Implementation of Diagnostics Module in Car-Infotainment system

[1]Swathi K, [2]S M Narasimhan
[1]*PG Student (M.Tech) E&E Dept., The National Institute of Engineering, Mysore, Karnataka, India*
[2]*Prof. E&E Dept., The National Institute of Engineering, Mysore, Karnataka, India*

Abstract— Nowadays In-vehicle entertainment is flourishing and is integrated with automotive navigation system. This constitutes a complete "in vehicle infotainment". The present day radio in the automobile has advance features like the traditional Tuner sources - FM, AM. Media Sources like CD/DVD, USB Audio, Picture, Video, SD Card support, iPod, Pair a phone and listen to Music and access the Phone book and make or accept calls, configure the Radio and so much more like Navigation etc. In such In-vehicle entertainment systems, status of different modules and their connections becomes important for a technician who is performing its evaluation. In this scenario diagnostics comes into picture. Diagnostics refers to a vehicle's self-diagnostic and reporting capability. This paper presents implementation of Diagnostics in Car Radio which is done using three tests viz., Speaker Test, Display test, Connection Test and System Version Information test.

Index Terms— Functional Unit, Frame Buffer Viewer, Application programming interface, building block, System Version Information, Human Machine Interface, Cathode Ray Oscilloscope.

1 Introduction

With the advances in technology, the auto motive industry is moving towards the radios with more integrated features in them. The present day radio in the automobile has features like

- Tuner sources - FM, AM.
- Media Sources like USB Audio, Picture, Video, SD Card support, iPod, AUX.
- Wireless connectivity: Bluetooth, Hands-free, Phone book, Internet, Phone app access
- Telematics: GPS, Modem
- Speech Recognition
- Reconfigurable displays
- Rear-seat entertainment
- Rear View Camera

In such an infotainment system, status of different modules becomes important to know whether they are working up to the expectation and also to prevent any malfunction in future. Here diagnostics comes in to picture. Diagnostics is an automotive term referring to a vehicle's self-diagnostic and reporting capability. It gives the vehicle owner or repair technician access to the status of the various vehicle sub-systems.
In this paper three tests of diagnostics are implemented namely Speaker test which tests the audio output from four speakers Left front, Rear Left, Right Front and Rear Right. Display test is used to test the display quality. Connection test shows the connection status of different components. System Vesrion Information test gives the version information of different components.

2 Software Architecture

In this paper, model based design approach is introduced which is easily understandable by the system, software, hardware managers and customers. This focuses on code reusability, portability, extensibility and proves to be more efficient. The same structure can also be used throughout multiple projects.
In such architecture the main project is divided into small modules which have minimal dependencies on other modules. This enables testing and proper functioning of the feature at the modular level and also enables error checking during the development and helps recover from the problem during deployment.
Here the radio architecture is divided into layers of modules. The various layers include HMI, sub-systems, device drivers, base drivers etc. Each of these layers has a number of modules with their application interfaces.
The communication from HMI to the building blocks is shown in fig 1.

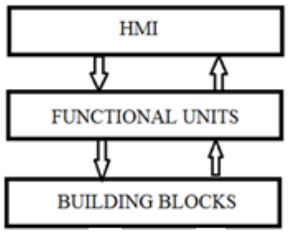

Fig1: Software Architecture-module based

Human Machine Interface (HMI) is the top most layers which include designing user interfaces such as Touch screen display using HMI development tools.

Functional unit acts as the interface layer between HMI and Building block. Its functions are:
To give definition to the auto generated code from HMI and to subscribe to Building block events

Building block is the area where actual code resides. Its func-

tions are:
-To give interface to API's.
-To do the actual functionality.
-To send back the data after processing.

Example for Building block is Tuner, navigation, Rear view camera, Bluetooth, Media etc.

3. SPEAKER TEST

Speaker Test is conducted to know the audio output quality of the four speakers of Car Radio namely Left Front (LF), Left Right (LR), Right Front (RF) and Rear Right (RR). When the user selects speaker test, each speaker is tested for 1.5 seconds and there is a time delay of 1 second between the speaker tests. The total duration of Speaker Test is around 10 seconds. For this test the modules involved are HMI, Functional unit (fu), Diagnostics and audio building blocks.

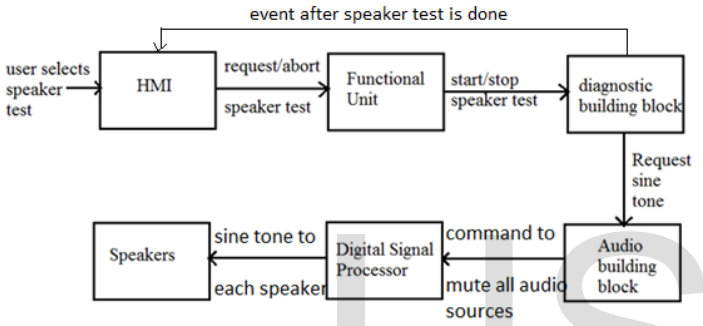

Fig.2: Block diagram showing the flow of data from HMI to speakers

When the user selects Speaker test, the HMI sends data to the functional unit which calls the Application programming Interface (API) of Diagnostic Building Block (BB) to perform the actual function. To test the speaker's quality, test sine tone is required so the diagnostics BB calls API of Audio block to send the sine tone.

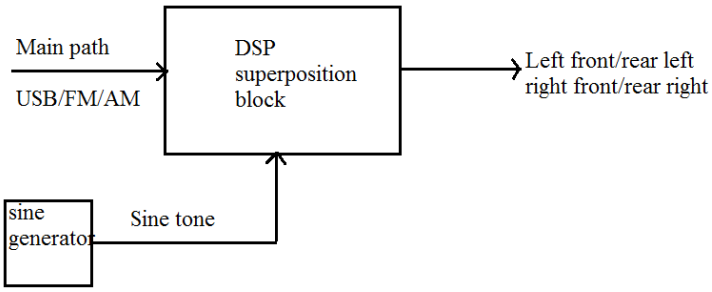

Fig.3: Sine tone channeled to specific speakers using DSP superposition block

The audio block mutes all the speakers and also the AM/FM/USB main channel and directs sine tone of frequency 20 kHz to the DSP superposition block. The superposition block sends this tone to each of the four speakers for a period of 1.5 seconds each. The output from speaker is connected to a CRO. Using the frequency response method the quality of the speakers is determined.

4 DISPLAY TEST

This test allows the service technician to check the display quality. Screen displays five colors in sequence: Black, White, Red, Green, and Blue. Each screen is displayed for five seconds and the technician will decide whether every pixel of the display displays the same color or not.

There are two Frame Buffers (fb0 and fb1) in the Application processor of the Car Radio. One frame buffer is used For HMI display and the other is used to display USB videos, animations, navigation screens etc.

Fig.4: Example of an HMI display Screen using frame buffer 0

Fig.5: Example showing a Back up Camera which uses frame buffer 1

Fig.6: Combination of HMI display and Navigation

Video Arbitration is a module that selects between the two frame buffers by moving one of them to the background. For example, during the normal operation HMI display frame buffer (fb0) will be in the foreground and the Video buffer (fb1) will be in the background. If the driver puts reverse gear

rear view camera (fb1) comes to the foreground.

For the Display test the modules involved are the HMI, Diagnostic, Video arbitration, screen check building block and frame buffer viewer (fbv). When the user selects Display test, the HMI sends data to the functional unit which calls the API of diagnostic building block to perform the actual function. At this point of time the fb0 (HMI) will be in the foreground and fb1 which has the display screens will be in the background. So the diagnostic BB calls the API of video arbitration BB to move fb1 to the foreground. When fb1 comes to the foreground the screen will have some junk data and hence it calls the API of screen check BB which clears the background and fills each pixel of the screen with a particular color. This results in display test screens with five colors one after the other. Finally these screens are displayed using Frame buffer viewer (fbv) utility.

5 CONNECTION TESTS

This test allows the service technician to check the connection status and view the average signal strength of the currently tuned frequency.

Various tests include

* Detecting Rear Video Camera connection status
*Detecting Speaker connection status
*Detecting GPS antenna connection status

When user selects Connection test, tests are conducted automatically and will run until completion; then display the test results on the screen. If the connection is detected as "Fail", the root cause will be displayed in Remarks column.

5.1 Detecting Rear Video Camera connection status

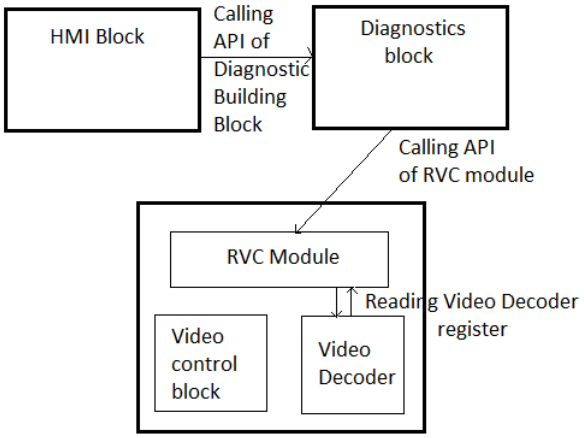

Fig.8: Data flow from HMI to the Video Decoder

During this test, the HMI block calls the Application Programming Interface (API) of the Diagnostic block which intern calls the API of Rear view camera (RVC) building block. The RVC module talks to the video decoder through the I2C communication lines. It reads the value present in the particular address of the video decoder which specifies whether the rear view camera video is in sync or not. If the value in this address is 1 it means that the video is in sync and this test returns pass else it gives the result as fail and the remark as video is out of sync.

5.2 Detecting Speaker Connection Status

The amplifier in the Car radio has two major functions. One is to amplify the input signal and the other is to perform Diagnostics. Diagnostics is the in-built quality of amplifier where it detects the connection status of the four speakers connected to it. Using I2C communication bus the amplifier writes to the control register for enabling diagnostic test. It takes around 600- 900 ms to perform diagnostics and the result can be read from the status register. The information obtained is whether the speaker is short to ground, short to battery, open load and short to load.

5.3 Detecting GPS Antenna Connection Status

The information about the GPS antenna connection status is obtained from GPS receiver chips connected to the ARM processor in Car radio via I2C communication bus.

5 SYSTEM VERSION INFORMATION TEST

This function allows the service technician to view the system hardware and software version information like Bluetooth firmware version, VIP SW version etc. The AHU will execute this function automatically and will run until completion; then Display results on the screen.

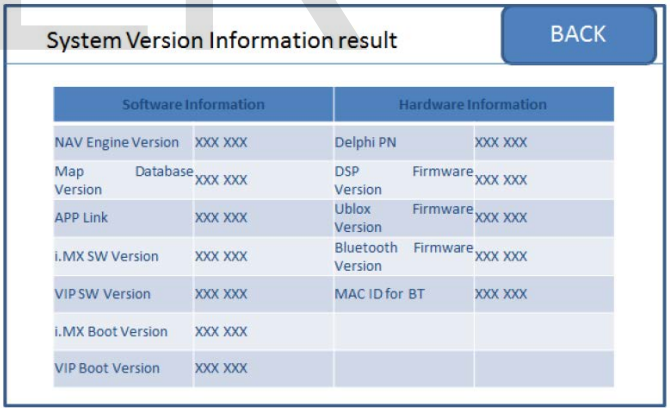

Fig.9: Example System Version Information Result screen

This allows the service technician to view the system hardware and software version information like Bluetooth firmware version, VIP SW version etc. the advantage of this test is that the technician will get to know about the component versions which helps him in providing solution if any fault occurs in any of the components.

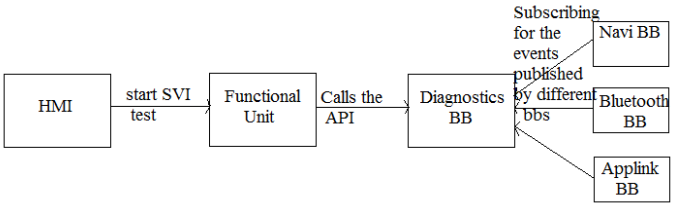

Fig.10: Data flow from HMI to Diagnostics BB for the SVI test

As shown in figure the HMI initiates the functional unit to perform system version information test. The fu calls the respective API of diagnostics bb to start the test. The diagnostics bb uses a buffer which is dynamically allocated as and when the version information is got. The bbs such as navigation, Bluetooth, VIP etc publish their component version information to the entire set of bbs so that if any bb is interested it can subscribe to this information. Here diagnostic bb subscribes to this information and stores in buffer which is then read by functional unit and displayed on HMI.

6 Conclusion

As seen Diagnostics in any In-vehicle entertainment system plays an important role as it is helpful in monitoring the status of various modules. A technician comes to know immediately if any fault exits in Car Radio and can find the root cause of it. Diagnostics module is an important part of any Car Radio and its design becomes crucial since this module has to interact with other components in order to know their status.
This paper presents implementation of Diagnostics to one of the advanced Car Radios. There are numerous tests in diagnostics among which three popular tests are briefed namely speaker test, Display test and Connection Test.

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