DESIGN AND CONSTRUCTION

OF

WATER PUMP ACTUATOR

BY

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A PROJECT REPORT SUBMITTED TO THE
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CERTIFICATION

This is to certify that this project, "DESIGN AND CONSTRUCTION OF WATER PUMP ACTUATOR" was presented by AHMAD USMAN SHEHU, 98/6840EE, of the department of Electrical /Computer Engineering, School of Engineering and Engineering Technology, Federal University of Technology Minna, and that he has met the required standard acceptable by the above named department.

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DECLARATION

I, AHMAD U. SHEHU, hereby declare that this project report presented for the degree of bachelor of engineering, is an original work of mine and has never been presented either wholly or partially for the award of diploma or degree in any other institution as far as I know.

The information derived from published work of others is acknowledged in the reference section.

.... 8/12/2004
AHMAD USMAN .S. Date

ACKNOWLEDGEMENT

I am very indebted to my mother, who has been there for me supporting me morally, financially and spiritually. I cannot thank you enough. Gratitude also goes to my uncle S.G.Umar and his beloved wife for their indelible contribution.

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ABSTRACT

The water pump actuator is a system designed to regulate the flow of water in a tank and operate the pump appropriately. Once water gets to a low level, the actuator triggers the pump via the switching interface unit, to enable water be pumped to a certain high level before the pump is switched off. Another application of the device is to automatically switch ON/OFF any electric device connected to it, thus giving it a wide range of application both in industries and at home.

The major parts could be divided into the following functional block: Power supply unit, water sensing unit, switching interface unit and the logic control unit which when coordinated together, forms the water pump actuator.

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CHAPTER ONE

1.0 INTRODUCTION

Electronic systems refine, extend or supplement human facilities and ability to observe, perceive, communicate, remember, calculate or reason. Electronic systems are classified as either analog or digital.

Analog systems change their signal output linearly with the input and can be represented on a scale by means of a pointer. On the other hand, digital instruments or circuits represent their output as two discrete levels ('1' or '0') and could show their output in a digital display either numerically or alphabetically.

An actuating device or component is one which triggers electrical contacts like relays to effect signal transmission while an actuating system is an automatically or manually operated system that starts (sometimes stops or modifies) an operation.

The water pump actuator, which is the topic of this project automatically detects the water level in a tank and starts the pump when the level is low or has reached any preset level and stops it when the tank is full or has reached a desired preset level.

Liquid level sensors are employed to sense these levels. Once a preset level is sensed, electronic logic control circuits are triggered to control the pump via a transistor switching interface circuit. The circuit has a lot of domestic and commercial applications. It can be made to trigger alarms when water in a bath or liquid in a tank reaches a preset level, or when rain falls across a pair of contacts, when flooding occurs in a cell or basement or when an impact wave is generated as a person or object falls into a swimming pool or tank.

An actuation system can also be adapted to work for steam. It can be made to act as a control when high pressure valve or a fractured pipe release some amount of steam or when steam emerges from a kettle or container as the liquid inside it reaches its boiling point.

Although this project is a water pump actuator, the applications extend beyond just the water pump. The sensors are a pair of probes using galvanized metal. These pair of metal probes detects the presence or absence of water in a tank. In the absence of water or a medium (in a case of other liquids or steam) the 'probes' see a near infinite resistance, but in the presence of the medium the resistance of the probe falls to a relatively low level. This falls in resistance is sensed by a comparator and used to control the operation of a digital logic device, which triggers the pump actuation process.

In the case of water the resistance may be less than a few kilo-ohms. When steam or oil is used, the resistance may be greater than several mega ohms. Of course this project deals with water since it is a water pump actuator. The generalized block diagram is shown in fig. 1.1 below.

1.1 GENERALIZED BLOCK DIAGRAM

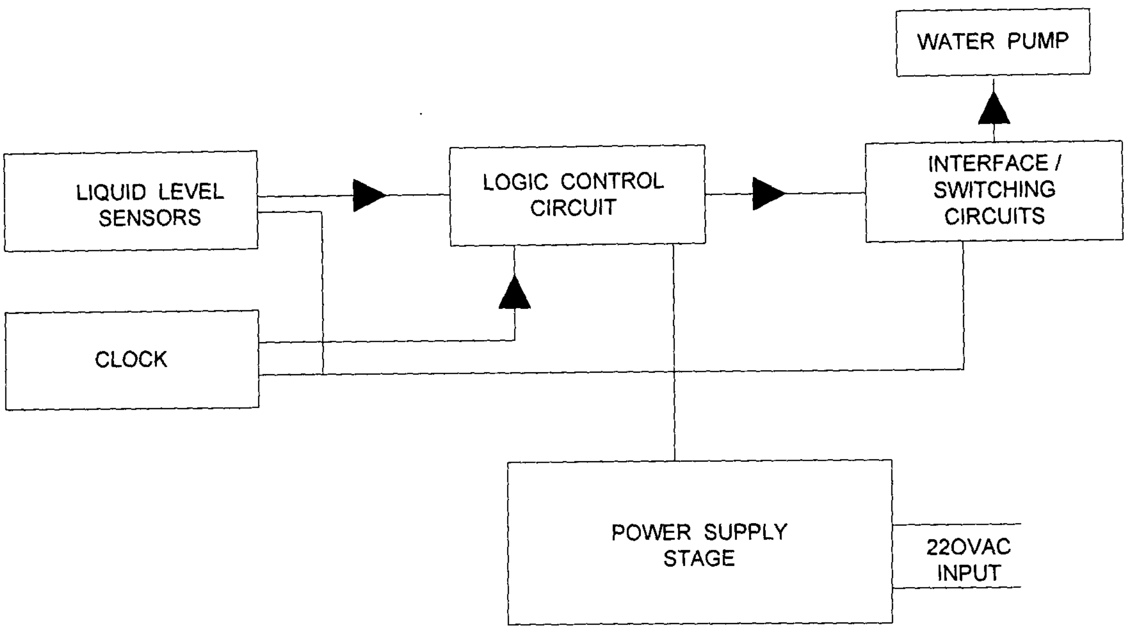

FIG 1.1 GENERALIZED DIAGRAM FOR WATER PUMP ACTU ATOR

DESIGN SPECIFICATIONS

INPUT VOLTAGE	:	220VAC
MAX. PUMP POWER	:	3HP
SUPPLY VOLTAGE	:	+12V.D.C & 5VDC
SENSOR TYPE	:	GALVANIZED METAL
MEDIUM	:	WATER

1.2 AIMS AND OBJECTIVE

The design and construction of the water pump actuator is aimed at achieving the following goals;

1. It introduces the student to the practical application of the theory courses taught in the classroom, like analogue, digital and power electronics.
2. In another perspective, the device so produced is aimed at reducing the cost of labour for employers and make life easier in home application.

1.3 PROJECT OUTLINE

Chapter one: This chapter gives general overview of the project, the introduction, the generalized block diagram and the design specification. Also included are the aims and the objectives.

Chapter two: This contains the literature review. It covers the explanation of the various components used in the design, namely the op-amp, flip-flops, transistors, IC-timers, etc.

Chapter three: This contains the detailed design, analysis and consideration. The principles of operation and design calculations of all the units that make up the system are discussed in this chapter.

Chapter four: This chapter covers the detail of construction and testing procedures employed to achieve the final product. It spans soldering of component on the vero board, case construction, testing, troubleshooting and results obtained. Problems encountered are also listed here.

Chapter five: This contains the conclusion drawn from the results of testing. References, list the books and materials consulted.

CHAPTER TWO

2.0 OP-AMPS & COMPARATORS

An operational amplifier is a differential amplifier with an extremely high open voltage gain. Negative feedback circuits are employed in op-amps to control the gain where precise gain values are needed. The comparator is an operational amplifier without a feedback. Hence, it is controlled by the open loop voltage gain. It is a circuit that compares an input voltage with a reference voltage. The output of the comparator then indicates whether the input signal is above or the reference voltage. The output voltage approaches $+v_{s.}$ (supply voltage) when input signal is slightly greater than the reference voltage (v_{ref}).

The op-amp was originally developed for use with analog computers but now they found place in almost all aspect of electronics. The ideal op-amp has the following ideal characteristics;

Infinite voltage gain

Infinite input impedance

Infinite Bandwidth.

Zero output impedance

In practice however there are deviations from ideal conditions due to manufacturing processes and other physical conditions the various components might be subjected to which make up the op-amps. The actual characteristics of µA741 op-amp is shown below:

Voltage gain – 106dB (numerical gain = 2000000.0)

Input impedance – 1MΩ

Output impedance – 75Ω

Zero output impedance

The voltage gain and bandwidth are two parameters that must be critically observed, for successful application of this device.

$V_{out} = A_0 V_{in}$

Where A_0 = open loop voltage gain.

And $V_{in} = V^+ - V^-$

Due to the very high A_0, V_{out} will tend to saturate upon any difference in input. Other op-amp circuits include, inverting and non – inverting amplifiers, summing amplifiers, unity gain buffers etc.

2.1 FLIP FLOPS AND LATCHES.

Latches and flip-flops fall under sequential logic circuits. The flip-flop may be defined as a 1 – bit memory element (or latch) having two outputs, which take up complementary states 0 i.e.0 and 1 when signal are applied to the input. The output condition would then be retained until another input signal combination causes the output stage to change.

Flip-flops generally form the building block for IC latches. Some of the widely used flip-flops are the SR (set reset), JK, D and T-type flip-flops but the JK flip-flop is the most versatile of the various types of flip-flops since it can be used as a basic element to generate all the other types. Most flip-flops are designed using combinational logic circuits (i.e. logic gates etc) but in situations where large numbers of bits are involved, commercially available flip-flops become handy.

Examples of commercially available flip-flops are, 7474, 7473, and 7427, 74373, 74374...

The 74374 are 8-bit edge triggered register coupled to eight tri state output buffers. The two sections of the device are controlled independently by an external clock pulse (CP), and output enables OE to the gates.

The register is fully edge triggered and the state of each D (data) input one setup time before a low to high clock transition is transferred to the corresponding Q output of the flip-flop. The clock buffer has about 400mv of hysterisis built in to help minimize problems that signal and ground noise can cause in clocking operation

2.2 TRANSISTORS.

Transistors are active components used basically as amplifiers and switches. The two main types of transistors are: The bipolar transistors whose operation depends on the flow of both minority and majority carriers, and the unipolar or field effect transistors (called FETs) in which current is due to majority carriers only (either electrons or holes). The transistor as a switch operates in class A mode. In this mode of bias the circuit is designed such that current flows without any signal present. The value of bias current is either increased or decreased about its mean value by the input signal (if operated as an amplifier), or ON and OFF by the input signal if operated as a switch.

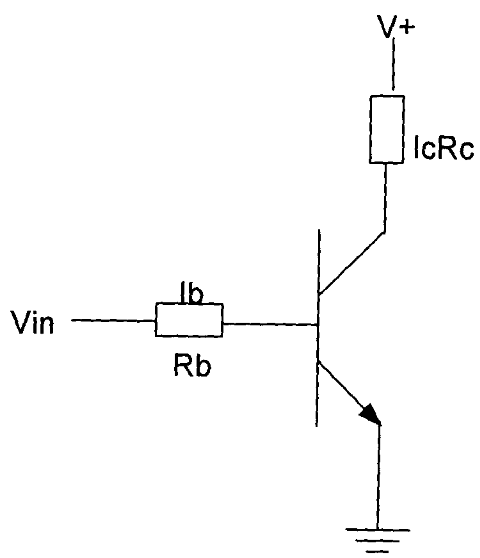

Fig.2.2a TRANSISTOR AS A SWITCH.

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For the transistor configuration, since the transistor is biased to saturation.

V_{CE} =O, when the transistor is ON.

This implies that,

$V_+ = I_c R_c + V_{CE}$ -------------------- (2.5)

$V_{in} = I_B R_B + V_{BE}$ --------------- (2.6)

$$\frac{I_c}{I_b} = h_{fe} \quad \text{------------------------ (2.7)}$$

$$R_b = \frac{V_{in} - V_{BE}}{I_f} \quad \text{---------------- (2.8)}$$

Where,

. I_c = collector current

I_b = base current

V_{in} = input voltage

V+ = supply voltage

V_{CE} = collector-emitter voltage

h_{fe} = current gain.

2.3 IC TIMERS.

The emanation of IC timers eliminated a wide range of mechanical and electromechanical timing devices .It also helped in the generation of clock and oscillator circuits.

Timing circuits are those, which will provide an output change after a predetermined time interval. This is, of course, the action of the monostable multivibrator, which will give time delay after a fraction of a second to several minutes quite accurately. The most popular of the ICs, which are available in an eight-pin dual in line package, are in both bipolar and CMOS form. The 555 timers is a relatively stable IC capable of being operated as an accurate bistable, monostable or astable multivibrators.

MULTIVIBRATOR

The monostable vibrator is a circuit whose output has only one stable state usually low. When the circuit is externally triggered, it's output goes to the unstable state usually the high state (for a predetermined time), after which it will returns to its stable state.

An RC time constant determines the time for the unstable state. Monostable vibrators are often called timers since they provide an out put pulse for a given duration. They are called "one shots" because when triggered they generate a single pulse of a fixed time duration.

They are used for turning some circuit or external component on or off for a specific length of time .It is also used for generating delays.

In this application, the duration of the out pulse in seconds is approximately

$T = 1.1 * R*C$, T=time in seconds.

R = resistance in ohm

C = capacitance in farads.

The timer comprises of 23 transistors, 2diodes and 16 resistors in its internal circuitry. Its connection diagram is shown below in fig 2.1

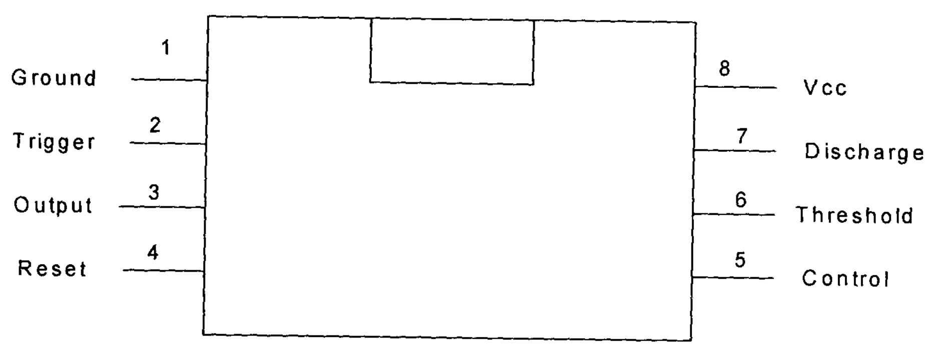


Fig 2.1 555 timer pin orientations

The functional diagram of 555 timers consists of two comparators, a flip-flop, two control transistors and a high current output stage. The two comparators are actually operational amplifiers that compare input voltage to internal reference voltages which are generated by internal voltage divider of three 5K resistors.

The reference voltage provided are one third and two third of V_{cc}. When the input voltage to either of the comparators is higher than the reference voltage for the comparator, the amplifier goes to saturation and produces an output signal to trigger the flip-flop. The output of the flip-flop controls the output stage of the timer. The 555 timer chip works from a d. c. supply between 3-15V and can source or sink up to 200mA at its output.

The operation of the 555 timers is further explained by defining the functions of all the pins. The details regarding connection made to pins are as follows:
Pin 1: This is the ground pin and should be connected to the negative side of the supply voltage.

Pin 2: This is the trigger input. A negative going voltage pulse applied to this pin below 1/3Vcc causes the comparator output to change state. The output level then switches from LOW to HIGH. The trigger pulse must be of shorter duration than the time interval set by the external RC network, otherwise the output remains high until trigger input is driven high again.

Pin 3: This is the output pin and is capable of sinking or sourcing a load requiring up to 200mV and can drive TTL circuits. The output voltage available is approximately –1.7V.

Pin 4: This is the reset pin and is used to reset the flip-flop that controls the state of output pin 3. Reset is activated with a voltage level of between 0V and 0.4V and forces the out put low regardless of the state of the other flip-flop inputs. If reset is not required, then pin 4 should be connected to same point as pin 8 to prevent accidental resetting.

Pin 5: This is the control voltage input. A voltage applied to this pin allows the timing variations independent of the external timing network. Control voltage may be varied from between 45 to 90 of the Vcc value in monostable mode. In astable mode the variation is from 1.7 to the full value of supply voltage. This pin is connected to the internal voltage divider so that the voltage measurement from here to ground should read 2/3 of the voltage applied to pin 8. If this pin is not used it should be bypassed to ground, typically use a 10nF capacitor. This helps to maintain immunity from noise. The CMOS ICs for most applications will not require the controlled voltage to be decoupled and it should be left unconnected.

Pin 6: This is the threshold input. It resets the flip-flop and hence drives the output low if the applied voltage rises above two-third of the voltage applied to pin 8. Additional current of minimum value 0.1 A must be supplied to this pin since this determines the maximum value of resistance that can be connected between the positive side of the supply and this pin. For a 15V supply the maximum value of resistance is 20M.

Pin 7: This is the discharge pin .It is connected to the collector of an npn transistor while the emitter is grounded. Thus when the transistor is turned "on", pin 7 is effectively grounded. Usually the external timing capacitor is connected between pin 7 and ground and is thus discharged when the transistor goes on.

Pin 8: This is the power supply pin and is connected to the positive of the supply. The voltage applied may vary from 4.5V to 16V although devices, which operate up to 18V, are available

2.4 RELAYS & ELECTROMECHANICAL DEVICES

Relays and electromechanical devices operate on the principle of electromagnetism. Relays are used where a small current in one circuit is used to control another circuit containing a device such as lamp or electric motor, which requires a large current, or is used to control several different switches simultaneously.

The diagram below shows the symbol of a relay. The current needed to operate a relay is called the pull-in current and the dropout current is the current in the coil when the relay just stops working.

If the coil resistance of a relay is R and its operating voltage is V, then, the pull-in current $I = V/R$

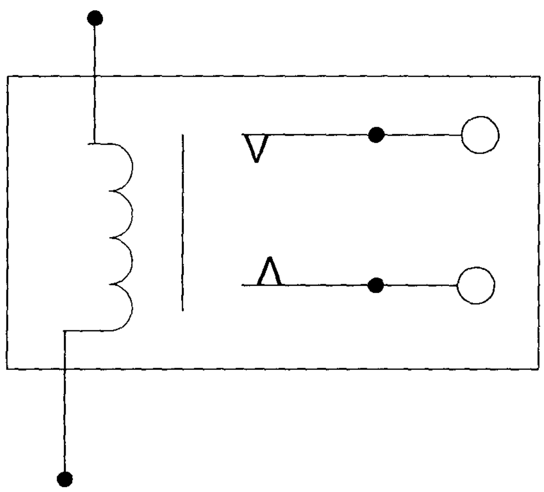


Fig 2.4 Relay symbol

2.5 OTHER PASSIVE COMPONENTS

Passive components are components, which cannot amplify power and require an external power source to operate. They include resistors, capacitors, indicators and transformers etc. Their applications range from potential dividers to control of current (as in resistors), filtration of ripples voltages and blocking of unwanted D.C voltages (as in capacitors). They form the elements of the network circuit oscillator stages and are also used generally for signal conditioning in circuits. Their schematic diagrams and symbols are shown in fig 2.4a.

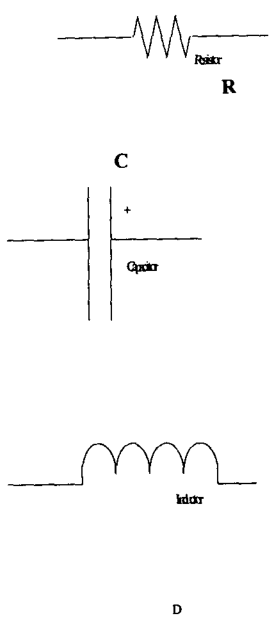


Fig 2.4a-c Schematic Representation For Passive Components.

CHAPTER 3
DESIGN & ANALYSIS

3.0 PRINCIPLE OF OPERATION

The principle of operation has to do with the sensing of different water levels to activate the actuating device. The water resistance once sensed biases the comparator stage and gives an output, which clocks and put the flip-flop in a SET MODE. The flip-flop is triggered and controls a transistor stage, which triggers the relay.

The flip-flop is triggered from a monostable multivibrator, which gives a LOW to HIGH clock transition once the liquid level is LOW so as to initiate the pump. The two sensors in the tank are placed at the two discrete levels to detect when the water is full or low. Once full, the upper sensor senses the liquid and gives a LOW output from a comparator to RESET the flip-flop and stop the flow of water to the tank.

The water pump is activated when the relay switches 220VAC to the pump (i.e. when the water level is low). The pump continues till the second sensor switches the relay OFF. The analysis of other stages is shown below.

3.1COMPARATOR/LIQUID LEVEL SENSOR

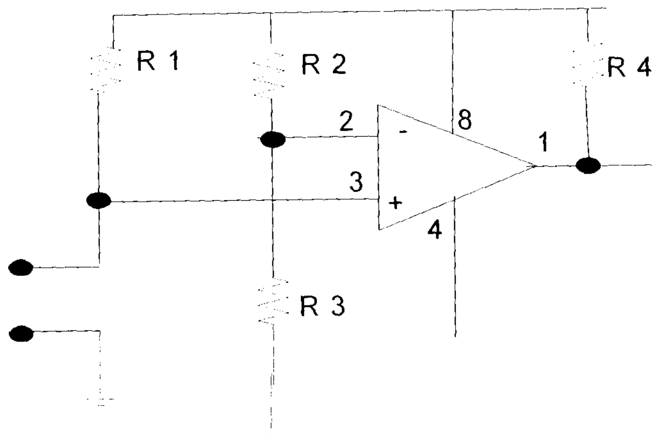


Fig 3.1 comparator stage

The liquid level detector stage uses a set of probes immersed into water. It operates on the principle that water has less electrical resistance than air. Once inserted into the medium, resistance of water creates a potential difference which when compared with a reference voltage gives an output at the comparator. These probes are usually used in series with high value fixed resistors as potential divider inputs.

Once the probes are outside the medium, resistance across the probes will be infinite (more or less an open circuit). Hence there'll be full voltage drop across the probes. It implies $V^+ > V^-$ and $V_{out} = V_S$
(Supply voltage)

Once in the medium, the resistance drops to a few kilo ohms, approximately 100 kΩ for water. Hence, the drop across probes would be

$V_P = L_R/(L_R + R_1) \times V^+$ (L_R is the resistance of the medium)

$= 100\ k\Omega / (100\ k\Omega + 1\ M\Omega) \times 12\ V$

$= 1.09\ V$

It implies, when the probes are open circuited there will be a 12 V drop across it. When immersed in the water medium the voltage drop will be 1 V. To obtain the reference voltage V_{REF}, using potential divider technique across resistors R_2 and R_3

$V_{REF} = V_{R3} = R_3\backslash(R_3 + R_2) \times V^+$

$R_3 = 2.2\ k\Omega$, $R_2 = 1\ k\Omega$ (from component list)

$V_{REF} = 2.2\ k\Omega\backslash\ (2.2\ k\Omega + 1\ k\Omega) \times 12\ V$

$= 0.67 \times 12\ v$

$= 8\ V$

3.2 LOGIC CONTROL STAGE.

The logic control is built around a D- type flip-flop. The basic D-flip-flop operates by simply transferring the voltage level on the D input to the Q output when the clock is HIGH. When the clock is LOW, the Q and $\bar{Q}$ outputs remain in their last state. It is the flip-flop that tells the system when to start and stop the pumping process. The operation of the system is described in the truth table below.

Mode	D input	Ck	Q	$\bar{Q}$	R
Set	1	↑	1	0	1
Reset	0	↑	0	1	1
Hold	X	0	P.S	P.S	0

X ...... Don't care

↑ ... Rising edge

Q and Q ...... Outputs

D ...... Data input

P.S .... Previous state

The logic control circuit operates in its set and reset mode. When the Astable multivibrator sends clock signal, the flip-flop shifts data from the data input to the Q output to switch the relay; in order words if there is no input to the flip-flop, the Q output will be low. The diagram of the flip-flop stage is shown in fig 3.2 below.

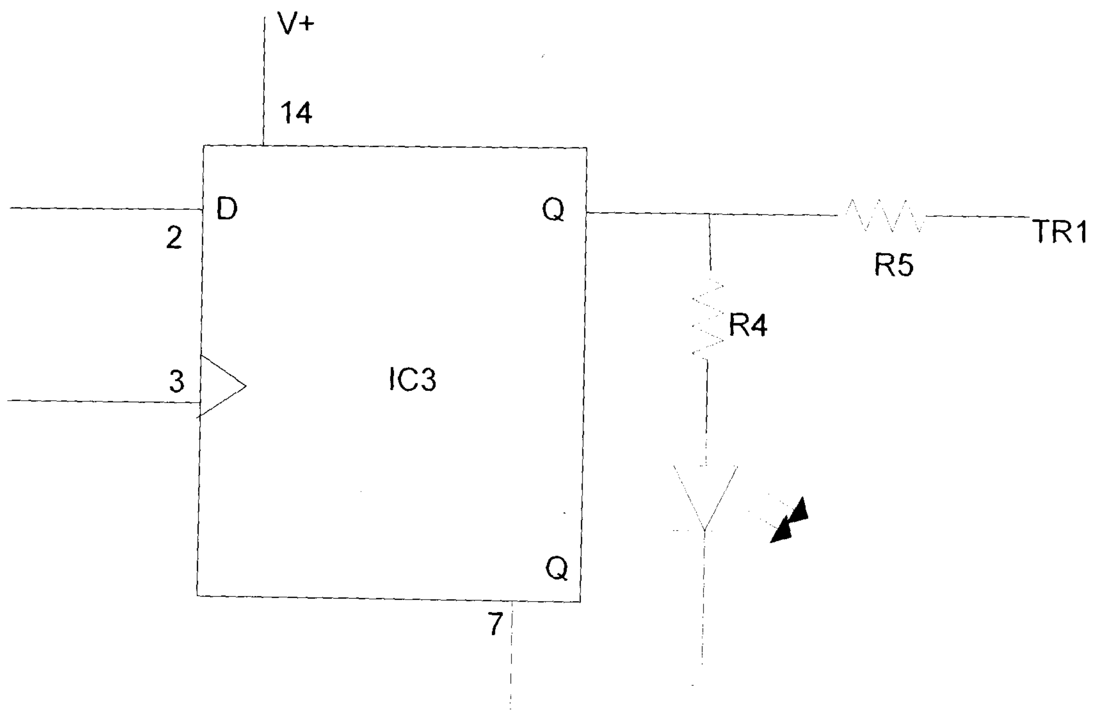


Fig 3.2 D- type flip- flop

3.3 SWITCHING TRANSISTOR STAGE.

This unit performs the major task of switching the pump ON and OFF. It is driven from the out pin of the D-flip-flop. The power supply for this unit is +12 V, because of the relay rating used. Transistor switching is used to provide the current necessary to energize the relay coil, in this instance BC337 transistor was used for the switching stage.

When the D-flip-flop outputs a HIGH, the relay circuit is energized and closes a switch, which turns on the pump. When LOW it opens the switch when the energizing current is removed.Fig.3.3 below shows the switching circuit.

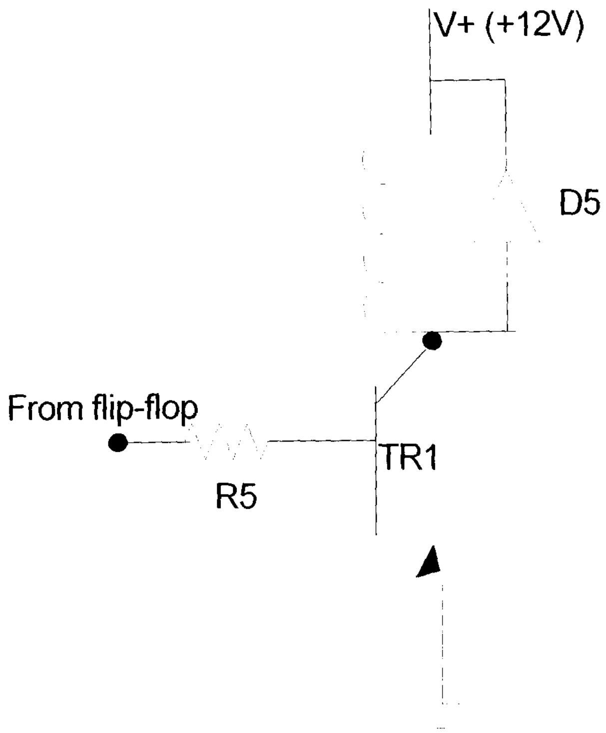


Fig 3.3 Transistor switch

A base resistor is required to ensure perfect switching of the transistor in saturation. To achieve this, the base resistor chosen must be able to able to withstand excess base current due to reduced h_{fe} (current gain) at low V_{CE} (collector-emitter voltage). Since an inductive load is used i.e. the relay coil, the transistor is protected with a diode across the load as shown in fig 3.3.This protects the transistor from back emf that might be generated.

A preferred value for the base resistance R5 is obtained given the following parameters:

R_c =400 Ω (collector resistance, relay coil resistance)

V^+ = 12 V (regulated voltage from the power supply)

V_{be} = 0.6 V (silicon)

V_{ce} = 0 V (when transistor is switched)

V_{in} = 5 V (from the D flip-flop)

$h_{fe} = 300$ (from data sheet for BC546)

$V_+ = I_c R_c + V_{CE}$ ----------------------(1.0)

$V_{in} = I_B R_B + V_{BE}$ ----------------(2.0)

$\frac{I_C}{I_B} = h_{fe}$ ----------------(3.0)

$R_b = \frac{V_{in} - V_{BE}}{I_B}$ ----------------(4.0)

Where,

I_C = collector current

I_B = base current

V_{in} = input voltage

V^+ = supply voltage

V_{CE} = collector-emitter voltage

h_{fe} = current gain.

From 1.0, $12 = I_C R_C + V_{CE}$

$12 = Ic\,(400) + 0$

And, $Ic = 30$ mA

From 3.0, I_B = 30mA/300

= 100 μA

From 2.0, $5 = 100\ \mu A\ R_B + 0.6$

R_B = 4.5/100 A

= 44 kΩ

R_5 = 47 kΩ (Preferred value)

3.4 POWER SUPPLY STAGE

The power supply stage is a linear power supply type and involves a step down transformer, filter capacitor, and a voltage regulator to give the 5V. The power supply circuit diagram is shown in fig. 3.4

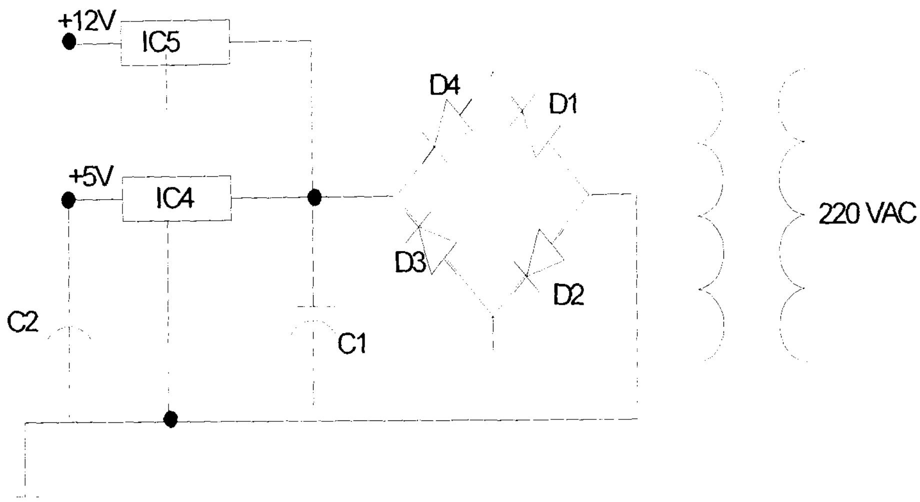


FIG 3.4 POWER SUPPLY CIRCUIT

The rectifier is designed with four diodes to form a full wave bridge network. C_1 is the filter capacitor and C_1 is inversely proportional to the ripple gradient of the power supply. Fig. 3.8b shows the ripple gradient

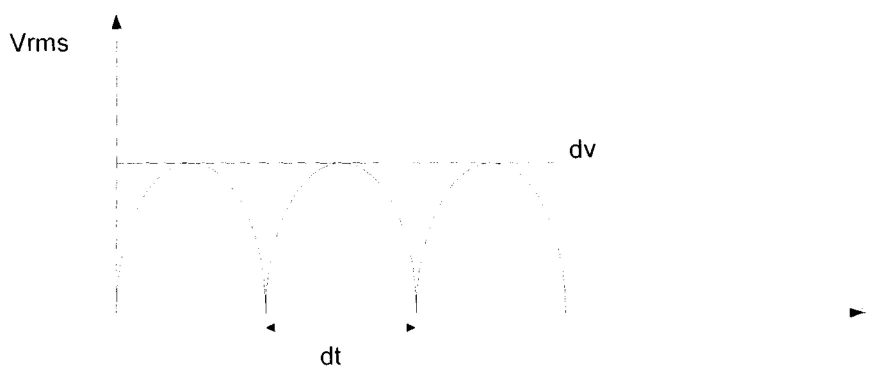


Fig. 3.4b ripple gradient of power supply stage.

Where dv is the ripple voltage for time dt, and dt is a dependent in power supply frequency.

For an rms voltage of 12 volts (from transformer)

Vpeak = 12 x √2 (i.e., rms x √2)

= 16.9 V

Hence letting a ripple voltage of 15% makes dv = 2.5

$$\text{But } 1/C = \frac{dv}{dt}$$

$$C = \frac{dt}{dv}$$

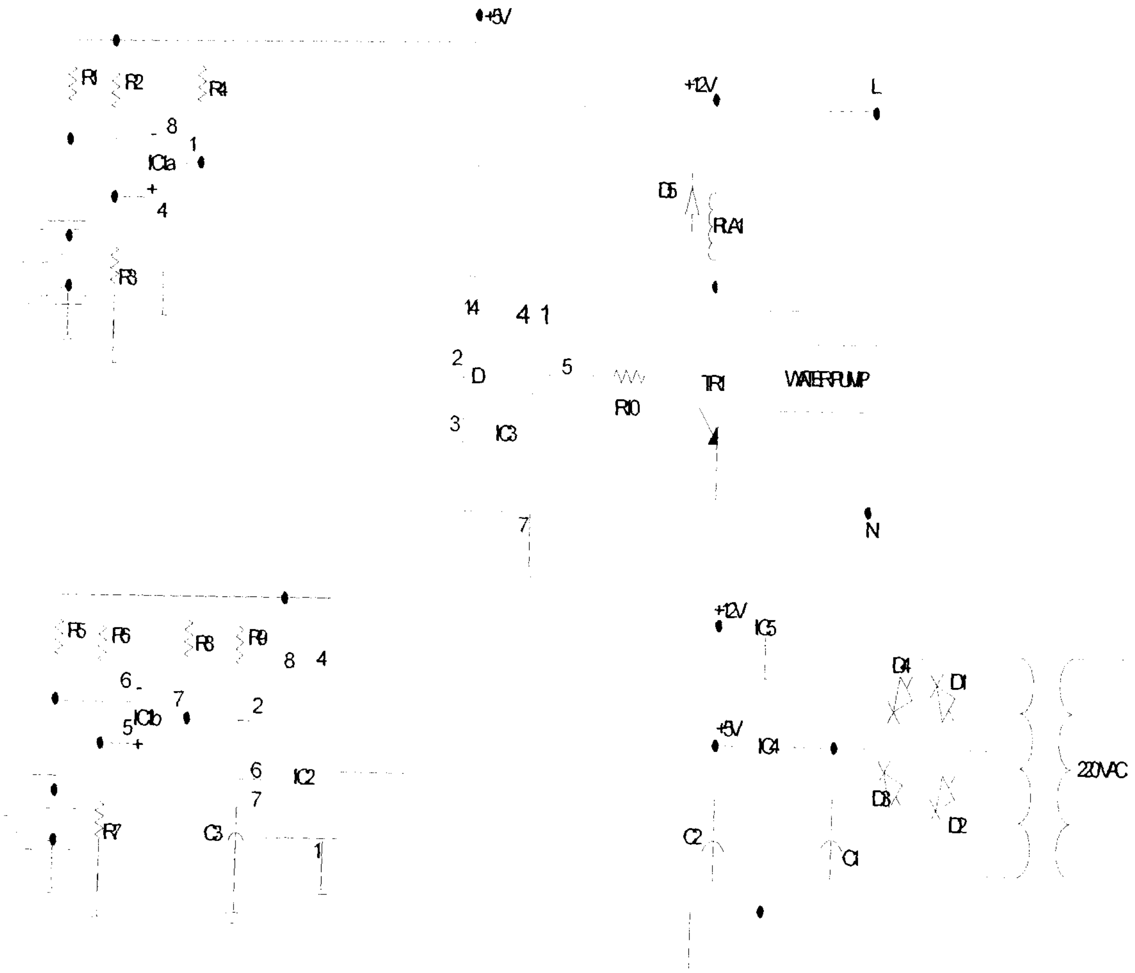
$$= \frac{10\text{ ms}}{2.5\text{ V}} \text{ (where dt = 10ms for 50 Hz)}$$

$$= 2222.8\ \mu F$$

A preferred value of 2200 μF was employed for the power supply stage.

7812 and 7805 regulators were used for the power supply stage.

3.5 COMPREHENSIVE CIRCUIT DIAGRAM



3.6 COMPONENTS LIST

COMPONENTS	VALUES
R1, R5	2 MΩ
R4, R8, R2, R8	1 KΩ
R3, R7	2.2 KΩ
R9	10 KΩ
R10	47 KΩ
C1	3300 μF
C3, C2	100 μF
D1 – D5	IN4001
IC1	LM393
IC2	NE555
IC3	7474
IC4	7805
IC5	7812
TR1	BC337
RLA1	12 V, 10 A

CHAPTER FOUR
TESTING AND CONSTRUCTION

4.0 TESTING

The physical realization of the project is very vital. This is where the fantasy of the whole idea meets reality. The designer will see his or her work not just on paper but also as a finished hardware.

After carrying out all the paper design and analysis, the project was implemented and tested to ensure it's working ability, and was finally constructed to meet desired specifications. The process of testing and implementation involved the use of some equipment stated below.

(I) BENCH POWER SUPPLY: This was used to supply voltage to the various stages of the circuit during the breadboard test before the power supply in the circuit was built. Also during the soldering of the project, the power supply was still used to test various stages before the D.C power supply used in the project was finally constructed.

(ii) OSCILLOSCOPE: The oscilloscope was used to observe the ripples in the power supply waveform and to ensure that all waveforms were correct and their frequencies were accurate. The waveform of the power supply and monostable multivibrator stages was checked.

DIGITAL MULTIMETER: The digital multimeter basically measures voltage, resistance, continuity, current, frequency, temperature and transistor h_{fe}. The process of implementation of the design on the bread- board required the measurement of parameters like, voltage, continuity, and resistance values of the components, in some cases frequency measurement. The digital multimeter was used to check the various voltage levels of the stages and was also used in troubleshooting during the project in areas where problems were encountered.

4.1 IMPLEMENTATION

The implementation of this project was done on the breadboard. The power supply was first derived from a bench power supply in the school electronics lab (to confirm the workability of the circuit before the power supply stage was soldered).

Stage by stage testing was done according to the block representation on the breadboard, before soldering of circuit commenced on vero board. The various circuits and stages were soldered in order to meet desired workability of the project.

For proper understanding of how the system operates and allow for troubleshooting, the pin configuration of the Ics and other active components used are shown below. Fig 4.1a shows the pin out of the LM393, which was used as a voltage comparator in the liquid level detector stage.

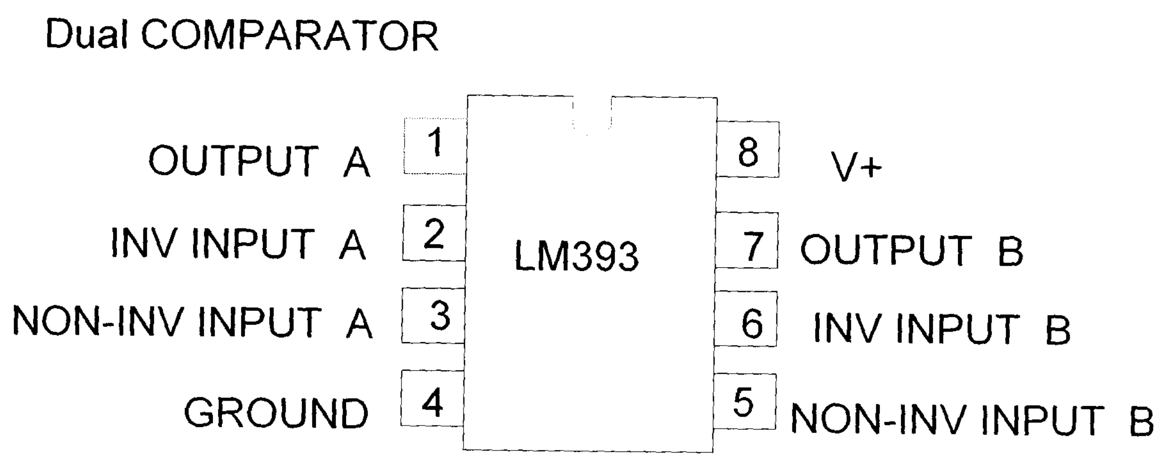


Fig. 4.1a LM393

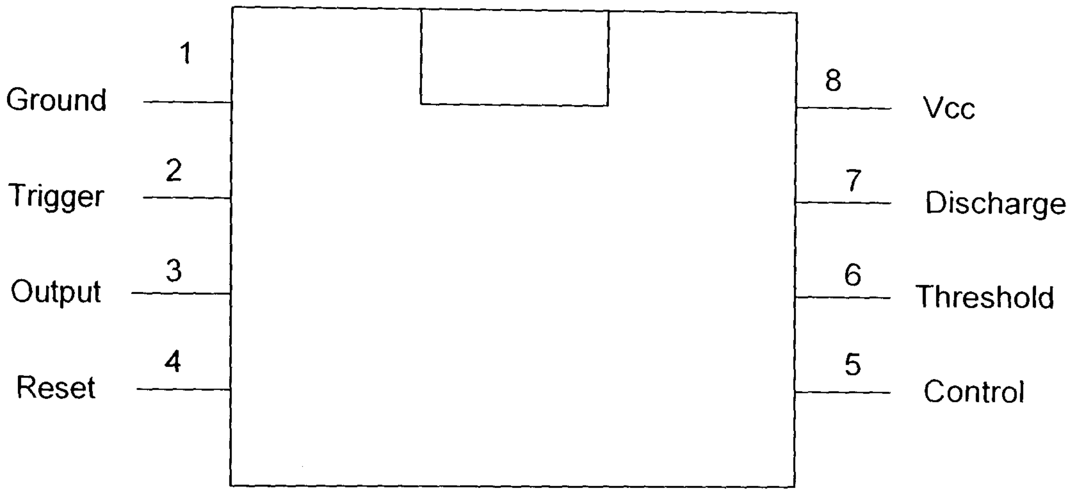
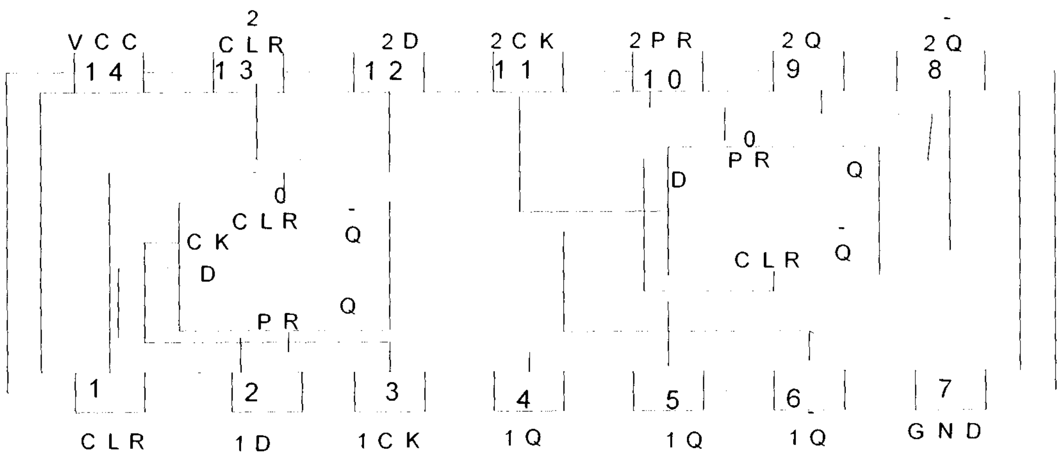


Fig 4.2b 555 timer pin orientation

The NE555 was used as a monostable



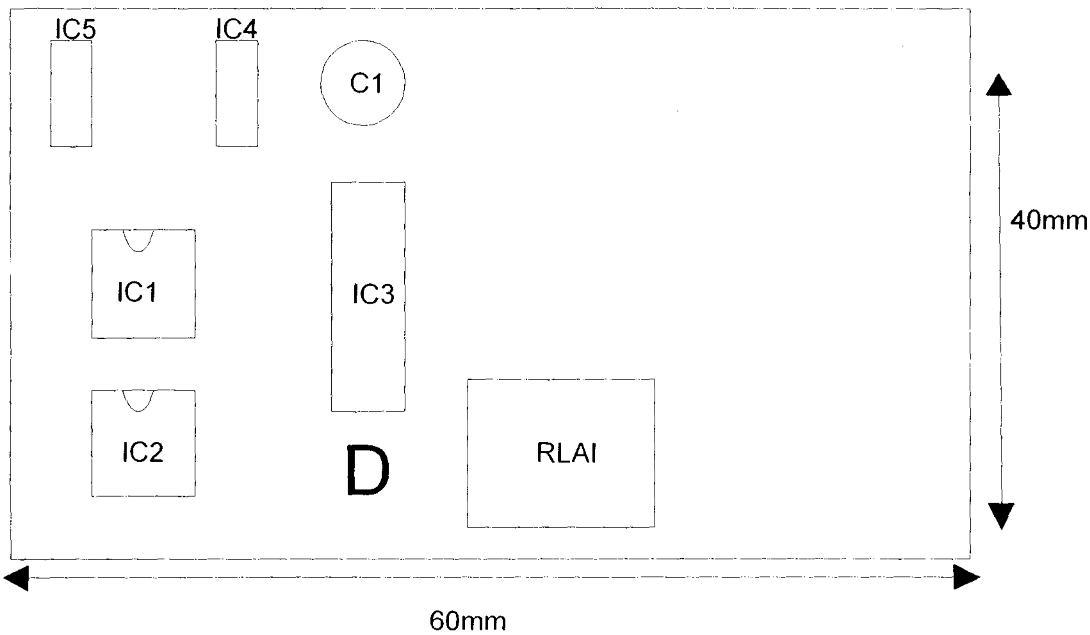
7474

The 7474 D flip-flop was used for logic control of the switching of the pump

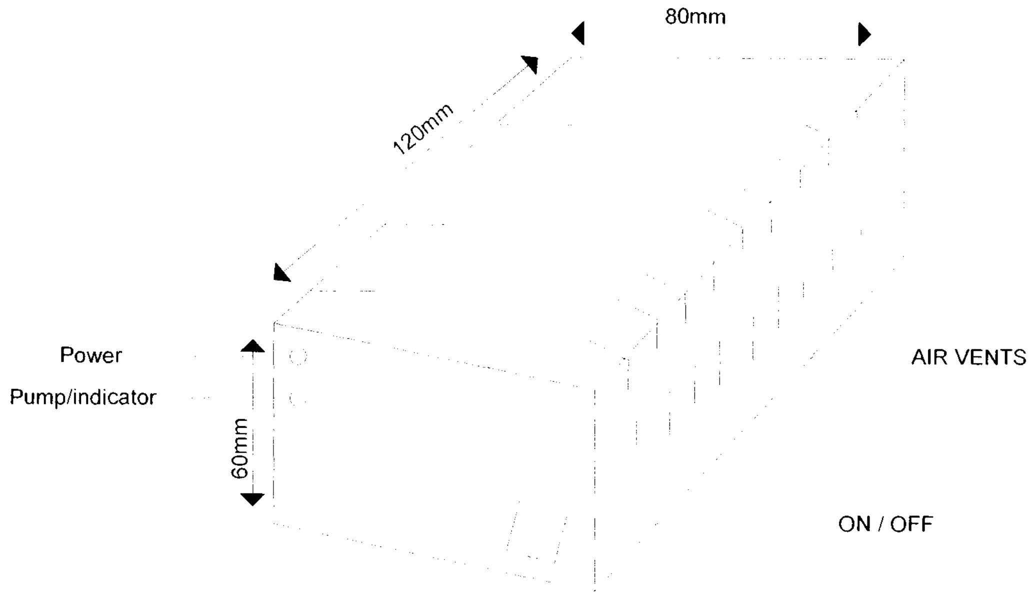
4.1 CONSTRUCTION

The construction of the project was done in two different stages: the soldering of the circuits and the coupling of the entire project to the casing. The soldering of the project was done on a vero- board, and was soldered on a single vero board. Fig 4.1a below shows the picture of the component arrangement on the vero board.

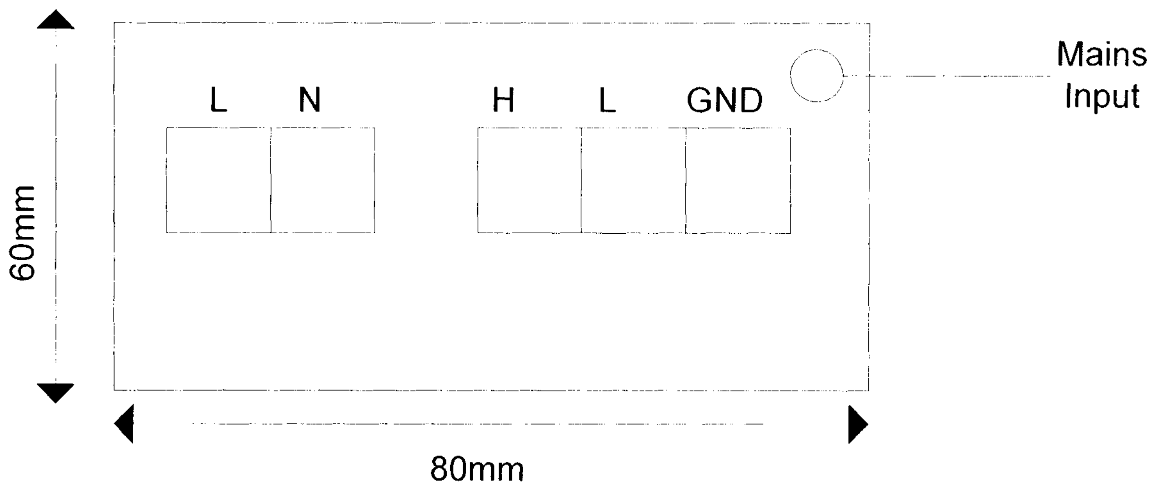
Fig 4.1a component arrangement



IC1	LM393
IC2	NE555
IC3	7474
IC4	7805
IC5	7812



SIDE VIEW



BACK VIEW

Fig 4.2a Isometric views of the casing with dimensions.

4.2 PROBLEMS ENCOUNTERED

Series of problems were encountered during the implementation, testing and construction of the project, which are as follows,

1. There was noise on the dc-regulated supply. This must be due to small ripples on the supply. A capacitor of 10μF was put at the output of the power supply to filter off the unwanted noise signals.

2. The relay was arcing at some instances. This was discovered to be due to hysterisis. The problem was solved by using filter capacitors at the output of the comparator and across the relays.

3. Drilling and cutting out of the metal parts of the casing to desired shape and filing the edges wasn't an easy task at all, particularly, in the absence of precision machines.

4.3 CONSTRUCTION PRECAUTION

1. All soldered joints were tested for continuity so as to avoid open circuits.
2. Excessive lead was removed to avoid bridges (short circuits) on the board.
3. Polarities of electrolytic capacitors and pin configuration of transistors and Ics were checked properly before soldering.
4. Ics were mounted on IC sockets to avoid over-heating them and for easier troubleshooting.
5. Excessive heating of the components was avoided so that they do not burn out.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.0 CONCLUSION

The project which is the design and construction of a WATER PUMP ACTUATOR was designed considering some factors such as economy, availability of components and research materials, efficiency, compatibility and portability and also durability. The performance of the project after test met design specifications.

The general operation of the project and performance is dependent on the user who is prone to human error such as not connecting the sensor probes at the appropriate points on the tank

Also the operation is dependent on how well the soldering is done, and the positioning if the components on the vero-board. ICs were soldered away from components that radiate heat and the power supply stage since this could affect the system performance.

The construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user should there be any system breakdown.

The project has really exposed me to power electronics and practical electronics generally, which is one of the major challenges I shall meet in my field now and in future. The design of the WATER PUMP ACTUATOR involved research in both digital and analog electronics. Intensive work was done on comparators and other electronic circuits as well.

The project was quite challenging, and tedious but eventually was a success.

I wish to thank the department, my supervisor and project co-coordinator for giving me the opportunity to do this project. However, like every aspect of engineering there is still room for improvement and further research on the project as suggested in the recommendations below.

5.1 RECOMMENDATIONS

I would recommend that further work be done on the following area

1. A backup power supply be designed since the system cannot work without constant supply just like any other automatic system (e.g. an inverter, ups or a standby generator)
2. A software model of the design should be done to enable further research and improve the performance of the system.
3. The department should acquire more research-oriented books in the departmental library, to make enough materials available for students.

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