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Development Method of Simulation and Test System for Vehicle Body CAN Bus Based on CANoe

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Abstract: *The CAN bus which has been widely used in Electric Vehicle Control System have many characteristics such as high transmission efficiency, high reliability, good real-time feature and so on. The CANoe which is the product of German company Vector is a practical and powerful tool for system design and analysis. Firstly, A design scheme of simulation and test system for vehicle body CAN bus network is brought forward, which mainly includes the topology of network, the hierarchical model of network and the selection of bus baud rate. Secondly, a method of how to use CANoe to construct the simulation and test environment for vehicle body CAN bus system is introduced. Finally, the simulation and test system for vehicle body CAN bus is completed by CANoe. Experiments demonstrate that the development method of simulation and test system is feasible.*

Keywords: *CAN bus, CANoe, Simulation, Test*

I. Introduction

As the development of automotive electronic technology and the continued enhancement of automotive capability requirements, electronic devices in vehicle become more and more. The large application of electronic equipments will inevitably lead to the massive and complex body wiring harness, the shortage of installation space, the fall of operational reliability and the increased difficulty of failure maintaining. In order to enhance the utilized rate of signal, a large amount of data information is requested to be shared in different electronic units and a large number of control signals in the automobile control system need real-time exchange. Most of the traditional electrical systems use point-to-point communications, and have been unable to meet the demand by far. Therefore, automotive network technology emerges as the times require. Automotive network has a variety of advantages such as reducing harness in large extent, realizing data sharing, remarkably improving the intelligent control level of vehicle, improving capabilities of failure diagnosis and repair and so on.

CAN (Controller Area Network) bus is a serial data communication protocol which was developed by German company BOSCH in the 1980s to solve data exchange among numerous control and test equipments in modern vehicles. CAN bus has been widely used in electric vehicle control system, due to its advantages such as good real-time feature, high reliability, quick communications rate, simple structure, good interoperability, perfect error handling mechanism of bus protocol, high flexibility, low price and so on.

CANoe is a practical and powerful tool for system design and analysis developed by German company Vector. It can realize the link between virtual bus and real physical bus through Vector's CAN bus interface hardware. With CANoe we can realize the total digital simulation of bus application system based on total virtual nodes, the half-physical simulation of the combination of physical node and virtual node, and can also realize real-time monitoring of the real physical bus communication. CANoe supports the whole process of the bus development - from the initial design, simulation and final test analysis, and realizes the seamless integration of the design, simulation and test of the network.

This paper mainly researches the development method of simulation and test system for vehicle body CAN network, and uses CANoe software to carry through actual simulation and test. Finally, it proves that the simulation and test system for vehicle body CAN network which has been designed is feasible.

II. Design Scheme of Simulation and Test System for Vehicle Body CAN Network

According to the top-down requirement analysis, the bottom-up system design idea, and the analysis of the functional requirements of CAN bus network system, we establish the design scheme of simulation and test system for vehicle body CAN network. Detailed design schemes are enumerated as follows.

A. Topology of Simulation and Test System for Vehicle Body CAN Network

Vehicle CAN bus network system includes Communication Network System, Gateway Unit, Vehicle Power Distribution and Failure Diagnosis System. Among these, the communication network system consists of Engine Electronic Control System, Automatic Transmission Control System, ABS Electronic Control Unit, Vehicle Stability System Body Electronic Control System, etc. The designed network system is composed of Instrument Cluster, Multiplex Input/Output Module, Vehicle Power Distribution Module, Gateway, Body Electronic Control System, Vehicle Light System, Interior Multimedia Information System, etc. According to the requirement analysis, we design the topology of simulation and test system for vehicle body CAN network which is shown in Figure 1.

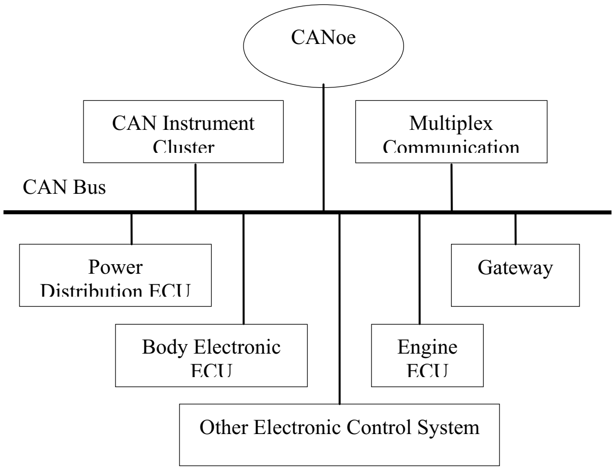

Fig. 1 Topology of simulation and test system for vehicle body CAN network

B. Hierarchical Model of Simulation and Test System for Vehicle Body CAN Network

The communications network constructed on CAN bus is designed by hierarchical structure in accordance with the OSI standard. As the relatively small amount of the information transmission of CAN network, the high requirement of real-time features of information transmission and the relatively simple connection mode of the network, so the CAN bus network only uses the lowest two layers of communication model - Physical Layer and Data Link Layer. And the Application Layer at the top only.

In addition, CAN2.0 is divided into two parts - standard data frame and expanded data frame. The identifier length of CAN standard format is 11 bits, and the identifier length of CAN expanded format is 29 bits. CAN2.0A version provides that CAN controller must have an identifier with 11 bits. Meanwhile, CAN2.0B version provides that the identifier length of CAN controller can be 11 bits or 29 bits. CAN controller which keeps to the CAN2.0B protocol can send and receive standard format message with 11 bits identifier or expanded format message with 29 bits identifier. If it is forbidden to use CAN2.0B, CAN controller can only send and receive standard format message with 11 bits identifier, and neglect the message structure of expanded format without error. Both physical layer and data link layer of the designed network system keep to the CAN2.0B protocol.

Application layer can be defined according to the function requirements of the designed body network, and can also be customized. In this system the application layer use the SAE J1939 protocol which has been become the most widely used protocol of the application in mayor vehicles presently. Its communications rate can achieve 250Kbps, and it is on the basis of CAN2.0B. The J1939 protocol based on CAN bus is relative to the traditional protocol standard. And the J1939 which exerts the outstanding performance of CAN in greatly extent has a number of advantages such as high transmission speed, lower cost of vehicle, advanced reliability of the system, improved flexibility of the system and so on. The Figure 2 shows the hierarchical model of network system.

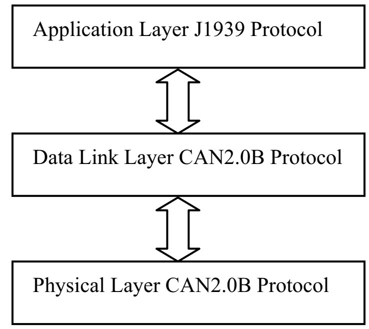

Fig. 2 Hierarchical model of network system

C. Selection of CAN Bus Baud Rate

CAN communications protocol requires that the same CAN network can only use the same baud rate to communicate. If a node's baud rate is set by mistake, it will affect the communications of the whole CAN network. Therefore, when we are choosing the baud rate of the CAN bus network system, we should consider the two aspects as follows:

1) The data size of the bus system communications, that is to say the size of bus load;

2) The work environment of the CAN bus system, mainly the characteristics of outside interference.

As the above two conditions considered, we establish the baud rate of CAN bus communications which is 250Kbit/s.

III. Using CANoe to Realize the Simulation and Test System for Vehicle Body CAN Bus

A. Building the Simulation and Test Environment for Vehicle Body CAN Bus

According to the design scheme of vehicle CAN bus network system, we build the simulation and test environment from the following steps.

1) *Configuration of Database:* CANdb++ is a data management program which can be used to create and modify these databases. With it we can import parameters defined in application layer into the development environment of CANoe. Configure network node which is the interface to connect control units which can send and receive datum from CAN bus through database and a network. Configure transmission data frame which is defined by message which is consisted of one signal and more whose maximum size is 8 bytes; Configure parameters in frames which is defined by signal. Configure environment variable which is the bridge among CANdb++, CAPL language programming and user-defined panels. An environment variable has to be created in CANdb++ firstly, and then can be used in CAPL and user-defined panels. Figure 3 shows the configuration interface of this system's CAN database-howo.dbc.

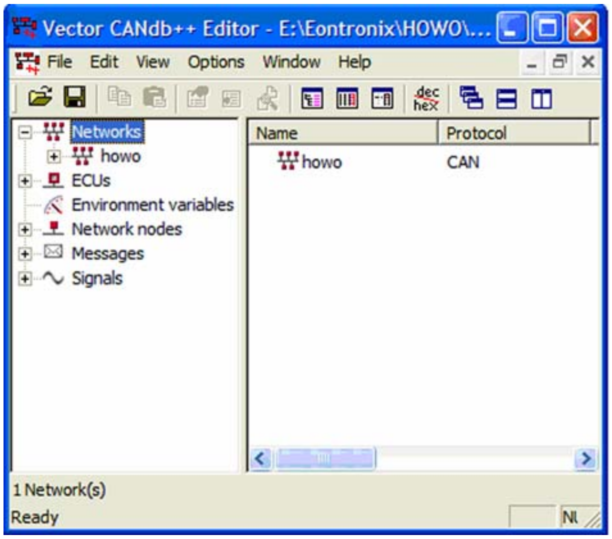

Fig. 3 Configuration of CANdb++

2) *Simulation Setup:* In this process, we can open the simulation setup window and insert into simulation nodes. According to the topology of CAN bus network system, we can configure networks and network nodes graphically. For example, we only use one CAN channel in this system, and one of the simulation nodes – light node (Fig. 4).

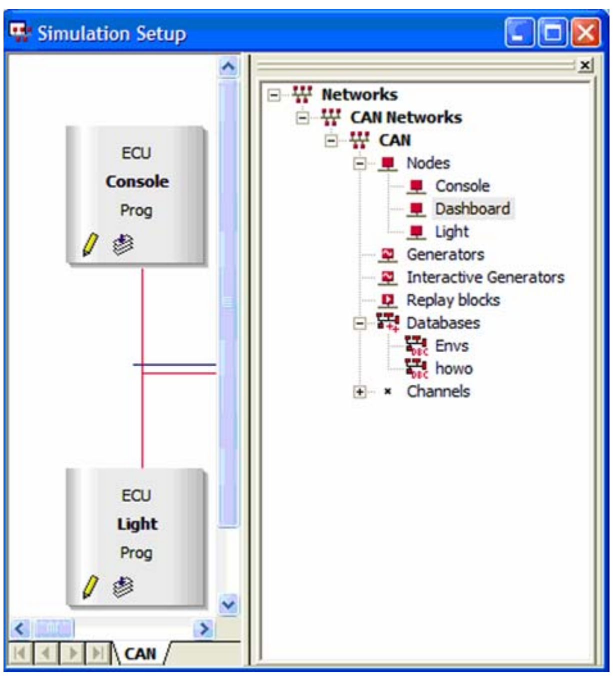

Fig. 4 Interface of simulation setup

3) *Configuration of Panel:* With the Panel Editor you can create graphic panels, on which the user can interactively change the values of discrete and continuous environment variables during the simulation, as well as display signals. For example, Figure 5 shows the Instrument Cluster panel of the design system, and Figure 6 shows the simulation sensors. Among these, the Instrument Cluster mainly displays some failure sensor signals, light signals, car speed, engine speed etc. The simulation sensor panel mainly sends signal values of Car Speed and Engine Speed to the bus to replace physical nodes which is easy to be operated.

Fig. 5 Instrument Cluster panel

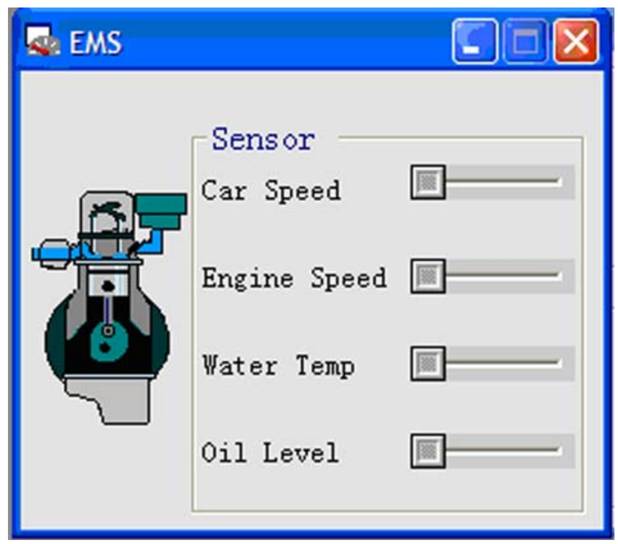

Fig. 6 Simulation sensor panel

4) *CAPL (Communication Access Programming Language) Program:* It is a C-like programming language and event-trigger language which is integrated in CANoe development environment. With CAPL we can program each virtual node and simulate the function of real physical nodes to send, receive and deal with data frames. Here, the physical node is real and used in actual work environment nodes; the virtual node is the node that the interface and function are the same as the relative physical node in CANoe. Figure 7 shows the CAPL programming .

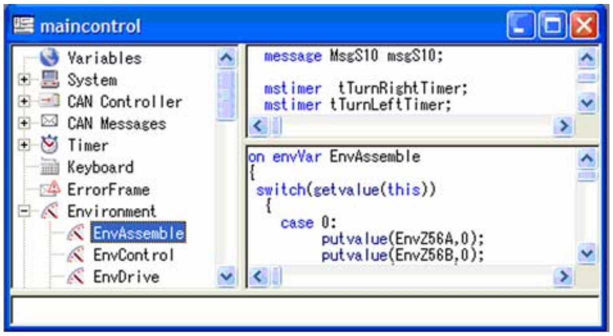

Fig. 7 CAPL programming environment

B. Development of Simulation and Test environment for Vehicle Body CAN Bus

According to the design scheme of CAN bus network system, this system completes the work of development and test of nodes from the following several aspects.

1) Development and Test of Single Signal: Take the CAN bus Instrument Cluster (record as node 1) as example. First of all, disconnecting the connection between virtual node 1 and virtual bus, and maintaining the connection between virtual nodes and virtual bus. Then connecting the physical node 1 to the CAN bus. Finally, running the CANoe simulation environment has been created, and monitoring the running status of the system. If the whole system works normally, we can think that the node 1 primarily realizes the functional requirement of the system. Through the same method, we can complete the development and test of other nodes.

2) Real Partial Simulation and Test: With the CAN hardware interface of Vector CANoe can connect the real physical and virtual CAN bus to realize the real partial simulation of the combination of physical and virtual nodes. We select a node whose function is relatively simple (e.g., the light node) through analyzing each node's complexity. In CANoe, we disconnect the light node from virtual bus, and replace it with the real physical node which is then connected to the physical bus. Then we run the configurable file to complete simulation and test for the node and datum from the bus. Through those steps we can realize the functional test of the node.

3) Real Total Test: First we connect all physical nodes to CAN bus and disconnect the total connection between virtual nodes and virtual bus. Then we start every physical node and monitor the communications situation by CANoe. In this process, we observe datum from the bus through trace window and check whether several equipments work normally or not through display panel. Consequently, we can adjust each node to meet the demand of the design of vehicle body network system according to the monitoring results.

4) System Debugging: We connect all units of vehicle body network system and park them into real work environment to debug the system. We mainly complete the following aspects: making the harmonized and functional test of the whole system, monitoring the communications situation of the bus with CANoe, testing the anti-jamming capability of the system, validating whether the CAN bus system meet the demand of scheduled function. In the process of system debugging, we run the configuration file and observe the sending and receiving situation of data frames from the CAN bus with statistics window. We test the CAN bus system from the following aspects.

a) Functional test of nodes: that is to say testing each node whether can complete their function. This process can be completed through interactive control. Take the functional test of light node as example. Trough operating real light switches, we can observe whether the bus receives right datum. If the bus receives the right datum, the relative light can be lit or extinguished. Otherwise, it shows that the light has failure and need to be replaced.

b) Analyzing the load situation of the CAN bus: We test whether the average load rate and peak load rate of bus reach the design requirements. We can observe datum in bus statistic window. If it can not reach the design requirements, designer has to debug the system according to actual situation.

c) Analyzing the data frames: We can track datum from the bus with the trace window, and observe whether there is wrong frame. We can also observe and judge whether the sending and receiving datum are right. That can help develop engineers debug and modify the program, and improve develop efficiency. In the process of debugging, some data frames are shown in Figure 8.

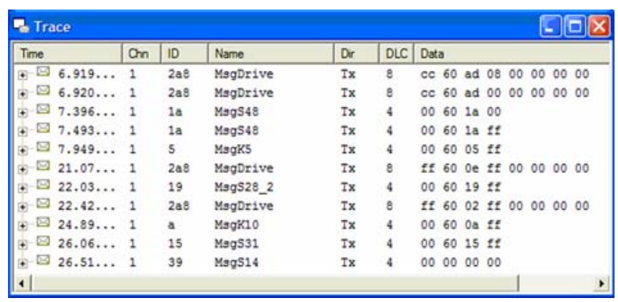

Fig. 8 Trace window

We complete the development and test of each node through the above-mentioned aspects of the work. Through the simulation, test and analysis of the entire system, we validate that the design system for vehicle body CAN bus meets the scheduled functional requirements and actual need.

IV. Conclusion

This paper mainly introduces the development method of simulation and test system for vehicle body CAN bus. With the system development and analysis tool - CANoe, we create the simulation and test environment in which we complete the simulation and test for every node of this system and the test of coordination of the entire system. Finally, we complete the development of the design method of simulation and test system for vehicle body CAN bus, get a feasible network system for vehicle body CAN bus, and achieve the desired requirements.

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