A SURVEY ON ENGINE CONTROL UNIT

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ABSTRACT

The Engine Control Unit is considered as heart of the vehicle engine system and it provides a control for a variety of systems within the engine. It controls a series of actuators to ensure the optimal performance. Several sensors are embedded in ECU that helps to control actuators in vehicle. It controls the functioning of vehicle by using the information from sensors that are embedded in ECU. There are different types of ECU that can be used in diverse forms of vehicles. This paper presents a survey on ECU, different types of ECU, working of ECU, design and testing of ECU.

Keyword: *Engine Control Unit, firmware, sensor, Printed Circuit Board, Controller Area Network.*

1. INTRODUCTION

An Engine Control Unit (ECU) is an electronic control unit that controls a series of actuators in the engine to ensure the performance is optimal. It reads values from multiple sensors within the engine bay, interprets the data and adjusts the engine actuators accordingly. In the Automobile industry, an ECU is an embedded electronic device like a digital computer that reads the signals from various sensors placed at various parts and in different components of the car and depending on that information, it controls various important units. An ECU is made up of hardware and software (firmware). [1] The hardware is composed of various electronic components on a Printed Circuit Board (PCB). The most important component is a microcontroller chip along with an EPROM or a Flash memory chip. The software (firmware) is a set of instructions programmed on a microcontroller. The ECU governs the engine based on engine speed, temperature and accelerator pedal position. This input information is processed in the control unit and the control signals for the individual assemblies are calculated based on the processing that has been carried out in the control unit. 16-bit or 32-bit processors are required for processing huge amount of data. Based on the type of engine, it controls ignition timing, injection timing and quantity, throttle position and camshaft adjustment. In case of any deviation from normal operation, they are stored in the fault memory for future verifications. The ECU is distinguished by many analog and digital I/O lines, power device interface, different communication protocols, large switching matrices for both low and high power signal, high voltage tests, intelligent communication interface adapters, automatic fixture recognition and software sequence enable and power device simulation[2] .The ECU is made up of many micro controller chips such as CJ135,SMP 480.ECU mainly controls air-fuel ratio, ignition timing and idle speed, prior to the concept of ECU, these were set and controlled by mechanical and pneumatic means. The ECU used in automobiles is shown in Fig 1.

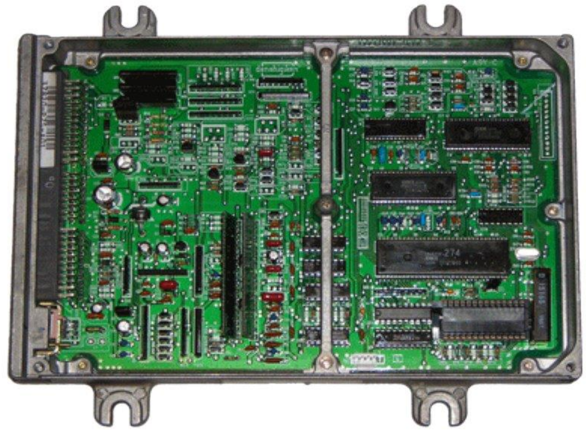

Fig 1: Engine Control Unit

2. MAIN FUNCTIONS OF ECU

The main functions of ECU are given below

2.1 Control of air/fuel ratio

A Spark Ignition Engine requires a spark to initiate combustion in the combustion chamber. An ECU can adjust the exact timing of the spark to provide better power and economy. If the ECU detects knock, a condition which is potentially destructive to engines, and determines it to be the result of the ignition timing occurring too early in the compression stroke, it will delay (retard) the timing of the spark to prevent this. Since knock tends to occur more easily at lower rpm, the ECU may send a signal for the automatic transmission to downshift as a first attempt to alleviate knock.

2.2 Control of ignition timing

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. Early Throttle Body Injection (TBI) systems used an idle air control stepper motor. Effective idle speed control must anticipate the engine load at idle .A full authority throttle control system may be used to control idle speed, cruise control functions and top speed limitation.

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2.4 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 optimize the flow of air into the cylinder, increasing power and fuel economy. Modern ECUs use a microprocessor which can process the inputs from the engine sensors in real-time. An electronic control unit contains the hardware and software. The hardware consists of electronic components on a Printed Circuit Board (PCB), ceramic substrate or a thin laminate substrate. The main component on this circuit board is a microcontroller chip (CPU). The software is stored in the microcontroller or other chips on the PCB, typically in EPROMs or flash memory. So the CPU can be re-programmed by uploading updated code or replacing chips. This is known as Engine Management System. Sophisticated engine management systems receive inputs from other sources, and control other parts of the engine. The Controller Area Network (CAN) bus automotive network is often used to achieve communication between these devices. A CAN bus is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other in applications without a host computer. It is a message-based protocol, designed originally for multiplex electrical wiring within automobiles, but is also used in many other contexts. The properties of CAN bus are prioritization of messages, guarantee of latency times, configuration flexibility, system wide data consistency, multimaster, error detection and signaling ,automatic retransmission of corrupted message as soon as the bus is idle again.

3. DIFFERENT TYPES OF ENGINE CONTROL UNIT

Engine Control Unit are of different types and they are given below.

3.1 Engine Control Module

The Engine Control Module(ECM)s is also known as Engine management system (EMS), is an ECU in an internal combustion engine and it controls various functions like, air and fuel ratio, Ignition timing, Idle Speed and Variable valve timing. ECM controls these functions of an engine by obtaining the data like engine coolant temperature, air flow, crank position received from various sensors. It also constantly monitors emissions performance through also constantly monitors emissions performance through charging system. It also interacts with the transmission controller, stability control system, body control module, climate control module and anti-theft system. The performance of the ECM can be reduced by corrosion, excessive heat and vibration.

3.2 Brake Control Module

Brake Control Module (BCM) is an ECU used in the Anti-lock Braking System (ABS) module of the car. ABS is an automobile safety system that provides improved vehicle control and avoids uncontrolled skidding. The BCM regulates the braking systems on the basis of five inputs that it receives from various parts of the vehicle.
Brake - This input gives the status of the brake pedal. It can be either deflection or assertion. This information is obtained in a digital or analog format.
The 4 W.D (4 Wheel-Drive mode) - This input gives the information about whether the vehicle is in the 4-Wheel-Drivemode. 4-Wheel-Drivemode is a form of drivetrain capable of providing power to all wheel ends of a two-axled vehicle simultaneously. This input is in the digital format.
The Ignition - This input registers if the ignition key is in place, and if the engine is running or not.
Vehicle speed - This input gives the information about the speed of the vehicle.
Wheel speed - Wheel Speed represents a set of four input signals that provides the information concerning the speed of each wheel.

3.3 Power-train Control Module

A power-train control module (PCM), is a control unit used on motor vehicles. It is a combined control unit that consists of Engine Control Unit (ECU) and Transmission Control Unit (TCU).

3.4 Vehicle Control Module

Vehicle Control Module (VCM) is connected to various sensors in order to control the functioning of the car. VCM is an ECU that is installed in the middle of the car between the passenger and engine compartment. They read input from micro-machined accelerometers also known as crash sensors that determine weight, seating position, seat belt use and position of the seat to determine the force by which the frontal air bags should be used. VCM monitors Electronic Power Steering (EPS) systems, Adaptive Cruise control (ACC) systems, Airbag control system (ACS) systems and Electronic Stability Control (ESC) systems. VCM reads input from Steering wheel angle sensors.

4. DIFFERENT TYPES OF SENSORS

Micro controller chips embedded in ECU ensures proper functioning of vehicle by reading the values from sensor. Various sensors are embedded in vehicles and they provide information that are needed to control actuators in vehicle. The main function of sensors are listed below.
Engine Coolant Temperature Sensor is to instruct the radiator fan to turn on and cool down the liquid if the temperature is greater than 75 degrees. It is located at the bottom or top of the radiator.

- Air Temperature Sensor provides information about temperature of air going into the engine and it is located in a filter box.
- Manifold Absolute Pressure Sensor measures air pressure and informs ECU about the current altitude of a vehicle.
- Mass Airflow Sensor measures the volume of air entering into engine and it produces more current to keep temperature required by the manufacturer. It is located on air cleaner box.
- Crank Shaft Sensor works to locate the exact position of crank shaft and to show Revolution per minute of engine. It is located at the bottom of engine and closed to crank shaft. Crank Shaft Sensor is an electromagnetic sensor fixed at the end of the camshaft. It produces voltage when a metal object moves over it. It contacts with ECU to position the camshaft.
- Throttle Position Sensor is located in the throttle body and linked with accelerator pedal. It sends information about injector pulse width and spark timing.
- Oxygen Sensor detects the oxygen content so as to know about amount of fuel consumed by the engine.
- Knock Sensor contains a crystal and the crystal detects mechanical stress and produces a voltage when the car knocks.

5. WORKING OF AN ECU

Engine Control Unit (ECU) in automotive industry is considered as a computer that monitors the engine to provide an optimal performance. Each ECU in the car performs several jobs such as controlling the engine, rolling up or down windows, unlocking doors. ECU consists of many sensors connected to it or to any parts of the car and it also consists of switches wired in to read various signals such as pressure, temperature, voltage, acceleration at different angles like steering angle .When an ECU needs signals from the sensor, Controller Area Network (CAN) bus is used to read these signals from the sensors and transmits to ECU .Each ECU transmits all its sensors and programming information constantly and these information float around the network and at the same time each ECU listens to the network to obtain the piece of information it required to perform the desired work[4]. There is no central hub and information flows around the network continuously and are made available to the ECU's. Before CAN was developed many dedicated wires are used to establish a connection between ECU's and sensors, but with CAN the sensors and ECU directly communicate through network and dedicated wires are not required to establish direct communication between sensors and ECU. [5]CAN bus has many advantages such as significant cost savings to the consumer, much lighter weight, reduced reliance on rubber and copper resources, and far better reliability with fewer wires to break over time.

6. DESIGN AND TESTING OF AN ECU

Automotive embedded systems are built by developing hardware boards that represent the ECU or part of the ECU and part of its surroundings. These systems are known as plant models. These are used for bench testing, but there are drawbacks in bench testing. The major drawback is creating all the needed hardware boards is costly and this bench testing is based on a sequential design process by which hardware is developed, plant model prototypes are built and then the software development begins. To overcome these disadvantages, ECU are designed based on a design process known as "V" diagram[6].The development of ECU is an iterative process and it will not be carried out in a sequential manner. In this process, the overall requirements of the system are divided into sub-systems and components, so that individual products are developed and tested individually and then they are integrated. The steps involved in "V" design process are, System definition, Prototyping, Targeting, Hardware-in-the-Loop Testing, System Testing [7].

7. CONCLUSION

Engine Control Unit controls a series of actuators to ensure optimal engine performance. It provides control for a variety of systems within the engine including the control of air fuel ratio, ignition timing and idle speed. Various sensors provide information about different functions of vehicle and these information helps in maintenance of ECU. Thus, it is very essential for a vehicle to have ECU for optimal performance. Ideal performance of an ECU ensures optimal performance of vehicle. In this paper, different types of ECU and the importance of ECU has been discussed.

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