# A Microcontroller Based Ultrasonic Range Finding Module for Target Detection from a Mobile Robot

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*Abstract* - **This paper describes the working principle of ultrasonic range sensor, reports the in house development of an electronic module for measurement of range of targets from a mobile robot platform. A schematic layout of electronic circuit design is illustrated. The design incorporates Time of Flight method for distance measurement of the target. The paper also describes the merits and demerits of ultrasonic range sensors over the other types.**

*Keywords* – **ultrasonic sensor, time of flight, robotic range sensor, AT89C2051 microcontroller, bandwidth**

## I. INTRODUCTION

A primary objective in mobile robot design is endowing the robot with enough environmental awareness to make intelligent movement possible. One step toward solving this problem is to acquire information about the surrounding environment by using combination of tactile, range and vision sensors along with very fast smart processors. The range sensors are grouped in two categories i.e. passive devices, such as stereoscopic vision and swept-focus ranging systems and active devices such as laser, microwave and ultrasonic range-finding systems. In this paper we have described design and development of an AT89C2051 microcontroller based ultrasonic range finding module where capacitive type transmitter- receiver pair is used.

## II. TIME OF FLIGHT MEASUREMENT

The most common method of distance measurement is based on time elapsed between transmission and reception of an ultrasonic pulse called time-of-flight (ToF ) method . The duration of echo and amplitude are used to analyze the distance x and the characteristics of the object [3]. Taking ultrasound speed in air as v = 343 m/s at $20^0$ C, the minimum distance corresponding to a burst of 8 pulses at 40kHz will be

$x = v\ t / 2$
$x_0 = v\ t_0 / 2 = 0.0343$ m = 3.4 cm
where $t_0 = 200\ \mu$ s (time duration of the burst).

The maximum range that can be covered by a transducer pair will depend on the energy of the incident beam i.e. operating voltage and current of the transducer, reflection coefficient and the sensitivity of the electronic module used. In our application, a pair of capacitive sensors is used at 10 Volt R.M.S to cover a distance of 5 meter.

## III. DESCRIPTION OF ELECTRONIC MODULE

An AT89C2051 microcontroller [5] is used to generate the burst of eight cycles of 40 kHz after receiving a request from the onboard computer of the mobile robot. A transistor, 2N3904 switches current into an inductor creating a fly-back voltage output of about 10 volt peak to the ultrasonic transmitter connected in parallel with the inductor. The 40 KHz is based on a software division of the 11.0592 MHz reference crystal oscillator connected to the microcontroller. The detector circuit contains a receiver, two stage tuned amplifier, a modulator and a comparator which are realized using IC LM324. The ultrasonic receiver is also tuned at 40 kHz using combination of inductance, capacitance and resistance to stop normal sound and vehicle vibration from being the dominant input [1]. Two stages of LM324 are used to amplify milli-volt input to an output of a couple of volts. The signal is modulated to a voltage-envelop and is compared by a comparator circuit with a range sensitive threshold [2] and gives logic '1' when it exceeds the threshold. A pulse, generated by the detector circuit corresponding to the echo is received by the microcontroller. The request for a data and the data corresponding to the elapsed time are communicated between the microcontroller and the host computer through RS232 port (Ref: Fig 1). The microcontroller programme is written in

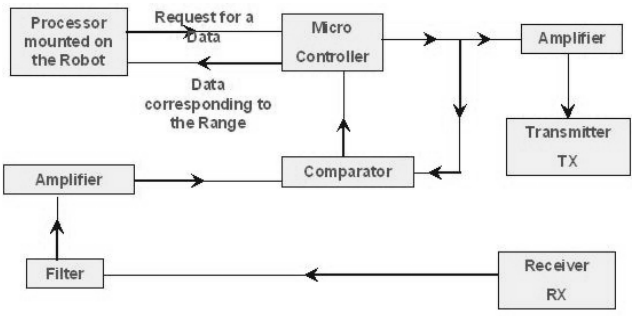


Fig. 1 Block Diagram

assembly language and a HEX100 programmer is used to convert into machine language and to download into the microcontroller. The communication programme between the host computer and the microcontroller is written in C language. The circuit also incorporates repetitive burst generator realized by two NE555 and one 74LS00 ICs for off-

line testing. A switch is provided to change over the control to timer circuit from the microcontroller and vice-versa.

## IV. SPECIFICATION OF SENSOR

Diameter - 16mm
Operating Frequency - 40 ±1kHz
Operating Range - 5m
Direction Angle - 30˚
Input Voltage (Maximum) for Tx - 20 Volt R.M.S
Capacitance - 1100pF
Operating Temperature - -20˚C to + 60˚C

## V. SIZE OF PCB

Proto type boards (Ref. Fig. 2) are made having sizes of sensor board : 4cm × 6cm, to be mounted on the front panel of the mobile robot and control board : 9cm ×12cm, to be mounted on the base of the mobile robot. However it is possible to make smaller boards.

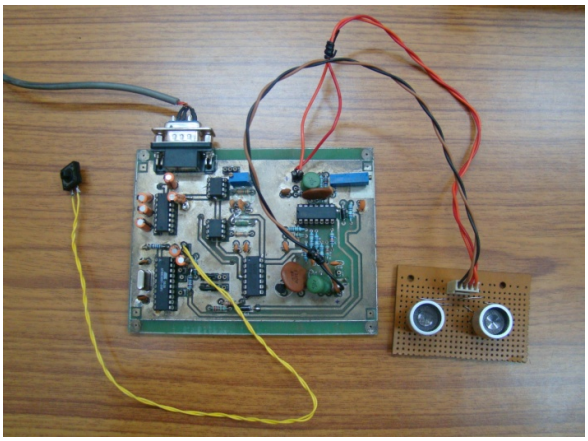

Fig. 2 The Electronic Module

## VI. MERITS AND DEMERITS

The capacitive and piezo-ceramic type ultrasonic transmitter-receiver pair are more popular because of their small size, low cost, low power consumption during sonic burst as well as quiescent condition. These are widely used in robotics for collision avoidance and map building purposes [1] compared to laser and camera because of their low bandwidth, less data processing requirement and light independent characteristics. On the other hand, there are some demerits of these type of sensors are their less range compared to Laser and vision sensors. Polaroid ultrasonic sensor provides more range but needs more power and bigger space to accommodate. Temperature and humidity dependence of ultrasound velocity affects the distance measurement in this method. Also, wide beam width and low band width of the ultrasonic sensor reduce the resolution making close objects indistinguishable.

## VII. CONCLUSION

The reflected beam will experience additional spreading depending on the density of the object and it's surface finish . So, only a fraction of the incident energy will arrive to the receiver. The amplitude of the echo is therefore a function of the characteristics of the target [3], [4] which can be utilized to differentiate different targets like metal, non-metal, wall-corners e.t.c. Further development of electronic hardware and software is required for this purpose. This electronic module is developed to meet a requirement of NIT, Rourkela. The module is able to measure a maximum distance of 5 meter with an accuracy of ±1cm.


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