"V-TEST for FlexRay" – Verification Tool for the FlexRay Communication System

FUKUDA Noritaka, KANEDA Yukinori

Abstract

Considering the rapid progress of electronic control and networking of In-vehicle systems, the adoption of FlexRay is underway as a communication standard of the next generation. NEC Communication Systems, Ltd. have developed and announced V-TEST for FlexRay as the first demonstration tool in Japan for use with the FlexRay communication system. V-TEST for FlexRay incorporates functions that match the characteristics of FlexRay to improve the efficiency of FlexRay network design and the verification of In-vehicle systems.

1. Introduction

In order to support recent improvements in the safety, reliability and performance of automobiles, the electronic control of In-vehicle and car body and the related networking of electrical control units (ECUs) are currently making rapid advances. However, as a result of this trend the increase in the number of ECUs and their associated networking requirements have tended to result in increased costs and communication bandwidth insufficiencies that are posing serious difficulties. In order to deal with this matter the FlexRay Consortium established FlexRay as a next-generation In-vehicle communication standard, featuring high reliability and high-speed communication compatibility and the specifications were made public in 2004. At present, the automobile industry is examining the possibility of the future adoption of FlexRay.

At NEC Communication Systems, Ltd., we began to provide total verification solutions for the embedded systems market that covers In-vehicle and mechatronic equipment in 2004. Then, in 2005, we developed and announced V-TEST for FlexRay, which is a tool for use by the automobile industry for the verification of FlexRay-based In-vehicle communications systems. This paper is intended to describe the configuration and architecture of V-TEST for FlexRay together with its functions and features.

2. V-TEST

Our Systems Solutions Division had previously developed V-TEST (Verification Tool for Embedded SysTems), which later became the basis of V-TEST for FlexRay. V-TEST was a tool for improving the efficiency of verification of the hardware/software coordination of embedded systems as well as of the systems themselves. In the following we would like to begin the description with that of V-TEST.

2.1 Configuration and Main Functions of V-TEST

Fig. 1 shows the configuration of V-TEST.
As shown in Fig. 1, V-TEST is composed of two modules; 1) the PC Control Module that runs on the PC to control the user interface and verification procedures (evaluation scenarios) and; 2) the Execution Module that runs on the CPU board on which the evaluation targets (mainly the control LSIs) are packaged to perform setup of the evaluation targets and collect the evaluation results. The main functions of V-TEST are as follows.

(1) Evaluation Target Setup Function
This function consists of the user operation for setting values in the registers and memories of the evaluation targets.
(2) Evaluation Target Status Recording Function
This function consists of the user operation for reading and recording the values of the registers and memories of the evaluation targets.
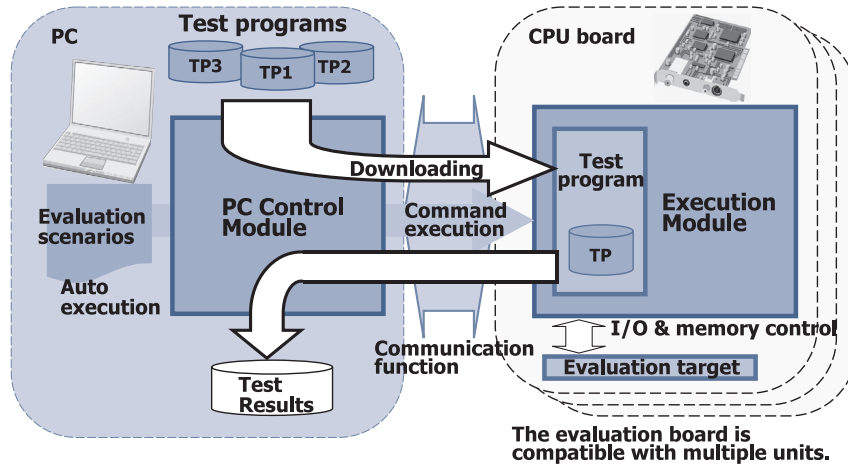
Fig. 1 Configuration of V-TEST.

(3) Evaluation Scenario Function

In evaluation using V-TEST, the user should repeat operations (such as setup and readout of values) on the registers and memories of the evaluation targets using the evaluation target setup and evaluation target status recording functions for several times, but this leads to an increase in the frequency of occurrences of operational mistakes. The evaluation scenario function compiles the operations performed by the user on the PC Control Module into an evaluation scenario file and executes that file when evaluation is required. This function can reduce the operation mistakes and enable re-evaluation by reusing the same evaluation scenario file. With V-TEST, this function is also capable of recall from an evaluation scenario as well as of performing automated or long duration evaluations based on the successive execution of evaluation scenarios.

(4) Test Program Functions

Apart from the evaluation in which the user performs the evaluation operation using the evaluation target setup and evaluation target status recording functions, V-TEST also offers an evaluation method in which a test program is created in advance and downloaded in the memory on the CPU board for execution. An evaluation using the test program function is mainly used when it is required to record the values of the registers and memories of the evaluation targets in real time. The test program function allows the values in the evaluation target registers/memories at minimum intervals of 20μseconds.

(5) Address-Symbol Conversion Function

When the address information in the evaluation target registers/memories and/or the CPU board memory is changed, the user should usually correct the existing evaluation scenarios.

However, considering that it is important for V-TEST to be capable of using the evaluation scenarios that have been used before without correction, we decided to provide the address-symbol function. This function converts the addresses in the evaluation target registers/memories and CPU board memory into symbols, manages the correspondence between addresses and symbols in a separate file and references this file as required. **Fig. 2** shows an example of a symbol definition file that shows the correspondence between the addresses and the symbols.

When the user specifies symbols in the evaluation target setup or evaluation target status recording function, the symbols are converted into addresses by referencing the symbol definition file in the PC Control Module, and these addresses are used in the control (setup and readout of values) of the evaluation target registers/memories and CPU board memory. This function allows the users to use the existing evaluation scenarios by simply change the symbol definition file, without correcting the existing evaluation scenarios, even when addresses of the evaluation target registers/memories and/or CPU board memory are changed.

```
#Symbol name     Address、Bit location, Bit width
CCSV_POCS        0x0201010C, 0, 6
SCV_SCCA         0x02020120, 0,11
MTCCV_CCV        0x02040840,16, 6
```

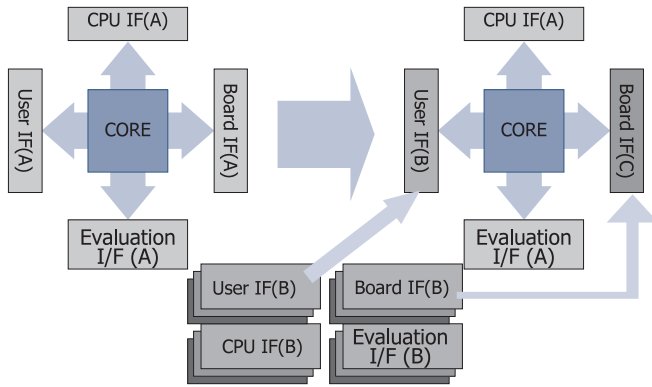Fig. 2 Example of symbol definition file.

Fig. 3 Concept of V-TEST architecture.

2.2 Architecture of V-TEST

An embedded system handles a wide variety of CPUs and LSIs as well as external interfaces on the CPU board. To deal with the widely variable environments V-TEST adopts a component architecture as shown in **Fig. 3**.

Fig. 3 shows that V-TEST is composed of the following five components. The four components other than the CORE component can be changed according to the environment.

A brief summary of each component follows:

(1) CORE
This component implements the main functions of V-TEST. It cannot be altered.

(2) Evaluation Interface
This component implements operations (setup and readout of values) on the registers and the memories of the evaluation targets. This component should be changed when the evaluation targets are changed.

(3) User Interface
This component implements the user interface. It should be changed when it is required to change the user interface.

(4) Board Interface
This component implements interfacing between the PC and CPU board. It should be changed when the external interface of the CPU board is changed.

(5) CPU Interface
This component controls the CPU initialization and the interrupts on the CPU board. It should be changed when the CPU is changed.

3. V-TEST for FlexRay

As described in Section 2 above, the V-TEST embedded system verification tool adopts component architecture in order to deal with various environments. We have therefore developed V-TEST for FlexRay by using the same architecture, adding the V850E/IAI version by NEC Electronics Corp. as the CPU interface and the FlexRay communication controller version as the evaluation interface. **Fig. 4** shows the configuration of V-TEST for FlexRay.

As shown in Fig. 4, each Execution Module of V-TEST for FlexRay runs on the FlexRay evaluation board on which each FlexRay communication controller, which is the evaluation target, is mounted. Meanwhile, the PC Control Module runs on the PC in a similar manner to V-TEST. Since V-TEST for FlexRay needs to control multiple FlexRay evaluation boards for evaluation of the FlexRay communication system, it is also provided with a function that allows the single PC Control
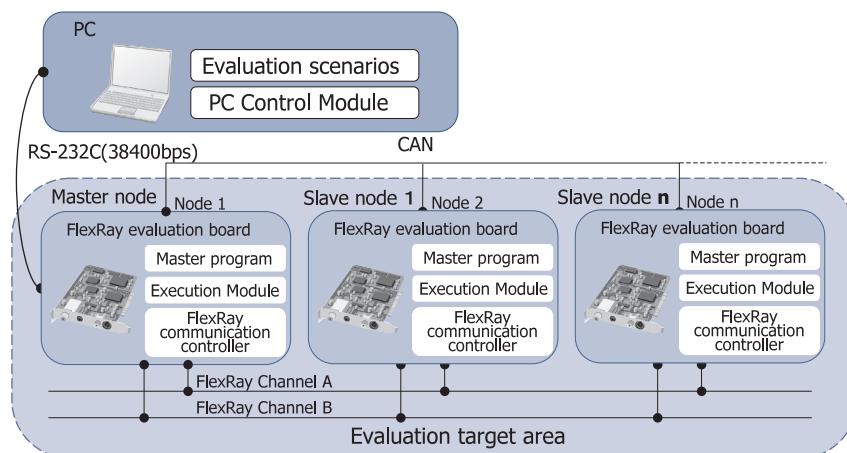

Fig. 4 Configuration of V-TEST for FlexRay.

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Module to control multiple Execution Modules. The control of multiple Execution Modules is made possible also by using the CAN (Controller Area Network) for interfacing between the FlexRay evaluation boards and the RS-232C for interfacing between the PC Control Module and the Execution Modules.

In developing V-TEST for FlexRay, we implemented some functions in addition to those of V-TEST by considering the following two points.

1) FlexRay defines more than 100 network parameters and the FlexRay communication controller supports almost all of the network parameters.

2) The CPU interrupt is supported in interfacing between the FlexRay communication controller and CPU.

3.1 Additional Function of V-TEST for FlexRay

(1) Addition of the FlexRay Communication Controller Setup Function
This function allows the user operation to set up values in the registers and memories of the FlexRay communication controllers.

(2) Addition of the FlexRay Communication Controller Status Collection Function
This function allows the user operation to read and record the values in the registers and memories of the FlexRay communication controllers. To support successive readouts of network parameters, the area read function based on the read target and read area specifications has also been added.

(3) Enhancement of the Evaluation Scenario Function
This function of V-TEST has been extended for FlexRay so that all of the newly added functions can be activated from the evaluation scenarios.

(4) Enhancement of the Test Program Function
Since the FlexRay communication controller utilizes interrupts, this function has been extended so that it supports the interrupt type test programs that are run by interrupts. The interrupt type test programs can be created and used in the same way as ordinary programs except that they should be described using symbols that have been defined in advance. When an interrupt occurs, V-TEST for FlexRay controls entirely the execution of the interrupt type test program corresponding to that interrupt. The support of interrupt type test programs has made it possible to collect the status in the case of an error with the FlexRay communication as well as to modify the send data according to the communication status.

(5) Addition of the FlexRay Communication Controller Initialization Function
The FlexRay communication controller supports more than

100 network parameters, and it is required to set about 60 network parameters in order to perform evaluation. In addition, it is also required to change the network parameter values every time the network is changed.

Although the above settings are possible using the FlexRay communication controller setup and evaluation scenario functions, this leads to increases in the time required for set-up and in the probability of setting mistakes. Therefore, we added a function for initializing the FlexRay communication according to the FlexRay communication controller initialization data file that has been created in advance using a specific file format.

(6) Addition of the FlexRay Communication Controller Data Collection Function
This function automatically collects the send/receive data and the values of the registers and memories of the FlexRay communication controller. It makes it possible to record the FlexRay send/receive data and the FlexRay communication controller status during execution of a test program.

V-TEST for FlexRay supports the following setup items for this function;
· setup of the collection target registers;
· setup of the FlexRay send/receive data filtering;
· setup of the recording format;
· setup of the collection timing.

3.2 Effects of V-TEST for FlexRay

The functions described in Section 3.1 above bring about the following effects for verifications using V-TEST for FlexRay.

(1) Improvement of the FlexRay Network Design Efficiency
Usually, when designing a network, the network designer repeats the cycle in which checks are made of the results of a specific design on an actual network and then feeds back the results to the network design. Since FlexRay has a very large number of network parameters, the number of network design process steps would tend to increase because the network designer repeats the cycle of operation check and feeds back the results to the design multiple times. However, when V-TEST for FlexRay is applied to network designing, the work loads can be reduced because the operation check on the actual network is facilitated thanks to the FlexRay communication controller initialization and test program functions.

(2) Reduction of Evaluation Period of FlexRay Communication System
When we applied V-TEST for FlexRay in the evaluation of an actual FlexRay communication system, we were able to

complete evaluation in about 1/5th of the time period expected in advance because we could evaluate the daytime and nighttime operations by using the evaluation scenario function and reuse the previously used evaluation scenarios and test programs. Similar effects can also be expected in the evaluation preparation period as well as in the evaluation period even when the evaluation environment and/or evaluation targets are changed in the future.

4. Conclusion

Our Systems Solutions Division developed and announced V-TEST for FlexRay as the first product of this kind for the automobile industry by making full use of our expertise in the development of communication systems. To strengthen the solution development power to the automobile industry, we joined 'JasPar'. We intend to continue the provision of total verification systems for use with In-vehicle systems and also to release new development environments and verification tools aiming at contributing to improvements in the QCD of In-vehicle systems.

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*FlexRay is a registered trademark or trademark of Daimler Chrysler AG in Japan and other countries.

Authors' Profiles

FUKUDA Noritaka
Manager, Embedded Systems Solutions Division,
NEC Communication Systems, Ltd.

KANEDA Yukinori
Assistant Manager, Embedded Systems Solutions Division,
NEC Communication Systems, Ltd.

●Product introduction: V-TEST for FlexRay
Related URL: http://embedded.ncos.co.jp/v-test/
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