



Blind Person Verification Using Temperature Compensated Ultrasonic Ranging

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ABSTRACT

It contains a method to implement a mobility aid for blind person and also can be used in automatic robots, self-propelling vehicles in automated production factories etc. Model contains signal processing unit with PIC microcontroller which receives data from Ultrasonic sensor and Temperature sensor then processed it and delivers it to the computer using serial input/output port & gives alert to the blind person using voice processor with earphone. This paper contains a method to implement a mobility aid for blind person and also can be used in automatic robots, self-propelling vehicles in automated production factories etc. Model contains signal processing unit with PIC microcontroller which receives data from Ultrasonic sensor and Temperature sensor then processed it and delivers it to the computer using serial input/output port & gives alert to the blind person using voice processor with earphone. Paper contains temperature compensation method to reduce the error in measurement of distance using ultrasonic sensors. Signal processing unit contains PIC microcontroller which is used for interfacing between different sensors and computer. Then received data is verified using MATLAB. The main advantage of this project is its simplicity and feasibility. In future the analysis can be done for different materials so that effect of all material can be analysed. Other factors such as humidity and pressure can also be included so that the combined compensation can reduce more error. Then received data is verified using MATLAB.

Keywords — Human machine interface, MATLAB, PIC, Signal Processing unit, Temperature compensation, Ultrasonic sensor, Voice processor.

1. INTRODUCTION

There are various methods to measure the distance of obstacle. One of the methods is by means of ultrasonic. Ultrasonic sensors have several applications in electronics and robotics including obstacle detection and avoidance, mapping and navigation, object recognition and identification. In this paper firstly we provides information about the ultrasonic sensors based on the output waveform whose pulse width varies with round trip delay time of sonic pulse or distance measured & Temperature sensor with processing unit. In the second part the paper will describe how to build an ultrasonic distance measurement system using temperature compensation. We proposed an ultrasonic method with temperature compensation to reduce the error in distance measurement using sensors. The sensors were tested both on static frame and on real machine detecting different obstacles from 60 cm up to five meters. The results are better when the object is in front or moving along the axis of the sensor. The Sensors are connected in series and are in ranging mode all the time.

The experimental results show that the environmental factors like, air turbulence and temperature change affect the speed of sound in air and measuring range. The ranging value is better indoors than the outdoors for same obstacles. However, the results are better on less windy day and also when the surface is strong reflector. It is noted that the results get improved when a cone made of paper or plastic is wrapped around the transducer. The sensor is protected with a water proof casing made of PVC plastic material and it is noted that the casing made of aluminum does not yield good results as compared with the plastic casing. The two or more sensors attached in line increase the covering area of the system.

2. SYSTEM ARCHITECTURE

The setup consists of different sensors like ultrasonic sensor and the temperature sensor as the input units. Different types of ultrasonic sensor and temperature sensors are available in the market. Ultrasonic sensor measures the round trip delay which is directly proportional to output pulse width so that distance measured. Temperature sensor measures the environment temperature in which the device operates. The distance measured varies with environment temperature so temperature compensation is necessary. The processing unit provides power to other devices and its main function is to provide an interface between sensors and computer. The block diagram of proposed hardware is shown in Fig. 1.

The microcontroller triggers the ultrasonic sensor and receives echo and also communicate with the temperature sensor. The microcontroller collects information from ultrasonic sensor and environment temperature from temperature sensor. It computes the distance with temperature compensation using the formula given in equation (2). The



microcontroller works on the 5v TTL signal and the computer receive serial data RS-232 interface so MAX-232 IC converts TTL to the RS-232 signal. The serial data are Pulse width, temperature and distance with temperature compensation. The serial data is displayed on PC using Micro C software which plays as a human machine interface. The alert is given to user by voice processor with earphone. Alerts are based on various conditions as HELP, STOP, WALK, DANGER etc. The received data is analyzed using MAT LAB.

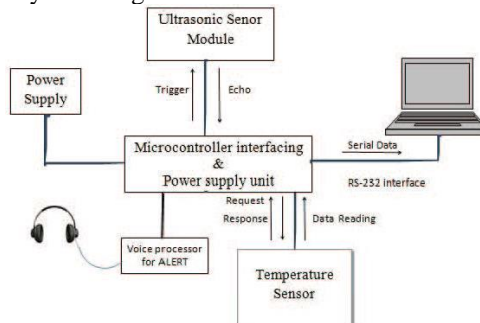


Fig.1 : Block Diagram of set up

3. PROPOSED HARDWARE DESIGN

Distance of obstacle depends upon speed of ultrasonic and time required to traveling it. If the time required in traveling the pulse from sensor to object and return back to sensor can be measured than the measurement of distance can be done. This can be achieved by using an ultrasonic module which can give the time waveform on C.R.O. in terms of pulse width. The output pulse width will vary in proportional to the distance travel by the ultrasonic wave.

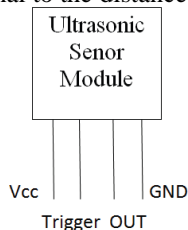


Fig 2: Pin diagram of Ultrasonic sensor

The sensor transmits an ultrasonic wave and returns an output pulse that is directly proportional to round trip delay. By measuring the pulse width of output wave, the distance to target can easily be calculated. The ultrasonic sensor produces Pulse width in the output. Ultrasonic sensor contains 4 pins these are Vcc, Trigger, OUT and GND as shown in Fig. 2. Vcc and GND are supply and ground pins. Trigger input receives 10µs trigger pulse. Microcontroller will make this pin HIGH then delay for about 10 µs and make pin LOW again. OUT pin gives the Output pulse width depending upon distance travel. After the trigger is given to microcontroller it measures pulse output on OUT pin. Timing diagram of ultrasonic sensor output wave is shown in Fig. 3. The output pulse duration is converted to distance measured and the temperature effect is also considered.

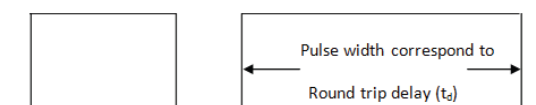


Fig 3 : Ultrasonic sensor output wave

Ultrasonic sensor has three pulses first is a short pulse which is transmitted at the time of 10µS trigger input pulse. Second pulse is the pulse reflected by an object and third pulse is the signal that the sensor receives and converts it to a pulse of variable duration.

The temperature sensor is used for temperature measurement. The pin diagram of temperature sensor is shown in Fig. 4. There are 4 pins in Temperature sensor out of which 3 pins are Vcc, Data and GND and one pin has no connection. Vcc and GND are supply and ground pins and Data pin gives the output temperature.

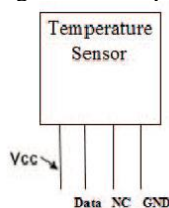


Fig 4: Pin Diagram of temperature sensor



Communication with microcontroller is divided into three steps. In the first step the microcontroller makes the data pin low for 18ms and then make the pin high for 40μS so that Temperature Sensor understand that a request receives from microcontroller. In the second step Temperature Sensor gives an automatic reply which indicates that Temperature sensor received microcontroller request. The response is 54μS low and 80μS high pulse. In the third step Data Reading comes as shown in Fig. 5. The data has total 40 bits which are divided into 5 parts of 8 bits each. These 5 parts are integer Relative humidity, decimal Relative humidity, integer temperature, decimal temperature and Parity bits of 8 bits each.

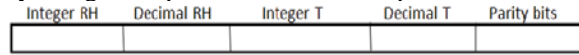


Fig 5: Output data of 5 segments of 8 bits each

Firstly all the required components are connected on a PCB and microcontroller burned with the program. Trouble shooting is important so it consume more time and efforts. Different sensors are used for taking input and then computer is connected to receive output from RS-232 serial adapter. Block diagram of processing unit is shown in Fig. 6.

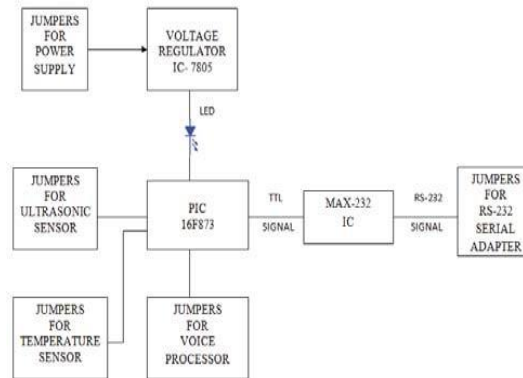


Fig 6: Block diagram of processing unit

PCB manufactured manually has several disadvantages like large size, more power loss etc. Trouble shooting is complex so the circuit diagram and layout preparation is done on the ORCAD software. Layout of processing unit is shown in Fig.7. The final layout is manufactured for PCB fabrication.

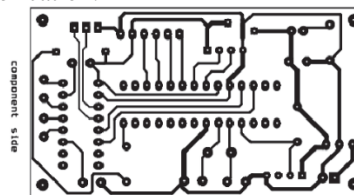


Fig 7: Layout of processing unit

When PCB layout fabrication done than all the components from manual PCB are extracted and mounted on the PCB manufactured and testing process starts. Troubleshooting, error detection and Testing is the most time consuming part of the development to get the required output. All circuits are tested using Multimeter and connectivity is checked. After testing errors are eliminated. Output is analyzed whether it is correct or not. Human machine interface is required because the data has to be compatible with the PC. The USB receives serial data using serial adapter(RS-232 interface). PIC works on 5v TTL signal so RS-232 serial data is provided to computer. The data required at the output are Pulse Width, Temperature and Distance with Temperature compensation which is calculated by the use of Pulse Width and Temperature. The round trip delay (td) is measured by Pulse Width which is scaled by a factor 16.5 calculated by the use of manual distance measurement.

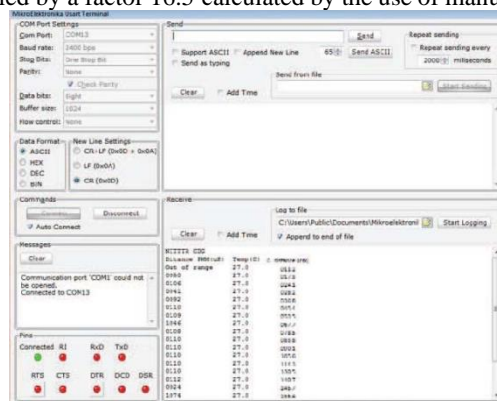


Fig 8: Display of serial data on Computer



$$D_1(\text{cm}) = [(C^{\text{cm}}/s) - 60.7T]t_d \quad (1)$$

$$= [(33146 - 60.7T)t_d \cdot 10^{-6} /]$$

$$= [(33146 - 60.7T)16.5W \cdot 10^{-6} /]^2$$

$$= [(33146 * 8.25 - 60.7 * 8.25T)W10^{-6}]^2$$

$$= [(273.4545 - 0.500775T)W10^{-3}]$$

$$D_1(\text{cm}) = [(0.27345 - 0.0005T)W] \quad (2)$$

The microcontroller program is written and the equation (2) is inserted to calculate the distance with temperature compensation. Voice processor with earphone can be used to alert the blind person by audio messages like STOP when the distance measured is less than 50 cm, DANGER when the distance measured is less than 100 cm, WALK when the distance measured is greater than 100 cm, HELP when the distance measured is out of range. The data can be displayed using serial communication software which can be Mikro C PRO for PIC or Terminal etc.

4. RESULT VERIFICATION USING MATLAB

Arrays of input data's are distance taken manually, Pulse Width, Temperature and distance with temperature compensation are processed using MATLAB shown in Fig. 9. Percentage error between manual distance and distance with temperature compensation is calculated using MATLAB shown in Table 1 & Table 2 respectively then graph of various parameters are generated. These graphs are W Vs D and E Vs

D. Graph (1) shows the change in Pulse width with change in manual distance. Graph (2) shows the change in percentage of error with the change in manual distance.

TABLE I. INPUT SERIAL DATA TO MATLAB

S.N.	Distance Taken Manually D (cm)	Pulse Width (Round Trip delay) W (μ sec)	Temperature T (°C)	Distance With T.C. D ₁ (cm)
1	11	0044	33.0	011.2
2	17	0067	23.0	017.3
3	23	0092	29.0	024.1
4	27	0110	42.0	028.2
5	35	0140	27.0	036.8
6	44	0174	25.0	045.4
7	51	0208	36.0	053.5
8	67	0263	21.0	067.7
9	75	0302	43.0	078.5
10	82	0320	19.0	083.8
11	89	0351	24.0	090.1
12	102	0405	35.0	105.6
13	113	0452	40.0	114.3
14	128	0518	33.0	130.5
15	137	0549	38.0	140.7
16	144	0563	17.0	145.7
17	156	0615	28.0	156.4
18	168	0672	37.0	174.6
19	180	0711	24.0	185.5
20	188	0750	29.0	195.3

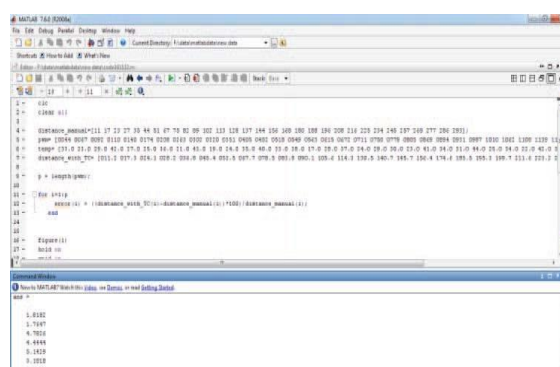


Fig 9: Data processing using MATLAB

5. CONCLUSION

Results show that a mobility aid with temperature compensation is manufactured. The average error with temperature compensation is calculated. The error is reduced from 8.6082 of without temperature compensation to 2.8383 with temperature compensation and better results are found in terms of percentage of error. Also a voice processor is added with microphone to give alerts to the blind person. Voice processor alerts the blind person with various messages like HELP, STOP, WALK, DANGER etc. The analysis can be done for different Materials so that effect of all material and their errors with temperature compensation can be analyzed. The error is reduced using Temperature compensation method but humidity and pressure are also other factors which can be included and more efforts can be done on these factors.



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