

# Smartphone-based Engine Sound Enhancing System

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## Abstract

Nowadays, engine sound enhancement technologies have generally used to improve the sporty character of internal combustion engine sounds. This technique is generally based on a vehicle audio system. The audio amplifier or external controller has received the engine information via the engine control unit and has generating engine sounds by using speakers in the cabin.

In this work, we present the smartphone-based engine sound enhancing system that can replace the controller of the vehicle. Driving information about the vehicle was acquired through the wireless CAN-BUS communication device. And each corresponding order component sounds were synchronized along to engine revolution and generated. Next, the synthesized sound was reproduced considering the system delay and the transfer function of the cabin. The developed algorithm was implemented as a smartphone app that can also tune the volume and timbre. Finally, this system was successfully implemented and verified to the real vehicle.

## Introduction

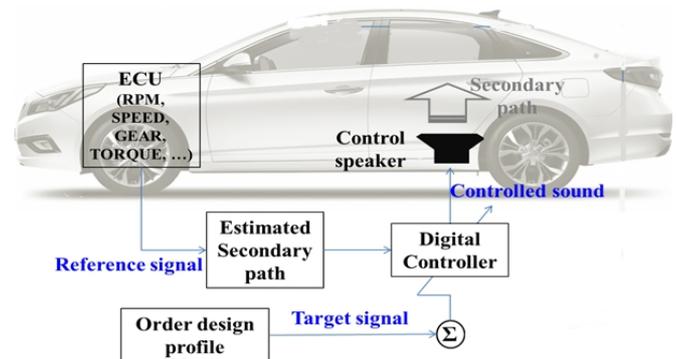
The engine sound is one of the important elements that consist of the identity of the car. So, the automotive engineer tries to realize an attractive sound which can fulfill the emotional quality to the driver. Nowadays, various active control approach is widely used for enhancing the engine sound character or increasing the sound quality. Especially, active sound design technology is mostly used to enhancing the sporty or powerful sensation of the acceleration sound. The active sound design system is based on the vehicle audio system. The active sound design system uses speakers in the cabin as a control actuator. And the real time controller is placed in the external audio amplifier or individual controller. Also, the CAN-BUS is connected to the controller to acquire the driving information which is consisted of engine revolution speed, vehicle speed, engine torque or gas pedal position, etc [1][2][3].

In this research, we present the smartphone-based active sound design system. The smartphone was used as a real time controller. First, we have developed the active sound design algorithm. And developed algorithm was converted to the smartphone environment. Also, smartphone application was developed to interact the user. User can change the volume and sound character by using developed application.

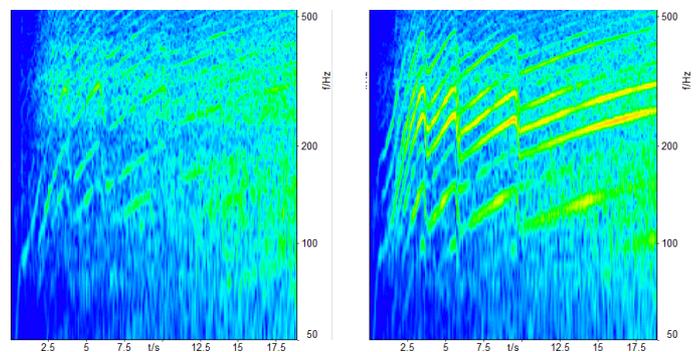
## Active Sound Design

The active sound design system is a technology that generates and reproduces engine sounds which is corresponding the order components using the in-vehicle speaker system. Figure 1 shows the configuration of the active sound design system.

The purpose of ASD is to realize the target sound by combining the control sound with the original engine sound. The control sound is generated using sinusoidal signals which is synchronized with the engine RPM. Figure 2 shows the effect of the ASD. Figure 2 (a) shows the original acceleration sound in the driver seat and (b) shows the acceleration sound with the active sound design. Engine order components were more emphasis on enhancing the sound character.



**Figure 1:** Configuration of the active sound design system based on the vehicle audio system.



(a) Original sound

(b) Designed sound

**Figure 2:** Example of acceleration engine sounds in the cabin: (a) is original acceleration sound and (b) is designed sound with active sound design

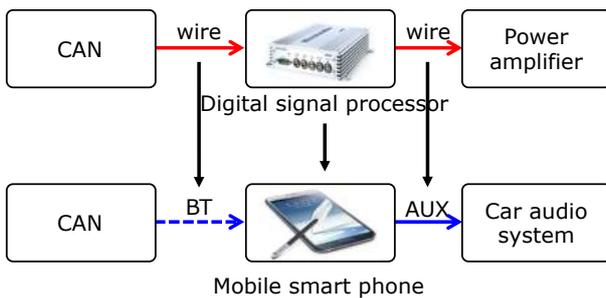
## Smartphone-based Active Sound Design

The control algorithm was coded on Android basis and implemented in the form of smartphone application. In order to using the smartphone, CAN interface and audio connecting module were also developed. Figure 3 shows the configuration of the smartphone-based the control system. To receive the vehicle driving information, bluetooth communication was used. Generated sound was sent to the vehicle audio system by using AUX. Figure 4 shows the simple diagram of the signal flow. Upper diagram shows the traditional control system based the wiring communication

and bottom diagram shows the developed system based on the smartphone.



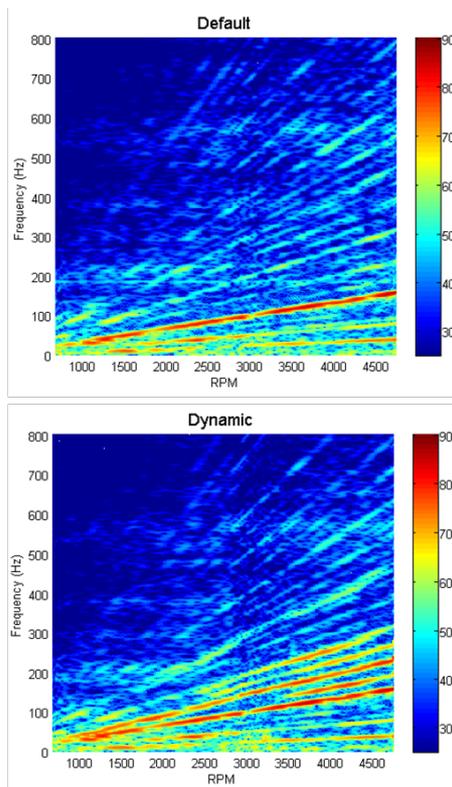
**Figure 3:** Configuration of the active sound design system based on the smartphone



**Figure 4:** Upper diagram shows the traditional control system and bottom diagram shows the developed system.

### Implementation

Developed control system were implemented to the real vehicle. For enhancing the sound character, we selected the several engine order components, i.e., C2, C2.5, C3, C3.5, C4, etc.



**Figure 5:** Original sound and synthesized sound with smartphone-based active sound design system

Selected signal was synthesized and generated in the smartphone controller and reproduced by using audio speaker in the cabin. Figure 5 show the example of reproduced sounds.

### Conclusion

In this study, we developed the active sound design algorithm which is based on smartphone system. As a result of the evaluation of the vehicle, it was confirmed that the performance of the ASD algorithm is correctly implemented.

### Reference

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