© 2017 IJEDR | Volume 5, Issue 1 | ISSN: 2321-9939

Designing and Development of Solar SCADA

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***Abstract*— The main aim of this work is to Design and Develop the SCADA (Major) and Control System (Minor) of a Solar Plant to continuously monitor various energy parameters. Supervisory control and data acquisition (SCADA) systems are used in solar power plants for monitoring, control, remote communication purpose. The Solar plant does not have any moving parts, as a result we need live and historical details about the plant, so we use SCADA system that monitors all the critical field devices such as inverters, mfm, smb and weather parameters like humidity, temperature and weather. All this is combined to provide a real time and plant comprehensive view of the entire solar plant with continuous alert system, viewed from anywhere (at site/corporate office) - on PC/Mobile.**

***Index Terms*— Opto22 Snap PAC R1 controller, solar SCADA monitoring and optimization, data acquisition system, PAC Control Pro, PAC Display Pro, Supervisory monitoring and control station.**

I. INTRODUCTION

Sunlight is the best form of renewable energy. The sun will eventually run out of fuel, but, thankfully for us, not for several million years. Sunlight is free and can be converted into electricity.

This process of generating electricity from sunlight using different methods, is known as "Solar Power". The photovoltaic solar energy (PV) is clean and economical viable alternative that has been recently an increasing investment. Sunlight is converted into electricity via what are known as photovoltaic cells, or PV cells for short. When sunlight falls on PV cells electrons are knocked loose from the atoms in the semiconductor material. These electrons are captured and the flow of electrons is what, powers all kinds of electrical devices. Sunlight is virtually unlimited, and you can store some of the electricity created while the sun is shining to be used in the evenings and at night once the sun has dipped below the horizon. Using solar energy reduces your reliance on other, less eco-friendly methods of energy production, such as electricity produced by burning coal. Of all the routes for conversion of solar into useful energy, direct conversion of sunlight to electricity through solar photovoltaic technology is well accepted.

There are two main types of solar technology: **photovoltaic (PV)** and **concentrated solar power (CSP)**. Solar PV technology captures sunlight to generate electric power, and CSP harnesses the sun's heat and uses it to generate thermal energy that powers heaters or turbines.

A solar PV array is comprised of hundreds, sometimes thousands of solar cells, that individually convert radiant sun light into electrical currents. The average solar cell is approximately 15% efficient, which means nearly 85% of the sunlight that hits them does not get converted into electricity. When you combine several solar panels, you create a solar array. A solar array is the totality of solar cells, modules and panels. Remote monitoring allows a solar plant operator not only to control, but, in many cases, to track and monitor the plant from a distance.

In the past year alone, there have been milestones in solar efficiency, solar energy storage, wearable solar technology and solar design tech. Monitoring and performance analysis of solar PV plants have become extremely critical as high performance is required. On-site weather data, production data from the panel strings, inverters and transformers are required to be continuously collected for monitoring and analysis of performance.

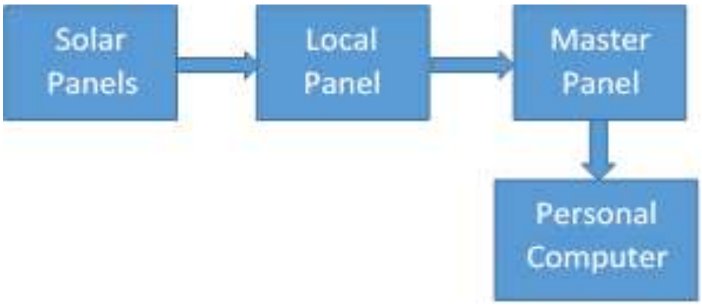

Fig 1: Functional block diagram

Figure 1 shows the flow diagram of the system, Block 1 consists of the solar panels which are mounted on field, solar panels transmit the voltage to the inverters which passes the electricity to the grid or further use, the electricity data like Ampere,Voltage,Power, are transmitted to the PAC Controller mounted in the Local field Panel (Block 2) through Modbus communication, which then transmits the data to the controller mounted in the Master Control Panel (Block 3) situated in the control room through Fiber Optic communication. These data can be monitored and controlled on the SCADA installed in the Personal Computer (PC) in the Control room.

II. SYSTEM DESIGN AND DEVELOPMENT

The development of this monitoring system mainly comprises of three parts - namely acquiring and transmitting data signal, monitoring, analysis and alert system.

Figure 2 shows the flow diagram of the system, in which digital and Analog Signals are transmitted from the field to the main control room and to other remote places through Internet.

In this paper the data signals of the power plant will be transmitted to the PAC controller in the Local control panel located in the field near the PV Solar panel, these signals will be controlled by the Controller in the panel. These signals are communicating through Modbus with the controller in the local panel. The local controller communicates over Ethernet and transmits the data to the Ethernet switch. From the Ethernet switch the data is transmitted to the long distance master control panel through the fiber optic cable. In the control room the signals are passed through the Ethernet/FO converter and transmitted to the Master Controller through the Ethernet communication. The master controller controls the various parameters and gives the data to the Personal Computer connected with it in which SCADA Server is installed which acquires the data and generates the alarms, trends and reports.
The operator in the control room controls the plant from the SCADA server and maintains the appropriate data.

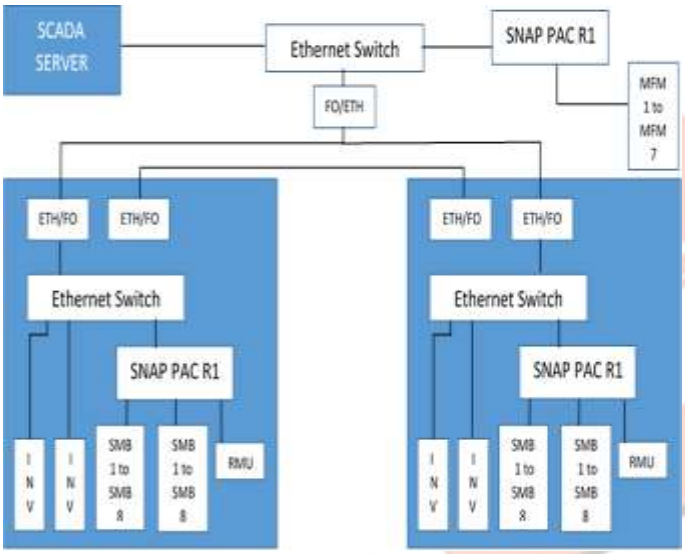

Fig 2: Flow diagram

a. Acquiring and transmitting data signal:

Electrical data of different parameters are acquired by the controller through Modbus communication and are transmitted to other controller by Ethernet and fiber optic cable. The fiber optic cable is used here as the data has to be transmitted over a long area and the data security is also needed. The main advantages of fiber over Ethernet are, it is intrinsically safe, small size and lightweight, Wide bandwidth and High sensitivity to inputs. The Ethernet transmit data signals at 10MB/s over a distance of only 100 meters whereas the fiber optic transmits data signals at 1GB/s over distance of 1km.

b. Monitoring and Controlling:

The data is received by the local controller and sent to the master controller in the control room. The data of all parameters is monitored in SCADA in the control room which is given by the master controller. PAC Display SCADA shows the real time values of various parameters like voltage, current, KVAR, KW, total load, PF, weather parameters, inverter functioning, multifunction meter parameters, SMB parameters, communication parameters and total generation of Power in plant. SCADA monitors these real time parameters and also control various parameters like tripping switches. The local controllers control the local individual panels and the master controller controls the high priority and risky switching breakers to protect the plant in an emergency. Trends can also be monitored in the real time SCADA.

c. Alert System:

The data received by the local controllers is compared with the set points and ranges which are programmed in them and generates alarms if an inappropriate condition occurs. Precautions are made to generate alarms and initiates the hooters announcing and emergency in the plant.

III. HARDWARE

a. SNAP PAC Controller Kit:

The SNAP-PAC-R1 programmable automation controller provides control, communication, and I/O processing in a compact, rack-mounted package. One of four components of the SNAP PAC System, the SNAP-PAC-R1 is fully integrated with PAC Project software, SNAP PAC brains, and SNAP I/O modules.

As shown in Figure 3, the SNAP-PAC-R1 is mounted in the SNAP PAC kit on the rack with one Digital Input module (DI-4channel), one Digital Output module (DO-4channel), one Analog Input module (AI-4channel), one Analog Output module (AO-4channel) and one Communication module (CP). It also comprises of one potentiometer which work as an analog input, one analog meter which works as analog output, two toggle switches and two on/off switches which work as digital input, four LED indications which work as digital output, one temperature sensor and one alarm buzzer.
Used with the included PAC Project Basic software suite (or PAC Project Professional, purchased separately), the Ethernet-based SNAP-PAC-R1 can handle almost all your industrial control, remote monitoring, and data acquisition needs.

Fig 3: Opto22 SNAP PAC Controller Kit

IV. SOFTWARE

The The controller is the main heart of the solar automation, it controls the different parameters of the plant. This controllers are mounted on racks in the local controller panel and also in the master controller panel.

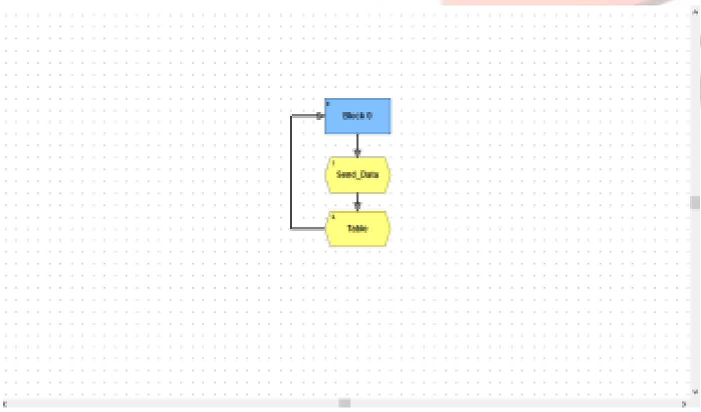

Fig 4: PAC Control Strategy Program

Figure 4 shows the Program block of the project, in which the program is executed block by block where the data first will be fetched by the local controller and then send to the master controller in the control panel.

Fig 5: PAC Control Opto Script Logic of Solar SCADA

Figure 5 shows the opto scripting logic of the programming of our project. Here the various set points are mentioned and compared with the PV (Process Value) value to generate alarms and maintain the ratings of the parameters for safe plant functioning.

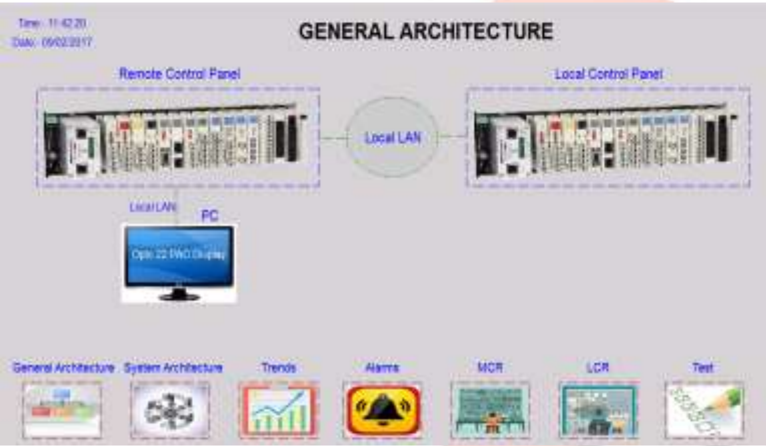

Fig 6: PAC Display General Architecture of Solar SCADA

Figure 6 shows the general architecture of Solar SCADA in which the data of the parameters is transferred from the field to the local control panel where the controller controls the local field plant and then it sends the data to the remote or master control panel. The SCADA is installed in the PC in the control room which monitors and controls the whole plant.

V. RESULTS

Fig 7: Trends of Solar SCADA

Fig 8: Alarms of Solar SCADA

Fig 9: Local controller data

Fig 10: Master controller data

Figure 7 shows the real time data trends of the various parameters of the solar plant, Figure 8 shows the alarms of the plant which occur in an abnormal conditions, Figure 9 shows the data of different parameters of the plant in the local controller and Figure 10 shows data in the master controller.

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