Development of Fuel Injection System for Different Fuel Injection Timing

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Abstract: In this Paper, a new method is devised to control the fuel injection timing. An electronic circuit is designed which controls the fuel injector. This new method eliminates the use of sophisticated ECU for study. It is simple & economical. The paper aimed at providing a new method for controlling fuel injection timing for experimental studies. To verify the working of this method, experimental tests are investigated.

Index Terms—Fuel Supply System, Fuel Injection System, Carburettor, Petrol injection, Diesel injection

I.INTRODUCTION

Fuel injection system is the most important part of the internal combustion engines. It mainly consists of fuel pump, fuel injection system & fuel injector. Each of these parts play an important role in better performance of the engine. The parameters which affect the performance are fuel pressure or injection pressure, fuel injection timing, fuel injection duration, engine speed, spray atomization & mixture formation[7].

Fuel injection timing is the significant parameter of performance in IC engines. There are different methods for controlling fuel injection timing.

The fuel injection timing is controlled by a electronically controlled unit. Various sensors are installed which transmits signal to the ECU & as pre programmed, the ECU commands the fuel injector[9]. Mani kaushik[4] tested the GDI technology in two wheeler engine successfully. He designed different cam lobes to control the valve timing & a pump housing to regulate injector pressure. His work concluded that there is need to minimise cyclic variations in pressure of the engine to improve performance of engine. Sanjay Patil[1] simulated a computer model using Double Weibe's function to study effect of variation of fuel injection timing on performance, combustion & emissions characteristics of CI engines fuelled with palm oil methyl ester. Alp Tekin tried to investigate the effect of various fuel injection advance angle on the combustion characteristics of bio-diesel blends. He used PLC to control the injection timing. His set u included oscilloscope, pressure transducer, temperature logger, soot meter, gas analyser, pressure control system & inc. Encoder. However he could not obtain substancial values as the results obtained were undesirable. Maleboyena Mastaniah[5] investigated the performance of electronic fuel injection system using compressor & controller. He used compressor to pressurise fuel in order to save engine power which lost in running fuel pump & controller & a throttle position sensor to control the operation of injector. It didn't vary the injection timing as the micro controller was pre programmed to work on the the input signals from throttle position sensor.

Wen- Chang Tsai & Peng-Cheng Yu[4] designed a electric drive for the high pressure GDI injector to pace up the response time & finer the precision control. All these techniques involved , at some stage, use of sophisticated ECU. In our research, we devised a circuit, especially from study point of view that is simple & efficient.

II. FUEL INJECTOR TIMING CONTROL CIRCUIT:

When a negative (0V) pulse is applied to the trigger input (pin 2) of the Monostable configured 555 Timer oscillator, the internal comparator, (comparator No1) detects this input and "sets" the state of the flip-flop, changing the output from a "LOW" state to a "HIGH" state. This action in turn turns "OFF" the discharge transistor connected to pin 7, thereby removing the short circuit across the external timing capacitor, C1.

This action allows the timing capacitor to start to charge up through resistor, R1 until the voltage across the capacitor reaches the threshold (pin 6) voltage of 2/3Vcc set up by the internal voltage divider network. At this point the comparators output goes "HIGH" and "resets" the flip-flop back to its original state which in turn turns "ON" the transistor and discharges the capacitor to ground through pin 7. This causes the output to change its state back to the original stable "LOW" value awaiting another trigger pulse to start the timing process over again. Then as before, the Monostable Multivibrator has only "ONE" stable state.

The Monostable 555 Timer circuit triggers on a negative-going pulse applied to pin 2 and this trigger pulse must be much shorter than the output pulse width allowing time for the timing capacitor to charge and then discharge fully. Once triggered, the 555 Monostable will remain in this "HIGH" unstable output state until the time period set up by the R_1 x C_1 network has elapsed. The amount of time that the output voltage remains "HIGH" or at a logic "1″ level, is given by the following time constant equation[10].

Y=1.1 RC

R=1KΩ, C=.001µF

T=0.0000011 seconds

T=1.1 µs

Where, t is in seconds, R is in Ω's and C in Farads.

The IC TLP 250 & a LED is connected in series with the output of the basic timer circuit to accomplish our objective of driving an injector.

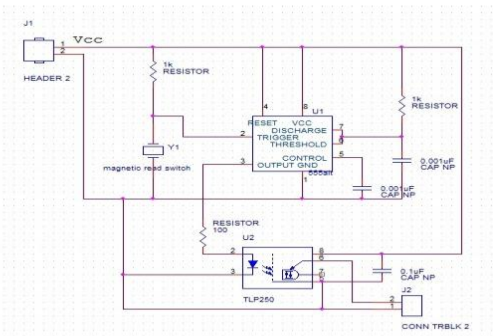


Figure 1: DRIVER CIRCUIT DIAGRAM

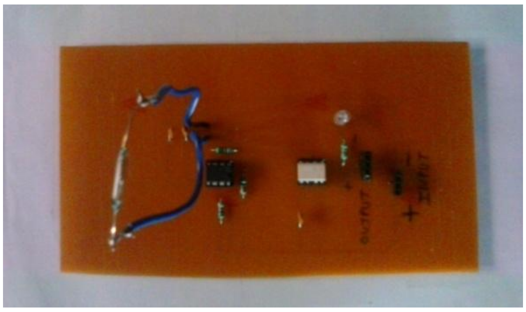
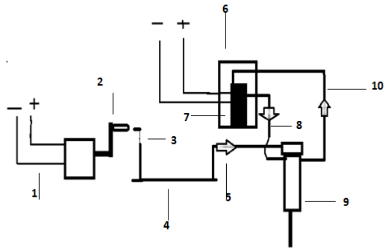


Figure 2: CIRCUIT ON PCB

III. EXPERIMENTAL SET UP & PROCEDURE:

The experimental set up mainly consists of fuel tank, electric fuel pump, supply line, return line, pressure gauge, ball flow control valve, fuel injector, electric driver circuit, battery & fuel injector.

The details of each part is given in this chapter. The electric fuel pump having maximum pressure of 6 bar is used to supply the fuel to the injector. A conventional pressure gauge is integrated along the supply line to read the pressure. A ball flow control valve is attached to the return & supply line, to vary the pressure in the supply line. The electric driver circuit is the main component of the set up which drives the fuel injector, it contains IC 555 & IC 250 along with resistors of 1 k value & capacitors of 0.001uf value.. The supply & return line are the high pressure pipes of 14mm OD & 12 mm ID capable of sustaining pressure up to 160bar. Nozzles & Adapters of 0.25 inch diameters are used for connections. The circular plate with magnet is run by a small dc Motor, the speed of which is varied using a Regulator.



1. MOTOR
2. MAGNET
3. MAGNETIC REED SWITCH
4. CIRCUIT
5. OUTPUT
6. FUEL CONTAINER
7. FUEL PUMP MOTOR
8. SUPPLY LINE
9. INJECTOR
10. RETURN LINE

Figure 3: EXPERIMENTAL SET UP

IV. RESULTS:

The spray angle & patternation length is determined to test the feasibility of the method. Both the spray characteristics are determined by mechanical method. A plate is kept a constant distance of 50 mm from the nozzle tip for every condition. The diameter of spray is determined measuring the wet portion on the plate[7]. Then by using protractor the angles are determined. The patternation length is determined. Table 1 shows variation of patternation length with the pressure & table 2 shows variation in spray angle with change in pressure.

In table 1 it can be seen that there was increase in patternation length with increase in pressure which confirms the fact that patternation length is the function of pressure.

In table 2 it can be seen that there was increase in spray angle with increase I pressure which again validates the fact that spray angle also is a function pressure.

Table 1:values of patternation length

Pressure in bar	Spray angle in degrees
1	37.5
3	47
5	56

Table 2: values of spray angle

Pressure in bar	Patternation length in mm
1	17.25
3	22
5	30.5

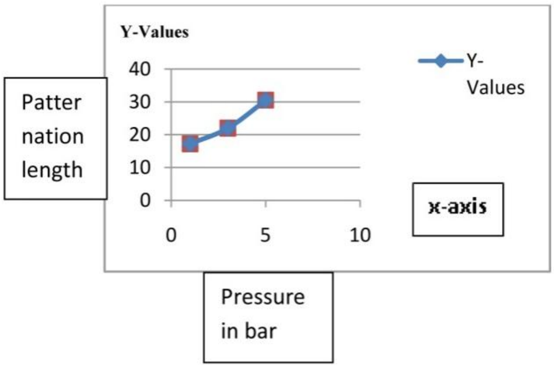


Figure 4: patternation length vs pressure

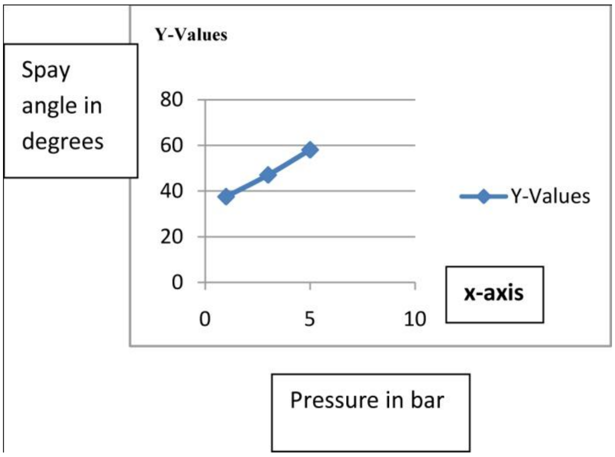


Figure 5: spray angle vs pressure

Conclusion: The designed circuit is working successfully & efficiently. The circuit is compatible with the injector.

The same circuit can be used to drive different injectors. The circuit is tested with Diesel Injector & has proved to be successful. However small modifications are required to use it for diesel injector as output from circuit is insufficient to drive the diesel injector efficiently. The circuit designed is simple, economical & efficient . The circuit is suitable for experimental studies on fuel injection system.

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