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Design of a Portable Contact-less Tachometer using Infrared Sensor for Laboratory Application

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Abstract:- *A tachometer is a device that measures the rotational speed of a shaft or disk in motor or other machines. This paper presents the design of a simple, easy to implement contactless tachometer using low cost linear digital integrated circuits (ICs). This tachometer can be easily used for both industrial and laboratory purposes where it should be able to measure rpm and display reading in revolutions per minute (RPM) on the liquid crystal display (LCD module). This device is an embedded system; it is built using an alpha-numeric liquid crystal display (LCD) module and an infrared system to detect the rotation of the machine whose speed is being measured. The system is economical and has wide applications in automobile industry and medical field. Tachometer plays a vital role in measurement of speed of any rotating device and it is essential for any control system especially in servomechanism. Most of the controllers employed in the industry to control industrial process use a tachometer which gives the provision of feedback in a control circuit. It can measure the speed of rotating objects (examples of rotating objects include: a bike tyre, a car tyre, or any other motor) in the most accurate form possible. In automotives, it is used as a gauge showing the speed of the engine shaft that is driving the transmission, usually in thousands of rotations per minute.*

Key Words*: *tachometer, revolutions per minute, arduino uno, infrared sensor, speed measurement.

1. INTRODUCTION

In this modern era of industrialization most of the industries contain rotating objects such as motor, rotor etc for its proper monitoring its speed has to be measured and controlled. For such measurements, there are many methods and one of such method is use of tachometer. Tachometer is an instrument which measures the speed of any rotating objects in revolution per minute (RPM). There exist mechanical tachometers, where direct contact between motor and the tachometer is needed for measurement of RPM. This kind of tachometers requires regular maintenance and is complicated to use. These instruments suffer from wear and tear. Hence there is a requirement for a contactless digital tachometer which can be easily used with monitoring system. This paper is about contact-less digital tachometer designed using infrared methodology. It works on the principle that the number of times the IR receiver-transmitter circuit is cut and re-established in a second gives the number of rotations per second. The value is displayed on the LCD display. The screen is refreshed after each second. The sensor unit used for measurement is IR sensor and the processing unit used is Arduino-Uno. The measured value is displayed using a 16X2 LCD module. This kind of tachometer can employed in the region where speed is unit of measurement and size and precision is a factor. This model can be employed in vehicles and robotic arms. This is also used in aircraft, rails and traffic engineering to estimate traffic speed and volume.

Digital tachometers are preferable due to its better accuracy, no A/D conversion, less maintenance (as they are brushless) and noise immunity. A digital tachometer works on the principle of frequency measurement which has two distinct approaches which are –

(1) Measurement of elapsed time between successive pulses.
(2) Counting the number of pulses in a fixed period of time.

2. BACKGROUNGD

In olden days tachometers were completely mechanical, but tachometers have changed due to development of modern technology. The first mechanical tachometer was similar in operation to a centrifugal governor. The inventor of the first mechanical tachometer is assumed to be a German engineer Dietrich Uhlhorn; he used it for measuring the speed of machines in 1817. Since after then, it has been used to measure the speed of locomotives in automobiles, trucks, tractors and aircrafts. Early tachometer designs were based on the principle of mono stable multi vibrator, which has one stable state and one quasi stable state. The circuit remained in a stable state, producing no output. However when it receives triggering current pulse from the ignition system, the circuit transitions to the quasi stable state for a given time before returning again to the stable state. This way, each ignition pulse produced a clean pulse of fixed duration that was fed to the gauge mechanism. The more of such fixed duration pulses the gauge received per second, the higher it read. The mono stable multi vibrator is still used in tachometers today, although the tendency is to use voltage pulses rather than current pulses, the latter requiring that the ignition coil current passes through the tachometer on its way to the coils. Later designs of tachometer were in no way to do any improvement on the early type; indeed the change seemed to have been made to be more economical. Integrated Circuit (IC) where in their infancy in the late

1960's and was both expensive and not proven to be robust in automobile applications.

3. WORKING PRINCIPLE

Tachometer is an RPM counter which counts the no. of rotation per minute. There are two types of tachometer one mechanical and other one is digital. Here we have designed an Arduino based digital tachometer using IR sensor module to detect object for count rotation of any rotating body. As IR transmits IR rays which reflect back to IR receiver and then IR Module generates an output or pulse which is detected by the arduino controller when we press start button. It counts continuously for 5 seconds.

After 5 seconds arduino calculate RPM for a minute using given formula.
RPM= Count x 12 for single object rotating body.
But here we demonstrate this project using ceiling fan. So we have done some changes that is given below:
RPM=count x 12 / objects
where object = number of blades in fan.
The methodology employed in this work is shown in the Figure 1 below.

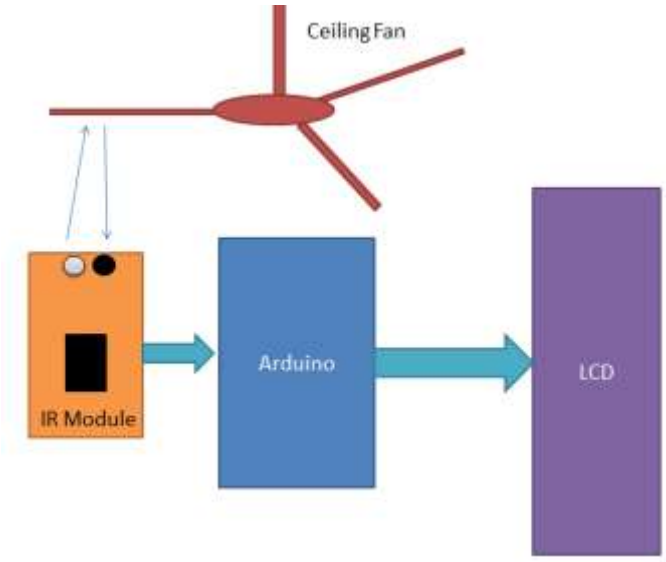

Fig-1: Block Diagram showing Working Principle of Contactless Tachometer

The hardware components required for the above system are given below:
1. Arduino
2. IR sensor Module
3. 16x2 LCD Display
4. Push button
5. Bread board
6. 9 volt battery
7. Connecting wires

4. SYSTEM ARCHITECTURE

The system works mainly on infrared transmission principle. It has mainly controlling unit, sensing unit display unit and motor. The object of interest I.e. motor is placed in front of sensors. The sensor has IR LED and photodiode and the IR LED emits continuous beam of light rays. When motor starts rotating this light ray will be interrupted. The light ray will be rebound back and will be absorbed by the photodiode. This interruption of light ray is continuous in each and every rotation. This results in pulse of light ray that is fed to the microcontroller. The microcontroller counts the number of pulses and that in turn is the number of rotations. This obtained value will be displayed on the LCD screen. Tachometer using arduino is shown in figure 2.

Fig-2: Tachometer using Arduino

4.1 Arduino-Uno

The Arduino-uno is microcontroller which is shown in Figure 3.The board is equipped with set of digital and analog input/output pins that may be interfaced o various expansion boards or breadboard and other circuits. The boards feature serial communications interfaces including USB (universal serial bus) on some models which are also used for loading programs. The microcontroller is typically programmed using a dialect of features from the programming languages c and c++ in addition to using traditional compiler tool chains, the Arduino project.

Fig-3: Arduino-Uno

4.2 Infrared (IR) sensor

An infrared sensor which is shown in Figure 4 is an electronic instrument which is used to sense certain characteristics of its surroundings by either emitting detecting infrared radiation. These sensors function by using a certain light sensor to detect a light wavelength in the IR spectrum. By the use of an LED, which produces light at the same wavelength as the sensor detects, we can study the intensity of the received light. At the time when the object is near the sensor, the light from the LED bounces off the object and into the light sensor. This results in increment in energy on a large scale intensity, which we can detect using a threshold. Infrared sensors are also capable of measuring the heat being emitted by an object and detecting motion. IR transceiver is used here for determining the number of rotations of the motor shaft per second. This is done by counting the number of times the slot comes in line of sight with the transmitter receiver pair.

Fig-4: Infrared sensor

4.3 LCD 16x2

The LCD screen which is shown in Figure 5 is more energy efficient and can be disposed of more safely than a CRT can. Its low electrical power consumption enables it to be used in battery powered electronic equipment more efficiently than CRTs can be a 16x2 LCD display is used in the project which displays the count or number of rotation. LCDs are used in a wide range of applications including LCD televisions, computer monitors, instrument panels. Small LCD screens are common in portable consumer devices such as digital cameras, watches, calculators, and mobile telephones, including smartphones. LCD screens are also used on consumer electronics products such as DVD players, video game devices and clocks. LCD screens have replaced heavy, bulky cathode ray tube (CRT) displays in nearly all applications. LCD screens are available in a wider range of screen sizes than CRT and plasma displays, with LCD screens available in sizes ranging from tiny digital watches to very large television receivers.

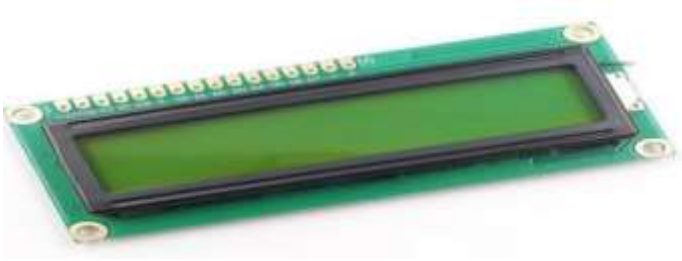

Fig.-5: Liquid crystal display (LCD)

5. CIRCUIT OPERATION

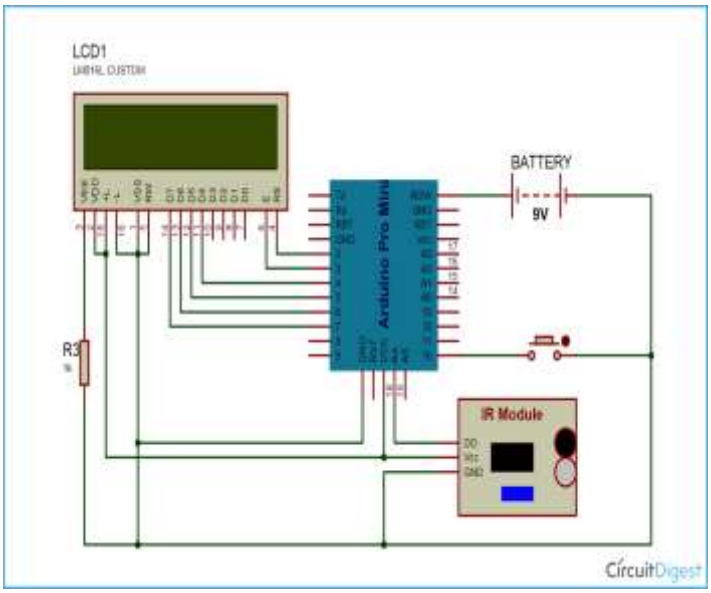

Fig-6: Circuit Diagram of Digital Contactless Tachometer

As shown in the above tachometer circuit of Figure 6, it contains Arduino Pro Mini, IR sensor module, buzzer and LCD. Arduino controls the whole the process like reading pulse that IR sensor module generate according to object detection, calculating RPM and sending RPM value to LCD. IR sensor is used for sensing object. We can set sensitivity of this sensor module by inbuilt potentiometer situated on IR module. IR sensor module consist an IR transmitter and a photo diode which detects or receives infrared rays. IR transmitter transmits infrared rays, when these rays fall on any surface, they reflect back and sensed by photo diode. The output of photo diode is connected to a comparator, which compare photo diode output with reference voltage and result is given as output to arduino. Operation of infrared module in contactless tachometer is shown in Figure 7.

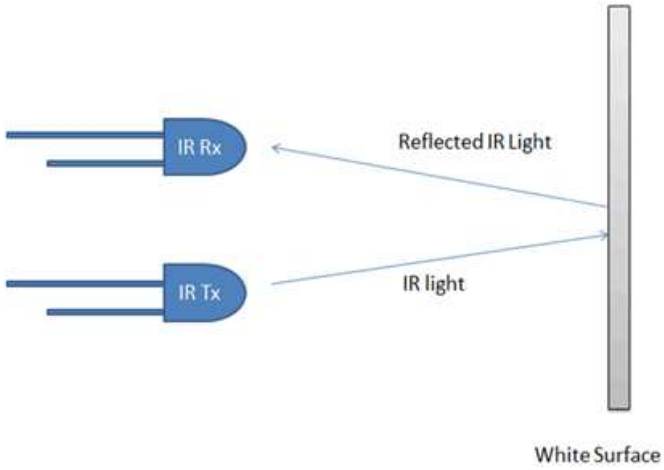

Fig-7: Operation of Infrared Module in Contactless Tachometer

IR sensor module output pin is directly connected to pin 18 (A4). Vcc and GND are connected to Vcc and GND of arduino. A 16x2 LCD is connected with arduino in 4-bit mode. Control pin RS, RW and En are directly connected to arduino pin 2, GND and 3. And data pin D4-D7 is connected to pins 4, 5, 6 and 7 of arduino. A push button is also added in this project. When we need to count RPM we press this button to start this Arduino Tachometer to count RPM for five seconds. This push button is connected to pin 10 of arduino with respect to ground. Printed circuit board of tachometer is shown in Figure 8.

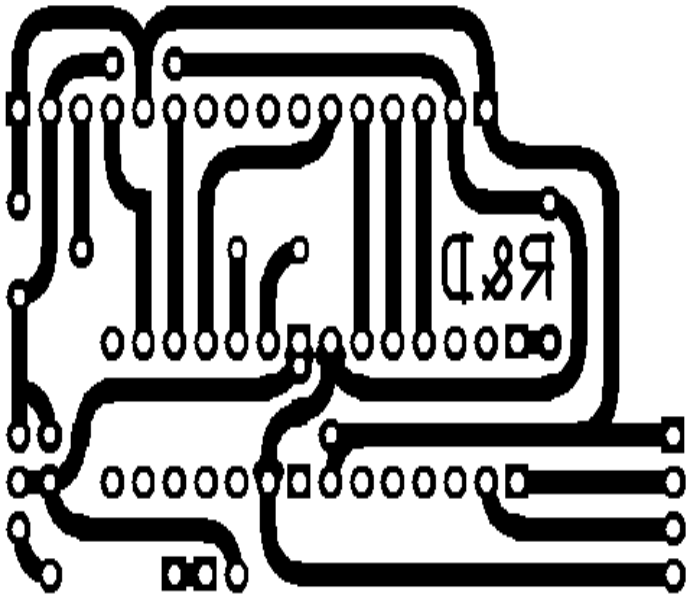

Fig-8: Printed Circuit Board (PCB) of Tachometer

6. RESULT

We have designed the circuit to work with least error. We have checked the circuit up to the primary level and it is successfully capable to determining the speed of the motor. Whenever any rotating motor is detected within the range of the circuit, the input starts to flow to the arduino board and thus resulting in its speed detection. Complete circuit is verified and tested.

7. CONCLUSION

The tachometer circuit is a digital innovative device that is active in measuring the speed of a rotating object. In this modern world all industries have motors whose speed has to be monitored properly. This device is nothing but a simple electronic digital transducer. Normally, it is used for measuring the speed of a rotating shaft. The number of revolutions per minute (rpm) is valuable information for understanding any rotational system. We have tried maximum in bringing up this contactless tachometer. This is low cost and gives proper output. Therefore, the circuit of our paper was designed and implemented and the speed of the motor is displayed on the LCD display every second.

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