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Digital Tachometer

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Abstract:- The measurement of instantaneous torque in terms of voltage displaying rotating speed in revolution per minute (RPM) of a rotating shaft is known as a digital tachometer. An infrared module is used as the input that senses the interruption in terms of beam of rays caused by rotating shaft, generating a pulse. The usual method of counting pulse coming from the encoder in a fixed period of time produces a high precision velocity estimate in the high-speed range. The encoded signal is latched and further sent to decoder that decodes the latched pulse i.e. speed displayed in 7 segment display. This paper mainly focuses on developing a contact-less digital tachometer of maximum 3digit with the help of integrated circuits (ICs).

I. INTRODUCTION

A tachometer is an instrument which measures the rotation speed of a shaft or disk, as in a motor or other machine. It displays the speed in revolution per minute (RPM). Tachometer is also known as revolution-counter, and its operating principle can be electromagnetic, electronic, or optical-based. Tachometers can be analog or digital indicating meters; however, this article focuses only on the digital tachometer based on IC. A tachometer that does not need any physical contact with the rotating shaft is called a non-contact digital tachometer. Digital tachometers are more common these days and they provide numerical readings instead of gauge that usually displays the RPM on a calibrated analogue dials and needles. Digital tachometers are used in different applications such as automobiles, airplanes, and medical and instrumentation applications.

II. LITERATURE REVIEW

A tachometer is also known by several other terms as a revcounter and rpm gauge. It was first used to measure speed on a vehicle (a locomotive) in 1840. Even though the first petrol or gasoline powered automobile was developed in 1886 by Karl Benz, it is unclear when the first car featured a tachometer [1]. 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 [2]. Since then it has been used to measure the speed of locomotives in automobiles, trucks. Early tachometers design was based on the principle of monostable multivibrator, which has one stable state and one quasi-stable state. A paper named "Design of a high-performance digital tachometer with a microcontroller" describes the basic construction of a low-cost optical tachometer and analyzes its performance. The basic tachometer circuit consists of two stages. In the first stage monostable wired around IC NE555 is used, and in the second stage a digital counter based 4-digit counter IC 74C926 is used for the construction of the tachometer. A 5V regulated power supply circuit and an infrared light source circuit are also used. The instrument can measure speed up to 9999 RPM [2].

Another paper named" A Digital Tachometer for Measurement of Very low Speeds" a new approach to the digital measurement of angular velocity is presented. This new instrument performs the division by time that has been carefully avoided in the existing instruments. The accuracy and resolution of the transducer does not depend upon the number of revolutions. The measurements can be made in a very short time, leading to up to 14,700 samples per second [1].

Similarly, a paper named" Contactless Speed Monitoring and Displaying" contactless tachometer measures the speed in RPM is designed with the help of microcontroller and diodes. The author uses At89s52 as a microcontroller. This is programmed in c program and complied using keil complier [3].

III. OVERVIEW OF THE SYSTEM

This system basically contains of timer IC, Decade counter, gate driver, IR transmitter/receiver, seven segment display unit and some led. At first timer IC configured as monostable and it produce timing pulse for certain time when switch is pressed, the LED indicates the sensing duration. The IR transmitter and receiver are used to produce changing logic levels depends on the blocking or interrupting IR light beams. Logic gate enables decade counter and decade counter drives seven segment display. There are three-decade counter and three seven segment display to show RPS from 000 to 999. This illustration shows how to make a rotating interrupter, measure the slot width and depth of the shaft or rotating machine. One interruption to the IR beam by the rotating disc, which will take as one count and total count of rotation is RPS, by this way multiplying 60 to RPS revolution per minute (RPM) can be obtained.

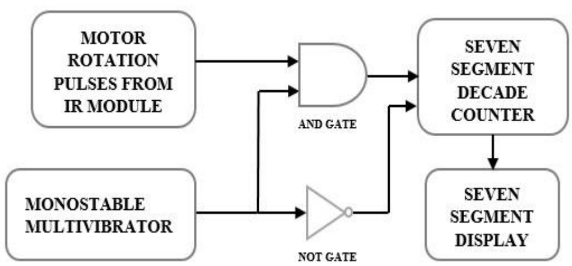

Fig 1: Block Diagram

The given Fig 1 is the block diagram of the system. The decade counter gets the pulse input from the output of the gate driver. The output of the IR transmitter and receiver is fed to the gate logic with the monostable timer and which is fed to the latch pin of the decoder by inverting it, in order to display the value in the seven-segment display after certain time by converting it into RPM.

The basic principle behind converting the RPS reading into RPM is shown below:

Counting time: 10 secs
Then, no. of pulses in 10 secs = x
Now, in 1 sec no. of pulses = x/10
In 60 sec no. of pulses = (x/10) *60 i.e. x*6
Now if we have 6 holes/areas to read then the rpm is simply (x*6)/6
So, we get the data directly in RPM. I.e. x

By this way the required speed of the rotating shaft is determined in the terms of per minute i.e. RPM.

IV. DESCRIPTION OF DESIGN

A. Counter

A special type of sequential circuit used to count the pulse is known as a counter, or a collection of flip flops where the clock signal is applied is known as counters.

B. Latch

A latch is a storage device that holds the data using the feedback lane. The latches have low and high two stable. Latches operate with enable signal, which is level sensitive states.

C. Decoder

The combinational circuit that change the binary information into 2N output lines is known as decoders. The binary information is passed in the form Of N input lines. The output lines define the 2N-bit code for the binary information.

D. CD 4026

The IC CD4026 is an IC which can perform the function of both a counter as well a 7-segment Driver. The whole function of counter, latch and decoder is done by an IC of CMOS series of 4026 as shown in block diagram. Its operating voltage is 5v.

E. NE555

The NE555 is a highly stable controller capable of producing accurate timing pulse. The operation, the time delay and the frequency are controlled by external resistors and capacitors. A timer can be used as linear ramp, pulse position modulation, pulse width modulation, frequency divider and in astable, monostable and bistable mode. Here, we have used the timer in Monostable mode to generate the pulse width modulated waves.

F. Seven Segment Display

A seven-segment display is a form of electronic display for displaying decimal numerals that is an alternative to the more complex dot matrix displays. Seven-segment displays are widely used in digital clocks, electronic meters, basic calculators, and other electronic devices that display numerical information. The output data from the decoder is displayed using a seven-segment display which is one of the most important section. We use three seven segments display to show RPS from 000 to 999.

G. IR Transmitter/Receiver

IR transmitter receiver works by letting one component flash an infrared light in a particular pattern, which another component can pick up and translate into an instruction. These transmitter receivers are used in our remote and televisions. Basically, the concept of transmitter and receiver is for the purpose of generating pulses which is further detected by CD4026 decade counter. The transmitter sends the IR through a rotating disc and reflects towards the receiver that counts the pulse. The IR module is sensitive towards the direct sunlight which may fluctuate the generated pulse.

H. Logic Gates

Logic gates are basic building blocks of any digital system. It is a circuit having one or more than one input followed by only one output. AND gate and NOT gate is used in this project as shown in the circuit diagram. The output of T1 timer (monostable state for 10sec) and pulse generated from the rotating disc is send to the output as input. The NE555 timer is in monostable state that reads the pulses only for 10 seconds. The main purpose of AND gate is to read high and low pulses for 10 second. The data read is multiplied by 6 to convert it to RPM whereas the rotating disc is also designed with the reflecting surfaces accordingly with the pulses read for 10 second. The output of AND is sent to CD4026 IC for counter for counting purpose.

The NOT gate is used to invert the receiving signal as an input for decoder to display through common cathode seven segment displays.

I. Capacitor

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance.

J. Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, etc.

K. Rotating Disk

A rotating disk is a simple disc divided into 12 small regions coated with black and white colors alternately as shown in figure below. A DC motor is attached to the rotating disk which rotates it.

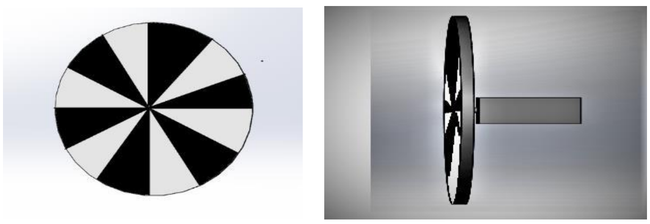

Fig 2: CAD Design of Rotating Disc with DC motor

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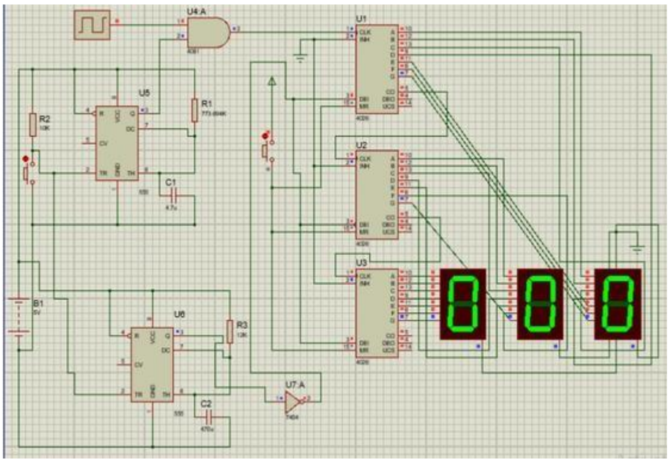

Fig 3: Proteus Simulation of the Circuit

V. HARDWARE IMPLEMENTATION

Firstly, the IR sensor calibration was done and feeding some arbitrary values according to the conditions after striking on the plate which is mounted on the motor shaft according to the varying speed of the motor. The output of the IR sensor was seen in the digital Oscilloscope as in the Fig 5. After that 555Timer was operated in the monostable mode for 10 seconds because only the data of 10 sec was taken for converting it to the rpm by relating it to the rotating disc mounted on the shaft of the motor.

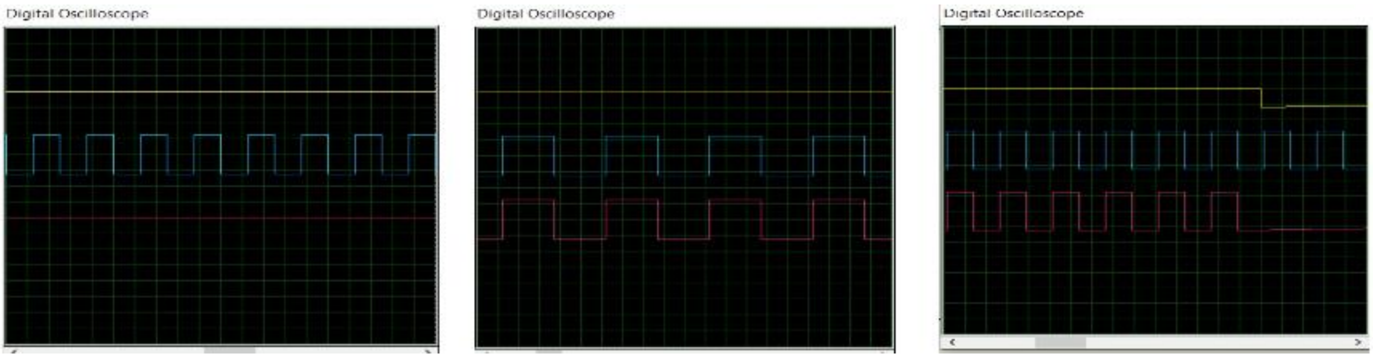

Fig 5: Overall Output Graph of the System

The basic principle behind converting the RPS reading into RPM is shown below:
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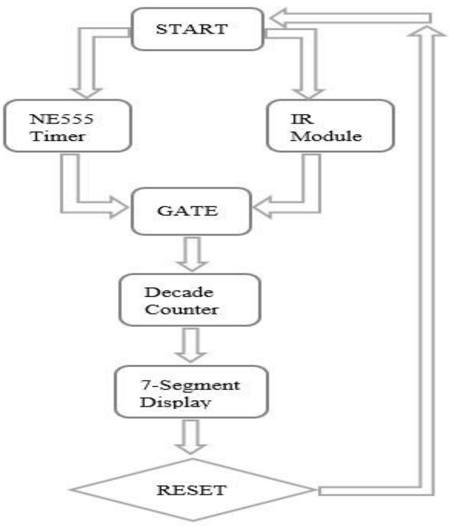

Fig 4: Methodology of Hardware Implementation

The reason behind for taking the data of 10 sec is mention above clearly. The data input of 10 sec should be counted. So, it should be passed from the AND gate, i.e. which gives only high output when both the inputs are high. One input of the AND gate is the output of the timer IC and another is output of the IR sensor. The output of the AND gate is fed into the clock input of the Decade counter 4026. So, with the help of AND gate after 10 Sec that data fed into the Decade counter will be zero. The output graphs of the 555 timer, IR module and Clock input in the decade Counter is shown in the Figure 5.
Channel A- Yellow- 555 timer output
Channel B- Blue – IR Module
Channel C- Pink- AND gate output/Input for Decade Counter

After the data/signal is fed into the clock pin of the 4026 IC, it converts the data and act as the decoder and display the RPM into the seven-segment display. The same output of the 555 timer is passed through the not gate to the display pin of the 4026 IC which will display the value after 10 sec exactly by doing the calculation. Cascading three 4026 IC is done for threedigit display. Similarly, to display N number of digit cascading of N 4026 must be used with N number of 7-segement display. For the new reading a reset pin is connected to the 4026 IC to reset the latched value manually. Fig 6, shows the developed digital tachometer.

Fig 6: Developed System

VI. APPLICATION

Tachometer is a measuring device that measures the revolution speed of the rotating objects. It is used for measuring the rotation frequency or speed of a rotating object such as shafts or disk, in the motor vehicles or in other machines where rotation speed is the driving force.

VII. DISCUSSION AND RESULTS

A simple digital tachometer has been constructed with standard CMOS integrated circuits for maximum three digits. The system reads the signal from IR module for 10 seconds, the obtained data is further encoded, latched and decoded by an IC CD 4026 and displays the resultant speed (RPM) in 7-segment display. This approach eliminates rapid changes in the frequency, one must start over for the new reading by pressing reset button. The speed in RPM of a particular rotating shaft was taken by varying its voltage for each reading with the lab's tachometer and developed tachometer is shown in table 1. Bar graph of the obtained data from the table 1 is represented in figure 7.

Table 1: Obtained Results

S.N.	Lab Tachometer (RPM)	Developed Tachometer (RPM)	Error
1	230	228	2
2	285	285	0
3	368	369	1
4	567	565	2
5	654	654	0
6	732	734	2
7	888	891	3
8	925	920	5

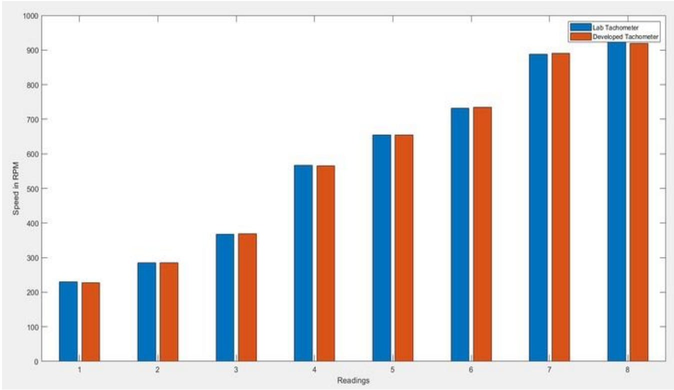

Fig 7: Bar Graph of Obtained Results

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