Development of an Embedded System for Distance Measuring Using Ultrasonic Sensor

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Abstract: ***There are several ways to measure distance without contact. One way is to use ultrasonic waves at 40 kHz for distance measurement. Ultrasonic transducers measure the amount of time taken for a pulse of sound to travel to a particular surface and return as the reflected echo. This circuit calculates the distance based on the speed of sound at 25°C ambient temperature and shows it on LCD display. Using it, we can measure distance up to 2.5 meters. In this circuit, a 40 kHz transducer is used for measurement in the air medium.In this project, we excite the ultrasonic transmitter unit with a 40 kHz pulse burst and expect an echo from the object whose distance we want to measure. It travels to the object in the air and the echo signal is picked up by another ultrasonic transducer unit (receiver), also a 40 kHz pre-tuned unit.***

Keywords: Ultrasonic sensor, ATMEGA16, LCD module.

1. . Introduction

In the existing system, human hand movements are sensed by the robot through sensors and it follow the same. As the person moves their hand, the accelerometer also moves accordingly sensor displaces and this sensor senses the parameter according to the position of hand.

In this system, a gesture driven robotic vehicle is developed, in which the vehicle movements and manipulations ie, handling and control is depends on the gesture of the user. In this system, gesture is captured by accelerometer and it is processed by software namely, microcontroller software and the parameters are sent to microcontroller and encoder circuit, It is further transmitted (transmitter section) by RF433 MHZ transmitter. In the receiver section, the RF 433 MHZ receiver holds down the received parameters and process with microcontroller and gives those parameters to the robotic vehicle so that it act accordingly to the gesture. By this system, it is possible to achieve processing of long distance. This system is knowingly developed to apply in medical field for nursing assistance to physicians and in surgeries.

2. Block Diagram

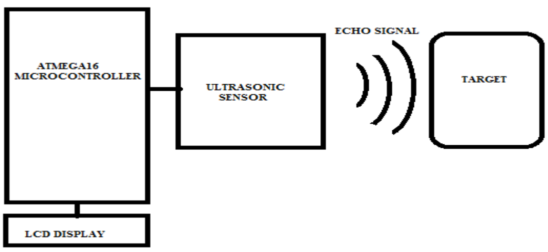

Figure 1: Block diagram of system

LCD display:- LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segment and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments) animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

ATMEGA16 microcontroller: The microcontroller ATMEGA16 has been used to take the controlling action of the security system. It is an 8 bit microcontroller with low power consumption characteristic. It has advanced RISC based architecture. The architecture consists powerful instruction set which requires only one clock cycle for execution. This enables the microcontroller to achieve the throughput of 1 MIPS per MHz which results to a very less power consumption. It is a very high performance microcontroller. It contains 16KB in self-programmable flash memory for programming, 512 bytes of EEPROM and to provide additional security to the software it contains programming locks. The RISC architecture consists of 131 powerful instructions set in which most of the instruction are of one clock cycle. The architecture also consists 32 general purpose registers each of 8 bits. It can give a maximum throughput of 16 MIPS at the frequency 16 MHz. It has the data retention period of 20-25 years in the room temperature values.

Ultrasonic sensor:- Ultrasonic sensors (also known as transceivers when they both send and receive) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. This technology can be used for measuring: wind speed and direction (anemometer), fullness of a tank and speed through air or water. For measuring speed or direction a device uses multiple detectors and calculates the speed from the relative distances to particulates in the air water.

Echosignal:- Reflection of sound wave back to its source in sufficient strength and with sufficient time lag to be separately distinguish is a eco signal

Target:-The object whose distance is to be measured in the atmosphere is termed as target. In addition, objects that absorb sound or have a soft or irregular surface, such as a stuffed animal, may not reflect enough sound to be detected accurately. The sensor will detect the surface of water, however it is not rated for outdoor use or continual use in a wet environment. Condensation on its transducers may affect performance and lifespan of the device.

3. System implementation

3.1 Methodology for ultrasonic sensor

The ultrasonic sensor for automotive application can detect a target in a short range but the device must be compact and waterproof .Those requirements limits the application to user friendly system such as parking assist system and rear sonar system. For pre-crash applications, generally proposed sensor like stereo cameras, radar or lidar are able to detect obstacle at long distance, but they are much more expensive than ultrasonic sensors. This paper proposes a range enhancement method for ultrasonic sensor to make them usable. Ultrasonic sensors are often called transducers. The function of the transducers is to convert electrical energy into mechanical energy, which directly corresponds to ultrasonic vibration, and vice versa. The most common way of generating and detecting ultrasonic waves utilizes the piezoelectric effect of a certain crystalline material such as quartz. The system is composed of two sensors, which can operate both as transmitter and as receiver.

3.2 Methodology for signal

Transmitter and Receiver Module

The transmitter transmits a high frequency signal. Ultrasonic sensors emit a sound pulse whose frequency is 40Hz. The ultrasonic sensor uses a pair of transducers. The sensor emits a sound pulse and measures the distance of the object depending on the time taken by the echo to return back to the other side.Electrical energy is converted to sound to send the pulse, and then the sound received back is converted to digital signal which is displayed in the LCD module.

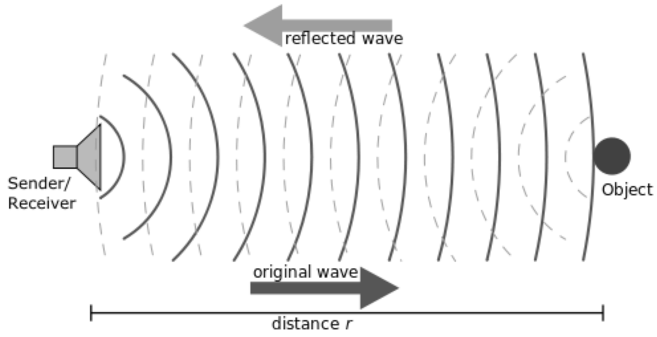

Figure 2: Measuring distance using the echolocation concept

3.3 Methodology for distance measurement

The technique of distance measurement using ultrasonic in air include continuous wave & pulse echo technique. In the pulse echo method, a burst of pulses is sent through the transmission medium & is reflected by an object kept at special distance. The time taken for the pulse to propagate from transmitter to receiver is proportional to the distance of object. For contact less measurement of distance, the device has to rely on the target to reflect the pulse back to itself. The target needs to have a proper orientation that is it needs to be perpendicular to the direction of propagation of the pulses. The amplitude of the received signal gets significantly attenuated and is a function of nature of the medium and the distance between the transmitter and target. The pulse echo or time-of-flight method of range measurement is subject to high levels of signal attenuation when used in an air medium, thus limiting its distance range.

The system consists of only one main component, a microcontroller unit which acts as the brain of the system. Input and output components such as transmitter unit, receiver circuit, temperature control and LCD modules are connected to the system brain.The transmitter generates a 40Hz signals and begin the transmission time together with the process of sending signals. While the signals begin to transmit through ultrasonic transducer, the microcontroller will capture the starting point of transmission time and hold it until the receiver gets the echo signal back .The signal will contact with any obstacle ahead and will bounce back to the receiver circuit. When the signal is back ,the receiver must detect the echo signal, process & send to the microcontroller. The microcontroller will stop the transmission time immediately and will calculate the range using the transmission time and display the range on LCD modules. If the transmit signal cannot touch any obstacle in front it, or the time is very fast, the system will display error message on the LCD modules, indicate the range is not suitable for the system.

4. Working of microcontroller ATMEGA16

The microcontroller ATMEGA16 has been used to take the controlling action of the security system. It is an 8 bit microcontroller with low power consumption characteristic. It has advanced RISC based architecture. The architecture consists powerful instruction set which requires only one clock cycle for execution. This enables the microcontroller to achieve the throughput of 1 MIPS per MHz which results to a very less power consumption. It is a very high performance microcontroller. It contains 16KB in self-programmable flash memory for programming, 512 bytes of EEPROM and to provide additional security to the software it contains programming locks. The RISC architecture consists of 131 powerful instructions set in which most of the instruction are of one clock cycle. The architecture also consists 32 general purpose registers each of 8 bits. It can give a maximum throughput of 16 MIPS at the frequency 16 MHZ. It has the data retention period of 20-25 years in the room temperature values. It provides standard JTAG interface, SPI serial interface and ISP interface. It also has programmable serial USART for serial communication. It has two 8 bit timers with separate prescalers and a 16 bit timer again with separate prescaler, compare and capture mode. It also contains real time counters. The microcontroller has four PWM channels each of 8 bits. It has 8 channels of 10 bit analog to digital convertors. It has on chip analog comparator and a watch dog timer with separate prescaler and oscillator. It has additional features of power on reset, internal and external interrupt handling and six different sleep modes for the effective consumption of power. It has 32 programmable input output lines and it is available in 40 pin dual integrated packages. Its operating voltage is 4.5 to 5.5 volts. The power consumption in active mode 1.1mA, in idle mode 0.35 mA and in power down mode it is < 1μA. In the project two microcontrollers ATMEGA16 are used, one is connected to CPU and another is connected to the alarming system and GSM modem. The controllers are connected to each other also.

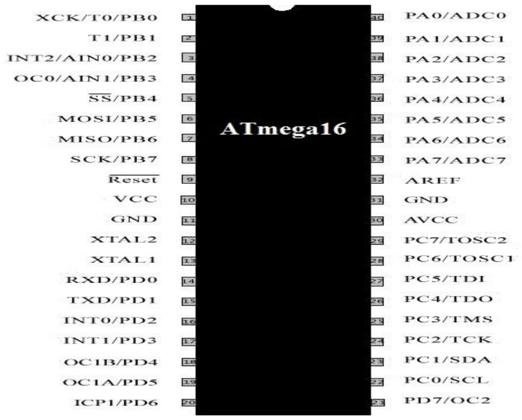

Figure 3: Pin Diagram of Microcontroller ATMEGA16

5. Results

The working model of the proposed Atmega16 a microcontroller-based distance measuring using ultrasonic sensor was successfully designed and implemented. Fig 6.1 shows the circuit implemented on a PCB. The performance of the circuit was analyzed for different conditions. The circuit was able to measure distance up to 2m without interfering in human activity. Circuit was tested for measurement of various distances in different atmospheric conditions, accurately.It has a fast response. The ultrasonic sensor works fine. It responds to the incoming echo accordingly. By using ATMEGA16, we were able to reduce the cost and increase efficiency

6. Conclusion

- The system is able to detect object within the sensing range.
- The system can calculate the distance of obstruction with sufficient accuracy.
- This can also communicate with pc through its serial ports.
- This offers a low cost and efficient solution for non-contact type distance measurement.
- The microcontroller with LCD makes it user friendly.
- Less hardware are used so smaller in size.
- Inexpensive components are used so that reduces the cost per unit.
- The circuit can easily be implemented on breadboard and tested for its functionality by varying the distance between the sensor and the target.
- The system can calculate the distance of obstruction with sufficient accuracy.
- This can also communicate with pc through its serial ports.
- This offers a low cost and efficient solution for non-contact type distance measurement.
- It is beneficial to use in the places where the accurate readings are not required.

7. Future Scope

- The range can be considerably increased by using high power drive circuit.
- Using temperature compensation, it can be used over wide temperature range.
- The resolution of the measurement can be improved by incorporating phase shift method along with time of flight method.
- Can be used as parking assistance system in vehicles with high power ultrasonic transmitter.
- The 40 kHz signal can be generated using microcontroller itself which will reduce hardware
- We have found that this project is effectively useful in research and development areas as well as in Army and Civil area.
- Major outcome is that this project can replace too many costly types of equipments.
- Product is also eco friendly because it does not harm any Earth's environment.
- Project is less complicated than other ,so analysis and replacement of components is easy.

References

[1] Spasov Peter ,Microcontroller Technology the 68HC11 and 68HC12 Upper Saddle River, Pearson Prentice Hall, Fifth Edition, 2004.
[2] Sinclair Ian R. and Dunton John,Practical Electronic Handbook,6th Edition,2007.
[3] Horton Ivor,Beginning C,Wrox Press Ltd, Birmingham, U.K, 2nd Edition, 2002.
[4] Deshmukh V Ajay, Microcontroller Theory and Application.New Delhi, Tata McGraw-Hill Publishing Co. Ltd, 2005.
[5] Honeywell Sensing and Control Catalog. (2000) Series 940-942 Ultrasonic Sensors. [Online]. Available: www.honeywell.ca/sensing/.

[6] M. Parrilla, J. J. Anaya, and C. Fritsch, "Digital signal processing techniques for high accuracy ultrasonic range measurements," IEEE Trans. Instrum. Meas., vol. 40, pp. 759–763, Aug. 1991.
[7] D. Marioli, C. Narduzzi, C. Offelli, D. Petri, E. Sardini, and A. Taroni, "Digital time-of-flight measurement for ultrasonic sensors," IEEE Trans. Instrum. Meas., vol. 41, pp. 93–97, Feb. 1992.
[8] C. Cai and P. L. Regtien, "Accurate digital time-of-flight measurement using self-interference," IEEE Trans. Instrum. Meas., vol. 42, pp. 990–994, Dec. 1993.
[9] F. Gueuning, M. Varlan, C. Eugène, and P. Dupuis, "Accurate distance measurement by an autonomous ultrasonic system combining time-offlight and phase-shift methods," in Proc. IMTC, vol. I, pp. 399–404 , June 4–6, 1996.
[10] G. Andria, F. Attivissimo, and A. Lanzolla, "Digital measuring techniques for high accuracy ultrasonic sensor application," in Proc. IMTC, vol. II, pp. 1056–1061 May 18-21, 1998.
[11] Carullo, F. Ferraris, S. Graziani, U. Grimaldi, and M. Parvis, "Ultrasonic distance sensor improvement using a two-level neural network," IEEE Trans. Instrument. Measurement, vol. 45, pp. 677–682, April 1996.
[12] ENV 13 005, "Guide to the expression of uncertainty in measurement,",May 1999.
[13] U. Grimaldi and M. Parvis, "Enhancing ultrasonic sensor performance by optimization of the driving signal," Measurement, vol. 14, pp. 219–228, 1995.
[14] U. Grimaldi and M. Parvis, "Noise-tolerant ultrasonic distance sensor based on a multiple driving approach,"Measurement, vol. 15, pp. 33–41,1995