Monitoring and Control of
Solar Power System using Reliance SCADA

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ABSTRACT

This system presents the monitoring and control of real time data acquisition of a solar power system in reliance SCADA. SCADA (supervisory control and data acquisition) systems are currently employed in many applications, such as home automation, greenhouse automation, and hybrid power systems. Commercial SCADA systems are costly to set up and maintain; therefore those are not used for small renewable energy systems. This system demonstrates applying Reliance SCADA and Arduino Uno on a small photovoltaic (PV) power system to monitor the current, voltage, of the PV and battery and also control the load from SCADA. The designed system uses low-cost sensors, an Arduino Uno microcontroller, and free Reliance SCADA software. The Arduino Uno microcontroller collects data from sensors and communicates with a computer through a USB cable. Uno has been programmed to transmit data to Reliance SCADA on PC. In addition, Modbus library has been uploaded on Arduino to allow communication between the Arduino and our SCADA system by using the MODBUS RTU protocol. The results of the experiments demonstrate that SCADA works in real time and can be effectively used in monitoring a solar energy system.

KEYWORDS: Current Sensor, Voltage Sensor, Solar PV System, Reliance SCADA

I. INTRODUCTION

For several hundred years, fossil fuels have been consumed as the main source of energy on Earth. As a result, they are now experiencing rapid depletion.

Researchers and scientists who understand the importance of renewable energy have dedicated their efforts to the research, expansion, and deployment of new energy sources to replace fossil fuels. Photovoltaic (PV) is an important renewable energy source. Solar energy is the energy that is available from the sun in abundance. Solar power is the conversion of sunlight into electricity. Electricity can be generated in two ways with the help of solar energy or the sun's energy. It can be generated Firstly, with the help of photovoltaic electricity and secondly with solar thermal electricity. Photovoltaic electricity is a method that uses photovoltaic cells to capture direct sunlight. Solar energy plays an important role as a primary source of energy, especially for a rural area. This paper aims at the development of process and Reliance SCADA for real-time monitoring [1].

SCADA is a software process control system that enables a site operator to monitor and control processes that are distributed among various different sites. SCADA system is often referred to as telemetry importance. Traditionally, SCADA systems have made use of the Public Switched Network (PSN) for monitoring purposes to save time. Today many systems are monitored using the infrastructure of the corporate Local Area Network (LAN)/Wide Area Network (WAN) and industrial networking. Another common term used to describe a SCADA system is just like to Human Machine Interface (HMI). It is used to describe any system that provides an interface between a person and a piece of machinery in a field. The Industrial SCADA System falls into this category for monitoring. It provides an HMI by displaying process variables to the operator and allowing control of the plan. Functions of the SCADA system A SCADA system have two basic functions, the first of which is to display information about the current operating conditions of a plant in an informative and graphical interface/trends and the second is to allow supervisory control of the plant by personnel/data acquisition [2].

In this paper, designed SCADA system is of lower price compared with a commercial SCADA system, and it delivers the same performance. In order to test this work, the SCADA system is employed for monitoring the parameters of solar energy systems (photovoltaic) in real time, which consist of a solar module and batteries. The parameters are the current and voltage of the photovoltaic (PV) system and the current and voltage of the battery. The data acquisition system is by Arduino controller and sensors. All data are sent to a PC and are shown on a user interface designed by Reliance SCADA.

II. Block Diagram Of The System

Figure 1 shows the block diagram of the overall system. A SCADA system is used for automation and controlling of the other supporting devices: those are microcontroller and many sensors. Actually, this system consists of three sections. They are power section, data collecting and sending section and monitoring and control section.
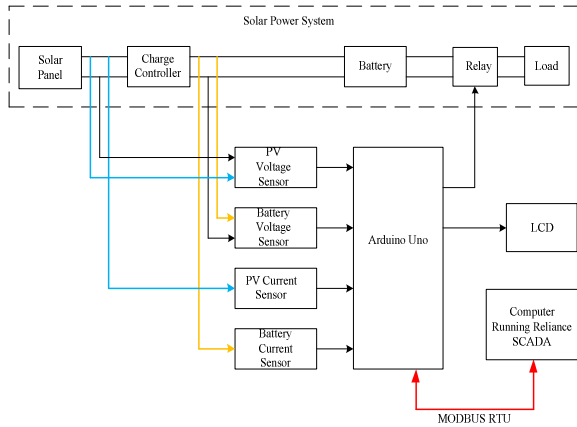
Figure1. Block Diagram of Proposed System

In the power section, there are four devices. They are solar panel, charge controller, battery and load. The first device is a solar panel which converts directly to electricity from sunlight. This electricity is stored in the battery through the second device to use the energy at night. The second device is a charge controller, which is installed between the solar panel and battery to detect the overload voltage. The device which included in power section is load.

In the second section, this section which acts on collecting and sending data. Arduino microcontroller is the main device in this section. This microcontroller collects the parameter data such as voltage and current from the solar power system by voltage and current sensors. These sensors are connected with analog pins of the Arduino microcontroller. The parameter data of solar and battery such as voltage and current are sent to the third section by the microcontroller through the USB cable. This USB cable is MODBUS RTU with a speed rate of 9600.

In monitoring and control section, the computer running Reliance SCADA is including. The user can be seen the values of voltage and current come from a solar power system on this SCADA screen. In this SCADA system, the user can also be controlled such as ON/OFF function to the load. In this research, designed SCADA system is lower price compared with a commercial SCADA system, and it delivers the same performance. System flowchart of this system is shown in Figure 2.
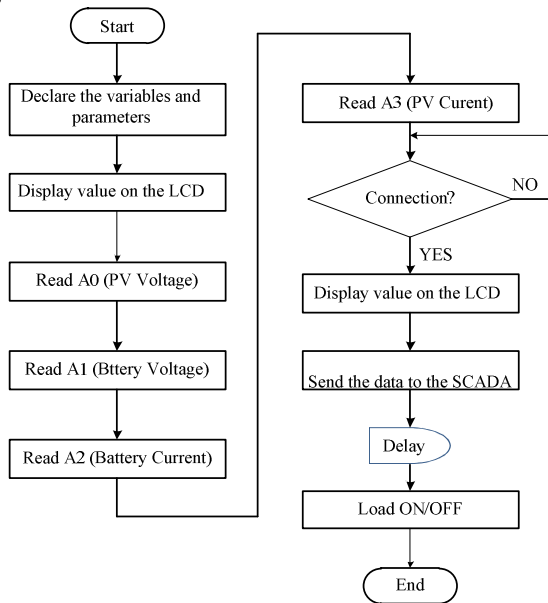

Figure2. Flowchart of the System

III. Hardware Configurations
A. Arduino UNO
The Arduino Uno is a microcontroller board based on the ATmega328P shown in figure 3. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FUDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter [3].

Figure3. Arduino Uno Microcontroller

B. Current Sensor
Current sensors for DC currents must be able to measure range currents for PV and batteries between 0A and 20A. In this system, the ACS 712 sensor used for sensing the current. The current sensor is as shown in Figure 4. It is designed to be easily used with any microcontroller, such as Arduino. The sensors are based on the Allegro AC712ELC chip. The scale value of ACS 712, which is used in this design, is 20 amps, which is appropriate for sensing current. Two sensors are installed: one is installed before the charge controller to measure the PV current and the other is installed after the charge controller to measure the battery current. Figure 4 demonstrates how it connects in an electrical circuit with Arduino Uno.
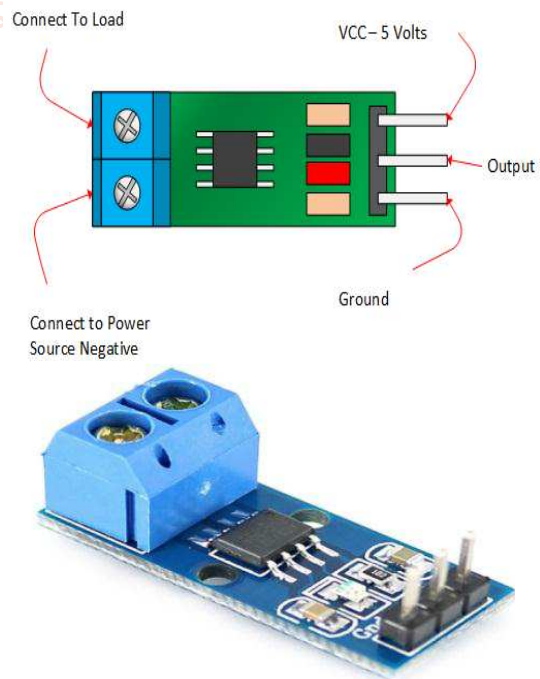

Figure4. Current Sensor

C. Voltage Sensor

The function of voltage sensors, which are based on just two resistors, is to turn a large voltage into a small one. In this work, the voltage sensor is a 30V-sensor with two resistors of 50KΩ and 10 KΩ. The maximum voltage of either PV is 30V or battery is 13V, so this sensor is appropriate.
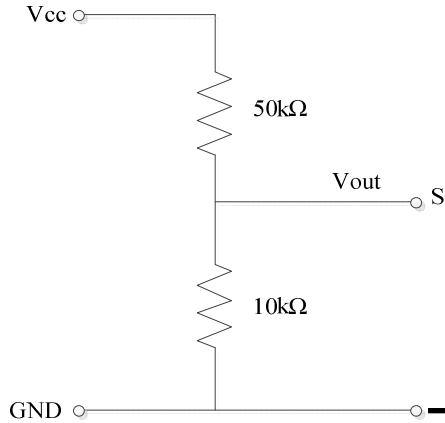
Figure 5: Voltage sensing circuit

The output of the voltage sensor is between 0V and 5V. This scale is suitable to the Arduino analog inputs. In this proposed system, two voltage sensors: one is installed before the charge controller to measure the PV voltage and the other is installed after the charge controller to measure the battery voltage. Figure 5 demonstrates how it connects in an electrical circuit with Arduino Uno.

IV. Software Description
A. Reliance SCADA

Reliance software is employed in numerous technologies for monitoring and controlling systems. It can also be used for connecting to a smart phone or the web. Reliance is used in many colleges and universities around the world for education or scientific research purposes. Figure.6 shows a user interface designed by Reliance SCADA software to monitor the parameters of the photovoltaic system. The user interface has four real-time trends and four display icons to show values as digital numbers. MODBUS library is added to Arduino Uno to allow communication with Reliance SCADA via a USB cable using MODBUS RTU protocol.
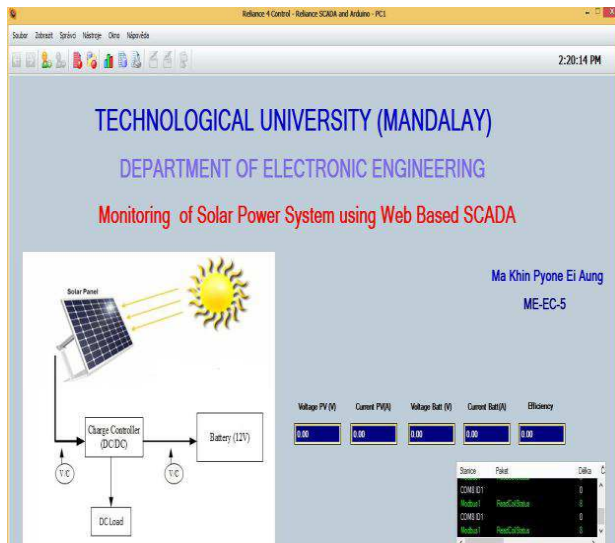
Figure6. The user interface of the SCADA system

B. The communication system between Arduino and SCADA

Table1: Allocation of MODBUS address for MODBUS RTU

Arduino Address	Variable name	MODBUS RTU address
3001	The voltage of the PV system	0
3002	The current of the PV system	1
3003	Voltage of battery	2
3004	Voltage of Current	3
3005	The efficiency of the charge controller	4

MODBUS library is added to Arduino Uno to allow communication with Reliance SCADA via a USB cable using MODBUS RTU protocol. Table 1 shows the allocation of MODBUS address for MODBUS RTU on Reliance SCADA software, with the MODBUS address for Arduino Uno mentioned in the Arduino code.

V. Test And Result Of The System

Figure7. Testing the Overall System

In Figure 7, the Arduino and sensors were setups on the circuit board and when it was successfully worked the LCD monitor has displayed the solar voltage, solar current, battery voltage, and battery current. These values are sensed by Arduino microcontroller to the computer running reliance SCADA through the USB cable (MODBUS) with the speed rate of 9600bps. Arduino IDE software is used for the system. Reliance SCADA software was used for SCADA server.

The reliance SCADA system was designed and built with Reliance SCADA software and Arduino Uno. The SCADA system was applied to a stand-alone photovoltaic system to monitor the current and voltage of PV and batteries. This voltage is varying with respect to the atmospheric condition such as irradiation value of solar light and atmospheric temperature. The results show the voltage variation and behavior of the solar panel recorded during different duration of time and days. Due to the low and high intensity of the sunrays, the voltage of the solar panel varies. The total simulation has been successfully simulated in Reliance SCADA using Arduino.
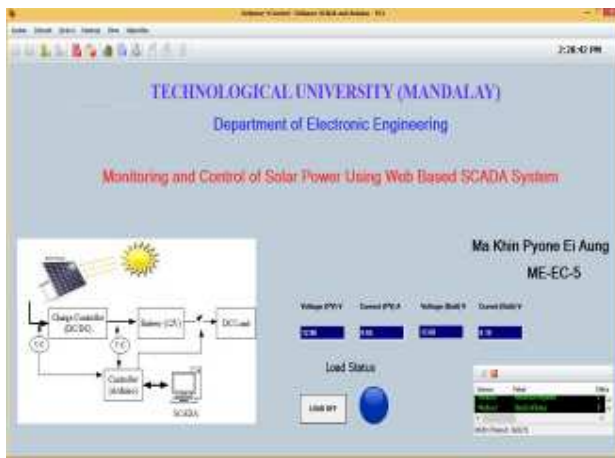
Figure8. User Interface of SCADA System while Running with Load (OFF)

In this research, relay and load are used to detect controlling from a computer running Reliance SCADA. The load (ON/OFF) can be controlled from SCADA. This condition is as shown in Figure 8 and 9.

Figure9. User Interface of SCADA System while Running with Load (ON)

VI.   Conclusions

In this system, the Reliance SCADA system is used to monitor the values of current and voltage where PV and battery and control the load. A Reliance SCADA system was designed with Reliance SCADA software and Arduino Uno. The SCADA system was applied to a stand-alone photovoltaic system to monitor the current and voltage of PV and batteries. Arduino collects data from many sensors and these data are sending to the computer running Reliance SCADA through the USB cable by the microcontroller. For monitoring the values of current and voltage, analog pins of the Arduino are used and digital pins used for load control. This voltage is varying with respect to the atmospheric condition such as irradiation value of solar light and atmospheric temperature. In order to test this work, the SCADA system is employed for monitoring the parameters of solar energy systems (photovoltaic) in real-time, which consists of a solar module, MPPT charge controller, and batteries. The parameters are the current and voltage of the photovoltaic (PV) system and the current and voltage of the battery. The data acquisition system is by Arduino controller and sensors. All data are sent to a PC and are shown on a user interface designed by Reliance SCADA via MODBUS. This proposed system not only monitors the sensor data, like the voltage, current but also actuates a process according to the user command, for example switching on the light when it gets dark. As the Reliance SCADA software is free, numbers of sensors are limited (at most four sensors).

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