WHITEPAPER

Modular Display Verification Tool

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Abstract

Automotive OEMs develop a Modular Display System that is used as primary display tools for vehicle systems. Most of these Displays have a core UI platform that will be used by various vehicle platforms in order to develop application specific to vehicles. These OEMs need to perform different types of validation operations for their developed Modular Display Software. L&T Technology Services' Modular Display Verification Tool provides a complete automation solution for Functional & Stability Verification of Display to be installed in any automotive.

This white paper presents a detailed study on L&T Technology Services' Modular Display Verification Tool.

Keywords:
MDVT (Modular Display Verification Tool), HIL (Hardware In Loop), CAN (Controlled Area Network), OEM (Original Equipment Manufacturer), CANalyzer, CAN Case, J1939, UDS (Unified Diagnostic Services), ECU (Electronic Control Unit)

1. Introduction

A recent trend in the market has begun, to replace traditional displays in Vehicles with touch sensitive Modular Displays (with Built-In OS). Major automotive companies are coming up with Modular Displays with more and more features to encourage its use over Traditional vehicle Displays.

Automobiles are no longer just mechanical systems. Today's automobiles contain a number of different electronic components networked together, that as a whole are responsible for monitoring and controlling the state of the vehicle.

Modern automobiles contain upwards of 50 electronic control units (ECUs) networked together. The overall safety of the vehicle relies on near real-time communication between these various ECUs. While communicating with each other, ECUs are responsible for predicting crashes, faults, status, detecting skids,

performing anti-lock braking, etc. Modular Display is responsible for communicating to/from all these ECUs of vehicle system.

Some roles of Modular Display could be pointed as:

i. Sending command (CAN) signals to specific/all ECUs (Destination Specific or Broadcast)
ii. Display received status from different ECUs (for safety, convenience, informative purpose)
iii. Status of Fuel Level
iv. Engine Speed, Rotation, temperature
v. Accelerator Feedback to Display
vi. Status of Faults & current condition of ECU
vii. Show navigational information
viii. Allow vehicle driver to set different ECU state by providing User Friendly Interface

2. Scope of the Study

Modular Display is a generic concept as it can be used with both On-Road & Off-Road vehicles. Its sole purpose is to command all electronic components & get real time status of those components. All above explanation makes Modular Display an emerging Driver Assistant.

When there are so many electronic networked components added to any vehicle & these components are interacting with Modular Display, questions of the robustness and reliability of the software running on the Display arise. When vehicle safety is in question, as in the case of the automobiles, software reliability becomes an even more pertinent issue.

The case as above raises a need for strong validation of software running on Modular Display. When it comes to Manual Verification, it has its own limitations:

- More time & resource consumption leading to lesser test coverage
- Less accurate
- Performance testing is impractical in manual operation
- Not suitable for unattended man hours (Overnight batch validation process)

Modular Displays are developed for Automobiles, which are large scale & time bounded projects. For such project requirements Automation comes to rescue.

The Tool is used for verification of On-Road & Off-Road vehicles Display developed on any customized platform (e.g. Android). Verification coverage focuses on UI validation, functional requirement validation, negative or failure conditions and boundary conditions if applicable based on the specification defined.

MDVT can be customized for any vehicle Display System to provide value addition to Automotive Original Equipment Manufacturer (OEM) for validation of robustness of their displays.

3. Solution

The Tool has been developed to validate:

- Modular Display (User Interface)
- Developed Software for Display
- Implemented Protocol (CAN: Controlled Area Network Specification)
- Communication with ECUs

In order to facilitate interaction with Modular Display, MDVT has functional modules to send and receive events from the Platform (OS) Layer. The purpose of these modules will be to aid in sending the input events to drive the display through the various screens based on the scenario under test. The Tool will handle failure cases where an unexpected screen comes up or a reset is seen on the display. In such cases the test case will abort at the point, if so defined in the validation sheet and continue execution from the next test case. Also, these modules will facilitate screen capture in order to validate the scenario.

The Tool exercises the validation operations on Modular Display & verifies the outcome of operations as per Automotive OEM specifications.

The main focus of Operations Specification is to validate above things, so as to check the behavior of Modular Display while its use in real-time setup (Display installed on actual vehicle).

Categorization of the setup according to the need of validation stages:

- Lab Setup
  - First stage proving case study for MDVT stability with CANalyzer
- Setup with HIL (Hardware In Loop)
  - Second stage proving MDVT with virtual ECUs

The following section explains the details of these setups.

3.1 Lab Setup

In this setup instead of HIL & actual vehicle, CANalyzer will be used. CANalyzer is the comprehensive software tool with intuitive operation for analysis and stimulation of bus communication. Use CANalyzer to check whether and what type of communication is occurring on the bus. It can also be used to send or log data. CANalyzer is a perfect replacement for actual physical ECUs transmitting Can Data over Bus for Case Study purpose.

Following figure illustrates the representation of this setup:

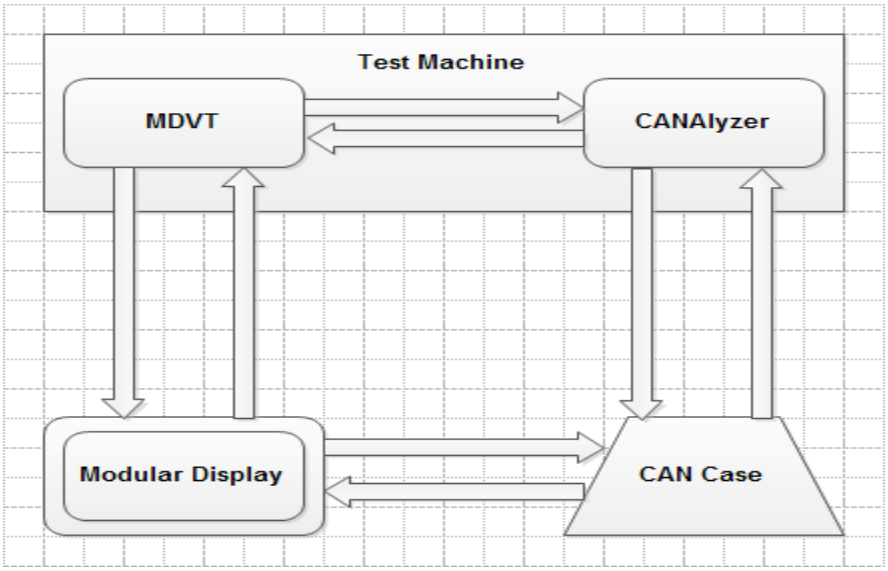

Fig. 1: MDVT Lab Setup

MDVT is installed on the test machine. CAN Case Hardware acts as an intermediate between Modular Display & CANalyzer installed on Test Machine, thus, to co-

ordinate the transmission of CAN Data between these two entities (In case of CAN Protocol Verification). CANalyzer will be used to create the Virtual Nodes, which act as Physical Nodes on actual Vehicle System. These Nodes will have their own address for communication purpose as per CAN specification.
These Nodes will also respond to CAN Data received, thus to provide the outcome of CAN test performed by Modular Display Verification Tool.

3.2 Setup with HIL (Hardware In Loop)

In this setup instead of actual vehicle, HIL will be used. HIL acts as a representative of vehicle hardware in real-time.

The following figure illustrates the representation of this setup:

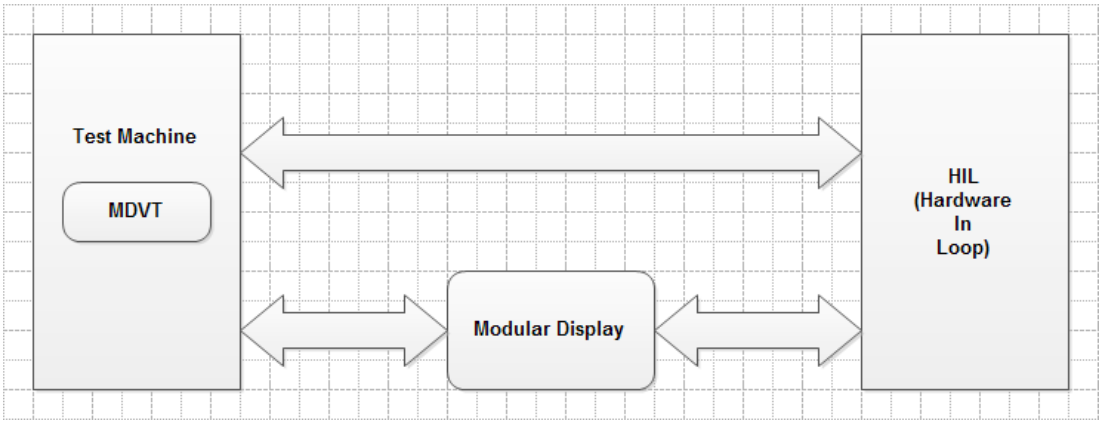

Fig. 2: MDVT HIL Setup

HIL will be used to create the Virtual Nodes, which act as Physical Nodes on actual Vehicle System. These Nodes will have their own address for communication purpose as per CAN specification.
These Nodes will also respond to CAN Data received, thus to provide the outcome of CAN test performed by Modular Display Verification Tool.

3.3 Validation Coverage

The Solution provides the following Validation coverage for Modular Display Software:

- Verification of Display functionality as per OEM specification:
  - Communication with controller on UI triggers
  - Display validation on incoming signals from Controller
  - Display Stability for longer duration operation
  - Check for Display Freeze Reset while in operation

- Verification of Display UI as per OEM specification:
  - Placement and size of widgets
  - UI Screen flow for test scenarios
  - Different Icons verification on screen
- Verification of different scenarios as per CAN Specifications:
  - Different types of CAN messages (Requests, Commands, Broadcast, and Error.)
  - Timing between data frames
  - Segmentation/Assembly of packets in case of more than one data frame
  - Data Length Code
  - Message Filtering and masking
  - Sequencing, Error Management and Priority
  - Connection Management
  - CAN bus Off errors
  - Behavior under high CAN traffic
  - Diagnostic Protocol Verification
  - Onboard: J1939
  - Offboard: Unified Diagnostic Services

4. Use Case

4.1 Agricultural Vehicle Display

Most of Automotive OEMs are manufacturing multiple Off-Road (Agricultural) Vehicles, for which they are also creating Modular Displays instead of Traditional Displays. The Tool can be used for functional verification of display of Vehicles manufactured by these OEMs (Agricultural Vehicle; Tractor).

The Modular Display created for vehicle has customized platform developed by OEM which makes suitable environment for the Tool to do verification activities. Before deploying display on actual vehicle, it is tested in the laboratory with HIL setup. HIL setup acts as an actual vehicle & provides similar behavior of vehicle in terms of sending signals to display (Wheel speed, Fuel Level, Rotation, GPS Location, etc.)

There will be UI changes on Display upon receiving signals from HIL setup. This UI change verification can be performed using Item Verification or Image Comparison & OCR.
Input System Interface developed is also used for performing operations on Display & thus verification of UI changes through those operations.

4.2 Project Activities

4.2.1 Integration of Modular Display Verification Tool

This stage comprises the following activities:
- Design strategy to integrate the Tool with Setups.
- Customization & deployment of the Tool according to design to be able to use with setups explained above.
- Resolution of the defects in deployment

4.2.2 Test Strategy & Approach – Display & CAN Testing

Define proposed test approach for validating the CAN Interfaces and the display requirements related to that. This can be based on the requirement and architecture documents provided by Automotive OEM describing the implementation of CAN protocol for basic communication, on-board and off-board diagnostics and design verification scenarios.

4.2.3 Script Development and Execution

Develop the required scripts for simulating the behavior for testing Display Requirements & CAN Specification implementation end to end. This will involve simulating the required operations and then validating the response sent from Display or CAN Hardware.

The aim of these test cases would be to perform Stress testing of the Display & implement the CAN protocol by Automotive OEM.

Test execution will be executed on major formal releases made as per the sprint plan. After each release, regression testing would be carried out followed by validation of the new features added.

4.2.4 Maintenance of Tool & Scripts

Maintenance of Tool & Test Scripts so as to support any specific use cases added or modified which require a change in the Tool or Scripts is done. This support will also include enhancements which are requested by the test team in order to improve the test coverage. Some of these examples are negative test cases, boundary and stress testing of the modules which require an external trigger. Team will take ownership of maintenance from the date of delivery.

5. Business Impact

MDVT improves testing hours by continuous cycles of execution ensuring extensive regression per display thus providing end-to-end test solution for Vehicle Display. Using this Tool will simulate the CAN messages to be sent for the various scenarios while input events sent over USB will be used to simulate the Platform events. The Modular Display created for vehicle can be customized for display software platform developed by Automotive OEMs.

For validating the display independently the Tool will simulate the CAN messages to be sent for the various scenarios while input events sent over USB will be used to simulate the Platform events. At this point, the focus will be to exercise all possible inputs to the display in the form of CAN messages and key inputsprovided by the operator. Since the display under test is a touch display, the user events will be simulated to achieve the user interaction.

Automating these activities provides the following benefits to Automotive OEMs:

- Cost Effective (less time & resource consumption)
- Time-to-market (Fast Testing & Production of product)
- Reduced user errors
- Troubleshoot the Existing products Manufacturing defects

On sending the required inputs, validation of the display will include verifying the positions and content in the form of item objects or image.
For this customized item, verification algorithm & image comparison method is used. Cases where display changes would result in a CAN message being generated will be verified by reading byte values of CAN message from CAN using MDVT.

6. Conclusion

The successful implementation of the Tool has raised the customer's confidence in our abilities to deliver challenging solutions in quicker time frames. The mileage gained from this project's success has gone a long way in promoting growth in our customer accounts and thus, getting new projects. This technically challenging low cost Tool will be a great value addition to the current Automotive OEMs for validating their Vehicle Displays.

Modular Display Verification Tool will act as a major differentiator for any Modular Display. This display powered with new features will be a trend setter while working as a strong replacement for Traditional Displays.

7. About the Author

Mr. Vinayak Wagh was employed by Larsen & Toubro Infotech from November 22, 2011 until his transfer to Larsen & Toubro Technology Services Ltd on January 1, 2014 as a Senior Test Engineer in our Product Engineering Services.

Mr. Vinayak Wagh is a key member of the team who developed and tested the complete "Modular Display Verification Tool". Mr. Vinayak Wagh has contributed in the complete Design, Development, Deployment, Setup and execution.

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