DESIGN AND CONSTRUCTION OF AUTOMATIC LIQUID LEVEL INDICATOR/CONTROLLER

BY

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A PROJECT REPORT SUBMITTED TO
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CERTIFICATION

This is to certify that this project work was carried out by

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DEDICATION

This piece of work is dedicated to God Almighty for his constant love, guidance and protection; to the loving memory of those who I miss till this day; Agene Atojoko, Aminatu Saba, Elder James Amana.

Mallam Abubakar Saba Atojoko and Mrs. Ramatu Fakoyejo.

And to the young generation of Nigeria, who must strive to learn, think and work hard to acquire knowledge and break new grounds for the development of our country and renewal of our culture.

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To all those whose names I missed out, it is not intentional, know that you are appreciated.

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ABSTRACT

The design presented here is a facility that will monitor and indicate liquid level in an overhead or stationary tank and control a submersible or an external liquid pump.

The liquid level sensor keeps watch over the level of water in the overhead tank; the overhead tank serves as a liquid storage point and houses the liquid level sensing unit. When liquid level falls or rises to a certain level preset to be low or high, in the tank, the liquid level sensor sends an appropriate signal to the pump control circuit; the liquid level indicator at the same time indicates the present level of the liquid in the tank as the liquid alterates accordingly. The pump is switched 'ON' or 'OFF' by the pump control circuit depending on the nature of signals reaching it.

The pump control circuit failure alarm is designed to work whenever there is a malfunction of the pump control circuit. The manual override isolates power from the entire circuitry and delivers (AC) mains to the pump (in times of failure of the Pump Control circuit or during maintenance work).

CHAPTER ONE
GENERAL INTRODUCTION

1.0 INTRODUCTION

An Automatic Liquid level indicator/Controller becomes enormously useful at places where people have private boreholes, in industries and refineries and factories where one form of liquid storage and transfer takes place.

Liquids, (e.g. water) are a basic necessity of life and most of the government organization strives to provide potable water to the public. However, despite concerted effort by government to make water available to all her citizens, the supply of this liquid (water) to most villages and cities is grossly inadequate.

There are usually cases of liquid being supplied at low pressures that can hardly flow on to the first floor in a storey building. This informs the decision of many homes, hospitals, industries e.t.c. to install pumps and overhead, surface or underground tanks for liquid storage.

Motor Pumps are often employed in pumping liquid from a storage point (reservoir) into a tank (stationary or overhead) when their taps go dry. The installation of pumps in buildings, hospitals e.t.c. to pump liquid to an overhead tank for storage and redistribution, requires an operator to monitor the liquid level in the tank, which may be tens of metres above the ground level and operate the pump as appropriate.

These pumps needs to be switched 'ON' to pump, (when the liquid level falls low) and 'OFF' when the overhead tank overflows. This often results in unnecessary wastage and sometimes non availability of the liquid in cases of emergency, since there is no one stationed to monitor the pumping.

It could be hazardous, especially in refineries, if volatile liquids like petrol, kerosene e.t.c. are left to be pumped to overflow for too long before the pump is put off; this means that someone must be stationed to keep watch over the tank.

A simple but effective and actualisable design is adopted in combating this problem. The Automatic Liquid Level Indicator and controller is designed to monitor the liquid level in a tank and switch the pump 'ON/OFF' when the level of the liquid reaches predetermined levels * on the tank, and also to alert the operator of possible dangers if any part of the system fails thus, eliminating the drawbacks associated with manual pump operation.

The cost of making available, material to be needed for the design and how the design is intended to fit into the existing structure is to be taken into consideration. The following theories are utilized or used in carrying out this project; they are: Ohm's Law, Law of flotation, Law of Magnetism, Kirchoffs Voltage Law (where transistors are used)

1.1 AIMS AND OBJECTIVES

1. The device so produced is aimed at reducing the cost of labour for employers and the monotony of operation for operators both in industrial and home applications.
2. To reduce to the barest minimum, cases of unnecessary wastage and to check non availability of the liquid in cases of emergency.
3. To increase efficiency in production for industries by ensuring a steady level of liquid needed for prefabrication processes at all times.
4. To reduce the hazards associated with volatile liquids (e.g. petrol) overflow especially as the case may be in refineries or other industries where volatile liquids are utilized in production processes.

1.2 LITERATURE REVIEW

Essential to all automatic control mechanisms is the feedback principle which enables a designer to equip a machine with the capacity for self correction. A feedback loop is a mechanical, pneumatic or electronic device that senses or measures a physical quantity such as position, temperature, size or speed, compares it with a pre-established value and takes whatever pre-programmed action necessary to maintain the measured quantity within the limits of the acceptable standard.

Automation describes systems in which automatic or programmed devices can operate independently or nearly independently of human control. These systems are designed to extend the capability of machines to perform tasks formally done by human beings and to control sequences of operation without human intervention.

Russian Polzunov I. invented the first historical feedback system for liquid level control in 1765. It consisted of a float attached to a level, which in turn controls a valve. The system was used in a boiler where the float detects the water level and controls the valve that covers the water inlet in the boiler. [3]

Since then, several approaches to controlling liquid flow in a container (tank) have been developed. One of such is the float switch contact (mechanical arrangement) used to operate a motor that pumps liquid into a tank. The disadvantage with this arrangement is the contamination of the medium (usually due to rust), and clumsy installation. [5]

Usually, transducers using electric conduction or variation in resistance or capacitance principle are employed for level sensing. In conduction type of sensing the electric current passes through the liquid. The corrosion of contacts is a major problem while using Dc excitation; the cost and size are the two restrictive factors in using Ac excitation.

Furthermore, passing current through the liquid in combustive environments is not permissible. In resistance type sensors the resistance is altered through some mechanical arrangement, which means a force is required which may be a problem in small tanks. In capacitive transducer type, the construction cost is high. [6]

In the present project, an easy but effective liquid level controller is presented using the magnetic principle. It is a non-contact type and hence can be used in almost all applications, irrespective of whether the liquid is conductive or not.

Two reed switches (with glass enclosure) and a ring magnet (normally used in loudspeakers) form the sensor unit. The reed switches used are the normally open type and they close when placed (and oriented properly) in a magnetic field.

The electronic Circuit is a simple bistable multivibrator wired around the common 555 Timer IC. It can be set or reset by the closure of the reed switches connected to it. The output of the multivibrator drives the relay which controls the AC mains supply to the pump motor or any other controller (such as a solenoid-operated valve).

1.3 PROJECT OUTLINE

Chapter one gives a general overview of the project, Literature review that highlights previous works on the subject, and the aims and objectives.

Chapter two discusses a detailed design analysis and considerations. The principles of operation and circuit diagram of all the units that make up the system are discussed, also physical diagram of tank connections with the nature of indication and level sensing are presented.

Chapter three covers the details of the design calculations and how individual component values are obtained.

Chapter four highlights the details of construction and testing procedures employed to achieve the final product. It spans soldering of components on the Vero board, case construction, testing, trouble shooting and results obtained, difficulties encountered are also listed here.

Chapter Five Contains the conclusion drawn from the results of testing, with reference to the objectives and goals of the project and recommendations.

References of books and materials consulted and appendices that expose the final circuit diagram of the project, and also the list of components used are presented.

CHAPTER TWO

2.0 SYSTEM DESIGN AND ANALYSIS

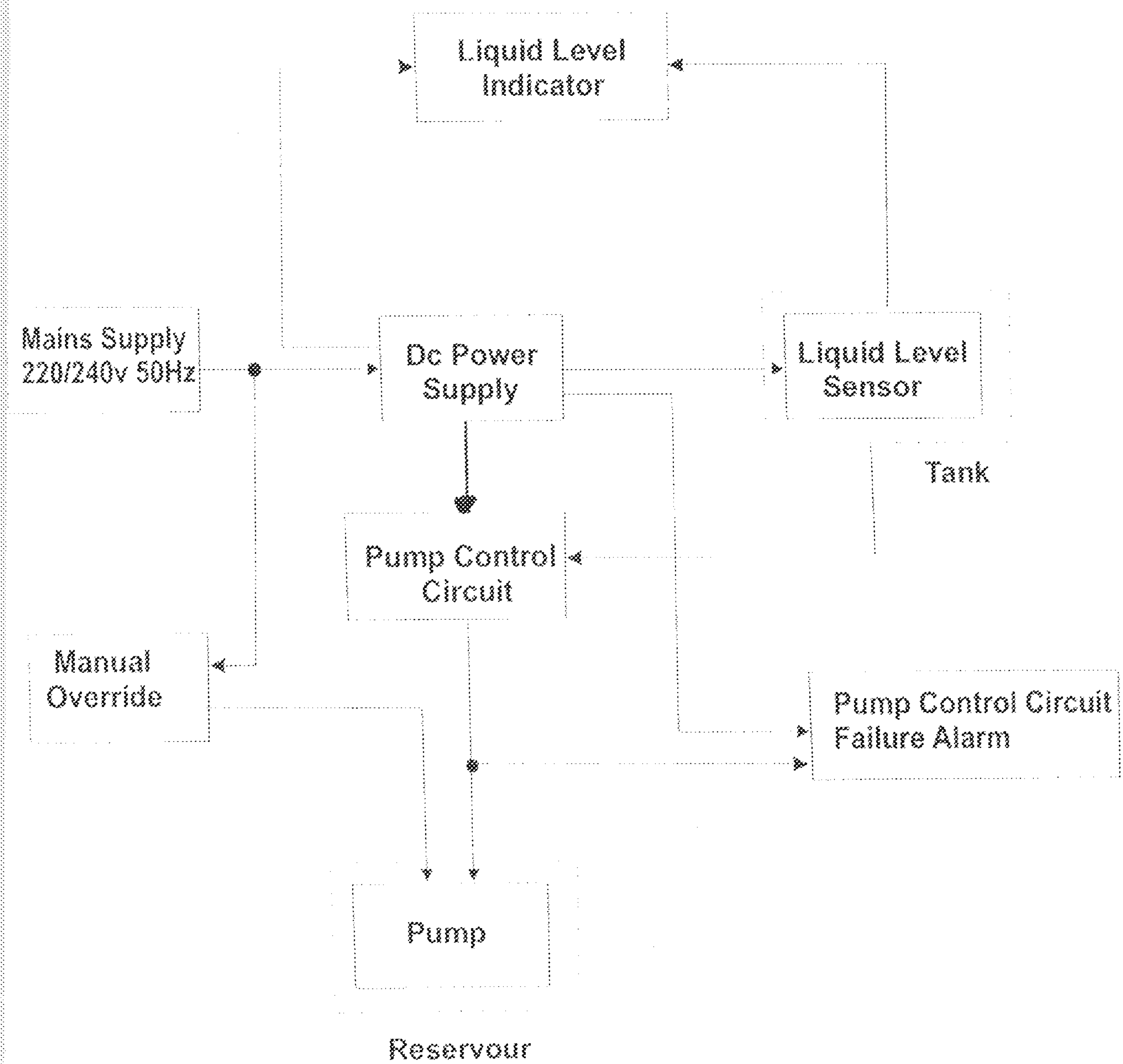


Fig.1.0 Block Diagram of the Automatic Liquid Level Indicator/ Controller

2.1 BLOCK DIAGRAM

The units required for system operation and other basic functions and relational nature of signal flow are as explained below.

2.11 Overhead Liquid Tank

This serves as a reservoir for the liquid; it also houses the liquid level indicator/controller. The tank distributes the liquid at atmospheric pressure to all outlets in its piping network. The liquid is continuously distributed until it is nearly empty, then the liquid pump control system refills it.

2.12 Liquid Level Sensor

This circuitry does the sensing of the liquid level in the tank, it initiates the pumping action of the pump when the liquid level falls to low level and initiates pump stopping action when the liquid level gets to the preset high or full level by sending signals of the corresponding liquid level to the pump control circuit for action. Signals are also sent to the liquid level indicator for appropriate level indication.

2.13 Liquid Level Indicator

This circuit works hand-in-hand with the liquid level sensing circuit, as the liquid level sensor, senses the level of liquid in the tank, the liquid level indicator, indicates the corresponding level at that point in time via Light Emitting Diodes (LED).

2.14 Pump Control Circuit

This circuit's chief operation is the switching of the liquid pump to either "ON" or "OFF" when appropriate signals are sent to it from the liquid level sensing circuit. The pump power comes from the mains power supply or generator at 220-240 volts.

2.15 Pump Control Circuit Failure Alarm

This circuit plays the main function of sensing and indicating pump action failure. It flags an alarm, when there is pump failure. It achieves this by signals sent to it from the pump control circuit.

2.16 Power Supply Circuit

Two types of power are needed for the whole system to function properly. DC power is needed for the electronic components on the various circuits, while AC power is needed for the pump to operate. The DC power is obtained from the Ac line by conversion from a step down transformer.

2.17 The Manual Override

This is a switch which turns the pump "ON" on a switching without help from the pump control circuit. It isolates the pump control circuit and hence can be used in bypassing the circuit; it comes in handy when there is a fault with the pump control circuit.

2.18 Submersible Liquid Pump

This device is used to pump liquid from the underground liquid well to the overhead tank. It is a single phase 220 – 240v pump and draws liquids from reservoir, well or bore holes

2.2 POWER SUPPLY UNIT

This unit supplies all the necessary power required by the electronic circuit in the system. All electronic devices require a direct current (dc) voltage source to operate; some form of conversion must take place before this dc voltage source is made available.

This system uses one of such circuits to provide the required voltage for operation. Fig. 2 shows a block diagram of the power supply unit and the waveform at each stage.

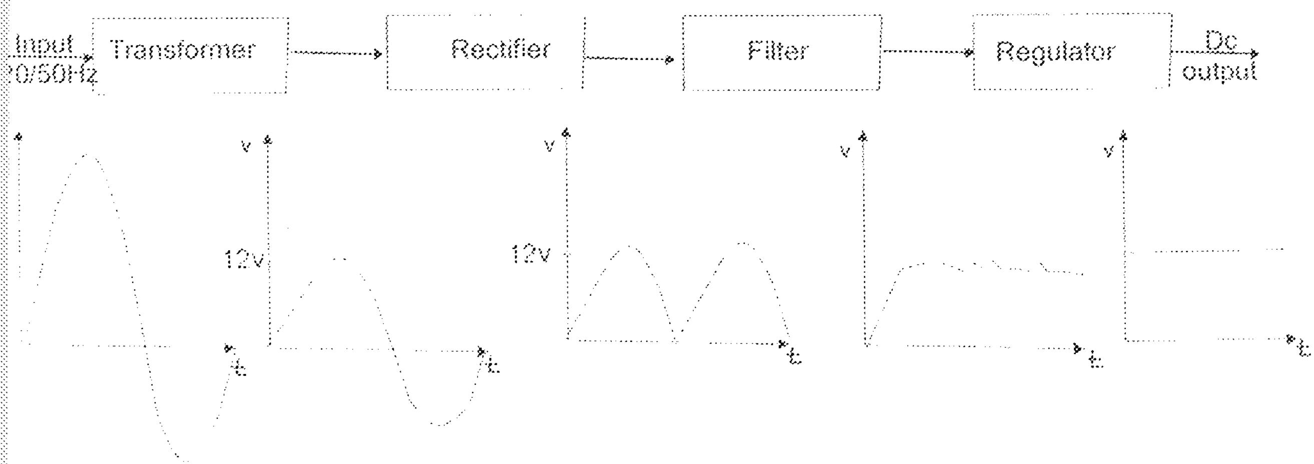


Fig. 2. Power Supply Block Diagram and Waveforms

2.21 The Transformer

The transformer steps down a voltage of 220vac from the mains to about 12vac in the first stage of the power supply design with the aid of 220v/12v 300MA transformer whose current is enough to drive the entire circuit.

The transformer provides physical isolation between the 220ac mains and the rest of the system. The only link is by means of magnetic flux, thus eliminating the risk of shock. It consists of two coils, the Primary (input) Winding and Secondary (output) Winding. Fig 2.1 shows the circuit symbol of a transformer. The ratio of the Primary voltage V1 to that of the secondary V2 is equal to the ratio of the number of turns in Primary N1 winding and secondary N2 winding

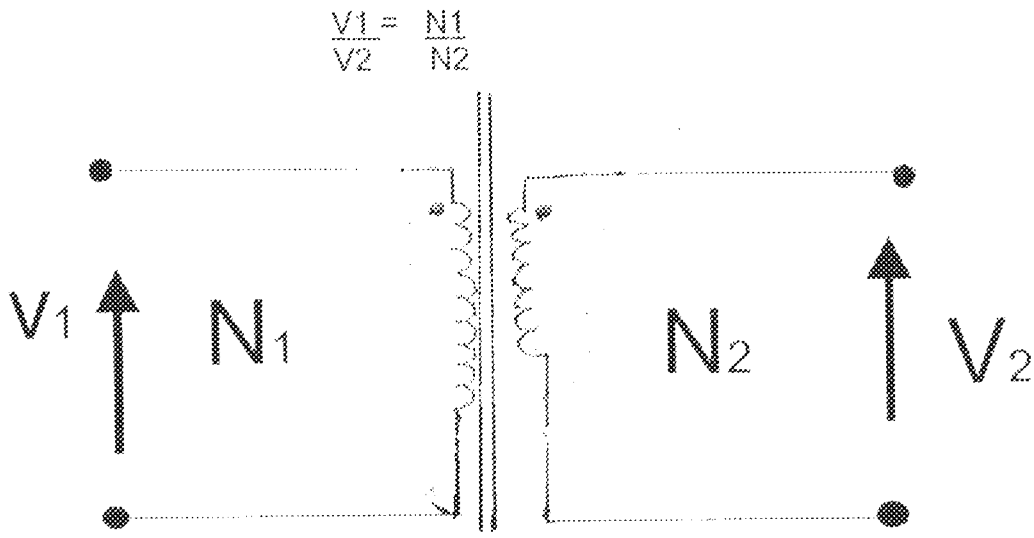


Fig. 2.1 Transformer Circuit Symbol

A fuse (1A) is incorporated at the primary side to protect the transformer and the rest of the circuit from excessive current from the mains.

2.22 The Rectifier

The rectifier converts the 12Vac voltage from the Secondary side of the transformer into a pulsating Dc voltage and the process is called rectification.

A full wave bridge rectifier is used for the rectification, it consist of four {IN4O01} diodes in the arrangement shown in figure 2.2 below.

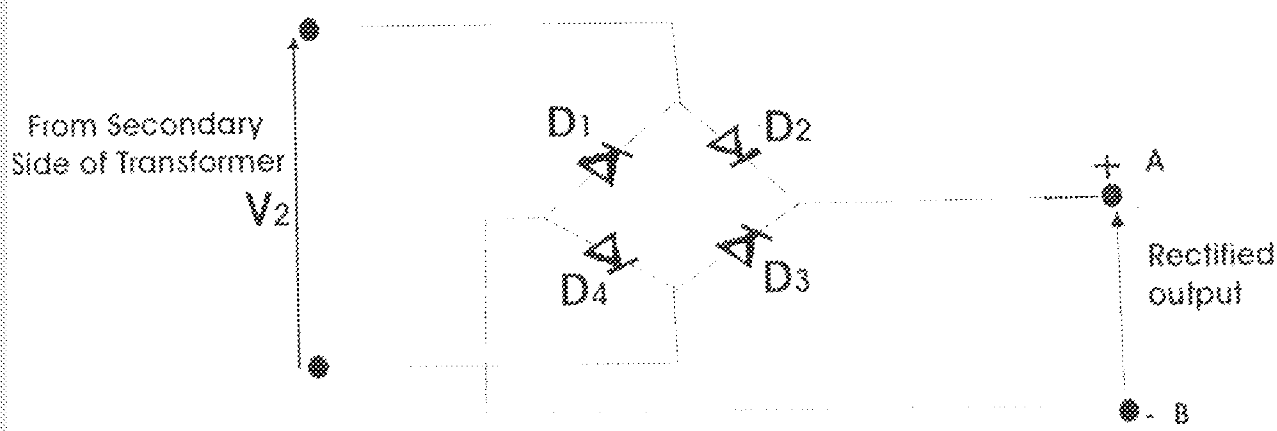


Fig. 2.2 Full – Wave Bridge Rectifier

During the positive half cycles, diodes D2 and D3 are forward biased and current flows through any load connected at terminals AB. In the negative half cycle, diodes D1 and D4 are forward biased. Since the load current is in the same direction in both half cycles, the full-wave rectifier signal appears across the load. The average dc voltage across AB is:-

$$VDC = \frac{2V_2\,(peak)}{\pi} = \frac{2\sqrt{2}V_{rms}}{\pi} = \underline{2 \times \sqrt{2 \times 12}} = \underline{10.8v}$$

Where V_2 (peak) and V_{rms} are the peak output and the root mean square voltage of the Secondary winding of the transformer respectively.

The diodes were so chosen such that their peak inverse voltage rating is greater than V_2 (peak) so that they do not break down when reverse biased.

2.23 The Filter

The pulsating dc voltage from the rectifier is only suitable for limited applications such as charging batteries and running dc motors. Most electronic circuits require dc voltage that is constant in value. A filter is used to convert the Full-wave rectified signal into a constant dc voltage.

Capacitive filtering is adopted in this design where a large electrolytic capacitor is connected across the rectifier output. The capacitor charges up during the diode conduction period to the peak value and when the rectifier voltage falls below this value the capacitor discharges through the load, so that the load receives almost steady dc voltage. The discharge time constant, which the time is taken for the capacitor to drop to 33% of the peak value, is given thus:

$$T_d = R_L C$$

Where R_L is load resistance, C is capacitance

Since R_L is a constant for any given circuit, it follows that the larger the C, the smaller the ripple voltage. A 2200uf, 25v Capacitor was chosen for this circuit which is large enough for the intended purpose.

2.24 The Regulator

The output of the filter capacitor varies when load current or the input voltage varies. This effect is undesirable. An Lm7812 regulator is used to supply steady 12v to drive the switching unit and energize the rest of the circuit respectively. These regulator chips supply the rated voltage with a wide range of voltage input (7v – 35v) and variations in the load current.

2.25 The Protecting Diode

This protects the regulator form being destroyed by current feed back from the main circuitry, it is the common IN4001 diode put across the input and output leg of the regulator.

Figure 2.3 is a complete circuit diagram of the power supply unit

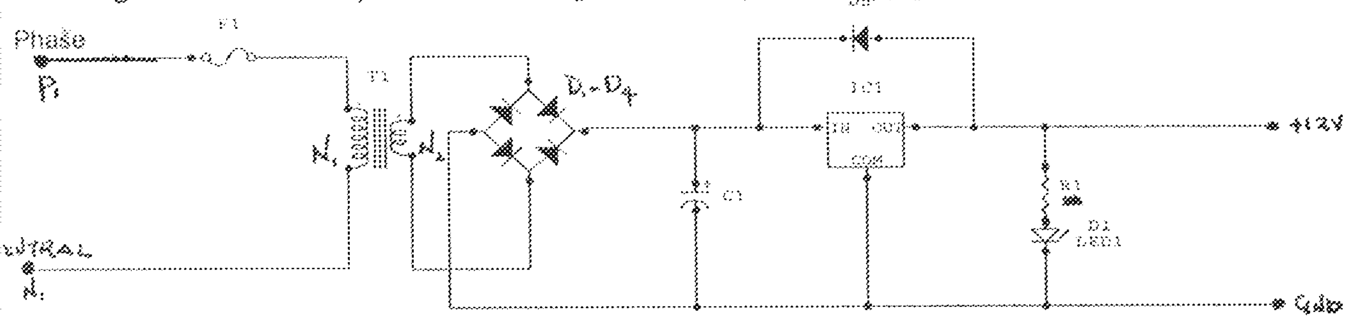


Fig .2.3 Power Supply Unit Circuit Diagram

The LED functions as an indicator when power is available.

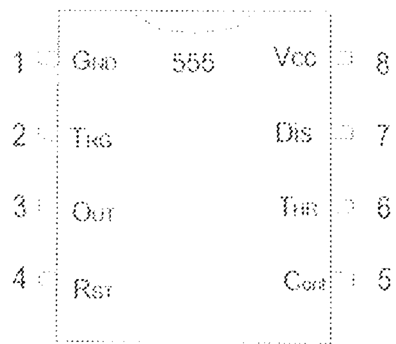
2.3 THE PUMP CONTROL CIRCUIT

The pump control circuit receives appropriate signals from the liquid level sensing circuit, to determine what action or operation signal to be sent to the output. A relay is connected to the output leg of the 555 timer via an NPN transistor. Signals from the liquid level sensor reaching pin 2 (trigger) of the 555 timer makes it to see ground (0 volts; less than 1/3rd of Vcc). This will cause pin 3 (output) to go high.

When the output of the 555 timer IC is high, it makes available biasing voltage for the base of the NPN transistor Q1. Meanwhile, the required current is made available by the current conditioning resistor R4 that makes transistors Q1 to go into saturation. By this the collector current flows and the relay (RLY1) is energized.

The water pump is connected to mains voltage through the contacts of the relay and pumping is effected. When the liquid in the tank reaches it's full point as preset, RS1 (Reed Switch) closes and pin 6 of the 555 timer is made to see more than 2/3rd of Vcc, therefore pin 3 goes low and there is the cutting of biasing voltage for NPN transistor Q1, the relay is de-energized and pumping is stopped.

Fig 3.0 is the diagram of the 555 timer IC:



The circuit diagram of the pump control circuit is as shown below

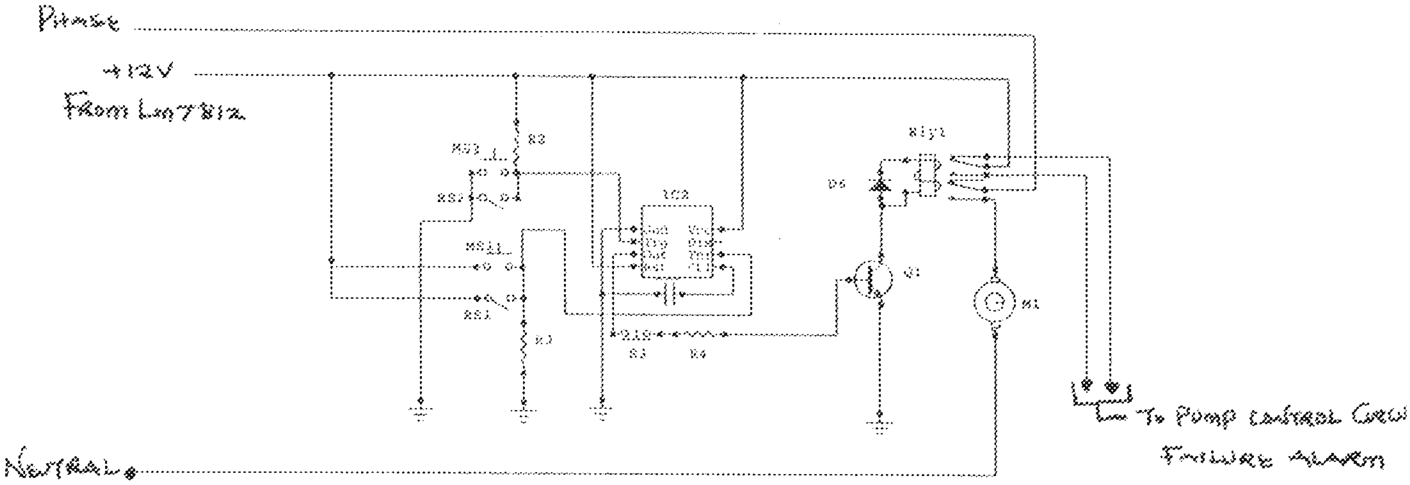


Fig .3.1 Circuit Diagram of The Pump Control Circuit

2.4 THE LIQUID LEVEL SENSOR/INDICATOR

The liquid level sensor is housed in the overhead tank or whichever tank the level is desired to be controlled. It is basically made up of three reed switches (RS1, RS2, and RS3). The switches are normally open switches that close when a magnet is brought close to them.

These switches are arranged in a vertical tubing or pipe with a float around it. The float carries the magnet that will close the reed switches; the magnet is encased in between the float (made of Teflon), the float is inserted over the tubing which houses the reed switches. It is the encased magnet in the float that closes the reed switches momentarily, the switches close with the presence of a magnetic field so as to send appropriate signals at different liquid levels as the magnet floats along with the variation in the liquid level.

The following diagram in Fig 4.0 and 4.1 show the nature of the Liquid Level sensor:-

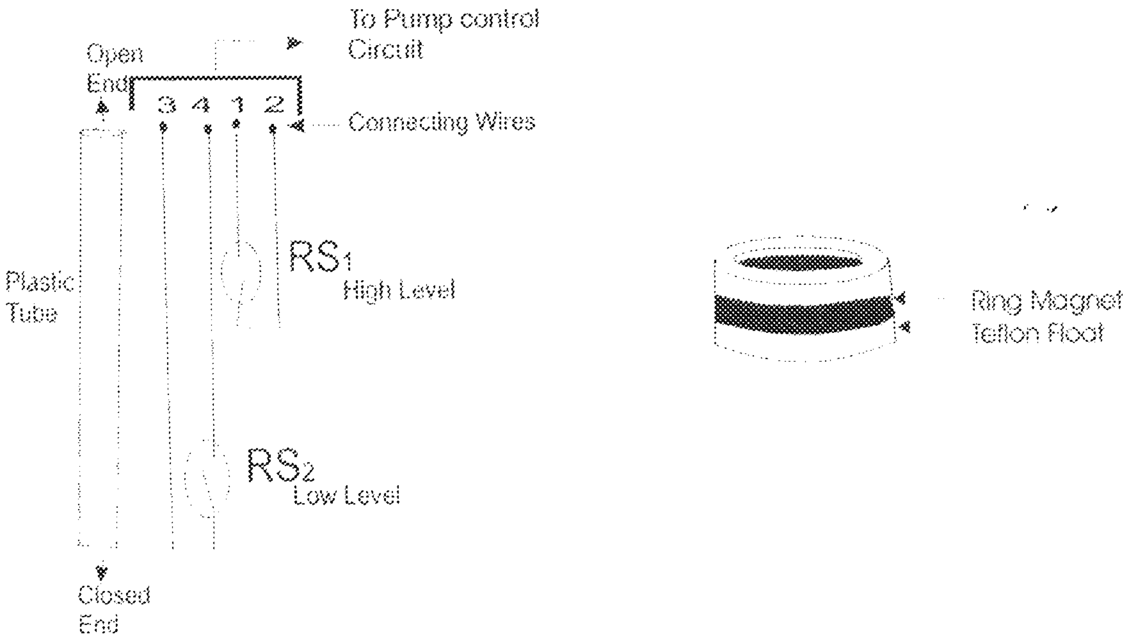


Fig .4.0 Liquid Level Sensor Components

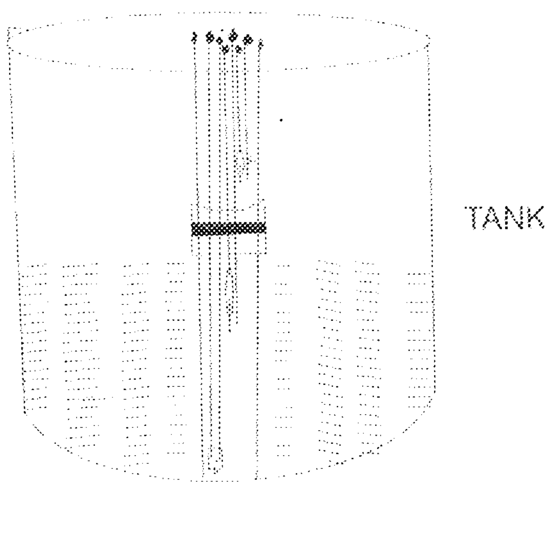


FIG 4.1 LIQUID LEVEL SENSING CIRCUIT AS MOUNTED IN TANK

The first Reed Switch (RS1) is place at a level preset to be full or high, while the second Reed Switch (RS2) is placed at a level set to be low, and then the third reed switch is placed at a level indicating the mid point.

When pin2 (trigger) of the 555 timer IC has not received any signal it implies (RS2) is open; at this point, pin2 (trigger) has a voltage more than 1/3rd of the supply voltage across it so that the multivibrator stays 'OFF' and pin3 (output) remains low, at this time pin6 has less than 2/3rd of supply or even close to zero (o) volt.

As soon as Reed Switch two (RS2) closes, pin2 (trigger) will have less than 1/3rd of the supply voltage (Vcc) across itself and the multivibrator is set into action. At this time, the voltage across pin6 (threshold) and the multivibrator is set into action. At this time, the voltage across pin6 is still below 2/3rd of the supply voltage. Immediately RS1 is closed, more than 2/3rd of the supply voltage will fall across pin6 (threshold) and it resets the multivibrator thereby returning the voltage across pin2 (trigger) to above 1/3rd of the supply voltage.

When the liquid level drops to the level of RS2 the magnet with the help of the float will rise to the level of RS2 in the tank, therefore Reed switch closes, this initiates liquid tank refill action by sending an appropriate signal to the pump control circuit. This signal is received by the pump control circuit through pin2 (trigger) of the 555 timer IC in the circuitry.

As the tank is being refilled, the float carries the magnet along with the liquid level till it gets to the level where RS1 is, on getting there, RS1 closes thereby stopping the pump action by sending the appropriate signal to the pump control circuit. The signal is received by the pump control circuit through pin6 (threshold) of the 555 timer IC in the circuit. MS1,MS2 and MS3 are manual switches, they(MS1 and MS2) are there for manually switching 'ON' and 'OFF' the liquid pump or for deceiving the circuit when the need arises; they are also used for testing the operational efficiency of the liquid level indicators.

2.5 THE LIQUID LEVEL INDICATOR

This circuit indicates the present level of the liquid in the tank with the help of Light Emitting Diodes (LED) based on signals that are sent to it from the liquid level sensor.

The point type of indication is adopted for this project; three manual (push button) switches are connected to enable easy testing of these indicators to ensure that they are in good operating condition. Two of these switches serve the same purpose the Reed Switches serve at the 'High High' (HH) level and at the 'Low Low' (LL) level. They are used in deceiving the system to manually switch 'ON' or 'OFF' the pump. They are also used to test the efficacy of the pump control circuit. The circuit diagram is as shown in Fig 5.0 below:-

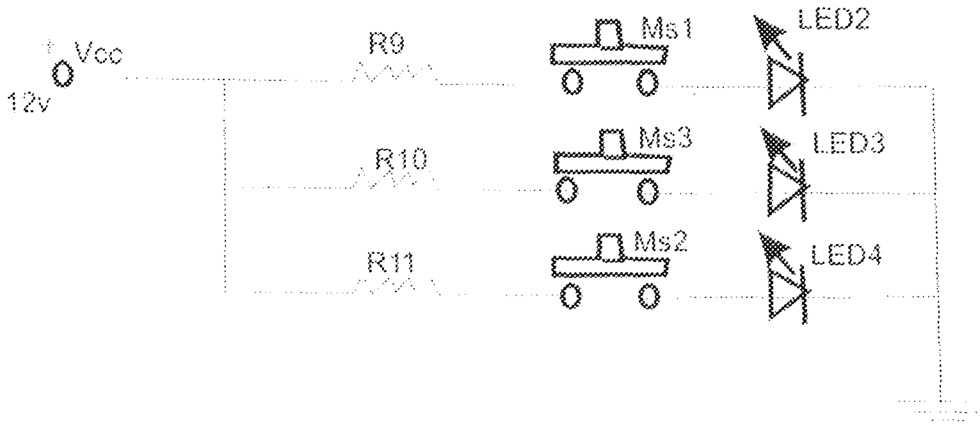


Fig 5.0 Circuit Diagram of The Liquid Level Indicator

A reasonable size ready to use front panel for display is as shown below:-

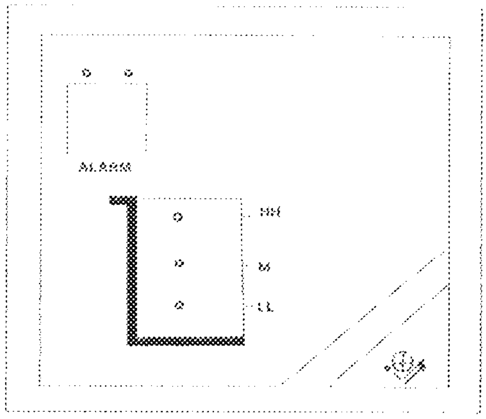


Fig. 5.1 Front Panel for Display

2.6 PUMP CONTROL CIRCUIT FAILURE ALARM

This circuit is designed to flag an alarm whenever there is a fault in the pump control circuit. Two alarm conditions are taken into consideration to achieve this. They are:-

1. Pump 'ON' Voltage available but pump is OFF
2. Pump 'OFF' Voltage available but pump is ON

These conditions occur at the 'High High' and 'Low Low' levels when pumping action is required to stop or start respectively.

Two separate alarm circuits are adopted here for the two alarm conditions, their circuit diagram is as shown on the next page.

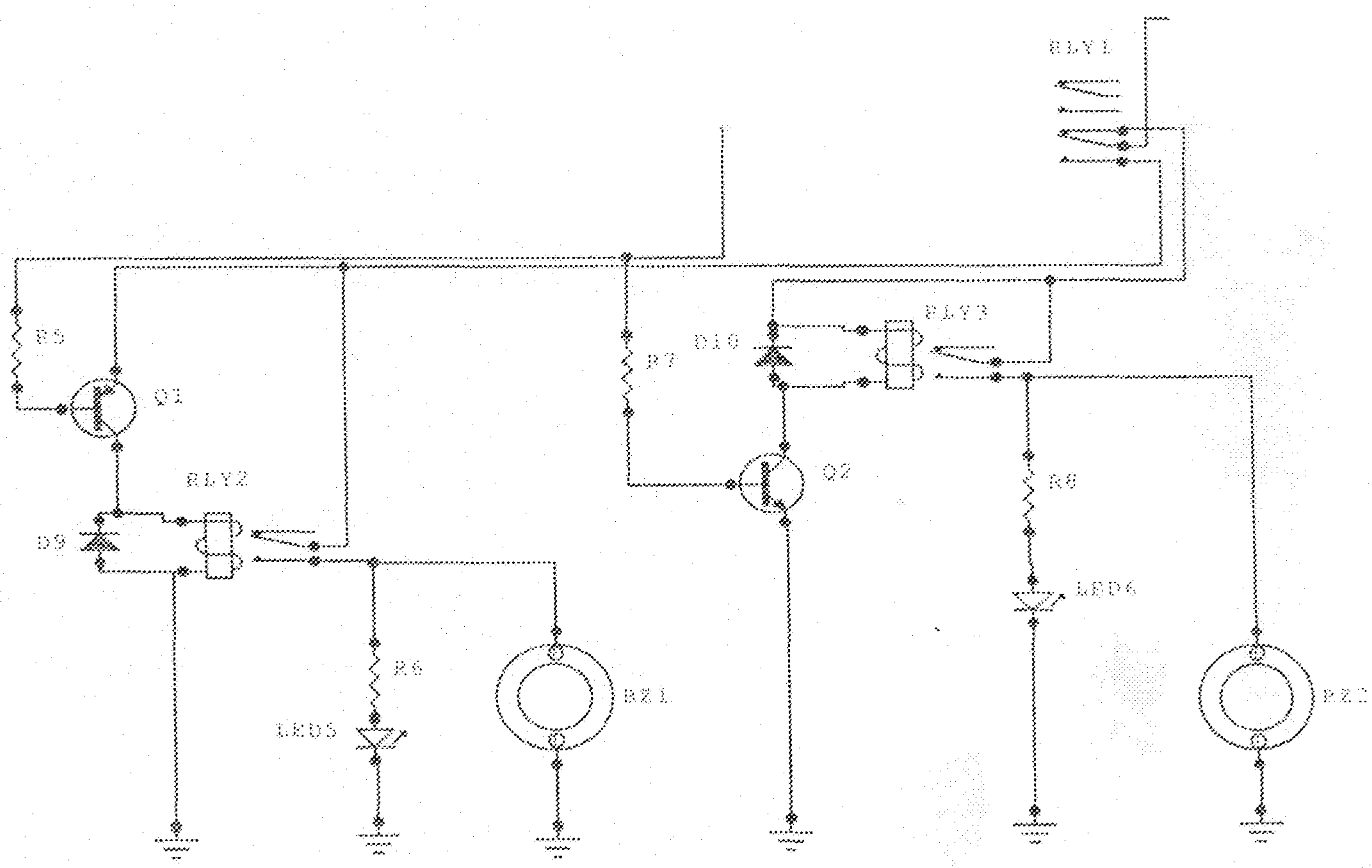


Fig. 6: Circuit Diagram of the Pump Control Circuit Failure Alarm

CHAPTER THREE

The full circuit diagram of the Automatic Liquid Level controller is as shown in Fig. 7 as shown below

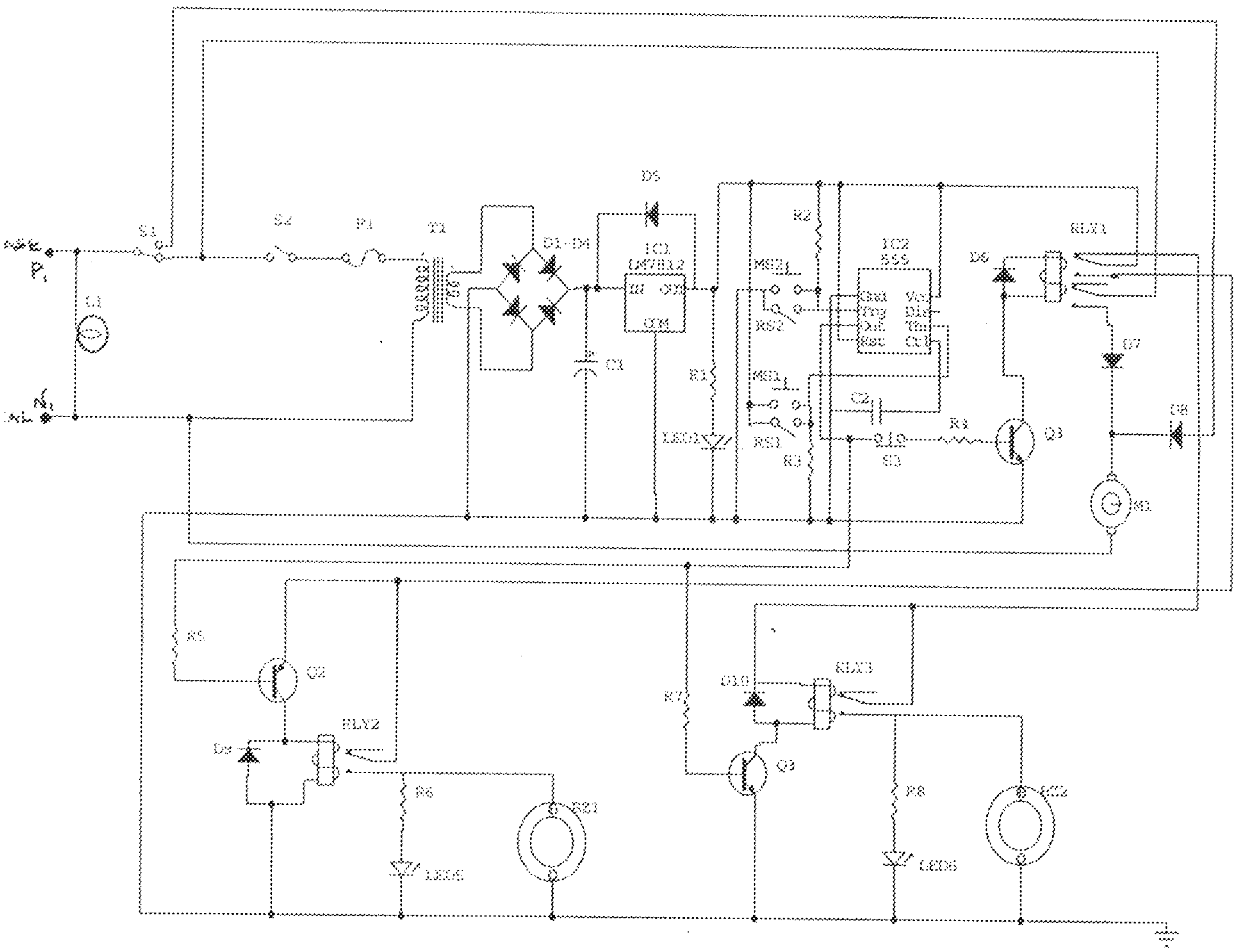


Fig. 7 Automatic Liquid Level Controller Circuit Diagram

3.1 DESIGN CALCULATIONS

For Limiting resistor for all the Light Emitting Diodes (LED), for power (Dc) indication, level indication, and for alarm indication respectively the following value was arrived at.

$$R = \frac{V_{CC} - V_{LED}}{I_{LED}} \text{ ---------- } (1)$$

$V_{CC} = 12V$
$V_{LED} = 2.2V$
$I_{LED} = 30mA$

$$R = \frac{12 - 2.2}{30 \times 10^{-3}} = \frac{9.8}{30 \times 10^{-3}} = 326.7ohms$$

From component date book, the preferred value close to this is 330 ohms and it is adopted for use throughout the design. So for R1, R6, R8, R9, R10, and R11; 330ohm was used.

3.11 FOR RELAY 1

Resistance of relay coil: R (Rly1) = 291

Therefore current flowing through the coil

is

$$I(Rly1) = \frac{Vcc}{R(Rly1)} \text{ ---------- } (2)$$

where; I (Rly1) = Current through relay coil 1
R (Rly1) = resistance of relay coil 1
Vcc = Supply Voltage

Since the relay coil current is the collector load

$$Ic = I(Rly1) = \frac{Vcc}{R(Rly1)} \text{ - } (2)$$

Vcc = 12volts
R (Rly1) = 291ohms

$$Ic = \frac{12}{291} = 41mA$$

$$Ic = 41mA$$

Making I_{Cmax} 150% of I_C

$41 \times 10 \times 1.5 = 61.5mA$

$I_{Cmax} = 61.5mA$;

Working with a beta factor of ten (10) we can calculate the value of I_B using the current gain equation

$I_C = \beta I_B$ ----------(3)

$$I_B = \frac{I_C}{\beta}$$

Where I_C (collector Current) = 61.5mA

I_B = Base Current = ?

β = Beta = 10

$$I_B = \frac{I_C}{\beta} = \frac{61.5 \times 10^{-3}}{10} = 6.15mA$$

$I_B = 6.15mA$

Calculating the value of the base resistor (R_B) of transistor Q1 using Kirchhoffs voltage law (KVL) in the input loop.

$V_{CC} = V_{BE} + I_B R_B$ ---------- (4)

Output voltage of the 555 timer IC is given by

$V_{CC} - 1.7 = V_{out}$

Therefore Vcc in the above equation (4) is replaced with Vout

$V_{out} = V_{BE} + I_B R_B$ $I_B = 6.15mA$

$V_{out} = 12 - 1.7 = 10.3$ R_B (Base Resistance) =?

$V_{BE} = 0.7$

From the Equation

$V_{out} = V_{BE} + I_B R_B$

$10.3 = 0.7 + 6.15 \times 10^{-3} \times R_B$

$R_B = \frac{10.3 - 0.7}{6.15 \times 10^{-3}} = \frac{9.6}{6.15 \times 10^{-3}} = 1560.98\text{-}2$

From the component data the preferred value closest to this is 2.2k ohm therefore $R_B = R4$ = 2.2k ohm (chosen for this case).

Power dissipation on R_B using => $P = I_B^2 R_B$ --------- (5)

Where I_B =Base current

R_B =Base resistance

$P = (6.15 \times 10^{-3})^2 \times 2.2 \times 10^{3}$

=> 83.2 2mW =0.0832

Using 2.2 KΩ ¼ watt resistors.

From the value of I_{Cmax} = 61.5mA, it was found that NPN transistors of the code BC 107 – BC 109 could serve and was selected.

From component data book

NPN – BC 108 – 50v, 0.1A, 0.3w, 300MHZ

With I_{Cmax} of 61.5mA which is way below 0.1A for the Bc 108 rating an NPN Bc108 transistor was chosen.

For R2 and R3 a 10kΩ resistor Value is chosen for the two, in order to limit the current drain so that it will not tell so much on the power supply, this is so because the value here is not so critical

From ohms law $V = IR$, $I = V/R = \frac{12}{10{,}000} = 1.2mA$

$R = R3 = 10k$ ohms

Power dissipation = $I^2 R$

$(1.2 \times 10^{-3})^2 \times 10{,}000$

= 0.24w

Using 10K 1/4 W resistor

For the alarm circuits components were selected based on the following calculations.

The alarm circuits are two:

- ✓ The first handles the first alarm condition and;
- ✓ The second handles the second alarm condition:

Each of the circuit is made up of the following

- ✓ A 12v buzzer
- ✓ A transistor
- ✓ A resistor
- ✓ A relay 12 volt
- ✓ A blocking diode
- ✓ An indicator (LED with Limiting Resistor)

3.12 FOR RELAY 2

Resistance of Relay coil: R (Rly 2) => 413 (same for both Rly2 and Rly3)

Therefore current that will flow through the relay coil is $I_{(Rly2)} = \frac{Vcc}{R_{(Rly2)}}$

Where $I_{(Rly2)}$ = current through relay Coil 2

$R_{(Rly2)}$ = Resistance of relay Coil 2

Vcc = supply voltage.

$I_c = I_{(Rly2)}$ (since the relay Coil current is the collector load)

$$I_c = I_{(Rly2)} = \frac{Vcc}{R_{(Rly2)}} \quad \text{from equation (2)}$$

$$I_c = \frac{12}{413} = 29 \times 10^{-3} A$$

I_c = 29mA

Making I_{Cmax} 150% of Ic

$$\Rightarrow 29 \times 10^{-3} \times 1.5 = 43.5mA$$

$$I_{C\,max} = 43.5mA$$

From equation (4)

$$V_{out} = V_{BE} + I_B R_B$$

$$10.3 = 0.7 + 2.9 \times 10^{-3} \times R_B$$

$$R_B = \frac{10.3 - 0.7}{2.9 \times 10^{-3}} = \frac{9.6}{2.9 \times 10^{-3}} \quad 3.310\Omega$$

From component data book a preferred valve of 3,5K ohm was chosen for this value;

R_B used = 3.5k; R_B = R5 = R7 = 3.5K

Power dissipation on R_B using equation (5)

$$P = I_B^2 R_B$$

Where I_B = Base current, R_B = Base resistance

$$P = (2.9 \times 10^{-3})^2 \times 3.5 \times 10^3 \quad \Rightarrow 29.4 \text{ mw} \quad = 0.0\ 29W$$

Hence a 3.5kΩ one quarter (¼) watt Resistor is used.

3.2 CALCULATION FOR THE OVERALL CURRENT DEMAND

3.21 TOTAL CURRENT DRAWN BY PUMP CONTROL CIRCUIT

555 TIMER IC=6.02 mA--------------6.02 x 10^{-3}

RELAY Coil: Ic =41 mA-------------------41 x 10^{-3}

CURRENT THROUGH TRANSISTOR (Q1), BASE CURRENT

$$I_B = \frac{12 - 1.7 - 0.7}{2.2 \times 10^3} = \frac{9.6}{2.2 \times 10^3} = 4.36 \times 10^{-3}$$

CURRENT THROUGH 10kΩ RESISTOR

$$I = \frac{12}{10 \times 10^3} = 1.2mA \Rightarrow 1.2 \times 10^{-3}$$

TOTAL => $6.02 \times 10^{-3}\ A + 41 \times 10^{-3} A + 4.36 \times 10^{-3} A + 1.2 \times 10A$

$= 52.6 \times 10^{-3}\ A$

⇨ 52.6mA

3.22 TOTAL CURRENT DRAWN BY ALARM CIRCUIT

Current through Q2 = IQ2 = $\frac{12-0.7-1.7}{3.5 \times 10}$ $\frac{9.6}{3.5 \times 10}$ = 2.7mA

Current through relay Coil (R_{ly2}) = $\frac{12}{413}$ = 29mA =29 x 10^{-3} A

Current through resistor (for LED indication) =$\frac{12 - 2.2}{330}$ = 29.7×10^{-3} A

Current consumed by Buzzer = 3.5 mA

Total => $2.7 \times 10^{-3}\ A + 29 \times 10^{-3} A + 29.7 \times 10^{-3} A$ +3.5mA

⇨ 64.9mA

3.23 TOTAL CURRENT DRAWN BY INDICATOR CIRCUITS

For Dc power indication $I = \frac{12}{330}$ ---------- 36.4 mA

Current drawn by Level indicator ----------29.7mA

Total -- 66.1mA

3.24 CURRENT DRAWN BY REGULATOR

LM7812 = 8mA (Quiescent current)

Therefore current drawn by the entire system is

Total current drawn by pump control circuit => 52.6 mA
+
Total current drawn by alarm circuit => 64.9mA
+
Total current drawn by indicator circuit => 66. ImA

Total current drawn = 52.6mA + 64.9mA + 66.ImA = 183.6mA

Calculating the out put current for the supply

Quiescent current for IC regulator = 8mA

Total current drawn by the entire system = 183.6mA

Total dc output current (Idc) = $8 \times 10^{-3} + 183.6 \times 10^{-3}$ = 191.6mA

I_{dc} = 191.6mA

3.3 CALCULATION FOR DC VOLTAGE OUTPUT (Vdc)

Drop out voltage for IC regulator = 2 Volts

Voltage required by the system = 12 Volts

Total Voltage = 12 + 2 + 1.4 = 15.4 Volts

$$\left.\begin{array}{l} V_{dc} = 1.41 \times V_{ac} \\ I_{dc} = 0.62 \times I_{ac}\ . \end{array}\right\} \quad (6)$$

$V_{dc} = 15.4V$

$I_{dc} = 191.6mA$

$V_{dc} = 1.41 \times V_{ac}$

$15.4 = 1.41 \times V_{ac}$

$$V_{ac} = \frac{15.4}{1.41} = 10.92$$

$I_{dc} = 0.62 \times I_{ac}$

$191.6 \times 10^{-3} = 0.62 \times I_{ac}$

$$I_{ac} = \frac{191.6\times10^{-3}}{0.62} = 309mA$$

3.4 FILTER CAPACITOR

For the filter capacitor;

dc = Dc output current

Vr = ripple voltage

Vdc = Dc Supply voltage

F = frequency =50Hz

Idc = 191.6mA

$$C = \frac{I_{dc}}{V_r \times 2f} = \frac{191.6 \times 10^{-3}}{V_r \times 100}$$

$$V_r = \frac{V_{dc}}{10} = \frac{15.4}{10} = 1.54$$

$$C = \frac{191.6 \times 10^{-3}}{1.54 \times 100} = \frac{191.6 \times 10^{-3}}{154}$$

$$C = \frac{191.6 \times 10^{-3}}{154}$$

C =1244 uf

The filter capacitor value chosen closest to this value is 2200uf, for better filtering and better ripple rejection because of the vast difference in value calculated and value actually used; there will be almost compete ripple rejection. (C1 = 2200 uf)

The capacitor working voltage is specified as 25V because 2 it is twice the required supply voltage and so this will allow for sufficient charge space.

3.5 BLOCKING DIODES

For blocking diodes

Peak inverse voltage (PIV) = 1.5 x Vac and:

Forward Current (If) = 0.5 x Idc

Where

V_{ac} is the transformer secondary output voltage

Idc is the Dc current at the filter capacitor

PIV = 1.5 x 12V = 95.8mA

If = $0.5 \times 191.6 \times 10^{-3}$ = 95.8mA

From component data book the PIV of IN4001 is 1000v and If is 1000mA, therefore it can serve as a blocking diode.

IN4001 as used for the bridge rectifier; also for diodes D1, D3, D6 and D8

CHAPTER FOUR

4.0 CONSTRUCTION AND TESTING

4.1 TOOLS AND MATERIALS USED

During the construction of Automatic Liquid Level Indicator & controller some tools and materials were used. Some of them are briefly discussed here.

- Bread board – this is a plastics board on which the circuit is set up temporarily to ascertain that it is working according to design before it is transferred to a Vero board
- Vero board – this is a perforated plastic, overlaid with strips of metal conductors. It is used for permanent construction of the project prototype.
- Lead – this is a metal with low melting point. It is used to hold components and connecting wires in place on the Vero board.
- Soldering iron – it provides the heat needed to melt the lead onto the Vero board when connected to ac mains.
- Lead sucker – this is used to suck up molten lead from the Vero board when de-soldering a connection.
- Digital multimeter – this is a multifunction electronic measuring instrument employed in the measurement of voltages, resistances, transistor current gains, and checking for continuity.

Others are pliers, wire cutters, drilling machine, file chisel, scissors, hammer nails, screws and gum.

4.2 HARWARE CONSTRUCTION

In construction of the project, careful planning of the circuit layout and simple wiring minimized errors and made trouble shooting easier.

Each unit was soldered independently and tested to ensure that is was working fine before interconnection as specified in the design.

IC used was connected via an IC adapter for easy replacement in times of maintenance and this made it easy to keep track of pin numbers during soldering and trouble shooting.

Connection between the current and the liquid level sensing circuit is achieved by the use of connecters. The power input & output use 2-pin sockets respectively.

4.3 PROJECT CASING

Wood with formica finishing is used to case the project, with dimensions 250mm x 174mm x 90mm. The side panel is cut at convenient positions for the main switch, the manual override, and the fuse. The front panel is perforated to allow for the Ac on lights, the three level indicators, the Dc power 'ON' LED, the two LEDs for the alarm circuit the Pump 'ON' 220V Ac lamp, the buzzer alarm unit and the manual switches (push button switches). The casing has holes drilled on strategic locations for Ventilation.

The back panel has connectors fixed to it for interconnection between the pump control circuit and the liquid level sensing circuit. The Ac power cable also passes through one the side panels.

Each component on the front, back and side panels are labelled for easy identification.

4.4 SYSTEM COUPLING

The transformer is mounted, using screws. The circuit board is mounted horizontally at the base inside the casing to allow all the outgoing wires to the panel easily traceable. The switch, fuse and connectors are firmly screwed on the casing. The LEDs are put in place using gum.

4.5 CONSTRUCTION PRECAUTIONS

- ICs were mounted on Ic sockets to avoid over heating them and for easier trouble shooting
- Excessive heating of components during soldering was avoided so that they do not bum out.
- All excessive lead was removed to avoid bridges (short circuit) on the board.
- All soldered joints were tested for continuity so as to avoid open circuits.
- Polarities of components and pin configuration of transistors and Ic's were checked properly before soldering.

- All components are tested and certified okay before soldering them to the board
- The terminals of all components were scraped and Vero board surface scraped before soldering.

4.6 TESTING AND RESULT

The system was set up by connecting the power cable, and connecting the liquid level sensor switches to their respective connection points/outlets at the back of the device. A magnet (ring) which serves as the level sensor was used for simulating the various levels to be controlled and indicated. In the absence of a liquid pump a 220v light bulb was used as load.

The device was switched on and the Ac indication lights came on, the main switch at this time was in the 'OFF' mode, the toggle switch was also in the 'OFF' mode and the manual switches were in their normal positions.

As soon as the main switch was put 'ON' the green LED indicating that dc power supply is available came on. Furthermore as switches (MS2/RS2) was closed the Red LED indicating low level of liquid came on, and at the same time the 220v bulb (representing signals to pump motor) came 'ON' indicating that pumping action is taking place.

As the magnet is varied along the length of pipe housing the reed switches (liquid level sensors); the mid point (yellow LED) came 'ON' at the mid point of the pipe (indication that liquid level is at mid point).

With the closure of switch 6 (RS1) located at the 'high High' level in the tank, the green LED (indicating tank full level) came up and at the same time signals to the 220v lamp was cut off and the lamp switched 'OFF' indicating that pumping action has been terminated.

Ms1& Ms2 (manual switches) were also tested and were found to function the same way as Rs1 & Rs2 (Reed switches), Ms2 (low level manual switch) when pushed 'ON' remains on until Ms1 (high level manual switch) is pushed 'ON', and Ms2 action is turned 'OFF', they also serve as a means of testing if the LEDs of the indicating circuits is in normal condition.

Switch3 (Normally connected) was pushed 'OFF' when lamp 220v was 'ON', the LED6 and Bz2 (Buzzer2) of the alarm circuit came 'ON' and the alarm blared audibly.

When S1 (the manual override) was switched 'ON', the green (LED1) light indicating Dc power supply went 'OFF' and the 220v lamp came 'ON'.

4.7 PROBLEMS ENCOUNTERED

During the testing period, it was found that the system was not responding to changes in liquid level as switches 5 and 6 were closed, it was discovered that the relay was bad, and wasn't switching properly.

At some point after this the (Dc Power 'ON')LED indication was not coming 'ON', it was found that it was as a result of wrong polarity, the polarity was reversed and the LED lights glowed clearly.

It wasn't easy, getting the Reed switches; it took quite a while before they were sourced.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The project worked as expected from the result of the tests carried out. The material used in building the Automatic Liquid Level Indicator / controller were locally sourced with careful attention given to materials constituting the medium and hence chances of contaminating the medium reduced to zero.

The construction of the design exposed and made the student more expounded in knowledge and practical skills with electronics components; which guaranteed efficiency with the handling of construction tools.

The pump control circuit will act accordingly by turning on the multivibrator which will make the output of the 555 timer Ic to go high or low as the case may be thereby making available or cutting 'OFF' biasing voltage for transistor Q1 and collector current will either flow or stop flowing which will make the relay energize or de-energize and the liquid pump is either turned 'ON' or "OFF"

Finally, the aims and objectives of the project has been achieved, though with little problems encountered but duly resolved.

5.2 RECOMMENDATIONS

The liquid level in this design was measured at discrete points only. This can be improved by using differential approach like varying resistance with liquid level. Thus making it possible to know the exact liquid level in the container at any point in time.

This design does not have any means of communication to a distant operator station, this mode of operation can be further worked on to bring out more functionality from the device when operated in this mode.

Furthermore, interfacing the device with a computer with developed programming controlling routine signal processes would be a step ahead, especially if the program has an explicit way of locating and displaying faults whenever they occur.

5.4 LIST OF PARTS

S1	--	Toggle Switch
S2	--	Main Switch
F1	-	Fuse (1amps)
T1	-	Transformer(12V;300Ma)
D1-D4	-	Bride rectifier (Diodes,IN4001)
C1	-	2200 uf capacitor
D5	-	Protection diode for voltage Regulator IC (Lm7812)

R1, R6, R8, R9, R10, R11------ 330 ohms

LED (1, 2, 3, 4, 5, and 6) Light Emitting Diodes

MS2	-	Manual Switch 2
MS1	-	Manual Switch 1
MS3	-	Manual Switch3
RS2	-	Reed Switch 2
RS1	-	Reed Switch 1
R1, R3	-	10K ohms
IC1	-	Voltage regulator
IC2	-	555 Timer IC
C2	-	O.I Uf
S3	-	(Normally Closed) manual Switch
R4	-	2.2k
Rly1	-	Relay(DPDT) 12V
Q1&Q3	-	NPN Transistor (BCI08)

D6, D5, D7, D8 D9, D10, - Protection Diodes

M1 - motor pump

R5, R7 - 3,5K

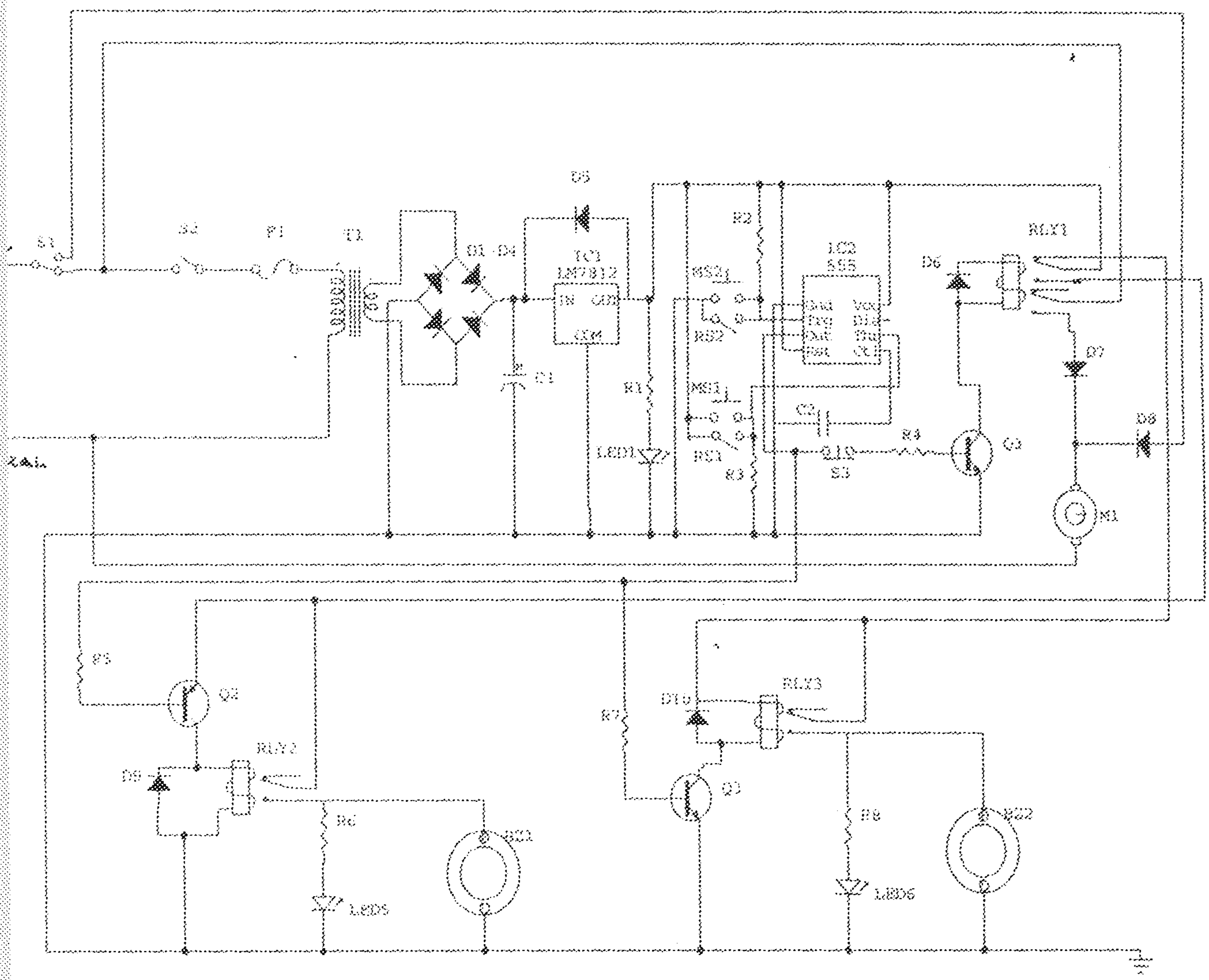
Q2 - PNP transistor (2N2904.A)

Rly2& Rly3 - Relay (SPST) 12V

Bz1 & Bz2 - Dc Buzzer; 3.15Ma

L1 - Ac(220v) Lamp

APPENDIX A: Complete Schematic Circuit Diagram for the System.



APPENDIX B; Circuit Diagram of the Liquid Level Indicator