بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Design of Automatic Plant Irrigation System Using Microcontroller

تصميم نظام الرى الالى للنبات باستخدام المتحكم الدقيق

A thesis Submitted in Partial Fulfillment for the
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بسم الله الرحمن الرحيم

أَوَلَمْ يَرَ الَّذِينَ كَفَرُوا أَنَّ السَّمَوَاتِ وَالْأَرْضَ كَانَتَا رَتْقًا
فَفَتَقْنَاهُمَا وَجَعَلْنَا مِنَ الْمَاءِ كُلَّ شَيْءٍ حَيٍّ أَفَلَا يُؤْمِنُونَ
(30) وَجَعَلْنَا فِي الْأَرْضِ رَوَاسِيَ أَنْ تَمِيدَ بِهِمْ وَجَعَلْنَا
فِيهَا فِجَاجًا سُبُلًا لَعَلَّهُمْ يَهْتَدُونَ (31) وَجَعَلْنَا السَّمَاءَ سَقْفًا
مَحْفُوظًا وَهُمْ عَنْ آَيَاتِهَا مُعْرِضُونَ (32) وَهُوَ الَّذِي خَلَقَ
اللَّيْلَ وَالنَّهَارَ وَالشَّمْسَ وَالْقَمَرَ كُلٌّ فِي فَلَكٍ يَسْبَحُونَ

الأ نبياء

DEDICATION

This thesis is lovingly dedicated to my parent, my brothers, my sisters and my wife whose has been constant source of inspiration for me. Without their love and support this project would not have been made possible.

ACKNOWLEDGMENT

In the name of Allah, Most Gracious, Most Merciful

First and foremost, praises and thanks to Allah, the Almighty, on whom ultimately we depend for the completion of this master's thesis. Only due to His blessings I could finish this thesis.

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ABSTRACT

Automatic plant irrigation system rise as a good choice and alternative to the traditional irrigation methods since it is saving time and effort that consumed by the traditional methods where peoples are compelled to stop doing their important activities.

The aim of this thesis is to develop a microcontroller based automatic irrigation system. This system will run automatically by referring to the level of soil moisture. The humidity sensor type connected to the microcontroller is soil moisture sensor YL-69. The level of moisture will be displayed on the LCD screen to inform the user about their plant condition. The system was tested on three soil types (loam, sand and red) .From the results we can observe that the red soil has lower resistance by increasing the water contents.

مستخلص

يعتبر نظام الرى الالى الحل الامثل و البديل للرى بالطرق التقليدية حيث انه يعمل على توفير الوقت و الجهد الذى تستهلكه الطرق التقليدية حيث يضطر العاملون الى ترك بعض الانشطة المهمة.

يهدف هذا البحث الى تطويرنظام رى الى باستخدام المتحكم الدقيق. هذا النظام سيعمل اليا وفقا لمستوى رطوبة التربة. نوع حساس الرطوبة الذى تم ربطه مع المتحكم الدقيق هو YL-69. يتم عرض مستوى الرطوبة على شاشة الكريستال السائل لاعلام المستخدم عن حالة التربة. تم اختبار هذا النظام على ثلاثة انواع من التربة (الطيينية، الرملية و الحمراء .من خلال نتائج الاختبار وجد ان التربه الحمراء هى الاكثر انخفاضا في مقا ومتها كلما زادة نسبة المياه فيها.

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LIST OF ABBREVIATIONS

PWM	Pulse Width Modulation
RH	Relative Humidity
WBIC	Weather -Based Irrigation Control
RC	Resister-Capacitor
RCL	Resister-Capacitor-inductor
PC	Purpose Computer
DSP	Digital Signal Processing
ADC	Analogue to Digital Converter
DAC	Digital to Analogue Converter
PECL	Positive-Emitter-coupled-Logic
LVDS	Low-Voltage Differential- Signaling logic
DIP	Dual In Line
TTL	Transistor-Transistor Logic
CMOS	
MSB	Most Significant Bit
LSB	Least Significant Bit
dB	decibel
LCD	Liquid Crystal Display
MCU	Microcontroller
PCB	Printed Circuit Board
I/O	Input Output Ports
IDE	Integrated Development Environment
ANSI	American National Standard Institute
SMS	Short Message Service

CHAPTER ONE

INTRODUCTION

1.1 General

The micro-controller based automated real time Irrigation system will supply the following:

As there is no unexpected usage of water, a lot of water is saved from being wasted. The irrigation system is use only when there is not sufficient moisture in the soil and the microcontroller decides when should the pump be turned on/off, saves a lot time and water for the farmers. As there is no unanticipated usage of water, a lot of water is saved from creature wasted. This also gives much wanted rest to the farmers, as they don't have to go and revolve the pump on/off automatically. The constant increasing command of the food provisions requires a rapid improvement in food production technology. The main reasons is the not have of rains & insufficiency of land lake water. The continuous removal of water at normal intervals from earth is dropping the water level as a result of which the zones of un-irrigated land are frequently increasing. Also, the unexpected use of water accidentally results in wastage of water [1].

In an Automated Irrigation System using microcontrollers, the most significant advantage is that water is supplied only when the moisture in soil goes below a determined threshold value. In current times, the farmers have been using irrigation system through the labor-intensive control in which the farmers irrigate the land at regular intervals by turning the water-pump on/off when essential. These procedures sometimes consume more water and sometimes the water supply to the land is delayed due to which the crops dry off. Water shortage deteriorate plants enlargement before visible wilting occurs [1].

In addition to this slow development rate, lighter mass fruit follows water shortage. This problem can be absolutely rectified if we use Automated Irrigation System in which the irrigation will take place only when there will be strong requirement of water, as optional by the moisture in the soil.

Irrigation is the artificial application of water to the soil usually for supporting in rising crops. In crop manufacture it is mostly used in waterless areas and in periods of rainfall shortfalls, but also to protect plants against hoarfrost [1].

1.2 Problem statement & solution:

Now days, water shortage is becoming one of the biggest problem in the world. Many different methods are developed for conservation of water.

Water is considered to be basic need of human. Water is needed for everyone human beings, animals, plants, etc .Agriculture is one of the fields where water is required in tremendous quantity. Wastage of water is major problem in agriculture. Every time excess of water is given to the fields.

There are many techniques to save or to control wastage of water from agriculture .Automatic irrigation systems are convenient, especially for those who travel. If installed and programmed properly, automatic irrigation systems can even save you money and help in water conservation. Dead lawn grass and plants need to be replaced, and that can be expensive. But the savings from automatic irrigation systems can go beyond that. Watering with a hose or with oscillator, wastes water. Neither method targets plant roots with any significant degree of precision. Automatic irrigation systems can be programmed to discharge more precise amounts of water in a targeted area, which promotes water conservation.

1.3 Objectives

The main objective of this Thesis is to develop a microcontroller based system to irrigate the plant automatically.

This system also supports water management decision, which determines the controlling time for the process.

1.4 Methodology

The block diagram of this automatic plant irrigation system comprises three main components namely a microcontroller, a motor-driver circuit and a sensor circuit. When the sensor circuit senses the condition of soil, it compares it with the reference voltage 5v. This process is done by a timer. When the soil condition is less than the reference voltage, i.e., 5v, then the soil is considered as dry and instantly the timer sends the logic signal 1 to the microcontroller. The microcontroller then turns on the motor driver circuit and prompts the motor to pump water to the plants. When the soil condition is greater than the reference voltage, the soil becomes wet. Then the timer sends the logic signal 0 to the microcontroller, this turns off the motor driver circuit and prompts motor to pump water to the fields.

1.5 Thesis outline

This thesis consists of five chapters, Chapter one represents an introduction to this thesis. Chapter two presents the literature review. Chapter three presents the electronic circuit design and software. Chapter four presents the results and its discussion. Finally, Chapter five provides the conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In the world of man and machines there is a revolutionary change of machines dominating the world of man. Auto farmer is one of the mean machine project. Improving irrigation efficiency can contribute greatly to reducing production costs of vegetables, making the industry more competitive and sustainable. Through proper irrigation, average vegetable yields can be maintained (or increased) while minimizing environmental impacts caused by excess applied water and subsequent agrichemical leaching. Recent technological advances have made soil water sensors available for efficient and automatic operation of irrigation systems. Automatic soil water sensor-based irrigation seeks to maintain a desired soil water range in the root zone that is optimal for plant growth. The target soil water status is usually set in terms of soil tension or metric potential (expressed in k Pa or c bar, 1 k Pa=1 c bar), or volumetric moisture (expressed in percent of water volume in a volume of undisturbed soil). Another benefit of automatic irrigation techniques is convenience. In a previous experience working with a soil-moisture-based automatic irrigation system, Dukes et al. (2003) found that once such a system is set up and verified, only weekly observation was required. This type of system adapts the amount of water applied according to plant needs and actual weather conditions throughout the season. This translates not only into convenience for the manager but into substantial water savings compared to irrigation management based on average historical weather conditions [2].

Irrigation is the artificial application of water to the land or soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and re vegetation of disturbed soils in dry areas and during periods of inadequate rainfall. When a zone comes on, the water flows through the lateral lines and ultimately ends up at the irrigation emitter (drip) or sprinkler heads. Many sprinklers have pipe thread inlets on the bottom of them which allows a fitting and the pipe to be attached to them. The sprinklers are usually installed with the top of the head flush with the ground surface. When the water is pressurized, the head will pop up out of the ground and water the desired area until the valve closes and shuts off that zone. Once there is no more water pressure in the lateral line, the sprinkler head will retract back into the ground. Emitters are generally laid on the soil surface or buried a few inches to reduce evaporation losses. Healthy plants can transpire a lot of water, resulting in an increase in the humidity of the greenhouse air. A high relative humidity (above 80-85%) should be avoided because it can increase the incidence of disease and reduce plant transpiration. Sufficient venting or successive heating and venting can prevent condensation on plants surfaces and the greenhouse structure. The use of cooling systems during the warmer summer months increases the greenhouse air humidity. During periods with warm and humid outdoor conditions, humidity control inside the greenhouse can be a challenge. Greenhouses located in dry, dessert environments benefit greatly from evaporative cooling systems because large amounts of water can be evaporated into the incoming air, resulting in significant temperature drops. Since the relative humidity alone does not tell us anything about the absolute water holding capacity of air, a different measurement is sometime used to describe the absolute moisture status of the soil. The vapor pressure deficit is a measure of the difference between the amount of moisture the air contains at a given moment and the amount of moisture it can hold at that temperature when the air would be saturated. Pressure deficit measurement can tell us how easy it is for plants to transpire: higher values stimulate transpiration (but too high can cause wilting), and lower values inhibit transpiration and can lead to condensation on leaf and greenhouse surfaces [3].

In the mid 20th century, the advent of diesel and electric motors led to systems that could pump groundwater out of major aquifers faster than drainage basins could refill them. This can lead to permanent loss of aquifer capacity, decreased water quality, ground subsidence, and other problems. Apart from all these problems and failures, there has been a considerable evolution in the methods to perform irrigation with the help of technology. The application of technology in the areas of irrigation has proven to be of great help as they deliver efficiency and accuracy [3].

2.2 Microcontroller

A microcontroller often serves as the “brain” of a mechatronic system. Like a mini, self-contained computer, it can be programmed to interact with both the hardware of the system and the user. Even the most basic microcontroller can perform simple math operations, control digital outputs, and monitor digital inputs. As the computer industry has evolved so the technology associated with microcontrollers. Newer microcontrollers are much faster, have more memory, and have a host of input and output features that dwarf the ability of earlier models. Most modern controllers have analog-to-digital converters, high-speed timers and counters; interrupt capabilities, outputs that can be pulse-width modulated, serial communication ports, etc [4].

PIC 16F877A microcontroller is chosen as the main processor, since it has a good range of interfaces, including analogue and digital pins, pulse width modulation (PWM) and in-circuit debugging. This microcontroller can generate PWM signals on ten pins (PORT D and two pins from PORT C). Figure A.1 in the appendix shows the ‘pin-out’ diagram of the PIC 16F877A. This diagram is very useful, because it tells you where power and ground should be connected, which pins tie to which functional hardware, etc.

2.3 Humidity Sensor

Humidity is the presence of water in air. The amount of water vapor in air can affect human comfort as well as many manufacturing processes in industries. The presence of water vapor also influences various physical, chemical, and biological processes. Humidity measurement in industries is critical because it may affect the business cost of the product and the health and safety of the personnel. Hence, humidity sensing is very important, especially in the control systems for industrial processes and human comfort. Controlling or monitoring humidity is of paramount importance in many industrial & domestic applications. In semiconductor industry, humidity or moisture levels needs to be properly controlled & monitored during wafer processing. In medical applications, humidity control is required for respiratory equipments, sterilizers, incubators, pharmaceutical processing, and biological products. Humidity control is also necessary in chemical gas purification, dryers, ovens, film desiccation, paper and textile production, and food processing. In agriculture, measurement of humidity is important for plantation protection (dew prevention), soil moisture monitoring, etc. For domestic applications, humidity control is required for living environment in buildings, cooking control for microwave ovens, etc. In all such applications and many others, humidity sensors are employed to provide an indication of the moisture levels in the environment [5].

2.3.1 Relevant moisture terms

To mention moisture levels, variety of terminologies are used. The study of water vapor concentration in air as a function of temperature and pressure falls under the area of psychometrics. Psychometrics deals with the thermodynamic properties of moist gases while the term “humidity’ simply refers to the presence of water vapour in air or other carrier gas. Humidity measurement determines the amount of water vapor present in a gas that can be a mixture, such as air, or a pure gas, such as nitrogen or argon [5].

2.3.2 Classification & principles

According to the measurement units, humidity sensors are divided into two types Relative humidity (RH) sensors and absolute humidity (moisture) sensors. Most humidity sensors are relative humidity sensors and use different sensing principles [5].

2.3.3 Sensing Principle

Humidity measurement can be done using dry and wet bulb hygrometers, dew point hygrometers, and electronic hygrometers. There has been a surge in the demand of electronic hygrometers, often called humidity sensors .Electronic type hygrometers or humidity sensors can be broadly divided into two categories: one employs capacitive sensing principle, while other use resistive effects [5].

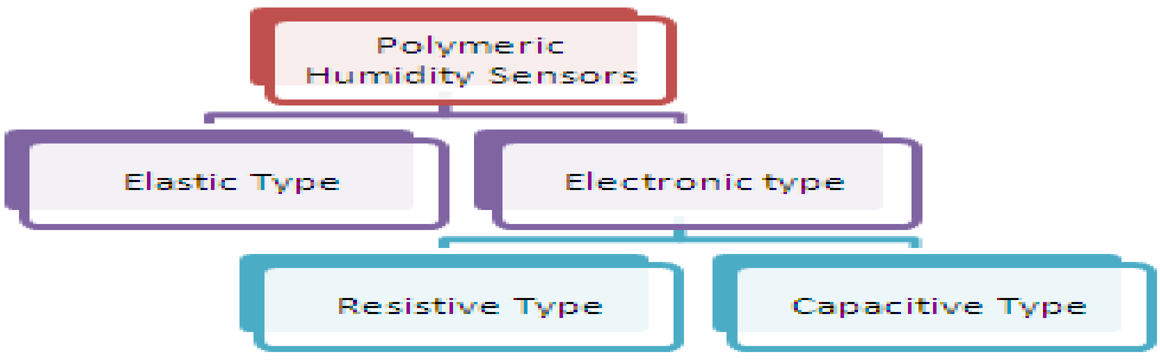


Figure 2.2: Classifications of humidity Sensors

2.3.3.1 Sensors based on capacitive effect

Humidity sensors relying on this principle consists of a hygroscopic dielectric material sandwiched between a pair of electrodes forming a small capacitor. Most capacitive sensors use a plastic or polymer as the dielectric material, with a typical dielectric constant ranging from 2 to 15. In absence of moisture, the dielectric constant of the hygroscopic dielectric material and the sensor geometry determine the value of capacitance [5].

At normal room temperature, the dielectric constant of water vapor has a value of about 80, a value much larger than the constant of the sensor dielectric material. Therefore, absorption of water vapor by the sensor results in an increase in sensor capacitance. At equilibrium conditions, the amount of moisture present in a hygroscopic material depends on both the ambient temperature and the ambient water vapor pressure. This is true also for the hygroscopic dielectric material used on the sensor. By definition, relative humidity is a function of both the ambient temperature and water vapor pressure. Therefore there is a relationship between relative humidity, the amount of moisture present in the sensor, and sensor capacitance. This relationship governs the operation of a capacitive humidity instrument. Basic structure of capacitive type humidity sensor is shown in the appendix figureA.3 [5].

On Alumina substrate, lower electrode is formed using gold, platinum or other material. A polymer layer such as PVA is deposited on the electrode. This layers senses humidity. On top of this polymer film, gold layer is deposited which acts as top electrode. The top electrode also allows water vapour to pass through it, into the sensing layer. The vapors enter or leave the hygroscopic sensing layer until the vapour content is in equilibrium with the ambient air or gas. Thus capacitive type sensor is basically a capacitor with humidity sensitive polymer film as the dielectric [5].

2.3.3.2 Sensors based on Resistive effect

Resistive type humidity sensors pick up changes in the resistance value of the sensor element in response to the change in the humidity. Basic structure of resistive type humidity sensor from TDK is shown in the appendix figureA.4 Thick film conductor of precious metals like gold, ruthenium oxide is printed and cachinnated in the shape of the comb to form an electrode. Then a polymeric film is applied on the electrode; the film acts as a humidity sensing film due to the existence of movable ions. Change in impedance occurs due to the change in the number of movable ions [5].

2.3.4 Soil moisture sensor

A soil moisture sensor measures soil moisture content in the active root zone on your property. The sensor should be placed in a location that best represents the overall soil moisture condition of the site, and must be connected to an irrigation system controller that accepts a signal from the sensor. A measurement is taken before each scheduled irrigation event, and the irrigation controller bypasses the scheduled run cycle if the soil moisture is above a certain threshold level defined by the user. So Cal Water $mart eligible soil moisture sensor systems must include a sensor and a calibrator (these are typically packaged together in the same device) and an irrigation controller. A sensor/calibrator can be added to an existing compatible irrigation controller; however, it is not eligible for a rebate if the user already received a rebate for a Weather Based Irrigation Controller. Rebates are not available for both the Soil Moisture Sensor System and a Weather Based Irrigation Controller if purchased together .Weather-based irrigation controllers (WBICs) allow for more accurate, customized irrigation by automatically adjusting the schedule and amount of water in response to changing weather conditions. Not only does this save water by reducing unnecessary watering, it allows you to tailor irrigation to meet your landscape's specific plant and climate needs [6].

2.4 Converters

2.4.1 Filters

Filters are used to remove unwanted bandwidths from a signal Filter classification according to implementation.

Active filters include RC networks and op-amps Suitable for low frequency, small signal Active filters are preferred since avoid the bulk and non-linearity of inductors and can have gains greater than 0dB However, active filters require a power supply Passive filters consist of RCL networks Simple, more suitable for frequencies above audio range, where active filters are limited by the op-map bandwidth Digital filters A digital filter uses a digital processor to perform numerical calculations on sampled values of the signal. The processor may be a general-purpose computer such as a PC, or a specialized DSP chip Filter classification according to frequency response [7].

- Low-pass filter
- High-pass filter
- Band-pass filter
- Band-stop (Notch) nal Processor) chip

2.4.2 Analog-to-digital converters (ADCs)

Translate analog quantities, which are characteristic of most phenomena in the "real world," to digital language, used in information processing, computing, data transmission, and control systems. Whatever their origin, are most frequently converted by transducers into voltages or currents. These electrical quantities may appear (1) as fast or slow "dc" continuous direct measurements of a phenomenon in the time domain, (2) as modulated ac waveforms (using a wide variety of modulation techniques), (3) or in some combination, with a spatial configuration of related variables to represent examples of the first are outputs of thermocouples, potentiometers on dc references, and analog computing circuitry; of the second, "chopped" optical measurements, ac strain gage or bridge outputs, and digital signals buried in noise; and of the third, synchronism and resolvers [8].

The analog variables are those involving voltages or currents representing the actual analog phenomena. They may be either wideband or narrowband. They may be either scaled from the direct measurement, or subjected to some form of analog pre-processing, such as linearization, combination, demodulation, filtering, sample-hold, etc. As part of the process, the voltages and currents are "normalized" to ranges compatible with assigned ADC input ranges. Analog output voltages or currents from DACs are direct and in normalized form, but they may be subsequently post-processed (e.g., scaled, filtered, amplified, etc.) [8].

Information in digital form is normally represented by arbitrarily fixed voltage levels referred to "ground," either occurring at the outputs of logic gates, or applied to their inputs. The digital numbers used are all basically binary; that is, each "bit," or unit of information has one of two possible states. These states are "off," "false," or "0," and "on," "true," or "1." It is also possible to represent the two logic states by two different levels of current; however this is much less popular than using voltages. There is also no particular reason why the voltages need be referenced to ground—as in the case of emitter-coupled-logic (ECL), positive-emitter-coupled-logic (PECL) or low-voltage differential- signaling logic (LVDS) for example [8].

Words are groups of levels representing digital numbers; the levels may appear Simultaneously in parallel, on a bus or groups of gate inputs or outputs, serially (or in a time sequence) on a single line or as a sequence of parallel bytes (i.e., byte-serial") or nibbles (small bytes). For example, a 16-bit word may occupy the 16 bits of a 16-bit bus, or it may be divided into two sequential bytes for an 8-bit bus, or four 4-bit nibbles for a 4-bit bus.

Although there are several systems of logic, the most widely used choice of levels are those used in TTL (transistor-transistor logic) and, in which positive true, or 1, corresponds to a minimum output level of +2.4 V (inputs respond unequivocally to "1" for levels greater than 2.0 V); and false, or 0, corresponds to a maximum output level of +0.4 V (inputs respond unequivocally to "0" for anything less than +0.8 V). It should be noted that even though CMOS is more popular today than TTL, CMOS logic levels are generally made to be compatible with the older TTL logic standard. A unique parallel or serial grouping of digital levels, or a number, or code, is assigned to each analog level which is quantized (i.e., represents a unique portion of the analog range). A typical digital code would be this array:

a7 a6 a5 a4 a3 a2 a1 a0 = 1 0 1 1 1 0 0 1 It is composed of eight bits. The "1" at the extreme left is called the "" (MSB, or Bit 1), and the one at the right is called the "least significant bit" (LSB, orbit N: 8 in this case). The meaning of the code, as a number, a character, or a representation of an analog variable, is unknown until the code and the conversion relationship have been defined. It is important not to confuse the designation of a particular bit (i.e., Bit 1, Bit 2, etc.) with the subscripts associated with the "a" array. The subscripts correspond to the power of 2 associated with the weight of a particular bit in the sequence. The best-known code (other than base 10) is natural or straight binary (base 2). Binary codes are most familiar in representing integers; i.e., in a natural binary integer code having N bits, the LSB has a weight of 20 (i.e., 1), the next bit has a weight of 21 (i.e., 2), and so on up to the MSB, which has a weight of 2N–1 (i.e., 2N/2). The value of a binary number is obtained by adding up the weights of all non-zero bits. When the weighted bits are added up, they form a unique number having any value from 0 to 2N – 1. Each additional trailing zero bit, if present, essentially doubles the size of the number. In converter technology, full-scale (abbreviated FS) is independent of the number of bits of resolution, N. A more useful coding is fractional binary which is always normalized to full-scale. Integer binary can be interpreted as fractional binary if all integer values are divided by 2N. For example, the MSB has a weight of ½ (i.e., 2(N–1)/2N = 2–1), the next bit has a weight of ¼ (i.e., 2–2), and so forth down to the LSB, which has a weight of 1/2N (i.e., 2–N). When the weighted bits are added up, they form a number with any of 2N values, from 0 to (1 – 2–N) of full-scale. Additional bits simply provide more fine structure without affecting full-scale range [8].

2.4.2 .1 Gray Code

Another code worth mentioning at this point is the Gray code (or reflective-binary) which was invented by Elisha Gray in 1878and later re-invented by Frank Gray in 1949.. Although it is rarely used in computer arithmetic, it has some useful properties which make it attractive to A/D conversion. Notice that in Gray code, as the number value changes, the transitions from one code to the next involve only one bit at a time. Contrast this to the binary code where all the bits change when making the transition between 0111 and 1000. Some ADCs make use of it internally and then convert the Gray code to a binary code why do we need Analog to Digital converters? In the real world, most data is characterized by analog signals. In order to manipulate the data using a microprocessor, we need to convert the analog signals to the digital signals, so that the microprocessor will be able to read, understand and manipulate the data [8].

2.4.2 .2 How does an A/D Converter work?

The main goal of A/D Converter is to digitize the analog signals, which means to record and store the analog signals in number. There are two parameters to control in converting the analog signals to the digital signals:

· Sampling Rate, fs – controls the number of samples taken in a second.

· Sampling Precision, N – controls the number of different gradations (quantization levels) for the sampling process.

Let us consider the following analog signal:

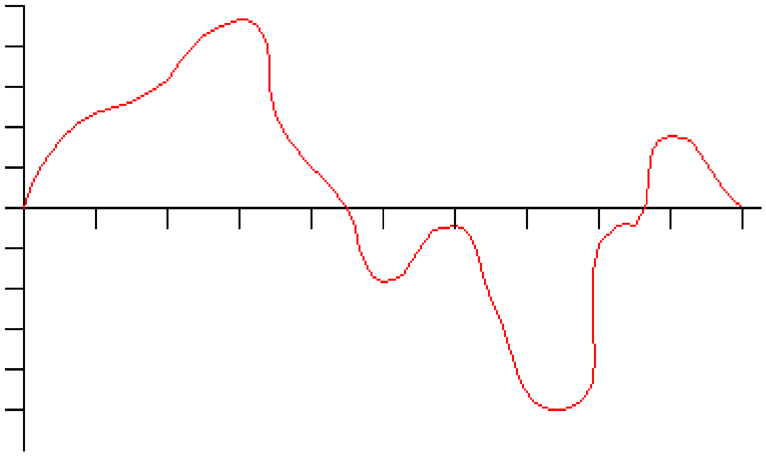


Figure 2.5: Analog Signal

If we assume that:

· fs = 1000 samples per second

· N = 10 (dividing the y-axis to 10 intervals

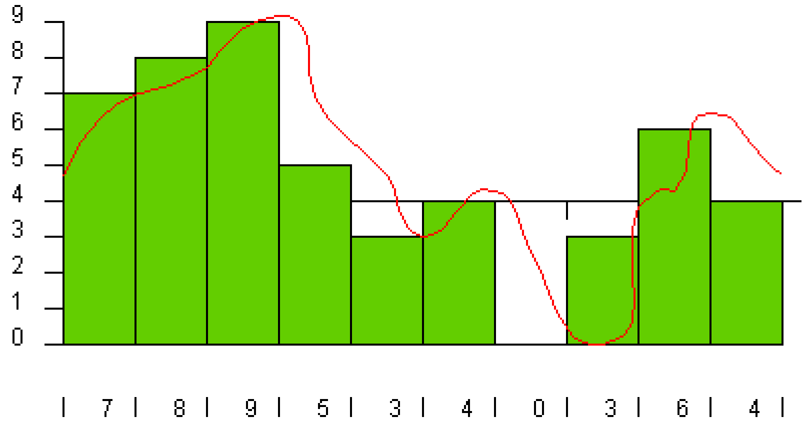


Figure 2.6: Sampling Signal

According to the sampling precision, the y-axis is divided into ten intervals (0-9). And according to the sampling frequency, the A/D converter samples the analog signals once per one-thousandth of a second. The A/D Converter then stores the analog signals to the closest number that it can find on they-axis. The chosen number is indicated on the x-axis of the above figure. According to the digitized data (the number on the x-axis of the above figure), we can plot the following graph showing what the microprocessor is actually reading [9].

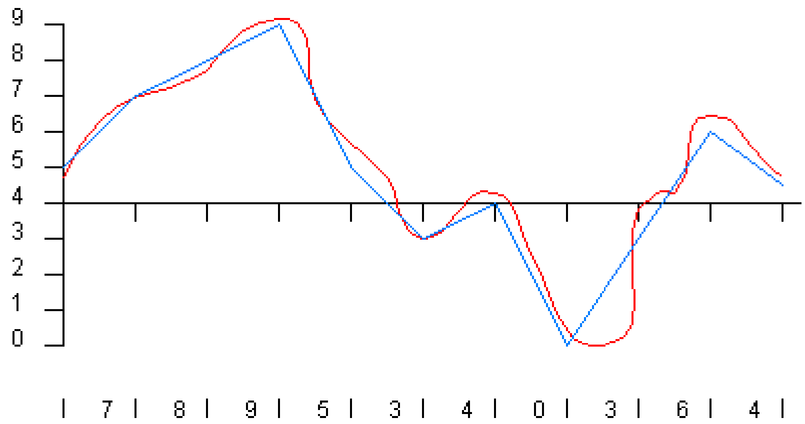


Figure 2.7: microprocessor actual reading

As you can see, we have lost quite a bit of the details of the original wave. This is the sampling error. In order to reduce the sampling error, we must increase the sampling rate, fs, and the sampling precision, N. So, if we improve the sampling rate, fs, and the sampling precision, N, by a factor of two, we will get the following graph [9].

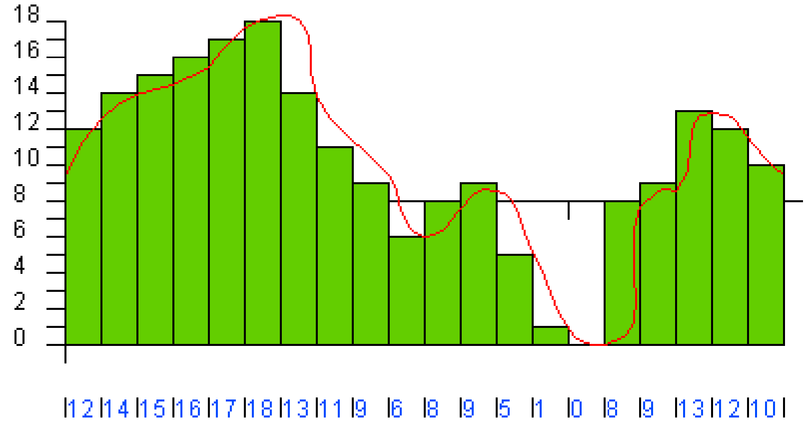


Figure 2.8: Improve sampling rate and precision

And, if we increase the sampling rate and the sampling precision by a factor of four, we will get the following digitized data.

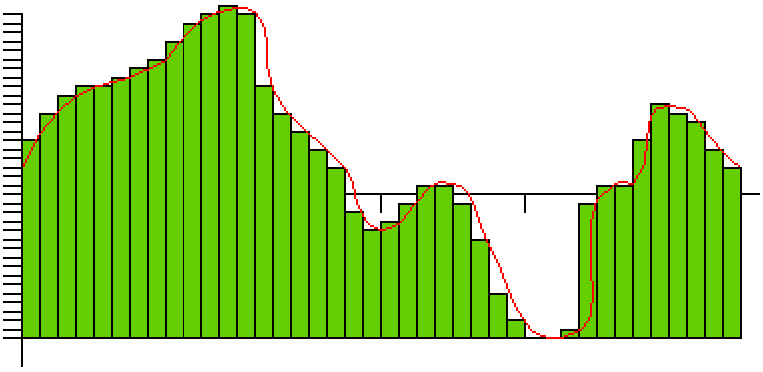


Figure 2.9: digitized data

Therefore, in order to digitize the analog data accurately, we need to sample the analog signal as fast as possible with an A/D that has large number of bits [9].

Sampling Theorem: A signal must be sampled at a rate at least two times the maximum frequency component occurring in the signal. The sampling precision is characterized by the number of the bits in the A/D converter. In other words the number of bits is used to define the quality of an A/D converter (the precision of the A/D converter). The number of bits, n, is related with the number of different gradations, N, by the following equation:

Resolution: $N = 2^n$, where n = number of bits of the A/D converter

Table 2.1: Resolution

number of bits (n)	number of different gradations (N)
4	16
8	256
10	1024
12	4096

It can be seen that for a 4-bit A/D converter, the precision of the A/D converter is 1/16 of the full scale of the analog signal. And for a 10-bit A/D converter the precision of the A/D converter is 1/1024 of the full scale of the analog signal. 2407 has a 10-bit converter [9].

. 2.5. Water pump

The water pump is used to artificially supply water for a particular task. It can be electronically controlled by interfacing it to a microcontroller. It can be triggered ON/OFF by sending signals as required. The process of artificially supplying water is known as pumping. There are many varieties of water pumps used. The pumping of water is a basic and practical technique, far more practical than scooping it up with one's hands or lifting it in a hand-held bucket. This is true whether the water is drawn from a fresh source, moved to a needed location, purified, or used for irrigation, washing, or sewage treatment, or for evacuating water from an undesirable location. Regardless of the outcome, the energy required to pump water is an extremely demanding component of water consumption. All other processes depend or benefit either from water descending from a higher elevation or some pressurized plumbing system [10].

CHAPTER THREE

ELECTRONIC CIRCUIT DESIGN AND SOFTWARE

3.1. Introduction

For the design and development of the system, the methodology used involves the software and hardware implementation. The actual implementation of the system involves the following steps:

3.1.1 **System Definition**: Broad definition of system hardware including microcontroller and its interface with display, soil moisture sensor, buzzer, etc.

3.1.2 **Circuit Design**: Selection of PIC16F877A microcontroller and other interfacing devices, as per system definition. Design of hardware circuit and its testing on laboratory kits with some simple microcontroller software routines.

3.1.3 **PCB Design and Fabrication**: Generation of schematic diagrams and the production of circuit board layout data for the procurement of the circuit board.

3.1.4 **Hardware Modifications**: Making any hardware changes found necessary after the initial hardware tests, to produce a revised circuit board schematic diagram and layout.

3.1.5 **Software Design**: Developing algorithm for the system, allocating memory blocks as per functionality, coding and testing.

3.1.6 **Integration and Final Testing**: Integrating the entire hardware and software modules and its final testing for operation [11].

Thus the complete design is divided into two parts:

Hardware Implementation.

Software Implementation.

3.2. Hardware Implementation

It involves the details of the set of design specifications. The hardware design consists of, the selection of system components as per the requirement, the details of subsystems that are required for the complete implementation of the system and full hardware schematics for the PCB layout. Design of the circuit and its testing has been carried out. It involves the component selection, component description and hardware details of the system designed [11].

Component selection and description.

Hardware details of the system designed.

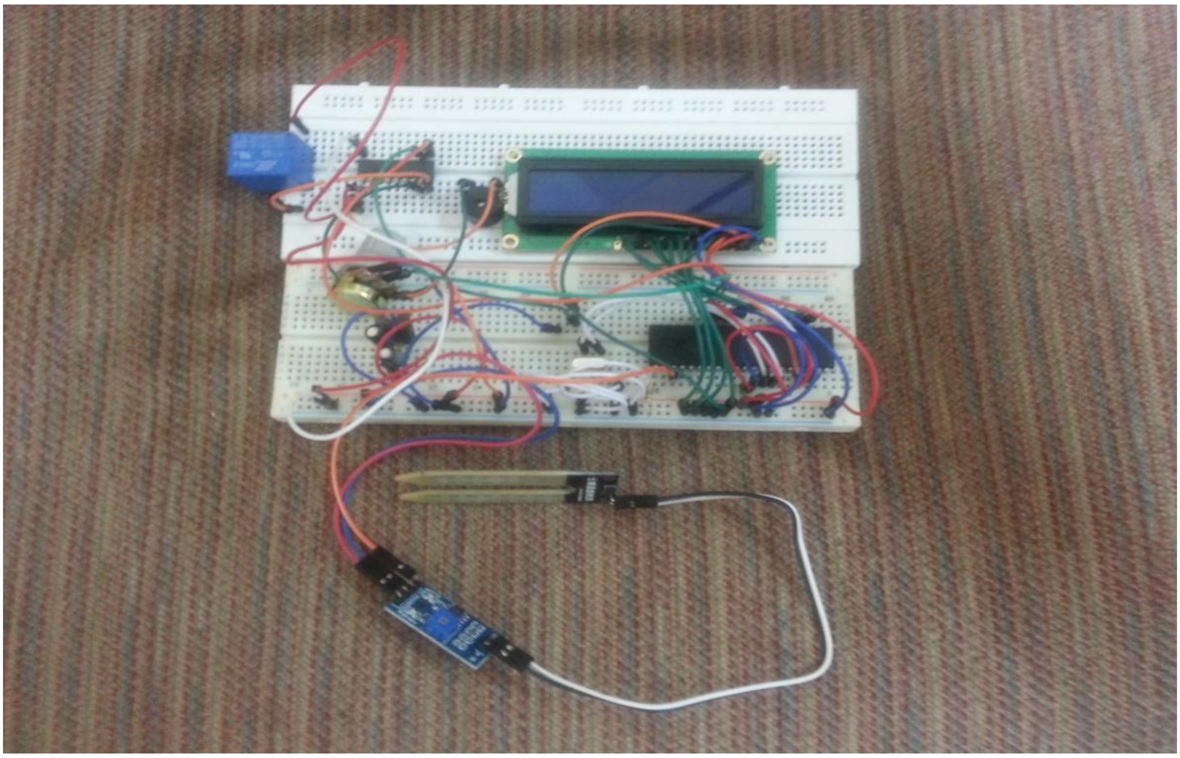


Figure 3.1: Hardware Design

3.2.1. Component selection and description

Automatic irrigation system using microcontroller includes the following components:

- Soil Moisture Sensor (YL-69).
- Microcontroller (PIC16F877A)

- Liquid Crystal Display (LCD-1602A)
- High Current Darlington Transistor (ULN2803)
- 5V DC Relay
- Buzzer

3.2.2. Soil Moisture Sensor (YL-69)

This is an Electrical resistance Sensor. The sensor is made up of two electrodes. This soil moisture sensor reads the moisture content around it. A current is passed across the electrodes through the soil and the resistance to the current in the soil determines the soil moisture. If the soil has more water resistance will be low and thus more current will pass through. On the other hand when the soil moisture is low the sensor module outputs a high level of resistance. This sensor has both digital and analogue outputs. Digital output is simple to use but is not as accurate as the analogue output [12].

YL-69 soil moisture sensor has the following specifications as in table 3.1.

Table 3.1: Specifications of YL-69 soil moisture sensor

Vcc power supply	3.3V or 5V
Current	35mA
Signal output voltage	0-4.2V
Digital Outputs	0 or 1
Analog	Resistance (Ω)
Panel Dimension	3.0cm by 1.6cm
Probe Dimension	6.0cm by 3.0cm
GND	Connected to ground

The sensor comes with a small PCB board fitted with LM393 comparator chip and a digital potentiometer as in figure B.2 in the appendix

3.2.2.1 Digital potentiometer

A potentiometer is basically a variable resistor. Like analog potentiometers, digital potentiometers are used to scale or adjust resistance of a circuit Digital potentiometers are also known as a digital pot or digipot. Digipots are used mostly in scaling analog signals to be used in a microcontroller [12].

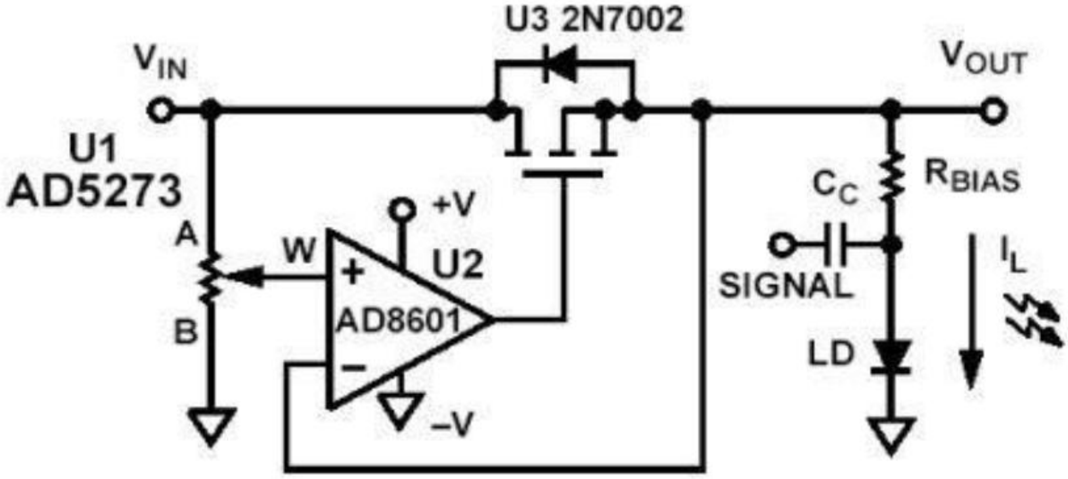


Figure 3.2: Digipot schematic

Digipot output resistance is variable based on digital inputs and thus also know as resistive digital-to-analog converters (RDACs). Some RDACs come with nonvolatile memory thus provide wiper setting retention after a power ON to OFF cycle. Digipots are available as integrated circuits (ICs) [12].

On the soil moisture sensor the digital potentiometer acts as a low resolution digital to analog convertor (DAC) thus adjusting it varies the sensitivity of the sensor [12].

3.2.2.2 LM393 comparator

A comparator is an electronic device that compares two voltages or currents and gives a digital signal as the output. It indicates which of the two compared quantities is large. A comparator has a least two input pins and one output pin. Operational amplifier operating in open loop configuration and without negative feedback can be used as a simple comparator [12].

One of the most commonly used comparators is LM393. It is available as an IC.

It is preferred due to the following characteristics as table 3.2.

Table 3.2: LM 393 Comparator specifications

• Supply Voltage	(2.0 to 36.0) V
• Supply	Single or dual (±1.0 to ±18.0) V
• Current drain	0.4 mA
• Biasing current	25 nA
• Offset current	± 5 nA
• Saturation Voltage	± 3 mV
• Compatibility	TTL, DTL,ECL, MOS and CMOS logic systems
• Differential input voltage range	Same as power supply voltage

LM393 finds application in limit comparators, simple ADC, time delay generators and square wave generators among others. The capability of LM393 to interface with low power drain is an advantage over other types of comparators [12].

3.2.3. Microcontroller

The PIC microcontroller is the control unit selected for this project and it is manufactured by microchip. The control unit is used to interface between sensor, LCD display and water pump. It will receive the calibrated humidity data in form of voltage, manipulated them and sent the data to be displayed on the LCD. The microcontroller type is

PIC16F877A. The features of the microcontroller are shown in Appendix.

3.2.3.1 Pin Descriptions

As it has been mentioned before, there are 40 pins of this microcontroller IC. It consists of two 8 bit and one 16 bit timer. Capture and compare modules, serial ports, parallel ports and five input/output ports are also present in it.

PIN 1: MCLR

The first pin is the master clear pin of this IC. It resets the microcontroller and is active low, meaning that it should constantly be given a voltage of 5V and if 0 V are given then the controller is reset. Resetting the controller will bring it back to the first line of the program that has been burned into the IC.

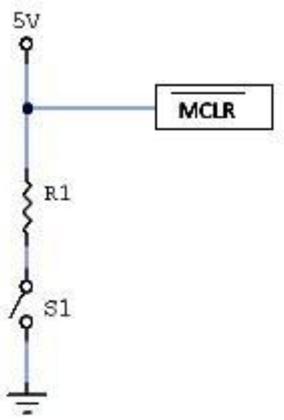


Figure 3.3: MCLR pin connection

A push button and a resistor are connected to the pin as figure 3.10. The pin is already being supplied by constant 5V. When we want to reset the IC we just have to push the button which will bring the MCLR pin to 0 potential thereby resetting the controller.

PIN 2: RA0/AN0

PORTA consists of 6 pins, from pin 2 to pin 7, all of these are bidirectional input/output pins. Pin 2 is the first pin of this port. This pin can also be used as an analog pin AN0. It is built in analog to digital converter.

PIN 3: RA1/AN1

This can be the analog input 1.

PIN 4: RA2/AN2/Vref-

It can also act as the analog input2. Or negative analog reference voltage can be given to it.

PIN 5: RA3/AN3/Vref+

It can act as the analog input 3. Or can act as the analog positive reference voltage.

PIN 6: RA0/T0CKI

To timer0 this pin can act as the clock input pin, the type of output is open drain.

PIN 7: RA5/SS/AN4

This can be the analog input 4. There is synchronous serial port in the controller also and this pin can be used as the slave select for that port.

PIN 8: RE0/RD/AN5

PORTE starts from pin 8 to pin 10 and this is also a bidirectional input output port. It can be the analog input 5 or for parallel slave port it can act as a ‘read control’ pin which will be active low.

PIN 9: RE1/WR/AN6

It can be the analog input 6. And for the parallel slave port it can act as the ‘write control’ which will be active low.

PIN 10: RE2/CS/A7

It can be the analog input 7, or for the parallel slave port it can act as the ‘control select’ which will also be active low just like read and write control pins.

PIN 11 and 32: VDD

These two pins are the positive supply for the input/output and logic pins. Both of them should be connected to 5V.

PIN 12 and 31: VSS

These pins are the ground reference for input/output and logic pins. They should be connected to 0 potential.

PIN 13: OSC1/CLKIN

This is the oscillator input or the external clock input pin.

PIN 14: OSC2/CLKOUT

This is the oscillator output pin. A crystal resonator is connected between pin 13 and 14 to provide external clock to the microcontroller. ¼ of the frequency of OSC1 is outputted by OSC2 in case of RC mode. This indicates the instruction cycle rate.

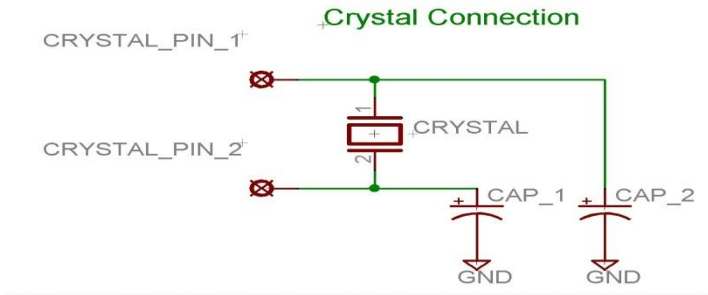


Figure 3.4: Crystal connection

PIN 15: RC0/T1OCO/T1CKI

PORTC consists of 8 pins. It is also a bidirectional input output port. Of them, pin 15 is the first. It can be the clock input of timer 1 or the oscillator output of timer 2.

PIN 16: RC1/T1OSI/CCP2

It can be the oscillator input of timer 1 or the capture 2 input/compare 2 outputs/ PWM 2 output.

PIN 17: RC2/CCP1

It can be the capture 1 input/ compare 1 output/ PWM 1 output.

PIN 18: RC3/SCK/SCL

It can be the output for SPI or I2C modes and can be the input/output for synchronous serial clock.

PIN 23: RC4/SDI/SDA

It can be the SPI data in pin. Or in I2C mode it can be data input/output pin.

PIN 24: RC5/SDO

It can be the data out of SPI in the SPI mode.

PIN 25: RC6/TX/CK

It can be the synchronous clock or USART Asynchronous transmit pin.

PIN 26: RC7/RX/DT

It can be the synchronous data pin or the USART receive pin.

PIN 19, 20,21,22,27,28,29,30:

All of these pins belong to PORTD which is again a bidirectional input and output port. When the microprocessor bus is to be interfaced, it can act as the parallel slave port.

PIN 33-40: PORT B

All these pins belong to PORTB. Out of which RB0 can be used as the external interrupt pin and RB6 and RB7 can be used as in-circuit debugger pins [13].

3.2.4. LCD-1602A

The type of LCD display used is 2 by 16 which number 2 is denoted as the two lines while number 16 means the LCD display can display up to 16 characters.

Table 3.3: LCD 16 x 2 Characters [14]

PIN NUMBER	SYMBOL	FUNCTION
1	Vss	GND
2	Vdd	+ 3V or + 5V
3	Vo	Contrast Adjustment
4	RS	H/L Register Select Signal
5	R/W	H/L Read/Write Signal
6	E	H -L Enable Signal
7	DBO	H/L Data Bus Line
8	DB1	H/L Data Bus Line
9	DB2	H/L Data Bus Line
10	DB3	H/L Data Bus Line
11	DB4	H/L Data Bus Line
12	DB5	H/L Data Bus Line
13	DB6	H/L Data Bus Line
14	DB7	H/L Data Bus Line
15	A/Vee	+ 4.2V for LED/Negative Voltage Output
16	K	Power Supply for B/L (OV)

3.2.5. High Current Darlington Transistor (ULN2803)

The eight NPN Darlington connected transistors in this family of arrays are ideally suited for interfacing between low logic level digital circuitry (such as TTL, CMOS or PMOS/NMOS) and the higher current/voltage requirements of lamps, relays, printer hammers or other similar loads for a broad range of computer, industrial, and consumer applications. All devices feature open collector outputs and freewheeling clamp diodes for transient suppression.

The ULN2803 is designed to be compatible with standard TTL families while the ULN2804 is optimized for 6 to 15 volt high level CMOS or PMOS [15].

3.2.6. 5V DC Relay

Relay is an electromagnetic device which is used to isolate two circuits electrically and connect them magnetically. They are very useful devices and allow one circuit to switch another one while they are completely separate. They are often used to interface an electronic circuit (working at a low voltage) to an electrical circuit which works at very high voltage. For example, a relay can make a 5V DC battery circuit to switch a 230V AC mains circuit. Thus a small sensor circuit can drive, say, a fan or an electric bulb [16].

A relay switch can be divided into two parts: input and output. The input section has a coil which generates magnetic field when a small voltage from an electronic circuit is applied to it. This voltage is called the operating voltage. Commonly used relays are available in different configuration of operating voltages like 6V, 9V, 12V, 24V etc. The output section consists of contactors which connect or disconnect mechanically. In a basic relay there are three contactors: normally open (NO), normally closed (NC) and common (COM). At no input state, the COM is connected to NC. When the operating voltage is applied the relay coil gets energized and the COM changes contact to NO [16].

A 5-pin relay was used in this project. It is single pole double throw type relay. A protection diode is used to prevent from the high voltage that is produced when a relay is switched off.

3.2.7. Buzzer

A buzzer or beeper is an audio signaling device; which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke .

The type of buzzer used in this system is a piezoelectric as in figure B.11 in the appendix.

3.2.8. Hardware details of system designed

Figure 3.5 shows the block diagram of the system hardware and figure 3.6 shows the schematic for the implementation of the hardware for this purpose

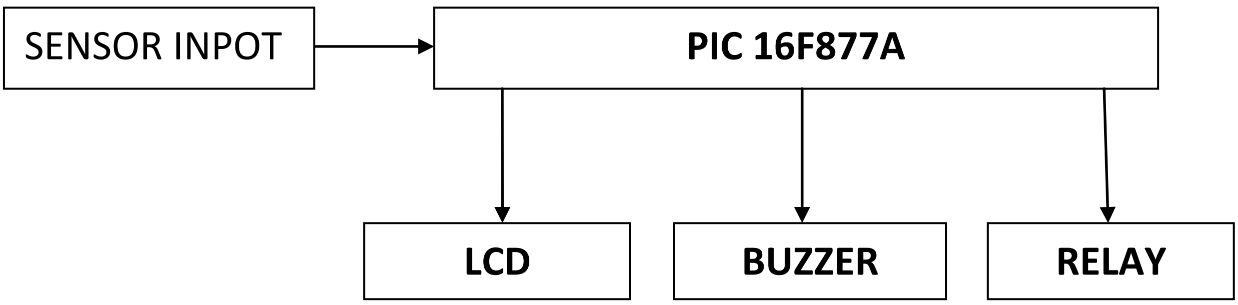


Figure 3.5: Block diagram of the system hardware

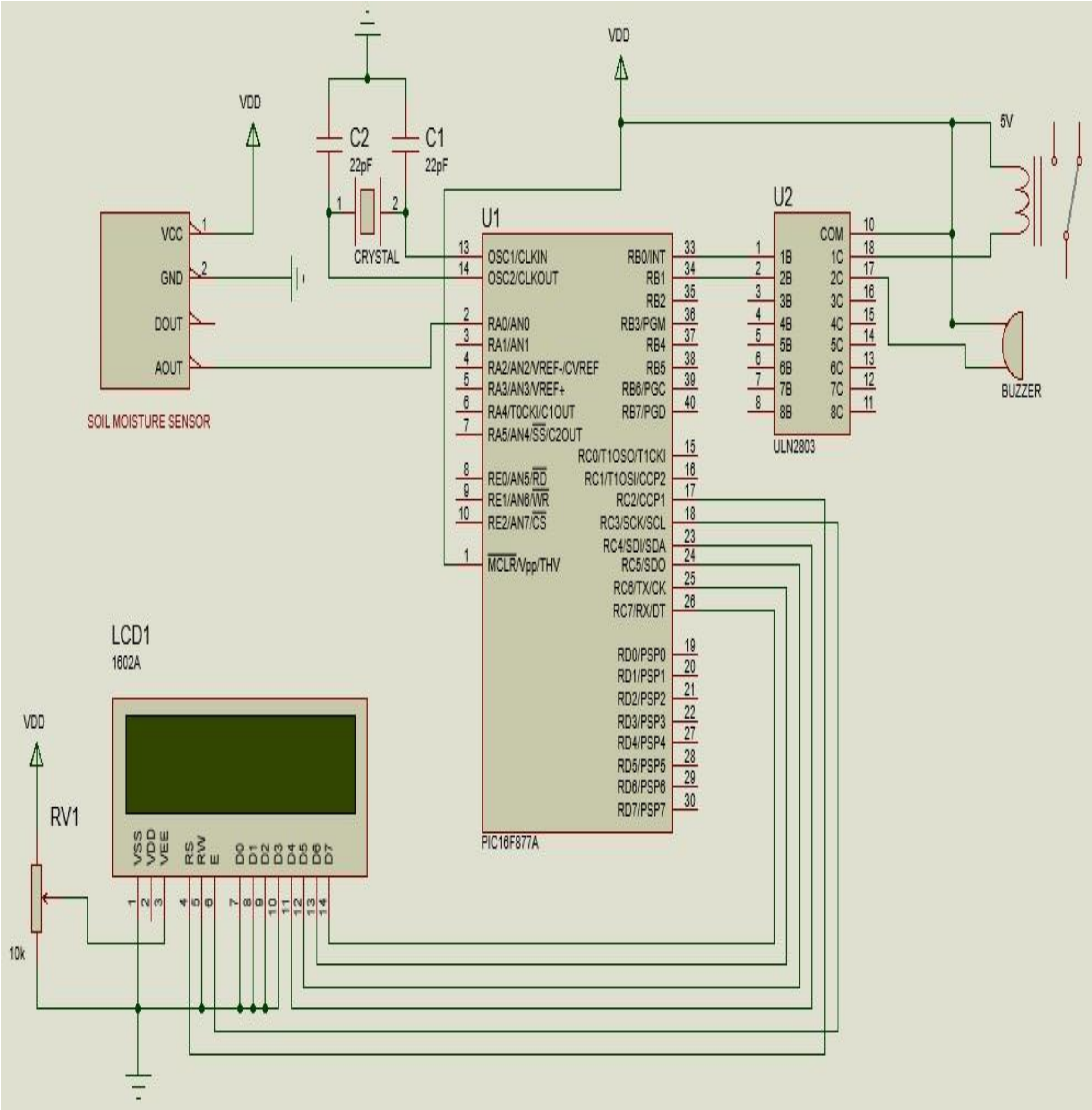


Figure 3.6: Schematic diagram

The details of the circuit component connections are as given below:

3.2.8.1. Microcontroller PIC16F877A

The four I/O ports of the microcontroller are used for interfacing the external peripherals. Port C is interfaced to the LCD, port B is interfaced to the output signal (rely, buzzer) and port A is interfaced to the analog input signal (moisture sensor) .

1- Port C: - pin (17) RC2 connected to the H/L register select signal, pin (18) RC3 are connected to the H/L Enable signal and pin (23)

RC4, pin (24) RC5, pin (25) RC6 and pin (26) RC7 connected to (D4, D5, D6 and D7) D H/L Data Bus line.

2- Port B: - pin (33) RB0 and pin (34) RB1 connected to pin 1B and pin 2B of high current Darlington transistor arrays (ULN2803).

3- Port A: - pin (2) RA0 connected to Output of soil moisture sensor.

4- Pin (11) and pin (32) connected to the power supply V_{DD}. Pin (12) and pin (31) connected to ground V_{SS}.

3.2.8.2. Soil Moisture Sensor

First pin is connected to power supply V_{CC}, Second pin to ground and the fourth pin is connected to input channel.

3.2.8.3. LCD-1602A

Pin 14, pin13, pin12 and pin 11 connected to pin26, pin25, pin24 and pin23 at port C of microcontroller. H /L Enable signal pin 6 of LCD connected to pin 18 of microcontroller. The H/L register pin 4 of LCD connected to pin 17 of microcontroller. Pins 1, 5, 7, 8, 9, 10 are connected to ground. Pin 2 connected to VDD. Pin3 Contrast Adjustment connected to the potentiometer.

3.2.8.4. High Current Darlington Transistor

Pin 1and pin 2 connected to pin 33 and pin 33 at port B of microcontroller. Pin18 connected to the relay .pin 17 connected to the buzzer. Pin 10 connected to VCC and pin 9 connected to ground.

3.2.8.5. Power supply section

A power supply section is the regulated DC power supply of +5 Volts. +5 Volts is generated using LM7805 fixed voltage regulator. Rectification of the AC supply is carried out using a dc adapter which outputs 9 v connected to pin 1 of LM7805.Pin 2 is connected to ground and Pin 3 is connected to VCC. The output of this section is free from ripples and distortions.

3.3. Software design and development

The development software that is used in this project is mikroC for PIC microcontrollers. MikroC provides a successful match featuring a highly advanced IDE, ANSI compliant compiler, and broad set of hardware libraries, comprehensive documentation, and plenty of ready-to-run examples. MikroC allows the developing and deploying of complex applications such as:

- Writing C source code using the built-in Code Editor (Code and Parameter Assistants, Syntax Highlighting, Auto Correct, Code Templates)
- Using the included mikroC libraries to dramatically speed up the development: data acquisition, memory, displays, conversions, and communications.
- Generate commented, human-readable assembly, and standard HEX compatible with all programmers. Inspect program flow and debug executable logic with the integrated Debugger.

Figure 3.17 below shows the starting of the programming process using the mikroC IDE compiler. MikroC software is much easier to be used compare to other software because the clock set and different kind of PIC can be used to program the microcontroller. In addition, the elements that can be used for the PIC can also be selected and changed by custom default. The mikroC software can also be used to generate the .HEX file that need to be uploaded into the PIC.

Also a flow chart of the software is shown in figure. The designing the flow chart provides the designer with brief ideas on programming flow for software development. The flow chart becomes a guide during writing the programming for the system.

In the beginning the ADC and LCD initialized. Then soil moisture sensor value is acquired and compared against the maximum set point if it is greater that means there is water. LCD will display “WATER!!” and if the pump is running it will be turned off. If the sensor value reading is not greater than the maximum then it will be compared to check whether it is less than maximum and greater than minimum, if so then LCD will display the humidity of the soil and also if the pump is running it will be turned off. If the above conditions not fulfilled that means the soil is dry and so LCD will display “Dry!!” buzzer will turn on and also the pump until the soil moisture is greater than minimum.

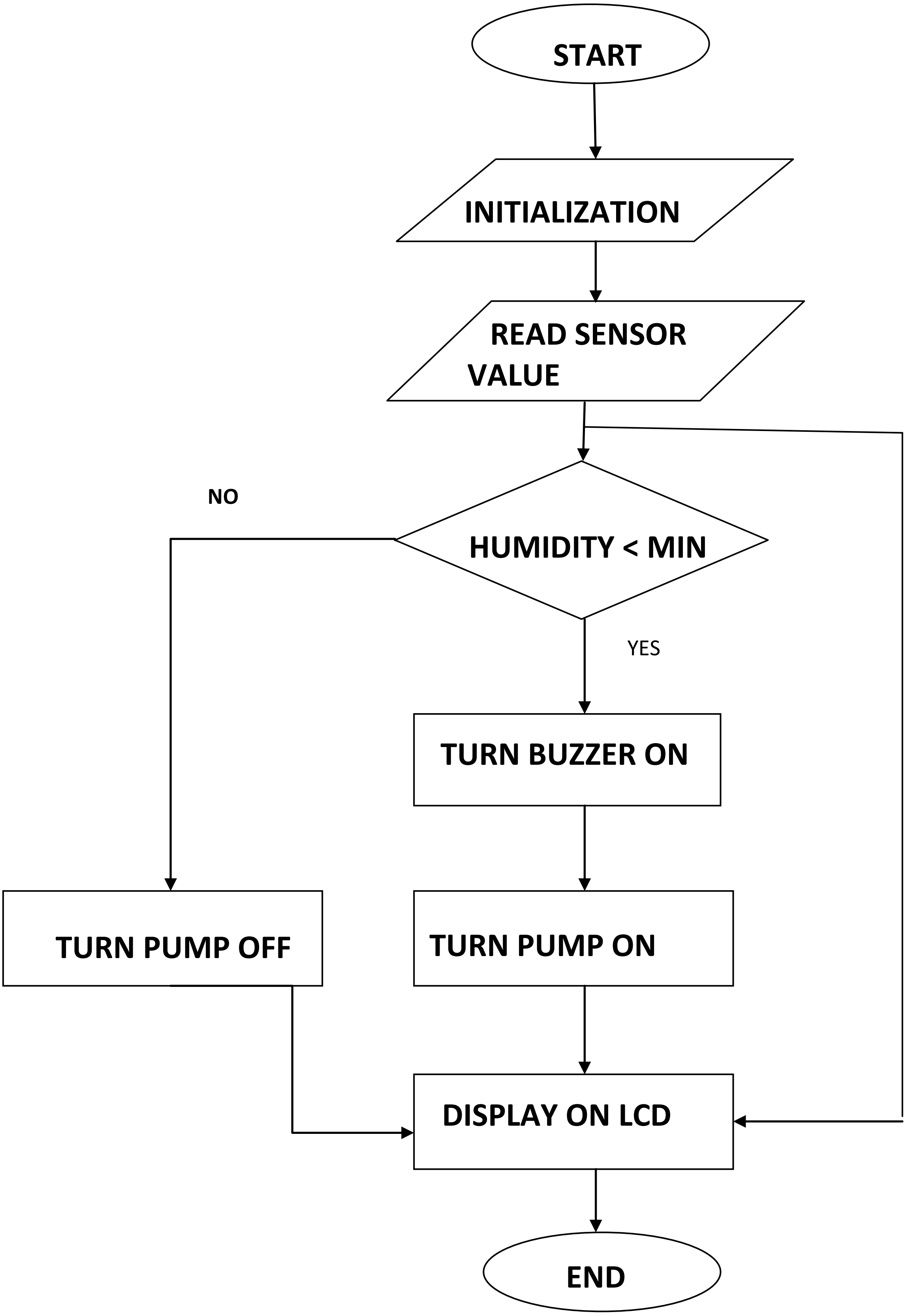


Figure 3. 7: Software flow chart

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Results

The volumetric water content of sand soil, red soil and loam soils were calculated, figure 4.1 shows the system with the three types of soil. The raw data collected from the soil moisture sensor was recorded as shown in table 4.1. The soil was measured in equal amount of 500 grams. Water was added in the soils in steps and the sensor values recorded.

Figure 4.1: Reading sensor values from sand, loam and red soil

Table 4.1: Sensor values

Soil water content (ml)	Sensor Reading(ohm)		
	Sand soil	Red soil	Loam soil
0	1023	1023	1022
25	585	348	730
50	411	271	366
75	377	260	328
100	371	230	290

4.2. Discussion

There were two MikroC programs used for this system, one for reading sensor values and the other for running the whole system. The first program was loaded individually in PIC16F877A microcontroller to read the sensor values. The data obtained from the sensor reading and recorded in table 4.1 was used to plot a graph of Soil water content against sensor reading.

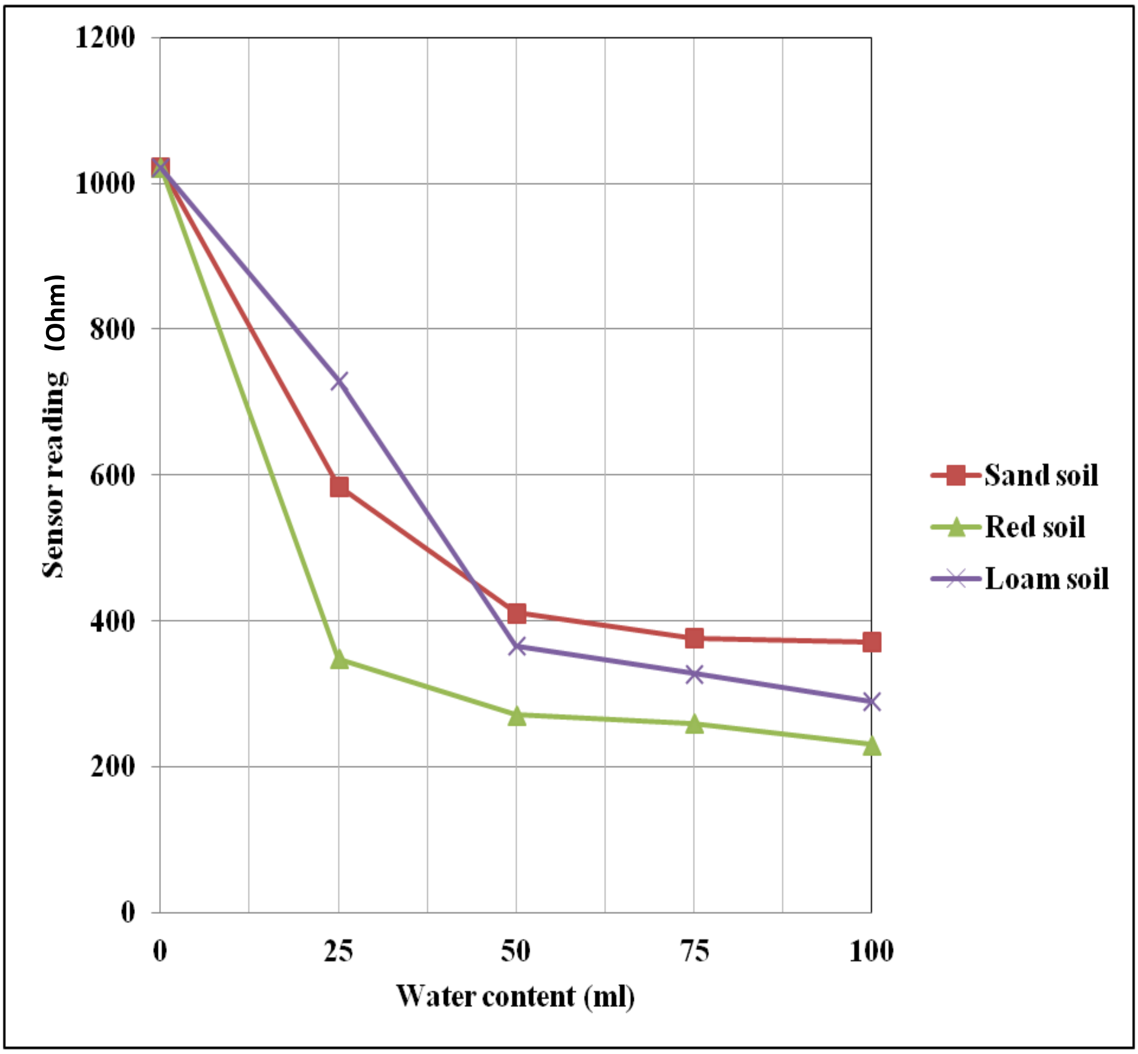


Figure 4.2: Plot of Soil water content against sensor reading

The soil moisture sensor (YL-69) used is a resistance sensor type. Its output is the resistance in the soil between the two soil moisture sensor probes. The obtained graph is an exponential one. The value of the soil resistance decreases with increase in water content to a certain point. 500 grams was measured for the red soil, loam soil and the sand soil. Water was added in steps of 25ml and sensor value recorded. The value of soil sensor at dry soil was almost equal for the three soils at(1023, 1023, 1022) ohm for sand soil, red soil and loam soil respectively. On adding 25ml the resistance value reduced drastically to the average range of 550 ohm. On adding more water the resistance value kept reducing. At around 75ml of water the reduction on the soil resistance stated reducing at a much lower rate. This is because at this point the soil is now becoming saturated with water and thus adding more water has a small effect on the soil resistance.

Then the second MikroC program was loaded in PIC16F877A microcontroller. The sensor was calibrated and three states defined. The states are water, humid and dry .Those states are obtained when the soil moisture sensor start operating and the data is manipulated by the microcontroller that will convert the value into percentage value so that easy to be understood.

After displaying the humidity value, the microcontroller will again manipulate the information and decide whether the pump will start operating or not. When the value obtained from the sensor is below the moisture level needed in the soil, the LCD will display “Dry Soil!!” in the first line and the soil humidity in percentage in the second line, the pump relay will start operating, buzzer will turn on and the water will be supplied until the moisture level is more than the minimum moisture level needed by the soil, then LCD will display “Humid soil” in the first line and the soil humidity in percentage in the second line after that pump relay and buzzer will turn off. Also if the soil moisture is over the maximum moisture level, the LCD will display “WATER!!” in the first line and the soil humidity in percentage in the second line, if pump relay is starting it will be turned off. The process is continuously running until power source is cut off.

The real auto irrigation system is shown in figures 4.3, 4.4 and 4.5.

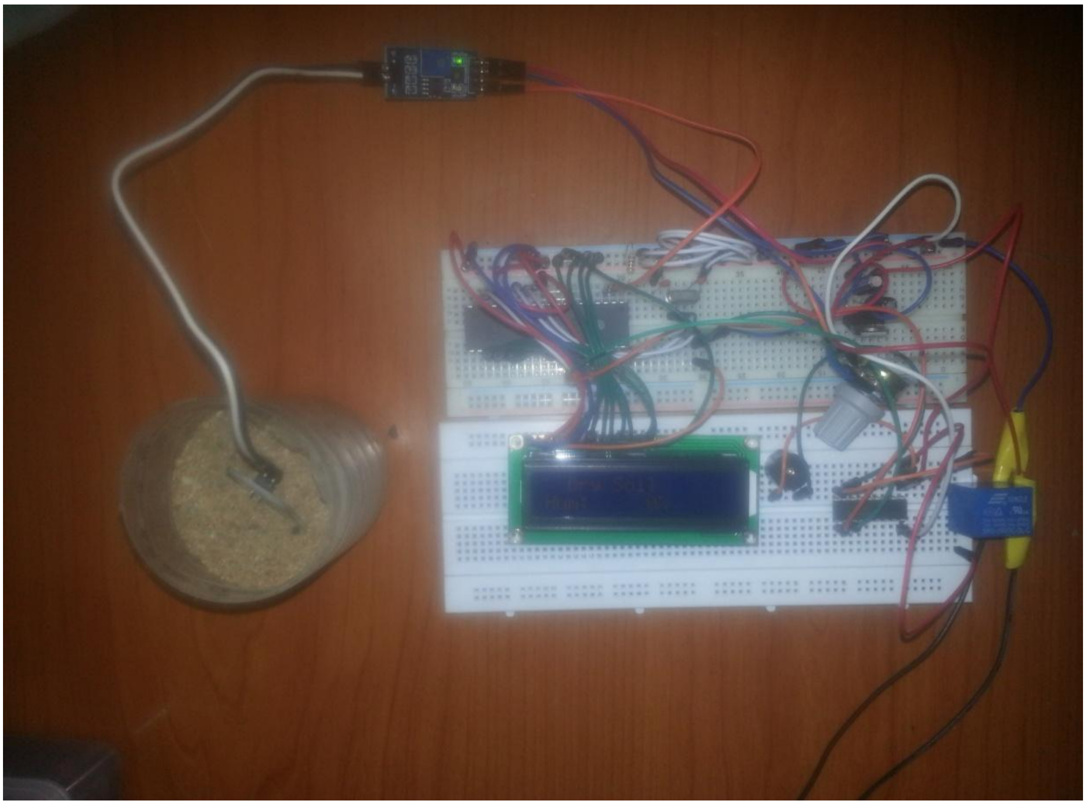


Figure 4.3: Soil moisture sensor inserted in dry soil 0%

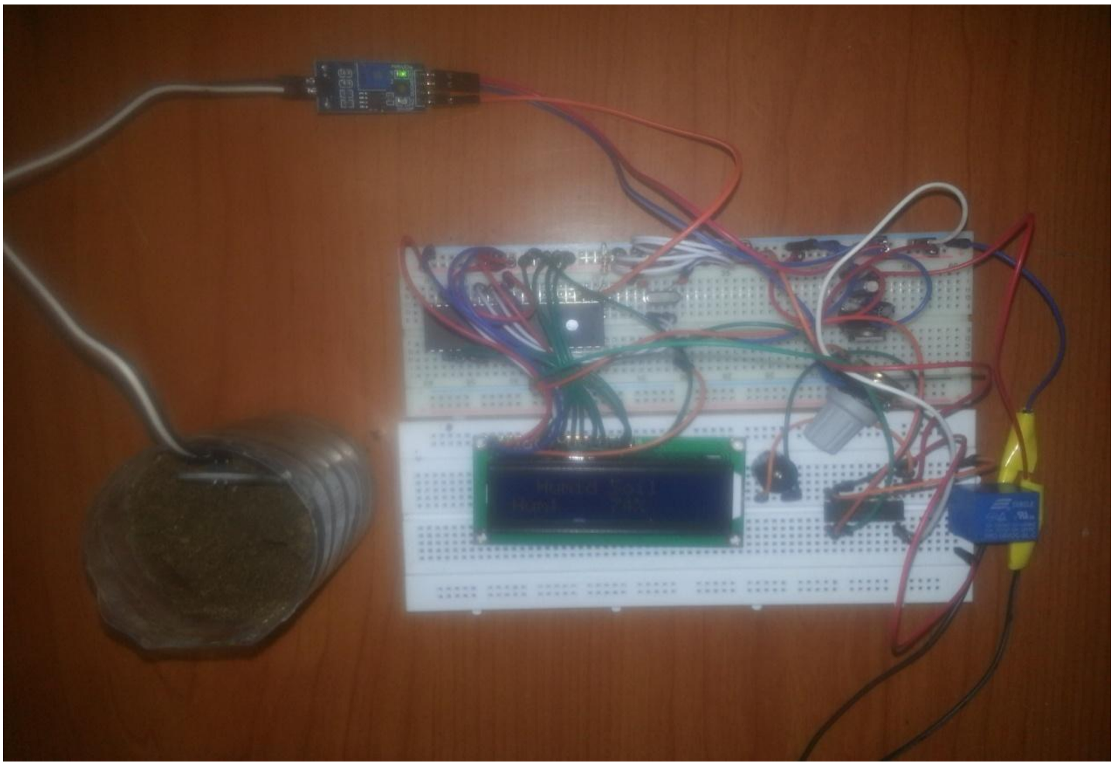


Figure 4.4: Soil moisture sensor inserted in humid soil 74%

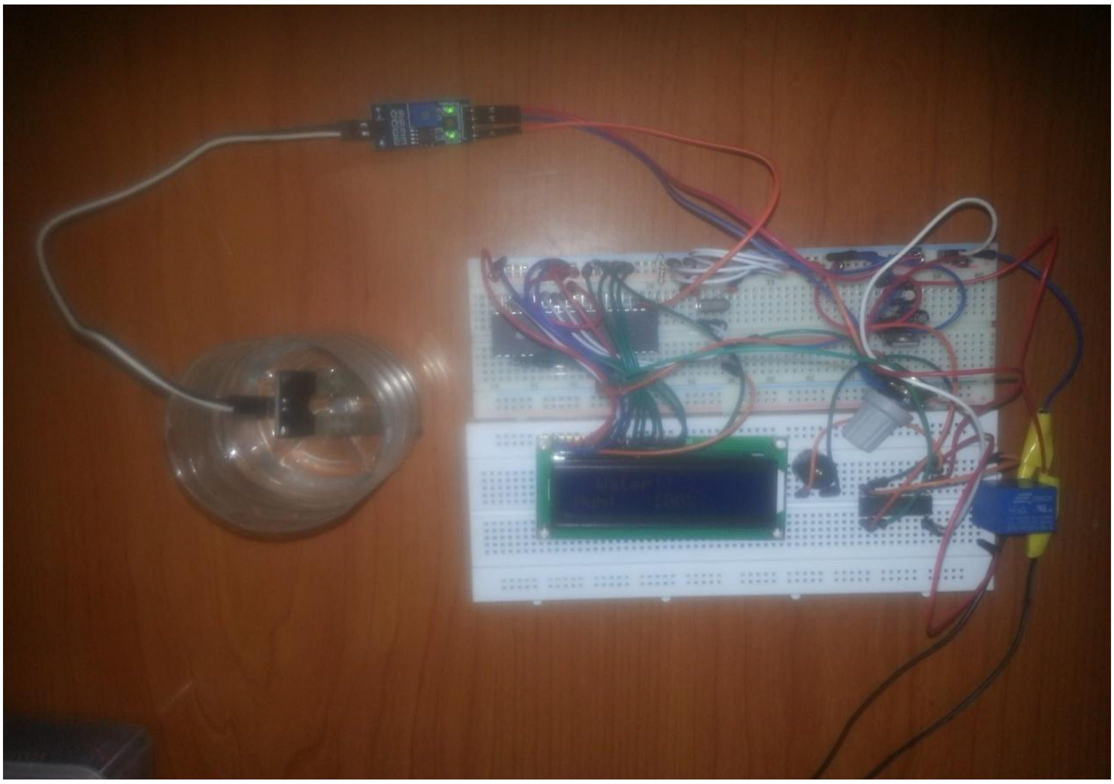


Figure 4.5: Soil moisture sensor inserted in water 100%

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

A system to monitor moisture levels in the soil was designed. The system consists of two major parts which are hardware that include sensor, LCD display, relay and buzzer and another important part is software developing. Both hardware and software part are working successfully and operate as instructed by the brain that connected to these two parts which is PIC microcontroller.

The system was used to switch on/off the watering pump relay according to set soil moisture levels. The control unit the prototype was implemented using a PIC16F877A microcontroller while the sensing element was implemented using a soil moisture sensor YL-69. An LCD was used to implement the display of the three soil states i.e. dry soil, humid soil and water soil states.

5.2. Recommendations

To improve on the effectiveness and efficiency of the system the following recommendations can be put into considerations:

- Cost effective techniques to overcome the limitation of requiring a soil specific calibration should be employed.
- Integrating GSM technology can be used, such that whenever the water pump switches ON/OFF, an SMS is sent to the concerned person regarding the status of the pump.
- The project is intended for small gardens and residential environment. By using advanced wireless soil moisture sensor, the same circuit can be expanded to large agricultural fields.
- The system can be integrated with temperature and humidity sensors to monitor the weather conditions in the farm.

REFERENCES

[1]. Chaitali R. Fule and Pranjali K. Awachat, (2014). Design and Implementation of Real Time Irrigation System using a Wireless Sensor Network. International Journal of Advance Research in Computer Science and Management Studies.

[2]. Tanay Chowdhury et al., (2013). AUTO FARMER USING RENEWABLE ENERGY. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 2.

[3]. http://www.yardmanlandscaping.com/services.htm,access date on July 2014.

[4]. http://www.engr.sjsu.edu/bjfurman/course, access date on July 2014.

[5]. Zhi Chen, Chi Lu, "*Humidity Sensors: A Review of Materials and Mechanisms*", Sensor Letters, 2005.

[6]. http://socalwatersmart.com/?page_id=2977, access date on July 2014.

[7]. Technical University of Cluj-Napoca University, Converters.

[8]. Thomas E.Brewer, "Experiments in Analog & Digital Electronics", Kendall/Hunt Publishing Company, 2006.

[9]. http://courses.me.berkely.edu, access date on July 2014.

[10]. S. V. Devika et al., (2014). Arduino Based Automatic Plant Watering Sysem. International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 4, Issue 10.

[11]. Deepika, 2006. *Designing a Microcontroller Based Temperature Data Logger".* M.Sc. in Electrical and Instrumentation Engineering. Patiala: Deemed University.

[12]. Kimani Paul Njoroge, 2008. MICROCONTROLLER-BASED IRRIGATION SYSTEM. BSc in Electrical and Information Engineering. Nairobi: University of Nairobi.

[13]. Tolli William D ,2007.Electronic Communication Devices and Methods .

[14]. Divelbiss Adam W,2007 Method and apparatus for stereoscopic display using column interleaved data with digital light processing .

[15]. Http://www.ventor.co.in/motor-driver-c-5_52/uln2803-high-current-darlington-array-p-9.html-darlington-array-p-9.html access date on august 2014 .

[16]. Http://www.engineeringsgarage.com/electronic components/relays, access date on July 2014.

APPENDICES

APPENDIX A

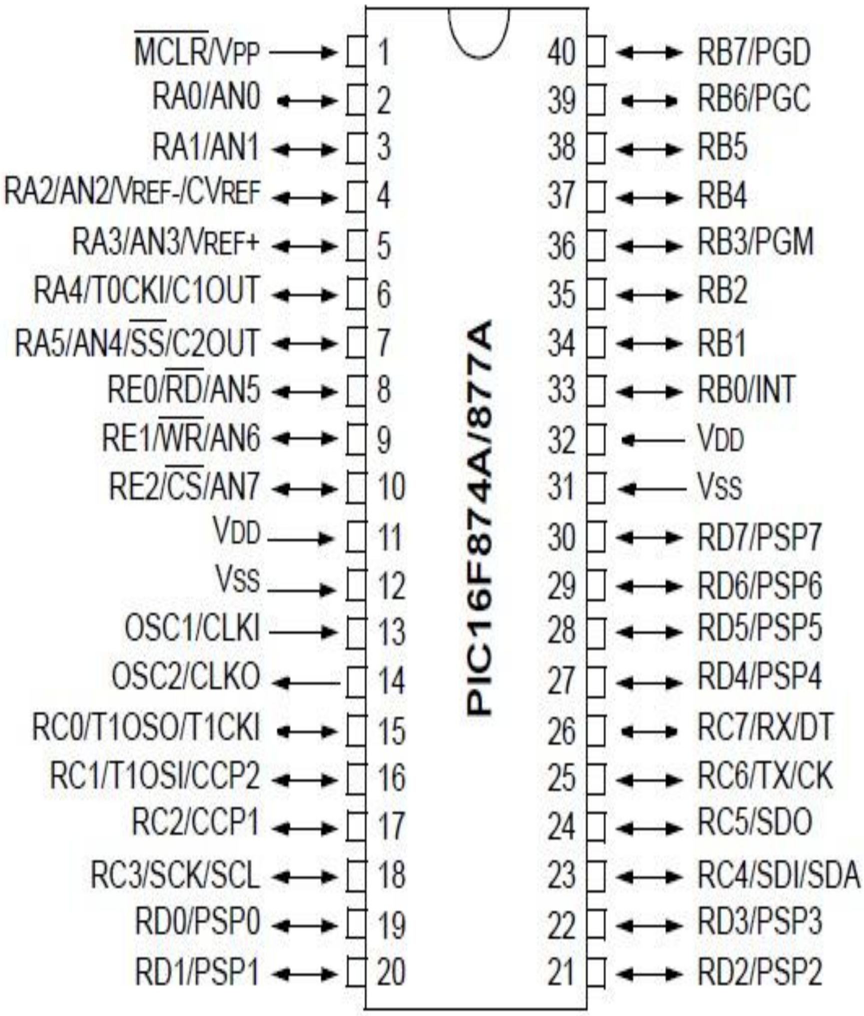


Figure A.1: Pin diagram of PIC16F877A

Features of PIC16F877A microcontroller

- High-Performance RISC CPU

  - Only 35 single word instructions to learn

- All instructions are single cycle (1µs) except for program branches

- Operating speed: DC - 20MHz clock input

- 8 kBytes Flash Program Memory

- 368 Byte RAM Data Memory

- 256 Byte EEPROM Data Memory

- In-circuit Serial Programming

- Interrupt Capability (up to 10 sources)

- Peripheral Features

  - Two 8-bit timer/counter (TMR0, TMR2) with 8-bit programmable prescaler.

  - One 16 bit timer/counter (TMR1)

  - High current source/sink for direct LED drive

  - Watchdog Timer (WDT) with Separate RC Oscillator

  - Two Capture, Compare, PWM Modules

  - Synchronous Serial Port with SPI and I²C

  - Eight Channel, 10-bit Analog to Digital Converter

  - Universal Synchronous Asynchronous Receiver Transmitter (USART)

- Special Microcontroller Features

  - Power-On Reset

  - Power-up Timer (PWRT) and Oscillator Start-Up Timer (OST)

  - 1,000 erase/write cycles Enhanced Flash Program Memory

  - 1,000,000 typical erase/write cycles EEPROM Data Memory

- Selectable Oscillator Options

- CMOS Technology

  - Low power, high speed CMOS FLASH technology

  - Fully Static Design

  - Low Power Consumption

- I/O and Packages

  - 33 I/O pins with individual direction control

  - 40-pin DIP

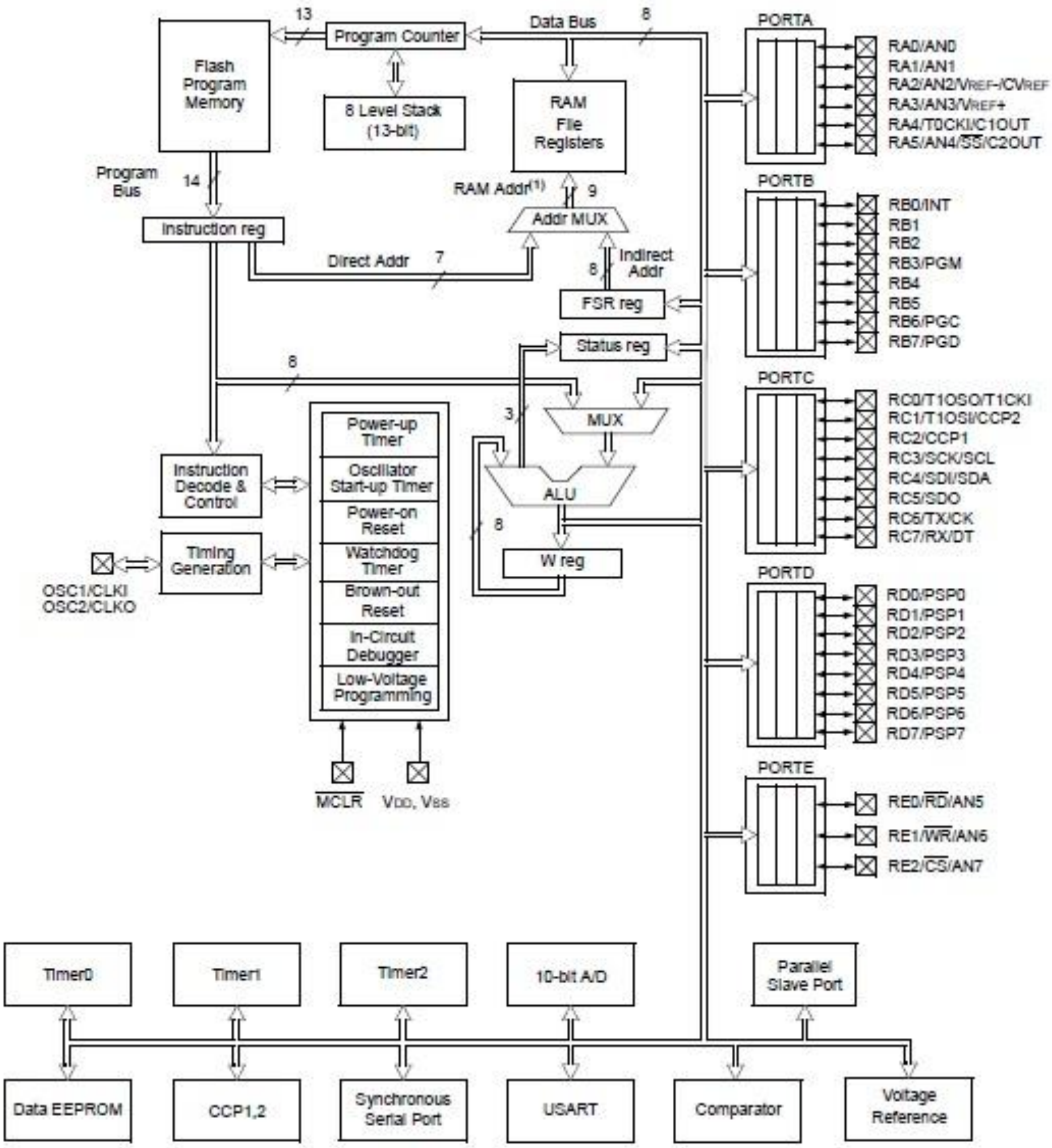


Figure A.2: block diagram of PIC16F877A

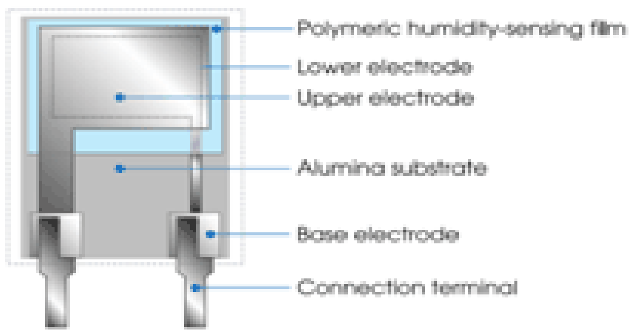
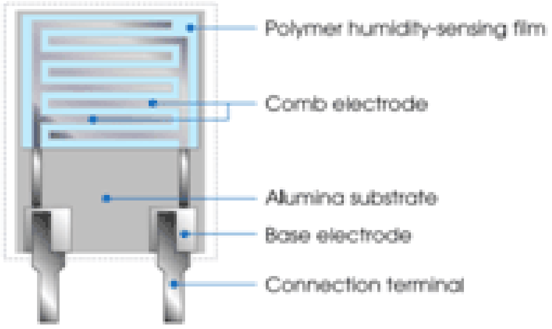


Figure A.3: capacitive type humidity sensor



FigureA.4: Basic structure of resistive type humidity sensor

APPENDIX B

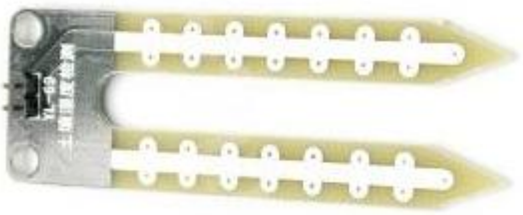


Figure B.1: YL-69 Sensor

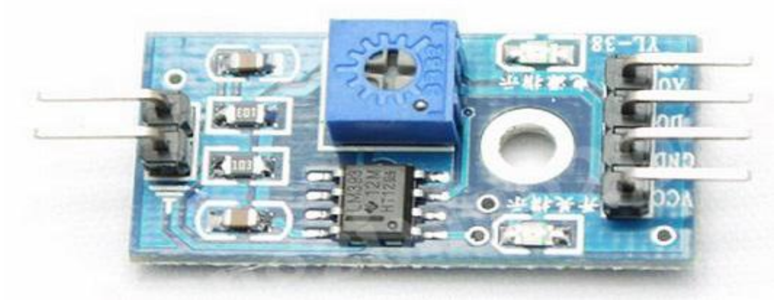


Figure B.2: YL-69 PCB

Figure B.3: P3362 Electronic potentiometer

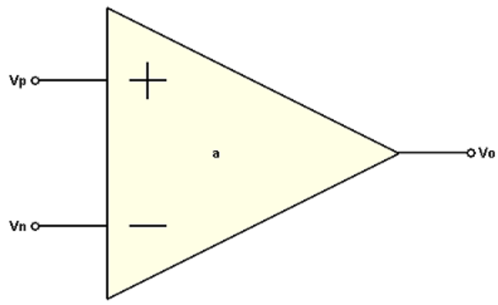


Figure B.4: Operational amplifier

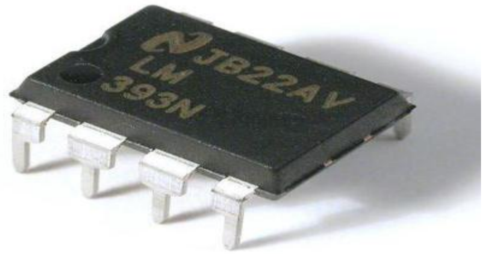


Figure B.5: LM393 Comparator

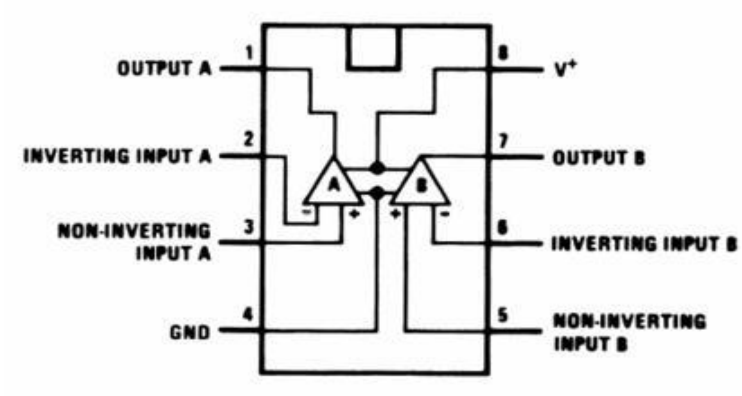


Figure B.6: LM393 pin configuration

Figure B.7: PIC16F877A microcontroller

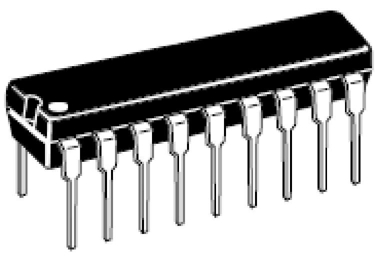


Figure B.8: High Current Darlington Transistor (ULN2803)

Features of ULN2803

(TA = 25°C and rating apply to any one device in the Package, unless otherwise noted.)

- Output Voltage 50 V
- Input Voltage (Except ULN2801) 30 V
- Collector Current – Continuous 500 mA
- Base Current – Continuous 25 mA
- Operating Ambient Temperature Range 0 to +70 °C
- Storage Temperature Range –55 to +150 °C
- Junction Temperature 125 °C

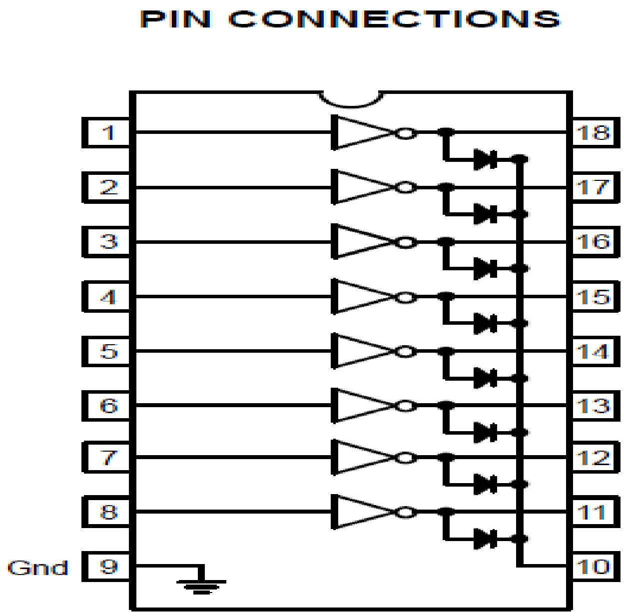


Figure B.9: ULN2803 pin connections

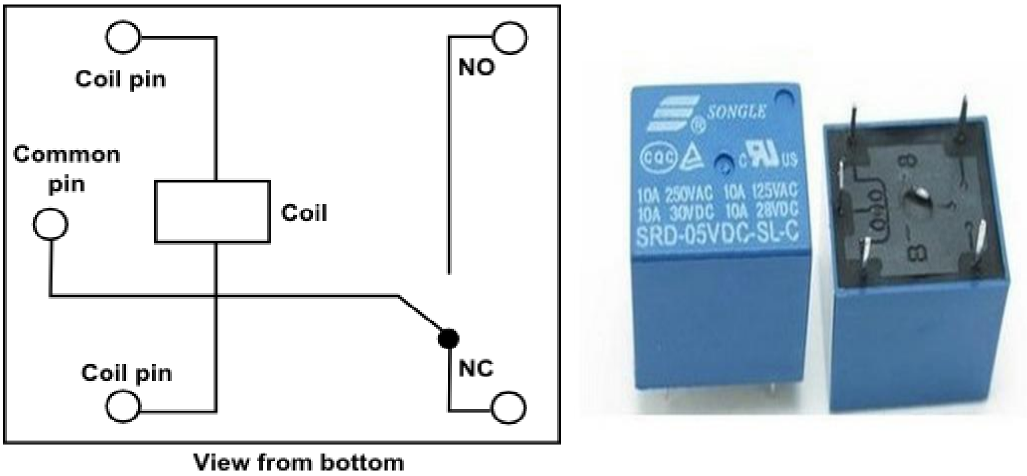


Figure B.10: 5VDC Relay

Figure B.11: piezoelectric Buzzer

APPENDIX C

MikroC Code for sensor reading value

```
  // LCD module connections
 sbit LCD_RS at RC2_bit;
 sbit LCD_EN at RC3_bit;
 sbit LCD_D4 at RC4_bit;
 sbit LCD_D5 at RC5_bit;
 sbit LCD_D6 at RC6_bit;
 sbit LCD_D7 at RC7_bit;
 sbit LCD_RS_Direction at TRISC7_bit;
 sbit LCD_EN_Direction at TRISC6_bit;
 sbit LCD_D4_Direction at TRISC5_bit;
 sbit LCD_D5_Direction at TRISC4_bit;
 sbit LCD_D6_Direction at TRISC3_bit;
 sbit LCD_D7_Direction at TRISC2_bit;
// End LCD module connections
 unsigned int source=0;
 char txt[6];
 void main() {
   CMCON = 0X07;
   ADCON1 = 0x80; // For ADC Module configuration(means use port a as
analog)
```

```
TRISA = 0xFF; // PORTA is input (ADC Input)

TRISD.F1=1;  //

TRISB.F0=0;  //

TRISB.F1=0;  //

PORTB.F0=0;

PORTB.F1=0;

ADC_Init();           // Initialize ADC

Lcd_Init();           // Initialize LCD

Lcd_Cmd(_LCD_CLEAR);       // Clear display

Lcd_Cmd(_LCD_CURSOR_OFF);    // Cursor off


while(1){

source=Adc_Read(1);

inttostr(source,txt);

        Lcd_Out(1,3, "Humid Soil");

        Lcd_Out(2,1, "Hum:");

        Lcd_Out(2,5,txt);

        Lcd_Chr(2,11,'%');

        delay_ms(1000);


    }

}
```

MikroC code for auto irrigation system

```
  // LCD module connections
 sbit LCD_RS at RC2_bit;
 sbit LCD_EN at RC3_bit;
 sbit LCD_D4 at RC4_bit;
 sbit LCD_D5 at RC5_bit;
 sbit LCD_D6 at RC6_bit;
 sbit LCD_D7 at RC7_bit;
 sbit LCD_RS_Direction at TRISC7_bit;
 sbit LCD_EN_Direction at TRISC6_bit;
 sbit LCD_D4_Direction at TRISC5_bit;
 sbit LCD_D5_Direction at TRISC4_bit;
 sbit LCD_D6_Direction at TRISC3_bit;
 sbit LCD_D7_Direction at TRISC2_bit;
// End LCD module connections
 double source=0;
 char txt[6];
 void main() {
   ADCON1 = 0x80; // For ADC Module configuration(means use port a as
analog)
```

```
 TRISA = 0xFF; // PORTA is input (ADC Input)

 TRISD.F1=1;  //

 TRISB.F0=0;  //

 TRISB.F1=0;  //

 PORTB.F0=0;

 PORTB.F1=0;

 ADC_Init();            // Initialize ADC

 Lcd_Init();            // Initialize LCD

 Lcd_Cmd(_LCD_CLEAR);       // Clear display

 Lcd_Cmd(_LCD_CURSOR_OFF);     // Cursor off

 Lcd_Cmd(_LCD_CLEAR);       // Clear display


while(1){

source=Adc_Read(1);

source=1023-source;

source=100*source;

source=source/(650);

  if(source>96){

       source=100;

   }

inttostr(source,txt);
```

```
if(source>83){
          Lcd_Cmd(_LCD_CLEAR);
          Lcd_Out(1,3, "Water!!");
          Lcd_Out(2,1, "Hum:");
          Lcd_Out(2,5,txt);
          Lcd_Chr(2,11,0x25);
          Lcd_Chr(2,12,' ');
          Lcd_Chr(2,13,' ');
          Lcd_Chr(2,14,' ');
          Lcd_Chr(2,15,' ');
          Lcd_Chr(2,16,' ');
          delay_ms(1000);
          PORTB.F0=0; //motor off
          PORTB.F1=0; //buzzer off
             }
else if(source>33&&source<=83){
         Lcd_Cmd(_LCD_CLEAR);
         Lcd_Out(1,3, "Humid Soil");
         Lcd_Out(2,1, "Hum:");
         Lcd_Out(2,5,txt);
         Lcd_Chr(2,11,0x25);
         Lcd_Chr(2,12,' ');
```

```
        Lcd_Chr(2,13,' ');
        Lcd_Chr(2,14,' ');
        Lcd_Chr(2,15,' ');
        Lcd_Chr(2,16,' ');
        delay_ms(1000);
        PORTB.F0=0; //motor off
        PORTB.F1=0; //buzzer off
    } else{
        Lcd_Cmd(_LCD_CLEAR);
        Lcd_Out(1,3, "Dry Soil");
        Lcd_Out(2,1, "Hum:");
        Lcd_Out(2,5,txt);
        Lcd_Chr(2,11,0x25);
        Lcd_Chr(2,12,' ');
        Lcd_Chr(2,13,' ');
        Lcd_Chr(2,14,' ');
        Lcd_Chr(2,15,' ');
        Lcd_Chr(2,16,' ');
        PORTB.F0=1;
        delay_ms(1000);
        PORTB.F0=1;    // motor on
        delay_ms(1000);
```

```
        PORTB.F1=1;     // buzzer on

        delay_ms(1000);

        }

    }

}
```