PIC Microcontroller Based Ultrasonic Distance Measurement

Y.Ege, H.Çıtak, M.Çoramık, M. Kabadayı, O.Kalender

Abstract— **Classical measurement methods cannot be used at situations in which distance between two objects is constantly changing. Therefore, ultrasonic sound is used for distance measurement because it has high energy, it can easily reflect from hard surfaces and it follows linear-straight path. At ultrasonic distance measurement, the return time of the sound pulse that is generated from sound source is measured and object's distance from sound source is determined by using speed of sound. In the study, 40 kHz ultrasonic ultrasonic receiver-transmitter pair is used for distance measurement. Trigger pulse which is appropriate to ultrasonic transmitter is provided by the PIC microcontroller. The time that passes between transmitter and receiver is evaluated by microcontroller. After that, distance is calculated and displayed on the LCD screen with sensivity of 0.1 cm. Also the data can be recorded with 750 ms sampling time and 12 bit resolution. But recording capacity is limited with PIC's EEPROM. If required, recording capacity can be increased with AT24C512 EEPROM and the data can be transferred into the computer via serial port. In the paper, the distance measuring system developed will be discussed in detail with system's set up and operation.**

Index Terms— **Microcontroller, EEPROM, Ultrasonic receiver-transmitter.**

I. INTRODUCTION

The sounds which have higher frequency than our hearing limit, the range of 300 Hz-14000Hz, are called "ultrasound". High frequency of ultrasound makes the sound waves follow a linear and straight way. Ultrasound can reach long distances because of its high energy and it can easily reflect from hard objects that are in front of it. These characteristics of ultrasound can be used in distance measurement. If the distance changes during the distance measurement constantly, classical distance measurement methods cannot be used in this case. Ultrasound sources are used for determining distance because of the distance constantly changes such as determining the direction of movement, distance determination at automotive and robotic applications, infrared communication applications and object detection studies [1]-[8].

In addition, continuously distance measurement plays an important role for decision-making at algorithms which run according to previous data bank at buried mine detection

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applications. Because, after the help of using algorithm and comparing instant distance and sensor voltage values with the previous ones in the data bank, we can draw a conclusion about buried subject's physical features. At ultrasonic distance measurement, due to the fact that, the time that is passing for back reflection of the sound wave is measured, the sound's speed in the environment is getting more importance. Variables that effect the speed such as temperature, density and humidity of ambient are effective at distance measuring. In the study, distance is measured by using 40 kHz Ultrasonic receiver transmitter pair.

Sending appropriate trigger pulse to the ultrasonic receiver, calculating the time between transmitter and receiver and displaying results on the LCD screen with sensivity of 0.1 cm are done by PIC microcontroller. Also the data can be recorded with 750 ms sampling time and 12 bit resolution. But recording capacity is limited with PIC's EEPROM. If required, recording capacity can be increased with AT24C512 EEPROM and the data can be transferred to the computer via serial port.

In the next parts of paper, set up and operation of the measuring system will be explained in detail.

II. MATERIAL AND METHOD

First of all, 40 kHz ultrasonic receiver – transmitter pair, PIC 16F877 Microcontroller, LCD Panel, Max 232 serial port driver, DS1307 real-time clock and AT24C512 EEPROM are provided to develop our distance measurement system. These are shown at Fig.2.1 with connection diagrams.

In the study, PIC16F877 Microcontroller generates starting pulse for transmitter, measures reflected pulse's width which comes to receiver (Fig.2.2), measures distance with operating the calculation code, sends measured value to LCD panel, and records calculated value to memory (AT24C512) in accordance with real-time clock (DS1307).

The ultrasonic receiver transmitter pair used in the study has an effective area about 3.3 m. Therefore, the subjects which are further away than 3.3 m cannot be determined with this measurement system.

In addition, if the angle between transmitter which sends starting pulse and object is above 45 degrees, the ultrasonic sound coming to receiver from object gets weak and measurement error is occur. If it is desired to assign small objects with ultrasonic receiver transmitter pair, it should be held in an upright position (Fig.2.3)

Ultrasonic receiver-transmitter pair gives error above 11-12 percentage of 0-70 °C.

(a)

(b)

(c)

(d)

(e)
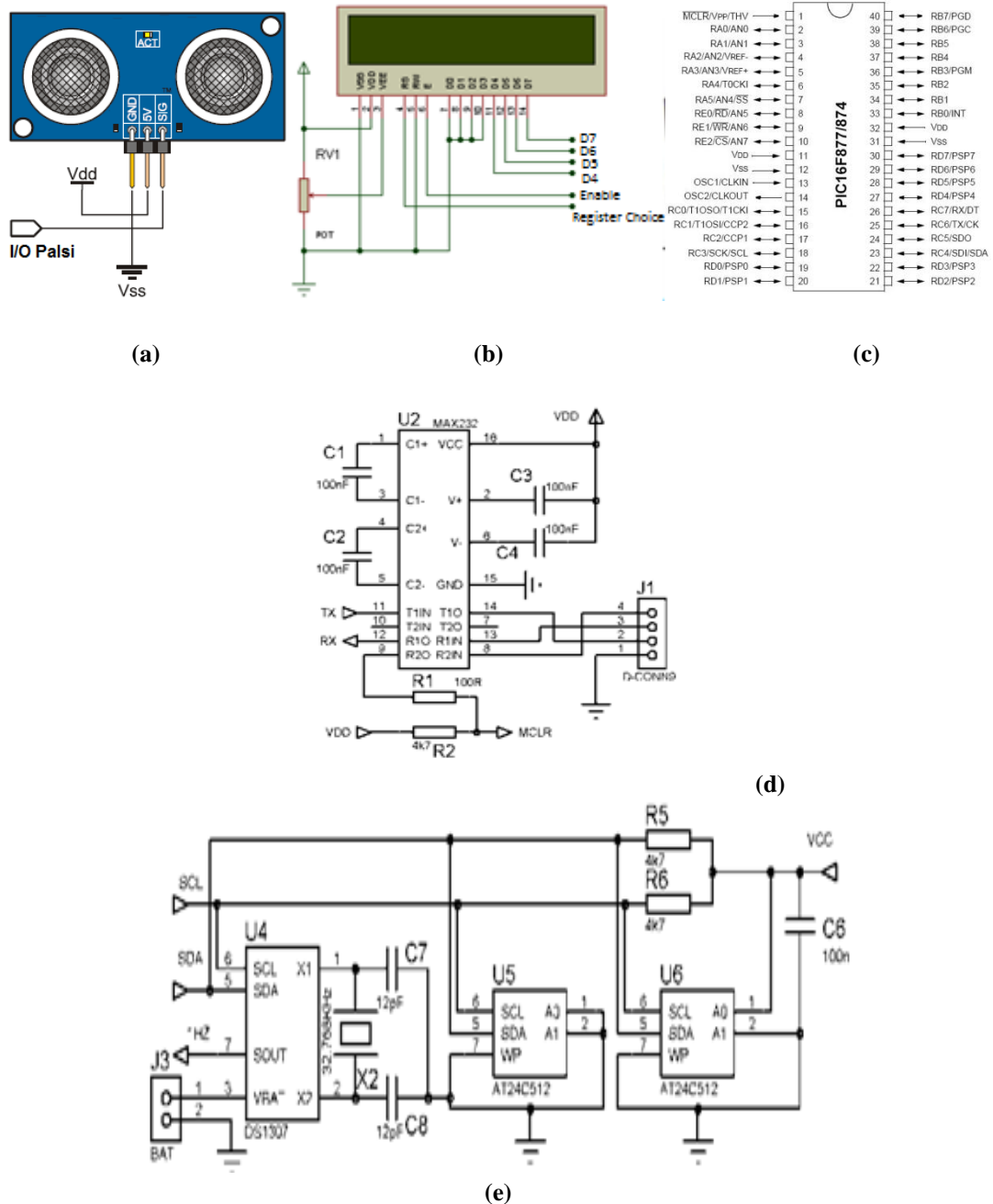
Fig.2.1: (a) Ultrasonic receiver – transmitter pair, (b) LCD Panel, (c) PIC 16F877 Microcontroller, (d) Max232 Serial Port Driver, (e) DS1307 Real-time clock and AT24C512 EEPROM.
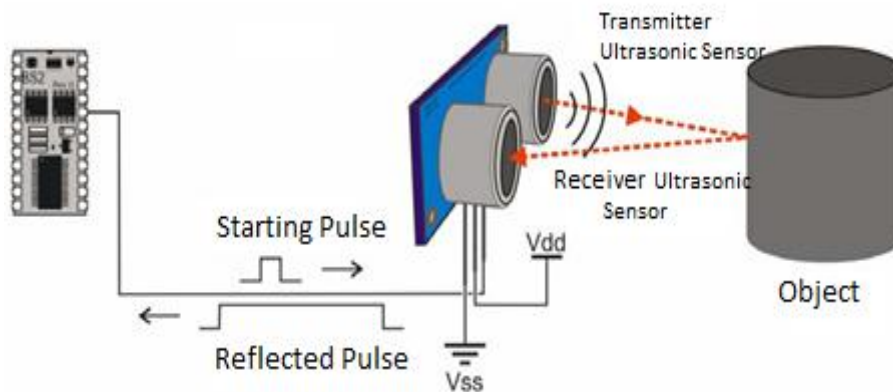

Fig.2.2: Operation of ultrasonic receiver – transmitter pair [5].

Fig.2.3: The application conditions of ultrasonic receiver – transmitter pair [6].

At Fig.2.4, the effective area of receiver – transmitter pair from 1 m is given for cylindrical object (diameter: 8.9 cm, object (length: 30.5cm, width: 30.5 cm thickness: 2.5 cm). As it is seen at Fig.2.4, the geometry of the object is effective on the correct determining area of the measurement system. For be paid attention to subject receiver-transmitter is in the direction of surface normal.

height: 121.9 cm) and prismatic

this case, while the distances of subjects with prismatic geometry are being determined, it should
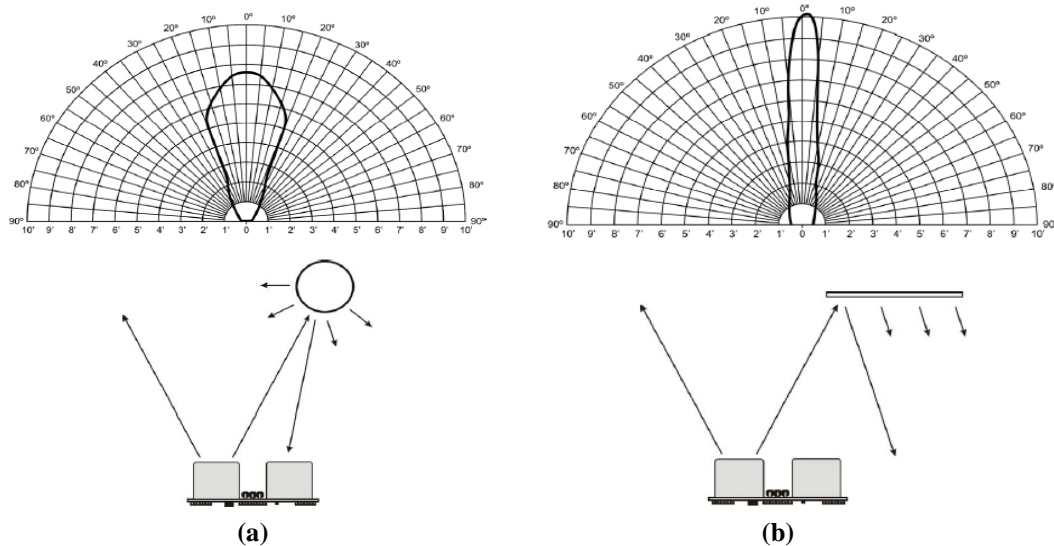
Fig.2.4: The active area of distance measurement for (a) cylindrical, (b) prismatic objects [6].

At distance measurement, the distance with transmitter and receiver is very important for increasing the effective area. The increase of the distance between transmitter and receiver effects effective area as Gaussian not as linear.

Thus, the distance between receiver and transmitter should be kept an optimum value. Surely, for distance settings, the transmitter and receiver must be separated (Fig.2.5).

Speed of sound in air is an important variable at calculations which are made by PIC 16F877 at distance measuring system. Speed of sound in air varies with ambient temperature.

$$V_{Hair} = 331.5 + (0.6 \times T) \text{ m/s} \tag{1}$$

Subject distance can be calculated with;

$$S_{Object-m} = (V_{air} \times t) / 2 \text{ m}$$

Here, the "t" value indicates to the width of reflected sound wave pulse that is formed in receiver in terms of second.

The distance of object for the ambient temperature of 22.2 ^{0}C can calculate with;

$$S_{Object-cm} = 0.03448 \times t_{reflected-pulse} \tag{2}$$

$$S_{object-cm} = 0.03448 \times t_{reflected\ pulse} \tag{3}$$

Here, the most important issue is to determine reflected pulse width correctly with PIC 16F877. The circuit diagram of distance measurement system which is developed by us is given at Fig.2.6. It should be given +5V from 5 kΩ resistance to the first pin of microcontroller in order to make the program in PIC16F877 microcontroller active. PIC Basic Pro programming language is used to program PIC16F877 microcontroller. The flow diagram of written program is shown in Fig.2.7.

(a)

(b)

Fig.2.5: Circuit diagrams for Independent ultrasonic receiver and transmitter

(a)

(b)
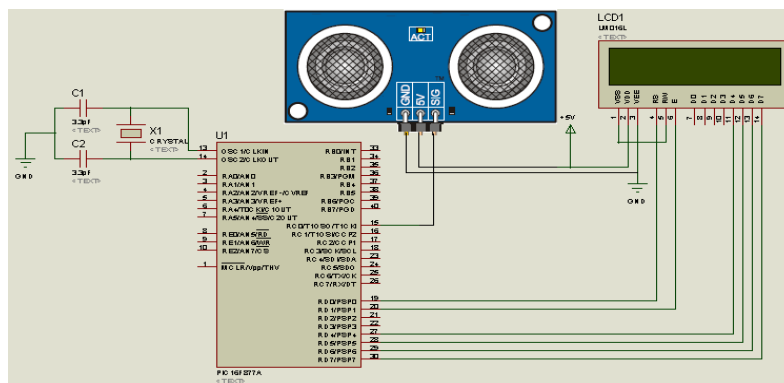
Fig.2.6: (a) Circuit diagram of distance measurement system b) photograph of distance measurement system

Distance is measured and sent to the serial port as well as the LCD panel at one cycle of the program. In the study, the connection with the computer is made by taking outputs from 25th and 26th pins of microcontroller to the serial port. The case that, at which speed and resolution the communication by serial port will be made is identified with both microcontroller and Visual Basic based program that is developed for data intake from serial port. VB based program's interface is shown in Fig.2.8.

III. DISCUSSION AND CONCLUSION

In this study, 40 kHz ultrasonic transmitter-receiver pair is used for distance measurement. Trigger pulse that is appropriate to ultrasonic transmitter is provided by PIC microcontroller. The time passed between transmitter and receiver is evaluated by microcontroller. After that, distance is calculated and displayed on the LCD screen with sensivity of 0.1 cm. Also the data can be recorded with 750 ms sampling time and 12 bit resolution. But, recording capacity is limited with PIC's EEPROM. If required, recording capacity can be increased with AT24C512 EEPROM and the data can be transferred into the computer via serial port. Transmitter-receiver pair can be measured at the maximum distance of 3.3 m and it should be operated at the distance between 0-70° C. It would be more appropriate to use ultrasonic transmitter and receiver separately for creating a large effective area. In addition, the geometry of material is also important at determining the distance.

Because of the fact that, effective area for cylindrical samples are higher, range determination can be done more reliable in cylindrical samples. At the range determination of small subjects, receiver-transmitter module should be at the opposite of the subject. The angle between the surface normal of ultrasonic receiver-transmitter module and the subject should be in the range of 45 degree. Being open to every kinds of addition and its low cost are the advantages of our developed distance measurement system.

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