WATER LEVEL INDICATOR WITH AUDIO ALARM

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OCTOBER, 2006.

DECLARATION

I OLATINWO OLUWABUNMI KHADIJAH, declare that this work was done by me and has never been presented elsewhere for the ward of a degree. I also hereby relinquish the copyright to the Federal University of Technology Minna.

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DEDICATION

I dedicate this project to the Almighty ALLAH (SBUH), who by His Grace this project work is carried out successfully, and to my lovely parents for seeing me through.

ACKNOWLEDGEMENT

Praise be to Almighty Allah, the Beneficent, the Merciful, for giving me good health, protection and guidance.

My sincere appreciation goes to my project supervisor Engr. M.S Ahmed for his assistance, guidance and encouragement.

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My profound gratitude goes to my parents Dr and Mrs. A.A. Olatinwo for seeing me through a successful academic achievement of my academic program. Also to my brothers and sisters for their moral support, to my Vida thanks for being there your love is highly appreciated.

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ABSTRACT

The use of water level indicator is frequently encountered in many industries and public water containers. Effective handling of the system is very necessary; thereby the need arises for us to make it available and at low cost.

Logic gates are the processing tools. The aim of five steps water level indicator with audio alarm is to tell the user the state of the tank. This requires knowing the volume of the tank. The probes are located at each fifth of the tank volume. Better precision of the water level in the tank can be obtained by the use of more probes.

This system can be used specially in public water container to prevent sudden water interruption in a town.

The Circuit consist of Oscillator, Water probes, Input amplifiers, Inverters, Level blinking indicators, Blinking/switching transistor, Logic mixer, Audio alarm unit and Power unit.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

This project is based on the design and construction of a five-step water level indicator with an audio alarm, which enables the monitoring of the level of water in a storage tank.

The project provides a suitable and simple electronic means of reading the level of water in tanks. It is accompanied by external water detection capability and the design involves five water probes one serves for the empty, one-quarter filled respectively. Each of the probes involves two metallic conductor pointers are separated with a small gap. The sensors work with the basic principle of water ionization. When the early two metallic conductor pointers are submersed in water, the gap between them are/is electrically bridged, so that the two behave partially like same body.

The design holds a control unit that logically identifies any submerged water probe. The probes are logically arranged alongside the wall of the tank, and location of a particular probe is significant to a familiar level. The control unit is attributed to an output that switches on some specific light indicators to show the level of the water in the tank. The design posses some interesting interactive features, for instance there is always a specific alarm for an empty condition i.e when the water probes are dry and another for a filled condition. The effect is designed to stop the flow of further water into the tank to cut wastage. There's a switch for muting the alarm's output, but the light indicators still provides a visual, easy and comprehensive manner of getting the level of water in a tank known.

The related integrated circuits are based on complementary metallic oxide (CMOS) technology therefore a low power consumption electronic device is quite visible. The probes require a long cable connection to the main circuit package for ease in read-out. Concisely the circuit is designed with easy-to-get, cheap and highly compact or minimum number of electronic component.

1.2 OBJECTIVE OF THE PROJECT

The main objective of this project is to design, construct and test an electronic water level indicator with audio alarm. To provide a useful and easier manner of knowing the quantity of water left in a storage tank.

1.3 PROJECT LAYOUT

The first chapter contains the introductory concept of the entire project, objective and motivation.

The second chapter includes the literature review, chapter three covers the design and analysis of the project also the calculations leading to the choice of the component is carried out.

Chapter four is assigned with the construction techniques, testing, results coming out the ended work. The results of the project are also discussed. The fifth chapter includes recommendations and conclusions.

CHAPTER TWO

2.1 LITERATURE REVIEW

Water (from an old English word "waeter"), in it's pure form is a tasteless, odorless substance that is essential to all known forms of life and is termed as a universal solvent [3]. It appears colourless to the naked eye in small quantities and sometimes appears as blue in large quantities or with scientic instruments. Water fit for human consumption is called drinking water or portable water, and when it's not specifically made for drinking but is not harmful to human when used for food preparation is called 'Sule' water [3].

Water is very important to live, therefore it's storage is dated back to the beginning of man's existence, but the ability to provide an accurate and easy manner of getting the quantity of liquid in a storage facility known, grew with time and experience.

The earliest and easiest way of knowing the quantity of water in a storage tank is through eye sighting, mere looking at an exposed container simply tells off the amount of water inside. It was a general practice for many decades even till today, but, as the storage cans got larger and larger due to increasing need for water, the chance of mere looking at the water level was reduced. For long, this stood as a problem for lager tanks, but by the time transparent and translucent materials took the place of traditional ceramic materials for the construction of water storage facilities, the eye-contact method was still getting useful.

Moreover, in situation whereby the container are made of oblique material, people started feeling the outside walls of the container to gauge through respective sectional temperature since the level or section with water is cooler than where there's no water.

This leading method is still in use today; the technique is most suitable for metallic containers, which is due to better temperature conductivity of the material. Some other people dip a clean flexible rod into the concerned tanks so that the level of water in it can be known through the wet section of the rod. This crude method is especially done to underground tanks with at least a single exposed outlet.

Mechanical water gauging devices were in sue before 20^{th} century [1] they were designed with a floating light ball-shape object on the water level and with the use of additional mechanical links and attachments, the level of the object inside the tank could be observed. The instrument was quite effective but the problem was high initial cost of the device. Even the operation time span was greatly minimum.

After the discovery of a reliable and practical solid-state electronic in the early 60's [1], the gauging of a liquid in its storage tank went more electrical than mechanical, although, some recent applications involve electro-mechanical configuration which is very obvious in automobile fuel tank system. The system holds the sender unit and indicator, the main aim is to show or display the quantity of liquid in a tank.

In the sending unit [4], there's usually a float connected to a long variable resistor. When the tank is full, the resistor is set to its low resistance value. As the tank empties, the float drops and slides a moving contact along the resistor increasing its resistance, finally reaching its highest value when the tank is empty. Meanwhile, the indicator unit (usually mounted on the instrument panel) is measuring and displaying the quantity of electrical current flowing through the sending unit when the tank is high, when maximum current flows, the needle points "F" indicating a full tank, and when the tank is empty the least current is flowing and needle points to "E" indicating empty tank.

The system is a fail state. A fault that opens the electrical circuit causes the indicator to show the tank as being empty. This technology is not suitable for conductive liquid such as water, this is because a short circuit is very possible, and therefore the altogether unit is not applicable. The design is more useful for non-electrical conductive liquid such as "Petrol".

The water-gauge application [2] that involves the electrical conductivity of water is merely the best. Water sensors are placed at different important levels at the tanks, these simple devices are designed to short circuit due to the electrical conductivity of water, therefore signal from the sensors are fed into a central electronic unit that interprets the inputs as a visual information.

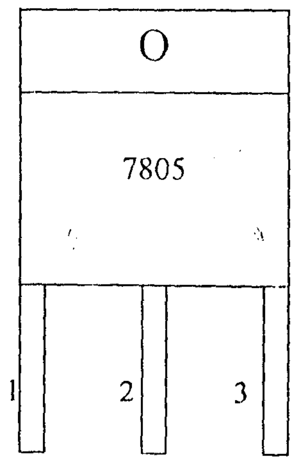
Modern devices involves computer interfacing in which, its operators can monitor the quantity of water in their storage tank through computer system. Good application softwares can incorporate into the set-up to calculate the rate of water usage; even some are designed to control the flow of water into a tank.

The usage of electronic water sensors is quite diverse. They can be used to monitor water leakage of a tank as well. This application is fixed for external not internal use as relative to the storage tank.

2.2 DESCRIPTION OF THE MAJOR COMPONENTS OF THE DESIGN

2.2.1 7805 (5V REGULATOR)

The 7805 is a three-terminal positive regulator that is available in the 10-220 ID-PAK package. It employs internal current limiting thermal shut down and safe operating area protections, making it essentially indestructible at abnormally high voltage supply. If adequate heat sinking is provided, it can deliver over 1A output current, although designed as fixed voltage regulators, the device can be used with external components to obtain adjustable voltages and currents.



	Function
1	Vin
2	Ground
3	Vout

FIG. 2.2.1 THE PIN ASSIGNMENT OF 7805.

2.2.2 2SC945

The 2SC945 is a NPN bipolar transistor designed for use in driver stage of Audio frequency (AF) amplifier and low speed switching applications.

It's features includes [4]:

* High voltage LV_{CEO} = 50v min.

* Excellent h_{fe} linearity

$h_{fe}1 = (o.1MA/h_{FE}\ 2(1.OMA)) = 0.92$ typical.

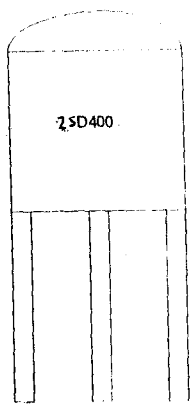
The absolute maximum ratings involves:

- Maximum temperature
- Storage temperature – 55 to +150°c
- Junction temperature + 150°c maximum
- Maximum power dissipation (TA = 25°c)
- Total power dissipation 250mw
- V_{CBO} collector to base voltage 60mv
- V_{CEO} collector to emitter voltage 50v
- V_{EBO} emitter to base voltage 5.0v
- I_C collector current 100mA
- I_B base current 20mA

Moreover, the average current gain (h_{fe}) of the device is 170 at about 30°c. Temperature easily influences the current gain of the device.

2.2.3 2SD400

It is a NPN epitaxial planar silicon transistor. It is complementary of 2SB544 (it's PNP equivalent), it posses maximum collector to base voltage V_{CBO} and collector to Emitter voltage V_{CEO} of 25v, that of emitter to base voltage V_{EBO} is 5v. This device handles maximum collector current I_c of 1A but it reaches 2A when it is pulsed, therefore, it possesses a peak power output of 900MN and the effective operating temperature is 150°c.



2SD400

FIG. 2.2.3 THE PIN ASSIGNMENT OF 2SD400

2.2.4 4060B

It is a 14 – stage counter/oscillator CMOS integrated circuit (IC) and is designed for multiple frequency application. The single device generates ten different frequencies at once through internal logical dividers and the 16 –Pin electronic oscillator operates both in the RC and crystal modes. The latter mode provides an effective output in stability also the RC mode is usually used for simple applications e.g time delay circuits, counter controllers and frequency dividing circuit.

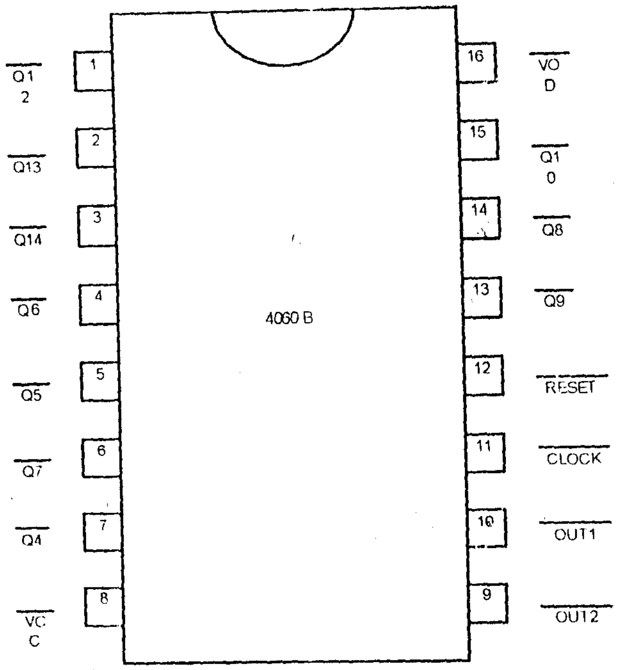


FIG. 2.2.4a THE PIN ASSIGNMENT OF 4060B

The chip posses a reset function on it's pin 12, which places all outputs into zero state and disables the oscillator. A negative transition on clock input (pin 11) will advance on the input line permits very slow input rise and full times.

CLOCK	RESET	OUTPUT STATE
↑	L	NO CHANGE
↓	L	ADVANCE TO NEXT STATE
X	H	ALL OUTPUTS ARE LOW

X – DO NOT CARE

FIG. 2.2.4b TRUTH TABLE OF 4060B

The pin 12 of the integrated circuit must be logic 'o' or grounded for it to work. The output involves ten frequencies from internal logical division of a particular or main frequency. The value of the main frequency depends on the value of the connected resistors and capacitor.

The following relationship estimates the value of the main frequency [5]:

$$F_m = \frac{1}{2.3R_{tc} \cdot C_{tc}} \qquad (1)$$

If $1KHz \leq f \leq 100KHz$

And $2Rtc \leq Rs \leq 10\,R_{tc}$

(f in Hz, R in ohms, (in farads)

The formula may vary for other frequencies recommended at maximum value of the resistor in 1mΩ. Therefore, due to internal division, the frequency at each output pin given by [5]:-

$$F\ pin\ \ x = \frac{F_m}{2^Q} \qquad (2)$$

For instance, the frequency output from pin 1 is given by

$$F\ pin\ 1 = \frac{F_m}{2^9}$$

This formula is applicable for other pins by taking into consideration the Q value of the pin. Moreover, like other 4000 series CMOS integrated circuits (I C's), 4060 works with voltage range of 3 – 18v, which is fully static in operation. Diode protection is incorporated into all it's input and it's outputs are capable of driving two 100 – power TTL loads or one low-power schottky TTL load over the rated temperature range.

2.2.5 4069VB

This complementary metallic oxide semiconductor (CMOS) holds integrated circuit (IC) which holds six inverter gates. It is usually called Hex NOT gate integrated circuit.

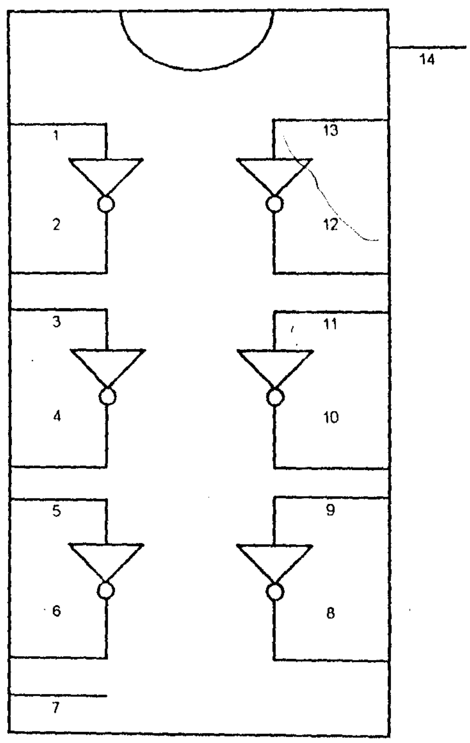


FIG. 2.2.5a THE PIN ASSIGNMENT OF 4069

Power is supplied to the integrated circuit through pin 14 and 7, the positive and negative terminals respectively. The other pins serve the internal or built in inverter connections.

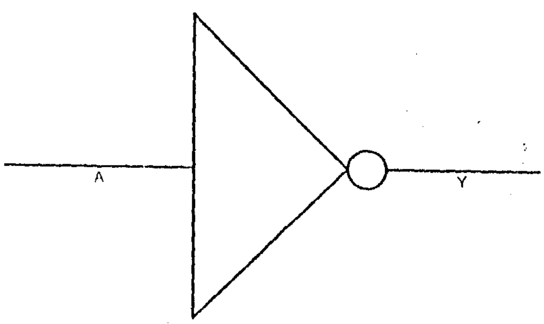


FIG. 2.2.5b AN INVERTER GATE

A	Y
0	1
1	0

FIG. 2.2.5c THE TRUTH TABLE OF AN INVERTER GATE

A NOT gate inverts the input logical level to the output.

2.2.6 4081B

This is a quad -2-input AND gate package, that is it possess four 2 – input AND gates. It is 14 –pin integrated circuit (IC).

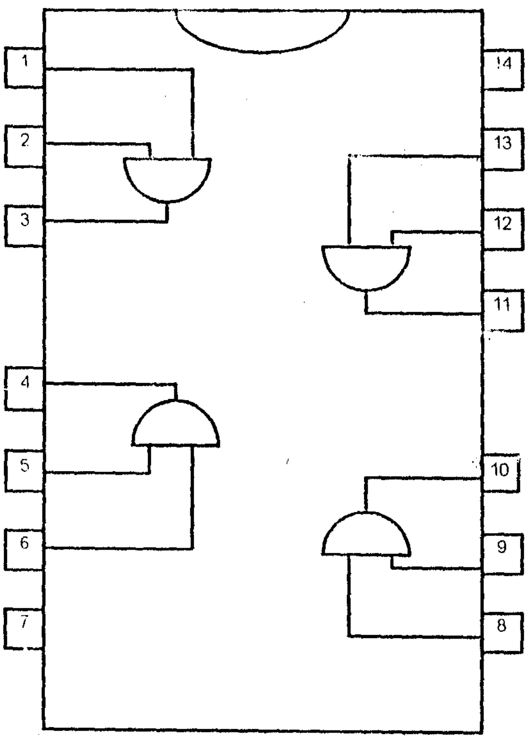


FIG. 2.2.6a THE PIN ASSIGNMENT OF 4081B

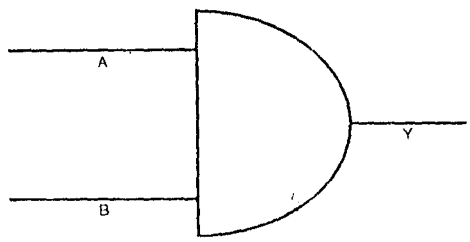


FIG. 2.2.6b THE SYMBOL OF 2-INPUT AND-GATE

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

FIG. 2.2.6c THE TRUTH TABLE OF 2-INPUT AND-GATE

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 INTRODUCTION

The project is designed for low-power consumption and low-initial cost, it's all about economizing. Therefore, the suitable and major electronic component class (or integrated circuit group) for the task is 4000 series. 7400 series doesn't fit this purpose due to higher power consumption and low compatibility. Although the later is faster than the choice, but speed is immaterial for these particular design.

The 4000 series is the general classification used for the industry standard integrated circuits, which implement a variety of logic functions using complementary metallic oxide semiconductor (CMOS) technology. They were created in the 1960's as a low power and more versatile alternative to the 7400 series or TTL logic chips. Almost all IC manufacturers have fabricated this series in part or whole over the years.

Initially, the 4000 series were slower than the popular 7400 TTL chips, but had the advantage of much lower power consumption, the ability to operate over a much wider range supply of voltages and simpler circuit design due to the vastly increased fan out. However, their slower speed (initially only capable of about $1MH_z$ operation when compared with TTL's $10MH_z$) meant that their applications were limited to static or slow speed designs. Later, new fabrication technology largely overcame the speed problems, while retaining backward compatibility with most circuit designs, a circuit could be made much faster by simply dropping in the newer chips. Although all semiconductors can be damaged by electrostatic discharge, the high impedance of CMOS inputs made them more suspectable than bipolar, TTL, devices. The CMOS integrated circuit sampler such as 4081B (AND gate), 4060B (oscillator) and 4069VB (inverter) are used in the circuit design [5].

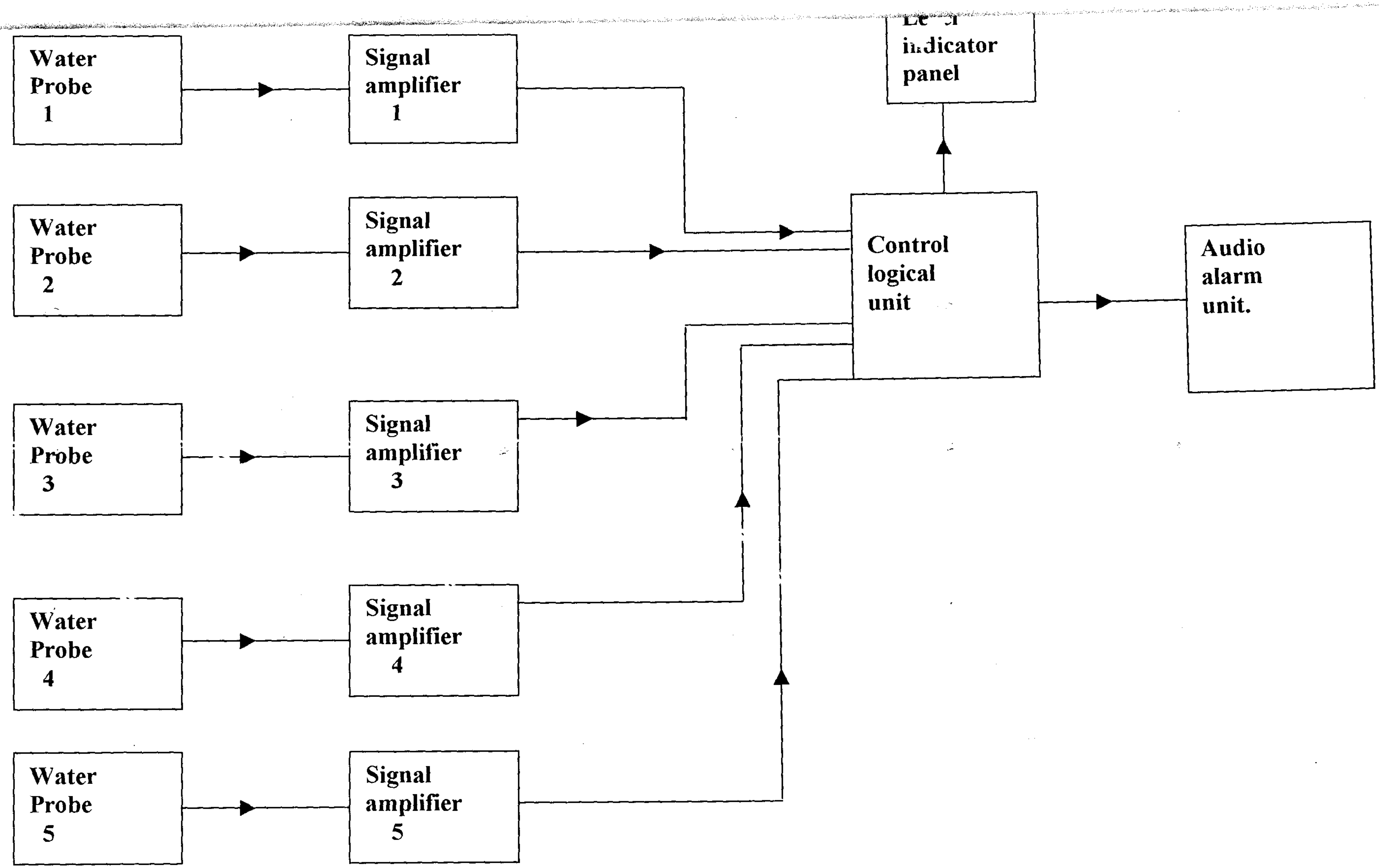


FIG. 3.2a BLOCK DIAGRAM OF A WATER MONITORING UNIT

3.2 THE CIRCUIT DIVISION

The block diagram is shown in fig. 3.2a

The circuit can be divided into nine main parts, they are:

1. Oscillator
2. Water probes
3. Input amplifiers
4. Inverters
5. Level blinking indicators
6. Blinking/switching transistor
7. Logic mixer
8. Audio alarm unit
9. Power unit

3.2.1 THE OSCILLATOR

The oscillator circuit involves a 4060 CMOS integrated circuit, two resistors and a single capacitor. As earlier stated, 4060B is a 14-bit binary counter and oscillator. It is an extremely important pulse generator and the circuit uses three of the available ten frequency outputs. See fig. 3.2.1

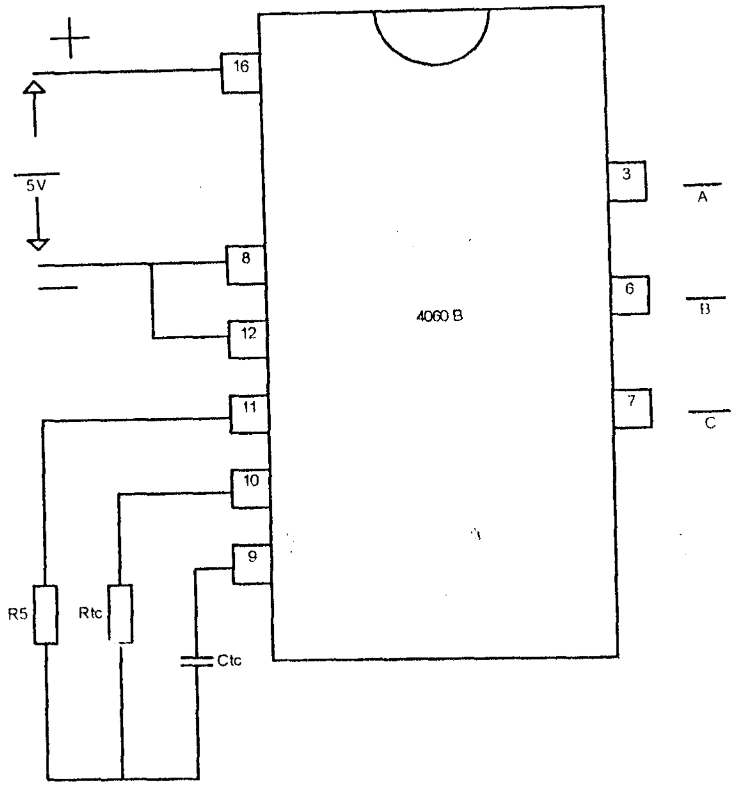


FIG. 3.2.1 THE OSCILLATOR CIRCUIT

The above circuit describes the involved oscillator, where the left side defines the input and the output is at the right. The integrated circuit is supplied with regulated 5v supply form the power unit. Such power supply is conventionally used for logic circuits if the pin 16 and 18 are the positive and negative terminals respectively. As stated in the data sheet, if the integrated circuit, pin 12 is grounded for any reasonable operation, it is stated as the RESET input. Pin 11, 10 and 9 are terminals connected at 100kΩresistor, 33kΩ resistor and 0.001mf capacitor respectively. They handle the output frequencies of the device. They are related by the frequency formula [5]:

$$F = \frac{1}{2.3\, R_{tc}\ C_{tc}}$$

Rs is taken as 100 kΩ (it passes for the limit)

$$2R_{tc} < Rs < 10R_{tc}$$

If 1 KHz $\leq f \leq$ 100 KHz is the frequency range

R_{tc} is 33 kΩ.

$$\text{Therefore } F = \frac{1}{2.3 \times 33 \times 10^{3} \times 0.001 \times 10^{-6}}$$

F = 13175Hz

or

F = 13.2kHz

The frequency is not really the actual value, it simply provides the ideal of the output frequency. Based on internal division of the frequency device, the output terminal A,B and C are attributed to different frequencies.

As earlier explained in (1) and (2) the frequencies and periods of the terminals are given by the following formula's:

$$\text{F pin (the frequency output of pin 3) } \frac{F}{2^{14}} = \frac{13.2 \times 10^{3}}{16384} = 0.805\text{Hz}$$

$$\text{T pin 3 (the period of the output pin 3)} = \frac{1}{0.805} = 1.24\text{seconds}$$

$$\text{F pin 6 (the frequency output of pin 6)} = \frac{F}{2^{7}} = \frac{13200}{128} = 103.12\text{Hz}$$

$$\text{T pin 6 (the period of pin 6 output)} = \frac{1}{\text{Fpin6}} = \frac{1}{103.125\text{Hz}} = 0.0097\text{s}$$

$$\text{F pin 7 (the frequency output of pin 7)} = \frac{F}{2^{4}} = \frac{13200}{16} = 825\text{Hz}$$

$$\text{T pin 7 (the period of pin 7 output)} = \frac{1}{\text{Fpin7}} = \frac{1}{829} = 0.001212\text{seconds}$$

Fpin7 is the highest frequency, followed by Fpin6, Fpin3 is very small or slow, it is used for the indicators blinking effect and for switching on and off the other two in generating an audio alarm effect. The 825Hz frequency is used for sounding the filled tank condition while the 103.125Hz frequency alarms whenever the tank is empty. The effect is achieved along side the mixer logic in which the operation will be started later. The only active or concern pins of the integrated circuit is shown in the early figure and the other pins are not connected.

3.2.2 WATER PROBES

A water probe is a very simple sensor. It is usually made up of two conductors, which is separated by a small gap as shown below; see fig 3.2.2 (a).

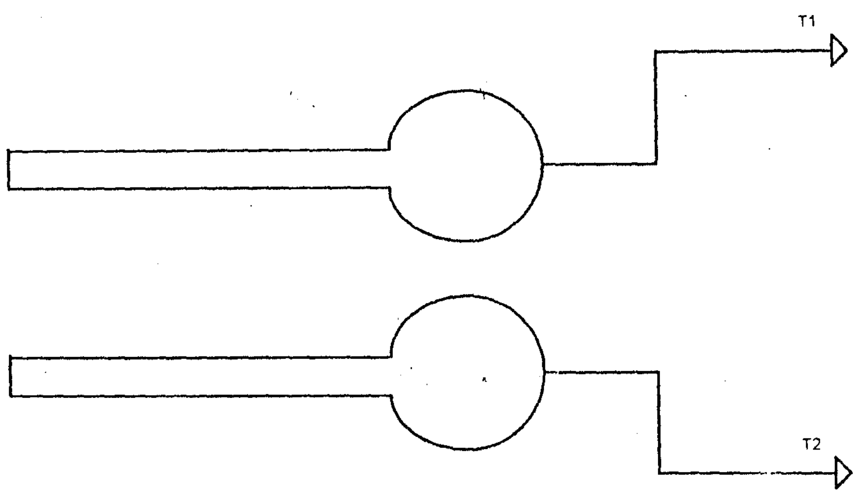


FIG. 3.2.a A SIMPLE WATER PROBE CONSTRUCTION

The space is added for water to bridge the circuit of the two conductors. The conduction is different from the case of metallic materials because in water, ions transfer electric current; therefore, the ions result into the bridge of the two-separated metallic terminal and as that, the simple construction act as a switch. This kind of switch is opened whenever water is absent from the involved terminal, but water causes the switch to be closed. See fig. 3.2.2(b).

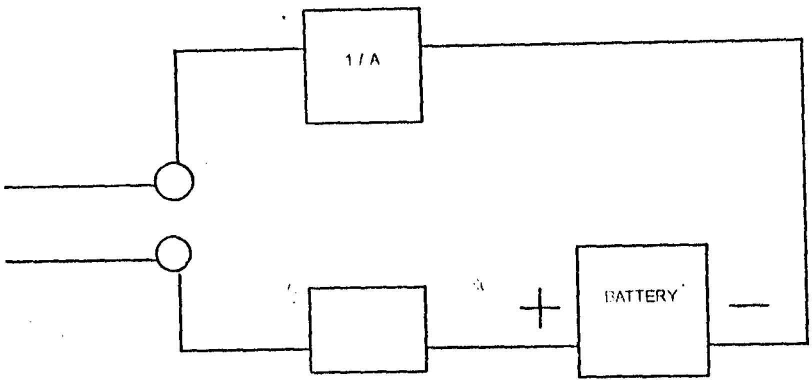


FIG. 3.2.2b A SIMPLE WATER PROBE CONNECTION

The above circuit shows the basic operation of a water probe, there's no current indication at the meter whenever the probe's contacts are dry, but whenever water is in contact with the probe, the meter deflects to show flow of current. This mechanism is the basic concept of detecting water for the monitoring of the level of substance in the tank. For ease in operation, a water probe is usually connected to the input of an amplifier; this is quite evident in the circuit.

3.2.3 INPUT AMPLIFIERS

The amplifiers operates with the input sensors, they are designed with the use of NPN bipolar transistor (2SC945) in the common emitter mode or configuration. A common emitter is a type of electronic amplifier stage based on a bipolar transistor in series with a load element such as a resistor. The term "common emitter" refers to the fact that the emitter mode of the transistor (indicated by an arrow symbol) is connected to the output load, and the base mode acts as input. Common emitter circuits are used to amplify weak voltage signals such as the faint radio signals detected by an antenna, as shown in fig. 3.2.3a

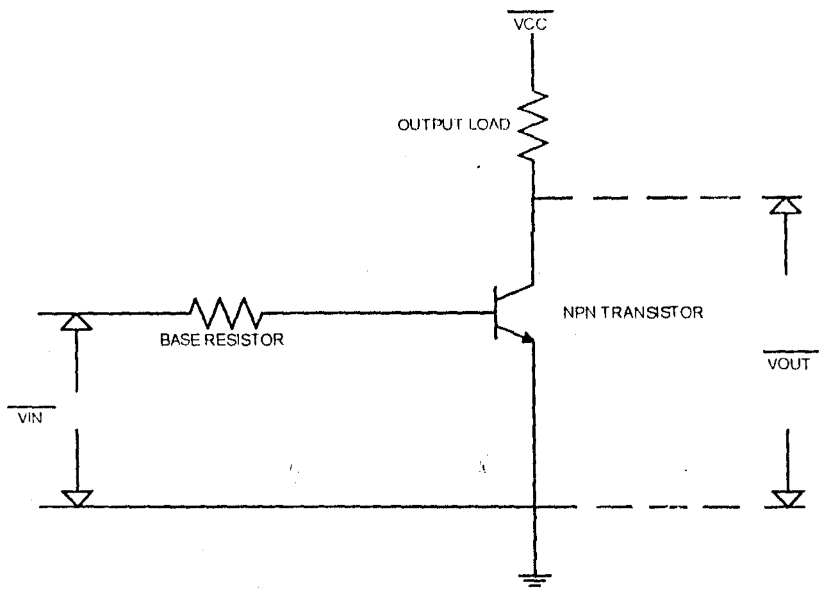


FIG. 3.2.3a A SIMPLE BIPOLAR NPN TRANSISTOR COMMON-EMITTER CONFIGURATION

The water probes provide the input signal for the related amplifiers. They are connected to the base of the transistors and the connection is quite simple. The figure below describes a single connection of such circuit.

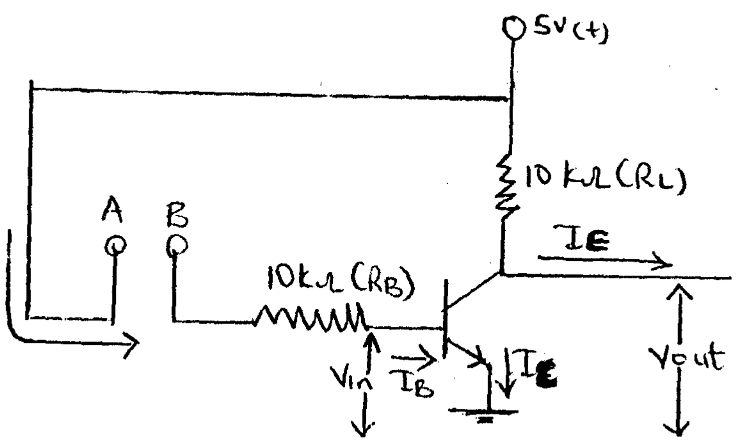


FIG.3.23b THE WATER PROBE AMPLIFIER CIRCUIT.

Whenever, point A and B are dry (or without water contact), the Vin voltage of the NPN transistor is low or OV, with reference to the ground or negative terminal of the power supply, therefore, the base of the bipolar transistor is at the same voltage level whereby, the output voltage (Vout) of the circuit is at Vcc. The circuit is supplied with 5v. The output of the circuit can be defined as logical 1, due to it's relative high level to the referenced ground. But in a situation where terminal A and B are in contact with water or are wet, current flows from point A to B through the ions of the water. These results into relatively increase in Vin. The potential difference at the base of the transistor raises to a value of about 0.6v.

This causes the output of the circuit to transit from the initially relative high voltage to low, in other words, from logical '1' to logical '0'. This action merely defines the detection of water at the concerned probe. As related to the water tank, the level of water is detected by the circuit through the two metallic conductors of the probe. In water, the probes behave as if input switches for the output of the amplifiers even the amplifiers are best defined as transistor switches.

In designing the circuit, the current gain of the transistor (2SC945) is taken as 170. The data sheet of the device defines a variation in current gain due to the temperature changes; therefore, the transistor could be at different current gain mode under a specific temperature. The condition of saturation, while the output or collector is low as reflective to ground is closely considered in the circuit. It involves getting enough base current to make the base-emitter junction approximately 0.6v. The probe must allow a minimum current of 0.003MA flow to the base of the transistor for useful output signal (This is assuming the water is purely a conductor of electricity). However, the case is not true, because water conducts through free ions and not electrons, therefore, the gap between the two terminals of the probe is a resistance in series with R_B Moreover, the voltage across the base resistor is givèn by:

$$5 - 0.6 = 4.4v \text{ ------------------ } (3)$$

The 5v is assumed. This is because; due to the resistance of water, the value should be lower, so that the value of the base resistor is given by:

$$R_B = \frac{4.4}{0.003 \times 10^{-3}} = 1466.6\ k\Omega \text{ ---------------- } (4)$$

The value of the resistance is quite high for a true operational value therefore, for related experiment review; a suitable value between 4kΩ to 15kΩ is used. The error in calculation is attributed to the union sided resistance at the probe's terminal, so a value of 10kΩ is chosen for the circuit and the other resistance goes to the water probe. The load or collector resistance goes with the current gain of transistor [4] which is taken as 170

$$I_C = \beta \times I_B$$

$$I_C = 170 \times 0.003 \times 10^{-3}$$

The collector resistance is:

$$\frac{5}{0.51 \times 10^{-3}} = 9.8\text{kohm}$$

A 10 kΩ is chosen because 9.8kΩ resistor is not available and the 10kΩ is acceptable as substitute.

3.2.4 THE INVERTERS

The output of every amplifier recognizes the detection of water with a low output, for ease in design, a relatively high or logical 1 is required therefore, an inverter is connected to these output. The inverters are realized for a Hex inverter 4069B CMOS integrated circuit and it possesses six in-built NOT or inverter gates, but only five of the device are used in the circuit.

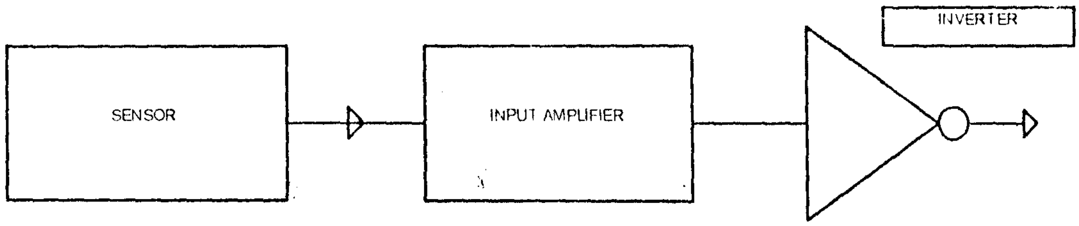


FIG. 3.2.4 FLOW OF SIGNAL FROM THE INPUT TO THE INVERTER

3.2.5 THE LEVEL BLINKING INDICATORS

This level/unit is designed to show or indicate the level of water in the tank. It provides a simple manner of getting information about the inside condition of the tank. It merely holds 470Ω resistor and five Light Emitting Diode (LED). The electronic devices are connected in pairs and a resistor is connected in series with corresponding Light Emitting Diode (LED). The resistor serves as a current emitting agent for the other device, this is because a Light Emitting Diode (LED) operates around 2.3v therefore, connecting a signal of 5v to the device gets it damaged.

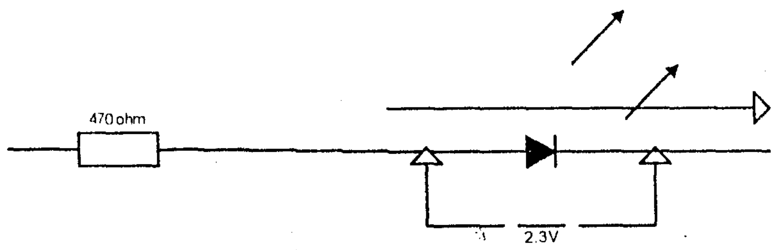


FIG. 3.2.5 A SINGLE CIRCUIT OF THE LEVEL BLINKING INDICATOR UNIT

The series resistor causes a potential difference drop at the light emitting diode (LED). Typically, a current of 8MA flow through such current therefore, for a 5v power supply to the unit, the voltage across the resistor is expected to be:

$$5 - 2.3 = 2.7v$$

and series resistance: $\frac{2.7}{8x10^{-3}} = 337.5\Omega$.

However, 470Ω. is used instead and the performance remained the same. The connection is done in a manner that allows a particular light emitting diode (LED) to come on in response to a corresponding probe submerged in water. The amplifier/inverter circuit provides the required positive signal to the 'P' terminal of the corresponding LED for an indication and the level blinking indicator unit involves five of such circuit for complete monitoring of water in the tank. The 'N' terminals of the LED are made into common connection, which requires negative level signal 'O'. The terminal is connected to the blinking/switching transistor.

3.2.6 THE BLINKING/SWITCHING TRANSISTOR CIRCUIT

This is a simple NPN transistor common emitter configuration switching circuit It involves a 2SD400 bipolar NPN transistor and a 2.2kΩ resistor, the load of the circuit is the level blinking indicator unit. This circuit provides a blinking negative signal to the load and results into 'ON' and 'OFF' effect on the involved LED'S. This blinking action is attributed to the 1Hz frequency from the oscillator. This signal is fed into the base of the related transistor and the pulse switches 'ON" and 'OFF' the transistor with 1 second period (this action is referred to the load). The transistor is chosen the 2.2kΩ base resistance suits such load condition so that, a reasonable current level is dissipated at the load.

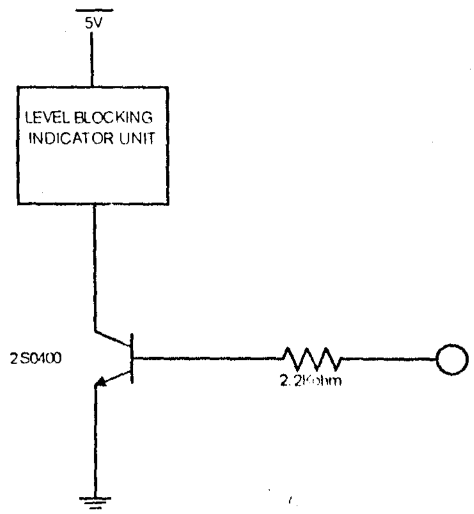


FIG. 3.2.6 THE BLINKING / SWITCHING TRANSISTOR CIRCUIT

3.2.7 LOGIC MIXER

The unit is designed for selecting a particular audio frequency to the output stage (the audio alarm output). The selection involves the three frequencies from the oscillator and the purpose of the unit or circuit is for indicating whether the tank is emptied or filled, a specific alarm goes for each condition.

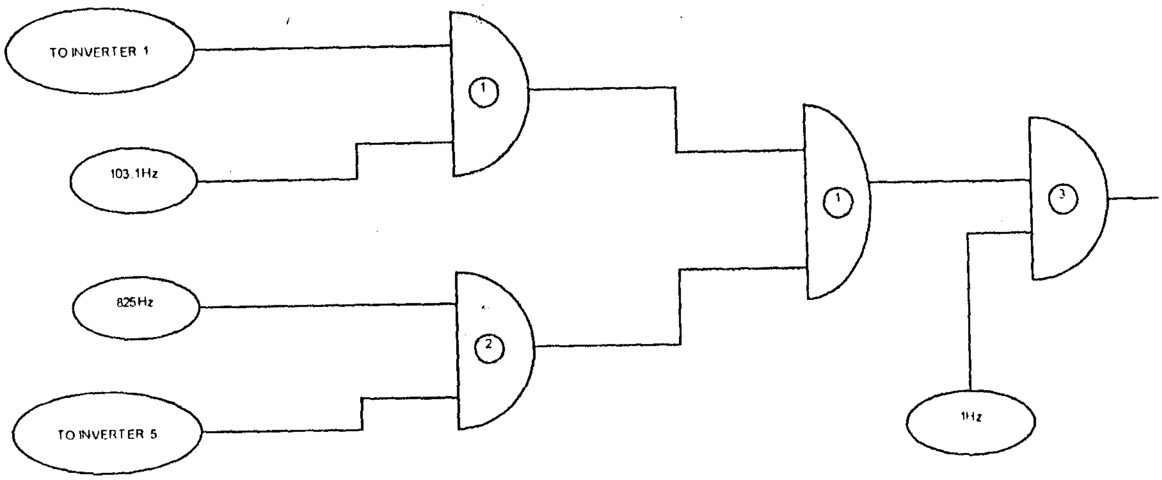


FIG. 3.2.7a A SIMPLE ILLUSTRATION OF LOGIC MIXER CIRCUIT

The above figure describes the signal paths involve in the mixer circuit where the unit works based on the truth table of AND gate. It is obvious that for logical '1' to appear at the output of such gate, all input must be at HIGH logical level, so that a particular input can be used for enabling. The enabling action is done by connecting or feeding one input of each AND gate to the corresponding inverter output. It is easily discussed that the signal flow from the inverters with respect to the water probes is quite high (active). Therefore, for AND gate 1, an input is connected to the output of inverter 1 while the other is connected to 103.1Hz frequency form the oscillator, the other AND gate inputs are connected to inverter 5 and 825Hz signal. AND gate '1' deals with the filled tank condition and the AND gate 2 is connected to the empty tank condition. Signal flows through a particular gate whenever the corresponding inverter input is logical 1. The OR gate series up the two output from the two AND gates into a particular terminal. AND gate 3 is added to generated alarm effect with a 1Hz pulse signal. For purpose of economy, the involved 2 – input OR gate is derived from diode resistor logic configuration.

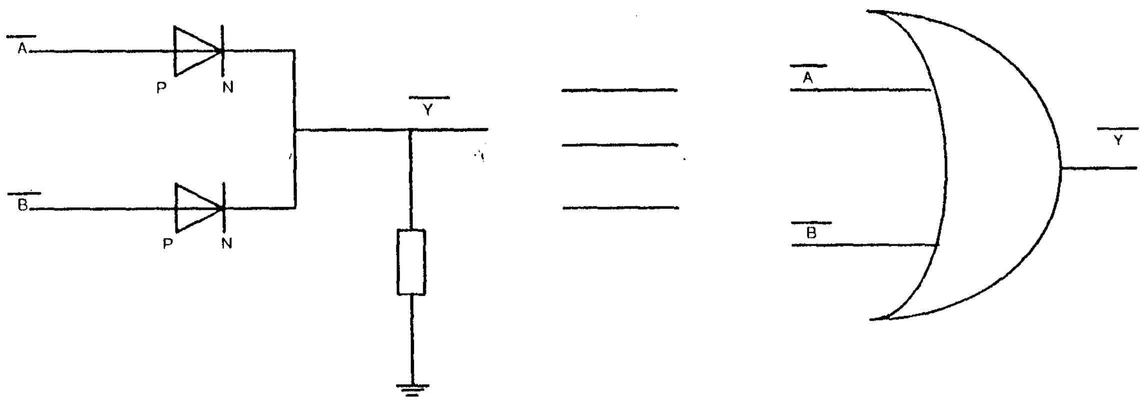


FIG. 3.2.7b THE 2-INPUT OR-GATE EQUIVALENT

The P side of the diodes helps feed positive or high level flow to the common output thereby, the altogether configuration behaves like a 2 –input OR gate, the grounded resistor acts in completing, the forward bias flow of the diodes.

3.2.8 THE AUDIO ALARM UNIT

This unit is the output of the altogether circuit. It is basically a simple single NPN transistor amplifier and the configuration is common emitter therefore, the base of the transistor holds the output signal from logic mixer unit. The output of the circuit is connected to a 1 –watt 8ohms speaker, also the signal at it's input is strengthened to the output.

3.2.9 POWER UNIT

The circuits power supply unit involves both 5V and 12v outputs. The two are derived form the A.C mains supply through a 12V step down transformer. This leading device is rated 500mA and it produces an alternating current at roughly 12V. This voltage is required to be rectified or converted into corresponding direct current (D.C) output using a full-wave bridge rectifier. The bridge rectifier makes use of four IN4001 diodes in a bridge arrangement to achieve full wave rectification; this is widely used in configuration, both with individual diodes connection and with single component bridges where the diodes bridge are wired internally.

The connection involves the joining of two opposite terminals form two diodes together. There are two of such connections and each set is connected to the output from the step-down transformer. The other two terminals provide the rectified output or direct current.

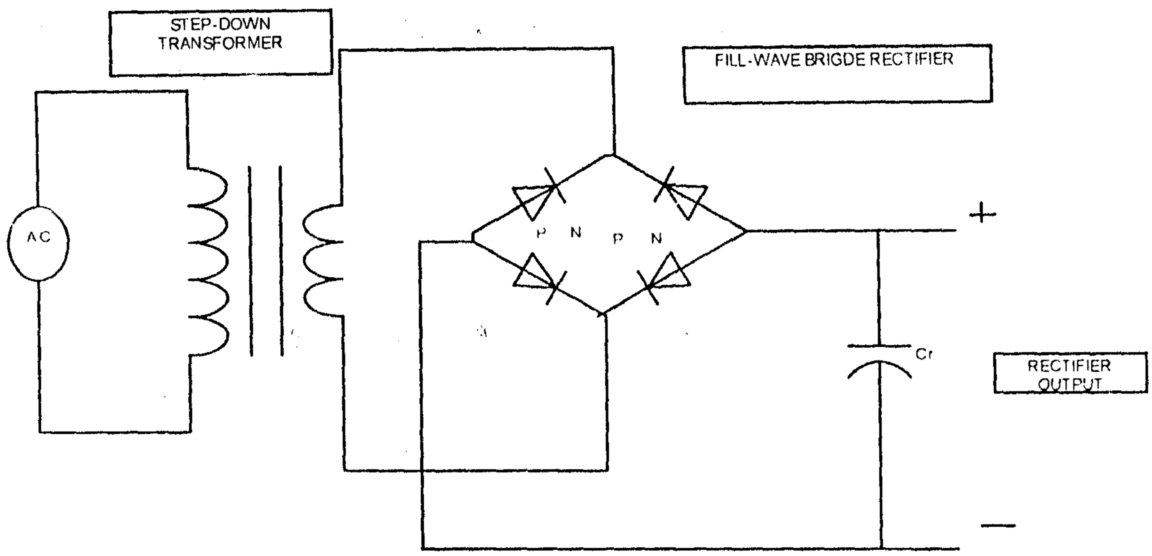


FIG. 3.2.9a A FULL – WAVE BRIGDE RECTIFICATION CIRCUIT

The basic operation is that, for both positive and negative swings of the transformer, there is a forward path through the diode bridge. Both conduction paths cause current to flow in the same direction through the load or output, accomplishing full-wave rectification. While one set of diodes is forward biased, the other set is reversed biased and effectively eliminated from the circuit. The major advantage of this configuration over centered-trapped rectification is that nearly twice the output voltage is achieved through the same transformer. Moreover, the output of the rectifier is not passed for a good direct current (CD) supply therefore, the usual practice is to add an electrolytic capacitor in parallel to the output terminals, the higher the value, the smoother the concerned voltage.

The value of the capacitor for 12V circuits is usually around 1000 – 3300mf. The capacitors voltage rating is usually twice the operating voltage of the circuit, therefore 25v is quite suitable for the design. The selected capacitor is 2200mf 25v, it provides a good ripple removal operation in the circuit. This circuit provides roughly 12v direct current (DC) supply and the 5v is supplied through a 7805 regulator integrated circuit.

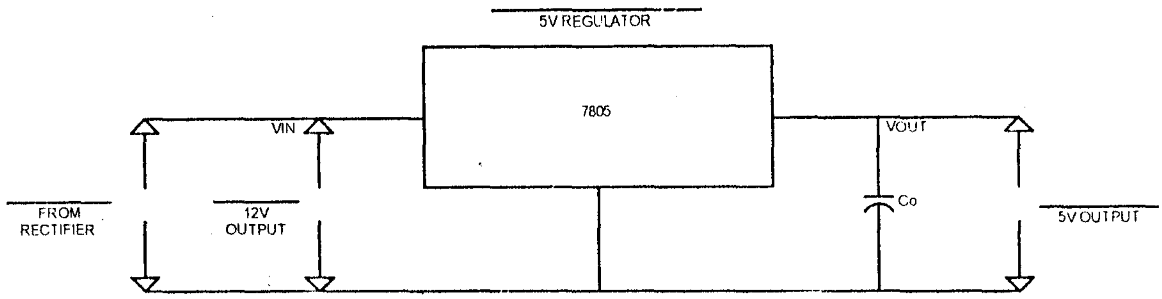
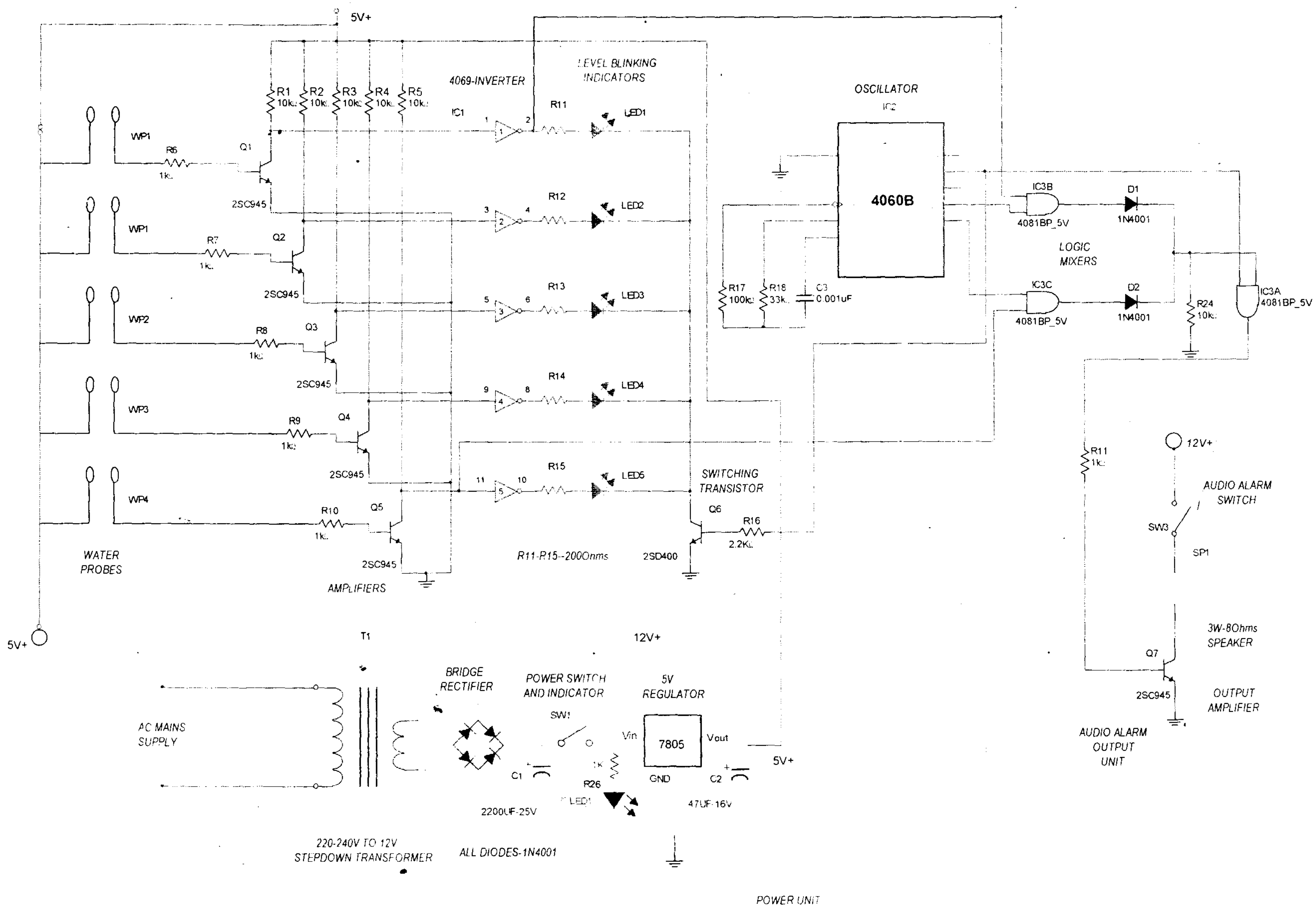


FIG. 3.2.9b THE TWO OUTPUTS OF THE POWER UNIT

The 12v output is used for powering the audio alarm circuit. This is because of the high current factor requirement for larger output strength. The 5v supplies the other part of the circuit, especially the integrated circuits, a small electrolytic capacitor of value 47mf 16v is usually connected to the output of the 5v regulator for filtering.



5V+
4069-INVERTER
LEVEL BLINKING INDICATORS
OSCILLATOR
4060B
R1 10k
R2 10k
R3 10k
R4 10k
R5 10k
IC1
R11
R12
R13
R14
R15
LED1
LED2
LED3
LED4
LED5
WP1
WP2
WP3
WP4
R6 1k
R7 1k
R8 1k
R9 1k
R10 1k
Q1
Q2
Q3
Q4
Q5
2SC945
IC3B
IC3C
IC3A
4081BP_5V
D1
D2
1N4001
LOGIC MIXERS
R17 100k
R18 33k
C3 0.001uF
R24 10k
WATER PROBES
AMPLIFIERS
R11-R15--200Ohms
SWITCHING TRANSISTOR
Q6
R16 2.2K
2SD400
12V+
AUDIO ALARM SWITCH
SW3
SP1
3W-8Ohms SPEAKER
Q7
OUTPUT AMPLIFIER
AUDIO ALARM OUTPUT UNIT
T1
AC MAINS SUPPLY
BRIDGE RECTIFIER
POWER SWITCH AND INDICATOR
SW1
5V REGULATOR
7805
Vin
Vout
GND
C1
C2
R26
1K
LED1
2200UF-25V
47UF-16V
220-240V TO 12V STEPDOWN TRANSFORMER
ALL DIODES-1N4001
POWER UNIT

3.3 THE OPERATION OF THE CIRCUIT

The input of the design involves the water probes. The level indicators and audio alarm defines the output, and other devices such as the input amplifiers, inverters, blink transistor, oscillator, logic mixers, audio alarm amplifier, deals with the co-ordination of the input with the output.

Each water probe is connected to an input amplifier, which results into five of such connection. The detection of water by any probe results into low output at the corresponding transistor, the leading probe causes considerable current flow to the corresponding base of the transistor and it results into a slightly negative condition at the collector (as earlier explained) so that each time water is detected by a probe, the corresponding transistor produces a negative or low output.

The connection goes further with the attachment of an inverter to every transistor's output, this results into five of such connection. The invertion changes the state of our output form the detection of water at the probes in which every detection now is recognized by high or positive output and not low or negative output. A negative or low output can be described as "logical O" and the high or positive output can be described as "logical 1". The inverters do not only change the state of the output, but they act like buffers between the input and output of the circuit. They suit the impedance level between the output of the transistor amplifiers with the further or connected circuit. This avoids damage or excessive flow of current from the amplifier stage to other section of the whole circuit. The design simply provides a good result and circuits efficiency.

The level blinking indicators show the water affected probes. They are mere Light Emitting Diodes (LED) through a 470Ω resistor. The purpose of such connection is for current limiting to the involved indicators, moreover the negative terminals of the light Emitting Diodes (LED's) are made common through joint connection, where the single common terminal is connected to the collector of a 2SD400 NPN transistor. The transistor provides the indicators with the required negative signal to complete the circuit, but the base of the transistor is pulsed by a low frequency pulse of roughly 1Hz. The signal is taken from the oscillator (4060B) and it results into blinking negative feed to the LED's. The rate of 'ON' and 'OFF' of concerned indicators is the period of the involved frequency that is roughly one second. The main aim of the blinking effect on the indicators is to cause attraction on the indicators.

The oscillators generates three different frequencies for the circuit, they are: 1Hz, 103.125Hz and 825Hz. The highest (825Hz)is used for the empty –tank condition, the 103.125Hz deals with the full-tank condition and the lowest frequency (1Hz) is used for controlling the alarm and blinking effect on the light indicators. The logic mixer unit works with the first and last input inverters in getting a particular audio alarm ON. A high tone audio output defines the empty-tank condition while a low tone audio output is attributed to the full-tank condition. These outputs are heard at the speaker. In a case whereby the sound outputs are not required, an output-disenabling switch is put in place.

In summary, five probes are used in detecting water level in the storage tank, they provide information about the empty, one-quarter, half, three-quarter and filled condition. Each level corresponds to a particular Light Emitting Diode (LED) indicator. There are two audio alarms involved in the circuit, a high tone for the empty-tank condition and a low tone for the filled-tank condition. The device is merely designed to monitor the level of water in a storage tank.

CHAPTER FOUR

TESTING AND RESULTS

4.1 INITIAL TESTING OF THE CIRCUIT

The project was firstly carried out on a breadboard; it involved the temporary connections of the altogether circuit (the involved components). The connection involved placing each component into the breadboard and linking them together through jumper wires according to the circuit. There was no requirement for soldering operation, therefore different adjustments were performed on board to make the circuit okay and acceptable by standard.

The major change was at the audio alarm output, where the output or alarm frequencies were altered for more audibility. The circuit ended up working according to the specified aim.

4.2 THE MAIN TESTING

The five water sensors were placed at different position in an open-top plastic water bucket, where the bucket served as the water tank, the number five, four, three, two and one water sensors were placed at ground level, one-quarter, half, three-quarter and top levels respectively (see fig 4.2a).

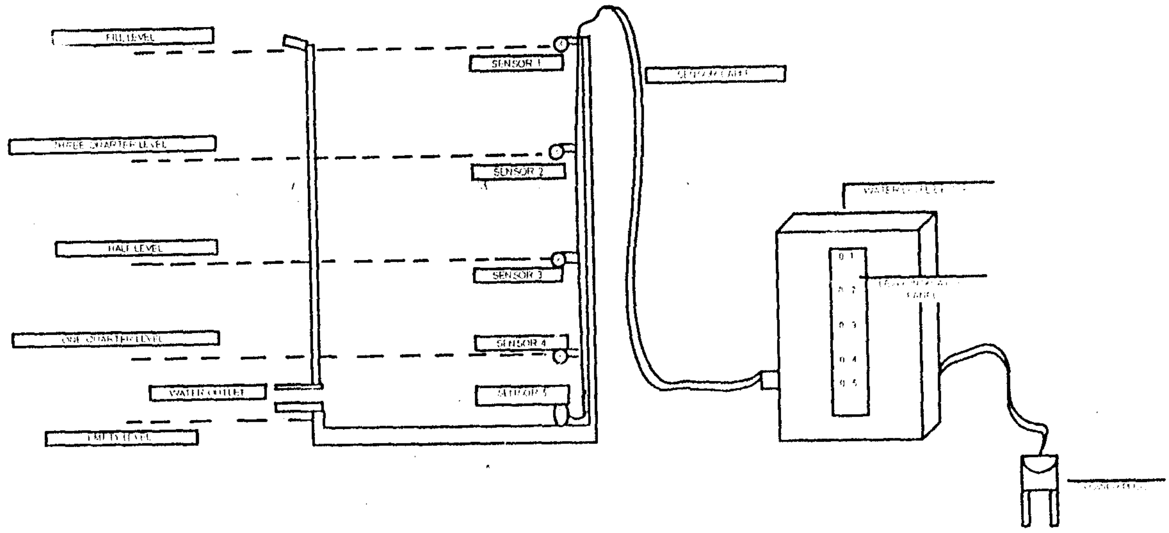


FIG. 4.2TEST SETUP

The next step was the connection of the circuit to the A.C main supply and power switch of the device was moved from OFF to ON mode.

The next step was the attempt to gradually fill up the container with water while the indicators were carefully observed for any change. Moreover, when the container was finally filled, the water was driven out of the container through a floor-outlet. The response of the level indicators were carefully observed throughout the exercise and the audio alarm output was also monitored for any sound.

4.3 RESULT OF THE TEST

The moment the device was powered with electricity, the power indicator came on. A loud audio alarm was heard at the output speaker, since the speaker switch was on at that moment. The switch (speaker) was turned off and no sound was heard again. It was observed that none of the involved light emitting diodes (LED's) at the level indicator panel was on, but as water got into the container, the number five level indicator started blinking and the initial audio alarm got off, it was followed by the number four light indicator and the alarm wasn't heard again. The number three light emitting diode started blinking as the water got to the middle level of the container, the number two indicator joined the blinking team as water got to the three-quarter level of the container, but as the container was filled with water, the first light indicator started blinking and another tone of the audio alarm came on. The sound here was quite different from that which was heard for the empty condition.

As water in the water-fill container was trapped out, the initial audio alarm became off along with the switching off of the first light indicator. As the water was down –passed the one-quarter level, the number two, three and four light indicators were off. At the empty-container condition, the fifth light indicator went off and audio alarm came on.

4.4 DISCUSSSION OF RESULT

The light indicator panel merely described the response of respective water sensors to water at particular levels through visual indication. The logic was that as water touches a particular water sensor at a specified level, a corresponding light indicator comes on. Also, as water leaves a particular level, the corresponding light indicator goes off.

The sound effect of the fill and empty levels defines their importance and sensitivity. The sound alarms responds only to the two levels therefore, for a proper water level monitoring, the five sensors must be placed at right positions in a given container or tank.

4.5 LIST OF COMPONENTS

List of components with their functions, quantities and the cost for each is been shown below:

NOS	NAME OF COMPONENT	FUNCTION/ DESCRIPTION	QUANTITY	COST FOR EACH
1.	2SC945 NPN Transistor	Input amplifier	5	₦-10
2.	Water sensor	Senses water	5	₦-100
3.	10 kΩ	Resistor	11	₦-5
4.	100kΩ	Resistor	1	₦-5
5.	33kΩ	Resistor	1	₦-5
6.	0.001uf	Capacitor	1	₦-5
7.	1kΩ	Resistor	1	₦-5
8.	IN 4001	Rectifying diode	6	₦-5
9.	12v transformer	Voltage source	1	₦-150
10.	7805	5v regulator	1	₦-50
11.	LED	Indicator	6	₦-10
12.	Toggle switch	Switching device	2	₦ 50
13.	2200uf16v	Filter capacitor	1	₦-30
14.	47uf 16v	Filter capacitor	1	₦-15
15.	2.2kΩ	Resistor	1	₦-5
16.	4069vB	INVERTER logic	1	₦-130
17.	4081B	AND gate logic	1	₦-130
18.	4060B	Oscillator	1	₦-130
19.	10Ω	resistor	1	₦-5
20.	8Ω1watt speaker	Alarm output	1	₦-100
21	470Ω	Resistor	5	₦-5

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 THE SUMMARY OF THE PROJECT

The project was quite a success, it worked to purpose. The involved design or hardware was able to monitor water level in a tank or any other reasonable capacity containers. It displayed the water level in five points of such containers. The circuit is attributed to an audio alarm output that responds to empty and filled tanks condition differently. This feature worked along with the design.

5.2 PROBLEMS ENCOUNTERED IN THE PROJECT

The search and purchase of the involved electronic components were not so tasking because they were quite available and not so expensive. Also, every integrated circuit in the circuit possessed a socket, therefore the occasion whereby a particular one failed to work, the replacement was done with ease.

Moreover the search for information about the project was quite tasking. The involved data sheets on the respective integrated circuits was searched on the internet and referenced books. The casing of the whole work was carried out with the help of experts, this was due to usual circuit damage during the course of casing. In all, little challenge was faced in the process of the project.

5.3 RECOMMENDATIONS

I. The project or circuit could be configured with a personal computer for further advanced features.

II. The design could incorporate a feature that automatically turns off the flow of water to the tank at fill-condition.

III. Additional features such as programmed water outlet could be used to secure the se of water from specific storage facilities.

IV. Additional probes could offer better water monitoring.

V. The circuit is made more compact through the use of embedded unit.

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