Active Local Noise Control in Open Space

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ABSTRACT: Local noise control is a practical option of active noise control in open space when the control sources and the primary sources can not be closely located. In many cases, the local control system attenuates the sound pressure in some areas at the cost of total sound power output increase. Two indicators of control efficiency, quiet zone size and total sound power output, are dependent upon the configuration of the control system. It has been found that for the multi-channel control system, there exists a range of optimal configuration of the control system, in which the control system can create the largest quiet zone with the lowest increase of total sound power output. This optimally arranged control system can be also effective to broadband noise source and non-point noise source.

INTRODUCTION

Much of the progress on active noise control in duct as well as in small enclosure has been achieved. The active noise control in open space, though is relatively difficult, has also attracted increasing attention. Generally, there are two approaches for active noise control in free space: global control and local control. The former is to minimize sound power output from the noise sources, while the latter is to minimize the total sound pressure at one or several positions in the space. The global control of noise in open space has been thoroughly investigated by Nelson and Elliott (1-3). Their conclusion showed that the global control is effective only when the control sources are placed very close to the primary sources. When the condition of short separation of control and primary sources can not be met, the local control seems to be a practical option.

The objective of this paper is to show that an optimally arranged local control system can be very effective, and to review some general guidelines in designing local active noise control system in open space.

OPTIMAL CONFIGURATION OF THE CONTROL SYSTEM

The local control strategy is used in the cases where the global control of noise is difficult to achieve, or when only noise cancellation in some areas or directions is required. The arrangement of the secondary source is to generate the destructive interference of the primary and secondary fields in the desired area or direction. The local control system can then create quiet zones in the desired area. This is achieved by adjusting the control source to cancel the primary field at a specific position inside the area where quiet zone is to be created (normally the position of the error microphone). To ensure that the quiet zone is the largest, the control system should be such arranged that the area of wavefront matching between the primary and control fields in the position of error microphone is the largest. This is the arrangement that the control source is in between the primary source and error microphone (4).

When the control source is adjusted to cancel the primary sound pressure in specific directions or areas, constructive interference between the primary and secondary fields may occur in some other directions. In other words, while the control source creates quiet zones in some areas, it may cause the sound pressure to increase in other areas. The local control of noise is achieved at the cost of the total sound power output increase (or increase of sound pressure outside the quiet zone). It has been found that for some arrangements of the control system, especially for the multi-channel control system, this total sound power output increase can be very large, which in return will decrease the size of quiet zone created by the control system. There exist the optimal configurations of the control system that can create the largest quiet zone with least increase of total power output. The research on multi-channel ANC control in open space found that the optimal configuration of the control system can be expressed in term of a range of control source and error microphone spacings when the control sources and the error microphones are placed in two parallel equally spaced lines or planes. The upper and lower limits of the optimal range are analytically obtained (4, 5).

The optimal range corresponds to the optimal configuration of the control system. The control system can create the largest quiet zone when it is arranged within the optimal range, otherwise, the control system may either become insignificant, or even largely increase the primary noise field. Figure 1 shows the experimental results of quiet zones created by a 3-channel control system when the control sources and error microphones are equally spaced.
placed in two parallel lines, where in Fig. 1(a), the spacing of the control sources is within the optimal range, and in Fig. 1(b) the spacing of the control sources is outside the optimal range. A totally different result is observed. A large quiet zone is obtained for the control system being optimally arranged. When the separation of the control sources is larger than the upper limit of the optimal range, the sound attenuation only occurs in a very small area around the error microphones, the sound pressure suffers a big increase in other space.

![Diagram](image)

**FIGURE 1.** Sound pressure attenuation using a 3-channel control system with two configurations.

The study showed that the optimally arranged local control system was also effective to the non-point and broadband noise source (6). The reflection from the nearby rigid ground significantly reduces the size of the quiet zone created by the control system for most configurations, however, this size reduction usually decreases as the height of the system to the surface increases (7). The application of this developed MIMO control system to the noise barriers has also been investigated. The results indicate that an optimally designed multi-channel ANC system can significantly increase the insertion loss of a noise barrier, especially at low frequency range (8).

**GENERAL DESIGN GUIDELINES**

When applying ANC to control the outdoor noise, the determination of the feasible control objective and design of an optimal control system are extremely important. While a well-designed control system can be very effective in attenuating noise either globally or locally, a badly designed control system may even increase the noise field in very large scale. The general design of the ANC system for local control in open space can follow the following steps:
1. Measuring the characteristics of the primary noise and determine the main components of the noise to be controlled.
2. Determining the control objective according to the requirement (such as the size and minimum level of noise reduction), the noise characteristics, and the environmental conditions.
3. Selecting the control strategies according to the control objectives.
4. Determining the number of channels and the arrangement of the control sources and error microphones according to the desired total power output attenuation or the size and location of the desired quiet zone.
5. Arranging the control sources and/or error microphones optimally by using the expressions described in (4, 5).

**REFERENCES**