

Automobile Engine EGR Valve Quick Detection Device

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ABSTRACT

Under the background of the rapid development of the automobile industry and energy conservation and emission reduction, preventing automobile exhaust emissions is very important to control environmental pollution. While directly endangering human health, exhaust gas also has a profound impact on the human living environment. As an essential part of the exhaust gas recirculation device, EGR(Exhaust Gas Recirculation) valve is an electromechanical integration product installed on the engine to control the amount of exhaust gas recirculation of the intake system. Problems with the EGR valve will seriously affect the performance of the engine. This paper aims to develop a testing and quality control device for EGR valve to solve the problems of multi-parameter detection and field test of EGR valve, which can be portable and easy to operate and meet international standards.

Keywords : EGR, Automobile Engine, Troubleshooting, Detection Device

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I. INTRODUCTION

The EGR (Exhaust Gas Recirculation) Valve is an electromechanical integration product installed on the engine to control the amount of exhaust gas recirculation of the intake system. The EGR system works by cooling down the exhaust gas in the engine exhaust pipe through the pipeline and radiator, then the exhaust gas enters the intake system through the

EGR valve, and will get into the cylinder mixing with the air for combustion. As some of the exhaust gas is involved in combustion, which can effectively inhibit the formation of hydroxide in the engine exhaust gas and lower the engine combustion temperature, the aim of reducing the engine exhaust emission can be achieved. The EGR valve lowers the combustor temperature by directing the exhaust gas caused by the engine combustion to the intake manifold to

participate in combustion so as to increase the engine efficiency, improve the combustion environment, and decrease the engine load to effectively reduce NO compound emissions and detonation and extend the service life of each component. Modern electronically controlled engine set position sensors to regulate the opening and closing of the EGR valve to prevent the amount of exhaust gas recirculation from having an excessive impact on engine performance.

This paper provides an EGR valve testing device whose principle is to use PWM (Pulse Width Modulation)-promoted MOS(Metal Oxide Semiconductor Field Effect Transistor) tube driver board to simulate the engine ECU control signal to drive and control the EGR valve tested, then the valve spool opening degree is controlled in the process of the SCM (Single-Chip Microcomputer) control module adjusting the PWM signal to regulate the duty cycle, and the data is transmitted to the touch-sensitive screen for display. In addition to some touching operation buttons, the touch-sensitive screen can also display information such as driving voltage, driving current, EGR valve spool opening degree and EGR valve response time, which can be used for comprehensive analysis of the EGR valve. This device is a touch-sensitive intelligent testing equipment for electronically controlled EGR valve, as well as a testing and quality control device for EGR valve to solve the problems of multi-parameter detection and field test of EGR valve, which can be portable and easy to operate and meet international standards.

II. EGR Valve Detection Device Hardware Indicators

The hardware part of EGR valve detection device mainly consists of touch-sensitive screen, Arduino Uno micro control board, MOS driver board, etc.

A. Touch-Sensitive screen

As a new type of computer input device, touch-sensitive screen allows users to carry out the operation by simply clicking on the text or pattern on the viewing screen, so that human-computer interaction no longer depends on the mouse and keyboard, bringing convenience and efficiency to the user. Combining with the specific requirements of the system and economic and practical considerations, we used BOE 10.4-inch LCD screen: BA104S01-300, with the advantageous size of 10.4-inch, resolution of 800 (RGB)×600, brightness of 350, and the LCD touch-sensitive screen. This product boasts a high-performance and high-rate processor based on ARMv7, which is a powerful embedded touch-sensitive screen. As shown in Fig. 1.



Fig. 1: Touch-Sensitive screen

B. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (6 of which can be used as PWM outputs), 6 analog inputs, 16MHz crystal oscillator, USB connection, power jack, ICSP connector and reset button. Power supply, program download and data communication can be done by simply connecting to a PC via USB cable. The main features of this microcontroller are: the model is ATMEGA328P; operating voltage is 5V; input voltage

(recommended) is 7-12V; input voltage (limited) is 6-20V; 14 digital I/O pins; 6 PWM digital I/O pins; 6 analog input pins; DC current of 3.3V pins is 20mA; flash memory is 50mA ; SRAM is 32KB; EEPROM is 1KB; clock speed is 16MHz; LEED_BUILTIN is 13; 68.6mm long; 53.4mm wide, and weighs 25g.

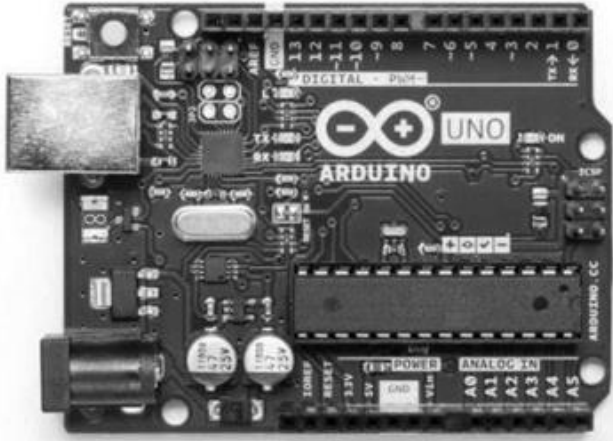


Fig. 2: Microcontroller

III. The Measurement and Control System Design of EGR Valve Detection Device

The measurement and control system of EGR valve detection device consists of measurement and control module, touch-sensitive screen control module, power drive module, power supply module, electrical signal conversion module, and human-machine data interaction module.

A. Structural composition of measurement and control system

The measurement and control module is the core part of the EGR valve detection device, and its core function is to control the input signal, collect the current data of the motor-drive circuit, achieve start-stop control of the system and the interaction function of data communication. The architecture diagram of the measurement and control system of the EGR valve feature extraction system is shown in Fig. 3.

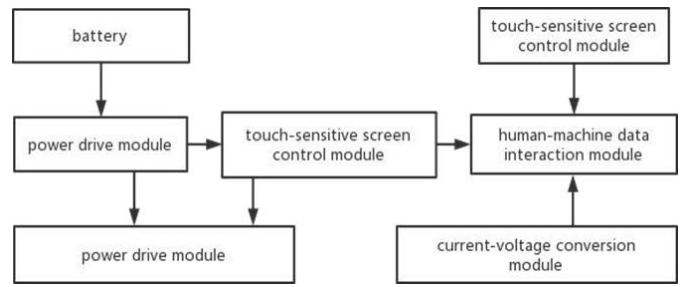


Fig. 3: Measurement and control system architecture of EGR valve feature extraction system

The human-machine data interaction module is mainly responsible for the data interaction between the EGR valve detection device and the outside world, which can transfer the EGR valve feature information data obtained by the detection device to the upper computer for storage, and then transmit it to the mobile device through the data cable for reading and analysis to extract the EGR valve feature information.

When touch-sensitive screen control module device starts on feature extraction operation, tester should click the switch button, input the pulse width, then the device starts to work, and the EGR valve spool opening degree changes. At the same time, the input pulse width and the corresponding valve spool opening degree are displayed on the control interface, which makes it easy for the tester to carry out the inspection of the EGR valve device. When the test is finished, the device stops working by clicking the switch button again. The touch-sensitive screen control interface is shown in Fig. 4.

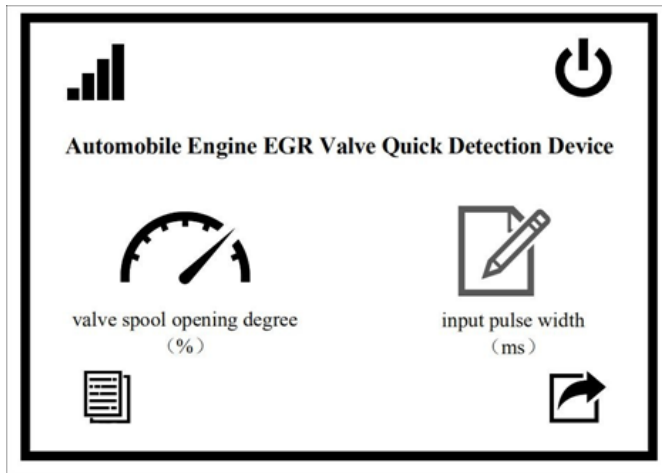


Fig. 4 : EGR valve testing device touch screen control interface

The power supply module consists of a battery pack, which can output 24 volts to power the motor equipment of EGR valve feature extraction system. At the same time, it ensures that the working current of the whole system does not exceed the safety threshold during normal operation, which provides guarantee for the safety of the system.

The motor power drive module implements the PWM signal to drive and control the MOS circuit of the EGR valve to complete the drive of the motor. The electric drive circuit current of the motor can be converted into analog voltage value through the electric signal conversion module, and the analog voltage value is amplified by the amplifier and transmitted to the main control chip for conversion, then the change of electric drive voltage can be obtained for the EGR valve feature extraction.

B. Workflow of the measurement and control system

The measurement and control system of the EGR valve detection device is responsible for the control of the equipment and the processing and transmission of data during the EGR valve feature extraction operation, which requires high stability, economy and convenience in the process of extracting EGR valve features. Before the feature extraction, the operator sets a specific input pulse width for the motor. When

the system starts working, the measurement and control system keeps detecting the current level in the working circuit to prevent the circuit from being overloaded. In the event of a circuit overload, the system will automatically stop the motor and save the current data acquired and alert the operator.

IV. Algorithm Design for EGR Valve Detection Device

The key technology of the Algorithm design for EGR valve detection device is Arduino.

A. The key technology

Arduino is a software and hardware platform based on open source code. It is an open source electronic prototyping platform which is convenient, flexible and easy to operate, including hardware and software. Arduino is built on the open source code simple I/O interface version, and has a Processing/Wiring development environment like Java and C language.

Arduino can sense the environment by means of a variety of sensors and give the feedback and influence the environment by controlling lights, motors and other devices. The microcontroller on the board can write programme through Arduino's programming language, then compiles into a binary file, and burns into the microcontroller. Programming of Arduino is realized by using the Arduino programming language and the Arduino exploitation environment. Projects based on Arduino can contain mere Arduino, or they can contain Arduino and some other software running on a PC, and they communicate directly to achieve it.

B. Principle and flow diagram

The main flow diagram of the control system of the touch-sensitive intelligent EGR valve detection device is divided into frequency setting, manual or automatic control mode, core processing algorithm, and PWM control signal output. As shown in Fig. 5,

the main flow diagram of the system software is as follows.

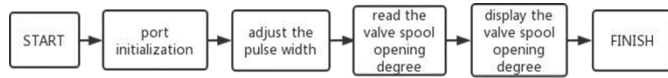


Fig. 5 : Main flow diagram of the software

Through the flow diagram, we can see that when the system starts to run, the ports of the SCM are firstly processed, including some parameter settings, the initialized assignment operation of IO port. After initialization, the control mode selection is carried out, including manual control mode and automatic control mode.

When in automatic control mode, the system first reads the valve spool opening degree feedback and displays the read-out value on the touch-sensitive screen. The valve spool opening degree setting value is read and then processed by the algorithm to make the IO port of the SCM output a pulse width to drive the EGR valve through the drive circuit.

When the control mode is in manual control which is relatively simple, the pulse width is completely determined by human factors. According to the feedback value of the valve spool opening degree, the pulse width of the SCM output can be changed manually through the touch-sensitive screen.

In the software design, the output pulse width of the IO port of SCM or the size of the duty cycle of PWM

pulses is controlled through the touch-sensitive screen. The pulse width output from the SCM goes through the driver to make the EGR valve start to work.

V. Summary and Prospect

In order to verify the effectiveness and accuracy of the EGR valve detection device, we applied the

feature detection algorithm to test the EGR valve. First, the EGR valve is driven and controlled by the PWM- promoted MOS tube driver board, and then the duty cycle of the PWM signal is adjusted by the SCM control module to determine the valve position based on the voltage data coming from the EGR valve. The accuracy of the device is then tested by comparing it with the calculated results displayed on the touch- sensitive screen.

The model detection results are very satisfactory, and the detection function of the device for the EGR valve is basically realized. The experimental results show that the system can effectively measure the valve spool opening degree. The experiments proved that the theory of measurement and control system and practical application results of the detection device are consistent. It can be seen that the device prototype has basically met the productization requirements in terms of performance indicators. In the future, we will increase the product performance testing items, expand the scope of application, and improve the advantages of promotion and application.

The study of the automobile engine EGR valve quick detection device can improve the EGR valve research system, solve the current problem of no technical EGR valve testing instruments in both service stations and repair shops and high maintenance costs, meet the needs of the application market, and lay the foundation for subsequent research. At the same time, the results of the study will advance future research on the inspection of automotive components and help raise the attention of this field for further development of research.

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