DESIGN AND CONSTRUCTION OF AN AUTOMATIC IRRIGATOR FOR DRY SEASON FARMING

BY

TSWAFIA EMILY SODE-SHINNI

2000/9922EE

DEPT. OF ELECTRICAL AND COMPUTER ENGINEERING

SCHOOL OF ENGINEERING TECHNOLOGY

F.U.T. MINNA

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A THESIS SUMITTED TO THE DEPARTMENT OF ELECTRICAL ENGINEERING IN THE PARTIAL FULFILMENT OF THE REQUIREMENT NECESSARY FOR THE AWARD OF BACHELOR OF ENGINEERING IN ELECTRICAL AND COMPUTER ENGINEERING

DECLARATION

I hereby declare that this thesis is an original work of mine and has never been presented in any form for the award of diploma or degree certificate.

The information derived from published and unpublished work has been acknowledged.

______________	11/10/2006.
Candidate (Tswafia E. Sode-shinni)	Date
______________	12/10/06
Supervisor (Mr. U. S. Dauda)	Date
______________	______________
Head of department (Engr. M.D Abdullahi)	Date
______________	______________
External Examiner	Date

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Also I thank the entire staff and student of Electrical and Computer Engineering department for the knowledge impacted.

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I appreciate the interaction with my colleagues and friends during the course of the degree programme.

Above all my gratitude goes to God Almighty for His Grace and favor over me.

DEDICATION

This project is dedicated to the entire member of the Sode-shinni family and all up-coming Nigeria Engineers to the Glory of God Almighty.

ABSTRACT

The aim of this project is to activate an irrigation pump (water sprayer pump) electrically by sending the variation of soil resistance between two metal probes spaced a known distance apart.

It is well known that different types of soil have different conductivity in their dry state, and that humidity (amount of water) in the soil reduces the resistance per meter thus increasing its conductivity [5, 10, 11].

Also, crops grown in different soil types require different minimum amount of moisture to survive [2, 4, 7, 13].

The electronic subsection of the design uses two metal probes spaced apart in the soil as the soil conductivity sensor.

When the soil conductivity falls below a preset value for the soil and crop type, the irrigation pump is activated and sprays the soil with water until the moisture content level desired is reached and hence the soil conductivity reaches a defined value.

The Automatic Irrigator featured in this project is an original design, equipped with a reservoir water level detector which detects low water level in the reservoir using the same principle of variation in resistance between two metal probes when in its dry and moist state.

This project also exposes ways in which the Op Amp could be used to implement ideas and solve engineering problems. It also gives a brilliant idea on the relation between nature and electrical engineering.

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CHAPTER ONE

INTRODUCTION

1.0 Background

The economic importance of dry season farming system cannot be over emphasized; therefore it is important to put in measures to ensue its effectiveness.

During the dry season, rainfall which is the major source of water becomes low and consequently insufficient for plant survival, which leaves the farmer the choice of irrigation. Irrigation provides the way to ensure that plants receive the appropriate amount of water in a timely fashion. The amount of water needed by a plant depends on the plant type, plant size and the weather condition which make it necessary to employ the use of appropriate irrigation system [8].

Major problems associated with the manual system of irrigation which include erosion, waterlogging, and poor water distribution and management is greatly minimized with the use of the Automatic Irrigator System which ensures proper water distribution by the aid of electrically controlled moisture sensor (probes), adequate supply of water to plant by its control knob and proper water management by the use of the reservoir water level detector.

1.1 Motivation

It is professional that simple circuits are the best in that they are easier to understand implement and they develop less complication and are therefore easier to maintain.

This project takes into consideration, professionalism in electrical design by employing the use of a simple voltage comparator circuit to solve practical problems.

As an undergraduate of electrical engineering, the task of building an automatic irrigator which would both be professional and cost effective was embarked upon. This essentially required basic foundation in electrical engineering, in which I acknowledge contributions from various resource persons, whose ideas and suggestions brought to reality this project. (See acknowledgement). Consultations were also made to various material and these were duly referenced. (See references).

1.2 Project report layout

Chapter one gives a general introduction of the project and its constraints. Chapter two give a literature review on the economics of irrigation farming system, and answers questions on why the choice of technology in Irrigation, what makes the Automatic Irrigator a farmers best choice, the basic engineering concept of irrigation and the potential impact of improper irrigation system design. Chapter three highlights the circuit's description, design component selection; computer based simulation and calculations done based on design and circuit simulation. Chapter four discuses on the construction, the electrical sub- system, mounting of components, design of casing and the general precautions observed. Chapter five highlights the test and measurement carried out on the design and the basic fault diagnosis of the system, while chapter six concludes the report stating the achievement and recommendation.

1.3 Sources of Components

In a relatively small town with few number of specialty electronic store, building an electronic circuit could be a lot more challenging than could be imagined; as the local available shops just might not have what you need. This results to choosing alternative equivalent guided by the use of data book.

However, materials used for this project were locally sourced.

1.4 Cost of components

The unit cost of material (components) varies significantly depending on its application. The material and their cost applicable to this project are listed as follows.

Table 1.4 Component Cost Table

Material	**Unit**	**Unit cost (Naira)**	**Total cost (Naira)**
Color Resistor	9	20	180
Variable Resistor	1	20	20
LED	1	20	20
Transistors	1	40	40
Op-Amp	1	100	100
Diodes	1	20	20
Buzzer	1	100	100
Vero board	1	180	180
14 pin I.C socket	1	30	30
Connection wires	1 yard	50	50
Screws	10	50	50
12V rechargeable battery	1	1,500	1,500
Layout board		500	500
Motor/ sprayer module	1	1,000	1,000
Probes	2	50	100
TOTAL			3,890

1.5 Constraints

This project is just a model design, which makes everything to be designed in model size. Obtaining a motor/sprayer module which would fit into the model design was the primary limiting factor in this design, as small motor/sprayer module which could operate on a small D.C voltage of between 9 and 12V were in limited market supply.

During the process of circuit design, the challenge of choosing the right type of Comparator came up, as many of the available comparators simply gave a low voltage output for variations in resistance value; this lead to the option of choosing from the available Op-Amp which could act as a voltage switch between high and low.

CHAPTER TWO

LITERATURE REVIEW

2.0 The economics of irrigated farming system.

Finding the most economic method of water application is important to the managers of irrigated farm as water is increasingly becoming a scarce and highly competitive resource due to population growth, industrial expansion, and recreation interest. This is the more reason why an irrigation system with good water management should be employed.

The automatic irrigator is highly economical it is very simple to implement and the cost of production and maintenance is minimal compared to the manual irrigation system. Labour is also very cheap as no special training is required to operate the automatic irrigator and energy is conserved.

In manual irrigation, the cost of irrigation is incremental most especially during the first irrigation due to the cost of energy and labour added to the cost of purchasing the equipment and its installation.

For many irrigation projects, water is sold on per-acre basis. A contract is made at the beginning of the irrigation season for the irrigation of a specified number of acres. Here, the amount of water used per acre becomes irrelevant. Under such circumstances, the marginal returns to water are not as important to the farm manager as the amount of water necessary for maximum yields. In such a case, the water cost is variable. This situation, of course is not true of those farms where water is purchased on an acre- foot basis or pumped from wells. In such cases, the marginal cost of water is relevant [1].

2.1 The choice of technology

Many of the irrigation systems which originated several thousand years ago in the East and Far East have continued without significant changes in their overall layout and methods of operation until the present time [2]. Some of the ancient methods of irrigation include the use of watering cans (manual water lifting) and mechanically operated systems using sprinklers and spray heads [4].

In recent time there have been various attempts in automation of irrigation. Some of the major attempts involved the use of valves operated by hand but with automatic closing through timing or volumetric mechanism (partial automation); valves with automatic opening and closing on sequential basis (time elapsed or volume delivered); valves with automatic opening and closing on non-sequential basis through programming or sensing devices [3].

Automatic sequential systems include, hydraulically operated systems the most common of which is diaphragm or piston valves also is the electrically operated systems where diaphragm or piston valves are controlled with a solenoid switch

Non-sequential operated systems are fully automatic systems control; electric or hydraulic valves which are operating independently of each other both in time and in quantity. Some of the attempts include soil moisture sensor for automation- resistance blocks and tensionmeter, evaporimeter for automation [3].

The choice of technology depends largely on various factors, some of which are installation cost, maintenance cost, efficiency of equipment, downward compatibility and so on. The cost of installation and maintenance of the Automatic Irrigator for dry Season farming is low as only the cost of installation of general farm mechanism is necessary, it is also highly efficient and downward compatible as it could be operated with earlier irrigation equipment. Generally the Automatic Irrigator is very convenient.

Subsequent chapters of this report, gives more detail on what makes the automatic Irrigator for Dry Season Farming meets the above criterion of technology choice.

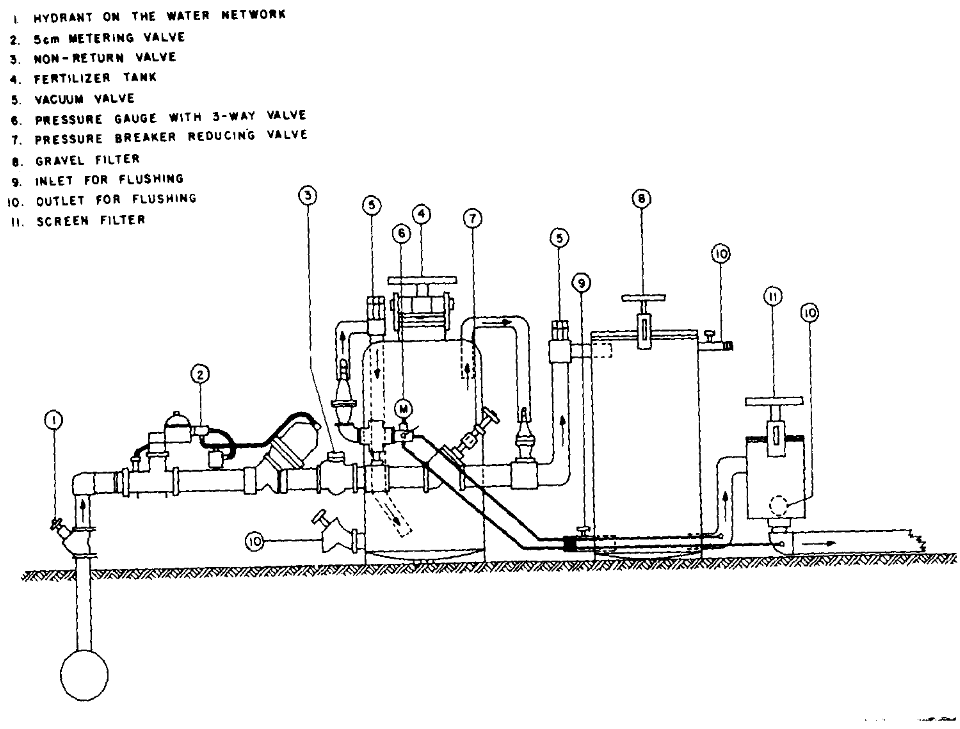


Fig 2.0 Example of an attempt of Automation in Irrigation using valve (partial automation)

2.2 Automatic Irrigator in Dry Season farming

The Automatic Irrigator is an easy, improved and enhanced method of dry season irrigation. Understanding the various methods of irrigation is essential in the use of Automatic Irrigator so as to maximize crop yield. Regardless of the choice method, automatic irrigator could be employed. All that is necessary to operate the Automatic irrigator is a source of water (reservoir) and the water distributor which depends on the method of irrigation adopted either surface irrigation, sub- soil irrigation or over head irrigation. Section 2.1 and 2.1 of this report gives insight as to factors to consider when making a choice.

The water distributor is attached to the end of the pump; one of the probes goes to the reservoir while the other goes to the farm all of which are controlled by the circuit. The complete system can be said to be a negative feedback system whereby the pumping action is determined by the soil condition (either wet or dry) and preset values depending on the soil and crop type [6].

2.3 Basic Engineering Concept

Apart from gravel and stones, the soil mineral particles are conventionally classified, on the basis of their equivalent spherical diameters, into size groups according to various grading systems. Thus the system adopted by the International Society of Soil Science (I.S.S.S), divide them into coarse sand (2.0- 0.2mm), fine sand (0.3 – 0.02mm), silt (0.02 -0.002mm) and clay (< 0.002mm).

The soil texture described in terms such as sand, sandy loam, silty loam, clay loam and clay – relates to the relative proportions of sand, silt and clay in the soil [7]. These influence the aggregate stability, permeability to air and water – holding capacity, ease of cultivation and nutrient status of the soil and consequently the soil resistance/ conductance. A standard relation of these factors to the conductivity of the soil is yet to be determined; this is an issue open to both agricultural and electrical engineer to tackle for future improvement on the Design and Construction of the Automatic Irrigator for Dry Season farming.

2.3.1 The concept of flow

Water movement through soil is proportional to the product of the driving force and the conductivity of the soil for water. This movement, both liquid and vapor, can be expressed by the equation

$$Q = cDK$$

Where Q = flow velocity

c = proportionality factor

D = driving force

K = conductivity of the medium

This relation holds true for heat transfer and flow of electricity as well as for water movement.

2.3.2 Definition of terms

The driving force:

The driving force in the case of water is a pressure gradient. Water moves from a position of high pressure to a position of low pressure. This is true for saturated and unsaturated liquid flow and for vapor flow.

In the case of saturated flow the pressure gradient may be brought about by differences in hydrostatic head (gravity, "water seeks its own level"). This pressure gradient may also be brought about by mechanical force (pressure from weight on soil surface or swelling colloids)

In the case of unsaturated flow the pressure gradient is the sum of the difference in hydrostatic head and the difference in soil- moisture tension.

The hydraulic conductivity:

The conductivity of soil for liquid water depends on the cross-sectional area of the pores and on the size of the pores. In saturated flow the conductivity increases as the fourth power of the radius. In unsaturated flow the conductivity depends on the degree of unsaturation. The drier the soil, the smaller is its conductivity.

We can conclude from these statements that the hydraulic conductivity is no simple function of porosity. Although the conductivity of a very porous soil is generally higher than that of a less porous soil as far as saturated flow is concerned, this relationship may be reversed for unsaturated flow.

Generally the rate of saturated flow in soil of various textures is in the sequence: Sand > Loam > Clay

From the law of Darcy, the velocity of floe of a liquid through a porous medium is proportional to the force causing the flow and to the hydraulic conductivity of the medium. This can be expressed in several ways. The equation can be based on pressure gradient as the driving force:

$Q = (cKAP)/ L$

Where Q = flow velocity (L^3T^{-1})

c = dimensionless proportionality constant

K = hydraulic conductivity ($ML^{-1}T$)

A = cross- sectional area (L^2) of the porous medium

P = pressure gradient ($ML^{-1}T^{-2}$)

L = length of the porous medium

Or the equation can be based on the hydraulic- head gradient as the driving force:

$$V = Ki$$

Where V = flow rate (LT^{-1})

K = hydraulic conductivity (LT^{-1})

i = hydraulic- head gradient (a dimensionless ratio)

It is noted that the dimensions of the hydraulic conductivity depend on the form of the equation. The actual magnitude of the hydraulic gradient or the coefficient of permeability has to be determined for every case. It depends not only on the nature of the porous medium but also on the viscosity of the liquid.

CHAPTER THREE

SYSTEM DESCRIPTION AND DESIGN

3.0 System overview

In circuit design as in most aspect of life, simplicity as opposed to complexity is the desired goal as it maximizes reliability, minimizes space, reduces realization cost and makes it easy to trouble shoot [8]. It is on this backdrop, the Automatic Irrigator was designed so as to meet required engineering standards [9]

The overview of the design concept is given in the logic table of Table 3.1

Table 3.1 Logic table showing an overview of the design concept

Soil Condition	Reservoir water level	Output of Soil moisture Sensor	Output of buzzer
Dry	High	High	Low
Dry	Low	High	High
Wet	High	Low	Low
Wet	Low	Low	Low

3.1 System Operation

The circuit operation is illustrated in the block schematic of fig 3.10 and in the flow chart of fig. 3.1. 1

The operation of the circuit can be divided into six main units; the power unit, the sensor unit consisting of the soil moisture detector and the low water level detector, comparator unit, the relay driver unit the pump activity indicator unit and the buzzer unit.

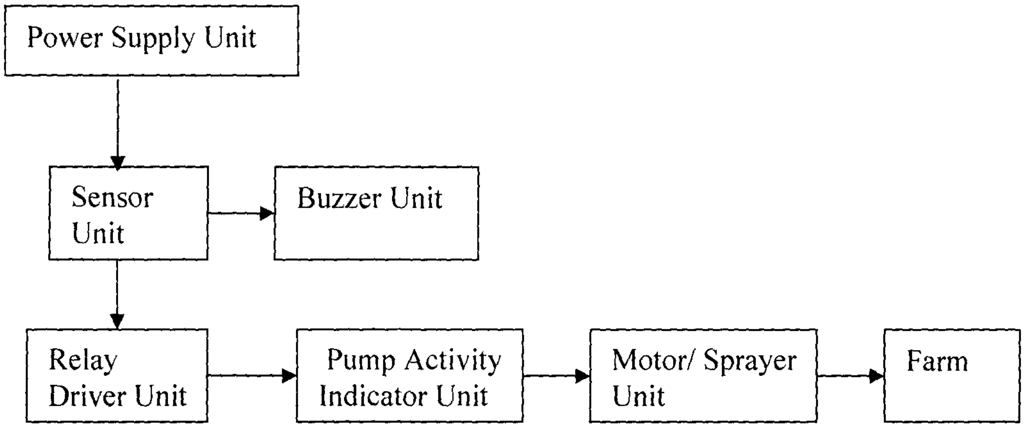


Fig 3.1.0 Block diagram of the Automatic Irrigator for Dry Season Farming

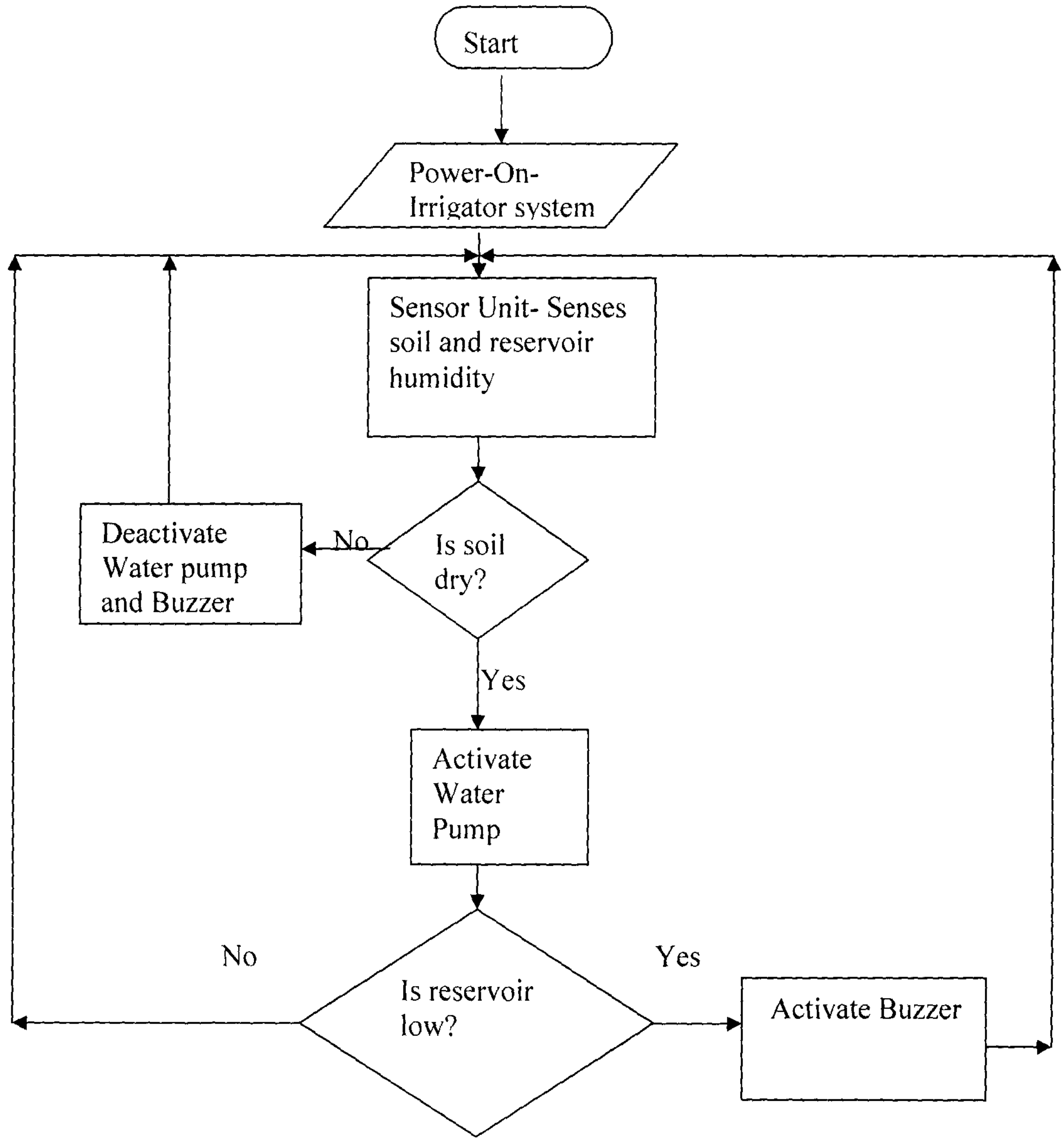


Fig. 3.1 Flow chat Automatic Irrigator Operation

The reference voltage level is set at the inverting input of the Op-Amp. The probe, spaced apart in the soil, is connected to the inverting input with a voltage preset for the datum soil type resistance.

The output from the Op- Amp (voltage comparator) is dependent on whether the voltage at the inverting input exceeds that of the non- inverting input, vice versa, this in turn activates or deactivates a relay driver that switches a sprayer motor.

Once the soil has reached sufficient moisture level as per calibration for soil type, the sensor circuit deactivates the pumping action of the sprayer motor.

3.2 Functional Units

The circuit has been sub divided into series of units, these units include:

- The power supply unit
- The sensor unit
- Relay driver unit
- Pump activity indicator unit
- Motor/ water sprinkler unit
- Buzzer unit

3.2.1 *The Power Supply Unit*

The Power supply unit of the Automatic irrigator For Dry Season Farming uses a 12V D.C power supply. This is simply to make it compatible with the available 12V D.C. water sprinkler motor.

3.2.2 *The Sensor Unit*

The sensor unit comprises a voltage comparator (LM324 Op-Amp) that compares the inverting input voltage to the non inverting input voltage via the aid of a probe connected to the output unit.

The design incorporates two sensing units, that is, the soil moisture detector and the reservoir low moisture detector. A single chip quad Op- Amp, LM324 serves as comparator for the voltage differential in the bridge circuit in which the sensor probe form a part.

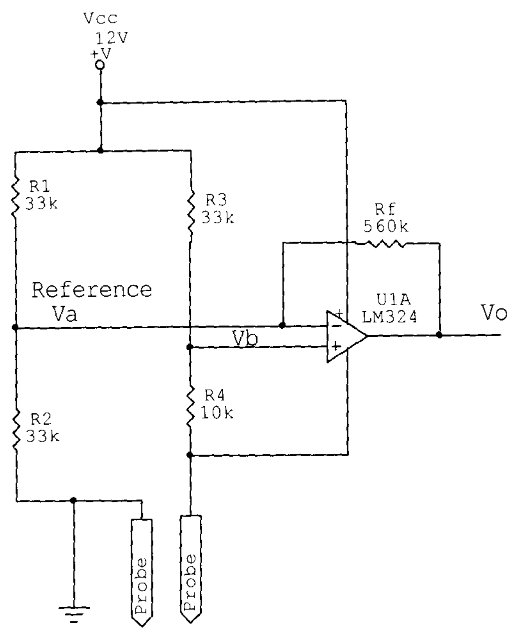


Fig. 3.2 Voltage Comparator Unit

Let the voltage at the inverting input voltage be Va

The non-inverting input voltage be Vb

From the circuit of Fig.3.2, we derive the relations:

$Va = Vcc * R2 / (R1 + R2)$ .... (1)

$Vb = Vcc * R4 / (R3 + R4)$ .... (2)

In the circuit, Va is used as the reference voltage fixed at half rail voltage by design, while Vb is the variable voltage, dependent on soil resistivity developed at the non-inverting input terminal of the comparator.

The feedback resistor Rf in the circuit help to reduce the voltage gain and stabilizes the circuit to prevent unnecessary voltage swings.

For an A.C equivalent circuit for voltage gain of the inverting amplifier, is illustrated in Fig.3.3

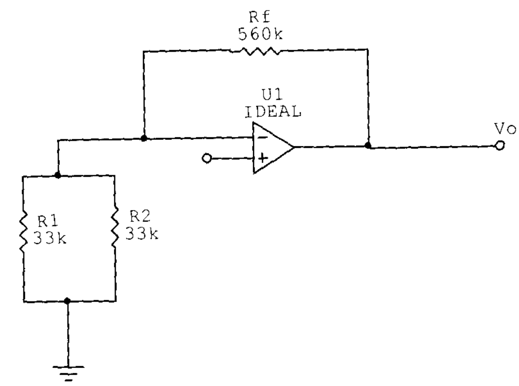


Fig 3.3 Inverting Amplifier

Voltage at the inverting input at he inverting input of an Op- Amp, equals that of the non inverting input (reason: because of its high impedance)

$\rightarrow V_+ = V_-$

But $V_+ = Vb$

Therefore, $|V_-| = Vb = V_+$.. (3)

Voltage amplification, A:

A = Rf/ (R1// R2) .... (4)

Also,

$A = Vo/ V_+$ .... (5)

We then choose Rf (feedback resistance) such that it gives voltage swing close to Vcc for the expected input signal differential between the inverting and non-inverting inputs.

From equation (5),

$Vo = A^* V_+$.. (6)

But Vo ≈ Vcc, from our design specifications.

Substituting equation (4) into (6)

→ we have to choose Rf :

$Rf= Vcc/(V_b/ [(R1* R2)/ (R1+R2)]$

Now $Vb = Vcc* R4/ (R3+ R4)$ form (2)

Hence $Rf = [(R3 + R4)*(R1 + R2)]/[(R4)* (R1 + R2)]$..............(7)

Where R4 is taken to be equal to the minimum envisaged soil resistance between the probes.

3.2.2 *The Relay Driver Unit*

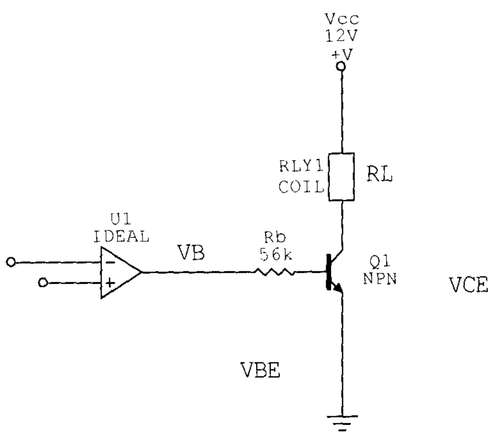


Fig. 3.4 Relay Driver Sub circuitry

When the voltage at the non-inverting input terminal exceeds that on the inverting terminal, the output of the Op-Amp swings high approaching Vcc

On this state we design such that the relay driver transistor Q is saturated to ensure maximum voltage drop across the relay, RL

The relay chosen has a coil resistance RL of 230Ω

Assume:

Ic is the current flowing in the collector of Q

Ib is the base current

Vb is the output voltage of the Op. Amp. Dtiving transistor Q

Vcc is the supply voltage

V_{BE} is the base- emitter voltage drop across Q

$V_{CE(sat)}$ is the collector- emitter Voltage of Q at saturation

hFE is the D.C current gain of transistor Q

Then the following relation holds at saturation of Q

$Vcc = Ic * RL + V_{CE(Sat)}$.. (8)

$Vb = Ib * Rb + VBE$... (9)

Now: $hFE = Ic/ Ib$ .... (10)

Based on experimental measurement on the test circuit,

The relay resistance, $RL = 230\Omega$

$Vb \approx 10.7v$

And from the data book specification for the BC337 transistor used as Q

$V_{CE(Sat)} = 0.2v$; $V_{BE} = 0.7$ v; $hFE \approx 285$

Substituting these values in equation eqn (8)

$Ic = (12- 0.2)/ 230$

$Ic = 0.0513$ A

also from eqn (9)

$Ib = Ic / hFE$

Substitute values

$Ib = (0.0513/ 285)$ A

$Ib = 0.00018$ A

From eqn (9), $Rb = (Vb - VBE)/ ib$

Substitute values respectively

$Rb = [(10.7 - 0.7)/ 0.00018]\ \Omega$

$= 55.556\ K\Omega$

Viz Rb ≈ 56 KΩ

3.2.3 *Pump Activity Indicator Unit*

The pump activity indicator consists of a light emitting diode (LED) connected to the collector of a BC337 transistor in series with relay coil RL. The LED lights whenever the voltage Vb goes high causing transistor Q1 to be saturated.

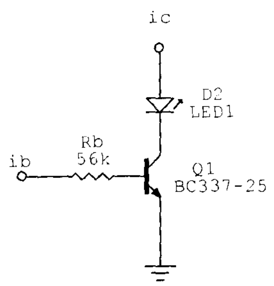


fig. 3.5 Pump Activity indicator Unit

(In this state also, when the collector of transistor Q (Fig. 3.4) goes high causing the relay, RL to switch on the motor pump motor)

When Vb goes low, the LED is deactivated indicating that pumping action has stopped.

We note that Pump Acitivity is a consequence of soil moisture level. When the soil moisture is high, the LED goes OFF while when the soil moisture is LOW the LED lights.

3.2.3 *The Motor/Water Sprinkler Unit*

The motor/water sprinkler unit is a mechanical sub unit of the design controlled by the output of the of the previous sub units. The motor/water sprinkler unit is the output with which the irrigation water reaches the farm. The motor of the water sprinkler is activated by the relay RL (Fig. 3.4)

3.2.4 *Buzzer Unit*

The buzzer unit indicates alerts on the state of the level of water in the reservoir. This unit is similar in design topology to the water sprinkler activation unit. The buzzer is also controlled by the sensor unit feeding another LM324 Op- Amp. When the output from the Op- Amp goes high, indicating low reservoir water level, the buzzer is consequently activated. The buzzer is deactivated when the output of the Op- Amp goes low indicating high reservoir water level.

3.3 Component Selection/ Design Specifications

The designer of a circuit must have a working knowledge of the information of the various components. In addition, he must know the specification for the particular circuit to be designed; those specifications may take on various forms. For practical designs, information of the following type is necessary:

- Available power- supply potential
- Operating and storage temperature range
- Cost, weight and size requirement
- Environmental conditions
- Sensitivity to parameter and supply- voltage variation
- Input and output impedance levels
- Allowable current drain from power supply
- Noise and distortion
- Life expectancy

Components selected for use in the Automatic Irrigator for Dry Season Farming were guided by the above specifications.

3.3.1 *The choice of a BC337 Transistor*

To design even the simplest transistor circuit requires that the designer use all available information including test data taken especially for the purpose, to create a circuit that satisfies the given specification.

The design of the Automatic Irrigator required a transistor type suitable for switching the relay activating the water sprinkler motor.

The choice of BC337 transistor was made based on the following criteria:

- BC337 is readily available and cost effective
- BC337 is a silicon transistor which gives it the characteristics of larger energy gap resulting in a much lower leakage current (Ico) and lower sensitivity to temperature extreme compared to Germanium transistors
- It has medium current amplification factor
- It has high maximum collector- voltage ratings
- It has suitable physical size, and mounting dimensions.

3.3.2 *The choice of LM324 Op- Amp*

The choice of LM324, taking into consideration design specifications, was guided by the following:

It is suitable as a voltage switch

- It has enough sensitivity to change in resistance necessary for operation of the Automatic Irrigator circuit

- It is economical as it contains four Op-Amps in one Dual in Line Package which also help to minimize the over all space occupied by the circuit. on the Vero board

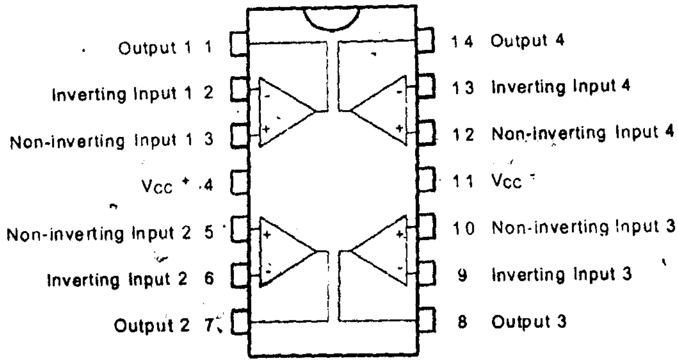


Fig 3.6.Pin connection of LM324 Op-Amp

- It is a CMOS IC which supports a high range of power supply of up to 15v.
- LM324 Op-Amp is ready available and cost effective

3.3.3 *The choice of minimum wattage for resistor power dissipation*

From the circuit design simulations, the maximum power dissipated in any one resistor in the circuit is in the milli-Watt range. We chose resistors with minimum wattage rating of 1/2W to conveniently maintain stability in the circuit caused by unnecessary over heating of resistors. Also high stability metal-oxide film resistors are most readily available and cost effective.

3.3.4 *The choice of the Relay*

There are two main purposes of the relay,

- To enable a large current to be controlled by a small current. It is therefore a sensitive switch so that a small current change can control devices which use heavier currents, such as lamps, motors, solenoids, etc

- To enable the control circuit to be isolated from the controlled circuit.

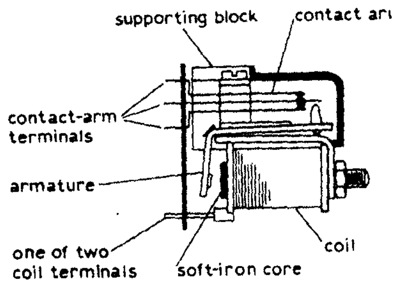


Fig. 3.7 The structure of a simple relay

For this design a 9V relay wa chosen which has a minimum turn-on voltage of 6V. This ensures the relay is reliably switched on and off when activated by a near 12V D.C, source, with no latching.

3.3.5 *The choice of a buzzer*

The buzzer is an electro magnetic device used to convert electrical energy to audio energy. It was chosen in the design so as to alert when the reservoir water level is low.

A piezo-electric buzzer was chosen because of its high impedance that ensures little current is drained from the battery when it is activated.

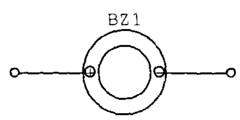


Fig. 3.8 Circuit symbol of a buzzer

3.4 Computer Based Simulation

Before a project is embarked upon, it is important to understand what is expected of its input- output functional behaviour. A theoretical model of the circuit design (if such exist) can be useful in design planning and implementation.

Manual calculations based on theoretical models are tedious, often impossible for D.C. circuits consisting of non-linear elements, and gives only a rough estimate of input-output behavior. On the other hand, Computer Aided Design simulations with in-built component level characteristics are fast and give a good insight on how the circuit would behave in practice.

For this reason, Simulation was carried out to predict the Irrigator circuit input-output behavior using the proven and commercially available Electronic Computer Aided Design (ECAD) simulation program – Circuit Maker 2000 [15]. Simulations were carried out using "what-if" scenario which consequently helped to fix values for certain components – certain resistors in particular. Simulations were also carried out using the specified and derived component values to predict if the circuit would behave as envisaged.

Simulation results for the Sensor sub-unit (Fig.3.9) transient output voltage, Vo, characteristic, at two extremes of expected soil resistance are shown in Fig. 3.10.

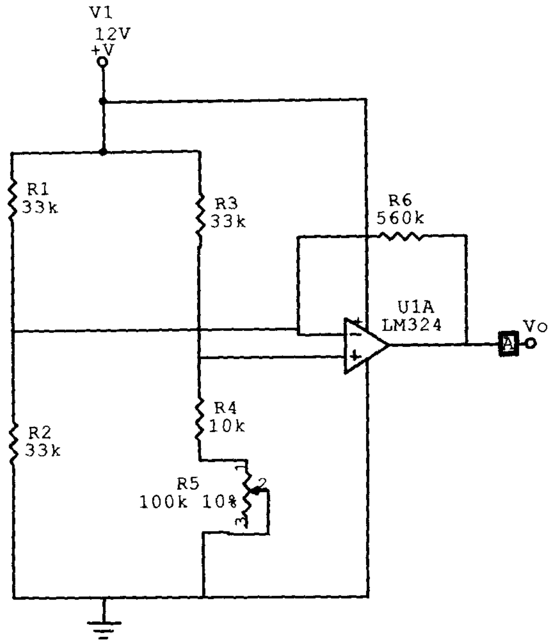


Fig. 3.9 Simulation model for the sensor circuit.

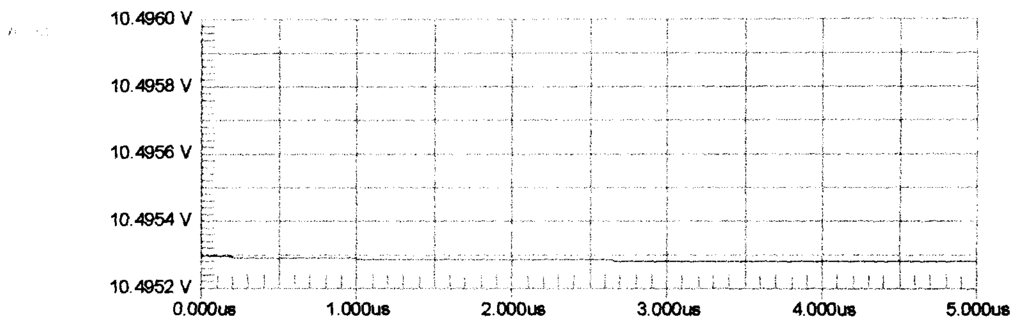


Fig 3.10.1 Transient voltage output at point A (Fig. 3.9) for high soil resistance (low moisture condition).

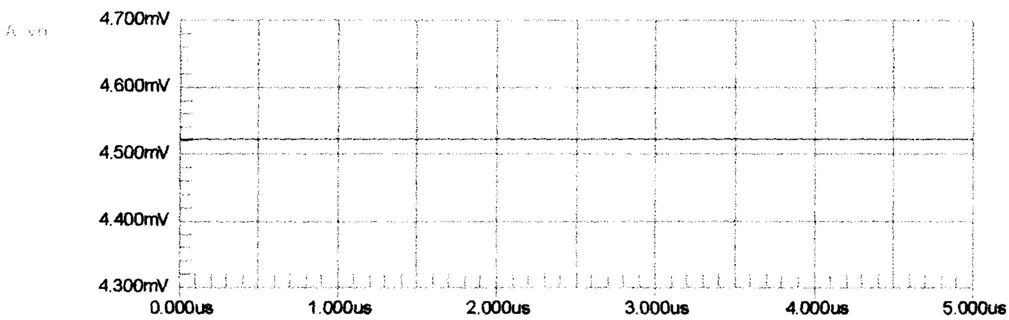


Fig 3.10.2 Transient voltage output at point A (Fig. 3.9) for low soil resistance (moist soil)

Simulation was also carried out on the relay driver unit to determine relay switch-on and switch-off behavior under output voltage level variations of the LM324 driver Op. Amp corresponding to variations in soil moisture as detected by the sensor unit..

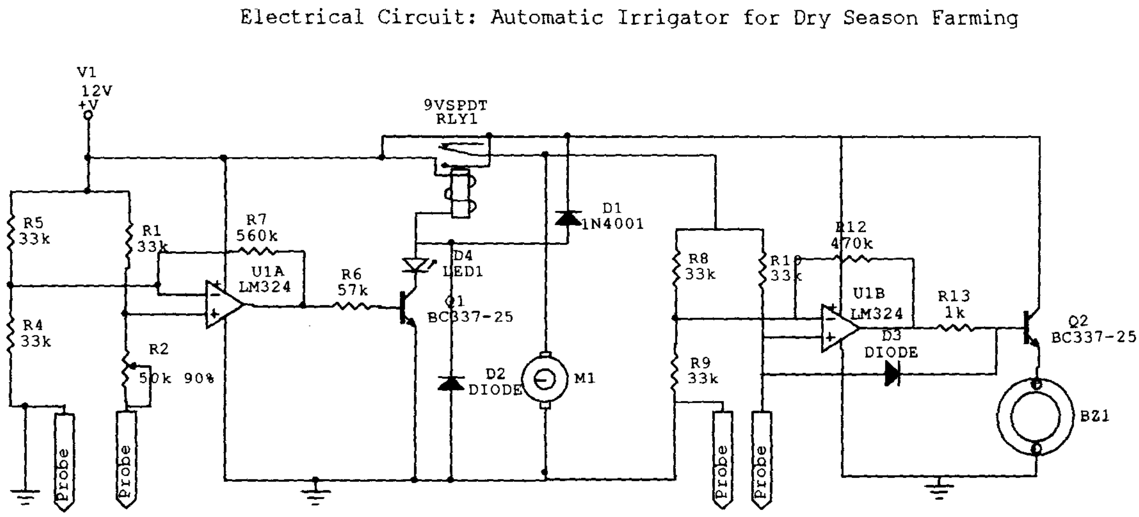
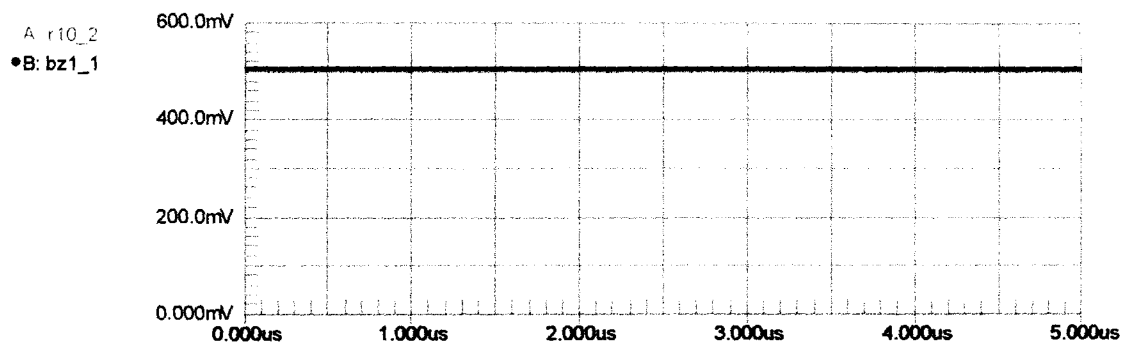


Fig 3.1.1 Simulation model circuit diagram of the Automatic Irrigator



KEY: Green trace: Transient voltage behavior at point A

Red Trace: Transient voltage behavior at point B

Fig. 3.12 Transient voltage output at point A and B (Fig. 3.11)

From the result of the simulation its is noticed that the Auto irrigators is de-activated, as long as the reservoir low water level remains low. This conforms to required design operation as indicated in the logic table of Table3.1

CHAPTER FOUR

CONSTRUCTION

4.0 Construction overview

The overall construction was carried out in two phases- the electrical component mounting phase on Vero-board and the mounting of input-output sockets as well as the board on the casing.

The electrical component mounting phase involved the arrangement of various components on a 0.1inch pitch Vero board guided by the circuit diagram while the casing design involved the building of a ventilated enclosure for mounting Vero-board, controls, indicators as well as sockets for various inputs and outputs. The o.1inch spacing pitch Vero-board was chosen since it conforms to general Dual-in-line Integrated circuit pin spacing such as LM324 which forms part of the design.

4.1 Electrical Sub-system

The data book specifications for the dimension of each component served as a guide in planning the layout of the electronic components on the Vero-board. The electrical components include resistors, transistors, potentiometer, Operational Amplifier, rectifying diodes, light emitting diode, relay, buzzer and switch.

4.2 Mounting of Components

Almost all the components used in the electronic industry are equipped with leads allowing them to be mounted in suitable sockets or more frequently inserted into holes in a printed board then soldered in place [16].

A number of design rules were strictly applied during the mounting of the various components of the Automatic Irrigator on the Vero-board.

These include:

- Ensuring polarity is in the same direction
- Providing sufficient space around component to ease repair
- Ensuring continuity on sections of the Vero-board
- The use of solder to fit the component in place
- The use of I.C socket to insert the LM324 I.C, to enable easy replacement if damaged.

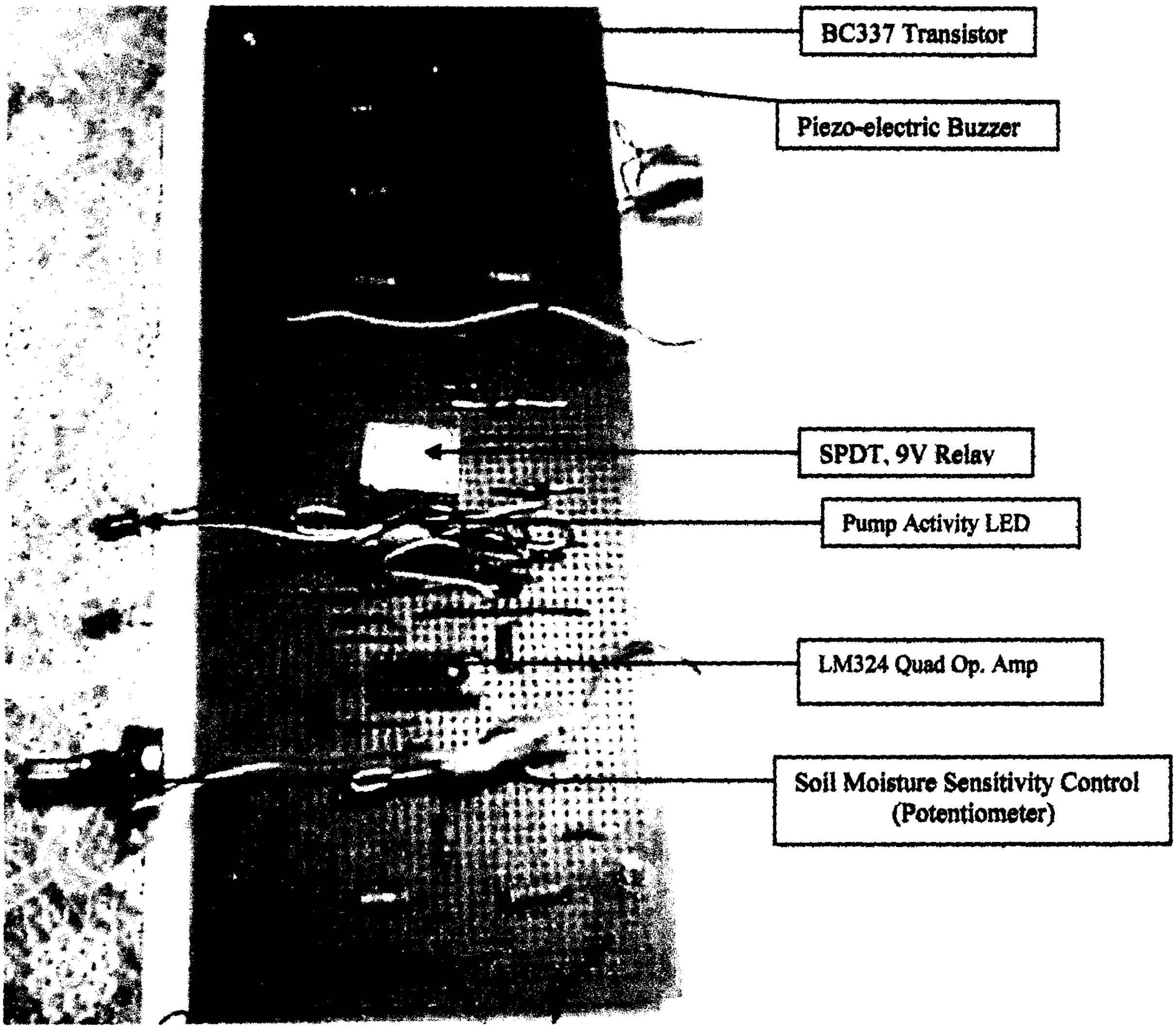


Fig 4.2 Component layout of Auto Irrigator on Vero Board

4.3 Casing Design

Casing of an electrical system is important to ensure safety and neatness of design

The type of material to use depends on the characteristics of the electrical system in question.

In designing the casing for the Automatic Irrigator, various factors were considered, some of which include

- Concept of the design
- Application of design
- Material type
- Safety
- Cost

4.4 Safety Precaution Observed

Safety precautions were observed at various stages of the design to protect the operator and the circuit.

To protect the transistors against reverse voltage breakdown caused by back e.m.f. generated by inductive switching of the relays, free-wheeling diodes were inserted across the relay coils. Terminals to which voltage sources are fed or polarized components are connected were colour coded to prevent human error in connection.

Plastic casing was used to protect the operator from shock due to electrical leakage.

CHAPTER FIVE

TESTS AND MEASRUREMENTS

5.0 Overview

Before an electronic system is certified, the components that make up the system must function to design specification. Tests and measurements are therefore carried out to this effect.

Each component that makes up the Auto Irrigator circuit is of unique importance to the overall performance of the system [refer to chapter three]. If any of the components should fail, the system would malfunction.

Test and measurements were carried out in each section that makes up the Auto Irrigator (the soil sensor/motor sprinkler and the reservoir water level/ buzzer circuitry) and the overall test performance test was also carried out.

5.1 The Soil Sensor/ Motor Sprinkler circuitry

By the design, the soil moisture sensor is to detect changes in soil humidity and output voltage corresponding to such changes activating or deactivating the motor of the water sprinkler as the case may be [Refer to chapter three, fig 3.1, Table 3.1].

Measurements of the output voltages from the soil sensor were taken at various soil humidity state using a Multi-meter and the result confirmed that the behavior of the soil moisture/ water Sprinkler Circuitry conformed to design specification. Test was also carried out on the motor of the water sprinkler and the result certified that the sub-circuitry performed its specified function as designed.

5.2 Reservoir Water Level Sensor/ Buzzer circuitry

Digital Multi-meter was used to measure the output voltages of the reservoir Water Level Sensor at both high and low sate. The buzzer was activated when the water level was low and deactivated when water level is high. The result confirmed that the various part of the Sub- circuit is working as envisaged in design specifications.

5.3 Overall Circuit Performance

The soil moisture sensor/ Water sprinkler and the Reservoir water level sensor/ buzzer were designed to concurrently function as subsystems of the Automatic Irrigator for Dry Season Farming. An overall circuit performance test was carried out on the combined sub-circuitry and the following results were obtained:

- When the soil was dry and the reservoir water level high, the motor of the water sprinkler was activated, the activity indicator lighted and the buzzer was deactivated
- When the soil was dry and the reservoir water level low, the motor the pump activity indicator was lighted buzzer was activated.
- When the soil was wet and the reservoir water level high, the motor sprinkler and the buzzer were deactivated and the activity indicator off
- When the soil was wet and the reservoir water level low, the motor sprinkler and the buzzer were deactivated and the activity indicator off

From the result summarized above, it can be concluded that the desired objective was achieved

5.4 Basic Fault Diagnosis

Fault diagnosis requires the system view. There are all sorts of thing that can go wrong with a system like faulty power sources (including dead battery, bad connectors and loose connector, open cables and cables connected incorrectly, input signal missing, incorrectly set control, component failure etc.

It is important to carry out preliminary visual inspection checking out for the following:

- Burned and discolored component
- Broken wires and component
- Cracked or burned circuit board
- Foreign object
- Bent transistors leads that may be touching including other non insulated leads as well
- Part falling out of socket or only partly seated
- Loose or partly seated connectors
- Leaking components especially battery and electrolytic capacitors

The use of instruments such as multi meters can be used to test output voltage value and comparism made to the expected value to diagnose fault.

It is important to observe the operational guide for operating the Automatic Irrigator to ensure its optimal life.

CHAPTER SIX

CONCLUSION

6.0 Achievement

It was found that the Automatic Irrigator for Dry Season farming is an easy, effective, efficient, and economical method of irrigation.

The project also exposes ways in which the op-Amp could be employed to solve practical engineering problems.

The system was made as flexible and cost effective as possible. It could therefore be mass produced at cheap cost.

6.1 Recommendation

For mass production, it is recommended that the components be mounted on a printed circuit board. This would give greater reliability and aesthetic appeal. The design could also be made more commercially more attractive, by computerizing or configuring it to a micro controller which would in turn be interfaced with seven segment displays, to display in digital mode of the preset value and the outputs from the reservoir moisture detector and the soil moisture sensor.

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APPENDIX A

OPERATION MANUAL

Power switch: this is an ON, OFF switch used to activate or deactivate the Auto Irrigator

Reservoir probe terminal: this is the output terminal that connects the reservoir probe to the circuit

Soil probe terminals: this is an output terminal that connects the soil probes to the circuit

Pump activity Indicator: this is a light emitting diode that indicates, pumping action

Soil Moisture Sensitivity Control: a potentiometer that is adjusted to increase to reduce the circuit sensitivity to soil moisture level detection.

12V Power Supply Terminals: this is an output terminal that connects a 12V D.C power supply to the circuit

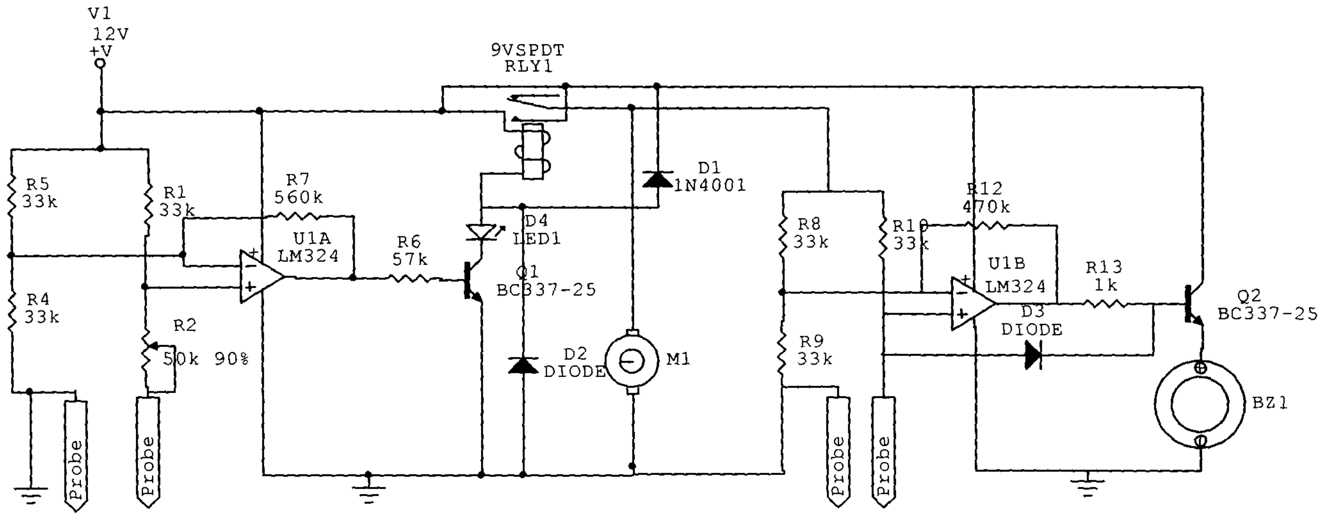
Motor Terminals: this is an output terminal that connects a 12V D.C powered sprinkler motor to the circuit

Each probe is connected to its corresponding output terminal in its correct polarity.

The soil probe is then inserted into the soil spaced apart a known distance in the soil (depending on the datum soil) while the reservoir probe is inserted into the reservoir each, apart.

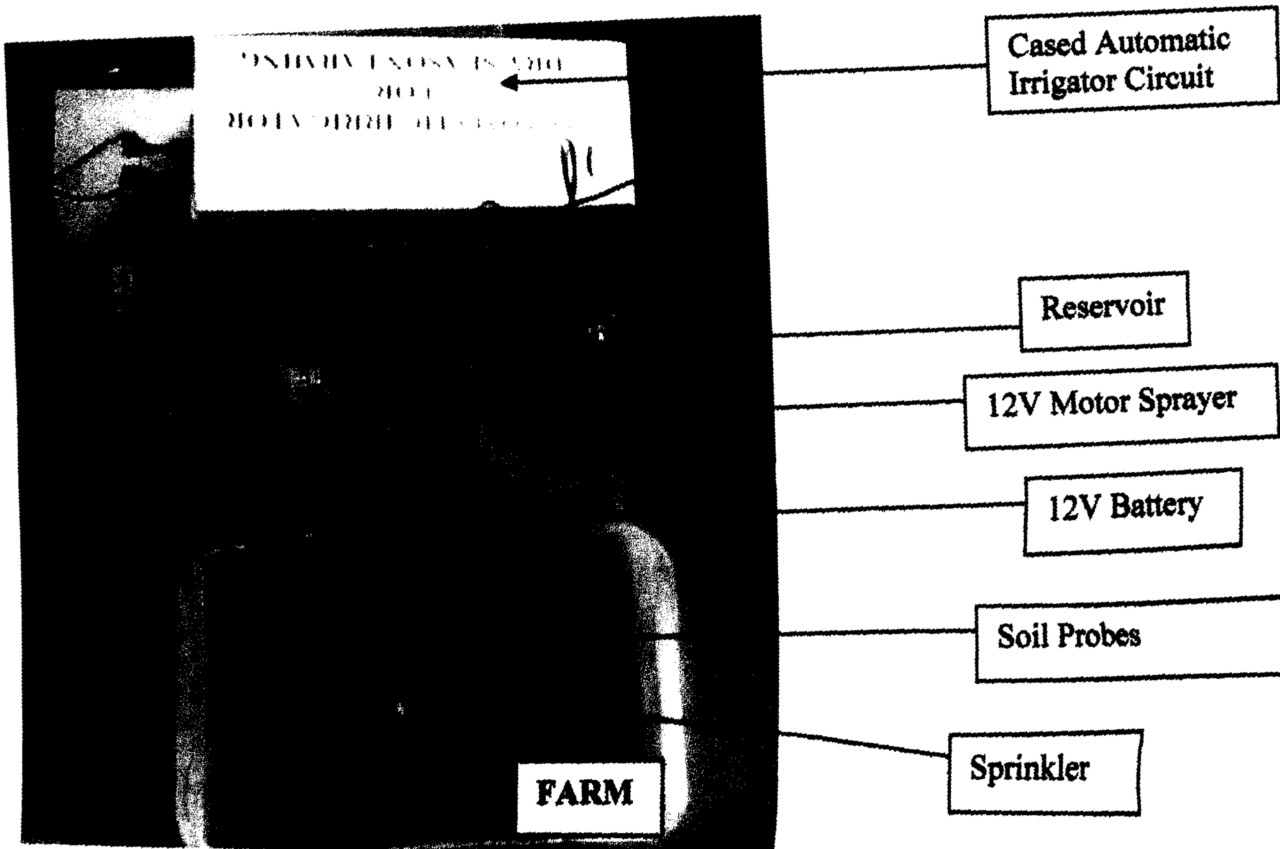
The Power Supply connectors are connected to their corresponding terminals in the correct polarity to the 12V battery. The circuit is then powered using the power switch.

APPENDIX B



Automatic Irrigator Circuit Diagram

APPENDIX C



Complete Layout of Automatic Irrigator for Dry Season Farming