DESIGN AND CONSTRUCTION OF AUTOMATIC IRRIGATION CONTROL SYSTEM

BY

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(EE/08/1722)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, SCHOOL OF ENGINNERING AND ENGINEERING TECHNOLOGY, MODIBBO ADAMA UNVERSITY OF TECHNOLOGY YOLA, NIGERIA

DECEMBER, 2012

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, SCHOOL OF ENGINNERING AND ENGINEERING TECHNOLOGY, MODIBBO ADAMA UNVERSITY OF TECHNOLOGY YOLA, IN PARTIAL FUFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINNEERING.

DECEMBER, 2012

DECLARATION

I **Maissala, Domwa** hereby declare that this project report was written by me and it is a record of my own research work. It has not been presented before in any previous application for a bachelor's degree. References made to published literature have been duly acknowledged.

…………………….. Date:…………………….

Maissala, Domwa

(Student)

The above declaration is confirmed

……………………….. Date:……………………..

Engr. A. S. Kadalla

(Supervisor)

CERTIFICATION

This project entitled **“ Design and construction of automatic irrigation control system”** by **Maissala, Domwa (EE/08/1722)** meet the regulation governing the award of bachelor’s degree of the Midibbo Adamawa University of Technology, Yola and is approved for its contribution to knowledge and literary presentation.

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Engr. A. S. Kadalla

(Supervisor)

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…………………….. Date:……………………..

Prof. E. E. Omizegba

(External Examiner)

DEDICATION

This project report is dedicated to almighty God and to my lovely family.

ACKNOWLEDGEMENTS

Firstly I want to be thankful to almighty God for his Grace and protection upon my life.

I wish to express my profound gratitude to my indefatigable supervisor Engr. A. S. Kadalla for his continued encouragement, inspiration, support and constructive crictisms. My gratitude to my head of department Engr. I. M. Visa and to all the lectures from Electrical and Electronic Engineering department for the impact of knowledge on us. I would also like to thank my external supervisor Prof. E .E. Omizegba for his encouragement and correction of this work.

I am greatly indebted to my parents, particularly to my mother Assam Sara, my brother and Sister Engr. Doba Maissala, Welga Maissala, Wainmené M. and my uncle Gnonkreo Wilkissam for their moral and financial supports during my study.

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Lastly I am grateful to all those who have had a direct or indirect impact on this work may almighty God blesses you all.

ABSTRAC
T

Efficient use of water for agriculture production is highly emphasized by the Government of many countries in Africa due to limited available water resource to meet the growing need of ever increasing population. The farmers have been using traditional irrigation (manual) for more than a century which has caused not only water logging resulting from over-irrigation but also insufficient of water due to under- irrigation. This project presents the design and construction of automatic irrigation control system which involves use of PIC18F2520 microcontroller with a soil moisture sensor and a LDR connected to it as input. The desired value and the actual reading from the sensor are displayed on a LCD connected to the controller and also the water pump is turned on and off by received the signal from the controller. The experiment was carried out for the calibration of soil sensor moisture. It was observed that the soil moisture sensor responds to different type of soil, though care must be taken in the calibration of sensor. For conclusion some recommendations were made for better management of this kind of project and suggestions for further researches.

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LIST OF ABREVIATIONS AND SYMBOLS

1- PIC = Programmable Interrupt Controller
2- LCD = Liquid Crystal Display
3- RAM = Random Access Memory
4- ROM = Read Only Memory
5- RS = Select Register
6- EN = Enable
7- LED = Light Emitting Diode
8- RW = Read and Write
9- LDR = Light Dependent Resistor
10- I/O = Input and Output
11- AD = Analogue to Digital converter
12- SCI = Serial Communication Interface
13- SPI = Serial Peripheral Interface
14- USB = Universal Serial Bus
15- PWM = Pulse Width Modulation
16- CPU = Central Processing Unit
17- BJT = Bipolar Junction Transistor
18- MOSFET = Metal Oxide Semiconductor Field Effect Transistor.

CHAPTER ONE: INTRODUCTION

1.0 BACKGROUND

More than 40% of the agricultural lands are under arid or semi-arid climatic conditions [1]. In such environments; water is the most limiting factor in reducing agricultural production. Many areas of agricultural fields are effectively over-or under-irrigated due to spatial variability in water infiltration and runoff of rainfall and irrigation, crop water use and irrigation depth. Under-irrigated areas are subjected to water stress, resulting in production loss, while over-irrigated areas suffer from plant disease and nutrient leaching [2] Through proper irrigation, average production yields can be maintained (or increased) while minimizing environmental impacts caused by excess applied water and subsequent agrichemical leaching.

The continuous increasing demand of the food requires the rapid improvement in food production technology. In many countries, where the economy is mainly based on agriculture and the climatic conditions are isotropic, still we are not able to make full use of agricultural resources. The main reason is the lack of rains and scarcity of land reservoir water. Another very important reason of this is due to unplanned use of water due to which a significant amount of water goes waste. In the modern automated irrigation systems, the most significant advantage is that water is supplied at accurate time which saves a large quantity of water. At the present era, the farmers have been using irrigation technique in Africa through the manual control in which the farmers irrigate the land at the regular intervals. This process sometimes consumes more water or sometimes the water reaches late due to which the crops get dried. Water deficiency can be detrimental to plants before visible wilting occurs. Slowed growth rate, lighter weight fruit follows slight water deficiency.

This problem can be perfectly rectified if we use automatic irrigation system in which the irrigation will take place only when there will be intense requirement of water. Irrigation system uses valves to turn irrigation ON and OFF. These valves may be easily automated by using controllers and solenoids. Automating farm or nursery irrigation allows farmers to apply the right amount of water at the right time, regardless of the availability of labor to turn valves on and off. In addition, farmers using automation equipment are able to reduce runoff from over watering saturated soils, avoid irrigating at the wrong time of day, which will improve crop performance by ensuring adequate water and nutrients when needed. Automatic Irrigation control system is a valuable tool for accurate soil moisture control in highly specialized greenhouse vegetable production and it is a simple, precise method for irrigation. It also helps in time saving, removal of human error in adjusting available soil moisture levels and to maximize their net profits.

1.2 STATEMENT OF PROBLEM

The significant problem with manual irrigation system that is in practice today is that it leads to under or over irrigation and this grossly affect crop yield. An automatic irrigation control system is a potential solution to optimize water management by sensing soil water conditions and site-specifically controlling irrigation valves.

1.3 OBJECTIVES

The irrigation is beneficial only when is properly managed and controlled. It is the intention of this project therefore to automate the irrigation system through the design and construction of a microcontroller based automation irrigation system that is capable of doing the following tasks:

- To determine the soil moisture,
- To decide when to irrigate the land for better growth of plants,
- To determine the quantity of water needed to irrigate the land
- To water the land regardless of the availability of labor to turn valves and pump motor on and off.

1.4 SIGNIFICANCE

Water is an essential ingredient of crops. Knowing when crops need water, how much they need and how best to apply it are the keys to a good irrigation management program. Improve the irrigation system usually leads to increase intensity of cultivation, high input results in high output stable production and reduce the risk of crop failure. The automatic irrigation control system is more applicable in area where the quantity of rainfall is insignificant and the automatic irrigation control system is also used during the dry season to save water and energy.

1.5 SCOPE

This work is solely focus on one channel irrigation control system which it will be used for a particular plant. Multichannel irrigation control system which can be use for different types of plants and the control system of water in tanker or reservoir which is also a significant aspect of irrigation system, would not be covered in this project but they are reserved for further researches.

CHAPTER TWO: LITERATURE REVIEW

2.0 IRRIGATION SYSTEM

Irrigation, the ancient agricultural technique of artificially supplying water to land to sustain crop’s growth, may have been practiced as early as 5,000 BC along the banks of such regularly flooding rivers as the Nile. Ancient remnants of these structures have been found in Egypt, China, Mexico, India, and the United States [3].

2.1 MANUAL IRRIGATION SYSTEM

System, all operations are completed manually, such as pumps, valves open, close, irrigation, the length of time, when the irrigation and so on. Of such systems has the advantage of lower costs, control part of the technical content is not high, easy to use and maintain, it is suitable for the vast rural areas but disadvantage of this irrigation is that, it leads to under or over-irrigation.

2.2 SEMI-AUTOMATIC IRRIGATION SYSTEM

The system is not installed sensors in irrigation areas, irrigation time, irrigation amount and irrigation cycle of fliers based on pre-programmed, rather than crop and soil moisture and meteorological data feedback information to control. Degree of automation of such systems varies, and some part of the implementation of automatic control, and some automatic control of several parts.

2.3 AUTOMATIC IRRIGATION SYSTEM

Systems do not directly participate, through pre-programmed control procedures and in accordance with crop water requirement to reflect some of the parameters can be a long water pump and automatic open and close automatically according to a certain order of rotation irrigation. The role of the control procedures is an adjustment, and maintenance control equipment. This system, in addition to irrigation emitters, pipes, pipe fittings and pumps, motors, also including the central controller, automatic valves, sensors (soil moisture sensors, temperature sensors, pressure sensors, level sensors and rain sensors, etc.) and electrical wiring

2.3.1 WHY AUTOMATIC IRRIGATION SYSTEM

Land and water are the two essential factors required for agricultural development and economic advancement of a country. Nature has bestowed Africa with abundant water resources. However, due to limitations of topography, geology, physiology, dependability, quality & the present state of technology, only a part of available water resources can be utilized. The farmers have been using traditional surface irrigation for more than a century which has caused tremendous loss of not only the productive land due to water logging resulting from over-irrigation but also deprived the users of already short irrigation water. Further, yields per unit of water in some countries in Africa are the lowest in the world. There is a need to maximize the per unit production of water. This challenge can only be fulfilled by better & efficient use of these two natural resources. Adoption of advanced irrigation water saving methods like drip or sprinkler controlled automatically can help to achieve this goal.

2.4 THE METHODS OF IRRIGATION

Water is basic need of plants for all metabolic and production process within. A crop is grown in different land situations, soil type, climatic conditions, seasons and water supply situation. Besides, crops differ in the structures and habits. Their water requirements thus vary widely. Water management pertains to optimum and efficient use of water for best possible crop production keeping water losses to the minimum. Serious water losses occur unless it is properly monitored while irrigating field. Various methods are adopted to irrigate crops and the main aim is to store water in the effective root zone uniformly and in maximum quality possible ensuring water losses to the minimum [3].

2.4.0 Surface irrigation methods

Surface irrigation refers to irrigating the lands by allowing water to flow over the soil surface from a supply channel at upper reach of the field. The principles involved in surface irrigation are: (i) field is divided into plots or strip to uniformly irrigate the soil to desire depth throughout the field, (ii) water is discharged at highest level of field allowing water to flow down the gentle slope by gravity flow, (iii) efficiency of irrigation is kept at high and (iv) size of stream should be such as to have an adequate control of water. Crops are irrigated mostly by surface irrigation. Advantages of surface irrigation are:

- Variable sizes of streams can be used.
- Large flow of water can be easily controlled.
- Sufficiently skilled person are not required for water application.

And it has the following limitations:

- Considerable land is wasted in construction of channels and bunds.
- High cost construction.
- Rodent and animals often cause damages to channel bunds.
- Channels and bunds interfere with movement of farm tools, machinery.

2.4.1 Subsurface irrigation methods

Surface irrigation, also designated as sub-irrigation, involves irrigation to crops by applying water from beneath the soil surface either by constructing trenches or installing underground perforated pipe lines or tile lines. Water is discharged into trenches and allowed to stand during the whole period of irrigation for lateral and upward movement of water by capillarity to the soil between trenches. Underground perforated pipes or tiles in which water is forced, trickle out water through perforations in pipes or gaps in between tiles. Water moves laterally and upward to moist the root zone soil under capillary tensions. Pipelines remain filled with water during the period of irrigation. The upper layers of soil remain relatively dry owing to constant evaporation while the lower layers remain moist.

2.4.2 Overhead or sprinkler irrigation methods

Sprinkler irrigation refers to application of water to crops in form of spray from above the crop like rain. It is also the overhead irrigation as water is allowed to fall as sprays from above crop. Water under pressure is carried and sprayed into the air above the crop through a system of overhead perforated pipes, nozzle lines or through nozzles fitted to riser pipes attached to a system of pipes laid on ground.

Sprinkler system is designed according to necessity. It may be for main irrigations or for protective irrigations. In arid regions, sprinkler may be used to apply the full quantity of water needed by the grown as the irrigation water is scarce and the sprinkler irrigation ensures a high efficiency of water application.

Fig2. 1: Example of sprinkler irrigation system

2.4.3 Drip irrigation methods

Drip irrigation, called trickle irrigation, refers to the application at a slow rate drop by drop through perforations in pipes or through nozzles attached to tubes spread over the soil to irrigate a limited area around the plant. The soil water can be maintained at field capacity or at low tension during the crop growing period. The soil factors are thus less important in deciding the frequency of irrigation. Deep percolation loss can be completely prevented and the evaporation loss is also reduced. The method is profitably used in arid region where water is scarce and often of poor

2.5 IRRIGATION WATER SOURCES

Irrigation water is obtained from two sources, surface water and ground water, [3].

2.5.0 Surface water

Rain and welting snow form streams, rivers and lakes and fill reservoirs tanks and ponds. These constitute the resources of surfaces water. The surface water provides the largest quantity of irrigation water. Dams are constructed across rivers and water is diverted to agricultural field through canal and distributaries by gravity flow. Water is lifted or pumped up when the lake, tank and pond are at lower level than the field.

2.5.1 Ground water

The free water found beneath the ground surface is referred to as ground water. When a hole is bore sufficiently deep into the soil, free water accumulate into the hole and surface of water in the hole is terminated as water table.

2.6 WATER PUMPS

There are two main classifications for pumps used in irrigation systems, Rotodynamic (Centrifugal) and Positive Displacement pumps. Rotodynamic pumps have an impellor that rotates in the liquid and imparts energy to the liquid to create pressure. This pressure then moves the liquid down the pipeline. Positive displacement pumps apply force to a liquid in a container vessel creating pressure which moves the liquid down the pipeline

2.6.0 Rotodynamic (centrifugal) pumps

Rotodynamic pumps are by far the most common pumps used in irrigation systems. This is because of the basic design can be modified to cater for a large range of operational needs. The Rotodynamic pumps can be classified by the different shaped impellors used in the pumps. There are 3 different types of impellors, radial flow, mixed flow and axial flow.

2.6.1 Positive displacement pumps

Positive Displacement pumps are less commonly used. These pumps produce high head and low flows, more often used to fill tanks located along way from the water source or at a high elevation above the water source. The flow of water is intermittent because of the backwards and forwards action of the pumps.

The smaller positive displacement pumps (metering pumps) are used in fertilization systems to accurately add the fertilizer solutions to the irrigation water.

2.6.2 Electro-submersible pumps

The electro-submersible pump is a multi-staged centrifugal pump close-coupled to an electric motor. The motor and pump are in the one unit. The motor is underneath to keep the unit submerged. The motor depends on the pumped water for cooling, and a failure of the water supply can result in serious damage to the unit.

The pump is dimensioned for use in bores and is very long in comparison to its diameter. This type of pump can also be used in rivers where flooding may be a problem.

2.7 THE SOIL SYSTEM

Soil is three-phase systems consisting of solid, liquid and gases. The minerals and organic matters in soil together constitute the solid phase, while water forms the liquid phase and the soil air, the gaseous phase. Mineral matters comprise the largest fraction of soil and exist in the form of particles of different sizes and shapes encompassing the void space. The soil air is totally expelled from soil when water is present in excess amount as in water logged soil, while water in liquid form may be absent in dry sands of deserts. The volume of these soils component varies widely and a typical silt soil contains about 50 percent soil solids including organic matter, 30 percent water and 20 percent air.

2.8 THE SOIL MOISTURE SENSORS

Measurement of soil-water is essential for proper scheduling of irrigation and estimating the amount of water needed for irrigation. Since soil water is most dynamic, knowledge on changes in soil water content from time to time is important for proper monitoring of water management practices both in irrigated and rainfed forming. Several methods have been developed for measurement of soil water. Some of them have received well acceptance, while others have not. A method is adopted in situation depending on the rapidity and accuracy wanted convenience and equipment available for measurement.

2.8.0 Electrical resistances method

This method is used to measure indirectly soil water content by electrical conductivity of a porous solid depends on the water content present in it. The amount of electricity that passes through a porous medium is dependent partly on the material and partly on water content. Electrical resistance varies inversely with moisture content. i.e the resistance increase with decrease in water content. The resistance is measured in ohms. Resistance unit consists essentially of two electrodes made of single core cable or 20 mesh screen of stainless embedded in gypsum block which acts an absorbent material.

Advantages of this method are many. It provides quite an accurate measurement of soil water and resistance units can be prepared and installed in the field easily. The resistance measuring meter and the resistance units and are portable and their handling is easy. Determination of soil water can be done at different depths of soil in the same location continuously till the units are not damaged or dissolved inside the soil.

Difficulties with gypsum blocks are that they are not very sensitive to higher range of available water and cannot be used in soils that get waterlogged or are irrigated frequently as gypsum blocks dissolve slowly in this soil. Units are also not durable and are affected by salts in the soil. Again, the resistances reading are affected by temperature variation.

2.8.1 Thermal conductivity method

The method takes advantage of the thermal conductivity of soils to determine the water content since heat conductivity and heat capacity of soils vary with soil water contents. An electric heating element with temperature measuring device is inserted into soil to the desired depth. Constant energy is supplied and the rise in temperature is noted at intervals. The electrical energy consumed and temperature gradients obtained are used as measure of soil water. Soil, when dry acts as a heat insulating medium and consequently a considerable rise in temperature occurs on application of heat which is not dissipated easily. On the other hand, heat gets quickly dissipated from the source when soils are wet and the rise of temperature is slow. This temperature is then calibrated to find out the soil water content.

The method is not popular because of laborious calibration with the instrument and variations of temperature due to differences in soil packing at different depths. Further, it requires repeated calibrations at different site. However, the method may be used for wide range of soil water.

2.8.2 Dielectric soil measurement method

Dielectric soil moisture sensors determine the soil moisture by measuring the dielectric constant of the soil, an electrical property that is highly dependent on the moisture content. The constant for dry soil is between 3 and 5; about one for air, and is about 80 for water. Thus changes in the moisture content cause a substantial changes in the dielectric content. The most common dielectric devices are capacitance sensors and time-domain-reflectometry (TDR) sensors although other types of dielectric sensors exist.

Advantages of dielectric soil moisture sensors include the ability to be left in place to continuously log soil moisture content, repeatability of measurement; sensitivity to small changes in soil moisture content; and their precise resolution with depth because of the narrow vertical zone of influence. Disadvantages include the need for a calibration equation; the difficulty in developing the equation; the relatively small zone of influence; possible influence of soil salinity on probe reading; and sensitivity to air gaps surrounding the sensor.

CHAPTER THREE: DESIGN AND CONSTRUCTION PROCEDURES

3.0 SYSTEM DESCRIPTION

As shown in the block diagram, the inputs to the controller are the power circuit, soil moisture sensor and the light depending resistor & the outputs are the LCD display and the water pump. When the soil moisture sensor detects that there is not enough water in the soil (0V-No moisture, 3VMoisture present) it signals the microcontroller by sending the analog input values as a result of the reading from the soil. These analog values are sampled and compared to the desired value. If there is enough moisture, the water-pump does not start. But, if the sensor detects no moisture presence in the soil, it signals to the microcontroller, which in turn check the time whether it is convenient to water, if so it drives the water-pump into on state. The actual quantity of water in soil detected by the sensor is displayed on the LCD; this value varies with quantity of water in the soil. If the water supplied by the pump reach the desired value, the sensor will signal the microcontroller again and the microcontroller also in turn drive the pump into off state.

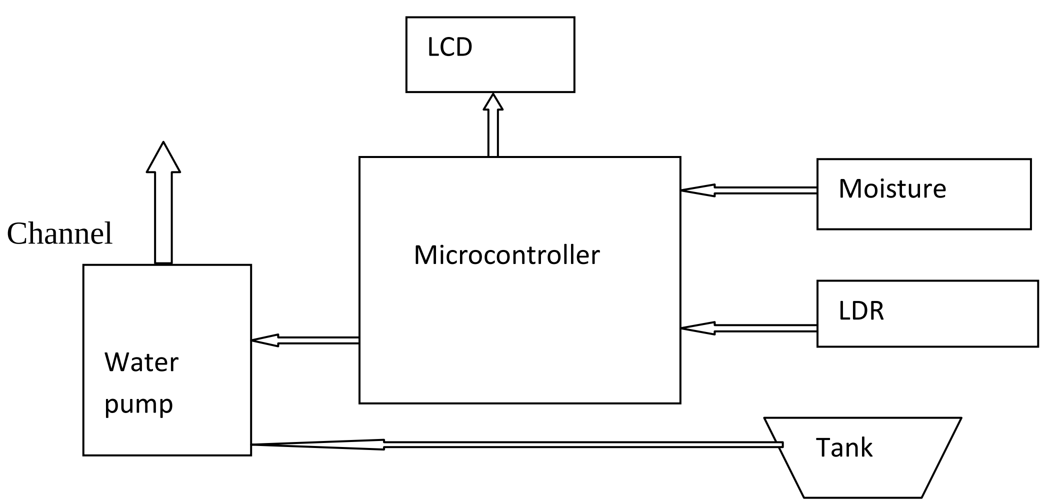


Fig 3.0 System block diagram

3.1 POWER SUPPLY UNIT DESIGN

The system requires a 5v, 1A DC for proper operation. This is achieved by using a regulated power supply circuit as show in figure below. A linear voltage regulator (LM317) is used to achieve the required voltage regulation.

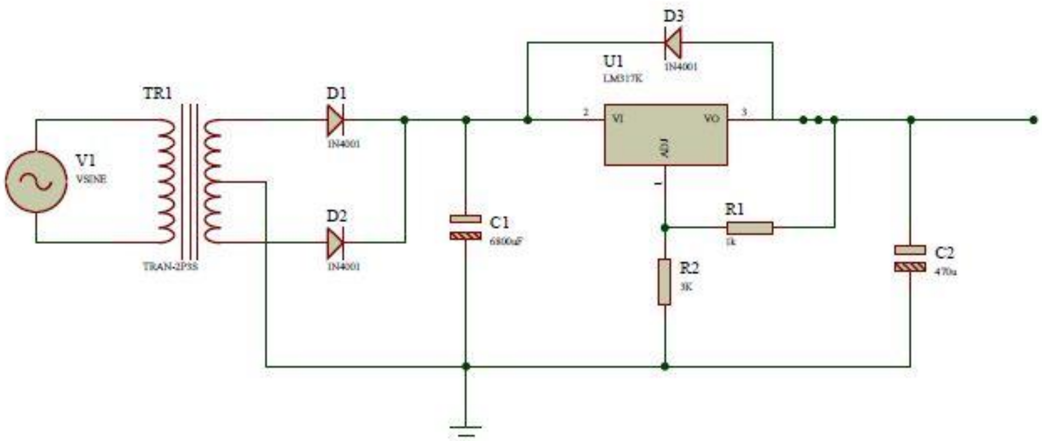


Figure 3.1 Power supply Unit

From the datasheet,

$V_{out} = V_{ref}\left[1+\frac{R_2}{R_1}\right] + I_{adj}(R_2)$……………………………………………………3.0

$$V_{out} = 5V$$

$V_{ref} = 1.25V$

$I_{adj} = 100\mu A$

$V_{out} = VR_1 + VR_2 = 5V$……………………………………………………….3.1

$VR_1 = I_1 R_1$……………………………………………………………………3.2

$$VR_2 = (I_1 + I_{adj})R_2$$

But I_{adj} is very small when compared with I1, hence it is negligible and

$V_{out} = I_1(R_1 + R_2) = 5$ But $I_1 = \frac{V_{ref}}{R_1}$ $and\ V_{ref} = 1.25V \therefore \frac{V_{ref}}{R_1}(R_1 + R_2) =$

$V_{ref}\left(1 + \frac{R_1}{R_2}\right) = V_{ref}\left(1 + {R_1}/{R_2}\right) = 5{,}5 = 1.25\left(1 + {R_2}/{R_1}\right)$

$\frac{5}{1.25} = 1 + \frac{R_2}{R_1} = 4 - 1 = {R_2}/{R_1} \therefore R_2 = 3R_1$ Let R_1= 1KΩ, then R_2 = 3KΩ. Hence the resistors R_1 and R_2 are 1000Ω and 3000Ω respectively.

The value of C1 recommended can be calculated as show below.

$Vin = Vout + 5$……………………………………………………………..3.2

From the datasheet of LM317

$$Vin = 5 + 5$$

$$= 10V$$

The rms voltage of transformer $Vt$is

$Vt = \frac{Vin}{\sqrt{2}}$…………………………………………………………….3.3

$7.07V$ But 7.07 is not available, therefore $12V$ is shown

$= 12V$

The voltage across the capacitor $C1(Vac2)$

$Vac2 = Vt \times \sqrt{2}$……………………………………………………………3.4

$$12 \times \sqrt{2} = 16.9$$

The working voltage of the capacitor (Vw)

$(Vw) = 2$ The working voltage of the capacitor (Vw)

$Vw = 2 \times Vac2$……………………………………………………………3.5

$= 2 \times 17 = 34v$

In the absent of$34v, 35v$ is selected as adequate voltage therefore $(Vw) = 35v$

The capacitance of capacitor is rating $35v$ is by

$I = \frac{dQ}{dt}$………………………………………………………………………….3.6

$Q = CV$………………………………………………………………………..3.7

$I = \frac{cdv}{dt}$…………………………………………………………………………3.8

$dt = \frac{T}{2}, \quad T = \frac{1}{f}$…………………………………………………………..……3.9

$C = \frac{iT}{2dv}$……………………………………………………….………...…3.10

$C = \frac{i}{2fdDv}$……………………………...3.11

$Dv =$ Ripple percentage

f =Frequency,$f = 50Hz$ f

I =Load current, $I = 1A$

Taking 10% of the voltage as ripple, then

$\Delta V = \frac{10}{100} Vp$……………………………………………………………………………..3.12

Where $Vp = 16v$

$$C1 = \frac{100}{2 \times 10 \times 50 \times 16} = 0.00626F$$

$$\approx 6250uF$$

In absent of this, $6800\mu F$ is selected. As specified in LM317 datasheet.

From the datasheet of LM317,

$Vout = Vref\left(1 + \frac{R1}{R2}\right) + Iadj \times R2$……………………………………………...…….3.13

From the datasheet $Vref = 1.25,\ Iadj = 50\mu A$ and from the power circuit diagram

$$R1 = 1K\ and\ R2 = 3K$$

$$Vout = 1.25(1 + 3) + 0.00005 \times 3000 = 5.15V$$

We know that$Q = CV\ and\ I = \frac{dQ}{dt}$……………………………………………………….3.14

$$Idt = dQ$$

$$Q = \int_0^T Idt$$

$= IT$……...3.15

$$I = Iout = 1.25A\ and\ Vout = 5.15V$$

$$= \frac{1.25}{50}$$

= 0.025= $0.025A$

$C2 = \frac{Q}{Vout} = 0.025/5.15$

$$= 0.00485F$$

= $485\mu F$ and $470\mu F$ is selected for this design.

3.2 PIC MICROCONTROLLER

The PIC (Programmable Interrupt Controller) microcontroller family is manufactured by Microchip Technology Inc. Currently they are one of the most popular microcontrollers, used in many commercial and industrial applications. The PIC microcontroller architecture is based on a modified Harvard RISC (Reduced Instruction Set Computer) instruction set with dual-bus architecture, providing fast and flexible design with an easy migration path from only 6 pins to 80 pins, and from 384 bytes to 128kbytes of program memory.

The microcontroller may be considered as a specialized computer-on-a-chip or a single-chip computer. The word ‘micro’ suggests that the device is small, and the word ‘controller’ suggests that the device may be used to control one or more functions of objects, processes or events. It is also called an embedded controller as microcontrollers are often embedded in the device or system that they control. The microcontroller contains a simplified processor, some memory (RAM and ROM), I/O ports and peripheral devices such as counters/timers, analogue-to-digital converters, etc., all integrated on a single chip.

It is this feature of the processor and peripheral components available on a single chip that distinguishes it from a microprocessor-based system.

3.2.0 SELECTION OF MICROCONTROLLER

Although there are several hundred models of PIC microcontrollers, choosing a microcontroller for an application is not a difficult task and requires taking into account these factors:

- Number of I/O pins required
- Required peripherals (e.g. USB)
- The minimum size of program memory
- The minimum size of RAM
- Whether or not EEPROM nonvolatile data memory is required
- Speed
- Physical size
- Cost

The important point to remember is that there could be many models that satisfy all of these requirements. You should always try to find the model that satisfies your minimum requirements and the one that does not offer more than you may need.

3.2.1 INSIDE THE MICROCONTROLLER

Figure 3.1 shows the block schematic arrangement of various components of a microcontroller. As outlined earlier, a microcontroller is an integrated chip with an on-chip CPU, memory, I/O ports and some peripheral devices to make a complete functional unit. A typical microcontroller as depicted inFig.3.1 has the following components: a central processing unit (CPU), a random access memory(RAM), a read only memory (ROM), special-function registers and peripheral components including serial and/or parallel ports, timers and counters, analogue-to-digital (A/D) converters and digital-to analogue(D/A) converters.

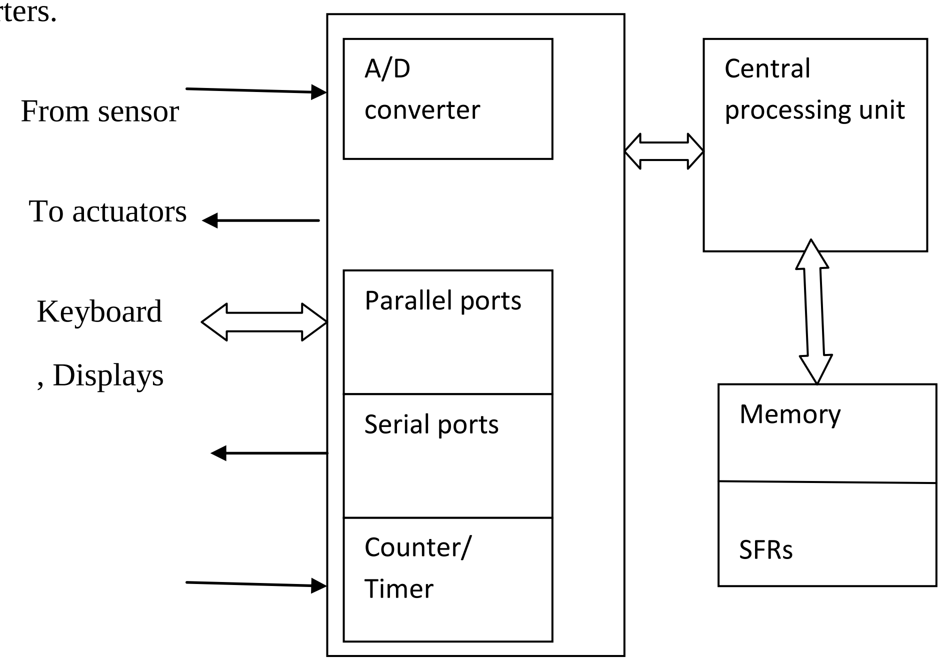


Fig 3.2 inside microcontroller

3.2.2 OSCILLATOR CONFIGURATIONS

PIC18F2520 device can be operated in ten different oscillator modes. The user can program the configuration bits, FOSC3:FOSC0, in Configuration Register 1H to select one of these ten modes. The selection of this mode is based on frequency of operation and selection of capacitor is related to frequency. The PIC18F2520 device includes an internal oscillator block which generates two different clock signals; either can be used as the microcontroller's clock source. This may eliminate the need for external oscillator circuits on the OSC1 and/or OSC2 pins. The internal oscillator's output has been calibrated at the factory but can be adjusted in the user's application. This is done by writing to the OSCTUNE register.

3.2.3 ANALOGUE-TO-DIGITAL CONFIGURATION

The A/D converter is used to interface analog signals to the microcontroller. The A/D converts analog signals (e.g., voltage) into digital form so that they can be connected to a computer. A/D converter registers are used to control the A/D converter ports. On most PIC microcontrollers equipped with A/D, PORTA pins are used for analog input and these port pins are shared between digital and analog functions. The Analog-to-Digital (A/D) converter module has 10 inputs for the 28-pin devices. This module allows conversion of an analog input signal to a corresponding 10-bit digital number.

The module has five registers:

- A/D Result High Register (ADRESH)
- A/D Result Low Register (ADRESL)
- A/D Control Register 0 (ADCON0)
- A/D Control Register 1 (ADCON1)
- A/D Control Register 2 (ADCON2)

The ADCON0 register controls the operation of the A/D module. The ADCON1 register, shown configures the functions of the port pins. The ADCON2 register configures the A/D clock source, programmed acquisition time and justification.

3.2.4 COMPARATOR CONFIGURATIONS

The analog comparator module contains two comparators that can be configured in a variety of ways. The inputs can be selected from the analog inputs multiplexed with pins RA0 through RA5, as well as the on-chip voltage reference (see "Comparator Voltage Reference Module"). The digital outputs (normal or inverted) are available at the pin level and can also be read through the control register. The CMCON register selects the comparator input and output configuration. Block diagrams of the various comparator configurations are shown in PIC18F2520 datasheet [5].

3.2.5 INTERRUPTS CONFIGURATIONS

The PIC18F2520 device have multiple interrupt sources and an interrupt priority feature that allows most interrupt sources to be assigned a high priority level or a low priority level. The high priority interrupt vector is at 0008h and the low priority interrupt vector is at 0018h. High priority interrupt events will interrupt any low priority interrupts that may be in progress. There are ten registers which are used to control interrupt operation. These registers are:

- RCON
- INTCON
- INTCON2
- INTCON3

- PIR1, PIR2
- PIE1, PIE2
- IPR1, IPR2

It is recommended that the Microchip header files supplied with MPLAB® IDE be used for the symbolic bit names in these registers. This allows the assembler/ compiler to automatically take care of the placement of these bits within the specified register [5].

In general, interrupt sources have three bits to control their operation. They are:

- **Flag bit** to indicate that an interrupt event occurred
- **Enable bit** that allows program execution to branch to the interrupt vector address when the flag bit is set
- **Priority bit** to select high priority or low priority

3.2.6 CONFIGURATION OF PINS

The I/O registers are used for the I/O control. Every I/O port in the PIC microcontroller has two registers: port data register and port direction control register.

Port data register has the same name as the port it controls. For example, the PIC16F84 microcontroller has two port data registers, PORTA and PORTB. A PIC18F2520 has PORTA, PORTB and PORTC and PIC16F877 microcontroller has five port data registers, PORTA, PORTB, PORTC, PORTD, and PORTE. Eight bits of data can be sent to any port, or 8 bits of data can be read from the ports. It is also possible to read or write to individual port pins. For example, any bit of a given port can be set or cleared, or data can be read from one or more port pins at the same time. Ports in a PIC microcontroller are bidirectional. Thus, each pin of a port can be used as an input or an output pin. Port direction control register configures the port pins as either inputs or outputs. This register is called the TRIS register and every port has a TRIS register named after its port name. For example, TRISA is the direction control register for PORTA. Similarly, TRISB is the direction control register for PORTB and so on. Setting a bit in the TRIS register makes the corresponding port register pin as an input. Clearing a bit in the TRIS register makes the corresponding port pin an output. For example, to make bits 0 and 1 of PORTB input and the other bits output; we have to load the TRISB register with the bit pattern.[5]

3.3 LIGHT DEPENDANT RESISTOR (LDR)

A Light Dependant Resistor (LDR) is a resistor that changes in value according to the light falling on it. A commonly used device, the ORP-12, has a high resistance in the dark, and a low resistance in the light. Connecting the LDR to the microcontroller is very straight forward, but some software 'calibrating' is required. It should be remembered that the LDR response is not linear, and so the readings will not change in exactly the same way as with a potentiometer. In general there is a larger resistance change at brighter light levels. This can be compensated for in the software by using a smaller range at darker light levels.

3.4 SWITCHING SYSTEM

To switch on and off the water pump we make using of a MOSFET which it is Metal Oxide Semiconductor Field Effect Transistor that utilizes silicon glass (SIO_2) as the separating material between the gate and the other terminals. Depending on type of channel doping used, MOSFETs could be divided into enhancement mode (both n-channel and p-channel) and depletion mode (only P-channel). High power FETs are mostly available in their MOSFETs category with the n-channel enhancement mode. For proper operation, the drain is made more positive than the source, upon application of gate voltage (V_{GS}) greater than certain threshold voltage (V_T) ($V_{GS} > V_T$), current flows from the drain to the source.

Just like the BJT curves we are presented with three regions of operation; the linear, cutoff and saturation regions respectively. In power electronics the transistor is operated as an on and off switch, this making saturation and cutoff our regions of interest. MOSFETs have the following advantages over BJTs,

1- MOSFETs have high input impedance making them simpler to drive.

2- MOSFETs saturate with almost zero drain-source voltage unlike the BJT which saturate at $V_{CE(sat)}$ of 0.2V

3- MOSFETs can easily be paralleled without the need for current-equalizing resistors that are necessary with BJTs

3.5 DESIGN OF SOIL MOISTURE SENSOR

Moisture sensor is made of two electrodes where one is connected to 12v AC power supplied the other is connected to a preset resistor. Also a rectifier diode (1N4148) is connected across the preset resistor and one capacitor (10uF, 25v) and 3K resistor. The circuit is shown below.

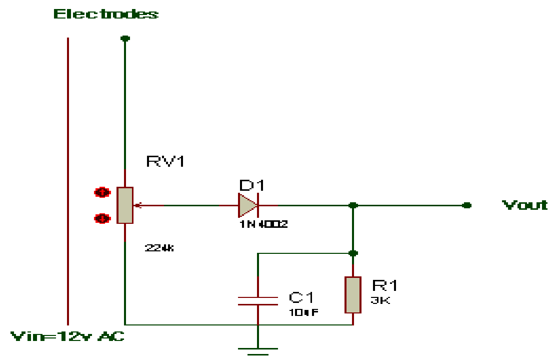


Fig 3.3 soil moisture sensor circuit

3.6 INTERFACING OF MOISTURE SENSOR WITH MICROCONTROLLER

The soil moisture sensor is connected to the microcontroller through a resistor at PORTA, pin RA3 of microcontroller. Any change in soil content is automatically detected by the sensor and to the microcontroller. The connection circuit is shown below.

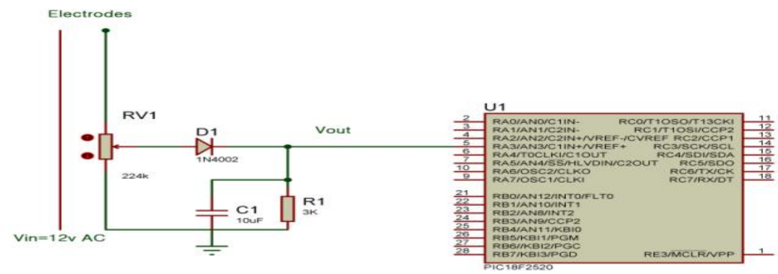


Fig 3.4 Interfacing of sensor with PIC

3.7 INTERFACING OF WATER PUMP WITH MICROCONTROLLER

The water pump is connected to the microcontroller through a MOSFET

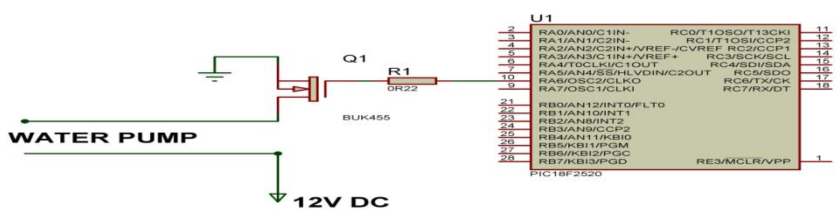


Fig3.5 Interfacing pump with microcontroller

3.8 INTERFACING OF LCD

Liquid crystal displays allow a better user interface compared with LED displays as it is much easier to display text messages in LCD displays. They also consume much less power than LED displays. However, LED displays have better intensity than LCD displays.

LCD displays are available typically in 8×2, 16×2, 20×2 or 20×4 formats. 20×2 means two

Lines of 20 character each. These displays come with an LCD controller that drives the display. There are three control lines, namely EN (enable), RS (register select) and RW (read/write). The EN line is used to instruct the LCD that the microcontroller is sending the data. When the RS line is HIGH, the data comprise text data to be displayed on the LCD. When the RS is LOW, the data are treated as a command or instruction to the LCD module. When the RW line is LOW, the instruction on the data bus is written on the LCD. When the RW line is HIGH, the data are being read from the LCD.

The software routine initializes the LCD firstly by setting the width of the data bus, selecting the character, font, etc., clearing the LCD, turning on the LCD module and the cursor, setting the cursor position and so on. Then the data to be displayed are sent on the data lines, and the three control signals are made use of to ensure proper LCD operation.

3.9 GENERAL CONNECTION

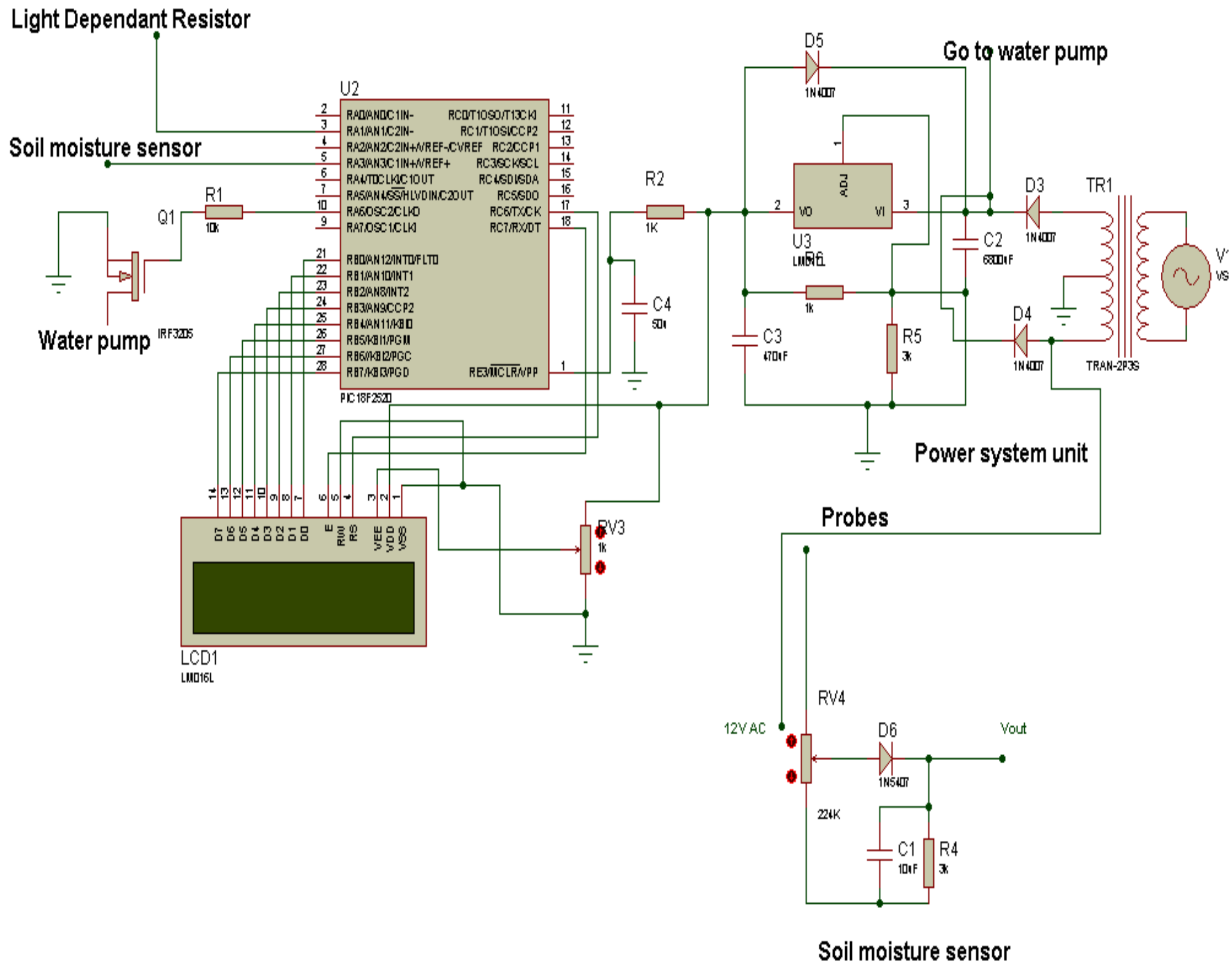


Fig. 3.5 Overall schematic diagram

CHAPTER FOUR: PERFORMANCE AND COST EVALUATION

4.0 PERFORMANCE

For normal calibration of moisture sensor the experiment was carried out on sensor and the following devices were used:

1- 12V AC
2- Soil Moisture sensor
3- Multimeter
4- 700ml of water

The moisture sensor was placed in soil, the probes were separated at 10 cm, 12V AC power was supplied to the sensor and a measurement tool was connected to the output of sensor. The reading was taken at each 35ml water adding to the soil after 30 seconds, the reading table is shown below.

Table 4.0 Result obtained from soil moisture sensor

S/N	Quantity of water (ml)	Voltage Equivalent (V)	Decimal Equivalent value	Hexadecimal equivalent value
1	0	0	0	0
2	35	0.5	102	66
3	70	0.75	152	98
4	105	1.05	215	D7

5	140	1.35	276	114
6	175	2.0	419	1A3
7	210	2.20	450	1C2
8	245	2.35	481	1E1
9	280	2.50	511	1FF
10	315	2.70	552	288
11	350	2.96	614	266
12	385	3.20	655	28F
13	420	3.30	675	2A3
14	455	3.35	685	2AD
15	490	3.44	696	2B8
16	525	3.50	716	2CC
17	560	3.52	720	2D0
18	595	3.53	722	2D2
19	630	3.55	724	2D4
20	665	3.56	724	2D4
21	Pure water	4.50	921	399

Comment

From result it shows that voltage varies with quantity of water in soil. When the two probes of sensor reaching water, the voltage increases rapidly. It was observed that the moisture sensor responds to different type of soil according to type of soil. Though care must be taken in the calibration of the sensor.

4.1 COST EVALUATION

Table 4.1 Cost evaluation

S/N	ELEMENTS	NUMBER	PRIZE PER UNIT(Naira)	TOTAL AMOUNT (Naira)
1	Resistor	6	10	60
2	capacitor	4	10	40
3	PIC18F2520	1	1500	1000
4	LM317	1	100	100
5	IRF3205	1	100	100
6	Diode	3	10	300
7	LCD	1	1500	1500
8	Preset resistor	2	50	100
9	Transformer	1	500	500
10	Water pump	1	1000	1000
11	Electrode	2	10	20
12	Cables	1	100	100
13	Vera board	1	300	300
14	package	1	500	500
15	**TOTAL**			**6120**

CHAPTER FIVE: CONCLUSIONS

5.0 SUMMARY

Design of an automatic control system required accurate researches to be carried before starting the design such as; soil system, the quantity of water needed for a particular plant etc.

In summary of project, chapter one descript the need of automatic irrigation system and the objectives and limitation of the project. Chapter two narrates some literature review on the irrigation and automatic irrigation system, design and construction are decrypted in chapter three of the project. Performance, cost evaluation and conclusions are found in chapter four and five respectively.

Several problems were encountered while carrying out the work; includes lack of availability of some components or exact values of components as prepared in design stage. As a result, approximated values of components were used in most cases.

5.1 CONCLUSIONS

Automatic irrigation technology is relatively new in Africa. There is a lot of potential in this technology because of the water scarcity in the foreseeable future and the effect of under and over-irrigation on the plants. The following conclusions have been drawn based on the design and construction of this project.

- Firstly the soil moisture sensor responds to different type of soil and the calibration was done based on the experiment

- Secondly designing an automatic irrigation control system needs the adequate studies on the type of the soil.
- Thirdly it was observed that the selection of plant is necessary to determine the accurate quantity of water for the plant to avoid the effect of over and under irrigation of plants.

5.2 RECOMMENDATIONS

The following recommendations have been made.

i) The soil moisture sensor must be placed at appropriate level in soil.

ii) Proper calibration should be made relative to the quantity of water required for the plants.

iii) The salinity of the soil should be checked and controlled for proper performance of the sensor

iv) The government should build the local capacity keeping in view the National Water Policy with respect to irrigated agriculture.

v) Technical and financial support systems may be promoted through the Action Plans with respect to manufacturing of cost effective systems, their installation, O&M, availability of spare parts and training of farmers etc.

REFERENCES

1- Gamo, M (1999). Classification of arid regions by climate and vegetation. Journal of Arid Land Studies, India 1, 9-17.

2- Pereira, L.S., Oweis, T. and Zairi, A (2002). Irrigation management under water scarcity. Agricultural Water Management, India 57, 175-206.

3- Dilip Kumar Majumidar, (2009), Irrigation water management: Principles and practices, India. By DHI learning private limited New Delhi, pp.100-116, 186-221.

4- Design and evaluation of a low-cost automatic control device for pressurized at faculty member at central luzon state university (2005) muñoz, nuevaecija, philippines.

5- PIC18F2420/2520/4420/4520 Data Sheet 28/40/44-Pin Enhanced Flash Microcontrollers with 10-Bit A/D and nano Watt Technology. 2004, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

6- Anil K. Mani (2007) Digital Electronics: Principles , Devices and Applications 2007John Wiley & Sons LTD (India) PP.525-603

7- Lusio Di jasio, Tim wilmsthurst, Dogan Ibrahim, John Morton, Martin bates, Jack Smith, D.W Smith, and Chuck Hellebuyck (2008) PIC microcontrollers : know it all, Oxford,Ox2 8DP,UK, Burlington USA

8- http://www.microchip.com

9- www.datasheetlog.com

APPENDICES

1- PROGRAM

```
;******************************************************************************
;   This file is a basic template for assembly code for a PIC18F2520. Copy    *
;   this file into your project directory and modify or add to it as needed.  *
;                                                                             *
;   Refer to the MPASM User's Guide for additional information on the         *
;   features of the assembler.                                                *
;                                                                             *
;   Refer to the PIC18Fx420/x520 Data Sheet for additional                    *
;   information on the architecture and instruction set [5].                  *
;                                                                             *
;******************************************************************************
;                                                                             *
;    Filename:                                                                *
;    Date:                                                                    *
;    File Version:                                                            *
;                                                                             *
;    Author:                                                                  *
;    Company:                                                                 *
;                                                                             *
;******************************************************************************
;                                                                             *
;    Files Required: P18F2520.INC                                             *
;                                                                             *
;******************************************************************************

	LIST P=18F2520		;directive to define processor
	#include <P18F2520.INC>	;processor specific variable definitions

;******************************************************************************
;Configuration bits
;Microchip has changed the format for defining the configuration bits, please
;see the .inc file for futher details on notation.  Below are a few examples.

;   Oscillator Selection:
;    CONFIG	OSC = INTOSC		;INTIO2

;******************************************************************************
; Variable definitions
; These variables are only needed if low priority interrupts are used.
; More variables may be needed to store other special function registers used
```

```
; in the interrupt routines.

                CBLOCK      0x080
                WREG_TEMP           ; variable used for context saving
                STATUS_TEMP         ;variable used for context saving
                BSR_TEMP    ;variable used for context saving
                ENDC

                CBLOCK      0x000
                count1      ;example of a variable in access RAM
                count2
                var1
                var2
                thu
                hun
                ten
                unit
                DH
                DL
                varH
                varL
                DVAR1
                DVAR2
                DVAR3
                ENDC

;**********************************************************************
;EEPROM data
; Data to be programmed into the Data EEPROM is defined here

                ORG   0xf00000

                DE    "Test Data",0,1,2,3,4,5,6,7,8,9

;**********************************************************************
;Reset vector
; This code will start executing when a reset occurs.

                ORG   0x0000

                goto  Main          ;go to start of main code

;**********************************************************************
;High priority interrupt vector
; This code will start executing when a high priority interrupt occurs or
; when any interrupt occurs if interrupt priorities are not enabled.
```

```
                ORG   0x0008

                bra   HighInt                ;go to high priority interrupt routine

;******************************************************************************
;Low priority interrupt vector and routine
; This code will start executing when a low priority interrupt occurs.
; This code can be removed if low priority interrupts are not used.

                ORG   0x0018

                movff  STATUS,STATUS_TEMP    ;save STATUS register
                movff  WREG,WREG_TEMP                ;save working register
                movff  BSR,BSR_TEMP          ;save BSR register

;            *** low priority interrupt code goes here ***


                movff  BSR_TEMP,BSR          ;restore BSR register
                movff  WREG_TEMP,WREG                ;restore working register
                movff  STATUS_TEMP,STATUS    ;restore STATUS register
                retfie

;******************************************************************************
;High priority interrupt routine
; The high priority interrupt code is placed here to avoid conflicting with
; the low priority interrupt vector.

HighInt:

;            *** high priority interrupt code goes here ***
             ;btfss     PIR1, 6, 0 ; Check ADC Interrupt Flag
;            goto      NotAdc
;            bcf       PIR1, 6, 0 ; Clear ADC Interrupt Flag
;*****************************************************************************
;ADC_SUBROUTINE
;*****************************************************************************
ADC_SUB
   BSF    ADCON0, 1, 0
ADC_POOL
   BTFSC   ADCON0, 1, 0
goto    ADC_POOL
             movff     ADRESH, varH
             movff     ADRESL, varL
             call      BCD_CONV, 0
```

```
        movlw   0xca
        call    comnwrt, 0
        call    DISPLAY
return

;***********************************************************************
;MOISTURE_CHECK
;***********************************************************************
MOISTURE_TEST
        movff   ADRESH, WREG
        cpfseq  DH, 0
        goto    Test_Greater
        goto    Test_Lower
Test_Greater
        cpfsgt  DH, 0
        goto    Pump_Off
Pump_On
        btfsc   PORTA, 6, 0
        return 0
        bsf     PORTA, 5, 0
        bsf     PORTA, 6, 0
        return 0
Pump_Off
        btfss   PORTA, 6, 0
        return 0
        bcf     PORTA, 5, 0
        bcf     PORTA, 6, 0
        return 0
Test_Lower
        movff   ADRESL, WREG
        cpfseq  DL, 0
        goto    Test_Lesser
        goto    Pump_Off
Test_Lesser
        cpfslt  DL, 0
        goto    Pump_On
        goto    Pump_Off
        return 0
;************************************************************************
;       BCD CONVERT SUBROUTINE
;************************************************************************
BCD_CONV
        clrf    STATUS
        clrf    thu
        clrf    ten, 0
        clrf    unit, 0
```

```
        clrf    hun, 0
        movlw   0x10
        movwf   count1, 0
        movlw   0xff
        movwf   count2, 0
        movff   varL, WREG
        andlw   0x0f
        bcf     STATUS, 0, 0
        daW
        movwf   var1, 0
        movff   varL, WREG
        andlw   0xf0
        movwf   var2, 0
        swapf   var2, 0, 0
        bcf     STATUS, 0, 0
        daW
        movwf   var2, 0
        movf    var1, 0, 0
Loop
        bcf     STATUS, 0, 0
        addwf   var2, 0
        DAW
        bnc             NoInc
        incf    hun, 1, 0
NoInc
        decfsz  count1, 1,      0
        goto    Loop
        movwf   ten, 0
        movff   varH, WREG
        andlw   0x0f
        bcf     STATUS, 0, 0
        daw
        movwf   var2, 0
        movf    ten, 0, 0
Loop2
        bcf     STATUS, 0, 0
        addwf   var2, 0
        daw
        bnc             NoInc2
        bcf     STATUS, 0, 0
        movwf   var1, 0
        incf    hun, 0, 0
        daw
        movwf   hun, 0
        movf    var1, 0, 0
NoInc2
```

```
		decfsz	count2, 1, 0
		goto	Loop2
		bcf	STATUS, 0, 0
		addwf	var2, 0
		daw
		bnc		NoInc3
		bcf	STATUS, 0, 0
		movwf	var1, 0
		incf	hun, 0, 0
		daw
		movwf	hun, 0
		movf	var1, 0, 0
NoInc3
		movwf	ten, 0
		andlw	0x0f
		movwf	unit, 0
		movf	ten, 0, 0
		andlw	0xf0
		movwf	ten, 0
		swapf	ten, 1, 0
		movf	hun, 0, 0
		andlw	0xf0
		movwf	thu, 0
		swapf	thu, 1, 0
		movf	hun, 0, 0
		andlw	0x0f
		movwf	hun, 0
		return	0
;*********************************************************************
;Start of main program
; The main program code is placed here.
Main:
		movlw	0xf2
		movwf	OSCCON
		clrf	INTCON
		clrf	INTCON2
		clrf	INTCON3
		clrf	PIR1
		movlw	0x40
		movwf	OSCTUNE
movlw	0x40
		movwf	PIE1
		clrf	IPR1
		clrf	PIR2
		clrf	PIE2
		clrf	IPR2
```

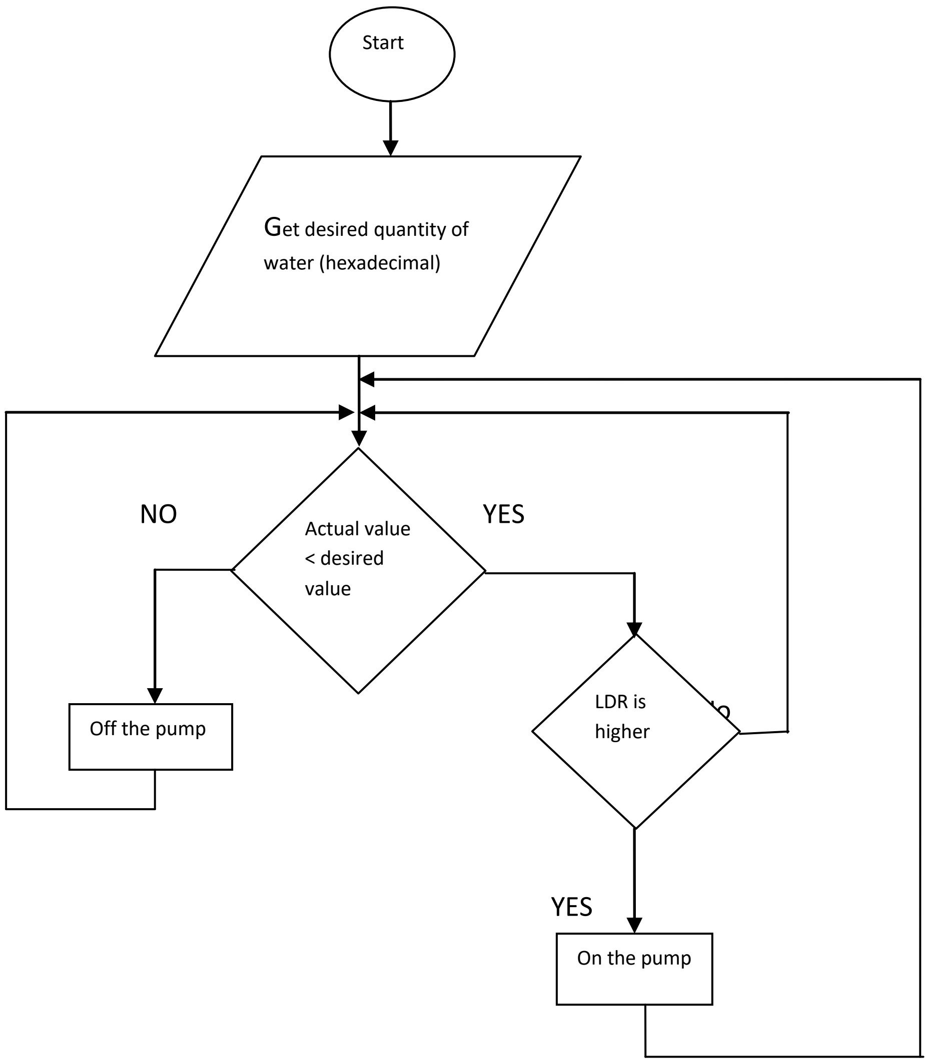
```
movlw   0x5F
movwf   RCON
        movlw     0x0D
        movwf     ADCON0
        movlw     0x0B
        movwf     ADCON1
        movlw     0xA2
        movwf     ADCON2
        movlw     0x06
        movwf     CMCON
movlw   0xEC
        movwf     CVRCON
        clrf   WREG
        clrf   PORTC      ; clear PORTC
        clrf   TRISC     ; configure PORTC as all outputs
        clrf   PORTB      ; clear PORTB
        clrf   TRISB     ; configure PORTB as all outputs
        movlw     0x0F
        movwf     PORTA
        movwf     TRISA
        movlw     0x03
        movwf     DH, 0
        movlw     0x03
        movwf     DL, 0
        movff     DH, varH
        movff     DL, varL
        movlw     0x38
        call      comnwrt, 0
        movlw     0x0c
        call      comnwrt, 0
        movlw     0x01
        call      comnwrt, 0
        movlw     0x06
        call      comnwrt, 0
        movlw     0x80
        call      comnwrt, 0
        movlw     'D'
        call      datawrt, 0
        movlw     'E'
        call      datawrt, 0
        movlw     'S'
        call      datawrt, 0
        movlw     'I'
        call      datawrt, 0
        movlw     'R'
        call      datawrt, 0
```

```
                movlw     'E'
                call      datawrt, 0
                movlw     'D'
                call      datawrt, 0
                movlw     ' '
                call      datawrt, 0
                movlw     '='
                call      datawrt, 0
                movlw     ' '
                call      datawrt, 0
                call      BCD_CONV, 0
                call      DISPLAY, 0
                movlw     0xc0
                call      comnwrt, 0
                movlw     'A'
                call      datawrt, 0
                movlw     'C'
                call      datawrt, 0
                movlw     'T'
                call      datawrt, 0
                movlw     'U'
                call      datawrt, 0
                movlw     'A'
                call      datawrt, 0
                movlw     'L'
                call      datawrt, 0
                movlw     ' '
                call      datawrt, 0
                movlw     ' '
                call      datawrt, 0
                movlw     '='
                call      datawrt, 0
                movlw     ' '
                call      datawrt, 0
COMP_CHECK
call    CHECK_DELAY
call    ADC_SUB
                BTFSC   CMCON, 7, 0
                goto    MOIST_CHECK
                BTFSS   PORTA, 6, 0
goto    COMP_CHECK
                bcf     PORTA, 6, 0
                bcf     PORTA, 5, 0
goto            COMP_CHECK
MOIST_CHECK
call    MOISTURE_TEST
```

```
goto    COMP_CHECK
;*************************************************************************
;              DELAY SUBROUTINE1
;*************************************************************************
CHECK_DELAY
               movlw   0x04
               movwf   DVAR3,A    ; set outer delay loop
               movlw      0x02
               movwf      DVAR2,A
               movlw      0x01
               movwf      DVAR1,A
DelayInner1
decfsz  DVAR1,F,A
goto    DelayInner1

decfsz  DVAR2,F,A
goto    DelayInner1

decfsz  DVAR3,F,A
goto    DelayInner1

nop
return        0

;*************************************************************************
               SUBROUTINE DISPLAY
;*************************************************************************
DISPLAY
               movff       thu, WREG
               addlw       0x30
               call        datawrt, 0
               movff       hun, WREG
               addlw       0x30
               call        datawrt, 0
               movff       ten, WREG
               addlw       0x30
               call        datawrt, 0
               movff       unit, WREG
               addlw       0x30
               call        datawrt, 0
               return      0

;******************************************************************
               LCD COMMAND WRITE SUBROUTINE
;******************************************************************
comnwrt
```

```
            movwf     PORTB, 0
            bcf       PORTC, 6, 0
            bsf       PORTC, 7, 0
            bcf       PORTC, 7, 0
            call      LCD_Delay, 0
            return    0

;****************************************************************
;           LCD DATAWRITE SUBROUTINE
;****************************************************************
datawrt
            movwf     PORTB, 0
            bsf       PORTC, 6, 0
            bsf       PORTC, 7, 0
            bcf       PORTC, 7, 0
            call      LCD_Delay, 0
            return    0

;****************************************************************
;           DELAY SUBROUTINE
;****************************************************************
LCD_Delay
            movlw   0x01
            movwf   DVAR3,A    ; set outer delay loop
            movlw     0x38
            movwf     DVAR2,A
            movlw     0x48
            movwf     DVAR1,A
DelayInner
decfsz  DVAR1,F,A
gotoDelayInner

decfsz  DVAR2,F,A
gotoDelayInner

decfsz  DVAR3,F,A
gotoDelayInner
nop
return 0
;************************************************************************

END; End of program
```

2- FLOWCHART OF PROGRAM



3- Packaging process.