**Development of Android DA**

**1 Introduction**

Along with widespread spread of smartphones, users of devices (information devices) in general can freely select functions that they desire to use on those devices. For example, smartphones can provide various services in a timely manner by updating applications. In these circumstances, there is a need that vehicle-mounted infotainment devices provide the latest functions and services, as smartphones do, although the life cycle of those devices is longer. Taking into account the market trend and growth of global sales of the infotainment devices, FUJITSU TEN realized the environment where users, car manufacturers and suppliers can select and use applications available and executable on vehicle-mounted infotainment devices including the Google’s Android OS, which is an open platform expected to spread most widely in the future.

The display audio (DA) developed this time by FUJITSU TEN includes the three categories of functions: "conventional functions of vehicle-mounted devices," "functions available by being connected to smartphones" and "functions specific to Android."

This paper elaborates on our efforts to develop the DA that satisfies restrictions on vehicle-mounted infotainment devices and, at the same time, that can provide convenience of smartphones.

**2 Installation of Android OS**

Fig. 1 illustrates the configuration of the Android DA system.

**Table 1 Representative Functions of DA**

<table>
<thead>
<tr>
<th>Category</th>
<th>Representative function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional functions of vehicle-mounted devices</td>
<td>CD, radio [FM (RDS), MW, LW], DAB, USB audio, iPod, HDMI, GPS navigation system, rear camera, etc.</td>
</tr>
</tbody>
</table>
| Smartphone-connected function         | · Handsfree and audio playback via Bluetooth  
|                                       | · Audio playback via iPhone  
|                                       | · Mirror Link  
|                                       | · Siri EFM |
| Android function                      | Possible to add new service by download of safe applications from the server established by car manufacturers |

Being equipped with the Android OS, the Android DA is configured with: Tegra 3 microprocessor that mainly controls the HMI for users; and the SH microprocessor, including a real-time OS, that mainly controls vehicle signals and system power supply.

**2.1 Configuration of Two Microprocessors [Tegra 3 microprocessor]**

Tegra 3 microprocessor includes the Android OS and applications executable on it. In order to develop the core of the Android OS, we cooperated with Fujitsu Limited who has experience in developing smartphones and we actively used its development assets. Moreover, we modified the Android OS for smartphones and tablet PCs, to use it for vehicle-mounted infotainment devices. In addition, a development working group was established by five Fujitsu group companies to discuss feasibility of the system and to solve problems at the early stage of the development in order to ensure functions and credibility.

**Table 2** concretely shows typical examples of required functions and credibility that differ between vehicle-mounted infotainment devices and smartphones.
Table 2 Requirements for Vehicle-mounted Infotainment Device and Smartphone

<table>
<thead>
<tr>
<th>Item</th>
<th>Vehicle-mounted infotainment</th>
<th>Smartphones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound</td>
<td>4 channels or more</td>
<td>2 channels (headset)</td>
</tr>
<tr>
<td>Presence of interrupting</td>
<td>Presence of interrupting</td>
<td>Absence of interrupting</td>
</tr>
<tr>
<td>sound per channel</td>
<td>sound per channel</td>
<td>sound per channel</td>
</tr>
<tr>
<td>Image</td>
<td>Regulated while driving a</td>
<td>Not regulated while</td>
</tr>
<tr>
<td></td>
<td>vehicle</td>
<td>driving a vehicle</td>
</tr>
<tr>
<td>Security</td>
<td>Vehicle-mounted device</td>
<td>Information device</td>
</tr>
<tr>
<td>Power supply</td>
<td>Vehicle battery</td>
<td>Built-in battery</td>
</tr>
<tr>
<td></td>
<td>Instantaneous interruption</td>
<td>Stable</td>
</tr>
</tbody>
</table>

[SH microprocessor]

By concentrating processes necessary for the interface with the vehicle, the SH microprocessor responds changes of vehicle states on a real-time basis at the same level as before and monitors the "security," described later. Moreover, it controls the power supply of the entire system and ensures the credibility at the same level, in this regard, too, as conventional vehicle-mounted infotainment devices.

2.2 Application of Android OS to Vehicle-mounted Device

(1) [Security]

In addition to the assured security policy on smartphones and other information devices, a security policy particular to vehicle-mounted infotainment devices is required to prevent interference with users who are driving a vehicle. The development working group newly defined the policy for the Android DA and formulated its security measures. The listed below are some concrete examples of the security measures against attacks coming through connected networks and applications that cause an adverse effect on vehicle functions and users.

① Separation of CPU for vehicle connection control from CPU for Android OS

The CPU for the Android OS is used for connection to external networks via Wi-Fi, Bluetooth and USB, and a different CPU is used only for signals necessary to connect devices to be installed on vehicles with the vehicles in production line. Thus, an attack against the Android OS has no influence on the vehicle signals.

② Application control based on whitelist

By allowing installation of only applications approved by car manufacturers and then by defining their attributes including necessity of image display and presence/absence of audio, limited operations become available for each application.

③ Encryption of bootloader

Encryption of bootloader prevents custom ROMs from being installed onto the CPU for the Android OS. (Writing of custom ROMs is one of methods of rooting the Android OS)

④ [Audio control]

Although audios with 2-channel stereo are common for smartphones, loudspeakers with 4 channels are normally used in vehicles. In addition, interrupting sound (telephone, sound of car navigation system, etc.) should be considered.

As for the reproducible sound included in all the applications installed in the Android DA, we defined their attributes, such as normal 4 channel sound, mixed interrupting sound and independent interrupting sound. Then, by controlling them (limiting available operations for each application, as described above), we realized the audio control at the same level as the one for regular vehicle-mounted infotainment devices.

⑤ Startup and shutdown processes]

Smartphones are supplied with power from their built-in batteries. However, vehicle-mounted infotainment devices are powered by the batteries of the vehicle. Therefore, those devices need special control for speedy startup, like smartphones, while meeting changing conditions of power supplied from the vehicle. It is not possible to predict instantaneous interruption of power supplied from the vehicle. If the interruption occurs in the suspend mode (termination processing), power stored in the capacitor in the device may be insufficient to keep supplying the power to the device until the suspend process is completed. In the case where the power is not enough to keep the device on for the time necessary to complete the process, it will takes some ten seconds for the device to startup next time, due to cold start.

In order to make use of versatility of Android, we could not change the startup/termination method for suspend/resume*. Therefore, we adopted the up-to-date SOC* to achieve higher processing performance and management of power used for the processing. The adopted power management method is described below.

① Fine power control

In order to individually control the power supply to the devices, we categorized them into two groups: one for devices that can be turned off instantly at the time of termination process and the other for devices that need the suspend process. As a result, consumed power to turn them off was reduced.

② Optimal use of multi-core

We studied processes performed to turn off the power and found that many of them are simple or wait so that high throughput is not required. Therefore, we reviewed whether the consumed power could be reduced by keeping the processing amount of SOC low during the termination process. Fig. 2 illustrates the result of the review about relationships between SOC processing amount and consumed power.

* (1) Function that moves into a standby mode, storing the ongoing application status and then restarts the program from the point where the application was stopped when the standby mode is released.

* (2) System On Chip — A design method of integrated circuits that stores a series of necessary functions (systems) on one semiconductor chip.
SOC has two CPU cores of which properties are different from each other. As a result of study of optimal processing load shared by those cores, in the case where the processing amount is small, it is advantageous that the processes are performed by the core A. In the case where the processing amount is large, the processes performed by the core B is more advantageous.

Based on the result, we decided to use the core B for the usual operation and the core A for the termination process.

As described above, by switching the CPU cores depending on types of task processing, we developed a system that consumes less power and that completes the termination process within the time period in which the power is sustained.

### Adoption of Electrostatic Touch Panel

In order to materialize convenience and operability of smartphones, we have adopted, for the Android DA, the electrostatic touch panel that is used for smartphones, for the first time for our products. Fig. 3 below illustrates the method of detecting touch operations made with the electrostatic touch panel of the DA.

**Detection method of touch operation** The electromagnetic field is generated on the X pattern by the controller IC transmitting square waves at a predetermined frequency. When a touch operation is performed, a change is detected in the electromagnetic field on the Y pattern and the controller IC determines presence or absence of the touch operation based on arithmetic processing.

Noise should be generated as little as possible in the cabin of the vehicle. However, electrostatic touch panels generate unnecessary radiation noise due to the electromagnetic field for structural reasons. It is effective to lower the level of the electromagnetic field radiated from the X pattern to reduce the unnecessary radiation noise. However, in that case, change in the electromagnetic field to be detected in the Y pattern is also reduced, which makes it difficult to detect touch operations and thus deteriorates operability, one of the characteristics of the electromagnetic touch panel.

We set a target for each of the operability and the noise reduction, which are requirements contradictory to each other, as described above, and realized optimal design. Thus, we could ensure merchantability.

**[Target]**
- Unnecessary radiation noise level should satisfy the criteria of FUJITSU TEN.
- Operability should not be lower than a reference model installing Android OS.

**[Optimized points]**
1. Touch panel sensor patterns
2. Values set for IC resistor
3. Constant of hardware filter

### Product Configuration

Fig. 4 below illustrates the Android DA configuration (internal mechanism).
Three, in total, printed circuit boards are placed for audio, CPUs and CDs from the bottom. As for the product configuration, the biggest challenge for us was dissipation of heat generated by Tegra 3 microprocessor.

This part generates a large amount of heat so that careful design consideration is required when it is mounted on a vehicle and is used under the tough temperature environment. In our design, a heatsink is placed immediately above the Tegra 3 microprocessor and a heat dissipation sheet is adopted between the CPU and the heatsink to reduce stress on components mounted on the board and to enhance efficiency of the heat transmission. Moreover, a cooling fan is provided to a back side of the product to ensure the performance of heat dissipation. Accordingly, we could meet the product specifications. There are some variations of this product, as derived models. Their component structures are different from the one of this model. However, the components used for them are the same as those for this model through commonization of designs.

5 Conclusion

We had many issues to solve to install the Android OS developed for smartphones in a vehicle-mounted device. One among those issues was power fluctuation of which elimination was a requirement for vehicle-mounted infotainment devices. Thanks to kind cooperation of the FUJITSU group companies and the related department of FUJITSU TEN, we realized commercialization of the world’s first(3) Android compatible vehicle-mounted product certified by Google. Here again, we would like to extend our heartfelt appreciation to them.

(3) Researched by FUJITSU TEN in March 2011

Profiles of Writers

Yuta MORIYA
CI Engineering Group
Engineering Dept.2

Ryota TAKEMURA
SS Engineering Group
Software Engineering Dept 2

Daisuke KANNO
SS Engineering Group
Software Engineering Dept 2

Hiroshi OMAE
CI Engineering Group
Engineering Dept.2

Google and Android are registered trademarks of Google Inc.
iPod, iPhone and Siri are registered trademarks of Apple Inc.
Mirror Link is a registered trademark of Car Connectivity Consortium LLC.
Wi-Fi is a registered trademark of Wi-Fi Alliance.
Bluetooth is a registered trademark of Bluetooth SIG, Inc.
The listed product names, trade names, service names, etc. are trademarks or registered trademarks of individual companies.