UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM)

Engine RPM Based Sensing Techniques

Thesis submitted in accordance with the partial requirements of the

Universiti Teknikal Malaysia Melaka for the

Bachelor of Manufacturing Engineering (Hons)(Robotics and Automation)

By

Hairol Farisah Jaafar

Faculty *of* Manufacturing Engineering

May 2008

ENGINE RPM BASED SENSING TECHNIQUES

HAIROL FARISAH B. JAAFAR

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS TESIS*

JUDUL: Engine RPM Based Sensing Technique

SESI PENGAJIAN : 2007/2008

Saya HAIROL FARISAH BIN JAAFAR
(HURUF BESAR)

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Universiti Teknikal Malaysia Melaka .
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	TIDAK TERHAD	

Disahkan oleh:

(TANDATANGAN PENULIS) (TANDATANGAN PENYELIA)

Alamat Tetap:
PWD 7412, ROSE GARDEN,
JALAN PENAMPANG, 88300
KOTA KINABALU, SABAH

Cop Rasmi:

Tarikh: Tarikh:

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this project entitled "**Engine RPM Based Sensing Technique**" is the results of my own research except as cited in references.

Signature	:	……..
Author's Name	:	HAIROL FARISAH BIN JAAFAR ….
Date	:	……

APPROVAL

This report submitted to the Senate of UTeM and has been accepted as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation). The member of the supervisory committee is as follow:

…….

Project Supervisor

May 2008

ABSTRACT

This research is intended to find about how to derive an output signal (electrical) from a rotating body. The objective is to design a system that can detect the rotating body revolution per minute (rpm) value. The system must also have the capability to produce output(s) at certain triggering point(s) which is operator-defined. The signal produce from the system can be manipulated to trigger other system or device. In designing the system, flexibility will be taken into account so that if the system works, it can be implemented not only on vehicle's engine system but also in any rotating/ reciprocating body. Other design considerations are accuracy, repeatability, rigidity, simplicity, reliability and cost. Complex system will try to be avoided if possible to ease tuning and troubleshooting. This project is highly significance in the automation industry as motorized device is a must in this industry and such system is still lacking. This system can be implemented in automation for example as a switch for other subsystem, speed control for motor/ lights or just for data logging.

ABSTRAK

Matlamat kajian ini dijalankan adalah untuk menerbitkan signal keluaran (dalam bentuk elektrik) berdasarkan putaran sesuatu jasad atau objek. Objektif kajian adalah untuk mengembangkan sebuah sIstem yang mampu mengesan kelajuan (ppm-putaran per minit) putaran sesebuah jasad. Sistem juga harus mampu menerbitkan signal keluaran pada nilai-nilai kelajuan ppm yang tertentu mengikut kemahuan pengoperasi. Signal keluaran tersebut boleh digunakan untuk mengaktifkan sistem atau alat yang lain. Semasa mengembangkan sistem ini, fleksibiliti sistem diambil kira agar sekiranya sistem ini berjaya beroperasi, ia boleh diimplementasikan bukan sahaja ke atas sistem enjin kenderaan bermotor tetapi juga kepada semua jasad berputar. Pertimbangan lain yang diambil kira dalam pembinaan sistem termasuklah ketepatan, kejituan, ketahanan, keringkasan sistem dan kos. Sistem yang kompleks cuba dihindari agar kerja-kerja menyelaras dan membaiki mudah. Projek ini amat signifikan dalam bidang automasi kerana ia banyak menggunakan motor. Sistem ini boleh diimplementasikan dalam automasi contohnya sebagai suis kepada sub-sistem, pengawal kelajuan motor/ cahaya ataupun untuk merekodkan data.

DEDICATION

For my beloved family, Father, Mother, Sister and Brother.

ACKNOWLEDGEMENTS

I would like to express my gratitude to all those who gave me the possibility to complete this thesis. My special thanks goes to my beloved family, my father Jaafar Othman and mother Siti Afsah Mohd Kudi who support me in good and bad times that without their support I would not be able to finish this project. I am deeply indebted to my supervisor Mr. Sivarao for always being there, encouraging and stimulating suggestions in spite of his heavy work and teaching schedule. I also would to thanks my colleagues, Nur Nazatul Nura Mohamed Fouzy and Mohamed Azraai Ahmad Puad for encouragement and friendship and helping me immensely by hearing my ideas out loud and reflecting them in suggestion which is vital in writing this thesis and doing this project. Thanks also go to Mr. Chen from Mechatronics Sdn. Bhd. and Mr. Johnny from T.S. Electrical Sdn. Bhd. for spending some time helping me sourcing parts and solution for my electrical parts problems. For every other person whose names were too long to be listed here who have helped in finishing this project directly or indirectly, I gave you all my gratitude. Last but not least I would like to thank God for giving us all a wonderful life.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

AC	-	Alternate Current
DC	-	Direct CurrentAnalysis of Variance
EEM	-	Electronic Engine Management
I.C.	-	Integrated Circuit
L.E.D.	-	Light Emitting Diode
LCD	-	Liquid Crystal Display
PC	-	Personal Computer
PIC	-	Programmable Input Controller
PID	-	Proportional–Integral–Derivative
PLC	-	Programmable Logic Controller
PSM	-	Projek Sarjana Muda
RPM	-	Revolution per minute
TDC	-	Top Dead Centre
UTeM	-	Universiti Teknikal Malaysia Melaka

CHAPTER 1
INTRODUCTION

1.1 Introduction

Speed sensing has grown along with the automation industry since the 1970's. Today there are many type of speed sensing available whether it is a linear or angular motion speed sensing. The sensors vary from contact mechanical type sensor using linkage and gears, non-contact digital type sensors using magnetic system to optical sensor. This broad selection provides solution to particular speed sensing problem but not universally. For every moving or rotating body system, a unique system has to be developed to monitor the speed. Some other system can be adapted to the system while other cannot and new system has to be developed for them. For such reason this study is conducted in hope that a more universal system can be design and applicable to not only to sense engine rpm but other moving or rotating body as well.

1.2 Problem Statements

The main concern in this study is how to derive output(s) from rpm value. Device which can sense rpm value is readily available in today's market. The problem arises when a system needs a method to produce an output at certain point in the rpm range. The reason to produce such method is to be as a speed control for example to prevent a system from over/under running. A system which uses transition method for example low volume pump switch to high volume pump at certain rpm will also be in favor of this system.

1.3 Objective of the Research

In this study, the main objective is:

(a) To detect angular speed of a rotating body (engine crank).

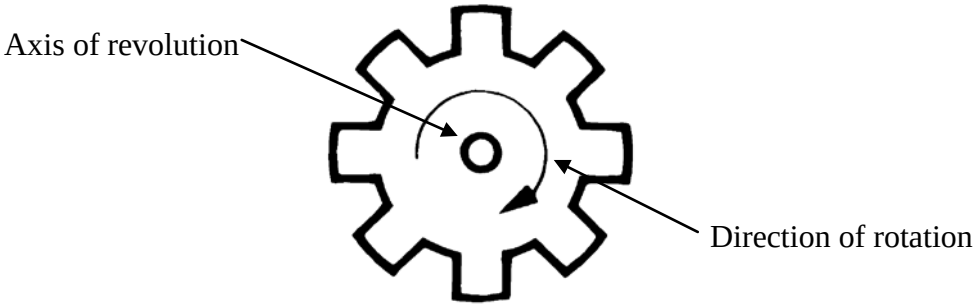

Figure 1.1. Gear, example of a rotating body.

(b) To produce a readable output corresponding to the engine's rpm.

- In the form of voltage or current reading

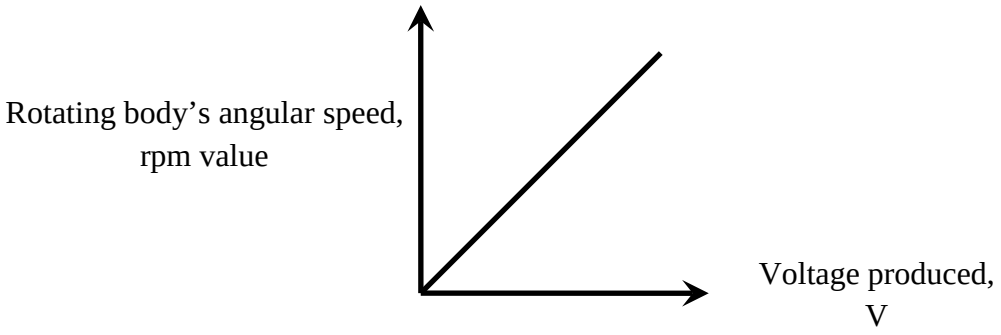

Figure 1.2. Expected linear correlation between engine rpm's value and sensor's output

(c) To produce an output signal when the rpm value equals to the defined triggering rpm point.

(d) To use the output as an input for indicator/ another control system.

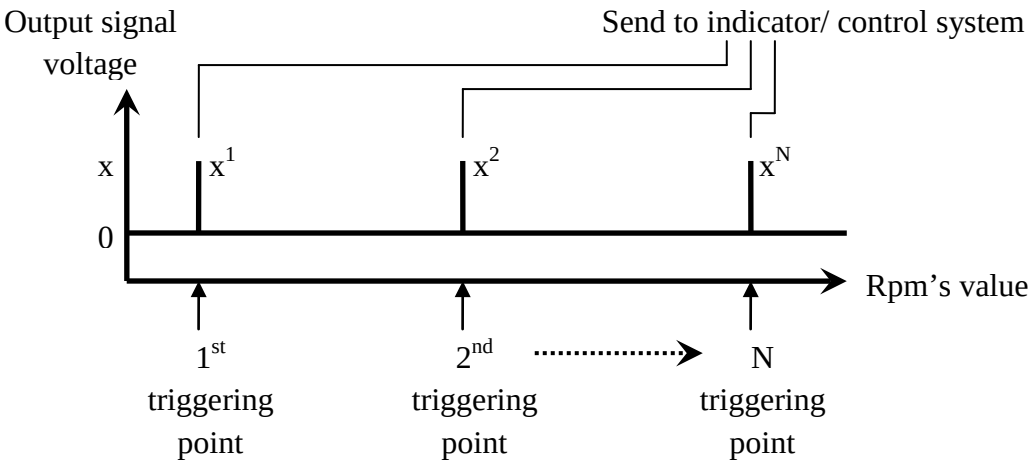

Figure 1.3. Triggering points along the rpm range and the output signal

There are three basic needs that need to be fulfilled in achieving the above objectives. The first thing is to determine a suitable existing output from the engine to be the input to the system. The second thing is to select from the wide selection of sensors available which type of sensing that will most suited the study. The third thing is to determine what kind of system that will convert signal sense by the sensor into a form of rpm value.

1.4 Scope

There are certain limitations and borders set to help in focusing in what is important and needed in this project. The scope is set by considering the relevancy of the components to this course and project.

The scope in this study will cover:

(a) Design of sensing system.

(b) Design of signal processing and output system from the sensor.

(c) Design of a prototype of the complete system.

(d) Fabricating and development of the system into working prototype.

This study will not cover:

(a) Detail designing of the electronic system.

(b) Building circuit from scratch. Standard parts such as integrated circuit will be used whereas possible as this is not an electronic project.

1.5 Significant of Study

Although a lot of manufacturer have already produced many type of rpm sensor (tachometer), a universal type of rpm sensing system is still hard to find. There is still less type of sensor that can be simply mounted on a rotating body and get the reading instantly without much hassle. This system also can give many benefits to the automation sector as there is a lot of area where speed control is needed and crucial. The realization of this project can provide more opportunities in improving the automation industries.

1.6 Conclusion

This project is challenging yet interesting to be done especially because it consists of mechanical, electrical and electronic elements. Many hours of studying and complete understanding of those elements involve are needed to make sure this project can be done.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Researches throughout the globe regarding this topic are not very easy to find. However by searching through the sub component of the project it can be found. This review gives a brief description about the level of development of sensing system and signal processing nowadays. From the information based on the literature reviewed, the tooth-wheeled variable reluctance sensing system is used as it suits this project the most. The three basic parts which are the sensor, processing part and the output part selected are explained below.

2.2 The System

The system is built based on a crankshaft position sensor system. The only requirement needed for a system to be mounted with such system is that the rotating body to be measured must have toothed ferromagnetic wheel as in figure below:

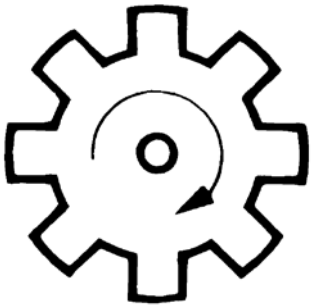

Figure 2.1. Tooth Ferromagnetic Wheel with known teeth, N

The sensor will be mounted in front of the rotating tooth as follows:

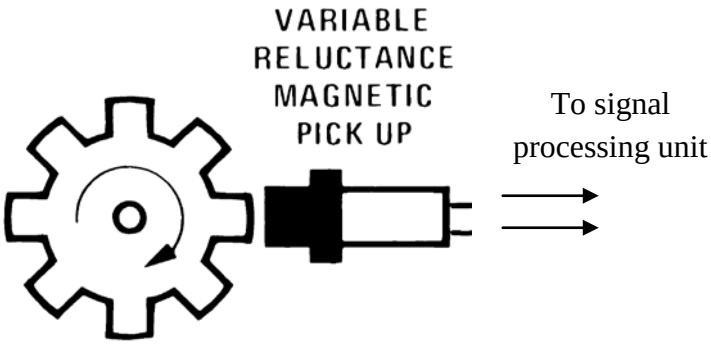

Figure 2.2. Sensor orientation

Ferromagnetic materials are material that is ferrous based (steel) and react to magnet. The example is such as mild steel and stainless steel which is really easy to find especially on a rotating shaft. The example of tooth ferromagnetic wheels can be found on engine's flywheel, gears and transmission and bike's sprocket.

2.2.1 The Sensor

The selected sensor comes from non-contact sensor family called variable reluctance sensor. The sensing architecture consists of a permanent magnet and two pick-up coil as shown below.

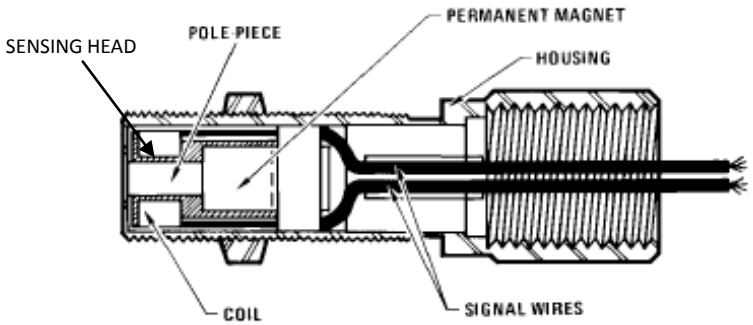

Figure 2.3. Variable Resistance pick-up sensor

The reason behind this selection from all other sensor in the market is the simple and robust design. There are only two working components and there is no contact part. The sensor is fully encapsulated inside housing that covers all the part to protect it from the environment. This means it is rigid, reliable and has a relatively long lifespan. It has been used in automotive industry for crankshaft positioning sensor and proven its average lifespan is longer than the vehicle itself. It is made from common material thus the cost is low.

However, there is some problem faced when using this sensor. This sensor operates based on Faraday's Law where the output voltage changes linearly with the magnetic flux variation (produced when toothed steel wheel cut through the flux). From this law, the output voltage does not increase linearly but produces a continuous sinusoidal voltage wave form where the frequency varies linearly to the toothed steel wheel speed. Therefore, a circuitry system needs to be design to process and convert the frequency input into voltage so it can be displayed on a voltmeter as the rpm display system.

2.2.2 The Processing System (LM2907)

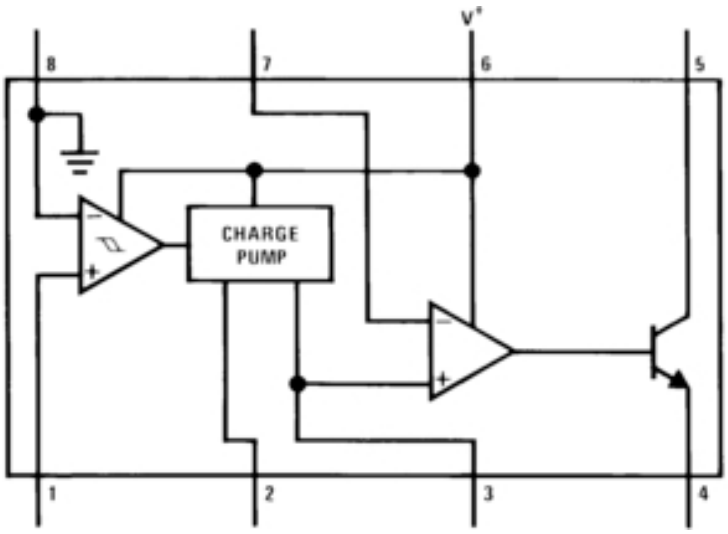

Figure 2.4. LM2907 building block and pin numbering

For the signal processing part, a standard part LM2907 is used. It is a frequency to voltage converter chip with built-in input hysteresis amplifier, charge pump and op amp/ comparator. The building block for the chip when connected to the sensor will be as follows:

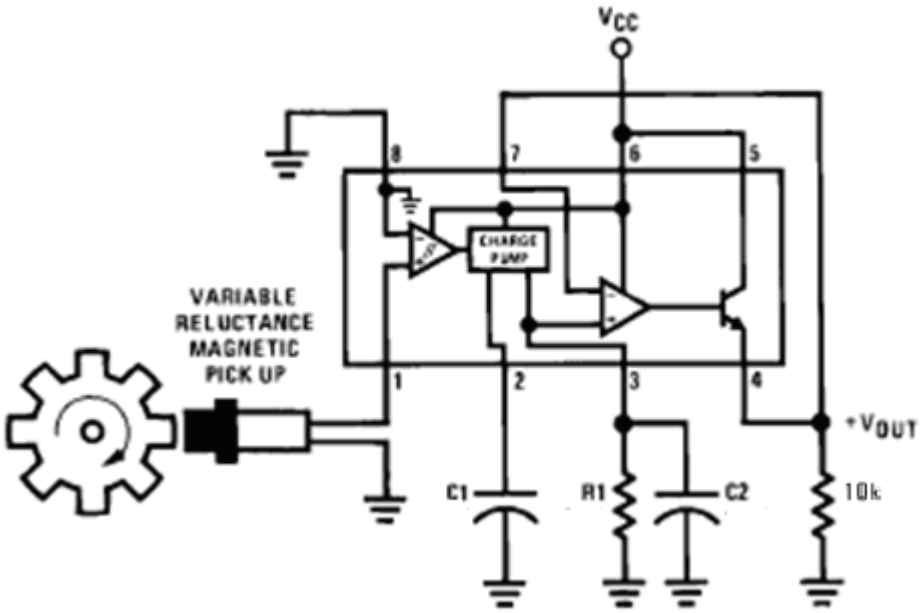

Figure 2.5. LM2907 connection

The operating concept of the circuit will not be explain in detail because it is more on electronics which is outside the scope of this study. The basic operation of the system consists of three main components as follows;

(a) Input hysteresis amplifier (signal conditioner)

- amplify the signal, filter the noise, produce binary signal (on-off) from the sinusoidal wave form.

(b) Charge Pump

- act as a capacitor, collect the voltage signal and discharge it at a constant rate.
- this bind the frequency to voltage relation, higher frequency = higher discharge voltage.