Evolution in Electrical and Electronic Engineering Vol. 3 No. 1 (2022) 300-308

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Water Pump and Irrigation Monitoring System on ThingSpeak

Fatin Najiha Ahmad Kambali[1], **Jabbar Al-Fattah Yahaya**[1]*

[1]Department of Electrical Engineering, Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2022.03.01.034
Received 22 January 2022; Accepted 08 April 2022; Available online 30 June 2022

Abstract: This paper focuses on the use of modern irrigation method with the ability to monitor moisture of soil as irrigation process affect the crops yield production. For this paper, the work is aim to design an irrigation monitoring system on ThingSpeak integrating with the solar energy to allow the user in observing the data collected by Soil Moisture Sensor and DHT11 on ThingSpeak. The ESP8266 Wi-Fi module being used to allow the system connect with internet. This work employed gate driver connected with buck converter for controlling DC motor water pump through adjusting the PWM sequence using push button to control speed of water flow during irrigation process when the level of soil moisture below from set value. PWM charge controller connect with solar panel used for charge battery for supply power to the system and give power source to buck converter. The data presented on ThingSpeak is visualized in a line graph with collected values which is temperature (˚C) and humidity (%) from DHT11 and soil moisture (%) from Soil Moisture Sensor. It is concluded that the hardware design able to perform irrigation process using solar energy and the data collected by sensors can be monitored through Internet of Things (IoT) platform. In future, install the water level sensor for filling the water tank automatically will help to reduce user workloads. Further, possible attempt to allow the private Wi-Fi connect with the system should be study to build the system in bigger scale.

Keywords: Solar Energy, Irrigation Monitoring System, ThingSpeak

1. Introduction

Irrigation method important for farming purposes as it controlled the amount of water supply to the crops. The process of irrigation effects the growth and yields production which can lead to over watering and vice versa. Non effective method leads the crops to wilt and die as the farmers will do irrigation process based on their time schedule or with using a timer method without monitoring the amount of water in the soils. As the method used not able to measure soil moisture, it can lead to overwatering

**Corresponding author: jabbar@uthm.edu.my*

which the wastage of water will be caused over moisture in soils that can expose the fungal formation to the plants [1].

Modern irrigation technology using DC motor water pump cause high operating cost, especially during hot weather as the energy used during motor starting is higher than the rated voltage value and the DC motor water pump needs to on and off repeatedly. By integrating the solar panel into the system, the operating cost can be reduced as solar energy is a single most abundant resources with carbon-free despite can reduce the pollution rate [2]. The solar energy is converted into electrical energy to supply power to the system and can avoid the usage of conventional energy. The generated energy from solar panel can be stored in the battery for backup supply during cloudy days or night besides, can be used for DC or AC applications [3].

Through the growth in technology, Internet of Things (IoT) platform become popular which can help the community in working purposes. This system used a ThingSpeak to enable the data collected by Soil Moisture Sensor and DHT11 monitored by user and used ESP8266 Wi-Fi module help to connect the system with internet connection. ThingSpeak is an open-source interface with API Keys that listens to incoming data an interpret them in real-time data to present the output through visual graphs [4]. ThingSpeak channel is a crucial part where the data collected by sensor is placed and hence, the data transmission only happens with using the WriteAPIKey in the system codes [5].

DC motor water pump used in the system to supply the water to the crops during irrigation process. The range of operating voltage for the DC motor water pump being used is below the voltage value generate by the solar panel. To avoid the DC motor water pump received overvoltage, gate driver and buck converter being applied into the system to enable the DC motor water pump operates in the range of its voltage rating. The PWM circuit embedded to the system for DC motor water pump drive at consistent speed. PWM works in driven DC motor with series on and off pulse [6]. Hence, by adjusting the duty cycle, the DC motor speed can be varying and flowrate of water in the system can be controlled. Arduino UNO is used as a microcontroller in the system as the microcontroller is needed to generate PWM signal for speed control DC motor [7].

In this paper, the DC motor water pump is powered by the solar energy to operates based on the Soil Moisture Sensor values. The DC motor water pump can be controlled by adjusting the duty cycle while it connected to the gate driver and buck converter. This system uploads the data collected by the sensors in the ThingSpeak for user to monitor the value of temperature (˚C), humidity (%), and soil moisture (%) hence, the crops not faced the over watering or under watering which can lead to wit and die.

2. Materials and Methods

The water pump system method used in plantation includes advanced irrigation features like Arduino UNO, ESP8266 Wi-Fi module, and ThingSpeak. Figure 1 shows the Arduino connected to the DHT11, Soil Moisture Sensor and ESP8266 Wi-Fi module to enable the data from sensors to upload to the ThingSpeak for user monitoring purposes. The gate driver with buck converter connected to Arduino UNO to control the DC motor water pump speed. Solar panel connected to PWM charge controller to stored energy in battery and supply voltage to buck converter and system.

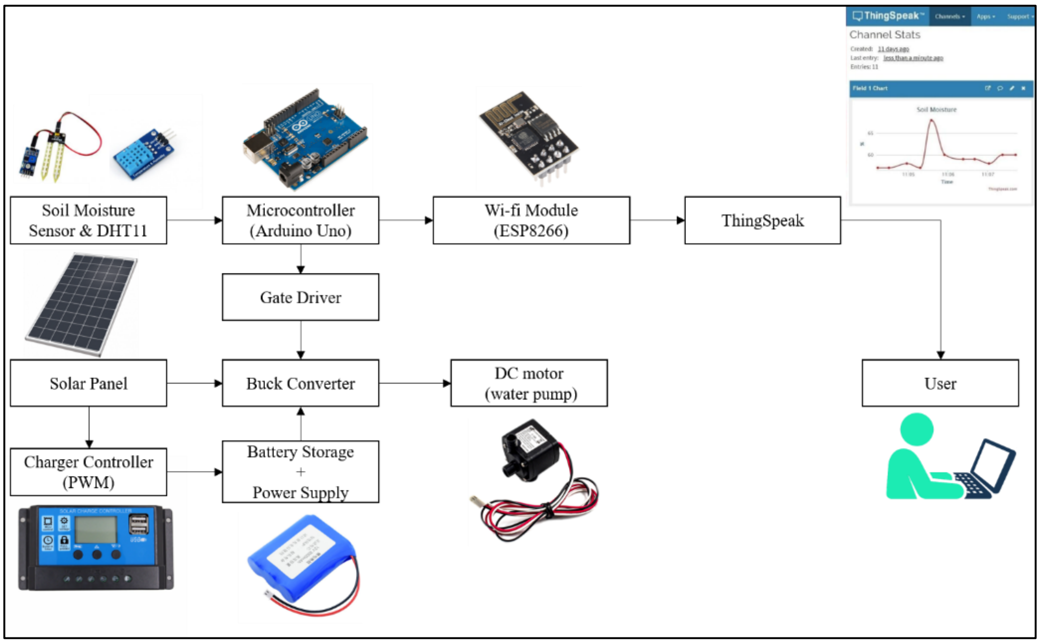

Figure 1: Block diagram of the system

2.1 Development Process Flowchart

The flowchart of the development process of the Water Pump System with Irrigation Monitoring on ThingSpeak allows the hardware to be developed in the correct sequence and situation. Figure 2 is a flowchart of the system development which consists of three phases. Phase 1 is a power supply part in which the solar energy is connected to the PWM charge controller and battery for supplying the DC source to the system. Phase 2 is related to the sensors being used in the system and with Arduino UNO communication features, the collected data will be transmitted to ThingSpeak for user monitor. Phase 3 is a gate driver and buck converter linked to a DC motor water pump for it operates insufficient voltage supply when the soil moisture is below 30%. The DC motor water pump operates depending on duty cycle adjustment by pressing the switch.

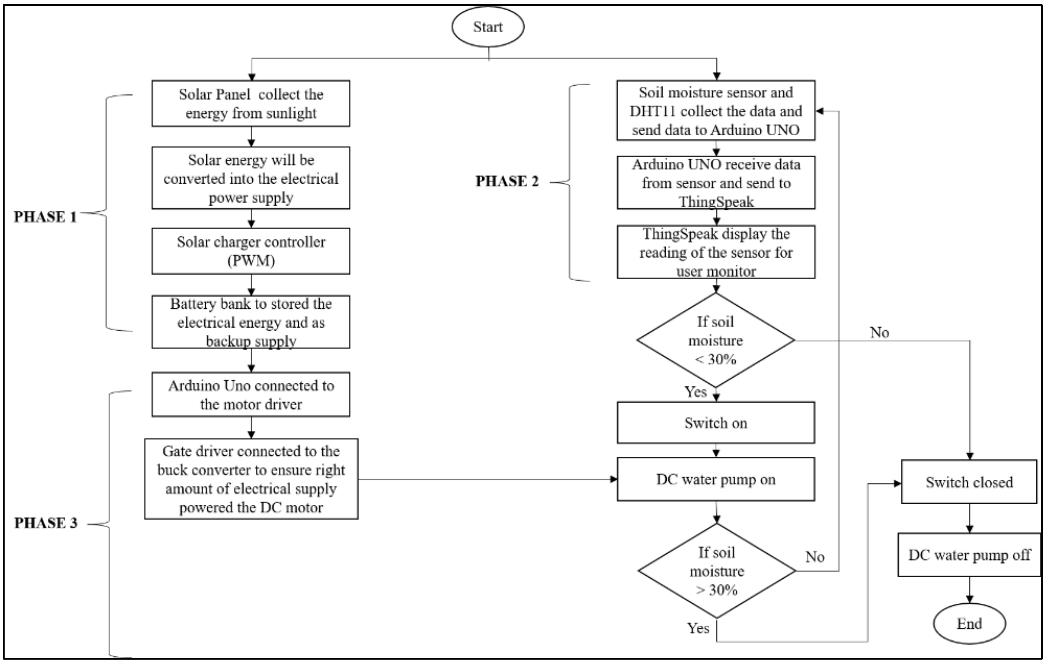

Figure 2: Flowchart of system development

2.2 Calibration of Soil Moisture Sensor

Soil Moisture Sensor is used to measure the soil moisture and the data is monitored by users through ThingSpeak. The working performance of the sensor is different based on its sensitiveness towards the types of soil being used and the environment at the plants being located. The type of sensor measures the volumetric water content which is the volume of liquid water per volume of soil represent in percentage. The calibration is conducted in a closed environment using the same types of soil and apply ratio method by manipulates the quantity of water and soils at the specific amount (Figure 3). The sensor being connected to Arduino UNO (Figure 4) and set in analog mood to get the output value in 0 – 1023. By using Arduino IDE, Eq. 1[8] is used in the codes to get the soil moisture values in percentage.

$$\text{Moisture Percentage } (\%) = \left[100 - \left(\left(\frac{Sensor\ Value}{1023.00}\right) \times 100\right)\right] \qquad Eq.\ 1$$

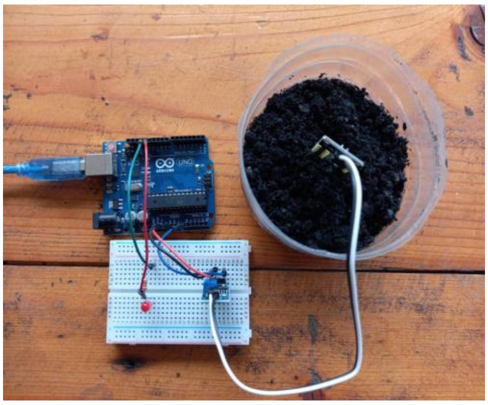

Figure 3: Sensor calibration setup

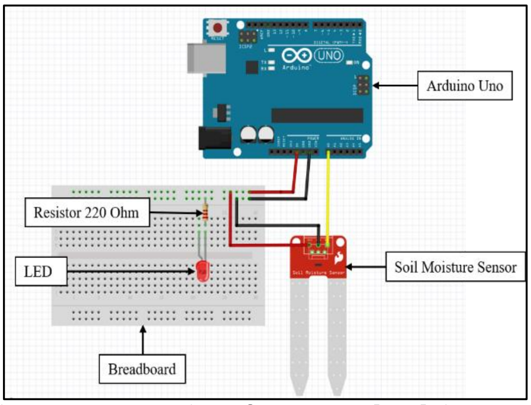

Figure 4: Connection of sensor and arduino UNO

2.3 Gate Driver and Buck Converter with PWM for Control DC Motor Water Pump

DC motor water pump can be controlled to produce a constant flow rate while irrigation process happened. The voltage rating of the Dc motor water pump used in the system is 4.4V to 12V. The buck converter is used to step down the voltage from the solar panel to avoid DC motor receiving overvoltage. Figure 5 shows a block diagram of the gate driver connected between Arduino UNO and buck converter to avoid the microcontroller damage by receiving overvoltage from the solar panel. Hence, the connection of the gate driver and buck converter is shown in Figure 6. Further, the motor speed can be varied by adjusting the duty cycle by pressing the push button which is linked with the PWM connection (Figure 7).

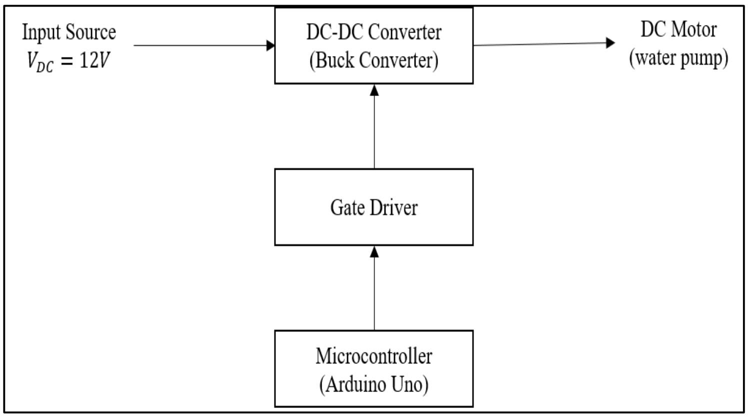

Figure 5: Block diagram of gate driver

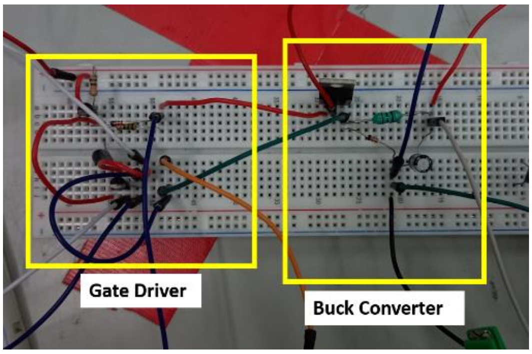

Figure 6: Connection of gate driver and buck converter

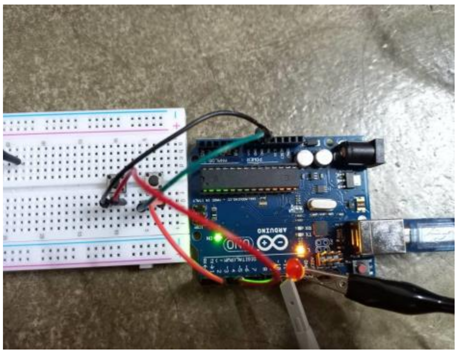

Figure 7: PWM circuit connection

2.4 Upload Data from DHT11 and Soil Moisture Sensor to ThingSpeak

Two types of sensors are used in the system which are DHT11 to measure temperature (˚C) and humidity (%) and Soil Moisture Sensor to measure soil moisture (%). Both sensors are connected to the Arduino UNO and the data is sent to ThingSpeak. By connecting the Wi-Fi module ESP8266 to Arduino UNO it caused the system to connect with the internet and be able to communicate with ThingSpeak. Figure 8 shows the connections of sensors and ESP8266 Wi-Fi module to Arduino UNO. To monitor the data on ThingSpeak, creating the account and channel is crucial for it to visualize the data measured from sensors. The data also can be monitored through the smartphone by installing ThingSpeak widget. Figure 9 shows the ThingSpeak page to set up channel and widget setting page on the smartphone.

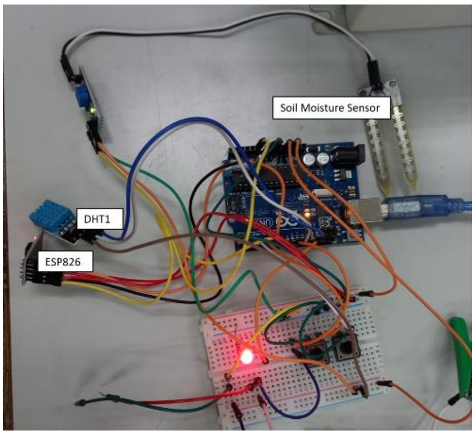

Figure 8: Sensors and ESP8266 connection to arduino uno

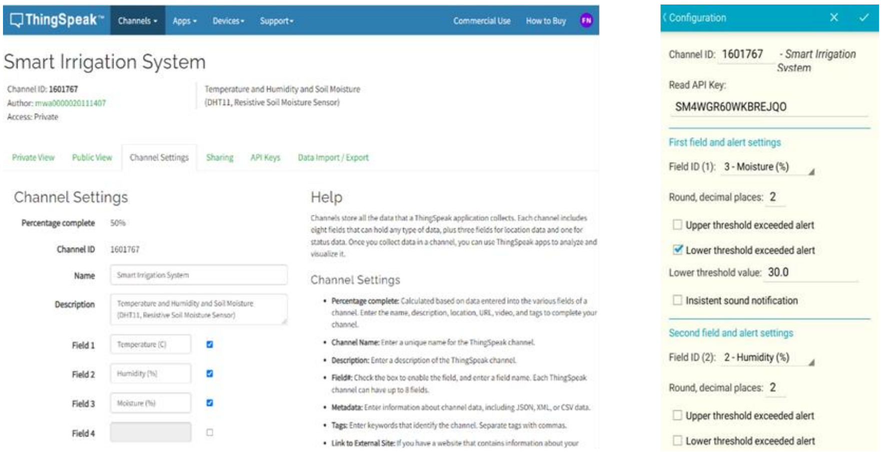

Figure 9: ThingSpeak channel and widget in smartphone setup

2.5 Solar Panel and Battery Sizing

The solar water pump system conducted in closed environment and small scale. A single prototype of the system being develop which require some calculation to identify the solar panel and battery sizing in order to make the system operates well. To find the solar panel and battery size, the energy consumption in hours (Wh), Eq.2 need to be calculated first. Few values needed in the calculation being estimated as the system is conducted in very small scale. With the value of energy consumption in hours (Wh), battery size (Ah) can be decided with using Eq.3 and solar panel sizing (W) using Eq.4. The full sunshine estimated to appear in four hours starting 11.00 a.m till 3.00p.m.

$$Load \times Hour(Wh) = DC\ motor\ power\ (watt) \times hours \qquad Eq.\ 2$$

$$Battery\ Size(Ah) = \frac{Load \times Hour(Wh)}{Battery\ Volt\ (v)} \qquad Eq.\ 3$$

$$Solar\ Panel\ Generation\ (W) = \frac{Load \times Hour(Wh)}{4\ hours\ (estimate\ full\ sunshine)} \qquad Eq.\ 4$$

3. Results and Discussion

The results obtained in this development of solar water pump system are analyzed and explained in this section. The system being analyzed by conducting circuit test in laboratory and calibration of the equipment with writing coding in Arduino IDE. A few conventional methods also used in calculating the solar panel and battery size using related formula.

3.1 Data Analysis from Soil Moisture Sensor Calibration

Based on data collected during the calibration of Soil Moisture Sensor in Table 1, the sensor sensitiveness is depending on the soil condition. Through the ratio method in calibration the sensor, when the sensor located in soil only, the percentage of moisture is in range 33% while in water is 83%. The result showed in the Table 1 prove that the sensor is function well as the soil moisture percentage is higher when located in the soil which have equal amount of water. From the results, sensor reading in 3 soils:3 water is higher which is in range 77% than 3 soil:1 water and vice versa which in range 76%. The sensor is more accurate when located into the soils with contain water as it functions to measure the volumetric water content which is the volume of liquid water per volume of soil.

Table 1: Calibration of soil moisture sensor data

TEST	**1**	**2**	**3**
RATIO	**Percentage of soil moisture sensor (%)**		
Soil only	33.43	33.53	33.43
3 soils:1 water	66.47	73.02	69.31
3 soils:2 waters	77.13	74.19	76.05
3 soils:3 waters	77.42	77.71	77.91
1 soil:3 waters	76.74	76.54	76.54
2 soils:3 waters	77.71	76.54	76.93
Water only	82.01	82.40	83.19

3.2 Gate Driver and Buck Converter Output Measurement in Laboratory Test

This solar water pump system used gate driver to isolate the Arduino UNO from directly connect to the solar panel to avoid the microcontroller damage because of overvoltage. The gate driver developed in this system is connected to the buck converter circuit. Figure 10 shows the results of buck converter which the output voltage is being reduced from 9.3V to 7.55V when the duty cycle 75%. This result met with the function of buck converter which is to step down the voltage. The signal display on the oscilloscope shows the output waveform from the gate driver output as the input connected to the PWM circuit with Arduino UNO. The gate driver operates correctly where the signal output is in square waveform. Also, by regulates the duty cycle by press the push button in PWM circuit, the buck converter voltage output is change and motor speed can be controlled.

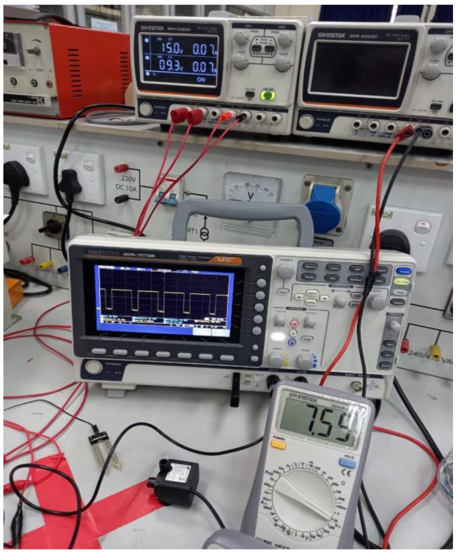

Figure 10: Output measured from gate diver and buck converter

3.3 DHT11 and Soil Moisture Sensor Output Data on ThingSpeak

The use of ThingSpeak platform in the system enable the user to keep monitoring the output data measured by the sensors. By connecting the ESP8266 Wi-Fi module to Arduino UNO, output data from sensors can be upload to ThingSpeak will be visualized in line graph pattern and each point has its own values, (Figure 11 – 13). Figure 11 and 12 show DHT11 output where the current temperature value is 27˚C and humidity is 95% while, Figure 13 shows the Soil Moisture Sensor output which the current soil moisture value is 37.34%. Further, by install ThingSpeak widget in smartphone, the status of current output data can be monitored through smartphone. Figure 14 shows the sensors output value displayed in smartphone home screen.

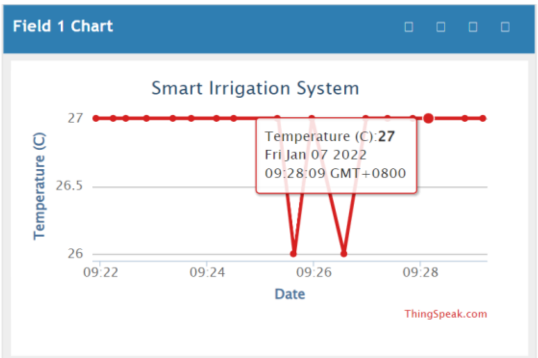

Figure 11: Temperature value recorded in ThingSpeak

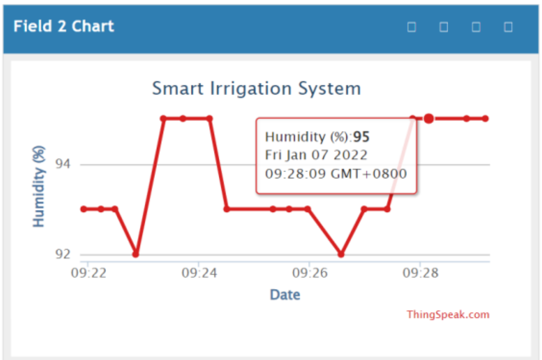

Figure 12: Humidity recorded value in ThingSpeak

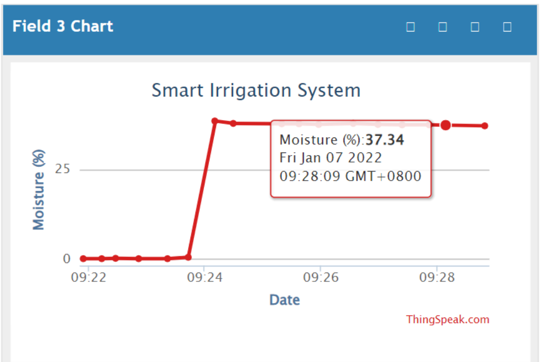

Figure 13: Soil moisture value recorded in ThingSpeak

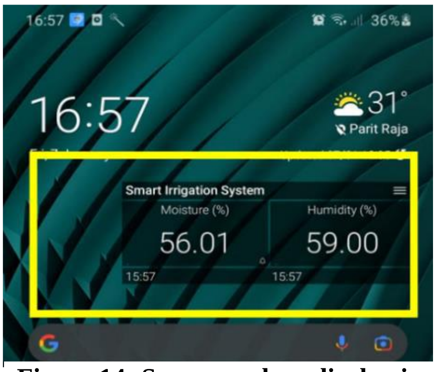

Figure 14: Sensors values display in smartphone ThingSpeak widget

3.4 Calculation Results of Solar Panel and Battery Sizing

Table 2 shows the results from the calculation with using formula Eq. 2 for energy consumption in hours and Eq. 3 for electrically charged, q for deciding battery size. DC water pump system being assumed to operate in two days if solar panel is disconnected. Hence, battery with can last longer for two days should be installed in the system for backup supply purposes. With using Eq. 5, the results of energy consumption, E is 10Wh and using Eq. 6 the electric charged, q is 0.88A. Besides, the calculation of the results to determine solar panel size shown in Table 3. From Eq. 7, by assuming the full sunshine is 4 hours, the solar panel should be can generates 2.5W. Based on the calculation results, 12V 2200Ah battery and 5W solar panel is used in the system.

$$E = (5watt \times 1\ hour) \times 2days \qquad Eq.\ 5$$

$$q = \frac{10Wh}{12V} \qquad Eq.\ 6$$

Table 2: Energy consumed in hours, e and electric charged, q calculation

Energy Consumed by Battery, E	Electric Charged, q
$E = 10Wh$	$q = 0.88A$ (12V, 2.2Ah battery selected)

$$W = \frac{10Wh}{4\ hours} \qquad Eq.\ 7$$

Table 3: Estimated solar panel generation can used in the system

Solar Panel Generation, W
$W = 2.5W$ (5watt solar panel connected)

4. Conclusion

Overall, the design of a solar water pump system using an electrical source generates from the solar panel is able to do the irrigation process with a constant flow rate of water as the motor speed can be controlled. Further, the system also allow user to monitor the data measured by the sensors through ThingSpeak platform either in the website or smartphone. Those data presented in a useful format which is in graph line pattern for easy understanding. However, the system faced a few limitations which is without the internet connection the data cannot be sent to ThingSpeak and hence, the system only suitable applied in a closed environment with an intranet connection. The system also is not flexible for the private internet connection, the further study should be done regarding making the system connect with a private internet connection.

Acknowledgment

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support

References

[1] K. K. Rout, S. Mallick, and S. Mishra, "Solar Powered Smart Irrigation System Using Internet of Things," *Proc. - 2nd Int. Conf. Data Sci. Bus. Anal. ICDSBA 2018*, no. December, pp. 144–149, 2018, doi: 10.1109/ICDSBA.2018.00033

[2] M. Sengupta, A. Habte, C. Gueymard, S. Wilbert, D. Renné, and T. Stoffel, Eds., *Best Practices Handbook for the Collection and Use of Solar Resource Data for Solar Energy Applications: Second Edition Solar Resource Solutions, LLC*, Second. National Renewable Energy Laboratory, 2017

[3] "What does PV or Photovoltaic mean? | Solar Electric Technology," *Esolar*, 2015. https://www.esolar.co.nz/what-does-pv-or-photo-voltaic-mean/ (accessed Jun. 18, 2021)

[4] M. A. Gómez Maureira, D. Oldenhof, and L. Teernstra, "ThingSpeak – an API and Web Service for the Internet of Things," *World Wide Web*, 2014, [Online]. Available: https://staas.home.xs4all.nl/t/swtr/documents/wt2014_thingspeak.pdf

[5] S. Kristiyana and A. Rinaldi, "Air Quality Monitoring System in Thingspeak-Based Applications Using Internet of Things (IOT)," *Wseas Trans. Comput. Res.*, vol. 8, no. May 2020, pp. 34–38, 2020, doi: 10.37394/232018.2020.8.6

[6] "Sensor Types | SoilSensor.com," *soilsensor.com*, 2019. https://soilsensor.com/sensors/sensor-types/ (accessed Jun. 18, 2021)

[7] "Calibrating Soil Moisture Sensors | ICT International," 2013. https://www.ictinternational.com/casestudies/calibrating-soil-moisture-sensors/ (accessed Jun. 18, 2021)

[8] "Soil Moisture Sensor Interfacing with Arduino UNO." *https://www.electronicwings.com/arduino/soil-moisture-sensor-interfacing-with-arduino-uno.*