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SUPERVISORY CONTROL (SCADA) SYSTEMS AND THEIR IMPLEMENTATION IN THE HIGH VOLTAGE PLANTS

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Abstract - SCADA (Supervisory Control and Data Acquisition) systems (or SCADA networks) are software support for supervision and control of industrial processes. Today there are thousands of installed SCADA systems, which can be mutually completely different in terms of their structure, but at the same time have a common basic elements and basic purposes: Monitoring, Control and Data Acquisition.

In the paper, in addition to basic information about SCADA systems, their function and elements, there will be presented their implementation in the high voltage 110 kV plant of the Thermal Power Plant of Kostolac A.

***Keywords* -** SCADA, system, monitoring, control, high voltage plant.

I. INTRODUCTION

SUPERVISORY control SCADA system (Supervisory Control And Data Acquisition) is a system that is used for automation of common processes, respectively that is used to collect data from sensors and instruments located at remote stations for transmission and presentation of those data in the central station for the purpose of supervision or control. The collected data is usually observed on one or more SCADA computers in the central (master) station. SCADA system in reality can monitor and control up to hundreds of thousands of input-output values. Conventional analog signals that SCADA system monitors (or controls) are the levels, temperatures, pressures, the speed of flow and the engine speed. Typical digital signals for supervision (control) are the level switches, pressure switches, status of generators, motors and relays. As its own name indicates, it does not have complete control over the system, but is more focused towards the level of monitoring and overseeing. SCADA are used not only in most of industrial processes such as steel making, production and distribution of electricity (conventional and nuclear), monitoring and control of chemical and transport processes, municipal water systems, but also more and more in everyday life. SCADA systems have achieved substatntial progress in recent years in terms of their functionality and performance.

II. SCADA SYSTEMS AND THEIR COMPONENTS

SCADA (Supervisory Control and Data Acquisition) systems (or SCADA networks) are software support for supervision and control of industrial processes. Today, there are thousands of installed SCADA systems, which can be mutually completely different in terms of their structure, but at the same time have a common basic elements and basic purposes: Monitoring, Control and Data Acquisition.

There are three types of SCADA systems.

1) *Basic SCADA – one purpose process, one terminal and processing unit (RTU and MTU),*
2) *Integrated SCADA – multiple terminal units (RTU), Distributed Control System (DCS),*
3) *Networked SCADA– multiple SCADA such as security systems, communication systems.*

The basic elements of the SCADA system are:

Master Terminal Unit (MTU) is a central computer of the SCADA system. It apparently controls all communications with remote computers and comparisons to other distributors. Data collected from all points of the system are sent to this computer, which process them and forward to other systems. It monitors all remote devices and perform ahead given actions if for them appear all anticipated conditions.

Remote Terminal Units (RTU) are devices designed exclusively for use in outdoor areas and industrial environments.

Intelligent Electronic Device (IED**)** is a device that performs the given program and provides a comparison in a given communication. This includes devices such as programmable controllers, intelligent sensors, RTU or PC classified as IED. As the amount of data in communication is increased, more and more «cleverness» should be integrated into these distributed devices, ie. IED.

SCADA system is consisted of three basic components: Master Station and HMI kompjuter(s), communication infrastructure and multiple remote terminal units (PLC), as shown in Fig. 1.

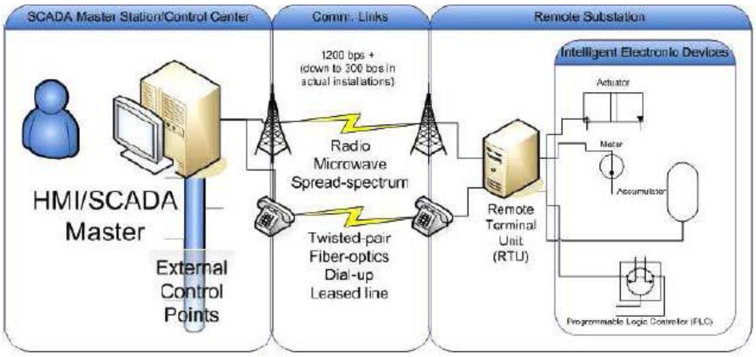

Fig. 1.- Basic components of the SCADA system

Although SCADA software is developed by various manufacturers from the analysis of available systems can be observed similarities in their architecture. We also can notice the existence of similar subsystems presented in Fig. 2, such as:

1) *Subsystem for defining the size in which is defined the size and their properties, such as upper and lower limit values of sizes, reading time, and so on. Input values represent the values of measured physical sizes from the process, and output sizes the values that are sent to the control unit. Often can be defined and the memory sizes (that are used for the calculations), and the system values which are specific for a used program.*
2) *Subsystem for alarms that serves to define and display alarm conditions in the system. The alarm condition may constitute an illegal or critical size value as an invalid action or operator command. Each alarm has its own properties such as the severity level of the alarm, place of origin, category, a message that is related to the alarm, and the like. The subsystem for alarms allows the change of alarm state operations through confirmation and deletion.*
3) *Subsystem for display of trends in which is shown the last change in value of size (trends in real time) and history of changes in value of size over an extended period of time (histogram). Well-defined subsystems for display of trends allow a comparative review of several sizes as well as archiving of the diagram.*
4) *In the subsystem of reports are formed reports in the changes of the size values, alarms, operator actions and other aspects of plant operation.*
5) *Graphic subsystem displays the state of the plant in a form that is most transparent for a man (operator) so that he can promptly react to changing state of the system. Size values are usually displayed in the form of numbers or "dynamic image", making it easier to detect changes in the image. In addition to displaying system state, the graphical subsystem should enable performance of some actions by the operator. For example, clicking a mouse on an object can be occurred performance of a previously defined macros or scripts.*
6) *The communication system enables connection of SCADA system with physical devices that performs direct supervision and control (PLC).*
7) *The sybsystem for access to databases allows permanent storage and review of data in relationa databases. New solutions use some of standard ways of archiving of the data that allow the user esay access to data from other software systems.*

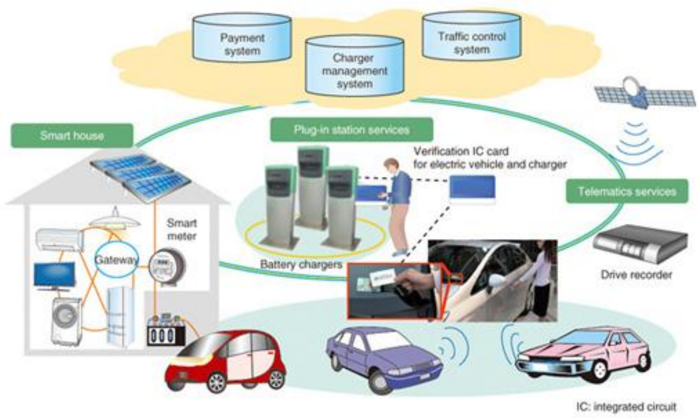

Fig. 2.- Subsystems of the SCADA system

A good example of the application of SCADA system is in the energy industry. SCADA systems in the energy sector are used to monitor, control and monitoring of the power system. They collect operational data of the remotely distributed power system and send them to the database of the central (master) computer. Users from different parts of the company and access to this data via the Internet. This is the main principle of operation of a typical SCADA system. In Fig. 3 is presented the principle of operation of an electric power system (network).

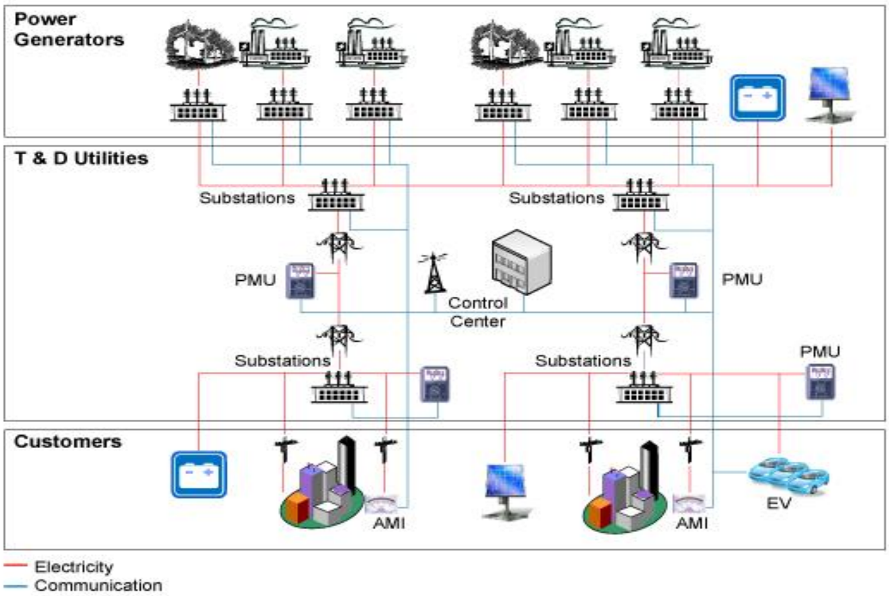

Fig. 3.- The principle control of an electric power system (network)

III. IMPLEMENTATION OF SCADA SYSTEM IN HIGH VOLTAGE 110 KV PLANTS

When implementing supervisory-control system using SCADA software, it is assumed that there exist a plant with associating measuring equipment and executive organs, that there is given technological scheme and desription of the plant, as well as electrical project at the level of the plant. Then the SCADA software is designed in a way to allow simple specification of all elements of the system, as well as an easy design of the operator interface and dispatching station. In doing so, there must be specified the way of communication, nodes in the network, scanning time of some stations or some signals in the stations, as well as collection (database) of data that are monitored and processed. As an example for implementation of such supervisory-control system is the high voltage 110 kV switchyard of the Thermal Power Plant of Kostolac A.

The thermal Power Plant of Kostolac A consists blocks A1-100 MW and A2-210 MW which through the high voltage 110 kV plant are connected to the electric power system. The plant, in addition of these two generator boxes, there are still: 8 – transmission line boxes, 2 – transformer boxes, 1–coupler and 1–measuring box. With the reconstruction of this high voltage plant, in addition to replacement of primary equipment are installed the modern microprocessor protective and control devices, thereby creating the conditions for the implementation of a new central supervisory-control SCADA system for complete 110 kV plant.

New central supervisory-control system represents a modern distributed information system for monitoring and control over processes. The basic components of this system are:

1) *two SCADA servers in a redundant configuration, both of which play a role of servers and operator stations.*
2) *RTL remote station is based on Real Time Linux platform.*

SCADA servers collect information from RTL devices, process the collected data and archive the events and measurements. RTL represents a multifunctional processing computer for monitoring and control in a power plant and is capable of collecting data and controlling the subordinated devices and I/O modules, thus achieving the possibility of complete control of overall protection and other parts of the power system with the full support of the master SCADA system. Communication in the control system of the 110 kV switchgear is carried out by different protocols whose block diagram is given in Fig. 4 SCADA.

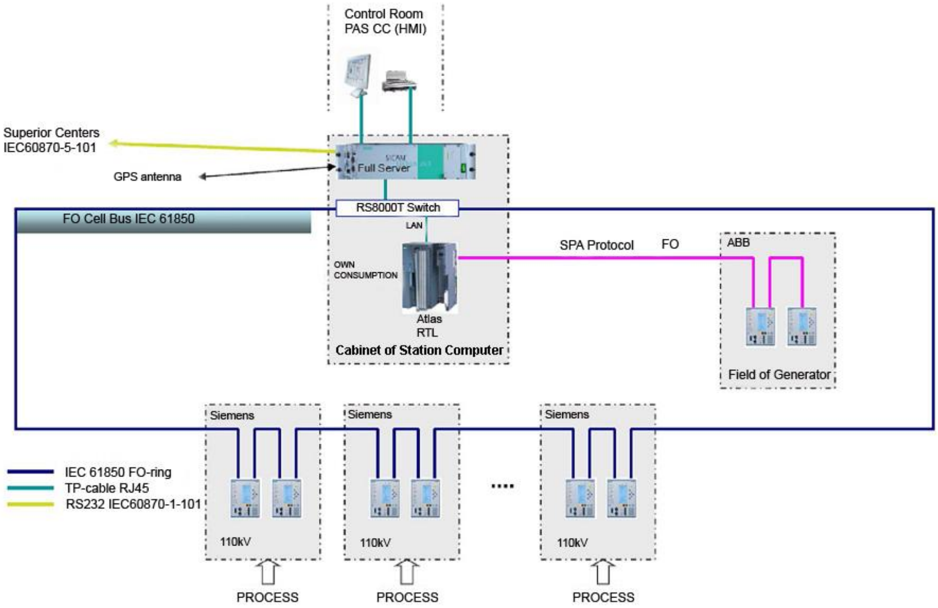

Fig. 4.- Block scheme of communication and communicational protocols of SCADA system of 110 kV switchgear

The controlling concept of the 110kV switchyard of TPP of Kostolac A anticipates more hieararchical levels:

- Local (manual) management, at field level
- Management by means of central computer of the (SCADA Server) in the plant
- Management from network regional dispatch centre

Exchange of data with other management systems: EES – the regional centre, the control system blocks of 1 and 2, and the control system of own consumption will be performed via remote station. The block scheme of the system with remote control and monitoring of 110 kV plant of the TPP of Kostolac A is shown in Fig. 5.

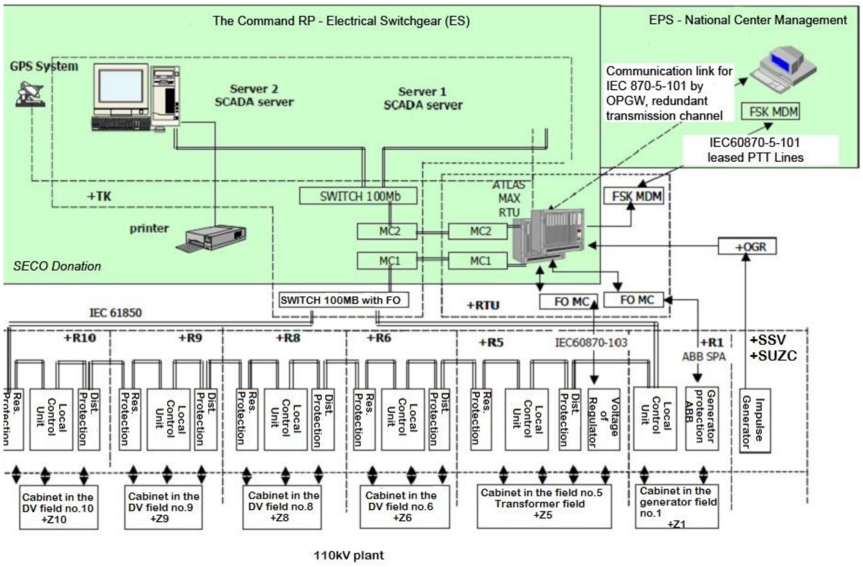

Fig. 5.- Block scheme of the system for remote control and monitoring of 110kV plant of TPP Kostolac A

Supervisory control system as superordinate level of management has the following functions:

1) *management-on/off of the switch and disconnector,*
2) *signaling states of switches and disconnectors,*
3) *registration and archiving of levels,*
4) *indication of measured values,*
5) *alarm signaling.*

This modern SCADA system has more dynamic graphical displays that illustrate what happens to the object system that is being monitored. They provide an overview of current situation and measurement values, current signal values of the switch and disconnector, alarm conditions and the state of power lines. In Fig. 6, we see the scheme of plants with elements that accompany the process and adapt their state what happens in it.

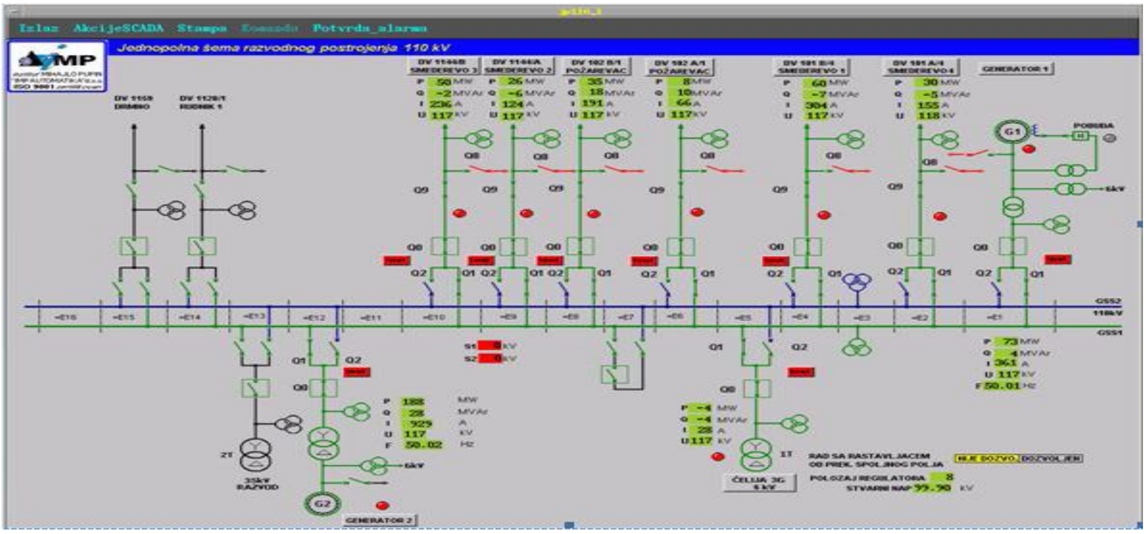

Fig. 6.- Dynamic image of the complete 110 kV plant

Hronological registration of events in the form of lists, represents the process of information acceptance and processing of events in supervised process with low temporal resolution and accepts all statuses and alarms. For the analysis of a default in the plant is formed a program to analyse failures (PMR-post mortem report), which will record all events 2 minutes before and 2 minutes after the failure in a particular PMR file. Graphical presentation of registration and archiving of events respectively failures is shown in Fig. 7.

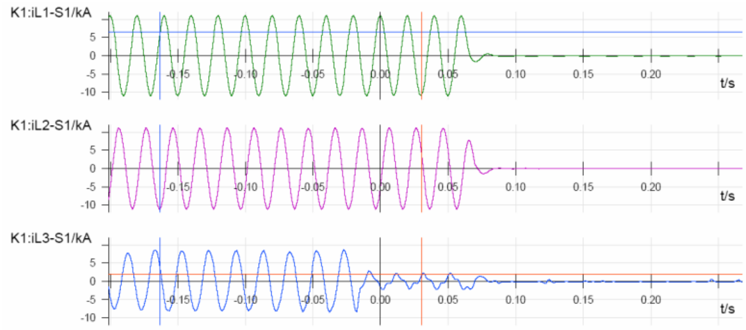

Fig. 7.- Record of system failure

CONCLUSION

SCADA (Supervisory Control and Data Acquisition) systems are software support for monitoring and control of industrial processes and serves for automation of common processes respectively for data acquisition from sensors and instruments located at remote stations and their transmission and display in the central station on one or more SCADA computers. For operation of SCADA systems there is a need for appropriate peripheral equipment that will enable collection of data ie. To exist a plant with associated measuring equipment and executive organs, to be given technological scheme and a description of the plant, as well as electrical project at the plant level.

The modernization of high voltage 110kV plant in the thermal power plant of Kostolac A, which in addition to the replacement of high voltage equipment included the installation of modern microprocessor protective and control devices and enabled the implementation of supervisory control SCADA systems. The primary purpose of SCADA system is to give advance warning of problems that may occur and that in case of failure enable rapid reaction of management staff. In addition, it allows monitoring of the switching state of equipment, chronological lists, compiling reports and analysis of failures and events in the plant. Based on the above it can be concluded that the supervisory control SCADA systems are the basis for modern work of the high voltage 110kV plant in the thermal power plant of Kostolac A.

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