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APPLICATION OF TIME-DELAYED COHERENCE MEASUREMENT FOR DETERMINATION OF NOISE FROM OUTDOOR NOISE SOURCES IN HIGH BACKGROUND NOISE

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INTRODUCTION

A general problem occurring in connection with measurement of environmental noise is high background noise. [1] deals with dual-channel FFT-analysis, where one microphone is placed near the noise source, and the other in the immission point. Compensation for the propagation-delay between the two microphone signals is obtained by means of a digital delay-line. The noise level in the immission point is determined on the basis of the measured coherent output power-spectrum. The method is very sensitive to phase fluctuations caused by the meteorological conditions (wind and temperature fluctuations, etc.). To reduce this problem a variation of the method is suggested in [2] . Here both microphones are placed in the immission point at a fixed relatively small distance and with the line-of-sight in the direction of the noise source. It is shown that the coherent output power-spectrum, and thus the noise level, will depend on the direction of sound, so that a reduction of noise from directions other than the measuring one is obtained.

During this paper will be shown how this directivity pattern depends on time domain weighting, distance between the microphones and record length of the FFT-analyzer. Experimental results illustrating the applicability of the method are also presented.

DIRECTIVITY PATTERN

As shown in [3] and [4] the estimated coherence will be diminished, due to a time displacement (τ) between the FFT time-records, by the factor:

$$\frac{\gamma^{2\prime}}{\gamma^2} = \begin{cases} (1 - \frac{|\tau|}{T})^2 & \text{for } |\tau| \leq T \\ 0 & \text{for } |\tau| > T \end{cases} \quad (1)$$

where T is the record lenght. The expression is a good approximation for wideband random signals and Uniform time domain weighting.

Fig. 2 shows how this reduction factor depends on $\frac{|\tau|}{T}$. Experimentally determined values for Hanning time domain weighting are also indicated.

If the signals come from two microphones placed as shown in fig. 1, the propagation delay for the angle of incidence α relative to the connecting line of the microphones will be: $(d \cdot \cos\alpha)/c$, where c is the velocity of sound in air.

If the propagation delay corresponding to $\alpha = 0^{\circ}$ is compensated for in the measuring system, the resulting delay will be:

$$|\tau| = \frac{d}{c}(1 - \cos\alpha) \qquad (2)$$

and

$$\frac{|\tau|}{T} = \frac{d}{T \cdot c}(1 - \cos\alpha) \qquad (3)$$

If this expression is combined with the results of fig. 2 (Hanning time domain weighting), the course of the reduction factor as a function of α and for different values of the parameter $\frac{d}{T \cdot c}$ can be calculated as shown in fig. 3.

It appears that the directivity pattern depends on d and T, and fig. 2 illustrates that the use of Hanning time domain weighting will increase the directivity for values of $\frac{|\tau|}{T}$ above approx. 0.18.

INSTRUMENTATION

The applied instrumentation is based on a dual-channel FFT-analyzer HP 3582A connected to a desk-top computer HP 9825A and a digital plotter HP 9872A. To compensate for the propagation delay is used a Lexicon digital delay-unit, model M 93. Moreover, sound measuring chains of the manufacture Brüel & Kjær have been applied.

In certain cases the noise signals are recorded on a dual-channel instrumentation tape recorder (NAGRA IV-SJ) and are later reproduced in the laboratory.

In order to realize the desired directivity pattern (see fig. 3), the record length of the FFT-analyzer, and thus the frequency range, must be selected in an appropriate relation to the distance between the microphones. For the FFT-analyzer HP 3582A - for instance for a frequency range of 0-10 kHz - T is equal to 12.5 ms, and the corresponding distance between the microphones d must be as stated in table 1.

$\frac{d}{T \cdot c}$	0.5	1	2
d,m	2.1	4.3	8.6

Table 1

Distances of 2-4 m between the microphones should not give rise to essential measurement-errors at wind velocities under 4-5 m/s [1] .

EXPERIMENTAL RESULTS

In order to check the applicability of the method the following experiments were carried through:

The A-weighted noise level from a noise source (B & K 4205, white noise), placed outdoors on the ground, was determined at a distance of about 16 m by means of the described measuring system (d = 4.3 m).

Behind the microphone array were several noise sources giving a background noise level of about 50 dB(A). The noise level of the noise source was adjusted to about 60 dB(A) at the measuring point, and was then reduced in steps of 10 dB (-10, -20 and -30 dB). Fig. 4 shows the measuring results.

CONCLUSION

The proposed method has worked satisfactorily in connection with the described experiments. It was possible to determine the noise level from the noise source with reasonable accuracy even when the background noise level was 10-15 dB(A) higher than the noise level of the noise source.

In connection with environmental noise measurements the described method will probably be able to improve the measuring accuracy in many situations with high background noise.

REFERENCES

[1] Determination of the noise level from individual noise sources in connection with environmental noise measurements. Application of coherence analysis. O. Dyrlund, Jutland Technological Institute, 1980 (in Danish).

[2] Noise Source Identification Using Dual Channel FFT Analysis. Lathi, Tapio, Paper H13, NAS 82, Stockholm.

[3] Engineering Applications of Correlation and Spectral Analysis. J.S. Bendat and A.G. Piersol, Wiley - Interscience, New York, 1980.

[4] Noise source Identification Using Coherent Output Power Spectra. W.G. Halvorsen and J.S. Bendat, Sound and Vibration (1975), 9, 15-24.

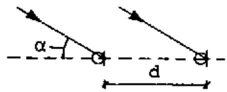

Fig. 1

Microphone array

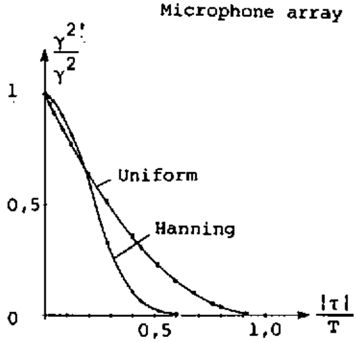

Fig. 2

Reduction factor for coherence function as a function of $\frac{|\tau|}{T}$ for Uniform and Hanning time domain weighting

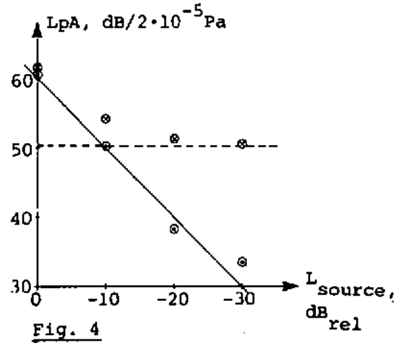

Fig. 4

A comparison between total LpA (⊗), coherent LpA (⊙), LpA from background noise sources (- -) and calculated LpA from noise source (—)

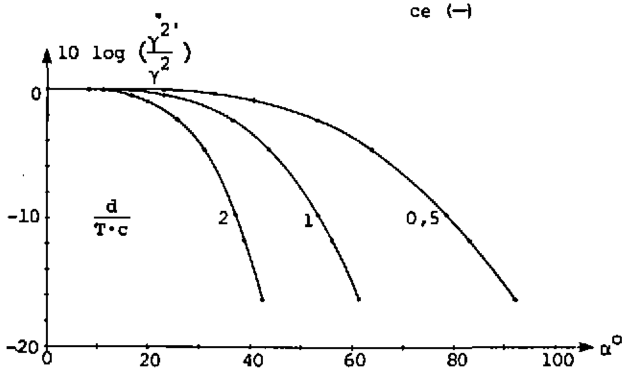

Fig. 3

Reduction in decibels for coherence function as a function of angle of incidence for different values of $\frac{d}{T \cdot c}$