Application of Scada in Modeling of Power Distribution Systems and Induction Motor

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Abstract: In this paper, Application of Supervisory Control and Data Acquisition (SCADA) in modeling of power distribution systems and AC induction motor presented. The software Rockwell was successfully used for SCADA. From the result of the induction motor modeling, it was seen that with increase of load current in either clockwise direction or in anticlockwise direction, in both cases the speed decreases. This justifies the performance of induction motor.

***Keywords**: SCADA, AC Induction Motor, Rockwell, Power Distribution Systems*

I. INTRODUCTION

SCADA is an acronym for Supervisory Control and Data Acquisition. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation. These systems encompass the transfer of data between a SCADA central host computer and a number of Remote Terminal Units (RTUs) and/or Programmable Logic Controllers (PLCs), and the central host and the operator terminals. A SCADA system gathers information (such as where a leak on a pipeline has occurred), transfers the information back to a central site, then alerts the home station that a leak has occurred, carrying out necessary analysis and control, such as determining if the leak is critical, and displaying the information in a logical and organized fashion[1]. These systems can be relatively simple, such as one that monitors environmental conditions of a small office building, or very complex, such as a system that monitors all the activity in a nuclear power plant or the activity of a municipal water system.

II. OVERVIEW OF SCADA SYSTEMS

SCADA comes from the acronyms "Supervisory Control and Data Acquisition", that is data acquisition and supervision control. It is a software application specially designed to work on computers in the production control, providing communication with the devices (independent controllers, programmable robots, etc.) and controlling the process from the screen of the computer. In addition, it provides all the information that is generated in the process to diverse users, as much as the same level as to other supervisors within the company: quality control, supervision, maintenance, etc [2].

In this type of systems there are usually exists a computer, which carries out tasks of supervision and management of alarms, as well as data processing and process control. All this is executed normally in real time, and is designed to give to the plant operator the possibility of supervising and controlling these processes. The necessary programs, and in this case the additional hardware that is needed, is generally denominated SCADA.

A. Typical SCADA System

The figure below shows a typical diagram of a SCADA system describing different components.

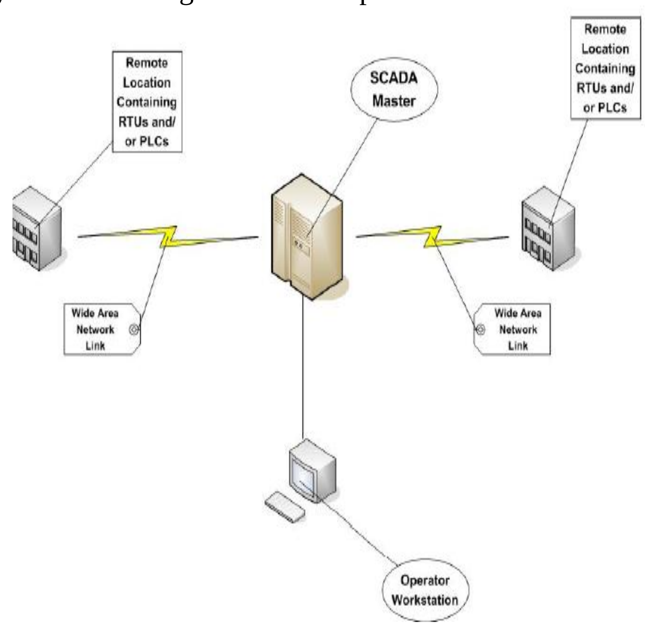

Figure1: Typical SCADA System [3]

B. Application of Scada to Electric Power Distribution Systems

A reliable power distribution system is an essential component for the economic growth and development of a country. Therefore, a modern electric power network system must be capable of performing 365 days a year and 24 hours a day with a high quality of uninterrupted power supply, even during the peak hours, to improve the performance of services to the customers. In view of the extensive size of the distribution networks, this can be achieved only by proper computer-based monitoring and control system as well as by efficient distribution and metering.

The "Monitoring and Control System" is the main part of a distribution automation network. This system was defined by IEEE as "A system that enables an electric company to remotely monitor, coordinate and operate distribution components in a real-time mode from remote location".

The location from where control decisions are initiated is generally called Distribution Control Center (DCC). Within this center, different kinds of application software are used, which cooperate among themselves to achieve the control task [4].

Many other types of equipments will also be used to support such automation of a power network. They include Automatic Meter Reading (AMR), Data Concentrator Unit (DCA), Remote Terminal Unit (RTU), Supervisory Control and Data Acquisition (SCADA), Communication equipments, etc.

In this discussion we would mainly focus on the customer service quality. Customer service requirements point to one key element: Information, i.e., the right amount of information to the right person or computer within the right amount of time. The flow of information requires data communication over extended networks of systems and users. In fact, utilities are becoming among the largest users of data and are the largest users of real-time information [5].

Hence, the implementation of power network automation system will provide better services to Electricity Distribution Company (EDC) customers and improve the power quality and reliability of the electric supply services, which would satisfy the following goals:

1. Respond to customer service interruptions more quickly.
2. More efficiency of the power system by maintaining acceptable power factors and reduced losses.
3. More control and limit of peak power demand.
4. Ability of EDC engineering staff to monitor and control the power system during normal and abnormal conditions by providing more reliable and appropriate real time data.
5. Ability of EDC engineering staff to perform the power system analysis and planning by providing increased access to past and current operations data and associated software tools.
6. Ability of EDC engineering staff to manage the power system assets and system operations by providing increased access to better performance data and historical statistics.

A simple architecture of a power network automation system is given in figure 2.

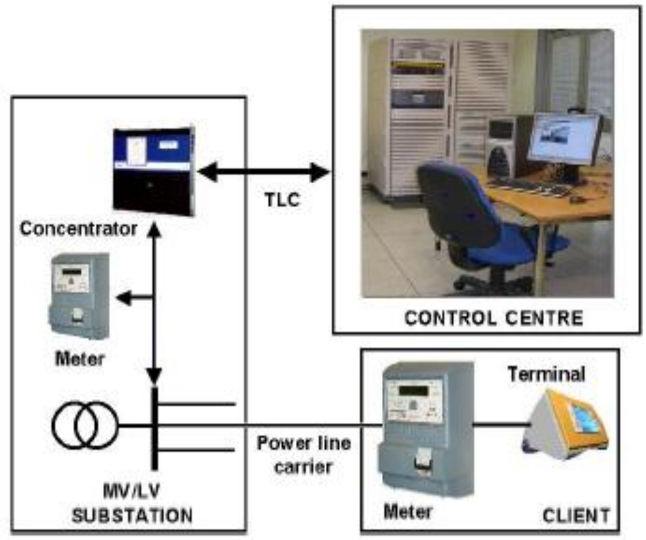

Figure 2: General architecture of the power network automation system [6].

Figure 2 outlines components and their locations in the chain going from the central computers, down to the electricity meters and optional terminal units which can be used by the customer to view the real time status of the network.

The control center represents the main part of a distribution automation network. It can be based on an open hardware architecture, which can be easily scalable and flexible for future additions, using a number of commercial equipments, such as:

1. A duplicated management server housing the application software and the alarms handler;
2. A duplicated data collection server;
3. One gateway server interfacing the control centre to the external commercial management system and another interfacing the remote-control system;
4. A firewall with an unlimited client number;
5. One router;
6. Three operator workstations;
7. One high storage media.

The terminal units at the customer location will be used for many tasks. They will display the consumption, service and billing information including hourly load curves. The customer can also remotely close the circuit breaker of an outdoor meter equipped with the motor option. Also, the terminal units will communicate with the control centre to receive messages, alert the client in time to reduce the load when it exceeds a given limit and prevent tripping of the meter breaker and finally support prepayment [7].

In order to exchange data, the different system components need equipments installed in the MV/LV substations, which manage the data transmission to and from the meters, by a Power Line Carrier (PLC) over the low voltage lines and provide the connection to a control centre, using a dedicated protocol, over public or private communication networks. As the amount of data to be exchanged is huge, it asks for the use of computer and other smart equipments to manage the power network in real time. One of the smart equipments used is the Automatic Meter Reading (AMR). The AMR has replaced the old conventional energy meter (disk type) because of its better performance to process a huge amount of data in real time.

The communication systems will include various equipments with microprocessor controllers such as SCADA, RTU, Data Concentrator (Logger) and fast computers to supervise and control the network [8].

III. DESIGN AND IMPLEMENTATION OF SCADA BASED INDUCTION MOTOR

A. Hardware Design

In the hardware design part, overall component such as Pulley, Belt, motor, and load on pulley will be integrated to form the complete prototype. The hardware components are the backbone of the system. More detailed information of each section will be discussed in the following sections.

B. Three Phase Induction Motor

The three-phase induction motors are the most widely used electric motors in industry. They run at essentially constant speed from no-load to full-load. However, the speed is frequency dependent and consequently these motors are not easily adapted to speed control. We usually prefer dc motors when large speed variations are required. Nevertheless, the 3-phase induction motors are simple, rugged, low-priced, easy to maintain and can be manufactured with characteristics to suit most industrial requirements [9].

C. Basic Construction and Operating Principle

Like most motors, an AC induction motor has a fixed outer portion, called the stator and a rotor that spins inside with a carefully engineered air gap between the two. Virtually all electrical motors use magnetic field rotation to spin their rotors. A three-phase AC induction motor is the only type where the rotating magnetic field is created naturally in the stator because of the nature of the supply. DC motors depend either on mechanical or electronic commutation to create rotating magnetic fields. A single-phase AC induction motor depends on extra electrical components to produce this rotating magnetic field [10].

Two sets of electromagnets are formed inside any motor. In an AC induction motor, one set of electromagnets is formed in the stator because of the AC supply connected to the stator windings. The alternating nature of the supply voltage induces an Electromagnetic Force (EMF) in the rotor (just like the voltage is induced in the transformer secondary) as per Lenz‟s law, thus generating another set of electromagnets; hence the name induction motor. Interaction between the magnetic fields of these electromagnets generates twisting force, or torque. As a result, the motor rotates in the direction of the resultant torque.

D. Stator

The stator is made up of several thin laminations of aluminum or cast iron. They are punched and clamped together to form a hollow cylinder (stator core) with slots [11]. Coils of insulated wires are inserted into these slots. Each grouping of coils, together with the core it surrounds, forms an electromagnet (a pair of poles) on the application of AC supply. The number of poles of an AC induction motor depends on the internal connection of the stator windings. The stator windings are connected directly to the power source [12]. Internally they are connected in such a way, that on applying AC supply, a rotating magnetic field is created.

E. Rotor

The rotor is made up of several thin steel laminations with evenly spaced bars, which are made up of aluminum or copper, along the periphery. In the most popular type of rotor (squirrel cage rotor), these bars are connected at ends mechanically and electrically by the use of rings. Almost 90% of induction motors have squirrel cage rotors. This is because the squirrel cage rotor has a simple and rugged construction. The rotor consists of a cylindrical laminated core with axially placed parallel slots for carrying the conductors. Each slot carries a copper, aluminum, or alloy bar. These rotor bars are permanently short-circuited at both ends by means of the end rings [13]. This total assembly resembles the look of a squirrel cage, which gives the rotor its name. The rotor slots are not exactly parallel to the shaft. Instead, they are given a skew for two main reasons. The first reason is to make the motor run quietly by reducing magnetic hum and to decrease slot harmonics. The second reason is to help reduce the locking tendency of the rotor. The rotor teeth tend to remain locked under the stator teeth due to direct magnetic attraction between the two. This happens when the numbers of stator teeth are equal to the number of rotor teeth. The rotor is mounted on the shaft using bearings on each end; one end of the shaft is normally kept longer than the other for driving the load. Some motors may have an accessory shaft on the non-driving end for mounting speed or position sensing devices. Between the stator and the rotor, there exists an air gap, through which due to induction, the energy is transferred from the stator to the rotor [14]. The generated torque forces the rotor and then the load to rotate. Regardless of the type of rotor used, the principle employed for rotation remains the same.

F. Working of the system

Through this research, the induction motor will start running in forward direction at rated speed when we press the start button on SCADA screen. The motor will stop for a fixed interval of time as we required in between forward & reverse running of induction motor, it will automatically start to run in reverse direction at the rated speed. After that if we press the stop2 button the motor stop normally. For the safety point of view there is an emergency stop button (emergency stop) is also provided on the SCADA control screen so that the operator can stop the process if there is any problem in the process which is going on. The complete project with hardware & Software SCADA screen is shown in figure 3.

Figure3: Project with hardware & Software SCADA screen

IV. RESULTS AND DISCUSSION

A. Results

The speed and current readings of the 3-phase IM running in clockwise direction at different loads are shown in Table1 and corresponding graph is shown in drawn in figure 4. And the status of motor is being displayed on Real time software SCADA which provides a supervisory control for the system when it run in clockwise (Forward) direction as shown in figure 4.

Table 1: Speed and Current Readings at Different Loads

IM in Clockwise Running Condition		**IM in Anti-clockwise Running Condition**	
Current (Amp.)	Speed (RPM)	Current (Amp.)	Speed (RPM)
1.64	1468	1.53	1480
1.68	1462	1.65	1466
1.70	1456	1.75	1458
1.80	1450	1.87	1454
1.92	1446	1.96	1450
2.00	1442	2.17	1440
2.13	1436	2.36	1432
2.31	1430	2.60	1424
2.52	1426	2.83	1414
2.66	1420	3.03	1410
2.85	1414	3.30	1398
3.02	1404	3.55	1392
3.25	1400		
3.50	1392		
3.70	1386		
3.90	1380		
4.06	1374		

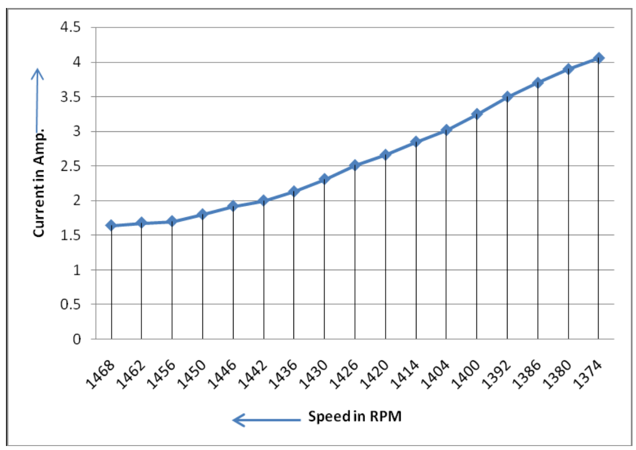

Figure 4: Performance of 3-Phase IM drive under Clockwise running Condition

The speed and current reading in anti-clockwise direction at different load conditions the 3-phase IM running is shown in Table 1 and corresponding graph is shown in drawn in figure5.

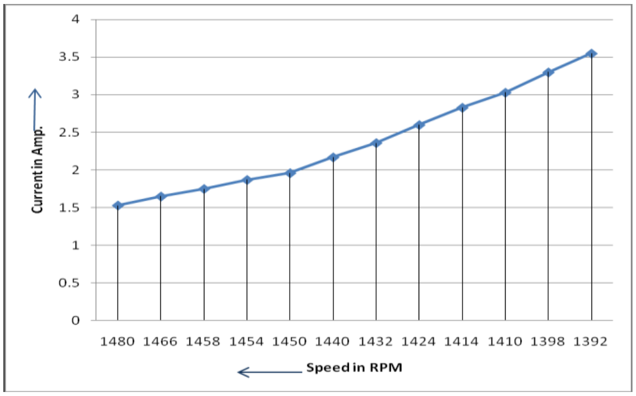

Figure 5: Performance of 3-Phase IM drive under Anti-clockwise running Condition

B. Discussion

From the result of the induction motor modeling, it was seen that with increase of load current in either clockwise direction or in anticlockwise direction, in both cases the speed decreases. This justifies the performance of induction motor. The curve drawn is almost a linear straight line which is accordance with the performance characteristics of induction motor. In this research, the software Rockwell has been successfully used for SCADA.

CONCLUSION

In this research, we proved the importance on using SCADA for sustainable development in the automation of the power distribution systems to improve the customers' service and the reliability of the network. Monitoring and control system is designed for three phase induction motor control. The system is successfully implemented and tested. After detailed experiment it is observed that proposed system is a feasible method for controlling the IM. The control system designed is based on the most advanced technology which gives high amount of flexibility and efficiency. Monitoring system gives facility of analyzing the operation of induction motor in online/offline mode which makes the system to be safe from any fault/error conditions.

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