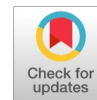


Design and Implementation of Smart Rural Home Water Supply System using PIC Microcontroller and Solar Energy

Sylvester Tirones, Yue Hu, Salvius Teke, Zephaniah Menau



Abstract: Water is imperative for survival, especially for living organisms and their biology. Water is essential for everyday use. Integrating solar photovoltaic systems with water supply provides a cost-effective mechanism to address the water scarcity problem; however, conventional water supply systems typically feature a water pump and reservoir for water storage, but lack precise monitoring systems. That means there is no control over the water flow from the ground level to the targeted reservoir. In this paper, we present the application of solar energy extraction that can be utilised through a controller mechanism, enabling water to be readily available for rural applications such as domestic households, agricultural farming, livestock, schools, and hospitals. The objective of the design is to utilise a PIC microcontroller to facilitate the entire operation of the solar-powered water supply system. We primarily focus on developing a cost-effective and straightforward controller that can be reliably installed on conventional water supply systems. The methods presented in this paper are based on simulation and prototyping. The results show that the controller can precisely monitor and control the reservoir's water level. The primary motivation of this system is to target the isolated and remotest areas of Papua New Guinea. It applies to other countries to provide a cheap and reliable solar-powered water supply system that will save labour and improve living standards by providing the recipient with easy access to clean water.

Keywords: Programmable Interface Controller (PIC) Microcontroller, Renewable Energy, Solar Photovoltaic, Standalone System, Water Supply

Abbreviations:

PIC: Programmable Interface Controller
MPPT: Maximum Power Point Tracking
ToF: Time-of-Flight
IDE: Integrated Development Environment
PV: Photovoltaic

I. INTRODUCTION

The lack of remote access to clean and reliable water

Supply globally has been a persistent challenge, affecting the health and well-being of the local population. Access to clean water is not only a fundamental human right but a critical factor for health, economic development, and social stability in these areas [1]. In rural regions, the availability of clean water for households is often limited, forcing residents to rely on manual methods that can be time-consuming and physically demanding. The existing water supply systems are usually inefficient, outdated, and unsustainable. To address these challenges, our project aims to harness the power of solar energy and utilise automation technology to deliver a reliable and sustainable water solution to rural homes. The integration of renewable energy systems, particularly photovoltaic (PV) technology, with innovative water management techniques holds immense promise for ensuring reliable and sustainable water access, especially in regions lacking traditional energy infrastructure [2].

The need for this project is underscored by the fact that many rural areas lack access to a consistent electricity supply, making conventional water pumping systems impractical. Water pumping is tremendously utilized in irrigation systems by many farmers worldwide [3]. Solar energy, as a renewable and environmentally friendly power source, offers an ideal solution to this problem. By integrating solar panels and a microcontroller-based system, we aim to create a water supply system that can operate efficiently even in off-grid rural areas.

Although there are some innovative works on using solar energy and water supply systems for wider applications and farming methods [1], our innovative work targets rural homes. It comprises mainly a controller design integrated into the existing solar PV and pumping system [2]. The sensors attached to the controller play a crucial role in detecting the water levels in the household reservoir tank. When the sensors detect low water levels, the microcontroller activates the solar-powered pump to deliver water to the tanks. This system ensures the house has a consistent and efficient water supply while conserving energy through the use of solar power. The sensors also provide the pump shuts off when the tank is full, preventing waste and optimizing water distribution.

Finally, in the future, we hope to collaborate with local organizations and authorities responsible for rural development projects to envision the deployment of such designs of water supply systems using the model and prototype in isolated rural areas of Papua New Guinea [4]. Ultimately, the goal is to pilot the system in select locations, with the potential for customisation tailored to specific community needs. Ultimately, The implementation of this solar-powered, microcontroller-driven water

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*Correspondence Author(s)

Sylvester Tirones*, Researcher, Department of Electrical Engineering, Shanghai Jiao Tong University, Shanghai, China. Email ID: stirones@sjtu.edu.cn, ORCID ID: [0009-0007-0241-1590](https://orcid.org/0009-0007-0241-1590)

Yue Hu, Senior Engineer, Department of Electrical Engineering, Shanghai Jiao Tong University, Shanghai, China. Email ID: yuehu@sjtu.edu.cn

Salvius Teke, Student, Department of Applied Physics, Electronics and Instrumentation, Papua New Guinea University of Technology, Lae, Papua New Guinea. Email ID: salviusteke6@gmail.com

Zephaniah Menau, Student, Department of Applied Physics, Electronics and Instrumentation, Papua New Guinea University of Technology, Lae, Papua New Guinea. Email ID: 19800572syti@pgs.pnugot.ac.pg

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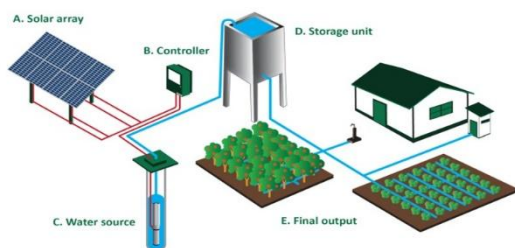
supply system has the potential to enhance the quality of life for rural residents, promote sustainability, and contribute to the overall development of rural communities.

II. METHODOLOGY

In this section, we shall present the existing designs of water supply systems and some of their major components. Due to the lack of a control mechanism, we shall fully integrate intelligence sensors to automate this system without human input. Figure 1 illustrates the conventional design of the water supply system utilising solar PV systems in rural locations.

A. Conventional System

The conventional system consists of a solar PV array, a water pump controller, a DC water pump, a storage unit, and the water outputs labelled A, B, C, D, and E.



[Fig.1: Conventional Design of Deep Well Submersible Solar-Powered Water System for Domestic Uses [5]]

The solar water pump kit is available for purchase and can be installed directly [6], for remote applications relating to water systems. Figure 2 shows the solar water pumping kit.



[Fig.2: Solar Water Pump Kit. (a) Solar Array, (b) Pumping Unit, and (c) Solar Pump Controller [6]]

Photovoltaic cells are integrated into solar arrays as shown in Figure 2(a). It converts the light energy into DC electrical energy. Many solar pumps require a controller if they are to be powered directly by Photovoltaic (PV) modules (without batteries). Solar pump controllers optimize the solar water pumping system by translating the current and voltage extracted from the PV panels into a combination that is better matched to that required by the pump [7].

The solar pump controller can run a water pump with solar power. When there is sufficient sunshine, it can convert DC from solar panels to AC to power the water pump, allowing water to be transported from water sources to areas that need it. The solar pump controller is shown in Figure 2(c). It is built based on MPPT Maximum Power Point Tracking (MPPT) technology, which can maximize the output efficiency of solar panels, and make full use of solar energy to create AC electricity [8].

Most rural homes are situated closer to such water sources for easy access. The pumping unit consists of a solar-powered water pump that supplies water from the sources to the reservoir. The submersible solar-powered water pump specification in Figure 2(b) can be chosen according to Table 1 below.

Table-I: Specification of Submersible DC Water Pump [5]

DC Pump Model	Pump Power	Water Flow (m ³ /h)	Water Head (m)	Outlet (inch)	Weight (kg)
3JTS(T)1.0/30-D24/80	80W	1.0	30	0.75"	7
3JTS(T)1.5/80-D24/210	210W	1.5	80	0.75"	7.5

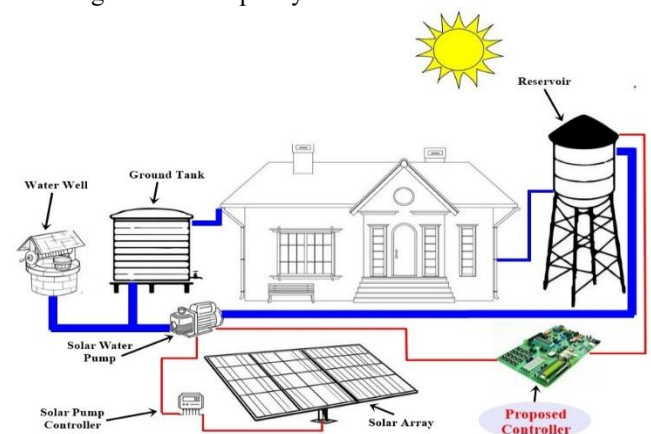
The storage unit is the reservoir. The reservoir can be a tank or a metallic structure that stores water at a certain height. The water inlet will be situated at the top, while the outlet can be at the bottom, as shown in Figure 1(d)—the solar-powered water pump's ability to determine the reservoir's height.

B. Design Approach

The proposed design approach section of this paper presents the overall work scope for the home water supply system. It also presents the design's simulation and computational analysis, including solar sizing, flow rate, and reservoir-tank selection.

C. Overall Proposed Design

Although the proposed design in Figure 3 is similar to the conventional system, it features an additional controller system, the PIC16F877A microcontroller, for monitoring and controlling the water capacity at the reservoir.



[Fig.3: The Overall Proposed Scheme of the Solar-Powered Water Supply System]

D. Solar Sizing

This simple setup requires a solar PV panel. The system operation is proposed to run during the day. The entire circuit will begin operating when the PV panel produces enough power. The specific solar module data for simulation is given in Table 2. The solar array maximum voltage for this design, using the pump model [3JTS(T) 1.0/30-D24/80], as listed in Table 1, is 36V. The solar water pump kit in Figure 2 can be purchased [6] and installed.

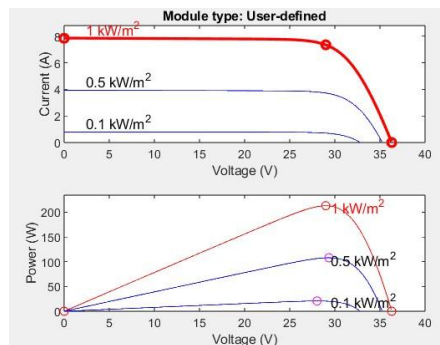


The solar pump controller is also included.

Table-II: The Selected Solar PV Module Specifications

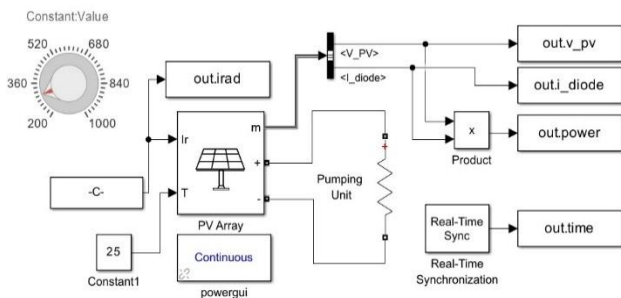
Solar PV Module Data	Parameters
Maximum power (W)	213.15
Cells per module (Ncell)	60.00
Open circuit voltage Voc (V)	36.30
Short circuit current Isc (A)	07.84
Voltage at maximum power point, Vmp (V)	29.00
Current at maximum power point Imp (A)	07.35

The I-V and P-V characteristics of the solar module are shown in Figure 4.



[Fig.4: The I-V and P-V Characteristics of a Solar Module at a Constant Temperature of 25°C.]

The average irradiance simulation in MATLAB for the PV array is depicted in Figure 5.



[Fig.5: Simulation of PV Array with MATLAB]

This is a DC system used for the pumping unit, which comprises the controller and the DC water pump. The result is provided in section 3.1.

E. Flow Rate

This is a DC system used for the pumping unit, which comprises the controller and the DC water pump. The result is provided in section 3.1.

$$Q = \frac{V}{t} = vA \quad \dots (1)$$

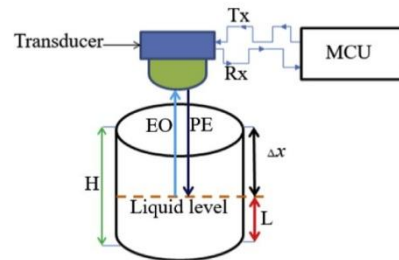
where V The volume, v , is the velocity, and A is the pipe's cross-sectional area. Using Table 1, if the height of the reservoir is chosen to be less than 30 meters, the 80W DC pump [3JTS(T)1.0/30-D24/80] is to be selected, with an average flow rate of 16.6 litres per minute, as calculated using Equation 1. Filling the reservoir with 1,000 litres of water and exposing it to constant sunlight would take one hour. The specific selected solar water pump kit is shown in Figure 2.

F. Principle of Reservoir System

The tank selection to be used as a reservoir can be computed using Equations 8 and 9, as shown in Figures 9 and 10. The tank is proposed to be the best fit for the design, with a wider

radius and a standard fix below a height of 21 meters. If the distance is greater, the performance of the ultrasonic sensor may decline. Pulse-Echo mode uses an ultrasonic transducer that serves both emitting and receiving functions, emitting a tone burst wave with a probe. Pulse-Echo configuration is mainly used for liquid-level sensing, and the computational analysis can be found in [9].

In Figure 6, the fluid level measuring transducer is installed at the top of the storage tank. The transducer is set into vibration with a series of amplified burst signals at a centre frequency range of kHz –MHz to generate a propagation wave that the transducer would detect as an echo after hitting the surface of a structure [9].



[Fig.6: Water Level Determination using Pulse-Echo Configuration [9]]

The depth of the empty tank is H , the depth of the tank from the transducer level to the water level surface is, and the depth of the water level is L . Time-of-Flight (ToF) is the total time taken for the transmitted Pulse (PE) signal to return to the transducer as Echo (EO) after interaction with the water surface [9].

$$PE_t = \frac{\Delta x}{v} \quad \dots (2)$$

$$EO_t = \frac{\Delta x}{v} \quad \dots (3)$$

$$TOF = \frac{2\Delta x}{v} \quad \dots (4)$$

$$v = f\lambda \quad \dots (5)$$

where;

PE_t = pulse transmission time

EO_t = echo transmission time

Δx = distance from the sensor to the water level surface

TOF = time of flight of sensor signal

Hence, the water depth in the reservoir tank is

$$L = H - \Delta x \quad \dots (6)$$

And the percentage of water in the reservoir tank is

$$W_{level} (\%) = \frac{(H - \Delta x)}{H} \times 100\% \quad \dots (7)$$

G. Circuit Component

The circuit components specify the materials and elements used in the design presented in this paper. The discussions of the The main components in Table 3 are present in the design of the controller and the prototype model, as shown in Figure 12. Other necessary

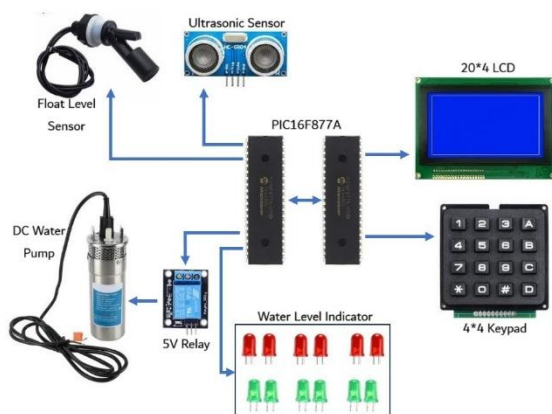


system requirements are discussed in sections 2.1 to 2.5.

Table-III: Main Components for the Design of the Water Supply System

No	Main Components	Functions
1	HC-SR04 ultrasonic sensor	It is used as a sensor to monitor the height or water level in the reservoir.
2	PIC16F877A	Used as a central controller for monitoring and controlling the entire function of the water supply system.
3	5V DC Relay	The relay is an electromechanical device that operates by switching the water pump on and off.
4	20x4 LCD	A liquid crystal display (LCD) displays prompt messages and the system's current operation.
5	4x4 Keypad	The keypad allows the user to enter the parameters for the modes of operation and the water level into the microcontroller.
6	LEDs	Light-emitting diodes (LEDs) indicate the modes of operation and the water level at the current state.
7	Float level sensor	This sensor measures the maximum volume of water in the reservoir. If the system fails, it acts as an emergency switch for the water pumping unit.

The power for the controller circuit is accessed through the PV array using a DC-DC buck converter. Figure 7 shows the main circuit components that utilise the design of the proposed water supply system.



[Fig.7: Circuit Diagram of the Proposed Controller for the Water Supply System]

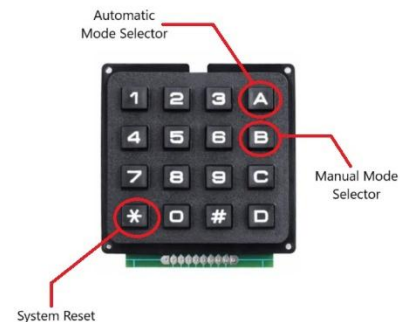
Due to the limited program memory size in the PIC16F877A microcontroller and the vast amount of source code, it is impossible to embed the entire program into a single microcontroller. Therefore, this application used two microcontrollers.

PIC microcontrollers (MCU) are widely used in applications that require automation and specific algorithms for the standalone operation of electronics [10]. For microcontrollers to function fully as hardware, they require specific software or an integrated development environment (IDE) that is responsible for flashing instructions into the microcontroller's program memory. The programming of the PIC16F877A MCU uses PIC Kit 3 [11].

H. Mode of Operation

The design focuses on building an automated controller for the water supply system. The controller's function is to monitor and control the operation of the pumping unit and the

water level within and outside the reservoir, while also providing the user with the flexibility to access and operate the system. The keypad input controls the mode of operation.



[Fig.8: Keystroke for Selection of the Mode of Operation]

The following highlights the main functions of the proposed controller design. There are three primary functional modes proposed.

I. Automatic Mode

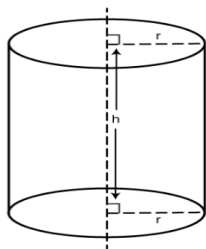
When choosing the automatic operation [Press '*' for 3 seconds and then 'A'], the system monitors the water level only at full capacity. The system will allow the pumping unit to supply water to the reservoir whenever needed. When the water reaches the full capacity or maximum volume of the reservoir, the controller enables the pumping unit to shut down, thereby disallowing water flow to the reservoir. If the water level drops below the full capacity, the controller automatically enables the pumping unit to switch on, allowing water to be pumped back into the reservoir. The pumping unit's switching is achieved by using an electromechanical relay, which acts as a switch for the pump.

Table 4 shows the prototyping capacity threshold. Therefore, the automatic operation will enable the reservoir to maintain the water level at full capacity of 100%.

J. Manual Mode

The manual operation [Press '*' for 3 seconds and then 'B'] enables the user to operate the system as they desire manually. The flexibility in manual design offers a range of options available for the amount of water to be stored in the reservoir. Three options are available or proposed in this design, given in a percentage scale. The three options correspond to the three sets of volumes that require monitoring. The threshold for each volume is pre-programmed during system installation. The volume of the water can be calculated using the formula below for specific tanks.

Fixed roof tanks are simple cylindrical storage tanks that may have flat or (more commonly) shallow conical roofs welded to the shell [12]. This design proposes two sets of reservoir tanks: the cylindrical and the cuboid reservoirs, as shown in Figures 9 and 10, respectively. The volume of a cylinder is the space occupied by the cylinder in a three-dimensional space. Calculation of the volume. The design of a cylinder helps create a cylindrical objects, such as water tanks and wells, bottles, containers, and pipes [13].



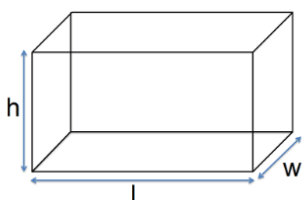
[Fig.9: Cylindrical Plane for Volume Computation [13]]

The volume $V_{cylinder}$ of a cylindrical tank used as a reservoir can be computed as

$$V_{cylinder} = \pi r^2 h \quad \dots (8)$$

Where r is the radius of the tank's base, and h is the height of the tank.

On the other hand, a cuboid tank can be used as a reservoir. It has six rectangular faces, as shown in Figure 10.



[Fig.10: Cuboid Plane for Volume Computation [14]]

The volume V_{cuboid} of the cuboid reservoir can be computed as

$$V_{cuboid} = lwh \quad \dots (9)$$

Where l is the length, w is the breadth or width, and h is the height of the cuboid. In the prototype, we demonstrate how the model functions in manual mode. By using a transparent bucket, we provide a specific percentage scale corresponding to the volume of the liquid. The threshold level for manual operation is computed in Table 4.

Table-IV: Reservoir Threshold for Manual Operation Using the Prototype

Level	Threshold (%)	Δx (cm)	L (cm)	Volume (cm ³)
0	0	∞	< 4	< 1256.6
1	25	29	4	1256.6
2	50	25	8	2513.3
3	75	21	12	3769.9
4	100	17	16	5026.5
Float Level Sensor Mode				> 5026.5

The volume is computed using Equation 6. The Δx represents the distance from the ultrasonic sensor to the water level, and L represents the distance from the water level to the tank base.

The tank has a diameter of 20 cm ($r = 10$ cm) and a height of 33 cm. Therefore, equation 2 is used to compute the tank's volume (cm³) from the base tank.

$$V_{tank} = \pi \times r^2 \times H \quad \dots (10)$$

The values in Table 4 are computed using Equations 6 and 10.

K. Emergency Mode

This special content proposes a float-level sensor as an

emergency shutdown switch for the pumping unit. The float level sensor is visible in Figure 11(a). The emergency shutdown purposely prioritises switching the pumping unit off only when the water reaches the reservoir at a level greater than the maximum capacity or 100% threshold.



[Fig.11: Prototyping Model of the Reservoir]

This sensor will operate only if the system produces an error when using the ultrasonic sensor. In this case, the pumping unit continuously pumps water to the reservoir. Thus, as soon as the water reaches the float level sensor, the relay will be activated and the pump will stop. Figures 11(a) and (b) illustrate the float level and ultrasonic sensors.

L. Prototype

This section presents the prototype of the water supply system using the PIC microcontroller. Although the work in [1] is quite advanced using the Internet of Things (IoT), it may not be more suitable in areas without network connectivity.



[Fig.12: Overall Prototyping Model of the Proposed Water Supply System]

The prototype comprises the necessary functional elements for designing the rural water supply system. The component in Figure 12 is used to test the functionality of the proposed design controller.

Table-V: List of Main Prototype Components in Figures 11 and 12

Key	Specification	Component
(a)	Bucket volume of 0.0104m ³	Reservoir (bucket)
(b)	Transparent rubber tube with a cross-sectional area of 0.00196m ² , 0.8m	Water inlet tube
(c)	12V, 40W, polycrystalline small solar panel	Solar panel
(d)	DC12V 60W Mini electric water pump	Water pump
(e)	12V 12Ah Solar battery	Battery
(f)	Proposed controller hardware	Proposed controller
(g)	Bucket volume of 0.0104m ³	Ground tank (bucket)
(h)	Transparent rubber tube with a cross-sectional area of 0.00196m ² , 0.5m	Reservoir outlet tube
(i)	Float level sensor	Figure 11 (a) Float level sensor
(j)	HC-SR04	Figure 11 (b) Ultrasonic sensor

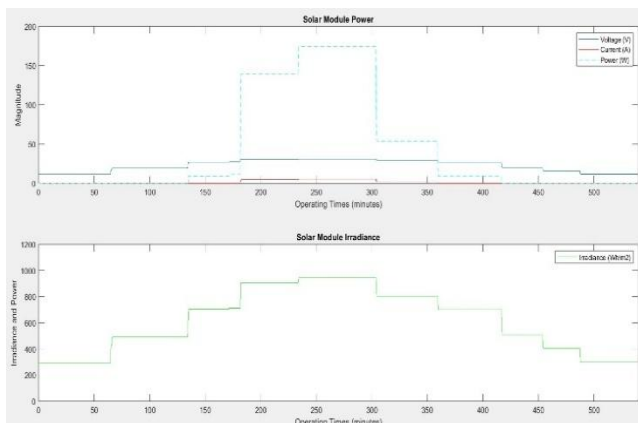
The component listed in Table 5 is used solely for building and testing the prototype. The prototype was used in the presentation of this system and was presented at the 2023 Annual Morobe Show in Papua New Guinea. The primary objective is to test the controller's functionality and verify whether it operates within the specified operating conditions as intended. Figure 12 (a) shows a bucket representing the reservoir. The bucket volume was computed and labelled in percentage for each operating condition. The result in the next section reports the outstanding feedback operation of the proposed controller, which adapts to changes in the input water to the reservoir and the change in the water volume stored in the reservoir.

III. RESULTS AND DISCUSSION

The results in this section elaborate on the design scope and specification of the working principles as identified in the design section of this paper. Section 3.1 presents the test results obtained during the simulation of the PV module's varying irradiance, as follows. The algorithm, which concerns the functional essence of this design, is also discussed in Section 3.2 as a flowchart.

A. Solar PV Module

Figure 13 shows the simulation result of the PV module in Section 2.2.2. It displays the solar module's power under varying irradiance throughout the day.



[Fig.13: Simulation Result of the PV Module with MATLAB]

Table 6 shows the specific simulation hours of the day and

the time intervals selected.

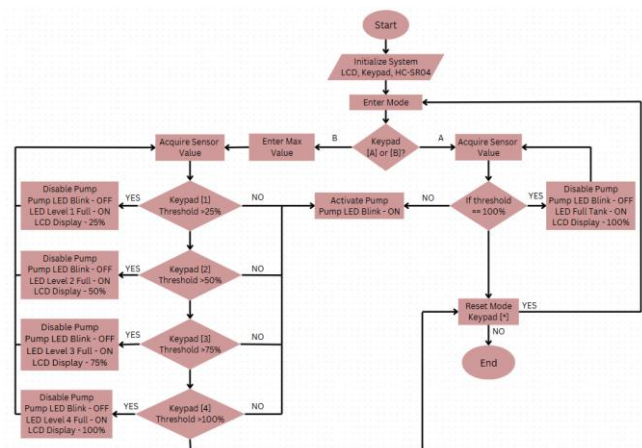
Table-VI: The Solar PV Irradiance Throughout the Day

Hour of Day	Irradiance (Wh/m ²)	Operating Time (60-minute interval)
08:00 – 09:00 am	300	60
09:00 – 10:00 am	500	120
10:00 – 11:00 am	700	180
11:00 – 12:00 pm	900	240
12:00 – 01:00 pm	950	300
01:00 – 02:00 pm	800	360
02:00 – 03:00 pm	700	420
03:00 – 04:00 pm	500	480
04:00 – 05:00 pm	300	540

The system's minimum rated power is from 9:00 am to 11:00 am and from 2:00 pm to 3:00 pm. Its maximum power is between 11:00 a.m. and 2:00 p.m.

B. Operation Mode

This design offers two operating modes, providing flexibility and enhanced performance. The flow chart indicates explicitly the overall operation of the algorithm embedded in the PIC MCU. The MCU controls the reservoir's water inlet and outlet through a network sensor, which is available for reading the reservoir's water level.



[Fig.14: Flow Chart Algorithm of the Proposed Water System]

The working of the automatic mode is described in section 2.4.1. On the other hand, the working of the manual mode is described in section 2.4.2. The manual mode is programmed using Table 4 for the prototype. The discussion presents the prototype testing of the two modes of operation.

C. Prototype Discussion

The test results of the water supply system using solar PV energy are shown below. The following descriptions and figures were obtained from the prototyping model, as given in section 2.5. The overall summary of the test is presented in the flow chart in Figure 14. The discussion is based on the following sequence of operations: start-up, Automatic Mode Test, and Manual Mode Test.

D. Start-Up

During start-up or power-on, the user is prompted to select one of the two modes, as shown in Figure 15.



[Fig.15: System Start-up - User Prompt Mode]

If the keypad (A) is pressed, the system will operate in automatic mode. The programming algorithm is illustrated in the flowchart in Figure 14. Automatic mode is discussed in sections 2.4.1 and 3.3.2.

The system will function manually if the keypad (B) is selected. The programming algorithm is illustrated in the flowchart in Figure 14. Manual mode is discussed in sections 2.4.2 and 3.3.3.

E. Automatic Test Mode

In this section, we shall present the test for the automatic mode. Figure 16 shows the controller displaying the automatic mode as active.



[Fig.16: Activation of Automatic Mode]

During this process, the water pump is pumping water to the reservoir. If the HC-SR04 ultrasonic sensor detects a threshold capacity of 100%, the PIC MCU will enable the relay to switch off the pumping unit.



[Fig.17: Automatic Mode Prototype Testing]

Figure 17 illustrates the proposed model of the water supply system, which maintains the water level at full capacity. If the water level falls slightly below the full capacity threshold, the pump will automatically turn on to replenish the reservoir and maintain its full capacity.

F. Manual Test Mode

This section presents the prototype test for the controller's manual mode. Four threshold algorithms are programmed into the PIC MCU. The threshold is illustrated in Table 4 of Section 2.4.2. When entering manual mode, as previously displayed in Figure 15 of Section 3.3.1 by pressing keypad (B), the system prompts the user to enter the maximum level

desired for each of the four thresholds. The level selection is shown in Figure 18.



[Fig.18: Maximum Level Selection Prompt in Manual Mode]

If the keypad (1) is selected, the level 1 manual mode is activated. Level 1 corresponds to the threshold of 25% of the water to be stored in the reservoir. When the water level drops below 25% of the threshold, the pump will automatically turn on, and water will be pumped to the reservoir. If the water reaches 25% of the threshold, the pump will be turned off.

If the keypad (2) is selected, the level 2 manual mode is activated as shown in Figure 19. Level 2 corresponds to the threshold where 50% of the water is stored in the reservoir. When the water level drops below 50% of the threshold, the pump will automatically turn on, and water will be pumped to the reservoir. The pump will be turned off if the water reaches 50% of the threshold.



[Fig.19: Manual Mode – Level 2 Prototyping Test]

If the keypad (3) is selected, the level 3 manual mode is activated, as shown in Figure 20. Level 3 corresponds to the threshold of 75% of the reservoir's capacity being filled. When the water level drops below 75% of the threshold, the pump is automatically turned on, and water is pumped to the reservoir. If the water reaches 75% of the threshold, the pump is turned off.



[Fig.20: Manual Mode - Level 3 Prototyping Test]

If the keypad (4) is selected, Then, the level 4 manual mode is activated. Level 4 corresponds to the threshold



of 100% of the water stored in the reservoir. When the water level drops below 100% of the threshold, the pump is automatically turned on and pumped to the reservoir. If the water reaches 100% of the threshold, the pump is turned off. Figure 21 shows the monitoring of the water level in the reservoir at full capacity under manual mode.



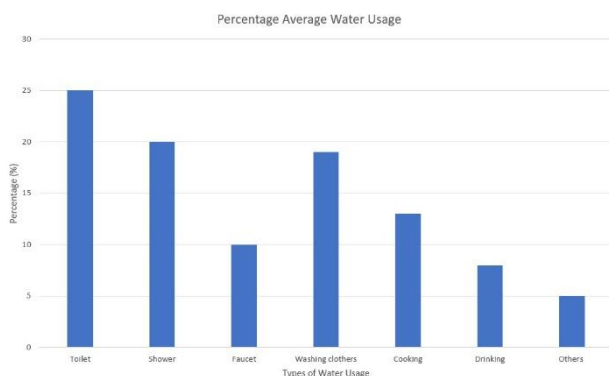
[Fig.21: Manual Mode - Level 4 Prototyping Test]

The tests were carried out successfully to test the algorithms of the embedded program in the PIC microcontrollers. The program codes are presented in the appendix section of this paper.

By using the prototyping model to test the functionality of the water supply system, it is possible to expand to applications of different sizes, especially the reservoir and its monitoring phenomena. The use of solar energy for such a system's performance enables flexibility in utilising the sun's energy to perform more tasks during the day than to collect water at night.

G. Daily Water Usage Survey

The survey of water consumption was conducted in several remote households in Morobe Province, Papua New Guinea [15]. The daily usage helps identify how the reservoir can be implemented to meet the demand per household. Although some studies on daily household water consumption have variations and are subject to the type of house [16], our finding is shown in Figure 22.



[Fig.22: Average Percentage of Rural Household Water Consumption]

IV. CONCLUSION

This paper explores the potential of developing a system that regulates the use of solar PV systems in rural water supply. Apart from the conventional design of water supply using a solar PV system, we integrate a control mechanism

that enables complete control of the system's function by utilising a PIC microcontroller. The design methods employed through experimentation and prototyping yield the best results.

The prototype model was tested and considered a suitable and fully functional approach for making water readily available at the reservoir for further usage. This paper discusses the two modes of operation, thus enabling the user to operate the RE water supply system with ease. The results show that the controller is capable of precisely monitoring and controlling the water level in the reservoir. The system's performance shows exceptional behaviour and, therefore, can be applied to related real-time applications.

The controller and its peripherals are portable and can be installed in all rural and urban areas for those who prefer solar energy. The primary purpose and motivation of this system design are to target the isolated and remotest regions of Papua New Guinea and other countries - especially homes, schools, hospitals, churches, etc.- to provide a cheap and reliable solar-powered water supply system that will save lives and improve living standards by providing easy access and clean water to the recipient.

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After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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AUTHOR'S PROFILE



Sylvester Tirones is an academic researcher at the Papua New Guinea University of Technology. I have completed my Master of Philosophy in Electrical and Communication Engineering, with a focus on electronics and microcontroller-embedded systems. I specialised in analogue and digital electronics design, as well as high-level microcontroller programming. I am doing my Ph.D at the School of Electronics, Information, and Electrical Engineering at Shanghai Jiao Tong University.



Yue Hu is a Senior Engineer and Academic at the Department of Electrical Engineering at Shanghai Jiao Tong University, China. He specialises in Electrical Engineering, Artificial Intelligence, Information Science, and Renewable Energy Plant Factory using microcontrollers. He is my Ph.d. supervisor at the School of Electronics, Information, and Electrical Engineering at Shanghai Jiao Tong University.



Salvius Teke is an undergraduate at the School of Applied Physics, PNG University of Technology. He specialises in electronics and instrumentation. He completed his Bachelor's degree in 2024 and graduated with honours. He is currently completing his industrial graduate development program training with the Benchmark Industrial Company.



Zephaniah Menau is an undergraduate at the School of Applied Physics, PNG University of Technology. He specialises in Physics applications, electromagnetism, and instrumentation. He graduated in 2024 with a Bachelor's degree and is currently participating in a graduate development program with South Pacific Brewery Ltd.

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