Palestine Polytechnic University

College of Engineering and Technology

Electrical Engineering Department

Electrical Power Technology Engineering

Graduation Project

Prototype for smart irrigation system based on solar cells

Project Team

Hadeel Saraheen   **Hammam Al-hersh**

Project Supervisor

Dr. Fouad Zaro

May 2019

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Submitted to the College of Engineering

In partial fulfillment of the requirements for the

Bachelor degree in Power Technology Engineering

Signature of the head of the Department ……………………….

Signature of the project supervisor. ……………………………..

Signature Of examining committee ……………… …………….

……………………………..

May,2019

شكر وتقدير

في مثل هذه اللحظات يتوقف اليَراعُ ليفكر قبل أن يخط الحروف ليجمعها في كلمات ... تبعثر الأحرف وعبثاً أن يحاول تجميعها في سطور ...

سطوراً كثيرة تمر في الخيال ولا يبقى لنا في نهاية المطاف إلا قليلاً من الذكريات وصور تجمعنا برفاق كانوا إلى جانبنا ...

فواجب علينا شكرهم ووداعهم ونحن نخطو خطوتنا الأولى في غمار الحياة ... ونخص بجزيل الشكر والعرفان إلى كل من أشعل شمعة في دروب عملنا ...

وإلى من وقف على المنابر وأعطى من حصيلة فكره لينير دربنا ... إلى الأساتذة الكرام في كلية الهندسة ...

ونتوجه بالشكر الجزيل إلى الدكتور فؤاد الزرو الذي تفضل بالإشراف على هذا المشروع فجزاه الله كل خير وله منا كل التقدير والاحترام ...

الإهداء

بسم الله الرحمن الرحيم

((وَفَوْقَ كُلِّ ذِي عِلْمٍ عَلِيم))

صدق الله العظيم

إلهي لا يطيب الليل إلا بشكرك ولا يطيب النهار إلا بطاعتك .. ولا تطيب اللحظات إلا بذكرك .. ولا تطيب الآخرة إلا بعفوك .. ولا تطيب الجنة إلا برؤيتك

الله جل جلاله

إلى من بلغ الرسالة وأدى الأمانة .. ونصح الأمة .. إلى نبي الرحمة ونور العالمين

سيدنا محمد صلى الله عليه وسلم

إلى من كلّله الله بالهيبة والوقار .. إلى من علمني العطاء بدون انتظار .. إلى من أحمل اسمه بكل افتخار .. أرجو من الله أن يمد في عمرك لترى ثماراً قد حان قطافها بعد طول انتظار وستبقى كلماتك نجوم أهتدي بها اليوم وفي الغد وإلى الأبد ..

والدي العزيز

إلى ملاكي في الحياة .. إلى معنى الحب وإلى معنى الحنان والتفاني .. إلى بسمة الحياة وسر الوجود

إلى من كان دعائها سر نجاحي وحنانها بلسم جراحي إلى أغلى الحبايب

أمي الحبيبة

إلى القلوب الطاهرة الرقيقة والنفوس البريئة إلى رياحين حياتي

إخوتي

الآن تفتح الأشرعة وترفع المرساة لتنطلق السفينة في عرض بحر واسع مظلم هو بحر الحياة وفي هذه الظلمة لا يضيء إلا قنديل الذكريات .. ذكريات الأخوة البعيدة إلى الذين أحببتهم وأحبوني

أصدقائي

إلى كليتي .. كلية الهندسة .. أقسامها.. وروادها..

إلى من قال فيهم أمير الشعراء يوما

قُــمْ للمعلّمِ وَفِّــه التبجيلا   كاد المعلم أن يكون رسولا

أساتذتي

Abstract

The lack of electricity in remote agricultural areas and rising costs of diesel affect the high cost of pumping water to plants, so the use of solar energy is an effective alternative to pumping system.

In this project, the smart irrigation system is designed, which provides remote control of the system and automatically irrigates plants, reducing the need for human intervention and can be controlled manually.

This project aims at reducing waste of water, pumping the appropriate quantities of agricultural produce and relying entirely on the exploitation of solar energy. This system mainly depends on the photovoltaic units, the control unit and the remote control system based on Arduino.

The system was reported in a practical way, the results were as expected and achieved the desired objectives.

الملخص

يؤثر نقص الكهرباء في المناطق الزراعية النائية وارتفاع تكاليف تشغيل المضخات التي تعتمد على الديزيل على ارتفاع تكلفة ضخ المياه إلى النباتات، لذا فإن استخدام الطاقة الشمسية هو بديل فعال لنظام الضخ.

في هذا المشروع تم تصميم نظام الري الذكي الذي يوفر سهولة التحكم في النظام عن بعد و بشكل تلقائي في ري النباتات مما يقلل الحاجة الى التدخل البشري وأيضا يمكن التحكم به بشكل يدوي ، فيهدف هذا المشروع الى تقليل هدر المياه ، وضخ الكميات المناسبة والمطلوبة للمحصول الزراعي والاعتماد بشكل كلي على استغلال الطاقة الشمسية.

هذا النظام المصمم يعتمد بشكل رئيسي على الوحدات الكهروضوئية ووحدة التحكم ونظام المراقبة عن بعد اعتماداً على الاردوينو . تم اخبار النظام بطريقة عملية فكانت النتائج كما هو متوقع وحقق الأهداف المطلوبة .

LIST OF FIGUER

LIST OF EQUATION

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CHAPTER ONE

Introduction

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1.3 Project Objectives

1.4 Project Importance

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1.1 Overview

Environmental concerns are increasing, environmental issues are becoming more and more, the idea of generating electricity becomes less attractive. Unlike traditional power systems, fuel is available from PV power at no cost. Photovoltaic solar systems generate pollution-free electrical power that can be easily installed on the roof of homes as well as on the walls of commercial buildings as a grid-connected PV application. In addition to photovoltaic systems on grid-connected surfaces, photovoltaic solar energy provides a solution to provide electricity to communities and remote sites that power companies cannot access[1].

Solar energy is the most abundant source in the world. It is widely used for running street lights or for heating water heaters or for use in irrigation systems. Solar energy is an environmentally friendly form. Does not cause any pollution and does not require any kind of fuel to produce it. The operation and maintenance cost is low[2].

The availability of electricity in remote areas is one of the major issues related to the design and operation of irrigation systems. However, it is very common in developing countries that access to the electrical grid is not available. With the development of photovoltaic technology that can convert solar energy into electricity, the use of photovoltaic cells has become a more attractive solution to provide the energy required for a water pumping system, especially in areas with abundant solar energy resources[3].

The exploitation of solar energy in remote areas through photovoltaic (PV) systems is the ideal solution for pumping water to irrigation systems. The design of the photovoltaic system is based mainly on estimating crop water requirements and land use, where

demand for water varies during the irrigation season and solar radiation changes over time. The project aims to develop a dynamic modeling tool for the design of the photovoltaic pumping system by combining the models of water demand, solar PV power and pumping system [3].

1.2 Project Motivation

1. The ease of installation and operation of photovoltaic cells they do not need maintenance and the cost of operating them is low in addition to its renewable and reliable source and its long life span.
2. Difficulty accessing electrical networks in remote agricultural areas.
3. Protect the planet from global warming by reducing the proportion of toxic gas emissions in the atmosphere such as carbon dioxide (co_2).

1.3 Project Objectives

1. Design a smart irrigation system based on PV cells.
2. Building a prototype of the proposed system.
3. Remote monitoring and control the system by mobile phone.
4. Testing the proposed system in the real state.

1.4 Project Importance

The importance of the project is to facilitate the availability of electricity in remote areas through the exploitation of solar cells and also to provide water in areas that suffer from the lack of this resource by pumping the appropriate amount of agricultural crop and to eliminate the high costs in cases of diesel use and rely on a reliable source and renewable and environmentally friendly, in addition to Improvement of income, food security Through the improved access to water the system can help to stabilize, increase and diversify production .

1.5 Project Description

An effective irrigation system will be designed to contribute to the low cost of energy using solar energy from irrigation systems in arable and desert lands in an environmentally friendly manner. The project involves the construction of an independent network system that is fully solar-powered. The DC pump is operated through the energy produced by the solar cells to pump water from the water source (Well or groundwater) to a high reservoir, for use in the process of irrigating the plants by second DC pump connected to the outlet of the tank, Where the second DC pump is

connected with Arduino and humidity and heat sensors to control the flow of water from the reservoir to the field. Batteries are used to store day-to-day energy for use in controller and sensor feeds or in small DC loads.

1.6 Methodology

1. Study and collect information from reliable scientific sources and apply for pre-project studies.
2. Determine the component needed to design the project and then make the necessary calculations for each component in proportion to the design.
3. Electrical circuit diagram of the project.
4. Build a practical model of the system.
5. Remote monitoring and controlling.

1.7 Time schedule

Table 1.1: First semester

Task/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Collect information	■	■	■	■											
Search for previous studies on system design.					■	■	■								
the system and component								■	■	■	■				
design of the proposed system									■	■	■	■	■	■	■

Table 2.1: Second semester

Task/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Purchase project components	■	■	■	■	■	■									
Programming code				■	■	■	■	■	■	■	■				
Installation of the project										■	■	■	■	■	■
Project results and analysis												■	■	■	■

2

CHAPTER TWO

Literature study

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2.1 Introduction

2.2 Previous studies on the application of the solar irrigation system

2.3 Summary of previous studies

2.1 Introduction

Due to climate change and high price of fossil fuel, demand of electricity for irrigation need is rising; the best solution is exploiting the solar energy.

Photovoltaic (PV) panels can be one of the most important solutions to this problem. Moreover, they are widely used in today's changing applications, the initial cost of building a photovoltaic system in the past has been high compared to with fossil fuel systems which limit the use of this system. Today the conditions favor has changed PV because of the increase in fossil fuel prices coupled with lower PV system prices, and increased efficiency. High efficiency has resulted in lower energy production cost.

Determining the best irrigation system is an important process, this can be done by selecting the optimal components of the system generally. The main system components include PV module for power generation, controller unit for irrigation system, control valves, batteries, and sensors, pumps, and the inverter can be used at times to reverse DC to AC.

This system will provide electricity bills because it will eliminate traditional electrical networks and rely on solar energy , This system will improve the required amount of water in the irrigation of the crop will be automatic irrigation if the soil is dry which helping to conserve water.

A series of studies on the design of this system will be presented in several countries, including Bangladesh, and Saudi Arabia, where the mechanism and results of the system will be presented [4]-[5].

2.2 Previous studies on the application of the solar irrigation system

2.2.1 Application system in Bangladesh

In this project the photovoltaic cells are connected directly with the water pumping system. There are three PV arrays, 3 DC series pump-motors and a control panel the capacity of total array is 2 kw .Three pipes are connected to the main bore well, There was also a storage tank to enable the conservation and use of irrigation water during periods when the sun radiation is not received sufficiently [4].

The three pumping will start to work at minimum 24V. At the starting of the day with low insolation at least one pump will start to run. From, at the middle of the day two pumps can run equally. With the availability of sufficient insolation 3 pumps can operate at the same time. The excess water can then be stored in the storage tank for later use [4].

The first pump has a smaller opening than the other two pumps so it can work in the morning or evening for less radiation. When the amount of radiation is enough, the other two pumps start working and the first pump is stopped because the maximum load is 2 kW, which is enough [4].

By studying this system, the maximum capacity of pumps during the morning and pump flow rate will be almost constant with a change in insulation indicating that the system is stable and functioning properly. The 3 pump has the maximum efficiency among the three pumps [4].

2.2.2 Application system in Saudi Arabia

In this project the system which designed consists of four major parts: Solar power supply, controller, input devices, and output devices [5].

The solar power supply used consists of two photovoltaic (PV) solar panels and two back up batteries. Two PV panels were connected in series to generate a total of 24 V DC that is required to supply the 24 V DC controller's power supply. The batteries, used as backup supply in the absence of sunlight due to overcast skies or rain, are rechargeable. And it charged from the PV cells [5].

The controller which is used is (logo); it provides control functions, operating and display unit, power supply, 6 inputs and 4 outputs and interface capability with a personal computer. The control functions that are utilized in this project are On/Off [5].

2.3 Summary of previous studies

Through Excess electricity produced during non-irrigating seasons can be used in Solar Home Systems or to drive other farming load. Also the advantage of the solar power is

that it is non-polluting and this system is economical, reliable and environmentally friendly.

- ❖ In this project an irrigation system for plants using solar cells has been created, the energy produced by these cells was used to run the DC pump. the user control system composed of the Arduino controller and sensors for temperature and humidity, and is powered by the electricity through batteries that charged from solar cells at the time of solar radiation, the mobile phone connect with control system to display the status of the system or remote control of the system.

3

CHAPTER THREE

System and components

Contents

3.1 Introduction

3.2 Project Cost Table

3.3 Description the proposed smart irrigation system

3.4 The proposed system components

3.1 Introduction

The design of the project and the explanation of its mechanism are explained in this chapter. The component of the system will be presented in detail with the clarification of the objective of each component.

3.2 Project Budget Estimate Table

component	# of components	Price ($)	Total price ($)
Photovoltaic module	1	80	80
DC Water pump	2	40	80
Arduino Uno	1	22	22
Soil moisture sensor	1	10	10
Lm 35 sensor	1	18	18
Charge controller	1	225	225
Batteries	1	200	200
Water level sensor	2	10	20
Relay Module	1	10	10
Bred board	1	5	5
Tank (16L)	2	10	20
Basin cultivation with soil	1	20	60
Internet Cable	1	10	10
Contact wires (25 mm)	-	10	10
Ethernet Module	1	25	25
-	-	Sum =	795

3.3 Description the proposed smart irrigation system

The water pumping system proposed is Direct-coupled without storage batteries. As shown in Figure 3.1, the system is very simple and consists of a single PV module, Charge controller, and a DC water pump. And Sub-systems will be programmed into the system to achieve the desired results.
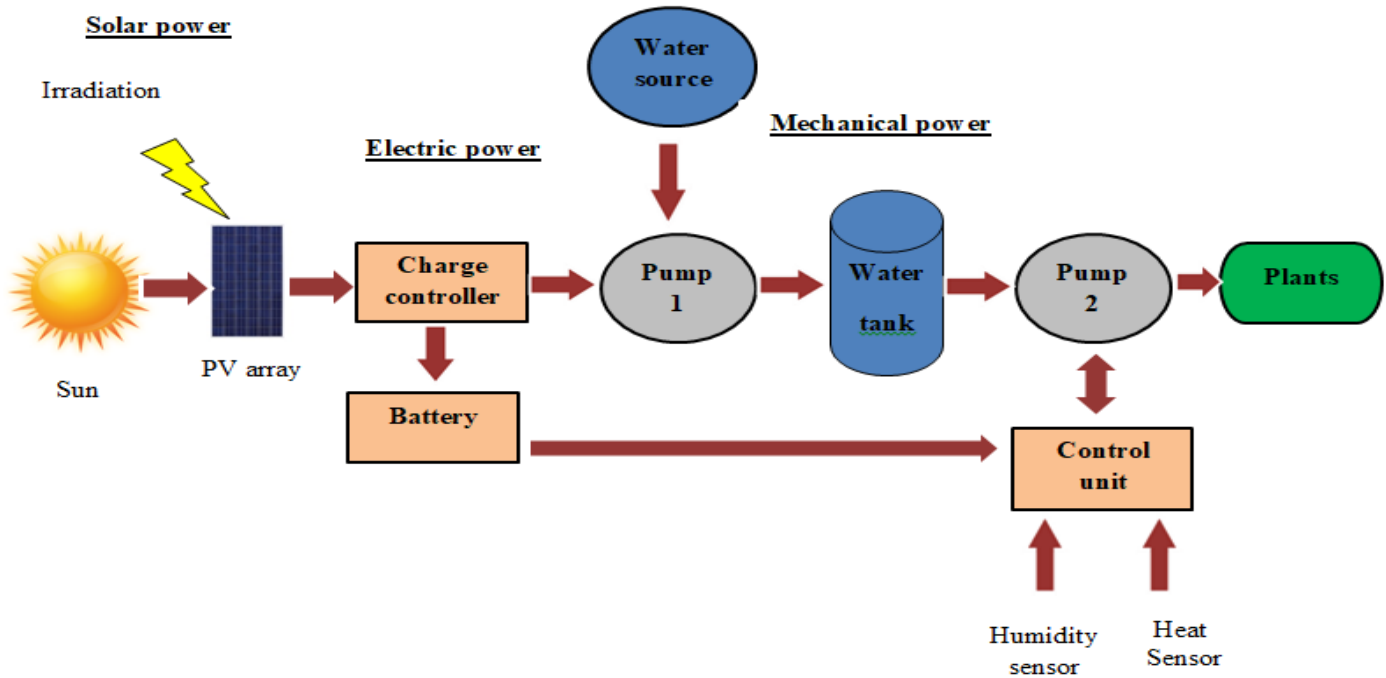
Figure 3.1: Block diagram of the proposed PV water pumping system

3.3.1 Direct-coupled pumping system

In the direct pumping system, the electricity is sent directly from the PV units to the pump, which in turn pumps the water through the pipes to the high water tank to irrigate the plants from them when needed. This system is designed to run water pump directly during the day with continuous irrigation at any time of the day. The amount of water pumped depends entirely on the amount of sunlight that reaches the PV panels, the irradiation angle and the type of pump. Depending on the plant type, Arduino is used to control the regulation of the irrigation process based on temperature and humidity. Power is stored in the battery to feed the controller unit.

During periods of ideal sunlight (morning and afternoon) the pump will operate at maximum efficiency with maximum flow of water. In the afternoon, the pump efficiency will be drop due to low light conditions.

During cloudy days, pump efficiency will drop off even more. To compensate for these variable flow rates, a good match between the pump and PV module is necessary to achieve efficient operation of the system [6].

Direct-coupled pumping system is sized to store extra water on sunny days so it is available on cloudy days and at night. Water can be stored in a larger-than-needed watering tank or in a separate storage tank and then fed to smaller watering tanks. Water-storage capacity is important in this pumping system, depending on climate and pattern of water usage. Storing water in tanks has its drawbacks. Considerable evaporation losses can occur if the water is stored in open tanks, while closed tanks big enough to store several days water supply can be expensive [6].

3.4 The proposed system components

In this system we need these components for design:

1. Photovoltaic Module
2. DC Water Pump
3. Arduino
4. Soil Moisture Sensor
5. LM35 sensor
6. Charge Controller (MPPT Charger)
7. Batteries
8. Water Level Sensor interfacing with Arduino

3.4.1 Photovoltaic Module

One of the most important components of the solar water pump system is the power supply which consists of PV panels. The smallest component in PV panels is the solar cell. Each solar cell produces direct current (DC) when exposed to light. This DC is assembled by wiring in the panel. It is then supplied either to a DC pump, which in turn

pumps water whenever the sun shines, or to batteries to store energy, and is used when needed in the absence of the sun.

Individual PV panels can be connected in a series or parallel to obtain the required voltage or current required to operate the pump. The output voltage of the wired panels in a series is the sum of all the voltages of the panels.
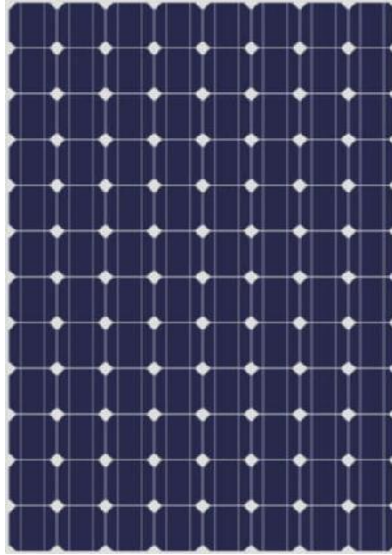
Figure 3.2: Photovoltaic panels

3.4.2 DC Water Pump

One of the most cost effective PV applications today is pumping water in remote areas. For a home or location outside or far from the grid, a simple PV system can pump Water from the reservoir or well to use it in Irrigation, or water supply in villages, especially in developing countries.

The PV water-pumping systems consist of a PV array attached to a dc pump. Water that is pumped when the sun is out may be used at that time or stored the energy in Batteries for used later use in pumping water.

In this project the DC water pump used without batteries, which mean that will be pumping the water on daytime only.

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Figure 3.3: DC water pump

3.4.3 Arduino

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software Arduino can be used to develop stand-alone interactive objects or can be connected to software on the computer.

Arduino Uno: Is a microcontroller board based on 8-bit ATmega328P microcontroller Along with ATmega328P, it consist other components such as crystal oscillator, serial communication, voltage regulator, etc. to support the microcontroller. Arduino Uno has 14 digital input/output pins (out of which 6 can be used as PWM outputs), 6 analog input pins, a USB connection, A Power barrel jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The 14 digital input/output pins can be used as input or output pins by using pin Mode (), digital Read () and digital Write () functions in Arduino programming. Each pin operate at 5V and can provide or receive a maximum of 40mA current, and has an internal pull-up resistor of 20-50 K Ohms which are disconnected by default.

Figure 3.4: Arduino Uno

3.4.4 Soil Moisture Sensor

This sensor can be used to test the moisture of soil, when the soil is having water shortage, the module output is at high level, and else the output is at low level. By using this sensor one can automatically water the flower plant, or any other plants requiring automatic watering technique, and it has some features:

- Sensitivity adjustable.

- Has fixed bolt hole, convenient installation.

- Module digital output is simple.

- Pin Name Details:

1	Out	Active high output
2	+5v	Power supply
3	GND	Power supply GND

- Using the Sensor:

  - Connect +5v to pin 2 and ground to pin 3

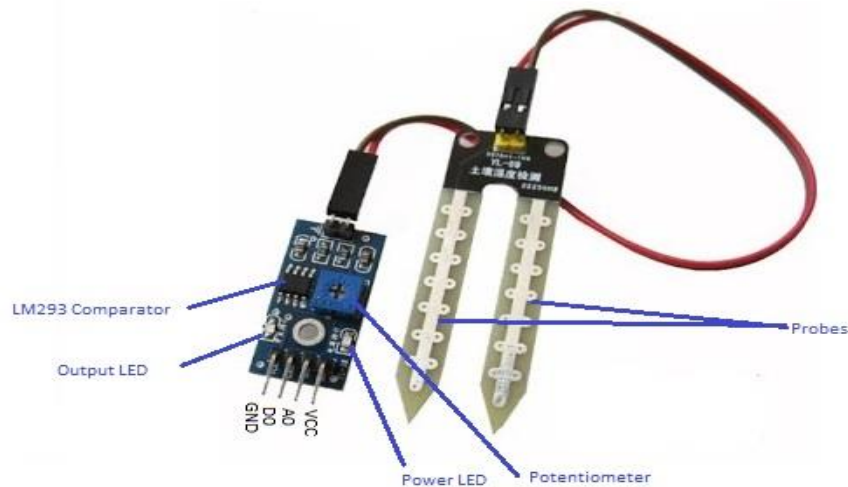 - Output pin connected with Arduino pin1

Figure 3.5: Soil Moisture Sensor

3.4.5 LM35 sensor

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C

in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range.

Applications: Capacitive Drive Capability Like most micro power circuits, the LM35 device have a limited ability to drive heavy capacitive loads. Alone, the LM35 device is able to drive 50 pF without special precautions. If heavier loads are anticipated, isolating or decoupling the load with a resistor is easy. The tolerance of capacitance can be improved with a series R-C damper from output to ground.

When the LM35 device is applied with a 200-Ω load resistor the device is relatively immune to wiring capacitance because the capacitance forms a bypass from ground to input and not on the output. However, as with any linear circuit connected to wires in a hostile environment, performance is affected adversely by intense electromagnetic sources (such as relays, radio transmitters, motors with arcing brushes, and SCR transients).
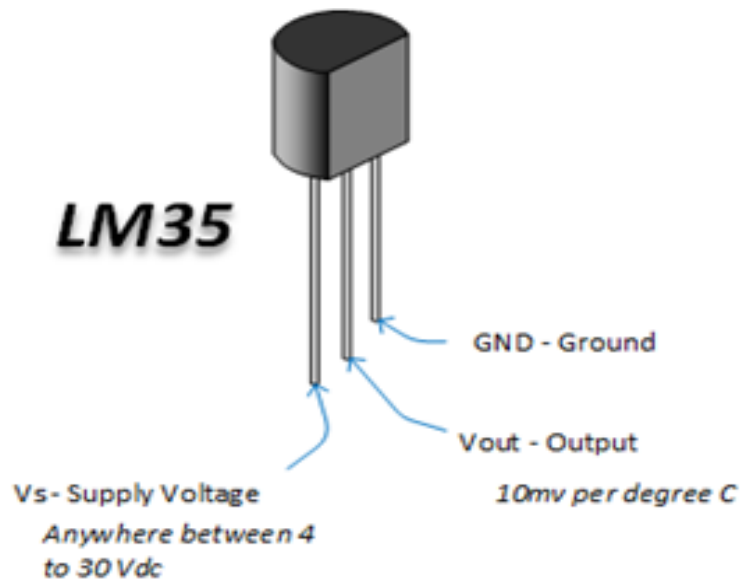

Figure 3.6: LM35 sensor

3.4.6 Charger Controllers

This device contains an internal fuse that protects the solar cell from damage touch the edges together and short circuit so that the fuse damage and prevent significant damage

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from solar cells, and can be replaced after that and working again is cheap and Works to purify and stabilize the outside voltage of the solar cell to the device that works DC voltage because the power of sunlight increases and decreases throughout the day due to clouds or because the angle of the sun changes until it completely disappears at sunset and work to ensure that the electrical current of the battery does not return to the cell again because it in the case of separation of the load and in the absence of a regulator of the charge, the solar cells can be considered as a load that pulls the current from the battery to the cells in reverse once again, it is damaged.

The MPPT or Maximum Power Point Tracking is algorithm (P&O method) that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called 'maximum power point' (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature.

The major principle of MPPT is to extract the maximum available power from PV module by making them operate at the most efficient voltage (maximum power point),

MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to a DC load, which is connected directly to the battery.

- MPPT is most effective under these conditions:
    - Cold weather, cloudy or hazy days: Normally, PV module works better at cold temperatures and MPPT is utilized to extract maximum power available from them.
    - When battery is deeply discharged: MPPT can extract more current and charge the battery if the state of charge in the battery is lowers.
- The main features of MPPT solar charge controller:
    - In any applications which PV module is energy source, MPPT solar charge controller is used to correct for detecting the variations in the current-voltage characteristics of solar cell.

- MPPT solar charge controller is necessary for any solar power systems need to extract maximum power from PV module; it forces PV module to operate at voltage close to maximum power point to draw maximum available power.
- MPPT solar charge controller allows users to use PV module with a higher voltage output than operating voltage of battery system.

For example, if PV module has to be placed far away from charge controller and battery, its wire size must be very large to reduce voltage drop. With a MPPT solar charge controller, users can wire PV module for 24 or 48 V (depending on charge controller and PV modules) and bring power into 12 or 24 V battery system. This means it reduces the wire size needed while retaining full output of PV module.

- MPPT solar charge controller reduces complexity of system while output of system is high efficiency. Additionally, it can be applied to use with more energy sources. Since PV output power is used to control DC-DC converter directly.
- MPPT solar charge controller can be applied to other renewable energy sources such as small water turbines, wind-power turbines, etc.

Figure 3.7: Charger Controller

3.4.7 Batteries

It is the unit responsible for storing energy and discharging it when needed that is, it has a dual function, to deal with the battery; you need to know at least two of the three voltage variables, measured in Volts and current, measured in Amps and power and measured in watts.

Batteries can be connected like the same way as solar cells to obtain different voltage and current values. The battery is indicated by the number of amperes per hour (Ah) called battery capacity.

In this project the batteries used to run the pump control system, and run small DC loads.

Figure 3.8: Batteries

3.4.8 Water Level Sensor interfacing with Arduino

Water level sensor is used to measure water level in water tank or in any other equipment. In our daily life we need to detect the level of water like in water tank at the top of roof which is not directly accessible and in laboratories where specific level of any

liquid is required to be monitored. In such applications water level sensor is very useful, the Water level sensor gives output into the form of voltage.

- Hardware Required:
  - Arduino UNO
  - Water level sensor
  - Connecting wires
- Pin Configuration: Water level sensor is provided with three output terminals:
  - + stands for +5V
  - – stands for GND
  - S stands for signal

Figure 3.9: Water Level Sensor

- Connect the circuit as follows:
  - Sensor S pin **with** Arduino Analog pin A0
  - Sensor + pin **with** Arduino 5V
  - Sensor – pin **with** Arduino GND
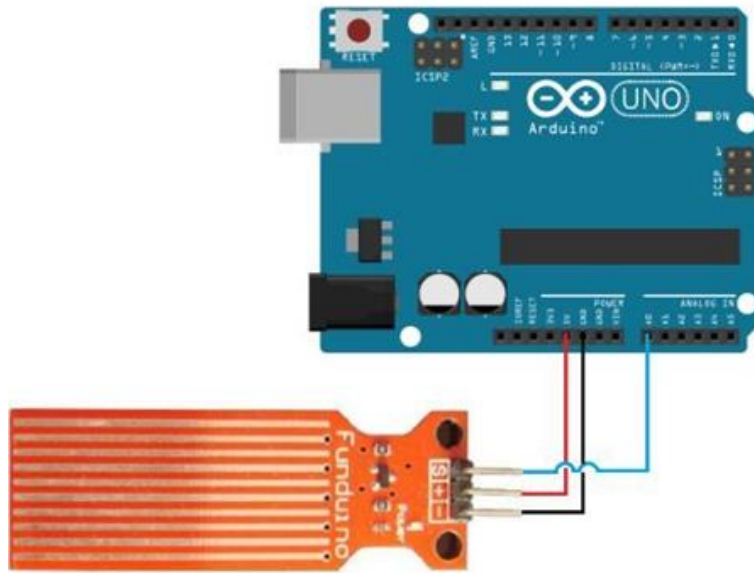
Figure 3.10: Water Level Sensor with Arduino

➢ **Protection devices**

In order to protect the components of the system from the risk of high current for any reason the fuses and relay module were used to protect the cells, batteries and pump in addition to DC over load to protect the pump from overload.

4

CHAPTER FOUR

Design of the proposed system

Contents

4.1 Introduction

4.2 Sizing system

4.3 Selections the components

4.4 Operation methodology

4.1 Introduction

In this part from project, we calculated the sizes and quantities of components needed to implement the plant irrigation prototype using solar energy, then choose the components with the sizes required for us from the market to be close to the calculated sizes.

We determined the size of solar cell, DC pump, charging regulator, batteries, and protection devices. The sizes of the components that will be calculated will not be identical to the sizes of the components that will be applied by the project, because of the unavailability of the components required in the market in exact sizes, but we will work to choose components as close to the desired as possible.

4.2 System Sizing

Before choosing the final components, the system should be roughly sized to allow viewing of approximate component sizes. The components must be sized by detailed electrical and mechanical design. The purpose of this section is to provide simple tools to roughly estimate the needed system size before contacting PV arrays.

4.2.1 Estimation of the electricity demand

The first step in designing a PV system must be careful examination of the electrical loads for these two reasons:

1. The sizing of the system components is dependent on the electricity and power demand. For stand-alone systems, his is crucial.

2. Oversized systems resulting from a poor load analysis and the idea of staying on the 'safe side' increase the system costs. This is particularly demanding in a field where poor economics are major drawback, which still is the case for PV.

The second reason also leads to the important issue of minimizing loads without decreasing the user's comfort [6].

4.2.2 Solar pump sizing

To determine the pump sizing we need these equations:

$$P \text{ (watts)} = 9.81 \times H \text{ (m)} \times Q \text{ (L/s)} \tag{4.1}$$

$$P \text{ (watts)} = 0.1885 \times H \text{ (ft)} \times Q \text{ (gpm)} \tag{4.2}$$

Where;

H: total head (static plus friction)

Q: Quantity of water

Add up all the bends and valves in a pipe run and find what equivalent length of

Straight pipe would have the same pressure drop.

The sum of the friction head and the static head is known as the total dynamic Head (H) [7].

4.2.3 Sizing of battery

1. Decide the number of days of storage needed. For a hybrid system, the choice depends on how running the PV perceived to be (2 days of storage is a Reasonable default).

2. Find the usable storage needed from the Total load (Ah/day) Total load (Ah/day @ System voltage) = (Total dc load (Wh / day)) / (System Voltage (V))

   Usable storage (Ah) = Total load (Ah/day) × Days of storage (days)

3. Using the days of storage as an indicator of the discharge rate C / T, along

   With anticipated minimum battery temperature, find the temperature and

   Discharge rate factor (T, DR) .

4. Pick the maximum depth of discharge (MDOD defaults: deep-cycle lead acid

   0.80).

5. Find the total storage capacity from total storage capacity

(Ah @ C/48, 25∘C) =   Usable storage capacity (Ah) / ((MDOD) × (T, DR)).

6. Check to be sure the battery capacity is sufficient to avoid a too-rapid discharge rate (default C/48 rate).

Minimum storage capacity (Ah) = (Maximum load power (W) × 5 h) / (System Voltage (V) × Max depth of discharge)

7. Number of battery;

Number of batteries in series = (System voltage) / (Nominal battery voltage)

Number of strings of batteries in parallel= (Total storage capacity (Ah)) / (Capacity Of a single battery (Ah)) [7].
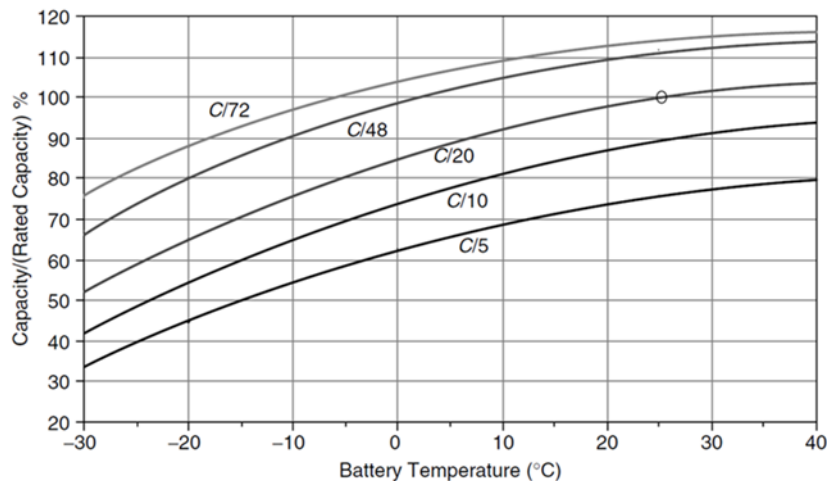

Figure 4.1: Lead acid battery capacity depends on discharge rate and temperature [8].

4.2.4 PV sizing

1. Using insolation data for the site (Appendix B), find the insolation (kWh/m2- Day = hours @ 1-sun), (latitude in Palestine is 31.95⁰ N, 5hours@1-sun)

2. The power required from PV must be capable of operating all loads connected to them (pump, control system and other DC loads).

3. Find an integer value for the number of parallel strings of modules based on Strings in parallel = (Design-month load (Ah/day)) / (Ah/day per module in design month)

4. Find the number of modules in series from Modules in series = (System Voltage (V)) / (Nominal module voltage (V)) [7].

4.3 Selection the components

4.3.1 Solar pump

On the assumption that we need every day pumping $2m^3$ of water for a high of up to 5 m, Radiation hours are ᵒhours/day.

$$Q = \frac{2\ m3}{5\ h}$$

$$Q = \frac{2\ m3}{5\ h} \times \frac{1000\ L}{1m3} \times \frac{1h}{3600s}$$

$$Q = 0.11\ L\ /s$$

$$= 6.66\ L / min$$

$$P_{Pump}\ (w) = 9.81 \times H\ (m) \times Q\ (L/s)$$

$$= 9.81 \times 5 \times 0.11$$

$$= 5.45\ watt$$

We need pump with power large than 5.45 watt and max flow large than 6.66 L∕min and max heat large than 5m.

From data sheet we select pump 8 watt.

4.3.2 PV

The power produce by the PV cell must be capable of running the pump, arduino, all sensors, and other dc load.

$$P \text{ in }_{Pump} = \frac{P \text{ pump}}{\eta} \tag{4.3}$$

$$\eta_{pump} = 0.75$$

$$P \text{ in }_{Pump} = \frac{8 \text{ w}}{0.75} = 10.66 \text{ watt}$$

Assuming that the power needed to operate the arduino and all sensors is 5w.

Dc load with maximum capacity is 15w.

$$P_{pv} = 2 \, P \text{ in }_{Pump} + P_{control\ unit} + P_{DC\ load}$$

$$= 2 \times 10.66 + 5 + 15$$

$$= 41.33 \text{ watt}$$

From data sheet we select 50 watt PV module.

4.3.3 Battery

The batteries will operate both the control system (Arduino and sensors) and Dc loads.

We need a battery capable of supplying the system with the required power for 48 hours (2 days).And the system voltage 24V.

To find the Max A.h of DC – load:

$$I_{DC\text{-}loads} = \frac{(5+15+10.66)}{12 \text{ v}} = 2.55 \text{ A.h @ 12 V.} \tag{4.4}$$

Let $I_{DC\ total} = 2.55$ (Dc load & control system)

If we use capacity ratio C/48 two days:

Battery storage $= 2.55 \times 48 = 122.66$ A.h

If we use the battery with maximum depth of discharge 80%:

$$\text{Battery storage} = \frac{122.66}{0.8} = 153.33 \text{ A.h} \qquad (4.5)$$

Affect the temperature, the worst case at $0C^0$, from Figure 4.1.

Capacity rated = 97%

$$\text{Battery storage} = \frac{153.33}{0.97} = 158.07 \text{A.h @12V} \qquad (4.6)$$

We select lead acid battery 12V / 160 A.h
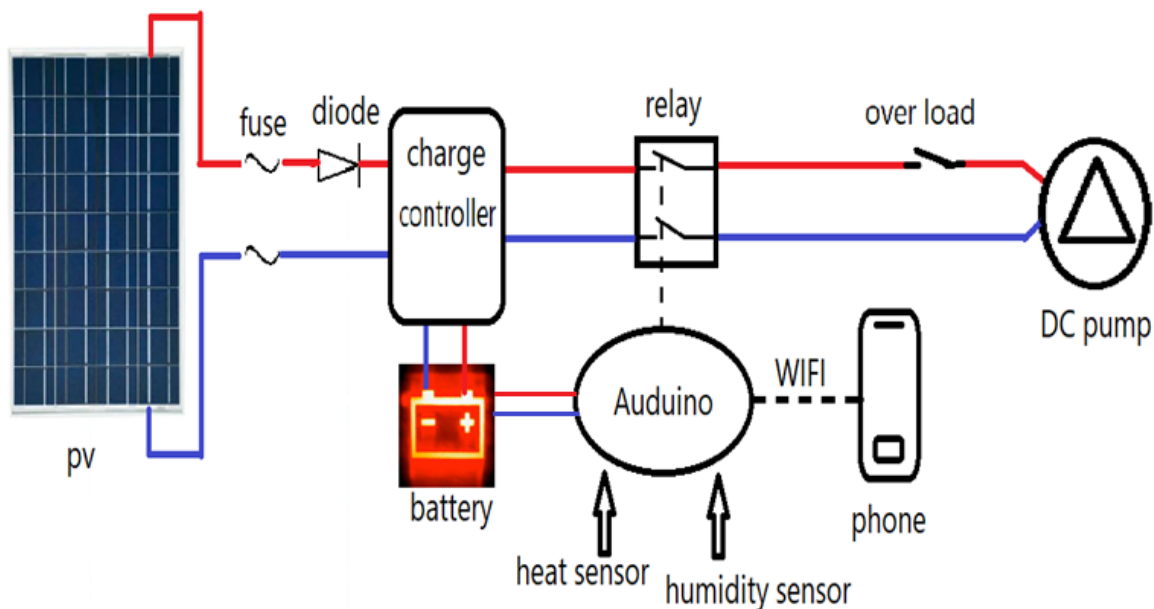
4.4 Operation methodology

Figure 4.2: Electrical circuit of the proposed system

Based on the previous design, the proposed system electrical principle is:

Photovoltaic cells convert solar energy into electrical energy. Cells are connected to a charging regulator that charges the batteries while simultaneously supplying the pump with electricity.

Batteries are charged in order to provide the sensors and the Arduino control with the necessary electricity to operate small dc loads. The pump is supplied with energy from the solar cells directly through the charger without the need for batteries and operates the pump directly in daylight hours only. The Arduino controller is then connected to the cell phone to display system information.

4.4.1 The cases of DC Water Pump1 operation

1. If the tank needs water at daytime (during solar radiation), the pump1 operated through the energy produced by solar cell directly.

2. If the tank does not need water during the day (during solar radiation), the energy produced by solar cells is stored in batteries to supply the control system, and when the battery is full the cells are separated.

3. The tank is filled only during daylight hours (at the time of solar radiation).

4. During the daytime the DC Water Pump1 is turned ON if the water level in the tank less than S1.

5. During the daytime the DC Water Pump1 is turned OFF if the tank is full (at S2).

6. The system information is also sent to the phone, and the DC Water Pump1 can be controlled by the phone.

4.4.2 The cases of DC Water Pump2 operation

1. If both temperature and humidity of the field below the required degrees of heat and humidity, the water is pumped from pump2 to the field.

2. The DC Water Pump2 is closed when the humidity of the field is slightly higher than the required humidity.
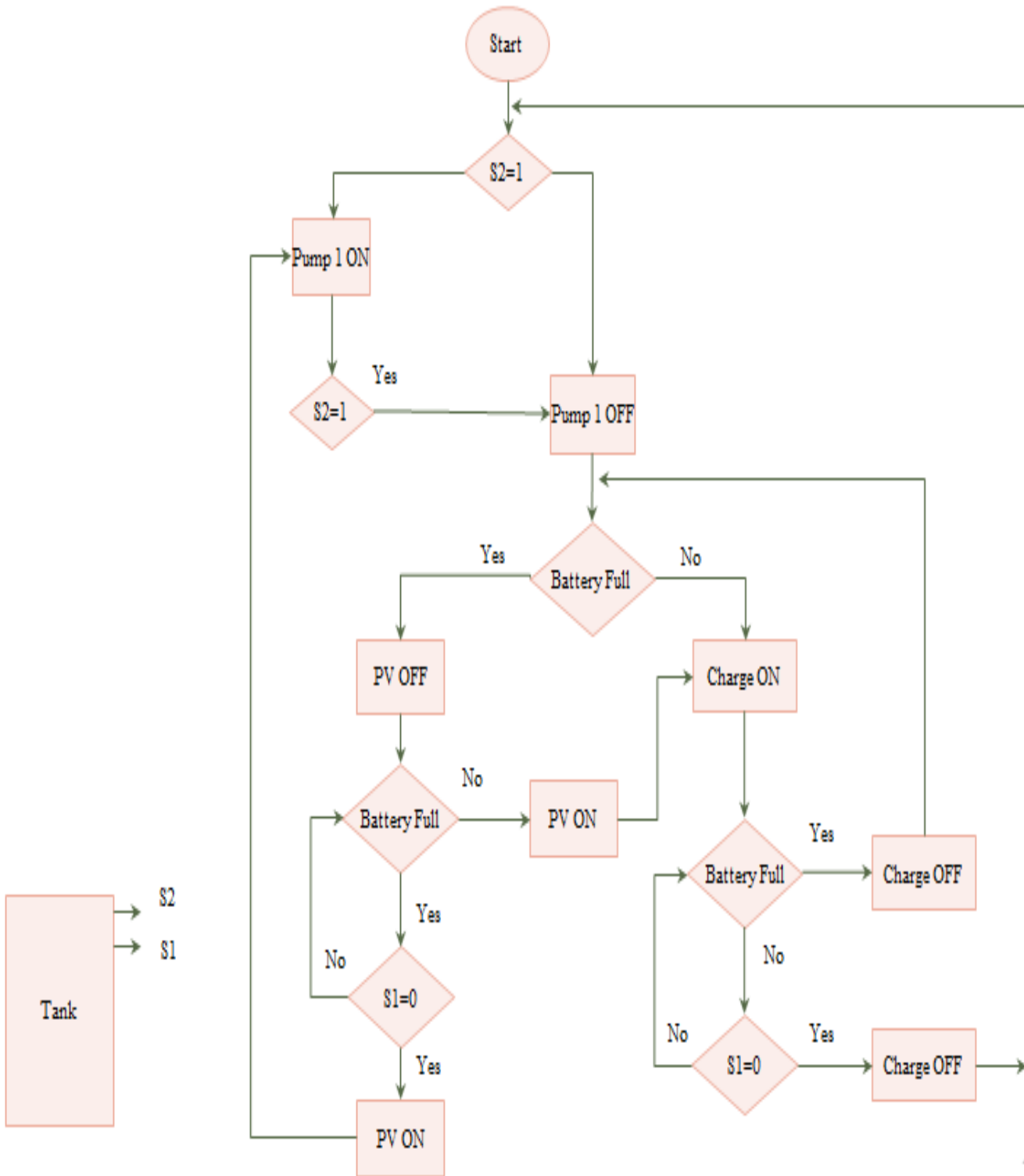
Figure 4.3: Flowchart of DC Water Pump1
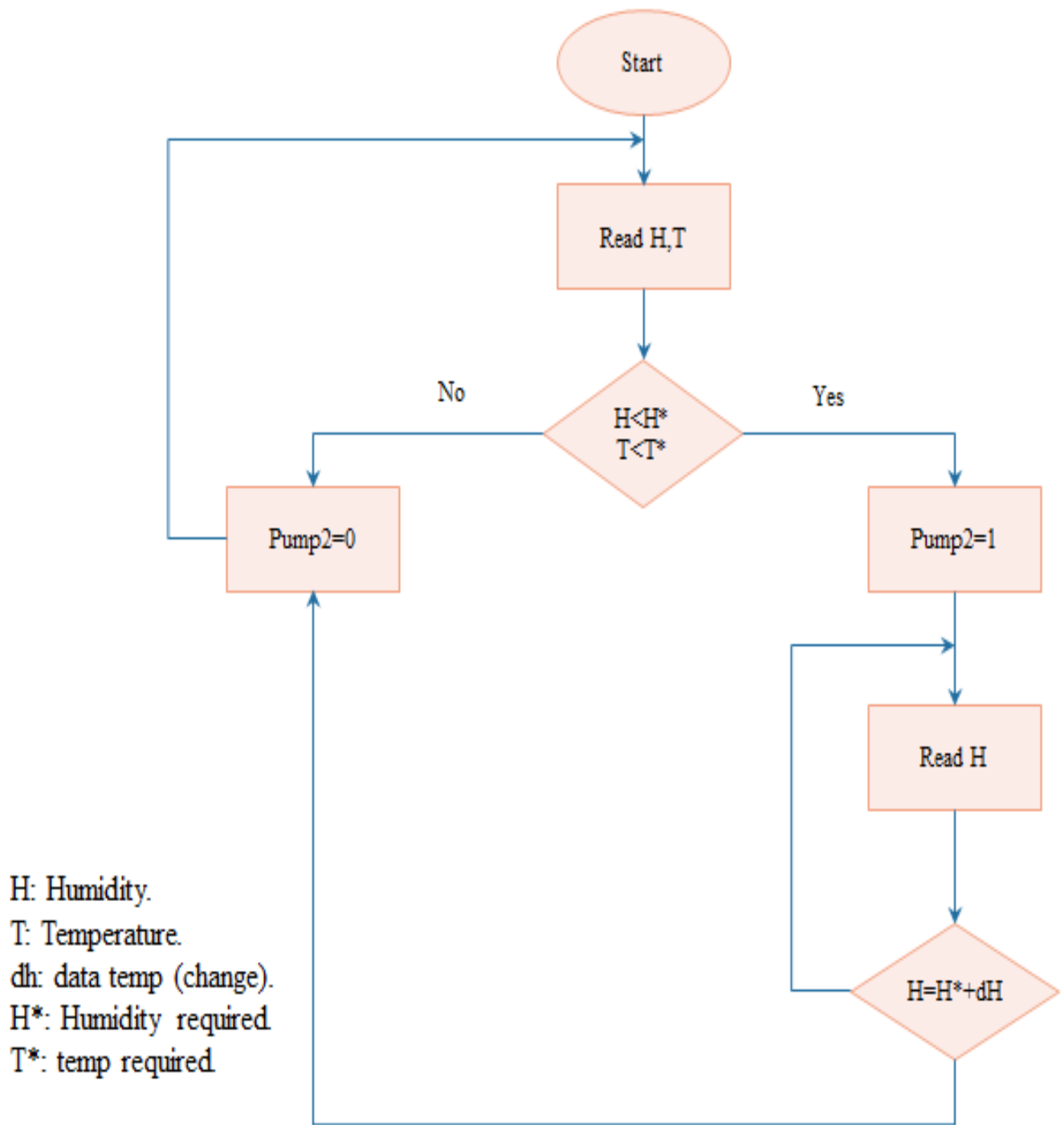
Figure 4.4: Flowchart of DC Water Pump2

5

CHAPTER FIVE

Project results and analysis

Contents

5.1 Design of the project model

5.2 Project implementation

5.3 Results & Analysis

5.4 Conclusion

5.5 The future plan

5.1 Design of the project model
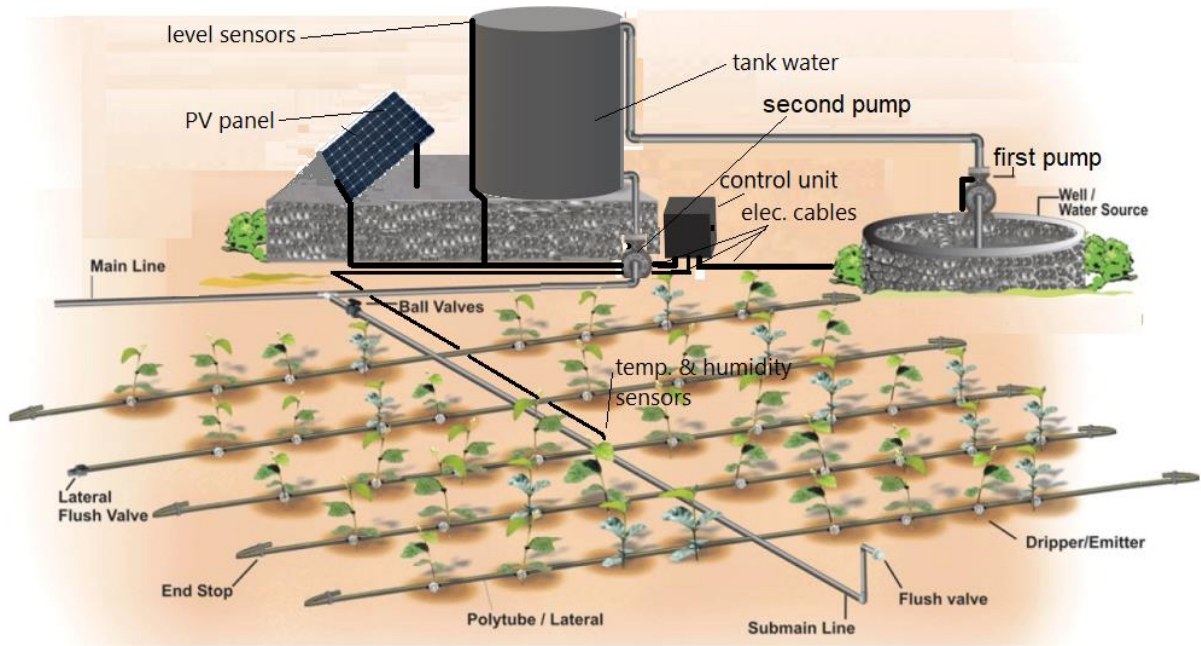
Figure 5.1: Graphical model of the prototype

5.2 Project implementation

Figure 5.2: Installation of the project

Figure 5.3: Pump 1 connected with water source

Figure 5.4: Pump 2 connected with water tank to the field

Figures 5.5: Battery connected with relay module and charger controller
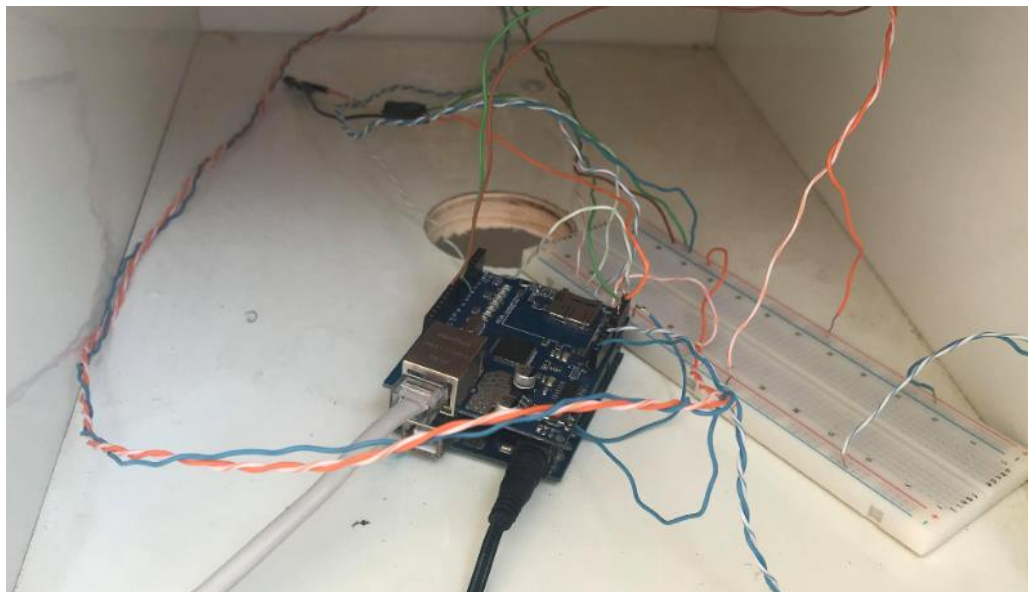
Figure 5.6: Arduino Uno and Ethernet module

Figure 5.7: Plant field with moisture sensor

5.3 Results & Analysis

At the end of this project we were able to achieve the desired goals and the project results were as expected:

- The system is automatically operated and easily controlled remotely by any mobile phone and connected to the Internet at anytime and anywhere and also can control the system manually.
- This system automatically detects the moisture of the soil through the moisture sensor. Accordingly, the water is pumped according to plant needs and as required.
- Exploitation of solar energy using photovoltaic cells for irrigation.

5.4 Conclusion

The smart irrigation system, which has been implemented cost-effectively to improve the water resources of agriculture and to provide electricity through the exploitation of solar

energy, allows this irrigation system to grow in water-deficient places and thus improve sustainability. Using this irrigation system it improves the use of water by limiting it reduces human intervention for farmers and increases the efficiency of the system and the quality of agricultural crops.

Using solar irrigation is an excellent way to reduce the cost of solar power plants instead of using expensive diesel.

Irrigation systems can be used based on solar energy in remote and remote areas that are not connected to the electrical grid, as well as the possibility of operating solar systems for long periods without the need for expensive maintenance.

The excess energy produced can also be given using the solar panels of the grid, which can be a source of farm yields and thus encourage agriculture while providing a solution to the energy crisis.

5.5 The future plan

The system can be integrated with a camera to monitor the health of plants. Farmers can control their plants at anytime and anywhere on the Internet. The PIR sensor can also be set to detect interference such as movement of animals within the agricultural field and keeping the field safe.

Reference

[1] A. Zahedi, "Solar photovoltaic (PV) energy; latest developments in the building integrated and hybrid PV systems," Renewable Energy, vol. 31, no. 5, pp. 711-718, 2006.

[2] S. Harishankar, R. S. Kumar, K. P. Sudharsan et al., "Solar powered smart irrigation system," Advance in Electronic and Electric Engineering, vol. 4, no. 4, pp. 341-346, 2014.

[3] H. Li, P. E. Campana, and J. Yan, "Dynamic Modeling of a PV Pumping System with Special Consideration on Water Demand."

[4] S. M. S. Reza, and N. I. Sarkar, "Design and performance analysis of a directly-coupled solar photovoltaic irrigation pump system at Gaibandha, Bangladesh." pp. 1-6.

[5] A. R. Al-Ali, S. Rehman, S. Al-Agili et al., "Usage of photovoltaics in an automated irrigation system," Renewable Energy, vol. 23, no. 1, pp. 17-26, 2001.

[6] M. Abu-Aligah, "Design of Photovoltaic Water Pumping System and Compare it with Diesel Powered Pump," Jordan Journal of Mechanical & Industrial Engineering, vol. 5, no. 3, 2011.

[7] G. M. Masters, Renewable and Efficient Electric Power Systems: Wiley, 2013.

Appendix

APPENDIX A

DATA SHHET FOR EACH COMPONENT

Table 1.A: Photovoltaic Module

Model	SP50P-36
Solar cell	Poly (52*156mm)
Dimension(mm)	537x665x30mm
Weight(kg)	4.3kg
Maximum Power(Pm)	50W
Current at Pmax(Imp)	2.73 A
Voltage at Pmax(Vmp)	18.3 V
Short-circuit current(Isc)	2.95 A
Open-circuit voltage(Voc)	22.3 V
Module Efficiency	14 %
Junction Box	IP67
Mechanical load	5400 Pa
STC	Irradiance 1000W/m^2,Cell Temperature 25℃, Air Mass1.5
Front Glass	3.2mm Ultra Clear Tempered ,Low Iron
Type of output terminal	Junction Box

Table 2.A: DC water pump

Type	LH-DC202
Voltage	12 / 24V
Flow (L/H)	600
Head	5 m
Outlet (mm)	18mm
Intake (mm)	16mm
Size (mm)	80*58*67mm
Watts	8 watt

Table 3.A: Water Level Sensor

Sensor Type	Analog
Operating Voltage	DC 5V
Working current	less than 20mA
Detection area	40mm x16mm

Table 4.A: Arduino

Microcontroller	ATmega328p
Operating Voltage	5v
Electrical voltage	7-12v
Input Voltage Limits	6-20v
Number of digital ports (I / O)	14
Control ports	6PWM
Number of analog ports (input)	6
DC power supply to 3.3 volts	50mA
DC current for digital input / output	40mA
Memory space	32KB

Hour speed	16MHZ
The dimensions of the panel	Length: 6.86 centimeters, width: 5.34 centimeters

Table 5.A: Charge controller (MPPT Charger)

Model	ML4860
System voltage	12V/24/36V/48V Auto
Load loss	0.7 W~1.2W
Battery voltage	9~70
Solar maximum input voltage	145V(25℃) 130V(-25℃)
Maximum power point voltage range	Battery voltage +2V to 120V
Rated charge current	60A
Rated load current	20A
Maximum capacitive load capacity	10000uF
Photovoltaic system maximum input power	800W/12V ; 1600W/24V; 2400W/36V ; 3200W/48V
Conversion efficiency	≤98%
MPPT tracking efficiency	>99%
Temperature compensation coefficient	-3mv/℃/2V(Defaults)
Operating temperature	-35℃ ~ +45℃
Protection level	IP32
way of communication	RS232 RS485
Altitude	≤ 3000m
Product Size	285*205*93mm

Table 6.A: Lead acid battery

Usage	UPS
Battery type	Sealed Rechargeable Battery
Nominal Capacity	160 A.h
voltage	12v
Size	552 * 110 * 287 mm
Application	UPS, Wind solar energy system, Telecommunication Equipment
Maintenance Type	free
Weight	43.8kg
Sealed Type	Sealed

APPENDIX B

TABLE OF SOLAR INSULATION

Title	Latitude 32.13 ºN												
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	year
Lat −15	3.5	4.3	5.2	6.1	6.2	6.1	6.0	5.6	5.1	4.8	3.9	3.4	5.0
Lat	4	4.7	5.4	6.0	5.8	5.7	5.6	5.4	5.1	5.1	4.4	3.9	5.1
Lat +15	4.3	4.8	5.3	5.6	5.2	4.9	4.9	5.0	4.9	5.2	4.6	4.2	4.9
90	3.7	3.8	3.6	3.0	2.3	2.0	2.1	2.5	3.0	3.8	3.9	3.7	3.1
1-Axis(Lat)	4.8	5.7	6.8	7.9	7.7	7.4	7.1	6.8	6.3	6.3	5.3	4.5	6.4
Temp.($\circ$C)	15.4	16.9	21.2	25.3	28.9	31.6	32.8	32.	29.6	25.3	21.1	16.8	24.7

APPENDIX C

ARDUINO UNO CODE

```
#   include <Ethernet.h<
byte mac[] = { 0x90, 0xA2, 0xDA, 0x0D, 0x78, 0xE0 } ;
byte ip } = []10 ,50 ,88 ,44;{
byte gateway } = []10 ,50 ,88 ,254 ;{
byte subnet } = []255 ,255 ,255 ,0;{
EthernetServer server)80;(
String readString;
int val;
  int automatic = 1;
  int manual = 0;
  int pump1 = 0;
  int pump2 = 0;
void setup} ()
  pinMode(5, OUTPUT);
  pinMode(6, OUTPUT);
  Ethernet.begin(mac, ip, gateway, subnet);
  server.begin;()
  Serial.begin)9600;(
  Serial.println("pump automation project")  ;
{
void loop} ()
```

```
   EthernetClient client = server.available;()
  if (client)}
    while (client.connected())}
     if (client.available())}
      char c = client.read;()
      if (readString.length() < 100)}
        readString += c;
{
      if (c == '\n')}
        Serial.println(readString);
        client.println("HTTP/1.1 200 OK") ;
        client.println("Content-Type: text/html");
        client.println;()
        client.println("<HTML>");
        client.println("<HEAD>");
        client.println("<meta name='apple-mobile-web-app-capable' content='yes' />");
        client.println("<meta name='apple-mobile-web-app-status-bar-style'
content='black-translucent' />");
        client.println("<h1> Pump Automation </h1>");
        client.println("<h2> Hammam Al-Hersh Project</h2>");
        client.println("</HEAD>");
        client.println("<body bgcolor=\"#D0D0D0\">");
        client.println("<hr/>");
        client.println("<hr/>");
        client.println("<h4><center><img border=\"0\" src=\"\" /></center></h4>");
        client.println("<hr/>");
        client.println("<hr/>");
      client.print("<h4> Running mode </h4>");
        client.print(F("<td>"));
        client.print(F("<INPUT TYPE=\"button\" VALUE=\"MANUAL "));
```

```
     client.print(F("\" onClick=\"parent.location='/?manual"));
     client.print(F("\"\"></td>\n"));
    client.print(F("<td>"));
     client.print(F("<INPUT TYPE=\"button\" VALUE=\"AUTOMATIC "));
     client.print(F("\" onClick=\"parent.location='/?automatic"));
     client.print(F("\"\"></td>\n"));
    client.print("<h4> Pump 1 </h4>");
     client.print(F("<td>"));
     client.print(F("<INPUT TYPE=\"button\" VALUE=\"ON "));
     client.print(F("\" onClick=\"parent.location='/?relay1on"));
     client.print(F("\"\"></td>\n"));
     client.print(F("<td>"));
     client.print(F("<INPUT TYPE=\"button\" VALUE=\"OFF "));
     client.print(F("\" onClick=\"parent.location='/?relay1off"));
     client.print(F("\"\"></td>\n"));
    client.print("<h4> Pump 2 </h4>");
     client.print(F("<td>"));
     client.print(F("<INPUT TYPE=\"button\" VALUE=\"ON "));
     client.print(F("\" onClick=\"parent.location='/?relay2on"));
     client.print(F("\"\"></td>\n"));
     client.print(F("<td>"));
     client.print(F("<INPUT TYPE=\"button\" VALUE=\"OFF "));
     client.print(F("\" onClick=\"parent.location='/?relay2off"));
     client.print(F("\"\"></td>\n"));
     if (readString.indexOf("?manual") > 0)
}

     automatic = 0;
     manual = 1;
{

     else}
     if (readString.indexOf("?automatic") > 0)
```

```
}
          automatic = 1;
          manual = 0;
{
{

     if (automatic)}


      val = analogRead(A0);
      float mv = ( val / 1024.0) * 5000;
      float cel = mv / 10;
      if (cel <= 25) && (analogRead(A1) >= 500))
}

       digitalWrite(5, HIGH);
       Serial.println("Pump 2 on");
       pump2 = 1;
{

     else if (cel >= 27) || (analogRead(A1) <= 500))
}

       digitalWrite(5, LOW);
       Serial.println("Pump 2 off");
      pump2 = 0;
{

     if (analogRead(A2) <= 500)
}

       digitalWrite(6, HIGH);
       Serial.println("Pump 1 on");
       pump1 = 1;
{

     if (analogRead(A3) >= 500)
}

       digitalWrite(6, LOW);
```

```
      Serial.println("Pump 1 off");
        pump1 = 0;
{
{
      if (readString.indexOf("?relay1on") > 0)
}
    if (manual)}
        digitalWrite(5, HIGH);
        Serial.println("Pump 1 on");
        pump1 = 1;


{
{
      else}
       if (readString.indexOf("?relay1off") > 0)
}
       if (manual)}
          digitalWrite(5, LOW);
          Serial.println("Pump 1 off");
          pump1 = 0;
{
{
{
      if (readString.indexOf("?relay2on") > 0)
}
       if (manual)}
       digitalWrite(6, HIGH);
          Serial.println("Pump 2 on");
          pump2 = 1;
{
```

```
     {

          else}

            if (readString.indexOf("?relay2off") > 0)

     }

              if (manual)}
                digitalWrite(6, LOW);
                Serial.println("Pump 2 off");
                pump2 = 0;


     {

     {

     {


          client.println("<center>");
          client.println("<table border=\"5\">");
          client.println("<tr>");


          if (pump1 == 1)}
            client.print("<td>Pump 1 is ON</td>");

     {

          else

     }

            client.print("<td>Pump 1 is OFF</td>");

     {

          client.println("<br />");


          if (pump2 == 1)}
            client.print("<td>Pump 2 is ON</td>");

     {

          else

     }
```

```
                    client.print("<td>Pump 2 is OFF</td>");
{

        client.println("</tr>");
        client.println("<tr>");


        client.print("<td>Operation Mode</td>");
        if (manual)}
          client.print("<td>Manual </td>");
{

        else if (automatic)
}

          client.print("<td>Automatic</td>");
{

      client.println("</tr>");
       client.println("</table>");
       client.println("</center>");
       readString;"" =
       client.println("</body>");
       client.println("</HTML>");
       delay)1;(
       client.stop;()
{
{
{
{
 if (automatic)}
  val = analogRead(A0);
   float mv = ( val / 1024.0) * 5000;
   float cel = mv / 10;
   if (cel <= 25) && (analogRead(A1) >= 500))
}
```

```
    digitalWrite(5, HIGH);

    Serial.println("Pump 2 on");

{

  else if (cel >= 27) || (analogRead(A1) <= 500))

}

    digitalWrite(5, LOW);

    Serial.println("Pump 2 off");

{

  if (analogRead(A2) >= 500)

}

    digitalWrite(6, HIGH);

    Serial.println("Pump 1 on");

{

  if (analogRead(A3) <= 500)

}

    digitalWrite(6, LOW);

    Serial.println("Pump 1 off");

{

{

{
```