Monitoring system for 5-kW Solar pumping system

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Abstract. Solar pumping system has been used extensively in agriculture and irrigation system. It is an old pumping system replacement because the old pumping system requires more maintenance and replacement. This article is reported on the study and development of the solar pumping system and the remote monitoring system. The system consists of the 5-kW solar panel and the 2.2kW submersible pump with a solar pump controller. It has been installed in the rural area which cannot easily accessible from the city. The monitoring system has been developed by integrating the electrical power modules, water measurement modules, weather measuring modules, and main controller modules. All of them communicate over the RS485 bus. The main controller unit integrates with software, gather all data from every modules and display on touch screen. It also makes data post-processing and records it on a USB drive and prepare data protocol for sending via communication modules. The system can work properly but it still need some further development in the future.

Keywords: Solar, pumping system, remote monitoring, Solar pumping system, monitoring system.

1. Introduction
Solar pumping systems have been used extensively in agriculture. They have to be used as an irrigation system for both agriculture and normal living in rural areas. The system consists of the solar panels (or PV), submerge pumps, system controller/inverter, and water tank. Generally, the solar pumping system should be required any service/maintenance as least as possible. In the past, the pumping system used the gasoline/diesel engine or even the natural gas engine which required periodic maintenance and also make some noise, air pollution and also unpredictable fuel cost. When comparing it with the solar pumping system, the solar pumping system does not need any fuel and also requires only a few service/maintenance because it has only a few mechanical parts.

The use of solar pumping systems in agriculture and rural areas will reduce system maintenance and also has a longer service life than the pumping system which using the engine. The system has fewer mechanical parts that required lower maintenance.
The solar pump system in the present day does not require batteries. We do not have to worry about the battery lifetime or the problem of battery due to the bad weather. The solar pumping system also supports integration between solar electricity systems with AC power in the building system which increases the capability of the system and reduces discontinuity problems [1][2].

Because the pumping systems installation areas are in agricultural areas or remote areas. The remote monitoring systems are essential. Administrators can inspect the work council without access to inspect the area. The remote monitoring system can notify problems in advance when it is necessary to be maintained which makes the work planning much more effective in advance. Besides, remote data collection from each pumping system can also lead to the analytic and planning system as well by analyzing data from several pumping system sites.

In this article, we present a system for recording the performance of solar pumping systems, consisting of various sensors such as voltage, current, power, temperature/humidity, flow rate and water quantity. The system also includes data display and export to communication devices suitable for use in the other application as well.

2. Background and Theory

In general, the solar power system can be divided into 2 main groups, the first group do not connect to external power sources. The system converts solar energy into the electrical energy and store into the battery, as shown in fig 1. Then the system supplies electrical power from the battery and solar system into the system. This system relies on batteries to accumulate energy during electricity generation. It is possible to use continuously during the night and in the low sunlight for a long time. The second group produces electricity and connects to the existing electrical systems which reduce the use of electrical energy in buildings from electricity production by the solar system as shown in figure 2. This system does not need a backup battery because all electrical energy can be supply to the grid and there is no need to collect energy in the battery.

For the solar pumping system, the advantages of both systems are applied together, as shown in figure 3. the system does not need batteries and only works when there is sufficient light. The energy will be stored in the form of a water head by pumping it to a higher place instead, figure 4 Therefore, it does not need batteries anymore. most systems are based on industrial electric motor control systems, so it can control and adjust power independently, the same as the industrial electric motors or water pumps. Some systems also work with AC power supplies to enhance system performance in the insufficient sunlight situation or continuously work in the night.
The remote monitoring system consists of a set of measuring equipment. Various signals will be collected and transformed into a form that can be easily processed. (Fig 5.) For the solar pumping system, the key variable is the measurement of solar power which be converted to electrical power in a period of time. The second thing is the output of the system that is the water pump power in the form of electrical energy. We can also measure the volume of water which reflects the overall efficiency values. The system may equip with additional sensors to increase the ability to monitor and control the operation of the system.

3. Method and Experiment
The solar pumping system with a remote monitoring system in this site consists of a 2.2 kW submersible pump with a 2.2 kW inverter that supports both AC and solar power. It works with a 5-kilowatts of solar panel using 250 watts’ panel in 10 panels series per string and 2 string in parallel. The system setup the inverter in MPPT (Maximum Power Point Tracking) mode for the highest solar efficiency [3]. There are 3 level sensors in the water tank to control the operation of the pump and the flowmeter to measure the rate of the total water flow. These sensors have been required to calculate the system efficiency and also used to measure the parameter which is required in the remote monitoring system because the pump controller does not have any communication function support [4][5].

In the monitoring system module, the system has been designed to measure several electrical quantities and measure the amount of water. By separating into independent modules in design, the measuring parameter will be processed in the different modules and communicate with each other over
the RS485 bus. All modules can be controlled by the main processor in the main modules [6]. With this design, we can separate the system into several modules, 1. Solar power measurement module, 2. AC Power measurement module, 3. water level and flow module, 4. Weather monitoring module, and 5. Main control equipment and display. (Fig. 6) In the operation, the main control device is responsible for communication to extract data from various measuring modules and display it on the screen. Including data processing Then saved to the memory installed on the machine and also prepare data for communicating to external devices via additional communication modules. Other module measured parameters related to their modules and calculate basic data as needed.

The solar power measurement module measures the electrical energy from the solar panel. Since the system has 10 PV in series, the system voltage is between 300–400 Volts. The signal conditioning module has been required to use. By using voltage divider to lower voltage range and shunt-resistor integrate into the system, we can measure voltage, current, and power of the system, as shown in figure 7. Furthermore, when using the time integration, we can record the cumulative electrical energy that has been developed from the solar panel. All parameters will be calculated and stored in the internal register, to wait for the main control module to gather data from itself [7].
The AC Power measurement modules use the ready-made instruments which support one channel single-phase AC power measurement which includes voltage, current, power, total energy. The meter has integrated with a signal conditioning circuit and also integrates the current transformer. All parameters stored in the internal register and ready for the main controller. In the water level and flow measurement, the system uses the electrical conductivity between the two electrode bars to check the water level. It also uses a pulse-rate flow meter installed in the water pipe which can send a pulse signal to the measuring device. (Fig.8) The device can read the status and using the counting circuit to calculate the water volume and calculate the flow rate. In addition to the other sensors, the system measures the temperature and humidity for reference, which makes it able to estimate the environment that is sunny, cloudy or rainy. Users can check with these data when needed if they founded the electric generation or water flow rate seem to be abnormal.

![Flow meter with pulse output](image)

**Figure 8.** Flow meter with pulse output

The main controller unit integrates with a 7-inch ready-made display. The device supports RS485 connection, so it can connect to all other devices in the system. The software is developed and integrated into the device so that the system can display various information in real-time. It can calculate additional parameters other than the measurement data. All measurements and calculated data will be recorded to the flash memory and ready to be used in the future. The system also prepares the data format available to transmit to an external communication module that can send out the data to the remote site or control center.

```plaintext
{api_key,name,temp,hum,acpower,acV,acA,ackWH,dcpower,dcV,dcA,dckWH,flowTotal,flowRate,Level,timestamp}

{RFVdyrs17g,Pumpwater01,36.3,49.70,17,231.20,0.14,0.71,274.9,2.57,46.3,11.95,3.6,10,7/17/2018 12:00:41 PM}
```

**Figure 9.** Data Protocol and sample
4. Results
From the monitoring system we designed, when all the equipment has been integrated, the system can operate by using the external power supply which is supplied separately to the other parts of the system. The system can work continuously even in the night time. (Fig 11, Fig 12) The Screen display all information from the system include the system status. Users can also monitor and control all functions directly from the device.

The data received to the system will be shown on screen. It shows only the current data and accumulated data. To display historical data or display in a graph, users have to use another software to process the recorded data to create a graph as well. (Fig 13) The system can create weather data, Solar energy, Electrical power production data, and the water data. [8]

Furthermore, When the communication equipment has been integrated into the system The system can transfer all data to the remote server (offline) or to the cloud. (Fig 14) The communication system can be used for both general long-distance wireless communication systems or through the network of various communication systems as well.
Figure 11. Modules in enclosure

Figure 12. System is running

Figure 13. System can create historical data

Figure 14. Remote monitoring on the cloud
5. Discussion and Conclusion

After installing the monitoring system, the user can easily check the system status and parameter and not necessary to measure data by themselves. The system can monitor all modules and create an alarm if the system is not working properly. When integrating with communication devices, the system can report information to the user directly. Users can plan service/maintenance while they are in office.

The current work, which is under development, is the construction of the data infrastructure including data and system security systems. Due to the device is far away, the system security must be the first priority. [9] Moreover, when there are more install sites, the number of data increases. The system infrastructure and the management system will be the next step. Also, access control should be the thing that is unavoidable.

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