A Design and Automation with PLC of a Solar System and Test Results

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Abstract—In this study, a solar garden lighting system was installed at Gazi University, OSTIM Vocational High School for educational with this project. The system was settled up by using the automation system S7-1200 PLC and followed by display. In the system there are three 100Wp each, a total power of 300Wp panels connected as parallel. Maximum amount of solar energy utilized in solar panels placed on the roof angle OSTIM Vocational High School made the necessary connections. Solar panels are used to charge the battery charge controller was added to the system. In automation system was used that Siemens PLC S7-1200 and 10” touch screen software has been completed and integrated into the system. Remote monitoring of the flow of energy derived from solar panels, wireless RF modules, electronic card design has been completed. Developed in conjunction with RF communication parameters of the system (battery, panel and the load current and voltage values) has been transferred to the control unit monitoring unit in a healthy way. SCADA system with remote automation system parameters have been obtained graphically recorded in the computer. After this stage, the students can use for training purposes as well as for academic research infrastructure was created.

Index Terms—solar energy, PLC, remote monitoring, energy monitoring

I. INTRODUCTION

Your goal is to simulate the usual appearance of papers in a Journal of the Engineering and Technology Publishing. We are requesting that you follow these guidelines as closely as possible.

In recent year, solar energy using has been increasing in many areas and there are a lot of different type energy conversation methods. But, most of these systems were not installed properly and no optimization because of insufficient well educated people and not enough data. So, the education of solar system in industrial school likes vocational and engineering schools very important.

According to the results obtained from research conducted in recent years show features complement each other with the use of alternative energy sources will increase the reliability of the system have been identified [1]-[5].

Choosing the best control strategy in the event of the element size and cost of the system will rise very little or even fall slightly according to the characteristics of the region are as established in [6]. Referred to as hybrid power generation system will include more elements of such systems will become a complex structure for the system. Another problem of hybrid energy system in the initial setup costs to a minimum, keep the dimensioning maximum reliability challenge. In our country, not only between the months of April-November, producing electrical energy from the sun, solar energy is required for the system should be used although there are resources to help during the winter months. Wind power in areas with high wind potential can be completed with open [7], [8]. Photovoltaic and hybrid wind/PV systems cost and effective analysis was published in 1998 [9]. Other solar-wind hybrid power generating, systems that were used for security lighting was designed by Engin and Çolak, in 2003 [10]-[11]. In this system after hybrid system was installed and solar cells, wind turbine, battery bank, charge regulators and inverter performance values were measured through the whole year.

Aktacir et al., GAP PV-wind hybrid system in the region can be used as an effective application of the experimental work carried out in [12]. Salmanoğlu and Cetin, hybrid (solar-wind) energy systems, components, systems should be used in preparing the optimal utilization rates, and presented to the user with the software [13].

In this study, different from other a solar power generation plant established renewable energy in vocational high school for teach to students most of specifications. The system includes the two different types of discrete manufacturers; energy production system ensuring continuity has been established thanks to the removal and storage elements. The obtained energy from the interior - exterior lighting (LED lights) for supply via the DC-DC converter to be controlled and the current DC loads (water pump, etc.), and the charging of batteries used. In addition, by monitoring the amount of
current energy storage elements, the present estimate of spending loads of time in order to be able to learn. The solar panels every 500 ms instantaneous current and voltage values of a PLC are stored on the PC can be read with the help of. We also observed and instant readings via the LCD touch panel can be traced graphically. So students can be at any time interfere with the system via a remote PC if required information is stored in the PC memory efficiency of the system in that area hourly, daily, monthly, seasonal and annual basis will help you plan for the installation of systems modeled after. Thus, vocational high school students learn most of characteristic of solar system in school during the education.

II. DESIGN AND AUTOMATION WITH PLC OF A SOLAR SYSTEM AND TEST RESULTS

A block diagram of the first year of the project was commissioned to design the system. Fig. 1 shows block diagram of the designed system. As a first stage of the study, in order to determine the system of solar panels response was simulated in MATLAB. Through the computer by means of solar panels, battery control unit is used for the condition. Energy stored in the battery charger that is obtained from the diet or DC loads are used in LED light bulbs.

![Block diagram of the designed system](image)

Fig. 1. Block diagram of the designed system

Fig. 2 shows the I-V characteristics of solar panels. Panels prepared using the values provided by the manufacturer; the maximum power point of the simulation was to determine the response of the system operation. I-V characteristics with the characteristics of the solar panels are the same.

![P-V Characteristic of Solar Panel](image)

Figure 3. P-V characteristic of the solar panel

Fig. 3 shows the P-V characteristics of solar panels using the values provided by the manufacturer.

![I-V Characteristic of Solar Panel](image)

Figure 2. I-V characteristics of solar panel

Fig. 4 shows the RF circuit module developed for UDEA brand used in the study UFM-M11 Radio Frequency Module (RFM). 3V voltage level to work with. Input voltage of supply circuit is set 12V. In this way, be fed with energy from the batteries. This module uses the low-power frequency of 434MHz, 400 to 500 meters in open space, and capable of multicasting UGPA-434 model is capable of communication is connected to the antenna. The module as modulation Frequency Shift Modulation (FSK, Frequency - shift keying) method uses. Maximum output power of 10dBm 434MHz, 10MW of module power consumption.

![RF circuit module](image)

Fig. 4 and Fig. 5 show hardware design, printed circuit board material, circuit drawing program, designed using the RFM module surface (material placement) and the surface of the printed circuit board. If the module is in the mode of data transmission and receiving, the currents are 30mA and 17mA, respectively. RS232 (serial port) connection MAX232 serial port buffer circuit has been designed for communication between PC and PLC.

![Hardware design](image)

In Fig. 6, the experimental setup of solar energy system in the Garden of OSTIM Vocational School was given. System 3 is a 100W solar panel connected in parallel to the battery of 100Ah stored. Thus, the system has been used elucidation of energy derived from the school grounds at night. Also connected to loads of different types of tests was carried out experimental study.

Solar panel charger was shown In Fig. 7. The current level and voltage of systems (battery, solar panel and load) could display.
Main CPU of PLC, analog input expansion module and touch screen (HMI) was shown in Fig. 8. PLC and HMI was connected with PROFINET protocol.

The name of the project and developers are written in start-up screen has been prepared for information purposes. Other values are displayed on the other screen (Fig. 9) which could reach pushing “next” button. Variables of system (voltages, currents) was displayed other screen is given in Fig. 9. On the left side of this screen, panel, battery, and load of currents and voltages’ values are shown. Instantaneous total power produced by
the solar panels and the value of the power consumed by the load is positioned in the upper right corner. The solar panel and the battery voltage were shown on the bottom right side of screen with bar graph. It allows the user to see in red color when excessive charge or discharge status of the battery was occurred.

![Image of system variables screen (second screen)](image)

**Figure 9. System variables screen (second screen)**

Fig. 10 gives an overview of the remote monitoring system includes PLC, LOGO power, CM1241 serial communication expansion module, RF module, an electronic card system. PLC S7-1200 side-coded serial port expansion module CM-1241 is controlled using the on-screen input parameters are applied to the RF module. The data sent by the RF module with baud rate 9600 and 434MHz on side of control system, was converted signal transmitted to the antenna and remote monitoring data was captured by RF module is located on remote monitoring side. This information is taken from the computer's serial port is connected. Displayed and recorded data saved on your computer thanks to the developed software by authors.

![Image of remote monitoring systems components](image)

**Figure 10. Remote monitoring systems components**

The data saved on the computer by using the values of the system parameters change during the day are presented in the following figures. Recording of data was started in the morning at 09:00 o’clock and recording continued until in the evening at 18:30.

Fig. 11 shows the solar panel output voltage variation during the day. At 10:00 o’clock, the load was switched on. It was caused by decreasing output voltage of solar panels. Output voltage is proportional to the intensity of sunlight and additionally the temperature value is also very effective. The load was switched off at 15:30 o’clock.

![Image of daily variation of output voltage of solar panels](image)

**Figure 11. Daily variation of output voltage of solar panels**

Fig. 12 shows the changing output current solar panels during the day. It was fluctuated around 6 A.

![Image of daily variation of output current of solar panels](image)

**Figure 12. Daily variation of output current of solar panels**

The output power of solar panels during the day was given in Fig. 13. It was clearly seen in the figure, the power was affected by sunlight. All calculation, feasibility studies or designing of solar panel systems this figure needed to be taken into consideration.

![Image of daily variation of output power solar panel](image)

**Figure 13. Daily variation of output power solar panel**
Fig. 14 shows the variation of load voltage during the day. The level of voltage was almost same with output voltage of battery cause of connection between battery and load. The voltage level was kept around 13.5V for battery standby. When the load was switched on, the voltage was decreased around 12V and fluctuated around this level. After load was switched off, it was increased around 13.5 standby voltage levels.

Daily variation of load current and power was given in Fig. 15 and Fig. 16, respectively.

Fig. 17 shows the variation of battery voltage during the day. The level of voltage was almost same with output voltage of load and it was explained above.

Daily variation of battery current and power was given in Fig. 18 and Fig. 19, respectively. The current was increased during day cause of charging. It is clearly seen in the figures, when the output current of solar panels met with load, excessive current was used for charging.
In this study, for educational purposes, a solar-powered garden lighting system was installed at Gazi University Vocational High School (OSTIM). S7-1200 PLC system is established and monitored by the automation system using the touch screen. Each of the System 100Wp, 300Wp power panels are connected in parallel. Maximum amount of solar energy utilized in solar panels placed on the roof of Vocational OSTIM angle made the necessary connections. Solar panels are used to charge the battery charge controller was added to the system. Siemens PLC S7-1200 is used in automation and 10” touch screen integrated into the system software has been completed. Remote monitoring of the flow of energy derived from solar panels, wireless RF modules, electronic card design has been completed. Developed in conjunction with RF communication parameters of the system (battery, panel and the load voltage and current values) to transfer control unit monitoring unit is provided in a healthy way. System with SCADA system with remote automation graphically recorded in the computer system parameters has been obtained. This will then be used by students for educational purposes as well as for academic research infrastructure established.

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REFERENCES


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