

Using VT System for Automated Testing of ECU

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Abstract: This paper presents an automated method of testing an Electronic control unit (ECU) of a car headlamp by simulating the loads and sensors that the ECU is built to control. Testing of an ECU in every phase of development is very important as the ECU is produced for performing many complex and critical tasks related to particular loads and sensors. And it is cheaper and easier to correct errors detected in early stages than those detected in later stages of development. So the ECU must undergo in-depth and comprehensive testing. The simulation of the loads and sensors are done using a Vector tool called VT System. It is important for the ECU to be in an environment that closely resembles that of the real vehicle. VT System fulfills these needs. The VT System is a modular I/O system that drives ECU inputs and outputs for functionality related testing with CANoe. It is able to create faults which should be detected by the ECU and display an error code. This is a way of partly testing an ECU. The use of software tool CANoe for simulation of other ECUs in a car is well-suited for tests on all development levels, due to its high scalability and flexibility. Automated testing includes faster test execution, higher accuracy and the reusability of tests. The ECU's I/O lines and any necessary sensors and actuators are connected to the VT System modules. The PC with CANoe is connected to the real-time Ether CAT via the computer's Ethernet port. This lets users set up flexible test systems with little integration or wiring effort.

Keywords: CA Noe, ECU, loads & sensors, simulation, VT system

I. Introduction

To satisfy the ever increasing needs for safety, comfort, and environment protection of today's vehicles, the Electronic Control Units (ECU) and various sensors are getting more and more complex [1], [2], [3]. Today's Vehicles are increasing in intelligence because of the increase in number and type of electronics. The more the vehicles inculcate electronics, the more likely will increase the number of bugs. Electronics components have become the essential part of today's vehicle. With the increase in number of ECUs used in vehicles and the convolution of ECU software, the number of bugs attributed to software is much higher than the bugs in mechanical and electrical systems.

There are several testing loops occurring in the development phases of an ECU. In an ECU development cycle, around 8 to 10 validation loops will be built. During a period of 3 years, each loop is a different sample [4]. For the development of ECU, it is important to have a proper validation process, able to find all the bugs early in the stage of the ECU's development.

Testing the functionality of ECU includes simulating it via software and hardware interfaces and evaluating its responses. It is important for the ECU to be in a surrounding that closely resembles that of the real vehicle, and most important is that the ECU should not be able to detect any difference between the actual environment in the vehicle and the simulated environment of the test bench. The use of tool CANoe for simulation of other ECUs in the car is well-suited for tests on all development phases, due to its high scalability and flexibility.

Manual testing is performed by an engineer using the software tool in the computer, carefully executing the test steps constructed based on the requirements. Manual testing is time consuming and may not be very accurate. Test Engineer may feel it as a very tedious work as he has to test the same requirements in all the development phases of an ECU. So, automating these testing processes can help a lot for the Test Engineer.

Automation Testing is using an automation tool to execute the test case suite. The automation software can also enter test data for the parameters in the services of an ECU, compare expected and actual results and generate detailed and validated test reports. Test Automation demands considerable investments of resources and money. Successive development phases will require execution of same test suite repeatedly. This is reusability of the test cases. Using a test automation tool called VTestStudio it is possible to document this test suite and use it as required. Any human intervention is not required once the test suite has been automated.

The VT System is modular hardware for accessing ECU hardware inputs or outputs for testing purposes. The VT System can be easily integrated with CANoe and the test cases are scripted in VTestStudio. The actuator and sensor connections of the ECU to be tested are linked directly to the VT System modules. And ECU is also connected to CANoe through CAN case VN1610 for Understanding and visualizing CAN communication [5] between real ECU and simulated ECUs.

1. System Design Of Testing Environment

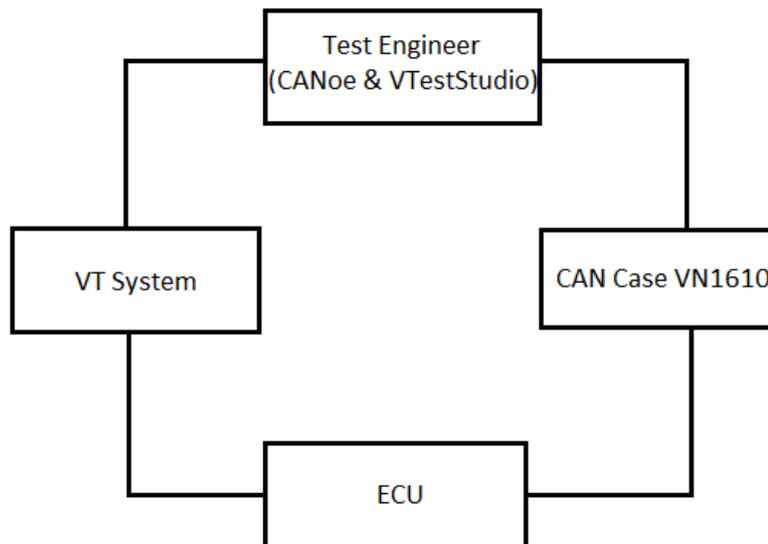


Figure 2.1 System Design of Testing Environment

All the pins of the ECU are connected to the particular modules of the VT System as per the requirements. VT System is connected to the computer through Ether CAT cable. CANoe will contain the database which has the messages to be transmitted between several ECUs, .cdd file containing the diagnostic services of the ECU and the other simulated ECUs attached to the periphery bus. CANoe with other simulated ECUs in the car is opened and then VT system configuration panel is opened in CANoe. All the modules connected in the VT System are added to CANoe. All the modules are configured as per requirements. For e.g. VT7001A module is configured with the supply mode as “sup1” as it is connected with the external power supply. CAN pins from the ECU are connected with the CAN case VN1610 and then the CAN case is connected to the computer using its USB cable. After this minimum setup, VTestStudio software is opened with the CANoe configuration imported to it. After importing the VTestStudio will contain the Messages present in the database, diagnostic services present in the .cdd file and the parameters of the VT System modules. Now the VTestStudio can be used to write test cases with having access to messages, diagnostic services and the VT System module parameters.

1.1 Electronic Control Unit

An Electronic control unit is a unit that controls a series of actuators inside a car. There can be one or more ECUs inside a car to control its functionalities. ECUs inside a car will be connected to each other through a communication bus. Here the ECU mentioned is a headlamp ECU which is capable of actuating the LED loads of a headlamp in a car. It is connected to other ECUs using CAN bus. An ECU will contain a connector with several pins to connect it to the headlamp. An ECU will contain microcontroller, memory, inputs such as supply voltage, Analog inputs and Digital inputs, outputs and communication links (CAN lines).

1.2 CAN case VN1610

The VN1600 interface set is an advanced version of CANcaseXL, which is a flexible and cost-efficient solution for CAN applications. The VN1600 interface set provides multi-application functionality that supports simultaneous operation of several different applications on one single channel, e. g. CANape and CANoe. Tasks accomplished by CAN case range from simple bus analysis to complex bus simulations also calibration, diagnostic, and reprogramming tasks. CAN trace window in CANoe software will display all the messages and diagnostics that is being transmitted between several ECUs over the CAN bus with the help of the connected CAN case VN1610.

1.3 CAN Protocol

CAN is abbreviated as Controller Area Network. It is a serial communication protocol. In automotive electronics, sensors, engine control units, etc. are connected using CAN. The purpose of this spec is to achieve compatibility between any CAN implementations. To achieve design implementation flexibility and transparency CAN has been subdivided into three different layers: (1) The object layer (2) The transfer layer (3) The physical layer The object and the transfer layer include all functions and services of the data link layer. The

scope of the object layer comprises of (1) Messages being transmitted (2) Deciding which received messages are actually to be used (3) Provide an interface to the hardware related to application layer

The scope of transfer layer is the transfer protocol, i.e. error checking, controlling the framing, and error signaling performing arbitration, and fault confinement. Within the transfer layer it is decided whether a reception is just initiated or whether the bus can start a new transmission.

The scope of physical layer is the actual transfer of the bits. And it takes place between the different nodes with respect to all the electrical properties.

1.4 CA Noe

CANoe is a robust software tool for ECU and bus simulation, bus analysis, and test automation. In CANoe the overall system is shown graphically with the CAN bus and all network nodes. CANoe is attached with CAN database containing all messages and .cdd file containing all diagnostic services. Start the measurement and CANoe will immediately begin to transmit the message cyclically configured in the generator block.

1.4.1 CAN Database

The CAN database defines the network nodes containing the CAN messages transmitted and received by them and the signals within each message. The names in this database can be imported in the VTestStudio for application in test cases and can also be used throughout the CANoe configuration. For example, displaying signal values in CANoe's graphical output windows, or creating test cases in the VTestStudio.

1.4.2 Diagnostics

A car consists of several CAN bus systems. A Candela Diagnostics Data file with extension .cdd is attached to the CANoe configuration which contains all diagnostic services allowed for addressing an ECU's diagnostic system to obtain diagnostic information. These services are then output by the diagnostic tester to establish diagnostic communication. As soon as a request is sent, the addressed ECU(s) react with either a positive or negative response.

1.5 V Test Studio

The VTestStudio software tool is an adaptable and integrated work environment for developing test cases for embedded systems. It is accomplished with 4 kinds of editor for writing test cases. The one being used here is the VTest Table editor. VTest Table editor is used as it is easy to use and can compress several lines of codes written in CAPL. It is a command based editor. One more advantage of VTest Table is that CAPL code can also be attached in this editor. It need not require any programming expertise as well.

1.6 VT System

The VT System is a hardware tool for testing. It is capable of accessing ECU's I/O for testing purposes. It is accomplished with specific test and simulation accessories like decade resistors and electronic loads. Another benefit when using the VT System is that all the required test hardware is contained in the modules. Thus there is no additional hardware needed when setting up a test bench.

The VT System is connected to ECU's particular pins instead of the real loads such as LED channels in the headlamp. The loads and sensors are simulated by the VT System modules or panels. However these modules can also be connected to the original actuators and sensors. All equipments required for testing the connected ECU inputs or outputs are integrated into the VT System modules.

The functions of VT System are (1) It can be used to simulate loads or sensors (2) It has relays for switching different signal paths (eg. internal or external load) (3) It can be used to create faults such as short circuits between the two signal lines and signal to ground or battery voltage (4) It also acts as a measuring unit with signal conditioning (5) It is possible to connect additional measurement and test devices via two additional bus bars (6) It displays status clearly on the front panel.

The ECU's output signals are measured and processed, and are passed to the test cases in VTestStudio in processed form so that they can be printed in the test report generated after the test cases are executed.

The VT System is accomplished with one or more 19" racks with a backplane to which the VT modules are inserted. The backplane takes the lower quarter of the back of VT; the module connectors are accessible in the upper region. The ECU wired lines and original loads can be plugged directly into these connectors. VT System is connected to CANoe through an Ethernet cable. The backplane links the EtherCAT bus and the power supply to the inserted VT modules.

There are several modules available, we can choose and use the appropriate ones but VT7001 module is must, as it is the power supply module. VT1004 module used for simulation purpose (Eg. Simulation of LED lights in headlamp) or even actual loads can be connected. Resistance values must be calculated and adjusted by

checking the current and voltage consumed by the actual load for simulating the actuators. VT2816 module can be used for current and voltage measurement. VT2820 is a relay module which can be used for creating faults or switching different lines of connections.

II. Conclusion

The concept of an automated test environment for ECUs using VT System described in this paper have become a necessary link in the development phase of the ECU. ECUs can be tested even before the production of the component to which it is going to be attached. VT System provides accurate measurement and test results. Since the test cases are automated, they can be executed and report can be generated and documented in all the development phases of the ECU. Proper documentation can be done in this environment effortlessly. Process of simulating the loads using the modules of VT System is not that easy and accurate. For e.g. Actual loads may be semiconductor load but the loads can be simulated only using resistive loads.

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