The design of the truck CAN network test system based on HIL

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Abstract

In order to meet the demand for vehicle test of vehicle factory, we design the CAN network testing system based on HIL for truck. This paper presents a design scheme of this test system, and realizes it using CANoe.J1939 software. This test system can realize the test for CAN bus communication performance for truck and ECU functions in the network.

Keywords

SAE J1939 protocol, HIL simulation, CAN network test, CANoe..

1. Introduction

With the increase of the automobile electronic technology development and ECU number of inside of the car, CAN bus has become the mainstream of buses in vehicle electronic systems in recent years [1]. In commercial vehicle, the SAE J1939 protocol [2] has gradually replaced the SAE J1587 protocol to become the most widely used protocol in heavy vehicle. The requirements for CAN network of truck are also increasingly complex. HIL (hardware-in-the-loop) test [3] [4] can simulate vehicle and work environment and run a large number of test for controller and network in virtual environment.

At present, the research for network test of truck isn't so much, and the tests are mostly just for individual ECU. What's more, the research for HIL test is not thorough enough. Hongyu Shen [5] designs a Test System of HGT Based on CANoe, but the test system only tests for high-performance gateway module. Jian Wu [6] designs automotive driving force control system of CAN bus based on SAE J1939, which is only for the relevant ECU about driving force control instead of the whole network. The test system in the Dandan Fu's paper [7] is for vehicle system, however the research system only two ECU: ABS and IC. They can't reach the requirements for comprehensive. Therefore, this paper designs a truck CAN network test system based on HIL for communication test of network and function test for ECU.

2. Operational principle of CAN network test based on HIL

HIL test, also known as hardware-in-loop test, semi-physical simulation testing, is the test method which combines simulation system test and physical test. It can give a test on the ECU and the system in a more comprehensive way. Especially for the ECU tests that have the need for actual vehicle operation or hazardous conditions, it can shorten the development cycle and it wouldn't cause harm to people and vehicles. Figure 1 shows the testing process for HIL test applied in CAN network of truck.

According to the V model development process of controller, the vehicle network test based on HIL belongs to integration test phase. Test process is as follows:

(1) According to the requirements of OEMs, analysis the test requirements of the truck network to be tested, form the test requirements document, and write the test cases as a test input based on the document.

(2) Import the message database of SAE J1939 protocol into CANoe software, and develop the test system in the CANoe. Instead of using control signal generated in the real ECU, we choose simulation signal for HIL test.

(3) Build the vehicle test environment for CAN network of truck. In this paper, we use CANoe simulation software as a platform model, and connect to CAN network via CANcaseXL, forming the closed CAN test environment of HIL.

(4) Perform the test and generate test reports.

Test results and analysis can provide reference for the optimization of the tested network, and verify the communication performance of network.

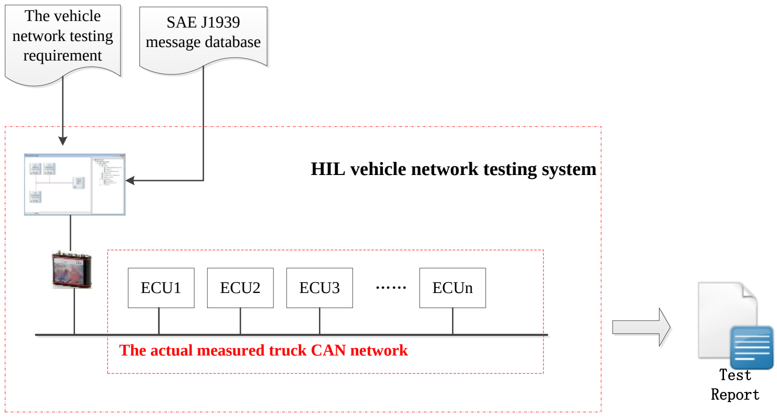

Figure1 testing process for HIL test in truck CAN network

3. Design for CAN network test system

Based on HIL test, we choose the existing vehicle testing platform for the test object and construct a closed loop system to achieve the network communication test and function test of ECUs. Vehicle test system for HIL consists of three parts: the PC test environment, CAN network and the CAN controller to be tested.

3.1 Design framework of test system

In the paper we choose the truck electrical/network system platform jointly developed by laboratory and OEMs as the network under test. We select the engine, retarder and ABS as the analog nodes, simulating together with the vehicle network. By simulating the function of these three ECU nodes, simulation signals are sent into the vehicle network, which are used to test whether the other nodes can work correctly and ensure normal communication of the vehicle network. CAN network topology is shown in Figure 2:

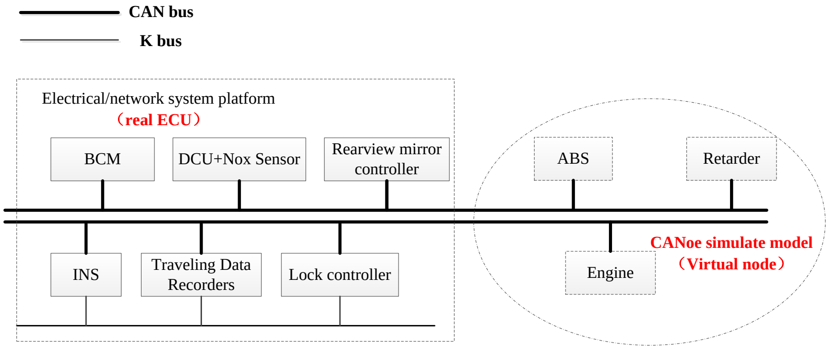

Figure 2 Test system topology diagram

Among them, the vehicle electrical/network system platform includes BCM, DCU + Nox sensor, rearview mirror controller, instruments, traveling data recorders, lock controllers. The PC software connects the vehicle network via CAN transceiver to simulate the message signals and send them on the CAN network.

In this paper the CANoe.J1939 software of Vector's is chosen to realize simulation and performance testing for the truck CAN network [8]. Detail methods are as follows:

(1) Connect CANoe.J1939 software with the tested network via CANcaseXL.

(2) Send simulated signal and drive other ECUs to run the control work. For example, send "High engine temperature alarm signal" and the alarm light on the instrument lights.

(3) Compare and analysis the behavior of the ECU in the network with the actual transmitted and received messages through the CANoe trace window. Verify whether the function of vehicle network and ECU meet the expected demand or not.

3.2 Test case design

According to SAE J1939 protocol, the CAN message testing mainly focus on ID (Identify), data transmission cycle and data [9]. The main task of the truck CAN network performance test is to determine whether the other nodes can communicate properly based on the simulated signals, and be able to respond to the corresponding control signals.

The PC software connects the vehicle network via CAN transceiver to simulate the message signals and send them on the CAN network. According to the action of the test network nodes and PC software trace window, we can determine whether the ECU and the network works properly or not.

In this paper, the message contents of engine, ABS and retarder are simulated to realize the test for vehicle network in a variety of conditions. In this list only relevant test projects are listed. The specific content and test cases setting are configured according to the requirements of ECUs. Test items shows in Table 1:

Table 1 engine part simulation project

No.	SimNode	Items	Relevant message
1	engine	Engine fault code display	DM1
		Engine water temperature	ET1
		Engine temperature alarm	EDC2BC
		Engine Shutdown	EDC2BC, BCAO1
		Cruise Control	BC2EDC, CCVS_ENG, TCO1
		PTO Control	BC2EDC, CCVS_ENG, TCO1, EEC1
		Engine Oil Pressure Display	EFL_P1
		Engine Oil Pressure Low	EDC2BC
		Engine intake preheating instructions	EDC2BC
		Engine brake lights	ERC1
		Engine speed indication	EEC1
		Brake pedal switch signal	CCVS_ENG
		Clutch switch signal	CCVS_ENG
		Engine fuel consumption	Request
		Engine hours	Request
		OBD light control	EDC2BC, DM1
		Emission monitoring system operating conditions	AMB, ET1
		OBD system operating conditions	AMB, ET1
		Urea injection management	EEC1, LFE, AMB
2	ABS	ABS fault code display	DM1
		Amber and red warning lights warning lights	EBC1
		ASR Status	EBC1
		Bridge speed	EBC2
		Wheel pressure limit information	EBC3

		Brake control information	EBC5
		Retarder fault code display	DM1
3	Retarder	Retarder indicate status Cruise control off request	PROP_IT3
		Electronic Retarder Control 1	ERC1

4. Test system software

4.1 Software design framework

The system uses the Vector's CANoe.J1939 software in German to develop. This software consists of CANdb++ Editor, CAPL Browser, Panel Editor & Panel Designer and other components. Software system design diagram shown in Figure 3:

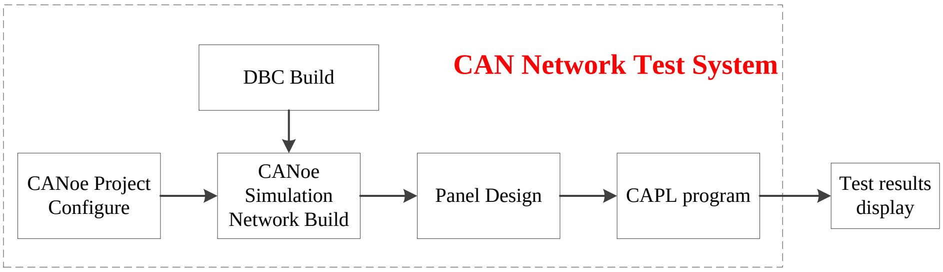

Figure 3 Software system design diagram

(1) CANoe hardware configuration. Build project in CANoe, configure the number of channels and baud rate. In this paper, the baud rate is 250kbit/s.

(2) DBC database creation. DBC database contains vehicle ECU name in the network nodes, message information of each node and environment variable configured for panel definition.

(3) Simulation model configuration. Import .dbc file into Simulation Setup window, add the network nodes. In the system, we add Engine1, BrakesSystemController, RetarderDriveline as simulation node to form the final simulation model. The simulation model structure shows in Figure 4:

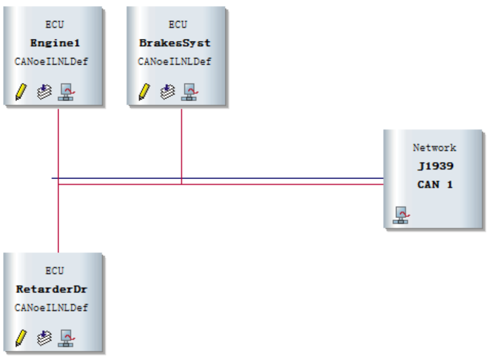

Figure 4 simulation model structure

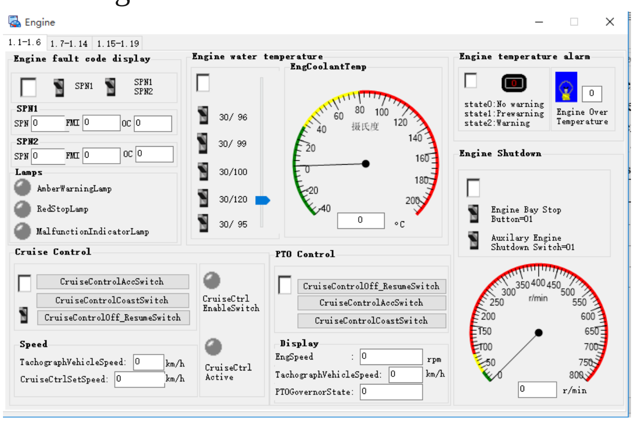

Figure 5 part of the test system panel

(4) Visual interface configuration. Add combined controls to Panel Designer to achieve graphical operating and status display. The combined controls in the panel bundles with environment variable which includes display type and control type used to display information and control. The panel of the test system shows in Figure 5:

(5) CAPL programming emulation. Write code with CAPL Browser to simulate the control operation of the ECU.

4.2 Test Project software implementation

In this paper CAPL (CAN Access Programming Language) is selected as the programming language. CAPL is a C-like language used to implement the development of the CAN bus in CANoe. CAPL is an event-oriented programming language that can be triggered based on events, such as bus events, key events, and time events. In CAPL, programming can be done to realize the control of panel.

An example of Engine fault code display shows the CAPL programming process. Program flow chart shows in Figure 6. At first, enter start () to set the default information and then start the test program to scan the timer T1 whose scan time is 10ms. If the detected test item variable is 1, then jump into the function engine1_01 () to start sending emulation information. In this test item, three cases are tested, which are default, simulation of one engine fault codes and simulation of two engine fault codes. After the test of this item, re-scan the other test projects.

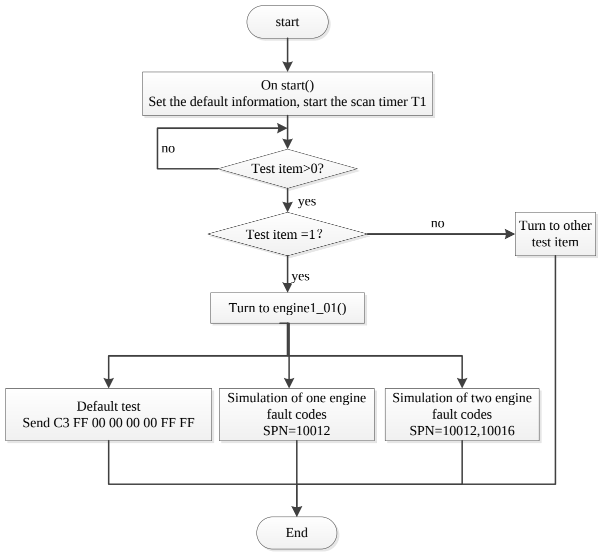

Figure 6 Engine fault code display program flow chart

5. System testing

After the above steps completed, combining CANoe and the vehicle network with CANcaseXL can realize the test for network performance and ECU function. Run CANoe and click the buttons on the engine panel can test the corresponding item. In the test item of Engine fault code display, control button variables are switch variables. In the test item of Engine water temperature, control button variable is a continuous volume.

Take engine fault code display item for example, test content is listed in table 2, divided into three test cases to simulate, which are default, one engine fault codes and two engine fault codes. Test results require that signals changes can be tracked in the trace window of CANoe, the corresponding fault code can be find in the instrument, the corresponding DTC information can be displayed on the DTC Monitor of CANoe, and the corresponding indicator can lights in the panel.

Table 2 engine fault code display test content

Project	Message	Test item	Remark
Engine fault code display	DM1	Send C3 FF 00 00 00 00 FF FF	Default send
	DM1	Setting enable switch to simulate a single engine fault codes SPN = 10012 Set fault mode = 04 Setting Amber Lamp status = 01 Setting Red Stop Lamp Status = 00 Setting the number of faults = 01 Setting MIL status = 00	
	DM1	Setting enable switch, simulate two engine fault codes SPN = 10012,10016 Set fault mode = 04 Setting Amber Lamp status = 00 Setting Red Stop Lamp Status = 01 Setting the number of faults = 01 Setting MIL status = 01	

From the test result, we can see that the simulation test results and simulation testing requirements fully consistent. In the electrical/network system platform, the corresponding fault code can be searched in the instrument which means the DM1 message can be received correctly on the bus, and the communication of the system is normal. The simulation results shows in Figure 7-9:

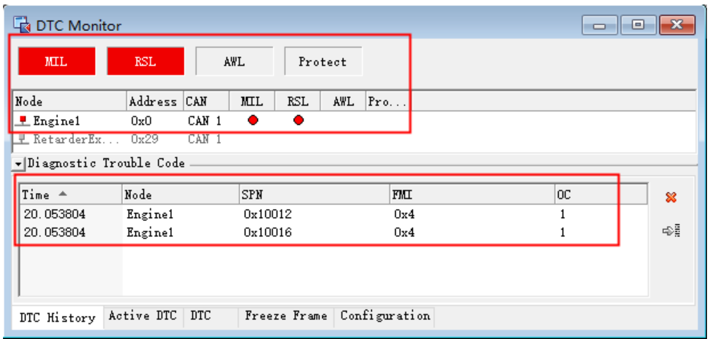

Figure 7 DTC Monitor display window

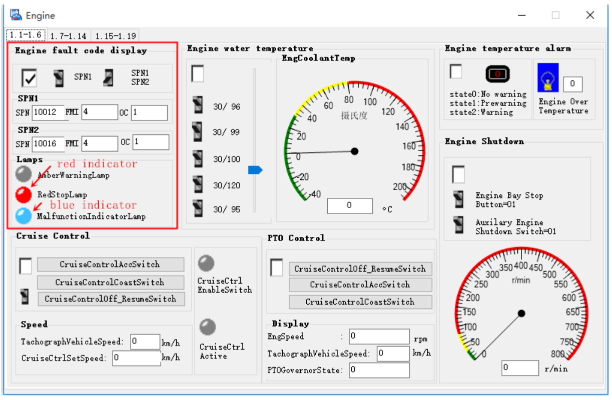

Figure 8 Engine Panel display

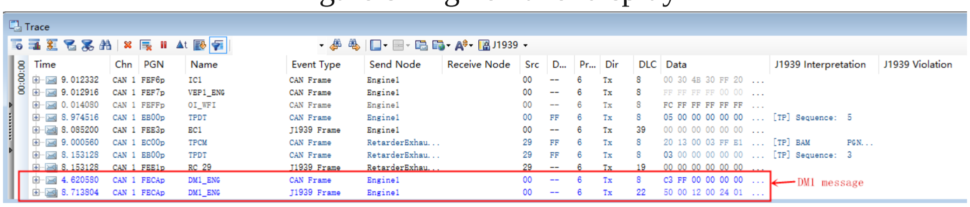

Figure 9 Trace window display

6. Conclusion

This paper introduces the development process of truck CAN network based on HIL. Through the simulation of engine node and others by CANoe, the communication test of the vehicle network platform and function test for ECUs are realized. Test results shOw that the system can meet the requirements of the OEM for the vehicle network test.

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