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THE DESIGN AND DEVELOPMENT OF VOLTAGE AMPLIFIERS USING MICROCONTROLLER FOR MASS ABSOLUTE PRESSURE (MAP) SENSOR IN THE TOYOTA AVANZA

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ABSTRACT

This research focus on the design of output voltage amplifier from MAP sensor. The purpose of this design research is to explain the process of designing and manufacturing and testing the voltage amplifier with Arduino Uno microcontroller and as a refinement of the previous tool which has been found but still using manual control. In addition, this research serves as a solution to the problems that researchers found in the field of vehicle performance began to decrease with the increasing age of vehicle usage. This type of research is level 3 research, researchers research and test to develop existing products. The object of this research is Toyota Avanza 1.3 G vehicle in 2010. Based on the research, it can be concluded that after adding the output voltage from the MAP sensor with variation of voltage addition of 0.3V, 0.5 V, and 0.7V, it can be concluded that there is an increase in power and torque significantly generated by the vehicle. The highest increase in power and torque occurs in the addition of MAP sensor output voltage of 0.5 V with a percentage increase of 85.87% and 28.4% when compared to power and torque without using a voltage amplifier on the MAP sensor output.

Keywords: MAP Sensor, Arduino Uno Microcontroller, power, torque

INTRODUCTION

The vehicles in Indonesia are growing rapidly, this also encourages the development of technology in the automotive sector. The development of automotive technology that has been felt is the injection vehicle whose work is regulated by the ECU. One of the functions of the ECU is to regulate the amount of fuel injected by the injector, but to do so requires a data base for the ECU in determining the amount of gasoline fuel (Sugiarto et al. 2013).

One of the data needed by the ECU is the ECU must know the amount of air entering the intake chamber. The sensor that detects the amount of air in the intake manifold is the MAP sensor, the output of the MAP sensor is the reference data for the ECU in determining the amount of fuel that must be injected. Increasing engine speed will result in a vacuum in the intake manifold. At low speed (750 rpm) the air vacuum through MAP is 29.00 Kpa, at medium speed (2000 rpm) the vacuum is 26.67 Kpa, and at high speeds (5000 rpm) the air vacuum in MAP is 27, 33 Kpa (Wiratmaja, 2010). By utilizing the changes in the air pressure occur in the intake chamber, the MAP sensor works, the output of the MAP sensor will change according to the level of vacuum in the intake chamber.

The internal combustion engine with injection systems are required to produce higher power, torque, and low emissions. The engine that uses electronic control (ECU), which is an electronic component that functions to regulate the work of the machine based on various types of engine conditions. One of the functions of the ECU is to regulate the total of fuel injection by adjusting the frequency and pulse width given to the injector, so that the fuel injection can be adjusted (Argana, 2014).

The setting of the fuel injection by the ECU is regulated based on the parameters or conditions of the engine at work. This parameter will be detected by various sensors in the EFI vehicle which then sends the signal to the ECU as a reference for the ECU to regulate the action of the actuator on the engine. The sensors in the injection system include Intake Air Temperature Sensor (IATS), Manifold absolute Pressure (MAP), Camshaft Position Sensor, Crankshaft Position Sensor (CKP), Engine Coolant Temperature (ECT), Oxygen Sensor (02 Sensors). Furthermore, it is clear that the MAP sensor has an important role in influencing the ECU to regulate the amount of fuel injection by the injector will be related to the performance of the engine (Yulian, 2017).

By reprogramming the output signal from the MAP sensor it will affect the ECU's performance and in regulating the total of fuel injection. Using a voltage amplifier in the output signal from the MAP sensor is one way to extend the voltage frequency of the ECU to the injector so that the injector injects the fuel longer which results in the increase in the total of fuel injection, so that the power and performance produced by the vehicle can be increased (Putra et al. 2017).

MAP sensors use vacuum in the manifold chamber. The vacuum in the manifold chamber approaches a perfect vacuum and is not affected by changes in atmospheric pressure that occur due to changes in altitude. This pressure sensor compares the intake manifold pressure with this vacuum, and emits a PIM (Pressure Intake Manifold) signal that is not affected by changes in pressure. This allows the ECU to maintain an air and fuel ratio at an optimal level even at high altitudes (Erzeddin et al. 2017). Silicon chips combined with a vacuum chamber are installed in the sensor unit. One side of the chip is faced with the intake manifold pressure and the other side is connected to the vacuum chamber. Changes in the intake manifold pressure cause the silicon chip shape to change, and the chip resistance value will change according to the level of change. This fluctuation in the resistance value is converted into a voltage signal by the IC in the sensor and this signal, then sent from the PIM terminal to the ECU Engine as the intake manifold pressure signal. The VC Engine terminal supplies a constant voltage of 5V as a power source for IC (sugiarto et al, 2017).

Reprogramming the MAP sensor output signal will affect the ECU's performance to adjust the fuel injection, so that the power and performance of the engine can be increased. From this background, this paper are interested in conducting a study entitled Design of Voltage Amplifiers with Microcontrollers on MAP Sensors against Power and Torque of the Toyota Avanza.

MAP sensor characteristics

The output of the MAP sensor will change according to the level of humidity in the intake chamber, the following is a characteristic form of the change in output voltage of the MAP sensor according to the level of air pressure in the intake chamber.

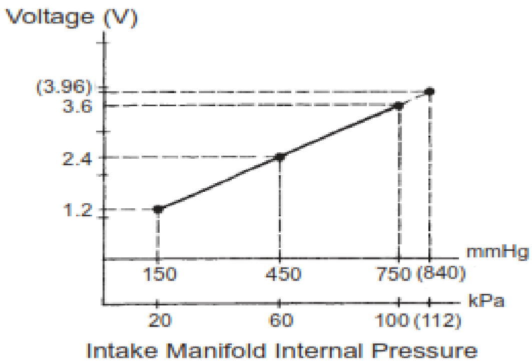

Fig 1. MAP sensor characteristics (sugiarto et al. 2017)

Figure 1 show that the MAP sensor characteristics, the higher the air pressure in the intake chamber, the higher the output voltage of the sensor. From the MAP sensor output voltage, the ECU will calculate the total of fuel that will be injected by the injector by way of adjusting the pulse width or signal frequency to the injector so that the work of the injector can be adjusted.

Microcontroller

Microcontroller is a chip that functions as an electronic circuit controller and generally can store programs in generally consisting of a CPU (Central Processing Unit), memory, certain I/O and supporting units such as Analog-to-Digital Converter (ADC) that are integrated, in other words the microcontroller is a mini or micro version of a computer because the microcontroller already contains several peripherals that can be directly utilized, such as parallel port, serial port, comparator, digital to analog conversion (DAC), analog to digital conversion (ADC) and so on only uses a minimal system that is not complicated or complex. Microcontroller is a microprocessor system in which there are several internal electronic components that are interconnected with each other and can be programmed according to the user's wishes with the rules set by the manufacturer (Sugiarto et al, 2017).

Design system for MAP Voltage amplifiers

The design system of amplifier with micro controller arduino uno as shown in Figure 2.

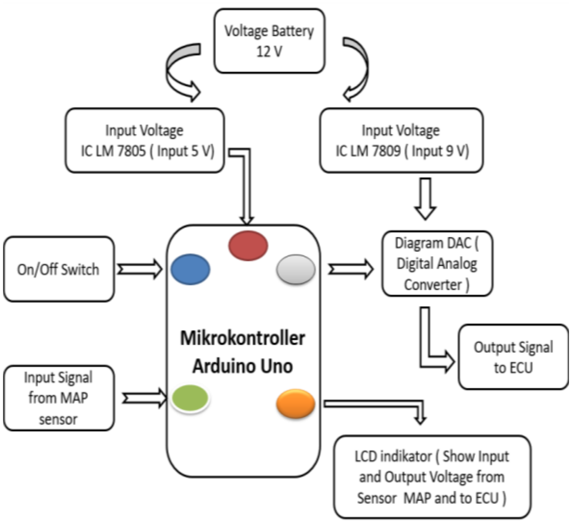

Fig 2. The design flow chat of MAP voltage amplifier

As for the parts of the electronic circuit diagram of the voltage amplifier based on the Arduino Uno microcontroller. Arduino is a microcontroller board based on ATmega328. The Arduino has 14 input / output pins where 6 pins can be used as PWM outputs, 6 analog inputs, a 16 MHz crystal oscillator, USB connection, power jack, ICSP head, and reset button. Arduino is able to support microcontrollers; can be connected to a computer using a USB cable.

This set of tools consists of a series of inputs, processes and outputs. The input circuit of this device is a signal that comes from the MAP sensor. MAP sensor is a sensor that functions to detect the amount of air entering the intake chamber as a reference data for the ECU in determining the amount of fuel to be injected into the combustion chamber. Input from the MAP sensor will be processed by the Arduino Uno microcontroller. The microcontroller on this tool serves to reset the voltage that will be sent to the ECU according to the program that has been uploaded into the microcontroller board. While the output of this device is in the form of a voltage signal that has been reprocessed beforehand by the microcontroller and will then be sent to the ECU as a basis for the ECU to determine the amount of fuel that will be injected into the combustion chamber.

RESEARCH METHODOLOGY

The research and development are used in this study, the research and development methods are used to produce certain products, and test the effectiveness of these products. To be able to generate certain products, research is used in the form of needs analysis (used survey or qualitative methods) and to test the effectiveness of these products so that they can function in the wider community, research is needed to test the effectiveness of these products (Sugiono, 2015).

Research and development is a research approach to produce new products or perfect existing products. The resulting product can be in the form of software, or hardware such as books, modules, packages, learning programs or learning aids. Research and development is different from ordinary research which only produces suggestions for improvement, research and development to produce products that can be directly used.

The research object is the target is the subject of the study. The object on this research is the Toyota Avanza. In this case, the data that will be taken is the result of the power and torque of the vehicle. The implementation of R & D research has several stages, namely (1) Potential and Problems, (2) Designing Products, (3) Design Validation, (4) Design Revisions, (5) Product Making, (6) Product Trial, (7) Product Revision, (8) User Trial, (9) Product revision. In this study the data collected is power and torque data with and without the use of a voltage amplifier on the MAP sensor output produced by the vehicle and tested using the dynotest equipment.

RESEARCH RESULTS AND DISCUSSION

The characteristics of MAP sensors using Voltage amplifier with Arduino Uno Microcontroller.

The characteristics of the MAP sensor test after using a voltage amplifier with a microcontroller is to determine the changes in the characteristics of the sensor before and after using the voltage amplifiers. This re-characteristic test phase was carried out to test the design results in the re-characteristics of the sensor output. From the results of testing the characteristics of the MAP sensor after using a voltage amplifier, data is obtained as shown in Figure 3.

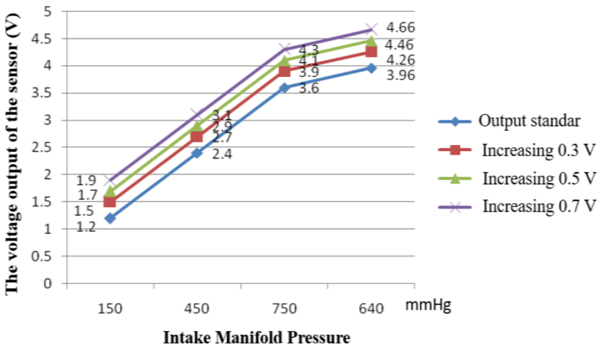

Fig 3. The characteristics output sensor

From the figure 3, can be seen that there is a characteristic change from the MAP sensor after using a voltage amplifier with a microcontroller. Changes in the sensor characteristics will affect the performance of the MAP sensor so that the output of the MAP sensor will also change and will affect the ECU's performance to regulate the amount of fuel injection by the injector.

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Power test results

From the testing data that has been carried out in the Automotive Engineering Testing Workshop of FT UNP on July 4, 2018, it can be seen that there is an increase in the power produced by adding a voltage amplifier which has an average greater than without using a voltage amplifier.

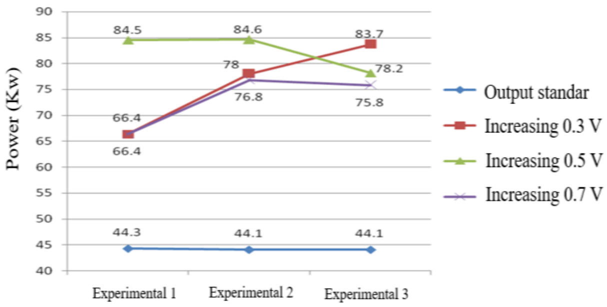

Fig 4. The engine power curve

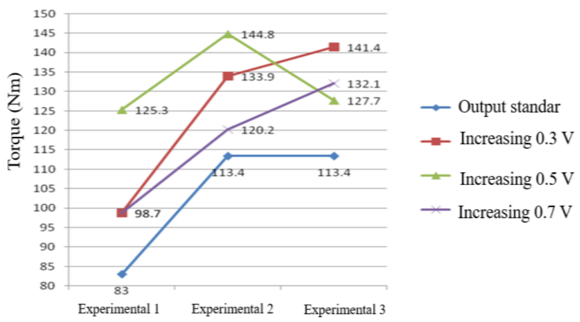

Fig 5. The engine torque curve

Figure 4 shows that there is a significant increase in power by using a voltage amplifier on the MAP sensor output. In the standard testing power conditions, the power produced by the vehicle only ranges from 44.1 Kw to 44.3 Kw, while the average power produced by a vehicle using a voltage amplifier increases with the highest increase occurring at a voltage gain of 0.5 V with average power of 82.1 Kw or an increase in the average power of 85.87%.

While the lowest power data analysis is generated at an additional voltage of 0.7 V with an average power of 73 Kw with an average power increase of 65.27%. When compared with the average power at the addition of other voltages, the addition of a voltage of 0.7 V is the lowest power. The author assumes this happens due to too high voltage increase from the MAP sensor output to the ECU so that the ECU instructs the injector to inject more fuel so that the mixture of air and fuel is too fat and causes combustion to be less perfect and cause the power produced is reduced.

The Torque test results

From the test results in Figure 5, can be seen that the average torque generated by the vehicle before and after using a voltage amplifier is increased. From the torque enhancement in Figure 5, the significant torque increase occurring in the addition of a voltage from the MAP sensor output to the ECU of 0.5 V with an average torque of 132.6 Nm or an increase of 28.4% when compared with torque produced by the vehicle without using additional tools. Whereas for the lowest torque increase during the use of a voltage amplifier occurs at a strengthening voltage of 0.7 V with a large torque of 98.7 Nm where an increase of 13.3%.

CONCLUSION

The design of voltage amplifiers with this microcontroller has gone through several stages of the R & D research process and undergoes several design revisions such as hardware and software or programs from the microcontroller. The results of the data taken using the dynotest equipment were tested at the FT UNP automotive engineering vehicle testing workshop. It can be concluded that the power and torque produced by the vehicle with and without using a voltage amplifier on the MAP sensor output has a significant difference.

Based on the data and research results that have been carried out on the Toyota Avanza 1.3 G vehicle, there is an increase in the power generated by the vehicle with the use of an output voltage amplifier on the MAP sensor. The highest power produced by a vehicle without using a voltage amplifier is 44.17 Kw at 6,524 rpm. While the highest power produced by the vehicle by using the output voltage amplifier on the MAP sensor that occurs at an increase in voltage of 0.5 V with a power of 82.1 Kw at a speed of 6206 rpm. From this data there is an increase in power of 37.93 Kw or 85.87%.

While the data from the torque generated by the vehicle, based on the data and research results that have been carried out on the Toyota Avanza 1.3 G vehicle, there is an increase in torque generated by the vehicle with the use of an output voltage amplifier on the MAP sensor. The highest torque produced by a vehicle without using a voltage amplifier is 103.27 Nm at a speed of 1,538 rpm. Whereas the highest torque produced by the vehicle using an output voltage amplifier on the MAP sensor is that it occurs at an increase in voltage of 0.5 V with a power of 132.6 Nm at 5727 rpm. From this data there is an increase in power by 29.33 Nm or by 28.4%.

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