HIL Testing of ADAS Features

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Abstract:- In recent years there is a drastic increase in the road accident. This was mainly because of the drivers inattention. Thus safety of the passengers and the driver became one of the important aspect of automotive industries. Automotive industries developed features that assist the driver to avoid accidents. These features are called Advanced Driver Assistance System(ADAS). These features are implemented using sensors and Electronic Control Unit(ECU). There is need to test and verify the ECU to make sure that they perform the ADAS functions. Hardware-In-Simulation(HIL) testing is used to test the ADAS ECU. It is a testing technique used to test the ECU in a real-time environment.

***Keywords**:- ADAS, sensors, ECU, testing, HIL.*

I. INTRODUCTION

The industrial revolution accelerated the growth of automotive industries. Advanced technologies embedded in the vehicles increased the number vehicles. As number of vehicles on roads increased , driving became more challenging. The inattention of the drivers caused many accidents. Thus safety became one of the most important aspect of automotive industries. System that had features to assist the driver were developed to avoid accidents. These features are called Advanced Driver Assistance System(ADAS).

The main ADAS features are Lane Departure Warning(LDW), Lane Keep Assistance(LKA), Adaptive Cruise Control (ACC) and Traffic Sign Recognition(TSR).These features are developed to avoid accidents. The features are implemented using sensors and ECUs. Radar and camera are the main sensors that gather data for the ADAS system. Radar can detect the distance between the target and host. It also detects the speed of the target. Camera captures the image and video Some of the sensors are Mid-Range Radar(MRR), Short Range Radar(SRR). They are mounted on different parts of the vehicle. The position at which the sensors are placed depends on the function it has to implement. For parking assistance camera is placed in the rear part. Whereas for detecting traffic the camera is placed in the front part of the vehicle. Thus sensors play a vital role in implementing ADAS features. Radar can detect the distance between the target and host. It also detects the speed of the target. Camera captures the image and video.

ECU is the brain of ADAS system. ECU has a processor unit, signal conditioning circuits and memory. The algorithm for the ADAS feature is flashed as a software in the ECU. The sensor data is processed by the ECU. The sensor data acts as input for the algorithm. The decision of the ECU depends on the detected data. Accordingly the ECU generates control signal.

A system becomes reliable only after testing and verifying it. The software flashed in the ECU performs the ADAS function. The software should be tested in real time environment to make the system more robust. Techniques are developed to test and verify the ADAS system. Hardware In Loop(HIL) test technique is used to test and verify the ECUs of ADAS system.

This paper has four section. Section one is the introduction. Section two describes the ADAS features. Section three discuss about the test methodology and flow of HIL testing. Section four explain about the hardware setup and software used for HIL testing. Section five gives the results of the HIL testing. The paper concludes with section six by summarizing the whole paper.

II. ADAS FEATURES

Many accidents occur due to the inattention of the drivers. Automotive industries started research to develop technologies to prevent accidents. Safety of the driver/passengers become one of the most important aspect of automotive industries. This led to the development of technologies that prevented collision of vehicles. Intelligent assistance system known as Advanced Driver Assistance System(ADAS), was developed to assist the driver to avoid the accidents. Some of the ADAS features are:

A. Lane Departure Warning(LDW)

Lane Departure Warning system reduces the amount of unintended lane departures. The LDW functionality can be divided into two processes:

- Lane Detection: The lane markings and road edges are detected then and estimate the car’s position in the lane
- Warning: The above details are used to give a warning to the driver, if there is an unintentional lane departure.

Here camera acts as a sensor to detect the lane marking. The lanes are detected and the signal is given to the

ECU. The control unit process the data. The warning is given to the driver when the vehicle is about to go out of the lane.

B. Lane Keep Assist(LKA)

This feature is similar to lane departure warning. The lane markings and road edges are detected by the camera then and estimate the car's position in the lane. These details are used to give a warning to the driver, if there is an unintentional lane departure. This feature is similar to lane departure warning. The extra function is, if the driver does not take any action ECU sends signal to gently steer back the vehicle onto the appropriate lane.

C. Traffic Sign Recognition(TSR)

Traffic sign board mainly give information about the speed limits, turns, warning or conveying information. One of the main aim of signs is to alert the driver to avoid accidents. At times drivers does not follow these signs which leads to accident. TSR avoids this situation.

Camera act as sensor and identifies a traffic sign depending on the color and shape of the board. The information extracted from the boards are displayed in the dash board of the car and alert the driver to take action accordingly. This reduces the occurrence of accidents caused by ignoring of traffic signs by the driver.In all the above features camera acts as the sensor. We test the ECU that gets data from the camera.

III. TEST METHODOLOGY

The reliability of any system increases only after testing and verifying it. The functions that the ECU should perform is decided by the software flashed in the ECU. Thus software testing is very important. The software is tested in the development stage. During the development phase it is not practical to test the ECU in a vehicle as it demands more time, cost and it has a risk factor. But if we are able to create a real time environment to test the ECU, then it is less dangerous, cost effective and more robust. This type of testing is called Hardware-In-Loop(HIL) testing. In HIL the entire vehicle system is modeled. The sensors, actuators, all inputs and outputs, communication channels that interact with the Device Under Test (DUT) are modeled.

For testing ADAS features we need to create a traffic condition similar to real time traffic. Only then we can verify the ECU function. The traffic environment which is created is played to the camera that detects the data for the ADAS ECU. The camera takes the video as real time scenario. The camera detects the data from the video and this data is given as input to the ADAS ECU. The ECU analyses and process the data. And the ECU takes decision accordingly. The ECU decision is generated as an output signal. This signal can either be a warning to the driver or can be a input to other ECU to take appropriate action. This can be monitored to verify whether the ECU performs its function.

Critical traffic scenarios are created to test the ECU. The above environment is developed by using the DSPACE hardware and software tools.

IV. TEST SETUP

The HIL test setup has both hardware and software tool. These tools are developed by DSPACE.

A. Hardware setup

SCALEXIO is used as a simulator for HIL testing of ADAS features. Scalexio is developed by DSAPACE. Scalexio simulate the system that is controlled by the ECU. Here the vehicle is the simulated system, thus Scalexio acts as a real time vehicle. Scalexio perform the following function.

- It can generate sensor signals that is required for an ECU.
- It can measure the signal generated by the ECU for controlling the actuator.
- It connects the signal generated by the ECU to loads.
- It act as the power supply for the ECU.

B. Software

Only once we configure the Scalexio it act as a vehicle. The traffic scenario that is played to the camera should be developed. All these are implemented using software tools provided by DSPACE. The main software components are

- MATLAB
- Configuration Desk
- Model Desk
- Motion Desk
- Control Desk

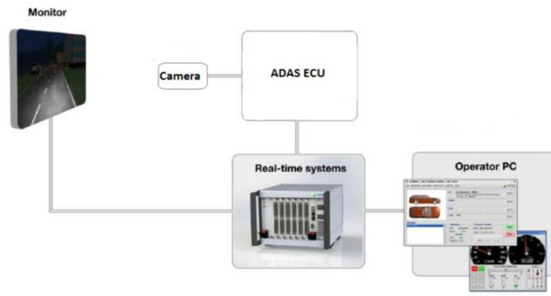

Fig 1:- HIL block diagram

- *MATLAB*

DSPACE provides a basic Automotive Simulation Model (ASM). This model is accessed through MATLAB. ASM has the dynamics of a car. The main parts of a care are Engine, vehicle body, drive train and four wheels.

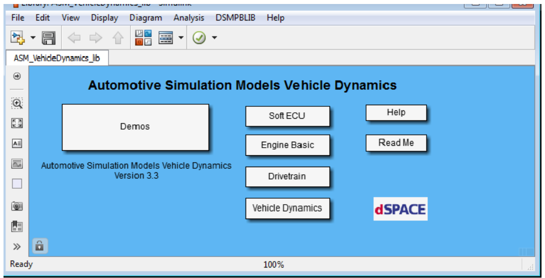

Fig 2:- Simulink model

This model includes the suspension kinematics, steering and brakes, tire road friction, forces and moments, a drive train.

- *Configuration Desk*

The real-time application runs in the Scalexio hardware. This application is divided into behavior model and I/O model. The behavior mode is developed in the MATLAB. It is the model of the controlled system. This model only contains the algorithm of the controlled model. But through this we cannot access the hardware. The access to the hardware is implemented through configuration desk. The function like accessing the hardware, generating I/O signals, measuring of I/O signals all are implemented through configuration desk. The behavior model in the MATLAB and the I/O model should be connected.

This is done through the model interface feature of configuration desk. The virtual ECUs can also be created in Configuration desk. Through the built process in Configuration desk an executable format of the model is created and this runs as a real-time application on the hardware. Now the hardware act as a vehicle.

- *Motion Desk*

The MATLAB has the ASM model. It is parameterized using model desk. Model desk acts as a graphical user interface for changing the parameters and managing the parameters of the ASM models. Motion desk also provides tools for creating roads and maneuver.

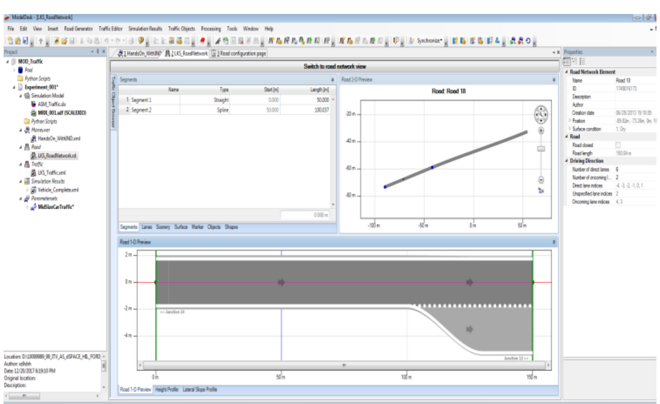

Fig 3:- Model Desk

The traffic environment is created using the tools provided by model desk. Using road generator of model desk road models are generated. Maneuver is developed using model desk. Maneuver describes how a vehicle should move. It defines when to start a vehicle, when to change the lane, when to take a turn, when to brake the vehicle. The fellow traffic vehicles are developed using model desk.

- *Motion Desk*

Motion desk is provided by DSPACE to visualize the movement of the mechanical objects in the 3D world. The vehicle model is parameterized in model desk. Roads, maneuver and traffic objects are created in model desk. But we cannot visualize the movement of vehicle.

Motion desk is used to visualize the motion of the vehicle along the road and the maneuver. The data in the model desk is synched with the motion desk through the model desk. Only after the synching process we can visualize the model in motion desk.

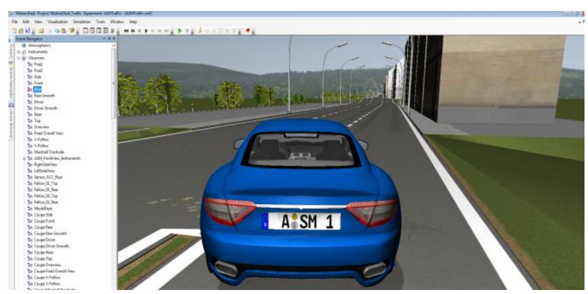

Fig 4:- MotionDesk

- *Control Desk*

Control desk is a component of DSPACE through which we can perform calibration of an ECU. Through control desk we can access the parameters of the model. We can control and monitor the parameters of the model. In control desk we can develop an GUI to access and control the parameters of the model.

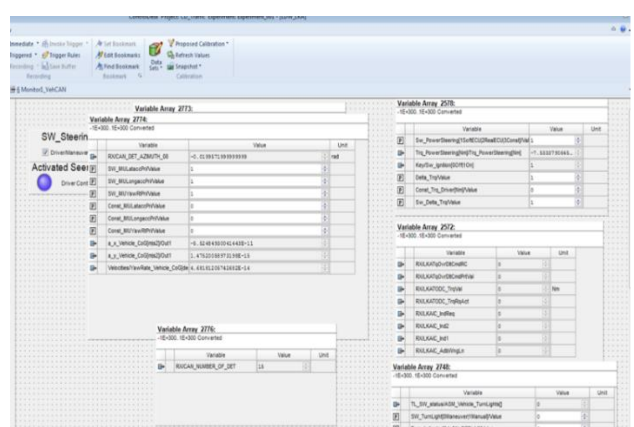

Fig 5:- Control Desk

Different test cases are developed to test the ADAS features. These test cases are created and executed using the above tools.

V. RESULTS

The ADAS ECU is tested in the real-time environment. The traffic scenarios created and played to the camera. The Camera detects the data. The ADAS ECU performs its function. The output action of ADAS ECU is monitored. It if found that ADAS ECU performs its function accordingly when it is tested in critical scenarios. The ADAS ECU is tested and verified in all possible scenarios. The report is generated.

VI. CONCLUSION

To reduce accidents ADAS features are implemented in the vehicles. ECUs perform the ADAS functions. It is important to test and verify the ADAS features. If we test the ECU in a real-time environment similar to on-vehicle test, then the test will be more robust and valid. Thus we use HIL testing. In this testing technique a real-time environment is developed and the ECU is tested. The main advantage is that test scenarios that has risk factor while testing on a vehicle can be tested using HIL testing. This one of the reason for using Hil testing. This technique can be used for testing most of the close loop system. The obtained results shows that this is a reliable testing technique.

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