An Opto-Coupler and Spark Plug Combination System for Vehicle Engine Ignition

Murtaza ACIKEL[1], Isa NAVRUZ [2], Filiz SARI [3]

Karel Electronics, CyberPlaza B Block, Bilkent Ankara – TURKEY[1]
Electronics Engineering Department, Faculty of Engineering, Ankara University – TURKEY[2, 3]
Phone: +90 (312) 2033472; Fax: +90 (312)2125480, murtaza_acikel@hotmail.com, inavruz@eng.ankara.edu.tr, icat@eng.ankara.edu.tr

Abstract— In this experimental work, an optoelectronic based prototype, basically a slotted opto-coupler plus a spark plug combination, for vehicle engine is constructed. Following the initial in- laboratory trials, the prototype is mounted on a one–cylinder motorcycle for the actual operation in the field. Compared to the conventional igniters, the field–tests have proven the advantages of the higher mechanical durability and ease of system integration of the prototype presented.

***Keywords* — vehicle engine ignition, opto-couplers, contact breaker, optoelectronics**

I. Introduction

Nowadays, various ignition systems are used for the vehicle engines that have one or more cylinders, operating with benzene and gas (LPG/CNG), i.e. conventional ignition system [1], electronics or magneto ignition systems [2], Hall-effect ignition system [3] and micro-controller based ignition system [4]. Most four-stroke engines have used a mechanically timed electrical ignition system named as conventional ignition system which is shown in Fig.1 [5]. This system consists of a battery, the contact breaker, the ignition coil known as induction coil and the spark plugs [6].

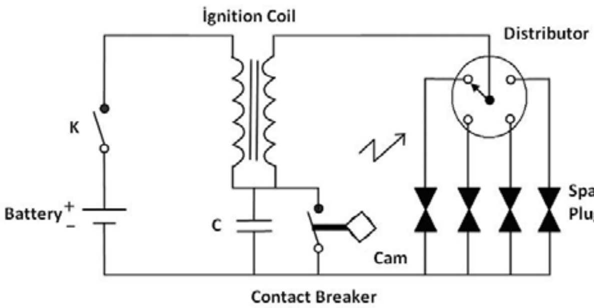


Fig.1. Schematic diagram of the conventional ignition system

The contact breaker is a mechanical switch triggering the ignition coil to produce a high voltage at the sparking plugs to ignite the air-fuel mixture. The cam is passed through the center of contact breaker and connected to the engine to have a circular motion; also ledge on the cam provides the contact breaker open and close position depend on the engine axle. The ignition coil produces nearly 10-30 kvolt voltage which causes a spark between the spark plugs' electrode gaps when the contact breaker is fully opened [7, 8]. The air-fuel mixture under pressure is ignited by this spark in the cylinders. Propulsion to the pistons is created by this explosion.

Arc is the main problem caused heating, abrasion and damage at the contact breaker. So, parallel capacitor to the contact breaker is used to prevent the arc at the conventional ignition systems. In spite of the capacitor, electrical arc problem still exist. Therefore vehicle manufacturers advise to check up the contact breaker and capacitors regularly and if it is necessary to change them [9].

Because of the disadvantages of capacitor - contact breaker pair, the breaker-point type of transistor ignition system developed to replace the conventional ignition system is shown in Fig.2 [2, 8, 10].

As shown in Fig. 2, the base terminal of transistor controls the ignition coil and the current between the contact breaker electrode gaps' is approximately mA level. This gives an advantage of solving arc problem however abrasion and friction at the contact breaker are still disadvantage [11].

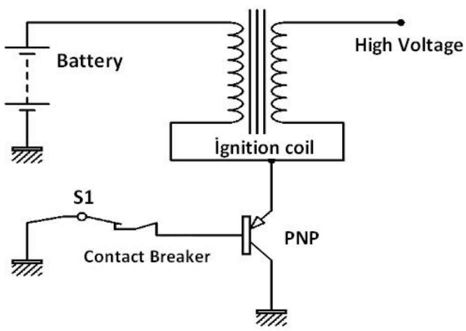


Fig.2. Electronics ignition system with transistor.

In this study, an optoelectronic based ignition system is developed by using a slotted opto-coupler instead of contact breaker to eliminate disadvantages of conventional and electronics ignition systems. First of all, this new system's prototype is prepared and then its performance is tested on the one cylinder engine. Results are compared with the conventional and electronics ignition systems.

II. Experimental Details

The general structure of the experimental setup for an optoelectronic vehicle ignition system using slotted opto-coupler is illustrated in Fig.3.

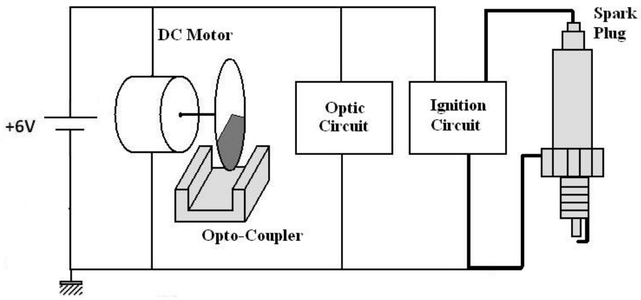


Fig.3. Experimental setup for an optoelectronic vehicle ignition system

The DC electric motor is used instead of the vehicle engine in order to be easily applicable in the experimental setup. A standard spark plug and induction coil that is used in 6V motorcycles are used in our system.

Unlike the conventional ignition systems, a transparent disc turning on the cam connected to the motor are used instead of the motor axle and contact breaker. The disc connected the DC motor passes through the slotted opto-coupler. One side of the disc is covered by metallic sheet like a paste slice for adjusting the ignition time depend on the position and the angle of metallic sheet. The optical circuit converts the signal coming from opto-coupler to logical data in which logic "0" and "1" represent low and high voltage levels respectively, and sends it to ignition circuit. The DC electric motor speed control potentiometer is inserted to the system in order to adjust the ignition velocity.

The ignition circuit controls the high voltage generating induction coil by the signal coming from the optical circuit and thus it acts as a switch between coil and the accumulator. The ignition circuit includes a high power transistor to transmit the current to the induction coil without any losses at the high speed.

III. Circuit Description

The circuits of optoelectronic vehicle ignition system using opto-coupler can be divided into two parts, as optical circuit and ignition circuit, as seen in Fig.4 (a) and (b) respectively.

In the optical circuit, the opto-coupler generates logic "1" and "0" levels amplified by Q_1 transistor motor axle turns. The logic level at the emitter point of Q1 transistor is "1" when the metallic sheet covered part of the disc passes through the opto-coupler and logic level is "0" in the other case.

The ignition circuit triggers the induction coil by the signal coming from the optical circuit. The ignition coil stores energy when the terminal of the optical circuit is at "1" state. As the output of optical circuit changes from "1" to "0", the energy of ignition coil suddenly discharges and causes to sparks between the plug electrodes.

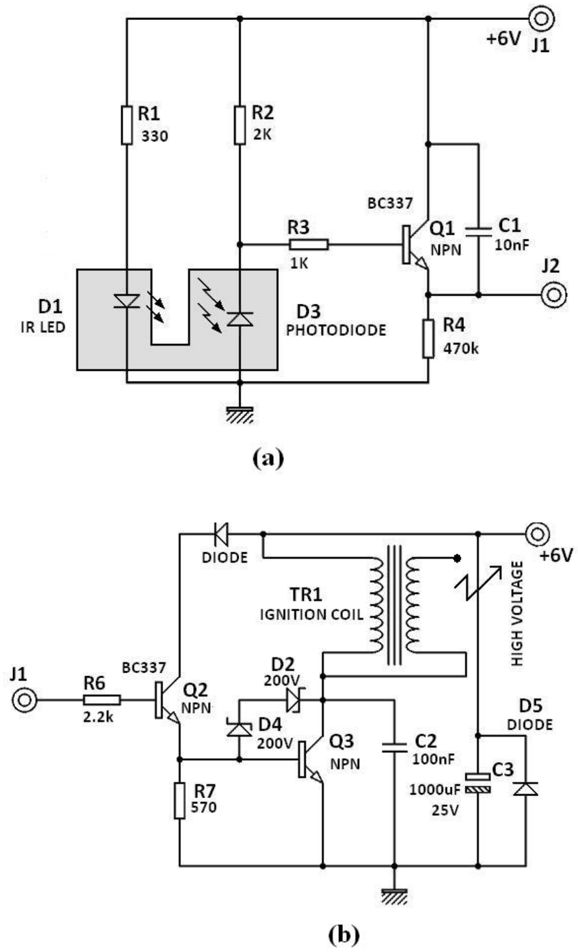
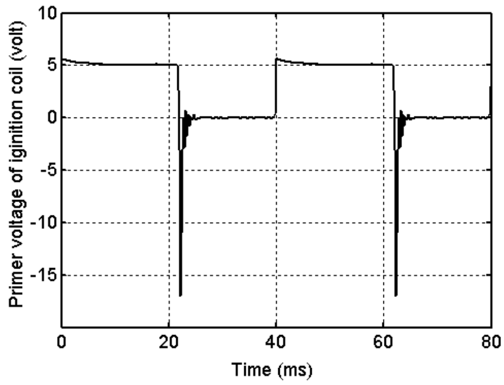


Fig.4. The circuits of ignition systems (a) Optical circuit (b) Ignition circuit

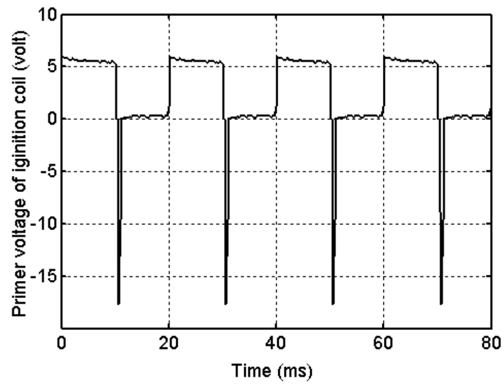
IV. Results

The sharpness and the smoothness of the pulse are very important for providing the ignition system to trigger the induction coil stably. Firstly, the output signal of the optical circuit at pre-stage of ignition system is analyzed for 1500 and 3000 rev/min motor speed as shown in Fig 5. In the case of 1500 rev/min motor speed, the output signal of the optical circuit is obtained very similar to a square wave as seen in Fig 5a. When speed of motor is increased to 3000 rev/min, the frequency of the output signal is doubled and no distortion in the shape of rectangular pulse train is observed as seen in Fig 5b. Whereas, increasing the engine speed causes an inevitable distortion of the shape of pulse at the conventional system.

The output signals generated by the ignition circuit at the second stage of the system for 1500 and 3000rev/min motor speed is given in Fig.6., respectively. The obtained shapes of pulses on signals are smooth and stable. Increased motor speed does not affect distortion at the pulse shape. The negative peaks in the curves correspond to the discharge times of the induction coil.



(a)



(b)

Fig.6. The output signals generated by the second stage for different engine speed. (a) 1500rev/min (b) 3000 rev/min.

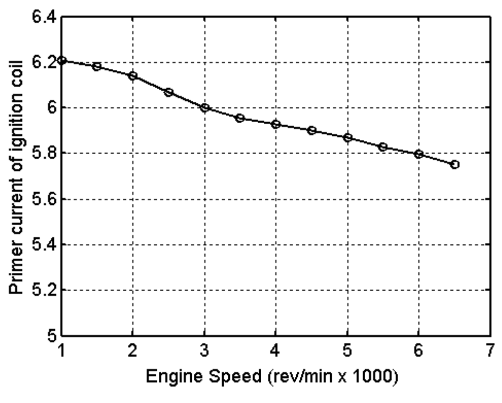


Fig.7. The variation of primer current related to engine speed.

The variation of primer current of induction coil related to the increase of motor speed is shown in Fig.7 As the speed of motor increases from 1000 to 7000 rev/min, the primary current reduces with amount of approximately 500 mA. The increment of engine speed naturally reduces the primer current, but the amount of reduction in the primer current is extremely small here.

Finally, the variations of the output signals of induction coil related to the variation of engine speed are sketched in Fig.8 for three ignition systems including the conventional, the electronics and the optoelectronic using opto-coupler. It is obviously seen that, the output of ignition systems using opto-coupler illustrated with solid line gives response decreasing slope less than other systems as increases engine speed.

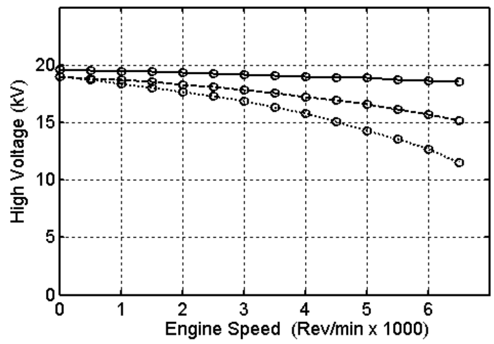


Fig.8. The high voltage related to engine speed for three different ignition systems, using opto-coupler (solid line), pure electronics (dashed line) and conventional (doted line).

V. Conclusion

In this paper, an optoelectronic vehicle ignition system is improved and the characteristics of this system are analyzed. Optoelectronic based ignition system prototype is constructed and measurement of this system is compared with the classical ignition systems. Opto-coupler used ignition system exhibits that more successful results obtained with Fig.6. and 7, with respect to conventional and pure electronics ignition systems. Also suggested system is having an advantage of easily applicable, long life-time and economic.

VI. References

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