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Application Note

A Guide to Ultrasonic Sensor Set Up and Testing
Instructions, Limitations, and Sample Applications

Executive Summary

This paper will discuss the implementations and limitations of an ultrasonic sensor. The primary goal of this sensor will be to monitor user presence by measuring the distance of an object from the sensor. Within this, the ultrasonic sensor will send a serial signal through a driver/receiver to a computer to enhance information density. This particular methodology for ultrasonic sensors will be investigated in different applications. This paper will explore primary communications between the PC and the sensor, the restrictions that ultrasonic sensors face when measuring distance, and the most commonly used applications for this particular scheme.

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Introduction

Ultrasonic sensors work by transmitting a pulse of sound, much like sonar detectors, outside the range of human hearing. This pulse travels away from the range finder in a conical shape at the speed of sound (340 m/s). The sound reflects off an object and back to the range finder. The sensor interprets this as an echo and calculates the time interval between sending the signal and receiving the echo. This interval is then computed by a controller to determine the distance of the object. In simple notation:

$$distance = \frac{elapsed\ time\ x\ speed\ of\ sound}{2}$$

This application note will principally focus on the LV-MaxSonar-EZ1 which is a High Performance Ultrasonic Range Finder and is shown below. This particular sensor is very useful for people detection as it balances high sensitivity while using a relative narrow beam width. The MaxSonar has the capability of outputting an analog voltage or serial data stream. This again is very useful because it does not limit the choice of usable microprocessors and interfaces. In addition to this, it implements a free run operation which can continually measure and output range information. This device has 7 pin outs, but the majority of these are unnecessary for a simple serial hook up to measure distance. However it is necessary to understand each for unseen future operations of the device.

(1)

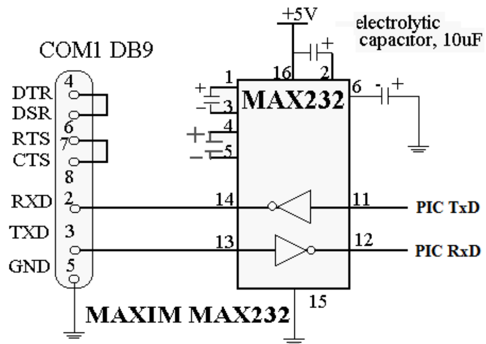
Pin Out	**Description**
GND	Circuit common and DC return
+5	Vcc: 2.5V-5.5V DC
TX	Serial out when BW is set low
RX	High (open) for ranging. Low to stop ranging.

AN	Analog Voltage Output A 5V supply yields ~9.8mV/in
PW	Pulse width representation
BW	Low (open) for serial output of TX. High for chaining.

(1)

Instructions

A sample set up will include an RS232 serial circuit set up, as shown below.



(3)

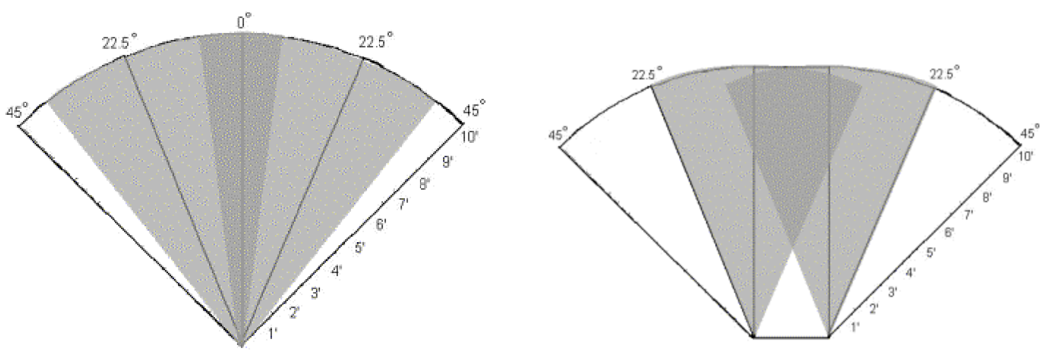
Because the sensor directly transmits a serial output with an RS232 format it is not necessary to use a large microprocessor. Indeed, the MaxSonar device could be connected directly to pin 2 of the COM1 DB9, but since the voltage produced by the MaxSonar 0-Vcc is out of the RS232 Standard[1] one can connect, if need be, a MAX232 chip to invert the voltage. The MAX232 chip will be the only interface between the sensor and the computer. Thus the TxD can be straight from the TX of the sensor and the RxD can be sent to the RX of the sensor to tell the sensor 1 (yes continue ranging) or 0 (no stop ranging). The ultrasonic sensor described in this application note will send five ASCII character over the serial transmission. These characters are an “R” followed by three numerals representing the distance in inches from 0-255 followed by a return character. This simple interface can then be coded in a software program like Microsoft Visual Studio or MATLAB to develop a Graphical User Interface (GUI). The code for this can be relatively straightforward in the sense that it will send the GUI instructions from the Sensor. For example, in simple language; If the object is this distance: Display this much information, Else if

[1] Standard RS232 is a standard developed by the Electronics Industries Association for serial binary data signals between a DTE (Data Terminal Equipment and a DCE (Data Circuit-Terminating Equipment).[5]

the object is this distance: Display this much information, Else: Do not display any information, etc.

Limitations

One of the most common limitations of ultrasonic sensors is its flexibility in detecting. Because the sensor operates on the echo principle as described above it cannot accurately distinguish between, say, a human and a chair, as both of these objects will return an echo. Most sensor application attempt to overcome this conflict by instilling two sensors. These sensors are either adjacent each other, as shown in the left-most figure below, or spaced a distance apart, as shown in the right-most figure below. The advantage of this is if both sensors sense the object (in the shaded area) one can have a better idea of its location and relative size, increasing the accuracy of the sensor.



(4)

In the case of the device described in this application, it utilizes only one sonic sensor. Because it is capable of covering a very wide range of distance (from 0 to ~254 inches) it is inherent that the device only be capable of detecting human presence and movement in a narrow area. Thus, to overcome the fact that these types of sensor can pick up the presence of all the objects in the room, the MaxSonar-EZ1 emits and receives a very narrow beam, approximately 1 in. diameter dowel under 10 feet and approximately 3.25 in. diameter rod under 15 feet and above 10 feet.

Another limitation for most ultrasonic sensors is its heightened sensitivity. Though in most cases this aspect of a sensor can be very helpful, in some instances a highly sensitivity device will lead to false triggers. This can be caused by a pulse of air ceiling fan or disturbed airwaves from an HVAC system.

Common Applications

For the most part, the applications of ultrasonic sensors fall into three main categories: Industrial, Public Ease, and Robotic. Other uses of ultrasonic sensors due exist but they are not as broadly used as these three.

Ultrasonic sensors are very popular in industrial tasks because they are impervious to target material composition. Thus, these devices can be used to detect clear objects or objects of any color as well as materials of any structure, be it liquid, porous, or solid. An example of this may be to continually measure liquid level in large vats to ensure a constant intake and outtake of the fluid. Other industrial applications may use the ultrasonic transducer to generate high frequency waves to produce vibration energy on a solvent for high precision cleaning.

The ultrasonic sensor device may also be seen in applications that provide ease of use to the public. Typically these applications consist of one or two sensors detecting the presence or absence of objects to aid the user of the device. This can be seen in uses such as automatic door openers at supermarkets or any large public department store. Ultrasonic sensors are commonly used in these applications due to the fact that they are naturally impervious to light, thus making them flexible agents throughout the day and night. Along these same lines, ultrasonic sensors are found in the rear fender of an automobile, alerting the driver if he/she is getting too close to an object.

Small scale ultrasonic sensors with low voltage consumptions, similar to the one described in this applications, are commonly found in robotic implementations. These sensors can be imagined as the “eyes” of the robot. These will detect objects and their distance and inform the motors of the wheels or legs of the robot to turn, slow down, or stop.

Conclusion

The ultrasonic sensor is a robust and flexible sensing agent with relatively few limitations. The MaxSonar-EZ1 described in this application can detect object distance with high sensitivity using a narrow beam width and very low voltage. Because of its serial format it is easily interfaced with a common MAX232 driver/receiver and can be programmed through a familiar coding language. Though many sensors have difficulty distinguishing objects, the narrow band of the sensor noted in this application will reduce this with a narrow beam width. Sensors of this size are typically found in robotic applications, however a diversity of uses can be found for an ultrasonic sensor as discussed. This application showed the principle design and possible implementation of a MaxSonar ultrasonic sensor for motion detection and information density display.

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