Research on Key Technologies of Integrated Teaching Platform for Automotive Engine ECU Control System

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Abstract: In order to ensure that high-skilled personnel can better grasp the internal structure of ECU control system of automobile engine and improve the maintenance skills, this paper analyses the teaching platform from two aspects of hardware and software; the former including the introduction of basic characteristics and platform building, and introduce the functions and components of the integrated teaching platform for control system of automobile engine. Through the analysis, the maintenance personnel can have a better understanding of the fault diagnosis and elimination of the ECU of the automobile engine, and provide a good reference basis.

1. Overview
This paper introduces the overall design and function of the integrated teaching platform for ECU control system of automobile engine developed in China, and uses the new working concept to diagnose and analyze the fault of ECU of automobile engine. The system analyses ECU from two aspects of hardware and software. In the hardware part, UG software is used to model and analyze, which shows the structure of the platform in a more intuitive way. In the software part, the control strategy of the engine ECU is studied, and the control process of the engine ECU is analyzed, so that the maintenance personnel can better understand the internal structure of the engine ECU.

2. Hardware Design
The integrated teaching platform for ECU control system of automobile engine is a high-quality product based on ECU of automobile engine, aiming at cultivating students’ interest and improving the level of maintenance personnel’s skill, and expanding the market of automobile electronic.

The training platform can intuitively understand and analyze the working principle of automotive ECU control system by comparing the schematic diagram with the actual object. By detecting terminals, electrical signals such as resistance, voltage, current, frequency and waveform signal of circuit elements of ECU control system can be detected directly on the panel. If equipped with fault setup system, 16 single faults and dozens of comprehensive faults can be set up. This teaching mode increases maintenance personnel’s ability of installation, debugging and maintenance of automotive electronic products, so that maintenance personnel can adapt to automotive electronics, automotive circuit maintenance and other fields. The main purpose of the research is to train high-quality technical specialists who can be engaged in automotive electronic product auxiliary design, automotive circuit maintenance and other posts. At the same time, some high-quality technical specialists who are engaged in automotive electronic product quality inspection and quality management, automotive claims settlement, sales and other posts are also trained.
2.1 Basic Characteristics
The integrated teaching platform for ECU control system of automobile engine solves the problem that it is not easy to observe, diagnose, analyze and detect the faults of internal ECU control system of automobile. This system enable the automobile maintenance personnel intuitively learn the structure, principle and detection technology of the internal control system of the ECU, and make up for the blank of the internal control system of the ECU that the automobile inspection and maintenance personnel of our country do not understand and have no data to check. The platform has the characteristics of advanced technology, intelligent control and large market demand.

1) The analog signal of the integral structure is integrated with the system circuit to facilitate the operation and observation of data.
2) The digital voltage signal display table of color circuit diagram is beautiful, intuitive and convenient.
3) The variable frequency speed regulating motor can directly drive the injector and the signal plate to run.
4) Multimedia remote fault setup system is adopted in this test-bed for users to choose, and the data of engine sensors can be analyzed at the same time.
5) It has communication functions such as data transmission and connection with upper computer.
6) This test-bed is specially designed for the integration of theory and practice of automotive engine ECU, which meets the relevant requirements of automotive ECU technology in the industry and the teaching needs of colleges and universities.

2.2 Building Platform
The experimental platform takes engine ECU as its core, removes the traditional engine body, and only retains some essential sensors and actuators. The whole system has the advantages of simple structure, small size, low cost and convenient detection (as shown in Figure 1). The analog signal generator can simulate the speed sensor, throttle position sensor and other signals input into the engine ECU. Through the operation of the ECU, it can output on the signal generator.

![Fig 1. Design schematic](image)

2.2.1 Minimum System of Single Chip Microcomputer
There is not much doubt about the choice of SCM. According to the circuit and requirements designed above, STC12C5A60S2 SCM can fully meet the requirements. STC12C5A60S2 series SCM is a single clock MCU produced by Hongchang Science and Technology. It is a new generation of 8051 MCU with high speed, low power consumption and strong anti-interference. The instruction code is fully compatible with the traditional 8051. It's internal integration is MAX810 dedicated reset circuit, 2-way PWM, 8-way high-speed 10-bit AD conversion, working voltage 5.5V to 3.3V, working frequency range 0 to 35 MHz, 44 universal I/O ports, reset quasi-bidirectional port/weak pull-up, can be set into a variety of modes. I/O port can drive up to 20 mA, but the whole single chip computer will
It has watchdog function, 8 channels and 10 bits precision ADC, conversion speed can reach up to 250K/S, and internal Flash program memory of 60 K bytes. As is shown in Figure 2.

![Fig 2. Minimum System of Single Chip Microcomputer](image1)

### 2.2.2 Relay circuit

The function of relay is to set the fault point by controlling the on-off of signal in ECU. According to the isolation mode, there are photoelectric coupler isolation, transformer isolation and so on. In this circuit, photoelectric coupler isolation is adopted. When the input P21 is at high level, the photocoupler transmitter does not work, the Q6 base level of the rear transistor is at low level, the transistor does not meet the conduction conditions, and the relay is in normal closed state. When the input P21 is low level, the photocoupler transmitter emits infrared signals, the receiver of the later stage is inductively conductive, the basic output of the transistor Q6 is high, and the transistor meets the conduction conditions, the relay changes state and turns on normally. As is shown in Figure 3.

![Fig 3. Relay drive circuit](image2)

The function of diode D in the circuit is to protect the rear driver. When the relay is sucked in, the diode D6 is cut off, which does not affect the normal operation of the circuit. When the relay is released, because of the inductance of the relay coil, the driver has been cut off, and high induction...
voltage will be generated at both ends of the coil, which will damage the driver. When the diode D6 is added, the induction current generated by the relay coil flows through the diode D6, so the high induction voltage will not be generated, and the driver is protected.

2.2.3 Fuel injection control system
The figure shows grouped injection, which generally divides the injectors of all cylinders into 2 to 4 groups. The engine control module (ECU) controls each group of injectors to alternately inject fuel. Four-cylinder engine generally divides the injector into two groups. Its control circuit is shown in Figure 4. In each working cycle, each injector injects once or twice. The injection action of the injector requires the microprocessor to produce a signal which is amplified by the driving circuit (PD166104GS) to control the completion of the injection action. The driving circuit (PD166104GS) in the figure integrates many transistors to achieve the purpose of power amplification. Breakpoint location seems simple, but in fact the internal is more complex, there are many resistors, capacitors, inductors and integrated circuits. The controller we designed is changed on the basis of the original one, so that the fault point can be moved inside the controller, which can enhance students' understanding of electronic circuits and their ability of eliminating faults in electronic circuits.

3. Control Strategy and Software Design
The main control functions of this experimental platform are ignition control and fuel injection control of ECU. The program adopts modular design and is divided into several relatively independent subroutines, which not only facilitates the reading of the program, but also facilitates the modification and transplantation of the program in the future. The software development of this system relies entirely on the C language platform of kile4 single chip computer. The program debugging of this platform is simple, and it has good continuity and expansibility. The flow chart of this program is shown in Figure 5.
4. Conclusion

The system uses analog signal generator to simulate the input signal of sensor, and displays it intuitively on the oscilloscope through the analysis and operation of engine ECU. According to the output data and graphics, the fault of sensors, actuators and ECU can be judged, which can provide a good reference for fault diagnosis and elimination of ECU.

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