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Designe and Development of Ardrino based Digital RPM Meter

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Abstract— Contact less Digital RPM meter is a device used to measure speed of a rotating body by counting the number of rotations per second of a rotating shaft using Arduino as the main controller along with the IR sensor with bluetooth connectivity to send the measured value of RPM to some remotely located receiver. It works on the principle of The IR sensor kept in front of a rotating body within a specified range of measurement. The number of counts from the IR sensar signal cut by the rotating body introduce the sense of RPM value which is displayed on the LCD display. The Arduino nano(ATmega 328P) is used as a microcontroller along with IRS sensar (MH-sensar-series, MH-B) and Bluetooth device (HC-05) are the main constituing parts of this measuring system. The designed system is unique from the conventional tachometers as the RPM measurement is not only contactless but it can also be transmitted to some remotely located control room for recording, processing and analysis of the rotating system parameters.

Keywords— *RPM- revolution per minute, IRS- Infrared reflective sensor,LCD- liquid crystal display*

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I. INTRODUCTION

The word 'tachometer' is derived from two Greek words: tachos means "speed" and matron means "to measure". Tachometer is a device used for measuring the number of revolutions of an object in a given interval of time. Usually it is expressed in revolutions per minute or RPM. Earlier tachometers purely mechanical where the revolution is transferred to the tachometer through mechanical coupling (cable or shaft), the rpm is determined using a gear mechanism and it is displayed on a dial. This article is about a contactless digital tachometer using Arduino. The RPM and all the other information's are displayed on a 16×2 LCD screen. Digital tachometer is an IRS encoder that determines the angular velocity of a rotating shaft of a motor or any rotating body having blades or propeller. RPM measurement are useful in different applications such as automobiles, aviation technology and Bio-medical instrumentation applications. A tachometer that does not need any physical contact with the rotating shaft is called as noncontact digital RPM meter.

In the present work an IR sensor is used with the Arduino system which sense the Rotation of the rotating shaft, and it can be read by an IR beam. This type of tachometer can measure from 1 to 99,999 rpm; the measurement angle is less than 120 degrees, and the tachometer has a five-digit LCD display. These types of tachometers are efficient, durable, accurate, and compact.

In this work the working principle of laser based digital tachometer mainly highlights the arduino based Digital Tachometer principle with Bluetooth features. Via Bluetooth the data is transmitted to the mobile phone or laptop or some storage devices which are remotely placed having Bluetooth connectivity.

The main objective of this project work is to make a digital tachometer with Bluetooth features along with remote data transmission wirelessly. In the laboratory, we are familiar with digital tacho-generator. But that system does not have the feature of data communication in remote place not also having the features of data store and analysis. So, we have chosen the area of research based on the earlier experiment on tacho-generator and hence modified the working principle of conventional tacho-generator with the introduction of Arduino based digital RPM meter having Bluetooth connectivity. The advancement of Arduino based system has its own features i.e. Bluetooth connectivity with the scope of remote data transmission. The peripheral devices are connected to the control room of the power plant where the field data are stored, analysed and accordingly the control signals are sent to the machines situated in the field so that the speed can be controlled remotely.

II. RELATED WORKS

A tachometer that does not need any physical contact with the rotating shaft is called as noncontact digital tachometer. In this type, a reflector is attached to the rotating shaft, reflection is directed by the IR sensor. This device is an embedded system; it is built using a microcontroller, an alpha-numeric LCD module and an infrared system to detect the rotation of the rotating body whose speed is being measured. The infrared system generates the pulses from the rotating body which will be sent to the microcontroller and the pulses will be counted; the reading is displayed on the liquid crystal display (LCD module) in revolution per minute (RPM). [1]

Digital remote tachometer based on a Hall Effect sensor is another very widely used technique for measuring the speed of a rotating body. A correct characterization is crucial to properly handle analyze and interpret signals from any kind of sensor. Whole telemetric system characterization, including sensing stage, wireless transmission and reception under IEEE standard, data analysis and display through a graphical user interface developed in software. A pulse train proportional to the motor speed is sent to a microcontroller to manage signals and compute speeds before wireless transmission. Once received, data is analyzed and displayed. [2]

Tachometer is used to measure speed of motor or shaft or propeller. This tachometer is designed using ATMega16 micro-controller. It uses low cost infrared transmitter-receiver pair for sensing propellers. It can measure Rotation per second (RPS) speed up to the desired value, depends on the speed of the motor. The microcontroller ATmega16 is programmed such that each time the voltage in the pin of microcontroller changes from zero to a high value, it initiates a timer interrupt. The interrupt counts the number of times the voltage variation occurs in the resistor in series with the receiver and sends the value to the LCD display every second. Another timer resets the counter after each second. So we get the number of rotations per second of the motor shaft. [3]

Tachometer is a device which is used to measure the rotational speed of a shaft or a disk in a motor or other machine. The conventional Tachometers require contact between the device and the rotating body, there are many situations where the direct contact between the tachometer and the device under investigation is not possible. To deal with such situations we need a tachometer which doesn't require direct contact with the rotating body, such tachometers are known as Contact-less Tachometer. The whole design is divided into two parts a transmitter section and a receiver section. For RPM values greater than 300 this algorithm works very well and the results are more accurate and stable. Also, for data logging the RPM values can be sent to a distant 'Monitoring unit', using on board RF ICs. [4]

The specified parameters of DC motor such as Torque constant, back-emf constant, viscous friction constant, internal resistance and inductance needed for modelling the system of a DC motor. Most popular controlling methods available are PID controller, Adaptive controller or intelligent controller in some cases. The current work builds a very simple, effective and cost-effective controller of a DC motor. Tachometer's RPM reading gives the feedback into controller function to compare against the desired RPM set by the user until they align on the same line. [5]

III. METHODOLOGY

Digital Tachometers are capable of measuring low-speeds at 0.5 rpm and high speed at 10,000 rpm and are equipped with a storage pocket for the circumferential measurement. The specifications of this tachometer are LCD 5-digit display, operational temperature range of 0 to + 40 ^{o}C, temperature storage range of – 20 to + 55 ^{o}C and rotating speed of about 0.5 to 10,000 rpm.

The IR circuit will generate output pulses whenever it is interrupted (this type of IR circuit is also known as a 'photo-interrupter' circuit). The ATmega 328P microcontroller will stand by waiting to see the rising edge of one of these pulses.

Anytime a rising edge is detected, the micorcontroler will interrupt the current software and run a special subroutine to take note that the change on the signal occurred. Now, if we keep track of how often that change occurs using a timer, we can estimate the instantaneous RPMs, making a digital tachometer.

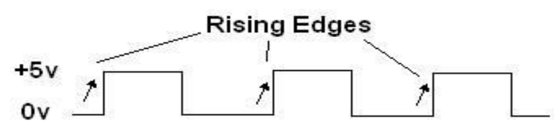

Figure 1. Output signal of IR module

The equation has been derived from the relationship of applied voltage in armature vs angular rotation of rotor. A DC motor voltage is the input of the system and speed is the output. Dc motor directly provides rotary motion. The equivalent electric circuit of the free body rotor and armature looks like as figure 2.

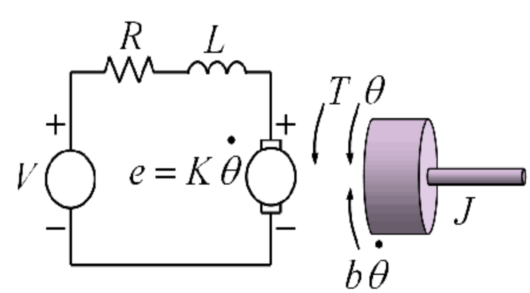

Figure 2. Armature and rotor Equivalent circuit of a DC motor

Two equations are derived using Kirchhoff's, voltage law and newton's second law from the diagram

$J\Theta + B\Theta = K*i$

$L\frac{di}{dt} + R*i = V - K*\Theta$

Here,
Armature Current= i; amp
Moment of inertia of the rotor= J; kg.m2
Motor viscous friction constant= b; Nm.s
Electromotive force constant= Ke; V/rad/sec
Motor torque constant= Kt; Nm. /amp
Electric resistance= R; Ω
Electric inductance= L; H
Angular velocity of the shaft= Ɵ
After deriving the equation, we get-

$$P(s) = \frac{\omega(s)}{V(s)} = \frac{K}{(Js+b)(Ls+R)+K^2} \quad [\frac{rad/sec}{V}]$$

A. Schematic diagram

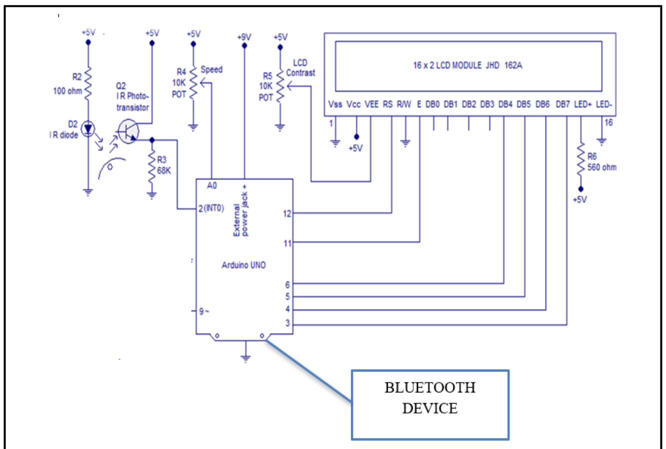

Figure 3. Schematic diagram of RPM measurement system

IV. Real-time Implementation of RPM Measiring System

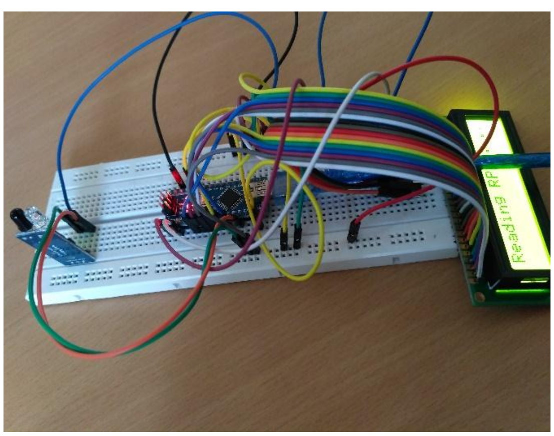

Figure 4. Hardware implementation of Digital RPM meter

A. Ardrino programe

The following Arduino programme has been used for the RPM sensing method.

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
#define sensor 9
#define start 12
int delay1()
{
 //unsigned int long k;
  int i,j;
  unsigned int count=0;
  for(i=0;i<1000;i++)
  {
   for(j=0;j<1227;j++)
   {
    if(digitalRead(sensor))
    {
     count++;
     while(digitalRead(sensor));
    }
   }
  }
  return count;
}
void setup()
{
 pinMode(sensor, INPUT);
 pinMode(start, INPUT);
 pinMode(2, OUTPUT);
 lcd.begin(16, 2);
 lcd.print("   Tachometer");
 delay(2000);
 digitalWrite(start, HIGH);
}
void loop()
{
   unsigned int time=0,RPM=0;
   lcd.clear();
   lcd.print("  Please Press  ");
   lcd.setCursor(0,1);
   lcd.print("Button to Start ");
   while(digitalRead(start));
   lcd.clear();
   lcd.print("Reading RPM.....");
   time=delay1();
   lcd.clear();
   lcd.print("Please Wait.....");
   RPM=time/3;
```

[the 1/3 term has been used in this programme considering the 3 blades of a fan. If the RPM of any motor is measured having only a single blade connected with the rotor shaft, then 1/3 is not required.]


```
    delay(2000);
    lcd.clear();
    lcd.print("RPM=");
    lcd.print(RPM);
    delay(5000);
}
```

V. RESULTS AND DISCUSSION

The system works mainly on infrared & Bluetooth transmission principle. The motor is placed in front of sensors. The sensor has IR LED and phototransistor The IR LED emits continuous beam of IR pulse trains. When motor starts rotating this IR pulse will be interrupted. The IR signal will rebound back and will be absorbed by the photo-transistor. This interruption of light ray is continuous in each rotation. This results in a pulse of light ray that is fed to the arduino. The arduino counts the number of pulses which in turn is the number of rotations per minute or the RPM. This obtained value will be displayed on the LCD screen and via Bluetooth, the data will be transferred to a storage device.

TABLE 1 : COMPARISON BETWEEN CONVENTIONAL CONTACT-TYPE TACHOMETER, LASER TACHOMETER AND DIGITAL RPM METER

No of Observation	Measurement of RPM using conventional Tachometer	Measurement of RPM using Laser Tachometer	Measurement of RPM using RPM Meter
1.	703	700	713
2.	921	910	929
3.	1220	1200	1250

VI. CONCLUSION AND FUTURE SCOPE

The designed system (Arduino based Digital Tachometer) having the features of Bluetooth connectivity will be implemented with proper design parameter and hardware availability. The objective of the project work will be fulfilled by the features of data transmission to the remotely located control room along with data storage and its analysis.

VII. ACKNOWLEDGMENT

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