

Development of Vehicle HMI Module Using Model-Based Design and RCP

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ABSTRACT

LCDs are effective to display abundant information in a compact space. Therefore, the use of TFT or DOT metric displays in dashboard instrument display is getting popular in recent years. However, it is important issue for car makers how to let users know information about vehicle functions or outside environment and manage plentiful information.

In this paper, the Rapid Control Prototyping (RCP) tool is proposed to design and standardize HMI logic associated with display contents in TFT or dot type LCD applied to an instrument cluster. In addition, it is possible to estimate HMI logic in advance by using this RCP. By this process, we can minimize the design and validation time of the vehicle specific HMI logic and improve the quality. As a result, we can dramatically reduce the total period of developing an instrument cluster.

The HMI simulation tool can minimize the difference between display output of simulation and realistic display outcome of instrumentation, because this tool models HMI logic and displays the result on real LCD hardware applied to an instrument cluster. Thus, the RCP simulation tool has an advantage to more realistically estimate the display outcome operated by HMI logic designed.

This paper demonstrates how engineers can connect the display hardware of an instrument cluster to the HMI logic created with MATLAB simulink® and assess HMI requirement and the display outcome in advance.

INTRODUCTION

Many of the instrument cluster in today's passenger vehicles involve sophisticated HMIs that process a series of inputs from the user and information from vehicle system, e.g., trip computer, cruise control, parking assistant system, tire pressure monitoring system, A/V, navigation, and so on. A significant amount of time and have to be devoted to designing the HMIs for these systems in addition to designing the underlying electronics [1].

On the other hands, switch inputs and signal outputs from units in a vehicle are transmitted to an instrument cluster through CAN(Controller Area Network) because car companies can achieve cost savings and weight optimization from reducing the number of electric wires in vehicle.

Accordingly, the CAN bus is used as the input channel to the HMI system in instrument cluster LCD. It is important issue to determine the display priority and the duration of the graphic image in LCD after interpreting

commands from the user and identifying the status of the vehicle.

This paper discusses the importance of using the Model-Based HMI and the real display hardware to test the HMI system during development. Motivated from these needs, we apply model-based approach combined with rapid prototyping for the development of LCD HMI module. In this paper we discuss in detail the application of MATLAB simulink® and CANoe simulation tools to the development of a specification of a LCD display of an instrument cluster in a car. We also illustrate the testing of the system to ensure that the design meets requirements and to identify inconsistent requirements[2].

After processing the HMI logic of the display priority and the duration using model-based design, the result data is transmitted to the LCD module through Vector CANoe tool and the module displays the specific graphic on the real LCD hardware according to the CAN signal from CANoe.

Fig.1 shows the scheme of the HMI simulation tool.

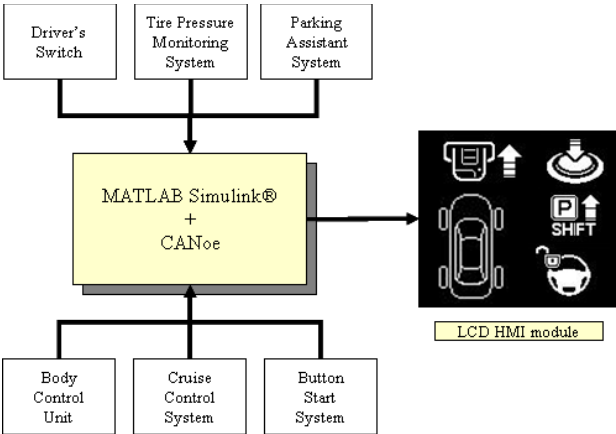


Fig.1 The concept of the HMI simulation tool

MAIN SECTION

2.1 DEVELOPMENT PROCESS

Fig.2 demonstrates the LCD HMI module in an instrument cluster. This module consists of micro-processor, LCD, speaker, regulator, CAN transceiver, connector, etc.

Battery power source as well as ignition, illumination are connected to the hardware input of this module.

2 channel CAN buses are designed on PCB of the HMI module for input of the vehicle status information and the HMI data.

MATLAB Stateflow® processes the information inputted from vehicle and output HMI state signal. The output signal are transmitted to the LCD HMI module through CAN bus.

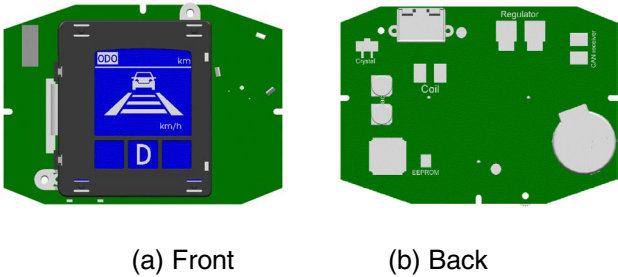


Fig.2 LCD HMI module of instrument cluster

Fig.3 illustrates the HMI software logic inside the LCD HMI module and shows which graphic image is displayed according to the value of 'CLU_HMI_status'. The LCD HMI module displays graphic images after periodically checking the value of 'CLU_HMI_status' signal sent from CANoe. For example, 'Cruise control' graphic image will be displayed if the value of 'CLU_HMI_status' signal is equal to #0101.

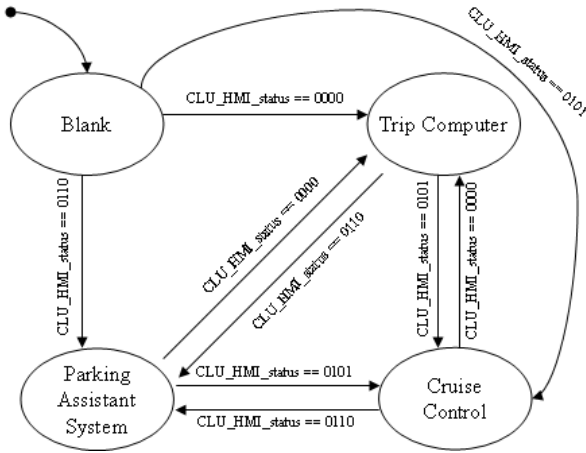


Fig.3 The HMI software logic inside the LCD HMI module

It is important to determine how often to check the value of 'CLU_HMI_status' periodically and update the graphic image because of the processor load. This principle is more critical in a real part. If the software checks more frequently, the load on the processor will be increased. On the contrary, the slow checking cycle will delay updating the graphic in the LCD HMI module.

2.1.1 How to update graphics displayed in LCD

Fig.4 demonstrates the process of updating the graphic image stored in LCD briefly.

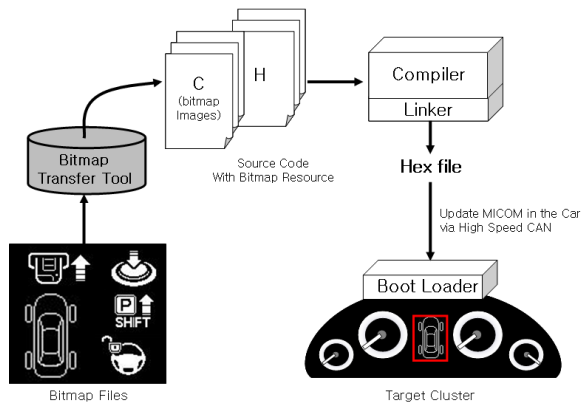


Fig.4 the process of updating graphic image in LCD

We necessarily need a transfer tool which can convert many bitmap graphic images into software source code.

As over 150 images are used in the current design, we developed bitmap transfer tool (BTT) which converts bitmap images (BMPs) into software source codes (refer to bitmap transfer tool (BTT) in fig.4). This software tool automatically converts all bitmap image used in LCD of an instrument cluster into source codes which form arrays and C compiler converts this image and other source code into machine code. This code can be downloaded to the LCD HMI module through CAN bus with the boot loader. Therefore, we can easily update graphic images on a LCD.

The graphic images which are updated through the previously mentioned procedure will be displayed on LCD according to the software logic illustrated in Fig.3.

2.1.2 Installation of LCD HMI module

Fig.5 demonstrates installation concept of instrument cluster and the LCD HMI module. The LCD HMI module operates independently of the instrument cluster in contrast with LCD module applied to the real instrument cluster. Therefore the same module will be able to be used irrespective of the vehicle model for validation in advance If the following two conditions are met.

- Share type and size of LCD applied to instrument clusters
- Standardize input signals of the instrument cluster from vehicle

We can achieve the first condition by following the trend of cost optimization and sharing design of instrument

clusters. Recently, the same LCD modules are used in different instrument clusters for cost reduction.

The second condition can be satisfied easily by managing the total signal used in a vehicle with car maker's standard. Therefore, several LCD HMI modules are able to design and evaluate the concept of the whole cluster LCD HMI in advance as long as previously mentioned conditions are met.

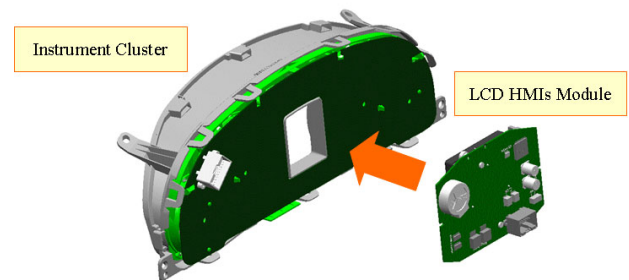


Fig.5 Installation of the LCD HMI module

2.1.3 The control signal of LCD HMI module

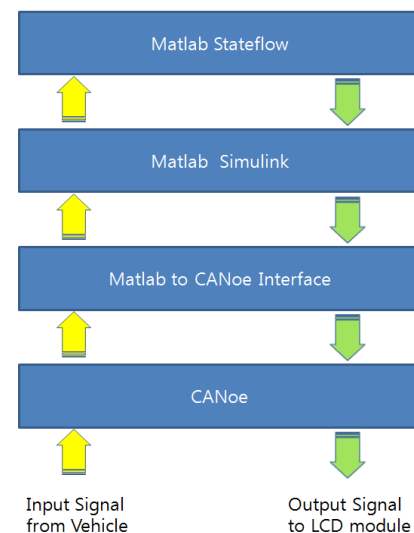


Fig.6 Signal flow inside the HMI simulation tool

CANoe linked with MATLAB Simulink® transmits 'CLU_HMI_status' to the LCD HMI module in order to update graphic displays according to the vehicle status and user switch inputs.

We should prepare CAN database in order to use CANoe. The process of designing the database and applying to the simulation tool consists of the following steps.