

Hardware In Loop The Validation for Multiple ECUs

Rupak Kumar[1)] · Eunjeong Kim[1)] · Kyeong Jin Song[1)] · Kyong Sik Kim[1)] · Seong Ku Seo[1)]

Mando Corporation[1)]

Abstract : HIL Testing is a widely used method for validating an automotive ECU software. As the ECU nodes are connected to form a network inside the vehicle, the HIL validation of the ECUs requires a similar network in the test rig. The communication between ECUs is very important factor for its behavior in normal, extreme & fails scenarios. This paper describes a work of testing of the ECU nodes individually and collectively in a multiple ECU network of six ECUs ESC, EPS, ACC, ECS, LKAS & SPAS so as to facilitate an efficient testing. A HIL simulator for executing the required tests, was developed in due course of this work.

Key words : HILS, Hardware in loop Simulation, Software Testing, ESC(Electronic Stability Control), EPS(Electric Power Steering), ACC(Adaptive Cruise Control), ECS(Electronic Control Suspension), LKAS(Lane Keeping Assistance System), SPAS(Smart Parking Assistance System).

1. INTRODUCTION

With increasing number of ECU nodes in a vehicle network, functionality of every ECU is getting more and more dependent on each other. Respective ECU's calculated and measured sensor data is shared between the modules for better performance. Validation of an ECU of such a network in the Hardware in Loop Simulation environment depends on the accuracy of all other simulated nodes in the network. The complete control over the simulated nodes in the HILS environment provides almost every permutation of the shared signals between the nodes thus enabling the verification of the ECU under test in extreme scenarios. However, inclusion of actual ECUs as dependent nodes with the ECU under test provides simulation results with accuracy similar to that received from a vehicle test. The real ECU nodes connected in a fashion similar to the network inside a vehicle with real respective actuators provides the ability to test the whole integrated system under completely controlled Hardware in Loop simulated environment enables a highly accurate validation with a wider range.

2. Multiple ECU HILS Validation

The overall testing was divided in three broad parts: ECU interface testing, failsafe testing and communication testing. The validation of all six ECUs was done using two methods. In first phase of standalone test, all ECU nodes of the vehicle network were simulated in the HIL simulator, except the ECU under test. In the second method of combined testing, all actual six ECU nodes were used.

i) Fig.1 shows the individual ECU HIL Tester.The use of simulated ECU nodes in the first method of individual ECU testing provided a complete verification of the ECU failsafe and communication functionalities. Besides fail testing of sensors, actuators, etc, the communication tests were made possible in very detail including implausible signals, transmission time, DLC, message counters, checksums etc.

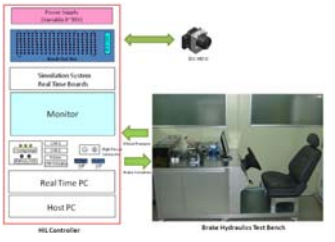

Fig.1 Individual ECU HIL Tester

ii) Fig.2 &3 shows the multiple ECU HIL Tester. As the functionalities are interdependent on each other, interface testing of the ECUs were performed in the second method after connecting all six ECUs in the CAN bus network. For ex- ESC needs EPS for its VSM function, SCC needs ESC for control, SPAS needs EPS, and so on.

Fig.2 Multi System HIL Tester

iii) Different chassis control ECUs contributes in vehicle dynamics improvement in braking, accelerating and handling scenarios. For ex- the Roll over protection of the vehicle is taken care by ESC as well as CDC ECU, hence the inclusion of the real ECUs instead of simulated nodes provides better estimation of the control in severe handling scenarios.

iv) The robustness of fail detection concepts of various ECUs can be compared easily if same fail condition is applied simultaneously to all ECUs. In some rare scenarios fail can be detected in one ECU but the same cannot be detected in another due to difference in detection logic. Those comparisons can easily be made if the tests are done in ECU network.

v) When operating in extreme scenarios, it is possible that an ECU can miscalculate and output wrong data while ECU still showing in normal condition. But, this can cause other connected ECUs to detect it as an error condition and hence facilitating detection of such rare scenarios with ease.

vi) ECU functionalities in boundary conditions are most vulnerable and can cause problem especially if two ECUs are interdependent but having different operation ranges. For ex- LKAS uses MDPS for its operation but if the operation voltage range of these two is different then the proper ECU operation cannot be guaranteed over the ECU specified voltage range.

3. CONCLUSION

The above explanation shows the capability of each method in verification & validation of the ECU under test. While the standalone ECU test method on HILS can be efficient in verification of the ECU functionalities, test of the same in a multisystem network is required to be done for validating the ECU behavior.

References

1. Quan-Zhong Yan, John M. Williams and Jim Li, “Chassis Control System Development Using Simulation: Software in the Loop, Rapid Prototyping, and Hardware in the Loop”, 2002 SAE Conference, Detroit, Michigan
2. Björn Müller and Susanne Köhl, “Simulating and Testing In-Vehicle Networks by Hardware-in-the-Loop Simulation”, 2008 SAE World Congress, Michigan

Fig.3 ADAS HILS for Multi ECU Testing