Design and implementation of Diagnostic system for Integrated body Controller Based on CAN bus

Dairong HU,Dongdong HOU,Kun GUO,Changqing SUN
Qilu University of Technology(Shandong Academy Of Sciences)
Institute Of Automation Shandong Academy Of Sciences
Shandong Provincial Key Laboratory Of Automotive Electronic Technology
Jinan Shandong,China
hudairong2007@126.com

***Abstract*—In the development and design process of automobile electronic control unit, the bus simulation test tool CANoe, developed by Vector can monitor and simulate the electronic control unit in real time, which brings convenience to the development of electronic control system and bus system.In this paper, the CANoe simulation software is used to test the integrated body control system of a certain vehicle, and the CANoe electronic unit diagnostic test case is written according to the UDS diagnostic service, so as to realize the functions of automatic fault simulation, fault diagnosis and test result analysis.Shorten the development cycle of the product, reduce the cost of product development and manufacture, and improve the quality of the product.**

Keywords—CAN bus; diagnosis; UDS;BCM

I. Introduction

With the rapid development of automobile electronic technology, the electronic equipment of automobile body is increasing. The traditional wire harness is far from meeting the requirements of complex control system. The introduction of automobile bus technology has brought a new leap to automobile electronic control technology.The bus technology not only meets the functional requirements of body control, reduces the cost and simplifies the redundant wire harness of the body, but also realizes the intelligence and networking of the automobile control system.At present, because of its high performance, high reliability and unique design, more and more automobile brands and models use CAN bus technology to realize the communication between electrical systems, which has become the mainstream development trend.The application of CAN bus technology greatly improves the transmission efficiency and reliability between control systems, and solves the problems caused by the increase of electronic equipment.The structure of the electronic unit of the automobile is becoming more and more complicated, and the fault diagnosis of the vehicle is becoming more and more important[1-3].

With the progress of automobile fault diagnosis technology, the diagnosis criteria are gradually improved and unified. At present, the application of diagnosis standard is not only limited to fault diagnosis, but also needs the application of diagnosis standard in the whole life cycle of automobile development, test, production and after-sale maintenance, and the diagnosis system can be extended from the original traditional function to realize calibration data, test ECU, fault diagnosis, measure parameters, upgrade code and so on[4].

UDS (Road vehicle- Unified diagnostic services) Diagnostic protocol can not only read dynamic data, controller configuration information and fault code in ECU, but also operate IO port to facilitate the development of production line testing equipment and the quality inspection of products in batch[5].In order to realize the diagnosis of the electric control unit, the paper makes use of the CANoe software of the German Vector Company, and develops the automobile diagnostic test software according to the UDS diagnosis service, and the verification is carried out on the integrated body controller of a certain vehicle type.

II. Automobile Diagnosis Technology

A. CAN bus

The CAN bus technology is a serial communication protocol, that is, the data stream is transmitted serially on a communication channel, so that the number of the signal lines can be effectively reduced, the reliability of the system can be improved, and the CAN bus technology can be applied to the real-time distribution control of high security level requirements.

The CAN bus uses a multi-master competitive bus structure that depends on the message frame ID. It only uses pairs of twisted-pair to communicate, and the highest transmission rate can reach 1Mbit/s. The message is sent to the bus in the form of broadcast, and any node can send the message to the network at any time, and the message sending arbitration only depends on the message identifier.

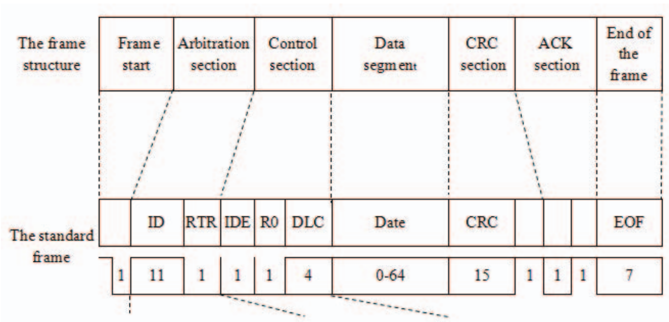


Fig.1 The format of CAN data message

CAN bus message is transmitted by frame in the process of communication. In order to realize different functions, message transmission is represented and controlled by four different frame types: data frame, remote frame, error frame and overload frame.In the on-board CAN bus, data frames are used between ECUs to transmit information, and the ECU broadcasts a data message with a specified ID to the network. The ECU on the network can have a selected reception or response message according to the message ID[6].This paper takes 11 bit standard data frame format as an example, and the data frame format is shown in Fig.1.

It can be seen from Fig.1 that the data frame consists of seven different bit fields: frame start, arbitration section, control section, data segment, CRC field, response field and frame end. The function of each potential field is different.

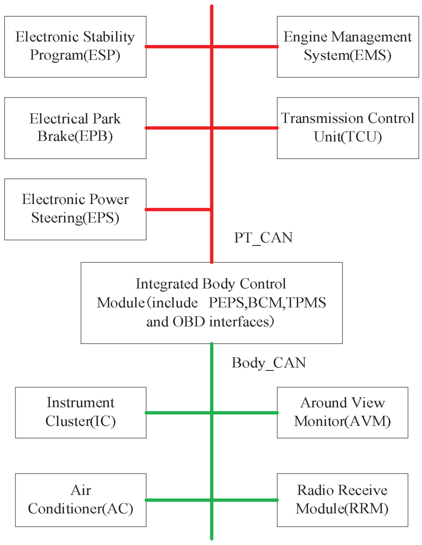


Fig.2 The architecture of network topology

In this paper, the integrated body control system designed by a new energy vehicle in China is diagnosed and tested. The CAN bus network topology of the vehicle is shown in Fig.2.The CAN network of the system is divided into two CAN segments. The controller contained in the PT_CAN network segment is as follows: ESP, EPS, EPB, EMS, TCU.And Body_CAN network segment includes: the IC, AC, AVM, RRM.Integrated BCM system is used as the gateway node, and it integrates PEPS, BCM, TPMS and OBD interfaces.

B. CANoe software

CANoe software is a tool for vehicle network development and ECU node development, testing and data analysis. It supports the whole process from requirement analysis to system implementation in the process of bus network development, including network model creation, simulation, testing, diagnosis and so on.CANoe mainly includes database editor, CAPL browser, main window, panel editor, CAPL program generator, panel generator, etc.CAN database can be created by using database editor, and links can be established between signal and message, message and network node, message signal and network node through object link function.Create a visual user interface using the controls provided by the panel editor.The CAPL is a CAN Access Programming Language, which is applied to the Vector CAN tool node programming and is a class C language, and CAPL is a language based on event (bus event, attribute event, time event) modeling and is easy to use.

III. UDS Diagnostic Service

In order to remind the motorists of the faults in time and to find out the causes and maintenance of the faults after sale, it is necessary to design the fault diagnosis function module in the design of the controller system.

The UDS diagnostic standard provides a unified diagnostic service, each diagnostic service uses a unique identity to identify the service itself, and defines the description format of the general diagnostic service, and lists the structure of the request, positive response and negative response of each service.According to the different diagnosis functions, the diagnosis services can be divided into five categories: diagnosis and communication management function unit, data transmission function unit, reading fault information function unit, online programming function unit, function and component test function unit.UDS common diagnostic service and its function description are shown in Table 1[7].

TABLE I. Common Diagnostic Service of UDS and its function

Diagnosis module	**Service code**	**Functional description**
Diagnosis and communication management	10	Diagnostic Session Control
	11	ECU Reset
	27	Security Access
	28	Communication Control
	3E	Tester Present
	85	Control DTC Setting
Data transmission	22	Read Data By Identifier
	2E	Write Data By Identifier
Reading fault information	19	Read DTC Information
	14	Clear Diagnostic Information
Online programming	34	Request download
	36	Data transmission
	37	Request exit transmission
Function and component test	2F	Input Output Control By Identifier
	31	Routine Control

The electronic control system is diagnosed by the CANoe software, a simulation node for diagnosing the actual equipment needs to be added, and the database, the panel and the CAPL of the node are edited.According to the diagnostic service, a visual user interface is created in the panel editor, and the environment variables corresponding to the panel control unit are defined in the diagnostic database. The diagnostic panel developed is shown in Fig.3.

As shown in Fig.3, the service that starts the diagnostic conversation is that the SDS, service number is 0x10, and the service can switch ECU in the default session, diagnostic session, and extended diagnostic session by selecting the switch.The service of the display tester is that the TP, service number is 0x3E, through which the tester can indicate his existence to the ECU to maintain the diagnosis.The secure access service is that the SA, service number is 0x27, and the service can switch ECU in the request seed and key calculation modes by selecting the switch.There are also TP switch keys that maintain diagnostics and text boxes that display ECU response results.

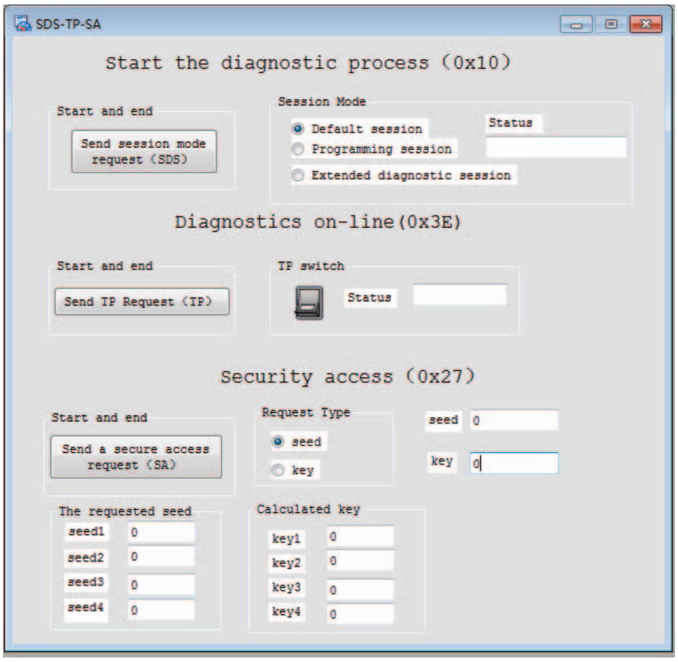


Fig.3 The diagnostic panel

IV. DIAGNOSIS OF INTEGRATED BODY CONTROLLER

A. System Design

In order to realize the rapid verification and function test of the integrated body control system during the development stage, the peripheral input of the switch and the LED is used to drive the test tool stand, and the test platform of the integrated body controller is built.The graphical operation interface is designed by CANoe software, the CANcardXL is connected to the computer through USB interface, the simulation node is mounted to the CAN network, and the test tool is connected to the test tool through the CANcardXL interface. The test tool is connected to the CAN network by connecting the cable and the body controller[8-9].

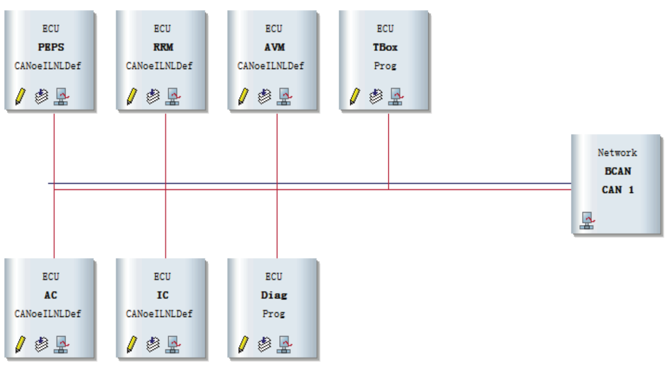


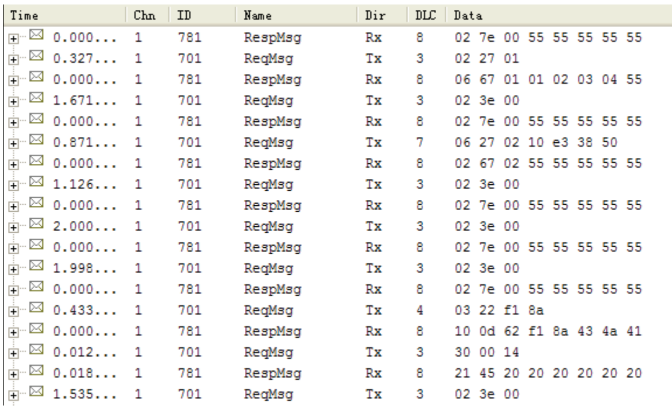
Fig. 4 The network structure of CANoe simulation

The topology of the body network segment simulated by CANoe software is shown in Fig.4. The nodes include PEPS,RRM,AVM,Tbox,AC,IC simulation node and diagnosis simulation node (Diag).

B. Diagnostic Application Example

For some ECUs, off-line operation(EOL)is required through diagnosis to correctly perform its function. This paper takes the remote key matching of the integrated body controller as an example.The CANoe diagnostic test software accesses the service of the ECU through the diagnostic message. The ECU has a separate physical address and a common functional address, so the diagnostic device can access to a single ECU or access to all ECUs.

Secure access realizes the protection of some important functions through encryption. when the diagnostic device requests the important function, it is necessary to request secure access first. ECU sends the key to the diagnostic device, the diagnostic device generates the key according to the encryption algorithm, and then sends it to ECU for verification. After verifying the correct diagnosis device, the diagnostic device can access these important functions, as shown in Fig.5.



Time	Chn	ID	Name	Dir	DLC	Data
0.000...	1	781	RespMsg	Rx	8	02 7e 00 55 55 55 55 55
0.327...	1	701	ReqMsg	Tx	3	02 27 01
0.000...	1	781	RespMsg	Rx	8	06 67 01 01 02 03 04 55
1.671...	1	701	ReqMsg	Tx	3	02 3e 00
0.000...	1	781	RespMsg	Rx	8	02 7e 00 55 55 55 55 55
0.871...	1	701	ReqMsg	Tx	7	06 27 02 10 e3 38 50
0.000...	1	781	RespMsg	Rx	8	02 67 02 55 55 55 55 55
1.126...	1	701	ReqMsg	Tx	3	02 3e 00
0.000...	1	781	RespMsg	Rx	8	02 7e 00 55 55 55 55 55
2.000...	1	701	ReqMsg	Tx	3	02 3e 00
0.000...	1	781	RespMsg	Rx	8	02 7e 00 55 55 55 55 55
1.998...	1	701	ReqMsg	Tx	3	02 3e 00
0.000...	1	781	RespMsg	Rx	8	02 7e 00 55 55 55 55 55
0.433...	1	701	ReqMsg	Tx	4	03 22 f1 8a
0.000...	1	781	RespMsg	Rx	8	10 0d 62 f1 8a 43 4a 41
0.012...	1	701	ReqMsg	Tx	3	30 00 14
0.018...	1	781	RespMsg	Rx	8	21 45 20 20 20 20 20 20
1.535...	1	701	ReqMsg	Tx	3	02 3e 00

Fig. 5 Secure access message diagnosed by CANoe

Routine controls provide control of long-life diagnostic services, such as key learning and key data queries, each with a Data Identity(DID). The design uses the CAN diagnostic equipment to enter the key learning mode, and the key matching learning process of the integrated body controller using the CANoe software design is shown in Fig.6.

The learning process of CAN diagnostic equipment needs to use the 10,27,31 service. Because the 31 routine control is procedural control, additional control types, control options and routine status are required after the service ID.The control type is a standard definition byte, 0x01 means the routine starts, 0x02 indicates the end of the routine, 0x03 represents the result of the query routine, and the other is an invalid value.When the CAN diagnostic device uses the 31 service request to start the key learning routine, the diagnostic learning program will enter the 10s key learning process and generate the key learning command.If the key learning is successful or the timer times out, the learning routine is completed, the learning results are filled in the corresponding register, and the learning results can be queried by 3103F101.

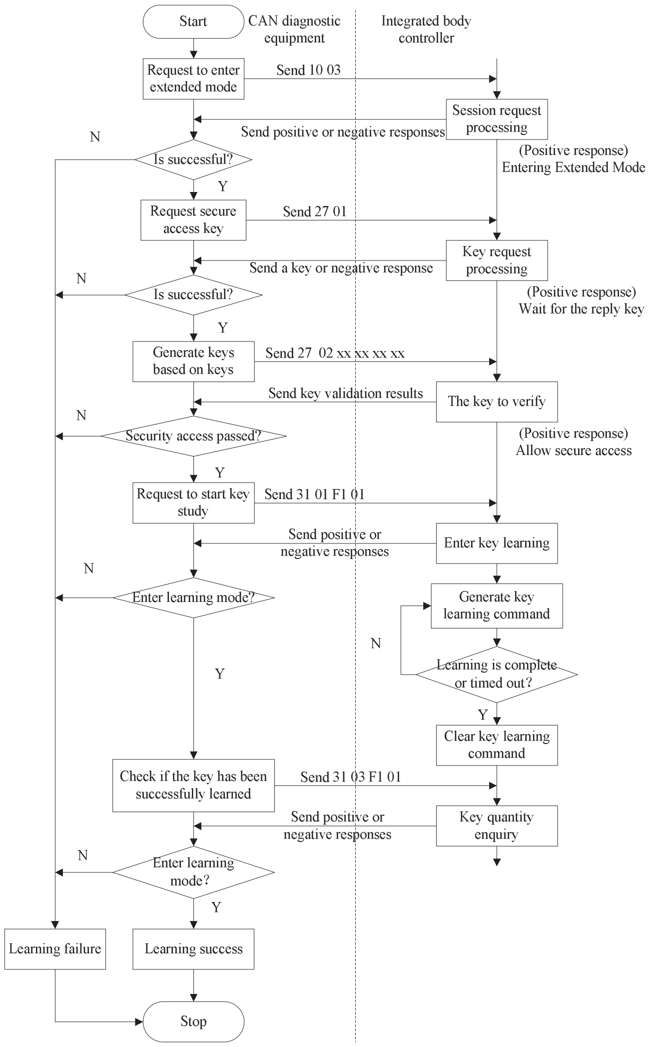


Fig. 6 Remote key matching learning process

V. CONCLUSION

Based on the simulation environment of the automobile BCM system diagnosis test established by the CANoe software, the communication condition of the on-board network can be simulated and effectively simulated, the diagnosis information on the on-board bus can be quickly and accurately acquired, analyzed and managed, the testing cost is greatly reduced, The method also improves the accuracy of the system test, and plays a very important role in the development and improvement of the automobile BCM system.

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