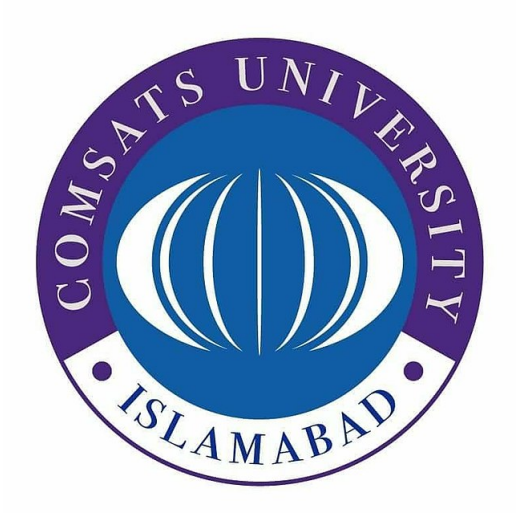
COMSATS University Islamabad Attock Campus

Department Of Electrical And Computer Engineering

July 2022



Ultrasonic Range Finder Using AT89C51

Microprocessor System And Interfacing

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ABSTRACT

Keywords Distance measurement,Ultrasonic, Sensors, Micro-Controller

Distance measurement of an object in the path of a person, equipment, or moving is used in large number of applications such as robotic movement control, medical application, blind man's walking stick, etc. Ultrasonic sensor is one of the cheapest among various options. In this project distance measurement of an obstacle by using ultrasonic sensor and microcontroller is presented. The microcontroller based Ultrasonic distance meter or is anon contact and non-loading distance measuring device. This device can be used to even large distance with pin point accuracy. The heart of this distance-meter is the microcontroller AT89C51. This system has very large applications not only in various industries, the luxury automobile sector but also in the armed force where accuracy and durability is of primary importance.

Electronic rangefinder measurement scope in 2cm to 500cm, 1 cm measurement precision, measurement with no direct contact with the object to be tested, able to display measurement results clear and stable. Because ultrasonic directivity is strong, energy consumption is slow, in the medium transmission distance is farther, so ultrasonic often used for distance measurement, such as range finder and level measurement instrument can be done by ultrasound.

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Chapter 1

INTRODUCTION

1.1 Objectives

Ultrasonic range finder, which can be used in reverse, the location of the construction site and some industrial site monitoring, can also be used for liquid level, well depth, pipe length measurement, etc. Using the ultrasonic detection tend to be more quick, convenient, simple calculation, easy to do real-time control, and in terms of measurement accuracy can meet the requirements of industrial practical, so on the development of the mobile robot is also widely used. We're developing a system that can estimate the objectives distance by ultrasonic waves with desirable properties

- Can measure the distance of objects using AT89C51 and HS-SR04.
- Sensor selection and installation at a defined angle to accurately measure the distance of obstacle.
- Work as a team, and efficiently communicate the concept, design, and results both orally and as a report.
- Understanding the concept of Micro-controller receive and transmission

1.2 Overview

A microcontroller (C or uC) is a solitary chip microcomputer fabricated from VLSI fabrication. A micro controller is also known as embedded controller. Today various types

of microcontrollers are available in market with different word lengths such as 4bit, 8bit, 64bit and 128bit microcontrollers. Microcontroller is a compressed micro computer manufactured to control the functions of embedded systems in office machines, robots, home appliances, motor vehicles, and a number of other gadgets. A microcontroller is comprises components like - memory, peripherals and most importantly a processor. Microcontrollers are basically employed in devices that need a degree of control to be ap plied by the user of the device.

A microcontroller is a small computer built on a single integrated circuit or chip and it contains the core processor, the memory and the input/output peripherals. The memory in the microcontroller is divided into two parts one is your RAM which is used during the execution of the code and other one is the flash memory in which your program code resides. So whenever you burn your program code into your microcontroller. It will go directly into the flash memory of your microcontroller. The basic difference between a microprocessor and a microcontroller is that the microprocessor has no on-chip memory and input/output peripherals. So microcontrollers are used everywhere where you want a task to be automated. They are used in your home appliances like washing machines, microwave ovens, air conditioners and mobile phones. They are also used in automation industrial automation artificial intelligence robotics and some years ago. They are not used for high voltage applications like home or industrial automation where we have to control the high voltages like 220 volt or above 220 volt because our generic relays or the electromechanical relays have a disadvantage of producing back EMF net can damage our microcontroller but as a time passed the solid-state relays come into the picture. the solid-state relays means the semiconductor relays in which MOSFETs and FETs are used for controlling the switching operation and the solid-state relays provides the optical isolation that optically isolates the high voltage. So they are preferred over the electromechanical relays.

1.2.1 Microcontroller Basics

Any electric appliance that stores, measures, displays information or calculates comprise of a microcontroller chip inside it. The basic structure of a microcontroller comprise of: -

1. CPU- Microcontrol lers brain is named as CPU. CPU is the device which is employed to fetch data, decode it and at the end complete the assigned task success-

fully. With the help of CPU all the components of microcontroller is connected into a single system. Instruction fetched by the programmable memory is decoded by the CPU.

2. Memory– In a microcontroller memory chip works same as microprocessor. Memory chip stores all programs data. Microcontrollers are built with certain amount of ROM or RAM (EPROM, EEPROM, etc) or flash memory for the storage of program source codes.

3. Input/output ports– I/O ports are basically employed to interface or drive different appliances such as - printers, LCD's, LED's, etc.

4. Serial Ports– These ports give serial interfaces amid microcontroller various other peripherals such as parallel port.

5. Timers– A microcontroller may be in-built with one or more timer or counters. The timers counters control all counting timing operations within a microcontroller. Timers are employed to count external pulses. The main operations performed by timers' are-pulse generations, clock functions, frequency measuring, modulations, making oscillations, etc.

6. ADC (Analog to digital converter)–ADC is employed to convert analog signals to digital ones. The input signals need to be analog for ADC. The digital signal production can be employed for different digital applications (such as measurement gadgets).

7. DAC (digital to analog converter)–this converter executes opposite functions that ADC perform. This device is generally employed to supervise analog appliances like-DC motors, etc.

8. Interpret Control- This controller is employed for giving delayed control for a working program. The interpret can be internal or external.

9. Special Functioning Block– Some special microcontrollers manufactured for special appliances like - space systems, robots, etc, comprise of this special function block. This special block has additional ports so as to carry out some special operations.

1.2.2 Types of Microcontroller

Microcontrollers are divided into categories according to their memory, architecture, bits and instruction sets. So let's discuss types of microcontrollers:

Bits: 8 bits microcontroller executes logic arithmetic operations. Examples of 8 bits micro controller is Intel 8031/8051.

16 bits microcontroller executes with greater accuracy and performance in contrast to 8-bit. Example of 16 bit microcontroller is Intel 8096.

32 bits microcontroller is employed mainly in automatically controlled appliances such as office machines, implantable medical appliances, etc. It requires 32 - bit instructions to carry out any logical or arithmetic function

Memory:

- External Memory MicrocontrollerWhen an embedded structure is built with a microcontroller which does not comprise of all the functioning blocks existing on a chip it is named as external memory microcontroller. For illustration - 8031 microcontroller does not have program memory on the chip.
- Embedded Memory Microcontroller-When an embedded structure is built with a microcontroller which comprise of all the functioning blocks existing on a chip it is named as embedded memory microcontroller. For illustration - 8051 microcontroller has all program data memory, counters timers, interrupts, I/O ports and therefore its embedded memory microcontroller.

Instruction Set

- CISC- CISC means complex instruction set computer, it allows the user to apply 1 instruction as an alternative to many simple instructions.
- RISC- RISC means Reduced Instruction Set Computers. RISC reduces the operation time by shortening the clock cycle per instruction.

Memory Architecture

- Harvard Memory Architecture Microcontroller
- Princeton Memory Architecture Microcontroller

1.2.3 8051 Microcontroller

The most universally employed set of microcontrollers come from the 8051 family. 8051 Microcontrollers persist to be an ideal choice for a huge group of hobbyists and experts. In the course of 8051, the humankind became eyewitness to the most ground- breaking set of microcontrollers. The original 8051 microcontroller was initially invented by Intel. The two other members of this 8051 family are

8052-This microcontroller has 3 timers 256 bytes of RAM. Additionally it has all the features of the traditional 8051 microcontroller. 8051 microcontroller is a subset of 8052 microcontroller.

8031 - This microcontroller is ROM less, other than that it has all the features of a traditional 8051 microcontroller. For execution an external ROM of size 64K bytes can be added to its chip.

8051 microcontroller brings into play 2 different sorts of memory such as - NV- RAM, UV - EPROM and Flash.

8051 Microcontroller Architecture 8051 microcontroller is an eight bit microcontroller launched in the year 1981 by Intel Corporation. It is available in 40 pin DIP (dual inline package). It has 4kb of ROM (on- chip programmable space) and 128 bytes of RAM space which is inbuilt, if desired 64KB of external memory can be interfaced with the microcontroller. There are four parallel 8 bits ports which are easily programmable as well as addressable. An on- chip crystal oscillator is integrated in the microcontroller which has crystal frequency of 12MHz. In the microcontroller there is a serial input/output port which has 2 pins. Two timers of 16 bits are also incorporated in it; these timers can be employed as timer for internal functioning as well as counter for external functioning. The microcontroller comprise of 5 interrupt sources namely- Serial Port Interrupt, Timer Interrupt 1, External Interrupt 0, Timer Interrupt 0, External Interrupt 1. The programming mode of this micro-controller includes GPRs (general purpose registers), SFRs (special function registers) and SPRs (special purpose registers).

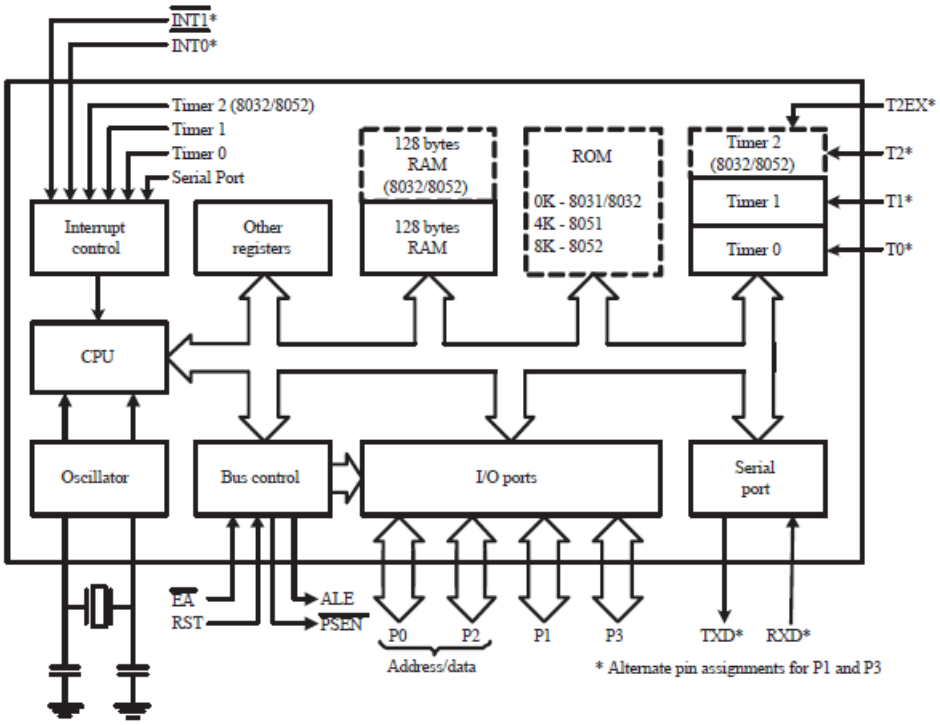


Figure 1.1: Block Diagram For 8051

1.3 Applications

Nowadays you can find micro controllers in all types of electronic devices. Any automobile or other device which measures, controls, calculates, stores, or displays information must have a micro controller chip inside it.

The microcontrollers used widely are in the industries (microcontrollers widely used for controlling engines and power controls in automobiles). Various other equipment contains microcontrollers inside it, such as keyboards, printers, computer mice, modems, and other peripherals. In various equipment, microcontrollers make it easy to add some features like the power to store measurements, to form and store user routines, and to display messages and waveforms.

Various other products that use microcontrollers include digital camcorders, optical players, LCD/LED display units, etc. And these are just a couple of examples.

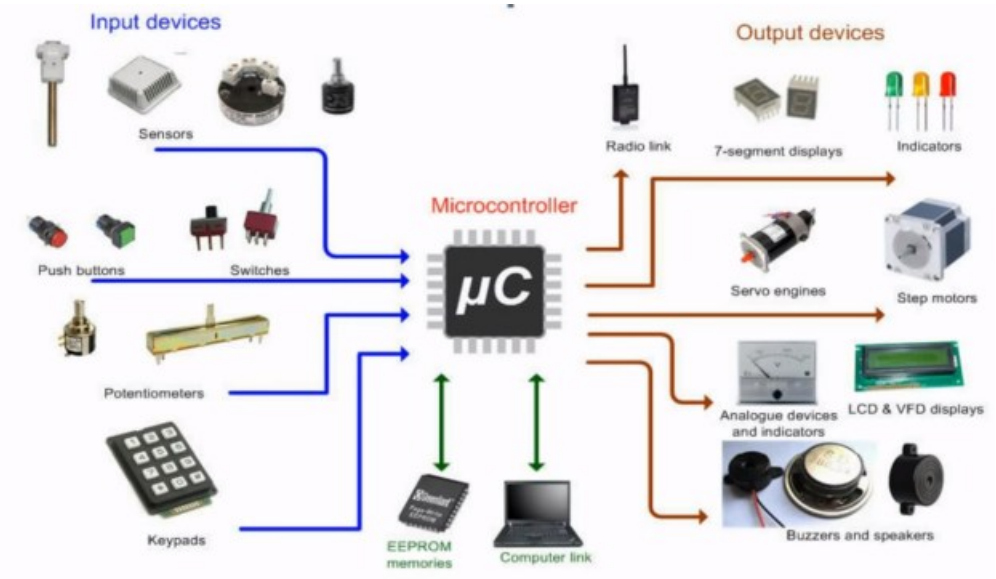


Figure 1.2: Application Of MIcrocontrollers

Here are some applications of a microcontroller are follows:

- Consumer Electronics Products – Any automatic home appliance like Robots, Toys, Cameras, Washing machines, Microwave Ovens, etc.
- Instrumentation and Process Control – Multimeter, Leakage Current Tester, Oscilloscopes, Data Acquisition and Control, etc.
- Fire Detection – Security alarm, Safety devices, etc.
- Medical Instruments – Medical machines like ECG, Accu-Chek, etc.
- Communication technology – Telephone Sets, Cell Phones, Answering Machines, etc.
- Multimedia Application – Mp3 Player, PDAs, etc.
- Office Machines – Fax machine, Printers, etc.
- Automobile – Auto-braking system, Speedometer, etc.

Chapter 2

METHODOLOGY

In previous chapter we've observed the types of Micro-controllers and studied deeply about the architecture along side its application and block diagrams. In this chapter our prime focus is on demonstrating the project we've working on Ultra sonic Range finder, We'll consider the Components, Code, Simulation in alot more details.

2.1 Components

A simple ultrasonic range finder using 8051 microcontroller is presented in this article. This ultrasonic rangefinder can measure distances up to 2cm to 500cm at an accuracy of 1 centi meter. AT89s51 microcontroller and the ultrasonic transducer module HC-SR04 forms the basis of this circuit. The ultrasonic module sends a signal to the object, then picks up its echo and outputs a wave form whose time period is proportional to the distance. The microcontroller accepts this signal, performs necessary processing and displays the corresponding distance on the 4 digit seven segment display. This circuit finds a lot of application in projects like automotive parking sensors, obstacle warning systems, terrain monitoring robots, industrial distance measurements etc.

2.1.1 AT89C51

- Pinout 40 - It is denoted as Vcc and plus five volts are given to this pinout.
- Pinouts 32 to 39- these pinouts are belonged to Port zero and operate as input and output pinouts.

- Pinout 31- This pinout is used to enable or disable the exterior memory interfacing.
- Pinout 30- It is ALE or aka address latch enables pinout which used to demultiplex the address-data signal at port zero.
- Pinout 29- It is PSEN pinout which used to reading of signal from the exterior memory unit.
- Pinout 21 to 28- This group of pinout is belonged to port 2 and used as input and output.
- Pinout 20- It is Vss and used for the ground connection.
- Pinout 18,19- Through these 2 pins, the exterior clock is given to the module.
- Pinout 10 to 17- This group of pinout belongs to port 3.
- Pinout 9- It is reset pinout
- Pinout 1 to 8- These pinouts are belonged to the port one and operate as input and output pins.

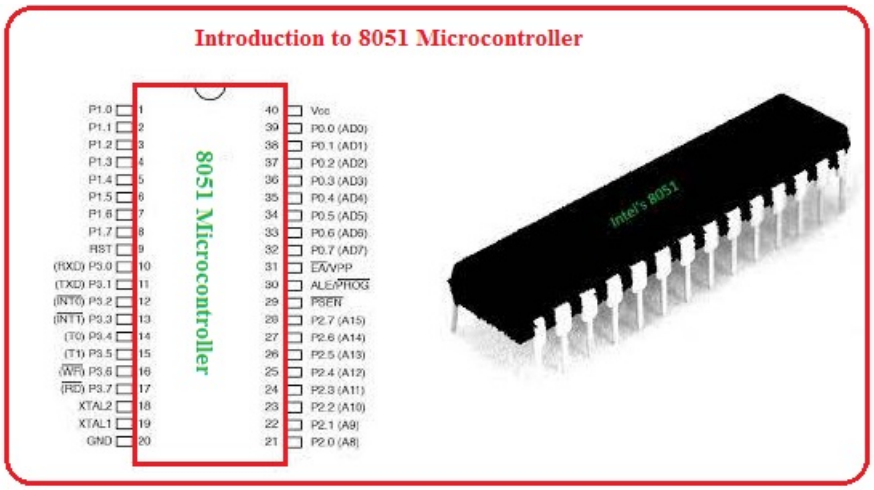


Figure 2.1: Pin Diagram For 8051

2.1.2 Ultrasonic Sensor HC-SR04

HC-SR04 is an ultrasonic ranging module designed for embedded system projects like this. It has a resolution of 0.3cm and the ranging distance is from 2cm to 500cm. It

operates from a 5V DC supply and the standby current is less than 2mA. The module transmits an ultrasonic signal, picks up its echo, measures the time elapsed between the two events and outputs a waveform whose high time is modulated by the measured time which is proportional to the distance. The supporting circuits fabricated on the module makes it almost stand alone and what the programmer need to do is to send a trigger signal to it for initiating transmission and receive the echo signal from it for distance calculation. The HR-SR04 has four pins namely Vcc, Trigger, Echo, GND.

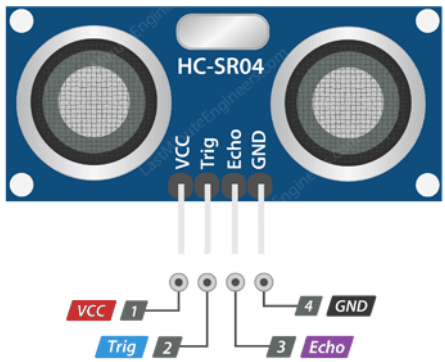
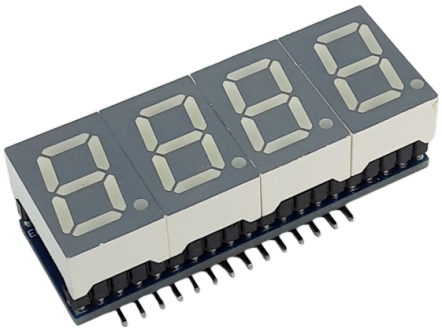


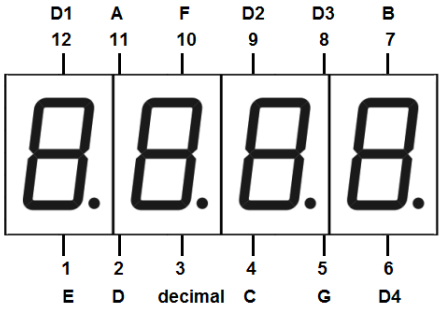
Figure 2.2: Ultra Sonic Sensor HC-SR04

2.1.3 Display MPX4

The seven segments displays are the oldest yet one of the efficient types of display used in embedded applications. This display has nothing more than 8 LED inside it. These 8 LEDs are separated into each segments which can be named as a,b,c,d,e,f,g,DP as shown in the picture above. These entire 8 segment LEDs have one end of their pins pulled out of the module as shown above and the other ends are connected together and pulled out as the Common pin. So to make an LED of a particular segment glow we just have to power common pin along with the segment pin. This way we can power more than one segment at a time to represent the numeric number 0-9 and also few Alphabets as shown on the graphic image below. We also have an option to show a decimal point using the DP pin.



(a) 4x7 Segment Display MPX4-CA



(b) Pinout For MPx4-CA

Figure 2.3: MPX4-CA 7-Segment Display Module

2.1.4 NPN2N222 Transistor

The 2N2222 is a common NPN bipolar junction transistor (BJT) used for general purpose low-power amplifying or switching applications. It is designed for low to medium current, low power, medium voltage, and can operate at moderately high speeds.

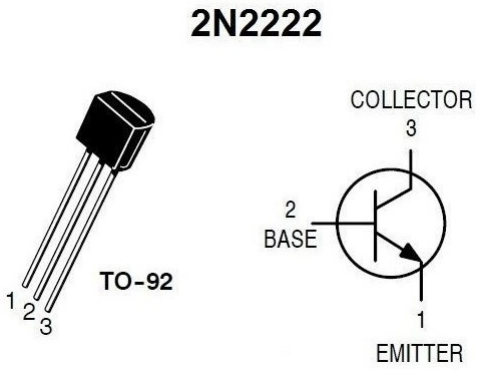


Figure 2.4: NPN Transisotr 2N2222

2.1.5 Capacitors

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals.

Figure 2.5: Capacitor

2.1.6 Resistors

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.

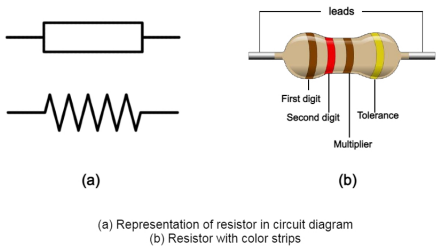


Figure 2.6: Resistors Diagram

2.1.7 Crystal Oscillator

Crystal Oscillator is an Electronics Oscillator circuit which uses the mechanical resonance of a vibrating crystal of piezoelectric material to generate an electrical signal with an accurate frequency. It also has automatic amplitude control and frequency drift is also very low due to change in temperature. Crystal Oscillators are only suitable for high-frequency application.

Figure 2.7: Oscillator For Micro controller

Every microcontroller needs a crystal oscillator, whenever selecting a crystal oscillator try to purchase silicon oscillator if the accuracy is adequate and the cost is also acceptable, otherwise choose quartz crystal.

2.2 Pseudo Code

The first part of the program sets the initial conditions. Port 0 and Port 1 are set as output ports for sending digit drive patterns and digit drive signals respectively. Port pin 3.0 is set as an output pin for sending the trigger signal to the ultrasonic module for starting transmission and port pin 3.1 is set as an input pin for receiving the echo. TMOD register of the microcontroller is so loaded that Timer 1 operates in mode2 8 bit autoreload mode. Timer 0 of the microcontroller is not used here. In the next part of the program (loop MAIN), the TL1 and TH1 registers of Timer1 are loaded with the initial values. TL1 is loaded with the initial value to start counting from and TH1 is loaded with the reload value. This is how timer 1 in mode 2 works: When the TR1 bit of the TCON register is set the TL1 starts counting from the initial value loaded into it and keeps counting until rollover (ie; 255D). When a rollover occurs, the TF1 flag is set and TL1 is automatically loaded with the reload value stored in TH1 and the sequence is repeated until TR1 is made low by the program. The TF1 goes high at the first rollover and if you want it as an indicator for each rollover, you have to clear it using the program after each rollover. In the next part of the MAIN loop, P3.0 is set high for 10uS and then cleared to make a 10uS triggering pulse. The ultrasonic module issues a 40Khz pulse waveform after receiving this trigger and the program waits until a valid echo is received at P3.1. The pulse width of the echo signal is proportional to the distance to the obstacle

2.3 Code

ORG 00H (origin)

MOV DPTR,#LUT (moves the address of LUT to DPTR)

MOV P1,#00000000B (sets P1 as output port)

MOV P0,#00000000B (sets P0 as output port)

CLR P3.0 (sets P3.0 as output for sending trigger)

SETB P3.1 (sets P3.1 as input for receiving echo)

MOV TMOD,#00100000B (sets timer1 as mode 2 auto reload timer)

MAIN: MOV TL1,#207D (loads the initial value to start counting from)

MOV TH1,#207D (loads the reload value)

MOV A,#00000000B (clears accumulator)

SETB P3.0 (starts the trigger pulse)

ACALL DELAY1 (gives 10uS width for the trigger pulse)

CLR P3.0 (ends the trigger pulse)

HERE: JNB P3.1,HERE (loops here until echo is received)

BACK: SETB TR1 (starts the timer1)

HERE1: JNB TF1,HERE1 (loops here until timer overflows (ie;48 count))

CLR TR1 (stops the timer)

CLR TF1 (clears timer flag 1)

INC A (increments A for every timer1 overflow)

JB P3.1,BACK (jumps to BACK if echo is still available)

MOV R4,A (saves the value of A to R4)

ACALL DLOOP (calls the display loop)

SJMP MAIN (jumps to MAIN loop)

DELAY1: MOV R6,#2D (10uS delay)

LABEL1: DJNZ R6,LABEL1

RET

DLOOP: MOV R5,#100D (loads R5 with 100D)

BACK1: MOV A,R4 (loads the value in R4 to A)

MOV B,#100D (loads B with 100D)

DIV AB (isolates the first digit)

SETB P1.0 (activates LED display unit D1)

```
ACALL DISPLAY (calls DISPLAY subroutine)
MOV P0,A (moves digit drive pattern for 1st digit to P0)
ACALL DELAY (1mS delay)
ACALL DELAY
MOV A,B (moves the remainder of 1st division to A)
MOV B,#10D (loads B with 10D)
DIV AB (isolates the second digit)
CLR P1.0 (deactivates LED display unit D1)
SETB P1.1 (activates LED display unit D2)
ACALL DISPLAY
MOV P0,A (moves digit drive pattern for 2nd digit to P0)
ACALL DELAY
ACALL DELAY
MOV A,B (moves the remainder of 2nd division to A)
CLR P1.1 (deactivates LED display unit D2)
SETB P1.2 (activates LED display unit D3)
ACALL DISPLAY
MOV P0,A (moves the digit drive pattern for 3rd digit to P0)
ACALL DELAY
ACALL DELAY
CLR P1.2 (deactivates LED display unit D3)
DJNZ R5,BACK1 (repeats the display loop 100 times)
RET
DELAY: MOV R7,#250D (1mS delay)
LABEL2: DJNZ R7,LABEL2
RET
DISPLAY: MOVC A,@A+DPTR (gets the digit drive pattern for the content in A)
CPL A (complements the digit drive pattern (see Note 1))
RET
LUT: DB 3FH (look up table (LUT) starts here)
DB 06H
DB 5BH
```

DB 4FH

DB 66H

DB 6DH

DB 7DH

DB 07H

DB 7FH

DB 6FH

END

2.4 Simulation

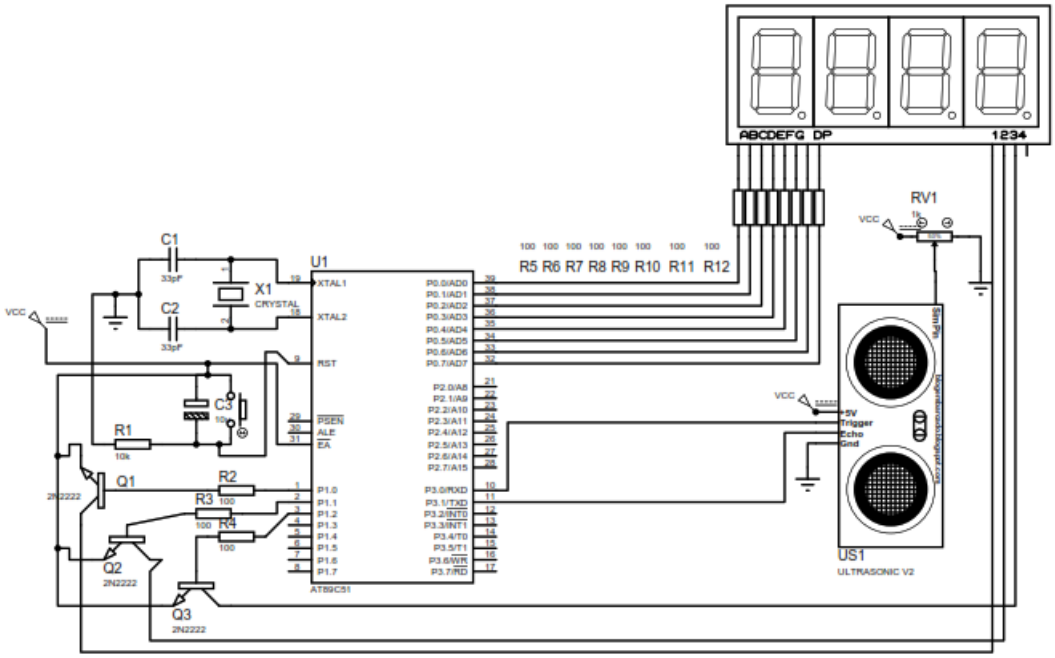


Figure 2.8: Simulation When System Is At Rest

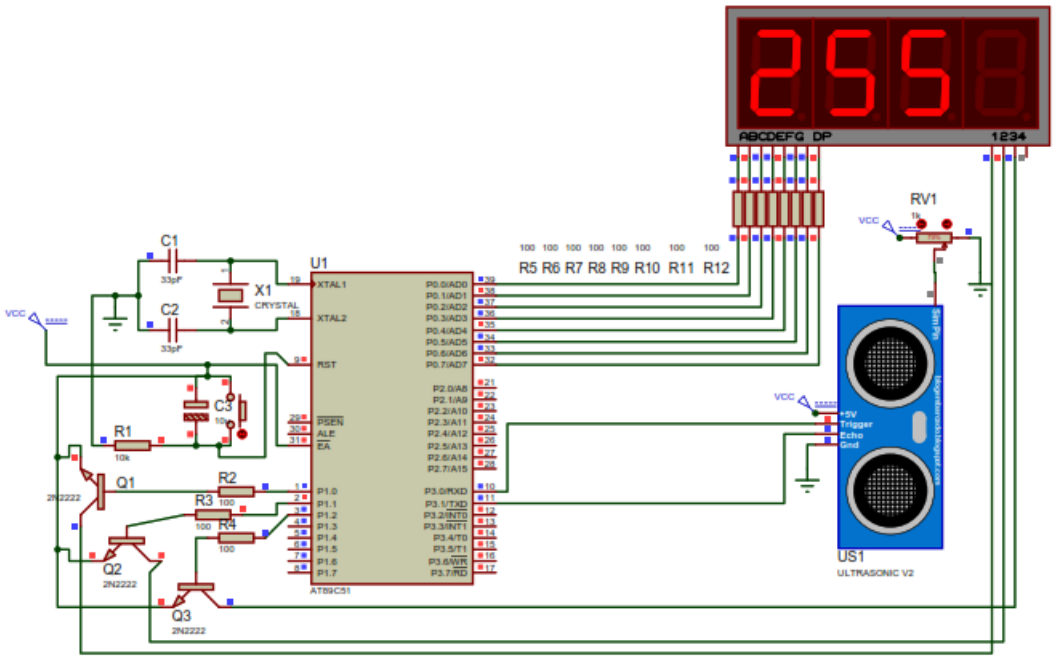


Figure 2.9: Simulation When Object Is At The Distance Of 255cm

The ultrasonic module is interfaced to the microcontroller through P3.0 and P3.1 pins. Port0 used for transmitting the 8-bit display data to the display and port pins P1.0, P1.1, P1.2 are used for transmitting display drive signals for the corresponding display units D1, D2, D3. Push-button switch S1, capacitor C3 and resistor R9 forms a de-bouncing reset circuitry. Capacitors C1, C2, and crystal X1 are associated with the clock circuit.

2.5 Hardware Design

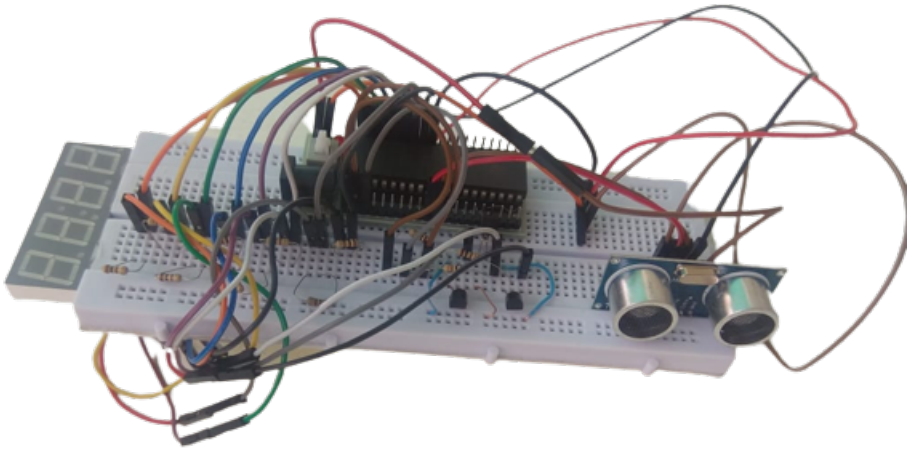


Figure 2.10: Considered Hardware For Ultrasonic Range Finder-A

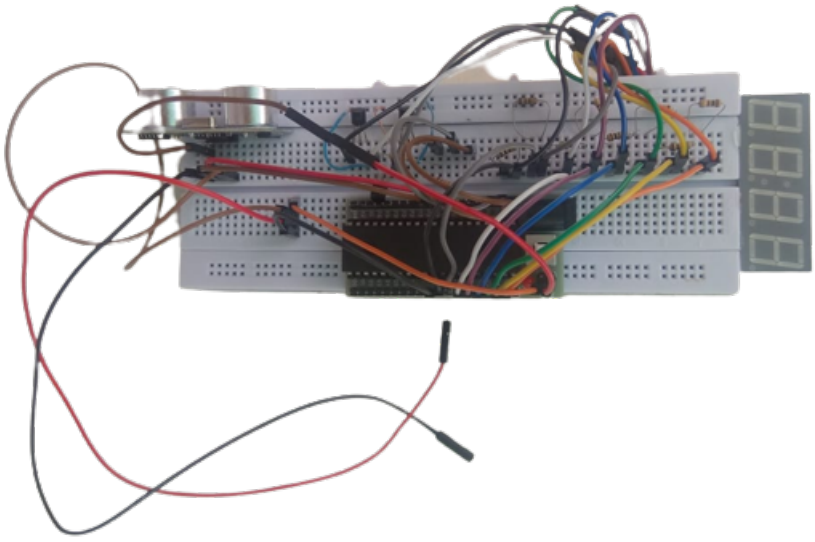


Figure 2.11: Considered Hardware For Ultrasonic Range Finder-B

2.6 Working Of Ultrasonic Range Finder

Ultrasonic sensors work by emitting sound waves at a frequency too high for humans to hear. They then wait for the sound to be reflected back, calculating distance based on the time required. This is similar to how radar measures the time it takes a radio wave

to return after hitting an object. While some sensors use a separate sound emitter and receiver, it's also possible to combine these into one package device, having an ultrasonic element alternate between emitting and receiving signals. This type of sensor can be manufactured in a smaller package than with separate elements, which is convenient for applications where size is at a premium. While radar and ultrasonic sensors can be used for some of the same purposes, sound-based sensors are readily available—they can be had for just a couple dollars in some cases—and in certain situations, they may detect objects more effectively than radar. For instance, while radar, or even light-based sensors, have a difficult time correctly processing clear plastic, ultrasonic sensors have no problem with this. In fact, they're unaffected by the color of the material they are sensing.

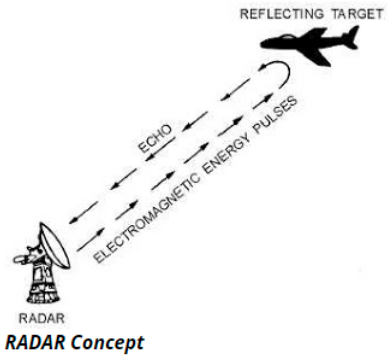


Figure 2.12: Working Of Ultrasonic Range Finder

On the other hand, if an object is made out of a material that absorbs sound or is shaped in such a way that it reflects the sound waves away from the receiver, readings will be unreliable. If you need to measure the specific distance from your sensor, this can be calculated based on this formula

Distance = ½ T x C

(T = Time and C = the speed of sound)

At 20°C (68°F), the speed of sound is 343 meters/second (1125 feet/second), but this varies depending on temperature and humidity.

Specially adapted ultrasonic sensors can also be used underwater. The speed of sound, however, is 4.3 times as fast in water as in air, so this calculation must be adjusted significantly.

2.6.1 How Ultrasonic Range Finder Work

- The HC-SR04 module has ultrasonic transmitter, receiver and control circuit on a single board. The module has only 4 pins, Vcc, Gnd, Trig and Echo.
- When a pulse of 10sec or more is given to the Trig pin, 8 pulses of 40 kHz are generated. After this, the Echo pin is made high by the control circuit in the module.
- Echo pin remains high till it gets echo signal of the transmitted pulses back.
- The time for which the echo pin remains high, i.e. the width of the Echo pin gives the time taken for generated ultrasonic sound to travel towards the object and return.
- Using this time and the speed of sound in air, we can find the distance of the object using a simple formula for distance using speed and time.

Chapter 3

CONCLUSIONS

We've considered the introduction and methodology to obtain the desired objective of projects in previous chapters. This chapter is all about final conclusion of the project.

3.1 Results And Discussions

Microcontroller may be a device that captures input, processes it and generates output supported knowledge captured. it's also called MC or MCU (Microcontroller Unit) which may be a compact digital processor on Metal-Oxide-Semiconductor Chip. Microcontrollers also are called as "special purpose computers". they're dedicated to execute specific task that's programmed and stored in ROM. they're available with on board Memory and I/O Ports which eliminates building a circuit that has separate external RAM, ROM and Peripheral chips. MC's works at lower speeds, and needs less power. These features of Microcontrollers make it a perfect choice for embedded applications.
Using the mechanism of ultrasonic sensor, Interfacing of Ultrasonic module HC-SR04 with 8051 Microcontroller was performed successfully and by moving the object to and fro towards ultrasonic module the distance up to 4 meters was measured correctly.

3.2 Conclusions

In this project, Interfacing of Ultrasonic module HC-SR04 with 8051 Microcontroller using Keil C software was performed successfully and using the mechanism of the ultrasonic sensor the object distance up to 4 meters was measured and this system (HC SR04

ultrasonic sensor) was not able to measure longer distances. hence, for more range, we can try replacing the sensor module.

- As one of our objective was to create a hardware that can measure the distance with the precision of 1cm and we have obtained it by following the steps mentioned in methodology section.
- We've made sensor and module selection very cost effective and at the end our whole hardware was well managed and working according to the initial requirements of project.
- Team work was the key factor in obtaining the desired output and with combination of working together and considerable planing we have completed the desired task ahead of the schedule.

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