DESIGN AND CONSTRUCTION OF A SIX STEPS WATER LEVEL INDICATOR WITH A SINGLE DECODED LIGHT EMITTING DIODE (LED)

BY

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FOR THE AWARD OF BACHELOR DEGREE (B. ENG).
IN ELECTRICAL /COMPUTER ENGINEERING.

OCTOBER, 2003

DECLARATION

I declare that this project work is carried out by me alone and it has not been presented before by anybody.

17/10/2008

MAMAN RABE

CERTIFICATION

This is to certify that this project work is carried out by MAMAN RABE in partial fulfillment of the requirement for the award of Bachelor of Engineering (B .ENG) degree in Electrical/ Computer Department.

....

M S Ahmed

Project supervisor

....

Sign & Date

....

Eng. M. N. Nwohu

Head of Department

28/2/07..........

Sign & Date

....

External Examiner

....

Sign & Date

DEDICATION

I dedicate this project to Allah, who by His grace this project work is carried out successfully, and also to my niece Nadiatou Inoussa M.K.

ACKNOWLEDGEMENT

Praise is to Almighty Allah, the Omnipotent who give me heath, protection and guidance in all my work.

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

-My thanks go to the other lectures especially PROF KHAN, and my H O D Dr. Y. A. A DEDIRAN

My profound gratitude goes to my parents, grand parents, relatives especially INOUSSA MAMANE M K and BRAH TSHAHIROU who assisted me financially and morally towards the successful achievement of my academic program

My special thanks to my friends and colleagues here in F U T and somewhere else, struggling for life such as NASSIROU ABDOU, BRAH SAMINOU, MAAZOU ILLIAH, ADOUL GANIOU, ASMANE MOSSOYI SALAO, and IDI RAHAMANE.

May Allah who knows best guide us. Amen

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 six steps water level indicator is to tell the user the state of the thank. 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

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CHAPTER ONE
GENERAL INTRODUCTION

1.1 INTRODUCTION

This project is base on the design and construction of a six-step water level indicator that is the art of indicating water level in a tank. In fact, it can be any system performing electrical sequence by means of electric power.

In this system, the basic function is to detect the different level that water may reach in the tank through led or alarm. At any position of a led on the casing it is assigned a volume of water that may be in the tank. Therefore, the content of the tank can be directly read from the decoded led.

Water is used as a conductor to complete the path for current flow, energizing the load. To accomplish this, the tank, which must be metal, is used as one current carrying conductor, and a probe insulated from the tank is the other. Water is to complete the electrical connection between the tank conductor and the probe conductor.

A six-step water level inductor has the following features:

-Materials

-Sensing Region (probes and water in a tank)

-Process Unit (quad two input NAND gate and a bilateral Switch gate)

-Timing device (frequency components, 555 timer)

-Output device (led and speaker)

-The general program (sequence of operation)

The probes are arranged in various positions indicating the division of the tank into five-(5) unit volume:

The first probe is positioned at one (1) centimeter from the tank

The second probe is positioned at one fifth of the tank volume.

The third probe is positioned at two fifth of the tank volume.

The fourth is positioned at three fifth of the tank volume

The fifth probe is positioned at four fifth of the tank volume

The six probe is positioned at five fifth of the tank volume.

The tank constitutes a positive terminal of the voltage supply Then the probes in the tank are arranged in such way that only water can ensure connection between them and the tank. A single led lights at each water level corresponding to a probe's position in the tank. When water gets below the first probe, a NAND gate connected to it will activate a timed alarm for which sound depends on the frequency components That is the values of resistor and capacitor chosen.

The essence of the alarm is to tell the user that the tank is empty.

1.2 LITTERATURE REVIEW

Several devices were commonly used for water level measurement since the beginning of the 19th century. That is in the past 100years.Various systems have been developed to obtain exactitude in liquid level in a container. Thereby Hook Gage was used for water level measurement from W.Unwin, a treatise on hydraulics, Mac Million 1912. From D. M. Considine, ed. Process Instrument and Control Handbook, Mc Graw-Hill 1957, there was:

-Gage glasses, which are of two kinds; low-pressure type and high- pressure type.

-Float Operated hydraulic level gage, with dual opposed hydraulic system.

-Gamma-ray level gage, used for difficult applications.

-Capacitance-probe –type level system for conducting liquid

-Capacitance probe-type system for dielectric liquid.

-Then finally, Gas-page system for level measurement in a closed tank.

From Taylor Instrument Co , there were systems like.

-Mercury manometer with two liquid seals at different levels in a tank

-Force Balance diaphragm-type transmitter for level measurement.

From Bristol Co. Instruments, water level Indicators were created such as:

-Gas-purge level system.

-And Trapped-gas system using diaphragm box, to minimize lead-line errors and venting.

There was also Grid-type element from Union oil Co. of California.

Then recently three water level measurement systems have been installed on Platform Harvest in Support of the Topex/Poseidon satellite Verification Experiment. Each of the systems has fundamentally different instrument configuration, which provides a unique simultaneous set of measurement in a deep-water exposed near- shore environment

-The NOAA Acoustic system (Morris et al 1995) which is a standard NOAA configuration from which the protective well has been significantly modified in Platform

-The NOAA Digital System has pressure-to-digital "blubber" configuration that only recently has been replayed by NOAA.

-The CU system (described by Kubitschek 1995) consists of two pharos depth sensors mounted in a cage specifically designed for deployment at the Plat form.

Water level instrument has ultimate utilization with the advent of water tank and bid reservoir in the industries or public society of water distribution using Hook gage, tape gage float gage 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 component can be integrated together.

With low cost integrated and logic circuits, water level indicator can be constructed. Typical example of it is the Six Step Water Level Indicator. It's circuit design required CMOS integrated circuit, 555 timer, transistors, capacitors, and resistors. The system was built with excellent performance and high sensitivity in water level detection.

1.3 PROJECT OBJECTIVE

The main objective of this project is to design and construct a six steps water level indicator with a single led response at a time or alarm.

The system will work by detecting the water level in the tank. It is intended that the system will be insensitive to vapor and moisture in a tank

1.4 PROJECT LAYOUT

This project in all is divided into four chapters:

Chapter one discusses general introduction of the project, the literature review, the objective and motivation of the project and its layout.

Chapter two is based on the system design .In this chapter, the calculations leading to the choice of the components is carried out.

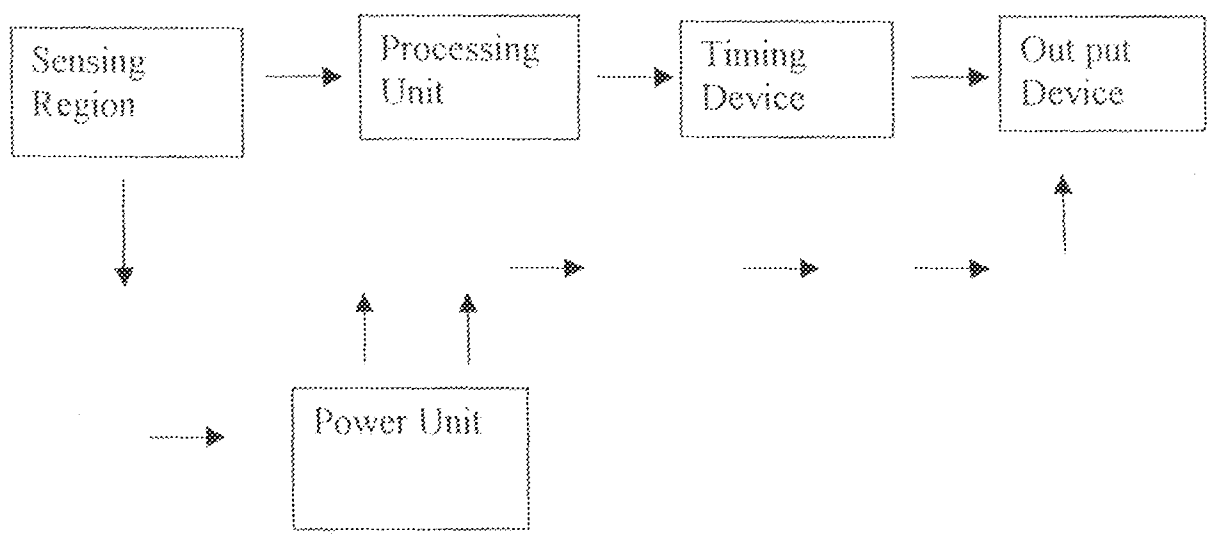
Chapter three is assigned with construction, testing, results coming out for the ended work. The discussions of results are also done

Chapter four includes recommendations, conclusion and references.

CHAPTER TWO

SYSTEM DESIGN AND ANALYSIS

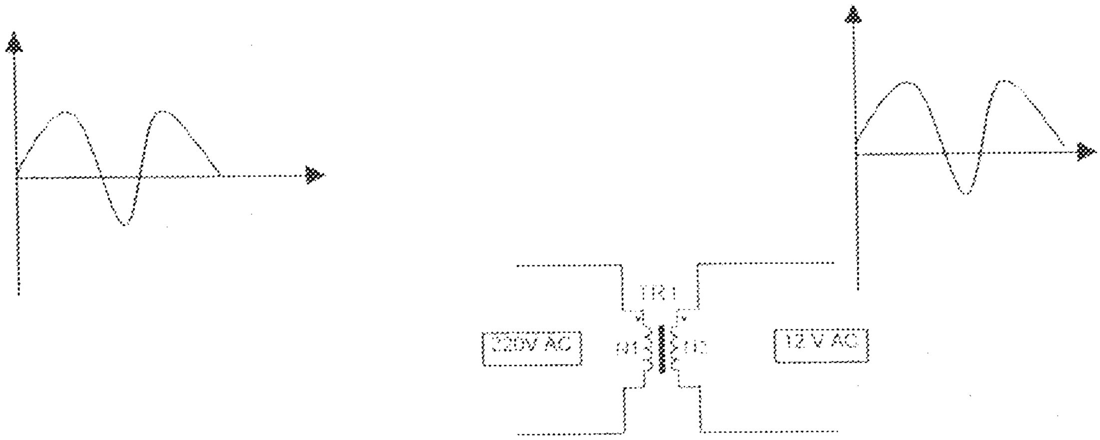
The different sections of the system can be distinguished from the block diagram shown below.



2.1 POWER UNIT

2.1.1 TRANSFORMATION STAGES

Applying transformer effect relationship: $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{12}{1}$



From the Fig 2.1.1 shown above we can see that V2/V1=12V/240V=1/20

V2=1/20V1

The frequency at the input is the same at the output.

That is F1=F2=50HZ

Where F1 is the primary frequency

F2 is the secondary frequency

Let I1 be the primary current and I2 the secondary current. We can now calculate the power consumed in the circuit by use of the formula

P=IV

Where P=power

I=current

V=voltage

Thus P1=I1V1=I2V2

I1V1=I2V2

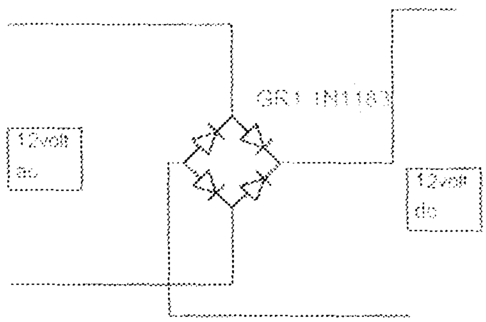
P2=I2V2

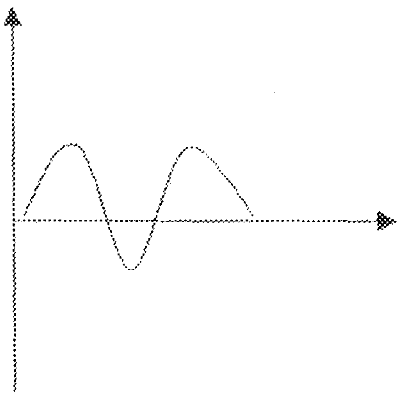
Then for a value of I2=0.5A

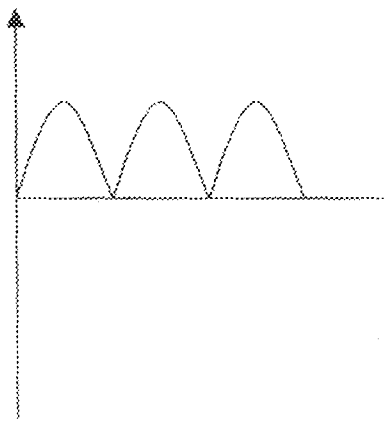
P2=12x0.5

=6watt

2.12 RECTIFICATION STAGE







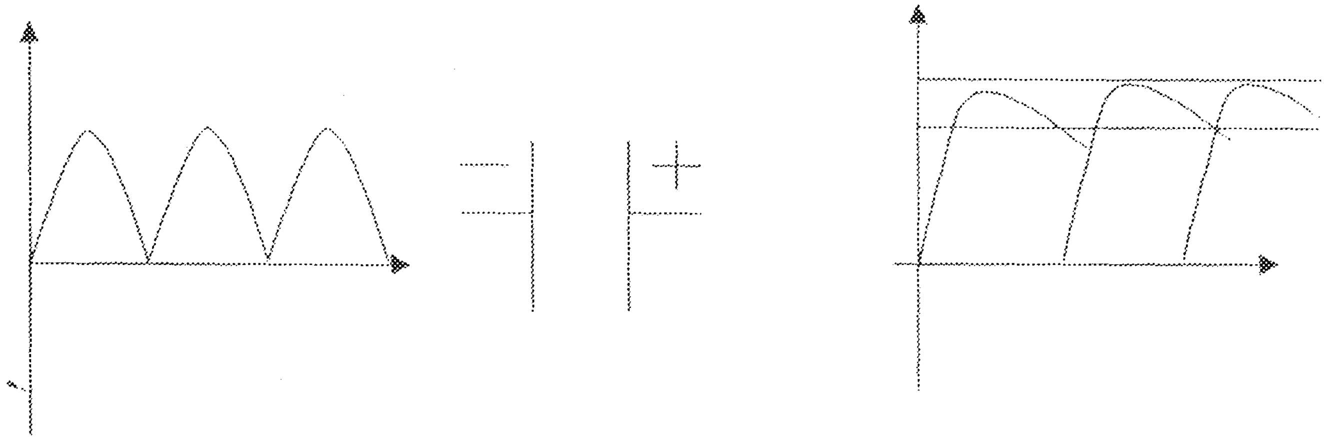
Ac waveform **dc waveform**

The average (Va) and the rms values of the voltage are obtained by the equation

rms= Va/V2=(1/V2)Va

=0.707Va

2.1.3 FILTERING STAGE



Let Vt = voltage across the zener diode V_{be} Voltage across the junction Base-Emitter of the transistor

Ve =the load voltage

Vl + Vbe - Vz = 0

Thus Vbe = Vz - Vl

2.2 SENSING REGION

2.2.1 A TANK

It is used as water container whereby water insures connection between vertically lined probes and the tank. There are two possible ways of connecting Vcc to the tank depending on whether the tank is made of plastic or iron. For plastic tank, a naked wire is placed alone the high of the tank and then connected to the Vcc.

For iron tank, the Vcc is directly connected to the tank.

2.2.2 PROBES IN THE TANK

The probes can be naked copper wires vertically lined in the tank in such a way covered wires are connected to them

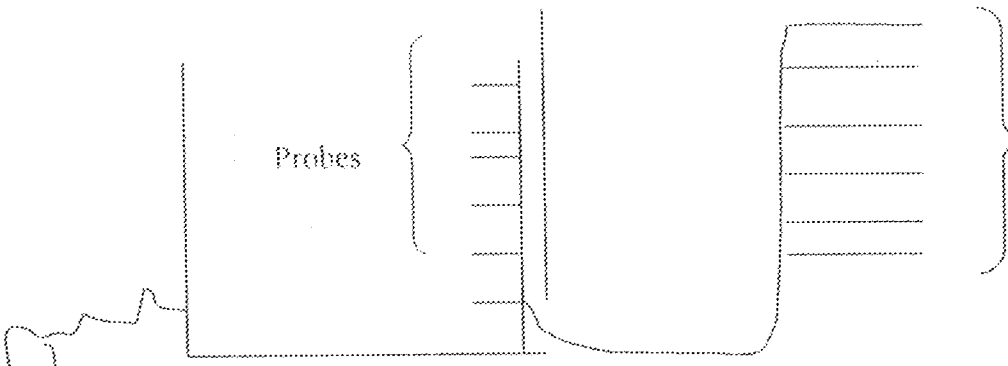


Fig 2.2.2 probes position in the tank

2.3 TRANSISTORS

The NPN bipolar transistor contains a thin p-region between two n-regions; In contrast, the PnP bipolar transistor contains a thin n-region sandwiched between two p-regions. The three regions and their terminal connections are called the emitter, base and collector Because the width of the base region is small, normally in the range of tenths of a micrometer (10^{th}) the operation of the device depends on the two-pn junctions being in close proximity to each other.

CONFIGURATION

When the transistor is biased in the forward-active mode, the B-E junction is forward biased and the B-C junction is reverse biased. Using the piecewise linear model of a pn junction, we assume that the B-E voltage is equal to Vbe (on), the junction turn=on voltage. Since Vcc=Vce + Ic*Rc, the power supply voltage must be sufficiently large to keep the B-C Junction reverse biased. The base current is established by V_{bb} and Rb, and the resulting collector current is $Ic = \beta I_b$

If we set $V_{BE}=0$, the B-E junction will have zero applied volts; therefore Ib=0, which implies that Ic=0. This condition is called cut off.

CURRENT RELATIONSHIP

If we treat the bipolar transistor a single mode, then by Kirchhoff's current law, we have

$Ie= Ic + Ib$.........1

If the transistor is biased in the forward active mode, then

$Ic=\beta * Ib$.........2

Substituting equation 1 into 2 we obtain

$IE=(1+\beta)\ IB$...........3

$I\,c=\frac{\beta}{1+\beta}(I_e)$.........4

$\alpha = \beta / (1+\beta)$.........5

So that equation becomes

$Ic= \alpha\ Ie$...........6

The parameter α is called the common-base current gain and is always slightly less than 1

We can state the common-emitter current gain in terms of the common-base current gain

$\beta = \alpha / (1 - \alpha)$ 7

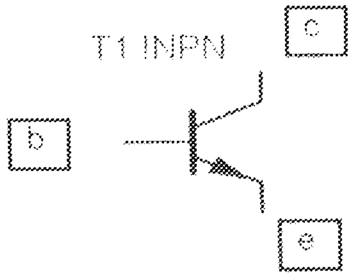


Fig 2.3.1 A NPN transistor

The transistors are bipolar junction transistors of the same number C 945.The provide the power gain that is needed for electronic applications.

A bipolar junction transistor (B J T) is composed of two p-n junction in a single crystal semi conducting material .For normal operation the emitter is forward biased while the collector is reverse biased .A BJT can be operated in three modes: common –collector arrangements .The most important used in configuration is the common emitter because of high current, voltage , power gain.The transistors used in this project are NPN transistors .see the diagram below.

2.3.2 INTEGRATED CIRCUITS

Logic gates constitute the internal structure of the integrated circuits used in this project

i) LOGIC GATE

The term logic gate is used to refer to electronic switching circuit that is used to accomplish the various operations performed on digital waveform. Logic gates have one, two or more inputs, depending on the type, and only one output .the waveform of a logic gate depends upon the input waveform and the input output characteristic of the gate described in terms of mathematical logic

ii) LOGIC FUNCTIONS

The output terminal and each of the input terminals of a logic gate can be in just one of the two states can only be high (1) or low (0) at a time. Logic gate perform seven basic functions; they are: the OR, the NOT, the AND, the NOR, the XOR, THE NAND and the XNOR operations. Three logic gates will be discussed for the purpose of this project.

iii) CMOS INVERTER

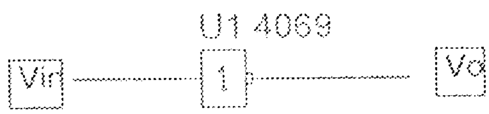


Fig 2.3.2 CMOS inverter (a)

In the CMOS inverter Fig 2.3.1 when Vin is at logic zero (0), the CMOS inverter provides an active pull-up That is Vo is at 1 (Vcc). When Vin is at logic 1 the CMOS inverter provides active pull down

Vo is then at logic zero (o) The input voltage controls that the state of both the driver and the load

iv) CMOS NAND GATE

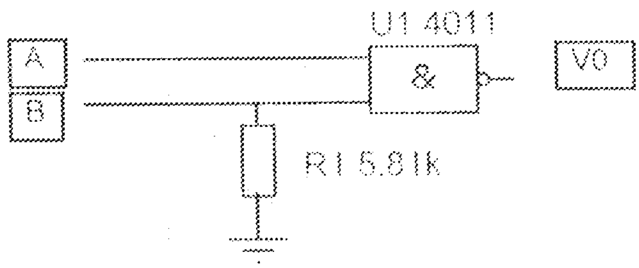


Fig 2.3 2 (b) CMOS NAND gate

The two inputs CMOS NAND gate of Fig (b) extends the last approach. Both input A and B must be at logic one (1) to pull the output voltage down to logic zero (o). Any other combination of inputs pulls the output voltage to logic one (1).

v) BILATERAL SWITCH

A bilateral switch insures the function of a switch when triggered. It has one pin-in, one pin-out and a pin-gate as shown in the diagram below

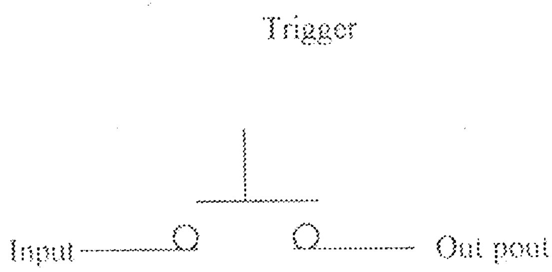


Fig 2.3.2. (C)

The high (1) or low (o) state of the pin input will appear in pin output only when pin trigger is at it's high (1) state.

2.3.3 RESISTORS

All the resistors used in the processing unit section are of range of one (1) and six (6) kilo ohms They are used as pull-up resistors. That is, their main function is to bring high the inputs of the NOT and NAND gate where there are connected to

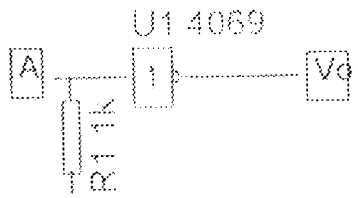


Fig 2.3.3 (a)

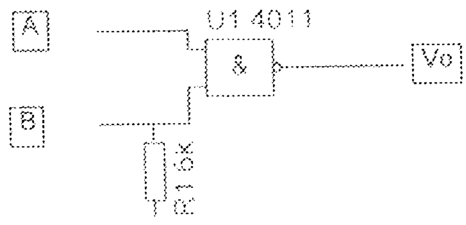


fig 2.3.3 (b)

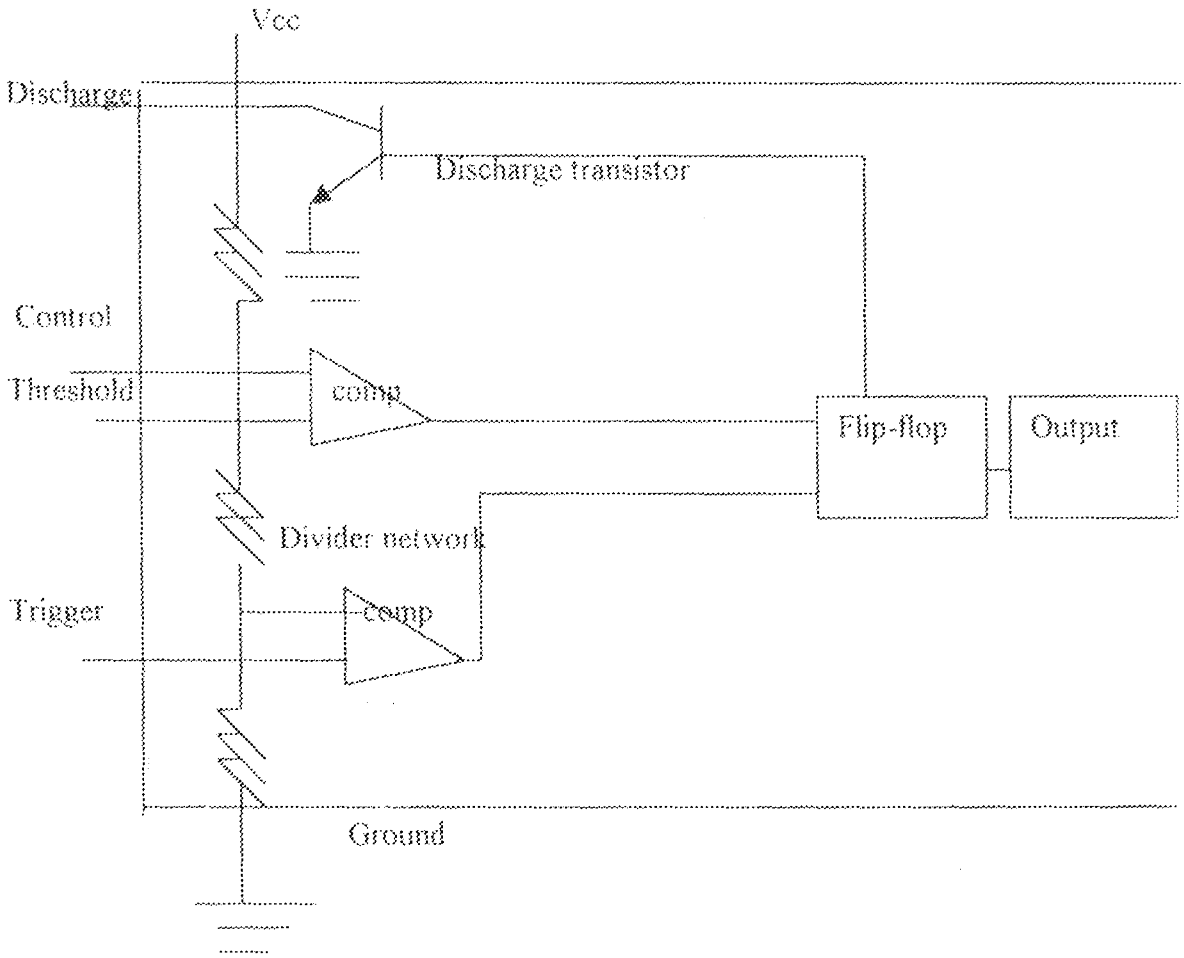
2.4 TIMING DEVICES

The timing device consists of 555 timer and its frequency components (capacitor and resistor).

2.4.1 555 TIMER IC

The 555 Timer provides stable time delays or free running oscillating .The time delay mode is RC controlled by two external component.. Timing from microseconds to hours is possible .The oscillator mode required three or more external components, depending on the desired output waveform. Frequencies from less than 1 HZ to 500 KHZ with duty cycles from 1 to 99 percent can be attained. Fig 2.4.1 shows the major sections of the 555 timer IC.IT contains two voltage comparators, a bi stable flip-flop, a discharge transistor, a resistor divider network, and on output amplifier with up to 200 mA current capability

There are three resistors and each is 5KΩ This divider network sets the THRESHOLD comparator trip point at 2/3 of Vcc and the trigger comparator at 1/3 of Vcc .Vcc may be range from 4.5 to 16V. Suppose that Vcc =9V in fig 2.4.1 (a) .In this case the trigger point will be 3V (1/3 x 9V). When pin 2 goes below 3V, the trigger comparator output switches states and sets the flip-flop to the high state and output pin 3 goes high .If pin 2 returns to some value than 3V, the output stays high because the flip-flop remember that it was set



Now, if pin 6 goes above 6v .The threshold comparator switches states and resets the flip-flop to its low state. This does two things: the output (pin 3) goes low and the discharge transistor is turned on. Note the output of the 555 timer is digital, it is either high or low. When it is high it is close to Vcc and when it is low it is near ground potential. Pin 6 in fig 2.4.1 (a) is normally connected to a capacitor that is part of an external RC timing network. When the capacitor voltage exceeds 2/3 Vcc, the threshold comparator resets the flip-flop to the low state This turns on the discharge transistor, which can be used to discharge the capacitor in preparation for another timing cycle. Pin4, the reset gives direct access to the flip-flop. This pin overrides the other timer functions and pins. It is a digital input and when it is taken low (to the ground potential) it resets the flip-flop, turn-on the discharge transistor, and drives output pin 3 low. But when it is high the output pin 3 is derived to high

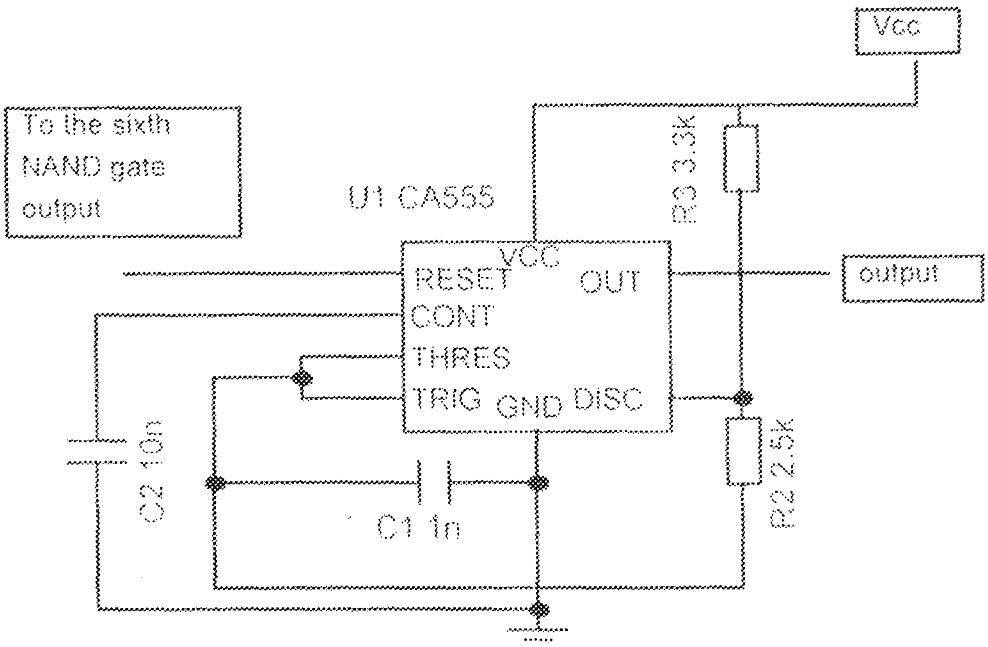


Fig 2.4.1(b) the as table mode or free-running mode.

Fig 2.4.1 (b) shows the timer configuration for the free running or as table mode .the trigger (pin 2) is tied to the threshold (pin 6). When the circuit is turned, timing capacitor C is discharged. It begins charging through the series combination of RA and RB. When the capacitor voltage reaches 2/3 Vcc, the output drops low and the discharge transistor comes on. The capacitor now discharges through RB. When the capacitor reaches 1/3 VCC the output switches high and the discharge transistor is turn off. The capacitor now begins charging through RA and RB again. The cycle will repeat continuously with the capacitor charging and discharging and the output switching high and low.

The charge path for the as table circuit is through two resistors and the time that the output will be held high is given by.

Thigh=0.69(RA+RB) C

The timing resistors in fig 2.4.1(b) are 3.3 k and 1.5K respectively for RA and RB. The capacitor is 100nF The output will remain high for

Thigh=0.69(3300+1500)*100*10-9

=0.000332s

=0.66ms.

The discharge path is through only one resistor (RB) so that the time that the output is held low is shorter.

T low=0.69RB C

=0.69*1500*100*10-9

=0.000103s

=0.103ms

The output waveform is nonsymmetrical.

The total period can be found by adding t high to t low. The output frequency will be equal to the reciprocal of the total period.

Total period

T = t high +t low

= 0.000332+0.000103

=0.000435

=0.435ms

The frequency

fo= 1/T

=1/0.000435 HZ

=2298.85=2.299 HZ

Or the frequency

fo =1.45/(RA +2RB)*C

=1.45/(3300+3000)*100*10-9

=2.3KHZ

2.5 OUTPUT DEVICE

The output device brings out the processed result in various form such as light, sand, picture and so on. Light Emitting Diode (led) and horn are the output traducers used for the purpose of this project.

2.5.1 LIGHT EMITTING DIODE

The light emitting (led) produces light trough the used of semiconductor material. A diode junction can emit light when electrical current is present. An electrical current produces light energy because electrons and holes are forced to recombine. The energy level of an electron as it passes trough the junction of a semiconductor can be graphically shown. To get trough the depletion region, the electron must acquire some additional energy. This additional energy comes from the positive field of the anode. If the field is not strong enough, the electron will get through the depletion region and no light will be emitted. For a standard silicon diode, a minimum of 0.6 volts must be present before the diode will conduct. For germanium diode, 0.3 volts must be present before the diode will conduct. Most led manufacturers make a larger depletion region that requires 1.5 volts for the electron to get across the depletion region: it gives up its extra Kinetic energy. The extra energy is converted to light.

LED CONSTRUCTION

Manufacturer of the led`s generally use a combination of gallium and arsenics with silicon or germanium to construct semiconductors. Adding and adjusting others can process impurities to the base semiconductors, different wavelengths of light. Led's are capable of producing a light that is not visible to human eye, called infrared light, or it may emit a visible red or green light. If other colors are desirable, the plastic lens may be of different color.

Like standard semiconductor diode, there must be a method for determining which end of an led is the anode and which end is the cathode. The flat side of the devise identifies the cathode lead, or it may have a notch cut into the ridge

A colored plastic lens magnifies the light produced at the wire of the led. Without the lens, the small amount of light produced at the wire would be diffused, and it would be virtually unusable as a light source. The size and shape of the led package deter mines how it must be positioned for proper viewing

The systematic symbol for led is exactly like that of photodiode, but the arrows point away from the diode. The led must be forward biased, and a current-limiting resistor is usually present to protect the led from excessive current.

These are semiconductor diodes that emit light when current passes through them. They are available in four different colors. red, yellow, orange and green.

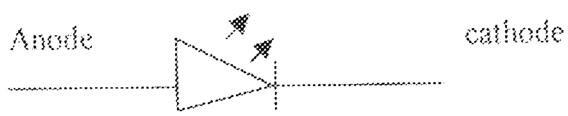


Fig 2.5.1 (a)

In operation led behave just like ordinary diodes in that the allow current to flow in one direction, but the similarly ends here because their appearance quite different.

Five diodes (led) are used for the purpose of this project. Limiting resistors of one-kilo ohm each protects them. See fig 2.5.1 (b) below.

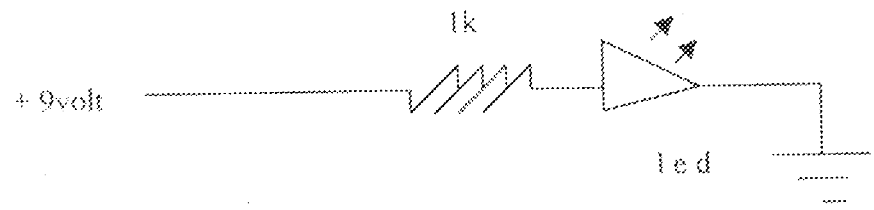


Fig 2.5.1 (b)

Let Rd be the led 's resistance

R the limiting resistor resistance (1 K)

Vd the led 's voltage drop (0.7V)

V: The voltage across the line That is the NOT gate output at high state (0)

Hence

V=IR + I *Rd where I is the current

V=(R+Rd)*I

The voltage drop across the resistance R is :

IR = V – IRD

=9-0.7

=8.3Volt

Hence

I= V/R

= 8.3/1000

=8.3mA

The power consumed by the line is.

P=VI

=9*8.3*10-3

=0.0747 watt

2.5.2 Horn

A horn is a sound output transducer. It can produce continuous or discontinuous sound depending on the signal received by it. The horn used for the purpose of this project is a speaker of 0.8 watt and 8 ohms. The speaker is fed by a NPN transistor (D.882) which base is connected to the 555 timer output (pin 3) through a 2 K resistor. (See fig 2.5.2)

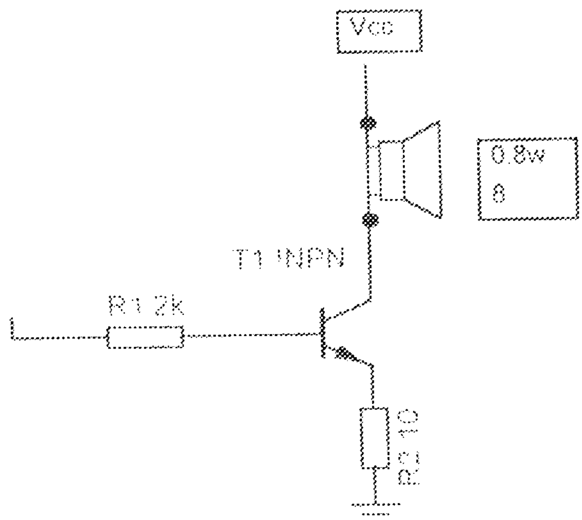


Fig 2.5.2

At high state pin 3 voltage is =9 Volt

Hence V=9V

Rb=2 K

Rc =8 ohm

P=30

Where Rb is the base resistance at the base

Rc is the resistance at the collector

Re is the resistance at the emitter

β is the transistor current gains

The current at the base Ic can be found as

Ib= V/Rb

=9/2000

=4.5mA

Ic= bIb

=30*4.5*10-3

=0.135A

Ie=Ib +Ic

=0.135+4.5*10-3

=0.140A

The voltage drop across the speaker

Vs=Ic*Ib

=0.135*8

=1.08V

CHAPTER THREE

CONSTRUCTION, TESTING, RESULTS AND DISCUSSION

In this chapter enlightens on how the different parts of the system are put together .It gives also an explicit detail of each block represented in chapter two.

3.1 CONSTRUCTION

In this section the circuitry of the system is shown and then the construction procedure is expanded.

3.1.1 POWER UNIT CIRCUITRY

The power unit circuitry involves, the transformation stage, the rectification stage; the filtering stage and the regulation stage.

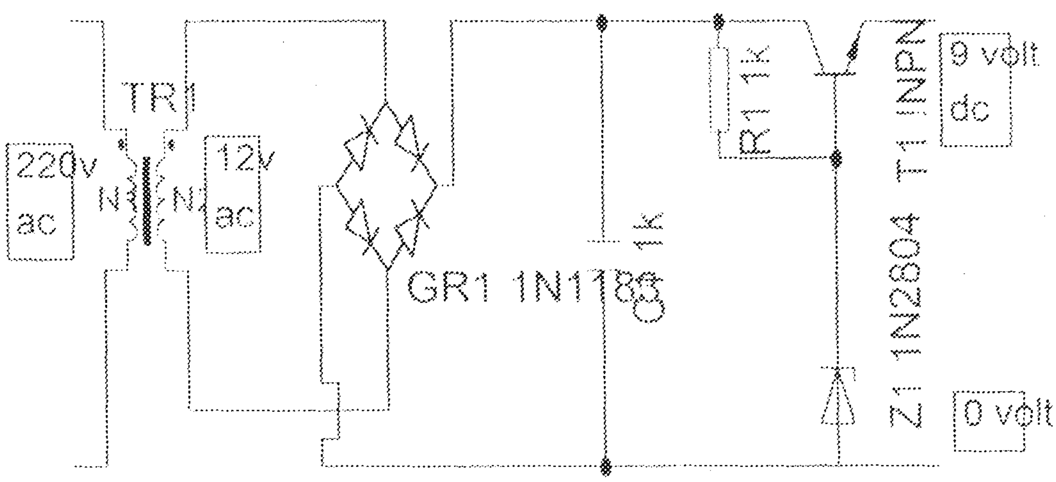


Fig 3.1.1

3.1.2 SENSING REGION

The probes in the tank and the wires connected to them are shown below

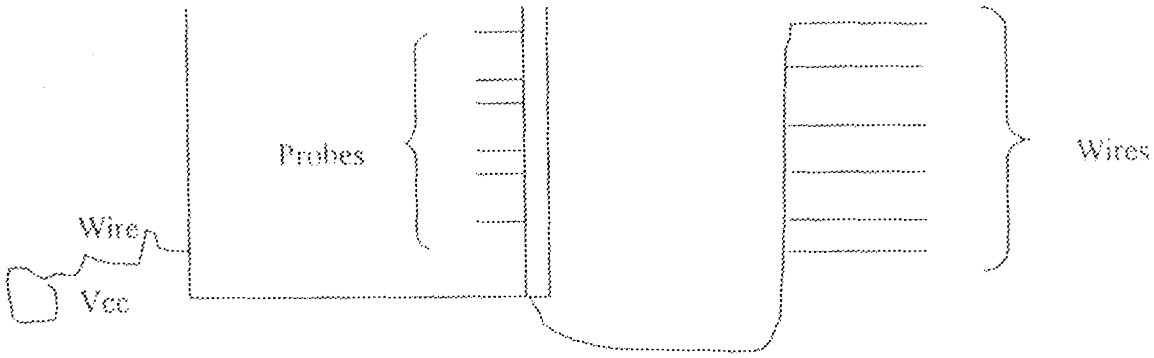


fig 3.1.2

3.1.3 PROCESSING UNIT

The five BJT transistors, the logic gates and the pull-up resistors constitute the processing unit.

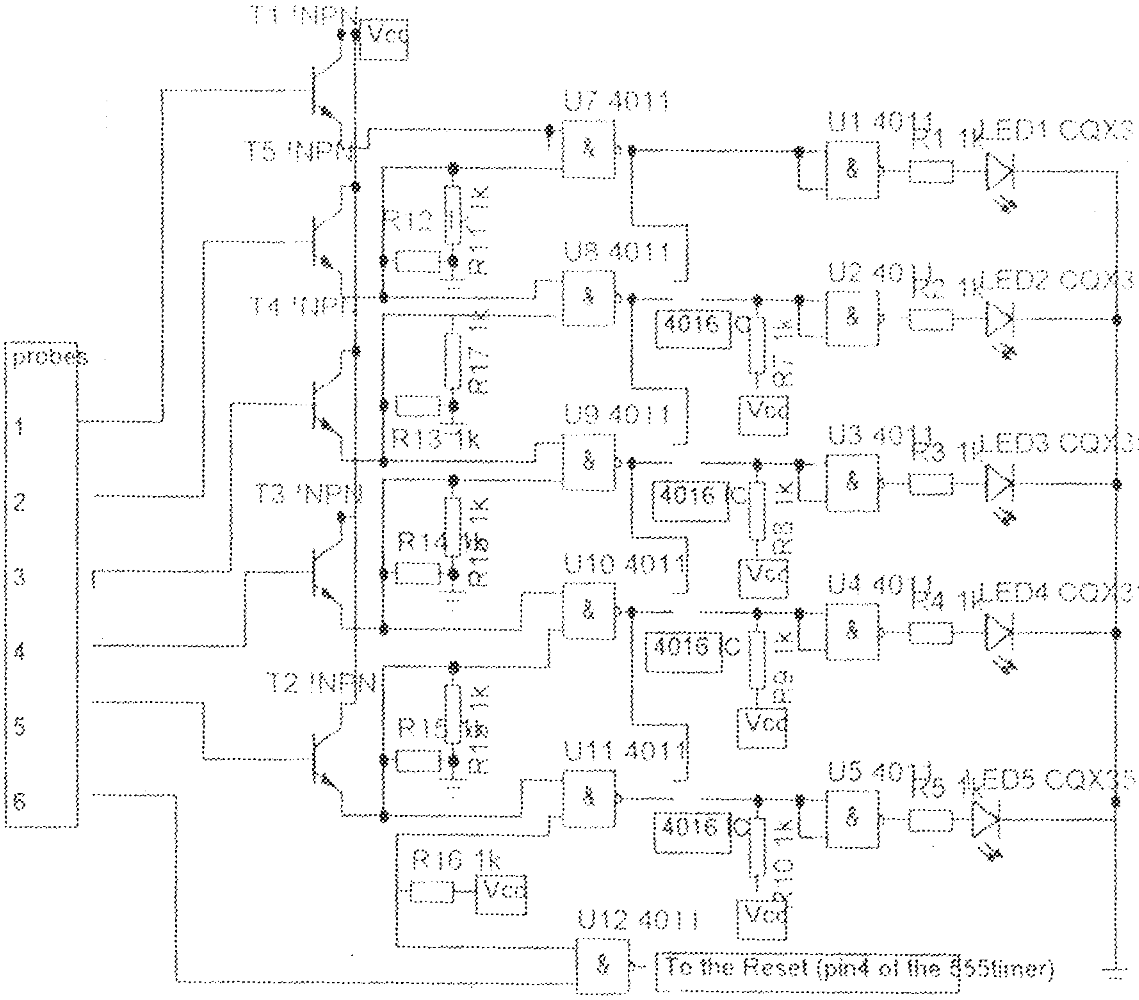


Fig 3.1.3 processing unit

3.1.4 OUTPUT DEVICES

i) THE LED

One-kilo ohm resistor limits each led input voltage and the five led's have common cathode grounded.

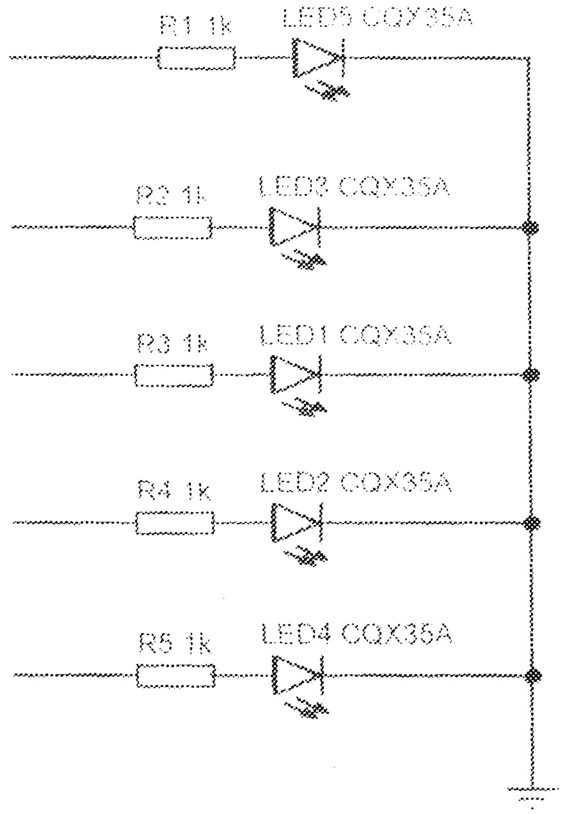


Fig 3.1.4 (a)

ii) THE TIME ALARM

The stable configuration of the 555 timer is used to activate the horn .The BJT used is to amplify the pin 3 output for a convenient power capable to sound the horn see figure below.

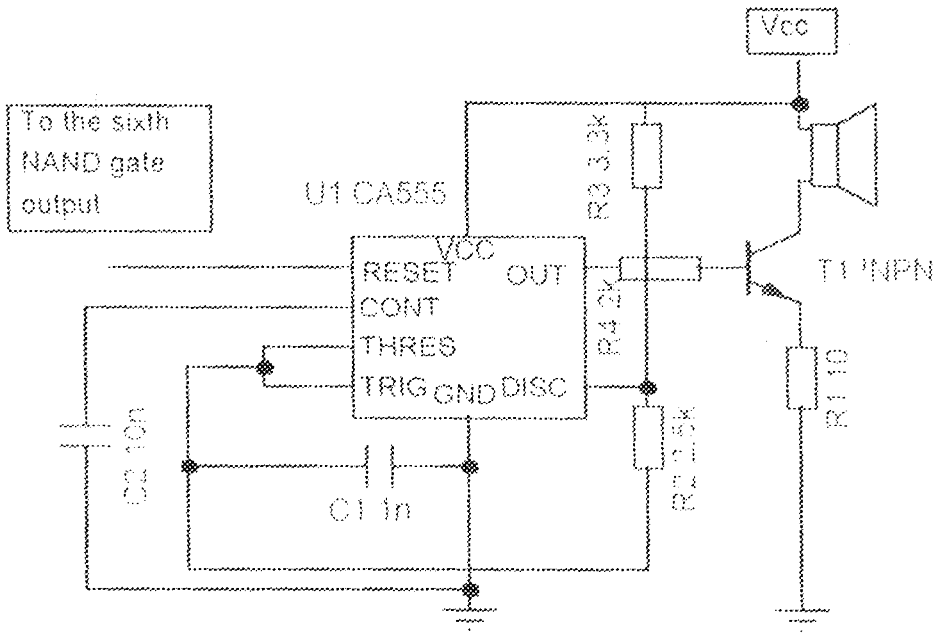


Fig 3.1.4 (b)

3.1.5 CONSTRUCTION PROCEDURE

The six steps water level indicator was built on circuit board .The construction work started by first designing the component layout for the system. This was done in such away that minimal space was used. Four 14 pin dual in line I C sockets were used to plug the IC into the circuit. This way of connecting the ICs is of vital importance because it aids in troubleshooting enormously as the ICs be removed when making check. The sockets were first soldered on the board and then using the IC pin positions as a guide, the best layout was determined .The other component were then fixed on the board, in their various positions Before soldering, proper checking of components connection was done. Polarized components such as electrolytic capacitors were well checked to be sure that they were fitted in the right way.

3.2 TESTING

3.2.1 THE TESTING STAGES

The testing is carried out by following the block diagram of the system representation After the 240V ac is supplied to the transformer, the transformer output is first tested then the dc voltage is measured to make sure that the output is 9Volt.

3.2.2 THE OVERALL SYSTEM TESTING

This consists of continuous fill-in or empty out the tank then the result of this process can be observed on the led and the alarm.

3.3 RESULTS

The results observed while testing fall in accordance with the design and construction specifications. During the testing, that is when the water is filling the tank; the led's light one by one from down to the top. But when the water in the tank, is reducing, the led's light one by one from the top to the down Then when the tank gets empty the alarm starts making continuous sounds as rated by the frequency components

3.4 DISCUSSIONS OF RESULTS

For the design and construction of the system, the goal was achieved even though it was, while solving many problems encountered such as:

-Choosing good ICs because many ICs are faulty right from the manufacturer.

-The unavailability of some electronic components here in Minna.

-It is also noted that a motor should have automatically controlled the designed system. That is, a motor can be used to pump water in the tank when it is empty which is not the case for this system.

CHAPTER FOUR

CONCLUSION, RECOMMENDATIONS

4.1 CONCLUSION

The design construction and testing of a six steps water level indicator has been considered in this project An important aspect of the system is that, power consumption is minimized by the fact that a single led lights at a time.

The system circuit is very simple with few components It is easy to maintain in case of faults because of the IC sockets used and the number of components involved .The availability of the components used ensures ease of replacement when they are faulty.

4.2 RECOMMENDATIONS

Several probes are used to allow for many different levels to be maintained. In these applications, two considerations must be given when using the tank and liquid as current carrying conductors. The first consideration is that the liquid must be a good conductor and not of any flammable material. The second consideration is that the current and voltage used to pass through the tank must be low enough and grounded properly to avoid any danger.

More probes would be needed at the sensing region for a good precision of the water level in the tank. Where by the same number of NAND gates would be needed to achieve that. However a second probe or alarm is needed to sound the alarm when the tank is about to overfull.

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