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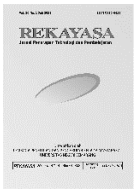

Implementation of Solar Panels as an Energy Source for Automatic Fish Feed Machine Control Systems

Edwar Mualim[1], Ojak Abdul Rozak[1]*, Muhammad Surya Fatah[1], Angga Septian MN[2]

[1]Electrical Engineering Department, Faculty of Engineering, Universitas Pamulang, Tangerang Selatan, 15310, Indonesia

[2]Informatics Engineering Department, Faculty of Engineering, Universitas Pamulang, Tangerang Selatan, 15310, Indonesia

Email: dosen01314@unpam.ac.id[1]

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Abstract

Feed is the primary need for fish consumption. Feeding is sometimes a problem for breeders. An automatic fish feed machine method with Arduino control via an Android phone's Bluetooth signal as the communication method, equipped with an alarm indicating the condition of the feed is running out, is the best solution. The automatic feed machine is placed in a pond outside the house so solar panels can absorb solar energy as a source of electrical energy for the machine and battery charger. Backup power when it is cloudy or at night and the machine does not need the State Electricity Company. Implementing a 2.5 Wp solar panel and a 3000 mAh battery in this automatic fish feed machine is needed to simplify the daily feeding process as this research aims. This research results that the maximum distance of control via an Android phone is 60 meters without obstructions and 30 meters with obstacles. When the battery voltage is 8 volts, the solar charger controller automatically cuts off the supply to the load to avoid a battery voltage drop. When the battery voltage rises to 10 volts, the load is activated again. From full 12.2-volt battery voltage to 8-volt drop, it takes 6 hours, and the load is automatically disconnected; 1.5 h is needed for the battery to be re-charged by solar panels when the weather conditions are sunny, and the load is active again.

Keywords: Arduino, bluetooth; solar panels; battery; backup power

INTRODUCTION

Feeding fish in outdoor ponds is typical for survival because no food is available for fish that do not live in the wild (Weku *et al*., 2015). However, there are times when these activities cannot be carried out according to schedule due to other activities outside of cultivation. Thus, it is necessary to have a system that can make it easier to feed fish with a flexible schedule, such as 2 to 3 times feeding in one day (Harel *et al*., 2019), cultivating fish ponds offshore with a diameter of 15 meters and a height of three meters using fish feeding with an automatic fish feeder system providing two types of food, namely fresh trash

fish and pellets (Karningsih et al., 2021). It is just that this system requires an independent energy source because it is outside the house where there is no available power source from the state electricity company. Indonesia is a country that is blessed with abundant energy sources, especially solar energy. Problems related to energy sources can be solved by using solar panels as a source of system electrical energy.

This research has been done previously using SMS, so it requires credit (and still uses the power supply from the state electricity company so that if it goes out, the engine will go out. It is necessary to use solar panels as a system energy source located outside the cultivation area (outdoor). Then using the automatic feeding schedule method, adding a semi-automatic method so feeding can be controlled directly using an Android application via Bluetooth signal communication (Vo et al., 2021). An automatic shrimp or fish feeding system can help solve problems with manual feeding operations (Ani et al., 2015). The automatic fish feeder is already working according to the microcontroller settings. In a day, the bait is periodically given three times by opening the lid of the servo motor (Dada et al., 2018). The microcontroller regulates movements that have a conditioned effect on time and moving motors (Singh et al., 2022).

Monocrystalline 2.5 Wp solar panel, 3000 mAh lithium battery is used as backup power and solar charger controller (SCC) as energy supply system. At the same time, the engine components consist of Arduino Uno R3 as a process system, RTC DS3132 as a feed scheduling time reader, and ultrasonic HC-SR04 as a feed availability reader MG995 360° servo motor as a mechanical drive for the feed valve (Piutri et al., 2021). This system aims to analyze the solar panel system, battery charging and discharging system in SCC, real-time clock (RTC) as a timer, distance range of the Bluetooth module as a control, and ultrasonic distance as a feed availability reader.

The photovoltaic effect is a physical phenomenon (light energy) that reaches the surface of a solar cell and is converted into electrical energy. The incoming light photon energy liberates electrons in the N and P-type semiconductor junctions, allowing an electric current to flow. If a load is connected between the two types of semiconductors, then the load will turn on when there is the movement of electrons that flow current. Electron excitation is successfully carried out by photons of light so that electric current is free to flow (Rossbach, 2019). More solar cells are needed to get a greater amperage output. Solar panels are a combination of several solar cells. The high current and voltage are enough to meet daily needs. Electronic equipment with pulse width modulation (PWM) technology can adjust the battery charging current and flow to the load (Majaw et al., 2018).

Arduino is an open-source and easy-to-use electronic platform for creating engaging, interactive projects (Zlatanov, 2016). The ultrasonic sensor in the form of the HC-SR04 module is used as a tool to measure distances with a range of 2 – 4 meters, with an accuracy of up to 3 mm. The tool has a series of transmitters, receivers and controls (Weku *et al*., 2015; Hoomod et al., 2017). Ultrasonic sensors constantly check the total food level in the silo tank and are equipped with an alarm trigger device to notify the condition if it exceeds the set level (Parra et al., 2018). Modul Bluetooth 2.0 fish owners will easily arrange a feeding schedule according to the recommended feed dosage and provide an aquarium cleaning schedule (Harani et al., 2020).

Date and time data can be stored in an active electronic component called RTC. The form of communication is I2C with 2 communication lines, namely: SDA and SCL (Alpares, 2016). DS3231 menginformasikan waktu dan kalender tentang detik, menit, jam, hari, tanggal, bulan, dan tahun pada register internal dan dapat diakses (Kusmanto, 2019).

Motor with closed feedback system (close loop). The motor shaft is connected to the control circuit. If the shaft rotation is not yet positioned, the control circuit will continue to correct the position until it is ordered (Ahlina, 2015). A Servo motor is a motor that rotates slowly but has a strong torque due to internal factors in the gear. The servo motor has three wires, including a positive (+) cable which is 5 volts, a negative or Ground (GND) cable, and one cable for control to the microcontroller pin. OLED 128x64 is an OLED-type LCD with 128 segments and 64 common or 128 x 64 pixels with a CMOS SSD1306 driver for standard cathode-type OLED panels. Four pins are needed to communicate with the microcontroller using I2C (Julisman, 2017). This website helps users to create their own Android applications by programming them. Based on this series of tools, this research aims to know the control of Android applications through Bluetooth communication, ultrasonic reading, and charge-discharge automation at the fish feed tank level when feeding.

METHOD

The experimental research method was chosen because it develops a tool and experiments on the object to be studied. The flowchart of research procedures for feeding fish as shown in Figure 1. Data collection for this study was carried out using an avometer, where data was taken for voltage (V) and current (A). The collection was carried out in 2 schemes to determine how much power solar cell panels generate to charge the battery. The solar panel is the primary power source for the battery, which is then sent to the Arduino microcontroller and other parts of the device: servo motors, RTC modules, ultrasonic sensors, OLEDs, and buzzers.

Ultrasonic sensor working system as shown in Figure 2, ultrasonic waves are generated by piezoelectricity at a frequency of 40 kHz when an oscillator is applied. The wave is sent to the target. If the target receives the wave, the wave will be reflected then the sensor captures and calculates the difference in time (t) between the wave sent and the time the wave is reflected. Where the distance (S) of objects can be calculated based on Equation (1):

$$S = \frac{340 \times t}{2} \quad (1)$$

Additional feed, supplement feed, and main feed are feed groups based on their level of need. Based on the feeding management, the weight of the fish kept determines the amount of feed that must be given, namely: 3-5 % with a frequency of 2-3 times a day, 8:00 – 9:00 am, 3:00 – 4:00 pm and 8:00 – 9:00 pm. All components used from Figure 3 can be further detailed in terms of specifications and functions in Table 1.

The workflow of an automatic fish feed system starts from initializing the I/O interface, reading feed availability by ultrasonic sensors, to scheduling fish feed automatically by the RTC, as shown in Figure 4 featuring Overall machine system for fish Feed

The servo motor function in the fish feed machine is designed to push the fish feed into the container. The servo motor will be active to push the fish feed when it is programmed on the microcontroller via the RTC module reading as shown in Figure 5.

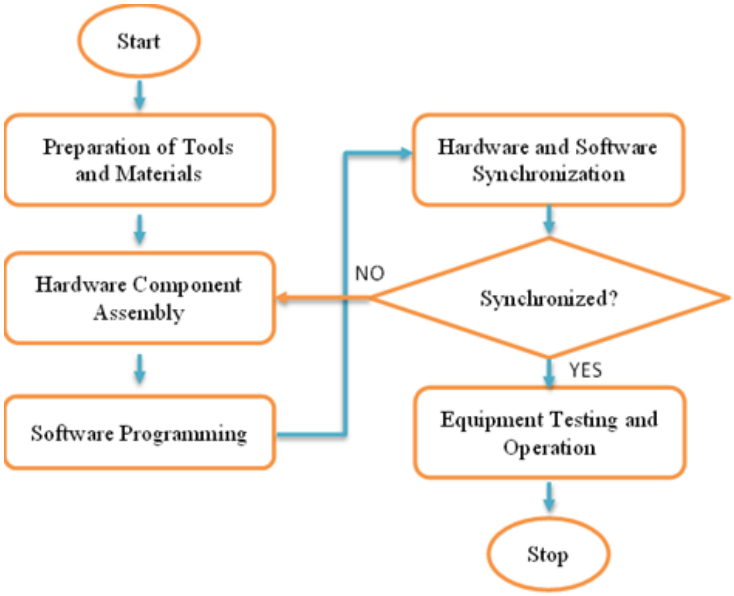


Figure 1. Flowchart of research procedures for feeding fish

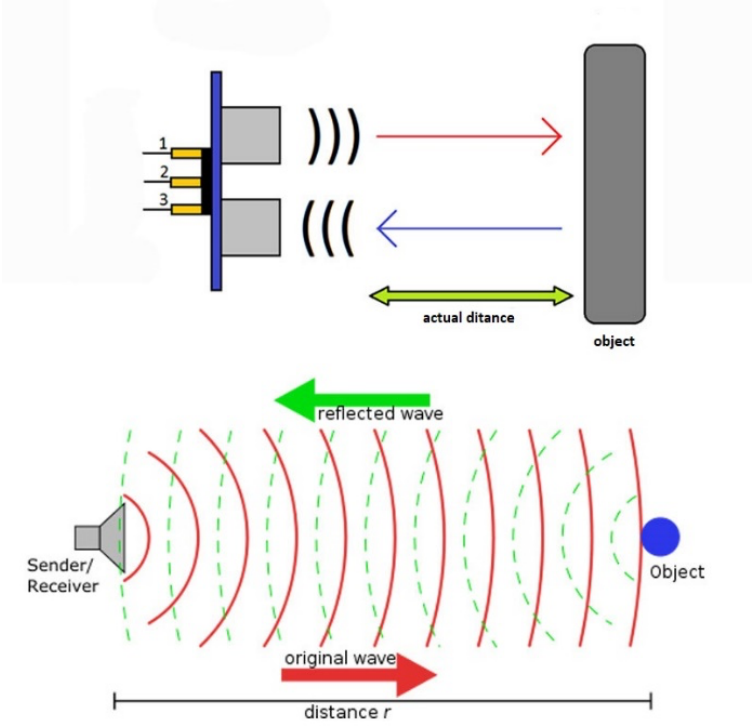


Figure 2. Ultrasonic sensor working system

Table 1. Component specifications

Hardware Name	Function	Hardware Name	Function
Arduino Uno R3	Processor	Mini Solar Cell 2.5 WP	Photovoltaic
Ultrasonic HC-SR04	Feed Detector	Solar Charge Controller	Battery Charging
RTC DS3231	Real-Time Timer	LM2596	Step-Down module
Servo MG995 360°	Feed mover	Lithium-ion 18650	Engine power source

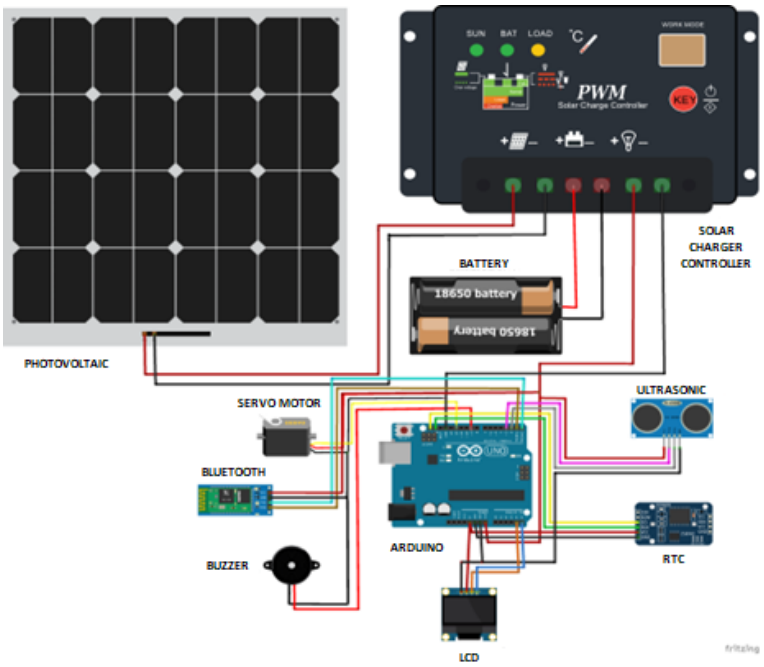


Figure 3. Schematic of the overall toolkit for feeding fish

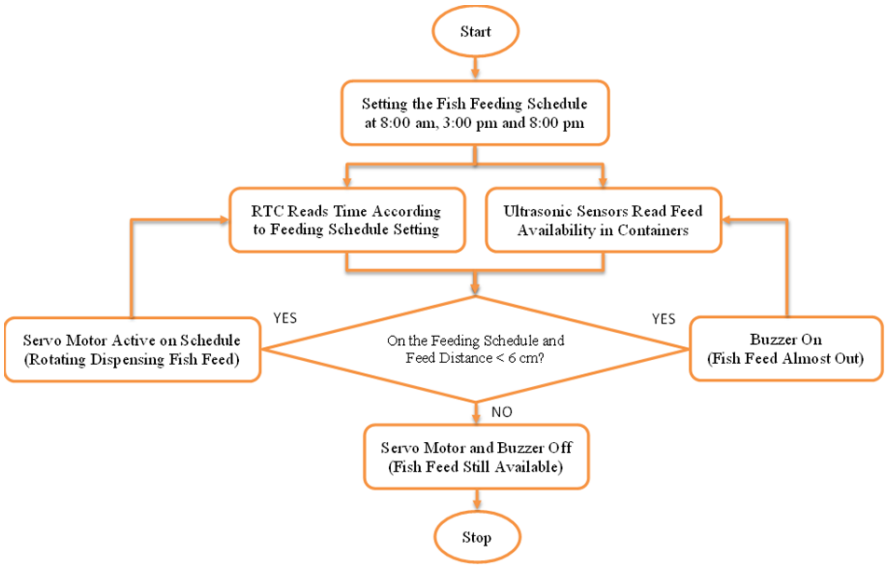


Figure 4. Overall machine system for fish Feed

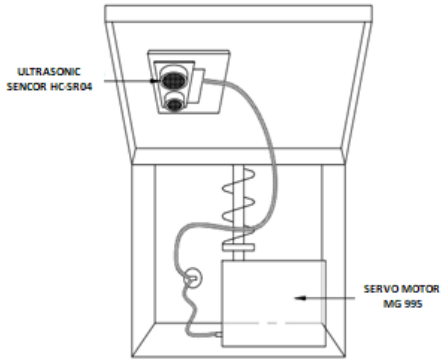


Figure 5. Overview of the fish feed container valve mechanical system

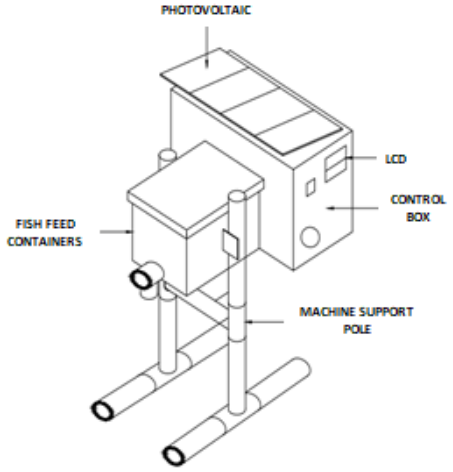


Figure 6. Design of an automatic fish feed machine.

Overall design overview for Automatic Fish Feed Machine, both the design of a solar power generation system as an energy source, as well as an automatic fish feed system as shown in Figure 6.

RESULT AND DISCUSSION

Hardware testing in the form of testing the response of the ultrasonic sensor to the availability of feed, testing the buzzer on the ultrasonic sensor, testing the feeder according to a schedule that has been set based on the time reading by the RTC DS3231 module, testing the solar charge controller on the battery, testing current, voltage and power every device as shown in Figure 7, (a) Automatic fish feeding machine, (b) rear view, (c) top view.

Feed Control Application Testing

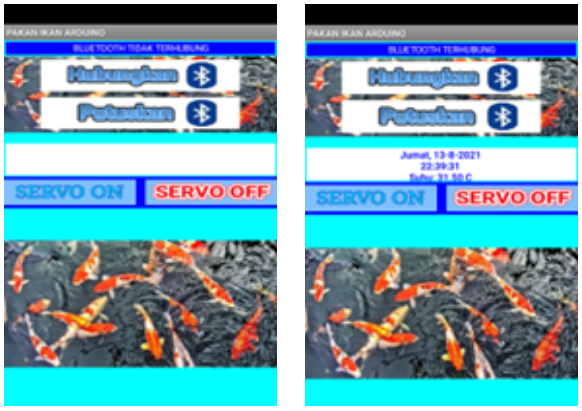
This testing phase activates the automatic fish feed machine and then opens the application; after the application interface appears, press the "connect" button and select the HC-05 Bluetooth address as shown in Figure 8, Figure 8. Bluetooth-connected application process, (a) The application is not connected (b) The application is connected. The application is successfully connected to the Bluetooth fish feed machine as shown in Table 2. Testing each module aims to determine the current, voltage and power value so that the modules can perform their functions as shown in Table 3.

The purpose of testing with this method is to determine the error value (difference) of two measurements as shown in Table 4. For ruler measurement at a distance of 1 cm, the ultrasonic sensor is read at a distance of 4 cm because the ultrasonic sensor can only read data at a minimum distance of 2 cm.

The condition of the detector bait on fish feed uses the HC-SR04 ultrasonic sensor so that the response test determines whether the buzzer as an indicator can function correctly. (Paculanan et al. 2021). When the feeding is almost complete, an indicator is indicated by an ultrasonic sensor reading ≥ 6 cm, and the buzzer activates a sound in the form of an intermittent beep (Parra et al., 2018). The buzzer will remain silent if the feed condition remains complete and the sensor reading is ≤ 6 cm. The overall height of the container is 8 cm, but if taken from the eye of the ultrasonic sensor, the distance to the bottom of the container is 5.7 cm as shown in Table 5. The ruler measurement results are at a distance of 1 cm, while the ultrasonic sensor reads 2279 cm because the ultrasonic sensor cannot read distances of less than 1 cm.

(a) (b) (c)

Figure 7. (a) Automatic fish feeding machine, (b) rear view, (c) top view



(a) **(b)**

Figure 8. Bluetooth-connected application process
(a) The application is not connected (b) The application is connected

Table 2. Machine control application testing

Servo Motor Control Buttons		Voltage (V)	Servo Motor Condition
On	1	4.98	Start
Off	0	0	Stop

Table 3. Testing current, voltage and module power

No	Module	Current (A)	Voltage (V)	Power (W)
1	Ultrasonic HC-SR04	0.002	4.96	0.009
2	Pewaktu RTC 3231	0.009	4.97	0.044
3	Servo MG995	0.959	4.98	4.770
4	LCD 128x64	0.007	4.97	0.034
5	Buzzer Alarm	0.004	4.98	0.019
6	Bluetooth HC-05	0.024	4.92	0.012
Total Daya (W)				4.99

Table 4. Ultrasonic distance measurement and ruler

Test	Reading		Difference (cm)	Accuracy (%)
	Ultrasonic (cm)	Ruler (cm)		
1	10	10.3	0.3	97.09
2	9	9.1	0.1	98.90
3	8	8.2	0.2	97.56
4	7	7.1	0.1	98.59
5	6	6	0	100
6	5	5	0	100
7	4	4	0	100
8	3	3	0	100
9	2	2	0	100
10	4	1	3	100
Average			0.37	91.71

Table 5. Testing of buzzer responses to feeding conditions read by sensors

Test-th	Reading		The difference in distance (cm)
	Ruler (cm)	Ultrasonic (cm)	
1	1	2279	2278
2	1.5	3	1.5
3	2	3	1
4	2.4	3	0.6
5	2.7	3	0.3
6	3	4	1
7	3.5	4	0.5
8	4.3	5	0.7
9	5	5	0
10	5.5	6	0.5

Testing the DS3231 RTC Module

The results of reading the RTC module time are in the form of date, month, year, day, hour, minute, and second. The output is also displayed on the OLED LCD module and serial monitor on the Arduino IDE as shown in Table 6.

Feeder Testing

The program created defines testing days on Monday, Tuesday, Wednesday, Thursday and Friday as busy days for automatic feed machine users. All Saturdays and Sundays are off. At 8:00:01 am, the servo mechanic moves to remove the feed from the container. At 3:00:01 pm, the servo mechanic moves to remove the feed from the container. At 8:00:01 pm, the servo mechanic moves to remove the feed from the container as shown in Table 7. The programming made "delay (5000)," which means the servo moves automatic control for 5 seconds.

The distance between the ultrasonic sensor and the bottom of the feed container is 6 cm. The distance read is closer when it is filled with feed in the form of pellets. If the distance is read ≥ 6

cm, then "Feed Almost Out". If the reading distance is ≤ 6 cm, "Feed is still safe" as shown in Figure 9 and Table 8.

Bluetooth Signal Distance Range Test

It aims to determine the range of distance between the data sender (fish feed application) and the data receiver (Bluetooth module installed on the machine) as shown in Table 9. Bluetooth communication can cover an area without using copper or data cables transmission to connect control systems to support the creation and achievement of revolution 4.0. The control and monitoring become easier and connect devices between other systems (Nugraha et al., 2021; Hiron & Andang, 2016). A maximum distance of 60 meters without obstruction and 30 meters with obstacles. Feeding equipment from other studies can spread fish feed with the farthest distance of more than 5 meters and the nearest 2 meters (Amir et al., 2020).

Arduino Based Automatic Fish Feeder has four parts: battery, fish feed dosing system, drivers and programs. Battery works voltage supply. Fish feed dosing. Functions as a processor of sown fish feed (Amir et al., 2020). Testing of solar panels and batteries aims to determine the value of voltage, current and power so that it can be seen whether the energy source used can be optimal for the performance of the designed fish feed equipment.

Table 6. Time testing of the DS3231 RTC module

Time (Laptop)	RTC Time (DS3231)	Time Difference (Seconds)
19:26:58	19:26:42	16
19:27:40	19:27:24	16
19:27:57	19:27:41	16
19:28:16	19:28:00	16
19:28:31	19:28:15	16
19:28:52	19:28:36	16
19:29:05	19:28:48	16
19:30:07	19:29:51	16
19:30:42	19:30:26	16
19:31:19	19:31:03	16

Table 7. Testing of the feeding schedule

Day	O'clock Feeding in 1 Day		
	8:00 am	3:00 pm	8:00 pm
Monday	√	√	√
Tuesday	√	√	√
Wednesday	√	√	√
Thursday	√	√	√
Friday	√	√	√

Information: √ : Rotating Servo Mechanics
: Removing Feed

(a)

(b)

Figure 9. LCD (a) feed is almost finished (b) feed is still safe

Table 8. LCD test Results

Real Time Clock Data					
Date	Month	Year	Hour	Minutes	Seconds
√	√	√	√	√	√
Ultrasonic Sensor Data					
Distance (cm)		Distance ≥ 6 cm		Distance ≤ 6 cm	
√		Feed Almost Out		Feed Still Safe	

√ : Successfully

Table 9. Bluetooth test results

Reach (Meters)	Bluetooth State	
	No Barriers	With Barrier
20	Connect	Connect
30	Connect	Connect
35	Connect	Not Connected
40	Connect	Not Connected
50	Connect	Not Connected
> 60	Not Connected	Not Connected

The SCC set must follow the type of battery used for a Lithium-Ion (Li-ion) 18650 battery with category B2. The program for this tool is Arduino Mega 2560, which is used for feeding fish and detecting water turbidity to be more effective, efficient and more accessible than manually (Henri et al., 2019).

CONCLUSION

The system for providing fish food has been implemented with the help of Solar Panels as an Energy Source Automatic Machine Control System. The control method using the Android application via Bluetooth communication produces a maximum distance of 60 meters without obstruction and 30 meters with obstacles.

Ultrasonic reading at a distance of ≥ 6 cm triggers the buzzer to sound, indicating that the feed is almost finished. The buzzer is silent when the sensor reading is ≤ 6 cm, indicating that feed is still available. Discharge stop and discharge reconnect SCC features have been successfully set. When the voltage is 8 V, the SCC automatically cuts off the flow to the load to avoid emptying the battery, with the load being disconnected for 6 hours. When the voltage reaches 10 V, the charging result from the solar panel, then the load is active again with a duration time from 8 V condition to 10 V active load for 1.5 hours as shown in Table 10.

Table 10. Battery Charging Solar Panel Testing

O'clock	SCC (V)	Condition		Battery Current (A)	Battery Status
		Weather	Load		
08:00	8	Sunny	Off	3	Filled
09:28	10.7	Sunny	On	4	Filled
10:47	11	Sunny	On	4	Filled
11:21	11.6	Sunny	On	4	Filled
12:02	11.3	Shady	On	4	Filled
14:10	11.7	Sunny	On	4	Filled
14:45	12.2	Sunny	On	5	Full
15:32	12.0	Cloudy	On	5	Full
16:07	12.3	Shady	On	5	Full
16:10	12.2	Shady	On	5	Full
16:48	12.0	Shady	On	5	Full
17:12	11.8	Shady	On	4	Contains
17:51	11.5	Cloudy	On	3	Contains
18:20	10.9	Dark	On	3	Contains
19:09	10.3	Dark	On	2	Contains
19:58	9.2	Dark	On	2	Contains
20:23	8.7	Dark	On	1	Contains
21:15	8.0	Dark	Off	0	Empty

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