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Automatic Fish Feeder Integrated with Solar Photovoltaic for Nutrient Film Technique Aquaponic System

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Abstract: Aquaponics is the process of raising aquatic plants and animals in a recirculating system. The phrase aquaponics comes from the word hydroponics, which refers to the cultivation of plants in water, and aquaculture, which is the practice of raising fish in a closed environment (the growing of plants usually in a soil-less environment). The Aquaponics system is a choice a lot today because it has several benefits such as a controlled environment. In an aquaponics system, the fish must still be manually fed in accordance with their feeding schedule and the precise amount of food needed for the entire population. Next, if the food provided does not contain a sufficient amount for the fish, it can lead to stunted growth in both the fish and the accompanying plants. Furthermore, any conventional energy that is created and used will have some form of environmental impact. The purpose of this project is to design an Automatic Fish Feeder integrated with the solar PV system. The system of Automatic Fish Feeder is to give automatically food to the fish at a specific time according to the command that has been given. This is where the Real Time Clock (RTC) function gives the real-time system to operate the 12V DC motor to rotate the drill to push the food into the fish pool at 9.00 a.m. and 6.00 p.m. Overall, the automated fish feeder using solar PV technology is an achievable and environmentally beneficial option for fish farming businesses. It improves feeding precision, decreases labour needs, and helps to make the aquaculture sector more sustainable. Future research might look at additional developments in the design and optimization of this integrated system in order to maximize its benefits and encourage wider usage in the aquaculture sector.

Keywords: Aquaponic, 12V DC Motor, Solar PV System, Automatic Fish Feeder

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1. Introduction

Aquaponics is the process of raising aquatic plants and animals in a recirculating system. The phrase aquaponics comes from the word hydroponics, which refers to the cultivation of plants in water, and aquaculture, which is the practice of raising fish in a closed environment (the growing of plants usually in a soil-less environment). The Aquaponics system is a choice a lot today because it has several benefits such as a controlled environment. In an aquaponics system, the environment can be controlled and optimized to provide the best-growing conditions for plants and fish. This results in healthier plants and higher yields. Next, cost-effective because even the initial setup cost of an aquaponics system can be higher compared to traditional agriculture, the long-term term of reduced water, fertilizer, and energy costs makes it a cost-effective solution for food production. Furthermore, versatility because aquaponics systems can be used to grow a wide range of crops, from leafy greens and herbs to fruits and vegetables. It can also be used to raise different types of fish, making it a versatile system for food production. There are several types of aquaponics systems such as Media Based, Nutrient Film Technique (NFT) and Deep-Water Culture. In this project, NFT has been chosen for a case study because NFT used waste from fish to get the nutrition to grow the plant. Therefore, for this project, an automatic fish feeder is being developed to feed the fish automatically at specified times [1].

The NFT aquaponics system has three different types of filters: radial flow, mechanical, and biological. The radial flow filter will be used to process fish waste that has been produced in the fish tank. This is to ensure that the solid waste is dumped into the radial flow filter's bottom tank. The water from the radial flow filter will next be sent into the mechanical filter tank to filter out heavy solids once again before entering the biological filter. The ammonia from the fish waste will next be converted into nitrites and then nitrates using the biofilter as the final filter. The nitrate-containing water will then be pumped into the grow pipes. The holes in the grow pipes are where the plants are inserted. The water from the growing pipes will then recirculate into the fish tank. Thus, in the NFT system, the fish plays a critical role as it produces the natural fertilizers needed by the plant to grow. Additionally, this is the reason why it's crucial to feed fish the precise amount and how often the fish should be fed per day to ensure the growth of the fish. Therefore, it is why automatic fish feeder is important because its function is to feed fish every day because they are required to produce the waste that will later be converted into the nitrates that plants will require [1].

The objective of this project is to design and develop an automatic fish feeder system for an aquaponics system. Then, the solar photovoltaic system has been integrated with the automatic fish feeder as an electricity supply. Finally, the performance of the developed automatic fish feeder integrated with a solar PV system will be determined.

2. Materials and Methods

2.1 Hardware of the project

Table 1 lists the project hardware components.

Table 1: Project Hardware components

Hardware	Description
12V DC motor 	The 12 V DC motor. Servo motors and DC motors are only two examples of the various motors that can be employed. One of the primary components of this project is a DC motor. The drill that will dispense fish food into the pool is rotated by a DC motor [2].

Arduino Uno 	The main system of this project is an Arduino UNO. The instruction that has been set to control the DC motor will be processed by the Arduino. The Arduino board will instruct the motor driver to run the DC motor to rotate for the specified amount of time that has been set [3].
L298N motor driver 	The motor driver is used for controlling the performance of the electric motor. It operates as a bridge between the motor and the microcontroller, supplying the power and control signals required to run the motor successfully [4].
Real-Time Clock Module 	The Real Time Clock module which is DS1307. The DS1307 module is an RTC IC that uses an internal quartz crystal to keep time. It can provide the current date and time as well as an alarm functionally. It is commonly used in embedded systems, such as in devices that require accurate timekeeping, even when the main power source is disconnected [5].
Solar PV Panel 	The solar panel converts light from the sun into electric energy. The electric energy from the solar panel will then be sent into the solar charge controller, battery, and electronics components. The type of solar panel that is used in this project is polycrystalline [6].
Seal Lead Acid Battery 	The battery is used to store electrical energy. Its function is to supply electrical energy to the system when the photovoltaic panels do not generate the necessary electricity [7].
PWM Solar Charger Controller 	The Pulse Width Modulation (PWM) solar charger controller. This device is the most important solar system circuit for this project because the solar PV panel, battery and motor driver will connect to this solar charger controller. This device connects the solar panel and the battery to prevent it from overcharging and over-discharging [8].

2.2 Arduino IDE for software development of automatic fish feeder

A text editor for writing code, a message box, a text terminal, a toolbar with buttons for essential operations, and several menus are all included in the Arduino Software (IDE). It connects to the Arduino hardware, enabling programming upload and communication. Programs made using the Arduino Software (IDE) are called sketches. In this project, Arduino IDE will be a code conduct for the automatic fish feeder. The coding will command the motor driver to rotate the drill according to the RTC that has been set. Figure 1 shows the Arduino IDE display of the Automatic fish feeder.

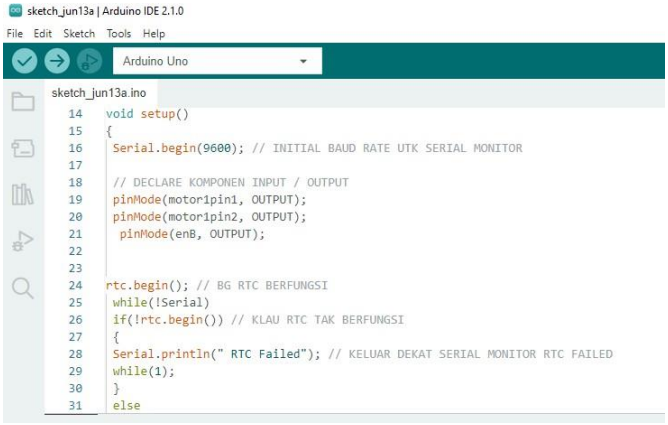

Figure 1: Arduino IDE display

2.3 Automatic fish feeder flowchart

Figure 2 shows a process flowchart of the automatic fish feeder.

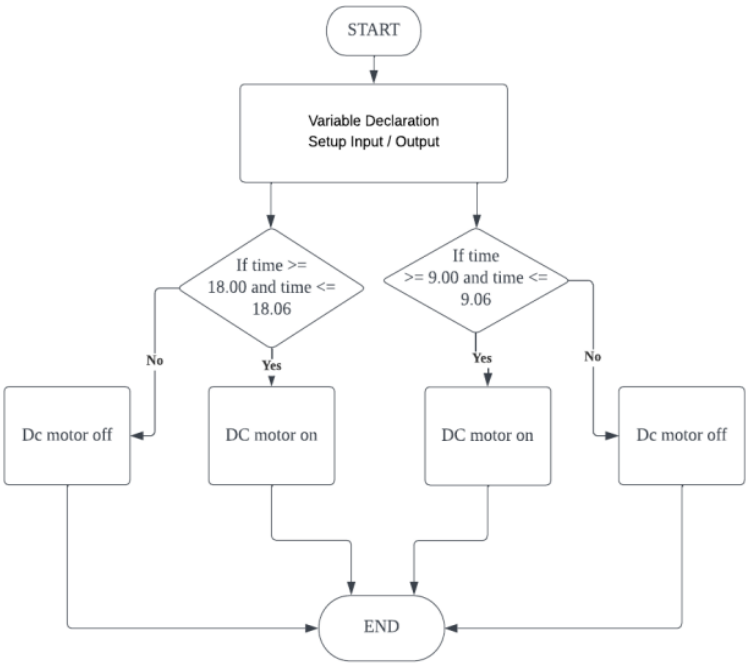

Figure 2: Process flowchart of automatic fish feeder

Figure 2 shows the whole process of the automatic fish feeder. The power supply from the solar system is very important to keep the automatic fish feeder always in the ON state, especially for the Arduino and motor drivers. When the Arduino and motor driver get the power supply, the system will

start running to operate the DC motor. For the first cycle, the DC motor will rotate the drill for 6 minutes to push the food into the pool at 9.00 a.m. Then, for the second cycle at 6:00 p.m., the DC motor will rotate again for 6 minutes to push the food into the pool. Then, the system will always be in a loop condition to feed the fish in the morning and evening every day.

2.4 Calculation for power consumption

In this investigation, the power consumption and electricity bill will becalculated for future reference by using an Automatic Fish Feeder integrated withPV solar. The equation to calculate the power consumption and the electricitybill for using an appliance as stated below:

Watt's law formula.

$$P = IV \quad \text{Eq. 1}$$

Where,

P = Power (W)

I = Current (A)

V = Voltage (V)

Power consumption of an appliance.

$$\text{Power consumption} = \text{Wattage} \times \text{Operational Hours} \quad \text{Eq. 2}$$

Electricity Bill for using an appliance**.**

$$\text{Electricity Bill} = \text{Power consumption} \times \text{Electricity Tariff} \quad \text{Eq. 3}$$

Energy consumption can be calculated.

The load analysis is performed based on the energy used, the total dailyconsumption, and the overall demand for alternating current power. It will decide the battery rating and the energy consumption of the DC motor.

$$E = Q \times PR \times t \quad \text{Eq. 4}$$

Where,

E: Energy consumption

Q: Quantity of electrical appliances

PR: Power rating of electrical appliances

t: Operating time of electrical appliances

2.5 Equation of parameters

2.5.1 Total load determination

The estimation of load determination is needed to produce the total power output of the system. To estimate the total load for each component, the power load for each electrical equipment and average hour usage should be determined.

$$Total\ Watt - hour/day\ (Watt) = (n) \times (P) \times Hour/day \quad \text{Eq. 5}$$

Where:

n = Quantity
P = Power

$$Watt_{Total} = n \times P \quad \text{Eq. 6}$$

2.5.2 Determine the number of solar panels

The number of solar panels that will be used is determined based on the total power consumption of the system divided by the power rating of the solar panel which was already manufactured from the factory.

Where:

$$N_{PV} = \frac{P_{Total}}{P_{PV\_Rate}} \quad \text{Eq. 7}$$

$\mathrm{N_{PV}} =$ Number of Solar Panel
$\mathrm{P_{Total}} =$ Total of Power Consumption
$\mathrm{P_{PV\_Rate}} =$ Power Rate of Solar Panel

2.5.3 Maximum power current for solar panel

Below is the formula to determine the maximum power current for solar panel which is Power (W) divided by Voltage (V) to get Current (A).

$$\frac{P}{V} = I \quad \text{Eq. 8}$$

Where,

P = Power (W)
I = Current (A)
V = Voltage (V)

2.5.4 Solar charger controller output current

A 100W solar array, for instance, will divide a 12V battery bank into 8.33A, hence the charge controller needs to be rated at least 10A. Below showsthe formula to get the current which is power need to divide by voltage.

$$P = I \times V \quad \text{Eq. 9}$$

$$I = \frac{P}{V}$$

3. Results and Discussion

3.1 Result on the condition of the Green Sawi Pak Choy plant

Figures 3 and 4 show the two conditions of the Green Sawi Pak Choy plant if with or without nutrition from fish.

3.1.1 Plant without nutrition from fish

Figure 3: Plant without nutrients from fish

Figure 3 shows the condition of the plants where they did not get sufficient nutrition from fish. The testing carried out with no pellet has been given to the fish for one week. From this testing, it can be concluded that if plants in an aquaponics system do not receive proper nutrition from fish, they may not grow and thrive as they should. The plant relies on fish waste, which is high in nitrogen and other essential nutrients to provide the nourishment to grow. Without this nutrition, the plants may become stunted, yellow, or even die. Additionally, if the plants do not receive proper nutrition, the water quality in the system may also deteriorate, which can be harmful to the fish. It is important to ensure that the plants are receiving the proper nutrition in an aquaponics system to maintain a healthy and balanced ecosystem.

3.1.2 Plant with nutrition from fish

Figure 4: Plant with nutrition from fish

Figure 4 shows the condition of the plant when it gets sufficient nutrients from fish after using the automatic fish feeder. From this testing, it can be concluded that the plant will grow perfectly if it receives proper nutrients from fish.

3.2 Prototype development

This prototype was created to be an automatic fish feeder by using electronic microcontrollers such as Arduino. The design of an automatic fish feeder has been made by using the RTC, 12V DC motor, motor driver and Arduino. Figure 5 shows the design of the prototype of an automatic fish feeder integrated with PV solar.

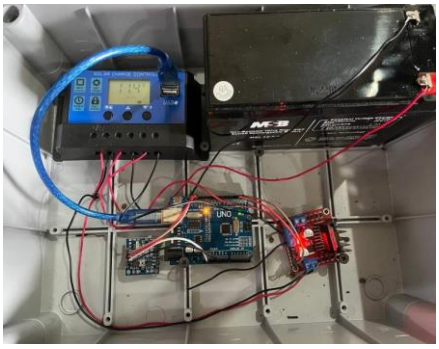

Figure 5: Circuit testing

Figure 5 shows the full circuit of the automatic fish feeder integrated with PV solar. The Arduino and motor driver are connected to the solar charge controller. From the solar charger controller, the 5V will be given to Arduino while 12V will be given to the motor driver to control the 12V DC motor.

Figure 6 shows the full view of an Automatic Fish Feeder integrated with PV solar. The solar panel was placed behind the container and attached to the steel structure. The electrical box that consists of all electronic parts such as Arduino, motor driver, RTC, solar charge controller and 12V battery was placed under the fish food container.

Figure 6: Full View of the automatic fish feeder integrated with Solar Photovoltaic

3.3 Performance of Solar PV system

Data for input solar PV panels has been measured by using the multimeter for one day. The voltage and current are measured according to different hours as shown in Table 2. The peak hours to get the peak value of voltage and current are from 11.00 a.m. to 2.00 p.m. The testing was conducted on 15 June 2023.

Table 2: Voltage, Current and Power value for solar PV panel

Time	Voltage (V)	Current (A)	Power (W)
7.00 a.m.	11.28	0.21	2.37
9.00 a.m.	12.42	0.31	3.85
11.00 a.m.	13.47	0.63	8.49
12.00 p.m.	13.48	0.65	8.76
1.00 p.m.	13.47	0.63	8.49
2.00 p.m.	13.46	0.61	8.21
3.00 p.m.	13.41	0.58	7.78
4.00 p.m.	12.82	0.44	5.64
5.00 p.m.	12.64	0.38	4.80
6.00 p.m.	12.61	0.36	4.53

3.4 Load Analysis

The Automatic Fish Feeder integrates with PV solar system's total load analysis for is shown in Table 3. Total load analysis is necessary for system design. The estimated power consumption of component was determined using the specification from the datasheet.

Table 3: Load Analysis of the system

No.	Load	Qty	Estimated power (W)	Operating time (h)	Daily energy consumption, (Wh)
1.	12V DC motor	1	33.6	0.2	6.72
2.	Arduino Uno	1	0.5	24	12
3.	RTC	1	0.0075	24	0.18
				Total daily energy consumption (Wh)	Total DC power demand (W)
				18.9	34.10

The calculation of energy consumption, total daily consumption, and the total DC power demand of the load is based on the total load estimate above. This calculation is used to determine the electricity bills for the monthly usage of electricity. Table 4 shows the electricity consumption per month and electricity bill per month.

Table 4: Electricity consumption per month and electricity bill per month

Electricity consumption per month	Electricity bill per month
0.567 kWh	RM 0.11

Calculating the electricity bills is necessary to estimate the energy consumption of the load by daily and monthly. Energy consumption per month can be calculated by total daily energy consumption multiplied by 30 days and divided by 1000 to get in kWh. Based on My TNB website the latest electricity cost was in March 2023, which is for homes and enterprises, the cost of electricity is RM 0.221 per kWh, which includes all fees associated with electricity use, distribution, and taxes.

4. Conclusion

In this research work, an auto fish feeder system for the NFT aquaponic system was successfully developed. The system was designed complete with the usage of Proteus software to design the circuit and the Arduino IDE software to make the coding to give the food automatically according to the time that has been set for the automatic fish feeder system. Chapter 3 illustrates the proteus circuit for the automatic fish feeder. The automatic fish feeder flowchart has been discussed for the process flow. The instructions for each system were programmed using the Arduino IDE software. The Arduino coding command file was exported to Proteus and imported into the Arduino hardware component. The auto fish feeder system was integrated with the solar PV system as the electricity supply. The calculation to determine the solar panel, solar charge controller and battery were carried out. In addition, all the specifications of solar panels, solar charge controller and battery are shown. This project also shows the equipment that was used and the connection to develop the fully Automatic Fish Feeder integrated with a solar PV system. Lastly, the third objective is the result of two conditions of the Green Sawi Pak Choy plant which are before and after the use of the automatic fish feeder. Next is to determine the performance of the developed automatic fish feeder integrated with PV solar system is shown in chapter

4. The data of input for solar PV panel which is voltage, current and power are shown and analyzed. The output of dc motor for voltage, current and power also are determined and analyzed Next, the load analysis of automatic fish feeder is carried out to get the total electricity consumption per month and the electricity bill per month.

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