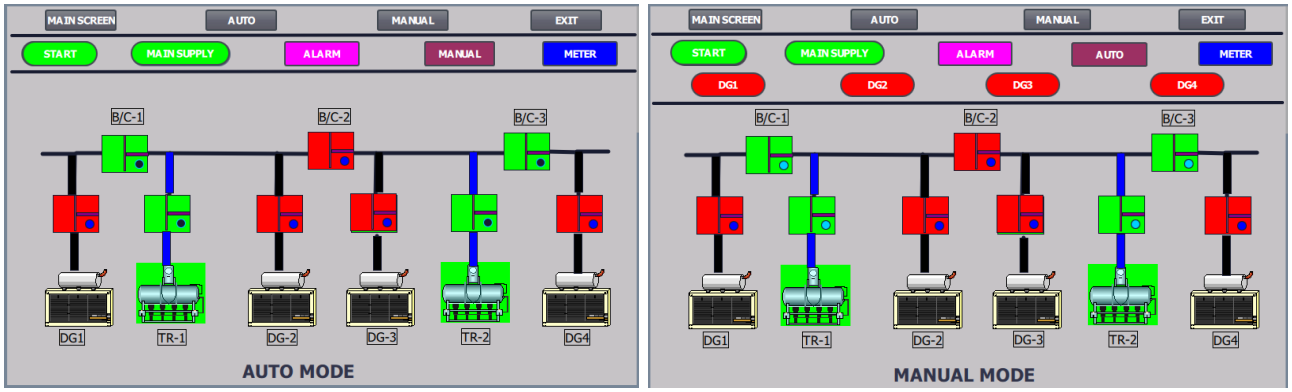


Fig. 3.16: AUTO MODE & MANUAL MODE

Figure 3.17 show diesel generator1 condition, when main supply fails then master1 which is DG1 will supply load. Load demand should be up to 340 KW. Bus coupler 1, bus coupler 2 and bus coupler 3 will be ON in this condition. They make sure load demand of system is fulfilled. If DG1 fails to start then load will be transferred to diesel generator 2.

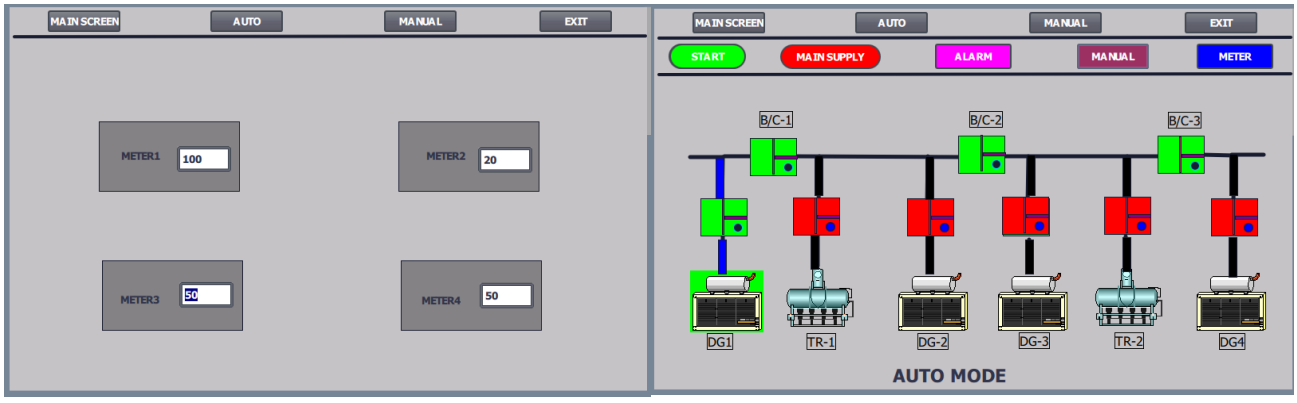


Fig. 3.17: When DG1 is supplying load

Figure 3.18 shows diesel generator 3 operating condition. There are two conditions for operating of DG3:

a) When diesel generator 1 and diesel generator 2 fails to start.

b) When load demand increases up to 435KW and DG1, DG2 fails to full fill demand.

In this condition also all bus coupler will be ON.

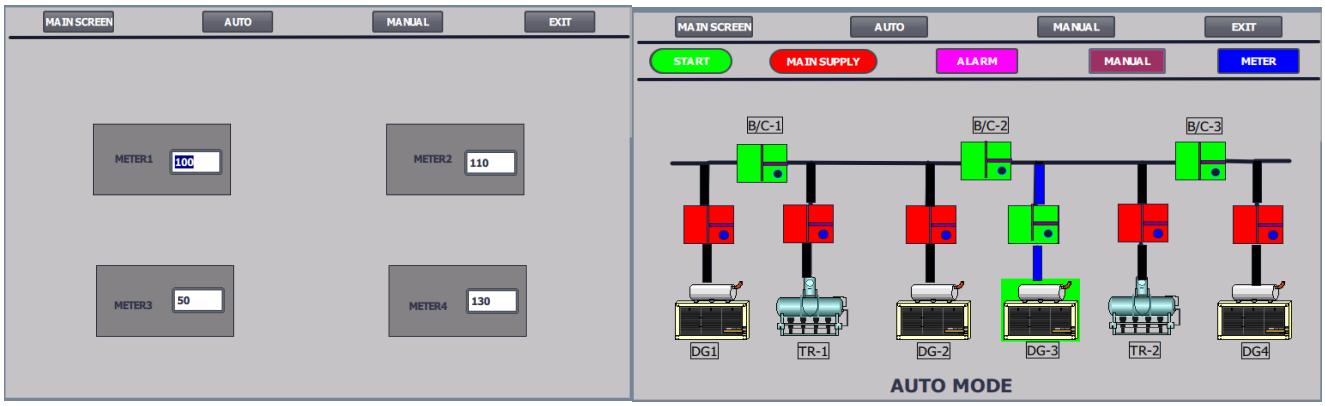


Fig. 3.18: When DG3 is supplying load

Figure 3.19 shows the condition where load demand increase from 435KW and load demand of bus section1&2 is up to 340KW (Bus section regions can be seen in fig. 6). In this condition DG1 will supply load to bus section 1 and bus section 2. Bus section 1&2 are connected by turning ON bus coupler 1 between them. Along with DG1, DG3 and DG4 will separately supply load to bus section 3 and bus section 4. If DG1 fails to operate then DG2 will supply load in bus section12.

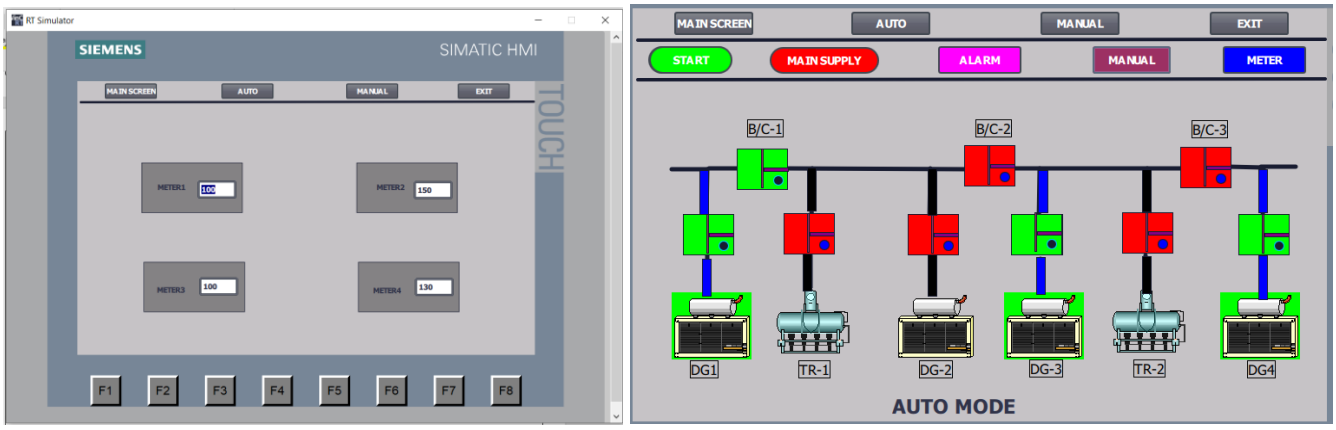


Fig. 3.19: When combined load of bus section 1&2 is upto 340kw

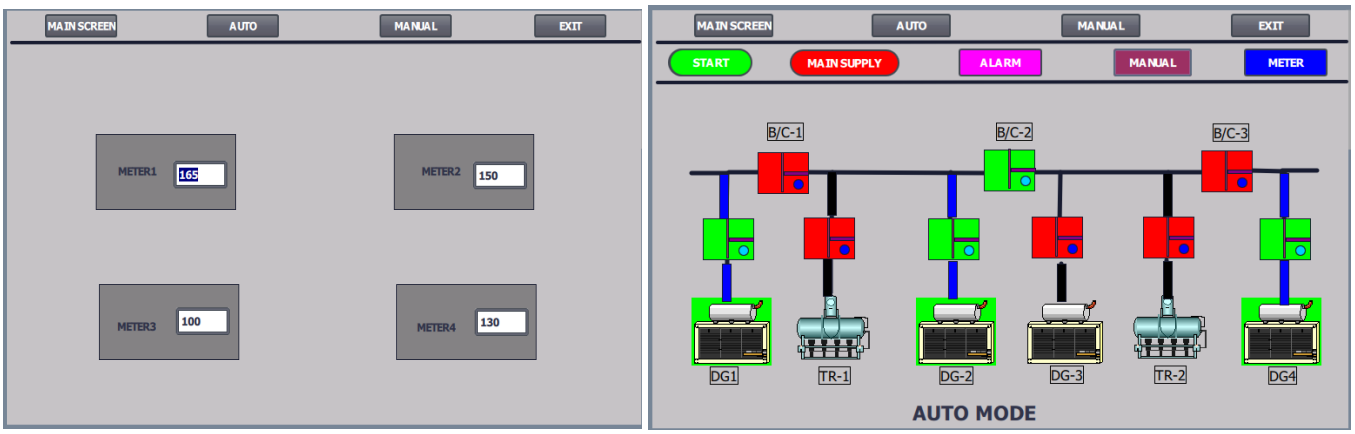


Fig. 3.20: When combined load of bus section 2&3 is upto 340kw

Figure 3.20 shows bus section23 conditions. If load demand of the system is more then 435KW and laod on bus section23 is up to 340 KW. Then DG2 will supply load to bus section23 and bus section 2&3 will be connected by turining ON bus coupler2. DG1 and DG4 will seprately provide load to Bus section1 and Bus section4. If DG2 fails to start or laod demand on bus section2&3 is up to 435KW. Then DG3 will supply load.

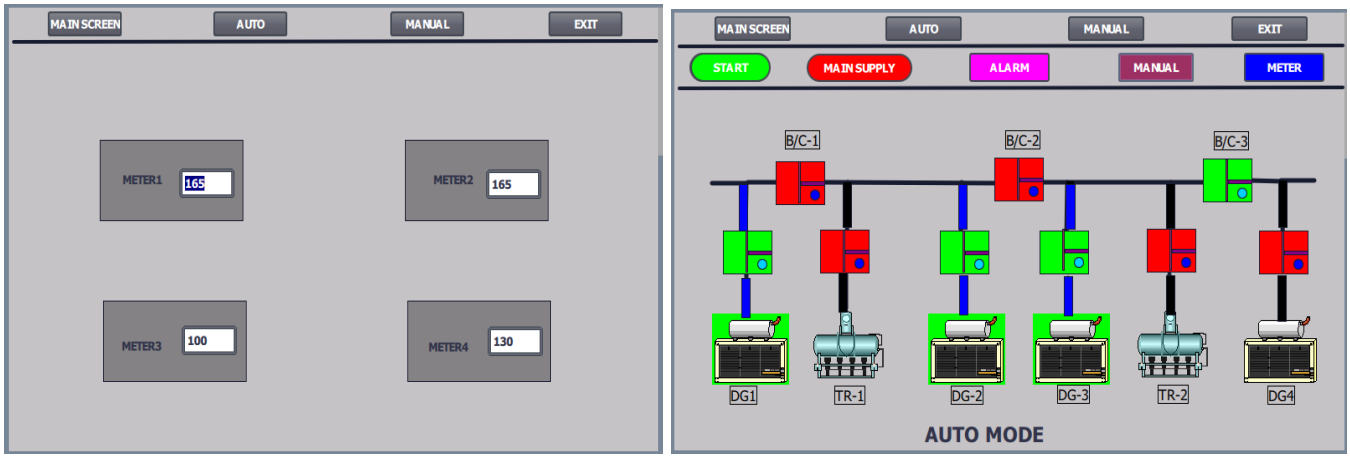


Fig. 3.21: When combined load of bus section 3&4 is upto 340kw

Figure 3.21 shows bus section34 conditions. If load demand of the system is more then 435KW and laod on bus section34 is up to 435 KW. Then DG3 will supply load to bus section34 and bus section 3&4 will be connected by turining ON bus coupler3. DG1 and DG2 will seprately provide load to Bus section1 and Bus section2. If DG3 fails to start then DG4 will supply load.

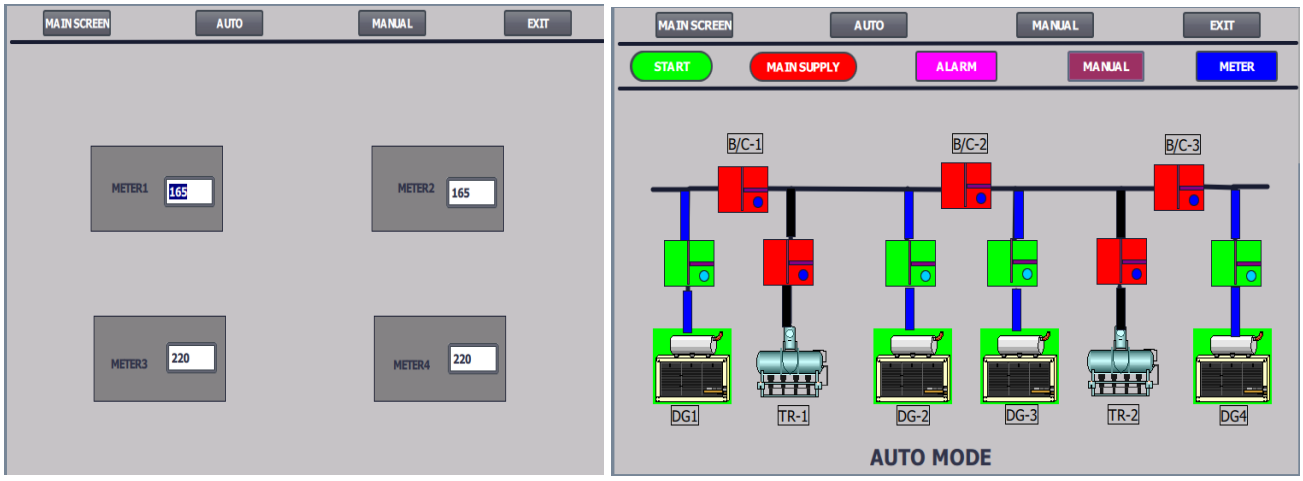


Fig. 3.22**:** When combined maximum demand load exceeds from 435KW

If laod demand increase from 435KW and no bus section condition is full filling laod demand. Then DG1 will sepearately provide load to bus section1, DG2 will provide load to bus section2, DG3 will provide load to bus section3, DG4 will provide load to bus section4. All bus coupler will be off in this condition. Fig. 3.22 shows the operating condition of DGs operating in separate bus sections.

3.6 Conclusion

This Chapter discuss about PLC based D.G Synchronization System. System is designed for high load demand industrial plant with generators for backup power supply. Using interlocking scheme and different operating conditions for DG synchronization system. PLC programming is done using ladder logic in Tia portal. For monitoring and controlling SCADA screen is designed in Wonderware Intouch/Siemens HMI. All conditions were checked using manual meter for and results are obtained in SCADA system.

CHAPTER-4

PLC BASED WATER BOTTLE RE-FILLING STATION

4.1 Introduction

The aim of this project is to reduce the use of plastic bottles and to prevent waste water. The designed system provides total water consumption and total value. of stored bottles. The system also monitors individual water use. The filling function is based on the userdefined volume in which the user can select the volume of the liquid to be filled. The system is designed using PLC (programmable logic controller), HMI (Human Interface System), Solenoid Valve, Relays, MCB, Indicators and pressure buttons. Filling is controlled by PLC using the ladder logic method. In the bottle filling system, the PLC detects the sensor response and controls the solenoid valve. The whole system is simplified, time-saving and easy to use. All the results lead to the conclusion that the performance of PLC is very encouraging. In the future this system could be used in colleges, universities, schools, beverage industries, portable water tanks and water resources.

The Designed System is operated by the MCB, where the main MCB is OPEN and the Bottle is placed before the sensor indicator will be ON.PLC gives the command to the solenoid valve and the solenoid valve will open. The channel is designed in both the default and manual mode. In the default mode one has to write reg no./code to monitor. For manual mode the bottle can be refilled using push buttons. Solenoid valve will close and water will stop when the sensor stops receiving the water bottle. Complete water use and individual water use and complete reusable bottles will be stored in PLC and can be transferred using a communication module.

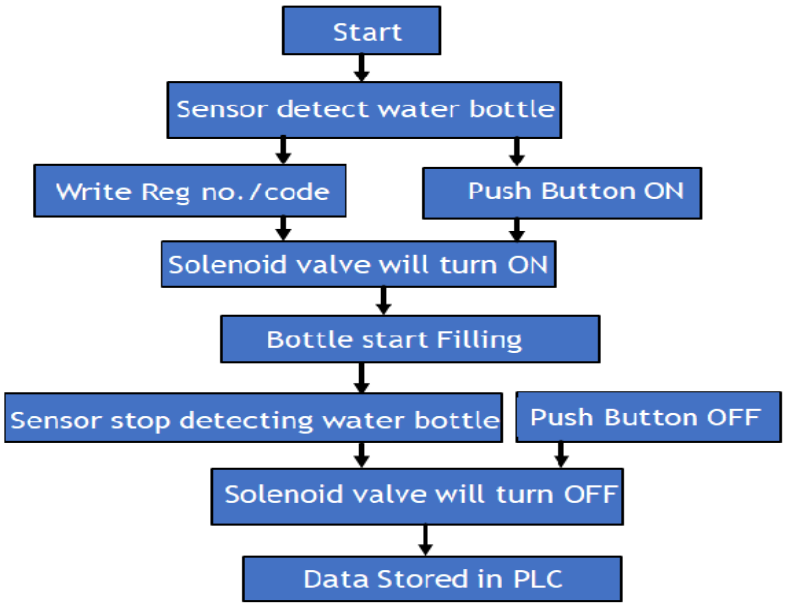


Fig. 4.1 Flow Chart of working principle of filling machine

4.2 Design of Re-filling station

Proposed re filling station is designed in AutoCAD software. Model is made from CRCA steel.

A. CRCA Metal

CRCA states, "cold wrapped around annealed." The cold metal is folded to fit, making it soft and not really valuable, followed by warming in a closed nitrogen climate or other non-oxidizing particles, which soften it while protecting it. In this way, ANY metal can be CRCA, not naturally soft metal. For steel assiduity, they use a cold coating of hotrolled steel to hold the coil in place of hydrogen, and reheat it to tighten the surface of the piece, in order to maintain an important distance from scratching. all consistency. Cold coated near an annealed means that after hot rolling and dipping, cold steel is wrapped in a reduced area, making it weaker and more application able, which is also followed by tightening in a closed nitrogen or other non-oxidizing environment, which does. it relaxes and protects the metal from heat. The term soft metal does not mean that it is important away from low carbon, and it can be hot rolled or cold.

B. Powder Coating

After cutting and burning the sheet model goes under the powder coating process. Powder coating is a dry finishing process that uses finely ground pigment particles and an electrically charged frame and sprayed on electrically supported parts. The charged powder particles stick to the part and store there until they melt and blend into a uniform dressing in a therapeutic oven. Powder coating contains 7 tanks with different chemicals that prevent corrosion. The "7 tank system" is just a process which are parts immersed in seven thighs in a row.

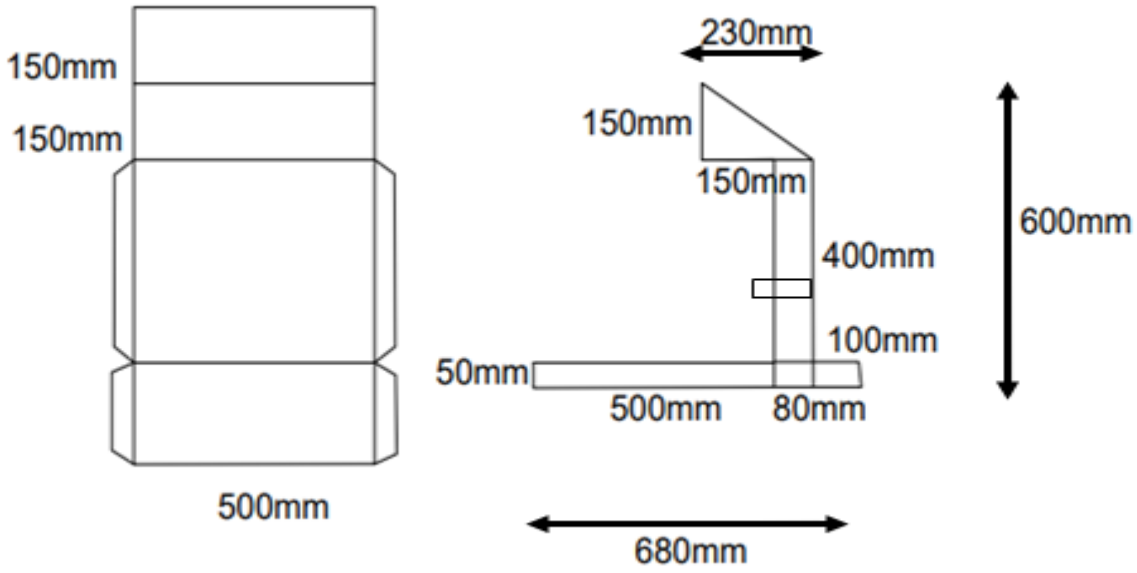


Fig. 4.2 Design of filling machine



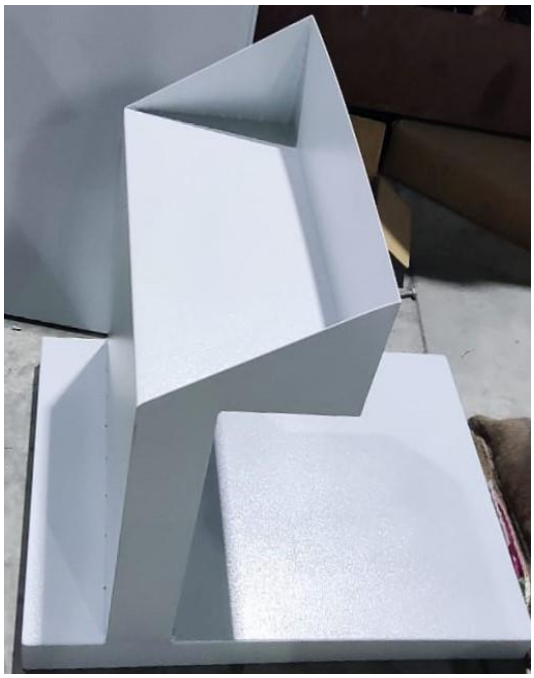



Fig. 4.3 Final Construction of an automatic bottle filling machine

4.3 Hardware and Software Specification

A. Human Machine Interface

Human machine interfaces (HMIs) is used as a control panel for drivers in Programmable logical controllers, Remote Terminal Units, and others. HMI converts custom switching, dialing, and other controls by introducing a photo and digital control system the controls in them have an impact on that process. Because HMI is software based, it changes real wires and controls software parameters, allowing them to be easily modified and adjusted.

HMI is available modern software applications running on modern applications, etc. do a lot of work. They act as a bridge between the human user and the complex understanding of one or more PLCs, which allows the operator to work on it a process instead of foundations the mind that performs function and control many activities throughout the environment are widespread and possible complex processes in one place. To do this, the user interface will be represented image is a controlled process, which combines sensor values with other values, e.g., well visual representation of exit conditions (which are open engines, open pumps, etc.).

Material	Quantity
PLC (RENU)	1
HMI (RENU)	1
Solenoid Valve	1
Relay	2
MCB	1
Photoelectric sensor	1
SMPS	1
Push Button	1
Indicator	1

Table 4.1: Material List of Re-filling station

B. Relays and Miniature Circuit Breaker

Relay is a simple electromechanical switch. While using standard switches to turn off or manually open circuit, Relay is also a switch that connects or cuts two circuits. But instead of manual operation, the relay uses an electronic signal to control it electromagnetic, connecting or crossing another circuit. Transfers can be personal various forms such as electromechanical, state solid. Electromechanical relays are frequently used. Let's take a look at the inner parts of this slide before we know it it works. Although many types of transfers exist, their function remains the same the same. Every electromechanical relay contains:

Miniature circuit breakers (MCBs) ensure electrical safety in homes, offices and other buildings and industrial systems by preventing overloading and short circuits. Once the fault is detected, the small circuit breaker automatically closes the electrical circuit to prevent cable damage and avoid fire hazard. To ensure the reliability and safety of people and property, MCBs are equipped with two intervening mechanisms: a delayed thermal offset to prevent overcrowding and a magnetic resilience mechanism to protect a short circuit.

C. Photoelectric Sensor

A photoelectric sensor is a control tool that works by detecting a visible or invisible beam light and response to changes in the intensity of the received light. Photoelectric sensors are formed two basic components: transmitter (light source) and receiver (sensor), The basic functions of a photoelectric sensor can be summarized as follows:

• The transmitter contains a light source, usually an LED and an oscillator.

• The oscillator switches on or off LED at high speed.

• The receiver determines the light beam and changes the output device, which meets the load.

• The receiver is tuned to the emitter frequency transmission and will only amplify the light signal that pulses with a certain frequency.

• Photoelectric sensors allow for adjustment of the amount of light that will cause the nerve output to change position.

D. Solenoid Valve & Mechanically Operated switch

The solenoid valve is an electrically controlled valve. Solenoid valve is a type of separator. The valve contains a solenoid, which is a ferromagnetic electric coil. spinal cord (plunger). A resting place, the plunger closes the small orifice. Electricity using coil c regenerates the magnetic field. The magnetic field uses a direct power in the plunger that opens the orifice. This is the basic system used to unlock and close solenoid valves.

Manually operated switches are controlled by hand. These include toggle switches, pushbutton switches, knife switches, and selector switches. Pushbutton switches are the most common form of manual control. A pushbutton operates by opening or closing contacts when pressed. Commonly used types of pushbutton switches, which include:

• **Normally open (NO)** • Normal pushbutton (NO), which activates the circuit when pressed and returns to its open position when the button is released.

• **Normally closed (NC)** pushbutton, which opens the circuit when it is pressed and returns to the closed position when the button is released.

• **Break-before-make** pushbutton in which the top section contacts are NC and the bottom section contacts are NO. When the button is pressed, the top contacts open before the bottom contacts are closed.

E. SMPS

The power switch is a power supply that integrates the switch control convert electrical energy accordingly. Like other electronic devices, SMPS transmission power to DC or AC source (usually high power) to DC load, as individual computer, while converting voltage and current features. Unlike line power supply, pass the transistor mode switch keeps changing during recess, full light and full closure, and it consumes very little time for high-density, low-density changes wasting energy. Ideally, the modified power supply mode does not waste energy. Electrical control is achieved by changing the output time ratio. On the contrary, the line the power that controls the output voltage by continuously dissipating energy to the ground transistor. This high-power conversion is an important advantage of a modified power supply. The electric power of the converted mode may be much smaller and lighter than line therefore consequently small transformer size and weight. For this project, 24 V DC and 12 V DC SMPS is electrically applied to various components used. For example, 12 V DC is used to power the water pump, DC geared motor and 24 V DC is used power solenoid valve, switch and photoelectric sensor.

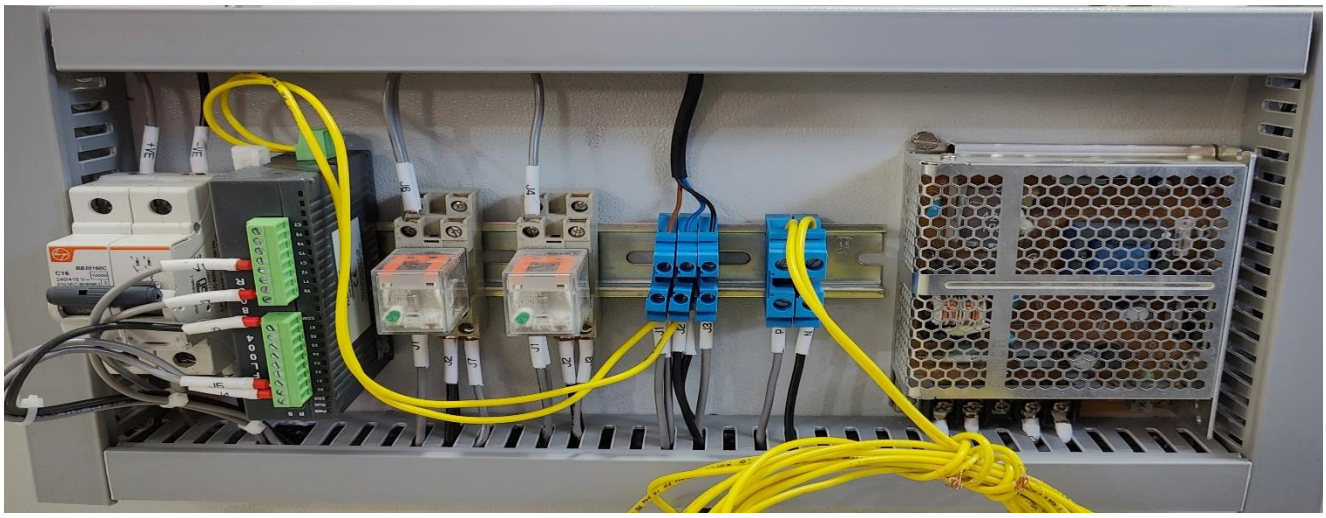


Fig. 4.4 Wiring of Re-filling Station

F. FlexiSoft

FlexiSoft is a PLC application designed to configure RENU HMI and PLC. It has a built-in web server with HMI tools. FlexiSoft displays Logic and HMI simulation and can import HMI logical screens and blocks from other apps.

G. AutoCAD

AutoCAD is a computer-based design program that uses a large number of design processes. It provides additional support for Digital accuracy helps with measurements and statistics, 3D components, and data sharing. Designers and designers use AutoCAD to design building plans, bridges, and roads. The house or apartment is where you currently live almost built using CAD software. It provides the designer with a tool to draw objects in it scale. This means that one can take these pictures and follow the scales embedded in them to form tangible objects that fit together precisely. These plans were previously hand-painted and copied. Having this ability on a computer does this the process is very easy very fast. CAD drawings can be modified and embedded in 3D printers and CNC machines for designing prototypes, custom tools, and parts for large devices. Small pieces can be precisely accurate built with CAD drawings that include making large machines. AutoCAD is software that helps engineers transfer designs from their ideas to the real world.

4.4 Power Circuit & Control Circuit

1. Power Circuit of Re-filling station

A power circuit is any circuit that is used to carry load. This may seem like a simple definition but it is important to separate power circuits from control circuits as they serve different purposes.

All components used in this project operates on 24V DC. For conversion of power supply, switched mode power supply is used which converts 230V AC to 24V DC. Main MCB controls overall power supply of system. SMPS provides 24V DC to HMI, PLC, solenoid valve, sensor and relay. Along with push button and indicator.

2. Control Circuit of Re-filling station

A control circuit is a unique type of circuit that is used to control the operation of a power circuit. In a designed system, the control cycle begins with a photoelectric sensor. When the sensor detects the bottle, it opens the normal relay from normal. Giving order to PLC. According to PLC the ladder logic controller opens the outlet relay which opens the solenoid valve IV and the bottle begins to fill. As well as the solenoid valve indicator re-opened in line with the ON indicator. HMI acts as a master giving command to the slave PLC.

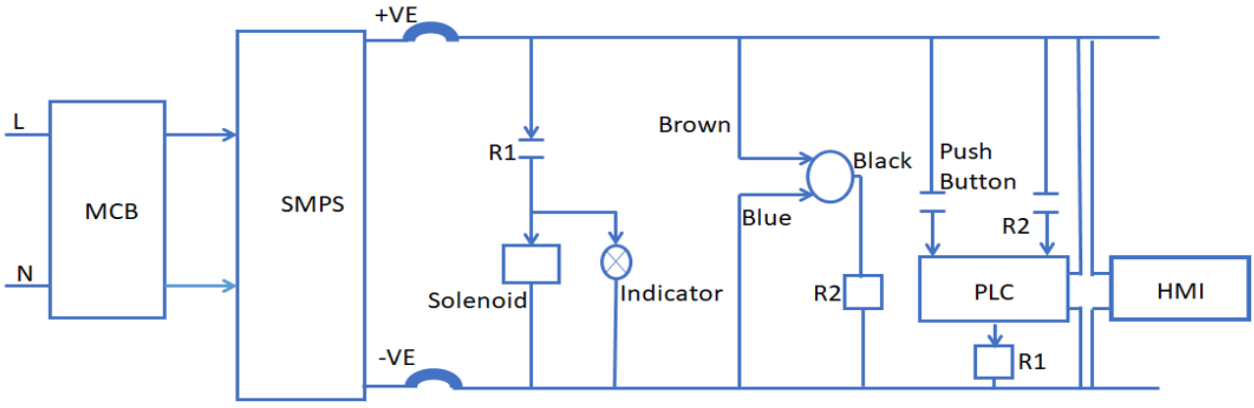


Fig. 4.5: Power Circuit & Control Circuit

4.5 HMI Screen Design & PLC programming

A. HMI Screen Design

HMI screen is designed in FlexiSoft software and uploaded in touch screen RENU HMI .

Screen shows indication of Push Button, Sensor and total no. of bottles. Data entry block is used for code entry and individual consumption is shown after code entry. Data Display Block shows no. of bottles. All PLC tags are transferred in HMI screen using USB and ethernet cable. All PLC tags were assigned to HMI as per ladder logic input and outputs. Once tags are assigned PLC and HMI communicate themselves using RS232.

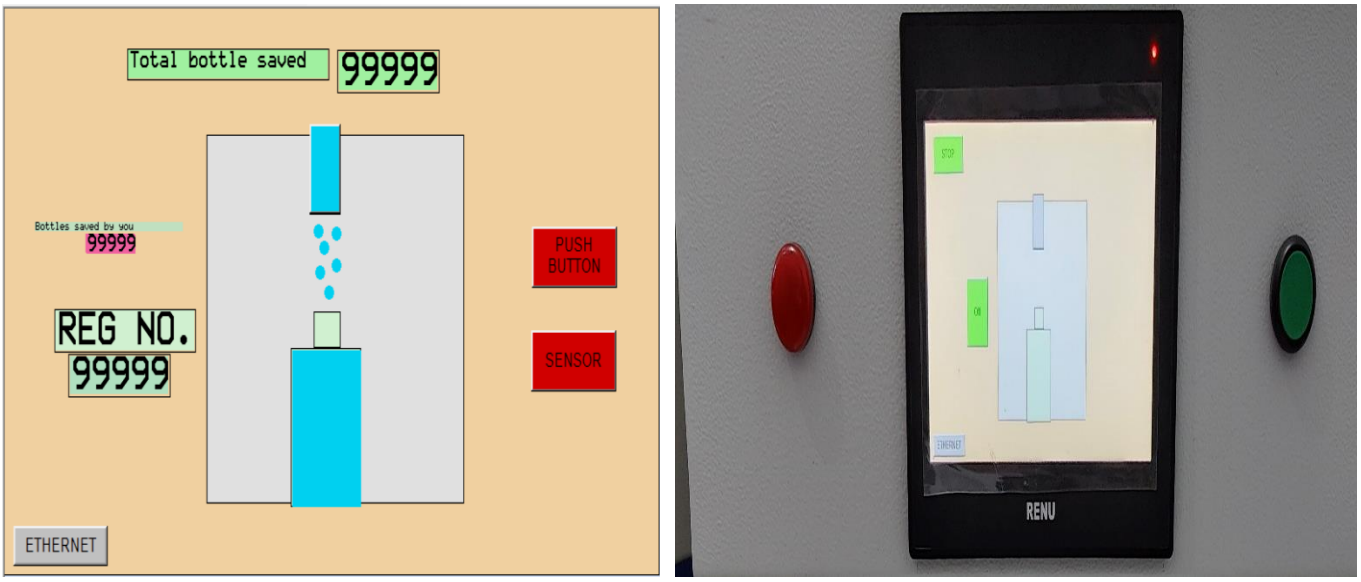


Fig. 4.6: HMI Screen Design

B. Water Bottle Re-Filling Station PLC Programming

PLC programming is done using ladder logic in FlexiSoft software. Bottle counting and water consumption is based on total time calculation.

Rung 1

In manual mode, Ladder logic programming is done for push button. Total consumption is noted in manual mode also.

Rung 2

In auto mode operation, bottles are detected by photoelectric sensor. Each individual is provided with separate code for water monitoring. Retentive timers are used for calculation.

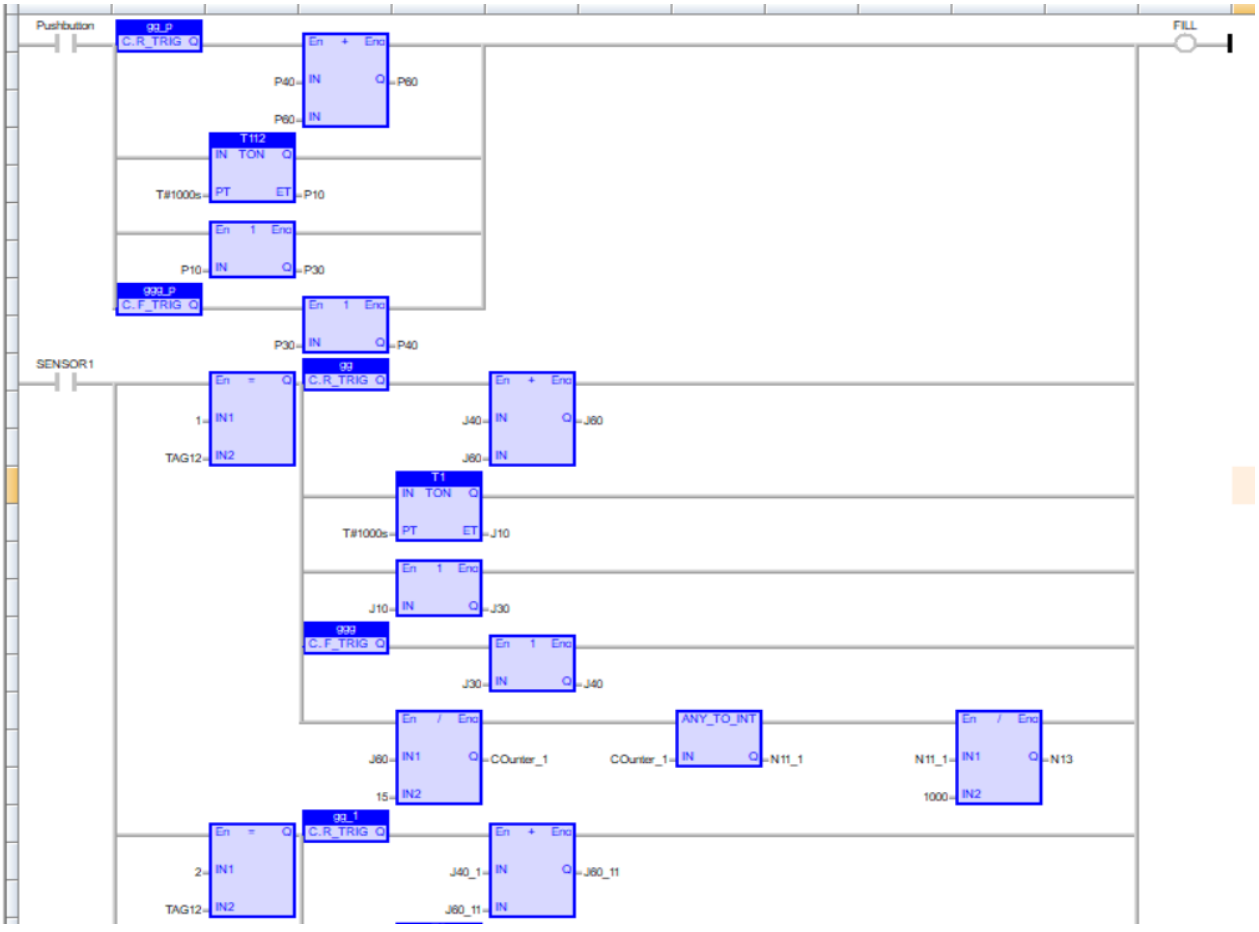


Fig. 4.7: Auto Mode & Manual Mode programming

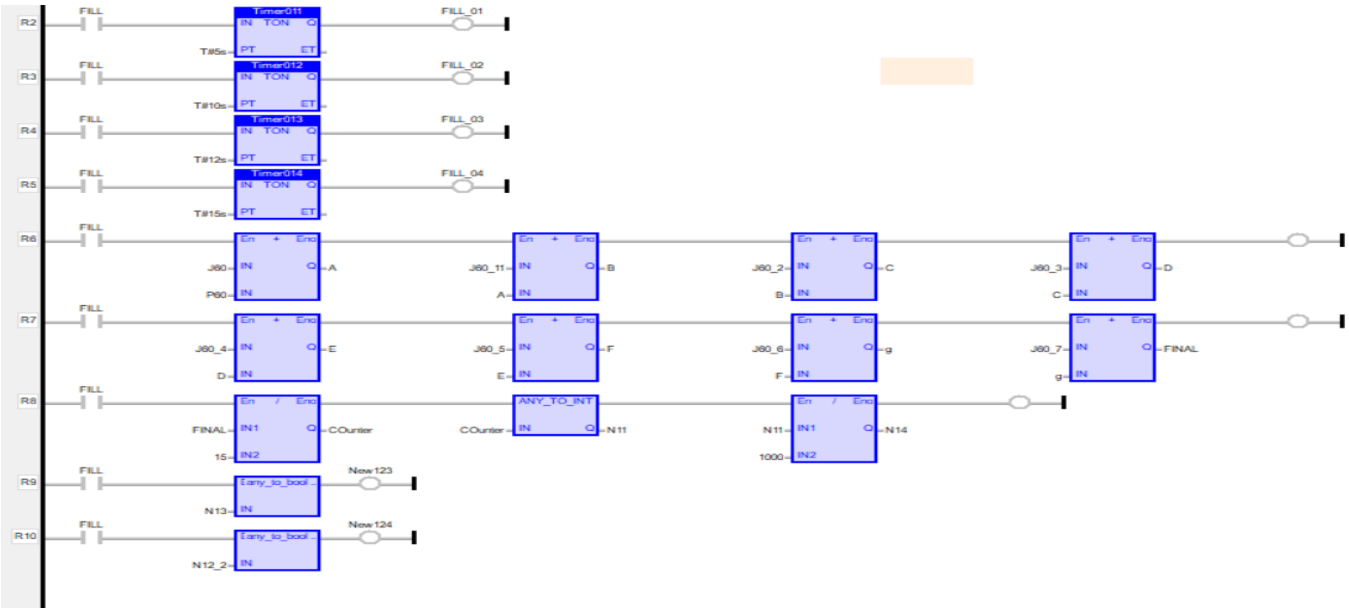


Fig. 4.8: Programming for different codes

4.6 Conclusion

Ladder logic programming for RENU FL004 0806R is done in FlexiSoft software. We obtained real time monitoring and controlling of proposed system with the help of input signals from photoelectric sensor connected with the PLC and sending signals to Solenoid valve and HMI for digital display. Visual representation of system can be obtained with the help of HMI and FlexiSoft software.

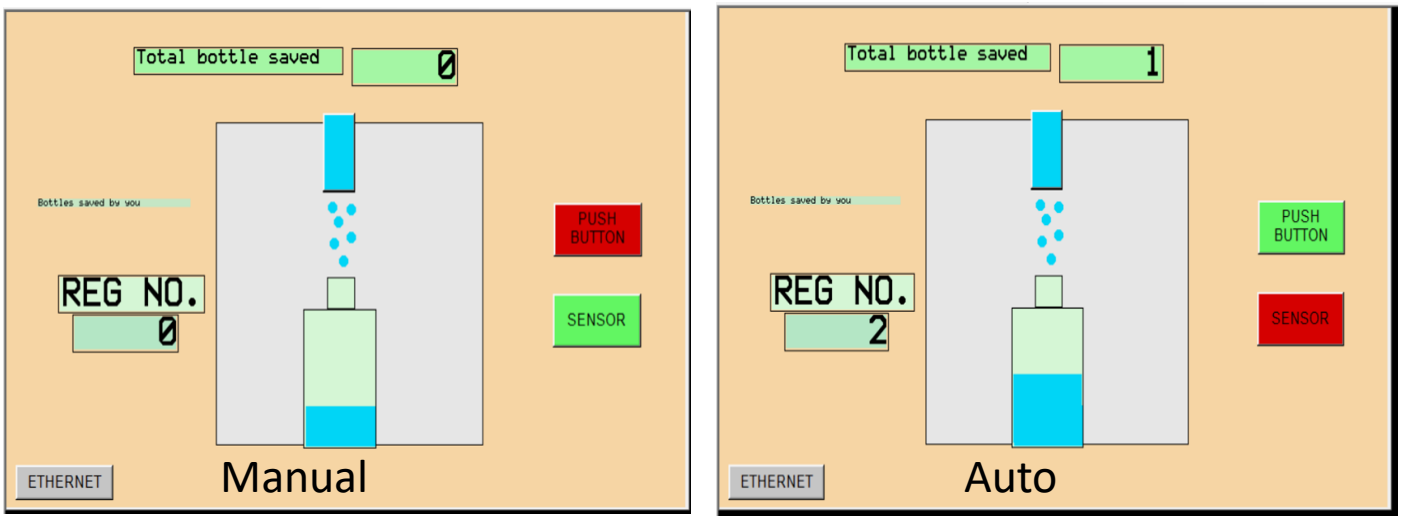


Fig. 4.9: Auto Mode & Manual Mode Screen

CHAPTER-5

CONCLUSION AND FUTURE WORK

This thesis presents PLC based automated system. The design and implementation of interlocking scheme of generators and transformers for high load demand system using PLC and SCADA. In addition, the nuances for selection of ACBs, transformers and DGs of appropriate rating are explained. The system is designed for high load demand industrial plants where generators are used for backup power supply. The developed system employs interlocking scheme based on different operating conditions for DG synchronization system, along with load shedding and alarm conditions. The system is tested for different load conditions and DG failure combinations. For monitoring and control of operations SCADA HMI screens are designed and the results are verified. PLCs being rugged are suitable for industrial applications capable of withstanding temperature variations, vibrations etc. The developed SCADA HMI screens are intuitive, do not require any specialized skills for the monitoring and operation of the system and can be suitably employed for load management, fast switching and monitoring of high load demand industrial plants where DGs are used for providing uninterrupted power supply.

An automatic bottle re-filling machine is designed and constructed. All the components are performing well. It can fill 500 ml bottle in 15 second. It is a time-based control system and it can fill 34 ml per second. Automation systems are used to increase productivity, which in turn brings economic progress. The main purpose of PLC in automation is used to control the whole system. The cost of installation of designed system is cheaper than available system in the market and can efficiently run for a long period of time. It saves human time and provide additional data. The entire system is more reliable, time saving and user friendly.

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