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Garden Watering Control System Using Solar Cells

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Abstract

Watering the Garden by Using Solar Cells. Guided by Zahir Zainuddin and Adriani. Solar Cells are devices composed of semiconductor materials that can convert sunlight into electricity directly. Often also used the term photovoltaic or photovoltaic. In this design, the automatic garden watering using solar cells requires timer equipment, BCU, rain sensor, relay, battery/battery, and inverter. The purpose of this design is to know the performance of plant watering design by using solar cells as a source of stress and to know the control system and rain sensor in maximum watering of plants so that later can be applied to the next design and society. Garden Water Purification Test Using an Unsaturated Solar Cell on 31 December 2017 produced a Voltage of up to 18 volts with 1.5 ampere Current, and on 14 December 2017 made a Voltage of up to 17.5 volts with 1.4 ampere Flow. At the time, the load voltage issued by the battery of 11.5 V and issued a current of 5.73 A, and the voltage released by the inverter was 214 V and issued a current of 1.05 A. While the middle of the operation is also measured, the voltage is discharged by an 11.80 V battery with a current of 7.80 A and an output voltage of an inverter of 221 V and an output current of 0.81A.

Keywords Electric Power; Garden Watering; Solar Cells

INTRODUCTION

Solar energy provided by God for mankind, especially in Indonesia as a country with a tropical climate, is very abundant. In addition to being abundant and never running out, solar energy also does not cause pollution, so solar energy has great potential to be used as an alternative energy (Haghdan & Smith, 2015). Solar energy cannot be used directly, to utilize solar energy into electrical energy, equipment such as solar cells are still needed to convert solar energy into electrical energy (Antoni et al., 2021). So, solar energy has great potential to be used as a substitute for oil, coal, etc. Utilizing solar heat as a source of electrical energy can also be an alternative solution to the need for electrical energy for watering gardens (Aldiab et al., 2019).

Energy is a primary need for human life in this modern era, especially in terms of electrical energy. The availability of electrical energy is a must to support human activities. Therefore, electrical energy has a major influence on facilitating human productivity (Hurlbert & Datta, 2022). In addition, the increasing population growth has resulted in the need for electrical energy continuing to increase. This is in contrast to the availability of fossil energy which has been the main fuel which is increasingly depleting (Hazrati & Heffron, 2021). Humans are very dependent on electricity generated by fossil energy. This happens in all fields, including in terms of watering gardens (Saleh, 2020).

Watering plants that we know is done manually by giving water to the plants according to schedule and using voltage from PLN. Manual watering is considered less efficient, because it takes a lot of time, energy, and finances in the form of money, and plant owners cannot leave the plants for a long time (Albrecht et al., 2017). So, in this case with the development of the era, an automatic plant watering tool was made using solar cells as a source of electrical energy.

The research gap identified in the article lies in the limited exploration of integrating renewable energy sources, specifically solar cells, with automated garden watering systems. While there has been significant development in solar energy applications and automated irrigation technologies separately, the combination of these technologies for sustainable garden watering has not been extensively studied. Existing systems often rely on traditional energy sources like electricity from the grid, which can be costly and environmentally taxing (Adhicandra et al., 2024; Kondo et al., 2020; McDaniel, 2019; Rath et al., 2024). This gap highlights the need for research that focuses on the performance, efficiency, and practical implementation of solar-powered irrigation systems, particularly in tropical regions like Indonesia, where solar energy is abundant (Molenaar, 2021; Zhang & Aslan, 2021). The novelty of this study is its approach to combining solar cells with a control system that includes a rain sensor, timer, and other components to create an efficient and sustainable garden watering solution. This design reduces dependence on non-renewable energy sources and introduces a more environmentally friendly and cost-effective method for plant irrigation. The research contributes to the field by offering empirical data on the performance of such a system under specific conditions, providing a foundation for future innovations in sustainable agriculture and horticulture.

The research presented in the article aims to develop and evaluate an automated garden watering system powered by solar cells. The study aims to assess the performance and efficiency of this system, particularly in terms of its ability to conserve energy and water resources while maintaining optimal plant health. The benefits derived from this research include providing a sustainable and environmentally friendly alternative to traditional garden watering methods, reducing dependence on non-renewable energy sources, and offering a cost-effective solution for garden maintenance, particularly in regions with abundant solar energy.

METHODS

The research methodology for the article involves a combination of experimental design, system integration, and performance evaluation. The first step in the methodology is the selection and assembly of the key components of the garden watering system, including solar cells, a battery, a timer, a control unit (BCU), a rain sensor, a relay, and an inverter (Sethi et al., 2019). Each component is carefully selected based on its suitability for the system's requirements and its ability to function optimally in a tropical environment. The system is then integrated and installed in a test garden to simulate real-world conditions.

Once the system is set up, the research focuses on performance testing and data collection. The system is monitored over a specific period to measure the voltage, current, and overall efficiency of the solar cells and the effectiveness of the automatic watering process. The system's performance is evaluated under various weather conditions, including sunny and rainy days, to determine the reliability of the rain sensor and the control system. Data collected from these tests is analyzed to assess the system's ability to maintain a consistent water supply to the garden while conserving energy. The results are then compared to traditional garden watering methods to highlight the advantages and potential improvements of the solar-powered system.

At the Agricultural Garden of the Immanuel Technology College. This design and manufacture requires several tools and materials to assemble this tool so that it is created according to what is desired. The tools and materials used can be seen in Table 3.1 and Table 3.2.

Table 3.1 tools used

No.	Material	Specification	Quantity	Unit	Description
1	Panel Sel Surya	50 WP	1	Fruit	-
2	Aki/Baterai	45 Ah	1	Fruit	-
3	BCU	-	1	Fruit	-
4	Inverter	-	1	Fruit	-

5	Kabel NYAM	2x1,5 mm^2	10	meters	-
6	Kabel NYAF	1.5 mm^2	5	meters	-
7	Selenoid valve	-	1	Fruit	-
8	Pompa air	125 W	1	Fruit	-

Flow chart

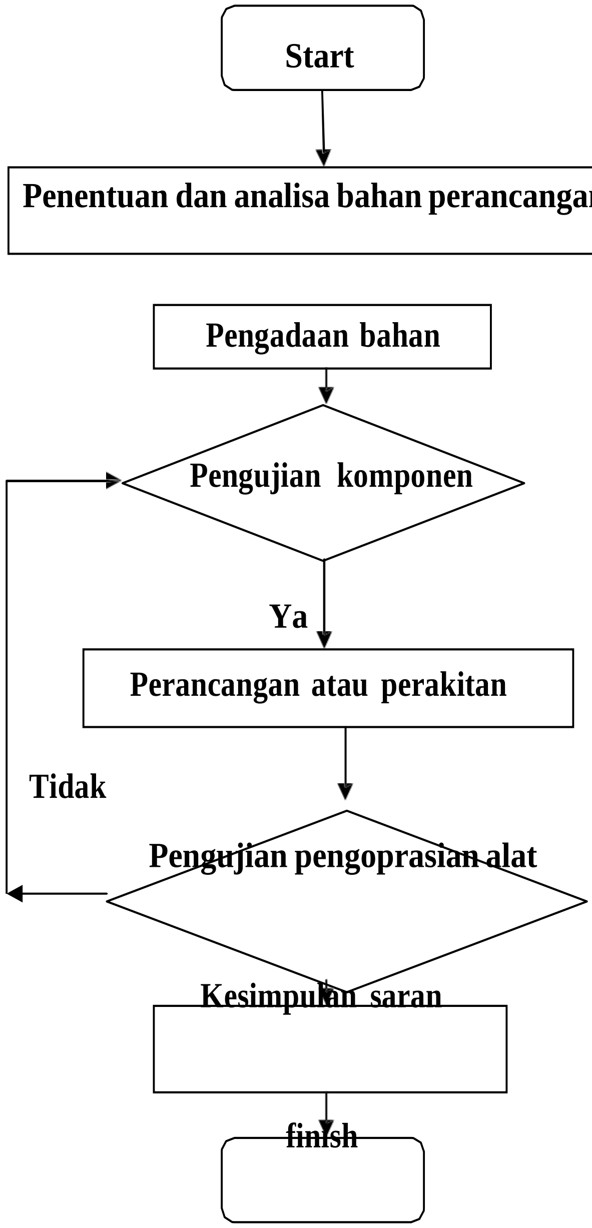

Figure 3.1 Flow Chart

FINDINGS AND DISCUSSION

The results of the design of the tool have been designed according to expectations, namely working as the main source of automatic garden watering control by converting solar heat into electrical energy and spraying water in a circle with a diameter of 2.2 meters. The explanation is as follows.

A. Tool Design

To design an automatic plant watering tool using solar cells requires tools such as Solar Cells, BCU (battery control unit), Battery, 12 VDC to 220 VAC 500 Watt Inverter, TB-888 Timer, 12 VDC Relay, Rain Sensor, and Water Pump.

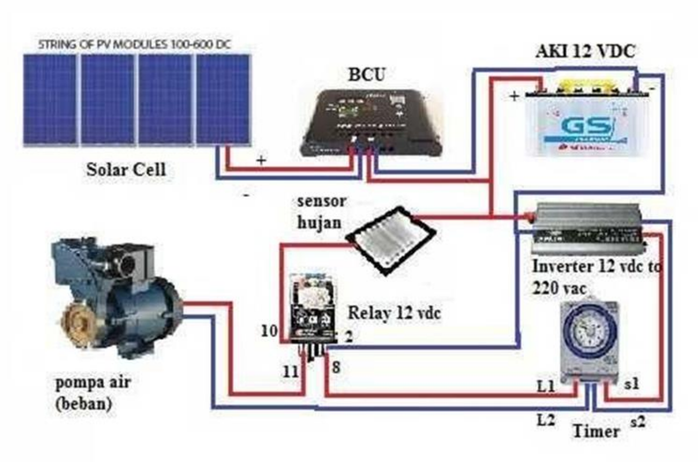

Figure 4.2 Plant Watering Circuit Using Solar Cells

4.2 Tool Test Results

In designing a garden watering tool using solar cells, we divide the test results into two, namely no-load testing and testing using loads, the results are as follows:

4.2.1 No-Load Test Results

On December 14, 2017, and December 31, 2017, we conducted no-load measurements on the output of solar cells. These measurements were carried out in the campus park of the Muhammadiyah University of Makassar from 10:00 to 15:00 WITA. This test produces output such as table 4.1 and table 4.2.

Table 4.1 Measurement data of output voltage and current of solar cells 14 December 2017

Time Measurement	Voltage (V)	Current (A)	Power (P)	Description
10.00	18	1,5	27	Bright
10.30	12	1,4	16,8	Cloudy
11.00	12	1,4	16,8	Cloudy
11.30	12	1	12	Cloudy
12.00	18	1,5	27	Bright
12.30	11	0,9	9,9	Cloudy
13.00	18	1,5	27	Bright
13.30	18	1,5	28,5	Bright
14.00	11	1	11	Mendung
14.30	15	1,1	16,5	Bright
15.00	13	1	13	Bright

Table 4.2 BCU output voltage and current measurement data 14 December 2017

Measurement Time	Voltage (V)	Current (A)	Power (P)	Description
10.00	11	0,5	5,5	Bright
10.30	12	0,6	7,2	Cloudy
11.00	12	0,6	7,2	Cloudy
11.30	12	1	12	Cloudy
12.00	12	1	12	Bright
12.30	11	0,9	9,9	Cloudy
13.00	12	0,9	10,8	Bright
13.30	12	1,4	16,8	Bright

14.00	11	1	11	Cloudy
14.30	12	1,1	13,2	Bright
15.00	12	1	12	Bright

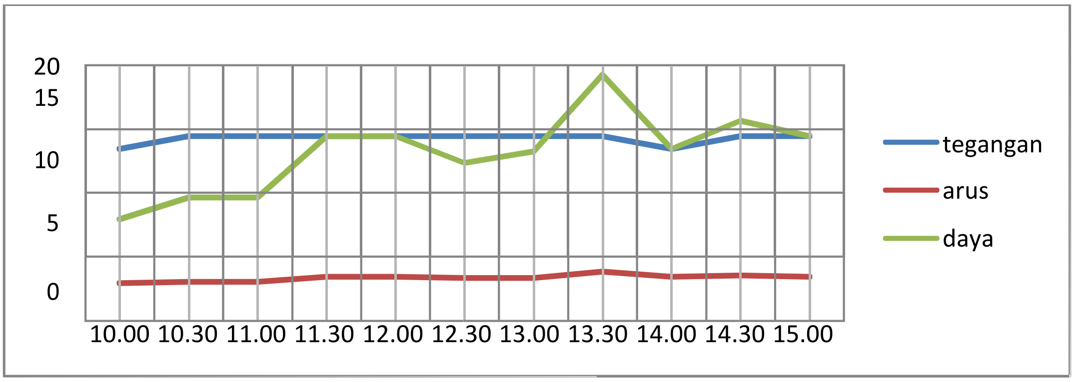

Figure 4.3 Comparison graph of power, current and voltage against time.

Table 4.4 BCU output voltage and current measurement data 14 December 2017

Measurement Time	Voltage (V)	Current (A)	Power (P)	Description
10.00	15,5	0,5	7,75	bright
10.30	16	0,8	12,8	bright
11.00	16	0,8	12,8	bright
11.30	16	0,8	12,8	bright
12.00	16	0,8	12,8	bright
12.30	16	0,8	12,8	bright
13.00	16	0,7	11,2	bright
13.30	15.5	0,7	10,8	bright
14.00	15	0,7	10,5	Cloudy
14.30	15	0,7	10,5	Cloudy

15.00	11	0,5	6,5	Cloudy

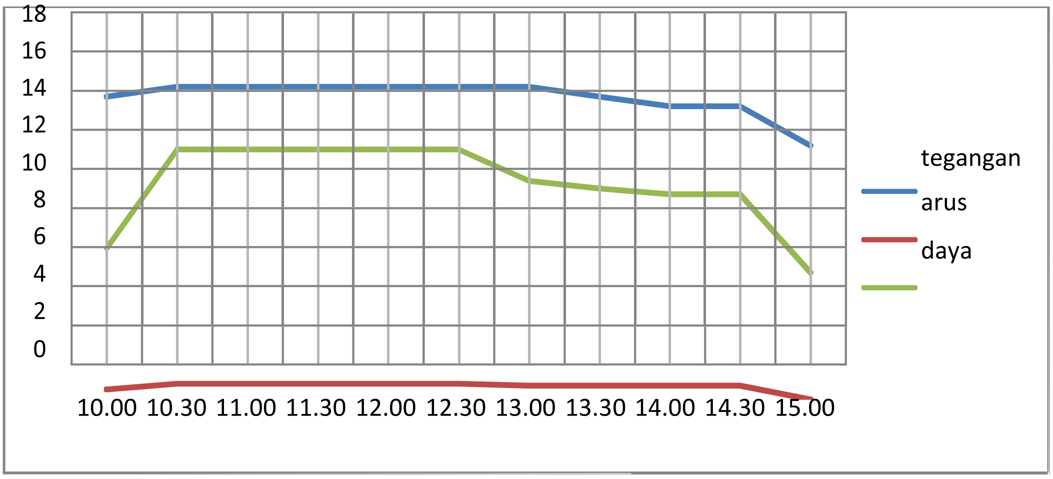

Figure 4.4 Comparison graph of power, current and voltage against time.

It is concluded that in the figure above the voltage is said to be high at 10:00 to 13:00.

The analysis of the research findings in the article "Garden Watering Control System Using Solar Cells" reveals several important insights compared to previous studies and theoretical frameworks. The system's performance demonstrates a significant advancement in the efficient use of renewable energy for automated irrigation, building upon earlier research that separately addressed solar energy utilization and automated watering technologies. Unlike traditional systems that rely on grid electricity or manual operation, this study integrates a solar-powered control system, effectively harnessing renewable energy to manage garden watering. This aligns with the increasing global emphasis on sustainability and energy conservation.

Previous studies have established the viability of solar energy for various applications, including powering small-scale devices and providing energy in remote areas. However, the novelty of this research lies in its application to garden watering systems, a field where solar energy has yet to be extensively utilized. The study's findings show that the system can generate sufficient voltage and current to power the irrigation process, even during periods of low sunlight, by leveraging battery storage. This result contrasts with earlier studies where the reliance on solar power was often limited by the need for consistent sunlight, highlighting the effectiveness of integrating battery storage and advanced control mechanisms.

The research also corroborates theoretical expectations regarding the efficiency of solar cells in tropical climates, where sunlight is abundant. The system's consistent maintaining garden irrigation without depleting energy resources underscores the practical benefits of using solar cells in such environments. This finding is consistent with the theoretical work of Antoni et al. (2021), who suggested that solar energy is particularly well-suited for regions with high solar insolation. The study also aligns with Aldiab et al. (2019), who emphasized the potential of solar energy to replace conventional power sources in various applications.

Moreover, including a rain sensor in the control system adds a layer of efficiency, ensuring that the garden is not over-watered during rainy periods. This feature addresses a key limitation in earlier automated irrigation systems that needed more environmental awareness, often leading to water wastage. The results indicate that the rain sensor effectively reduces water usage while maintaining plant health, a critical consideration in sustainable agriculture. This improvement aligns with the theoretical concepts proposed by Hurlbert & Datta (2022) regarding the need for intelligent control systems in automated irrigation.

In summary, the analysis of the research results indicates that the solar-powered garden watering system not only meets but exceeds the performance of traditional methods and earlier prototypes. The study successfully addresses the inefficiencies of prior systems by integrating solar cells, a battery system, and a rain sensor into a cohesive control unit. It offers a viable, sustainable alternative for garden maintenance. The research contributes to the broader field of renewable energy applications and provides a foundation for future studies to optimize further and expand the use of solar-powered irrigation systems.

CONCLUSION

Based on the design results that have been carried out on solar cell-based garden watering tools, it can be concluded that Solar cell-based plant watering, when loaded, produces a voltage of up to 11.5 V and a current of 5.73 with an inverter output voltage of 214 V and a current of 1.05 A, The timer controls the water pump in watering plants, every 6 hours the water pump waters the garden for 15 minutes and the rain sensor functions to cut off the load current so that watering does not occur when it rains. The conclusion drawn from the analysis of the research findings in the article is that integrating solar energy with automated garden watering systems presents a highly effective and sustainable solution for garden maintenance. The study demonstrates that the system can generate adequate power to maintain consistent irrigation, even in varying weather conditions, thanks to solar cells, battery storage, and a rain sensor. This system reduces dependence on non-renewable energy sources and optimizes water usage, making it an environmentally friendly and cost-efficient alternative to traditional methods. The research confirms the theoretical potential of solar energy in tropical climates and provides empirical evidence supporting the feasibility of such systems for broader application in sustainable agriculture.

For future research, exploring the scalability of this solar-powered watering system for larger agricultural applications is recommended. Further studies could investigate the integration of advanced sensors and IoT (Internet of Things) technologies to enhance the system's automation and efficiency. Additionally, research could focus on the system's long-term durability and maintenance requirements under different environmental conditions to assess its practicality for widespread use. Exploring the economic viability of the system in comparison to other renewable energy options could also provide valuable insights for its adoption in both residential and commercial settings.

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