

Automated Instrument Panel Cluster Testing using Hardware in the Loop Simulators

Shreyas C. Nagaraj and Mahendra D. Muli

dSPACE Inc, USA

Copyright © 2008 SAE International

ABSTRACT

User interface and feedback through the Instrument Panel Cluster (IPC) and other devices in the passenger compartment is another measure of customer satisfaction for today's cars. With addition of more visual information content in the vehicle passenger compartment, it is necessary to perform comprehensive tests of this visual content together with the rest of the electronics system. This paper discusses ideas to perform automated IPC testing together with other electronic control units for software verification. Various methods of image processing and applications of techniques such as optical character recognition (OCR) and optical character verification (OCV) are also discussed. Various benefits achieved by using simulation models of vehicle components such as Engine, Transmission and Vehicle Dynamics to simulate realistic test scenarios and behavior of instrument cluster in the test setup are presented. Additional issues of testing instrument clusters such as variant handling, multiple observers and limitations arising from computational loads due to image processing are discussed.

INTRODUCTION

Hardware in the loop (HIL) testing of embedded controllers has been widely used in the automotive and aerospace industry [1]. They are widely used for software development, testing and validation of engine, transmission, chassis controllers (Example: ABS, VDC) and body control applications [1]. Modern cars have advanced IPCs, infotainment systems, navigation systems, etc which present a wealth of information to the driver/passengers. With the widespread use of liquid crystal displays (LCD), IPCs not only display vital vehicle information such as vehicle speed, engine speed, temperature, fuel, telltales but also information such as service engine, tire pressures, bulb failure, mileage, outside/inside temperature, etc [7]. As IPCs become more sophisticated and complex, the software and electronics associated with it also increases in complexity. This consequently increases the amount of time required for developing the software and hence the time required for verification and testing.

In testing and validation of the IPCs the only way of validating all functions is by visual verification.

The focus of this paper is to discuss the challenges and demonstrate an automated technique of testing IPCs using camera feedback to a real-time hardware in the loop simulator.

REQUIREMENTS FOR TESTING OF VISUAL FEEDBACK DEVICES

Visual feedback components in the vehicle such as IPCs are open loop devices i.e. electronic systems that receive data from the vehicle and display it to the driver/user but do not directly receive any feedback. The feedback about functionality of this system can only be achieved by Man-In-the-Loop type testing. This has been the conventional method of testing an IPC. As it is known, Man-In-the-Loop type testing has several problems in the area of test resolution, repeatability and number of parallel components under test etc. These deficiencies together with the advances in the IPC technology can severely affect the results achieved by conventional means.

IPCs are also Electronic Control Units (ECUs) that are microprocessor based, have fairly decent sized software components that interact with various IO and communication channels. A test system for the instrument clusters should provide appropriate electrical interfaces for the instrument cluster. Such interfaces are typically battery power, sensor simulation signals e.g. temperature sensors, variable voltage inputs for light intensity adjustments, proper communication interfaces such as CAN, LIN etc.

It is important to note that the Instrument cluster is an interface to vehicle systems for the driver and cannot be isolated from other systems such as Powertrain, Body, Chassis systems etc. Therefore a meaningful testing of such a device is invariably coupled with system level integration testing. Events triggered on various systems in the vehicle have to be reliably conveyed to and displayed by the IPC. The timing of various events occurring in the system and its corresponding reflection in user feedback via the IPC forms an important aspect

of system testing. Since the various subsystems commonly use vehicle CAN bus for communication with the IPC, the bus load affects the overall behavior of the system. It is therefore beneficial to test the Instrument clusters as part of vehicle electronics integration testing. In lieu of such capability particularly at the supplier level, it is suggested to use RestBus communication technique to simulate various ECUs with their communication message timing behaviors to emulate vehicle communication bus traffic. An HIL system is a typical solution to address this bus traffic simulation and electrical interface requirements.

Important aspect of testing visual feedback devices is capturing image information and be able to process this data in a timely manner. The HIL test system works on real-time basis and requires the image processing also to be performed in a time deterministic manner for a meaningful closed loop performance. It is desired to have a frame rate that would be as high as possible within the constraints posed by image data capture and processing system. As always a balance between cost and performance has to be achieved. A typical frame rate requirement is in the range of 20-50 fps.

Processing image data efficiently in a timely manner is the heart of the system performance. IPCs present visual feedback data using Gauges, LEDs, LCDs, Color coding, etc. Therefore the necessary capabilities for IPC testing system are: High resolution needle position detection, LED detection, Color Detection, Character and Pattern Recognition etc.

To meet the challenge of testing visual feedback device such as IPC the necessary hardware components of the system include

- Real-Time HIL system
- Image Capture and Processing Tools

For proof of concept and to gather performance statistics of such a system, we developed an IPC test system using an IPC for Cadillac STS 2006. This system and its application in generality are presented and discussed in following sections. Finally, we also present the performance statistics achieved on this system which are indicative of achievable performance.

VISION BASED IPC TESTING OVERVIEW

The main components of this system are listed as follows

Hardware:

1. Closed loop, real-time HIL system
2. IPC
3. Image capturing and processing hardware
4. Test platform

Software:

1. Visualization, experiment management and modeling software
2. Image processing software
3. Test automation software

Similar to any conventional HIL testing of ECU's, the IPC is the hardware to be tested. The simulator emulates the sensor and controller inputs to the IPC.

The camera and IPC are mounted on the test platform, which acts as a rigid base so that there is minimum relative movement between the camera and IPC. This is significant for the image processing software as any relative movements could skew the results.

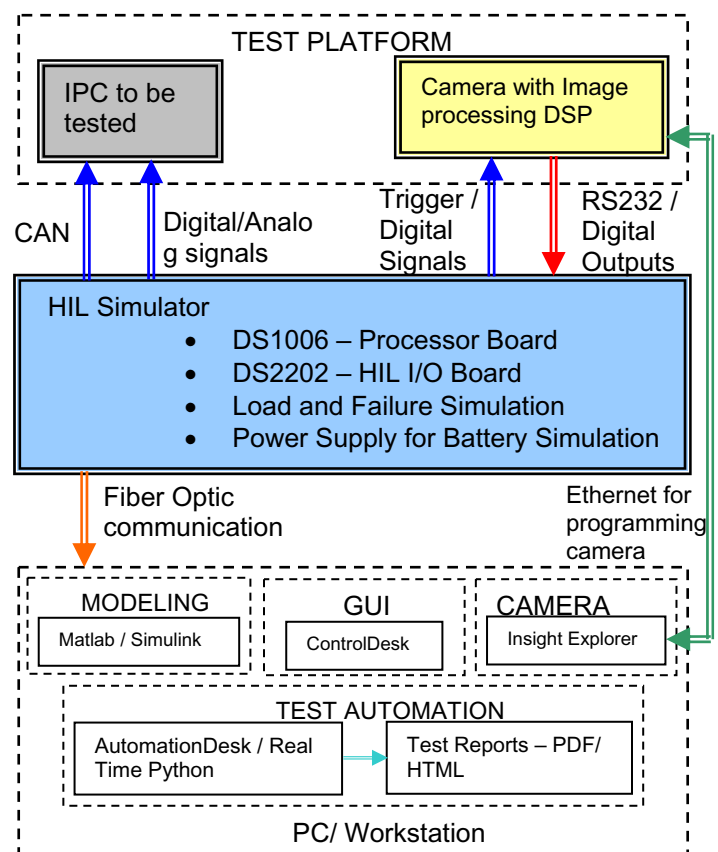


Figure 1: Overview of vision based IPC testing setup

The camera is interfaced to the HIL simulator that provides real time digital data based on Image processing results. The simulator software converts the digital data from the camera to engineering units and displays the results in a Graphical User Interface (GUI). The test automation software compares data sent to the IPC and the data received from the camera and displays

the results in a presentable format. A brief description of each component is described below.

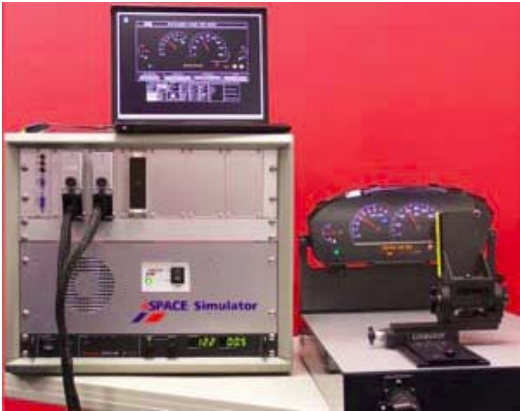


Figure 2: Test setup

HIL Hardware System

A dSPACE HIL simulator is used in this setup. The HIL simulation based testing is a proven and widely accepted technology in automotive industry. The HIL system mainly comprises of a processor board interfaced to various I/O boards. In addition to standard signal processing and I/O functions, proper signal conditioning for sensor and actuator interfaces is needed. A DS1006 processor board with a 2.6 GHz AMD processor based on x86 technology is used in this simulator [2]. In addition to performing complex calculations and interfacing to the I/O boards, this board has the capability to run test sequences in step-lock mode with simulation model calculations for accurate real-time testing. A DS2202 HIL I/O board with several A/D, D/A, Digital I/O, Timing I/O, CAN Controllers and Serial Communication is used. The system also facilitates use of simulated and real loads to prevent any diagnostic errors from occurring during testing. It also includes a Failure Insertion Unit (FIU), which is a network of software controllable relays that allow any of the ECU outputs or inputs to be shorted to battery, ground and open circuited or shorted between pins. In addition to the above hardware, this system has a software controllable DC power supply that emulates vehicle battery.



Figure 3: HIL Simulator

Visualization, Experiment Management and Modeling software

The programming of the simulation model and tasks on the processor board are done in Simulink®. dSPACE software provides Simulink® block library Real Time interface (RTI) that links dSPACE hardware and Simulink [2]. Real Time workshop® is used to deploy applications developed in Simulink on the processor boards. dSPACE software ControlDesk is used to develop customized user interfaces. All model parameters can be controlled, monitored and recorded by ControlDesk giving the user complete control over the simulation process. To simulate realistic test scenarios for the IPC, various Automotive Simulation Models (ASM) such as Engine, Transmission, Vehicle Dynamics, Driver, Environment, etc are used.

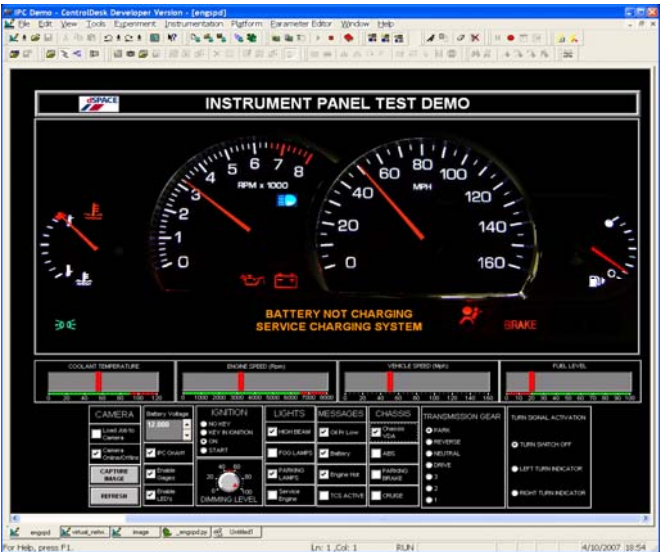


Figure 4: ControlDesk front panel

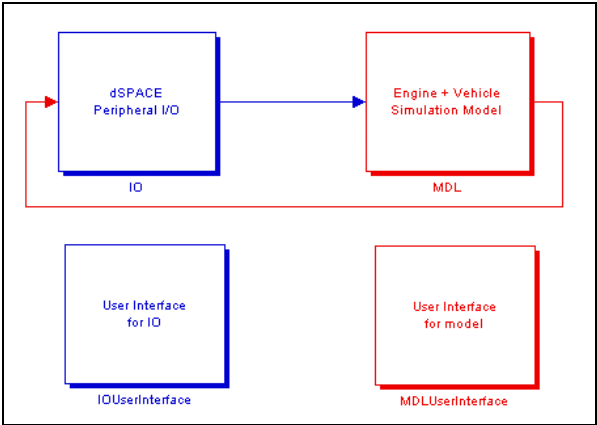


Figure 5: Top level of Simulink model