A CAN Bus Automatic Test System

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Abstract. In order to ensure the quality and stability on the CAN bus products，an automatic test system for CAN bus conformance testing is introduced, which allows the tester to execute the test validation automatically. CAN bus test module, test programs and some special test tools constitute the test system. All of the physical layer testing, data link layer testing, robust testing and communication testing are supported by the test system. Finally, this paper verifies the feasibility and functional integrity of the test system.

Introduction

CAN(Controller Area Network) is an asynchronous serial network protocol with using a bus topology, it is the most popular communication way on the vehicle in recent years. However, a little deviation of understanding between the CAN controller manufacturers and CAN transceiver manufactures is likely lead to the communication problem among the device[1]. Therefore, the quality and stability of communication are the most important performance parameters for a CAN bus products.

The most effective method for insuring the quality of CAN bus products and solving the product's design flaws is to set up a complete test validation mechanism for CAN bus products. When perform the test validation, the conformance testing is necessary, which is a black box test method and evaluate the DUT by the DUT's external performance[2]. To ensure the validity of the test, rigorous test specifications and standardized test process should be specified. However, the more test requirements there have, the more test cases needs to be tested. Therefore, developing an automatic test system is much necessary[3].

In foreign, some of the universities, companies and organizations had did a lot of work on the automatic test system for CAN bus conformance testing, Germany conducts the research in the automotive network bus test earlier than others. In china, the CAN bus conformance testing is still a minority research.

This paper introduces an automatic test system, which allows the tester to execute the test validation automatically. Besides, All of the physical layer testing, data link layer testing, robust testing and communication testing are supported by the test system.

Test specification. The test specification is a program for the entire test process, which has a highly instruction for standardizing the test process. All of the requirements which refer to the test should be defined in the test specification, such as the test purpose, test scope, test condition, test method, etc. Considering the difference among the test objects, the test is dived into physical layer testing, data link layer testing, robust testing and communication testing.

Before establishing the test specification, the following two things should be done first:

I. Researching on the CAN standard protocol ISO11898, which is the most fundamental work for formulating the specification.

II. Studying on the test specifications which were already applied in recent years, e.g. the international standard test specification.

In this paper, the test specification was generated based on the ISO11898 and some of the famous automobile companies' test specifications, all of the test cases are common and available.

Architecture and functional requirements of test system. In order to design the architecture of the test system, some of the current popular test systems are referenced[3,4,5]. Finally, the architecture of test system is designed as Fig.1.

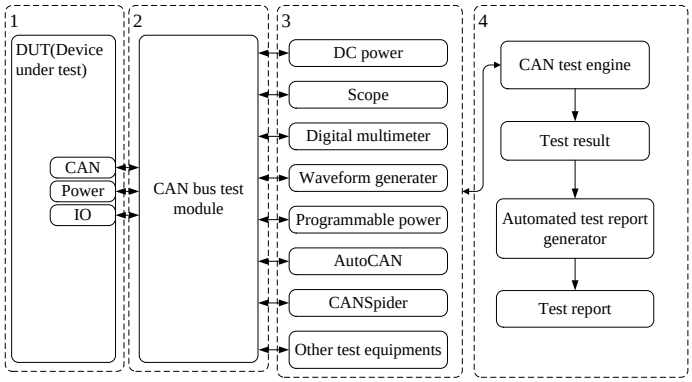


Fig.1 The architecture of CAN bus test system

In the architecture of Fig.1, all of the following functions should be meet:

I. The test system should able to set up all of the test circuits for each test case.

II. The test system should able to connect all of the test tools to a special test circuit if possible.

III. The test system should able to connect all of the DUT's pin to the test circuit if possible.

IV. All of the commands must be executed correctly, e.g. opening a relay.

V. The deviation of the test result should within a allowed range, e.g. -5%~+5%.

Hardware design. As described in Fig.1, the test system is divided into four parts, three parts should be completed in test system except part 1, which is provided by the supplier. Besides, part 2 is the hardware design work for the test system. In order to meet the requirements for all of the test cases and easier the design work, this paper divides the CAN bus test module into six basic function modules, which are listed in the Table 1. Besides, Fig.2 describes the CAN bus test module's architecture.

Module name	Function description
Power supply module	Power supplying for DUT with a variety of power supply mode, e.g. Over voltage supply and under voltage supply. Crank voltage simulation and power supply current monitor.
Signal generating module	Providing a signal source for other modules, e.g. Providing a pulse for an amplifier circuit.
Measurement module	Measuring the voltage or current of some key positions.
Physical layer basic character test module	Setting up a basic CAN communication circuit, creating an offset voltage on CAN wire and generating a variable voltage between CAN_H and CAN_L.
Physical layer fault tolerance test module	Generating fault event on CAN bus, e.g. CAN_H short to ground, CAN_H short to CAN_L.
Control module	Executing the remote control commands correctly, e.g. setting up a test circuit for the minimum supply voltage test.

Table 1 The basic function module's descriptions of the CAN bus test module

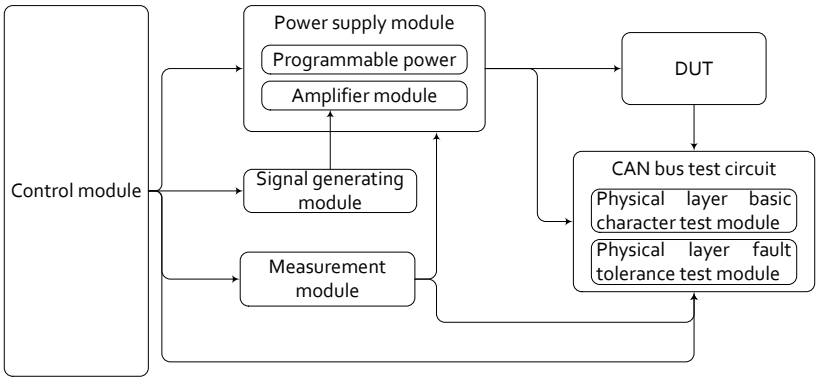


Fig.2 Architecture of the CAN bus test module

As described in Fig.2, the signal generating module provides a signal for the amplifier module, and the amplifier module is a part of power supply module. The power supply module is combined by programmable power and amplifier module, it provides power supply for DUT and CAN bus test circuit. The CAN bus test circuit is combined by physical layer basic character test module and physical layer fault tolerance test module, which is responsible for setting up test circuit for the test cases. The measurement module is responsible for monitoring the current or voltage for both power supply module and CAN bus test circuit. Finally, the control module is responsible for deciding whether connect one basic function module to the test circuit and changing the test circuit once it receives command from the computer.

Software design. Since the test system allows the tester to execute the test validation automatically, the following two things must be done:

I. Developing a driver for the CAN bus test module, which ensure the CAN bus test module execute the control command correctly, e.g. setting up a minimum supply voltage test circuit.

II. Developing a test program for each test case, which is responsible for achieving a specific test requirements, e.g. calling for the scope measure the differential voltage of CAN wire and generating a report.

As described in Fig.2, the CAN bus test module driver is used for response to the computer correctly and changing the test circuit once it receives the command. Therefore, the work for the driver is to change the state of the ECU IO interface. Fig.3 describes the architecture of the CAN bus test module driver.

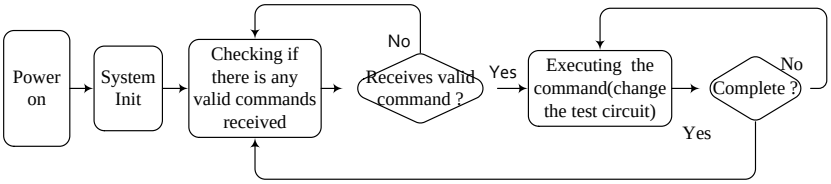
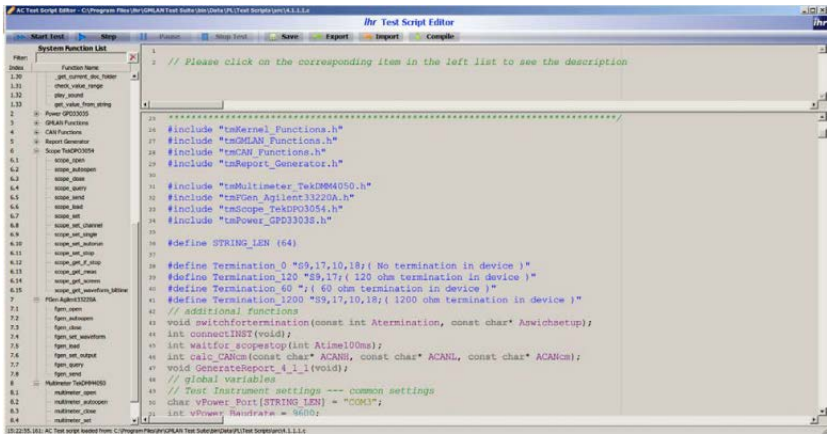


Fig.3 The architecture of CAN bus test module driver

Since the test case is used for measuring the character of the DUT, each test case has a different requirements. Therefore, the development of the test program is nearly entire different from each other. However, with the help of *ihr test script editor*[6], developing the test program is much easier, many useful commands are provided by it, such as calling the scope, opening the programmable power supply, etc. Besides, C programming is also supported. Fig.4 is the editing interface of the *ihr test script editor* and Fig.5 describes the program process for each test case.



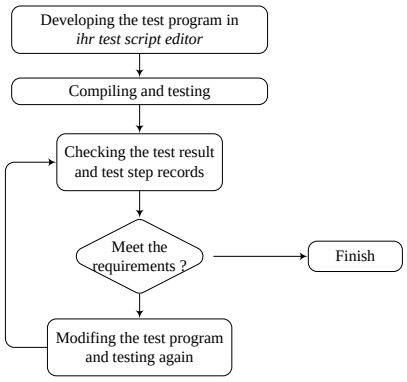


Fig.4 Editing interface of *ihr test script editor*

Fig.5 Program process for a test case

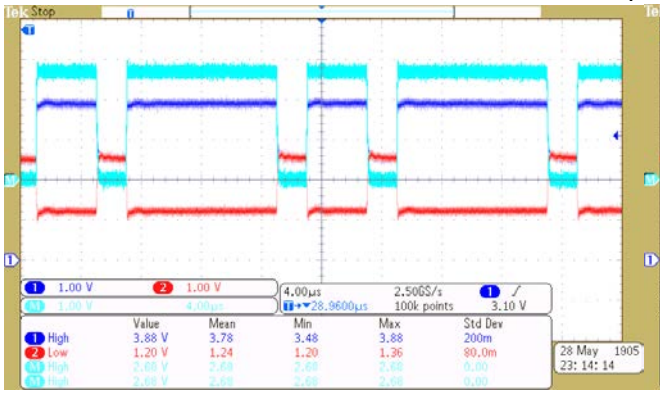
The analysis of test result. According to the requirements of the test system, Fig.6 is the final form of the test system, which integrates all of the test components, such as the CAN bus test module, scope, programmable power, *AutoCAN*[6], *CANSpider*[6], etc.

Fig.6 Final form of test system

The validation of physical layer testing(dominant output voltage levels of CAN bus). The scope of this test case is used for measuring the CAN bus output voltage levels in dominant state and check whether the levels meet the specification requirements. Table 2, Fig.7 and Fig.8 are the records for the test result. As the test result shows, the test system gets the right scope screen image, and reads the right value from the scope and outputs to the test report. Besides, the rating of the test result is also correct.

No.	Acceptance Criteria	Test Result			Rating
1	$2.75\ V \le V_{CAN\_H} \le 4.5\ V$	V_{CAN_H} =	3.88~3.88	V	OK
2	$0.5\ V \le V_{CAN\_L} \le 2.25\ V$	V_{CAN_L} =	1.20~1.20	V	OK
3	$1.5\ V \le V_{diff} \le 3.0\ V$	V_{diff} =	2.68~2.68	V	OK

Table 2 Test result of CAN bus output voltage levels for dominant state



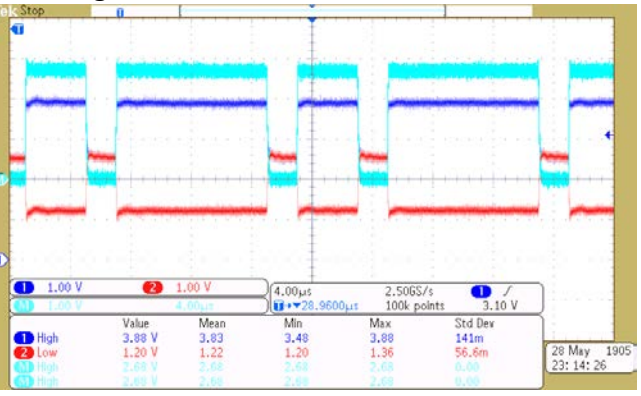


Fig.7 CAN dominant output voltage level at 60R

Fig.8 CAN dominant output voltage level at 45R

Conclusion

The test system allows the tester to execute the test validation automatically, it can be used for the CAN conformance testing, all of the physical layer testing, data link layer testing, robust testing and communication testing are supported, and all of the test requirements can be meet. Besides, it is a good reference for the development of the future test system.

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