Non-Contact Estimation of Surface Roughness

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Abstract

The texture of the surface of a component is known as its surface roughness, often shortened to roughness. The quantification of the surface roughness is done by calculating the deviation of in the direction of the normal vector drawn at a particular point on the surface from its ideal form. The amount of the roughness is directly proportional to the deviation. Another type of measurement of surface roughness is using ultrasonic sensor, in which the ultrasonic pulse is sent from the transmitter to the surface and then the echo is picked up by the receiver. The time difference in the echo received from the different points on the surface is calibrated in terms of surface roughness. In this paper the development of this type of system has been designed using an Arduino and a sonar sensor. In Arduino the program is implanted such way that it calculates the distance. As distance is directly proportional to the time, the different of time of the echo between the consecutive echos are expressed in terms of the roughness of the surface. If all value is same then the surface is 'Plane' else rough and this calculated by a program on a microcontroller and displayed on an LCD screen interface to the microcontroller. Measurement of surface roughness with using Arduino UNO and Ultrasonic sensor is low cost technology compared to laser technologies. It is very simple to design and easy operate with a high accuracy and easily available IC's are used to make this model.

Keywords: *Surface Roughness Comparator (SRC), Surface Profile Measurement (SPF), Non-Conductive type Surface Roughness (NCSR).*

1. Introduction

Roughness is a geometric characteristic of a surface caused by small variations in surface depth. As ultrasonic sensing in air is a range-area sensor it should be suitable for measuring surface roughness. All smooth surfaces possess some degree of roughness, even if only at the atomic level. For man-made surfaces, this roughness arises from the manufacturing process which may involve chemical deposition, grinding, polishing, etching or several other commonly used techniques. Correct function of the fabricated

component often is critically dependent on its degree of roughness.
In the manufacturing industry, surface must be within certain limits of roughness. Therefore, measuring surface roughness is vital to quality control of machining work piece, especially if it is non-contact method compared to the direct conventional method; which uses stylus type devices. In the direct contact method, measurements are obtained using a stylus drawn along the surface to be measured: the stylus motion perpendicular to the surface is registered. This registered profile is then used to calculate roughness parameters. This method requires interruption of the machine process, and the sharp diamond stylus may make micro-scratches on surfaces (i.e. destructive damaging effect).
Several attempts [1–6] have been reported of studying non-contact techniques for the assessment of surface roughness. Of these worth mentioning works, the study by Hilton [5], where he used two orthogonally polarized laser beams to produce two independent speckle patterns that are imaged and auto-correlated to deduce the roughness of the surface being illuminated. Roberts and Briggs [6], have used several techniques such as acoustic emission and incident X-ray scattering for the characterization of surface roughness and sub-surface damage. Bilge and Rose [7], theoretically analyzed and discussed the problem of the signal noise of back scattering generated by rough surface using modelled techniques [8].
In this paper, we proposed an ultrasonic non-contact sensor which implements the ultrasonic signal, instead of the ultrasonic travel-time to describe the roughness parameters and measures the distance. Using the ultrasonic signal, instead of the ultrasonic travel-time will result in a much lower dependency of the sensor on the sound velocity in air, which will provide a more precise measurement.

2. Objectives

The main objective of this module is to take the different consecutive value from surface and total time taken from sending the waves to the receiving end is calculated by taking into consideration the velocity of the sound.If the consecutive value are same then it will be considered it as a plane surface as reference value for other arbitrary surface. In Arduino the program is implanted in such way that in the LCD it will the calculated distance and detected the surface is “Rough” Or “Plane”[2-4]. The objectives of the components used are as follow:- Ultrasonic Sensor:-To measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. And sending signal to the Arduino. Arduino UNO:-To receive the signal and outputs a waveform with a time period proportional to the distance. Automatic(software)Reset: Arduino the program is implanted in such way. Liquid Crystal Display (LCD):- To display the calculation of distance and detected the surface is “Rough” Or “Plane”.

3. Block Diagram & Components Description

3.1 Block Diagram

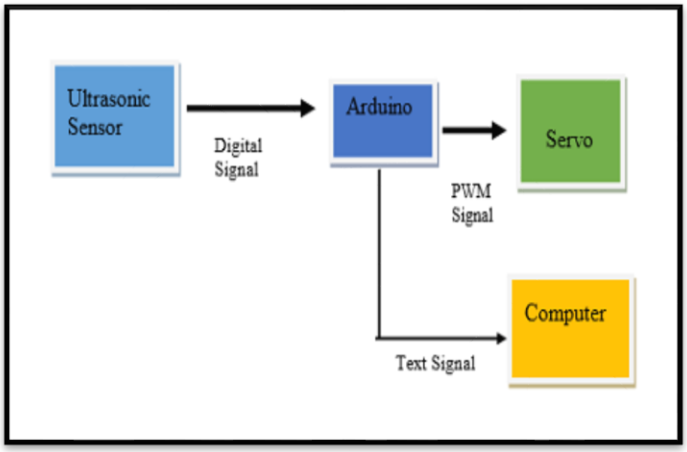

Fig. 1. Block diagram

The main component of the module ultrasonic sensor sends the ultrasonic signal to the arduino when it senses the rough surface . The motor servo recieves the signal as PWM signal through the arduino. The arduino sends the signal as the text signal to the computer. After the detection of the surface by the signal if "Rough" or "Smooth" and the calculation of the distance is displayed.

3.2 Ultrasonic sensor

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

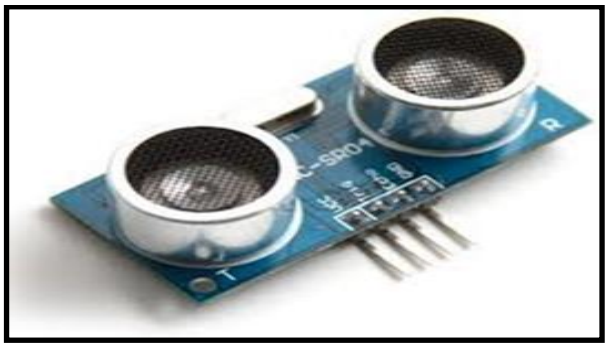

Fig. 2. Ultra-sonic sensor

4. Circuit connection and Working principle

4.1. Circuit diagram

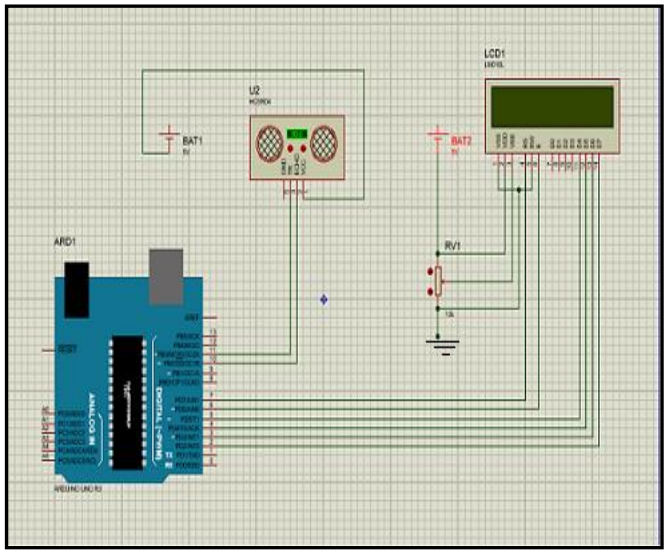

Fig. 3. Circuit diagram

4.2. Working Principle

First of all Sensor will sends an ultrasonic signal, eight pulses of 40 kHz square wave from the transmitter. Then echo is then picked up by the receiver and outputs a waveform with a time period proportional to the distance. Then the output of the ultrasonic sensor will send the signal to Arduino as shown in circuit. As we know that total time taken from sending the waves to the receiving end is calculated by taking into consideration the velocity of the sound. In Arduino the program is implanted in such way that in the LCD it will the calculated distance. As distance is directly proportional to time. So we will take different consecutive value from surface. If the consecutive vale are same then we considered it as a plane surface as reference value for other arbitrary surface. Then if all value is same then the surface is “Plane” else “Rough” and this calculated by a program running on the microcontroller and displayed on an LCD screen interfaced to the microcontroller.

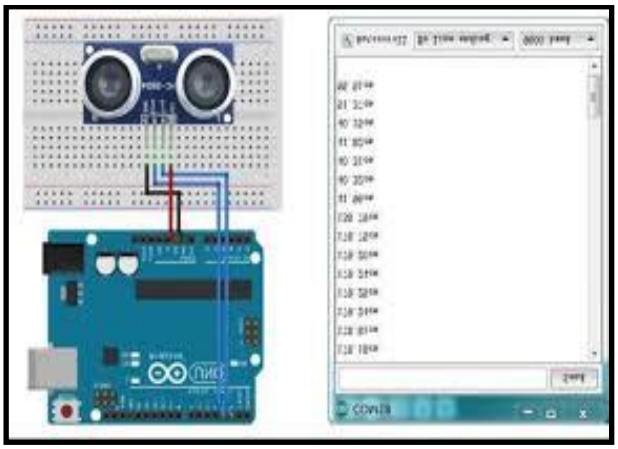

Fig. 4. Assembled circuit

5. Result and Analysis

Table 1: Data f**or distance vs voltage characteristics curve**

Distance(cm)(distance between sensor and surface)	**Voltage(mv)**
1	10.2
2	9.8
3	9.5
4	8.6
5	8.3
6	7.5
7	7.4
8	7
9	6.5
10	6.2
11	5.8
12	5
13	4.5
14	4.2
15	3.7
16	2.8
17	2.5
18	2.1
19	1.8

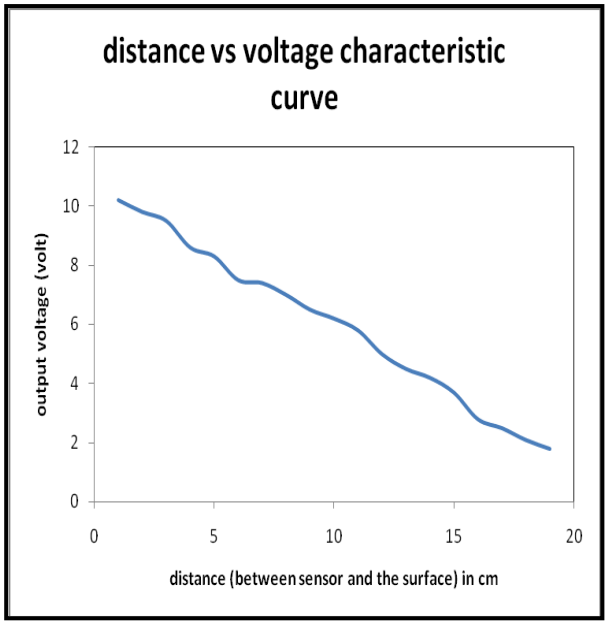

Fig. 5. Distance vs voltage curve

6. Conclusion

The virtues of this module include various features like it is in genuine. This module is simple for design and implementation. It is completely integrated so that once it is implemented in all industries then it will be impossible for errors occurred due to the surface finishing of an object. This module is easy to use and low cost compared to laser technologies. The module has high accuracy and the IC's used are easily available. It is used in quality checking section in industries like steel plants, manufacturing industries, production industries etc.

7. Acknowledgement

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