

TESTING OF CONTROL UNITS FOR THE APPLICATION OF WIRELESS COMMUNICATION PROTOCOLS IN ON-BOARD VEHICLE DIAGNOSTIC SYSTEMS

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Abstract: The article describes the testing of control units used in passenger cars. The article is divided into several sections. The first section is focused on theory and provides basic information about the control units structure. Control unit from BOSCH company was chosen for this project. Further in the section, testing software by HR Carsoft s.r.o. is described. The testing processes outside the vehicle are described afterwards. The practical section lists all the requisites for testing processes outside the vehicle. The final section discusses a device that is designed to meet the goals of the project. The basic information about device is provided in the text. The results confirm the proper procedure for testing control units of passenger cars.

Key words: EDC, EEPROM, control unit, actuators, emission

INTRODUCTION

Control units have undergone large changes in last 20 years, especially by diesel engines. Electronic control of the diesel engine allows accurate and differentiated construction of injection devices. Many requirements of international standards to be fulfilled by modern diesel engines can only be achieved by using modern digital technology. Electronic regulation of diesel engines, EDC (Electronic Diesel Control), is divided into three system groups. The first includes sensors and transmitters of the required values. The second includes the engine control unit itself. The third group consists of the active elements of diesel engine management (actuators) (Štěrba et al. 2011).

Decreasing the fuel consumption and the emissions of harmful substances (HC, CO, PM and NO_x) while simultaneously increasing specific power output and torque of the engine are some of the factors of the current development in the area of diesel engine technology. In recent years, these demands have led to the use of diesel engines with direct injection (DI) of the fuel to the engine cylinder, with injection pressures higher than in engines with indirect injection of the fuel. The introduction of direct fuel injection has decreased fuel consumption in diesel engines by 10 to 20%.

In addition, the development of modern diesel engines is affected by the high demands on driving comfort. Ever higher demands are also being placed on noise emissions. This results in increased demands on the injection system and its regulation with respect to the following parameters:

- high injection pressures,
- pilot injection of fuel,
- additional fuel injection(s),
- amount of fuel injected,
- intake pressure,
- exhaust gas recirculation,
- high hardware requirements on the structure of EDC units (Reif 2011).

Figure 1 shows the BOSCH EDC unit for testing purposes. The unit is used for the control of diesel engines of the VW concern. Its structure can be seen in Figure 1. The unit consists of an aluminium casing and connectors for plugging into the vehicle. Inside the unit, there is a printed circuit board fitted with electrical parts (Reif 2011).

Figure 1 The EDC unit



MATERIAL AND METHODS

Structure of the control unit

New possibilities of controlling and regulating electronic control units of passenger cars arise from the modern technology in the automotive industry. Various conditions and phenomena can affect the control and regulation of electronic control units. Therefore, only the best and most efficient systems are used to manage individual components (actuators). Direct injection control units receive electronic signals from the sensors, evaluate them, and calculate the signals for the actuators. The control program (software) is stored in memory which can be electronically programmed using external devices. The execution of the program is taken over by a micro-controller located on the printed circuit board. The structural components of the electronic control unit are referred to as hardware. The control unit includes all the control and regulation algorithms for engine management (fuel injection, production of the fuel mixture). The amount of electronic components in passenger cars and trucks has increased significantly in the last 20 years. The technological development in automotive microelectronics allows more complex functions due to increasing integration. It is interesting to note, that the output of Apollo 11, which circled the moon once in 1969, has been surpassed by the functionality of electronic systems incorporated in today's motor vehicles.

Conditions for use

Control units are subject to high demands and requirements. These come especially due to high load, which consists of several parts, such as:

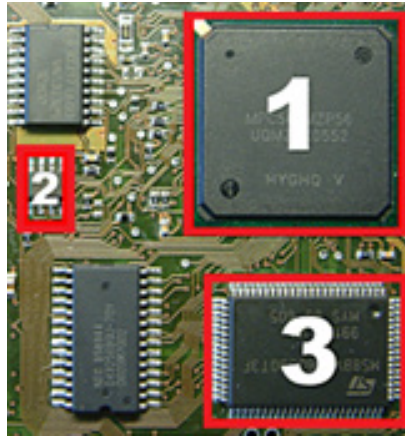
- extreme temperatures of the environment (in normal operation between -40 to 125°C),
- operating liquids (motor oil, fuel) affection,
- mechanical stress such as engine vibrations,
- significant temperature changes.

Hardware structure

The printed circuit board with electrical components (Figure 2) is located in a plastic or metal box (casing). The sensors, actuators and power supply are attached to the multiple-pole connector (socket) of the electronic control unit. The final output stages have been integrated into the electronic control unit casing for accurate actuator control in such a way as to allow excellent heat conduction and cooling of the internal structure. The majority of electronic components is manufactured using the SMD method (Surface Mounted Devices) (Reif 2011).

Figure 2 shows the structure of an electronic control unit. Three sections are highlighted, representing the basic structural elements of the electronic control unit.

Figure 2 Structure of an engine control unit



The first section is the processor; it executes the program stored in Flash EEPROM. The program controls the injection, for example.

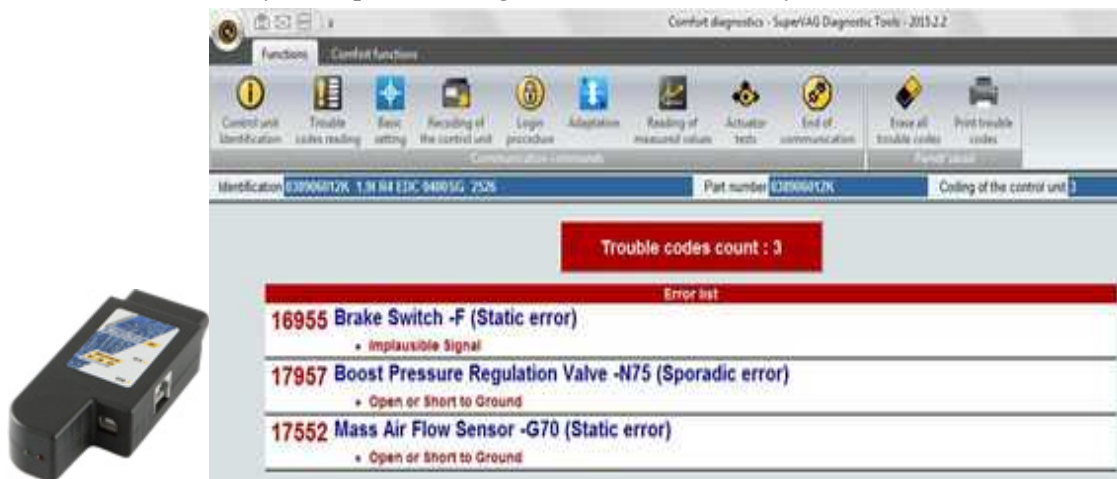
The second section is referred to as the serial EEPROM. It is a log containing the settings of the specific unit and the operating data. For instance, it stores the DTCs (Diagnostic Trouble Codes) detected during vehicle operation. The data can be read and written at will, 1 byte at a time. This memory type does not need to be erased. The serial EEPROM memory capacity ranges from 0.5 to 4 kB.

The third structural element is called Flash EEPROM. It contains the program itself as well as the data maps for controlling the engine unit. This element can be described as a DVD; the data is stored and does not change. The data is arranged in large blocks (e.g. 64 kB). Overwriting is done at least one block at a time. If the processor has no space to store the data, it is irretrievably lost and must be uploaded again. Here, the capacity ranges from 0.5 to 2 MB.

Testing environment

To test control units, correct testing conditions must be ensured. HR Carsoft s.r.o., a company dealing with development of diagnostic tools for control units of passenger cars, has been contacted for the individual tests. The company supplies devices containing hardware and software with the designation SuperVAG. Figure 3 shows the test adapter Multiplex 6I and software borrowed from HR Carsoft s.r.o. To goal of the test using SuperVAG was to determine the DTC. The Results and Discussion section contains comments to the results (Bosch 2005).

Figure 3 Demonstration of the SuperVAG diagnostic hardware and software



Testing procedure

For maximum utilization of the testing procedures, a proper system of data collection and analysis must be chosen. Before the testing on vehicles can begin, the units must first be tested outside the vehicle.

Unit testing is performed “on the table”, and is a non-destructive method which merely consists of removing the unit from the vehicle. The unit is not disassembled, welded or otherwise manipulated with.

The basic testing principle is making use of the wiring diagram of the engine control unit. This diagram is used to determine the connection of individual conductors which the unit needs to start-up and communicate with diagnostic tools.

Figure 4 shows a diagram of the EDC17C46 control unit circuitry, used in Volkswagen cars with diesel engines with a volume of 1986 cm³. After connecting the unit outside the vehicle, the unit is installed into a test case (Figure 4). Here, the control unit is connected to other components (ABS, Dashboard) and the communication between control units is tested.

Figure 4 Wiring diagram of engine control unit BOSCH EDC17C46 and the test case

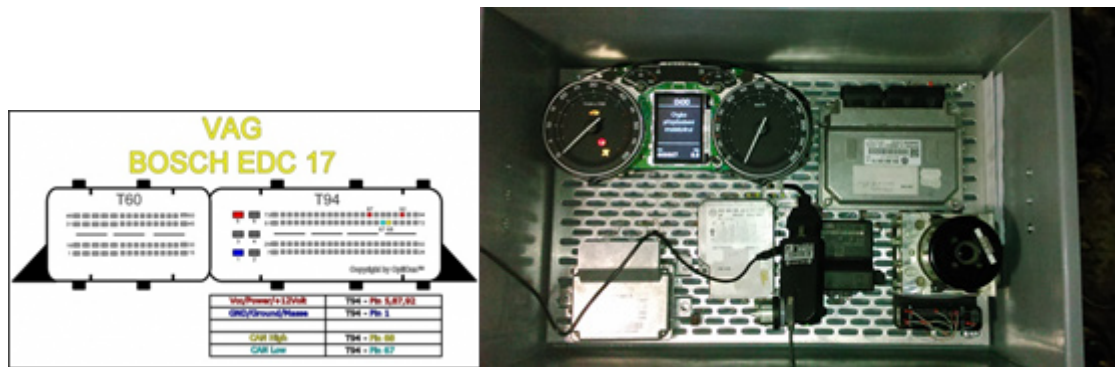
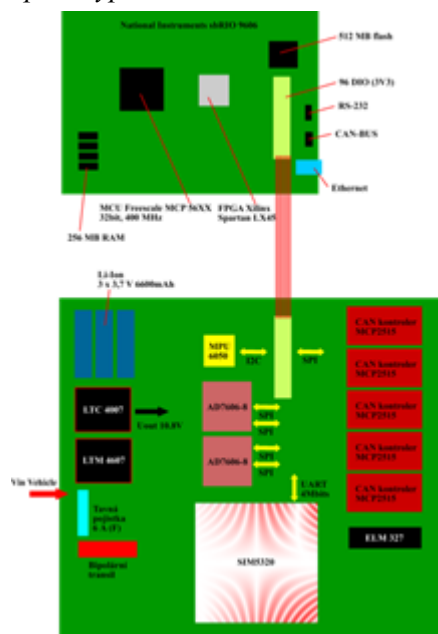


Figure 5 shows a block diagram of the testing unit, which was produced for the project and is currently in a testing phase. Based on the design, the prototype board is fitted with circuits for CAN bus, AD converters, IMU, communication processor with OBD2 protocol and a GSM module.

Figure 5 Block diagram of the prototype board



RESULTS AND DISCUSSION

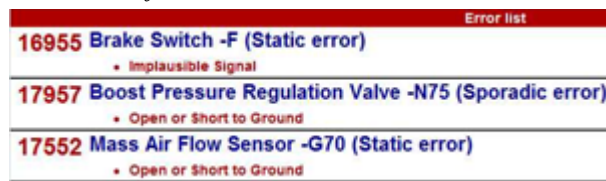
The use of the SuperVAG diagnostic environment was successful. The DTCs were read by simulating errors on a passenger car. The following table shows components which were disconnected.

Table 1 Disconnected components of the vehicle

Vehicle	Engine	Motorcode	Injection system	Disconnected components
Volkswagen Golf IV	1.9 TDI	AGR	EDC 15 VM+	EGR, Mass air flow sensor, Boost Pressure Regulation Valve

The resulting list of errors is shown in Figure 6. The control unit detected 3 DTCs.

Figure 6 Diagnostic Trouble Codes of the ECU



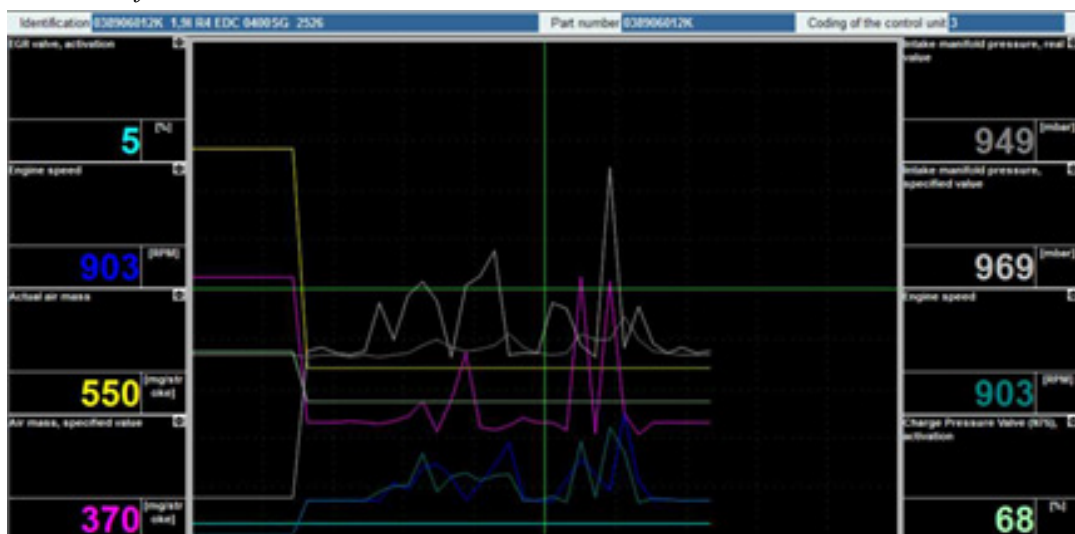
After connecting all the component and deleting the error codes, the error memory in the control unit was without errors. This is shown in Figure 7.

Figure 7 Diagnostic Trouble Codes of the ECU – No DTCs



Figure 8 shows the measurement of parameters when disconnected from the components of the passenger car. When idling, the required value for the Mass air flow sensor is $37 \cdot 10^{-5}$ kg per piston stroke. The real value is $18 \cdot 10^{-5}$ kg per piston stroke higher. This is due to the closed EGR valve.

Figure 8 Block of measured values



CONCLUSION

The article presents the basic diagnostic operations with an engine control unit. The first section presents the theory of control units and their historical development. The basic structural components of modern control units are listed; these are currently used in both passenger cars and trucks. The next section demonstrates the practical implementation of a cooperation between the academia and companies. For this test, cooperation was established with HR Carsoft s.r.o. The company has experience in repairing and testing control units. Its main philosophy is to test the control unit outside the vehicle or in it. Main emphasis is placed on non-destructive testing methods and unit programming. That means the casing of the control unit does not need to be dismantled and the structure of the unit need not be interfered with.

The objective of the test was fulfilled and the data obtained using the SuperVAG environment will be used for further experiments. This applies, in particular, to the board, which (is in the development phase. The main advantage of the board is the fact that it contains up to five CAN bus outputs. Using these outputs, it is possible to monitor the operating parameters of passenger cars and trucks, which will be further evaluated by the staff of the technical department.

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