Solar Powered Paddy Irrigation System Using Arduino UNO Microcontroller: Battery Performance

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Abstract. This project is about the innovation of automated irrigation system at paddy field. Paddy irrigation system traditionally was depending on raining seasons. The changing of raining seasons will affect paddy growth. The farmer will use water pump sourced from diesel to drain water into the paddy field. The diesel water pump produces smoke that causes air pollution and bad health to the farmer. Moreover, diesel was non-reusable energy plus the manual control of irrigation system wastes time and human energy to operate the water pump and observe the water level. This project proposed the photovoltaic system to power the irrigation system and develop the prototype to represent the element of real irrigation system at the paddy field. Standalone photovoltaic system consists of solar panel, battery as energy storage, solar charger controller and water pump and the irrigation system is fully automated system controlled by Arduino UNO. Result obtain the solar-powered paddy irrigation system success coverall supply electricity to the irrigation system. The water pump only runs when low water level which measures by polypropylene float switch. The proposed project can produce efficient irrigation system, reduce the air pollution at paddy field and make farmer better health.

1. Introduction
At Malaysia farmer will start separating the paddy seed in April because there are raining seasons. When raining seasons, the water level at ditch will be higher than the water hole at paddy filed. Due to water pressure and gravity, paddy field can obtained water from ditch. The changing of raining seasons will affect the paddy grow because the water level at ditch lower than the water hole at paddy filed. So, this will prevent water flow into the field. The farmer will use water pump to drain water into the field. The power of water pump was obtained from diesel and it was non-reusable source [1]. Additionally, it also release smoke that caused the air pollution to open environment. However, the paddy will grow up well with stable water and fertilizer.

Solar energy was sustainable energy that can generate the electricity. The use of solar energy in agriculture is helping farmers a lot to accomplish their task [2]. Irrigation system at paddy field can fully depend on solar energy to get their electricity source. The high request of crop production needs high-speed internal combustion engines typically use light petrol or diesel as fuel, and a challenging fuel hygiene [3]. Use of diesel to run the water pump is neither cost effective nor environment friendly. It causes the environmental pollution and noise cause pollution by emitting a huge amount of CO2 and other toxic gases [4]. The replacement from diesel source to solar source to power the water
pump can improve the irrigation system in term of eco-friendly energy, cost saving and farmer health [5]. Beside that solar energy can also utilize the automated system to control the irrigation system at paddy field. Beside it was green energy, it also environment-friendly that generated electricity by photovoltaic (PV) [6].

Manual controlled of water pump by farmer wastes time and human energy to operate the water pump and observe the water level. During non-rainy seasons farmers will switch on the water pump and switch off water pump manually [7]. Then farmers need to wait until water fill the paddy field at target level. This is the main source of wastage of times and human energy [8]. The development of automated irrigation system will save times and farmer energy to operate the water pump by developing the water pump using water level sensor to control the water pump. In paper [9] replace diesel water pump to solar water pump to preserve the environment and reduce the deterioration of pollution and global warming and to propose a system that uses solar energy to drive a motor capable of flushing certain terrains and with the help of a sensory circuit. Paper [10] study the comparison between solar sources and seasonal water requirements and determine the Photovoltaic water pumping system (PVWP). Paper [11] conduct a project to use appropriate agricultural resources due to high dependence on rain, and to provide maximum water consumption efficiency by monitoring soil moisturizers at optimum levels.

Paper [12] discuss effective rainfall during irrigation seasons depends on rainfall amount, rainfall intensity, soil infiltration rate, soil moisture, water management practices and so on. Figure 1 shows the water requirement of each stage of paddy and times for paddy growth.

![Figure 1. Water Requirement of Each Stage of Paddy and Times for Paddy Growth](image)

2. Materials and Methods
This project consists of the following components: the solar panel, solar charger controller, the battery, an Arduino Uno, Polypropylene (PP) float switch, the water pump, and the LCD display. The layout in the Figure 2 is the implement of hardware part. Solar energy utilize to power up the water pump while the solar charger controller is being used to control the charging and discharging of the battery. The PP float switch detect the water level at paddy filed. The signal from the PP float switch sent to the Arduino UNO as input signal to water pump. When the water level decreases below the targeted level, the water pump switched ON automatically until obtain the targeted level of water level. At the same time, LCD will display the motor condition and water level at paddy field.
Figure 2. Layout of Solar Powered Irrigation System in Paddy Field

Figure 3 shows the work flow of water pump. Water pump powered by solar energy and will operate when assign by water level sensor located at paddy field that controlled by Arduino Uno. When the water level sensor detects the water level low at paddy field the water pump will run until achieve the targeted water level. When water level achieved targeted level, water pump will stay stationary.

Figure 3. Flowchart of Water Pump Operation

2.1. Development of Irrigation System
This part explains the development of the automated irrigation system circuit powered by solar energy. The schematic circuit for the automated irrigation system was design using Proteus 8 Professional as shown in Figure 4. In Proteus 8 Professional they are no component of PP float switch. So, the single pole single through switch was representing the PP float switch. The Arduino UNO operated depend on Arduino coding. Arduino coding use Arduino IDE to write the code and upload the coding file to Arduino UNO at Proteus 8 Professional to simulate system operation.
Figure 4. Schematic Circuit Diagram for Automated Water Pump using Proteus Software

After that the real component was develop as designed with PV system to supply the power to system. The component connection complete irrigation system shown in Figure 5.

Figure 5. Prototype Component Connection of Full Circuit

3. Result and Discussion
This section explains the result of the project. It covered result of the simulation and hardware of automated irrigation system.

3.1. Simulation Result
Simulation circuit consists of the designed circuit of the system configuration. The status of water level detected by water level sensor and the controller switched the water pump to ON and OFF based on condition state at coding Arduino IDE. When low water level detected, PP float switch ON and sent signal to controller. The controller delivered the signal to run the water pump. This is done by giving a signal to the base of relay which is connected to the 13th pin of the Arduino. The motor will run until the water level higher than PP float switch. Simulation result of two different condition of the complete circuit of the project shown in Table 1. Figure 6 and Figure 7 shows the status of water when low water level and high water level.

| Water level    | Water Pump |
|----------------|------------|
| < PP float switch | ON        |
| > PP float switch  | OFF       |

Table 1. Simulation Result of the Complete Circuit of the Project
3.2. Hardware Result of Proposed System Development

This part discusses of the result of hardware testing for prototype of solar powered paddy irrigation system using Arduino UNO. Figure 8 shows the prototype build of solar powered paddy irrigation system.

Table 2 shows the indicator light result at solar charger controller in different condition of solar, battery and load.

| Condition         | Indicator Light                           |
|-------------------|-------------------------------------------|
| **Solar**         |                                           |
| Sunny             | Red continually                           |
| Cloudy            | OFF                                       |
| **Storage Battery**|                                          |
| Charging          | Green flash                               |
| Full              | Green                                     |
| Middle            | Red                                       |
| Over-discharger    | Red flash and OFF the load                |
| **Load**          |                                           |
| Motor Run         | Green continually                         |
| Motor Stop        | Green continually                         |
3.3. Performance of Battery and Photovoltaic Voltage Output

The analysis is taken to studies the voltage charging rate by using solar in different days. The condition of the prototype is in idle condition when the test is taken. The prototype is placed under the sun from 9 a.m. to 5 p.m. The rate of solar charging is recorded for every in one hour starting at 9 a.m. to 5 p.m. for 3 days at Parit Raja, Batu Pahat, Johor. The day 1 start on 9/110/2018, day 2 on 10/10/2018 and day 3 on 11/10/2018. The initial voltage level for each day, fixed to 11.30V. In the Figure 9 shows that rate of battery level using solar panel charging. The test is conducted at the same place and time frame. The battery start charging at 9 a.m. until 5 p.m. with the initial voltage is 11.30. After eight hours of charging, the battery voltage is increase to 11.40V at day 1. While, 11.41V and 11.42V for day 2 and day 3. The different final values of charging for three days are different due to the weather. The weather condition can affect solar power output from solar panels. The initial battery is 11.30V or 70.83% of voltage drop. The battery voltage level is increase to 11.40V or 74.99% of voltage drop. The charging rate for 8 hours, is 4.16% of rate.

![Battery Voltage Level for Three Days](image1)

**Figure 9.** Rate of Battery Level using Solar Panel Charging

Solar panel power input voltage can be referred from Figure 10. In Figure 10, the voltage peak at day 1 is at 1 p.m. until 2 p.m. The differences of the peak voltage for each day can be deference due to the weather condition.

![Solar Voltage Reading for Three Days](image2)

**Figure 10.** Solar Output Voltage for Three Days

4. Conclusion

In this study, solar powered paddy irrigation system was successful develop by solar energy obtained from the solar panel charged to a 12V lead acid battery and it can be used whenever required. The solar charger controller circuit prevent the 12V lead acid rechargeable battery from overcharging and reverse current at night. Automated water pump using solar energy at paddy field was successful to
design and develop by using PP float switch, Arduino UNO, solar panel, rechargeable battery, LCD display and water pump. An efficient irrigation system was developed by using water level sensor to control the water flow and it can save be waste water at same time.

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