Design and Application of SCADA Systems in the Electric Power Industry

(Software and Hardware of ABB Company)

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Volume II

Chapter 1

SCADA Systems and RTU

1-1. Need and Role of Control Systems

1-1-1. Introduction

The need for high-reliability electrical energy in today's societies is quite clear and has a very significant role. In general, the main goal of energy supply is to satisfy consumers, and in order to achieve this goal, the electrical system must be monitored and investigated accurate, constantly and thoroughly.

Obviously, the main goal of the establishment of power plants, transmission lines, substations and distribution networks is to provide electrical power demand. The application of electrical energy in today's life is inevitable and, given the scientific innovations of researchers and scientists, is being enlarged every day.

From another perspective, with the increasing population growth and various development plans, with the expansion of electrical networks, should provide the conditions for everyone to use this energy. The point to be taken into account here is to increase the quality and compliance with the permissible limits and the standard of energy demanded by consumers. Features such as continuity and energy supply, stable voltage and uniformity of it are important for consumers. From a competitive point of view, also the manufacturer must provide electrical energy at the lowest cost. To achieve this, various studies have to be done on how to secure the energy supply and to make the necessary controls, based on complex and accurate scientific calculations.

According to description mentioned above, three important points should be considered in power system operation:

1) Provide high quality electrical energy

2) secure electrical energy

3) Minimizing generation, transmission and ... costs.

1-1-2. Necessity to Use Control Systems in the Power Grid

In the vicinity of all power networks from the simplest to the most complex ones, there are one or more control centers that have the rule of Governance the network. This control system is called dispatching system. Current dispatching systems use SCADA technology to collect information and apply different

commands. The main purpose of this chapter is to provide a brief explanation of the SCADA system and its role in power networks control. Since the main task of the SCADA system is the collection of information and centralized control for optimal operation, this section first examines the control systems.

In general, control systems have a long way in the advancement process of technology. Among the factors that have led to changes in the control systems in the industry, economic issues, the need to control the quality of generation, increase the demand for more accuracy in measurement, speed in measurement and control, reduce energy losses, consider the behavior and experiences of the system history, preventing various events before occurrence, increasing the reliability of the system etc. have a special important.

In general, the advancement of control systems has always been concurrent with advancement of computer science, and whenever improvements have taken place in the computer industry, control systems have also undergone significant changes. In general, with a review of the history of the use of control systems, in particular PLC, DCS and SCADA show that use of control systems has been growth when the cost of computers is economically efficient. For example, the use of PLC systems at first was not economical due to the high costs of semiconductor chips. But with the development of the world of electronics and the emergence of LSI and VLSI demand for the use of these systems has greatly increased.

1-1-3. Introduction to various control systems

This section provides general information about various control systems for more information.

1-1-3-1. Local Control

In the first generation of process control systems in the industry, large equipment such as registers, controllers and indicators were in the process location and among all the signs and warnings, only send alarms to another location that users rest (the substation operator) or office shift responsible. Various boards such as relays and so on were in the location. In this case, the operators and engineers in the factory site examined the conditions at certain times note the special information from the indicator(s) or controllers to provide as work report. The problem of this system was low efficiency, low accuracy and lack of information collection.

1-1-3-2. Centralized Control

The centralized control is based on transmission of signals to one or more centers by cable and connecting them to the receiving equipment on the switchgear. Each control center, usually consisting of a command room and an aid switchgear room. In the command room, the main switchgears are placed with the mimic boards and worktable.

The characteristics of the centralized system with independent circuits are the simplicity, high volume of the equipment, and therefore the busy situation of the control room, the length of the boards, the high energy consumption, the middle efficiency of the users and the impossibility of processing the information in a comprehensible way, and record and maintain it for referencing in future.

This system does not work well in large industrial complexes that consist of multiple units, and for each unit a separate command room should be considered. In some units built in the 1970s, a supervisory system with large computers is intended for data collection.

Centralized systems at pump stations and gas pressure boost stations are sometimes designed for fully automated and non-user operation, but their efficiency has never been high due to the low reliability of the

equipment. Generally, on the control boards of the industries, most of the equipment by different generations are beside together.

1-1-3-3. Programmable Logic Controllers (PLCs)

In the last half century, due to the advancement of solid state technology and the emerging of microprocessors, industrial control systems have undergone dramatic changes, so that it can be said that the components and equipment used in industrial process control circuits have a lot of differences with equipment used in circuits even the past fifteen years, and these differences are mainly due to the use of electronic equipment.

PLCs have been used in the industry since 1969, and since 1974 using microprocessors as the brain of the system, they removed the contactor relay circuits and used PLC programmable controls (PLC) instead of them.

Today, designers of production lines and machinery and industrial processes do not have much interest to use of contact relays, and the use of contact relay circuits in the larger and complex industrial processes is almost obsolete. Due to these developments, PLC systems have been used in many of our factories and industrial centers in Iran, especially in the centers that have been installed since the 1980s.

Some of the disadvantages of electromechanical command circuits that replaced them with PLC are as follows:

1- When the big process and the control needs become more complex, the number of necessary components (relay, timer, counter, etc.) will increase, so the size of the switchgear become bigger and will occupy larger space.
2- Final cost of the control and command circuits increases.
3- Electromechanical circuits are more expensive than electronic circuits.
4- Due to energy losses in electromechanical circuits, appropriate ventilation is required.
5- The assembly of a switchgear with a large and complex wiring takes time and requires specialist personnel.
6- Electromechanical depreciation is high due to its mechanical parts.
7- The probability of mistake in assembly is high, and a specific algorithm and logic cannot be proposed for troubleshooting electromechanical command circuits.
8- A command switchgear constructed for a particular process is not usable for controlling another process and has a unique application, and changing the method or changing the control demands requires changing the wiring and adding or removing some parts, which requires a lot of time and money.
9- The disadvantages of the relay contact systems and advantages of PLC have led to a gradual change in the programmable logic controllers and replacing them with the contact control relay command circuits.

Figure (1) shows configuration of a system including a PLC.

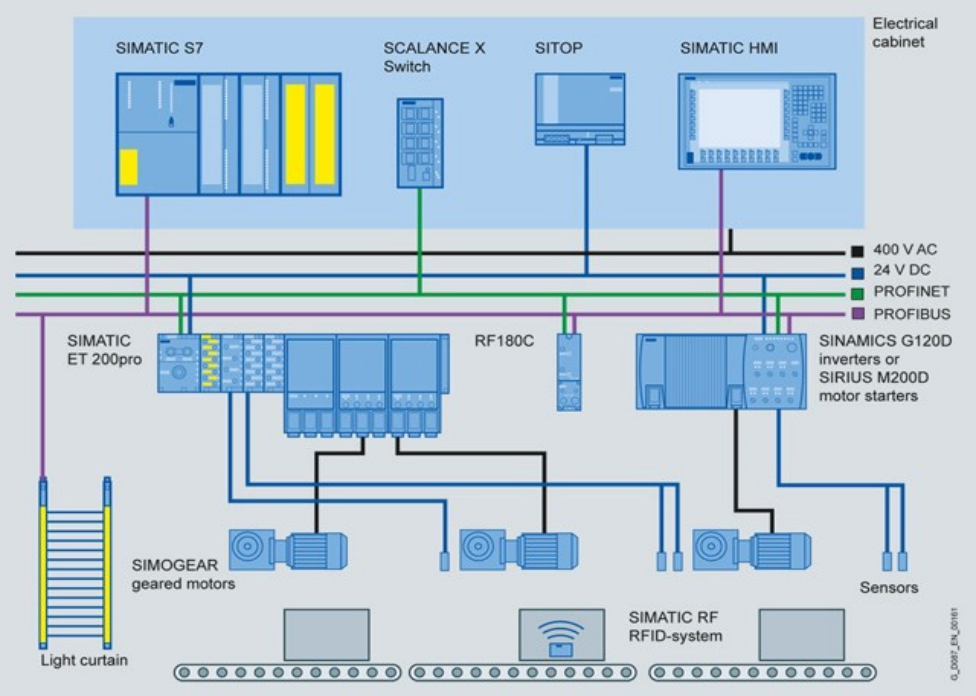

Figure 1- Configuration of a sample system using PLC

1-1-3-4. Distributed Control System

DCS is a distributed control system whose function is distributed rather than concentrated in a single point. A distributed control system consists of a number of microprocessor modules that control and monitor the performance of a system by co-operating with each other. Computers are distributed according to geographic location, which reduces the cost of installation and wiring.

It is a computer network but differs from home or office computer networks. In DCS real-time processing problem is important, unlike what is seen in processes on office or home computers. The difference between the two methods of processing is how they execute their programs. On traditional computers, processing is such that at one time only one single program is executed, so that the program starts with complicated calculations with a fixed set of data and ultimately ends up desirable, and when the process is completed, the program stopped to re-execute with a new data set. In the "real time" processing, process is started with a fixed data series, except that the same program is repeated continuously (several times per second) and updates the data according to the data in the previous step. As an example of a real-time performance, automobile speed control of a car is an example of real-time processing. The control starts with fixed speed data at optimal speed and at each step of the machine speed is sampled and due to its difference with the desired speed, control signals are applied to open or close the gas valve. A DCS controller also continuously monitors hundreds or perhaps thousands of under control systems and replicates computations based on a specific scheme for the respective systems. The data received from the environment can be divided into two groups:

a- Analog data

These data are continually changed and analyzed through control loops of software that may include relative controllers, Lead Lag, or PIDs, as needed, and appropriate output signals are send. For example, examples of this data are active and reactive power flowing through the line, the voltage of substation bus and so on.