

PLC & SCADA based Power Quality Improvisation in Induction Motor

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ABSTRACT: Energy conservation has been one of the most talked about topics in the past decade or so because of the decrease in the energy resources. Power shutdown is a major problem now-a-days and it occurs because a lot of power is wasted in industries. Energy monitoring and controlling deals with this type problem in a effective ways. We implement three phase induction motor monitoring and controlling with the help of PLC and SCADA. PLC can be connected with computer using RS-232 or Ethernet cable. PLC monitor different perimeter of IM such as over and under voltage, over current, over speed, etc. If any contingency will arise, SCADA give alert or shutdown system automatically. SCADA-of industrial processes used for serial communication to facilitate communication between the

KEYWORDS: Power quality, Energy Audit, Monitoring and Controlling System, PLCs, SCADA

I. INTRODUCTION

Power quality is often defined as the electrical networks of grid's ability to supply a clean and stable power supply to consumers. In other word, power quality ideally makes a perfect power supply that is always reliable, has a pure noise free sine wave shape and is within voltages and frequency tolerances. Power quality is of great importance in all modern environment where electricity is involved. Power quality can be essentially influenced by an important factor like quality service. Power quality, it is actually the quality of voltage that is being addressed in most cases. Technically, in engineering terms, power is the rate of energy delivery and it is proportional to product of voltage and current. The power supply system can only control the quality of voltage. Therefore, the standards in the power quality area are devoted to maintaining the supply voltage within certain limit.

The ultimate that we are interested in power quality is economic value. For economic view, it is necessary to maintain the quality of supplied power. One of the major concerns in electricity industry is power quality problem. It is defined as any problem manifested in voltage, current and frequency deviations that result in failure or malfunction of customer's equipment, Power Quality problems have a wide range of disturbances such as voltage sags/swells, flicker, harmonics distortion, impulse transient, and interruptions. Voltage sags/swells can occur more frequently than any other Power quality phenomenon. Of all the power quality problems, 92% of the interruptions in industrial installations are due to voltage sags and swells. To overcome or reduces the power quality problem there are some method or technique like Active and Passive filters, DSTATCOM, series and shut compensation, Harmonics filter, DVR, etc. Here we introduced automation based power quality problem monitoring and control using PLC & SCADA.

Over the past two decades, the electric power industry's involvement in power distribution automation has been principally focused on remote monitoring and control of distribution system & their equipment. In human life each and everything is automated which in turn emphasize the importance of electricity. In recent years, the demand for automated and accurate data management has keen importance due to many thing go wrong in industry. Development of an online energy monitoring system via PLCs in environment by the use of (a) Data Acquisition (b) Communication Protocol and (c) Processing within Energy meter and host main station. The objective of this idea is (a) Easiest way for energy auditing process (b) Reduce the manual cost (c) Online energy consumption calculation (d) Energy consumption monitoring using graph.

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II. POWER QUALITY

Power system has emphasized power quality problem since the late 1980s. There can be completely different definitions for power quality, depending on one's frame of reference. For example, a utility may define power quality as reliability and show statistics demonstrating that its system is 99.98 percent reliable. Power quality is ultimately a consumer driven issue and the end user's point of reference takes precedence. Therefore, power quality is defined in the IEEE 100 Authoritative dictionary of IEEE standard terms as the concept of powering and grounding electronic equipment in a manner that is suitable to the operation of the equipment and compatible with the premise wiring system and other connected equipment utilities may want to define power quality as reliability.

Power quality problems

Here, we present the most common power quality problem in a table.

Power quality problem	Description	Causes	Effect
Voltage sag	It is step-down of rms voltage for short duration at the power frequency	Due to start-up of large motor, incorrect VAR compensation, fault in consumer's installation	Equipment shutdown, Dim light, tripping of contactor, data error
Very short interruption	It is a total cut-off from electrical supply for duration of few millisecond to 1 or 2 seconds	Due to attempting of reclosed operation, insulation failure, short circuit	Tripping of protection device, loss of information, control malfunctions
Long interruption	Total cut-off from electrical supply for duration grater then 1 to 2 seconds	Storms and objects striking lines or poles, fire, human error, bad coordination	Stoppage of all equipment
Voltage spike	Very fast fluctuation in voltage value for duration from microseconds to milliseconds.	Lighting, disconnection of heavy loads	Electromagnetic interference, destruction of components
Voltage swell	Transitory increase of the voltage at power frequency for duration of more than one cycle & less than few seconds.	Start/stop heavy load, badly dimensioned power source	Data loss, flickering of light and screen, stoppage or damage of sensitive equipment
Harmonics distortion	Multiple integer of fundamental frequency. Voltage and current waveform assume non-sinusoidal shape.	Arc furnace, welding machine, rectifier, DC brush motor, non-linear load, switched mode power supply(SMPS)	Neutral overload in 3-phase system, overheating of cable and equipment, loss of efficiency in machine, tripping of thermal equipment
Voltage fluctuation	Oscillation of voltage, amplitude modulated by a signal with frequency of 0 to 30 Hz.	Arc furnace, oscillating load, frequent start/stop of electric motor	flickering of lighting and screens, giving the impression of unsteadiness of visual perception
Voltage unbalanced	A voltage variation in 3-phase system in which the voltage magnitude or the phase angle are not same.	Large single phase load, incorrect distribution of all single-phase load.	Most affected loads are 3-phase induction motor

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Why We Improve Power Quality:

The main reasons for improving power quality in supply system are:

- (a) The voltage regulation
- (b) Increased system stability
- (c) Better utilization of machine connected to the system
- (d) Reduction of losses associated with system
- (e) To prevent voltage sag as well as voltage swell.

As we mention above, power quality problem is directly join with economic dispatch of each industry. The quality of power can have a direct economic impact on many industrial consumers. There has recently been a great emphasis on revitalizing industry with more automation and more modern equipment. This usually means electronically controlled, energy-efficient equipment that is often much more sensitive to deviations in the supply voltage than were its electromechanical predecessors. Thus, like the blinking clock in residences, industrial customers are now more acutely aware of minor disturbances in the power system. There is big money associated with these disturbances. It is not uncommon for a single, commonplace, momentary utility breaker operation to result in a \$10,000 loss to an average-sized industrial.

Power Quality Monitoring and Controlling:

Power quality monitoring is the process of gathering, analysing, and the interpreting raw measurement data into useful information. The process of gathering data is usually carried out by continuous measurement of voltage and current over an extended period. The process of analysis and interpretation has been traditionally performed manually, but recent advances in signal processing and artificial intelligence fields have made it possible to design and implement intelligent systems to automatically analyse and interpret raw data into useful information with minimum human involvement.

Power quality monitoring programs are punctually driven by the demand for improving the systemwide power quality performance. Many industrial and commercial customers have equipment that is sensitive to power disturbances, and, therefore, it is more important to understand the quality of power being provided. Examples of these facilities include computer networking and telecommunication facilities, semiconductor and electronics manufacturing facilities, biotechnology and pharmaceutical laboratories, and financial data processing centres. Hence, in the last decade many utility companies have implemented extensive power quality monitoring programs.

Power quality monitoring can be achieve using Programmable Logic Controller (PLC). PLCs are used for measurement of power quality parameter like voltage, current frequency etc. Power quality measurement instruments (PLCs) are design to collect data from field. It can send data over the communication line to a central processing location or unit for analysis and interpretation. Users can collect data from computer software and using this data they can also monitor and control whole system from one master control room. Supervisory Control and Data Acquisition (SCADA) makes it easiest, SCADA is an important application that allows a utility operator to monitor and control processes that are distributed among various remote sites.

Here the PLCs are set to sense the system parameter, to show them on SCADA window also to control system from SCADA. Once the perimeters are sensed, PLCs will decide whether measured parameters are within limit or not. If parameter crosses the limit which is set by user, SCADA window will give warning message on computer. So, at supervisory level, user will be able to see system condition, its parameter whether they are crossing threshold or not. User also will be able to control system. A smart power quality monitor allows operator to take necessary or appropriate action in a timely manner.

Choosing Monitoring Location:

Obviously, we would like to monitor conditions at virtually all locations throughout the system to completely understand the overall power quality. However, such monitoring may be prohibitively expensive and there are challenges in data management, analysis, and interpretation. Fortunately, taking measurements from all possible locations is usually not necessary since measurements taken from several strategic locations can be used to determine characteristics of the overall system. Thus, it is very important that the monitoring locations be selected carefully based on the monitoring objectives. Another important aspect of the monitoring location when characterizing specific power quality problems is to locate the monitors as close as possible to the equipment affected by power quality variations.

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It is important that the monitor sees the same variations that the sensitive equipment sees. High-frequency transients, in particular, can be significantly different if there is significant separation between the monitor and the affected equipment.

A good compromise approach is to monitor at the substation and at selected customer service entrance locations. The substation is important because it is the PCC for most rms voltage variations. The voltage sag experienced at the substation during a feeder fault is experienced by all the customers on other feeders supplied from the same substation bus. Customer equipment sensitivity and location on a feeder together determine the service entrance locations for monitoring. For instance, it is valuable to have a location immediately down line from each protective device on the feeder.

III. PROPOSED SYSTEM

Here, we represent the block diagram of proposed system in figure. We measure and monitor the parameter of induction motor to maintain the power quality with help of PLCs and SCADA. This system contains different working element which mainly consist of induction motor, VFD, capacitor bank and 24-volt DC supply (SMPS). As seen from figure, induction motor is the last element whose parameter we must measure and monitor on SCADA window. Induction motor receives AC main supply through VFD.

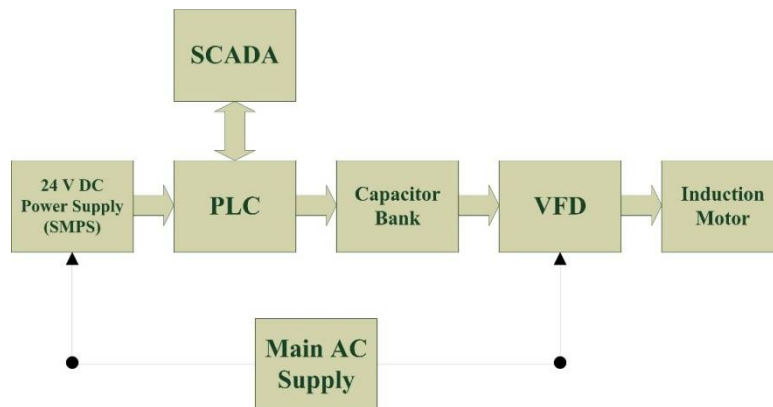


Fig 1-Block diagram of proposed system

VFD plays important role in system as it is protecting motor from various faults like overloading, overvoltage, over current etc. and controls the speed of motor. 24-volt DC supply (SMPS) also fed from AC main supply. Input rag of PLC relates to capacitor bank and VFD and output rag relates to personal computer which has SCADA window. User can show the various parameters of motor and control from computer. Here we communicate between PLC and SCADA using RS-232 communication cable.

SMPS: SMPS stand for switch-mode power supply. Basically, it is a converter that convert AC supply to DC regulated. It takes rectified AC input, performs power factor correction, and convert in lower DC supply. Here, we need 24 volt DC to run PLC so, we use 24 volt DC power supply.

PLC: PLC signify Programmable Logic Controller. Programmable logic controller is an electronic device that takes input from the machine via sensors and transmitters. A PLC is an example of a real-time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result. PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact.

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SACDA: SCADA signify Supervisory Control and Data Acquisition. SCADA refers to a system that collects data from various sensors at a factory, plant or in other remote locations and then sends this data to a central computer which then manages and controls the data. SCADA is real time industrial process control systems used to centrally monitor and control remote or local industrial equipment such as motors, valves, pumps, relays, etc. SCADA systems used to run on DOS, VMS and UNIX, in recent year some vendors moved to NT and some also to Linux.

VFD: Variable Frequency Drive-VFD as name suggest, is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor. In this system, we require handling high power devices operating electronically to control and protect the induction motor and we also require high input to the VFD. A VFD is useful for applications where-in speed control is of an essential importance due to load changes where-in the speed needs to be increased or decreased consequently. To provide these requirements we used VFD. It is also use to provide isolation between PLC control circuit and high voltage motor. VFD system basically consist of three main sections namely, Converter, DC Bus & Inverter. Converter section converts AC mains into DC, DC Bus that further rectifies and carries dc signal and finally Inverter section which again converts DC to AC but in PWM form.

Capacitor bank: A Capacitor Bank is a group of several capacitors of the same rating that are connected in series or parallel with each other to store electrical energy. Capacitor banks are used for problems such as lag or phase shifts. These banks can also be used simply to increase the energy storage of a system. These banks are often the most cost-efficient ways of dealing with power shift and AC power supply problems. Here, especially we use capacitor bank for correct AC power problems and to reduce harmonics from the system.

Induction motor: Here we use three phase induction motor whose parameter we must measure. Table shows the rating of an induction motor.

Type	: T.E.F.C	Current (amps)	: 4.7
Volts	: 415	Frame	: 100L
Phase/cycle	: 3/50	Connection type	: Delta
Power(kw/HP)	: 2.2/3	Insulation class	: B class
Speed in R.P.M	: 1400	Manufacturer	: Benn Electrical

IV. IMPLEMENTATION

In any industry, induction motor plays significant role due to its low cost and simplicity. By implementing a monitoring and control system for the speed of motor, the induction motor can be used in high performance variable speed applications. First and basic step is to select the rating of induction motor and according to it control devices are selected and the circuit is designed accordingly and finally the programming is done in the PLC according to inputs applied and the outputs required in the operation of the induction motor. Capacitor bank is connected in parallel with induction motor.

It is required for reduce harmonics and for improve power factor of motor. Capacitor bank also compensate reactive power of motor. The capacitor draws leading current and partly or neutralize lagging reactive component of load current. This will improve the power factor. Inputs are given to the PLC through VFD, current sensors, voltage sensors, tachometer to measure the rotor speed. Motor will run if the measure perimeter stays in permissible limit and as soon as they excess the permissible limit PLC send signal to SCADA window which gives the alarm to the operator. Operator can manually cut-off the supply and motor shuts down. If any abnormal condition or fault will arise, PLC send signal to MCB (Miniature Circuit Breaker), it will trip and cut-off the supply.

PLC (Programmable Logic Controller) read all field input devices via the input interfaces, execute the user program stored in application memory, then, based on whatever control scheme has been programmed by the user, turn the field output devices on or off, or perform whatever control is necessary for the process application. PLCs can be programmed using standard based programming language. Most of PLCs utilized Ladder Diagram programming. Ladder Diagram programming is a model which emulated electromechanical control panel device which PLCs replaced. It consists two vertical line representing the power rails. Circuit is connected as horizontal lines that is the rug of ladder between these two vertical lines.

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SCADA, it will collect the needed data from PLC and displaying them on the monitor of master computer of control room, store appropriate data in the hard drive of computer and allow the control of field device from the control room. As mention above, in any contingency SCADA would give alarm or automatically cut-off the supply. Here, for interfacing between PLC and SCADA we use RS-232 cable.

V. SOFTWARE AND RESULT

PLC: We use Rockwell RS-Logix Micro English software for Allen Bradley 1100 PLC. Its ladder diagram is as follow:

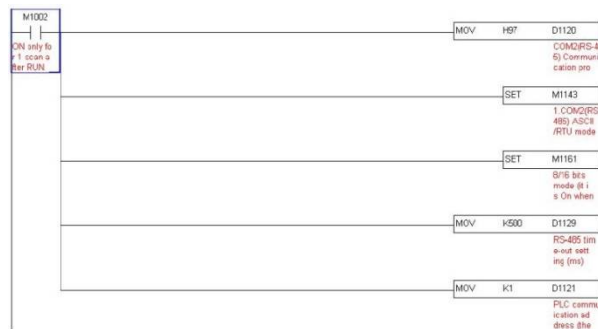


Fig 2-Ladder diagram of PLC

In programming window of software, we make the ladder diagram logic as per the Fig. 2 for the PLC. In this ladder diagram we use the different component to measure and improve the power quality. The component of the system are discribed below;

- **M1002:** When PLCs start to Run **M1002** is “ON” during the first scan and remains “OFF”
- **D1120** get the value above communication protocol and move in to the H97 in hexadecimal value. When the SET instruction is driven, the device is to be “ON” which will keep “ON” whether the SET instruction is still driven. You can use RST instruction to set the device “OFF”.
- Set **M1143** instruction is set the data of Modbus address in ASCII or RTU mode this instruction is used with MODRD/MODRW/MODWR.
- Set **M1161** is “ON” when it is in 8-bit mode.
- **D1129** in this time out setting after 500 micro-seconds in communication.
- **D1121** is an address that save PLC communication address, it is latched.
- **M1013** gives 1s clock pulse it means on for 0.5 s and off for 0.5s but it is operating in only positive clock pulse and Set **M1122** is sending request to the drive for getting data from the Modbus.

SCADA: -

For SCADA window, we use wonderware –Intouch. In SCADA window, main switch is ON motor is ON. Different parameter of motor is shown in window like phase voltage, current, speed of motor etcetera. Waveform of motor is shown in trend. When switch is ON motor colour is **GREEN**, it indicates motor is in running operation and vice versa in **RED** colour.

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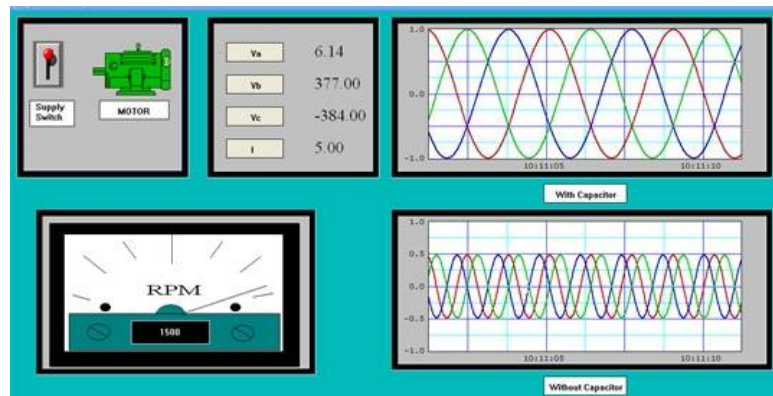


Fig 3-SCADA window and Waveform

After operating the system using PLC and SCADA, we get the results as per the Fig. 3. Here, we get the line voltage of all the three phases, frequency of the system, speed of the induction motor, output waveforms without capacitor and with capacitor. All the results are store in the memory for further analysis.

VI. CONCLUSION

We discuss on power quality issue and factor concerning related with modern utilities. We should know how to choose monitoring location and control scheme. We perform experiment on particular system to monitoring and controlling for three phase induction motor. The system is successfully implemented and tested. The software Rockwell has been successfully worked for PLC and Wonderware-Intouch for SCADA. With the use of PLC & SCADA, the control system is more reliable. Monitoring system gives facility of analysing the operation of an induction motor in online/offline mode which make the system to be safe from fault/error condition. It deals with the most important types of failures of an induction motor such as over and under voltage, over current, over speed etc. If any fault appears during the operation of motor then the motor stops immediately

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