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Automatic Voltage Regulation Using PLC's in Smart GSS

Naval Kishor Dagla[1], SSPM Sharma B[2] and Rahul Mishra[3]

[1] Department of Electrical Engineering, Mewar University, Chittorgarh, Rajasthan 312901, India

[2] Department of Electrical Engineering, Mewar University, Chittorgarh, Rajasthan 312901, India

[3] Department of Electrical Engineering, Mewar University, Chittorgarh, Rajasthan 312901, India

Abstract

With the increasing electricity demand and thereby meeting the continuous supply demand of consumers, mainly industrial which has now became a challenge to electrical engineers. So for proper consumption of power, substation monitoring is very important for the purpose of controlling the hardware & software. In order to reach strong conclusion about their actual impact on power grid monitoring and control without manpower the software like PLC can be helpful for optimization. Since, as power grid has to maintain a continuous 24hrs supply to industries. Normally industrial loads are connected with two lines, one will be in on mode and the other will be in off mode as a backup, which will be in operation when a fault occurs in the existing line. Mostly this operation of switching from one faulty line to a healthy line or coupling it with another line is done manually. In this paper, a PLC is used to reduce human interventions and thereby making this fault clearance for uninterrupted industrial supply. A line to line interlocking of voltage is done through plc.

Keywords: *PLC, Relay, Power grid system, fault isolation etc.*

1. Introduction

The electric power grid can be defined as the entire apparatus of wires and machines that connect the sources of electricity (i.e., the power plants) with customers and their myriad needs. Although it has been acclaimed as "the most significant engineering achievement of the 21th century", the existing power grid face various challenges. The demand for electricity has grown to an extent that transmission networks are being pushed ever closer to their stability and thermal limits. Loss of system stability, high transmission losses and voltage limit violations have become major issues. Moreover, it is not only simple supply reliability that consumers want today– they want high quality supply voltage. Automated manufacturing processes, the IT industry, financial institutions, hospitals, electronic consumer products are some major areas where high power quality is required. Last but not least, the concern on climate change has caused a pressing demand for shifting from fossil fuels to renewable energy sources. The traditional solutions of upgrading electric transmission system infrastructure in the form of new power plants, new transmission lines, substations and associated equipment cannot fully address these big challenges. It is very important more than ever to rethink the features, components and organization of the whole grid system. The shift in the development of transmission grids to be more intelligent has been summarized as "smart grid," as well as several other terminologies such as Intelligent Grid, Grid Wise, Future Grid, etc. The Smart Grids program, formed by the European Technology Platform (ETP) in 2005, created a joint vision for the European networks of 2020 and beyond. Its objective features were identified for Europe's electricity networks as flexible to customers' requests, accessible to network users and renewable power sources, reliable for security and quality of power supply and economic to provide the best value and efficient energy management. A Federal Smart Grid Task Force was established by the U.S. Department of Energy (DOE) under Title XIII of the Energy Independence and Security Act of 2007. In its Grid 2030 vision, the objectives are to construct a 21st century electric system to provide abundant, affordable, clean, efficient, and reliable electric power anytime, anywhere.

2. Voltage Regulation

A voltage regulator is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator

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plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.

2.1 Electronic voltage regulator

A simple voltage regulator can be made from a resistor in series with a diode (or series of diodes). Due to the logarithmic shape of diode V-I curves, the voltage across the diode changes only slightly due to changes in current drawn or changes in the input. When precise voltage control and efficiency regulation element is commanded, up to a point, to produce a higher output voltage–by dropping less of the input voltage (for linear series regulators and buck switching regulators), or to draw input current for longer periods (boost-type switching regulators); if the output voltage is too high, the regulation element will normally be commanded to produce a lower voltage. However, many regulators have over-current protection, so that they will entirely stop sourcing current (or limit the current in some way) if the output current is too high, and some regulators may also shut down if the input voltage is outside a given range (see also: crowbar Feedback voltage regulators operate by comparing the actual output voltage to some fixed reference voltage. Any difference is amplified and used to control the regulation element in such a way as to reduce the voltage error. This forms a negative feedback control loop; circuits) are not important, this design may work increasing the open-loop gain tends to increase regulation accuracy but reduce stability. (Stability is avoidance of oscillation, or ringing, during step changes). There will also be a trade-off between stability and the speed of the response to changes. If the output voltage is too low (Perhaps due to input voltage reducing or load current increasing).

2.2 Electromechanical regulators

The voltage regulation is easily accomplished by coiling the sensing wire to make an electromagnet. The magnetic field produced by the current attracts a moving ferrous core held back under spring tension or gravitational pull. As voltage increases, so does the current, strengthening the magnetic field produced by the coil and pulling the core towards the field. The magnet is physically connected to a mechanical power switch, which opens as the magnet moves into the field. As voltage decreases, so does the current, releasing spring tension or the weight of the core and causing it to retract. This closes the switch and allows the power to flow once more. If the mechanical regulator design is sensitive to small voltage fluctuations, the motion of the solenoid core can be used to move a selector switch across a range of resistances or transformer windings to gradually step the output voltage up or down, or to rotate the position of a moving-coil AC regulator.

Early automobile generators and alternators had a mechanical voltage regulator using one, two, or three relays and various resistors to stabilize the generator's output at slightly more than 6 or 12 V, independent of the engine's rpm or the varying load on the vehicle's electrical system. Essentially, the relay(s) employed pulse width modulation to regulate the output of the generator, controlling the field current reaching the generator (or alternator) and in this way controlling the output voltage producing back into the generator and attempting to run it as a motor. The rectifier diodes in an alternator automatically perform this function so that a specific relay is not required; this appreciably simplified the regulator design.

3. PLC'S

Programmable Logic Controller 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. PLCs are used in many industries and machines. PLCs are designed for multiple analogue and digital inputs and output arrangements, 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. The functionality of the PLC has evolved over the years to include sequential relay control, motion control, process control, distributed control systems and networking. The data handling, storage, processing power and communication capabilities of some modern PLCs are approximately equivalent to desktop computers. The main difference from other computers is that PLCs are armored for severe conditions (such as dust, moisture, heat, cold) and have the facility for extensive input/output (I/O) arrangements.

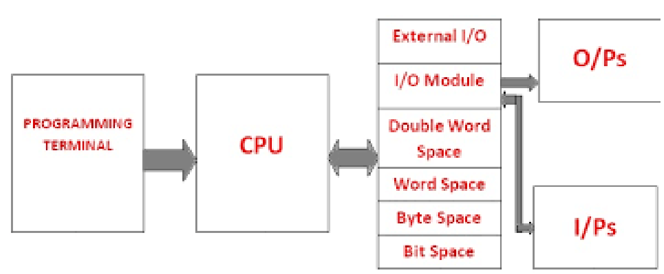

Fig. 1 Block diagram of plc

Control panel with PLC (grey elements in the centre). The unit consists of separate elements, from left to right; power supply, controller, relay units for in-and output The main difference from other computers is that PLCs are armoured for severe conditions (such as dust, moisture, heat, cold), and have the facility for extensive input/output (I/O) arrangements. These connect the PLC to sensors and actuators. PLCs read limit switches, analog process variables (such as temperature and pressure), and the positions of complex positioning systems. Some use machine vision. On the actuator side, PLCs operate electric motors, pneumatic or hydraulic cylinders, magnetic relays, solenoids, or analog outputs. The input/output arrangements may be built into a simple PLC, or the PLC may have external I/O modules attached to a computer network that plugs into the PLC.

3.1 programming

PLC programs are typically written in a special application on a personal computer, and then downloaded by a direct-connection cable or over a network to the PLC. The program is stored in the PLC either in battery-backed-up RAM or some other non-volatile flash memory. Often, a single PLC can be programmed to replace thousands of relays.

4. Power grid system

An electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers. Power stations may be located near a fuel source, at a dam site, or to take advantage of renewable energy sources, and are often located away from heavily populated areas. They are usually quite large to take advantage of the economies of scale. The electric power which is generated is stepped up to a higher voltage at which it connects to the transmission network. A substation receives its power from the transmission network; the power is stepped down with a transformer and sent to a bus from which feeders fan out in all directions across the countryside. These feeders carry three-phase power, and tend to follow the major streets near the substation. As the distance from the substation grows, the fan-out continues as smaller laterals spread out to cover areas missed by the feeders. This tree-like structure grows outward from the substation, but for reliability reasons, usually contains at least one indexing tool which helps create a coherent picture of the power system out of such data.

4.1 Smart grid system

A smart grid is an electricity network that can intelligently integrate the behavior and actions of all users connected to it generators, consumers and those that do both in order to efficiently deliver sustainable, economic and secure electricity supplies. Smart Grid incorporates monitoring, analysis, control and communication capabilities into the electric Power grid in order to improve reliability, optimize as set utilization, improve security, increase energy efficiency and allow diverse generation and storage options. Smart Grid also allows homeowners and businesses to utilize electricity as efficiently and economically as possible hence, reduces cost and increases reliability and transparency. In existing power grids, there is one way power flow from power stations, via transmission and distribution systems, to customers. Customers are uninformed and non-participative in the power system, which is dominated by central generation. A smart grid, on the other hand, is designed for bidirectional communication between appliances and power grids, to use electricity more efficiently than ever before which will give benefits to both consumers and producers. It will have informed, involved, and active consumers together with demand response and distributed energy resources.

5. Result

Industrial Loads coming from the power grid are operated continuously from time to time. In power grid system industrial loads have been classified into two lines which are treated in such a manner one line supply is continuously on for 24 hours and the second line supply is discontinued . In case any if any faults will occur in the line than the second line will be started manually and the supply of first line is discontinued. In this project we are trying to control industrial lines load voltage through PLC’s. By this manually process of continue supply of industrial line is going to be eliminated.

Components used in the project:

5.1 Relay

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid state relays. Relays are used where it is necessary to control a circuit by a separate low power signal, or where several circuits must be controlled by one signal. In this project three relays were used. In which function of two relays is to sense the faults on system and convey the information to PLC. And the third relay is used for interlocking mechanism of voltage between domestic line to industrial line.

5.2 MCB

Miniature circuit breaker is used in low voltage electrical network instead of fuse. Which are automatically switches off the electrical circuit during abnormal condition of the network means in over load condition as well as faulty condition. The fuse is not reliable while sensing the faults but miniature circuit breaker does it in more reliable way. MCB is much more sensitive to over current than fuse.

5.3 Transformer

In this project we had considered a step down transformer which transforms 220 v supplies into 12 v supply.

5.4 PLC

PLC is used for the performance of automatic operations of system.

5.5 Current sensor

A current sensor is a device that detects electric current (ac or dc) in wire, and generates a signal proportional to it. The generated signal could be analog voltage or current or even digital output. It can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose.

Let's considered with two loads first one is domestic load and second is industrial load. These loads are connected in series connections.

Consider 1st Line as Domestic Line
In domestic lines relays are connected in series with the line and MCB's are connected in series with the relay. Whenever supply is in on mode and there is no fault occurrence than the domestic line will be continuously in on mode. In case any fault occurs than the relay 1st is going to sense the faults and convey the information to PLC and PLC will provide an indication as red signal and MCB will trip and results in line supply which is interrupted automatically.

Consider Line 2nd as Industrial Line
In industrial lines relays are connected in series with the line and MCB's are connected in series with the relay. Whenever supply is in on mode and there is no fault occurrence than the Industrial line will be continuously in on mode. In case any fault occurs than the relay 2nd will sense the faults and convey the information to PLC and PLC will provide an indication as red signal and MCB will trip but line supply always starts with the help of relay 3rd which is performing a task of interlocking voltage with domestic line and industrial line.

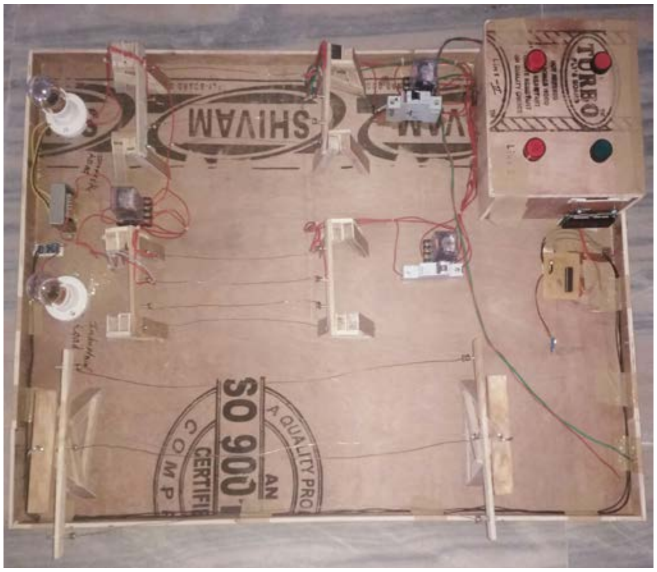

Fig.2 Circuit diagram of system

5.6 Ladder logic programming of PLC

Ladder logic is one form of drawing electrical logic schematic, and is a graphical language very popular for programming in programmable logic controllers. Ladder logic was originally invented to describe logic made from relays. The name is based on the observation that programs in this language resemble ladders, with two vertical "rails" and a series of horizontal "rungs" between them. Modern control system still includes relays, but these are rarely used for logic. A relay is a simple device that uses a magnetic field to control a switch.
When a voltage is applied to the inputs coil, the resulting current creates a magnetic field. The magnetic field pulls a metal switch towards it and the contacts touch, closing the switch. The contact that closes when the coil is energized is called normally open. The normally closed contacts touch when the input coil is not energized. Relays are normally drawn in schematic form using a circle to represent the input coil. The output contacts are shown with two parallel lines. Normally open contacts are shown

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as two lines, and will be open (non –conducting) when the inputs is not energized. Normally closed contacts are shown with two lines with a diagonal line through them. When the input coil is not energized the normally closed contacts will be closed (conducting).

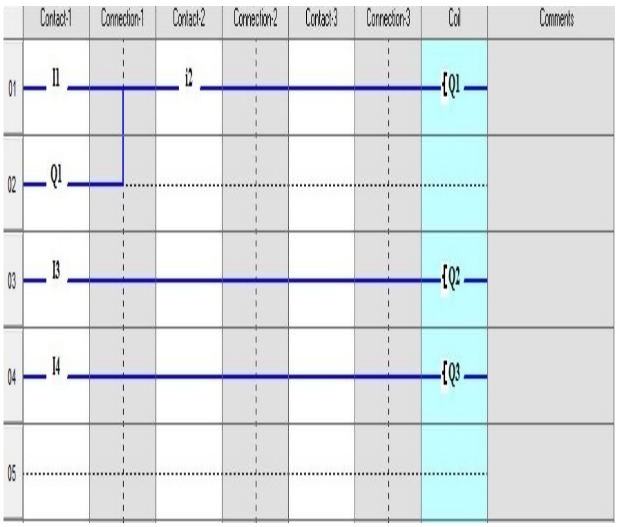

Fig. 3 Ladder Logic Program of system

Where
I1 = Base Module (Normally Open Contact)
Q1 = System Supply Control Output (Normally Open Contact)
Q2 = Indicate Red Signal/Output (Normally Open Contact)
Q3 = Indicate Red Signal/Output (Normally Open Contact)
i2 = Base Module/Normally Closed Contact
i3 = Relay Logic
i4 = Relay logic

6. Conclusion

Although the implementation of automation is costly & complex but it is worth investing, as one can achieve a lot from the system and can improve reliability, power quality and power handling and distribution capacity management. In this paper a PLC is implemented for reducing the human interventions. It is able to control peripheral device such as relay for automation and replacing the existing manual switching. So it can be interred that PLC can be implemented as a effective software or programmable tool through which we can possibly provide continuous power supply to industries. And therefore it can be suggested that this paper is helpful for renovating and improving towards system automation.

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First Author
Mr. Naval Kishor Dagla is M.Tech scholar in power system Engineering, Mewar university, Chittorgarh, Rajasthan. My Keen area of interest is in Automation of power systems.

Second Author
Mr. SSPM Sharma B Currently working as an Assistant Professor in Electrical Engineering Department, Mewar University. He has completed his M.Tech in Mechatronics from VIT University, Vellore and B.Tech in Electrical & Electronics Engineering from JNTUK University, Andhra Pradesh. He is currently working on the Research area of Automation & Renewable Energy System.

Third Author
Mr. Rahul Mishra Currently working as an Assistant Professor in Electrical Engineering Department, Mewar University. He has completed his M.Tech in Power system & Electric Drives, Thapar University, Patiala and B.Tech in Electrical Engineering from Gautam Bodh Technical University, U.P. He is currently working on the Research area of Power system & Control System.