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Design and Development of an ECU with Open Loop Feedback System for Homogenous Charge Compression Ignition(HCCI) Engine

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Abstract— The fuel injection is not a new concept. But the approach towards cost effectiveness, compatibility and reliable electronic control has a lot to do with the success of the fuel injection. Electronic is playing a key role in the fuel management and ignition. The precise control of the ignition and injection timing which is possible by electronic means allows reliable combustion. In the present work, an Electronic Control Unit(ECU) hardware device is developed for the fuel injection control of the duel fuel Homogenous Charge Compression Ignition(HCCI) Engine. This ECU will be used to control the injector timing of the fuel injection system.

Index Terms— *HCCI; ECU; Fuel Injection System; Open Loop control*

1 Introduction

The Homogenous Charge Compression Ignition (HCCI) is considered to be the promising future IC Engine concept. HCCI is the concept of hybrid combustion between SI and CI engine. HCCI engine can be highly efficient and also produce low emissions. They have efficiencies as high as CI engines while producing ultra low oxides(NOx) and particulate matter(PM) emissions. Also, this can operate on gasoline, diesel and other alternative fuels which make it more flexible. The recent introduction of the electronics i.e. sensors and controls has made HCCI engine a potential practical reality. Electronics gradually crept into the control devices, handling various systems like fuel injection, ignition systems.Today, there are no longer any systems featuring the mechanical control. The control of the engine by electronics has led to a vast improvement in the efficiency, power output and emissions. The content and complexity of electronics are destined to increase even more in the future.

An Electronic Control Unit (ECU) (also known as Engine Management System) is an electronic device, basically a computer in an internal combustion engine that reads several sensors in the engine and uses the information provided to control the fuel injection and ignition systems of the engine. This allows the engine's operations to be controlled in greater detail allowing greater fuel efficiency, better power and responsiveness and much lower pollution levels than earlier generation of the engines.

In the present work, the designed ECU is used to control the injector timing of both the fuels for HCCI engine, along with crankshaft position sensor, crank angle sensor, RPM sensor is used.

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2 ELECTRONIC CONTROL UNIT

In automotive electronics , Electronic Control Unit (ECU) is a generic term for any embedded system that controls one or more of the electrical system or subsystems in a transport vehicle. An ECU controls a series of actuators on an IC engine to ensure optimal engine performance. It does this by reading the values from many of the sensors within the engine bay, interpreting the data using performance maps (lookup tables) and adjusting the engine actuators accordingly. Before ECU's, air-fuel mixture, ignition timing and speed were mechanically set and dynamically controlled by mechanical and pneumatic means. 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). The main component on this circuit board is a micro-controller 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 reprogrammed by uploading updated code. This is also referred to as an (electronic) Engine Management System (EMS). Earlier ECU designs were based more on analogue computer circuitry, due to the fact that for analogue circuits processing speed is not an issue. It was not until around 1987 that digital electronics and embedded microprocessor systems became fast enough to process engine parameters in real time.

2.1 Design of ECU

In this work, the ECU is designed to control the fuel injection system of dual fuel HCCI engine. The ECU is divided into three main systems i.e. Microcontroller, Sensors and actuators or drivers. The proposed ECU block diagram with open loop control system is as shown below.

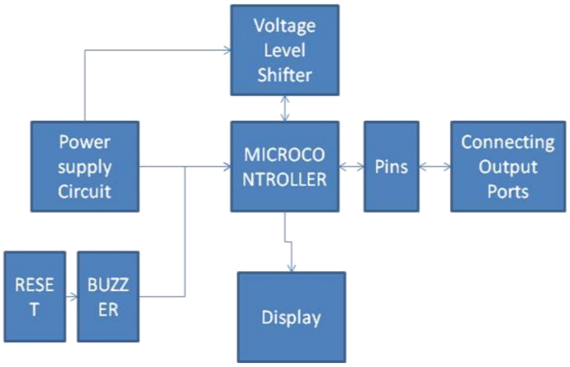

Fig. 2.1 ECU block Diagram

The designed ECU consists of basically three circuits. This circuits are designed in ORCAD software. The three circuits consists of one microcontroller circuit and two driver circuits. One driver circuit is the sensor circuit and other is the injector driver circuit. A 16 pin LCD display of size 16*2 is used. The ECU components circuits are described as below.

2.2 *Microcontroller*

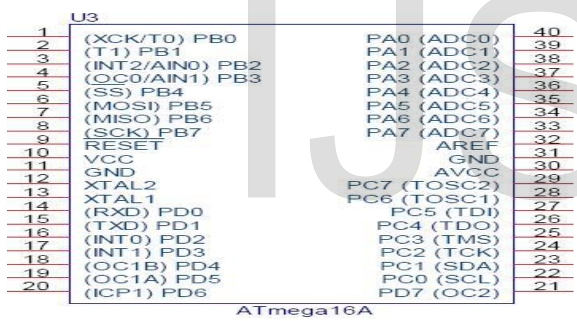

Fig.2.2 Microcontroller Circuit

Microcontroller is the processing unit of the ECU. It contains the major computational and control sections of a digital computer called the central processing unit (CPU) on a single integrated circuit (IC). Here, ATML-ATmega16A microcontroller is selected. It is a 40 pin circuit. It has a 8bit processor with 16kb flash and 16kb RAM. The endurance is of 10,000 cycles with 2*8bit timer/counters.

This microcontroller has basic 4 ports namely, PA, PB, PC, PD as shown. which are further divided into 8 sub ports. The other six ports are of the RESET, VCC for supply connection and GND is for ground as in the diagram.

2.3 Power Supply Circuit

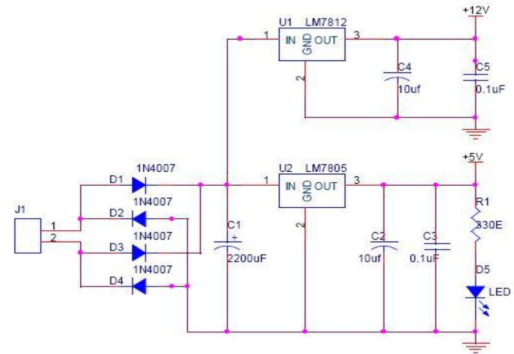

Fig. 3 Power Supply Circuit

This circuit basically consists of rectifiers and capacitors. This provides supply to the microcontroller and the sensors. It has two outputs of 12V and 5V. This circuit has reverse polarity protection thus, preventing it from the short circuiting. LED is used to indicate the power ON and OFF for the circuit.

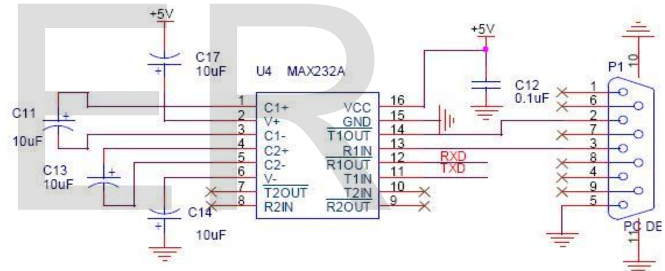

Fig. 4 Level Shifter Circuit

2.4. Level Shifter

Here, Max 232 level shifter circuit with 16 pins is used. The level shifter performs the function of providing the required supply to the microcontroller , even if the input supply varies. This circuit is provided with a 9 pin connector which makes it compatible to be interfaced with the display of the computer.

2.5. Port Connectors

This is the 6 connector port circuit of the ECU. Here, the sensors are connected to the microcontroller. Also, three extra ports are provided in the event of addition of extra sensors.

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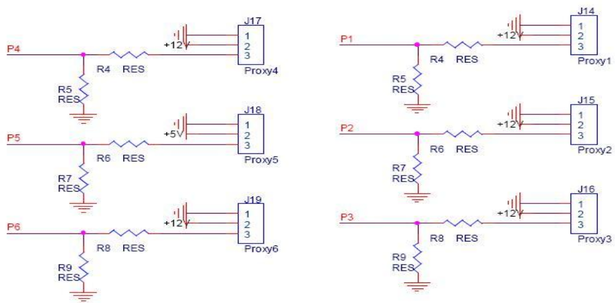

Fig. 5 Port Circuits

2.6. Proximity Sensors (Speed Sensor/Crankshaft Position Sensor)

These sensors produce a voltage signal that corresponds one to one with the fluctuations of the magnetic flux created by the rotating motion of the crankshaft.

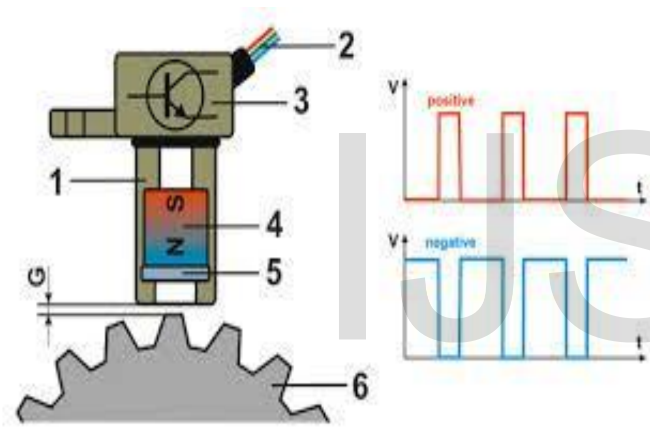

Fig. 6 Speed/Crankshaft Position Sensor[12]

The sensor used here is LJ18A3-8-Z. This sensor finds the position of the crankshaft with the help of the magnetized cog teeth. When the teeth passes near the sensor , it creates the magnetic field. This field causes the voltage difference which is proportional to the current passing through the sensors. This voltage is amplified and sent as a sensors output.

2.7. Pressure Sensor

Pressure sensor is used to measure the fuel pressure in the common rail and provide the data to the ECU. The fuel pressure determines the emissions out of the engine. Hence, the higher and constant fuel pressure is required to be maintained in the common rail. The sensor provides the information in the form of the voltage from 0.55V to 4.55V which corresponds to the pressure of about 200 bar to 300bar. Also, a pressure relief

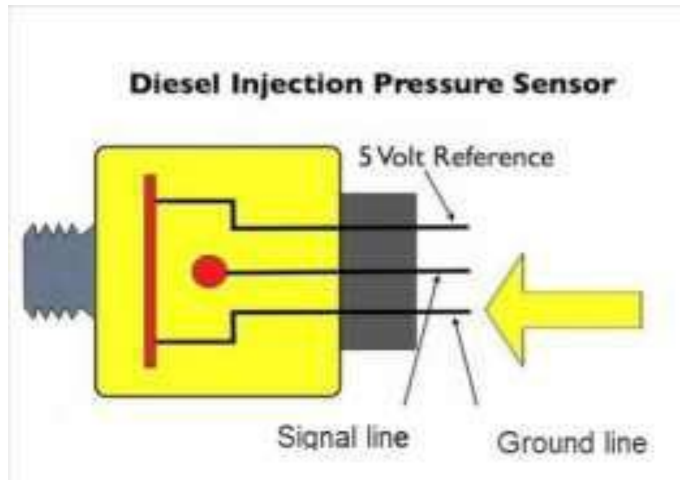

Fig. 7 Pressure Sensor[12]

valve is used to control the pressure of the rail.

3. ECU FINAL DESIGN

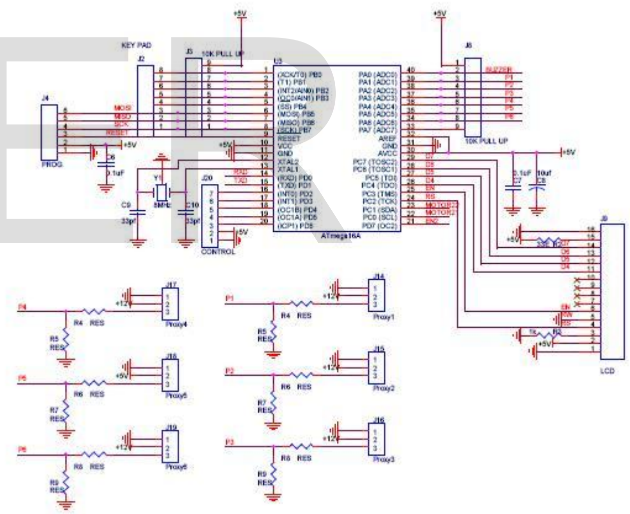

Fig. 8 Designed ECU Circuit Diagram

4. Conclusion

In this paper, an Electronic Control Unit(ECU) is designed for the duel Fuel Homogenous Charge Compression Ignition(HCCI) Engine is been presented. The earlier designed ECU was based on the closed loop system which had restrictions on the parameter variation. Here, the designed ECU is based on the open loop architecture were the fuel injection parameter is to be varied manually. This designed ECU will offer an increment in the present performance of the engine.OM XYZ.

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