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Engine Control Module: A Review

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Abstract: The automotive sector is constantly and rapidly upgrading and deploying advanced features into contemporary vehicles. To integrate these advanced features, numerous electronic systems are needed. Several control modules are used for enabling these systems to act jointly. Engine Control Module is a crucial part of vehicle's Engine Management System (EMS). Expanding interest for progressively controlled security features, traveler comfort, and operational ease in vehicles requires an exhaustive utilization of electronic control units (ECU). The Engine Control Module (ECM) provides the brains for the engine of the vehicle. It controls the fuel mixture; timing and emissions control system and variety of other systems and sensors. This paper presents a review on ECU, different types of control units in vehicle, automotive communication protocols and working of an ECU.

Keywords* — *Engine Control Unit, firmware, sensor, Printed Circuit Board, Controller Area Network, Electronic Engine Management System (EEMS)

I. INTRODUCTION

Modern day vehicles are not just a blend of engine, body, chassis and wheels. They are furnished with numerous sensors and electronic gadgets to help drivers. By 2020 it is estimated that about 35 percent of complete cost for manufacturing the vehicles will be for electronics. The automobile industry is growing exponentially and more functionality is being added to vehicles for safety and comfort of drivers. Most of these functionalities or features are coordinated and referred to as an electronic framework or sub module. To synchronize these electronic frameworks, Electronic Control Units was introduced [1].

ECM is a control unit that controls a movement of actuators utilized in the engine so as to guarantee the execution of an engine is ideal. It examines values from different sensors inside the engine, translates the information and changes the engine actuators accordingly. In the Automotive sector, an ECU is an inserted electronic gadget like an advanced PC that gathers information from different sensors set at different parts and relying upon that data, it controls different essential units. An ECU is comprised of hardware and software (firmware) [2]. The equipment is made from different electronic parts on a Printed Circuit Board (PCB). The most critical part is a microcontroller chip alongside an EPROM or a Flash memory chip. The software (firmware) consists of a lot of guidelines customized on a microcontroller.

The ECU controls the engine relative to engine speed, temperature and throttle position. This information data is prepared in the control unit and the control signals for the individual congregations are determined depending on the analysis that has been done in the control unit. Depending on type of engine, it controls start timing, infusion timing and amount, throttle position and camshaft alteration. If there is an occurrence of any deviation from ordinary activity, they are stored in the fault memory for future checks.

The ECU is recognized by numerous analog and digital I/O lines, control module interface, distinctive communication protocols and huge exchanging networks for both low and high power signal, high voltage tests, smart communication interface connectors and power device simulation [3]. The ECU is comprised of numerous miniaturized scale controller chips, for example, CJ135, SMP 480. Before the idea of ECU, start timing, injection timing and different parameters were set and constrained by mechanical and pneumatic methods. If the ECU has control of the fuel lines, at that point it is alluded to as an Electronic Engine Management System (EEMS). The fuel injection framework has the real job to control the motor's fuel supply. The entire component of the EEMS is constrained by a pile of sensors and actuators. Multiple network protocol implementations may also be integrated in the case of ECUs which require interfaces to different physical networks.

II. TYPES OF CONTROL UNITS

Control Unit is of different types and they are given below:

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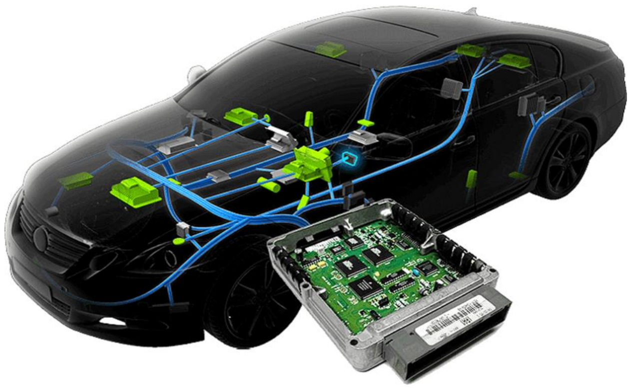

Figure 1: Prototypical of an ECM in automobile.

A. Door control unit (DCU)

Door control Unit (DCU) is the common term associated with control modules which controls a variety of electrical systems related to doors in sophisticated cars. Since more than one door is used in most of the vehicles, typically each door consists of the separate DCU. Some further functionality is added in the DCU associated with driver's door. This further functionality is the consequences of convoluted features like lockup, driver door switch pad, kid lock switches, and so forth, and that is mostly utilized in DCU deployed in the driver's door. A communication is established between the master DCU located in the driver's door and other doors which act as slave in the communication network.

Characteristics controlled by Door Control Unit:

- Window movement adjustment control
- Global Open-Close usefulness
- Child lock security include
- Side mirrors folding and adjustment

B. Engine control unit (ECU)

The Engine Control Module (ECM) is additionally called Engine management system; is an ECU enclosed in a combustion engine and it governs varied tasks like, air and fuel quantitative relation, Ignition timing arrangement, Idle Speed and Variable valve timing arrangement. ECU controls these functions associated with an engine by getting the information like engine fluid temperature, air flow, crank position received from varied sensors. It conjointly perpetually monitors emissions performance through charging system. It conjointly interacts with the transmission controller, stability system, body management module, climate management module and anti-theft system. The performance of the ECU may be reduced by corrosion, excessive heat and vibration.

C. Electric Power Steering Control Unit (PSCU)

The power steering management unit uses electrical power power-assisted steering to support individual in driving the vehicle. Steering system management units are found on electronically controlled steering system as compared to the critical older hydraulically controlled systems. The management unit applies torsion through the motor, which connects to the steering column or the gear. This permits assistance to be given to the driver, considering driving conditions and demand.

D. Human-machine interface (HMI)

Human-machine interface is used in an industrial system which acts as a UI (User Interface) that allows users to intercommunicate with the controller. An HMI includes electronic components for signaling and controlling automation systems.

E. Powertrain control module (PCM)

The PCM (Powertrain Control Module) is the main processor within the automobile that controls all its functions. By putting management of the transmission and engine into one unit, the PCM will be able to coordinate their functions for higher power delivery and fuel economy more efficiently. PCM contains a separate ECM and TCM, each with its own processors and programming computer memory. These act differently throughout most operations, and share knowledge once an operation needs each system to coordinate along. The PCM senses and monitors about hundred factors in an automobile

Following are a few of the most essential processes:

- Air-to-Gas Ratio
- Ignition Timing
- Idle Speed
- Performance Monitoring

F. Seat Control Unit

Seat management Unit is an advanced mechanical and electronic system in premium cars to make sure driver safety and luxury. Seat management offers the chance to fine tune several position settings – support angle, seat height or breadth and the ability to manage seating temperature by exploiting dedicated cooling/heating devices. All the seat changes are stored and retrieved whenever needed.

G.Speed control unit (SCU)

Speed management or cruise management may be a system in premium cars to mechanically control the rate at which vehicle is moving. The system may be a servo system that takes into account the management of the throttle of the automobile to keep up a gradual speed as set by the car user.

H. Telematic control unit (TCU)

In automotive sector, Telematic Control Unit is an onboard inserted framework utilized for movement of vehicle. A TCU incorporates a global positioning system (GPS) that determines the exact location of the vehicle by continuously

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tracing the geographical coordinates of the vehicle; an outside interface for mobile communication(GSM, GPRS, Wi-Fi, WiMAX, or LTE), that notifies the centrally operated geological framework (GIS) about tracked values; an processing unit like a microcontroller, microchip or field programmable gate array (FPGA), that operate on this data and acts on the interface between the GPS; a mobile communication unit; and some amount of memory for retaining GPS esteems just if there should arise an occurrence of mobile free zones or to store data concerning the vehicle's gadget information.

I. Transmission control unit (TCU)

A transmission control unit is a gadget that controls electronically programmed transmissions. A TCU more often utilizes sensors situated at various positions in the vehicle together with information given by the engine administration unit to compute and modify intends inside the vehicle for ideal execution, efficiency and move quality.

J. Brake Control Module

Brake Control Module is a control unit utilized in the Anti-Lock Braking System (ABS) of the vehicle. ABS is a car wellbeing framework that gives improved vehicle control and maintains a strategic distance from uncontrolled sliding. The BCM manages the stopping mechanisms dependent on five data sources that it gets from different pieces of the vehicle.

Following are the inputs received by the Brake Control Module:

- Brake – This info gives the status of the brake pedal. It very well may be either redirection or attestation. This data is acquired in an advanced or simple configuration.
- The 4 W.D (4 Wheel-Drive mode) - This information gives the data about whether the vehicle is in the 4-WheelDrivemode. 4-Wheel-Drivemode is a type of drive train equipped for giving capability to all wheel finishes of a two-hub vehicle at the same time.
- The Ignition - This data records if the begin key is set up, and whether the engine is functioning.
- Vehicle speed - This information gives the data about the rate at which vehicle is moving.
- Wheel speed - Wheel Speed addresses mostly four data signals which give the information about the rotational speed of four wheels of the car.

III. TYPES OF SENSORS USED IN AUTOMOBILES

The primary duty of an Engine Control Module is to get data from sensors situated at various positions in a car. The contributions from these sensors are utilized to take restorative measures to guarantee ideal engine execution.

Following are the sensors used in automobiles:

- Throttle position sensor
- Fuel temperature sensor
- Manifold pressure sensor
- Spark knock sensor
- Voltage sensor
- Crankshaft position sensor
- Oxygen sensor
- Mass air flow sensor
- Engine speed sensor
- Camshaft position sensor
- Wheel speed sensor
- Hall-effect sensor

IV. ACTUATORS

An actuator is a device that converts energy into some form of motion. Actuators are also called as movers. The data obtained from sensors situated at different locations is processed by the ECU and according to this data actuators are controlled. Adjusting idle speed of the engine, changing suspension height and regulation the flow of fuel in the engine are some of the operations performed by the actuators. Relays, solenoid and motors are some of the actuators used in an automobile.

Two most commonly used actuators in automobiles are stepper motor and solenoid.

***A. Stepper motor*:** Stepper motors are digital actuators. It moves in pre-decided augmentations in the two headings and can have more than 120 stages of movement. Stepper motors are regularly used together with ECU for controlling the speed of the engine in idle state. Idle air bypass and throttle body are some of the functions controlled by the stepper motor. Stepper motor is used together with an idle speed control valve (ISCV) which is located in an air intake chamber for rotating the valve shaft either in or out. Eventually it thus increments or diminishes the clearances between the valve and valve base consequently directing the quantity of air permitted into the chamber. 125 distinguishing valve opening positions are permitted by the ISCV stepper engine.

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B. Solenoid: Solenoids are actuator that has one of its inputs is connected to the supply and the other is appended to the PC which opens and shuts the ground circuit when required. At the point when solenoid is empowered it used a plunger or armature for controlling features like fuel infusion in the chamber and motion of the vacuum to different outflow related frameworks. Most of the actuators in a car are solenoids. Pulse-width and duty cycle are two possible ways of controlling the solenoids. Pulse width control is utilized when variation in frequency is allowed. Duty cycle control is utilized when constant frequency is required. A solenoid utilizing duty cycle control which is utilized in ABS is intended to be open and close for a time as per a predefined proportion such as open for 20% of time and off for the other 80%. Solenoids can be utilized to forge the idle speed control valves rather than a stepper engine. The flag is sent by the ECU to the ISCV for controlling the admission air. ECU transmissions also deploy solenoid valves. Solenoid is responsible for opening for closing the hydraulic driven entry to control fuel stream to the shift valves.

V. AUTOMOTIVE COMMUNICATION PROTOCOLS

Vehicle communication has been developing at a relentless rate since the principal Electronic Control Modules (ECM) began to intercommunicate with different modules. For a considerable length of time, the radio was the main electronic gadget in vehicle, yet beginning with guidelines actualized to decrease car emanations and pursued by the development of the semiconductor industry, electronics advanced into almost every feature of the vehicle [4].

Today several fieldbus technologies are used by different automotive system vendors. In this section, three of the most common fieldbus technologies are presented in detail, namely LIN, CAN and Byteflight. Today several fieldbus technologies are used by different automotive system vendors. In this section, three of the most common fieldbus technologies are presented in detail, namely LIN, CAN and Byteflight. Today several fieldbus technologies are used by different automotive system vendors. In this section, three of the most common fieldbus technologies are presented in detail, namely LIN, CAN and Byteflight.

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Now-a-days distinctive field bus technologies are utilized by various car framework merchants. In this area, three of the most regularly utilized advancements are introduced in detail in particular LIN, CAN and Byteflight.

A. LIN

LIN represents Local Area Network. It is a reasonable system, giving system rates of up to 20 Kbps. It is regularly utilized in body and comfort modules to control gadgets, for example, seat control, light sensors and atmosphere control [5]. LIN is frequently utilized together with CAN as LIN supplements CAN by being a lot less expensive and more straightforward yet giving the correspondences expected to run non-safety related car subsystems.

B. CAN-CONTROLLER AREA NETWORK

Controller Area Network or simply CAN is wireless communication protocol adopted by automotive industry to be deployed in vehicles to establish a fast and secure communication network between several independent modules of the system. The CAN protocol standardized by organizations such as ISO and SAE, proposes a multiple master-multiple slave bus architecture which is sequential and non concurrent and operates without the need to setup a host device. CAN protocol can deal with data rate of up to a maximum of 1 megabit per second (Mbit/s) and can withstand electrical interferences along with autonomous error detection and correction capabilities. The flow of information among the individual modules of the system is governed by the set of rules defined in the CAN communication standard. CAN communication standard is based on the lowest two layers of the Open System Interconnection (OSI) framework. The physical communication between two modules of the network is carried out by the physical layer. Each node in the network is assigned a unique identifier to achieve communication between the desired modules. Depending upon the number of modules in network, CAN defines two variants (Variant A and Variant B) providing sufficient number of unique identifiers which can be assigned to each independent module. Variant A consists of an 11-bit identifier and variant B consists of 29-bit identifier.

Features of CAN:

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- Message priority
- Deterministic Latency duration
- Time Division Multiplexing (TDM) based broadcast to multiple nodes/ receivers
- Data consistency
- Multi-master
- Autonomous Error identification and correction
- Re-transmission of erroneous messages/information
- Differentiation of temporary and permanent node failures
- Self disabling of defective nodes/modules

C. BYTEFLIGHT

The primary planned application space for Byteflight is security basic frameworks, where CAN is utilized today, yet not later on, as additional advancement will demand for higher transmission capacity. Byteflight communication protocol is commonly deployed in an airbag framework or safety belt applications as these systems have hard real time requirements and short mission-time. Adaptability, to promote occasion activated traffic, and much high data transfer capacities contrasted with CAN were the fundamental necessities at the point when Byteflight was created. Byteflight gives system speed of up to 10 Mbps and are accessible off the shelf [5].

VI. WORKING PRINCIPLE OF AN ECU

Controlling the engine is the most processor escalated work and the Engine control unit (ECU) is the most dominant PC in many automobiles. The ECU exploits closed loop control, a control that canopies output of a framework to control the contributions to a framework, dealing with the emanations and mileage of the engine. It assembles information from many miscellaneous sensors and with this information, it performs many computation each second, incorporating and considering qualities in tables, figuring the after paraphernalia of long conditions to settle on the best spark timing and deciding to what extent the fuel injector is open. The ECU does the majority of this to guarantee the most reduced emanations and best mileage. Contingent upon the information acquired from the sensor ECU controls arrangement of actuators like fuel injector.

Present day ECU contains a 32-bit, 40-MHz processor. Controller Area Network (CAN) bus is utilized to peruse these signals from the sensors and transmits to ECU. Each ECU transmits each of its sensors and programming data continuously and these data skim around the system and in the meantime each ECU tunes in to the system to acquire the data it required to carry out the ideal work [7]. There is no central hub and data streams around the system ceaselessly and are made accessible to the ECU's. Before CAN was developed many devoted wires were utilized to set up an association among ECU's and sensors, but with CAN the sensors and ECU easily pass on the information through the system and devoted wires are not required to build up direct correspondence among sensors and ECU [8].

VII. CONCLUSION

Under the survey of all different forms of control unit we can conclude that there are different types of control units required according to the application. 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 this 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.

After selecting the precise control unit applicable we can also go through the protection measures with which we can know the complete maintenance of the engine. In this paper, diverse sorts of ECU, significance of ECU and different automotive communication protocols have been examined.

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