بسم الله الرحمن الرحيم

Palestine Polytechnic University

Collage of IT and Computer Engineering

Graduation Project

Water Level Monitoring

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April 30, 2018

Acknowledgement

I would like to thank and express my great appreciation to Dr. HashemTamimi for his valuable and constructive suggestions during this project work. His willingness to give his time has been very appreciated as well as Eng.WaelAl_Takrouri for his advice and assistance.

I would like to thank my university, Palestine Polytechnic University, College of Computer Engineering and Information Technology represented by its educational staff for their efforts and support

Finally, I wish to thank my parents and friends for providing me with unfailing support and continuous encouragement throughout my years of study.

Abstract

The water is the most precious natural resources, it's necessary for the continuity of life, but Filling the reservoirs and wells without observing water levels is a major cause of wasted water, therefore causing of the biggest problem which is the scarcity of the water; therefore, we have to find a way (water level monitoring) to reduce this problem and reducing wasted water.

We can apply this idea (water level monitoring), at the level of tanks of residential buildings where the owner of each apartment can know the level of water in the reservoir of his apartment, and at agricultural land, factories, stone saws, and know the level of sea water or any facility based on water.

The methodology To implement this project, what we need is an ultrasonic sensor to measure the level of water and a raspberry pi to control the work of the sensor, based on a certain software is loaded on the raspberry pi, in other side I connect the raspberry pi to the internet (LAN), and the user connected to the same LAN, so he could access the result in an easy way.

In this project(the design of a water level monitoring system), that is able to detect the level of water in a certain water tank,or other water storage systems that is similar to it. The system senses the amount of water in the tank, and the user have the result while the tank is filling with waterusing his mobile phone as a practical, and low cost solution.

الملخص

الماء هو أثمن الموارد الطبيعية، وهو ضروري لاستمرارية الحياة، ولكن ملء الخزانات والآبار دون مراقبة مستويات المياه هو سبب رئيسي لهدر المياه، وبالتالي التسبب بالمشكلة الاكبر وهي ندرة المياه. لذلك علينا إيجاد طريقة (مراقبة مستوى الماء) للحد من هذه المشكلة والحد من المياه المهدورة.

يمكننا تطبيق هذه الفكرة (مراقبة مستوى المياه)، على مستوى خزانات المباني السكنية حيث يمكن لمالك كل شقة معرفة مستوى المياه في خزان شقته، وعلى الأراضيالزراعية، المصانع والمناشير الحجرية ومعرفة مستوى مياه البحر أو أي منشأة تعتمد على الماء.

المنهجية لتنفيذ هذا المشروع، ما نحتاجه هو جهاز استشعار (ultrasonic sensor) لقياس مستوى الماء والمتحكم (raspberry pi 3) للتحكم في عمل المستشعر، على أساس كود برمجي معين يتم تحميله علىالمتحكم (raspberry pi)، في الجانب الآخر قمت بتوصيلالمتحكم (raspberry pi3) إلى شبكة الإنترنت، والمستخدم المتصل بنفسشبكة الانترنت، حتى يتمكن المستخدم من الوصول إلى النتيجة بطريقة سهلة.

في هذا المشروع (تصميم نظام مراقبة مستوى المياه)، قادر على اكتشاف مستوى المياه في خزان مياه معين، أو غيرها من أنظمة تخزين المياه المشابهة. يستشعر النظام كمية المياه الموجودة في الخزان، ويكون لدى المستخدم النتيجة أثناء ملء الخزان بالماء باستخدام هاتفه المحمول كحل عملي ومنخفض التكلفة .

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Chapter 1: Introduction

1.1Overview:

The problem of water shortages is popular in most parts of the world, especially drinking water, is widespread for many reasons. One of these reasons is misuse or lack of control over water consumption.So we try to find ways to rationalize water consumption

In this project the aim is to monitor the water level, as a practical and low cost solution.

In this chapter, I will talk about the project idea in details, Motivations behind thisproject. Then show the project importance, a description of the project scope, project objectives.

1.2 Project Idea Description:

The main idea of this project is to monitor the level of water using a sensor (ultrasonic sensor) connected with microcontroller (here I used a raspberry pi3), then this information could be accessed from the user's phone .This project can be used in buildings with multiple floors, houses, and in all the institutions that use the water inlet sources and reservoirs.

1.3 Project objectives:

The goal of the project is a water level monitoring device to help the users and the communities reducing the problem of wasting water , the system have to be practical , easy to install and deal with, low cost , any one could have it , it did not require an expert, and suitable for all members of the community.

1.4Motivations:

Water shortage is one of the most challenging problems in our society, filling tanks and wells without monitoring the water levels in these reservoirs, far from being a difficult process where you need to check the water level several times until the completion of filling the reservoir, so if there were many reservoirs that need to fill or even know the amount of water inside, the process will be difficult and waste of time and effort. Else it's may result in loosing excess amounts of water; this would increase the water shortage problem. So finding several ways to keep the water levels, and without wasting can be one of the most important social and municipal tasks. Accordingly, in this project, we will design and implement a water monitoring system.

1.5Project Scope:

This project can be apply for tank water or a similar water storage system, but can be scales easily to tanks for houses and buildings with multiple floors where the owner of each apartment can know the level of water in the reservoir of his apartment, and institutions that use the water reservoirs and thus rationalize its consumption of water, and at agricultural land, factories, stone saws, and know the level of sea water, or any facility based on water at its work.

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1.6 Literature Review:

At this part, I will talk about the related works, the previous projects which relates to my project.

1) WATER LEVEL CONTROLLER:

The level of the water in a field is controlled using three main components which are PIC microcontroller, motor to control the water levels,sensor (to sense the level of water when its reach it). The sensor sense the intensity of water and give indication to the microcontroller.

The microcontroller produces the control signals to drive the motor. If there is no water then microcontroller gives control signal to start the motor and if there is sufficient water in the field then the microcontroller give control signal to stop the motor [1].

2) Wireless Automatic Water Level Control using Radio Frequency Communication:

In this project they use two main sections of the system, transmitting and Receiving section. Transmitting section has a level sensor, a sensor driver circuit, a microcontroller, RF transceiver module and an antenna. The receiving section consists of a level sensor, sensor driver, buzzer, relay logic, microcontroller, motor, pump, RF transceiver and an antenna. It has two microcontrollers placed one at the tank and another at the sump. They perform two levels of water the first one when the tank is almost empty as “LOW” and the second level when it's full as “HIGH”. Two sensors are placed at these two levels. The sensor outputs are amplified and given to the tank controller as interrupts for “LOW” or “HIGH” Level[2].

CHAPTER TWO:Background

2.1 Theoretical Background:

In the use of water level monitoring devices there are several components that we can used in my project, including the microcontroller and sensors?

1) Such as a microcontroller there is:

a- **Arduino**: which is an open source software, easy to deal with and low cost.

b- **Pic(Peripheral Interface Controller):** which is low cost, wide availability, large user base, extensive collection of application notes, and availability of low cost or free development tools, serial programming, and re-programmable [3].

Both are suitable for the project, but in my project I need a wireless connection and the possibility of getting the result from long distances, to achieve this I need a WIFI shield in addition to the microcontroller, therefor I am used a raspberry pi3 built in Wi-Fi which is more practical and low cost as one component compared with two components.

2) The sensor for water level monitoring:

I used an ultrasonic sensor because it's the most popular for distance measurements, low cost and high accuracy and easy to connect and Their high frequency, Which allows for continuous running and less downtime, the ultrasonic sensors are easy to use and not dangerous during operation to nearby objects, people or equipment, and its easily interface with microcontrollers as shown in **Figure 2.2 [4]**.

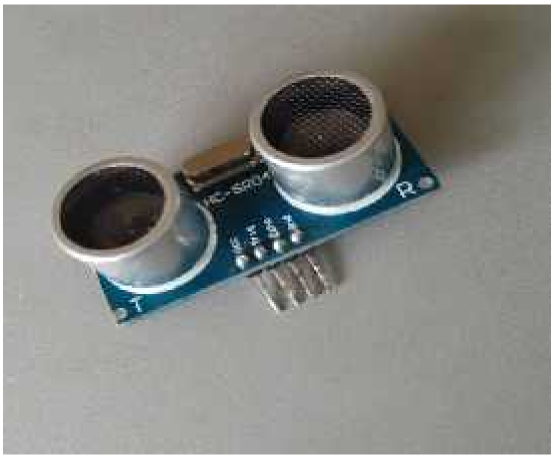


Figure 2. 1:ultrasonic sensor

2.2Hardware and Software

2.2.1 Hardware Components of the System:

Some Description of hardware and software components used in the system.

1) **Raspberry PI 3:**

The Raspberry Pi 3 Model B as shown in **Figure 2.3**is the latest version of the Raspberry Pi, Additionally Raspberry pi 3 can be connected to a local area network through Ethernet cable or USB WIFI adapter, and then it can be accessed through SSH remote login[5] .

a- **Why did I used theraspberry pi 3 for my project?**

Raspberry pi is Practical and easy to deal with as one component built in Wi-Fi, and low cost is less than using another microcontroller connect with Wi-Fi shield. Its Consistent board format, practical and suitable size for the project. Faster processing; therefor, faster processing of the water level monitoring [5].

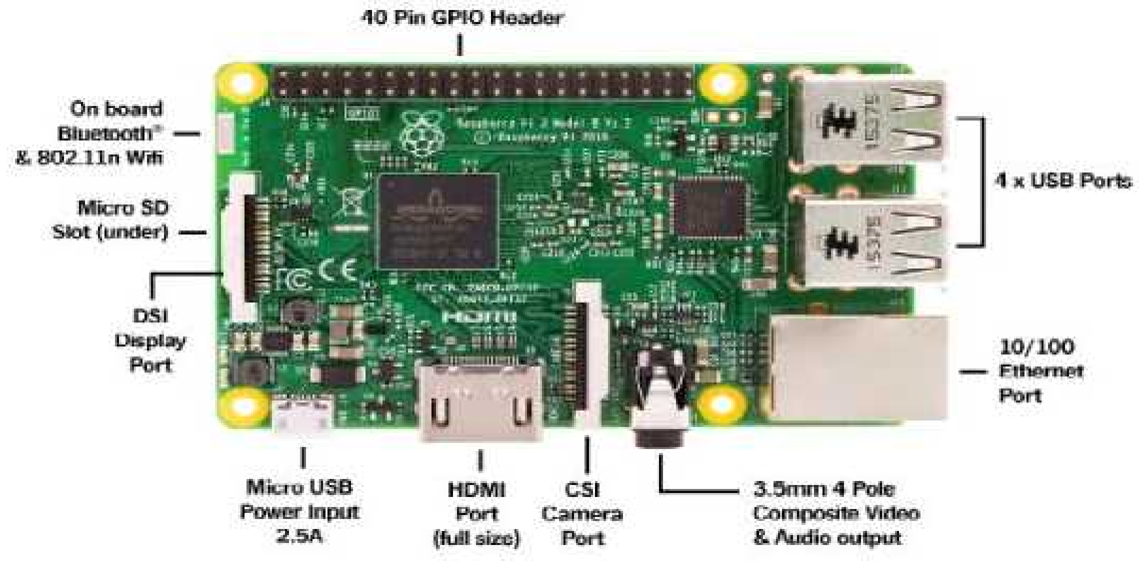


Figure 2. 2: Raspberry Pi 3 Model B

2) Ultrasonic Sensor:

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves as shown in **Figure 2.4**. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object [4].

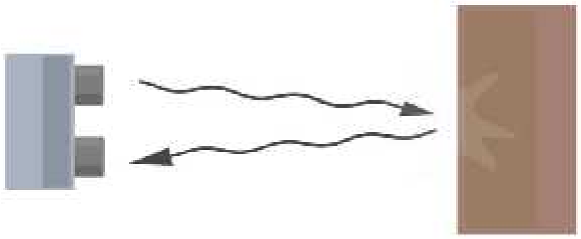


Figure 2. 3: ultrasonic sensor operation

To find the total round-trip distance of the sound wave. Round-trip means that the sound wave traveled 2 times the distance to the object before it was detected by the sensor; it includes the 'trip' from the sonar sensor to the object and the 'trip' from the object to the Ultrasonic sensor (after the sound wave bounced off the object). To find the distance to the object, simply divide the round-trip distance in half [4].

$$Distance = (speedofsound \times timetaken)/2$$

3) Connected Wire:

Wires as we define here are used for transmission of electricity or electrical signals.

Figure 2. 4: Connected Wire

4) Resistors:

The sensor output signal (ECHO) on the HC-SR04 is rated at 5V. However, the input pin on the Raspberry Pi GPIO is rated at 3.3V. Sending a 5V signal into that unprotected 3.3V input port could damage the GPIO pins, which is something I want to avoid! So I used a small voltage divider circuit, consisting of two resistors as shown in **Figure2.6**, to lower the sensor output voltage to something our Raspberry Pi can handle[5].

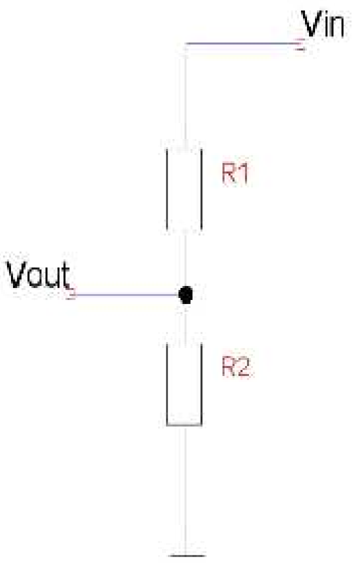


Figure 2. 5: voltage divider circuit

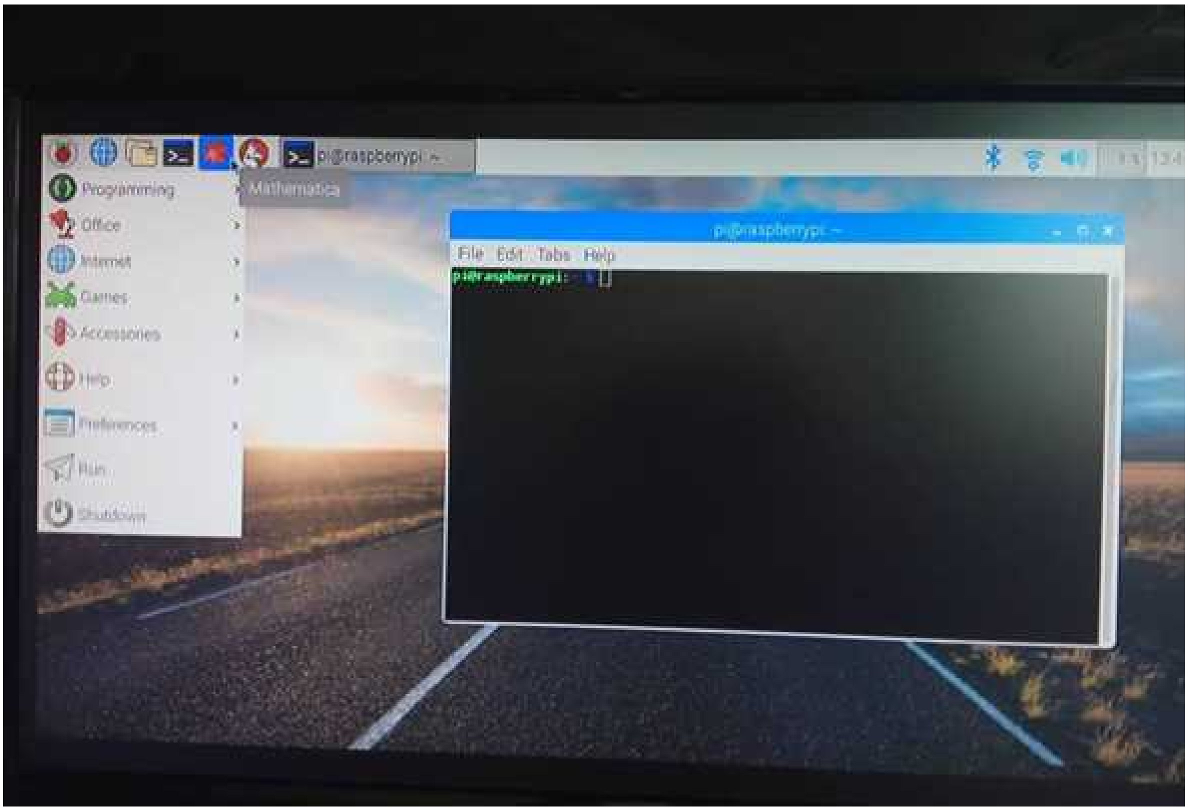
2.2.2 Software Components:

b- In this project I used a raspberry pi as a main processor, the Raspberry Pi itself doesn’t come with an operating system. For that, I have to install an operating system, which depends on the project idea .in my project I installed a Raspbian operating system.

c- Here’s why I chose a Raspbian operating system**.**

d- **Raspbian Operating System:**

Raspbian**Figure2.7** is the operating system of the Raspberry Pi and because of that, it’s the one I started with. It's a version of Linux built specifically for the Raspberry Pi,it’s depend on command line to manage the operations [6].



```
pi@raspberrypi: ~ $
```

Figure 2. 6:Raspbian operating system

e- SSH (SECURE SHELL):

SSH (also known as ‘secure shell’) is an encrypted networking technology that enables you to manage computers from the command line over a network as in **Figure 2.8**. You can access the command line of a Raspberry Pi remotely from another computer or device on the same network using SSH. The Raspberry Pi will act as a remote device, you can connect to it using a client on another machine.

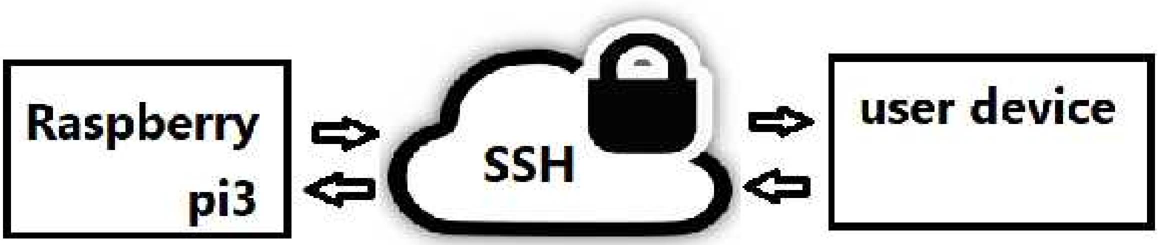


Figure 2. 7: SSH (Secure Shell)

Here the raspberry pi 3 acts as a "server" which have the operating system (Raspbian) and the software so it's have the management and the control of the ultrasonic sensor, and the user device acts as a "client" needed to access the server, and the SSH protocol that enables the user device to access the command line of a Raspberry Pi remotely on the same network.

Chapter 3: Requirementsand System Design

3.1 Brief Description of the System:

The system designed to be able to measure the level of water using ultrasonic sensor connecting with raspberry pi3 and access the device from the user mobile phone using SSH(secure shell) protocol depending on local area network built in raspberry pi3 .

3.2 Requirements:

This project is not the only one of its kind, there are many that serve the same idea, but in my project the goal was to find a system so that it is practical which mean that could work effectively in real circumstances, it lasts for a long time and easy to deal with , easy to handle in terms of installation and handling of components, it does not require expert intervention to install and to enable the connection between the hard ware components and user device, anyone can install it and deal with it easily and did not need Time or effort, and Low cost because in this project I used raspberry pi built in Wi-Fi (one component) and ultrasonic sensor ,instead of using another microcontroller and Wi-Fi shield(two component),using one component is lower cost , and less power consumption compared with using two component ,in addition of using ultrasonic sensor, its more accuracy and minimum effort and time ; moreover, using it with raspberry pi which is high processing speed and less time consumption; moreover , as a user I need to access the system wirelessly and so easily without climbing and from long distances.

3.3 Problem analysis:

In any water system, one of the most important problems we may encounter in trying to monitor the water level during the filling of the reservoir or any water storage unit is as follows:

1) Trying to climb and monitor the water level by anyone is a difficult, dangerous process, and takes time and effort.

2) If there are a number of reservoirs and not only one will be a much more difficult process and c

3) Physical monitoring of the amount of water in reservoirs cannot be relied upon because it will cause a lot of water to flow and thus loss of water without use.

3.4Design Option:

How we can work until we meet the requirements?

3.4.1 Hardware Design:

1) Raspberrypi3:

A Raspberry Pi is a general-purpose computer, usually with a Linux operating system, and the ability to run multiple programs. And a slightly faster graphics processor, another advantage is built-in Wi-Fi, makes it easier to stream content to the Pi [5].

2) Ultrasonic sensor:

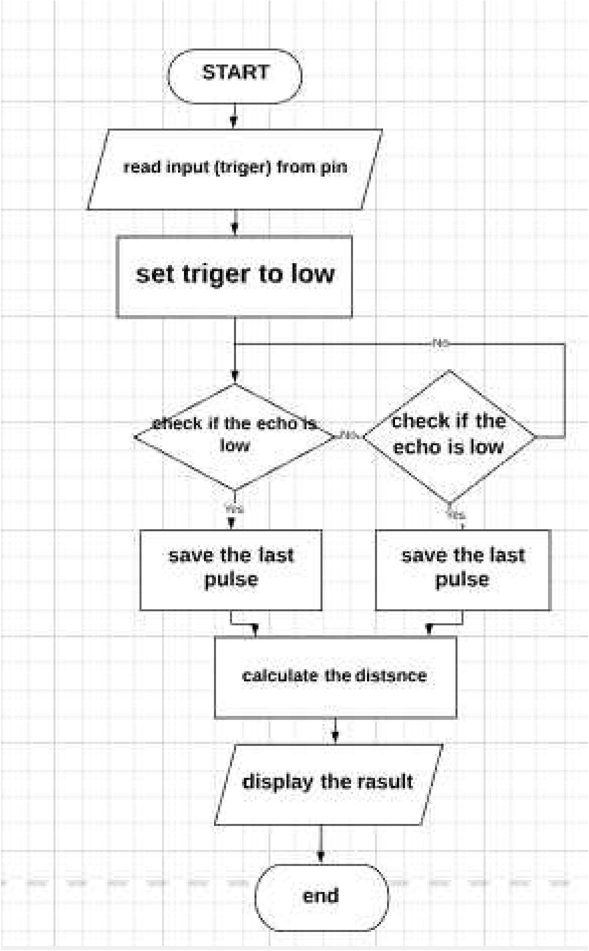
Ultrasonic sensors are a great fit for many applications, they have greater accuracy than many other methods at measuring distance , make it easy to detect external or deep objects, ultrasonic sensors are easy to use and not dangerous during operation to nearby objects, people or equipment, and easily interface with microcontrollers or any type of controllers[4] .

3.4.2 Software Design:

The code to control the ultrasonic sensor is written using python language, which is one of the primary programming languages hosted on the Raspberry Pi, then using the command line for execution.

A SSH, also known as Secure Socket Shell, is a network protocol that provides administrators with a secure way to access a remote computer. In this project you can access the command line of a Raspberry Pi remotely from another computer or device on the same network using SSH. Secure Shell provides strong authentication and secure encrypted data communications between two computers connecting over an insecure network such as the Internet [8].

Flowchart:



3.5 System Diagrams:

3.5.1 System Diagram:

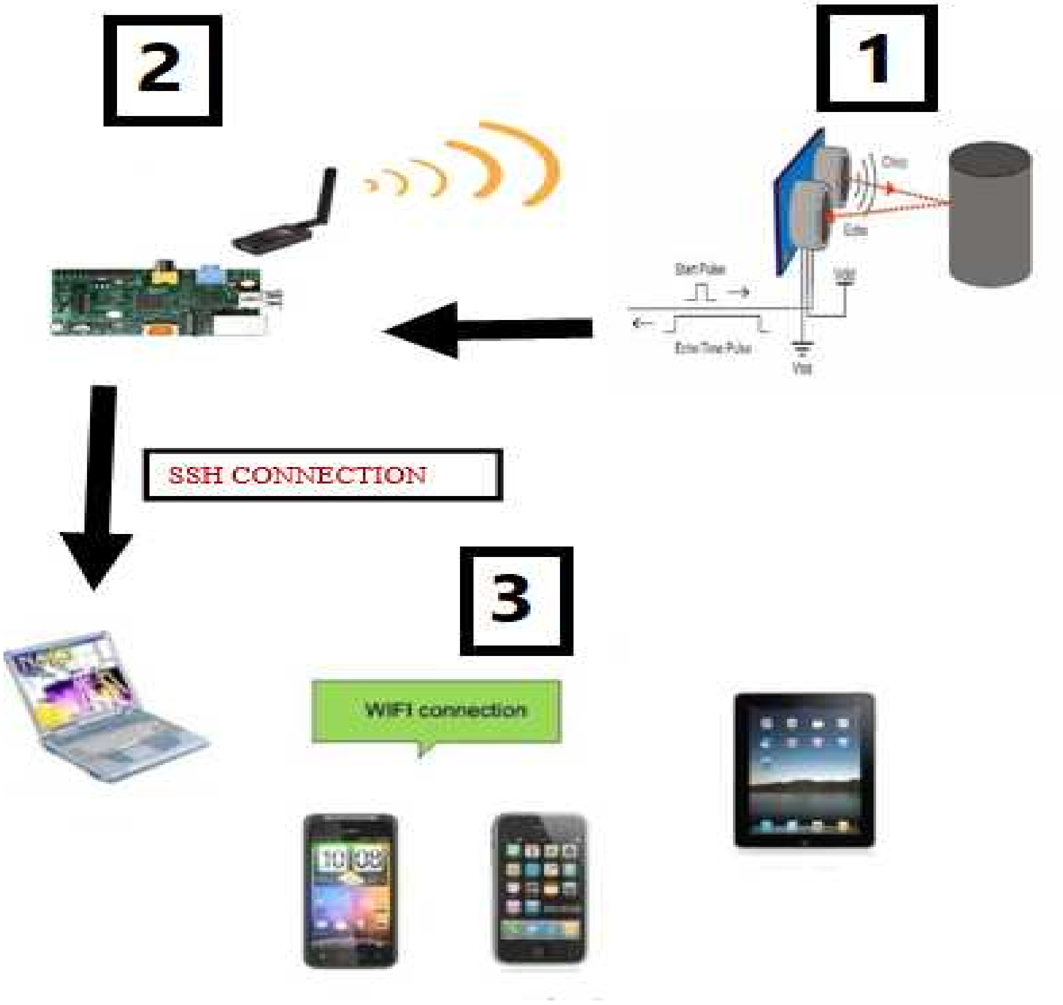


Figure 3. 1:System Diagram

System diagram shows how the hardware component(raspberry pi3 and ultrasonic sensor)work each one separately ,depends on its aim , and how the whole system components (hardware and software) depends and connected with each other to make a good result , and using user device remotely to access the system.

3.5.2 Block Diagram:

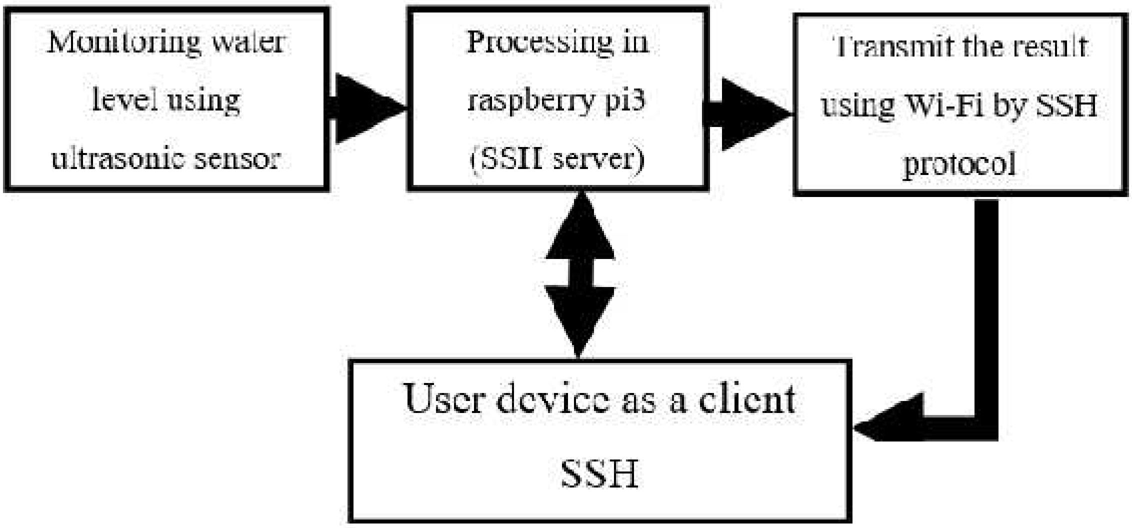

Monitoring water level using ultrasonic sensor
Processing in raspberry pi3 (SSII server)
Transmit the result using Wi-Fi by SSH protocol
User device as a client SSH

Figure 3. 2:Block Diagram

Block diagram shows how The Ultrasonic sensor will transmit the data (water level) to Raspberry pi 3. The raspberry pi 3 should receive data, and control the device from user mobile phone using SSH protocol 3 via LAN (Local Area Network).

3.5.3 Schematic diagram:

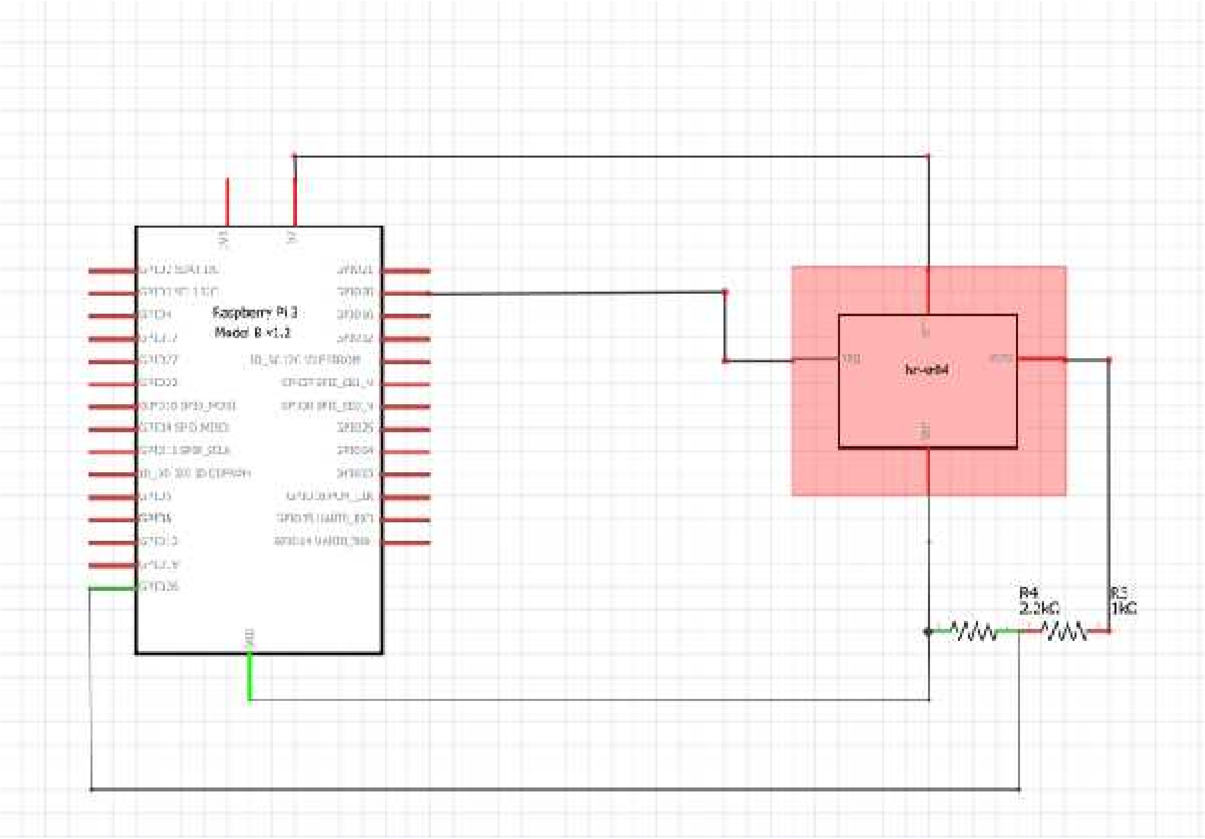


Figure 3. 3: schematic diagram

Schematic diagram shows how the internal connection of the system (raspberry pi3 and ultrasonic sensor), as follow:

Note: Raspberry Pi is a 3.3V device and HC-SR04 is a 5V device**. The ultrasonic sensor modulehave four pin to connect from**

1) VCC powers the module.
2) GND is used to ground it.
3) TRIG allows the sensor to receive a signal from the Pi, which then triggers the emission of an ultrasound pulse.
4) ECHO transmits back a signal when the sensor detects the reflected pulse.

The connection is:

1- VCC, +5V Supply Input Pin: connect with **5v** GPIO pin 2.
2- GND, Ground: connect with GND GPIO pin 6.
3- TRIG, Trigger Input Pin: connect with GPIO pins20
4- ECHO, Echo Output Pin:We can't simply attach the sensor's ECHO wire to the Pi's GPIO pin, as the sensor module would be outputting a 5v signal to a pin rated only for 3.3v, and this could result in damage to the Pi.Because of that I need a resistors to create a voltage divider to bring the voltage down to an acceptable level. A voltage divider consists of two resistors (R1 and R2) in series connected to an input voltage (VIN), which needs to be reduced to the output voltage (Vout). In the circuit, VIN will be ECHO, which needs to be decreased from 5V to our Vout of 3.3V.as shown in figure 3.4[6].

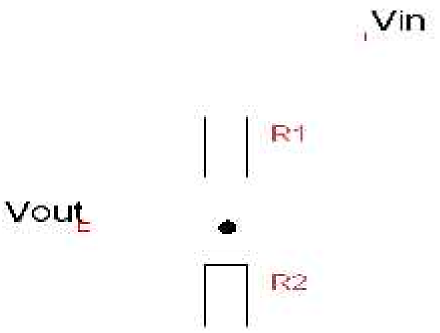


Figure 3. 4 :Voltage Divider

I used 1k ohm resistor for R1 and a 2.2k ohm resistor for R2.

Depend on this equation: $Vout = Vin * R2/(R1 + R2)$

3.4.3 Conclusion:

The main objective of this project was to build a system using raspberry pi3 (Hardware, Software) that will assist the users to monitor the level of water in an easy way from a long distances.

Chapter 4: Software and Hardware Implementation

4.1 Hardware Implementation

4.1.1 Raspberry pi3 with ultrasonic sensor:

I connect raspberry pi 3 with ultrasonic sensor to receive the data.

The circuit diagram of the project:

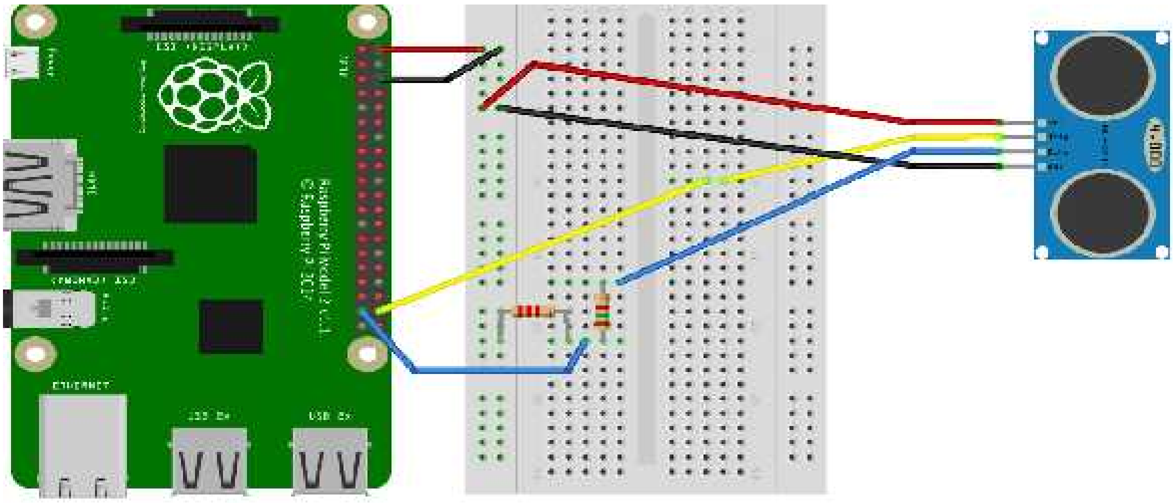


Figure 4. 1:Raspberry pi3 with ultrasonic sensor circuit diagram

Circuit diagram shows how the real component raspberry pi3 and ultrasonic sensor connected together using bread board.

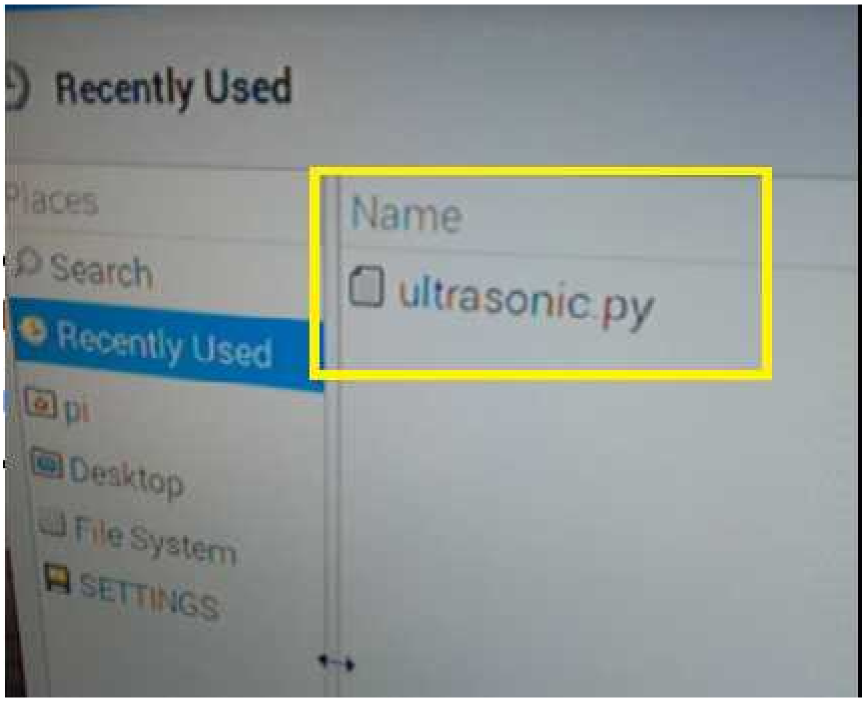
4.2 Software Implementation tools

I used Raspbian operating system and command line to control the system.

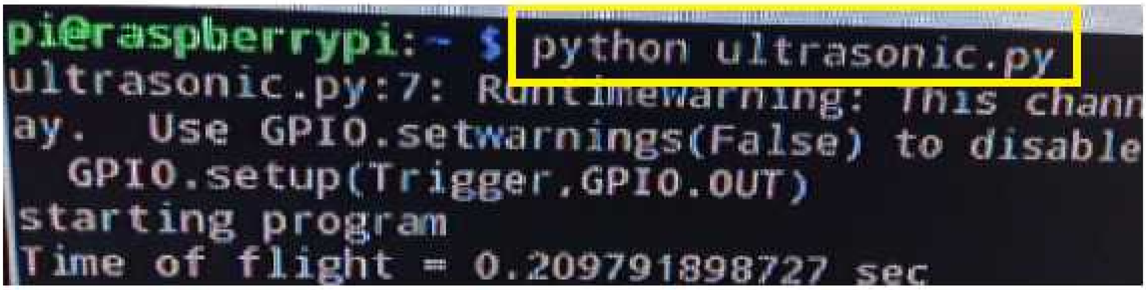
4.2.1 Programming language

1) The raspberry pi 3 has an operating system, installed on SD card, then put the CD card in the Raspberry pi 3, I used a Raspbian operating system.

2)Writing the python code and save it as (ultrasonic.py).



3) Using command line to execute the program which is:

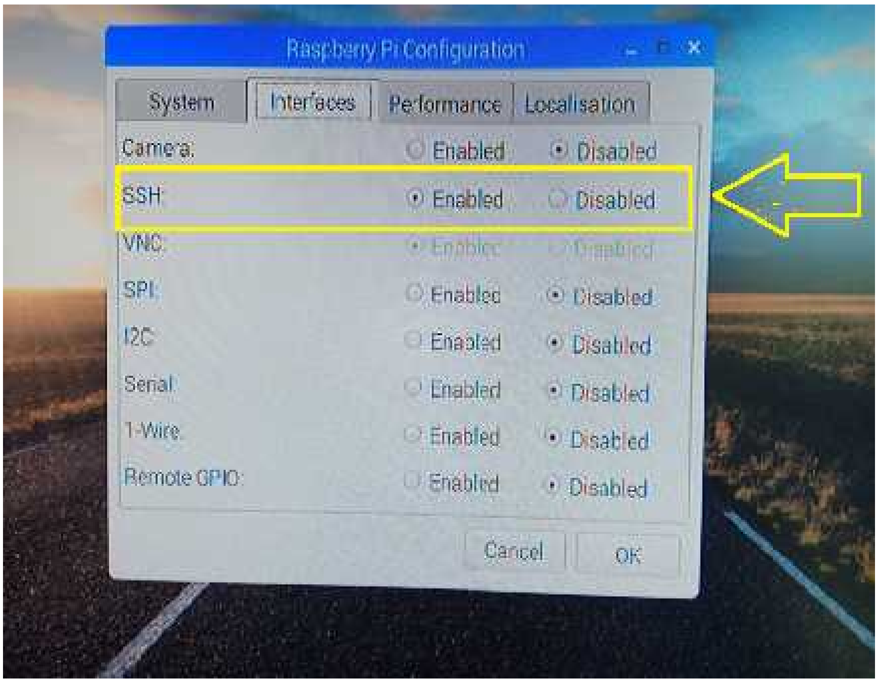


```
pi@raspberrypi:~ $ python ultrasonic.py
ultrasonic.py:7: RuntimeWarning: This chann
ay.  Use GPIO.setwarnings(False) to disable
  GPIO.setup(Trigger,GPIO.OUT)
starting program
Time of flight = 0.209791898727 sec
```

4) Then I have to c(remote control of the raspberry pi)to connect with raspberry pi 3 following those step:

a- Activate SSH in Raspbian as shown in **Figure 4.2**.

On Raspberry Pi, choose Menu > Preferences > Raspberry Pi Configuration. Click on Interfaces and set SSH to Enabled then Click OK.

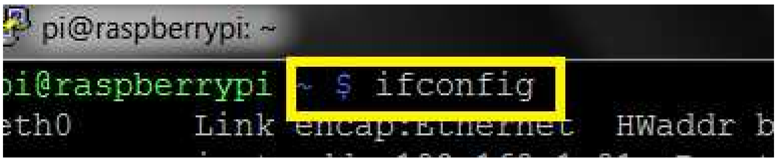


Camera:	○ Enabled	● Disabled
SSH:	● Enabled	○ Disabled
VNC:	● Enabled	○ Disabled
SPI:	○ Enabled	● Disabled
I2C:	○ Enabled	● Disabled
Serial:	○ Enabled	● Disabled
1-Wire:	○ Enabled	● Disabled
Remote GPIO:	○ Enabled	● Disabled

Figure 4. 2: Activate SSH in Raspbian

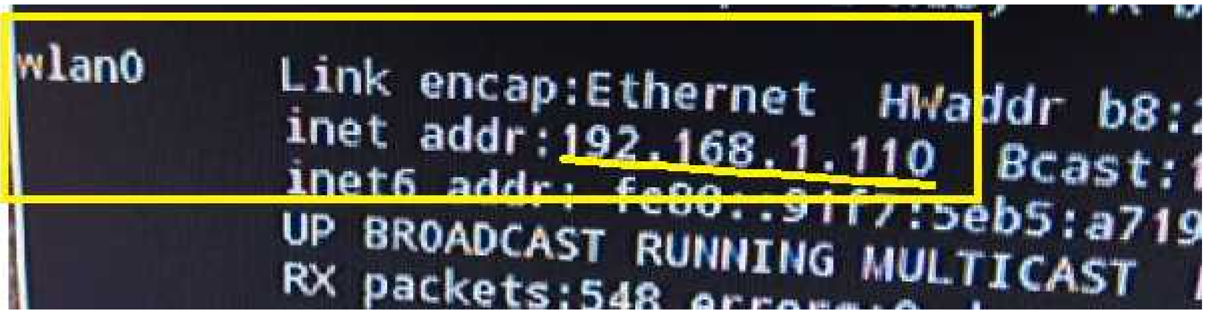
b- Get IP address :

Connect your Raspberry Pi to a local networkthenOpen a terminal and enter ifconfig to find the IP address.



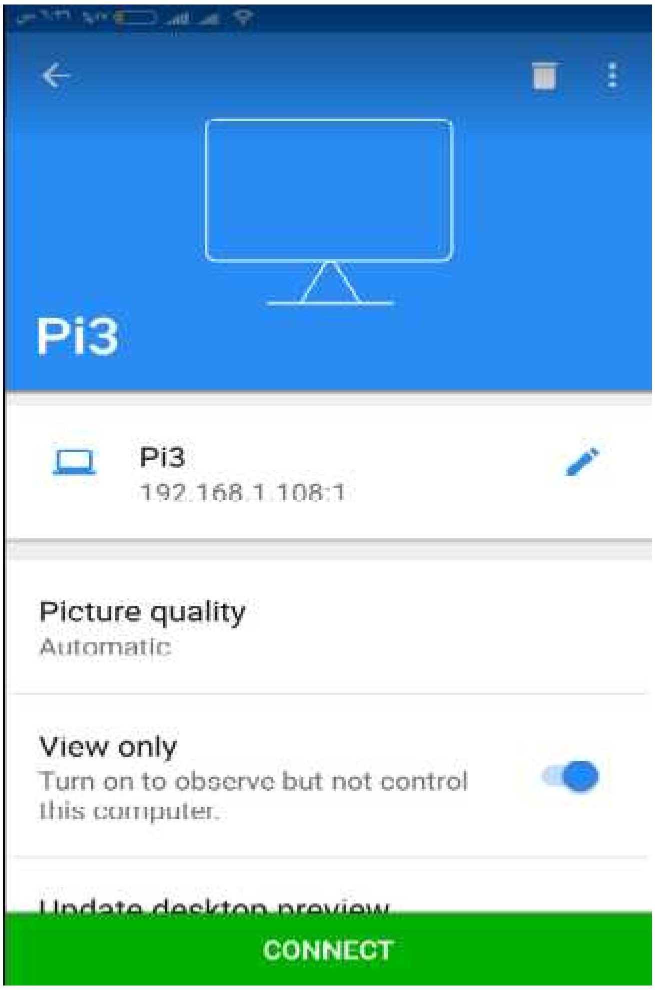
```
pi@raspberrypi: ~
pi@raspberrypi ~ $ ifconfig
eth0      Link encap:Ethernet  HWaddr b
```

And the ip address being in wlan as the follow:



```
wlan0     Link encap:Ethernet  HWaddr b8:
          inet addr:192.168.1.110  Bcast:
          inet6 addr: fe80::91f7:5eb5:a719
          UP BROADCAST RUNNING MULTICAST
          RX packets:548 errors:0
```

c- Set up the client : Start a SSH viewer, I used a VNC(Virtual Network Computing) viewer which is a system remote control , that transmits what happens immediately, depends on how the connection works,and a feature of the VNC system don't Depends on the specific operating system. Then enter the ip address of the raspberry pi.



Pi3
192.168.1.108:1

Picture quality
Automatic

View only
Turn on to observe but not control this computer.

Update desktop preview

d- Then using command line in user device to control the execution of the program wirelessly.

Chapter 5: Testing

5.1 Overview

In this chapter I describe and discuss the steps, results of the implementation and testing of the system.

5.2 Units Testing

I started by testing all the parts separately, to ensure that all of the functions works perfectly and without errors then connect all the system and test it as shown.

5.2.1 Hardware Testing

1. Testing the working of raspberry pi 3.

2. Testing the working of ultrasonic sensor.

3. Testing all components (Raspberry pi, ultrasonic, transistors) connected togetheras shown.

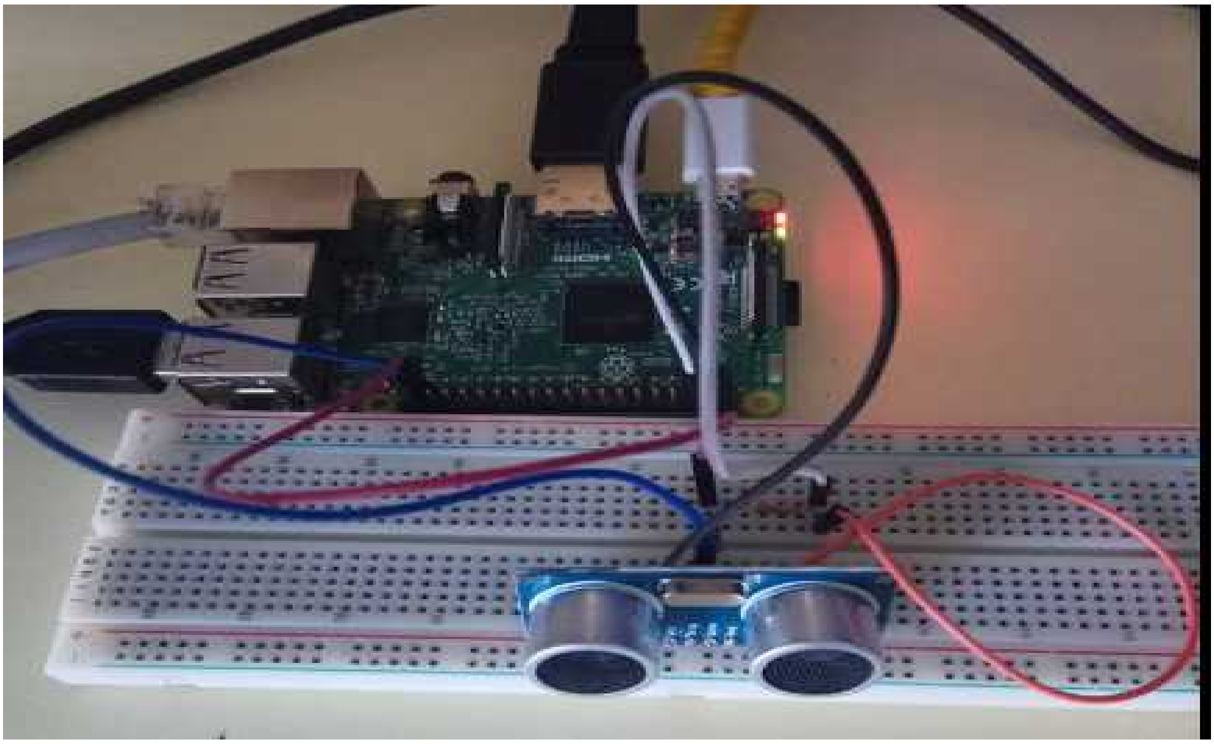


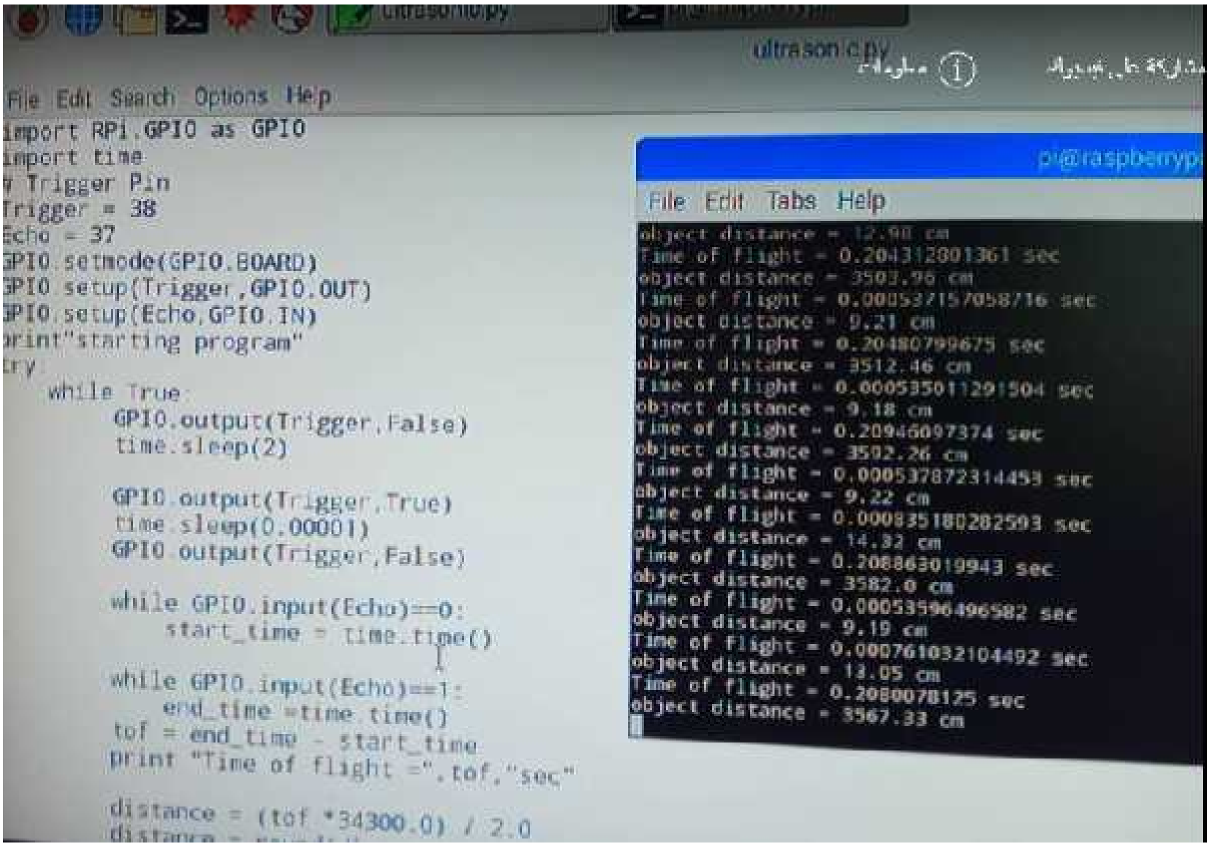
Figure 5. 1: Raspberry pi3 with ultrasonic sensor

5.2.2 Software Testing:

1) At the beginning I Connect the raspberry pi to a screen then write a python code using text editor file, and save it as a **(ultrasonic .py)** .

2) Using command line to execute the code and have a result.

The result is as shown in **Figure 5.2.**



```
import RPi.GPIO as GPIO
import time
# Trigger Pin
Trigger = 38
Echo = 37
GPIO.setmode(GPIO.BOARD)
GPIO.setup(Trigger,GPIO.OUT)
GPIO.setup(Echo,GPIO.IN)
print"starting program"
try:
    while True:
          GPIO.output(Trigger,False)
          time.sleep(2)

          GPIO.output(Trigger,True)
          time.sleep(0.00001)
          GPIO.output(Trigger,False)

          while GPIO.input(Echo)==0:
              start_time = time.time()

          while GPIO.input(Echo)==1:
              end_time =time.time()
          tof = end_time - start_time
          print "Time of flight =",tof,"sec"

          distance = (tof *34300.0) / 2.0
```

```
object distance = 12.98 cm
Time of flight = 0.204312001361 sec
object distance = 3503.96 cm
Time of flight = 0.000537157058716 sec
object distance = 9.21 cm
Time of flight = 0.20480799675 sec
object distance = 3512.46 cm
Time of flight = 0.000535011291504 sec
object distance = 9.18 cm
Time of flight = 0.20946097374 sec
object distance = 3592.26 cm
Time of flight = 0.000537872314453 sec
object distance = 9.22 cm
Time of flight = 0.000835180282593 sec
object distance = 14.32 cm
Time of flight = 0.208863019943 sec
object distance = 3582.0 cm
Time of flight = 0.000535964496582 sec
object distance = 9.19 cm
Time of flight = 0.000761032104492 sec
object distance = 13.05 cm
Time of flight = 0.2080078125 sec
object distance = 3567.33 cm
```

Figure 5. 2: software testing

Chapter 6: Conclusion and Future Work

6.1 Conclusion:

Water level monitoring system is a practical and low-cost system that is easy to deal with so that it does not require the intervention of experts and is a good solution to the problem of water scarcity, which is the excessive consumption of water and the lack of management or monitoring of water while filling reservoirs or wells.

The system consists of a sensor to measure the water level. The sensor is controlled by a raspberry pi 3 built in Wi-Fi, and the result is transmitted to the user device using SSH protocol connected with local area network.

The challenges I faced were the selection of low-cost, practical and convenient components for the project, and moreover I was using raspberry pi 3 which I had not dealt with in advance and therefore needed to learn before starting the project.

The decisions I have taken are for the project parts, and used a raspberry pi 3 built in

Wi-Fi and send the result wirelessly using SSH protocol.

6.3 future work

Project scope can be done on a larger scope, more reservoirs or water storage systems, and the use of the wireless Internet to access the system from anywhere not only within the local area network.

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