Contactless Rotor RPM Measurement using Raspberry Pi and Laser sensor

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***Abstract*: This paper presents an experimental study of high resolution rotation per minute (RPM) measurement of a rotating shaft using Laser sensor module. A novel method is implemented for measuring low speed as well as a high speed. Experiments are conducted using a raspberry pi which is based on ARM7 processor. The experimented results are presented for low speed as well as high speed separately and also calculated resolutions are shown.**

***Keywords*: Optical Sensor, Laser Sensor, Hall Effect, Resolution.**

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I. INTRODUCTION

The information of rotation per minute (RPM) is very consequential when controlling the speed of motors, conveyors and turbines etc. It is one of the most arduous and paramount quantifications in modern industrial monitoring and quantification systems for rotary machinery. There are sundry methods utilized for the speed quantification purposes. Some of them are 1) Mechanical 2) Optical [1]-[2] 3) Stroboscopic etc.

In mechanical based RPM measurement requires physical contact with the shaft of the motor and also have a low resolution between 20 and 20,000 rpm. In optical based RPM measurement, there is no require for physical contact but the resolution is less whereas in stroboscopic method resolution is high but it is costly.

It is usual and preferable in industry for the RPM measurement between the rotor and the stator to be contactless due to the troublesome mechanical issues associated with the bearing contact such as vibration, wear-out, and overheating. A typical contactless RPM quantification in industry is customarily predicated on electromagnetic RPM sensors [3]–[9] either by utilizing the Hall Effect, or electromagnetic induction, or the magneto resistive effect. These electromagnetic RPM sensors typically require the rotor position to have either one or more permanent magnets or a ferromagnetic gear with multiple teeth in rules of order to racetrack the rotation of the rotor.

Present use of optical based sensors are of low resolution and processor used is also low operating frequency.

In this paper higher resolution rotation per minute (RPM) based on optical sensors is presented. The merits of optical based RPM is non-contact, low cost, small size. A novel method for low speed as well as high speed measurement had been proposed and also practically experimented.

II. OPERATING PRINCIPLE OF LASER SENSOR MODULE

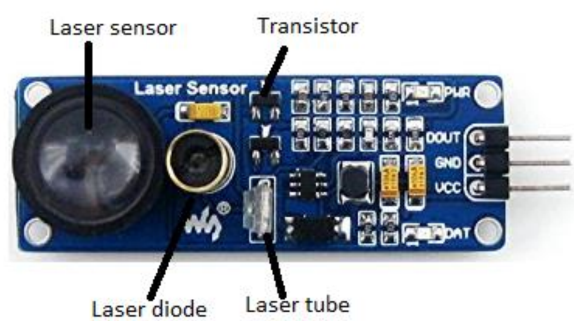

Fig. 1. Laser sensor module

Fig. 1 shows the schematic and operating principle of Laser sensor module. The module consists of Red Laser diode as transmitter and Laser receiver acts as a receiver. In the transmitter, there is an oscillating vacuum electron tube can engender a shockwave in a frequency of 180 kHz. After amplified by a junction transistor, the shockwave is applied to the optical maser tube for exhilarating.

In the receiving section, there is a receiving tube, matching to the oscillating tube, can receive the reflected luminance. Since the Laser sensor adopts intonation processing engineering science, the receiving tube can only receive the reflected light on the same frequency, efficiently preventing from visible light hence preventing from loss of pulses. The features of laser sensor module is shown in table 1.

TABLE 1: FEATURES OF LASER SENSOR MODULE

Characteristic	Value
Operating voltage	2.5V-5.0V
Dimensions	53.0mm*18.0mm
Fixing hole size	2.0mm
Effective distance	0.8m(typ), 1.5m(max)
Boost converter chip	PT1301

III. REFLECTING SURFACE DESIGN

The design of reflecting surface which is attached to the rotor shaft are important. The incident ray fall on the reflecting surface may get absorbed if reflecting surface is black color, not having proper dimension and orientation. Reflecting surfaces may not get reflected the incident ray when rotor runs at high speed. So choosing of reflecting surface is done with a material which has high reflecting surface with having proper dimension. The plane mirror acts as reflecting surface. The rotor shaft is attached with four plane mirror having dimension 1cm X 0.5cm which are separated with a fixed distance d as shown in fig. 2.

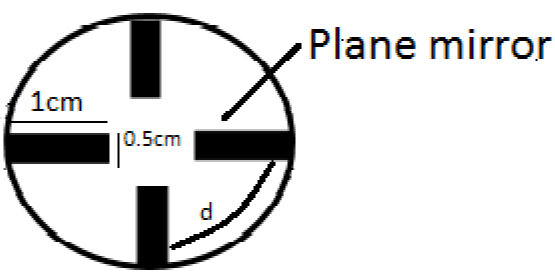

Fig. 2. Reflecting surface arrangement

By doing such arrangement number of the pulse generated from the shaft is high and more information about the rotor is obtained at low speed as well as high speed hence the resolution is high.

IV. STRATEGIES FOR MEASURING LOW SPEED AND HIGH SPEED

Fig. 3 shows the pulses generated from the Laser sensor module. These pulses are engendered felicitously with the rotation of shaft. The laser sensor produces four pulses per rotation since four mirrors are attached to the shaft of the motor. The pulses generated are counted at positive edge for high speed measurement i.e rising edge of the pulse as shown in fig.3.The generated pulses are checked for every half seconds means every one-second pulses are checked twice since the motor rotates at high speed, may produce more than 100 pulses per second. By doing this higher resolution could obtain.

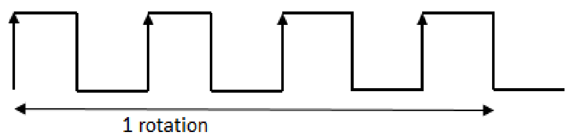

Fig. 3. Rising edge counting from Pulse

For measuring low speed measurement different strategy is applied. The time period between the pulses is calculated as shown in fig.4 by the processor and then rpm calculation is done. For determining the period between the pulses the counter must be clocked fast enough.

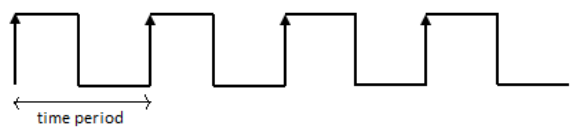

Fig. 4. Time period measurement

V. RPM MEASUREMENT

The given formula is used for RPM measurement
Speed = (New timer –Earlier timer/number of pulse count)* 60 seconds.
After every half seconds pulse counter is clear and updated with a new value for every half seconds. Timer function used to count the time taken between pulses and measured time is updated for every half seconds. Since the rotation is faster the number of pulses generated is nearly at 10 kHz so update RPM value is display at a fast rate.

A. Comparison of Resolution

Using one reflecting surface: At 500rpm the shaft rotates 8.3333 times per second hence in one second Count: 1 x 8.3333=8.3333 pulses
At 505rpm the shaft rotates 8.416667 times per second hence in one second count.
1 x 8.416667=8.416667 pulses
Using four reflecting surface: At 500rpm the shaft rotates 8.3333 times per second hence in one second Count: 4 x 8.3333=33.3332 pulses
At 505rpm the shaft rotates 8.416667 times per second hence in one second count.
4 x 8.416667= 33.666668 pulses

From the above calculation can conclude that more number of reflecting surface uses more resolution can have obtained.

. VI. EXPERIMENTAL RESULTS

The setup for experimental verification is shown in fig. 5. It was based on the Raspberry Pi based on ARM 7 processor which is working on 700MHz. A Laser sensor module was employed to count the number of rotation of the shaft which will generate output in the form of pulses. The laptop screen is used for displaying the RPM and the pulses generated by the Laser sensor module. Celerity is quantified from a 1 hp single phase induction motor. Experiment is performed in two ways 1) low speed measurement 2) high speed measurement shown in fig. 6 and fig. 7 respectively.

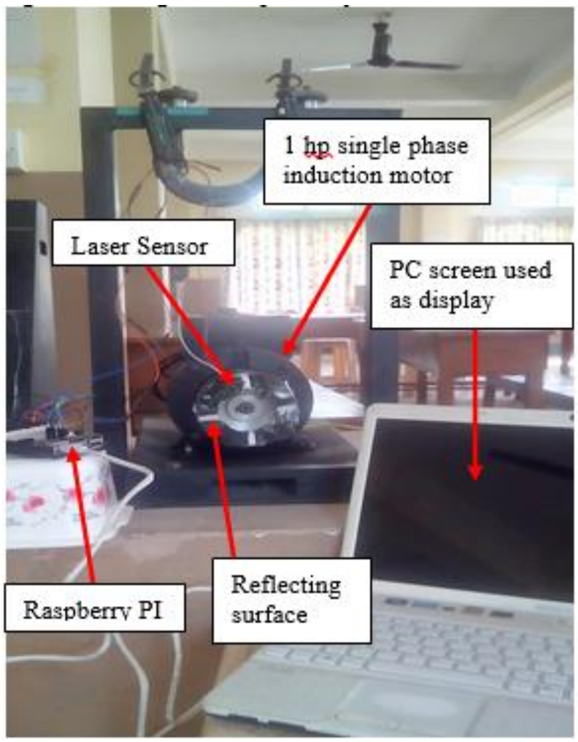

Fig. 5**.** Experimental setup

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('RPM=',   78.1158613757098)
('RPM=',   87.079704250394)
('RPM=',   41.510246603784)
('RPM=',   87.004089848971)
('RPM=',   41.5312579006245)
('RPM=',   87.011588620948)
('RPM=',   41.4593113724436)
('RPM=',   87.0090890259607)
('RPM=',   41.5159769276993)
('RPM=',   41.5127934116563)
('RPM=',   87.024711565643)
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('RPM=',   87.0878283473394)
('RPM=',   41.5261642253417)
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('RPM=',   41.3287978934272)
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('RPM=',   41.5153402239393)
('RPM=',   87.0378346296397)
('RPM=',   41.5529062173823)
('RPM=',   87.0353349892043)
('RPM=',   41.518523745495)
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Fig.6. Low variable speed measurement

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('RPM=', 2832.5703276230524)
('RPM=', 2778.044905185085)
('RPM=', 435.7401539628287)
('RPM=', 762.5923090459391)
('RPM=', 2723.5858163888156)
('RPM=', 4139.858505605338)
('RPM=', 3104.9079925107417)
('RPM=', 3159.376643278993)
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('RPM=', 2778.09060536697)
('RPM=', 2778.0551274636446)
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('RPM=', 2834.0474953465127)
('RPM=', 2778.095415999898)
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('RPM=', 2778.0731669622683)
('RPM=', 2778.133300316417)
('RPM=', 2723.598196434211)
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('RPM=', 2997.1121090992556)
('RPM=', 2451.236254489484)
('RPM=', 2887.032835353097)
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Fig.7. Speed measurement at high speed

VII. CONCLUSION

Designing of advance way of contactless speed measurement system is important nowadays. This work presents an optical based measurement of Rotation per minute (RPM) with the advanced processor and Laser light module. The resolutions and accuracy are much better as shown in experimental results. This system is can be applied in many fields such as high accuracy speed feedback system, Speed control of motors, Mechanical drives etc. Further, resolutions can be increased by increasing no of reflecting surfaces. In future this system can be modified to measure very low and high speeds depending on the frequency limitations of the sensor and the Reflecting Surface.

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He completed M Tech in Assam Don Bosco University, India in 2017. He received his B Tech degree in Electrical and Electronics Engineering from Lovely Professional University (India) in 2015. He has published 2 papers in areas of, Embedded System and Electrical Drives Simulation. His interest area are Embedded System, Power electronics, Electrical Drives and Renewable Energy. Now he is working as an Assistant Professor at Manipur Technical University (MTU) in Electrical Engineering Department.

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