Determination and Detection of Blind Zones in Vehicles Based on Microcontroller

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Abstract

In this paper, the PIC microcontroller (١٦F٨٧٧A) based on ultrasonic (PING) sensor is developed to determine and detect the blind zones in vehicles in addition it measures the distance of targets approaching a vehicle for avoiding lateral collisions and providing a safe driving. The temperature sensor (LM٣٥) circuit has been added to proposal hardware circuit to improve the precision in case of changing weather temperature in different seasons.

One of the benefits of this system is its ability to detect and alert the driver when a vehicle is in danger of collision, thus increasing the safety of not only the driver, but of the vehicle itself. The proposal system has low-cost, the implementation of convenient, easy to-use, flexible.The ranging values are real-time displayed in high precision and stable performance through the Liquid Crystal Display (LCD) which update for each second.

The software design of the proposal system is carried out by Proton IDE Basic program. This program is high-level language which is employed to program microcontroller.

Keywords: *Ultrasonic (PING) Sensor; Temperature Sensor; PIC ١٦F٨٧٧A Microcontroller.*

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تحديد وكشف المناطق العمياء في المركبات بالاعتماد على المسيطر الدقيق

الخلاصة

في هـذا البحـث تـم اعتمـاد المسـيطر الـدقيق للسـيطرة علـى المتحسـس الـذي يعمـل بـالترددات فـوق الصـوتية نـوع PING وتـم تطـويره لغـرض تحديـد وكشف المنـاطق العميـاء فـي المركبـات بالاضـافة الـى قيـاس المسـافة للأهـداف(المركبات الاخـرى) التـي تقتـرب مـن المركبـة المعنيـة لغـرض تجنـب الاصطدام الجـانبي وتقـديم قيـادة مركبـات أمنـة وقـد تـم استشـعار درجـة الحـرارة عـن طريـق المتحسـس LM ٣٥ وتـم اضـافته الـى التصـميم

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المقتـرح للـدائرة الالكترونيـة لغـرض تحسـين دقـة قيـاس المسـافة فـي حالـة تغيـر درجـة حـرارة الطقـس فـي المواسم المختلفة.

ومـن فوائـد هذا النظام هـو قدرتـه علـى كشف وتنبيـه السـائق عنـدما تكـون المركبـة فـي خطـر الأصطدام، وبالتـالي زيـادة سـلامة السـائق، لـيس فقـط، ولكـن سـلامة المركبـة نفسـها إلمنظومـة المقترحـة ذات كلفـة منخفضـة وتنفيـذها مـرن وسـهل الاسـتخدام والقـيم المقاسـة للمسـافة تعـرض بـالزمن الحقيقـي وبدقـة عاليـة واداء مسـتقر على شاشة الكريستال السائل LCD وهذه القيم تحدث كل ثانية.

ان تصـميم البرامجيـات للمنظومـة المقترحـة تـم تنفيـذها باسـتخدام لغـة بروتـون بيسك Proton BasicIDE وهي من اللغات المتقدمة لكتابة البرامج والتي يستخدمها المسيطر الدقيق.

١. Introduction

The ultrasonic ranging system has been applied in various applications, i.e., vehicle navigation, autonomous robotic control and distance measurement [١-٣]. Because of the low cost and ease in implementation, the ultrasonic sensor based on PIC١٦F٨٧٧A microcontroller is used to detect blind zones at both back sides of a vehicle during driving to avoid a lateral collision often causes severe traffic accidents. To improve visibility and avoid these blind zones are essential for driving in urban area at low speeds as there exist an increasing number of motorcycles, bicycles and pedestrians in city traffic.

Several researchers have studied sensing systems for avoiding of traffic accidents. Existing sensor systems onboard a vehicle for lateral object detection can be classified into four types: First, radar system: Some vehicular radar may even detect the shape of an object, [٤ and ٥].However, the vehicular radars usually have a smaller view field and have their blind spots. The range of the blind spots correlates with the number of the installed vehicular radars. Besides, the vehicular radar has a limited detection distance and is hard to detect an object moving in a large area. Second, infrared communication with low-cost and simple control of the implementation, easy-to-use and transmission characteristics of high reliability, is a more common means of communication. Infrared communication as a short-range wireless communications, has been widely used in single chip microcomputer (SCM)[٦-٩].

Infrared sensor system has been used for parking assistance of passenger cars, although infrared sensor is the most frequently used sensing device in vehicles to avoid blind zone [١٠ -١٢].It is not effective at different environment factors (temperature, humidity and etc). Third, Vision system, cameras are utilized to detect the side space of a car. The system can be installed near the rear-view mirror [١٣ and ١٤]. However, vision systems cost much computation time to extract useful information. Real-time performance is a challenge issue for vision-based systems. Lighting condition will also influence the image acquisition. It would be difficult to be used during the night. Finally, ultrasonic sensor system: This type of sensor has been widely used for environment detection and avoidance of accidents [١٥-١٧]. It has wide detection angle and offers a less expensive solution. However, the drawback of this type of sensor is that ultrasonic waves are transmitted through air and the reflex surface texture will affect the measurement.

The organization of this paper is as follows. The definition of blind zone and ultrasonic (PING) sensor is first introduced in Section (٢ and ٣). Principle of Ultrasonic Distance Measurement is then described in Section ٤. The PIC١٦F٨٧٧A microcontroller is discussed in Section ٥. Next, in Section ٦, hardware and software design are introduced. Next, in Section ٧, the results of proposed system are presented. Finally, concluding remarks and observations are given in Section ٨.

٢. Blind Zone Definition

The areas most commonly referred to as blind zones are the rear quarter blind zones, areas towards the rear of the vehicle on both sides. Vehicles in the adjacent lanes of the road may fall into these blind zones, and a driver may be unable to see them using only the car's mirrors. Other areas that are sometimes called blind zones are those that are too low to see behind and in front of a vehicle. Also, in cases where side vision is hindered, areas to the left or right can become blind zones as well [١٨]. Fig.١ below shows the blind zones for both sides.
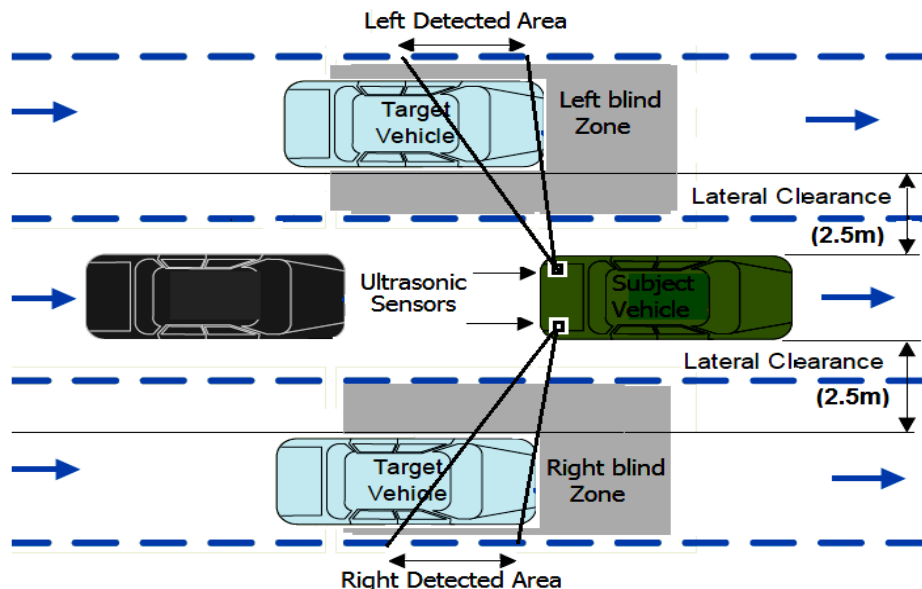

Fig.١: The blind zones of the vehicle on both sides.

٣. Ultrasonic (PING) Sensor

The Parallax (PING) ultrasonic sensor provides precise, non-contact distance measurements from about ٢ cm to ٣ meters. The PING sensor works by transmitting an ultrasonic (well above human hearing range) burst and providing an output pulse that corresponds to the time required for the burst echo to return to the sensor as shown in Fig.٢. By measuring the echo pulse width, the distance to target can easily be calculated [١٩].

Such a sensor is in fact a compound device consisting of an ultrasonic emitter and the "proper sensor" whose role is to detect the reflected signal sent by the emitter. The device is triggered by a pulse from the microcontroller forcing it to emit a ٤٠ kHz burst to the environment.
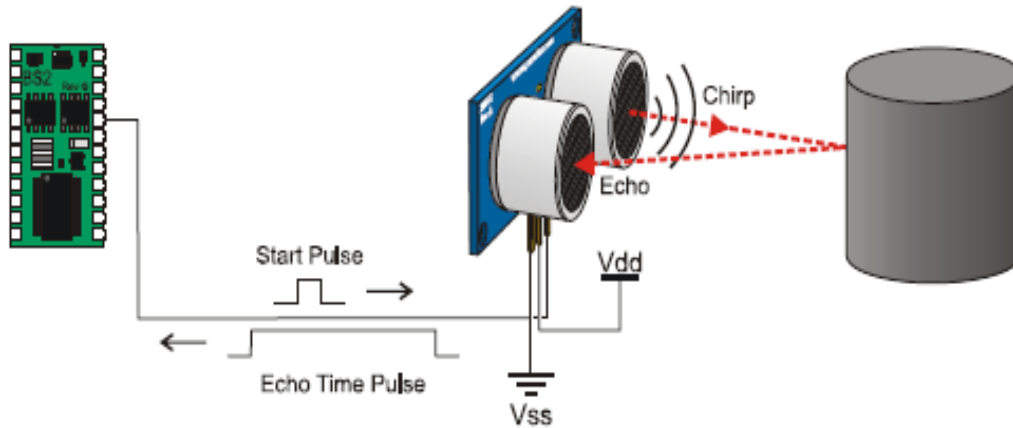
Fig.۲: Principles Parallax (PING) ultrasonic sensor.

Following the end of the burst, the microcontroller is expected to measure the amount of time elapsing until the arrival of the reflected signal, as perceived by the sensor. Fig.۳ shows a timing diagram illustrating the typical operation of a PING sensor and defines some period tabulated in table (۱). The simple interface consists of a single pin operating in two directions. Initially, the pin acts as input to the sensor. A measurement starts when the microcontroller pulls the pin high for a short interval t_{OUT} (the SIG phase) and then switches to monitoring the pin status. In response, the sensor will pull the pin low while it emits the ultrasonic burst, which takes the $t_{HOLDOFF}$ interval. Then, the sensor pulls the signal high (the t_{IN} phase) until it perceives the reflected signal, at which time it will pull the pin down. Thus, t_{IN} directly determines the distance between the sensor and the reflecting object. The amount of time separating the end of a measurement (the signal going down) from the beginning of the next one (the initial pulse sent by the microcontroller) is denoted by t_{DELAY}[۲۰ and ۲۱].
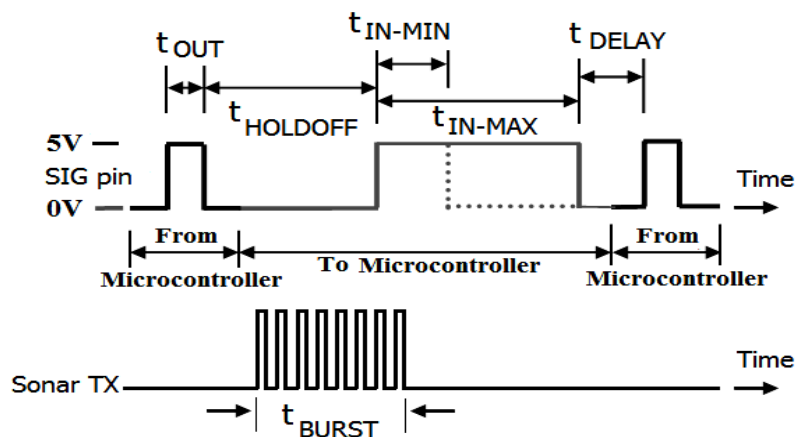

Fig.۳: Time diagram of ultrasonic PING sensor.

In this paper, the ultrasonic (PING) sensor system is selected considering the following advantages:

- It is less expensive and will be suitable for general applications.
- It is easy to program with microcontrollers.
- It can easily obtain distance information up to ۳.۳m.

- It has wide surface measurement, not just single point detection.

Table (١): The period of each signal

	Host Device	Input Trigger Pulse	t_{OUT}	2 μs (min), 5 μs typical
	PING))) Sensor	Echo Holdoff	$t_{HOLDOFF}$	750 μs
		Burst Frequency	t_{BURST}	200 μs @ 40 kHz
		Echo Return Pulse Minimum	t_{IN-MIN}	115 μs
		Echo Return Pulse Maximum	t_{IN-MAX}	18.5 ms
		Delay before next measurement		200 μs

٤. Principle of Ultrasonic Distance Measurement

The Ultrasonic wave propagation velocity in the air is approximately ٣٤٠ m/s at ١٥°C of air or atmospheric temperature, the same as sonic velocity. To be precise, the ultrasound velocity is governed by the medium and its temperature hence the velocity in the air is calculated using the formula (١) below [٢٢].

$$v = 340 + 0.6(T - 15) \dots \dots \dots \dots \dots \dots \dots \dots (1)$$

Where: v is the acoustic propagation velocity in m/s , and T the temperature in °C.

In this paper, a room temperature of ١٦ °C is assumed; hence the velocity of ultrasound in the air is taken as ٣٤٠٫٦ m/s. Because the travel distance is very short, the travel time is little affected by temperature. It takes approximately ٢٩.٣٦μsec for the ultrasound to propagate waves through ١cm distance; therefore it is possible to have ١cm resolution in the system [٢٣].

The speed of sound in the medium is known constant.The distance between the transducer and the reflection is [٢٤ and ٢٥].

$$S = \frac{1}{2}v.\Delta t \; \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (2)$$

Where v is the speed of sound in a medium and Δt the time between the transmitted pulse and the received echo pulse.The time monitored as seen in equation ٢ actually corresponds to double the distance to be measured, and thus divided by two.

٥. PIC١٦F٨٧٧A Microcontroller

Microcontrollers are embedded digital control devices, which have a central processing unit, interrupts, counters, timers, I/O ports, RAM, ROM/EPROM, are used to systems' control. The PICs (peripheral interface controllers) are the integrated circuits based on CMOS technology. The main components of a PIC are RAM, EPROM, EEPROM, and Peripheral Interface Adaptor (PIA). These components are inserted in the same integrated circuit to reduce the size, the cost of the system and make design of system easier.

The address bus, the data bus and the control bus connecting the components are placed into the PIC circuit by the manufacturer. Because of these advantages, PICs have been preferred devices in practical control applications. The PIC١٦F٨٧٧ used in this work operates at ٢٠ MHz clock frequency and runs each instruction as fast as ٢٠٠ ns. Flash Program Memory is up to ٨K×١٤ words. Data memory is partitioned into four banks, which contain the General Purpose Registers and the Special Function Registers. Bits RP١ and RP٠ are the bank select bits. Each bank extends up to ٧ Fh (١٢٨ bytes). It contains ١ K EEPROM as a program memory, ١٥ special hardware registers, ٣٦ general-purpose registers, and ٦٤ byte EEPROM as a data memory. PICs have been mostly preferred control devices because of their low cost, less energy consumption and having small volume in design [٢٦ and ٢٧].

٦. Hardware and Software Design

In this paper, PIC١٦F٨٧٧ microcontroller is used to determine and detect of blind zones in vehicles by using ultrasonic (PING) sensor. This system is also supported by temperature sensor (LM٣٥) to solve problems which occurs at increasing or decreasing temperatures degrees; in addition to correct distances reading. The circuit diagram and hardware circuit of the proposed system are shown in Fig. ٤, ٥ respectively.

The software is written by using Proton Basic IDE; the Proton language is a high level language consisting of ١٦٥ instructions. The proposed coding by using Proton IDE compiler and Software flowchart of the proposed system are respectively shown in Fig. ٦, ٧.
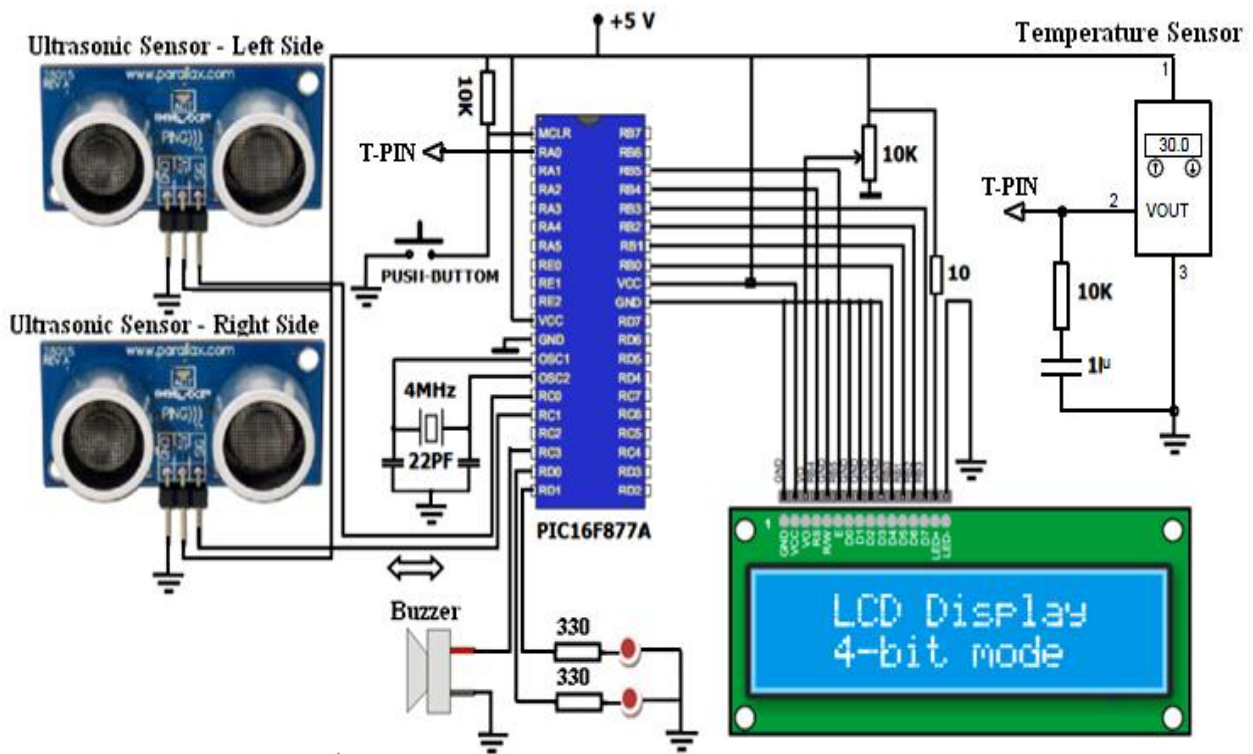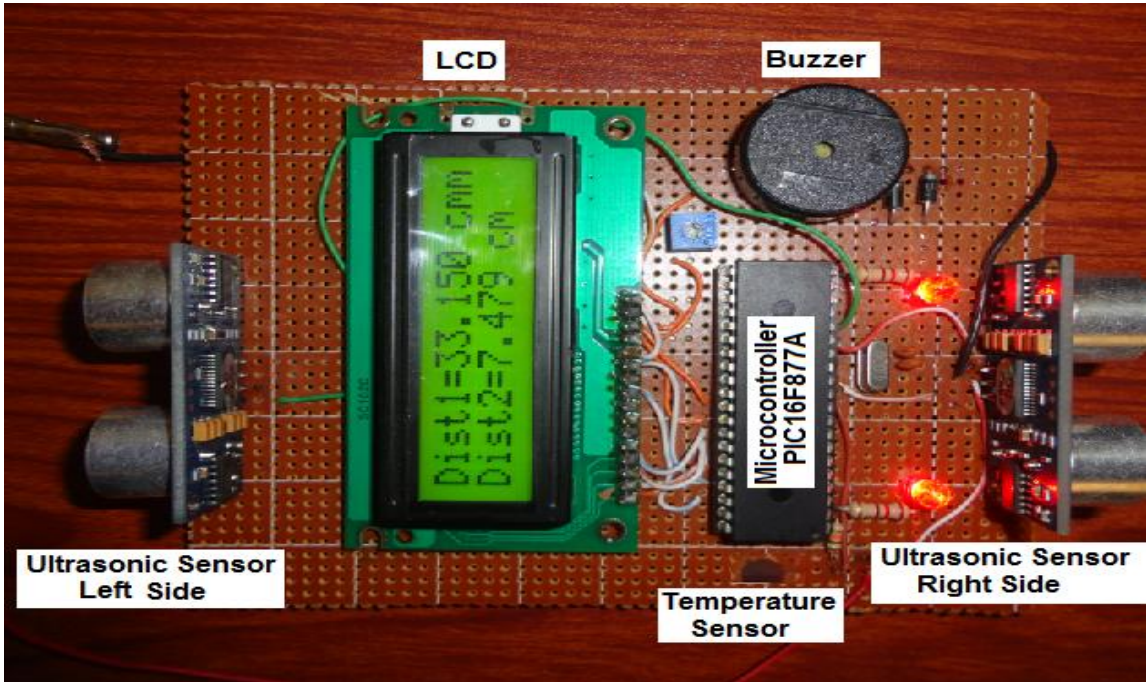

Fig.٤: Circuit diagram of proposed system.
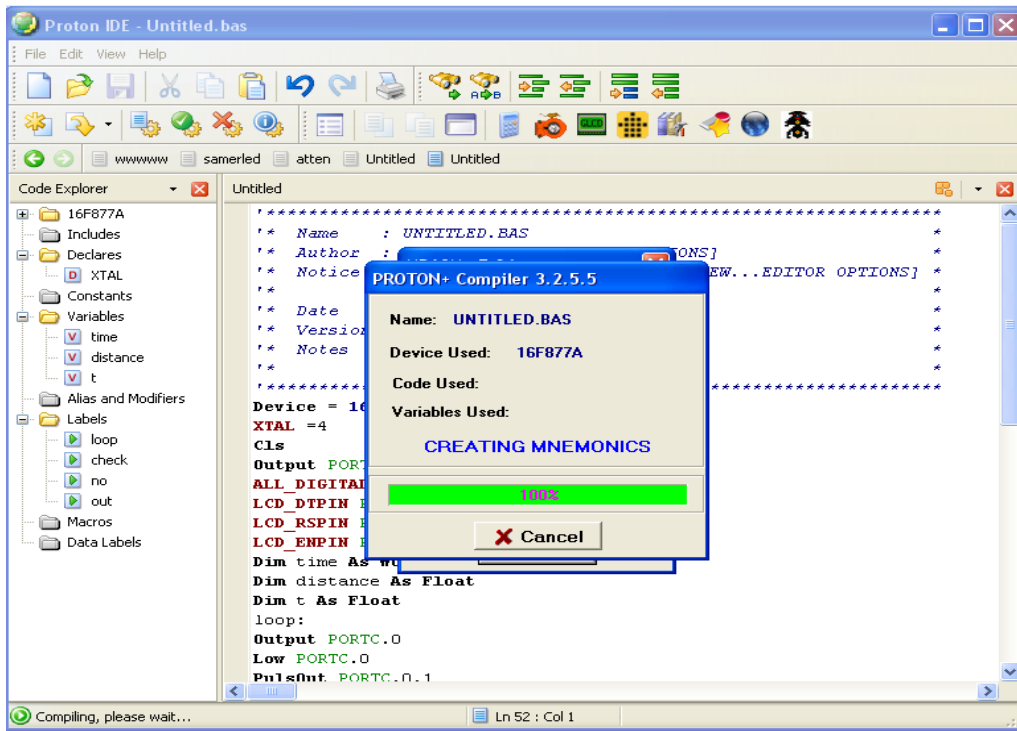
Fig.٥: Hardware circuit of proposed system.

Fig. ٦: Proton IDE coding of main program.

START

Initialize
PORTA as Input (Analog)
PORTB as Output port
PORTC as Output port

Initialize
LCD

Declare the variables
(tim١,time٢ and raw) as
Word sized

**Create a ٣٢-bit floating
point variable**
(distance١,distance٢,t١,t٢
,v,and raw)

Set the A/D convertor
-Resolution ١٠-bits
Choose RC oscillator for
ADC samples
-charge time١٠٠µs
-set PORTA analog port

Loop

L

PORTC equal to zero

Output ١٠µs pulse width
on PORTC (RC٠ and RC١) as
input to both ultrasonic
Sensors

Ultrasonic transmitter
transmit ٤٠KHz from both
Ultrasonic sensors

Measure the echo time
of the transmitted signal

Measure temperature
raw=ADIn٠
temp=(٥/١٠٢٣)*raw
temp=temp*١٠٠٠
temp=temp/١٠

Measure time
t١=tim١/٢
t٢=time٢/٢

Calculate a speed velocity
V=٣٤٠+٠,٦(T-١٥)

Calculate distance
Distance١=(v*t١)/١٠٠٠
Distance٢=(v*t٢)/١٠٠٠

**Is
Distance١
Less than
٢,٥m**   NO

YES

Alarm ON

Alarm OFF

**Is
Distance٢
Less than
٢,٥m**   NO

YES

Alarm ON

Alarm OFF

**Is
No echo
for both
Ultrasonic**   NO

YES

**Print on LCD
No**

Return to the Loop (L)

**Print on LCD
Distance١ in cm
Distance٢ in cm**

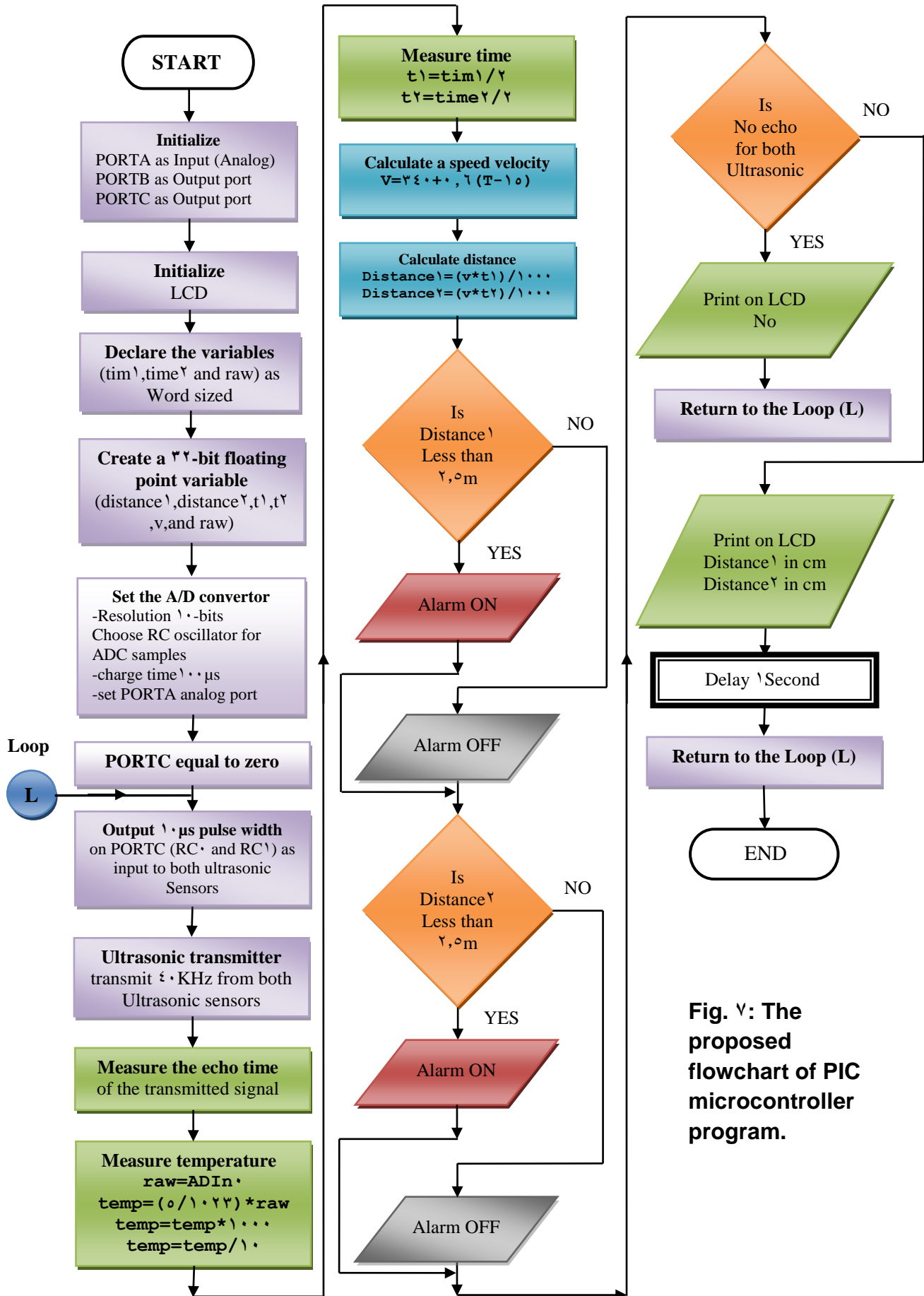**Delay ١Second**

Return to the Loop (L)

END

**Fig. ٧: The
proposed
flowchart of PIC
microcontroller
program.**

٧. Results

The results of the proposed system are discussed in this section. The results can be seen in LCD display at different distances (٥, ١٠, ٢٠, ٥٠, ١٠٠, ٢٠٠, and ٢٥٠) cm respectively from ultrasonic sensor- Left side (results are similar in Right side) as shown in Fig.٨, ٩,and ١٠ below; in addition to buzzer alarm appearing within the range (٠,٥cm-٢٥٠ cm). The message "out of range" will appear at distance longer than ٢٥٠ cm for both sides.
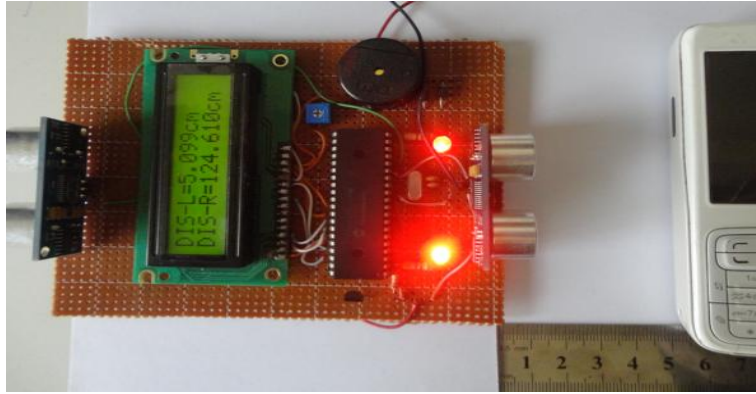

Fig.٨: LCD presents distance between target and PING sensor at ٥cm.
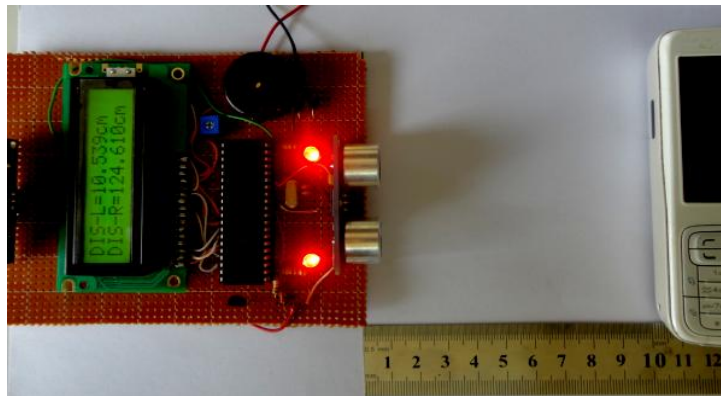
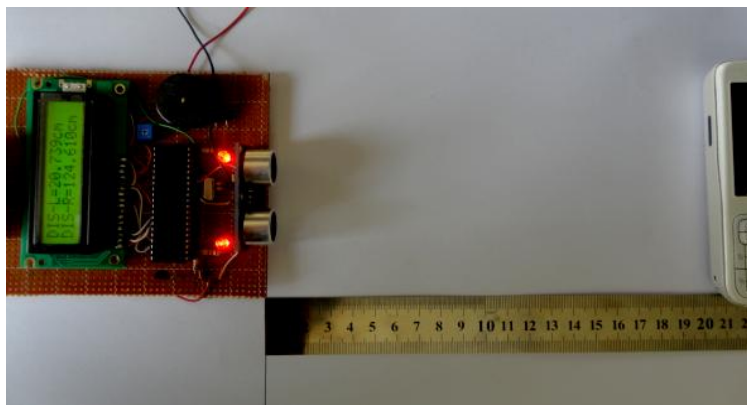**Fig.٩: LCD presents distance between target and PING sensor at ١٠cm.**

Fig.١٠: LCD presents distance between target and PING sensor at ٢٠cm.

To examine the capability of the distance measurement of the proposed system, the results of the actual distance, compared with the measured distance (٥-٢٥٠) cm at room temperature

(١٦°C), can be shown in Fig.١١. The actual distance between the ultrasonic transducer and an obstacle was calibrated by using metal ruler as shown in Fig.٨, ٩, and ١٠ .This measurement started from ٥cm to ٢٥٠cm.Also the errors in measured distance is drawn with respect to actual distance as shown in Fig.١٢.
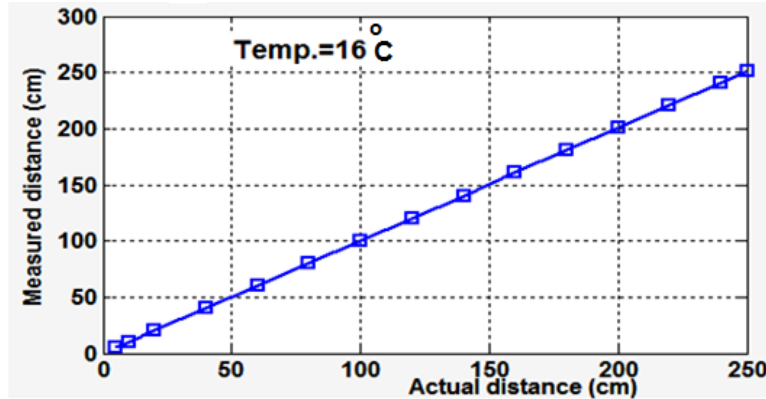

Fig.١١: Actual distance vs. measured distance at room temp.
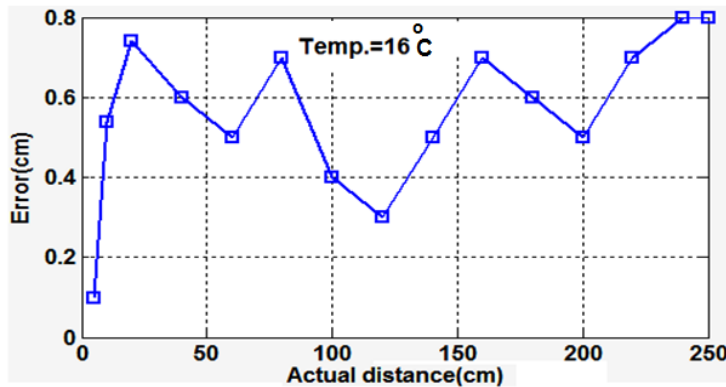

Fig.١٢: Error in measured distance vs. actual distance at room temp.

The effects of temperature on the measurements were investigated by holding the relative humidity constant and varying the temperature between ٠ and ٥٠ °C .By applying equation(١) was mentioned previously in section (٤) the speed of sound is calculated and drawn as shown in Fig.١٣.
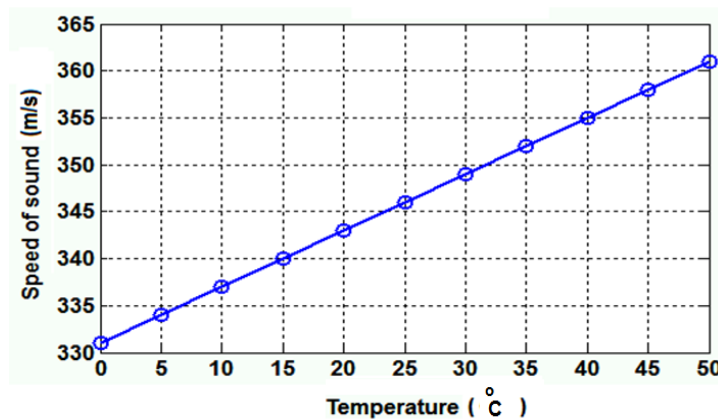

Fig.١٣: Relationship between temperature and speed of sound.

The temperature in this paper was adjusted (١٥°C to ٥٠°C) by adding heat source between ultrasonic transducer and obstacle which far ١٥cm from transducer. The distance measurement with and without correction is obtained as shown in Fig.١٤.
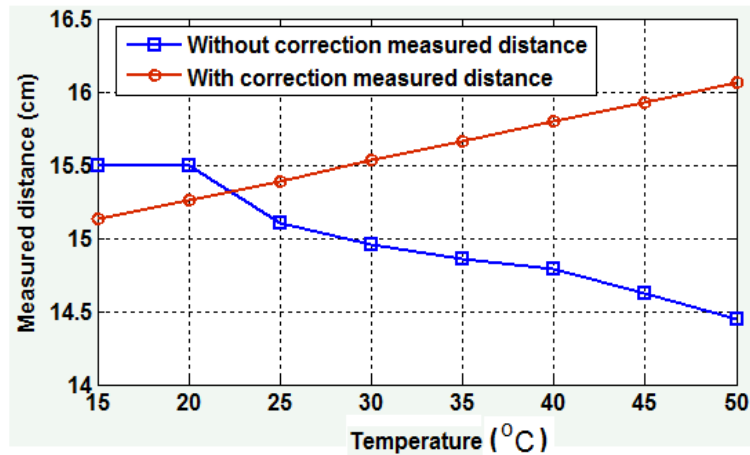

Fig. ١٤: Distance varying with different values of temperature.

٨. Discussion

In the proposed system which shown in Fig.٥ the results were obtained to measure the distance was accurately and clearly with real-time as shown in the Fig.٨،٩ and١٠ ,the rang of this distance starts from ٢ cm to ٢٥٠ cm maximum , this range refers to the possibility of an accident and the situation will be critical ,therefore the system will be give alarm sound for the purpose of alerting the driver to avoid the collision, at the same time the system shows the distance on the LCD in addition to shines a light emitting diode (LED) for the purpose of observation by the driver of the vehicle to avoiding the accident. That is to say there are three cases of alerting for the purpose of avoiding the accident.In the absence of the three cases above, it means that no vehicles in the blind zones.

The relationship between the actual distance which measured by using metal ruler and the measured distance by using proposed ultrasonic system was shown in Fig.١١, the measurements have some errors as shown in Fig.١٢, these errors was limited between (٠ to ٠,٨) cm at room temperature (١٦ °C) ,it is acceptable especially at greater than ١٥٠cm the errors were oscillating ٠,٣cm between (٠,٥ to ٠,٨) cm.

By applying equation (١) the relationship between temperature and speed of sound was obtained as shown in Fig.١٣, this leads us to this system offers high-precision of distance measurements because it used temperature sensor LM٣٥ to correct the measure distance at different values of temperature degrees .The measuring distance was decreased by rising of temperature without correction factor where as it was increased by rising temperature with correction factor as shown in Fig.١٤.

٩. Conclusions

Several conclusions can be observed in this paper as follows:

a. The PIC microcontroller based on ultrasonic (PING) sensor and temperature sensor has been designed and implemented successfully to determine and detect the blind zones in both sides of vehicles. The hardware implementation result is presented to verify the feasibility of the system.

b. The proposed system based on PIC microcontroller offers high performance ranging systems at low cost, and hence is suitable for commercial and industrial applications.

c. The proposed system can be used for other application such as distance measurements, robots, fluids level meter etc…

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