Automated Spark Ignition Timing Controller (ASITC) For Internal Combustion Engine Control Unit

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Abstract. Engine controller is a component that determines the engine running smoothly. With low cost, the Automated Spark Ignition Timing Controller (ASITC) can be designed for the suitability of the study. The ASITC is to control spark ignition. For this purpose, Arduino microcontroller is used. It is equipped with potentiometer and 1.8 in TFT display. Through ignition timing, a misfire condition and knocking is actuated by advance spark. Instrustar DAQ is used to record data from spark ignition, oxygen sensor and knocking sensor. From the data obtained, signal processing will be done to get the desired feature through the filtering process. This paper is to study the ASITC to be made for specific features as needed.

1. Introduction
In a few decades, number of vehicle models and production grow rapidly. The pollution that cause by industrial revolution contribute to environmental is inevitable for the future generation. Research from Mansha et al. (2012) [1] mention about secondary pollution from exhaust emission can produce more hazardous pollution. It has observed that engine condition making the environment worst reported by Gequn (2013)[2] and Kakae (2013) [3].

Inside the engine system, spark plugs are the main part that ignite in the combustion chamber. Libin et al. (2016) [4], Mansha et al. (2012) [1] and Jenson et al. (2015) [5] suggested spark plugs can be manipulated to overcome the imbalance combustion. Moreover, when the condition of incompletes condition due to different air fuel mixture, octane number of fuel and ion current supplied. These scenario as variables are the contribution to pollutants, but it can be solve by developing the multiple variable controller to actuate the right timing to the spark plugs as mentioned by Laurain et al (2015) [6].

Reference Naik(2004) [7], engine controller would able to identify misfire condition based on OBD II legislation. The use of pressure sensor is expensive Roos(2017) [8]. Therefore, by using knocking
sensor is an alternative to get the misfire condition, Ajmir et. al (2018) [9]. This microcontroller would able to custom the function of ECU in the automobile system. It may varies from spark plug timing, air fuel ratio, engine cooling, and others condition to be controlled and monitored by the microcontroller.

This paper will describes the design process and initiative study of spark plug timing controller by identifying the source to actuate the sequence during the process. The controller is for users to control spark timing either to actuate misfire and knocking condition or normal engine running condition. It is design for single cylinder engine.

2. Methodology

This section, we begin the study by focusing the related sensor. Crank position sensor (CPS) from the engine is use to actuate spark ignition timing. The frequency is use to design spark plug controller for the engine. Zaim et al. (2016)[10]is manipulating fuel injector to identify the para meters of misfire condition. Thru the experimental procedure, the design of spark plug controller is applied. While signals from oxygen sensor are recorded to be analyzed. Meanwhile in this project, an accelerometer is use to identify the misfire condition comparable to oxygen sensor signals. In order to execute the misfire condition, the accelerometer is mount to the nearest position of the engine piston.

Figure 1, show the project flowchart. A controller is design to initiate spark plug timing. It is to identify the ideal angel of spark plug timing based from the CPS signals. In other hand, the controller is use to actuate the misfire condition for further analysis.

![Figure 1: Project Flowchart](image-url)
2.1. Experiment Setup
A Yamaha LC135, water-cooled 135cc single cylinder engine at ISI Laboratory, School of Aerospace Engineering, and University Science Malaysia cylinder is mount on an engine bench. The bench is design to suit the usage laboratory experimental work. Signals of CPS are record to identify frequency to spark plug timing activation. The data will be use to design the engine controller. Figure 2 shows the equipment for the experiment.

![Image of the setup](image1)

**Figure 2:** Experiment setup.

A switch will be controlling the artificial misfire condition. The Arduino controller will be controlling the spark timing. Therefore, the switch for artificial misfire condition is located with the same controller. The accelerometer mounted on the engine will record the signal during the artificial misfire condition is activated.

Figure 3 show the knock sensor is mount to the engine block, red and black wire is attach to the oscilloscope to record signals. There are few wire wrapped with a black tape. It contains charging circuit and CPS wire circuit. CPS wire circuit is attach to oscilloscope to identify the signals. The signals are identify to design the Arduino controller for the engine.

![Image of the sensor](image2)

**Figure 3:** Knock sensor attached to the engine and CPS wire for signals identification.
3. Results and Discussion

Figure 4(c) shows signals from CPS recorded. The signals indicate an acceleration from 1000 RPM to 6000 RPM. The fluctuations show it produced alternate current, constantly within 5V. Different signals recorded for engine idling condition. Figure 4(a) show, where idling is the condition of the engine run at low speed constantly. Furthermore, figure 4(b) shows signal at high speed, about 6000 RPM. CPS signals show constant signals voltage but different width of peak-to-peak. It show the speed of the engine, whether it is on idling condition at low speed, acceleration from low speed to high speed or constantly in high-speed condition.

![Figure 4: (a) low speed; (b) high speed; (c) signals range 1000-6000 RPM](image)

From the signals recorded, it is possible to design spark plus timing controller based on the signals from the CPS. The CPS produced a constant voltage of 5V but different fluctuation between peak-to-peak conditions. The signals show the speed of the engine, where it is possible to actuate the spark plug timing, based on the peak-to-peak distance.
Figure 5, show the circuit design to actuate spark plug timing using Arduino controller. The CPS signals are used the actuate the spark plug timing. In other hand, to actuate misfire condition, a Arduino programmed based is used. The programmed is set to switch off the spark plug for a few times every 5-10 second. The condition are made to meet the misfire condition based to OBD II legislation refer to Bahram et al (2013)[11], Chu et al.(2005) [12].

4. Conclusion
Based on the analysed CPS signals, the peak-to-peak signal is the main trigger to spark plug timing using Arduino controller. Signal within 5V is detect to trigger the spark. Our signal manage to detect the peak-to-peak signal to initiate good timing based on the air fuel ratio and engine speed. Through model based, misfire condition can be design through the control unit. Over testing for hours, accuracy of 75% detection model based misfire condition. The knock sensor would able to detect misfire condition. In the same monitoring condition of knocking condition. For further analysis, a program can be add to comply the OBD II legislation to notify the misfire and knocking condition.

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References
[1] M. Mansha, E. M. Shahid, and A. H. Qureshi, 2012. Pak. J. Engg. & Appl. Sci. 11, no. x, pp. 114–128,
[2] G. Shu, J. Pan, and H. Wei, 2013 Appl. Therm. Eng. 51 no. 1–2, pp. 1297–1306,
[3] J. Zareei and A. H. Kakae 2013 Eur. Transp. Res. Rev. 5, no. 2, pp. 109–116,
[4] L. Jia, J. D. Naber, and J. R. Blough, 2016. J. Combust. vol. 2016,
[5] J. Abraham and A. R. Bhende, 2015 Int. J. Recent Innov. Trends Comput. Commun. 3, no. 2, pp. 129–132,
[6] T. Laurain, J. Lauber, and R. M. Palhares 2015 IEEE 10th Conference on Industrial Electronics and Applications (ICIEA)
[7] S. Naik, 2004 Int. J. Adapt. Control Signal Process 18, no. 2, pp. 181–198,
[8] A. Roos, 2017. Faculteit Economie Universiteit Gent
[9] M. S. Ajmir, J. M. Nabil, A. A. B Elmi, A. Mohammad Nazir, 2018. *proceeding iCompEx'18*.
[10] M. Z. M. Pauzi, E. A. Bakar, and M. F. Ismail, 2016. *IOP Conf. Ser. Mater. Sci. Eng.* 114, p. 012140,
[11] B. Bahri, A. A. Aziz, M. Shahbakhti, and M. F. M. Said, 2013 *Latest Trends Circuits, Control Signal Process* pp. 178–183,
[12] Y. Wang and F. Chu, 2005 *Mech. Syst. Signal Process* 19, no. 4, pp. 900–912,