DESIGN AND CONSTRUCTION OF AN AUTOMATIC WATER-LEVEL MONITORING/CONTROL SYSTEM

BY

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A THESIS SUBMITED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.Eng) DEGEE IN ELECTRICAL/COMPUTER ENGINEERING,

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DEDICATION

I would like to dedicate this project to God Almighty for all He has done for me, for his guidance and protection over me through these periods and always. For you Lord made it possible, I am ever grateful. Also, I dedicate this project to my late brother Francis Andrew Danladi and Uncle Engr. Anthony A.Omale. May your souls and all the faithful departed, rest in peace amen.

DECLARATION

I Ebiloma Cyrus Kani declare that this project was executed by me under the supervision of Engr. A. G. Raji, and that the project to the best of my knowledge has not been submitted for any award of degree elsewhere. All references extractions were fully acknowledged.

Ebiloma Cyrus Kani

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Student

16 Nov, 2011

....

Signature and Date

CERTIFICATION

This is to certify that this project titled Design and Construction of an "Automatic Water level Control/ Monitoring System" has met the requirement governing the award of B.Eng. Electrical and Computer Engineering, Federal University of Technology, Minna,

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(Nov. 17, 2011)
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Signature and Date

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Signature and Date 6/3/2012

ACKNOLEGDEMENT

I would like to show my appreciation to God Almighty for all he has done for me, for all his love and never ending grace and mercy upon me, throughout my studies as an undergraduate.My supervisor, Engr. A .G. Raji, I want to use this opportunity to express my gratitude for painstakingly reading and supervising all aspects of my project.

I want to express my gratitude to all my Lecturers and Technologists of Electrical and Computer Engineering Department who have in various ways taking time to impact knowledge to me most especially Dr Jacob Tsado.

My heartfelt gratitude goes to my parents Dr. and Mrs. F. A. Ebiloma for all their love, prayers and support throughout my academics. I am sincerely grateful.

To my siblings: Emmanuel, Musa (Tibla), Ajuma (Moraks), Francis (Original), Wajim, Peter Atakobi, Archie Ripiye ,Ali Ameh and all those to many to mention. I would love to use this opportunity to say thank you for all the love and assistance you have always been showing to me.

I want to seize this opportunity for the advices and encouragements of Mr H.M Ebiloma. May God Almighty grant you heart desires amen.

To my very close friends: Tony, Solomon, Samuel, Christopher and others too many to mention, I would love to use this opportunity to thank you for your friendship and advices.

ABSTRACT

The theory, design and construction of an automatic water level monitoring/control system is presented in this project. A fluid level sensor monitors the water level in a tank and also controls the "on" and "off" states of the pumping machine by means of generation and reception of ultrasonic waves. The objective of this project is to address: (1). The need to design a system in which has no contact with its fluid so it can be used to monitor ultrapure, slurry, dirty or corrosive liquids, and (2).To prevent both water wastage or spillage from occurring and the pumping machine from running when not required.

Table of Contents

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

A control system is a system consisting of interconnected components designed to achieve a desired purpose. To understand the purpose of a control system, it is useful to examine briefly the examples of control through the course of history. These early systems incorporated many of the same ideas of feedback control that are in use today.

Modern control engineering practices includes the use of control design strategies for improving manufacturing processes, the efficiency of energy use,advanced automobile control, among others.

In this modern world there's a high need for control of liquid level either for scientific research, industrial application, domestic uses etc. The control of liquid level brings about a system of feedback control and the feedback control brings about automation of a system.

The use of feedback to control a system has a fascinating history. The first application of feedback control appeared in the development of a float regulator mechanism in Greece in the period 300 to 1 B.C. The water clock of Ktesibios used a float regulator. An oil lamp devised by Philon in approximately 250 B.C used a float regulator in an oil lamp for maintaining a constant level of fuel oil.The temperature regulator byCornelisDrebbel(1572-1633). The first automatic feedback used in an industrial process is generally agreed to be James Watt's flyball governor developed in 1759 for controlling the speed of a steam engine. The first historical feedback system, claimed by Russia, is the water-level float regulator said to be have been invented by I.Polzunov in 1756. The float detects the water level and controls the valve that covers the water inlet in a boiler. Host of others, too many to mention used the principle of feedback to control parameter(s) giving the purpose for the need for a control system. Control engineering has a wide application in different aspects such as in the military, industries, power plants, farms, domestic areas etc.

In feedback control, the system tries to compare two parameters namely: the desired and the measured output. Therefore a feedback control or closed loop system is a control system that tends to maintain a prescribed relationship of one system variable to another by comparing functions of these variables and using the difference as a means of control. A feedback control system often uses a function of a prescribed relationship between the output and the reference input to control the process. Often the difference between the output of the process under control and the reference input is amplified and used to control the process so the difference is continually reduced. The feedback concept has been the foundation for control analysis and design. A simple example of a closed loop control is a person steering an automobile (assuming his or her eyes are open) by looking at the automobiles location on the road and making the appropriate adjustments.

In industries where there's requirement to control the amount of liquid in a container and also to operate the electric pumping machine required to pump the liquid into the tank or reservoir. Such industries usually require an operator to monitor the liquid level in the container or tank. As time goes by,the operator's performance declines gradually due to the monotonous nature of the job and also the discouraging tanks height (eg. Like those used to store petrochemical liquids in petrochemical plants, the overhead tanks used to create a pressure head of water in water board plants for pipe water distribution) thereby causing boredom and fatigue. This performance declination causes inefficiency and disturbs production. This decline may lead to overflow of the liquid in the tank or vessel leading to wastage, dryness of the tank or the electric pumping machine running when not required to do so. For example, in an industrial plant requiring water for cooling its machinery or for consumer goods production must have storage tanks readily due to the erratic water supply from public mains to provide adequate amount of water always. If water is in short supply, it will hinder production. These tanks need to be incorporated in a control system making sure there's continuouswater supply and the control of the electric pump is now automated to make production efficient and effective.

In domestic and agricultural application, water storage is critical especially in northern Nigeria or arid regions due to the erratic supply of pipe water from main supply as a result of long dry season in these regions. The use of an electric borehole to pump water into storage tanks needs to be incorporated in an automatic control system to ensure continuity of water supply at all times because lack of water brings discomfort.

The knowledge of liquid level of the tank or vessel is necessary to prevents so many situations such as empty tank, spillage of liquid when the tank is full. Large volume of liquid is wasted overtime due to overflow as a result of inability to detect the water level when the tank is full or empty.

1.1 AIMS AND OBJECTIVES

The design of a liquid level control system using ultrasound waves is aimed at achieving the following:

1). A sensor that can monitor/control the level of any liquid ranging from pure, ultrapure,non-conductive,conductive,slurry or corrosive liquids.

2). Eliminating the burden of monitoring the water level and manual control of the electric pump.

3).It is aimed at attaining optimum performance, efficiency, improving productivity and relieving the drudgery of many repetitive manual operations.

4).Avoidance of water wastage due to overflow of the tank when it's full.

5).Prevent the pumping machine from running when not required to do so.

1.2 METHODOLOGY

The method employed in the design and construction of an automatic water level monitoring/control system is based on the principle of echo (sound reflection) and converting the time of reflection of ultrasound waves into distance or height of the water in the tank or reservoir. The fluid level sensor consists of a transmitter, a receiver and its associated circuitry, a controller unit and a relay. The controller generates a 40 KHz signal. Gating "on" of the 40 KHz beam is done by the switching action of the gating transistor to "on/ off" the medium power transistor thereby producing an AC voltage across the transmitter. The timer (T1) in the controller is simultaneously enabled. The transmitter transmits a signal which is reflected and enters the receiver and its associated circuitry. The controller unit waits for signal reception by monitoring the comparator's output which is normally "HIGH".As the signal enters the receiver and its associated circuitry, It is amplified by a 2-stage high frequency amplifier. The amplified received signal is compared with the reference voltage at the comparator. If the amplified signal is greater than the reference voltage, the output of the comparator goes "LOW". The timer (T1) is simultaneously disabled. The timer's value is then used to compute the distance using the formula:Distance=(velocity of soundin air ×time of flight)/2.When the distance computed by the controller unit is 25 cm away from the fluid level sensor to the water surface, the controller unit triggers the relay to close in order to supply power to the pumping machine. And when the distance computed is 10cm away from the fluid level sensor to the water surface, the controller triggers the relay to open in order to cut-off supply from the pumping machine.10 cm and 25 cm denote the upper and lower set point respectively.The block diagram is shown below.

1.3 BLOCK DIAGRAM

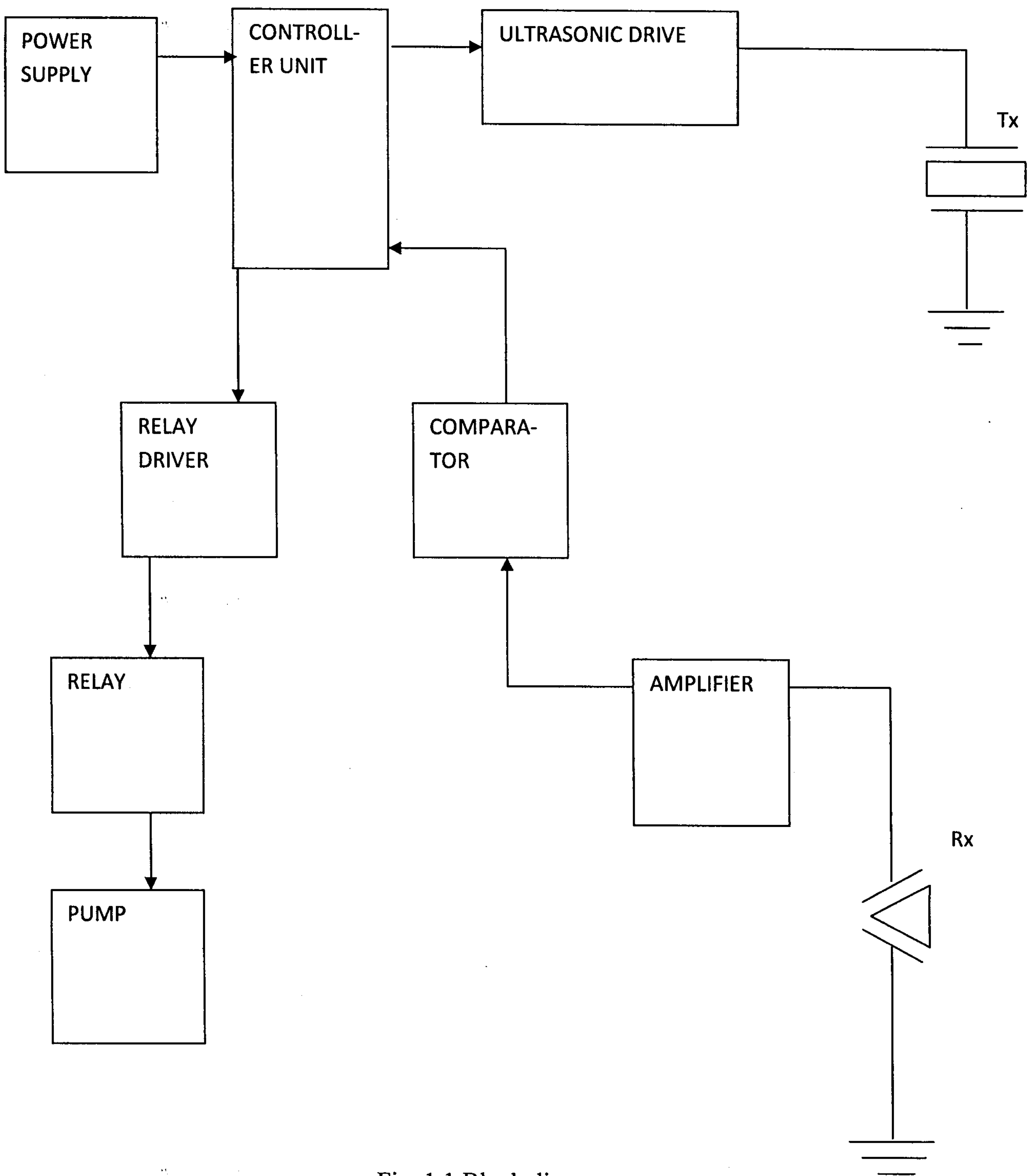

Fig. 1.1 Block diagram

CHAPTER TWO

2.0 LITERATURE REVIEW

Throughout the course of history to this present time, man has employed various means or methods of obtaining and controlling the level of a liquid. It goes far as using "eye level" to determine the level of liquid by placing the eye at line of best horizontal position, the ordinary dipstick is a simple device used for measuring liquid level. It consists of a metal bar calibrated with a scale on its surface and fixed at a known position in the liquid-containing vessel, removing the instrument from the vessel makes a level measurement and reading how far up the scale the liquid has wetted. These methods are prone to error, monotonous and tasking as the observer needs to be there constantly to monitor the liquid as it either rises or falls to the desired level. The need for providing a reliable method to detect the level and control its flow arises. Many in the past have tried to make methods that will function without intervention either by intuition or by invention. This has been realizable through the use of feedback control. Feedback control brings about automation.

The use of feedback control has a very fascinating history. The first application of feedback control to liquid-level appeared in the development of a float regulator mechanism in Greece in the period 300 to 1 B.C.The water clock of Ktesibios used a float regulator. An oil lamp devised by Philon in approximately 250 B.C used a float regulator for maintaining a constant level of fuel oil. The first historical application of feedback control to liquid level, claimed by Russia, is the water-level float regulator said to be invented by I.Pulzunov in 1765. The float detects the water level and controls the valve that covers the water inlet. [1]

The past 100 years have witnessed the emergence of various methods of water-level measurements and control as a result of improvement in technology witnessed during this period. Improvements have been made on previous inventions but with the same sole purpose with great effectiveness and efficiency. Floats have been used for liquid level since time immemorial. Floats can be as simple as a hollow ball (as used in a home toilet) or relatively sophisticated as in displacement types. In the former, the float is a sealed metal or plastic ball which floats on the liquid surface and rises and falls accordingly. The ball is connected to an arm, the arm maybe attached to an indicator or to a switch, allowing monitoring and control in a low-tech way. The cable or arm attached to the float is anchored at some point, allowing the float to tip up and trip up an internal switch at the desired level. Most tip-up floats are equipped with DPST (double pole single throw) switch allowing operation in both rising and falling directions.

2.1 HISTORICAL BACKGROUND

Displacement float switch is somewhat more complicated than the float switch discussed above. A series of calibrated floats are hung on a single cable, which is then hung within the vessel to be measured. As the liquid rises, the weight of each float is displaced, allowing a slight movement of the suspension cable. The cable moves a pre-determined amount for each float immersed in the liquid. At the point of suspension, a switch can be set to react to each successive movement of the cable, either in the up or down direction. This type of device is very sensitive to the amount of suspended matter in the liquid and is typically used for clean water or chemical application. Fouling by debris or heavy particulate makes application of this device limited in waste water field. The internal switch or contact maybe part of a motor control circuit, which drives as a pump. Float switches have some mechanical elements in them since there is movement before contact is made in them.

On the other hand, electronic devices are been used as switches which is more efficient and effective .Switches could be temperature operated, pressure operated, light operated, etc. Liquid-level can be sensed by taking some important parameters into consideration. These include temperature, pressure, weight, density, phase of matter, dielectric constant of medium, agitation, vibration , to mention a few. These have helped a long way to develop an appropriate transducer to suit a particular parameter chosen. [2]. Generally, liquid level is sensed using a level sensor based on either point level sensing or continuous level sensing .Point level sensing only indicate whether the substance is either above or below the sensing point while Continuous level sensing measures level within a specified range and determine the exact amount of substance in a certain place.[3]

Conductive level sensors or immersion switchesare simply two conductive rods or probes that form a circuit when a liquid bridges a gap between them. The energy used to create the electrical circuit is limited in current to avoid any accidents. Conductive level sensors use a low voltage current limited power source applied across separate electrodes. The power supply is matched to the conductivity of the liquid. The power source frequently incorporates some aspects of control such as high-low or alternating pump control. A conductive liquid contacting both the longest probe (common) and a shorter probe (return) completes a conductive circuit. Maintenance can be an issue. The probe must continue to be conductive. If build up insulates the probe from the liquid medium, it will stop working properly. A simple inspection of the probe will require an ohmmeter connected across the suspected probe and ground reference. Typically in most water and waste water wells, the well itself with its ladders, pumps and other metal installation provides ground return. However, in chemical tanks and non grounded water, the installer must supply a ground return, typically an earth rod. [2, 3]

Magnetic level device comes in different configurations. The most popular is the sight glass arrangement which contains metallic flags that indicate the level of the liquid being monitored. This is accomplished by the use of a magnetic float inside a tube that is part of the sight glass. Magnetic float level sensor also involves the opening and closing of a mechanical switch. Switching occurs when a permanent magnet sealed inside a float rises or falls to the actuation level. Parameters such as temperature, buoyancy, viscosity affect the selection of the stem and float.

Admittance level sensor operates using the electrical relationship between the measured liquid and an energised cable immersed in the liquid. As the liquid level rises and falls, the capacitance causes a change in an oscillator (RF source) located in the system electronics.The cable is a shielded co-axial cable in which a probe is driven through it. The co-axial nature of the cable eliminates the effect of changing capacitance to ground. When the level changes around the cable, a corresponding change in dielectric is observed. This changes the admittance of this imperfect capacitor and this change is measured to detect the change of liquid-level. Sensing cables are fitted with a weight at the bottom of the cable in order to provide some stability from movement which could have an adverse effect on accuracy if excessive.Sensing cables are fitted with a weight at the bottom of the cable in order to provide some stability from movement which could have an adverse effect on accuracy if excessive. [2, 3]

Pneumatic level sensors are used where hazardous conditions exist, where there is no electric power or its use prohibited or restricted, and in application involving sludge or slurry. As the compression of a column of air against a diaphragm is used to actuate a switch, no process liquid contacts the sensors moving parts. These sensors are suitable for use with highly viscous liquids such as grease, as well as water based and corrosive liquids. [3]

Resistive chain level sensors are similar to magnetic float level sensors in that a permanent magnet sealed inside a float moves inside moves up and down a stem in which closely spaced switches and resistors are sealed. When the switches are closed, the resistance is summed and converted to current or voltage signals that are proportional to the level of the liquid. Parameters that affect the selection of float are similar to magnetic float sensors discussed above. This sensor works well in marine, pharmaceuticals, food processing, waste water treatment etc.

Hydrostatic level sensors are submersible or externally mounted pressure sensors suitable for measuring the level of corrosive liquids in deep tanks or water in reservoirs. It utilizes the principle that the hydrostatic pressure due to a liquid is directly proportional to its depth and hence the liquid-level surface. The liquid-level (h) is then related to the measured pressure (Pm) as:

$$h=(Pm - \rho o)/(\rho v \times g).$$

Where h is the liquid level from the bottom of the vessel to the liquid-level's surface,Pm is the pressure due to the height of the liquid, ρo is the atmosphere pressure,ρv is the specific gravity of the liquid. In open topped vessels or covered ones that are vented to the atmosphere, the level of the liquid is determined by the compression of the weight of water or liquid and the atmospheric pressure on or against the sensitive diaphragm (transducer) inserted at the bottom of the vessel. Since these sensors sense increasing pressure with depth and because the specific gravities of liquids are different, the sensor must be properly calibrated for each application. In addition, large variation in temperature causes changes in specific gravity that should be accounted for when the pressure is converted to level. For use in open air applications where sensor cannot be mounted at the bottom of the tank, a special version of hydrostatic pressure level sensor can be suspended from a cable into the tank to the bottom to the bottom point that is to be measured. The sensor must be specially designed to seal the electronics from the liquid environment. In tanks with small head pressure, it's very important to vent the back of the sensor's gauge to atmospheric pressure. Otherwise, normal changes in barometric pressure will introduce large error in the sensor output signal. These instruments require periodic calibration and accuracy can suffer from build of sediments or debris.[1, 2, 3]

Principle of vibration sensor consists of two piezoelectric oscillators fixed to theinside of a hollow tube, which generates flexural vibrations in the tube at its resonant frequency. The resonant frequency of the tube varies according to the depth of its immersion in the liquid. A phase locked loop (PLL) circuit is used to track the change in resonant frequency and adjust the excitation frequency applied to the tube by the piezoelectric oscillator. Liquid level measurement is therefore obtained in terms of the output frequency of the tube when the tube is resonating.

This project operates on the basic principle of using ultrasonic waves to determine liquid/ solid/ slurries level. It consists of ultrasonic level transmitters and electronic circuitry. The ultrasonic level transmitters consists of two elements (1) a high efficiency transducer (2) An associated electronic transceiver. The electronic circuitry consists of a programmed micro-controller chip and other relevant circuit components. The ultrasonic level transmitters together, they operate to determine the time for a transmitted ultrasonic pulse and its reflected echo to make a return trip between non-contacting transducer and the sensed material level. A top-of-tank mounted transducer directs waves downward in burst onto the surface of the material whose level is to be measured. A piezoelectric crystal inside the transducer converts electrical pulses into ultrasoundenergy that travels in the form of a wave at an established frequency and at constant speed in a given medium (air). Echoes of these waves return to the transceiver. The software in the micro-controller chip performs the calculations to convert distance of wave travel into a measure of level in the tank. The time lapse between firing ultrasound and receiving the return echo is directly proportional to the distance between the transducer and the material (liquid) in the vessel. The medium is normally air over the materials surface but could also be a blanket of some other gases or vapour. The instrument measures the time for the burst to travel down to the reflected surface and return. This time will be proportional to the distance from the transducer to the surface and can be used to determine the level of the fluid in the tank. This basic principle lies at the heart of the ultrasonic measurement technology and is illustrated in the equation: Distance= (Velocity of sound in the medium × Time)/2.Two distances worth noting:

(1)." Dead Band" or Minimum measuring distance (Xmin): Is a feature common to all Ultrasonic level sensors.This is a short range infront of the sensor within which the ultrasonic device cannot measure.

(2). Maximum measuring distance (Xm): The longest range under ideal condition within which the device can measure. No measurement is possible beyond this point.

The frequency range for ultrasonic methods is in the range of 15-200 KHz. The lower frequency instruments are used for more difficult applications; such as long distances and solid level measurements and those with higher frequency are used for shorter liquid level measurements.

For practical applications of ultrasonic measurement method, a number of factors must be considered. A few key points are:

(1). Speed of sound through the medium (air) varies with medium's temperature. The transducer may contain a temperature sensor to compensate for changes in operating temperature (whose value is in the system's software) that would alter the speed of ultrasound and hence the distance calculation that determines an accurate level measurement.Temperature compensation could be provided to account for uniform temperature variances of the sound medium. The temperature sensor is usually placed inside the transducer and the signal sent to the transceiver via transducer wiring. However, this only takes into account the temperature at the sensor, which maybe different as the sound wave approaches the water.

(2). Debris, extreme turbulence of the liquid (water) can cause fluctuating readings. Use of a damping adjustment in the instrument or a response delay may help overcome this problem. Damping slows down the rate of response of the instrument especially when the liquid surface are in agitation or the material falls into sound path during filling of the tank or vessel.

(3). Very high concentration of the fine sediment in suspension can scatter and absorb the ultrasonic pulse, preventing reflection of a detectable echo.

(4). Build-up on the sensor head, even simple condensation can cause problems with the sensor operation.

(5). Ultrasonic sensors typically require more power than other water-level sensors.

These mentioned above gives the limitations of ultrasonic sensors for water-level measurement.[3 , 4]

Advantages of Ultrasonic sensors water-level measurement.

(1). Non-contact sensor allows for easy installation on a bridge or structure over the water.

(2).Non-contact sensor reduces the problem of sensor fouling or corrosion. Also, potential damage from debris is reduced.

There several other measurement techniques which can be employed nowadays. Some types are listed below:

1). Gamma-ray gauge, used for difficult applications.

2).Microwave sensors are ideal for use in moist, vaporous and dusty environments as well as in applications in which temperatures vary.

3).optical interface sensors

4).Air bubbler system

By the introduction of microprocessors system in science and technology, large parts of systems mechanism and large number of can be integrated together.

CHAPTER THREE

3.0 DESIGN AND IMPLEMENTATION

The ultrasonic liquid level sensing system was designed around the listed system blocks:

1).5-volt system supply

2).8 bit system controller

3).40-Khz software frequency generator

4). AC power relay switch

5).Ultrasonic transmitter/ receiver

6).Two stage HF amplifier

7).Comparator switch

The logic block requires a regulated 5-volt DC supply. This was derived from a15-volt step down transformer, a bridge rectifier and a 7805 5-volt regulator as shown in fig 3.0

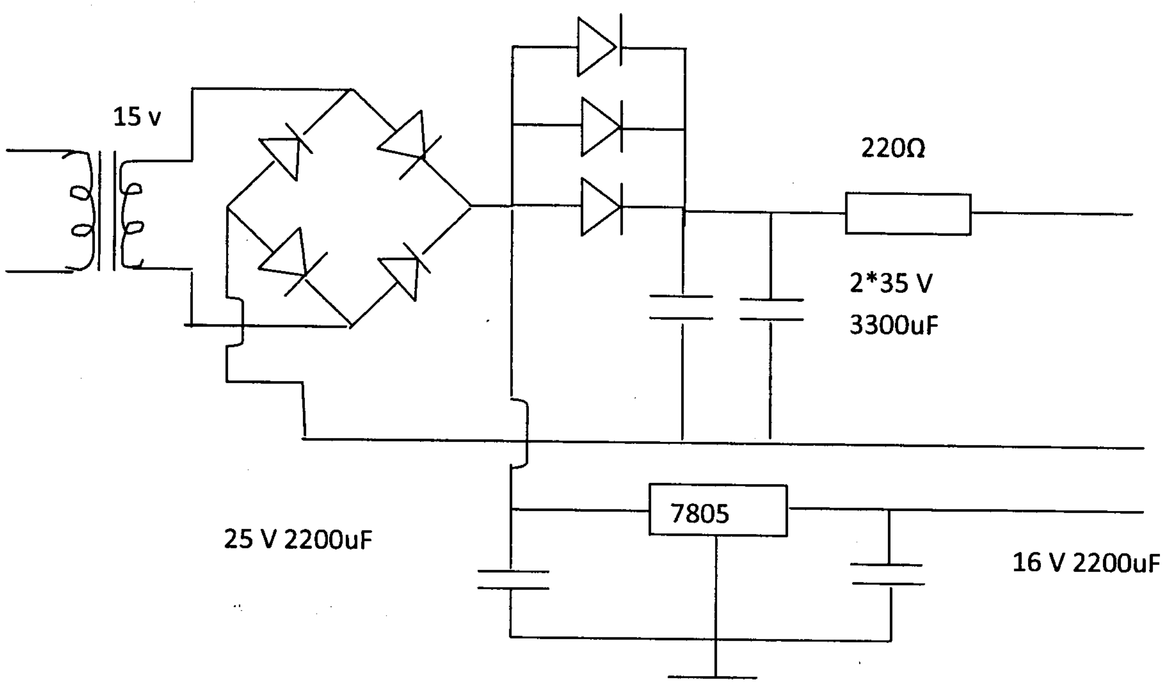

Fig 3.1 System power supply

A high-voltage 20-volt DC supply was required for ultrasonic transmission. This was also derived from the 15-volt step down transformer

For forward bias: $V_{diode}=2V_f=2\times0.7=1.4$

$V_{ac}=15v=V_{rms}$

From: $Q=CV=It$

C=Smoothing capacitance

$t=1/(2f)$

V=peak to peak AC ripple voltage

I=maximum load current

$C=(It)/(V)=[I\times(1/2f)]/(\Delta V)$

$f=50Hz$

$2f=100Hz$

$t=1/100=0.01s$ (ultrasonic detection).

For the 7805 regulator, the minimum input voltage =7 v= (5v+ 2v)

Where 2v=drop out voltage

$V_{rms}=15v$

$V_{peak}=(15\sqrt{(2)})-1.4$

$V_{peak}=19.8\ v\approx20v$

Maximum allowable peak to peak ripple voltage

19.8—7=12.8v

Vripple peak to peak=12.8v

C=[1×(1/100)]/(12.8)≈780uF

This is the minimum smoothing capacitance across the DC power rails.

The DC voltages were isolated by a three-diode network as shown in fig 3.0.The three diodes were connected in parallel to reduce the forward diode resistance (Rd), thereby increasing the maximum current the diodes can conduct in the forward direction.The logic supply live was smoothened by a 25-volt 2200uF capacitance and passed into a 7805 regulator to produce a regulated 5-volt output. The transducer-side supply was smoothened by two parallel-connected 3300uF capacitances and connected to the ultrasonic transmitter.

3.1 SYSTEM CONTROLLER

An 8952 micro-controller was integrated in the system design for the following reasons:

1). Generate a crystal-locked 40 KHz ultrasonic drive.

2). Effect the mathematical calculation required to extract liquid-level/ distance relative to the transducers as a function of the time-of-flight (TOF).

3).Insert hysteresis into the turn-on and turn-off of the connected water pump.

The controller had its timer 2 (T2) programmed in the frequency generator mode to produce a 40-KHz output frequency that switched the transmitter via the network of fig 3.1

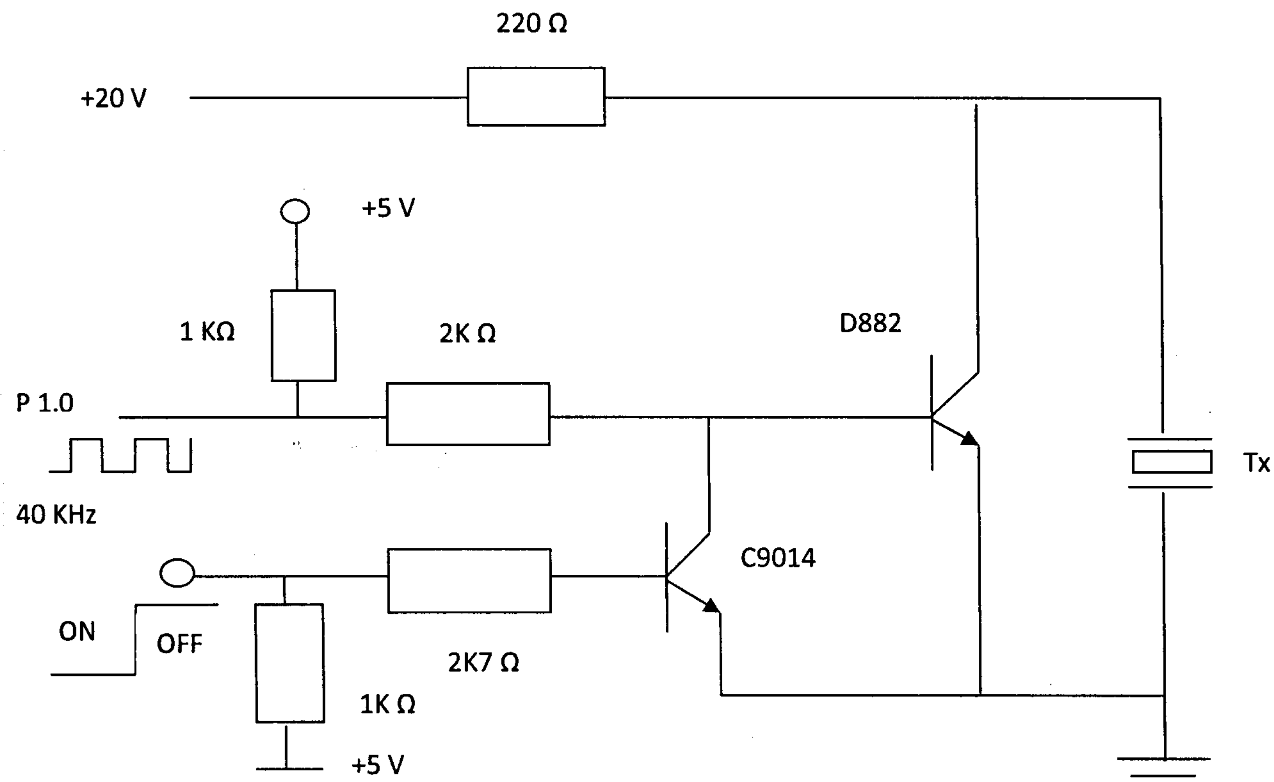

Fig 3.2Ultrasonic Transducer drive

Frequency gating was effected using a C9014 transistor to gate on/off a medium power D882 transistor. The 40 KHz switching of the D882 device generates an AC voltage across the transmitter, at a 40-KHz frequency.

3.2 AC RELAY POWER SWITCH.

To engage/ disengage the connected water pump (?) which could have starting current below the relay rating, a 12-volt/30 amp relay was incorporated as shown in fig 3.2.

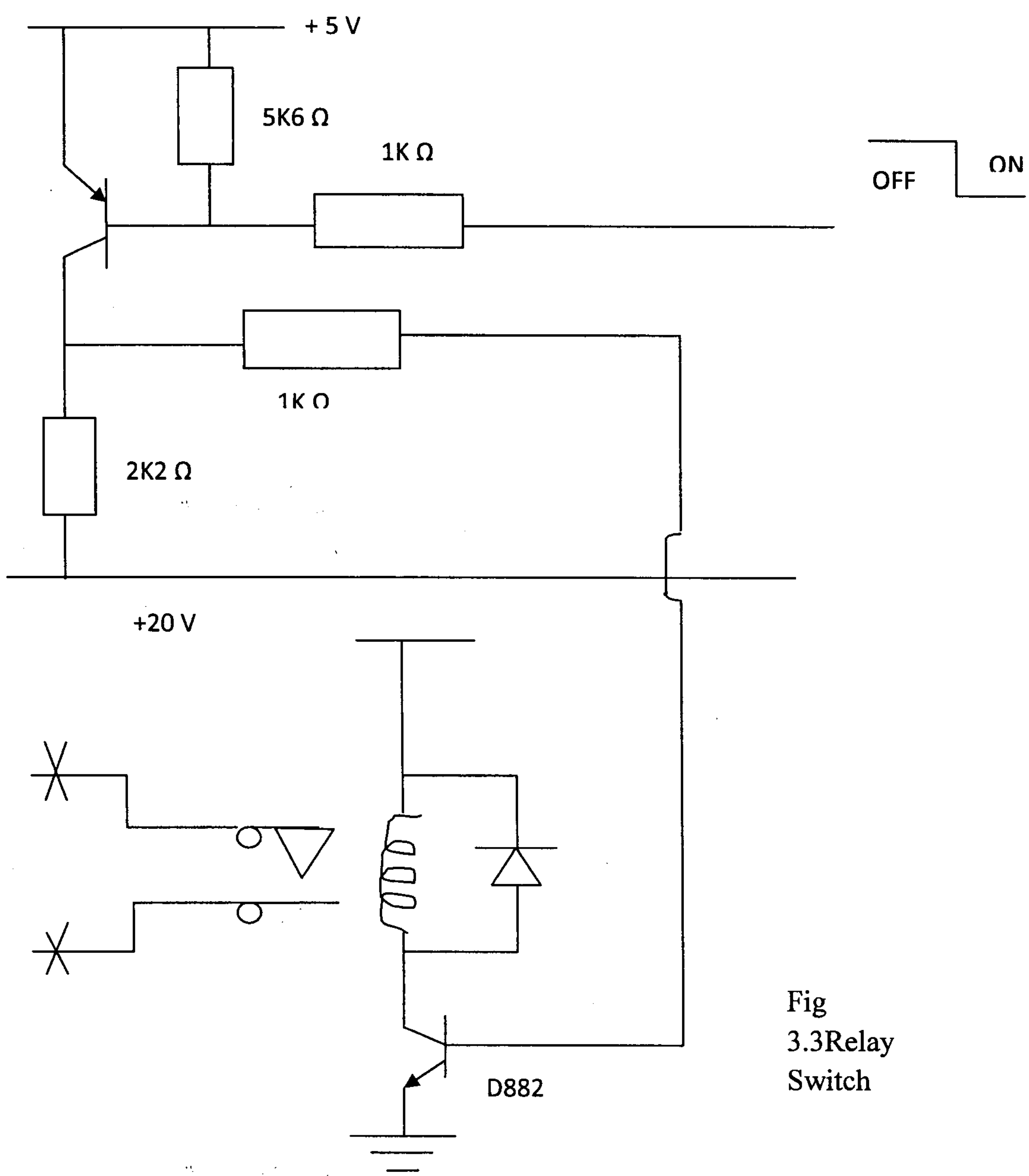

Fig 3.3Relay Switch

Relay turn-on /turn-off was effected via port 1.1 (P1.1) under software control.

3.3 ULTRASONIC FREQUENCY AMPLIFIER

To accurately measure the time of flight (TOF) of the transmitted ultrasonic wave, the reflected wave front had to be amplified by a two-stage high-gain AC amplifier as in fig 3.3

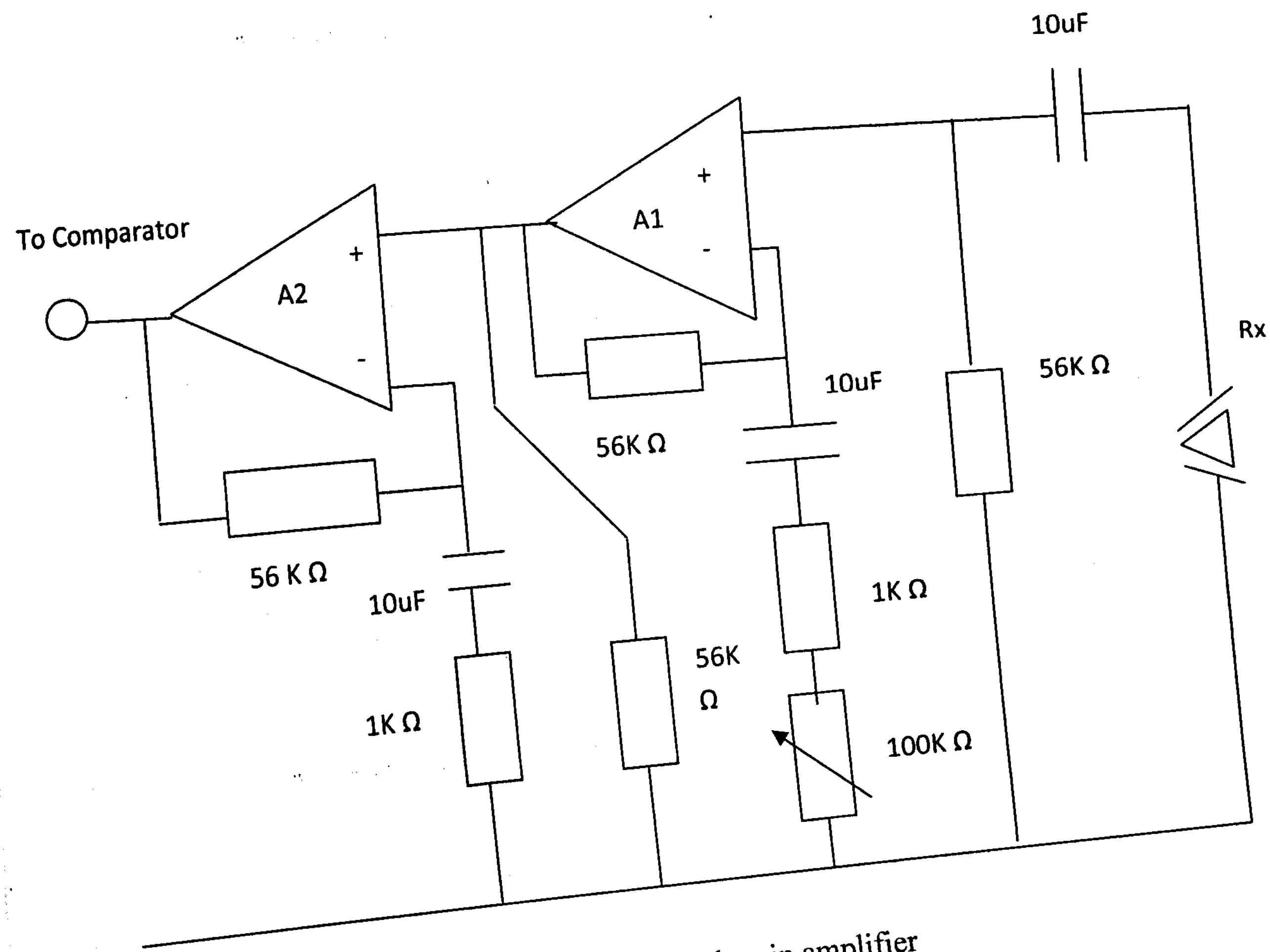

Fig 3.4 High gain amplifier

An LM358 dual op-amp was utilized as the gain element for the receiver .A part of the package was configured for a fixed gain of 57 and the other half for a variable gain of 1.56 to 57 maximum. The gain adjustment was needed to ensure system stability as too high, a gain would introduce instability in the amplifiers.The amplified signal led into the inverting output of the comparator designed around a second LM358 device.

3.4 COMPARATOR SWITCH

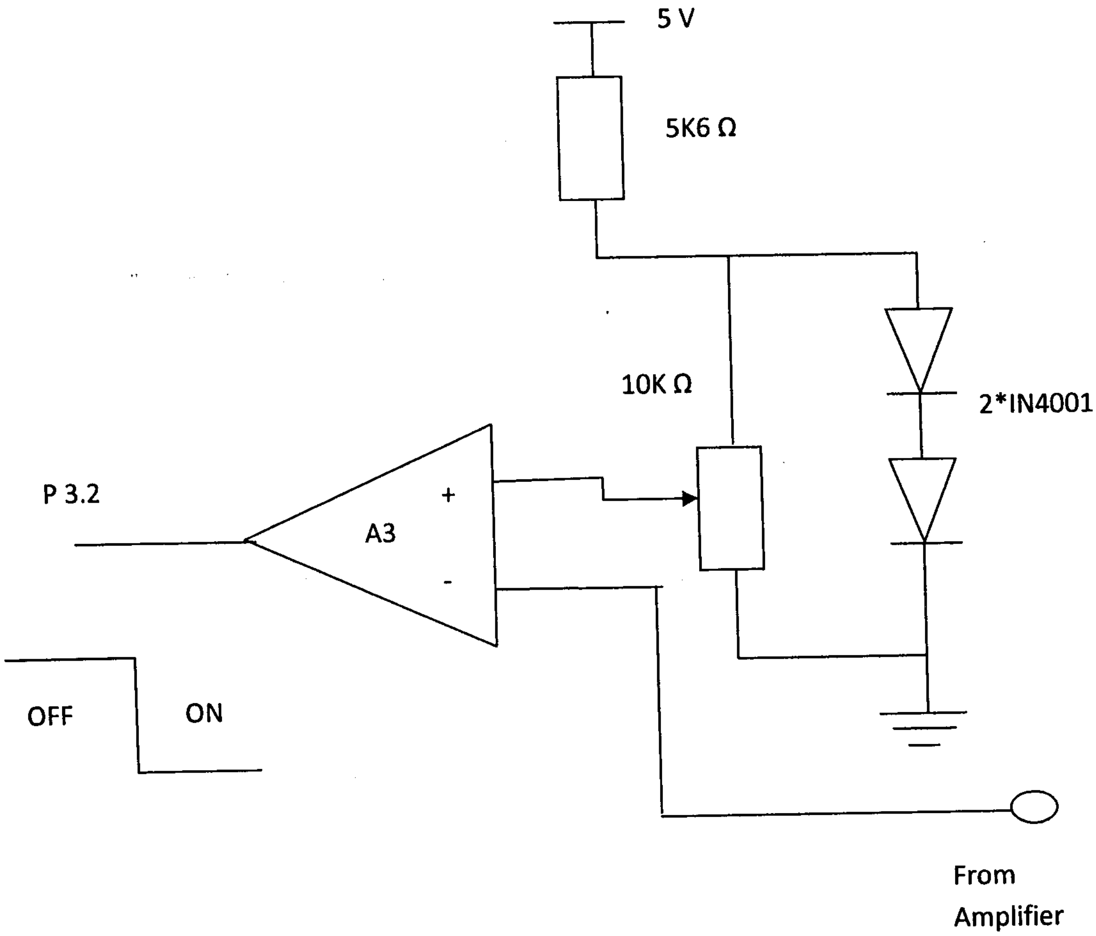

Fig 3.5
Comparator
switch

The comparator formed the interface between the analogue ultrasonic and digital computation engine. The amplified output from A1/A2 is directly related to the distance of the reflecting surface .The nearer the reflector, the greater the output voltage and vice-versa.

The software monitors a 1-to-0 transition on the port 3.0 (P3.0) input connected to the comparator to detect reception of the reflected wave front.

3.5 DISTANCE COMPUTATION CONSISTS OF THE FOLLOWING STEPS:

1).Software delay to eliminate transducer ringing and echoes from last sonic burst.

2). Gating on the 40-KHz beam and simultaneously enabling timer 1 (T1) in the 16-bit mode.

3). Waiting for signal reception by monitoring comparator output. When comparator switches low, the timer is disabled. Its value is then used to compute the distance based on:

Distance = (velocity of sound in air×TOF)/2

TOF=time of flight is extracted from timer 1 (T1) value. When the liquid level is beyond a measurable limit, the transmitted signal is not reflected back with enough amplitude to elicit detection by the comparator. In this event, the timer 1 (T1) overflows and no computation is done for the distance

Two distances were designed for software.

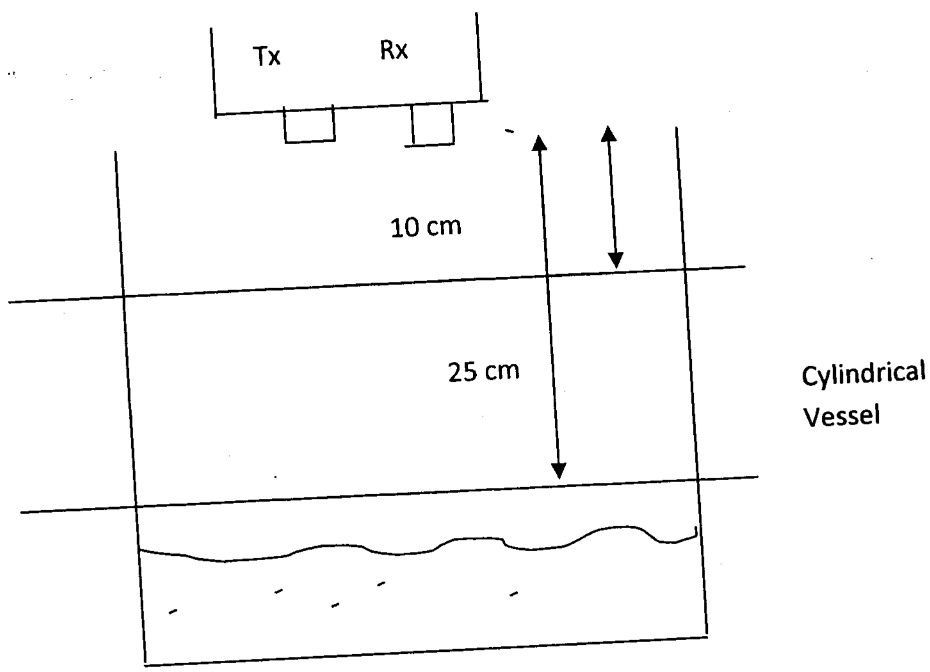

Fig 3.6 Switching distances

When the liquid level is just below the 25cm mark, liquid pumping commences via the relay switched on. Pumping continues until the liquid level relative to the transducers fall just below10cm mark. Here pumping stops .Pumping is not resumed until the level is detected greater than 25cm relative to the transducers. Measurement is computed every one second, introducing system latency designed to eliminate instability.

CHAPTER FOUR

4.0 TESTING, RESULT, DISCUSSION OF RESULT

4.1 TESTING

Firstly, each component was tested by putting the proper voltage supply across them and monitoring using a multi-meter. This was found to be satisfactory. The components were placed in their proper positions on a breadboard as placed in the circuit diagram. The bread boarded circuit was placed in a transparent plastic airtight glass rectangular case so as to avoid dampness or water from touching the circuitry as would this would lead to electric shock and probably lead to the damaging of the circuit components during testing. On one of the smaller sides of the transparent rectangular case, holes were drilled in order that terminals to supply and terminals to the pumping machine from the bread board could be passed through to an AC supply and pumping machine. The testing of ultrasonic liquid level device was carried out using a 30 cm deep cylindrical container. The ultrasonic device was mounted directly overhead by the edge of the cylindrical container. It was switched "on" from an AC supply and the power LED turned green. Water was poured manually and gradually into the cylindrical container. When the water level rose to a level just below the lower set point (25 cm from the ultrasonic device to the water level), the ultrasonic device triggered the motor to start via the turning-on of the relay. As the water level kept rising, the motor kept running. When the water level was just below 10 cm away from the ultrasonic device, the ultrasonic device turned-off the relay thereby disengaging the motor from AC supply. Note: that during testing the pumping machine was not pumping water but only running. The test was aimed at finding out two basically things namely:

1).What the system's response will be if the water level is just below 25 cm from the ultrasonic device (lower set point)?

2).What the system's response will be if the water level is just below 10 cm from the ultrasonic device (upper set point)?

Later, the circuit on the breadboard was carefully transferred to a veroboard. Each component was carefully soldered onto the veroboard using a soldering bit and soldering lead and correcting errors using a lead sucker to remove excess lead that could lead to a shunt or unwanted connection on the veroboard. The veroboarded circuit was tested and finally cased into the transparent rectangular plastic casing.(1). When the water level was just below 25 cm from the ultrasonic device, the motor turned-on automatically and kept running.(2).When the water level was just below 10 cm as water was still gradually been poured into the container, the motor turned-off automatically.

This confirms that the system was working properly.

4.2 RESULT

Five distances were selected between the upper and lower set points (inclusive of 10 cm & 25 cm) and corresponding output voltages of the high-gain amplifier was noted in the table 4.1 below.

Distance (cm)	Voltage at Output of the 2-Stage high Frequency Amplifier (Volts)
10	1.50
12	1.26
14	0.91
16	0.79
18	0.62
25	0.50

Table 4.1

Plotting distance on the x-axis and voltage on the y-axis

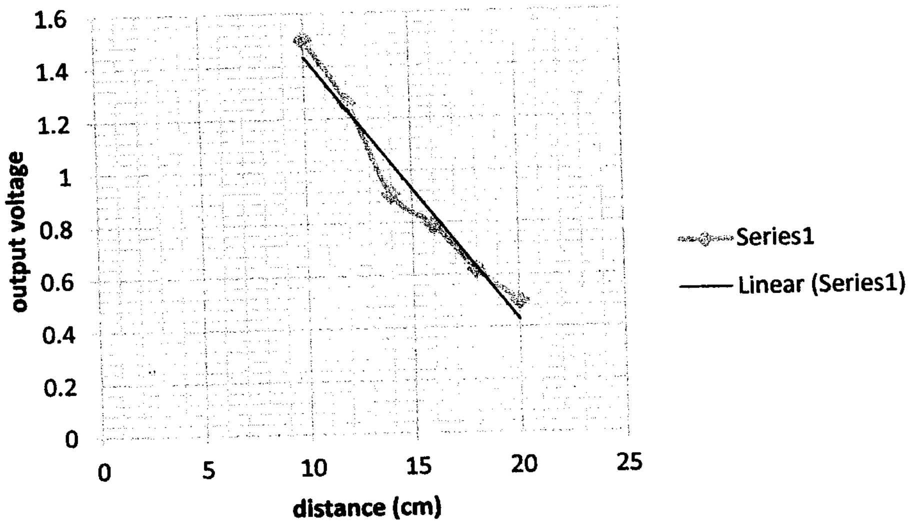

Fig. 4.1Plot of output voltage against distance

4.3 DISCUSSION OF RESULT

As the distance reduces (rise in water level), the voltage at the output of the high frequency amplifier increases .The nearer the reflection the greater the output voltage and vice-versa. This shows that the amplified output voltage from the amplifier is directly related to the distance of the reflecting surface.

CHAPTER FIVE

5.0 SUMMARY, RECOMMENDATION, CONCLUSION

5.1 SUMMARY

This project shows one of the practical applications of feedback control theory. In this case, it is the design of a system which controls the liquid level in a vessel or container. It also extends its use to the control of slurry, corrosive liquids or even granular solids like sand, cement etc. Since the sensing device has no contact with the variable it controls. This project basis its theory primarily on the principle of echo on an object or surface. In this case, reference is made to the water surface in the vessel. Incidence and reflection of the transmitted wave from its source comes into play or take place in order to ascertain the distance from the liquid's surface relative to the source's position producing the wave. Once this is done, we can determine where the liquid level is. Two set points are created namely, the upper and lower set point respectively. The upper set point indicates that the tank is full while the lower set point indicates that the liquid level is low. Also, the sensing device controls the pumping machine via the relay. During return of the transmitted signal after reflection, the signal would have lost some of its energies on entering the sensitive receiver circuitry. Before analysis, the signal will be amplified by a multistage amplifier and then will enter the comparator. The comparator forms an interface between the analogue ultrasonic and digital computing engine (micro-controller). The entire system is controlled by firmware in the micro-controller. It is the heart of the entire system.There were difficulties in construction of the project. This was due to uneasy search for some of the components used in the assembly of this project also the locating of reliable components in the market. Components such as: piezoelectric transmitter and receiver also, the pumping machine was so scarce to find.

5.2 RECOMENDATION

In situations where the vessel is really large in circumference and in depth such as storage tanks in refineries, temperature varies depth this also causes a variation in speed of sound in the surrounding environment inside the vessel. This relationship is given mathematically as:

Velocity of sound= (20) $\times\sqrt{T}$ (Where Temperature in Degree Kelvin)

In order to achieve accurate measurement of liquid-level, a sensor should be incorporated into the system. The sensor will aid in giving accurate value of the velocity of sound inside the vessel to be computed into the distance formula to give accurate distance of the liquid-level. Also, another suggestion is to incorporate a computer display and controls for the user of the system to input or adjust the lower and upper level set point he/she desires and also the sensing range must be made known to the user as he/she cannot exceed that limit.

5.3CONCLUSION

This project gives much advantage over other forms of liquid-level devices as it has no contact with the variable it is monitoring. It is an intelligent system since it is program controlled.

REFERENCES

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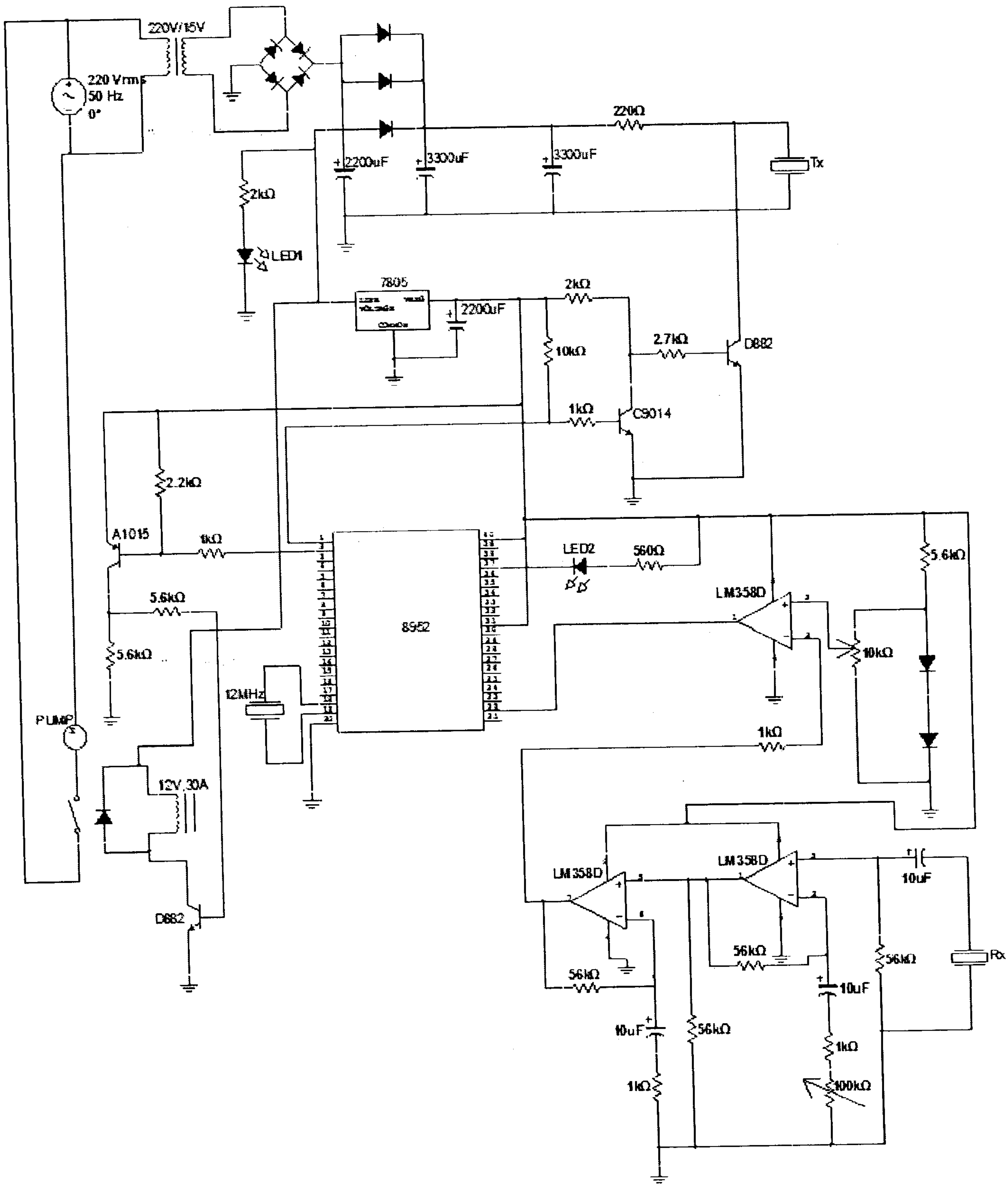
APPENDIX

APPENDIX A: COMPLETE CIRCUIT DIAGRAM



APPENDIX B: PROGRAM SOURCE CODE

```
#include<reg52.h>
#include <intrins.h>
#include<stdio.h>

//#define debug

sbitlcd_out = P0^0;
sbitlcd_clock= P0^3;
sbitlcd_load=P0^1;
sbitlcd_en=P0^2;
#define lcd_rslcd_out
//******************
sfr T2MOD=0xc9;
#define xtal 12000000UL
#define prescaler (unsigned char)12UL
#define min_level 17.0                    //centimeters
#define max_level 10.0
#define freq (unsigned int)40000UL
#define T0_reload (unsigned char)250UL
#define minute_tick  (((xtal/(T0_reload*prescaler)))*1)      //repeat every 2 seconds maybe 4
seconds
#define sample_intervalminute_tick*0.3
//#define freq_reload ((xtal)/(freq*4))
#define freq_reload (unsigned int)75UL
```

```
#define air_velöcity 347.0

code unsigned char lcd_table[]={0x38,0x38,0x38,0x0c,0x01,0x06,0x00};

unsigned char time_ok,overflow,update;

sbitfreq_out=P1^0;
sbitfreq_enable=P1^4;
sbitpump_dx=P1^3;
sbitrx_in=P3^2;
sbit test=P2^0;
sbitmeasure_led=P1^5;

#define time_base (unsigned char)(1000UL/T0_reload)

voidinit_dist(void);

voiddelay_ms(unsigned intt_delay)
{
        t_delay*=time_base;
        while(t_delay)
        {
                overflow=0;
                while(!overflow);       //wait for 250 machine clock tickes here
                t_delay--;
        }
}
```

```
//*******************
//*******************
void serialize(unsigned char c,unsigned char reg_select)
{
        unsigned char z;

        lcd_load=0;
        lcd_clock=0;
        lcd_en=0;

        for(z=0;z<8;z++)
        {
                lcd_out=!(c&0x80);
                lcd_clock=1;
                lcd_clock=0;
                c<<=1;
        }
        lcd_rs=reg_select;
        lcd_load=1;
        lcd_load=0;
        lcd_en=1;
        lcd_en=0;
}
//*******************
//*******************
voidlcd_data(unsigned char c)
{
```

```
        serialize(c,1);
        delay_ms(2);
}
//****************
//****************
voidlcd_cmd(unsigned char c)
{
        serialize(c,0);
        delay_ms(2);
}
//****************
//****************
voidlcd_clear(void)
{
        lcd_cmd(0x01);
}
//****************
//****************
voidprint_string(unsigned char *s)
{
        while(*s)lcd_data(*s++);
}
//*********************8
//*********************
voidlcd(unsigned char code *ptr)
{
        print_string(ptr);
```

```
}
//**************************
//**************************
voidinit_lcd(void)
{
        unsigned char code *s=lcd_table;

        while(*s)
        {
                lcd_cmd(*s++);
                delay_ms(100);
        }
}
//*******************
//*******************
voidshow_loading(void)
{
        lcd_clear();
        lcd("loading...");
        delay_ms(2000);
}
//************************
//***********************
voidshow_ready(void)
{
        lcd_clear();
        lcd("ready...");
```

```
}
//********************8
//********************
void TF0_isr(void) interrupt 1
{
        static unsigned int minute=sample_interval;


        overflow=1;
        if(!(--minute))
        {
                minute=sample_interval;
                time_ok=1;
        }
}
//************************
//*************************
voidpump_off(void)
{
        pump_dx=1;
}
//*********************8
//********************
voidpump_on(void)
{
        pump_dx=0;
}
//**********************8
```

```
//**********************
voidconfig_irq(void)
{
	ET0=1;
}
//*********************8
//***********************
voidconfig_timer(void)
{
	TMOD=0x12;
	TCON=0x00;
	TH0=-T0_reload;
	TL0=-T0_reload;
	TH1=0;
	TL1=0;
	T2MOD=0x02;
	T2CON=0x00;
	RCAP2H=-freq_reload>>8;
	RCAP2L=-freq_reload;
	TH2=RCAP2H;
	TL2=RCAP2L;
	TR2=1;
	TR0=1;
}
//************************
//************************
voidsys_init(void)
```

```
{
    EA=0;
    config_timer();
    config_irq();
    EA=1;
    pump_off();
    #ifdef debug
        init_lcd();
        show_loading();
        show_ready();
    #endif
    init_dist();
}
//*************************
//*************************
void reset_T1(void)
{
    freq_enable=1;        //gate off sonic output
    TR1=0;
    TH1=0;
    TL1=0;
    TF1=0;
    rx_in=1;
}
//***********************8
//***********************
floatcheck_level(void)
```

```
{
        floatdist;

        while(!rx_in);
        measure_led=0;
        reset_T1();
        freq_enable=0;
        TR1=1;
        while((!TF1)&&(rx_in));
        TR1=0;
        freq_enable=1;
        measure_led=1;
        if(TF1)
        {
                pump_on();
                return 999.9;
        }
        dist=(air_velocity*(((TH1*256)+TL1)*0.000001)*0.5)*100.0;     //returns dist in
 meters here
        //if(dist>=min_level)pump_on();
        //if(dist<=max_level)pump_off();
        returndist;
 }
 //**************************
 //**************************
 voidshow_level(float dist)
 {
```

```
unsigned char buff[10];

lcd_clear();
if(dist>100.0)lcd("OOR...");
else {
            sprintf(buff,"%.2f",dist);
            print_string(buff);
      }
//delay_ms(3000);
}
//*******************
//*******************
floataverage_dist(void)
{
   #define dist_sample_size (unsigned char)4UL

   unsigned char x;
   static float buff[dist_sample_size];
   static unsigned char cnt=0;
   floatdist_avg=0.0;

   for(x=0;x<dist_sample_size;x++)buff[x]=buff[x+1];
   buff[dist_sample_size-1]=check_level();
   if(++cnt>=dist_sample_size)
   {
      cnt=0;
      for(x=0;x<dist_sample_size;x++)dist_avg+=buff[x];
```

```
                dist_avg/=dist_sample_size;
                if(dist_avg>=min_level)pump_on();
                if(dist_avg<=max_level)pump_off();
                update=1;
        }
        returndist_avg;
}
//***************************
//****
voidinit_dist(void)
{
        unsigned char c;
        float t;

        for(c=0;c<dist_sample_size;c++)t=average_dist();
        //return t;
}
//**********************
//**********************
void main(void)
{
        floatdist;

        sys_init();
        while(1)
        {
                while(!time_ok);
```