Academic Journal of Engineering and Technology Science
ISSN 2616-5667 Vol.3, Issue 2: 57-65, DOI: 10.25236/AJETS.2020.030208

Design and Implementation of the UDS Diagnostic System Based on CAN Bus

Fei Shao*, Peng Kuang

Wuhan Institute of Marine Electric Propulsion, Wuhan, 430072, China
**Corresponding Author e-mail: ssff1@126.com*

ABSTRACT. *Based on the ISO15765 protocol and the electronic control unit (ECU) to complete the design and implementation of host computer software for the fault diagnosis function. The main contents include: This paper first introduces the basic requirements and specifications of CAN bus and ISO15765 protocol, then introduces the specific requirements and definitions of all diagnostic service in the implementation process , Using CANoe software simulation method implements the diagnostic requirements. Finally, it introduces the core process and state transfer process of the software design .Test the software and compare it with the traditional version which is carried out through CANoe software and then analyze the result and draw a conclusion.*

KEYWORDS: *CAN, ISO15765 protocol, fault diagnosis, network layer, application layer*

1. Introduction

The diagnostic instrument developed and implemented in this paper is realized through CAN bus. The protocol of this bus works in the mode of master-slave communication in data exchange and fault diagnosis [1]. PC diagnostic instrument with a diagnosis of ECU connection among the same CAN bus network, diagnostic instrument on a host computer and establish a logical connection between ECU hardware end, PC for ECU end sends the service request command, ECU after receive the PC request begins to execute the command, then reply to data response values or error code and message sent back to the PC to manipulate the results.

Wireless sensor network (WSN) is a set of sensor nodes with sensor detecting, communication and event processing capabilities deployed in the monitoring area. These nodes form a multi-hop and self-organizing network system by wireless communication way [3-5]. It is put forward and studied by the US military for military needs. With the rapid development of wireless communication technology, micro computer technology, system on chip and low-power embedded device, the application field of wireless sensor network is wider and wider. Because of its wide

ISSN 2616-5667 Vol.3, Issue 2: 57-65, DOI: 10.25236/AJETS.2020.030208

coverage and self-organizing ability, wireless sensor network has made great changes in information sensing field by adopting the advantages of wireless communication, low energy consumption and high reliability [6].

2. Diagnostic architecture and development environment

In deep research and analysis the ISO15765 diagnostic protocol in network layer and application layer [2], select the electronic control unit ECU based on a vehicle air conditioner controller as a foundation for the design of hardware, and the electronic control unit of the whole software layered architecture design and software development environment and the corresponding development tools was introduced in brief.

2.1 Development environment

Diagnostic software is the most important module in the diagnostic system. The simplicity, efficiency and reliability of the whole software operation will directly affect the efficiency and cost of ECU terminal diagnosis. The designed software development platform is Microsoft's Windows 10 operating system, and the software development and editing tools are Visual Studio 2018 software, and the programming language is C# program language.

2.2 Development tools

In order to meet the needs of automobile air conditioner controller diagnosis, the software of diagnosis instrument must be simple in operation, efficient in execution and high in reliability. Besides the transmission efficiency of the software data of the upper computer terminal diagnostic instrument, the high efficiency of the ECU terminal hardware control and execution is also essential. Only when the design and selection of software and hardware are appropriate can the diagnosis be performed more efficiently. As the CANoe simulation method is used to realize the diagnostic function [3], the ECU end used in this design is still the S12G single chip developed by freescale company with 16-bit central processing unit [4], and the chip is MC9S12G192.

Because the data in the vehicle system to transfer in the CAN bus, the ECU end data transmission with CAN interface, and PC diagnostic instrument data transmission using the traditional USB interface, so in order to complete the data in the PC and the ECU CAN smoothly exchange system must also use the USB-CAN interface adapter [6, 7], converts the USB interface of the data type is suitable for CAN interface types, so that CAN be used to transmit on CAN bus. The usb-can interface converter tool used in this design is CANTools.

ISSN 2616-5667 Vol.3, Issue 2: 57-65, DOI: 10.25236/AJETS.2020.030208

2.3 Diagnostic architecture

The overall software architecture design of the diagnostic instrument is the premise of this design. Whether the function of the diagnostic instrument can be fully realized is directly affected by the architectural design of the diagnostic control unit. Generally, the overall hierarchical structure of the diagnostic system in automotive electronics is shown in figure 1.

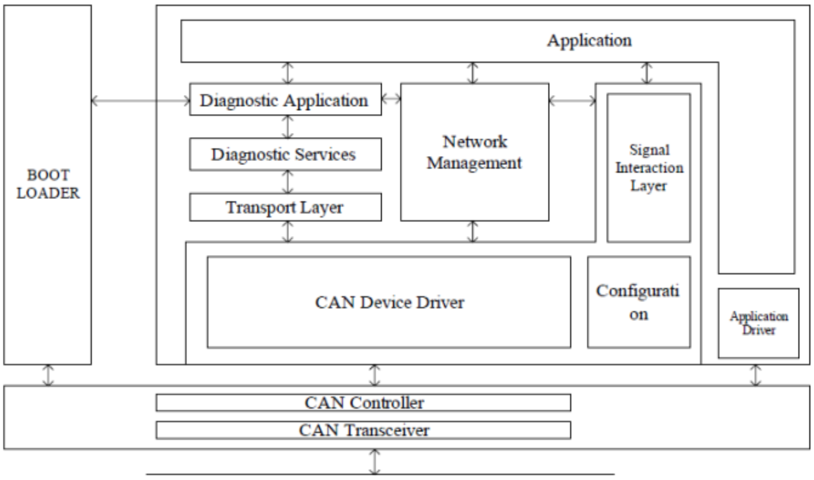

Figure. 1 Flow chart of target tracking process

As shown in the above, the general will be diagnosed according to the function to distinguish the system architecture is divided into the following several parts: the CAN bus Application layer at the top, and bottom communication configuration, data exchange processing, network layer, transport layer management, network management and diagnosis service layer, Application layer management and Bootloader, etc., including diagnostic services, network management and signal exchange belongs to Application function, the focus of this design is realized by programming with CAN bus communication module and diagnosis module.

The diagnostic service executes an ECU Application, which is an Application program. After ECU power on, before the implementation of diagnostic function, the Bootloader needs to be run first. Bootloader is the application and the underlying hardware in the middle of the program, can independence to compile and run, its main function is to initialize the hardware equipment and assign the corresponding memory mapping, this program bring diagnosis control unit of the hardware and software environment to a suitable operating state, then perform diagnostic procedures provide a favourable system environment. In addition, the Bootloader program will decide whether to update the application first or run the existing application directly. If the diagnostic application needs to be modified or upgraded,

ISSN 2616-5667 Vol.3, Issue 2: 57-65, DOI: 10.25236/AJETS.2020.030208

first erase the previous diagnostic program, and then download the updated diagnostic program into Flash through the bus, and then copy it into RAM to run again. If there is no need to update the diagnostic program, directly copy the diagnostic program stored in Flash to RAM, continue to run the original diagnostic program, and start the diagnostic function.

The whole diagnostic control unit is divided into upper computer and lower computer. The upper computer is the diagnostic instrument, which mainly completes the Application function, and the lower computer is the ECU, which mainly completes the Bootloader function. Correspondingly, the programs stored in ECU come from two parts: one is the Bootloader program, and the other is the Application program. After the Bootloader program is written to MCU through burn writing tool, the Bootloader program will not be changed, and the Application program can be updated through the Bootloader program.

The operation process of the ECU diagnostic equipment after power on is shown in figure 2. The first step is to enter the Bootloader program. At this time, the Bootloader will judge whether the upper computer has diagnostic Application program that needs to be requested. If so, it will exit the Bootlaoder program. If the upper computer has no diagnostic service request, the system stays in the Bootloader program. During the operation of the diagnostic instrument, if the diagnostic instrument sends a request for programming session mode to the ECU, it means that the Application program needs to be updated, and the MCU will be forced to reset.

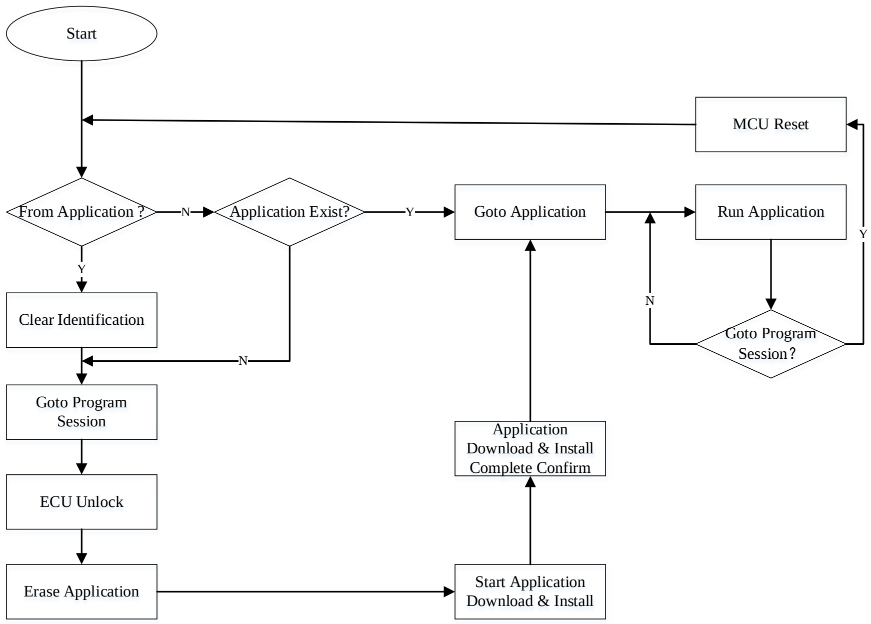

Figure. 2 The Process of Diagnostic system

ISSN 2616-5667 Vol.3, Issue 2: 57-65, DOI: 10.25236/AJETS.2020.030208

Before arrival, the system will stay in the Bootloader program for waiting, until the Application program update is completed, the system will jump back to the Application program to start running.

After ECU power on, always perform Bootloader operation first, and then perform other application service operations. When the ECU with Bootloader program is updating the diagnostic application, it is no longer necessary to remove the air conditioner controller from the car and then burn the program through the burner to update the application. Only the upper computer can complete the online update of the diagnostic application through the bus. The Bootloader program prepares the environment for the subsequent diagnostics.

3. Realization of Diagnostic system

The upper computer diagnostic instrument consists of two modules: communication function and diagnosis function. It involves the data sending and receiving of the network layer and the concrete implementation of the diagnostic service of the application layer.

3.1 Diagnostic Network Platform

The parameter transmission between functional modules and data of the designed upper computer diagnostic software, the upper computer and the ECU terminal transmit diagnostic data according to ISO15765 protocol. Before sending data, hardware configuration module is used to realize the configuration of baud rate and other parameters of the entire CAN bus network[8], and then diagnostic service is started. The 12 specific diagnostic services of the application layer are completed in the diagnostic function module, including the specific implementation of diagnostic service request and response. All diagnostic modules pass request and response data through the communication module. Finally, after the diagnosis is finished, the system starts the message display module to display the diagnosis response message, and saves the diagnosis result into the corresponding document through the file storage module, and starts the screen refresh module to refresh the screen. The saved diagnosis results shall be submitted to the diagnostic personnel to complete the analysis and processing of the diagnosis message.

3.2 Application layer state transition

The application layer is initially in a state of readiness when the diagnostic instrument sends a request for diagnostic data to the ECU.

At the sending end, the whole application layer is in the scheduling state, and then transferred to the processing state. The diagnostic data request sent from the network layer is packaged into a protocol data unit suitable for the processing of the application layer, waiting for the response processing at the ECU end[9,10], and the

ISSN 2616-5667 Vol.3, Issue 2: 57-65, DOI: 10.25236/AJETS.2020.030208

application layer is then converted to the preparation state. When the diagnostic response message is sent back to the diagnostic instrument after the ECU is processed, the diagnostic instrument is at the receiving end. The application layer receives the data transmitted from the network layer, and then converts it into a scheduling state after receiving the data. When the scheduling is completed, the application layer finally returns to the initial preparation state after processing all the data.

4. Test results and analysis

In order to verify the correctness and effectiveness of the designed diagnostic instrument, the software was run in the Visual Studio 2018 environment of the upper computer to test the diagnostic instrument. The test equipment includes computer, usb-can converter, hardware ECU and external power supply. Firstly, the test system platform is built. As the ECU adopted in this design, the 16-bit microcontroller based on freescale is connected to the diagnosed network through CAN line[11]. Then, it is connected to the USB interface of the computer through the usb-can adapter CANTools to carry out CAN communication.

4.1 Communication test

The upper computer address is set as 0x708, the physical address of CAN bus is 0x700, the functional address is 0x7DF, the bus speed is set as 500kb /s, and the physical address is selected for testing. Click the CAN Data control on the diagnostic device and select the CAN communication function.

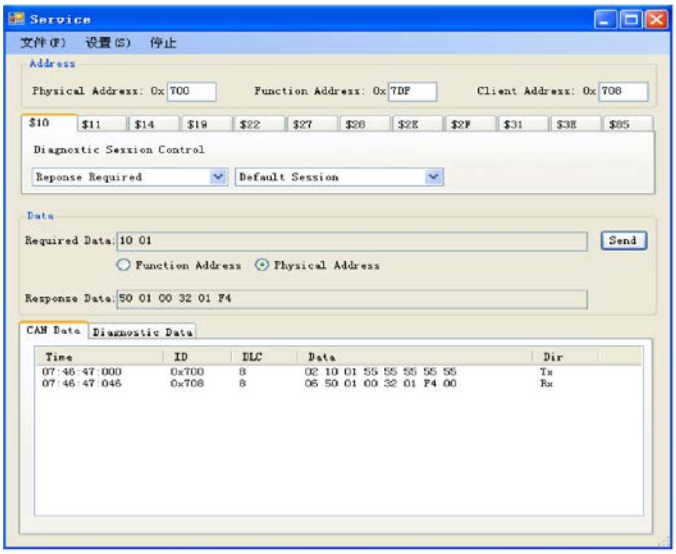

Figure. 3 Communication test

ISSN 2616-5667 Vol.3, Issue 2: 57-65, DOI: 10.25236/AJETS.2020.030208

The upper computer sends an 8-byte message data 0x02 10 01 55 55 55 55 55 55 to the ECU end. The test ECU then sends the response information back to the upper computer, which displays the sending time, ID number, data length and other information of the response message in detail. Test results show that CAN communication function is normal.

4.2 Diagnostic test

Test the diagnostic function of CAN after verifying that its communication function is normal. The diagnostic testing process consists of forward testing and reverse testing. Forward test means normal functional test. What happens to the diagnostic instrument is a positive response.

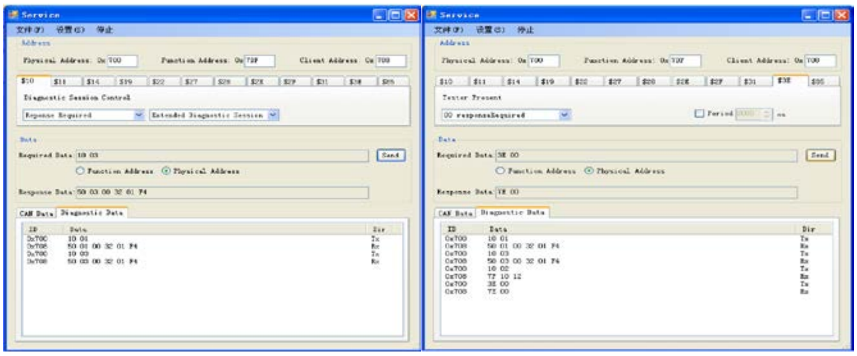

Figure. 4 Diagnostic test

According to the predetermined steps, the positive response of the diagnostic instrument is tested to meet the requirements of iso14229-1 protocol specification by sending the diagnostic message in the correct format. Reverse test, namely the error handling diagnostic instrument is the negative response, by sending the diagnosis of some wrong format message to test diagnosis instrument can identify various types of errors, the corresponding negative response and in accordance with the protocol to send the correct ISO14229-1 negative response message[12], to inform the diagnostic instrument ECU side produced a negative response to the service.

4.3 Analysis of Test Results

The test results show that the positive and negative responses of all diagnostic services designed in this paper are normal. However, due to space limitation, the test results of $10 and $3E are only listed here. The diagnostic instrument designed by completely satisfy the diagnosis of ISO15765 protocol communication requirement and ISO14229 requirements, and compared by using the method of diagnosis to CANoe simulation software to the operation is simple and efficient, all operations can be directly in the software interface by clicking on the operation to complete, no need to create a simulation node for each service in advance, more do not need to do programming with each node through the CAPL language, to improve the diagnostic efficiency, reducing the workload of diagnosis of personnel, at the same time compared to the CANoe hundreds of thousands of devices, the system also reduces the operating costs.

5. Conclusion

As a hot research technology, moving target tracking technology has been widely used in various fields. With the help of low cost, low power consumption, self-organization and high error tolerance of wireless sensor networks, moving target tracking based on wireless sensor networks also has broad application prospects.

References

[1] Yuanyuan Lu PhD, Xian Quan Shi PhD, Xiaohui Zhao PhD, et al. Value of Computer Software for Assisting Sonographers in the Diagnosis of Thyroid Imaging Reporting and Data System Grade 3 and 4 Thyroid Space - Occupying Lesions [J]. Journal of Ultrasound in Medicine, 2019, 38 (12): 3291-3300.
[2] Mao Song Wan, Qi Wen Qiu, Li Ya Lv, et al. Design and Analysis of CAN Communication Network Applied in Hybrid Electric Vehicle [J]. Advanced Materials Research, 2014, 3255: 1135-1140.
[3] C. Widanapathirana, X. Ang, J. C. Li, et al. A Hybrid Classifier Using Reduced Signatures for Automated Soft-Failure Diagnosis in Network End-User Devices [J]. Journal of Networks, 2014, 9 (12): 3275-3289.
[4] Bailit Howard L, Devitto Judy, Myne-Joslin Ronnie, et al. Federally qualified health center dental clinics: financial information. [J]. Journal of Public Health Dentistry, 2013, 73 (3): 224-9.
[5] Li Du, Peng Xie, Bing Zhou, et al. UDS in CAN flash programming [J]. IOP Conference Series: Materials Science and Engineering, 2019, 490 (7)
[6] R.A. Rohrer, S.K. Pitla, J.D. Luck. Tractor CAN bus interface tools and application development for real-time data analysis [J]. Computers and Electronics in Agriculture, 2019, 163
[7] Samuel E. Marx, Joe D. Luck, Santosh K. Pitla, et al. Comparing various hardware/software solutions and conversion methods for Controller Area Network (CAN) bus data collection [J]. Computers and Electronics in Agriculture, 2016, 128: 141-148.
[8] v. Egan-Krieger G., Stein T., Rahn J.. Object oriented device control using the CAN bus [J]. Nuclear Instruments & Methods in Physics Research. Section A: Accelerators, Spectrometers, Detectors, and Associated Equipment, 1994, 352 (1-2): 204-206.

ISSN 2616-5667 Vol.3, Issue 2: 57-65, DOI: 10.25236/AJETS.2020.030208

[9] Jiande Wang, Yunshan Zhou, Quan Li. Research on Fault Diagnostic System in CVT Based on UDS [J]. Advances in Mechanical Engineering, 2015, 7 (1): 741-765.
[10] Jin Kui Huang, Jin Rui Nan, Zhi Chai, et al. Analysis of UDS Diagnostic Service Applied on Vehicle ECU [J]. Applied Mechanics and Materials, 2013, 2773: 779-782.
[11] B.H. Chen, X.Z. Wang, S.H. Yang, et al. Application of wavelets and neural networks to diagnostic system development, 1, feature extraction [J]. Computers and Chemical Engineering, 1999, 23 (7): 899-906.
[12] Silvano Mussi. Diagnostic expert systems: a method for engineering knowledge used in sequential diagnosis [J]. Expert Systems, 2000, 17 (4):199-211.