

# EXPERIMENTAL STUDIES ON THE MULTI-CHANNEL ACTIVE CONTROL OF COMPLEX SOURCES IN THE FREE-FIELD

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## 1. INTRODUCTION

In this experimental study, single and multiple channel control of monopole and dipole primary sources in the free-field were investigated. In previous experiments of active control, most studies have concentrated on controlling a single-tone low-frequency signal; however, many real low-frequency noise sources also emit harmonic frequencies. In order to relate the experimental studies to more useful practical applications, such as the active control of propeller aircraft noise, the effectiveness of a control system on two-tone signals emitted from both a single primary source and two primary sources was investigated.

## 2. EXPERIMENTAL SETUP

The experiments were performed in a  $4.7 \times 4.2 \times 2.2 \text{ m}^3$  anechoic chamber at the University of British Columbia. A total of 56 points were measured at the height of the control system (1.3m) with a resolution of 0.5m, as shown in Fig. 1. 1-, 3- and 4-channel control was used on single dipole and single monopole primary sources, as well as two monopoles. Using computer simulations, the distance between the primary source and control speakers ( $d$ ), the distance between the control speakers and the error sensors ( $t$ ) and the distance between adjacent control channels ( $s$ ) were optimized for maximal noise reduction. The test signals were pure tones of 100Hz and 200Hz. In total, six different experiments were performed, as summarized in Table 1.

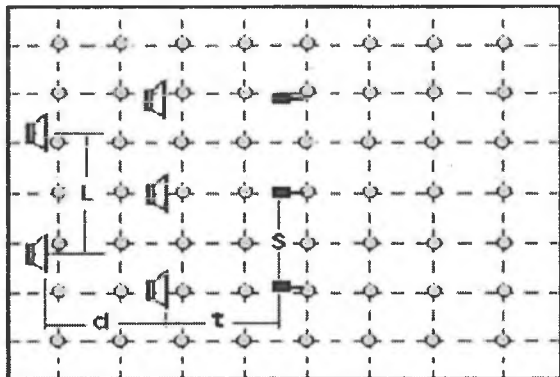


Fig. 1. Measurement points at the height of the control system.

Table 1. Summary of active control experiments.

No.	Noise	Control	Frequency
1	1 dipole	1 channel	100 Hz
2	1 dipole	3 channels	100 Hz
3	1 monopole	1 channel	100 + 200 Hz
4	1 monopole	3 channels	100 + 200 Hz
5	2 monopoles	3 channels	100 + 200 Hz
6	2 monopoles	4 channels	100 + 200 Hz

## 3. RESULTS

For active control of a dipole noise source, it has been found experimentally that an active control system is most effective when it is placed in the direction of the strongest primary noise directivity [2]. The dipole experiments were thus performed with a maximum of the dipole radiation facing the control system. Fig. 2 and Fig. 3 show the control results for a dipole source using a pure tone of 100Hz with one-channel control and three-channel control, respectively. For both cases,  $d=0.8\text{m}$  and  $t=0.6\text{m}$  were used, and in the three-channel case  $s=0.9\text{m}$  was used. Using one-channel control, the attenuation achieved in most areas of quiet zone was more than 12dB, with the maximum attenuation being 30dB. Using the three-channel system, the attenuation in most areas of the quiet zone increased to 15dB, with the maximum being 36dB.

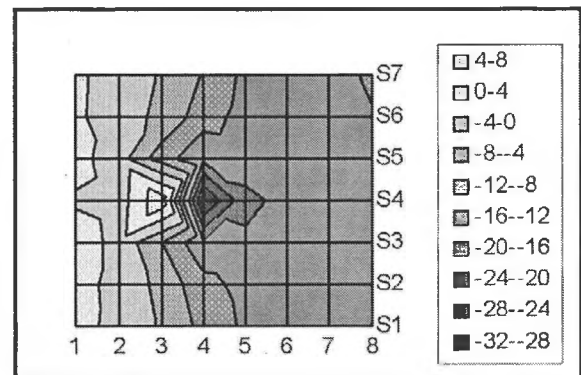


Fig.2. One-channel control of a single dipole at 100Hz.

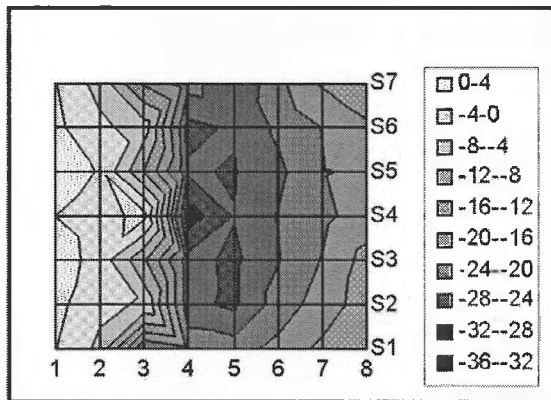


Fig. 3. Three-channel control of a single dipole at 100Hz.

The control results for a single monopole emitting two tones of 100 and 200Hz are shown in Fig. 4 (one channel) and Fig. 5 (three channels). In the one-channel case,  $d=0.8\text{m}$  and  $t=0.6\text{m}$  was used. Because of the two-tone signal, the size of quiet zone created by one channel control is very small. In most areas, only about 3dB of attenuation was achieved. For the three-channel system, using  $d=0.6\text{m}$ ,  $t=1.0\text{m}$  and  $s=0.9\text{m}$ , the quiet zone is expanded considerably, with attenuation of up to 27dB in the center.

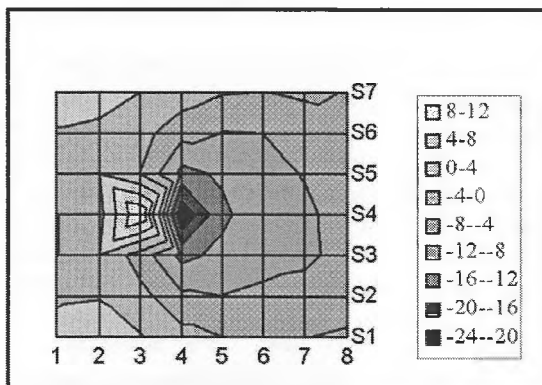


Fig. 4. One-channel control of a single monopole emitting a two-tone signal of 100 and 200Hz.

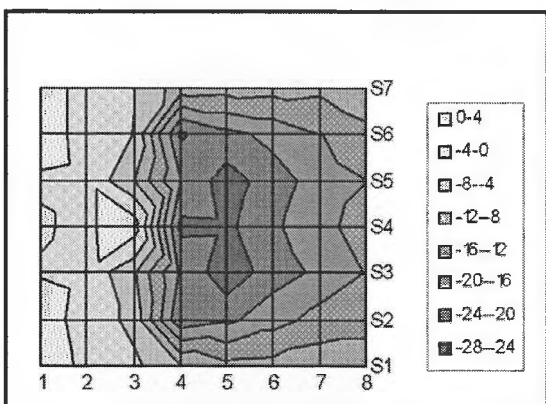


Fig. 5. Three-channel control of a single monopole emitting a two-tone signal of 100 and 200Hz.

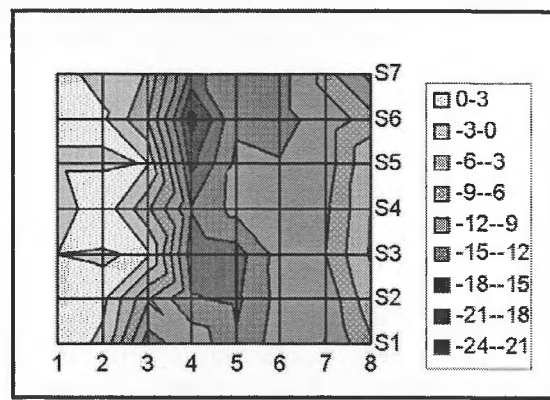


Fig. 6. Three-channel control of two monopole sources spaced 1.2m apart, emitting a two-tone signal of 100 and 200Hz.

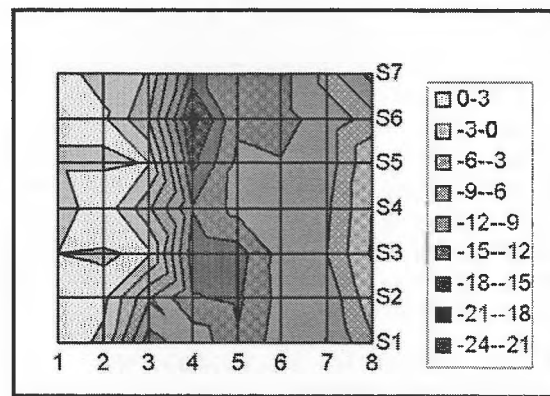


Fig. 7. Four-channel control of two monopole sources spaced 1.2m apart, emitting a two-tone signal of 100 and 200Hz.

The performance of the same three-channel control system on two monopoles, spaced 1.2m apart, emitting a two-tone signal of 100 and 200Hz is shown in Fig. 6. Comparing the results to those shown in Fig. 5, the effectiveness of the control system is reduced, as only about 3dB of attenuation was achieved in most areas. Increasing the number of control channels to four improved increased the attenuation to about 6dB as shown in Fig. 7.

#### 4. CONCLUSION

The experimental results clearly show that the performance of an active control system can be improved by using multiple control channels. A multi-channel system not only increased the attenuation of the control area, but also increased the size of quiet zone. It has also been shown that more complex noise sources can be controlled by using a multi-channel system, suggesting that it may be possible to control real noise sources such as propeller aircraft.

#### REFERENCES

1. J. Guo, J. Pan and C. Bao, "Actively created quiet zones by multiple control sources in free space" *J. Acoust. Soc. Am.* **101**(3), (1997).
2. A. Nakashima, J. Guo and M. Hodgson, "Preliminary investigation of active control for dipole noise sources", *ACTIVE 2002 proceedings* (2002).