Exterior Noise Contribution Analysis with Simulated Indoor Pass-by Measurement

Yunseon Ryu [1)] Andreas Schuhmacher [2)] Masamitsu Hirayama [3)]

The simulated indoor pass-by noise measurement system is the measurement tool to evaluate the pass-by noise at the test laboratory, without doing measurement at the field. This measurement system can overcome the limitations of the field measurement, i.e. weather conditions, reproducibility, ..

In this measurement, microphone array is located around the car on chassis dyno. The measured time-domain signals are synchronized with one signal, which is equivalent to the signal recorded in the field representing the moving source effect. By using FRF between indicator and receiver microphones, which are representing source strength and evaluation points correspondingly, source path contribution analysis is performed at 7.5m apart from the centerline of car.

In this paper, the measurement and signal process on top of the theoretical background would be discussed with the measurement example.

Key Words: **pass-by, array techniques, source path contribution**

1. INTRODUCTION

The pass-by noise measurement is the activity to measure the noise emission of road vehicle under the acceleration condition. This measurement is mandatory to the automotive manufacturers for the model certification. For this reason, International Standard Organization, i.e. ISO, regulates the measurement, analysis procedures, as well as the reporting format. Of course, this measurement could be one of the most important activities of trouble-shooting for the mass-production cars, for example, tyre noise and exhaust noise… The pass-by noise measurement method should be designed to meet the requirements of simplicity, as far they are consistent with the reproducibility of the results. Also, the pass-by noise measurement should be done in an extensive open space for type approval of commercial vehicles, and it should be measured on the manufacturing stage at the official test station. Thus, it has such an important meaning that the certification of emission noise measurement checks before the mass production.

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1)・2) Bruel & Kjaer (Skodsborgvej 307 Naerum 2850 Denmark) E-mail; ysryu@bksv.com

3) Bruel & Kjaer Japan

The specifications are intended to reproduce the noise levels, which are produced during the use of intermediate gears with full utilization of the engine power available as may occur in urban traffic. It should be noted that spot-checking of vehicles chosen at random could rarely be made in an ideal acoustical environment. It should be recognized that the obtained results might deviate appreciably from the results obtained using the specified conditions. As the general requirements, the test should be done with the vehicle in moving on road, also the vehicle should be in the normal operating conditions, which give the highest noise level. The noise measurement should be done on the test track under acceleration condition with widely open throttle status.

But, for some reasons, the pass-by noise measurement could not be done at the field, for example, bad weather condition, test track condition,… For these cases, the indoor simulated pass-by noise measurement is often used. The indoor simulated pass-by noise measurement cannot replace the field confirmation test of the certification, but this method offers number of advantages, i.e. good reproducibility, flexibility, easy-of-use.…

Mainly the indoor simulated pass-by noise measurement

system is the tool to make measurement and analysis simple and reliable for not only trouble-shooting, but also development procedure. This measurement must be available in room where the size does not allow to setting up the microphones in 7.5m distance from the center line of both sides.

In this paper, the exterior noise contribution analysis is introduced, especially with Indoor pass-by measurement. Using the FRF(frequency Response Function) between receiver and source indicator microphones are used for the calculation of the contribution analysis for the relevant noise sources. With this method, you can easily identify the contribution of the relevant noise sources.

2. SOURCE SUBSTITUTION PRINCIPLE

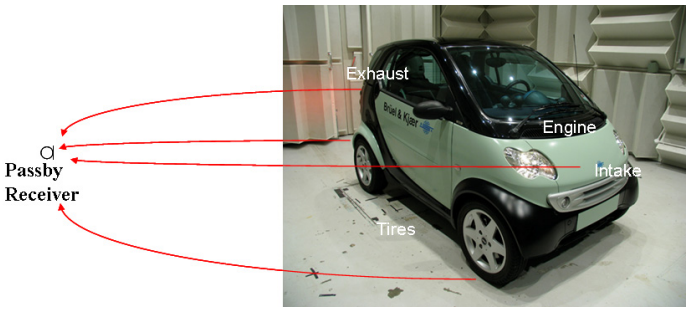

Fig. 1 Pass-by Receiver and Relevant Sound Sources

In the indoor pass-by noise measurement, the microphone array would be set around the car as receiver. In order to analyze the contribution of each sound sources, for example, engine, transmission, exhaust, intake, tires, the indicator microphones are required. The indicator microphones are representing the sound source strength of each source. So, it is very important to define the position of the indicator microphones. Sometimes, multiple indicator microphones are required to represent the sound source, for example, engine and transmission case.

The contributions of each sound source are validated at the receiver microphones, which are set around the car on the chassis dynamometer, as shown in Fig. 1.

First, the FRF between receiver and indicators are taken using the volume velocity sound source in the free field condition. At this case, the indicator microphones are assumed to represent the characteristics of sound source. Of course, FRF between the exact source position and the indicator microphones are also taken to verify the relationship between indicators and source points, as shown in Fig. 2.

As second step, it is said that the signals measured in the indicator microphones are representing the source characteristics on the operational condition. The indicator microphones are equivalent the source under the operational condition as shown in Fig. 3.

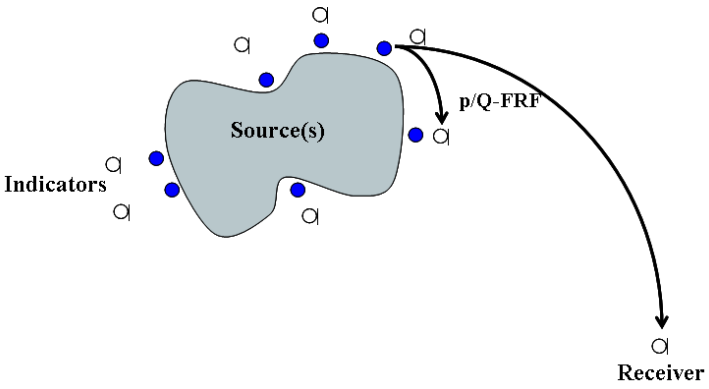

Fig. 2 Indicator Microphones

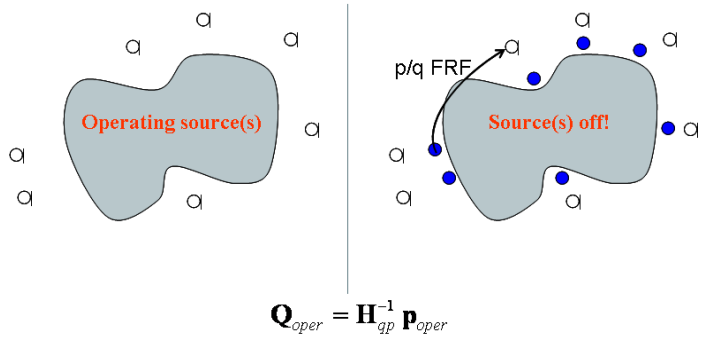

Fig. 3 Operational Source Equivalent

3. VEHICLE ACOUSTIC SOURCE MODEL

As shown in Fig. 4, the receiver microphones are located at both sides of a car on 7.5m position apart from the centerline. The measured signals of the each microphone are synthesized to a signal which is equivalent to measured with field pass-by in time domain. In the end this signal is used for receiver signal.

For the dominant sound sources, some points are taken as engine, transmission, exhaust, intake,..

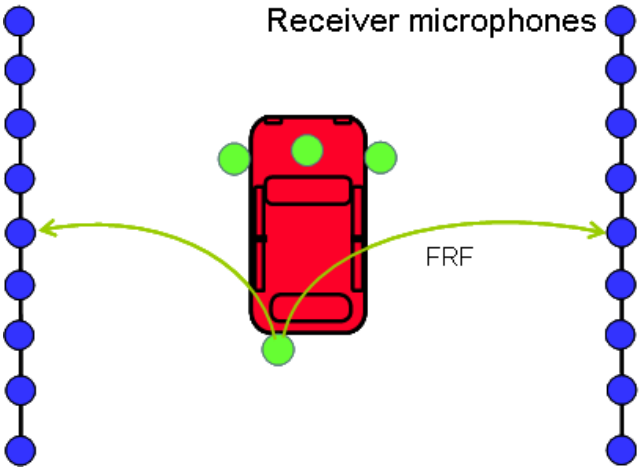

Fig. 4 Measurement Microphone Arrays

For the measurement of FRFs between indicator microphone array, which is located to the near points of the car, and specific sound source points, i.e. engine, transmission, exhaust, intake, as shown in Fig. 5. Of course, the FRFs between receiver microphone array and the indicator microphone array are measured for the separation of the sound source contribution.

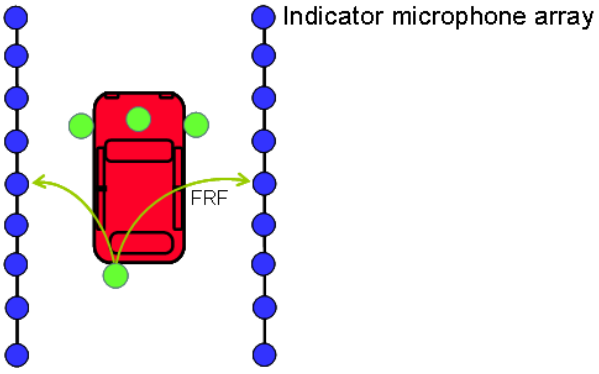

Fig. 5 Indicator Microphone Array

4. SIGNAL PROCESSING

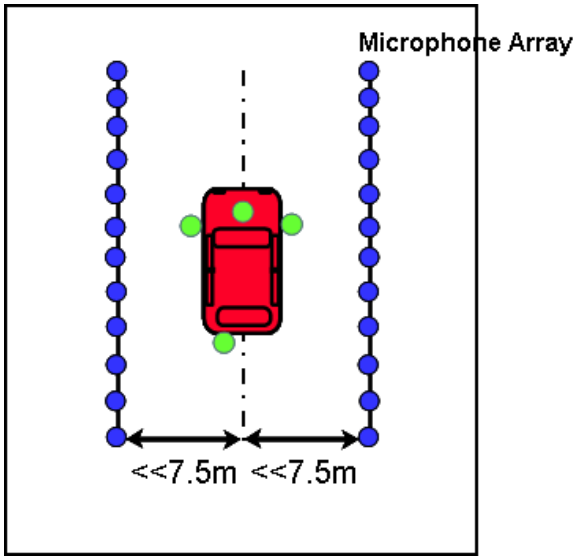

Fig. 6 Receiver Microphone Array

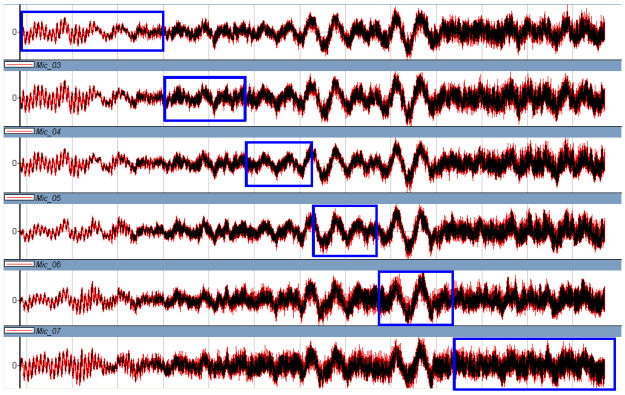

Fig. 7 Synchronization of the Time Signals

4.1 Measurement Procedure

In the anechoic chamber, a car is standing on the chassis dynamometer with the operational condition. During a car is rolling on the chassis dynamometer, the time signal are taken by the microphone array, which is located on 7.5m apart from the centerline. At the same time, the indicator microphones are taking the time signals, and calculating the source strength under the operational condition as shown in Fig. 6.

The measured signals are marked with the position of car, which is converted by the vehicle speed. All the contributions of the each microphone are cut and synchronized with a signal, which is equivalent to the signal measured in field pass-by in time domain as shown in Fig. 7. This routine is the same routine as indoor pass-by noise measurement, which is

mentioned in detail on ref. (4) and (5).

4.2 Signal Processing

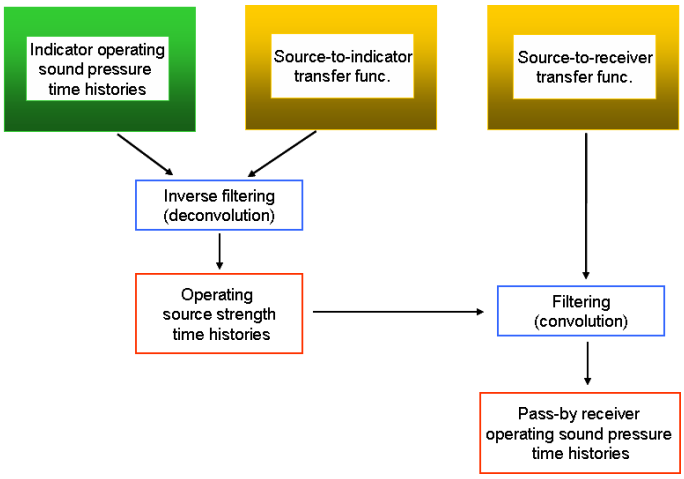

Fig. 8 Schematic Diagram of Signal Processing

The Figure 8 shows the schematic diagram of the signal processing. With the measured FRFs between sources and indicator microphones are used with indicator sound pressure on operational condition for making the inverse filter by deconvolution of time signals. At the same time, the filter is made with the convolution of FRFs between sources and receivers. Combining the operational source strength time history with filter defined by these FRFs, the pass-by operational sound pressure time history is obtained, finally.

5. CONCLUDING REMARKS

Pass-by noise measurement is the mandatory activity to get the certification or confirmation of the sound & vibration performance of the productive car. The test procedure is recommended by international standards, i.e. ISO 362, SAE 1470,..

The proposed Indoor Simulated Pass-by Noise Measurement System can be used for the purposes of R&D and trouble-shootings.

The exterior noise contribution analysis is done using FRF between source and receiver. With this analysis, each contribution is identified with sound sources at the receiver position. This activity is known as an extremely difficult and time-consuming work at field.

With the proposed method, the exterior noise contribution analysis is easily done on chassis dynamometer with Indoor Pass-by noise measurement technique. This method is also done in time-domain, so each contribution signal can be monitored by hearing.

Figure 9 shows the graphical user interface of this contribution analysis using FRF.

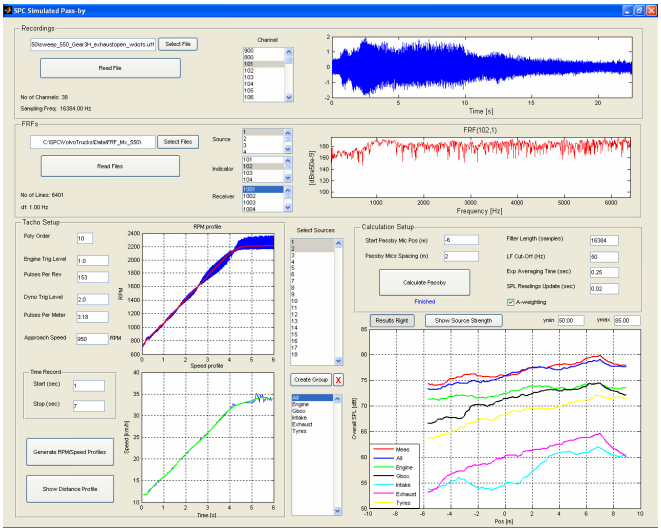

Fig. 9 Graphical User Interface

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