MAPPING OF TERRAIN USING ULTRASONIC RADAR

By

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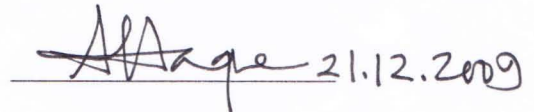(B.Sc. in EEE)

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Abstract

It seemed very attractive to us that the study and construction of hardware will be a good choice for us as an undergraduate project to complete our graduation. All of us have some interest about the RF and distance measuring technology. Although this technology is not new, we expected we will find it very interesting if we study and work on it. Moreover the construction of Radar will be a highlight and it will be an achievement if we can complete this successfully.

Distance measuring devices for terrain which use ultrasonic signals to determine the distance to obstacles in the surroundings are known as ultrasonic radar. It has various types of application.

In this paper we mainly focused on the construction procedure of an ultrasonic radar system. At the very beginning of the paper we tried to give an overview about the operation of the radar. Then we discussed about the highlighted and the important components of the system. Then we tried to go through different steps of construction of ultrasonic radar. We discussed the limitation and errors that we found in our constructed system too. We also mentioned some application of this device.

We hope our work will carry some meanings to all. It already means a lot to us as we tried hard to complete this job successfully.

Acknowledgements

In our project work we are grateful to those who contributed us with their valuable time and efforts.

At the very beginning we will mention the name of our project supervisor our most respectable teacher Dr. Ishfaqur Raza. We feel lucky and honored to get the chance of completion our project under the supervision of him. He provided us the information regarding different aspects of our project. He observed our development of the hardware and its implementation too. He has helped us by providing the indications where there need to be some adjustment. We are grateful to him also for reading and checking this thesis during time when his attention is greatly demanded by so many other people.

Special thanks to Dr. Anisul Haque, Chairperson EEE, East West University for his guidelines, support and care.

Then we will mention the names of Mr. Pinak Pani Mondal and Mr. Mohammad Mehedi Al Emran Hasan. They acted very helpfully during the hardware implementation of our project work. Mr. Pinak Pani Mondal is the person who helped a lot to develop the Radar Circuit that we constructed. Mr. Mohammad Mehedi Al Emran Hasan was also very helpful by providing us necessary feedback and response about the operating code of microcontroller.

Here it should be mentioned that all of the group members were helpful to each other.

Finally we would like to remember all of our friends and mates who encouraged us, provided valuable opinions and information regarding our project work.

We will name our parents for with a great respect. They provided financial and emotional support during our project work, without them, completion of this work would not be possible.

Authorization page

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1. Introduction

1.1. Thesis Motivation

This paper is a guided and written form of our project work on "Mapping of terrain using Ultrasonic Radar". We the member of our group was very intended to perform such project work in which we will be able to develop a device as well as we can write an informative and useful paper. The diversified application of the Radar attracted us to develop Radar. One of the main motivations is that we want to place Radar in the front side of the car. We found that placing of simple Radar in the vehicle will be helpful in case of security of the vehicle on the streets [1]. As it can warn the driver about the short distance between vehicles or it can be used in more advanced application like controlling of vehicle in emergency situations.

We also have our personal interests to develop electronic devices. The development of the Radar is an outcome of our interest. By completion of the construction of the Radar we can apply our theoretical knowledge in practical field.

1.2. Thesis Objective

In this thesis we tried to elaborate and focus the procedure of constructing ultrasonic Radar. This paper will help the reader to have a clear idea about the components of the Radar. We also mentioned detailed description of the important and major components. Necessary diagrams were provided to make the components more familiar to the readers. We also tried to mention some alternative components too. We described the procedure to develop Radar in details. We covered the preparation of the PCB, arrangements of the parts, interaction among different PCBs. As we developed this device as a system that can be used in our daily life, we tried to make the paper very friendly to the readers so that a person can initiate to construct Radar with enough ease.

Beyond the construction we also included some implementation of the ultrasonic Radar too. As the device we developed still has some drawbacks and faults, we also discussed about some amendments and future work which can make the Radar more useful and effective.

1.3. Organization of the Thesis:

For the better formation and clear understanding this thesis, we have written different chapters on different segments.

The first part of the second chapter has some history about the Radar. This chapter also contains the Radar equation. Here we mentioned the meaning of different notation that is used in the equation. The very important part in the second chapter is the working principle of the ultrasonic Radar. We described it step by step. We included two flowcharts to make the operation more understandable to the reader.

The third chapter is the main part of our paper. Here we described the process of development of the device. The first part of this chapter includes the descriptions of the different components of the Radar. We tried to make the description informative enough. On next part we moved to the construction of the complete Radar construction on PCB. We also described the PCBs briefly.

The next chapter shows the data analysis and solution which is the output of our work. We showed our result on a display in this part.

We included some implementations and utilities of the ultra sonic Radar in chapter five.

Finally we talked about some drawbacks and future works in this respect.

2. Theory

2.1. History:

There are several inventors, engineers and scientist who attribute to develop the Radar. Nikola Tesla, in August 1917, first established principles regarding frequency and power level for the first primitive radar units. Before the Second World War, developments by the Americans, the Germans, the French, the Soviets, and the British led to the modern version of the radar.

2.2. Radar – a brief history

Radar is often used to detect objects. In a commercial context it is widely used in safety applications, such as in air traffic control or speed cameras[1]. Having a modern and reliable radar system plays a significant part in communication and technological improvement [2]. Radars are designed to detect, locate and track targets. Most targets can be detected as a matter of time. When the target gets nearer to the radar position, the echoes become stronger, making it easier to be detected. The key objective of this thesis is to study ultrasonic radar and to develop radar that will be implemented as an outcome of our work. This paper focuses on techniques for tracking objects in a short range distance.

The term "Ultrasonic" relates with some aspects as below-

-time of flight distance measurement

-longer range than IR (infra-red)

-affected by wind

-affected by hardness of object

2.3. Radar Equation:

There are some equations which expresses the different components of the radar. The amount of power P_r returning to the receiving antenna is one of the deterministic components of the radar principle.

The amount of power P_r returning to the receiving antenna is given by the radar equation:

$$P_r = \frac{P_t G_t A_r \sigma F^4}{(4\pi)^2 R_t^2 R_r^2}$$

Where

P_t = transmitter power

G_t = gain of the transmitting antenna

A_r = effective aperture (area) of the receiving antenna

σ = radar cross section, or scattering coefficient, of the target

F = pattern propagation factor

R_t = distance from the transmitter to the target

R_r = distance from the target to the receiver.

In the common case where the transmitter and the receiver are at the same location, $R_t = R_r$ and the term $R_t^2 R_r^2$ can be replaced by R^4, where R is the range. This yield:

$$P_r = \frac{P_t G_t A_r \sigma F^4}{(4\pi)^2 R^4}.$$

Here this equation shows the received power that decrease as the fourth power of the range, which means that the reflected power from the distance is very small.

In this equation F=1 is a simplification for vacuum without interference. The propagation factor accounts for the effects of multi path and shadowing and depends on the details of the environment.

2.4. Working Principle:

The basic principal of a primary radar is easy to understand but the theory is quite complex. We have to understand the theory so that we can determine and operate the radar system properly. For establishing and maintaining a primary radar system involve a wide range of disciplines like building works, heavy mechanical and electrical engineering, high power microwave engineering, and advanced high speed signal and data processing techniques[3]. Here also some natural laws are important [3].

Radar measurement of range, or distance, is made possible because of the properties of radiated electromagnetic energy.

The electromagnetic waves are reflected if they meet an electrically leading surface. If these reflected waves are received again at the place of their origin, then that means an obstacle is in the propagation direction.

Electromagnetic energy travels through air at a constant speed, at approximately the speed of light,

300,000 kilometers per second or

186,000 statute miles per second or

162,000 nautical miles per second.

This constant speed allows the determination of the distance between the reflecting objects (airplanes, ships or cars) and the radar site by measuring the running time of the transmitted pulses.

This energy normally travels through space in a straight line, and will vary only slightly because of atmospheric and weather conditions. By using of special radar antennas this energy can be focused into a desired direction. Thus the direction of the reflecting objects can be measured.

The process can be elaborated as following diagram:

Transmission pulse   Reflected wave   Transmission pulse

— Detector start   — Capture end
                          — Convert capture data
— Get display revision data(A/D)   to distance
— Error detection prevention timer   — LED display data set

— Reflected wave reception check
— Detector stop
— Capture start
— 40KHz sound wave transmission(0.5msec)
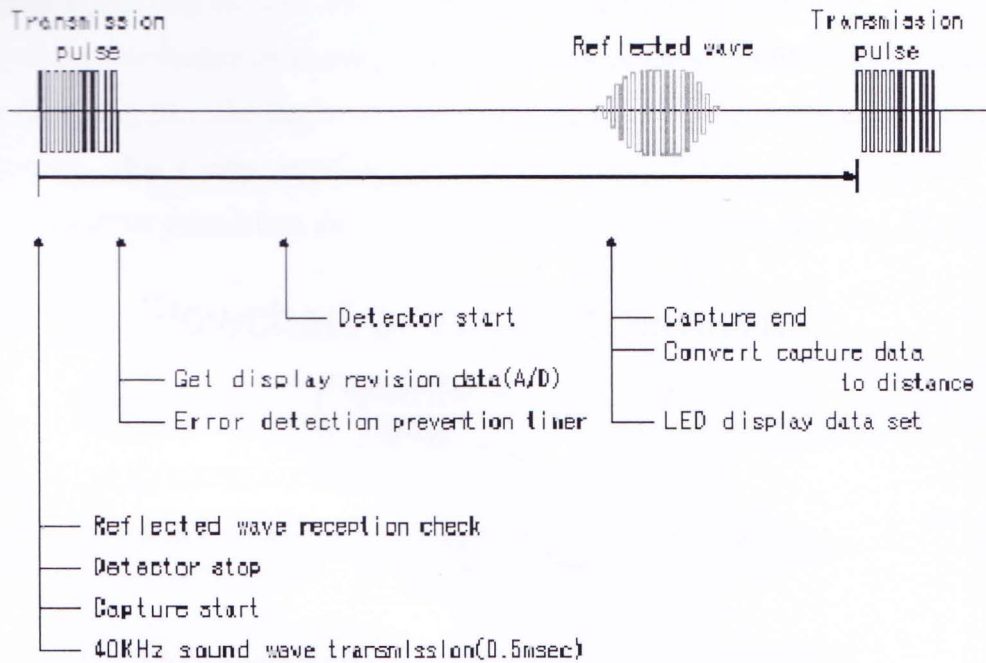
Figure 1: Graphical representation of conversion of signal

These principles can basically be implemented in a radar system, and allow the determination of the distance, the direction and the height of the reflecting object [3].

Flowchart of the total system:

Transmit	Reflect	Receive
Amplification	Rectification	µc Input
Processing in µc		Output to LCD
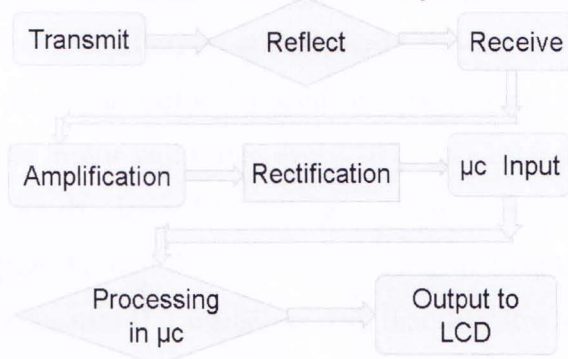
Figure 2: Flowchart of the total system

What happens is that we transmit the signal through the transmitter and then it will hit an object then reflect back. The receiver will receive the reflected signal. As the reflected signal will

not be the original signal that we sent and the strength of the signal is very poor, so we have to amplify the signal for our further processing [1]. As we used micro-controller for the calculation of the distance the signal traveled that's why we need a dc value of the signal to be the input of the micro controller. That's why rectification is needed. Then the feed back into the Micro controller input for further calculation and then the desired value is shown into the LCD display.

Flowchart of the µc operation:
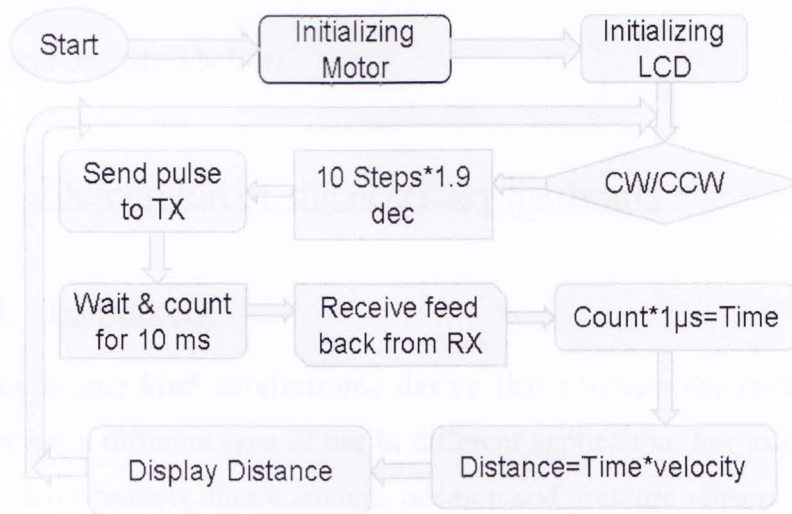
Figure 3: Flowchart of the operation in the micro controller

At first the micro-controller will initial itself. As our objective is to rotate the motor and transmit the signal every 10 degree after, so at first the micro-controller will initial the motor. And it will initial the LCD display as our main result will be showed in the LCD display. Now for the clockwise direction the motor will rotate every 10 degree after and here the motor rotate 1.9 degree in every step. So for the desired 10 degree rotation the motor should go for 10 steps. Then it will transmit the signal through the transmitter. After transmitting the signal the micro-controller will wait for 10ms because if it waits less than that then it won't be able to receive the signal and process it. Then the micro-controller will multiply the counting with the time to get the actual time. This multiplied with the velocity to get the distance and it's been showed to the display. Same process is applicable for the counter clockwise direction.

3. development of the Hardware

It is the main part of our project work to develop Radar that will continue our study on the various aspects of the Ultrasonic Radar. For this purpose we had to meet the necessary components of building Radar. The components will be highlighted and discussed in this chapter. Later we will discuss on necessary arrangements and organization of respective components.

The parts are listed and described below:

3.1. Description of the necessary hardware:

3.1.1. Transducers:

A transducer is one kind of electronic device that converts the energy one form to another. Transducer has a different type of use in different application. For example we can say about microphones, loudspeakers, thermometers, position and pressure sensors, and antenna [4]. In any transducer, Efficiency is a very important consideration. We can define the transducer in a ratio of power output of the desired power input. In mathematically, if P represents the total power input and Q represents the power output in the desired form, then the total efficiency E, as a ratio between 0 and 1, is given by:

$E = Q/P$

If E represents the efficiency as a percentage, then Percentage of, $E = 100*Q/P$

No transducer is 100 percent efficient. In the conversion process, always some power will lose. Normally this process is shows just because of heat. Some well design antenna can perform maximum efficiency or even it can be 100 percent. A well designed antenna supplied with 100 watts of radio frequency radiates power approximately 80 or 90 watts in the form of an electromagnetic field. In this time a few watts are loose as heat as antenna conductors. For example we can say about a 100 watts bulb that radiates only a few watts as visible light. A small

quantity of power radiates as the ultraviolet spectrum and maximum power loose as heat [5]. There are different kinds of transducers. They are as follows:

Antenna - converts electromagnetic waves into electric current and vice versa.

Cathode ray tube (CRT) - converts electrical signals into visual form

Fluorescent lamp, light bulb - converts electrical power into visible light

Magnetic cartridge - converts motion into electrical form

Pick up (music technology) - converts motion into electrical form

Photo detector or Photo resistor (LDR) - converts changes in light levels into resistance changes

Tape head - converts changing magnetic fields into electrical form

Hall Effect sensor - converts a magnetic field level into electrical form only.

40 kHz air transducer is designed for a variety of ultrasonic sensor products [5]. Its narrow beam makes it a good choice for demanding, longer-range proximity and position and level sensor applications. It can be used as a transmitter, receiver or both as needed. The seamless Kynar housing makes it perfect for applications in harsh environments. The housing comes with an M20 x 1.5threaded mount.

Figure 4: Physical view of Transducers

We showed a cross-sectional view of the sonar transducer below. The transducer that we used is of 16.2mm diameter [5]. There is a screen which is covering the resonator. From the base plate the screen is about 12mm separated.
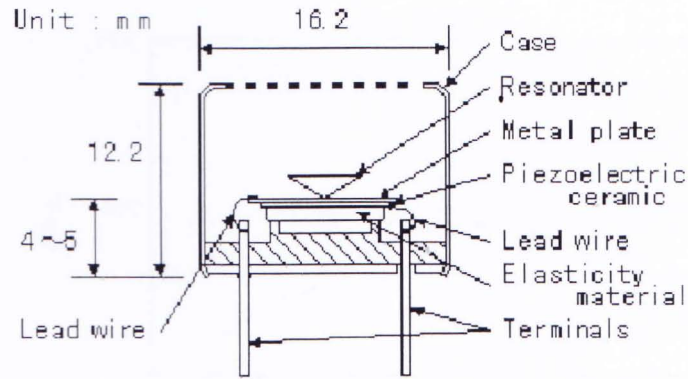
Figure 5: Cross-sectional view of transducer

Figure 6: radius of the transducer that we used

We designed a transducer model by using the ADS. We performed some simulations to gather some idea about the performance pattern of the transducer. Here we saw the variation of frequency response with open circuit sensitivity. The simulated graphical representation is stated below.
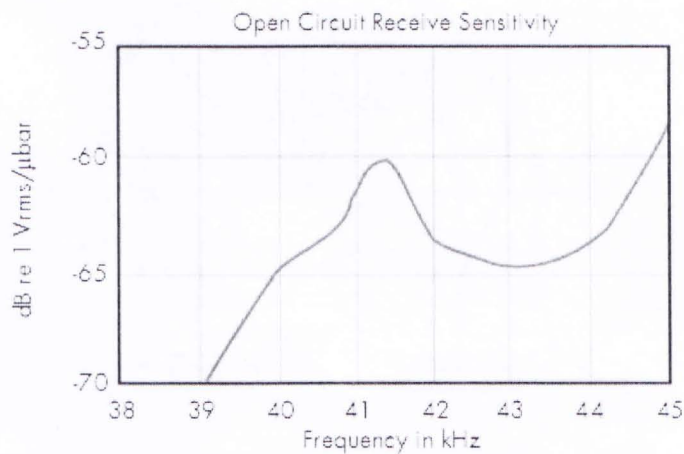
Figure 7: Open circuit receive sensitivity

We also saw the variation of frequency response with variable impedances. The simulated graphical representation is stated below.
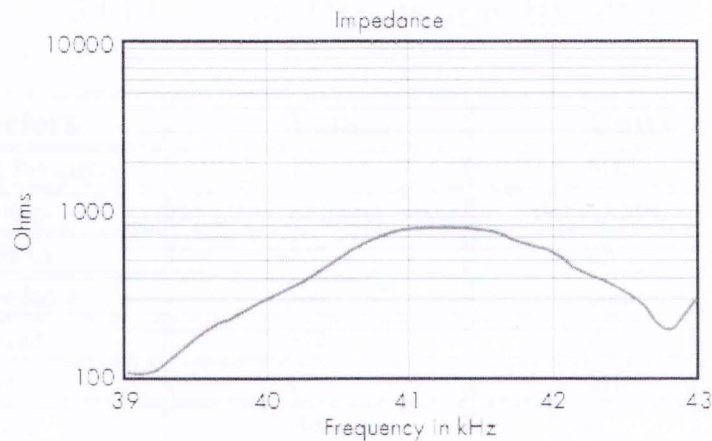
Figure 8: Frequency response of the transducer in different impedance

Here we observed another very important feature of the transducer. This is the directional response of the transducer. Here a Receiver and a Transmitter were placed according to the following arrangement and the different response level of the transducer was seen in different position and directions [6].
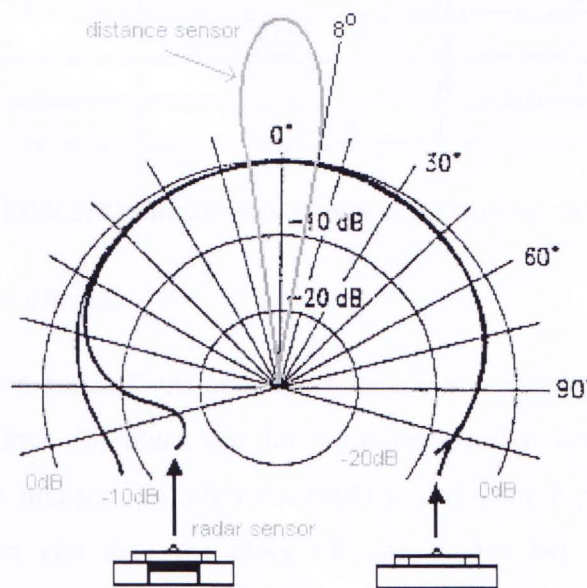
Figure 9: Directional response (Frequency response in different angles)

We placed here two tables to inform the specifications of the transducers that we used. First table is for the Transmitter specification while second one is for Receiver specification.

3.1.1.1   Electrical Specifications HE240STX

Parameters	Values	Units
Operating Frequency	40	kHz
Input Voltage	20 (max)	Volts (RMS)
Output (SPL)	120	db
Input Impedance	300	ohm
Beam Spread	±12	degrees
Bandwidth	1	kHz
Temperature	-40 to 100	°C

Table 1: Electrical Specifications of the Transmitter that we used

3.1.1.2   Electrical Specifications HE240SRX

Parameters	Values	Unit
Operating Frequency	40	kHz
Receive (Sensitivity)	-58	dB/V/Ubar
Output Impedance	300	ohm
Reception Angle	±12	degrees
Bandwidth	1	kHz
Temperature	-40 to 100	°C

Table 2: Electrical Specifications of the Receiver that we used

3.1.2. Microcontroller:

Microcontrollers are "embedded" inside some other device so that they can control the features or actions of the product. Another name for a microcontroller, therefore, is "embedded controller". One of the big advantages of a microcontroller is that a small program that we write and execute on the controller can take the place of many gates [4]. Microcontrollers are dedicated to one task and run one specific program. A microcontroller has a dedicated input device and often (but not always) has a small LED or LCD display for output. A microcontroller also takes input from the device it is controlling and controls the device by sending signals to different components in the device.

Here we used a micro controller from Atmel. It is a 40 Pin microcontroller with FLASH (reprogrammable) program memory [7]. The model is AT89C51. There are various models of micro controllers available which can perform same operation as this one. The design can use any µC of this family.

Here we have a physical view of the micro controller:
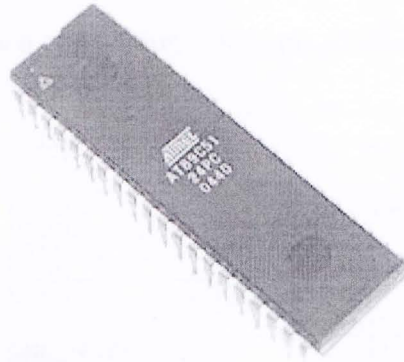
Figure 10: The micro controller

Internal view or the PIN diagram of the microprocessor is shown below.

Figure 11: PIN diagram of the micro controller

3.1.3. LCD Display:

We have used a 20x2 LCD device. Here 20x2 means, the display is capable to screen two lines and each line contains 20 characters each [1]. The display has 16 pins for its necessary connections. We are showing a module of a LCD that we used in our system.
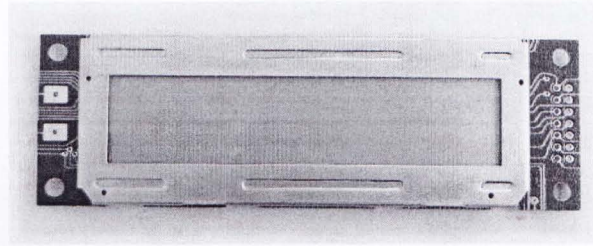
Figure 12: The LCD

We also want to show a connection schematic of the LCD that we used.
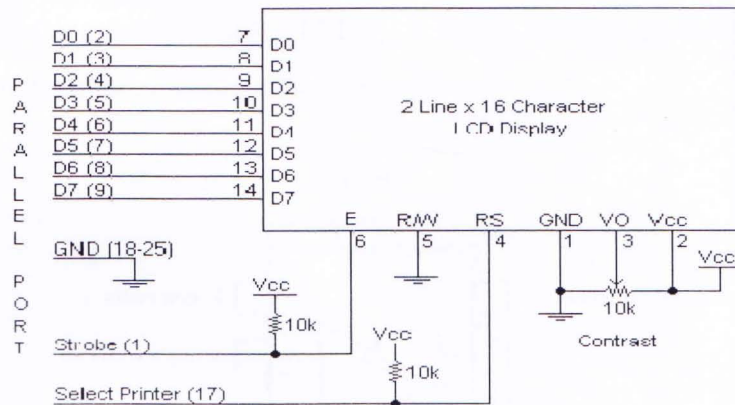
Figure 13: Connection schematic of the LCD

3.1.4. Operational Amplifiers:

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709 [8]. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications. The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations. The LM741C is identical to the LM741/LM741A except that the LM741C has their performance guaranteed over a 0°C to +70°C temperature range, instead of -55°C to +125°C [8].

The following figure shows the physical view of the LM741 amplifier.
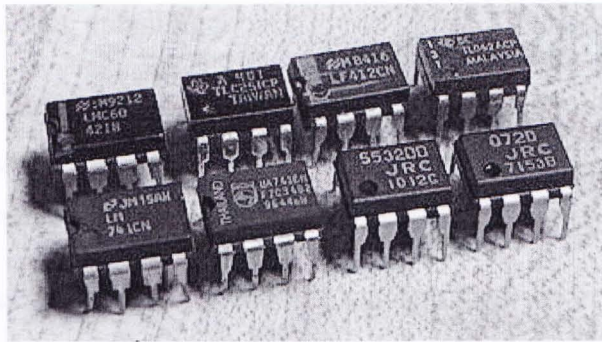
Figure 14: Operational Amplifier

The figure below is the schematic of the LM741. It shows the internal view of the LM741 operational amplifier with the internal connection inside this.

741

8-pin DIL (Dual In Line)

offset null 1	8 not connected
inverting input 2	7 + V
non-inverting input 3	6 output
– V 4	5 offset null

(viewed from above)
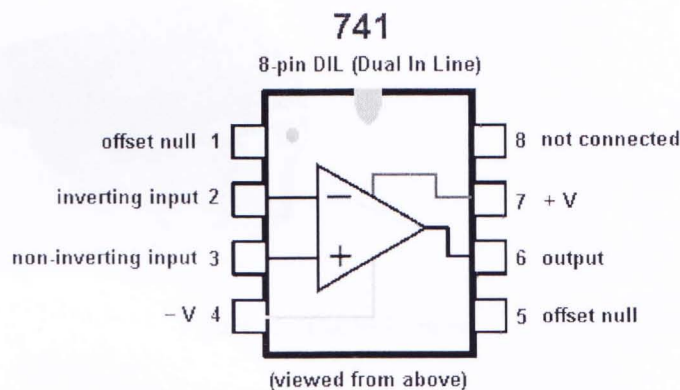
Figure 15: Schematic of the operational amplifier

3.1.5. 555 Timers:

The 555 Timer IC is an integrated circuit (chip) implementing a variety of timer and multivibrator applications. The IC was designed by Hans R. Camenzind in 1970 and brought to market in 1971 by Signetics (later acquired by Philips). The original name was the SE555 (metal can)/NE555 (plastic DIP) and the part was described as "The IC Time Machine. It has been claimed that the 555 gets its name from the three 5-kohm resistors used in typical early implementations, but Hanz Camenzind has stated that the number was arbitrary. The part is still in wide use, thanks to its ease of use, low price and good stability. As of 2003, it is estimated that 1 billion units are manufactured every year.

Depending on the manufacturer, the standard 555 package includes over 20 transistors, 2 diodes and 15 resistors on a silicon chip installed in an 8-pin mini dual-in-line package (DIP-8).

The 555 has three operating modes:

Monostable mode: in this mode, the 555 functions as a "one-shot". Applications include timers, missing pulse detection, bounce free switches, touch switches, frequency divider, capacitance measurement, pulse-width modulation (PWM) etc[5]

Astable - free running mode: the 555 can operate as an oscillator. Uses include LED and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, pulse position modulation, etc.

Bistable mode or Schmitt trigger: the 555 can operate as a flip-flop, if the DIS pin is not connected and no capacitor is used. Uses include bounce free latched switches, etc.
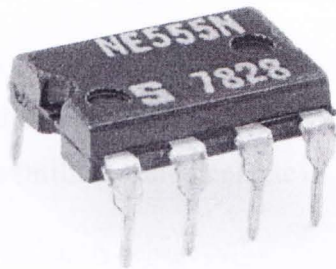
Figure 16: The 555 Timer

Now the following figure is the schematic of the 555 Timer with expressing the internal connections.
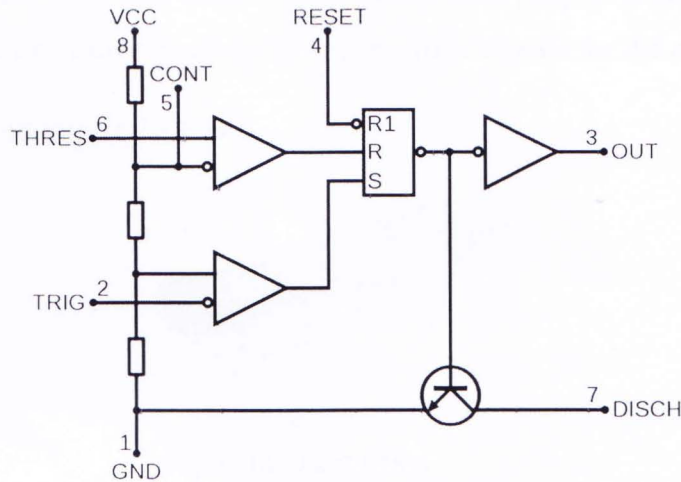
Figure 17: Schematic view of the 555 Timer

Specifications:

These specifications apply to the NE555. Other 555 timers can have better specifications depending on the grade (military, medical, etc).

Supply voltage (V_{CC})	4.5 to 15 V
Supply current (V_{CC} = +5 V)	3 to 6 mA
Supply current (V_{CC} = +15 V)	10 to 15 mA
Output current (maximum)	200 mA
Power dissipation	600 mW
Operating temperature	0 to 70 °C

Table 3: Specifications of 555 Timer.

We needed to use many other components to construct the radar circuit and to make it work functionally.

3.1.6 L297 Driver:

We have used two motor drivers for the operation of our stepper motor. These driver components are specially designed and can be efficiently used for the operation of stepper motor [1].

L297 is one of them. It's a 20 pin driver with 10 pins each side. It integrates all the control circuitry required to control bipolar or unipolar stepper motors [9]. Used with a dual

bridge driver such as L298. We also used a L298 driver here [10]. It receives control signals from the micro controller and provides all the necessary drive signals for the power stage.

Here we show a module of the L297.
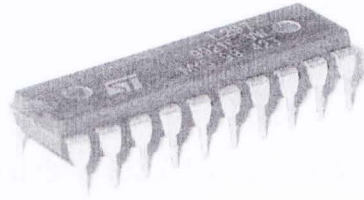
Figure 18: L297 Driver

Let see the schematic of a L297 driver. This diagram also shows different names of the pins.
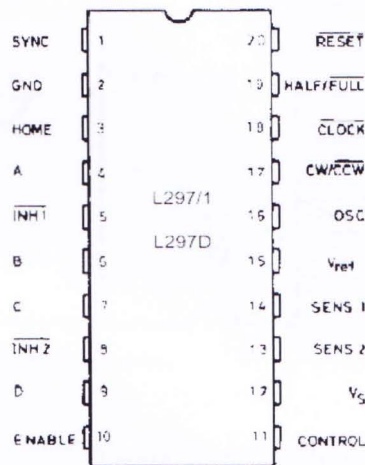
Figure 19: Schematic of L297 driver

3.1.7 L298 Driver:

It's a The L298 is a motor driver IC that is usable from 6 to 50V, at up to 4A total output current. The L298 Motor Driver makes the procedure convenient to use [10]. It is a high voltage, high current dual full-bridge driver. Its operations complete the rotation of the stepper motor successfully.

Figure 20: L298 Driver

Let have a glance on the schematic on this [10]. It has heat sink in its body.
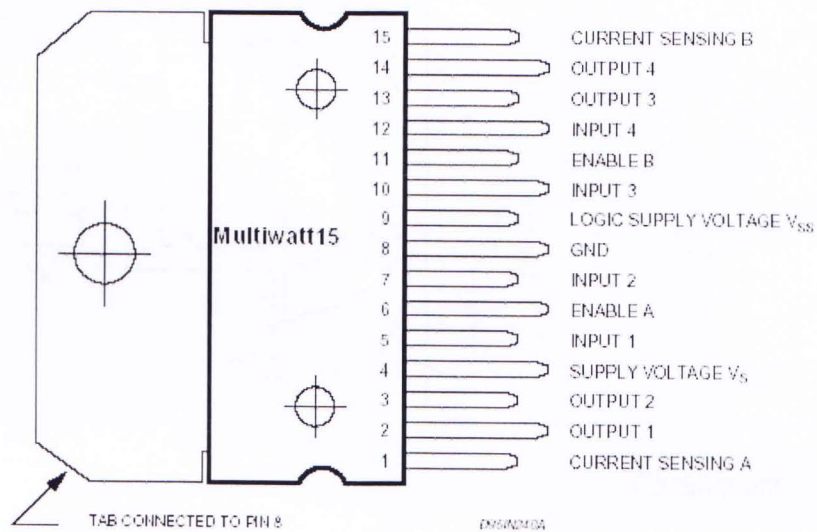
Figure 21: Schematic of L298 Driver

3.2. Construction:

3.2.1. The schematics:

The circuit was developed by the ordered arrangements of the components that we described above. The total radar circuit consists of several vital parts. For the description and to construct and to understand the whole system convincingly we performed this partition. Let's discuss the parts in turns.

Schematic 1:
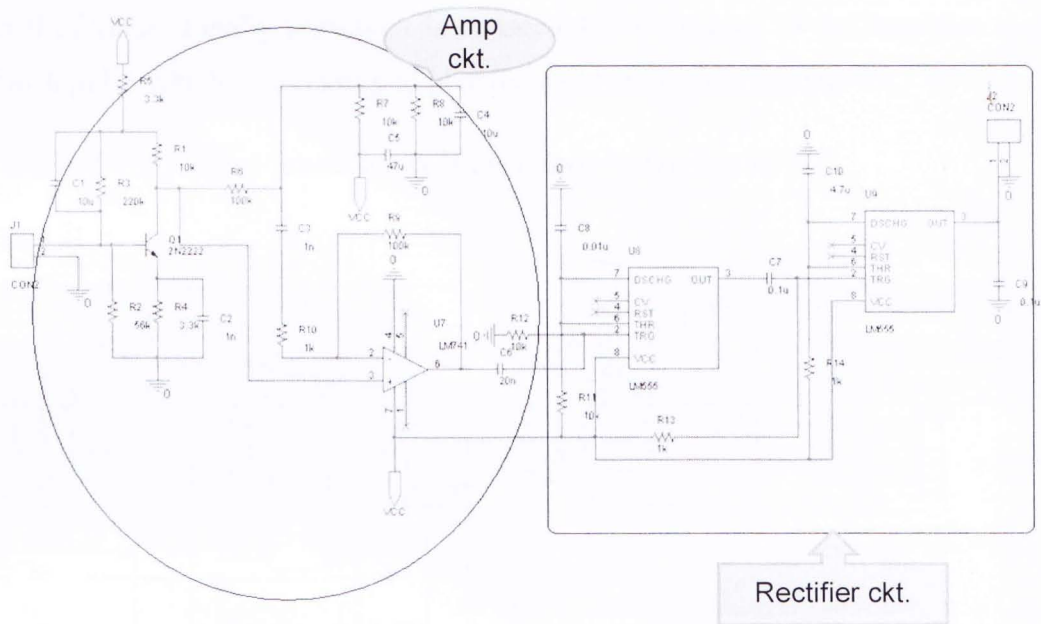
Figure 22: Schematic of the Transducer and Amplifier Circuit

The Radar circuit is the part where the transmission and the receiving process be performed. It has already been stated the circuit consists of an ultrasonic transmitter and a receiver both of which work at the same frequency [1]. They use ultrasonic transducers as output and input devices respectively and their frequency of operation is determined by the particular devices in use.

This is the part where the received signal is being amplified and rectified or trimmed suitably to use it as the input of the micro controller.

Let us start from the transmission stage of the signal to achieve a reflection from the terrain ahead of the Radar. Here a trimmer (LM555) is connected with the transmitter. The transmitter end will propagate a clock pulse which can be also stated as a square wave pulse. This signal is used the get the desired reflection at the receiver end.

The receiver is connected with an amplifier through a BJT. The collector of the BJT is meeting the amplifier. The reflected signal which is the resultant of the generated signal of transmitter will be collected by the receiver. The signal that will be received will be an irregular pulse, though we transmitted a square pulse to be reflected [3]. The reason of this event is, the reflected signal is a natural signal and all types of natural signals are irregular and analogue signal. The value of the reflected signal is very low. So an amplifier is used to meet our necessary level of value. Finally a trimmer is connected at the output of the amplifier to get a digital or a clock pulse which is necessary to give the input at the micro controller.

The design for the above functionality is expressed by the Figure 22.

Schematic 2:

Motor
control ckt

µc & LCD
ckt
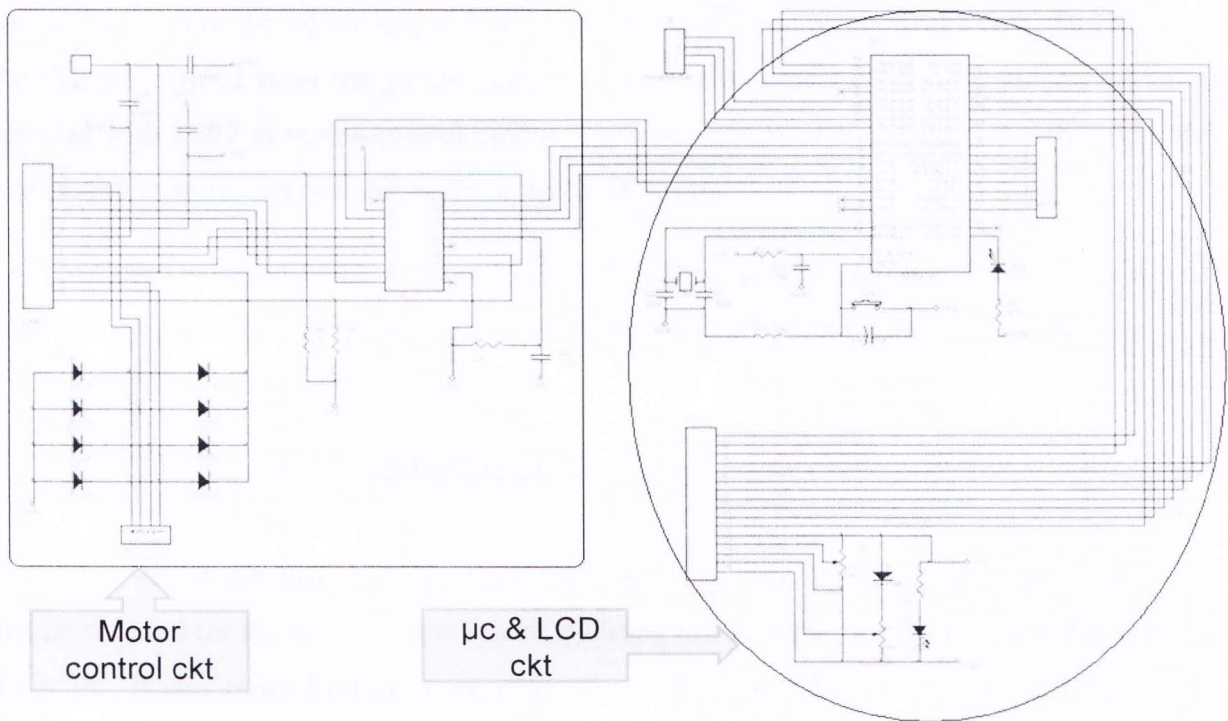
Figure 23: Schematic of the micro controller, LCD and the motor control circuit

Now let's have a look on the schematic of the micro controller, LCD and the motor control circuit.

The motor control circuit is the portion by which we control the direction of the rotation of the stepper motor [4]. Here we used a stepper motor to rotate the transducers in clock wise and in counter clock wise direction. Two ICs and eight diodes are the main components that used in

this part. We use a switch the motor control circuit to change the direction of the rotation of the motor.

This Stepper motor controller uses the L297 and L298N driver combination; it can be used as stand alone or controlled by microcontroller. It is designed to accept step pulses. By using this motor controller the motor current can be commanded to shut entirely off. The motor is getting input through the eight diodes that we mentioned above. The diodes are connected with the output ports of the L298 Motor Driver. Here the micro controller is sending the command to the L297 motor controller. The output of L297 is sending the signal to the L298 as its input.

Microcontroller is the heart of our system. It is powered by an external voltage source. Here we can control the supply to the micro controller. A voltage regulator (LM78M05) is used as the voltage controller of the micro controller. The Micro controller works with the modified input that is obtained from the gained reflected signal of the receiver. The Micro controller is connected with L297 at motor control circuit. The rest outputs of the micro controller perform the operation to show our desired result on the LCD display.

We used a 16 pin LCD display. 2 Pins are used for power supply to the LCD. Rest pins are used as the input interface with the microcontroller and different mode selection purpose.

3.2.2. Construction of the PCB:

First of all we designed the layout of the PCB with PCB designing software. The software we used for this purpose was Protel. By using this software we made a printable copy of the circuit. It was printed on the back page of a sticker paper by using a printer. We used a single layer PCB with a thin copper layer on it. Now the printed sticker paper was placed on the laminated board. Heat was applied make an image of the circuit on the PCB. We used an electric iron to apply heat. Then the PCB was etched by Ferric Chloride [7] to get the printed circuit on the PCB. By the process of etching the necessary connection lines of the copper remain on the board according to circuit. The other portion of copper layer is washed away. The Ferric Chloride is very common, popular and safe chemical for the etching process in PCB construction. Then the board was rinsed it off with a healthy amount of water. It was dried well

for further uses. Now the leads of the components were cleaned very well to make the connection as good as possible. Soldering the components to the board is the way to build the circuit. The soldering iron that we used was light and its power was around 25 Watts. We used a precision drill machine to make necessary penetration into the PCB. We checked and double the printed connection lines on the PCB. Finally we attached the components with PCB with maximum precision.

Transducer and the amplifier circuit board:
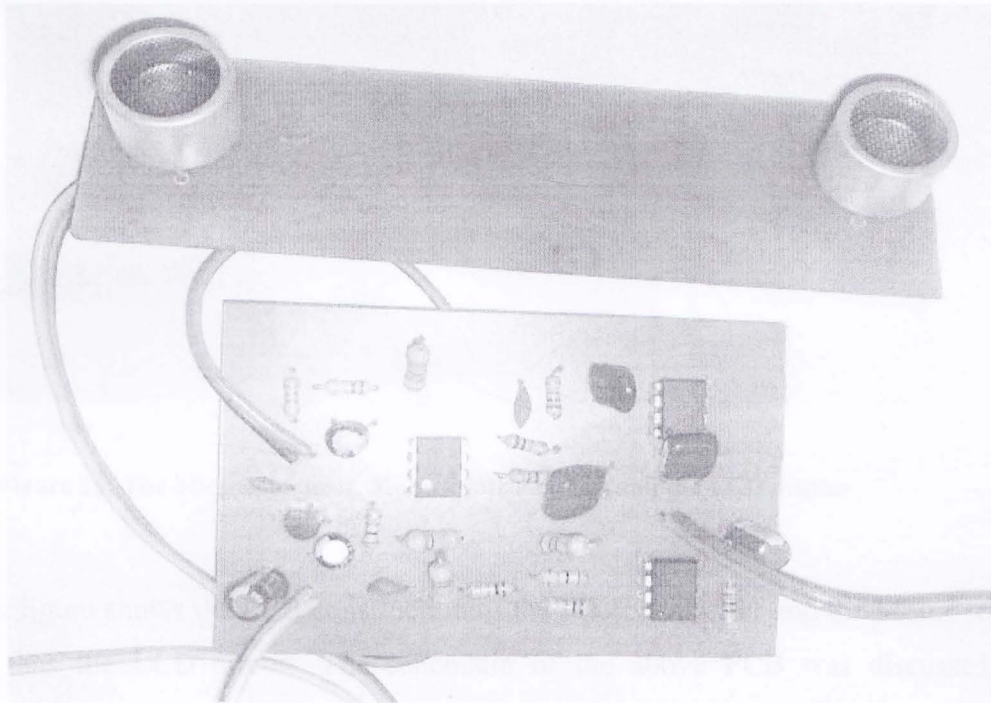
Figure 24: Transducer and the amplifier circuit

The above figure shows the PCB construction of the transducer arrangements. It also contains the amplifier and the rectifier circuit. In the above PCB the components were placed according to the schematic that we have shown previously.

The board that contains the transducer has the dimension of 2"x7" (inches) and the amplifier circuit board is a3.25"x4.75" (inches) board.

The Microcontroller, Motor control circuit and the LCD display PCB
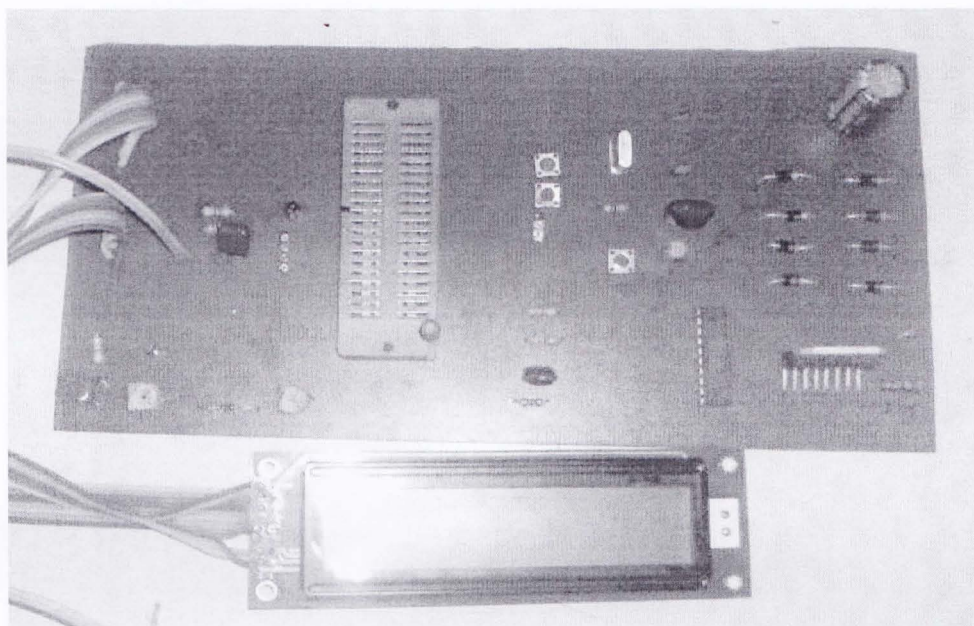
Figure 25: The Microcontroller, Motor control circuit and the LCD display

Here the figure shows the PCB construction of the Microcontroller and the Motor control circuit. It also has the LCD circuit. The schematic of the above PCB was discussed and elaborated before.

This PC board the dimension of 4"x8" (inches).

In this board we inserted a component ZIF [11] (zero insertion force). The component is used to place the micro controller on it. This makes the removal and placement of the micro controller in the circuit very convenient. We may need to remove the micro controller several times to load the code in it.

The full overview of the PCBs we constructed
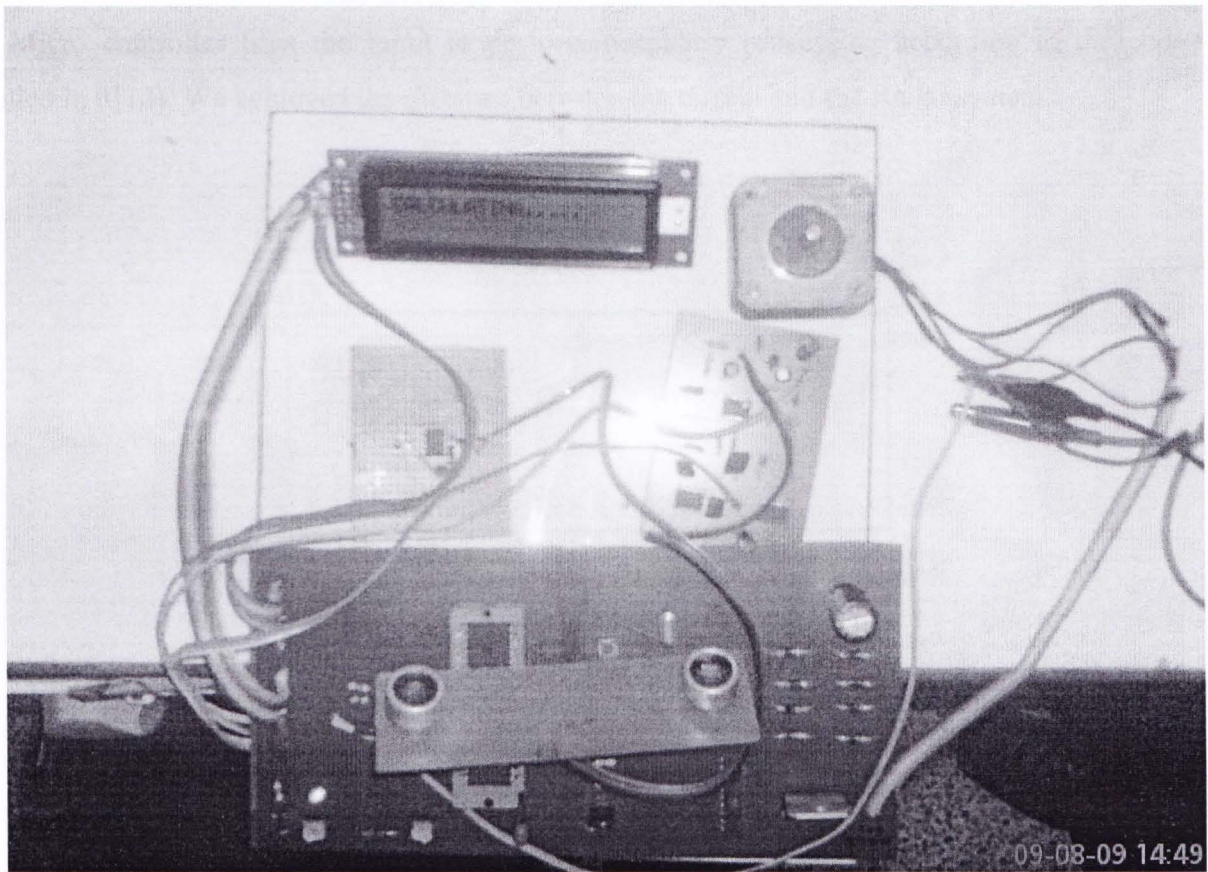
Figure 26: The full overview of the circuit we constructed

Here we are presenting the full system that was developed in our project work. Here we are seeing the arrangement of the transducer circuit, the amplifier and the rectifier circuit, micro controller, motor control circuit, motor and finally the LCD. The cables show here works for necessary power supplies and data interfacing.

4. Data Analysis And Solution

This is the part where the operation starts right after the reception of signal at the receiver end. Micro controller uses the input to perform necessary processing according to the code provided in it[12]. We achieved the distance between the terrain and the Radar system.
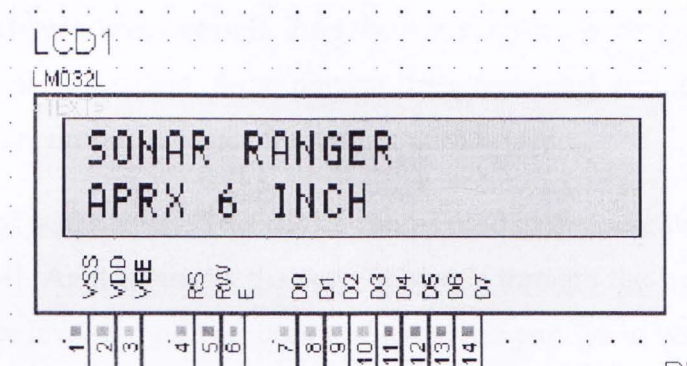
Figure 27: Display of Result on the LCD

5. <u>Implementation</u>

- <u>Use in traffic:</u> Helps to maintain safe distance between vehicles, it can be used to prevent collusion between vehicles in roads and highways**Error! Reference source not found.** [1][1][2].

- <u>Use in river route:</u> We all know that in every year in our country lots of people die as a result in the collusion between water vessels. And these water vessels also move at night so there always been a threat of accident. So to prevent these unwanted accidents they can use it in their board and maintain safe distance from other vessels [13].

- <u>Measuring depth of water levels:</u> This device can be used to measure the depth of sea or pool or watercourse [14]. As it transmits the wave it travels through the water level and hits the bottom of the water level and reflects back to the receiver end. So in between the total time is multiplied by the sound velocity which gives us the depth of the water level. But as our device is not that much strong to do this work due to its sensitivity.

- <u>Detecting flaws and cracks in metal:</u> I can also be used to detect if there is any cracks in metal. Like we send a wave and it reflects back and if we know the reflection co-efficient of the pure metal and if we compare that with out experimental metal and if we find any difference in their values then we can say that the experimental metal is impure [1].

- <u>The military uses:</u> Submarine & plane detection, in firearms, detection of object in dark. For the military purpose it can be very valuable device cause at night this device can be used to detect object [13][1].

- <u>It can help the deaf 'hear':</u> In experimental it's showed that this device can be helpful for the deaf people to hear by detecting signals they cannot pick up [15].

- <u>Use in measure the purity of liquid:</u> As we described above about the detection of the pure metal it's also possible to measure the purity of liquid. As in our country we often hear or even see that in petrol pump or in oil containers people mix the original liquid with the impure liquid. So to prevent this illegal activity this device might be pretty handy and useful.

6. <u>Conclusion</u>

We tried to make this project work as an implementation of our theoretical knowledge. We used several course contents in this project. We needed to read a lot of thesis and project papers on Radar technology and antenna development [16]. We also used our practical knowledge that we gathered through different laboratory performance and circuit operation.

From the very beginning of our projects work we have been met various types of problems. The major problem that we faced was the unavailability of the components that we needed. Finding the transducers [5] was one of the barriers here. Even we used to contact our overseas friends to collect this component. But fortunately we were able to collect all the components that we needed.

We had to travel and search through our local markets for different purposes related to this project too. We had to spend almost Taka 4000 (Four thousands) for the collection of all necessary components.

Finally, we found our project fruitful and meaningful by its successful completion. We hope this work will encourage our department to pay more attention to the development of various necessary and new hardware developments. It will certainly uplift and will add prestige for our department by which the department will acquire more attention and will go through a prosperous way.

7. Future Work

- Short range: In the future the range of the device can be improved. Our device can cover only 6-7 inch. It is very short in term of distance because in practical life it can not be useful with this short of range. So this is a vital point that the range should be improved so that the device can work properly and give the accurate distance.

- Error in Output Data: As we spoke above that our device works within the range of 6-7 inches therefore it can't give us the correct output data. Because as the wave travels so short distance and micro controller have to calculate the distance within the period before the next wave is transmitted so the micro controller gets very small time to calculate. As a result, the micro controller can't give us the accurate output data.

- Objects Sensitivity: This device can only detect fixed object. So this in future this device can be developed further to detect the moving object [17].

- Device Sensitivity: The devices we used in our experiment have low sensitivity. For that reason we were not been able to get the accurate result. So for this experiment devices played vital role for accurate result.

- More Accurate Output Data: If we can improve the range of the device then we will be able to get more accurate output data.

- Detection of Position: We here used this device to detect a fixed object, but it can also be developing further to detect an object and detect its position. If this is done then we will be able to sense an object doesn't matter if it's fixed or moveable but also its position and we can find that object very easily [3][1].

- Speed Detection: If the technology of its device can be upgraded further and modified enough then it will very valuable device for the Law enforcement forces. Because it can be used as a speed detection device [14][15]. So it will help for the police or other forces to catch the criminals who break the speed limits on the roads and highways.

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Appendix

The code that was used to operate the transducers through motor and to achieve the output at the LCD display is as follow:

```c
#include <rtx51tny.h> /* RTX-51 tiny functions & defines*/
#include <REG52.h>
#include <intrins.h>
#include<stdio.h>
#include<string.h>

int i,j,n,speed,dis,time;
float distance;

char k;

#define LCD_PORT P2

#define INST_REG 0        // LCD instruction register
#define DATA_REG 1        // LCD data register
#define LINE1_ADDR 0x00   // Start of line 1 in the DD-Ram
#define LINE2_ADDR 0x40   // Start of line 2 in the DD-Ram
#define CLEAR_DISPLAY 0x01 // LCD display clear command

/*************************************************************************
 *
 *              Global Variable Declarations
 *
 *************************************************************************/
sbit  E   = LCD_PORT^6;    // LCD I/O enable        pin 6
sbit  RS  = LCD_PORT^4;    // LCD I/O register select pin 4
sbit  RW  = LCD_PORT^5;    // LCD I/O R/W select    pin 5
sbit  SPKR = LCD_PORT^7;   // Speaker output

sbit sout= P0^7;//32
sbit sres= P0^6;//33

/**
 * Hardware crystal frequency in Hz.
 * Adjust \b DELAY_XTAL to match hardware.
 * \hideinitializer
 */
#define DELAY_XTAL      12000000

// Delay routine timing parameters
#define DELAY_CPU_CLOCK  DELAY_XTAL / 12    // 8051 clock rate (X1 mode)
#define DELAY_CONST      9.114584e-5        // Delay routine constant
#define DELAY_MULTPLR   (unsigned char)(DELAY_CONST * DELAY_CPU_CLOCK)

/*************************************************************************
 *
 *              Public Function Prototypes
 *
 *************************************************************************/
/**
 * Millisecond software delay function.
 * Implements a software timing loop based delay with millisecond precision.
 * See 'Usage' for notes regarding upper bounds on the delay period that may
 * be generated.
```

```
 * \param count The number of milliseconds to delay as an \b unsigned \b int.
 * \return -
 */

void delay_ms(volatile unsigned int count)
{

   for(count *= DELAY_MULTPLR; count > 0; count--) continue;

   return;
}

//      void delay_sec(volatile unsigned int count){
//                      long int i,k;
//                      for(i=0;i<count;i++){
//                                                      for(k=0;k<50000;k++){
//                                                      _nop_();
//                                              }
//                                      }
//
//              }


/************************************************************************
 *
 *                       Macro Definitions
 *
 ***********************************************************************/


/**
 * Sets lcd cursor position.
 * \param address The address to move cursor to as an \b unsigned \b char.
 * \return -
 * \hideinitializer
 */
#define LCD_SET_ADDR(address)  (lcd_wr_reg(INST_REG, (address) | 0x80))

/**
 * Gets lcd cursor position.
 * \param -
 * \return The address of the cursor as an \b unsigned \b char.
 * \hideinitializer
 */
#define LCD_GET_ADDR()   (lcd_rd_reg(INST_REG) & 0x7f)

/************************************************************************
 *
 *                     Public Function Prototypes
 *
 ***********************************************************************/


// extern char putchar(char c);     // defined in stdio.h

/**
 * Lcd module initialisation function.
 * Initialises hardware and the HD44780 LCD display controller for 4 bit
 * operation.
 * \param -
 * \return -
 */
extern void lcd_init(void);
```

```
/**
 * Lcd module audible alert.
 * Generates a variable length tone suitable for keyboard feedback and
 * ^g bell alerts.
 * \param count The number of on/ off cycles to emit as an \b unsigned \b char.
 * \return -
 */
extern void lcd_beep(unsigned char count);


/********************************************************************
 *
 *                     Private Function Prototypes
 *
 ********************************************************************/
static void lcd_clock_E(void);
static void lcd_wr_reg(bit reg, unsigned char inst);
static unsigned char lcd_rd_reg(bit reg);
static void lcd_backspace(void);
static void lcd_clear(void);
static void lcd_scroll_up(void);


/********************************************************************
 *
 *                     Private Function Implementation
 *
 ********************************************************************/


/********************************************************************
 *
 *                     lcd_clock_E()
 *
 ********************************************************************/
static void lcd_clock_E(void)
{
    E = 1;
    delay_ms(0);             // delay > 100us
    delay_ms(0);
    delay_ms(0);
    E = 0;
}


/********************************************************************
 *
 *                     lcd_wr_reg()
 *
 ********************************************************************/
static void lcd_wr_reg(bit reg, unsigned char inst)
{
    RS = reg;             // Select instruction or data register
    RW = 0;               // Select write operation
    LCD_PORT &= 0xF0;         // Clear port data
    LCD_PORT |= inst >> 4;    // Send D7..D4 to lcd
    lcd_clock_E();
    LCD_PORT &= 0xF0;         // Clear port data
    LCD_PORT |= inst & 0x0F;  // Send D3..D0 to lcd
    lcd_clock_E();
    LCD_PORT |= 0x0F;         // Set low nibble for input
                    // Prevent damage
}
```

```
/******************************************************************
 *
 *                    lcd_rd_reg()
 *
 ******************************************************************/
static unsigned char lcd_rd_reg(bit reg)
{
    unsigned char value;

    LCD_PORT |= 0x0F;        // Set low nibble for input
    RS = reg;                // Select instruction or data register
    RW = 1;                  // Select read operation
    delay_ms(0);             // Wait 40 ns minimum
    E = 1;                   // Enable output
    delay_ms(0);             // Wait 160 ns minimum
    value = LCD_PORT << 4;   // Retrieve D7..D4
    E = 0;                   // Disable output
    delay_ms(0);             // Wait 230 ns minimum
    E = 1;                   // Enable output
    delay_ms(0);             // Wait 160 ns minimum
    value |= LCD_PORT & 0x0F; // Retrieve D3..D0
    E = 0;                   // Disable output
    RW = 0;                  // Prevent damage

    return(value);
}

/******************************************************************
 *
 *                    lcd_backspace()
 *
 ******************************************************************/
static void lcd_backspace(void)
{
    unsigned char addr;

    addr = LCD_GET_ADDR();

    if ((addr != 0x00) && (addr != 0x40))
    {
        LCD_SET_ADDR(addr - 1);
    }
}

/******************************************************************
 *
 *                    lcd_clear()
 *
 ******************************************************************/
static void lcd_clear(void)
{
    lcd_wr_reg(INST_REG, CLEAR_DISPLAY);

    delay_ms(2);             // Wait more than 1.64ms
}

/******************************************************************
 *
 *                    lcd_scroll_up()
 *
 ******************************************************************/
static void lcd_scroll_up(void)
```

```
{
    unsigned char i;
    unsigned char c;

    for(i = LINE1_ADDR; i < 0x28; i++)
    {
        LCD_SET_ADDR(i + LINE2_ADDR);
        c = lcd_rd_reg(DATA_REG);
        LCD_SET_ADDR(i + LINE2_ADDR);
        lcd_wr_reg(DATA_REG, ' ');
        LCD_SET_ADDR(i);
        lcd_wr_reg(DATA_REG, c);
    }
    LCD_SET_ADDR(LINE2_ADDR);
}


/********************************************************************
 *
 *
 *                    Public Function Implementation
 *
 *********************************************************************/


/********************************************************************
 *
 *
 *                        init_lcd()
 *
 *********************************************************************/
void lcd_init(void)
{
    delay_ms(15);            // Wait more than 15ms
    LCD_PORT = 0x03;           // Startup Sequence
    lcd_clock_E();
    delay_ms(5);            // Wait more than 4.1ms
    lcd_clock_E();
    delay_ms(1);            // Wait more than 0.1ms
    lcd_clock_E();
    LCD_PORT = 0x02;
    lcd_clock_E();
    delay_ms(1);            // Wait more than 0.1ms

    lcd_wr_reg(INST_REG,0x28);  // Function Set
                    // DL=0 4bit, N=1 2Line, F=0 5x7

    lcd_wr_reg(INST_REG,0x0c);  // Display on/off control
                    // D=1 Disp on, C=0 Curs off, B=0 Blink off

    lcd_wr_reg(INST_REG,0x06);  // Entry Mode Set
                    // I/D=1 Increment, S=0 No shift

    lcd_wr_reg(INST_REG,0x01);  // Clear Display

    delay_ms(2);            // Wait more than 1.64ms

}


/********************************************************************
 *
 *
 *                        putchar()
 *
 *********************************************************************/
char putchar(char c)
```

```
      {
        switch(c)
        {
          case '\n':        // Newline
          {
            if (LCD_GET_ADDR() >= LINE2_ADDR)    // already in line 2 ?
            {
              lcd_scroll_up();
            }
            LCD_SET_ADDR(LINE2_ADDR);
            break;
          }
          case '\a':        // Bell (alert)
          {
            lcd_beep(50);
            break;
          }
          case '\b':        // Backspace
          {
            lcd_backspace();
            break;
          }
          case '\f':        // Form feed
          {
            lcd_clear();
            break;
          }
          default:
          {
            lcd_wr_reg(DATA_REG, c);
          }
        }
        return (c);
      }
/***************************************************************************
 *
 *                         getchar()
 *
 ***************************************************************************/
//      char getchar(){
//      add=LINE1_ADDR;
//              LCD_SET_ADDR(add);
/***************************************************************************
 *
 *                         getkey()
 *
 ***************************************************************************/
      char _getkey (void){
              unsigned char k;
                      k=lcd_rd_reg(DATA_REG);
              return ((unsigned char) k);
      }
/***************************************************************************
 *
 *                         lcd_beep()
 *
 ***************************************************************************/
      void lcd_beep(unsigned char count)
      {
        for (count; count > 0; count--)
        {
          SPKR = 1;
```

```
            delay_ms(1);
            SPKR = 0;
            delay_ms(1);
        }
    }

                    sbit cwM = P3^0;
                    sbit ccwM = P3^1;

        /****************************** Motor *********************************/

                    #define M_PORT P1


                    sbit enable = M_PORT^5;
                    sbit reset = M_PORT^0;
                    sbit halfull = M_PORT^1;
                    sbit ccwcw = M_PORT^3;
                    sbit clock = M_PORT^2;
                    sbit home =   M_PORT^4;
                    sbit cntrl = M_PORT^6;

        /****************************** Motor *******************************/

        /*******************************************************************/

        /*******************************************************************/

                    void delay(){
                            for (n=0;n<1000;n++){
                                    _nop_();
                            }
                    }

                    void delay1(long int msc){
                                    while(msc--);
                    }

                    void pulse(){

                                            clock=0;
                                                    delay();
                                            clock=1;
                                                    delay();

                    }
                    void initMotor(){
                                            //reset=0;
                                            //_nop_();
                                            //_nop_();
                                            reset=1;
                                            halfull=1; //half
                                            enable=1;
                            //              home=1; // home


                    }

    void measure(){
                    time=0;
                    sout=1;
                    while(sres!=1){
```

```
                                _nop_();
                                time++;
                                if(time>=5000){
                                        break;
                                }
                        }

                sout=0;

                dis=time;
                //dis=distance;
                LCD_SET_ADDR(LINE1_ADDR);
                printf("RANGE CALCULATED");
                LCD_SET_ADDR(LINE2_ADDR);
                printf("APROX %d      ",dis);
                if(time>=5000){
                        LCD_SET_ADDR(LINE2_ADDR);
                        printf("UNABLE TO CALC ",dis);
                }
        }

        void main(){
                j=0;
                speed=33;
                lcd_init();
                initMotor();
                LCD_SET_ADDR(LINE1_ADDR);
                printf("SONAR RANGER");
                LCD_SET_ADDR(LINE2_ADDR);
                printf("INITIALIZING..");


                while(1){

                        if((cwM==0)&&(ccwM==1)){
                                //        j++;
                                //        LCD_SET_ADDR(LINE2_ADDR);
                                //        printf("MOTOR C C W");

                                        ccwcw=1;
                                        for(k=0;k<10;k++){
                                                        pulse();
                                        }
                                        LCD_SET_ADDR(LINE1_ADDR);
                                        printf("CALCULATING.....");
                                        LCD_SET_ADDR(LINE2_ADDR);
                                        printf("                ");
                                        delay_ms(2000);
                                        measure();
                                        delay_ms(20000);

                        }
                        else if((cwM==1)&&(ccwM==0)){
                                //        j++;
                                //        LCD_SET_ADDR(LINE2_ADDR);
                                //        printf("MOTOR C W  ");
                                        ccwcw=0;
                                        for(k=0;k<10;k++){
                                                        pulse();
                                        }
                                        LCD_SET_ADDR(LINE1_ADDR);
                                        printf("CALCULATING.....");
```

```
                                        LCD_SET_ADDR(LINE2_ADDR);
                                        printf("            ");
                                        delay_ms(2000);

                                        measure();
                                        delay_ms(20000);

                }
                else{

                                        LCD_SET_ADDR(LINE1_ADDR);
                                        printf("CALCULATING.....");
                                        LCD_SET_ADDR(LINE2_ADDR);
                                        printf("            ");
                                        delay_ms(2000);
                                        measure();
                        delay_ms(20000);


                }


        }


   }
```