# Hall Effect Sensor Based Portable Tachometer for RPM Measurement

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**ABSTRACT**

Hall effect sensors has a wide variety of applications in position sensing, angular measurement, speed measurement...Etc. Reference[1] is a velocity measurement by using linear hall effect sensor. Basically Hall Effect sensor is a magnetic field detector which detects the changes in field strength .This paper tries to explain a tachometer based on Hall Effect sensor which is accurate, portable and contactless. By using latched Hall Effect sensor, rotational speed can be measured by counting the number of pulses per revolution. The tachometer shaft is made in contact with the motor shaft whose speed is to be measured and a number of magnets are mounted on tachometer shaft. Hall sensor is positioned stationary in such a way that it will closely face the rotating magnets. Since the output is in the form of pulses it becomes easy to manipulate the data. We could develop a model which counts the rotation and which handle high speeds up to 5000-6000 rpm. With the help of a microcontroller speed can be calculated and displayed. From the conventional analog tachometer the Hall Effect based tachometer is expected to give wide ranges of operating speed and increased accuracy.

***Key Words:*** *Hall Effect, Lorentz Force, Tachometer, Revolution per Minute*.

## INTRODUCTION

Hall Effect is a phenomenon that occurs in conductor carrying a current when it is placed in a magnetic field perpendicular to the current. The charge carrier in the conductor become deflected by the magnetic field and give rise to an electric field(Hall field)that is perpendicular to both current and magnetic field. If current density 'Jx' is along X and the magnetic field, 'Bz', is along Z, then the Hall field is either along +Y or –Y depending on the polarity of the charge carriers in the material. The force exerted on the charge carriers is given by Lorentz equation. The Lorentz force is the force experienced by a moving charge in a magnetic field. When a charge **q** is moving with a velocity **v** in a magnetic field **B**, within the presence of an electric field **E**, then it experience a force **F**, that is proportional t o magnitude of the charge **q**, its velocity **v**, and the field **B** such that,

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$

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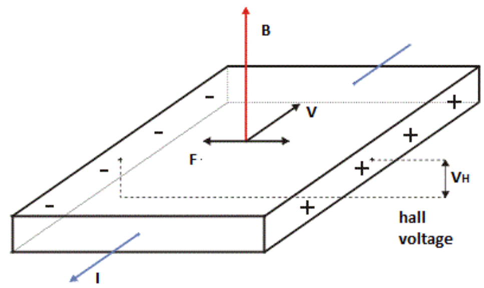


Fig 1. Hall Effect Theory

Fig 1. Explains the Hall Effect theory. Now here arises a question why we go for Hall Effect sensor based tachometer. To understand why, it requires some knowledge about other kinds of RPM detectors. Now consider a normal tachogenerator which gives analog response and requires a A /D converter to manipulate the signal and to display .But when we consider a Hall effect sensor it gives a direct digital (square or rectangular) output, which can be directly taken in to a microcontroller .When going for product like manufacturing this tachometer is expected to be less bulky. Optical and stroboscopic tachometers are the other options, but light beams are highly sensitive to vibrations .Normally a tachometer is expected to operate in a harmonic environment so precision in sensing is questioned .stroboscopic is the better choice of all but expensive. So Hall Effect based tachometer is an attempt to introduce a new RPM measuring device, which is precise less bulky and cost effective.

**The System Design**

Considering the design consideration of tachometer, the major priority was given for making a portable device, compromising the noise effect by contact. But it can be hopefully reduced by optimum and stable mechanical design. The prototype gives a similarity with normal tachogenerator which is contactable and a rotating shaft inside. Fig.2 shows the side view and Fig.3 shows the isometric view gives the overall design of the proposed device. A 6mm shaft which is supported and rotating over two bearings takes the speed in to the device. Over the shaft magnets are mounted axially like in figure. The hall element is is positioned stationary over the circuit board and the magnets are closely faced to the sensor. The sensor used is a digital Hall Effect sensor which gives square pulses, a unipolar sensor AH 44E, ALLEGRO make.

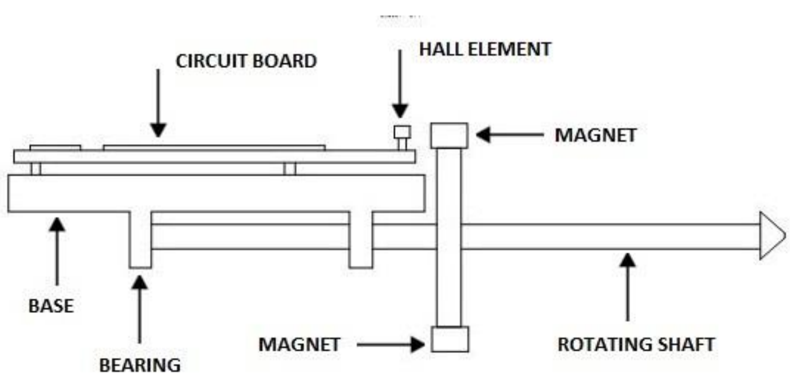


Fig 2. Side View

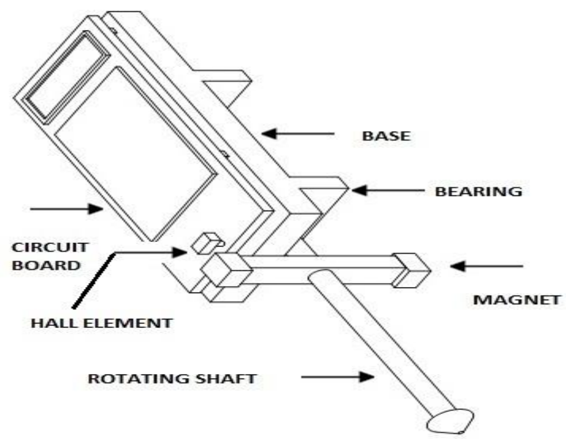


Fig.3 Isometric View

Over the shaft a platform is made, which is not conducting, and all the electronics are placed over it, including the sensor, an 89C51 development board with LCD displaying the RPM. The contacting Tip should be so designed that it is able to carry the torque exerted over and must well suitable in the dip given over motor shaft. The whole structure is protected with a external housing.

**1. Mechanical Design.**

It is an arrangement through which the device takes the speed (rpm) in to that. It should be so designed that which can handle inserting force, torque, speed and vibrations in higher speed of order 5000-6000 rpm. The tip of the device shaft must be in proper contact with the motor shaft, which is mounted between two metal palates with the help of two 6mm bearings. The use of bearing improves stability and the package become more resistant to mechanical vibrations.

Fig. 4 Shaft Bearing Assembly

Grooves are cut in upper and lower plates and which serves as the housing for bearings. Alignment of the bearing in grooves should be accurate and the plates are tightened with bearings in between. Shaft is inserted and affixed to the bearing via some strong industrial glue. This was the most important part of the mechanical design. Mounting magnets over the shaft is not a heavy task now. Over the top plate of this structure a non conductive sheet can be placed and all the circuitry is placed over that. The magnets will rotate with speed as that of shaft, over each revolution these magnets pass the stationary sensor there by magnetic field in the proximity of hall sensor varies with the same speed as that of motor shaft.

The number of output pulses depends on the number of magnets mounted on the device. These pulsating output manipulated gives the rpm. The prototype seems bit bulky since it is made with iron, but with some other material this disadvantage can be eliminated. Accepting the negatives in prototyping, the mechanical part will work well and is tried on about 5000- 6000 rpm. All these arrangement can be placed inside a housing which will give protection to the circuit. As of in Fig 2. And Fig. 3 magnets are attached to a separate nonmagnetic material and is mounted on the device shaft which is self-explanatory and doesn't need much discussion on that.

## 2. Electronics of Hall Effect Tachometer.

No complicated heavy algorithms required to manipulate the data sensed. A simple microcontroller coding can serve the purpose. The output range of a Hall Effect sensor is in the range of volts and can directly be given to the microcontroller. Fig 5 shows a simplified block diagram of all the electronics employed for this tachometer. A moving permanent magnet closely facing the sensor, which is sensitive to change in field strength, is the sensing element.

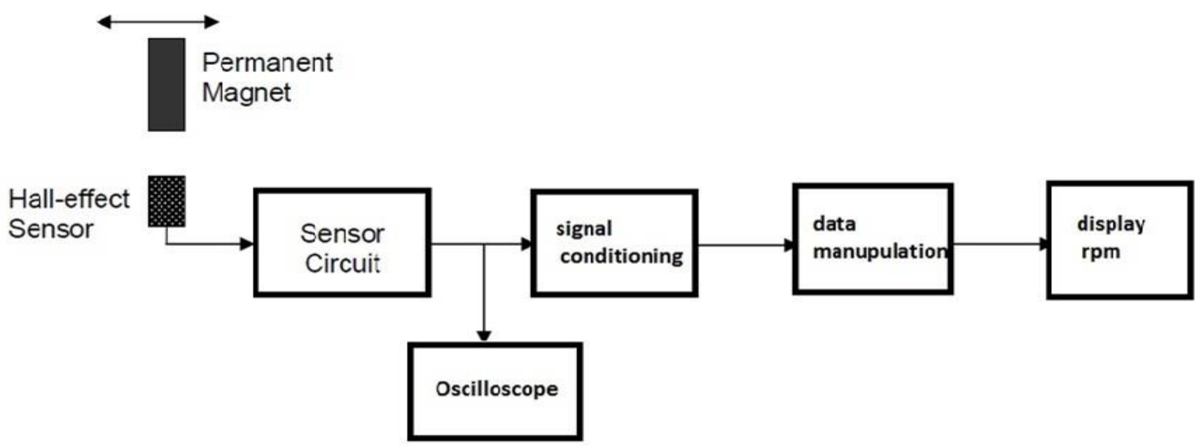


Fig. 5 Block diagram

As magnets moving field strength varies accordingly and the output of the sensor switches. When the magnet directly faces the hall element the output goes low and when the field strength is lowered the output become high. The sensor IC used is AH44E unipolar digital Hall Effect sensor by allegro. The AH44E is a small, versatile linear Hall-effect device that is operated by the magnetic field from a permanent magnet or an electromagnet. The output voltage is set by the supply voltage and varies in proportion to the strength of the magnetic field. The integrated circuitry features low noise output, which makes it unnecessary to use external filtering. It also includes precision resistors to provide increased temperature stability and accuracy. The operating temperature range of these linear Hall sensors is -40oC to 85oC, appropriate for commercial, consumer and industrial applications. The sensor has three pins pin1-Vcc, pin2-GND, and pin3-Output. Fig 6 shows the connection diagram and pins of hall sensor. The sensing circuit means the circuits associated with the sensor, which is inbuilt. Generally a signal amplifier is incorporated.

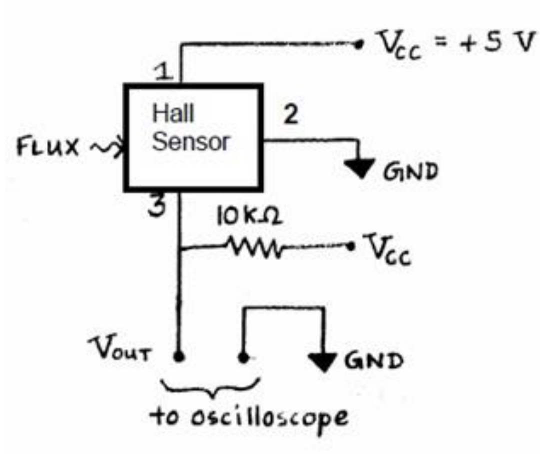


Fig. 6 Hall Sensor connection diagram.

The oscilloscope displays the output of sensor. Fig 7 is the observed output on the CRO. Based on this signal conditioner is designed. A digital Hall Effect sensor gives square wave in the range of volts and is of with less noise. Therefore signal conditioning became easy in this case. This is one of the advantages of Hall Effect sensor. Now why we go for a Hall Effect based tachometer??? There are certain advantages for that. It allows Non contact operation so there is no wear and friction. Hence unlimited number of operating cycles obtained. High speed operation - over 100 kHz possible. Whereas at high frequencies the inductive or capacitive sensor output begins to distort certainly it can measure zero speed also. It is immune to dust, air and water. These are certain reason why we go for Hall Effect based tachometer.

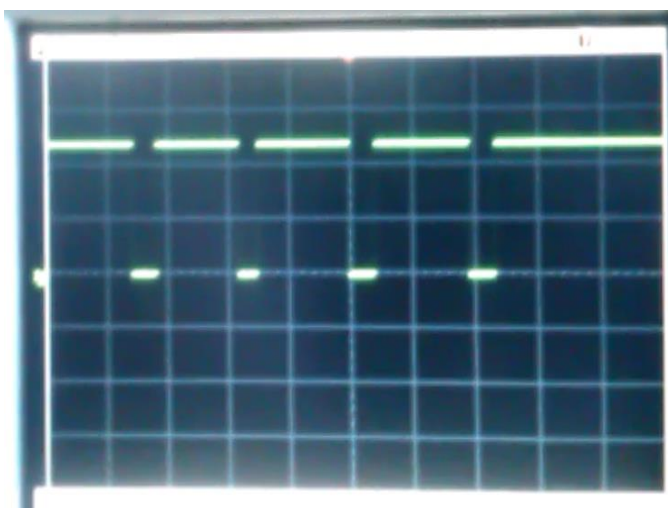

Fig. 7 Observed Output


Fig. 8 Microcontroller 8051 Development Board

A simple algorithm is written for data manipulation and display. The number of output pulses for one revolution is the number of magnets mounted on the device shaft. Here it is taken two. Therefore per revolution we get two pulses. This logic helps to find the rpm. Number of pulses in one minute divided by two gives the revolution per minute. Calculating per minute with microcontroller causes heavy delay. This delay will effect also in display. For avoiding this delay in display we cont pulses per milliseconds or pulses per seconds and then converted to rpm, which is simple. Which gives a gradual change of speed in LCD ie, the shaft speed is shown continuously. The register value of speed is displayed on LCD with some standard program.

**CONCLUSION**

With existing technology and idea implementing a new device for measuring RPM of a rotating shaft is illustrated by this paper. It is a practical way by which revolution per minute can be measured and displayed. With mounting notch on motor shaft and by placing magnet-sensor arrangement stationary we could measure the speed. But disadvantage of portability is there in that, which is completely eliminated in the proposed device. The complexity compared to other tachometers is less here and no heavy signal conditioning employed. With simple algorithms signals are manipulated. The major disadvantage here is that the system is bit bulky but can be made smaller and light weight if go for mass production with some improved mechanical considerations. Using some signal conditioning noise by vibration can be eliminated. With all these design limitations the prototype can work well. It's not about discovering new things; it's all about innovation creating new products with existing technology.

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