

# DESIGN OF LOW COST 3 DIGIT DIGITAL TACHOMETER

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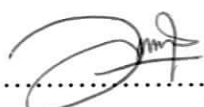
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To my beloved father and mother

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## ABSTRACT

The problems of using analog tachometer that is found in most cars, such as inability to display exact speed reading, has led to the recent development of digital tachometer. However, this digital tachometer, that read the rounding speed of engine, can only be found in luxury and advanced cars due to the high cost and higher damage risk. Thus, the low cost digital tachometer is proposed in this project. This project is an improvement to the previous PSM project where instead of 2 digits display, the tachometer is proposed to have 3 digit displays. At the end of this project, the main objectives of displaying the speed of the vehicle shaft rotating should be achieved. And from this project, it is hoped that all standard vehicles to use this digital tachometer.

## ABSTRAK

Masalah penggunaan meter kelajuan analog yang boleh didapati dalam kebanyakan kenderaan ialah masalah untuk memaparkan kelajuan sebenar sesebuah kenderaan itu. Oleh sebab itu, ia adalah lebih efektif jika menggunakan meter kelajuan digital. Walau bagaimanapun, meter kelajuan digital hanya boleh didapati di dalam kenderaan mewah dengan kos yang tinggi serta mempunyai risiko kerosakan yang tinggi. Meter kelajuan digital tidak digunakan secara meluas kerana kos untuk membinanya yang terlalu mahal. Dengan itu, mereka bentuk meter kelajuan digital dengan kos rendah dicadangkan dalam projek ini. Projek ini juga merupakan kesinambungan daripada projek PSM pada tahun lepas yang memaparkan dua digit pada LCD, dan pada kali ini projek ini bertujuan untuk memaparkan tiga digit kelajuan motor pada LCD. Di akhir projek ini, objektif utama iaitu memaparkan kelajuan putaran shaft kenderaan seharusnya dicapai. Dan diharapkan daripada projek ini, ia akan membuka peluang bagi semua jenis kenderaan untuk menggunakan digital tachometer ini.



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## LIST OF ACRONIMS

BCD	Binary Coded Decimal
CMOS	Complementary Metal Oxide Semiconductor
CV	Control Voltage
DC	Direct Current
IC	Integrated Circuit
IR	Infra Red
ITU	Integrated Timing Unit
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LT	Lamp Test
NPN	Bipolar junction transistor NPN
Op-Amp	Operational Amplifier
PIC	Programmable Integrated Circuit
PNP	Bipolar junction transistor PNP
PWM	Pulse Width Modulation
R	Resistance
RPM	Revolution per Minutes
V <sub>in</sub>	Input Voltage
V <sub>out</sub>	Output Voltage
VR	Variable Resistor
ZD	Zener Diode

## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

Tachometers are the instrument that indicates the speed, usually in revolutions per minute (rpm), at which an engine shaft or motor is rotating. Some tachometers, especially those used in automobiles, are similar in construction and operation to automotive speedometers. Other types, often connected directly to the shaft whose speed they indicate, are small electric generators whose output voltage is proportional to the speed. This voltage is applied to a voltmeter whose dial is calibrated in speed units. Another type, it is used only with engines having an ignition system, operates by counting the pulsations of current or voltage in the ignition system, the number of these being proportional to the speed of the shaft.

The traditional tachometer is laid out as a dial, with a needle indicating the current reading and marking safe and dangerous level. Recently, digital tachometers giving a direct numeric output have become more common. The problems of using analog tachometer that can be found on most cars, such as inability to display exact speed reading, has led to the recent development of digital tachometer.



There are two types of tachometer in the market, which is analog, and digital tachometer. In this case, digital tachometer has been proposed as a title of project because compares to analog system, digital is more accurate and easy to read the measurements.

## **1.2 Problem Statements**

There are several design of digital tachometer. At the moment, digital tachometer is used in high end automobiles because of the cost and the system requirement. In this project, it is proposed to design digital tachometer that is reduced in cost so it also can be used in standard vehicles.

## **1.3 Project Objectives**

At the end of this project, the main objectives that need to be achieved include:

- a) To design a low cost Digital Tachometer that can display exact speed reading based on how fast an engine shaft is rotating.
- b) To learn on how to construct the 3 Digit Digital Tachometer circuit.
- c) To display the measured speed by using 7 segments Light Emitting Diode (LED) display.

## **1.4 Scope of Works**

In order to make sure a smooth flow of the project work, the work is divided into several scopes.

### **1.4.1 Project Design**

The design solution comprised of two separate tasks; circuit design and hardware implementation. Each task is conceptually independent from the others, but each is necessary in order to the final product of work.

### **1.4.2 Circuit Design**

In order to build a project and prior to hardware implementation, the circuits have to be designed. After all the task done, the circuits are ready for construction and then combined all together to make it as a one perfect project.

### **1.4.3 Hardware Implementation**

In the hardware implementation, there are three main processes that need to be done to the circuit such as exposure, developing and etching process.

## **1.5 Thesis Layout**

There are five main chapters in this thesis.

Chapter 1 : The project is introduced where the problem is identified and thus the project objective is outlined. Besides that, the scope of work of this project is described.

Chapter 2 : Literature review such as the different concept in designing the tachometers that are constructed beforehand, types of tachometer and components required to build the tachometer.

- Chapter 3 : Methodology of this project is outlined in this chapter. The flow of the project works for two semester period is explained.
- Chapter 4 : Circuit Design and Results. In this chapter, the schematic diagram of the tachometer circuit is illustrated and the project results is described and discussed.
- Chapter 5 : In this chapter, conclusion of the project is explained and few further work suggestion is made.

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 Concept And Design**

Existing project is reviewed in this chapter to get an idea about the project design, conception and any information that related to improve the project. There are many tachometer projects that have been done by other people with different concepts and design. In this literature review, a few concepts in designing tachometer is described. Consequently, a lot of information is gained to help low cost 3 digit digital tachometer design.

Early tachometer design is based on the principles of the monostable multivibrator, which has one stable state and one quasistable state. The circuit is normally in the stable state, producing no output. However, when a triggering current pulse from the ignition system is received, the circuit transitions to the quasistable state for a given time before returning again to the stable state. In this way, each ignition pulse produced a clean pulse of fixed duration that is fed to the gauge mechanism. The more such fixed duration pulses the gauge receives per second, the higher it reads. The monostable multivibrator is still used in tachometers today, although the tendency is to

use voltage pulses rather than current pulses, the latter requiring that the ignition coil current passes through the tachometer on its way to the coils. [1]

Later design tachometer was in no way to do any improvement on the early type; indeed the change seems to have been made to be more economical. Integrated Circuit (IC) were in their infancy in the late 1960's and was both expensive and not proven to be robust in automobile applications. While a very sophisticated monostable multivibrator can now be bought for a few pennies as an IC, Smith's Industries choose to use discreet components in the MGB tachometers. The early design used 17 components but this was changed in the late tachometer to a far inferior circuit using just 7 components. The later design tachometer was never intended for use in positive ground vehicles.

In 1998, Andrew Huang [2] in his project took advantage of the integrated timing unit (ITU) feature of the SH-I to determine the duration between ignition pulses in the engine of his Toyota Corolla. From this number, it is easy to derive the number of RPMs. The signal from the engine is taken off the ignition diagnosis port, found near the driver's side shock absorber housing in the engine compartment. That signal is a 12V p-p nominal square wave with ignition occurring in the rising edges. The two cautions when using this signal are that there are 400V spikes on the rising edge, and that grounding this signal is potentially very damaging to the igniter. An opto-isolator is used to help protect against the spikes, and the wire carefully routed and the ignition is shorted to the ground. On the back end of the opto-isolator, a Transistor-Transistor Logic (TTL) buffer is used to provide a little extra protection in case the opto-isolator breaks down.

Steves [3] has created a tachometer that only made from the electronic kits. The display unit for the tachometer has only 2 digits and in the ordinary way it will display on hundreds and thousand of revolutions. 10 pulses per revolution is simply gave by the times 10 converters and enables the same equipment to display tens and hundreds of revolution without complicating the electronics. In the project, an infra-red transceiver/

receiver is used which is mounted on a magnetic base and is angle adjustable to enable a good signal to be established. To get more accurate reading, the x10 converter is used with the Stirling engine.

Sourabh Biyani [4] has built a tachometer and developed the speed measurement of the motor in Rotation per Minute (RPM) and displays it over 3 ½ digit display. The infra red sensor is also used to get the pulses. However, to calculate the output from the sensor, IC 74C925 is used in this project. IC 4029B is also used with other circuit to reset and set the IC 74C925 to zero. When the IC is reset the count is initialized to zero and the counting continues for 10 second in the background. In front the counter displays the previously counted signal as it is now latches. Thus in every 10 second, the display changes if there is any change in the RPM of the rotating shaft.

Simple tachometer design is used by Steve [3] while developing the object Avoiding Detector. An infrared (IR) LED is used that is oscillated at the frequency of 38 kHz pointed at the propeller. When the propeller passes in front of the IR then the light is reflected back to the detector which brings the output voltage low. As the propeller blade passes away from the LED light is no longer reflected back to the sensor so the output voltage goes high. The pulse is counted over a certain time period, and then the number of counts is divided by the time. Since the sensor is counting two blades the number needs to be divided by two to get the engine speed.

Tan Van Nguyen [5] said that although we can use an analog tachometer, the digital one has less cost, better performances, less sensitive to temperature and easier to implement in a custom IC. Tachometer design by him is control the actuator for the heads of an optical-disk drive. But in his project, he also applies to other motor-control application.

Digital tachometer is also created by Eelke Visser [5]. For his tachometer, the display is updated every quarter of a second. To reduce errors the measurement is taken during an interval of about 0.25 seconds. In this interval the time is measured from the

first to the last pulse and the amount of pulses are counted. The number of pulses measured is counted from zero. The formula that he used to calculate the RPM is:

$$RPM = 30000000 \times \frac{\text{Number of pulses measured}}{\text{Time from first to last pulse}} \quad (2.1)$$

The 30000000 is defined as  $30 \times 1000000$ . The 1000000 are used because the time is in microsecond's measurement. The amount of revolutions per minute (RPM) is shown. Therefore, the frequency ( $1/\text{Time}$ ) have to be multiplied with 60. However, 4 cylinder 4 stroke engines is ignited twice a revolution to get  $60/2 = 30$ . The formula is then produced by putting all the parameter together. This number is then put on the display.

A digital tachometer is constructed by Jim McGhee for his son in 1999 at his Ford F150 XL pickup truck [6]. The tachometer was installed in March of 2001. It was built by using PIC16C715, MAX7219 for LED display driver and also two Micrel MIC4574 voltage regulators. It also had LM34CZ temperature sensor for internal temperature readout.

A tachometer is created by Josepino by using PIC16F628 [7]. The sensor that can be used is optical sensor and magnetic or by using a switch. High voltage is informed since it can damage the PIC. If the input signal is more than 5 Volt, a driver as TTL, CMOS, Operational Amplifier (Op-Amp) or transistors is suggested as a solution.

A digital tachometer is designed by Embed Engineer [8]. High impedance, low power analog circuit to produce a clean digital pulse is designed when a magnet or sensing cog passes by the sensor. The circuit operated from  $\frac{1}{2}$  Hz at 20mm to over 10 kHz at 1mm. For their project, a Microchip PIC16C932 was used to capture the pulses, measured the period between them and invert the data to obtain speed. The result for the tachometer was displayed on a directly-driven 4 digit LCD display and the system could be configured via DIP switches to the number of pulses per shaft rotation, and the

desired output unit (RPM, Hz etc). An integrating mode could display accumulated shaft rotation instead of shaft speed.

In a Cypress Microsystem PSoC Design Challenge [9], there is one project that created 'A Non Contact Auto Ranging Digital Tachometer'. The project is for digital tachometer that can be used in measuring RPM of a rotational object. The components including the microcontroller, the digital and analog block are supplied by the PSoC device CY8C27223. The circuit for this project utilized an IR LED and a sensor to sense the rotation and LCD display to display the RPM. This digital tachometer can be used in robotic, machine tools and others.

An author in his website [7] mentioned that he decided to design a fully digital tachometer system to avoid the problems occur in his previous project such as the readings provided by the tachometer are not really accurate. Any tachometer simply measures the rate at which some events occurs and it done by counting the events such as contact closures, electrical pulses and others for a given period of time and then dividing the number of events by the time to get a rate. In this case, he had a rate of 1 pulse per engine revolution and using a tachometer that calibrated in events per minute, he could display revolutions per minute. In a spark ignition engine, tachometer typically use different mechanism to obtain engine speed, knowing how many cylinders and assuming a 4-stroke engine, which takes two revolutions to complete a full cycle, then calculation for relationship of ignition pulses to revolutions can be done as follows.

$$\text{Pulses Per Revolution} = \frac{\text{Number Of Cycles}}{2} \quad (2.2)$$

The first modification to his digital tachometer circuit that had been done is to increase the input pulse rate from 1 to 2 (or more) pulses per revolution.

In 1987, there is a team that design and build an electronic tachometer using optical sensing technology to measure the propeller RPM in a single engine aircraft with