MODELING AND SIMULATION OF ENGINE MANAGEMENT SYSTEM

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The PSM (Projek Sarjana Muda) report is considered as one of the essential for students to complete their bachelor program in Mechanical Engineering (Automotive)

Faculty of Mechanical
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27 MARCH 2008

I/We admit that have read

this work and in my opinion this work

is enough in terms of scope and quality to bestowal

Bachelor of Mechanical Engineering (Automotive)

Signature	: ………………………
Supervisor's Name	: ..……………………..
Date	: ………………………

"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya telah jelaskan sumbernya"

Tandatangan : …………………….
Nama Penulis :………………………
Tarikh :………………………

DEDICATION

To my beloved mother, father, brother and sister, and all my friends
All member of Bachelor of Mechanical Design Innovation Engineering (BMCA)
All lecturers from BMCA department
Staff of Faculty Mechanical Engineering
Staff of Universiti Teknikal Malaysia Melaka (UTEM)

Do You Have Time To Pray?
God Have Time To Listen

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I also like to take this opportunity to say thank you to my entire friend that always help me. Then I would like to show my gratitude to both of my parent and siblings that always support me and pray for me. Because of them, I have gain more strength to face my obstacle. Last but not least, thank to all that I not mention specificly for help me to finish this report.

THANK YOU

ABSTRACT

Nowadays, electric and electronic principe are the important to the modern car. Almost all the modern car uses this principe to make the car more complex. Engine management system is one of the electric principe that use in the car system. For this assignment, I was assigned to model and simulation Engine management system for electronic fuel injection system. This simulation is to show how injection system works. This simulation is in three stages. First, when the idle speed condition. In this condition, we will know the timing of the injector or injector pulse width. After that, from the value of injector timing we can know the percent of engine duty cycle. It is same with the part throttle condition or half load condition and the wide open throttle or full load condition. With this simulation we will understand the function of injection system, how it work and what happen if the engine in the three conditions like above. For this simulation, the engine management system is based on the engine Mitsubishi 4G92 1.6L. This engine was use in proton car like Satria and Wira. With this simulation model, I hope that it will help us to understand more about engine management system especially for electronic fuel injection system.

ABSTRAK

Pada masa sekarang, prinsip elektrik dan elektronik amat penting bagi kereta moden. Kebanyakan kereta sekarang menggunakan prinsip ini bagi menjadikannya lebih kompleks. Sistem pengurusan enjin adalah salah satu prinsip elektrik yang digunakan dalam kereta. Bagi tugasan ini, saya telah ditugaskan untuk membuat model dan simulasi sistem pengurusan enjin bagi sistem suntikan bahan api elektronik. Simulasi ini adalah untuk menunjukkan bagaimana sistem suntikan elektronik ini bekerja. Ia menunjukkan tiga keadaan. Pertama ialah pada peringkat laju terbiar (idle speed). Dalam keadaan ini, kita akan mengetahui masa suntikan atau lebar denyut penyuntik.selepas itu, daripada nilai tadi, kita akan mengetahui nilai peratus pusingan kerja bagi enjin. begitu juga dengan keadaan seterusnya iaitu keadaan beban separa dan pada keadaan beban penuh. Sistem pengurusan enjin yang digunakan dalam model ini adalah berasaskan model Mitsubishi 4G92 1.6L. Enjin ini digunakan dalam kereta proton jenis Satria dan Wira. Dengan model simulasi ini diharap kita akan lebih memahami konsep sistem pengurusan enjin ini terutama bagi sistem suntikan bahan api elektronik dengan lebih mendalam.

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SYMBOL	DEFINATION
D	displacement of engine (litres)
Rpm	revolution per minute
Ve	volumetric efficiency
EGR	exhaust gas recirculation (litre/s)
da	air density
p_i	intake air pressure
t_i	intake air temperature
d_o	value relates density under sea level standard day (SLSD)
p_o	value relates pressure under SLSD
t_o	value relates temperature under SLSD
AFR	desired air-fuel ratio
Rf	fuel injector delivery rate

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CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter is about the introduction of the project. There are including project objective, scope and project problem statement.

1.1 Objective

The main objective of this project is to develop modeling and simulation of engine management system for teaching and learning process.

1.2 Scope

The scope of this project is to develop the model engine management system for injection system. This simulation will be in three stages. It is to show the level of engine process. The first stage is injection timing when the idle speed condition. Second stage is when the throttle is in partial condition. Lastly, we can see the wide throttle or full throttle condition. In this stage, the vehicle is in the max speed.

1.3 Problem statement

Engine management system is an electronic system that controls the process of engine such as injection, ignition and many more. It is the main part of a car. We can assume it as a brain of the car. As an automotive student, we must know this main part of the car. Before this, we always see the model of EMS in real model. By this assignment, the computerized model of EMS will be developing. It will make us faster and easier to understand of the function of EMS especially for electronic fuel injection system. This simulation is looking simple to make sure we easy to understand the function of it. Besides that, student today is difficult to understand the function of EMS even though they have their own car. With this simulation, it can make student understand well about their EMS system especially about electronic fuel injection system. The characteristic that will discuss here is more about electronic fuel injection system.

CHAPTER 2

LITERATURE REVIEW

2.0 EMS literature review

Before we doing something, we must know what we want doing. Because of that question, in this chapter, overview about the engine management system will be explained.

2.1 What is EMS?

The performance and emissions that today's engines deliver would be impossible without the electronics that manage everything from ignition and fuel delivery to every aspect of emissions control. Electronics make possible engines that deliver excellent performance, good fuel economy and produce almost no pollution. Many Engine management systems or EMS today have 16-bit and even 32-bit processors. Though not as powerful as the latest desktop personal computers, EMS can still crunch a lot of information.

From the outside, most EMS looks similar just a metal box with some connectors on it. The EMS's job is to manage the power train. This includes the engine's ignition system, fuel injection system and emission controls. The EMS receives inputs from a wide variety of sensors and switches.

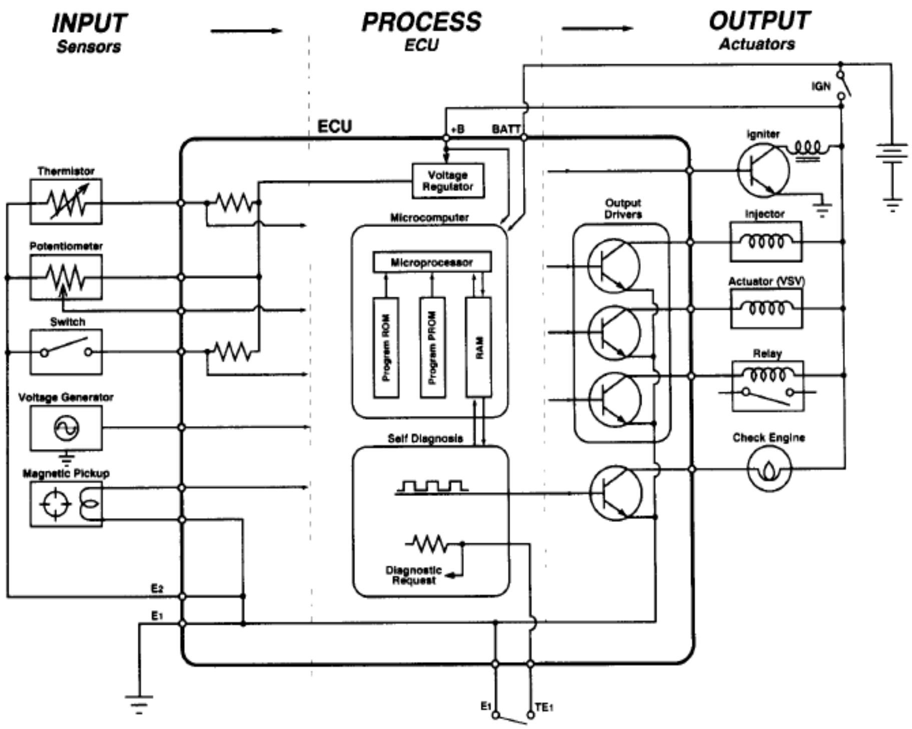

Figure 2.1 EMS diagram (source: www.autoshop101.com)

2.1.1 The sensors

The oxygen sensor provides information about the fuel mixture. The EMS uses this to constantly re-adjust and fine tune the air/fuel ratio. This keeps emissions and fuel consumption to a minimum. A bad oxygen sensor will typically make an engine run rich, use more fuel and pollute. Oxygen sensors deteriorate with age and may be contaminated if the engine burns oil or develops a coolant leak. On 1996 and newer vehicles, there is also an additional oxygen sensor behind the catalytic converter to monitor converter efficiency.

The coolant sensor monitors engine temperature. The EMS uses this information to regulate a wide variety of ignition, fuel and emission control functions. When the engine is cold, for example, the fuel mixture needs to be richer to improve drivability.

Once the engine reaches a certain temperature, the EMS starts using the signal from the oxygen sensor to vary the fuel mixture. This is called "closed loop" operation, and it is necessary to keep emissions to a minimum.

The throttle position sensor (TPS) keeps the EMS informed about throttle position. The EMS uses this input to change spark timing and the fuel mixture as engine load changes. A problem here can cause a flat spot during acceleration (like a bad accelerator pump in a carburetor) as well as other drivability complaints.

The Airflow Sensor, of which there are several types, tells the EMS how much air the engine is drawing in as it runs. The EMS uses this to further vary the fuel mixture as needed. There are several types of airflow sensors including hot wire mass airflow sensors and the older flap-style vane airflow sensors.

Some engines do not have an airflow sensor and only estimate how much air the engine is actually taking in by monitoring engine rpm and using inputs from the throttle position sensor, a manifold absolute pressure sensor (MAP) and manifold air temperature (MAT) sensor. Problems with the airflow sensor can upset the fuel mixture and various drivability problems such as hard starting, hesitation, stalling, and rough idle, etc.

The crankshaft position sensor serves the same function as the pickup assembly in an engine with a distributor. It does two things: It monitors engine rpm and helps the computer determine relative position of the crankshaft so the EMS can control spark timing and fuel delivery in the proper sequence.

The EMS also uses the crank sensor's input to regulate idle speed, which it does by sending a signal to an idle speed control motor or idle air bypass motor. On some engines, an additional camshaft position sensor is used to provide additional input to the EMS about valve timing. The manifold absolute pressure (MAP) sensor measures intake vacuum, which the EMS also uses to determine engine load. The MAP sensor's input affects ignition timing primarily, but also fuel delivery.

Knock sensors are used to detect vibrations produced by detonation. When the EMS receives a signal from the knock sensor, it momentarily retards timing while the engine is under load to protect the engine against spark knock.

The EGR position sensor tells the EMS when the exhaust gas recirculation (EGR) valve opens and how much. This allows the EMS to detect problems with the EGR system that would increase pollution.

The vehicle speed sensor (VSS) keeps the EMS informed about how fast the vehicle is traveling. This is needed to control other functions such as torque converter lockup. The VSS signal is also used by other control modules, including the antilock brake system (ABS).

2.1.2 Name of Control Unit in EMS

- ECU- engine or electronic control unit
- PCM- power train control module
- DCM- digital motor electronic
- MOTRONIC

2.2 Injection system

Injection system is the main system of a car. Nowadays, most of the modern car has injection system. For the engine that has fuel injection, EMS will determine the amount of fuel to provide based on number of parameter. Figure below show the injection system diagrammed.

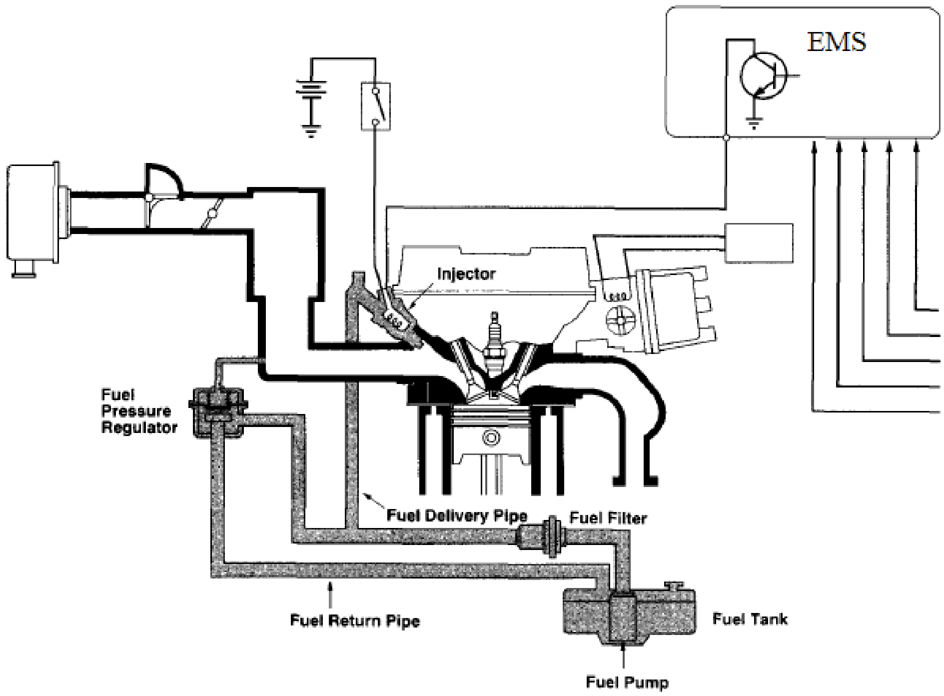

Figure 2.2 Electronic fuel injection system (source: www.autoshop101.com)

<u>Component parts</u>

- **Fuel tank** Holds a reservoir of fuel for the engine, is normally baffled to prevent fuel sloshing around and the resultant fuel starvation.
- **Fuel filter** Since an injector pump is a positive displacement pump any foreign material ingested can stall the pump and kill it stone dead; this pre-filter prevents rubbish from entering the pump.
- **Fuel pump** A high-pressure pump running at around 6 bar which supplies fuel to the injectors. The fuel pressure regulator regulates to this pressure between 3

and 4 bar (43 and 58PSI). On some installations the pump is housed inside the fuel tank with rudimentary filtration, the fuel filter then follows in the fuel line.

- **Fuel line** Fuel pipe that transports the fuel from the pump to the fuel rail.
- **Fuel rail** A small fuel gallery from which the injectors take their fuel supply.
- **Injectors** Electric valves which when open allow fuel to be injected into the engine under high pressure.
- **Pressure regulator** A device that keeps the fuel pressure at a constant rate and returns any excess fuel to the tank
- **Fuel return line** Fuel pipe which bleeds excess fuel back to the fuel tank

2.2.1 Single point injection

Single point injection systems use a single fuel injector that injects into the inlet manifold. The fuel injected is drawn in to the cylinders by airflow in a similar way to a carburettor. Because of the variations in length and orientation of the various branches in the inlet manifold, the fuel distribution characteristics are not ideal so economy or emissions and throttle response suffer as a result.

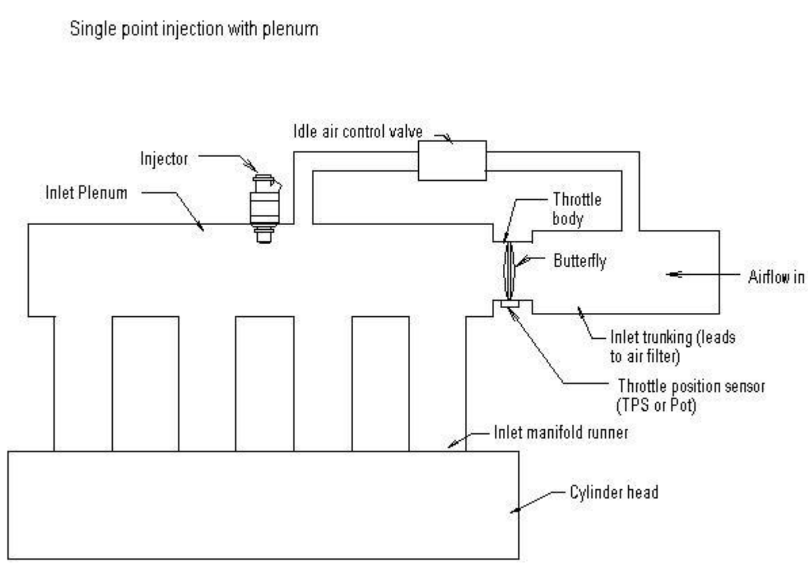

Figure 2.3 Single point injection (source: www.engine LogicsInc.)

Although the injector position is shown in the centre of the intake manifold, this is just for clarity, usually the injector will be mounted on or near the throttle body where air velocity is at its highest.

2.2.2 Multi point injection

Multi point injection systems are much more common and generally have an injector per cylinder located in each individual manifold runner. This configuration gives much better control of fuelling and better emissions since the fuel can be metered more closely, and there is less opportunity for the fuel spray to condense or drop out of the airflow since it is introduced as four small streams rather than one large one. The closer to the inlet valve the fuel injection takes place, the better the economy and transient throttle. Most systems use one injector per cylinder but on certain engines have only two inlet ports since two cylinders share a Siamese port, in this case multi-point would mean two injectors, one per inlet port, this is still better than a single injector system.

With multi-point (or multi injector) systems there is scope for timing the injection of fuel to better suit the engines duty cycle. If the EMS knows the relative position of each cylinder within the engines cycle (usually from a cam phase sensor) then it can fire the injectors at the optimum time for that cylinder. This is known as sequential injection; sometimes the EMS will only have knowledge of the crank position rather than the duty cycle position, in this case it can optimise for a pair of cylinders, this is known as semi-sequential or grouped injection.

Some EMS systems ignore the crank and cycle position when injecting fuel, they fire all of the injectors at the same time once per revolution, and this is known as batched injection**.** There is no penalty to pay power wise when using batched injection, however grouped and sequential injection give a slight edge on economy and transient throttle/emissions.

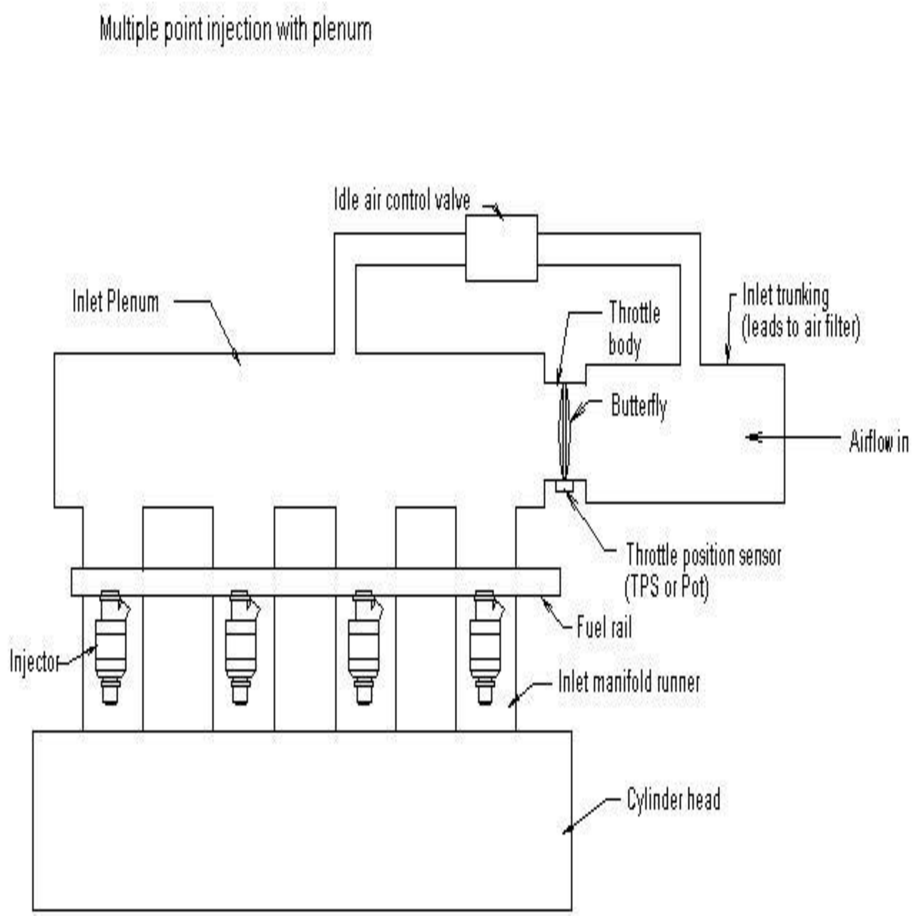

Figure 2.4 Multipoint injection (source: www.engine LogicsInc.)

2.2.3 Components of a fuel injection system

To supply right amount of fuel at the right injector timing, EMS must know some value from such parameter.

2.2.3.1 Crank sensor

This sensor is commonly used to determine the engine speed. It locates at the flywheel that turns with the engine. The disk has a certain number of teeth around its circumference and a fixed closely mounted induction sensor that pulses when it encounters a tooth. There is generally a pattern of missing teeth so that the EMS can tell exactly the crank position as well as speed. Although the EMS knows the engines crank position from this sensor, it does not know the engines cycle position.

2.2.3.2 Hall effect switches

A Hall Effect switch is frequently used to sense engine speed and crankshaft position. It provide a signal each time a piston reach top dead centre, and the signal serves as the primary input on which ignition timing is calculated. This type of sensor is commonly use nowadays because it provides a digital signal. On some applications, a separate Hall Effect switch is used to monitor camshaft position as well.

2.2.3.3 Throttle Position Sensor.

The most common engine load sensor especially on after market systems. A TPS is a small potentiometer (or ‘throttle pot’) which is connected directly to the throttle shaft and turns with it. It returns a value to the EMS depending on the throttle position. TPS sensors are normally used on performance engines where airflow sensors might become confused because of pulses in the inlet tract, because they do not measure airflow but simply give a throttle position, airflow is assumed to be constant for any given engine speed and throttle position. If the engine is further modified the airflow characteristics may change and the engine may need re-mapping. EMS systems that use direct airflow measurement can often cope with changes more effectively and can alter the fuelling to suit without a re-mapping session.

2.2.3.4 Mass air flow sensor or Air metering flap

Another way of determining the engine load is to measure the airflow into the engine and this can be done using a flap which is deflected by incoming air, this is commonly known as an air-metering flap. These are common on older injection systems, but can be confused by reverse pulses in the inlet tract when more extreme cams are used and can be restrictive to the inlet airflow.

2.2.3.5 Manifold Air Pressure sensor.

These measure the vacuum or air pressure in the inlet manifold that in turn gives an indication of load, more commonly used on turbocharged engines to give an indication of boost level.

2.2.3.6 Hot wire

This approach uses a heated platinum wire and measures the current required to keep it at a particular temperature. As air passes over the wire it cools it down, the more air that passes, the greater the cooling effect and therefore the greater the current. The hot wire system can be also be confused by reverse pulses when more extreme cams are used.

2.2.3.7 Engine temperature

When an engine starts from cold it is well below its normal operating temperature, this causes some of the fuel injected into the engine to condense rather than atomising and being drawn in efficiently. Combustion chamber temperatures are also low which leads to incomplete and slow combustion. These affects cause the engine to run weak and require that extra fuel be supplied to the engine to compensate. In a conventional system the ‘choke’ on the carburettor performs this function, on an injection system a coolant temperature sensor provides the EMS with the engines temperature and enables it to ‘correct’ the fuelling. This correction involves adding a percentage of extra fuel according to a pre-determined correction profile by temperature, up to the normal operating temperature of the engine. The amount of extra fuel will vary from engine to engine and according to engines temperature and RPM since the affects of condensing are less when airspeeds are higher.