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ENGINE ELECTRONIC CONTROL MODULE (ECM): AN INSTRUCTIONAL MOCK-UP DEVELOPMENT

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Abstract

This research study on electronic control module (ECM) is an output that provides detailed components on a mechanical study that showcase the combination and connectivity with the aid of a computer. An exploratory study of the Mechanical and Electronic Engineering students of Tagoloan Community College. It defines different functions that facilitate the link between system and sub-systems as an instrument for the engine to navigate and be ready for functional challenges. Settings, alignment, and including the positioning of the system is somewhat sophisticated as it adheres to the standard of the requisites and fits different functions and measurements. Its technical configuration in meeting set standards is very tremendous since its operation can become risky and causes disaster if any of the subsystems derailed the optimum intention for every mechanical project. The electronic control module (ECM) is a combination of digital and computerized aided backed by an analog that can meet or exceed the competition level in terms of performance. This electronic control module is designed with the sole intention and adherence to safety regulation as it is tested using the prescribed set of standards. Its connectivity requires stability to surface the different types of environment including the uphill and rugged terrain. Thus, the ECM modification and enhancement will guarantee an assurance of engine sustainability when it comes to operations and performance.

Keyword: *Engine electronic control module*

I. Introduction

The birth of engines of different classifications requires being equipped with electronic control. This electronic controls device helps the fuel injections system meet more rigorous centralized emission requirements (Rivard, 1973). As the system becomes more sophisticated, manufacturers begin to add more features making it competitive in terms of performance. All the things that can go wrong with a car, electrical system flaws are some of the most maddening. They're difficult to trace. Sometimes, the symptoms of electrical problems don't even seem electrical (T3Atlanta, 2017). The electronic control module (ECM) might betray a few hints, even in name alone (Jack furriers, 2020). It can determine the causes in the engine especially when it comes to trouble. It also locates the source of the malfunction of the engine parts. So, if you or your mechanic is going crazy trying to figure out to fix the trouble. Well, you can save time to find out how this trouble or problem comes and cure the symptoms. The ECM is an on-board computer in your car it's composed of hardware (a pretty standard circuit board) that's encoded with software (a program that tells the engine how to run). (AllPinouts, 1998) In automotive electronics, Electronic Control Unit (ECU) is a generic term for any embedded system that controls one or more of the electrical systems or subsystems in a transport vehicle. Designing an instructional mock-up is very important that serves as a guide that can be used by the people who are involved in the study.
According to (Carley, 2013), the Engine Control Module is the brain of the engine management system. It controls the fuel mixture, ignition timing, and variable cam timing and emissions control. It constantly monitors emissions performance via its OBD (On-board Diagnostics) programming, and it oversees the operation of the fuel pump, engine cooling fan, and charging system. It also interacts with the transmission controller (if separate), ABS/traction/stability control system, body control module, climate control module, and an anti-theft system. In short, the engine control module performs a wide variety of functions that are necessary to operate a vehicle. The study was supported by (Cuatto, 2003) an electronic Engine Control Unit (ECU) consists of a set of sensors that periodically measure the engine status, an electronic unit that

processes data coming from the sensors and drives the actuators, and the actuators themselves which execute the commands received from the control unit. In the study of (Kjellqvist, 2005) a control strategy is implemented in the electronic unit to optimize the fuel injection and ignition; in particular, it should minimize fuel consumption, minimize emissions of polluting substances and maximize torque and power, when possible. These requirements are usually competing, so the algorithm must find the best compromise for each situation. Electronic Control Unit (ECU) systems are widely used in modern vehicles; they are manufactured by a few companies and supplied to engine manufacturers. Automotive with factory-made ECUs designed to maximize the performance while minimizing cost. However, factory-made ECUs (FECU) have closed software and hardware. The control gain, lookup tables, and constants used in the algorithms are also calibrated for a particular engine design. (KUMAR, 2012) Stated that, unlike the carburetor, these systems cannot be opened and studied under different operating conditions to determine their characteristics and how they influence the performance of an engine, General Motors Company, (2013).

II. Method

2.1. Research Design

This study entitled "The development of an instructional mock-up engine in electronic control module is qualitative research that attempts to accumulate existing information and data regarding the governing principles and systems of engine operation in modern times. Doing qualitative research is to analyze and collect data gathering and become more experienced with a particular phenomenon of the researcher's interest to deliver a detailed description. This study wishes to depict more knowledge and creativity in the onset and spread of modern technology. The researcher decided to use the qualitative approach to verify the operation and function of each sensor activity in the engine and observe its function regarding the effects of electronic control in the engine.

2.2 Research Setting

The study was conducted in Tagoloan Community College, Baluarte, Tagoloan Misamis Oriental. The TCC vision is to be a premier community-based institution by 2030 producing globally competent graduates anchored to its mission that is to produce competent graduates fully equipped with knowledge and skills driven by value conforming to global standards.

2.3 Subject of the Study

The researchers chose this study to know how the electronic control module (ECM) works and acts as the brain of the engine and to improve the automotive laboratory facilities, which could be used by the students taking up the Automotive Technology. This instructional mock-up could give direct understanding to the students, as their instructor discussed the theory and application in actual function and operation principles of the electronic control module. The research also intends to modify the engine control system to make it more efficient and advantageous over a control module that controlled an electronic. The procedure of the study is shown in figure 2.3.1.

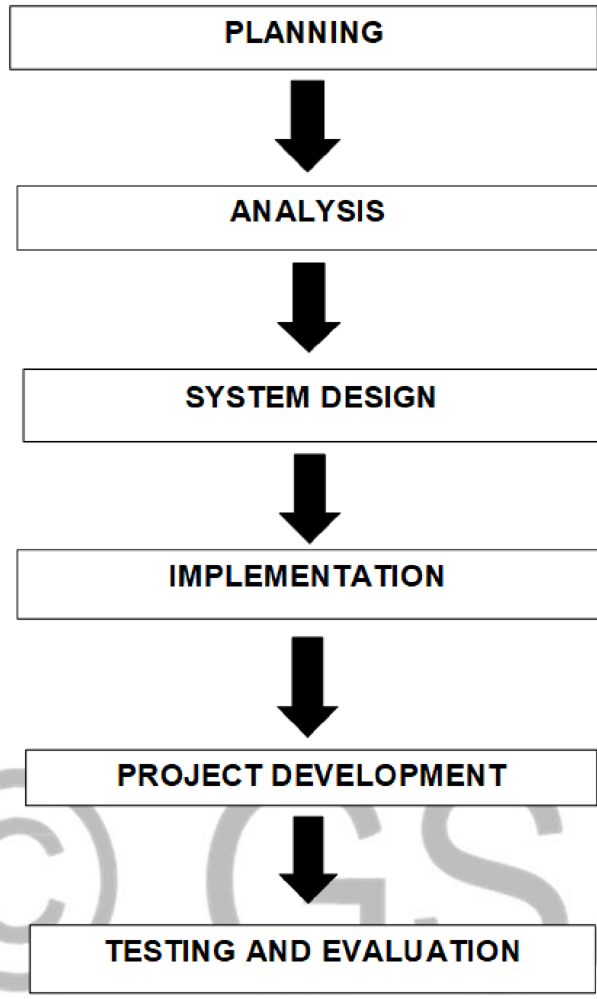

Figure 2.3.1 Procedure of the Study

2.4 Planning

The planning of the electronic control module gives an overview and purpose. The instructional mock-up in the engine using electronic control module also needed to develop new parts and proper installation. The system is running and also shows all parts and functions to prove that the engine control system operates properly.

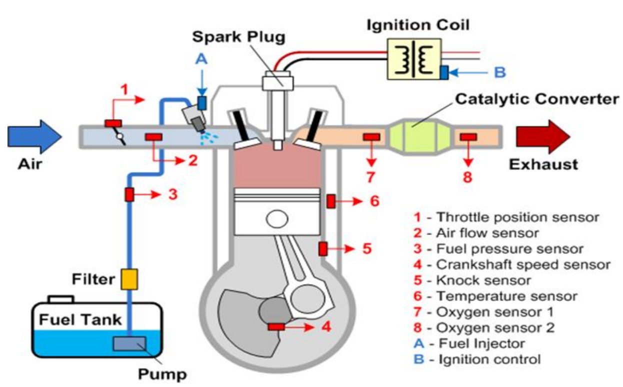

Figure 2.4.1Schematic Diagram of ECM Operation

2.5 Analysis

The problem encountered during the planning was analyzed. The system helps the people regarding the automotive background. The researcher analyzes the parts and functions for installation and operation properly. To make it function of the system it needs to be started to run the engine. For the data gathering, techniques were used to collect data of the system. The electronic control system was developed together with the new and latest electronic control installation. The researchers are proud of the current study. The major function of the analysis was obtained to determine the overall requirement of the system. The output of the system is to be a long life control engine, and give the benefits to the owner of the car which is capable of easy use. The principal tools use in this phase are the system model, data gathering techniques, data flow diagram, and data via the internet are from books, dictionaries, and magazines. The analysis phase includes the creation of the electronic control work and the benefit automobile greatly improves the performance of the car in several ways, and as a result has become commonplace, improve easy driving and difficulties in troubleshooting.

2.6 System Design

For the system design, the researchers found the important part of the system through the internet, books, magazine, encyclopedias, and actual analysis, on how it could be installed and connected to its parts. The function of the system it could be observed the engine performance and work properly advance during operation and also check. The researchers followed procedures that are made of electronic control parts.

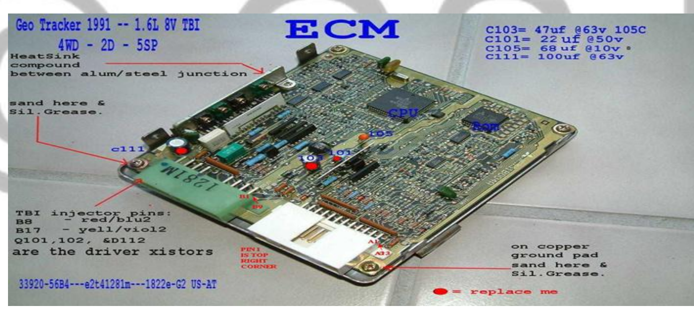

Figure 2.6.1 the ECU

Flow Chart

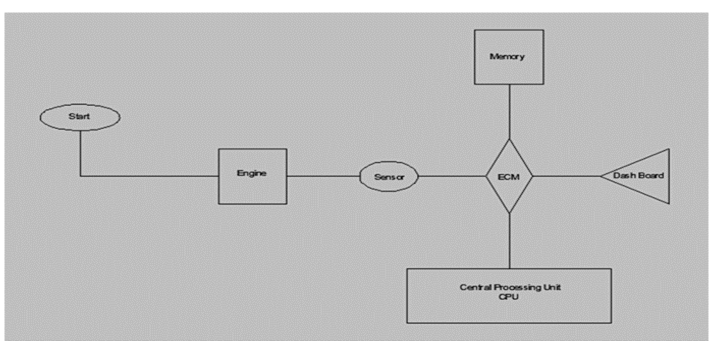

Figure 2.6.2 System Operation Diagram

2.7 Project Development

During the implementation phase, the researchers started to develop the electronic control module. The development of an ECU involves both hardware and software required to perform the functions expected from that particular module. Automotive ECUs are being developed following the V-model. Recently the trend is to dedicate a significant amount of time and effort to develop safe modules by following standards. A module is rarely developed fully from scratch. The design is generally iterative and improvements are made to both the hardware and software.

2.8 Testing and Operation Procedure

In this stage, the researchers generally test all parts of the electronic control module to make sure that all parts of the system will function. The testing method electronic control unit only checks all the individual components of the car by observing the panel board that is installed in the car.

2.9 Implementation

For the implementation phase, the ECM was tested in an automotive class for its operation. Moreover, the parts were checked on their function as a system and the output design. The researchers tried to operate the control module for the system to function furthermore, to see it can help the automotive students to deal knowledge and ability for easy understanding of the principles and as well as its importance.

III. Results and Discussions

3.1 Project Description

The Engine Control Module (also called the Powertrain Control Module or PCM) is the brain of the engine management system. In terms of operating principles, it controls the fuel mixture, ignition timing, and variable cam timing and emissions control. It constantly monitors emissions performance via its OBD (Onboard Diagnostics) programming, and it oversees the operation of the fuel pump, engine cooling fan, and charging system. It also interacts with the transmission controller. In short, the engine control module performs a wide variety of functions that are necessary to operate the engine. This PCM consists of electronics that are designed onto a multi-layer circuit board. It is a designated powerful computer which is often touted as being the brain of the engine control system since it manages many different systems of a car, such as an engine's ignition, fuel injection, and emission systems, as well as the operation of the automatic transmission and the anti-lock systems. There are two modes of computer operation-open loop and a closed loop. The open-loop operates on a preset program and is used when the engine is cold while the closed-loop is operating by using the various sensors and occurs when the engine is at operating temperature. It accepts information from various engine sensors and based on this information that has been programmed into its memory, the PCM generates output signals to control relays, actuators, and solenoids. It sends out a command to the fuel injectors that meters the appropriate quantity of fuel. The PCM automatically senses and compensates for any changes in altitude to monitor the overall health of the car. One of its function-ignition timing controls for a specific explication. Ignition timing is the pattern of sparks provided by spark plugs to ignite the fuel-air mixture in each cylinder of the engine. This pattern can be adjusted to cycle faster or slower depending on conditions in the engine such as revolutions per minute (RPM) which is how fast the engine is running. The module helps keep the ignition timing in sync with the RPM. One of the most important functions of ECU as it controls the fuel mixture used by the engine. It determines the amount of air-fuel mixture injected into the engine. The program received the necessary data and computes it and gives the appropriate amount of mixture. It also decides

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whether it is the right time to deliver the air-fuel mixture in a proper ratio or not. This process is also called injection duration. ECU adjusts the exact timing of the spark or the ignition timing to provide better power and economy. ECU detects itself whether there is a problem in the compression stroke or not and works according to and set the timing of the ignition. This mainly happens in the condition whenever there is an unburned air-fuel mixture left and it is subjected to a combination of heat and pressure. Control system in their ECU for controlling idle speed. Idle speed is controlled through the programmable throttle stop. Apart from controlling idle speed ECU also controls the timing at which the valve opens or closes in the engine cycle. The best suitable and appropriate timing of opening and closing of valve helps in increasing the power and economy of the engine. As it governs the fuel injection into the cylinder, it is programmed for the efficient performance of the engine in any environment whenever ECU encounters an increase in a load then it initiates a signal for more fuel injection & thus engines generate more BHP.

Figure 3.1.1 Electronic Control Module

The electronic control module (ECU) is an element that is considered as the major component and a computer-based installed in a unit (Zalman, 2017). Its function is to facilitate in regulating different systems and sub-system in an engine drive train and other components. This is also considered as the heart of the operating system a control module. An ECU receives data from various parts of the vehicle depending on its function. The ECU would then interact with the actuators, telling them to respond to the inputs by taking action.

Figure 3.1.2 Throttle Position Sensor

The throttle Position sensor is utilized to increase smother running performance, decrease and eliminate fires. Due to manufacturing tolerances, not all throttle bodies are identical in terms of starting and response. Some let slightly more air through than others, and altering the TPS voltage helps you to find the right balance setting that produces the greatest results for your throttle body (Dhenge, Deth, & Valujkar, 2017). This element called the throttle position sensor is connected or mounted in the throttle body whose function is to measure the opening and closing of the play and movement of the throttle valve that transmits to the engine module; information including the specific measurement. Areas subject to measurement include temperature, revolution per minute (RPM), and the mass of airflow (MAF) content that is used in the engine.

Figure 3.1.3 Crankshaft Position Sensor

The MagnetoElectric (ME) CKP sensor works based on providing precise level information regarding the location of the crankshaft. In theory, the proposed notion of measuring the angular position or speed of rotation of the shaft using the ME element can be applied to a variety of systems and designs that include movement (Petrov, Leontiev, Bichurin, & Kolesnikov, 2016). The crankshaft positioning sensor is a subsystem that monitors the position of the piston and sends a signal to the computer for fuel injections, ignition connecting the sparkplug to ignite air and fuel mixture in the cylinder. Once the engine is in motion, it produces power as a result of the conversion of heat into mechanical energy.

Figure 3.1.4 Manifold Absolute Pressure Sensor

The electrical control system of an engine uses the Manifold Pressure Sensor. Fuel injection is used in engines that use a pressure sensor. The sensor sends information about manifold pressure to the engine's electronic control unit in real-time. The information is used to compute air density and the engine's air mass flow rate, which determines the amount of fuel required for perfect combustion (DelphiTechnology, 2019). A subsystem that functions necessary for the maintenance and achieving the appropriate combination in terms of acceleration, fuel efficiency, achieving good emission level, and engine smoothness in terms of performance. It connects to the different subsystems and when the throttle is open wide, blow the air towards the intake manifold. In instances where the pressure drops, it gives a signal to the engine computer to reinforce fuel volume.

Figure 3.1.5 Oxygen Sensor

(Shuaishuai, Hongjun, Jiaqiao, & Haiqin, 2019), explained that the oxygen sensor needs to work 350^{o}C above, it takes more than 2 minutes or more from the engine start to oxygen sensor's working temperature state heated by exhaust gas. Then the electronic fuel injection (EFI) system can enter closed-loop control, and the exhaust emission cannot be controlled during the cold start time. Oxygen sensor or O2 sensor functions in monitoring the unborn volume of fuel and focuses on a mixture between air and fuel. If the mixture between fuel and the air is not even (more fuel than air), harmful gas or carbon monoxide can build up (odorless, colorless, and tasteless chemical). In some instances wherein there is a malfunction of the sensor, the electronic control module could no longer calculate the fuel volume injected. In this case, since the sensor is out of control, it will contribute to either low performance or fuel efficiency is no longer a guarantee.

Figure 3.1.6 Exhaust Gas Recirculation

The EGR system reduces NOx emissions by returning a tiny part of exhaust gas to the engine's combustion chambers via the intake manifold. This lowers combustion temperatures and thus reduces NOx emissions. The main element of the EGR system is the EGR valve, which is normally closed. It joins the exhaust and intake manifolds and is regulated by either a vacuum or an electric step motor incorporated in the manifold. The EGR valve's job is to control the flow of recirculated exhaust gas based on the engine's load (EvansHalshaw, 2021). This element functions by sending a signal to the computer unit to make the device (Exhaust Gas Recirculation) open in a very limited percentage of burning gas circulation going into the cylinder. Once the system is blocked by carbon, the signal going to the computer is out that requires servicing or cleaning of the subsystem to become functional.

Figure 3.1.7 Intake Air Temperature Sensor

(Fixdapp, 2018), discussed that the engine's Electronic Control Module (ECM) uses the Intake Air Temperature (IAT) Sensor to determine how quickly the engine should spark and inject gasoline for optimal performance. This is because the IAT sensor analyzes the air density and temperature in the car's environment to determine the appropriate amount of spark and fuel to inject. This makes it easier for the engine to start on cold days and keeps fuel economy consistent on hot days. The air intake temperature sensor monitors the air coming into the engine. This is needed in a computer-aided mechanism that monitors and estimates the density resulting in balancing the air and fuel mixture. The cooler the air present in the engine, represents more density than hot air. So, maintaining the appropriate ratio is vital that the engine so requires.

Figure 3.1.8 Idle Air Control Valve

This tiny element in the subsystem of the electronic control module serves to supplement air volume while idle. Maneuvering on standby mode appears to have a heavy load which affects the idle and open the sensor and allows the atmospheric air to come in. After which, the computer gives a signal to the fuel injector and provides the amount of fuel that compensates for the volume of air to keep the idle steady.

There aren't many car parts with more precise names than the idle air control valve. It is a device or valve that opens and closes to allow air or fluid flow (in this case, air) into the engine. The idle air control valve regulates the amount of air required to maintain a constant idle speed. It essentially acts as a throttle body plate bypass. The idle air control valve is usually located near the throttle body (Thedrive.com, 2020).

Figure 3.1.9 Engine Coolant Temperature (ECT) sensor

(Samarins, 2021) The cooling system in a car with an internal combustion engine keeps the engine at the proper temperature and protects it from overheating. An engine coolant temperature sensor or ECT measures the liquid coolant temperature. The primary computer is coupled to an ECT sensor (Electronic control module or ECM). The ECM provides a steady reference voltage (usually 5 volts) and monitors the ECT sensor signal. When the temperature reaches a pre-determined level, the ECM changes the engine performance and runs the electric radiator fans based on this signal. If the sensor signal is missing or outside the intended range, the ECM illuminates the Check Engine light and records the associated code. (Apogeeweb, 2021).

Figure 3.1.10 Anti-lock Brake System

The ABS control module is a microprocessor that performs diagnostic checks on a vehicle's antilock braking system and analyzes data from wheel-speed sensors and the hydraulic brake system to determine when to release braking pressure at a wheel that is ready to lock up and skid. The four major components of the Antilock Braking System have served several functions; the rotational speed of the wheel or wheels is monitored using speed sensors. Then, the valves in the brake line allow, block, and release pressure on the brakes by assuming three different positions, and the pumps are filled with hydraulic fluid and apply pressure to the brake drums or calipers on demand. The electronic control unit (ECU) is the ABS's brain, and it uses sensor data to determine whether or not to pump the brakes.

Figure 3.1.11 Wheel Speed Sensor

The wheel speed sensor, also known as the vehicle speed sensor (VSS), measures the speed of a vehicle's wheels. The wheel speed sensor's function is to communicate the wheel speed signal to the ABS electronic control unit. The sensor is made up of two parts: an electromagnetic induction sensor head and a magnetic ring gear. The sensor head is made up of a permanent magnetic core and an induction coil, with a ferromagnetic ring gear. The tooth tip and backlash alternately face the magnetic core while the ring gear turns. The space between the sensor head core and the ring gear is minimal when the ring gear moves to the tooth tip and confronts the sensor head magnetic core. When the ring gear rotates to the backlash and the sensor core, the gap between the sensor head core and the ring gear is the greatest, and the magnetic field lines generated by the permanent magnetic core cannot easily pass through the ring gear, and the magnetic field around the induction coil is weak; however, when the ring gear rotates to the backlash and the sensor core, the gap between them is the greatest, and the magnetic field lines generated by the permanent magnetic core cannot easily pass through the ring gear, and the magnetic (Apogeeweb, 2021).

Figure 3.1.12 Input and Output Speed Sensor

Transmission input/output sensors calculate the actual gear ratio of the transmission while the transmission is in use. Two sensors communicate the transmission data to the vehicle's electronic control module. The input sensor (Left) is the initial sensor, and it measures the speed of the transmission's input shaft. The output sensor (Right) is the second sensor, which measures the output shaft speed.

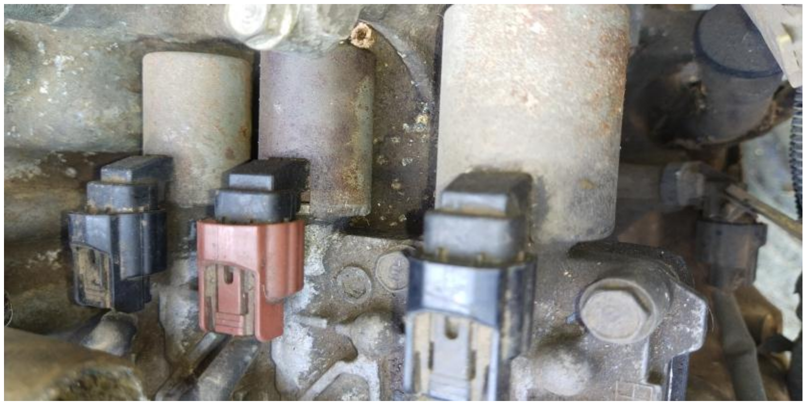


Figure 3.13 Shifting Solenoid Valve

A transmission solenoid, sometimes known as a cylinoid, is an electro-hydraulic valve that regulates the flow of fluid into and out of an automatic transmission. Solenoids can be either open or closed in their usual state. They are powered by the transmission computer or controller, which provides voltage or current. These transmission solenoids have a wire-wrapped spring-loaded plunger within. When the TCM / ECU sends an electrical signal to this coil of wire, the plunger opens, allowing transmission oil to flow into the valve body and pressurize the clutches and bands (Sabhadiya, 2021)

Project Appearance

Figure3.1. 14 Actual Photo of Instructional mock up engine in ECM

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 controlled by mechanical and pneumatic means. If the ECU has control over the fuel lines, then it is referred to as an Electronic Engine Management System (EEMS). The fuel injection system has a major role to control the engine's fuel supply. The whole mechanism of the EEMS is controlled by a stack of sensors and actuators. Modern E.C.U.s use a microprocessor that can process the inputs from the engine sensors in real-time. An electronic control unit contains the hardware and software (firmware). The hardware consists of electronic components on a printed circuit board (P.C.B.), ceramic substrate, or a thin laminate substrate. The main component of this circuit board is a microcontroller chip (CPU). The software is stored in the microcontroller or other chips on the P.C.B., typically in EPROMs or flash memory so the C.P.U. can be re-programmed by uploading updated code or replacing chips. This is also referred to as an (electronic) Engine Management System (E.M.S.). Sophisticated engine management systems receive inputs from other sources, and control other parts of the engine; for instance, some variable valve timing systems are electronically controlled, and turbocharger waste gates can also be managed. They also may communicate with transmission control units or directly interface electronically controlled automatic transmissions, traction control systems, and the like. The Controller Area Network or CAN bus automotive network is often used to achieve communication between these devices.

Project Capabilities and Limitations

The Engine Control Module is the brain of the engine management system. It's responsible to get information from sensors and run certain actuators. Sensors are placed in certain positions and give some insight as to how or what the sensors sense.

Engine Control Module Sensors

The throttle Position Sensor (TPS) is responsible to inform the computer about the rate of throttle opening and relative throttle position. A separate idle switch (sometimes called a "Nose" switch) and/or wide-open throttle (WOT) switch may also be used to signal the computer when these throttle positions exist. The TPS sensor is essentially a variable resistor that changes resistance as the throttle opens. Think of it as the electronic equivalent of a mechanical accelerator pump. By signaling the computer when the throttle opens, the computer can reach up the fuel mixture to maintain the proper air/fuel ratio.

Manifold Absolute Sensor (MAP) is responsible to provides instantaneous manifold pressure information to the engine's electronic control unit (ECU). The data is used to calculate air density and determine the engine's air mass flow rate, which in turn determines the required fuel metering for optimum combustion (see stoichiometry) and influences the advance or retard of ignition timing. The sensor generates a signal that is proportional to the amount of vacuum in the intake manifold. The engine computer then uses this information to adjust ignition timing and fuel enrichment.

Manifold Air Flow Sensor (MAF) is responsible to measure the volume and density of the air entering the engine so the computer can calculate how much fuel is needed to maintain the correct fuel mixture. It is using an electrical current to measure airflow. The sensing element, which is either a platinum wire (hot wire) or nickel foil grid (hot film), is heated electrically to keep it a certain number of degrees hotter than the incoming air. In the case of hot film MAFs, the grid is heated to 75 degrees C. above incoming ambient air temperature.

Coolant Sensor is a relatively simple sensor that monitors the internal temperature of the engine. The coolant inside the engine block and cylinder head(s) absorb heat from the cylinders when the engine is running. The coolant sensor detects the change in temperature and signals the Powertrain Control Module (PCM) so it can tell if the engine is cold, warming up, at normal operating temperature, or overheating.

Oxygen Sensor is one of the key sensors in this system. It is often referred to as the "O2" sensor because O2 is the chemical formula for oxygen (oxygen atoms always travel in pairs, never alone). It may also be referred to as the H2O2 for Heated Oxygen Sensor because it has an internal heater circuit to bring the sensor up to operating temperature following a cold start.

The Crankshaft Sensor is responsible to monitor the position or rotational speed of the crankshaft. This information is used by engine management systems to control the fuel injection or the ignition system timing and other engine parameters. Before electronic crank sensors were available, the distributor would have to be manually adjusted to a timing mark on petrol engines.

The Camshaft Sensor is responsible to monitor the relationship between the pistons and valves in the engine, which is particularly important in engines with variable valve timing. This method is also used to "synchronize" a four-stroke engine upon starting, allowing the management system to know when to inject the fuel. It is also commonly used as the primary source for the measurement of engine speed in revolutions per minute.

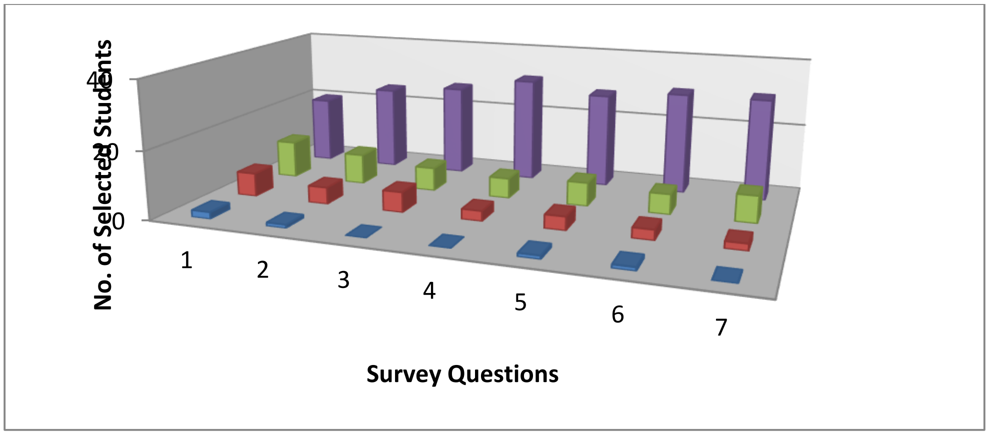
Intake Air Temperature Sensor (IAT) is responsible to monitor the temperature of the air entering the engine. The engine computer (PCM) needs this information to estimate air density so it can balance the air/fuel mixture. Colder air is denser than hot air, so cold air requires more fuel to maintain the same air/fuel ratio. The PCM changes the air/fuel ratio by changing the length (on time) of the injector pulses. It is usually mounted in the intake manifold so the tip will be exposed to air entering the engine.

Project Evaluation

In order to evaluate the effectiveness of the engine in the electronic control module (ECM) system instructional mock-up in the learning process of the students, the instructors can conduct various activities for the students to measure how the students have learned about this. In evaluating the effective function of the electronic control module (ECM) in the engine by the use of sensors, the researchers test the engine first to know if the engine is in good condition and observed it, if the engine had a defect the sensors activate by its own function and tell the electronic control module (ECM) what is wrong with the engine so that the driver, the mechanic knows.

Evaluation Table

	Rating			
	1	2	3	4
1. Applicable of this research to our laboratory.	2	7	11	20
2. This research really helps to our study.	1	5	9	25
3. This research with an actual operation and principles can provide easy understanding.	0	6	7	27
4. Using visual discussion can give the student faster learning.	0	3	6	31
5. This research is better to use in our study.	1	4	7	28
6. Compatibility of an instructional mock up to use as a tool to have a better knowledge.	1	3	6	30
7. The effectiveness of this research to the people who are involve in this research.	0	2	8	30



Bar Graph of Statistical Analysis

Based on the data gathered. Therefore, the development of an instructional mock-up engine in the electronic control module (ECM) is very helpful as a visual instructional tool material to gain knowledge, to learn an actual operation and principles can provide easy understanding. Using visual discussion can give the student faster learning and compatible instructional mock-up to use as a tool to have better knowledge.

IV. Findings/Recommendations

This study was designed to prove the effectiveness and efficiency of the electronic control module of the engine instructional mock-up. The context and the study sought to present the following components that embrace in designing the project. The development of an instructional mock-up, adds to the knowledge of the learners and entices them in becoming more skillful in seeking and addressing some technical difficulties and able to troubleshoot causes. As the primary aim is determining the effectiveness of the electronic control module, this will also help develop and unlock opportunities for people involved in the study through some discovery. In the context of this study, the researchers concluded that the engine controlled by the "*electronic control module*" guides the exploration of electronics and the automotive students and seems a very helpful tool for understanding the operating principles of the engine that is controlled on the research and study. They also used mock-ups as an aide to electronic and automotive enthusiasts in solving mechanical problems. The skeletal of the mock-up and computer box should be installed properly to avoid experiencing engine malfunctions through a misconception.

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