# Microcontroller Based Low Cost Device for Measuring the Speed of a Moving Object

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## ABSTRACT

Since long ago, measurement of speeds of moving objects have been used in many purposes such as to detect high speed vehicles on roads and to find speeds of base balls. Today, it is of utmost importance to control speeds of automobiles on roads and hence, measuring speeds has become an essential requirement. For this purpose, radar guns are excessively used by police officers throughout the world at present. Those devices use radar waves and digital signal processors for doing the job. Hence, they are very expensive. In this project, it was attempted to design a simple and a low cost device. For that, ultrasonic waves were used instead of radar waves and microcontrollers were used instead of digital signal processors. Similar to radar guns, the design is based on Doppler Effect. A signal of a 40 kHz frequency was generated and it was received after colliding on a moving object. The respective frequency change was calculated by a microcontroller and the speed of the moving object can be seen on a display.

**Keywords :** *Microcontroller, Doppler Effect, Ultrasonic*

## 1.0 INTRODUCTION

Measuring the speed of a moving object has a great importance in many arenas. Some of them are for law enforcement to measure the speed of automobiles and in sport activities to know the speed of balls, runners etc. The most commonly and frequently used device for the purpose is radar gun which was invented by John L. Barker after the World War II. In 1947, Connecticut police in USA tested this for traffic surveys as well as for issuing warnings to drivers for excessive speed. Gradually, the device has become popular specially among the law enforcement officers in the world. The principle on which radar gun relies on is Doppler Effect[1]. Austrian physicist, Johanne Christian Doppler in 1842, proposed this. The Doppler Effect is applicable to sound, light, microwave and radar waves. According to the Doppler Effect, there occurs a frequency change between waves emitted by a source and the waves received by a detector or an observer. The basic operation of a radar gun includes sending radar waves and receiving them back after it bounces off from a target. From the difference of frequencies of transmitted and received waves, the speed of the target can be calculated. As the radar guns use radar and digital signal processors, they are very expensive. Also, the design is complex. In the proposed design, it was attempted to be with low cost and simple concepts. Hence, instead of radar waves and digital signal processors, ultrasonic waves and microprocessors were used respectively. The latter was assigned for generating the signal as well as for calculating the speeds of the moving object. As the radar gun, the proposed design also follows the Doppler Effect in its operation.

## 2.0 THEORY

### 2.1 General case

It is seen that Doppler Effect can be apprehended under several situations in reference with the observer and the source.

They are:

- Stationary observer and moving sound source
- Stationary sound source and moving observer
- Both the source and the observer are moving

Following is the common equation, which depicts all above situations[2].

$$F_0 = \left|\frac{V \pm V_0}{V \pm V_S}\right| F \qquad (1)$$

where;

$V_s$ speed of the periodic sound source
$V$ speed of the sound waves
$V_o$ speed of the observer
$F$ sound wave frequency
$F_o$ perceived frequency

2.2 Theory used for the design

In the design, it has been considered only the stationary observer and the moving source and hence the moving object acts as the moving source. Then $Vo$ goes to zero and the equation (1) can be generalized as follows;

$$F_0 = \left[\frac{V}{V \pm V_S}\right] F \qquad (2)$$

Then, Vs can be calculated as follows;

$$V_S = \left(\frac{|F_0 - F|}{F_0}\right) V \qquad (3)$$

And the term [$F_o$ – F] can be identified as the Doppler shift because of the movement of the object.

If that Doppler shift is denoted as D, then the equation can be simplified as;

$$V_S = V\left(\frac{D}{F_0}\right) \qquad (4)$$

**3.0 EXPERIMENTAL**

The block diagram of the design is shown in Fig. 1. It is consisting of six units to carry out the above process.

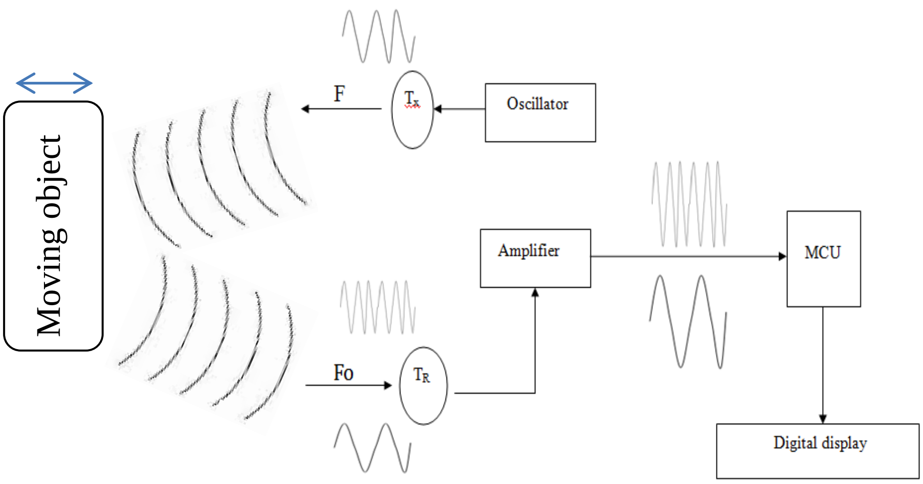


Fig. 1: Block diagram of the setup

They were;

1. Oscillator: This is to generate the waves with the desired frequency which is 40 kHz. As the oscillator, a microcontroller was used[3].

2. Transmitter: This transmits the signals generated by the oscillator to hit on the moving object. A piezoelectric transducer was used as the transmitter.

3. Receiver: The signals that are collided on the moving object and bounced back are captured by the receiver. A piezoelectric transducer was used as the receiver.

4. Amplifier: This amplifies the received weak signal and feed into the microcontroller. An operational amplifier was used for this purpose[4].

5. Microcontroller: This was programmed so as to calculate the change in frequency of transmitted and received signals and the speed of the moving object[5,6].

6. Digital display: This displays the final output which is the speed of the moving object.

Fig. 2 shows the total circuit diagram of the setup.

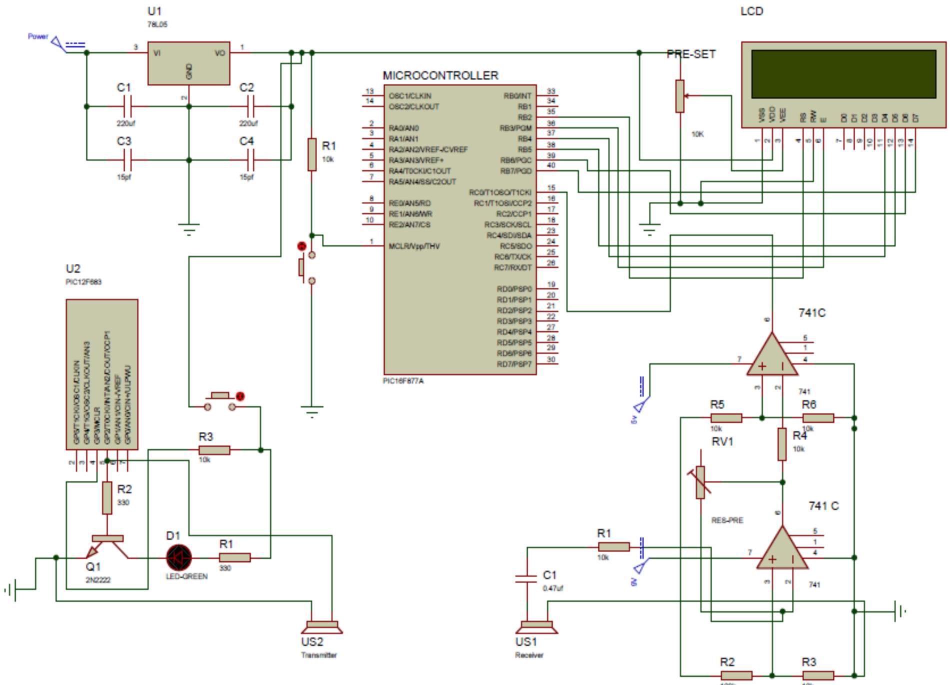


Fig. 2: Circuit diagram of the setup

To test the design with real world, an object was moved along a path of which the distance is known and the time taken was measured using a stop watch. At the same time, the reading on the display was noted down. This was repeated many times. Real velocity was calculated with the ratio between the distance and time for each repeating stage.

## 4.0 RESULTS

| Real velocity ($ms^{-1}$) | Observed velocity ($ms^{-1}$) |
|---|---|
| 2.1 | 1.91 |
| 2.4 | 2.13 |
| 2.5 | 2.30 |
| 2.7 | 2.48 |
| 2.9 | 2.71 |

## 5.0 CONCLUSION

In this research project, it was attempted to design a low cost device for measuring the speed of a moving object using a simple method. This design is a low cost one and the implementation of the setup has been done using simple methods. The operation of the design is based on Doppler Effect. The observed values are more or less deviated from the real value. This may because it was not possible to get a strong signal as per the components used in the present work. Use of more powerful amplifier stages and very sensitive ultrasonic transducers may improve the final output and the expected accuracy.

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