inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 7.1

DEVELOPMENT OF MULTI-FUNCTION TIME DOMAIN CONTRIBUTION ANALYZER AND ITS BASIC PERFORMANCE

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Keywords:
CONTRIBUTION, NOISE SOURCE, ADAPTIVE SIGNAL PROCESSING, ANALYZER

ABSTRACT
This paper describes the development of multi-function time domain contribution analyzer and its basic performance. This analyzer has two functions. One function is time domain contribution analyzing function and the other is spectrum analysis function. The contribution analyzing function is to identify the noise source using adaptive signal processing. The spectrum function is to monitor the signals from each channel and to calculate the power spectrum, coherence, transfer function and cross-correlation. The analyzer performance is verified by the speaker tests. Results show that the contribution level for each sound source can be estimated within 2 dB.

1 - INTRODUCTION

Noise is one of the most serious environment problems. We usually solve this problem by, determining the loudest or most unpleasant sound sources. Next, we find the main propagation route from the noise source to the receiver. Finally, we can then take measures against the noise problem.
If we can find the noise source from manufactured products quickly and accurately, we can solve the noise problem effectively. To minimize the cost of solving the noise problem, we have developed a new multi-function time-domain-contribution analyzer (TDCA).
This analyzer has two functions: time domain contribution analysis and spectrum analysis. The contribution analysis function can identify the noise source by using an adaptive signal technique.

2 - OUTLINE OF MULTI- FUNCTION TIME DOMAIN CONTRIBUTION ANALYZER

This analyzer consists of a personal computer and analyzing equipment. The spectrum analyzing function consists of

- Signal monitoring to check each input signal from the sensors.
- Power spectra calculation to check the power spectrum of each sensor signal.
- Coherence calculation to determine the contribution rate: the coherence between the evaluation microphone and the other sensors is calculated.

Table 1 shows the hardware specification. The function calculates the contribution rate in the time domain at evaluation point by using each reference signal. The contribution rate is calculated in real time by adaptive digital signal processing.

Sampling rate	24 kHz
Number of adaptive filter tap	1 024 (maximum)
Evaluation point	1
Maximum noise source number	16
Analysis frequency range	Available between 80 Hz and 8 kHz
Display function	Bar graph / Trend graph

Table 1: Hardware specification.

3 - PERFORMANCE TEST OF TDCA

3.1 - Test conditions

We measured the performance of TDCA by using four speakers in an experimental room. Figure 1 shows the layout of the four speakers and five microphones. In this figure, S1-S4 represents speakers, M1-M4 represents the reference microphones, and E marks the evaluation point. The direction of each arrow shows the direction in which each speaker or microphone points. The reference microphone sets in the front of each speaker. The distance between the reference microphone and the speaker is within 15 cm. Each speaker emits a different pink noise. These pink noises have no coherence. Figure 2 shows the coherence between S1 and S2.

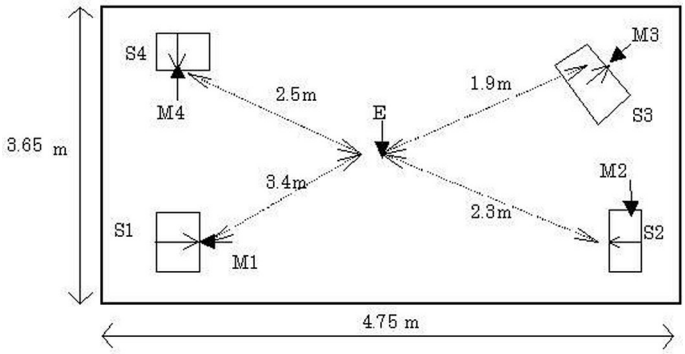

Figure 1: Arrangement of microphones and speakers.

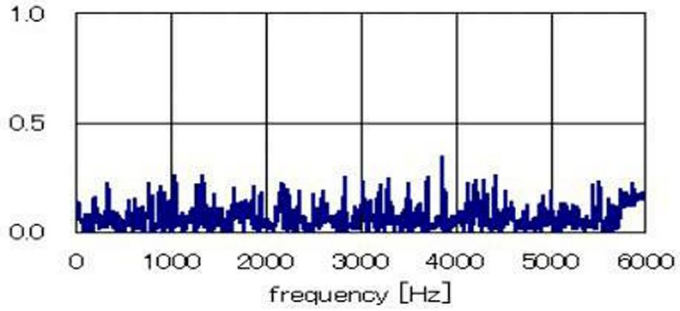

Figure 2: Coherence between S1 output signal and S2 output signal.

3.2 - Basic performance test

Under the above test conditions, the contribution rate was measured by the single speaker test (SSM). This test first, measures sound pressure level (SPL) at the evaluation point from each speaker. Next, it measures SPL, at the evaluation point, from all speakers out; thus, each contribution rate is obtained (Table 2).

	S1	S2	S3	S4
SPL	81.6 dB	80.6 dB	74.6 dB	73.8 dB
Contribution rate	46.4 %	36.8 %	9.2 %	7.6 %

Table 2: Measurement of SPL and contribution rate by SSM.

Using the same test conditions, we calculate the contribution rate by TDCA. Figure 3 shows the convergence curves. The error decreases with time. When the error is stable and small enough, we can thus obtain each contribution rate.
Figure 4 compares contribution rates determined by SSM with these by TDCA. This figure shows that

- The contribution priority of TDCA is same as SSM.
- The contribution rates determined by TDCA and SSM are within several percent.

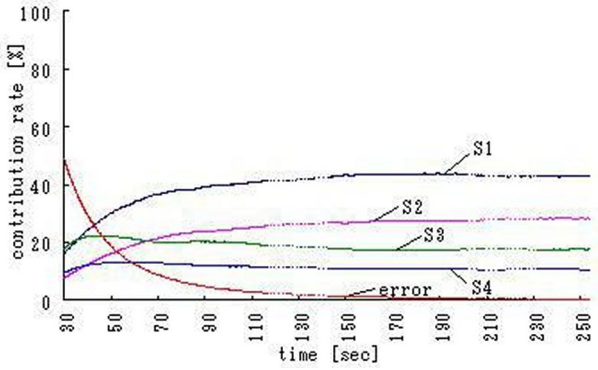

Figure 3: Convergence curves.

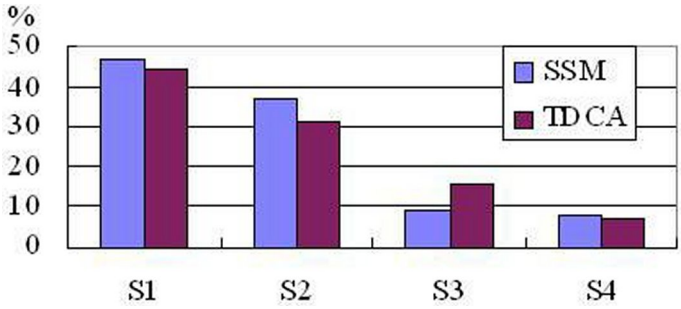

Figure 4: Comparison of contribution rate between SSM and TDCA.

The measured sound pressure level at evaluation point is 85 dB. We obtain the sound pressure level of each noise source by multiplying the contribution rate and this sound pressure level. The each measured and calculated sound pressure levels are compared Fig. 5, which shows the difference between them is less than 2 dB.

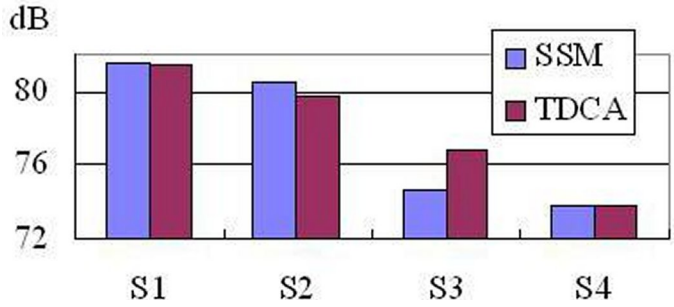

Figure 5: Comparison of sound pressure level between SSM and TDCA.

3.3 - Performance test using soundproof box

Speaker 1 is the source of the loudest sound at the evaluation point (Table 2). To decrease the sound pressure level at the evaluation point, we covered speaker 1 by a soundproof box. The sound pressure at the evaluation point could thus be changed: Reference microphone 1 is set in front of the soundproof box.

Under this test conditions, we determined the contribution rate by SSM and TDCA. Figure 6 compares contribution rates determined by SSM and TDCA (under the box-conditions). This figure shows that the contribution priority of TDCA is same as SSM.

Figure 7 compares sound pressure levels determined by SSM and TDCA. It is clear that the difference in measured and calculated sound pressure levels is within 2 dB.

4 - SUMMARY

We developed a multi-function time-domain-contribution analyzer for precisely determining a noise

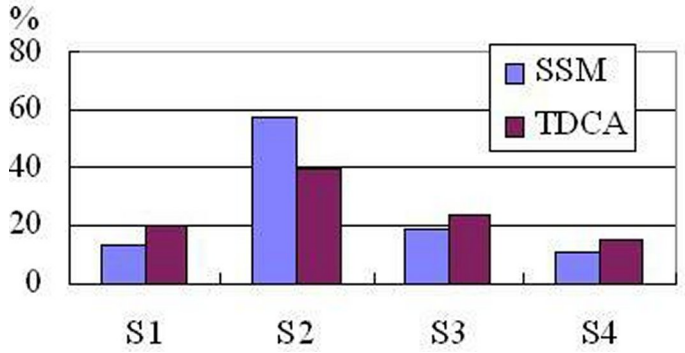

Figure 6: Comparison of contribution rate between SSM and TDCA.

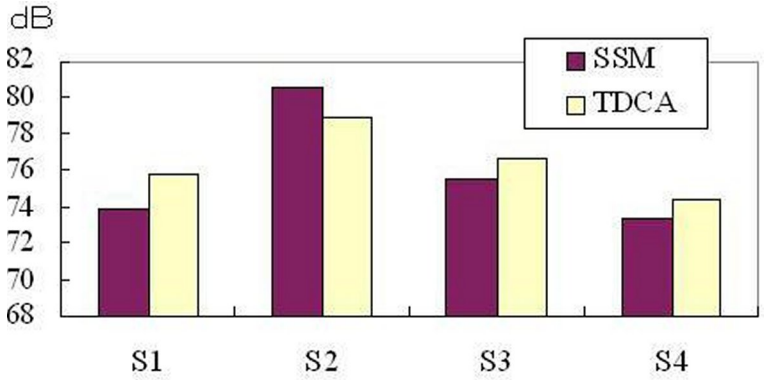

Figure 7: Comparison of sound pressure level between SSM and TDCA.

source. This analyzer has two functions: determining time domain contribution rate and analyzing noise spectrum. Speaker tests showed that this analyzer can estimate the contribution level from each sound source to within 2 dB.

REFERENCES

1. **B.Widrow and S.D.Stearns**, *Adaptive Signal Processing*

2. **O.Sekiguchi and al.**, Development of Multi-function Time Domain Contribution Analyzer, In *99 Symposium on Environment Engineering*, pp. 109-112, 1999