# Research on Application of Active Noise Reduction Technology in High-speed Rail

**Project background**

In the process of high-speed rail operation, the noise in high-speed rail passenger compartment is significantly increased due to the existence of the aerodynamic noise, wheel track vibration and other vibrations. In order to reduce the noise in the passenger compartment effectively without increasing the body weight and manufacturing cost, it is proposed to apply the active noise reduction technology for high-speed rail passenger compartment and cab, reducing the train wheel track noise and aerodynamic noise, noise traction etc. and improving the user experience and ride comfort. If the technology is developed successfully, a relatively quiet ride environment for the passengers may be achieved, greatly improving the passenger experience and also playing a positive role in expanding train riding population; in addition, the technology to; furthermore, the technology development achievements can be applied to the concrete engineering and the existing trains, resulting in huge economic benefits.

**1. Main research content**

Active noise control is based on the destructive interference principle of acoustic waves, which is similar to the daily-used noise cancelling headphone: two sine waves that have the same frequency and amplitude and have the phase difference of 180 degrees will offset each other after the phase superposition. At present, the application of active noise reduction technology on high-speed rail is still rare. Its working principle is as follows: the noise signal and the engine speed information received by the microphone which is installed in a specific area of the cabin will be input to the car power amplifier, and the power amplifier will, by means of unique internal algorithm, make the car speaker send a waveform which has the reverse phase against the engine second harmonic noise. Due to the interference effect of the wave, the two waves of reverse phases will offset each other when they meet in the air, thus significantly reducing the second harmonic noise level in the cabin. At the same time, the microphone in the car can continuously monitor and measure the noise transmitted from the dynamic system to the passenger compartment and achieve real-time control of the waveform and amplitude of the reverse phase wave from the speaker, thus keeping the passengers free from the car running noise.

Compared with the traditional passive noise reduction technology, the active noise reduction technology has two prominent advantages: 1. Initiative. The purposeful noise control can be achieved by virtue of the original noise characteristics, corresponding design and change of control system characteristics, thus realizing the selective operation; 2. Good low frequency noise control effect. Since low frequency noise takes the lead in internal noise, the traditional passive noise reduction measures, such as noise insulation, noise absorption and vibration isolation, show poor control effect against the noise in low frequency band and the active noise reduction technology has good low frequency noise control effect. In addition, the active noise reduction system features small volume, light weight, low additional cost and little influence on the structure and working characteristics of the car.

As early as 1991, Japan's Nissan Motor Corporation had applied the active noise reduction technology on Bluebird models, achieving the noise reduction effect up to 5-6dB. As shown in the active noise reduction research against the automotive engine noise conducted by University of Valencia, Spain, the car internal noise can be reduced by 10dB approximately, and the subjective evaluation effect is positive. At present, the active noise reduction technology has been widely applied by the automakers to the production of medium and premium models.

The application of active noise reduction technology in the railway field is still in the exploratory stage. According to public data, the Swedish Royal Institute of Technology (KTH) conducted an experimental research on the application of active noise reduction technology in the passenger compartment noise reduction in 2013, and the results show that the active noise reduction technology can reduce the internal noise by 15dB. The US Harris Miller Miller & Hanson Inc. also conducted a similar research on an electric locomotive, and the noise reduction technology reduces the internal noise by 15-20dB successfully.

There are still many research problems on the application of active noise reduction technology in high speed trains, which are mainly concentrated in high speed train noise source analysis, noise detection

method and general model determination, the research of active noise control intelligent algorithm, simulation and verification of active noise control system and so on. We intend to cooperate with UIUC to carry out the above research and work together to achieve the technology verification and optimization on the car.

**2. Expected results**

Complete the research on noise source analysis, noise detection methods and universal models, and provide the model algorithm.

Complete the research on the intelligent control algorithm of active noise control systems, and provide model algorithm, meet requirement of project realization, and keep noise reduced by 15dB as a minimum.

Complete the verification on simulation of active noise control systems, and provide the simulation verification platform and source codes, and keep value accuracy of simulation systems and actual application systems higher than 90%.

Two kinds of intellectual property rights are expected to be acquired.

**3. Task breakdown**

**3.1 Task 1:** Complete the research on noise source analysis, noise detecting methods and universal models.

Research content: Analyze the noise source and noise frequency spectrum distribution at various speeds and under various conditions for the specified high-speed train, and determine noise source at various frequency bands through various noise detection methods, and propose universal noise models and evaluation methods. Test and determine the applicable data and verify model validity through cooperation between both parties, for which no data is available now.

Expected results: Generate research reports, and provide universal models.

**3.2 Task 2:** Complete the research on the control algorithm of active noise control system.

Research content: Complete the research on the control algorithm of active noise control systems, including but not limited to background noise measurement, self-adaption noise offset, self-adaption filter design, research on system optimal control algorithm, relevant research on the control algorithm parameters, theoretical modeling of the control algorithm, design of active noise reduction systems and feasibility research of project.

Expected results: Provide the control algorithm, algorithm models, codes and feasibility reports of the active noise reduction technology. Obtain one patents.

**3.3 Task 3:** Complete verification on simulation of active noise control systems.

Research content: Complete the verification on simulation of active noise control systems, and provide the graphical system interface.

Expected results: Provide the simulation verification platform and source codes, and obtain one patent.

**4. Expected R&D period**

24 months