

Automated Engine Control Unit

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Abstract

This report is based on Electronic Control Unit (ECU)'s validation process for Input (crank signal) and Output Drivers (injector and ignition coil signals) characteristics, because of the code flashed on ECU using IDE for particular microcontroller that controls the injector driver and ignition driver pulses respectively. Based on the given PWM Input signal (crank signal) it will give injector and ignition pulses, which is used to obtain ECUs best result using generated and flashed code on microcontroller on virtual environment setup. Hardware-in-loop setup is act as a virtual engine setup, which gives the input sensor signals to ECU for their best performance under test on bench or in lab testing. Design of a fully programmable, ECU must make use of all the temperature, pressure, position and speed sensors as well as the original injectors and ignition coils that are already available on the engine. The ECU must provide the user access to all the maps and allow their full customization simply by connecting it to a PC. This will provide the user with the capability to adjust the engine's performance to its needs quickly and easily.

Keywords— *Electronic Fuel Injection, Engine Control Unit, embedded*

1. INTRODUCTION

An engine control unit (ECU), also commonly called an engine control module

(ECM), is a type of electronic control unit that controls a series of actuators on an internal combustion engine to ensure

optimal engine performance. It does this by reading values from a multitude of sensors within the engine bay, interpreting the data using multidimensional performance maps (called lookup tables), and adjusting the engine actuators accordingly. Before ECUs, air-fuel mixture, ignition timing, and idle speed were mechanically set and dynamically. If the ECU has control over the fuel lines, then it is referred to as a tolerance. In addition, the system has long-term calibration stability. As an added advantage, this type of system is very

flexible. Because it uses microcomputers, it can be modified through programming changes to meet a variety of different vehicle/engine combinations. Critical quantities that describe an engine can be changed easily by changing data stored in the system's computer memory.

The following chart shows a basic electronic engine control system. Sensors provide the needed data. The ECM will send the appropriate signal to the actuators.

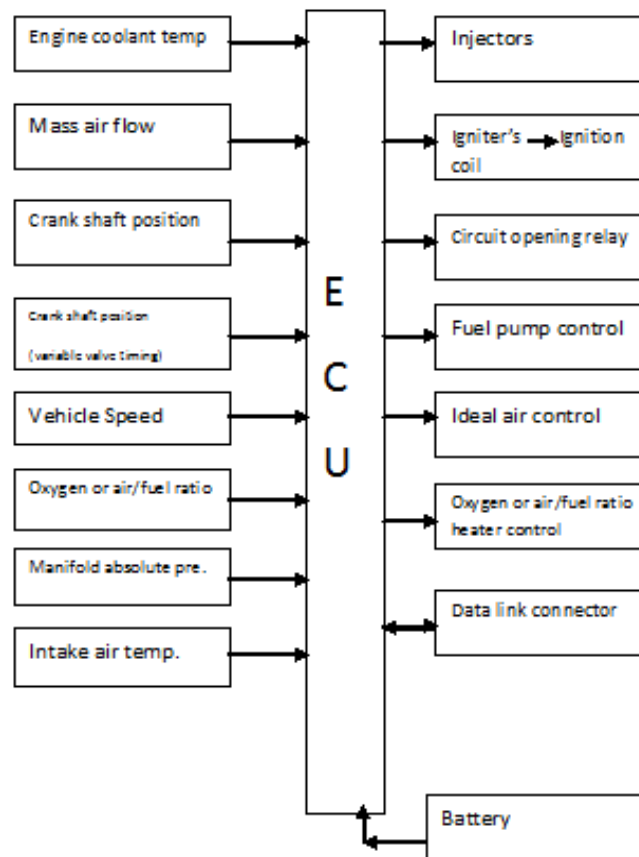


FIG. 01:- Basic Electronic Engine Control System

1. Control of air/fuel ratio

Most modern engines use some type of fuel injection to deliver fuel to the cylinders. The ECU determines the amount of fuel to inject based on a number of sensor readings. The throttle position sensors tell the ECU how far the throttle plate is opened when you press the accelerator. The mass air flow sensor measures the amount of air flowing into the engine through the throttle plate. The engine coolant temperature sensor measures whether the engine is warmed up or cool. (If the engine is still cool, additional fuel will be injected)

1.1. Fuel injector



FIG 2: Fuel Injector for 4-wheeler vehicle

Fuel Injectors are the actuators which control the fuel to be injected. The amount of fuel delivered by the fuel injector is determined electronically in accordance with

the air flow in such a way as to minimize pollutants in the exhaust gas. ECU provides drive signal to injector (normally closed valve) to open and remain in open condition (pulse width-ms) depending upon the engine operating conditions (speed/load). Also the pulse width is compensated for low battery voltage condition. The concept of Sequential injection means when ECU provides drive signal to each injector spray separately at the end of compression process.

1.2. The throttle position sensor

ECM adjusts throttle opening according to driver demand and vehicle conditions. This enhances vehicle performance and safety.

The Throttle Position Sensor (TPS) is attached to the throttle valve (Figure 7) and relays the current throttle pedal position to the ECU.



FIG 3 - TPS sensor

The TPS sensor is composed by a potentiometer connected to the valve's axis. When the driver accelerates, the valve is opened and the potentiometer's wiper arm moves along the resistor changing the output voltage of the sensor. Figure 5 shows the TPS sensor's voltage output.

1.3 Air flow sensor

Air filtered by the air cleaner is measured by the air flow sensor (commonly called the mass air flow sensor). The volume of air is regulated by the throttle valve. The idle air control valve regulates the amount of air bypassing the throttle valve to adjust idle speed. The air intake chamber and intake manifold are tuned for efficient engine operation.

1.4 Pressure Sensor

The Manifold Absolute Pressure Sensor (MAP) measures the pressure inside of the intake manifold. This provides the ECU with an accurate measure of the load being applied to the engine. Inside the MAP sensor is a small silicon chip placed between a vacuum chamber and a line leading to the intake manifold. As the pressure increases inside the manifold, the silicon chip flexes, acting like a strain gauge and changing its resistance.

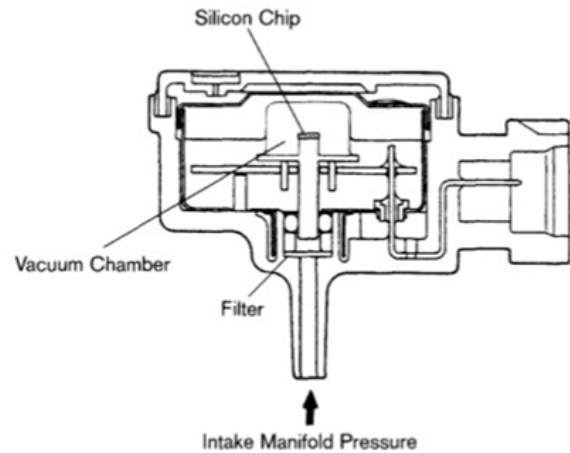


FIG 04 - MAP sensor

The chip is inserted in a Wheatstone bridge for a more accurate reading.

The MAP sensor's output is always dependant of the atmospheric pressure, therefore a calibration measurement is made prior to starting the engine and the engine load value is given in the form of a percentage where a load of 100% is equal to the atmospheric pressure and a load of 0% means the engine is in a perfect vacuum.

1.5 Temperature sensors

The temperature sensors measuring the Engine Coolant Temperature (ECT) and Intake Air Temperature (IAT) are comprised of a Negative Temperature Coefficient (NTC) thermistor. The NTC thermistor decreases it's resistance when it is heated.

2. CONTROL OF IDLE SPEED

Most engine systems have idle speed control built into the ECU. The engine RPM is monitored by the crankshaft position sensor which plays a primary role in the engine timing functions for fuel injection, spark events, and valve timing. Idle speed is controlled by a programmable throttle stop or an idle air bypass control stepper motor. Early carburetor-based systems used a programmable throttle stop using a bidirectional DC motor.

2.1 Crankshaft position sensor

Crank shaft position sensor is also known as Engine Speed Sensor or Crank Sensor. This sensor is mounted in an installation bore in the engine housing.

The crankshaft position sensor decides the situation and/or revolution per minute (RPM) of the crank wheel because this is its main aim. Inside engine management system, engine control units make use of the information comes from and to the sensor to control the engines parameters.

2.2. Engine Speed Sensor

The Engine Speed Sensor relays the engine's current angular speed, in (RPM), to the ECU. It uses a magnetized cog with 12

teeth attached to the engine's crankshaft and a Hall effect sensor.



FIG: 5 Engine Speed sensor.

When one of the cog's teeth passes near the sensor it creates a magnetic field creating a voltage difference across the sensor's surface. This voltage difference is proportional to the magnetic field applied and, through the use of an operational amplifier and a comparator, the sensor's output signal is converted to a series of pulses (one pulse each time a cog's teeth passes near the sensor).

3. CONTROL OF VARIABLE VALVE TIMING

Some engines have Variable Valve Timing. In such an engine, the ECU controls the time in the engine cycle at which the valves open. The valves are usually opened sooner at higher speed than at lower speed. This can

increase the flow of air into the cylinder, increasing power and fuel economy.

3.1 Electronic valve control

Engines have full electronic control of the intake and exhaust valve opening, valve closing and area of the valve opening. Such engines can be started and run without a starter motor for certain multi-cylinder engines equipped with precision timed electronic ignition and fuel injection. Such a static-start engine would provide the efficiency and pollution-reduction improvements of a mild hybrid-electric drive, but without the expense and complexity of an oversized starter motor.

Engines use electronic valve control which dramatically improves torque and horsepower, while reducing fuel consumption as much as 15%. Basically, the valves are opened by hydraulic pumps, which are operated by the ECU. The valves can open several times per intake stroke, based on engine load. The ECU then decides how much fuel should be injected to optimize combustion.

At steady load conditions, the valve opens, fuel is injected, and the valve closes. Under a sudden increase in throttle, the valve opens

in the same intake stroke and a greater amount of fuel is injected. This allows immediate acceleration. For the next stroke, the ECU calculates engine load at the new, higher RPM, and decides how to open the valve.

4. MAP CREATOR SOFTWARE

Adjustments to the fuel and ignition maps of the ECU are made using a specifically built windows application. This application communicates with the ECU via a USB to CAN converter. Within the application users can modify the ECU maps in real-time just by changing the values of the maps presented on the application's user interface. All values changed in the user interface are automatically updated in the ECU (if connected) as soon as the user is finished editing them.

The application implements a simple transmission protocol to ensure the correct arrival of the messages. Base fuel values are sent with message identifier 1 while Base Ignition values are sent with message identifier 2. Before transmitting the next value the application waits for a returning message with identifier 3.

APPLICATIONS

Such systems are used for many internal combustion engines in other applications. In aeronautical applications, the systems are known as "FADECs" (Full Authority Digital Engine Controls). This kind of electronic control is less common in piston-engined light fixed-wing aircraft and helicopters than in automobiles. This is due to the common configuration of a carbureted engine with a magneto ignition system that does not require electrical power generated by an alternator to run, which is considered a safety advantage.

FADEC works by receiving multiple input variables of the current flight condition including air density, throttle lever position, engine temperatures, engine pressures, and many other parameters. The inputs are received by the EEC and analyzed up to 70 times per second. Engine operating parameters such as fuel flow, stator vane position, bleed valve position, and others are computed from this data and applied as appropriate. FADEC also controls engine starting and restarting. The FADEC's basic purpose is to provide optimum engine efficiency for a given flight condition.

ACKNOWLEDGMENT

It is pleasant endeavor to present seminar report on "Automated Engine Control Unit". I avail this opportunity to express my deep sense of gratitude and whole hearted thanks to my guide Prof. V.S. Ghorade of STC, SERT, Shegaon. for substantial guidance and cooperation in the seminar work. He has provided all the facilities whenever I need and mostly for his gracious encouragement, advice and guidance to make this seminar a success.

CONCLUSION

For validation process of ECU, the perfect working of crank shaft sensor input and injector and ignition driver output is required for ECU's accurate operation on bench testing or in a virtual environment on PC or in a vehicle. This paper is based on working process of crank sensor input, injector driver and ignition coil driver in 4-wheeler vehicle and also gives their location in vehicle. For ECU's validation process perfect angular operation are required for injector and ignition coil driver, this paper gives the angular position and its working based on the generated code for crank input, injector driver and ignition coil driver with microcontroller. The results are shown here

which the standard results are for ECU and their working process.

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