Implementation of Electronic Control Unit (ECU) Simulator Engine for Improving Vehicle System Performance Modern

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Abstract. The Electronic Control Unit (ECU) is the system computerized embedded in modern vehicles. The presence of an electronic system in the vehicle provides limitations for in-depth system analysis of the Electronic Control Unit (ECU). The reason for the limitations of testing tools for computerized vehicle systems is that there are no simulation tools outside the vehicle to ensure damage to the vehicle hardware or Electronic Control Unit (ECU) hardware. Therefore, to make it easier and easier to analyze damage to the Electronic Control Unit (ECU) in vehicles, an Electronic Control Unit Engine Simulator design was carried out for Light Vehicles which aims to facilitate analysis of damage to both inputs and inputs to the ECU. The simulator makes it easier to assess the advanced analysis that occurs in the vehicle's computerized ECU, by carrying out a more time efficient simulation process, minimizing a lot of disassembly, and minimizing waste of vehicle fuel when testing the ECU on the vehicle directly when the engine tends to run for quite a long period of time. Error problems that occur in artificial simulators tend to be smaller because the use of Arduino and the use of a power supply and proper data coding provide resilience to the simulator.

Keywords: Simulator, ECU, Modern Vehicles

1 Introduction

The use of computerization in vehicles has had a greater effect on developments in vehicle damage analysis, in vehicles 70% of vehicle systems are controlled electronically by computers. The effect of using electronic vehicle controls makes vehicles tend to be more sensitive to external dangers such as floods, rat bites, ant nests or other external obstacles. On the other hand, various computers that have been produced and installed on vehicles have a service life limit that has been determined by the vehicle manufacturer (Viele, 2023).. This limitation is an obstacle for vehicle owners because the price of vehicle computers is relatively expensive at IDR 5,000,000 to IDR 20,000,000. The human resource factor which is not yet ready to handle electronic

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electrical problems in the computer control system is an obstacle in analyzing if a vehicle malfunctions. To help overcome problems with computerized vehicle damage analysis and minimize costs so that vehicle owners can use their vehicles again, an Electronic Control Unit Damage Analysis tool or often called an ECU simulator was created (Kim, 2020). This tool is a further development so that it can be used in Indonesia from a tool that has been created by previous researchers, namely: "Josh Stewart noisymime 30 August 2020 entitled Ardu-Stim for speeduino tester".

From the problems above, researchers tried to design an Electronic Control Module Simulator tool to analyze damage to vehicles (Kim, 2022). The range of analysis in the Simulator is to simulate the vehicle computer as if it were working as if it were installed on the vehicle (Rachmandani, 2021) and then the output on the vehicle computer is analyzed for trouble according to the initial constraints and the scan results that have been carried out at the beginning of the analysis on the vehicle, the output analyzed includes Injector Signal, Ignition Signal, ISC Signal, Throttle Motor Signal, Selenoid Timing Actuator signal, and many more.

Currently, Electronic Control Module Simulator devices tend to be rare because they are not produced by manufacturers and are dominantly DIY (Kim, 2020). The way this tool works is by utilizing the digital output on the Arduino to drive it to the SN7417 IC which then provides a bias feedback signal from the logic gate in the form of a 5v square signal and a 5v sine signal using an additional 1uf capacitor connected in series from the out logic IC so that it can produce a sine signal. each signal has a different number and form of signal depending on the type of vehicle that will be simulated and analyzed (Chaudhary, 2019).

2 Methodology

This research is a combination of experimental and combined methodology where the initial step taken is to analyze the signals and supporting things needed in the ECU simulation, both in terms of the number of crank waves, cam waves, and the type of signal needed, type of controlle, the type of programming language and characteristics needed in the field as well as the final results of ECU Simulator testing on the F15 JUKE ECU to analyze the performance of the Injector Signal on the ECU (Allen, 2021). This literature review step is needed to identify the tool design plan, theoretical concepts and basics needed to analyze the manufacture of the Simulator tool so that the tool can work as it should. The main purpose of making this simulator tool is not only to provide an input signal to turn on the ECU, but also as a tool to help analyze problems with the ECU. The results of the analysis on the ECU will be analyzed after the ECU can be analyzed. is turned on and in running or working mode. Apart from hardware preparation, coding is also carried out, at this stage using Arduino IDE software (Recktenwald, 2021). The following is a design research table on the ECU Simulator.

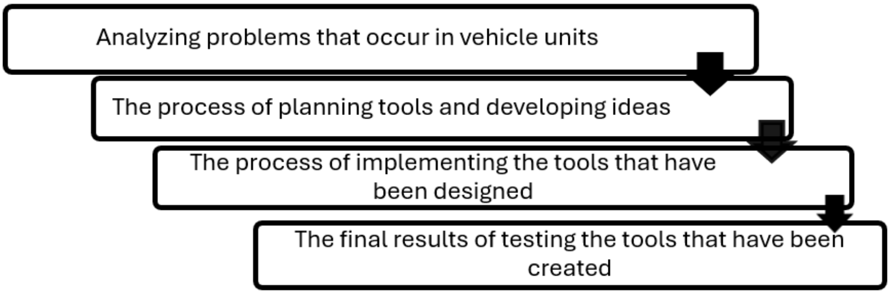


Figure 1. Electronic control unit simulator research design

The next stage is system implementation. At this stage, the simulator design is carried out as closely as possible, whereas preparation and coding development is focused so that the number of waves produced is appropriate to the type of vehicle to be tested. At the tool design stage, there are several things that must be arranged, including component preparation, component testing, and testing the results of the simulator output signal. The block diagram consists of a potentiometer input, Arduino Union R3 Processor, and IC Logic Output (Figure 3). The potentiometer input system has a variable resistor function connected to analog terminal 1 on the Arduino, the change in the potentiator resistor value is used as input by the Arduino then the value is processed and combined into Rpm. In the processor all signal data is stored, when the tool is on it will automatically display the Simulator signal type number 1, while processing the potential data into Rpm values and the processor displays the name of the vehicle signal along with the Rpm value on the LCD (Kumar, 2019). Next, the processor sends a PWM Digital Output signal to the Logic IC, then the Logic IC correlates the voltage to the 5v PWM.

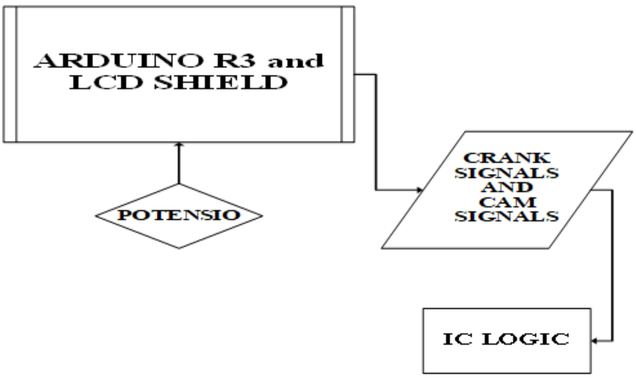


Figure 2. General design of the ECU simulator system

3 Result and Discussion

3.1 Result

The hardware of the prototype is described in detail, along with its main functions. The hardware implementation consists of two main parts: electrical and programming. Each of them is explained the function and way of performance of the tool.

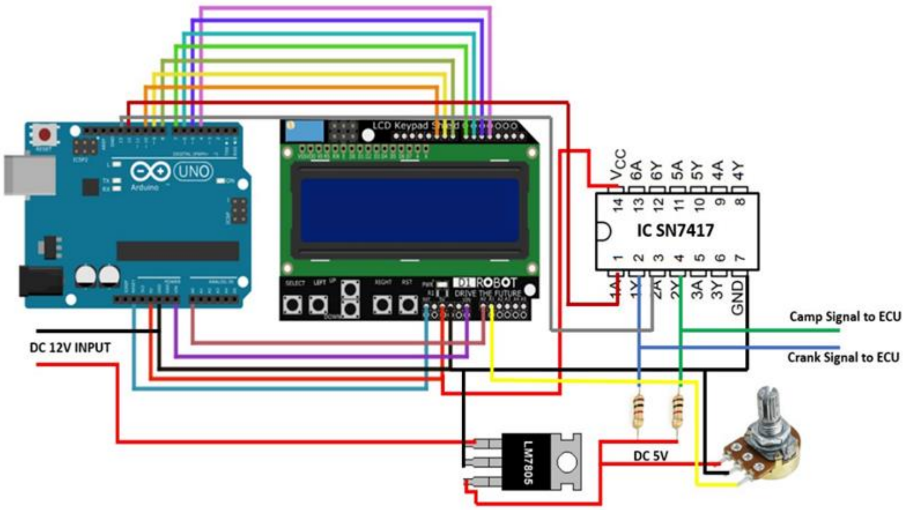


Figure 3. Proposed system circuit ECU simulator

Arduino UNO is one of the open microntrollers with hardware and software that is easy to use, in Figure 3. Arduino UNO can convert input into output to be able to do various things such as generate PWM signals, start the motor, turn on LEDs, read switch work, receive light sensor input, or upload something online with the support of additional device. This can be achieved by using the Processing-based Arduino software IDE and the Wiring-based Arduino Programming Language. The Arduino Uno microcontroller board contains six analog inputs, a 16 MHz quartz crystal, a USB connector, power plugs, an ICSP header, and a reset button. In addition, there are fourteen digital input/output pins, six of which are PWM outputs. In the prototype of the Arduino Uno Simulator, it is used as the main controller to control the signal by reading the potentio input as the signal time change value and the LCD shield as a menu shift button. Simple use and tends to be easy to choose Arduno as the main controller is the right choice, besides that with affordable prices Arduino can be operated by ordinary people.

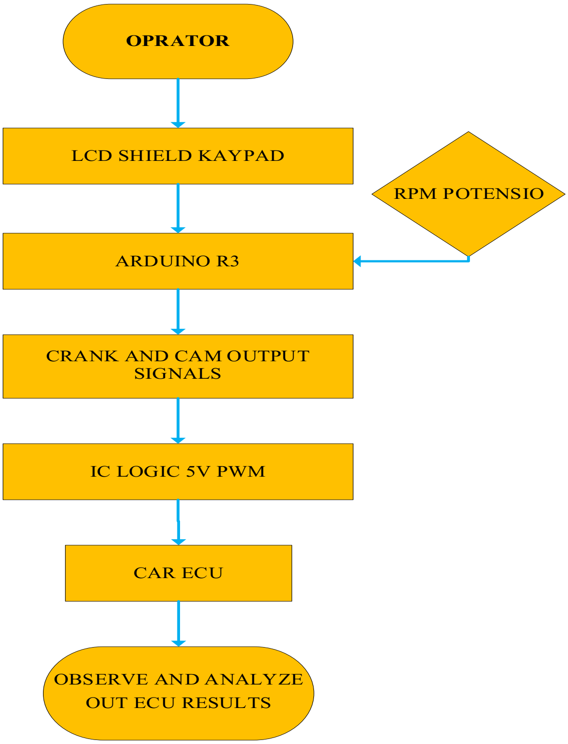


Figure 4. ECU simulator functional diagram

The diagram Figure 4 shows the basic functional of the device being developed. In the figure illustrated the main flow of the operating process from the user operating the tool, the results of the simulated signal until the ECU can actually be simulated.

3.2 Discussion

In this analysis, the ECU to be tested is the Juke F15 ECU with engine limping problems or imbalance of the fuel combustion system which causes the engine pull to feel heavy accompanied by the sound of the engine vibrating and abnormal. There are 3 stages of inspection carried out on the Juke F15 vehicle, DTC Scan examination, and the Power Balance process on the vehicle, at this stage will be checked data using the DBS Car 5

Scanner, the initial examination of DTC diagnosis found no problems in the sensor system on the vehicle.

The next stage is to carry out the Power Balance Process, which is testing the fuel system by turning off each injector of the material in each vehicle cylinder, from the results of the power balance Front 4 Injector signal experiences Off the system or does not work, where it can be proven when the process of turning off the cylinder 4 injector there is no influence of the engine position still vibrating or the absence of a decrease in RPM indicates that the Front 4 injector is experiencing interference, The proof that the injector has problems can be seen in the live data scanner fuel time schedul value is 3.2mc, where the standard value is 2.5-2.9ms (Boulat, 2001), if the injector is 1, 2, 3 in turn then RPM drops and engine vibration gets worse.The final step to minimize disassembly tends to be a lot in the ECU analysis process using ECU Simulator.The process of using ECU SIMULATOR is as follows: first, the ECU is installed in a socket connected to the ECU Simulator, the installation of the ECU must be in accordance with the terminal pins and functions of each ECU terminal so that there is no damage or incorrect installation on the ECU which can cause the ECU to suffer fatal damage. In the process of testing through several equations and comparisons to analyze the system, based on the test results the controller produces the right signal, the signal is sent to the IC Logic driver to then be used as an out pwm signal as a crank and cam signal as well as a safety for the Arduino R3.

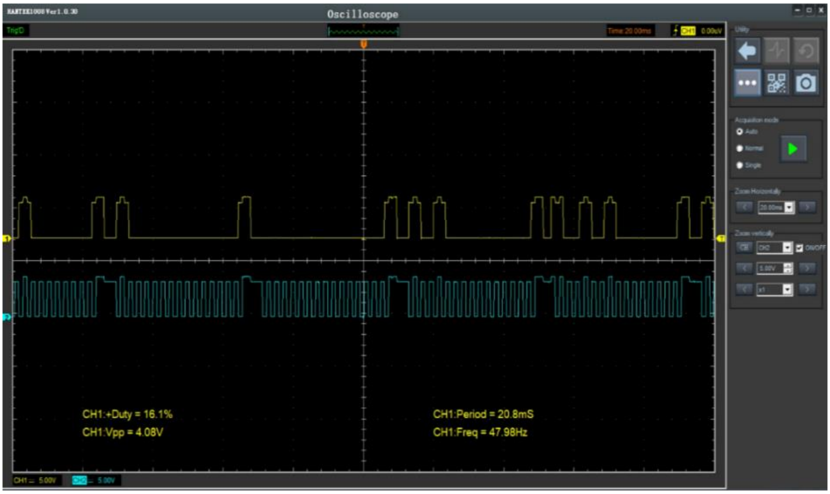


Figure 5. Display of crank and camp signal oscilloscopes produced by ECU simulator

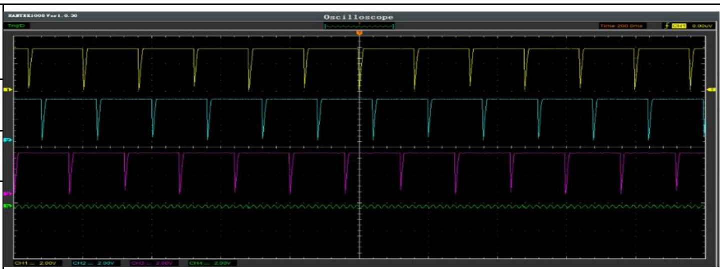
JUKE F15 ECU Simulation at 1000 RPM ECU Simulator	
FRONT 1 INJECTOR	
INJECTOR 2 FRONT	
FRONT 3 INJECTORS	
FRONT 4 INJECTORS	

Figure 6. Simulation of INJECTOR signal analysis RPM 1000

The initial stage of testing the Juke F15 ECU using the ECU Simulator initial setting of the Simulator at RPM 1000 with the RPM Ujustable Menu, in the simulation process accompanied by the use of oscilloscopes in reading the Injector output signal to obtain accuracy, this initial stage can be analyzed signal no 4 experiencing interference or a very drastic signal reduction, the working range of the standard Injector vpp 11-14v while in this analysis it reads below the standard value in the range of 3-4v, can be seen in the figure of Table 1, the signal decrease that occurs in the ECU Output causes engine performance instability causing the engine to experience vibration effects of imbalances in the performance of the combustion system on the engine, at this initial testing stage the process of analyzing the ECU system using the ECU Simulator through the Simulation process is declared successful.

JUKE F15 ECU Simulation on RPM 3000 ECU Simulator	
FRONT 1 INJECTOR	
INJECTOR 2 FRONT	
FRONT 3 INJECTORS	
FRONT 4 INJECTORS	

Figure 7. Simulation of INJECTOR signal analysis RPM 3000

The second testing process, the Juke F15 ECU uses the ECU Simulator using the 3000 RPM range adjustable mode. This second test stage is carried out to ensure the performance of the Injector 4 signal is real trouble in all conditions, minimizing the occurrence of intermittent trouble or ECU problems only appearing at low RPM. At this stage, the test will be carried out for approximately 10 minutes and obtained test results Using the ECU Simulator accompanied by readings using an Oscilloscope the performance value of the Injector 4 signal is still trouble, namely the weak signal produced by the ECU in driving the injector can be seen in figure 7. The ECU Simulator provides convenience in analyzing advanced analysis that occurs in vehicle computerization called ECU, by simulating more time efficiency, on the other hand also minimizing a lot of disassemblies, and minimizing the waste of vehicle fuel when in the ECU test test on direct vehicles where automatically if testing or ECU analysis is carried out directly on the vehicle the engine tends to be turned on within a period which is quite long.

The Ecu MST 9000+ is made by a Chinese manufacturer. Both of these tools have the same basic function, namely to simulate the performance of the ECU, the advantages and disadvantages of each Simulator are in Table 1.

Table 1. The advantages and disadvantages of each simulator

Types of simulators	Ecu simulator Assemblies	MST-9000+
Displaying Signals WIND	The same basic function	The same basic function
Displaying Signals Injector	The same basic function	The same basic function
Uji test COIL	Yes	Yes
Uji Test Injector	Yes	Yes
Output sinyal Uji Test Speedometer	Yes	Yes
Time Fuel Injection /ms	Not	Yes
Uji test sinyal Sensor O2, Maf, Map, Coolant Sensor	Not	Yes
Uji ISC Stepper	Not	Yes
Update Vehicle Signal Type	Easy to update and can be modified	Limited types of Indonesian vehicle crank signals and limited updates.
Dimension	Small 9cm x 15cm	Big

From the comparison in Table 1, the disadvantages and advantages of each ECU Simulator can be a reference in the ability and needs of technicians to help analyze damage to the ECU in the hope that making this prototype can provide qualified features close to factory-made ECU Simulators, by conducting a more time efficiency simulation process, it also minimizes a lot of disassembly and minimizes vehicle fuel waste when in the ECU test on the vehicle directly where automatically if testing or ECU analysis is carried out directly on the vehicle the engine tends to be turned on in a good period Long enough that affects the use of a lot of fuel and is hindered by hot engine temperatures. provides qualified features close to factory-made ECU Simulator, on the other hand, the purpose of making this prototype also helps in analyzing local vehicles and reducing costs in purchasing ECU Simulator so that it is easy to reach, easy to use, easy to maintain and when damaged to the ECU Simulator is easy to find replacement parts, compared to MST 9000+ with a price that is priced at tens of millions along with care and use that must be careful because the tool is made abroad. Small dimensions make the ECU Simulator easy to carry everywhere, and the name and type of local vehicle signal crank available make it easy to choose the type of vehicle.

4 Conclusion

The ECU Simulator has the main function of supplying Crank and Camp signals in the form of Digital PWM 0v – 5v signals at the Electronic Control Unit (ECU) input. The ECU simulation process can be done in 2 ways, the simulation process in the unit directly by removing the crank and camp signal input socket on the vehicle and connecting to the simulator tool, can be simulated on the table by providing 12v DC voltage to the ECU. power supply and connect the ECU to the simulator tool. The ECU Simulator makes it easy to assess advanced analysis that occurs in the vehicle's computerized ECU.

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