

Automatic Transfer Switch (ATS) for Floating Lift Net Powered by Hybrid Energy Source

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Abstract. The increasing demand for renewable energy as an alternative to fossil fuels has driven innovations in hybrid power systems. This study focuses on optimizing a hybrid energy system for a floating lift net utilizing solar panels (photovoltaic) and a backup generator managed by an Automatic Transfer Switch (ATS). The ATS system is designed to automatically switch to the backup generator when the primary photovoltaic system drops below a preset voltage threshold of 10V. Additionally, a Visual Basic monitoring system was developed to track key parameters, including battery capacity and the output voltage from both the main and backup systems. The results show significant fuel savings and reliable energy supply using the hybrid system on a floating lift net.

1 Introduction

Electricity is one of the basic needs of society, whether in developing countries like Indonesia or more developed nations. The global electricity demand continues to rise every year, in line with the advancement of human civilization. However, the supply of electricity from fossil fuels such as oil, natural gas, and coal has several limitations, including being non-renewable and causing pollution and environmental damage in both the short and long term. On the other hand, renewable energy sources, such as solar power, geothermal energy, wind, biomass, ocean currents, and waves, have not yet been fully utilized. Therefore, various research efforts have been undertaken in many developed countries to reduce greenhouse gas emissions by saving fossil fuel consumption and using renewable energy sources, one of which is through the implementation of hybrid systems.

A hybrid system is a concept that combines two or more different energy sources to meet the power demand. Hybrid systems often become a solution to address the fuel crisis by aiming to combine the advantages of each energy source while covering the weaknesses of each under certain conditions, thereby achieving a reliable power supply and making the system operate more economically and efficiently.

One hybrid power generation system with great potential for development in Indonesia is the combination of solar photovoltaic (PV) panels and generators. The role of photovoltaics is crucial today, driven by the need for renewable energy. Both governments and private sectors have made significant investments to support research in this field [1]. Photovoltaic

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technology is now applied in various areas, such as residential and commercial buildings, as well as power generation in remote areas [2]. This potential is due to Indonesia's geographical location on the equator, ensuring that the region receives sunlight for 10-12 hours per day. The solar energy potential in Indonesia averages 4.5 kWh per square meter per day, with around 2,000 hours of sunlight per year, making Indonesia rich in solar energy resources [3].

Hybrid electricity systems are particularly suitable for floating lift net, which traditionally rely solely on generators for power. By utilizing PV panels to convert sunlight into electricity and combining it with a backup generator, the system is expected to meet the electricity needs of floating platforms.

The hybrid power generation system uses PV panels and a generator, which works by automatically switching between sources. When the voltage of the primary power generation source reaches its minimum threshold, the load is transferred to the backup power source, and vice versa when the backup source reaches its minimum voltage. In an experiment conducted previously by Arif [4], battery 1, serving as the primary power source, took 44 minutes to supply a 240W load with an average current consumption of 0.182A. Meanwhile, battery 2, serving as the backup power source, required 28 minutes to supply the same 240W load with an average current consumption of 0.177A.

This research aims to design and optimize a hybrid power generation system utilizing both solar energy and a generator controlled by an Automatic Transfer Switch (ATS). The ATS ensures seamless switching between the power sources when voltage thresholds are reached. Furthermore, a Visual Basic-based monitoring application is developed to track system performance in real-time.

2 Literature Review

2.1 Floating Platform

A floating platform is a structure that operates offshore, where the sea floor lies below the lowest tide level or is situated beyond the wave-breaking zone. According to [3], offshore structures exhibit several key characteristics. These structures typically operate near oil wells or limited mining areas, and unlike ships, they are not designed to travel long distances. Offshore structures do not operate on land, and their components are not constructed on-site; they are manufactured onshore and later transported and assembled at the offshore location. They are designed to remain operational in the same location for extended periods, which requires them to withstand the worst possible conditions during their operational lifetime.

Ayodhya [5] also classified offshore structures into several categories. Based on their operational type, offshore structures are typically used for oil or gas extraction, mining, wave energy generation, or thermal energy conversion, such as in Ocean Thermal Energy Conversion (OTEC) systems. In terms of configuration, these structures can be vessel-type structures, which are typically modified ships with propulsion systems for deep-sea operations; barge structures, which lack propulsion and require towing; or platform structures, which are commonly used for oil exploration or production in shallow or intermediate waters.

Offshore structures are also classified by their function, including exploration structures used for drilling, production structures used for extracting oil or gas, and hybrid structures capable of both drilling and extraction. Furthermore, based on their construction material, offshore platforms can be made entirely of steel, concrete, or a hybrid of both, where the base is made of concrete and the deck is supported by a steel framework. Lastly, according to their mobility, offshore structures can be fixed, meaning they are anchored to the seabed in shallow

or intermediate waters or floating, making them suitable for deep-sea operations at any water depth.

2.2 Automatic Transfer Switch (ATS)

Electricity has become a critical necessity for operating electronic devices. Many devices, particularly in telecommunications, industry, and healthcare, require continuous power and cannot afford any interruptions. To ensure continuous operation, a backup power source is added, which can take over when the main power supply fails. This transition from the main to the backup power source must occur seamlessly without causing any downtime in the electronic systems. An Automatic Transfer Switch (ATS) is used to ensure this smooth transition [6].

An ATS system consists of several electrical components, including relays, timers, and magnetic contactors. Its primary function is to automatically switch the power supply from the main source to the backup source without interrupting the load. Several studies have been conducted on ATS technology, focusing on enhancing its functionality. Some studies have integrated microcontrollers into the ATS system, enabling the control and monitoring of the switch [6-9].

In a study conducted by [6], an ATS system was developed using an Arduino UNO microcontroller instead of traditional timers and magnetic contactors. The system included a CT transformer, voltage sensors, and relay modules. Monitoring was facilitated through current sensors and an Ethernet module, allowing communication over a LAN. The use of the Ethernet module enabled data storage in a database for monitoring purposes, making system information accessible through the network.

According to Pakpahan et al. [6], an ATS system can be designed by combining a microcontroller, relays, and voltage sensors. Figure 1 shows the block diagram of this system. The voltage sensor is placed between the power sources and the relays. Its primary functions include stepping down the AC voltage from the main power grid (PLN) and the backup generator and adjusting the current and voltage values so the microcontroller's analog pins can read them. The microcontroller used in this system is an Arduino UNO.

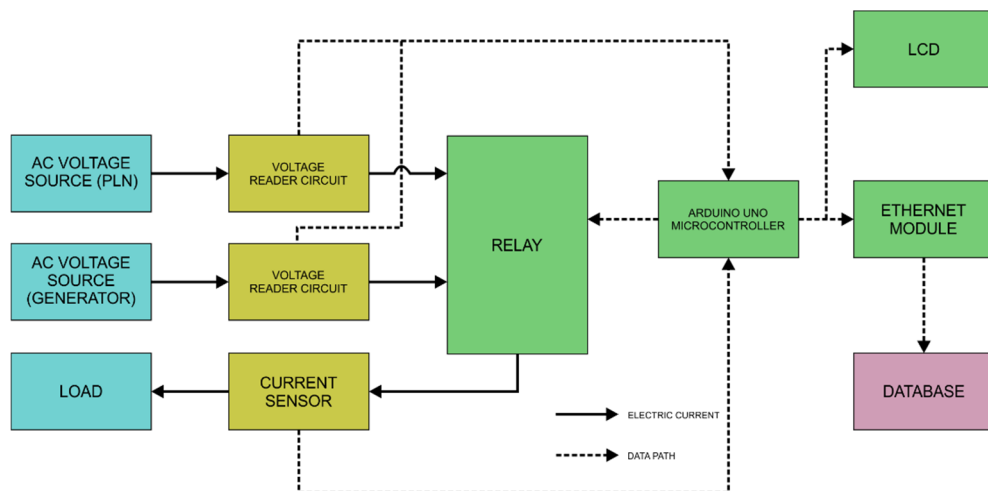


Fig. 1. Automatic Transfer Switch (ATS) system block diagram

A simpler alternative system, according to Sitilonga [10], an ATS system operates with components, including voltage sensors, a microcontroller, a switching circuit, and a power

supply, as shown in Figure 2. The main power supply (PLN) is connected to the switching circuit and the voltage sensor. The voltage sensor detects the presence of power from the main supply and sends a signal to the microcontroller. The microcontroller is powered independently to ensure continuous operation, even when the main supply is down. The microcontroller controls the generator's start-up and shutdown processes. The switching circuit is connected to both the main and backup power sources, and the microcontroller directs the circuit to switch between power supplies. The switching circuit supplies power to the load when active.

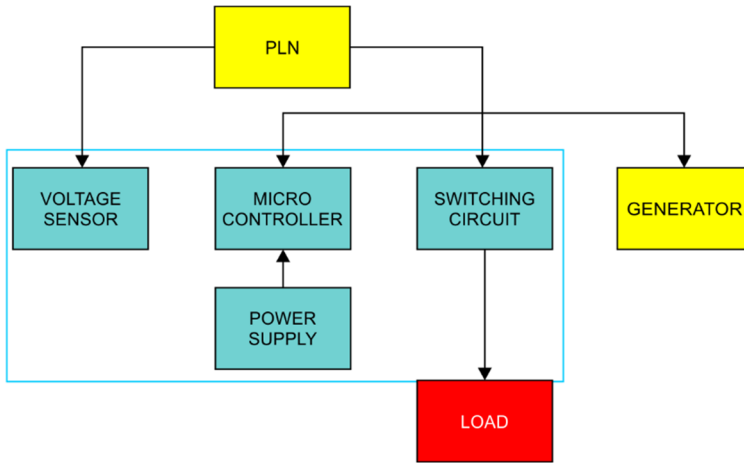


Fig. 2. Simpler automatic transfer switch block diagram [10]

3 Research Methodology

3.1 Research Stages

This research consisted of several stages, each involving key activities as outlined below:

3.1.1 Design of Equipment and Experimental Materials

The design process was divided into two parts: hardware and software design. The hardware design involved creating a miniature system, starting with a block diagram, system circuit, and flowchart diagram. The software design entailed developing a monitoring system for the photovoltaic panel using Visual Basic. Figure 3 illustrates the design of the hardware that was assembled for this research.

3.1.2 Testing and Data Collection

Testing and data collection were conducted using the hardware and software that had been designed. The goal was to measure the performance and reliability of the hybrid power system.

3.1.3 Analysis and Discussion

At this stage, data obtained from the measurements and tests were analyzed and discussed. The analysis was aimed at addressing the research objectives and determining the effectiveness of the hybrid power generation system.

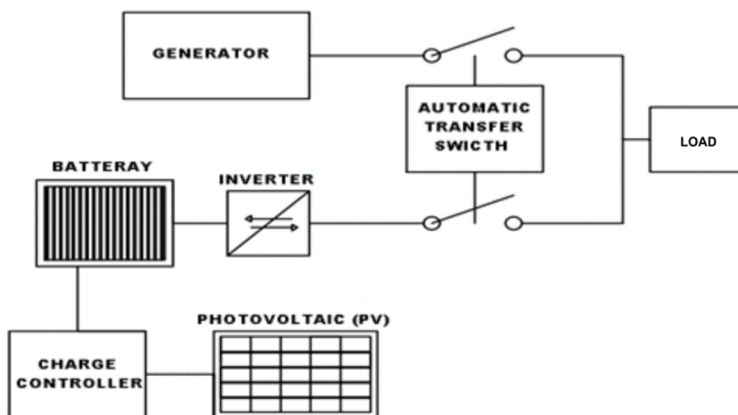


Fig. 3. Hardware design sketch

3.2 Floating Lift Net Data

The floating lift net shares similar construction characteristics with a fixed platform but with the advantage of mobility, allowing it to be moved to different locations by being towed by a boat. The structure is made from a framework of bamboo arranged in a square shape.

At the center of the floating platform is a small house structure, serving as a resting area, shelter for lamps from rain, and a vantage point for observing fish. Additionally, the platform is equipped with a roller made from bamboo, which is used to operate the netting system for catching fish.

Table 1 shows the dimensions of the floating lift net, measured in Pallameang Village, Pinrang District, South Sulawesi Province, Indonesia. The photo of the lift net is shown in Figure 4.

Table 1. Dimensions of the floating lift net

Parameter	Size
Length	12 m
Width	11 m
Stabilizers Height	1 m

4 Results and Discussion

4.1 Testing of the Hybrid Energy Floating Platform System

4.1.1 Arduino Uno Testing

The performance of the Arduino Uno was evaluated to ensure it met design specifications. The test involved measuring the output voltage of digital pins under high and low logic states as shown in Figures 6 and 7. The results, detailed in Table 2, indicated that the output voltage was 4.969V at high logic levels, which is consistent with the expected design value of 5V, with a deviation of 0.994%. The output voltage at low logic levels was 0V, confirming the correct functioning of the Arduino Uno's digital pins.



Fig. 6. Arduino uno digital pin voltage output testing at logic high state



Fig. 7. Arduino uno digital pin voltage output testing at logic low state

Table 2. Arduino uno voltage output test results

Pin	Logic High (V)	Logic Low (V)
A0	4.99	0
A1	4.99	0
A2	4.99	0
A3	4.99	0
A4	4.99	0
A5	4.99	0
1	4.99	0
2	4.99	0
3	4.99	0
4	4.99	0
5	4.99	0
6	4.99	0
7	4.99	0
8	4.99	0
9	4.99	0
10	4.99	0
11	4.99	0
12	4.99	0
13	4.99	0

4.1.2 LCD Testing

The LCD's functionality was assessed to confirm its ability to display data and characters as programmed. The LCD 16x2 was tested under various conditions, including initial display messages, system processing updates, and readings from the Automatic Transfer Switch (ATS). The LCD performed as expected, accurately reflecting the programmed messages and readings as shown in Figures 8.



Fig. 8. Example of LCD displays

4.1.3 Voltage Sensor Testing

Voltage sensors were tested to evaluate their ability to measure voltage accurately. Two types of voltage sensors were employed: an AC voltage sensor for the generator and a DC voltage sensor for the photovoltaic system. The sensors successfully read the voltage levels, and the data was correctly processed and displayed on the LCD as shown in Figure 9.



Fig. 9. Voltage sensor reading results

4.1.4 Comprehensive Testing of the Hybrid Power Generation System

After individual component testing, the entire hybrid power generation system was evaluated. The system was tested to ensure it operated according to the Arduino program's instructions. The test involved setting a minimum voltage threshold for the primary power source (photovoltaic) and verifying the automatic switch to the backup generator when the photovoltaic voltage fell below this threshold. The results, shown in Figure 10, demonstrated that when the photovoltaic voltage dropped below 10 volts, the relay switched to the generator, ensuring continuous power supply.

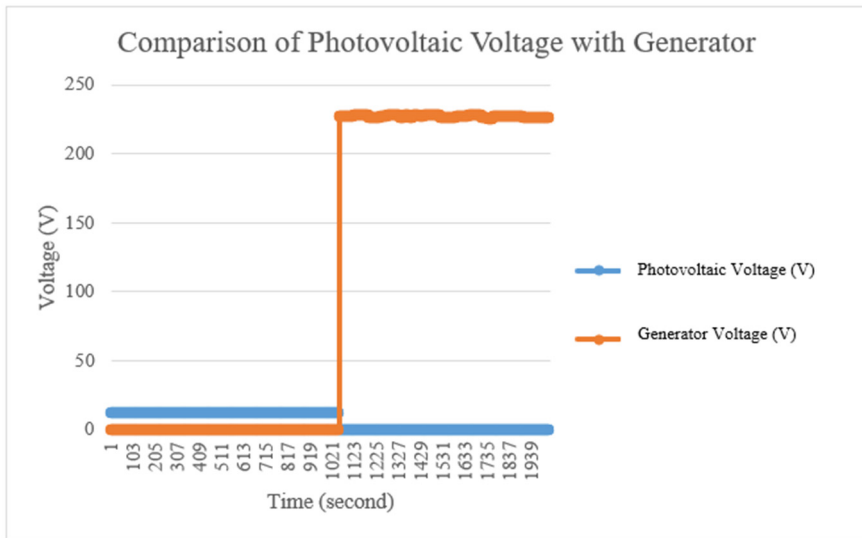


Fig. 10. Photovoltaic and generator voltage comparison

The testing confirmed that the system functioned correctly, with the relay switching between photovoltaic and generator power sources as intended.

4.2 Development of the Hybrid Power Generation System Monitoring Program

The Visual Basic 2010 program was developed to monitor the hybrid power generation system's output parameters. The development process included designing the program's user interface, implementing code for program execution, and integrating it with the Arduino IDE to read system output.

4.2.1 Main Program Interface Design

The main interface of the program was designed to include functionalities for scanning serial ports, setting baud rates, and connecting or disconnecting from the Arduino as shown in Figure 11. The interface also featured options for recording, stopping, and clearing data, as well as displaying real-time data in tables and graphs.

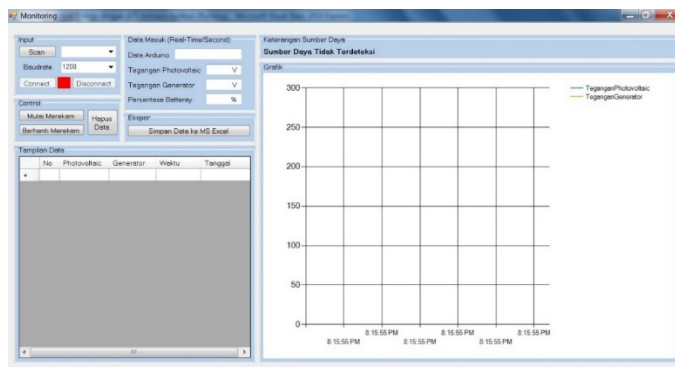


Fig. 11. Main program display design

4.3 Program Simulation

The program simulation tested the functionality of the monitoring system. Data was collected from the connected hardware and displayed in real time using the Visual Basic program. The simulation, conducted on October 23, 2019, over a 34-minute period, demonstrated that the monitoring application successfully recorded and displayed data without data loss, as shown in Figure 12.

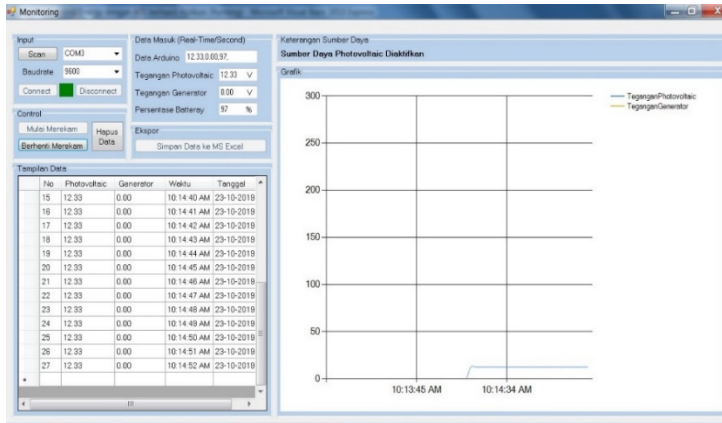


Fig. 12. Program simulation view

4.4 Electrical Load Calculation for Floating Platform

The electrical load calculation for the floating platform, based on a study by Mahmuddin [11], as shown in Table 3, was performed to determine the power requirements and assess the feasibility of different power sources.

Table 3. Electrical load requirements for floating platform [11]

Component	Quantity	Power (W)	Total Power (W)
LED Light 45W AC	8	45	360
LED Light 35W AC	8	35	280
Spotlight 30W AC	1	30	30
Total Load			670

The total energy requirement for 8 hours of operation amounts to 5.36 kWh.

4.5 Power Source Scenarios

4.5.1 Scenario 1: Full Generator Usage

In this scenario, the floating platform relies entirely on a generator for power. The generator used has a capacity of 800 W. Calculations indicate that 2.147 liters of fuel are required for 8 hours of operation.

4.5.2 Scenario 2: Hybrid Photovoltaic and Generator

In the hybrid scenario, photovoltaic panels are combined with a generator. With three dry batteries, each with a capacity of 0.88 kWh, the system can support the platform for approximately 3.94 hours. The remaining 4.06 hours of power are supplied by the generator, requiring 1.088 liters of fuel.

Table 4. Hybrid photovoltaic and generator usage

No	PV Battery		Generator		
	Battery Quantity	Duration (h)	Fuel Consumption (L)	Generator Duration (h)	Fuel Savings (L)
1	3	3.94	1.088	4.06	1.059
2	4	5.25	0.737	2.75	1.410
3	5	6.56	0.385	1.44	1.762
4	6	7.88	0.032	0.12	2.115

As shown in Table 4, increasing the number of batteries in the hybrid system reduces fuel consumption, highlighting the efficiency of the hybrid approach. This hybrid system also reduces reliance on fossil fuels and decreases air pollution.

5 Conclusion

The Automatic Transfer Switch (ATS) functions effectively by automatically switching from photovoltaic to generator power when the photovoltaic voltage drops below 10 volts, with data displayed every second in tabular and graphical form by the Visual Basic-based monitoring application in the hybrid photovoltaic and generator power system, using six batteries can meet the power requirements for 8 hours with fuel consumption of only 0.032 liters, saving 2.115 liters of fuel compared to using a full generator.

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