DESIGN AND CONSTRUCTION OF AN AUTOMATIC WATER-LEVEL INDICATOR AND PUMP CONTROLLING DEVICE WITH ALARM

BY

MOHAMMED JIYA NDA-ASEBE

(2001/12037EE)

DEPARTMENT OF ELECTRICAL/COMPUTER ENGINEERING
FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA
NIGER STATE
NIGERIA

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DECLARATION

I, Mohammed Jiya Nda-asebe (2001/12037EE) here by declare that this thesis presented for the award of degree (B.ENG) in the Department of Electrical/Computer Engineering, Federal University of Technology Minna, was fully carried out by me and has not been presented else where.

All information utilized and their source haves been duly acknowledged.

Mohammed Jiya Nda-asebe

05/12/2007

Date

CERTIFICATION

This is to certify that this project was fully carried out by Mohammed Jiya Nda-asebe, registration number 2001/12037EE of Department of Electrical and Computer Engineering, Federal University of Technology, Minna, under the supervision of Engr.S.N Rumala.

5/12/07

....

Engr.S N Rumala

(Project supervisor)

Date

....

Engr.M.D Abdullahi

(Head of department)

....

Date

....

(External Examiner)

....

Date

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DEDICATION

This thesis is specially dedicated to Almighty God and My Parents;

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ABSTRACT

This thesis provides an explanation on the theory, design and construction of an automatic water level indicator and pump controlling device with alarm.

The device is intended to display six LEDs (output) accordingly in bar graph mode to show the level of water (input) in tank. The device is capable of producing audio and visual outputs whenever water-level reached a specified level.

The system has probes inserted in the overhead tank. As water is pumped into this tank, the probes sense the water at some predetermined level which would be indicated by the level indicator [LEDs]. When the tank is filled up to the last discrete level, all the LEDs (light emitting diodes) would light up. Hence, the contents of the relay open thereby switching off the pumping machine. Otherwise, an alarm would sound if the water is due for overflow.

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Circuit diagram of an automatic Water-Level indicator and Pump Controlling Device with Alarm.

CHAPTER ONE

INTRODUCTION

1.1 HISTORICAL BACKGROUND

In the long term, one of the most important problems facing the world today is the provision of adequate supplies of fresh water for industry, for agriculture and for the continuance of mankind. Inherent in this problem is the avoidance of waste, one serious aspect of which is the loss of valuable water carried regularly to the sea in floods. In all countries the ultimate objective most surely be to conserve and control all fresh water in order that what is so freely provided by nature might be applied efficiently and effectively for the future well being of mankind. Coupled with this is full recognition of the seriousness of our rapidly diminishing reserves of fuel such as coal and oil, so vital at this time for the generation of power for industrial and domestic use. Unlike for soil and liquid fuels, water is not expendable; the supply by nature may vary from season to season and from year to year, but there is no general diminution. [1, 2]

These factors and others high light, the importance of water and the need to apply maximum engineering skills to its conservation. Mr Thomas, in his excellent book title [The engineering of large dams], has set out to guide engineers in the art of dam engineering [1].

Among renewable energy sources hydroelectric power seems to be the most desirable for utilities, and its economic feasibility has been successfully proven. These important power generating stations require a great volume of water stored in reservoir / dams for electricity generation, the knowledge of the level of water in the dam is necessary so that the spill way can be opened for excess water to flow out in other to prevent the flooding of the dam [1, 2].

Today dams exceeding 150metres in height often associated with difficult foundation and structural conditions, are by no means uncommon; in fact the world is now seeing dams that exceed 300 metres. Failure of dams of such dimensions could be expected to cause enormous loss of life and property. Among various factors responsible for the failure of hydro-power dams, flood is one of the most paramount natural disaster which occur when there is excess of water if not noticed and controlled immediately.

For instance, when the Cros Dam failed in Brazil in March, 1960, between 30 and 50 people were lost and 100,000 people were evacuated; some 730 million m^3 of water was released in 34hours with a peak flow of $9600m^3/s$. The flood front in the Jaguaribe River reached the Atlantic ocean, 340 kilometres away, in 4 days, the peak of the flood arriving 2 ½ days later, and the tail not for 13days. It is not difficult to visualize the devastation along the 340km [1].

The disasters caused by flood can not be mentioned all in this thesis but it brings about a need for an automatic device such as water level indicator and alarm that will monitor the level of water in dam and give audio/visual alarm when ever water level reached its maximum point to avoid flooding of the dam

1.2 NEED FOR THE PROJECT.

Water is universally considered to be one of the most essential ingredients that sustain lives of both plants and animals on earth, and probably man's most vital commodity, its optimum utilization will be of prime importance in our expanding civilization by devising means by which this water could be properly conserved and effectively used.

An automatic water level indicator and pump controlling device with alarm is a device that activates the pumping machine and continuously monitor the flow of water in to the overhead tank at various discrete levels which are indicated by the level indicators and stops the pumping machine immediately the tank is filled otherwise an alarm is sounded to alert human operator. The device is designed to display six (6) different levels. However, these display levels can be increased or decreased depending upon the level resolution required. This can be done by increasing or decreasing the number of level indicator metal strips and their associated components. This device gives alarm when water level is below the lowest level and also when the water just touches the highest level. [3]

Previous research had shown that water bodes occupy about two-third of the earth, the supply of water to most homes and industries in many cities is inadequate, thus, many buildings in urban areas have overhead storage tanks installed, so that water can be made available at all times because the unavailability of water will cause discomfort and obstruction of industrial processes

At home, knowledge of water level is necessary, so that domestic activities such as washing, bathing as well as cooking and other activities required to maintain cleanliness and personal hygiene do not become tedious or even impossible.

In the fish ponds where constant supply and monitoring of water is very necessary, it is important to design a device such as water level indicator with alarm that will automatically indicates different discrete levels reached by water and producing alarm when the water level is below the lowest level and also when water just reaches the highest level. [1, 3]

In the agricultural sector where a large quantity of water is needed for irrigation purposes, it is necessary that a certain reserve of water be maintained in the reservoir at a minimum or maximum level to avoid wilting of the plants or flooding of the farm land; as well as to provide for the dry season farming, by controlling the flow of water either into or out of the reservoir [3, 6]

In chemical industrial processes, the ideal of liquid level such as the distillation columns, boilers, evaporators and mixing tank is very important in the operation processes; a level which is too high can upset chemical reaction equilibrium, cause damage to equipment or lead to the spillage of hazardous chemicals. A level which is too low can equally have bad consequences such as over heating of equipment or complete failure of operation.

In Olympic games where swimming activities take place in swimming pools containing a large volume of water continuously supplied, a knowledge of water level indicator is very important to monitor the pumping system and to sound alarm when water is empty or very low as well as when the required level has been attained to prevent over filling and flooding of the pool.

The ideal of an automatic water level indicator and pump controlling device with alarm is aimed at eliminating the burden of monitoring the over head tank water level and the manual control of water pump. This device also provides the means for attaining optional performance of dynamic system, improving productivity and relieving the drudgery of many repetitive manual operations.

The design of this device is based on the conductivity of water only. And its application is also suitable for other liquids and could be used in the factories, hotels, residential buildings etc

1.3 AIMS AND OBJECTIVES

The aim of this project is to design and construct an automatic water level indicator with alarm. It is the function of the system/device to stop the pumping machine whenever the required level of water in the tank is attained. Other wise, the device should sound an alarm if the pump fails to stop as to alert human operator and to prevent water wastage.

1.4 METHODOLOGY

The method employed in the design and construction of an automatic water-level indicator and pump controlling device with alarm is based on the conductivity property of water. Multiple points (discrete) sensing technique and a semi controllable switch is used for the level indicator and water pump control device respectively.

1.5 PROJECT OUTLINE

Chapter one: This chapter gives information on the historical background and need fro the project. It also gives information on the aims and objectives as well as the methodology employed to achieve the desired goal.

Chapter two: This chapter basically explains all necessary literature reviews.

Chapter three: This chapter covers the detailed design and analysis of the project, the principle of operation and also an in-depth look at various components and sub-circuits that make up the entire system.

Chapter four: This chapter covers all the details of the construction and testing procedures employed to achieve the final product.

Chapter Five: This chapter summarises the work done so far from the theoretical principles to the physical realisation of the physical model. It also gives recommendation and conclusion on the areas the device can be improved and modified.

CHAPTER TWO

LITERATURE REVIEW

2.1 GENERAL OVERVIEW ON VARIOUS METHODS OF DECTECTING LIQUID LEVELS

Long time ago, where fluids [liquid and gases] have been contained, transported and used there has been leakage of one kind or another. As technology was developed for accumulation, storage, and distribution of water and other fluids; methods were needed to detect and locate leaks. The development of closed pressurized distribution system has furthered emphasized the importance of leak detection.

A leak may be sensed by the flow of fluids, detection of the fluids presence exterior to its container, or by a change of the pressure level of the fluid. Leak may be found by simple methods such as visual inspection, listening for the sound of escaping fluid, submerging the pressure vessel in water or the use of trace sensitive materials, mass spectrometers, ultrasonic, and other devices. [2]

The use of float switches in detection and control of water level has been in existence for very long time. These float switches are used in industries where water level need to be detected or controlled. The basic principle of a float switch is that, one of the switch contact floats on water while the other contact is made to be stationary. As water rises, the float rises until the switch becomes closed. This contact may be part of a motor control circuit, which drives a pump. Float switches have some mechanical elements since there is movement before contact is made in them.

On the Other hand, electronic devices have been used as switches. These include temperature operated switch, pressure operated switch, light operated switch etc. most of these switches are sensors. The sensor may be in a voltage divider network to apply potential to a switching circuit [2, 3]. Some of the switching circuits include; single transistor circuit; thyristors switching, Schmitt trigger switching circuit etc.

Liquid level can be sensed by taking some important physical parameter of the liquid in a vessel into consideration. This includes temperature pressure, weight and turbidity to mention a few. These have helped a long way to develop an appropriate transducer to suit a particular parameter chosen.

Generally, liquid level is sensed base on either obtaining a discrete indication when a predetermined level has been reached (other wise called point sensing) or obtaining an analogue representation of the level as it changes [i.e. continuous sensing].

Point sensing systems are usually simpler and cheaper than continuous sensing systems and should be used when a discrete indication has to be obtained. Further more, ...o or more discrete levels were to be ... d in a vessel, the use of two or more ... sensors wo... em. Apparently, this is due to ... g continuous sensing techniques. ... e of various methods of water ... nent in technology witnessed ... used for measuring liquid ... and fixed at a known position ... the vessel makes a level ... velted [3].

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Point sensing systems are usually simpler and cheaper than continuous sensing systems and should be used when a discrete indication has to be obtained. Further more, if two or more discrete levels were to be established in a vessel, the use of two or more point sensors would be preferable to continuous system. Apparently, this is due to inconsistency in the accuracy of the measurement using continuous sensing techniques.

The past 100 years have witnessed the emergence of various methods of water level measurement [detection] as a result of the improvement in technology witnessed within this period. The ordinary dipstick is a simple device used for measuring liquid level. It consists of a metal bar, on which a scale is etched, and fixed at a known position in the liquid containing vessel, removing the instrument from the vessel makes a level measurement and reading now far up the scale the liquid has welted [3].

Earlier, Barry G. W (1982) revealed that single transistor could be used as light operated switch. In his design, a photo cell was used in a voltage divider network to forward bias or reverse bias a transistor depending on the intensity of light on the photo cell [2, 3, 6].

In the optical dipstick method, light from a source is reflected from a mirror and it passes round a chamfered end of the dipstick and enters a light detector after reflection by a second mirror, the instrument can be moved up and down and its position is measured and hence the liquid level.

The Stevens submersible, depth transmitter is a sensing device designed for water level measurement application. Higher range units are used for ground water, storage tanks for other applications. Low range units are ideal for open channel flow, applications a stainless steel pressure transducer is used as the primary sensing element, and it measures the water depth by pressure above the unit [5].

Pressure measuring devices used fro water level measurement utilize the principle that the hydrostatic pressure due to a liquid is directly proportional to its depth and hence the level of its surface. In open tipped vessels or covered ones that are vented to the atmosphere, the level of liquid is measured using an appropriate pressure transducer inserted at the button of the vessel. The liquid level is then related to the measured pressure according to $h=p/\rho g$, where ρ= density of the liquid and g=acceleration due to gravity. [5, 7]

The ultrasonic level gauge principle uses energy from an ultrasonic source above the liquid reflected back from the liquid surface into an ultrasonic energy detection, measurement of the time of flight allows the liquid level to be inferred. The Stevens ultrasonic level transmitter is a non-contact, solid state device for sensing water level in channels, lakes or streams for input to a data logger or other monitoring unit; analogue output can be configured normal or inversely proportional to the distance from the target or water surface [5, 6].

The improvement in technology in the semiconductor industries, led to the development of the operational amplifier, transistors, integrated circuits etc which were developed initially for use in performing arithmetic operations such as addition, subtraction, multiplication and division. Later it was discovered that operational amplifier could be used for other purposes other than performing arithmetic operations; one of such use is a difference amplifier or differential amplifiers to amplify the voltage difference at its two inputs, as well as for comparison of voltages as a comparator, comparing a reference voltage with a varying voltage without any feedback the operational amplifier is used as a comparator [4, 5].

Conductivity of water is an important factor in the design of this proposed device. Water resistance from a path in the voltage divider network, which switches ON or OFF the Schmitt trigger.

Loach W. (1981), revealed the conductivities of different sources of water. The conductivity of water according to loach W. depends on the movement of ions in the water. These ions are dissolved spaces carrying an electric charge. Hence, the higher the number of ions, the greater the conductivity [4, 5].

2.2 THE THEORY OF WATER CONDUCTIVITY

Water conductivity is a quantitative measure of the ability of water to pass electric current. The ability depends on the movement of ions [dissolved spaces carrying an electric charge] in the water. Generally, it can be said that the greater the numbers of ions specific type in the water, the greater will be its ability to conduct. It should be noted that conductivity varies with temperature. Earlier, Loach Walter (1981), in his book titled 'hand book of water purification second edition. [4, 5] explained the conductivity of different sources of water at 25^{0}C as summarized in tabular form below

Table 2.1(a) Conductivity of different sources of Water at25^{0}C.

SOURCES	CONDUCTIVITY IN μ-second/(cm)	P. H
Sea Water	51, 100	7.9
River Water	915	7-8
Well Water	570	7.3-7.9
Moor land Water	150	6.5-7.2
Water from arid Zones	1000-7, 000	7.5-8.5

It should be noted that the reciprocal of each of these conductivities, gives the resistivity in mega ohms per cm. for instance, the resistivity of river is 1/915M ohms/cm. Now for a unit length, the resistance can be evaluated to be

1/915× 10mega ohms = 109K ohms which have less conductivity as compared with treated water. [4]

This is because most of the conduction ions have been remove during the treatment process. Walter Loach in his book title 'Hand book of water purification' second edition, chapter four page 95, Table 4.3, revealed the conductivity and resistivity of treated water. The fact that water has different mode of treatment, their conductivity also differs. Walter Loach classified the treatment in grades. His work is reproduced below in Table 2.1 (b) Conductivity and Resistivity

UNIT	GRADE 1	GRADE 2	GRADE 3	GRADE 4
	Chemically and biologically pure water	Chemically pure water with trace organism	Purified water with trace dissolved solids and gasses	Purified water with trace dissolved solids and CO_2 as feed H_2O
Conductivity in µ-second per cm at 20^0C	0.055	0.055	2-1	5-2
Resistivity in mega ohms per cm at 25^0C	18	18	0.5-1	0.2-0.5

2.3 LEVEL MEASUREMENT TECHNIQUES

There are several level measurement techniques which can be employed nowadays. One of such techniques, is the electronic level controller (ELC) which is a device used in monitoring and controlling the level of media in a vessel. It can be used for predetermined level in indication with ON-OF control and for continuous level measurement in a wide variety of process medium applications.

Some types of water level measurement techniques are listed below:

- Gauge glasses, which are of two kinds, low-pressure type and high-pressure type.
- Float-operated hydraulic level gauge, with dual opposed hydraulic system.
- Gamma- ray level gauge, used for difficult applications.
- Capacitance probe-type level system for dielectric liquid.
- Gas gauge system for level measurement in a tank.
- Mercury manometer with two liquid seals at different levels in a tank.
- Force balance diaphragm type transmitter for level measurement.
- Trapped-gas system using diaphragm box, to minimize lead-line errors and venting [4, 6].

Water level instrument has ultimate utilization with advent of water tank and bid reservoir in the industries or public society of water distribution using hook gauge tape gauge, float gauge etc but the recent advanced techniques on water level measurement lead to the electronic system performing the task. By the introduction of microprocessors system in science and technology, large parts of systems mechanism, and large number of components can be integrated together. Nowadays, with low cost integrated and logic circuits, water indicator can be constricted.

CHAPTER THREE

SYSTEM DESIGN AND ANALYSIS

3.1 INTRODUCTION

This chapter contains the principles of operation and detailed circuit design and the analysis of the project, which also shows an in-depth look at various components and sub circuits that make up the system.

The circuit design and analysis consists of the different stages namely; the power supply unit, the sensing unit. These various steps are analyzed extensively.

3.2 PRINCIPLES OF OPERATION

An automatic water level indicator and pump controlling device with alarm operates based on the principle that water conductivity increases as the number of ions presence in the water increases which give rise to its greater conductivity ability. The conductivity of water also increases with the increase in separation distance of the measuring probes, placed at different predetermined distances (levels) from the lowest region of the storage vessel. [8]

This device produces alarm when water level is below the lowest level (L1) and also when water just touches the highest level (L2). The device is designed to display six (6) different levels. However, these display levels can be increased or decreased depending upon the level resolution required. This can be done by increasing or decreasing the number level detector metal strips (L1 to L6) and their associated components [8, 9]

The block diagram of the water level indicator is shown in the figure 3.0 (a) and the output is based on light display of light emitting diodes LEDs (6) according to the level of water in the tank, which is the input. Sensors are placed in the tank at different levels and equally spaced using a plastic tube which is supported at the bottom of the tank. If the water level is below the second lowest sensor (critical level), one LED (red) is driven with the remaining five LEDs (orange) extinguished. [10]

When the water reaches the second lowest sensor in the water, the critical level indicator (red LED) is when the water level increases and is just above the next sensor, another LED (green) is driven and so on until all the five LEDs are driven when the water level is just above the topmost sensor in the tank to signify that the tank is full.

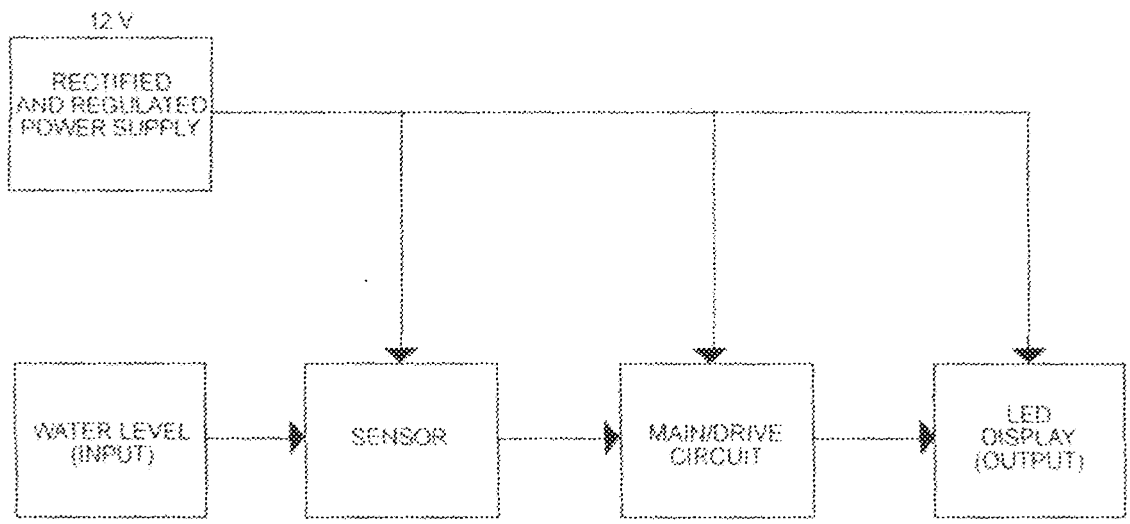


Figure 3.0 (a) Block diagram of the water level indicator design.

3.3 POWER SUPPLY UNIT

All electronic devices utilize a direct current (DC) voltage source for operation. The main electricity supply is an alternating current at a voltage of 230v AC. A circuit is therefore required to step down this voltage to the required value as well as to convert it to the direct current (DC) voltage form required by electronic devices for operation [10].

Although, batteries provide a cheaper source of direct current voltages, it cannot satisfy the amount of current drawn by most electric devices for a long time as the battery is quickly drained and thus becomes inefficient hence an AC to DC conversion is done by the power supply unit to avoid the inadequacies of the battery. [11]

The power supply unit consists of the transformer, a rectifier (bridge) a filter and a voltage regulator which all function together to transform the alternating current (AC) voltage supply from the mains into a regulated D.C supply as the output of the power supply unit. Figure 3 0(b) below show a block diagram of the power supply unit.

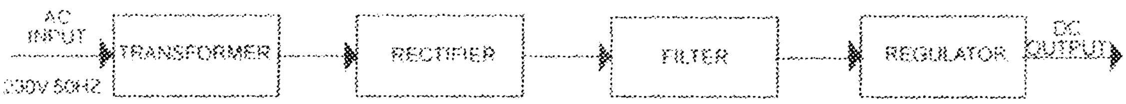


Figure 3.0 (b) Power Supply units block diagram.

3.4 THE TRANSFORMER SPECIFICATIONS

A 230 V_{rms} /18Vrms, 500mA transformer whose current capacity is enough to drive the entire circuit was used to step down the 230 V A.C supply to the desired 18 Volts (A.C).

The main function of a transformer is to step up or (mostly) step down A.C supply voltage to suit the requirement of the solid state electronic devices and circuit. Feed by D. C power supply. It also provides isolation from the supply which is an important safety consideration. The physical basis of a transformer is mutual induction between two circuits linked by a common magnetic flux. [8, 11]

In its simplest form, it consists of two inductive coils which are electrically separated but magnetically linked through a path of low resistance. The transformer achieves galvanic separation between the mains (AC input) and the DC output.

In a brief sense, a transformer is a device that;

i. Transforms electric power from one circuit to another.
ii. It does so without change of frequency.
iii. It accomplishes this by electro magnetic induction.
iv. Where the two electric circuits are on mutual inductive influence of each other.

Figure (3.1) shows the circuit symbol of a transformer.

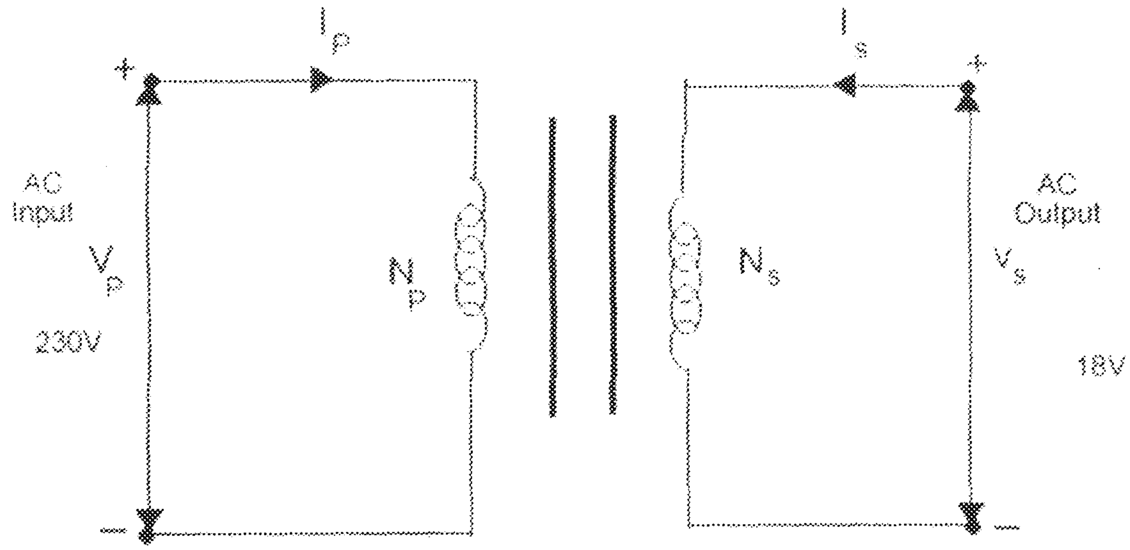


Figure 3.1 Transformer circuit Symbol.

From the transformer data

Vp =230V, Vs=18V, Is=500mA

The Frequency of the AC mains supply is 50Hz

The relationship between primary and the secondary voltages of an ideal transformer with its corresponding turn ratios is given as:

$$\frac{Vp}{Vs} = \frac{Np}{Ns} = \frac{230}{18} \approx 13$$

Hence the turns ratio Np: Ns=13:1

The magnetomotive force (MMF) =NI

Np Ip =Ns Is

$$\frac{Np}{Ns} = \frac{Is}{Ip} = 13$$

But Is=500mA

$$Ip = \frac{Is}{13} \quad \frac{500\times10^{-3}}{13} \quad \frac{0.5}{13} = 0.0385$$

Ip= 38.5mA

3.5 RECTIFIER SPECIFICATIONS

The full-wave bridge rectifier is the most commonly used rectifier circuit for several reasons;

1. It does not require the use of a centre-taped transformer.
2. it provides a high peak output voltage than full-wave rectifier does. This ultimately a higher DC output voltage from the power supply.

It consists of four discrete diodes as shown in figure (3.2) below. This was selected because of its availability, low cost and high breakdown voltage. [8, 13]

The bridge rectifier consist of two pairs of diode with a pair having its common anode terminal joined together while the other pair have its common cathode terminal joined in a similar way. Both pairs are connected together to the secondary terminal of the transformer as shown below

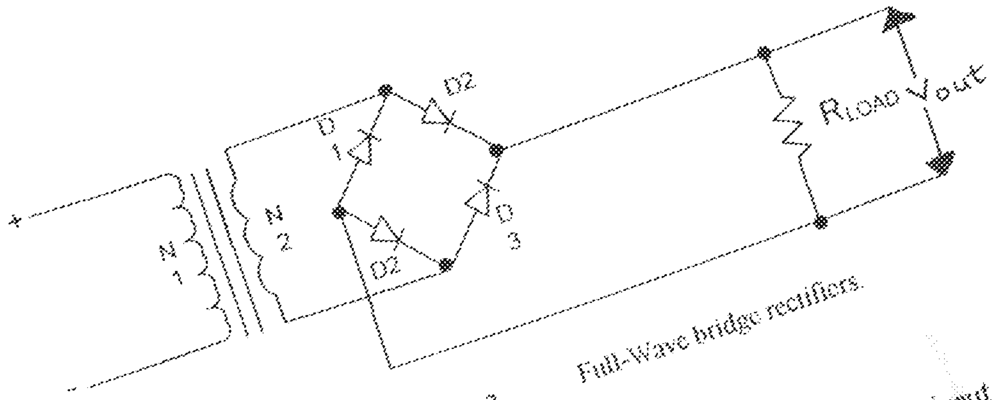


Figure 3.2 Full-Wave bridge rectifiers.

Therefore, two diodes which are always in series with the input voltage conduct simultaneously. For instance, during the positive half cycle of the transformer output diodes D1 and D3 conduct while D2 and D4 are reverse biased. Similarly, during the negative half cycle, D2 and D4 conduct while D1 and D3 reverse biased.

Hence current is sent into the load resistor through the same direcion as long as a pair of diode conducts.

In selecting diodes for the rectifier circuit, it is necessary to ow the peak inverse voltage of each diode. This is the voltage across a diode during thart of the cycle when the diode is reverse biased, thus, the peak inverse voltage across a diode is twice the maximum transformer secondary voltage. [3, 12, 15]

3.6 THE FILTER SPECIFICATIONS

A rectifier circuit is necessary to convert a signal having Zero average value into one that has non-Zero average value into one that has non-zero average. The output resulting from the rectifier is a pulsation dc and not yet suitable as a battery replacement. Such a voltage could be used in say a battery charger, where the average dc voltage is large to provide a charging current for the battery for dc supply voltages, as those used in computer and other electronic circuit, the pulsating dc voltage from a rectifier is not good enough. A filter circuit is necessary to provide a steady dc voltage.

The most popular filter circuit is the capacitor filter circuit shown in the figure 3.3 below.

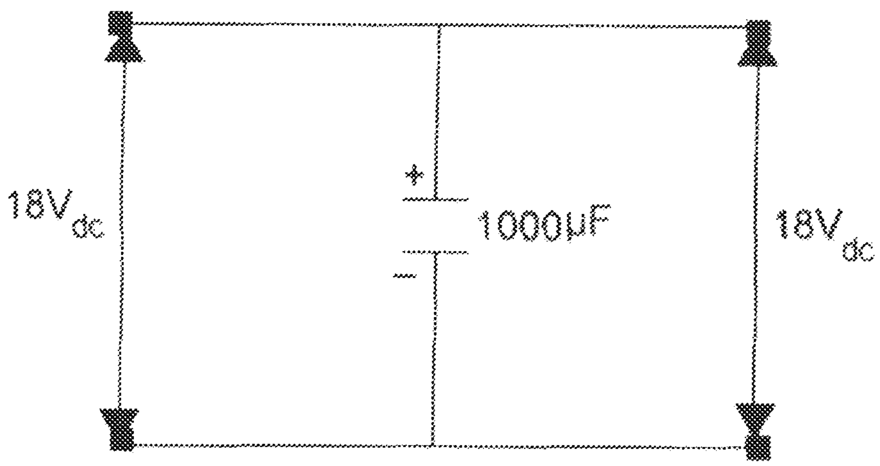


Figure (3.3) Filtering Capacitor circuit diagram.

A Filter capacitor with sufficiently large value is chosen to provide an acceptable low ripple voltage. The cyclic change in the output voltage otherwise termed ripple have its amplitude depending on the load current and capacitors value. The wave form at the rectifier output is shown in figure (3.4) below [11, 12]

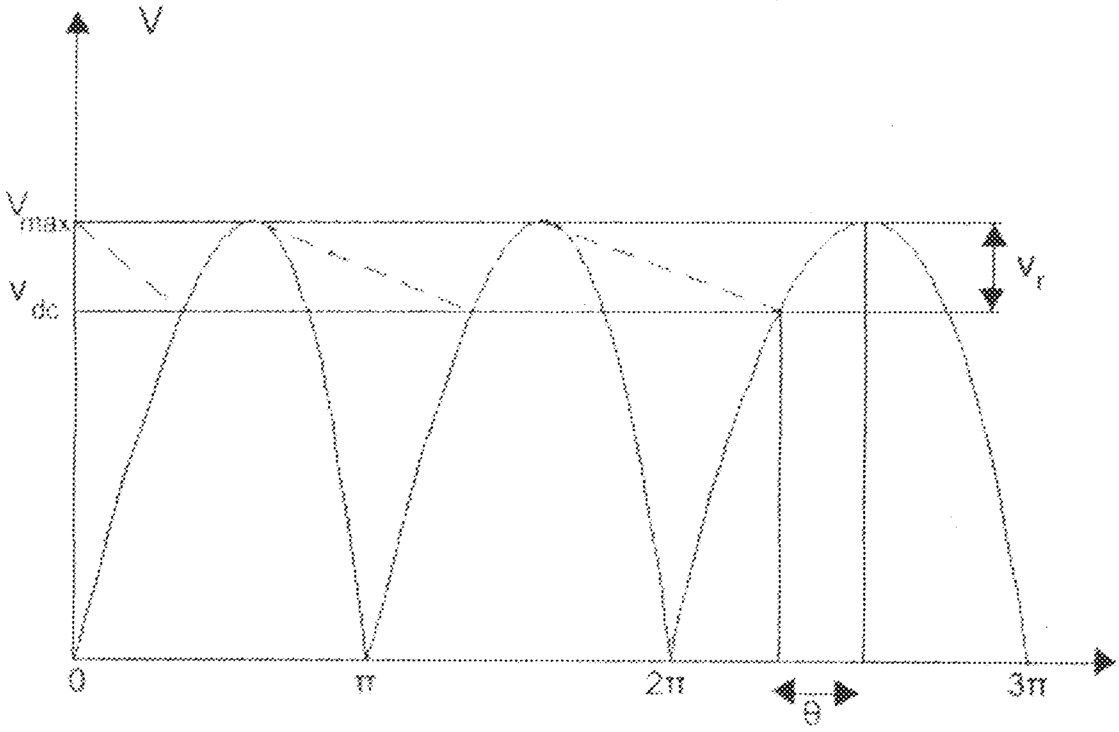


Figure (3.4) Wave form at the rectifier output.

Although, it is difficult to accurately determine the ripple amplitude because of the exponential decay of the capacitor voltage. However, a capacitor with sufficiently large value, the ripple amplitude will be small relative to V_{max} and the capacitor discharge over the full cycle (i.e. $\theta=0$).

Summary, a capacitor has the basic properties of opposing charges in voltages thus, a high value capacitor will tend to reduce the ripple magnitude, it has been found that increasing the capacitor value tends to:

1. Increase the magnitude of ripple voltage.
2. Reduce the magnitude of ripple voltage.
3. Reduce the time of flow of currents pulse through the diode.
4. Increase the peak current in the diode.

THE VOLTAGE REGULATION SPECIFICATIONS

The final circuit in the basic power supply is the voltage regulator. There are any types of voltage regulators. Many of these circuits contain the number of transistor an integrated circuit (IC) voltage regulator. IC units provide a fixed positive voltage, a xed negative voltage, or an adjustable set voltage.

n an unregulated power supply, the output voltage changes whenever input voltage or oad resistance changes. It is stable; voltage regulation is the changes in voltage from no-oad to full load condition. The purpose of the voltage regulator circuit is to reduce this variation to zero or the minimum possible value. The percentage regulation or simply regulation of power supply is given by:

$$\% \text{ Regulation} = \frac{V_{max} - V_{min}}{V_{max}} * 100$$

V_{max} = maximum dc output voltage.

V_{min} = minimum dc output voltage.

If the regulated dc supply is adequate, it is often necessary to make dc supply voltage to be constant as well as having a very low ripple amplitude. Thus, Zener diode is used to produce a stable output voltage. However, the stabilisation efficiency is increased by connecting the diode's cathode terminal to the transistor base as shown in figure (3.5) below; [8]

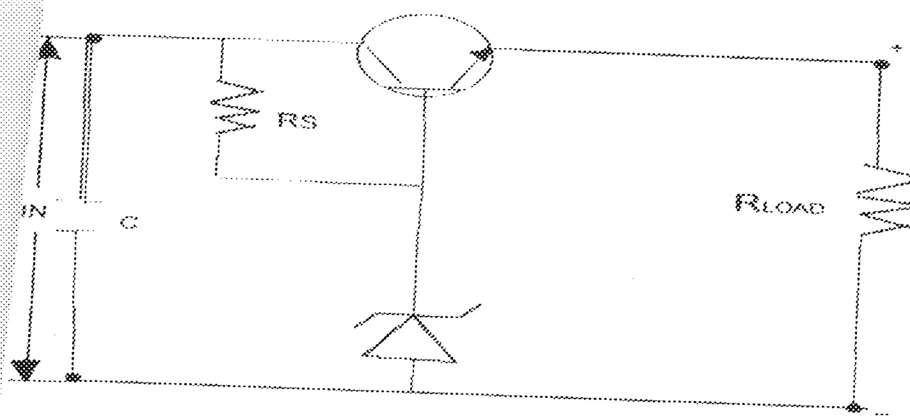


Figure (3.5) Filtering and voltage regulation Circuit.

In order to reduce the magnitude of current flowing in the diode, the transistor is connected as an emitter follower; the voltage at its emitter is approximately equal to the base voltage.

Meanwhile, the base voltage is specified by the Zener diode hence, the output is held constant within limits determined by the diode characteristics [11, 13].

3.8 DC ANALYSIS OF BIPOLAR JUNCTION TRANSISTOR

Most of the transistors used in this design are in common-emitter configuration. Hence, emphasis shall be given to its dc analysis. Below is a circuit for NPN common-emitter connected transistor for the purpose of analysis.

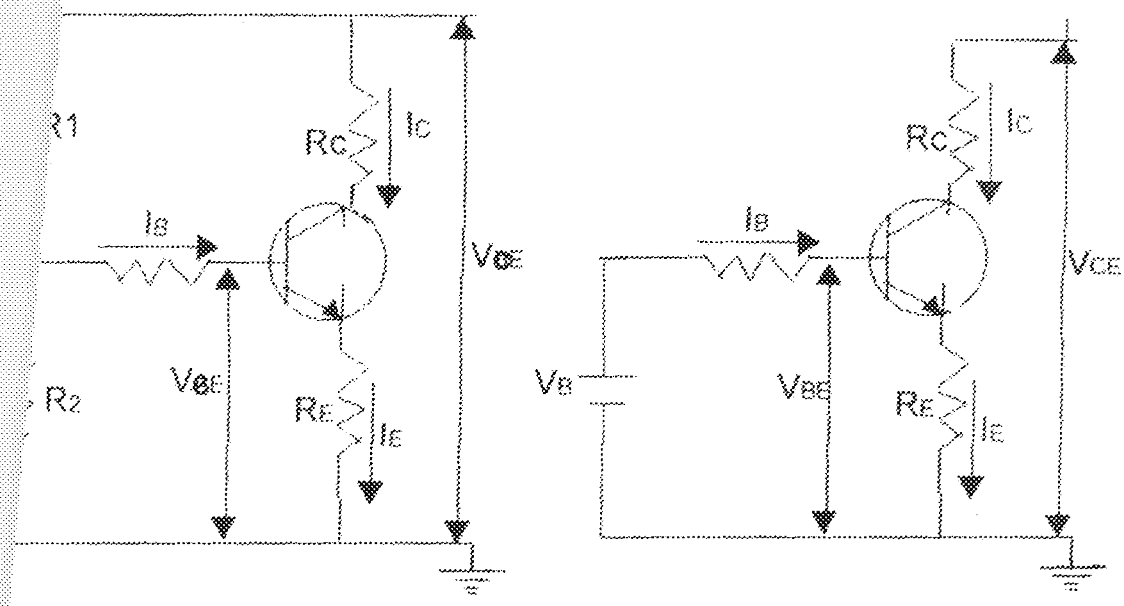


Figure 3.6 (a) NPN Transistor (b) Thevenin equivalent.

3.9 THE OUTPUT UNIT

The output device used in this project is the light emitting diode (LED) to give a visual indication of the water level and the alarm to call attention when water gets to the highest level in other to avoid possibility of water overfilling the tank and spilling away.

3.10 THE LIGHT EMITTING DIODE (LED) SPECIFICAATIONS

When sufficient voltage is applied to the LED chip across the loads of the LEDs, electrons can move easily in one direction across the junction, between the P and N regions. Each time an electron recombines with a positive charge; electric potential is converted into electromagnetic energy, for each recombination a quantum of electromagnetic energy is emitted in the form of photons of light. [8, 13]

Ordinary diodes are made of silicon, an opaque material that blocks the passage of light LEDs are different by using elements like gallium arsenic and phosphorous; a manufacturer can produce LEDs that radiate red, green, blue, orange, amber and white colours

The LED leads are identified with the anode lead being longer than the cathode lead and the cathode lead can be identified with a flat or notch cut on its lead plastic case side. The series resistance value (1 KΩ) required to limit current flow to the LED can be obtained from the relationship below,

$$R_{LED} = \frac{Vs - V_{LED}}{I_{LED}} \qquad (1)$$

Where; Vs = Supply voltage

V_{LED} = LED voltage

I_{LED} = LED Current

R_{LED} = LED Resistance

In the water level indicator, the LEDs [LED 1 and LED 2] are Red LEDs used to indicate when water is at low level. The orange LED 3 and LED 4 a red are used to indicate when the water is at the middle of the tank. The green LEDs [LED 5 and LED 6] are used to indicate when the water in the tank reaches a high level.

However, two additional orange LEDs and one Red LED are used to indicates when the power supply has reached the device as well as when the alarm is sounding and needs to be reset respectively.

To calculate the value of the current limiting resistor value for each of the Red LEDs, we have: $V_s = 9V$, $V_{LED} = 1.7V$, $I_{LED} = 30mA$

Using equation (ii),

$$\text{Recall } R_{R(LED)} = \frac{(9-1.7)}{30\times10^{-3}} = \frac{7.3}{30\times10^{-3}} = 343.33\Omega$$

Therefore R(green LED)=226.7Ω for each green LED.

How ever, in other to get approximately constant brightness, a preferred series resistor value of 1K Ω was used for all the LEDs.

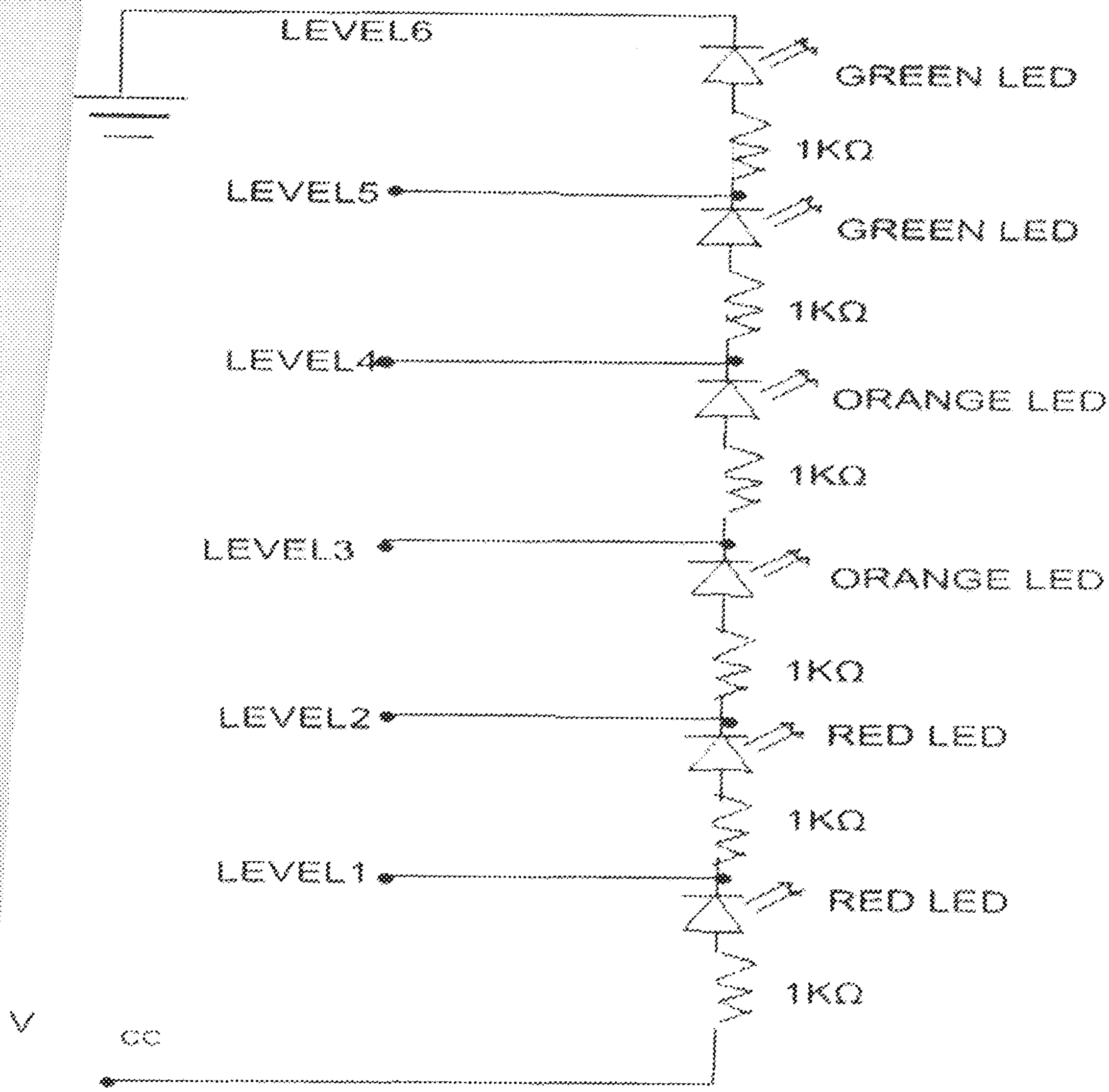


Figure 3.7 Light emitting diode arrangement.

3.11 THE WATER LEVEL DETECTION UNIT

The indicator unit consist of two main components namely, the transistor switch and the light emitting diodes (LED).

One of the most wide spread uses of Bipolar junction transistor is its application to switching circuits. Unlike an amplifier which usually aims at processing signals in analogue manner, without distorting wave shapes.

This transistor behaves like a switch when both junctions are forward biased in the saturated region and reverse biased in the cut-off region. Thus, the base emitter threshold voltage (VBE) determines the switching state of the transistor circuit. Any input less than the base-emitter voltage leaves the transistor in cut-off region [8].

When the switch is off, the circuit is opened no current flows and the full voltage is across the switch. As the input voltage increases, the transistor passes through its active region and eventually becomes saturated. This is the 'ON' state in which the circuit is closed, full current flows and there is no voltage drop across the switch.

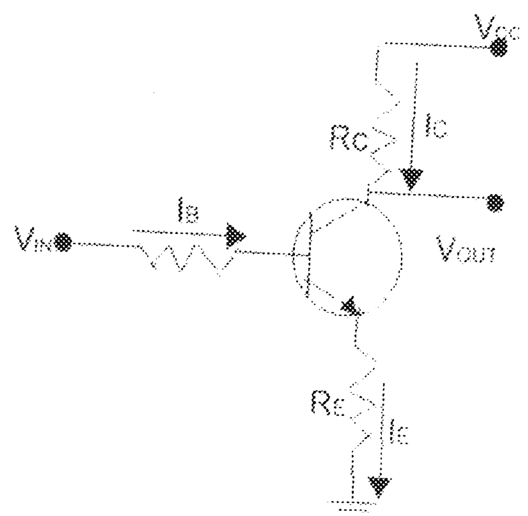


Figure 3 8 Functional diagram of a transistor switch.

Sic identical NPN transistors are used in the switching circuit of the indicator unit as shown in figure 3.9 later.

Application of positive voltage to the base of the transistor causes current to flow through the collector to the emitter and light up the LED. The magnitude of the collector current flowing is approximately equal Vcc/Rc as the transistor is in saturation and VCE approximately equals Zero.

It is necessary to determine the maximum value of base resistor RB, which will be enough for the transistor to operate in saturation over the full range of β (gain). However, it is noted that β varies for different specimen of a given type of transistor depending on the collector current, collector to emitter voltage and temperature. When β drops at low collector to base voltage, same extra base current is necessary to bring the transistor into full saturation. Hence the base resistor is conservatively selected to get plenty of excess base current at maximum value of β [ ] D 438 NPN transistor used as a switch has the following parameter,

I_C = 0.8A, VCE 0.4V, β=125, VCC=12V,

Hence, IB=IC/β =0.8/125 = 6.4mA

$$RB = \frac{12-0.7}{6.4} = 1.875\Omega$$

Thus, the total resistance to the base of each transistor should not exceed 1.9K Ω. However, 1K Ω fixed resistor is selected since the tank and content has their own resistance that is necessary to be considered. The higher the value of β will not affect this value as there is enough base current to derive the transistor into saturation.

This thyristor and relay form a complementary switch. Hence when the thyristor

·d 'ON', the relay is de-energized when the thyristor is 'OFF', the relay is

ed. [15]

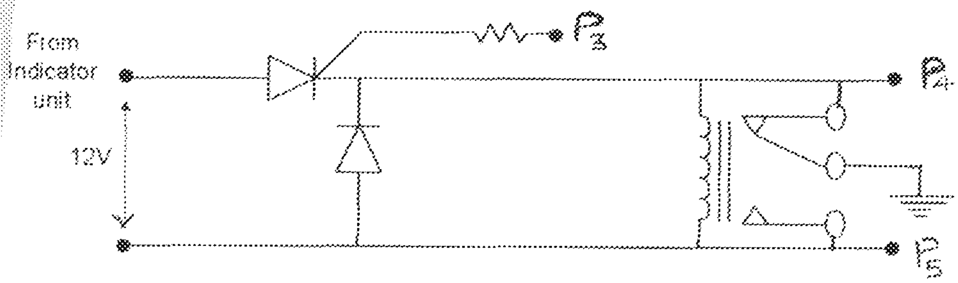


Figure 3.10 Pump Control Unit

he PIV rating of the diode should be grater than the coil applied voltage (12). Hence a

diode of PIV=50V is selected.

3.13 THE ALARM UNIT

The alarm unit consist of a transistor switch, diode, current limiting resistor, relay and output transducer.

Figure 3.13 below shows the circuit diagram of the alarm unit.

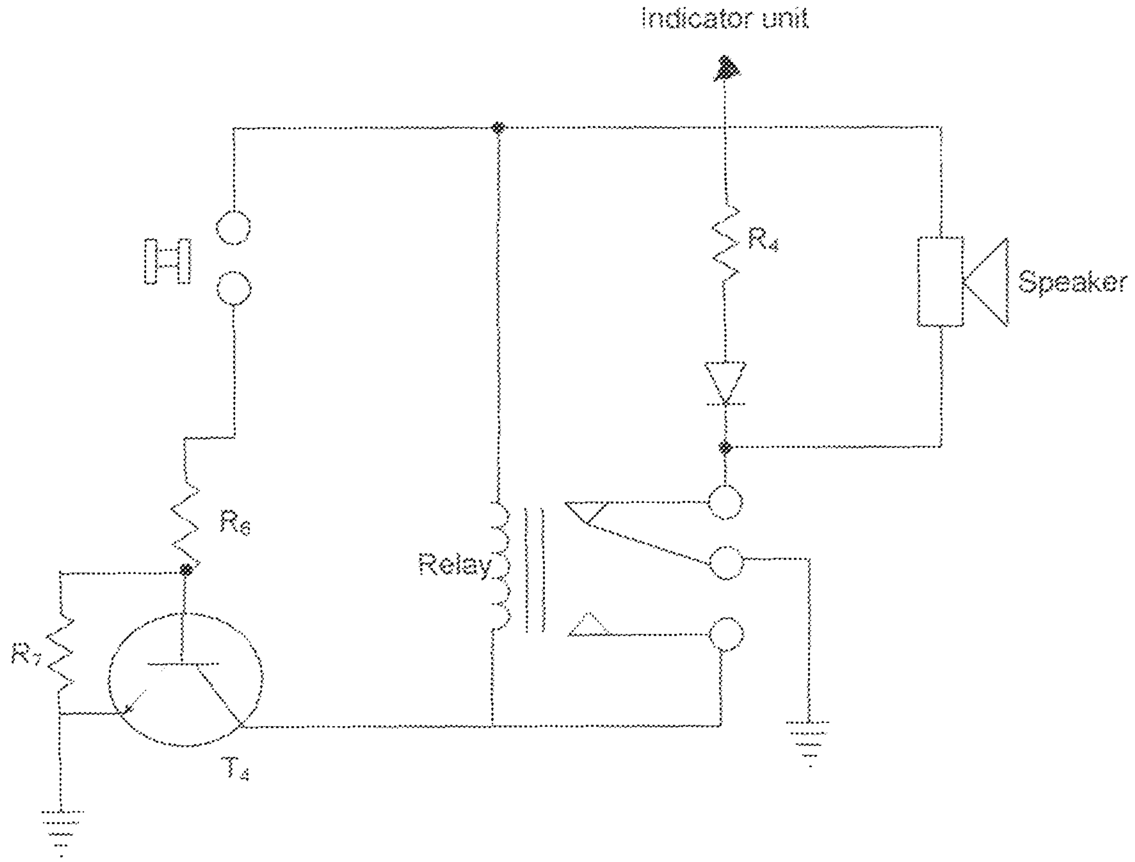


Figure 3.13 Circuit diagram of the alarm unit.

This unit is designed to give an audible tone indicating that the required level of water has been reached and to call the attention of the operator to turn off the tap or water pump in other to stop the supply of water to its container if the motor fails to stop automatically in case of any little problem or fault. [8, 10]

When the energizing current of a relay coil is switched off, the energy in the relay coil magnetic field produces a back e.m.f., which in turn could cause a damaging induced current surge through the circuit. To protect the circuit from this damaging effect, a diode is connected in reverse direction with respect to the relay driven polarity, such the relay coil dissipates its energy across the diode.

CHAPTER FOUR

CONSTRUCTION, TESTING AND RESULT.

4.1 CONSTRUCTION TOOLS AND MATERIALS.

The tools and materials as well as instrument used during the testing and the construction the construction of the project are briefly described below.

i. The simulation: the circuit diagram was tested on the computer using the circuit maker software for the simulation, the output voltage required to illuminate each of the light emitting diodes was measured to know, if the value will be sufficient to illuminate the LEDs, the waveform at the outputs was also viewed using problems.

The circuit diagram functioned as desired.

ii. The Breadboard: this is a temporary board for circuit testing with tiny sockets that allow for electric components (e. e. resistors, capacitors, Diodes, transistors e. t. c.) to be easily plugged or removed freely without damaging the component. The bread board is meant for pre-constriction testing of circuit and sub-circuits before the components are soldered on the Vero board.

iii. Analogue/digital multimeter: these were devices (instruments) used for measurement of electrical quantities such as resistance, voltage and current. They are also capable of being used to test circuit sections for continuity. The digital multimeter gives a digital output display of measured quantities while analogue meters give an indication of the value of measured quantities on a scale, the value of which is used on the position of the pointer on the scale.

The Vero Board. This is a perforated board on which electronic components can be inserted and soldered permanently. It is used for permanent construction of the proto-type from the circuit diagram.

Wires and connectors: Wires are used during the testing stage of the project on the breadboard to connect the component together as well as the different sub-units of the circuit, as well as during the soldering of the components on the Vero board. The type of wire used is the copper wire.

. Wire Cutters/Strippers: These tools are used to cut wires to the desired size required before use, as well as to strip off insulation of the wire in other to expose the conductor for proper and neat soldering.

vii. Soldering iron: This is a low power heating element typically 40watts. It provides the heat needed to melt the lead, so that it can be used for the connection of the components permanently on the Vero board. It usually connected in the A. C mains.

viii. Soldering lead: This is a metal (lead) wire of low melting point. It is used to electrically connect components and wires in fixed positions on the Vero board

ix. Lead Sucker: This is used to suck off excess molten lead from the Vero board to prevent short circuit (bridging) or undesirable electrical connections.

4.2 CONSTRUCTION DETAILS

The entire circuit was divided into different sections for easy trouble shooting and construction each of these units are soldered on different Vero boards.

CONSTRUCTION OF THE POWER SUPPLY UNIT.

A switch was connected to the primary of the 12V transformer for the control of .C power supply to the transformer, the secondary of the transformer was then ected to the bridge rectifier circuit formed by connecting four IN4001 diodes, the μF/50V capacitor was then connected between the output of the bridge rectifier and ground. The input pin of the 12V voltage regulator was then connected to the output pply after the capacitor and the second (terminal) pin connected to the ground terminal, output voltage was then obtained by connecting a wire to the third terminal of the oltage regulator a 1000μF was then connected on a continuous line in the Vero board, to btain the 12V DC output voltage.

.4 CONSTRUCTION OF THE WATER LEVEL DETECTION UNIT.

The water detection unit was constructed using copper wire conductors which were cut into seven numbers of different lengths. These were then positioned at different height/levels passing through holes at the height level made on a plastic conduct pipe. A connecting wire for the reference voltage was then connected to the reference probe placed at the lowest level.

The low middle and high level probes were then positioned and passed through the holes made in the plastic conduct pipe at the desired and predetermined level.

CONSTRUCTION OF THE ALARM UNIT

The design is incorporated with an alarming system which beeps to indicate the at which water is in the tank. It is also designed in such that when there is no water or overflow as a result of a fault within the system the alarm beeps to indicate no er flow.

CONSTRUCTION PRECAUTIONS

1) All soldered joints (points) were tested for continuity so as to avoid unnecessary open circuits.
2) All the excess leads were removed to avoid bridges (short circuits) on the boards.
3) Polarities of the electrolytic capacitors and LEDs were properly checked to be correctly positioned before connecting (soldering) on the Vero board.
4) Excessive heating of the components was avoided so that they do not burn by making the soldering process to a component very brief.

4.7 TESTING AND RESULTS

After all the components were arranged on the breadboard, they were tested to ensure the required output. The components and connecting wires which were soldered were tested for continuity using the continuity alarm tester of the multi-meter. The soldering joints were properly checked and errors detected were corrected by appropriate soldering and de-soldering actions.

At the end of the soldering operation, each unit was tested at every stage and the results obtained were adequate.

The device was set up by placing the water level sensors in the tank and connecting the power supply appropriately. A bowl of water was also provided. With the power supply connected, and no water in the tank, the red LED (L6) is turned on. When water was poured into the tank to reach the sensor (2), one green LED was turned on, and as water increased to sensor (3), another green LED (2) was also turned on and continuous increase in water level up to the highest level (sensor 6) would cause all the six LEDs to glow (L1-L6) and the alarm began to give an output sound.

Table 4.1 below shows a summary of the water level test and results obtained.

INPUT [WATER LEVEL]	OUTPUT					
	RED LEDs		YELLOW LEDs		GREEN LEDs	
	LEVEL1 (L1)	LEVEL2 (L2)	LEVEL 3 (L3)	LEVEL4 (L4)	LEVEL5 (L5)	LEVEL6 (L6)
AT SENSOR 1	ON	OFF	OFF	OFF	OFF	OFF
AT SENSOR 2	ON	ON	OFF	OFF	OFF	OFF
AT SENSOR 3	ON	ON	ON	OFF	OFF	OFF
AT SENSOR 4	ON	ON	ON	ON	OFF	OFF
AT SENSOR 5	ON	ON	ON	ON	ON	OFF
AT SENSOR 6	ON	ON	ON	ON	ON	ON

6	ON	ON	ON	ON	ON	ON

4.8 PROBLEMS ENCOUNTERED

i. When the project was first tested, the response was not satisfactory, the probes were then positioned to be directly above the reference probe and the reference voltage to the reference probe was adjusted. On testing again, a satisfactory result was obtained with the LEDs illuminating as expected and the alarm output being as desired.

ii. The initial stage of soldering was characterized by some mistake such as over flow of molten lead. But with time this difficulty was over come.

4.9 PROJECT CASING.

The project casing is made of plywood, which was carefully constructed to make provisions for the probes and the speaker, the power supply switch and the light emitting diodes. The casing is of dimension (21cm×9cm×9.5cm) as depicted by the photograph attached below.

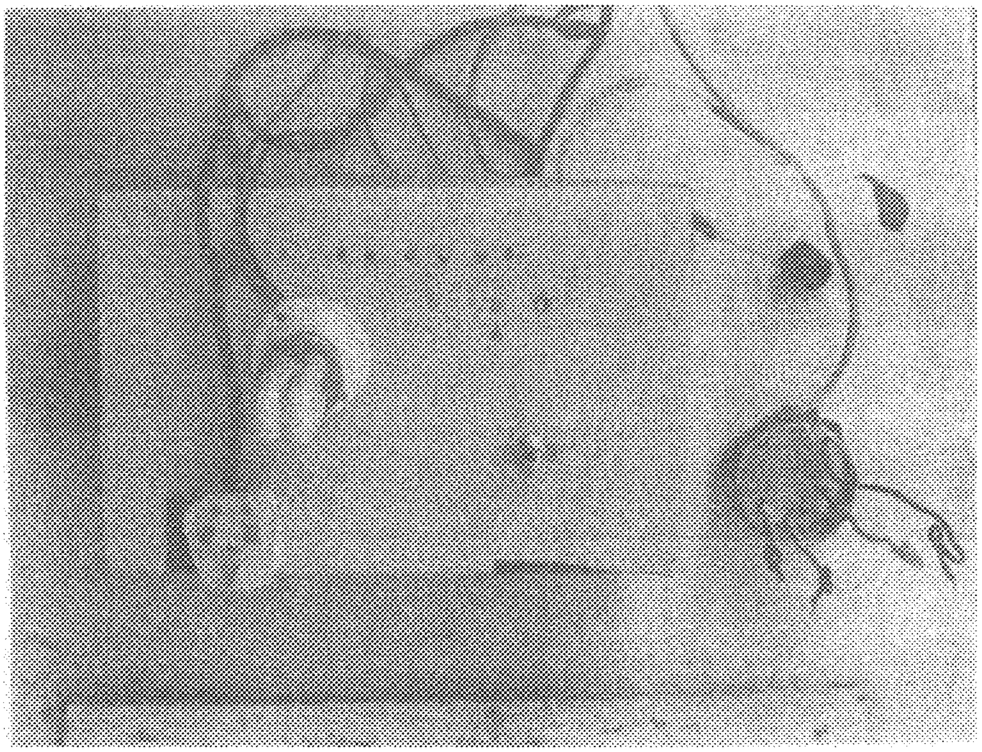


Fig 4.1 Project casing

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

From the results of the tests carried out after the construction of the project, the water level indicator was able to detect when the water in a tank or reservoir is at different levels up to the top of the tank. Hence the aim of the project has been achieved.

The components used in constructing the device are readily available. The device constructed will be useful in our homes, in the industries, hospitals, schools, etc to provide knowledge of the water quantity available for use.

5.1 RECOMMENDATION

In the construction of the project, the output unit consists of six (6) LEDs to indicate the level of water in the tank or storage level. This can be improved on by incorporating a display unit to display the volume of water in the tank on a seven segment display if the dimensions of the tank are known

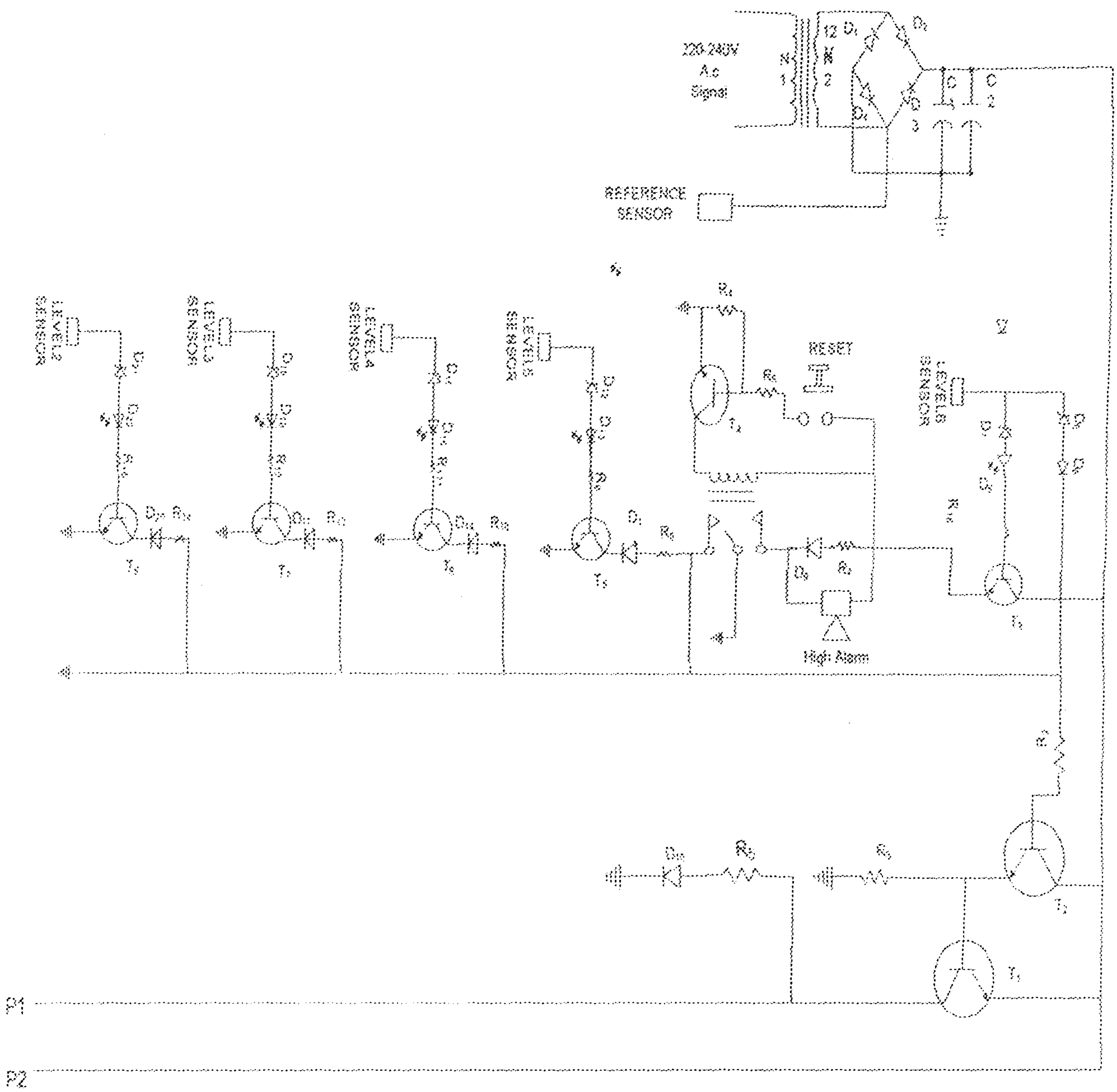
It is a known fact that water is capable of making a copper wire to rust which reduces its conducting ability. Since probes used in the construction of this device are mainly copper wires, the need to silver coat the un-insulated part of the wire cannot be over stressed. I there therefore recommend that the probes should be silver coated to prevent rusting.

I recommend that the water supplied should have high conducting ability and the power supply LED indicator must be checked ON to ensure that there is supply to the device.

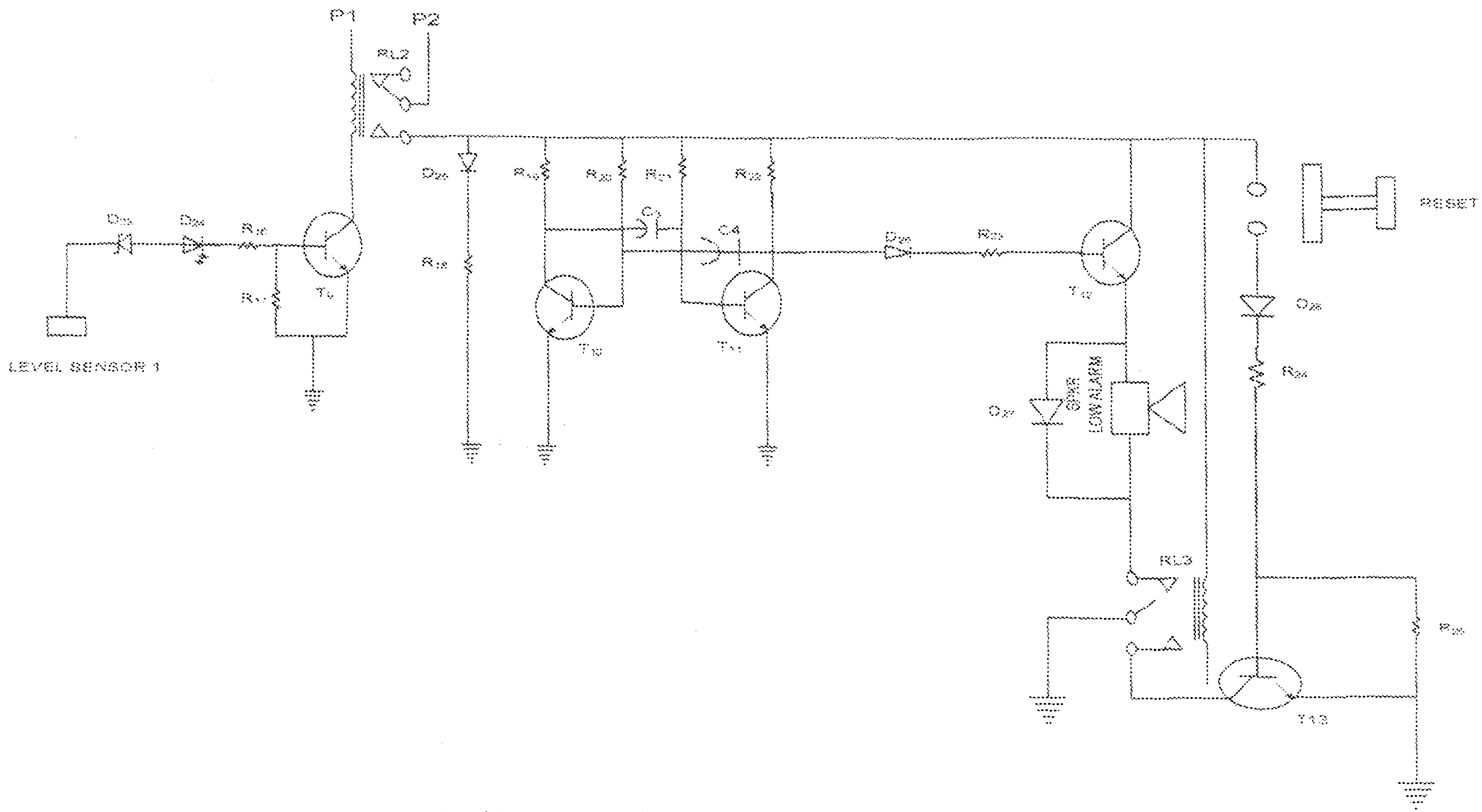
TABLE OF MATERIALS USED

COMPONENTS	TOTAL QUANTITY	DESCRIPTION
Transformer (12V)	1	Step-down Transformer
T1 and T9	1 and 1	A684 PNP transistor
T2 – T13	11	D438 NPN transistor
D12, D14, D16, D20, D22, D5	6	6 2V Zener diode.
D1-D27	21	IN5391 diode
R1-R12	12	1.5KΩ Resistor
R13-R18	6	1 KΩ Resistor
R19-R22	3	2.9 KΩ Resistor
R20 and R21	2	400 KΩ Resistor
R23-R25	3	1.5 KΩ Resistor
RL1-RL3	3	12V Relay
C1, C4	2	1000μF Ceramic Capacitor
C2	1	1000 μF/16V Electrolytic Capacitor

C3	1	1000 µF/35V Electrolytic Capacitor
C5	1	220µF/50V Electrolytic Capacitor
PL1	1	Mains plug and cable
S1	SPST	Push button
SPKR	2	8Ω, 0.5W Speaker
Miscellaneous	1	Wire, Vero Board, sockets, and conduit pipe probes.



(a) Circuit Diagram of an automatic water level indicator and Pump controlling device with alarm



(b) Circuit Diagram of an automatic water level indicator

and Pump controlling device with alarm

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