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PREDICTION OF SOUND POWER LEVEL AND SOUND PRESSURE LEVEL RADIATED BY COMPUTER FRAMES

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INTRODUCTION

The purpose of this paper is to present data on the prediction of noise levels of computer frames typical of those used in large computer systems. In such systems, the noise sources are typically power supplies or air-moving devices such as centrifugal blowers. The noise sources are, for practical purposes, statistically independent and therefore it is possible to add contributions from several sources on a mean-square basis in order to determine the sound pressure level at a given point. Similarly, the sound power level of the machine may be determined from the sound power levels of the individual sources after energy losses within the machine frame have been taken into account.

As part of this study, we investigated the losses in sound energy as sound propagates through gates typical of those used in large scale computers. In order to provide the necessary data, a set of modular units was constructed which contains cards typical of those used in large systems. Eight modules were constructed which could be arranged in various geometrical configurations. A typical module has dimension 35.2 cm long, 17.5 cm wide and 25 cm high.

In addition, a dummy module frame was constructed for holding these modules. One or two centrifugal blowers could be mounted in the frame. This frame can be, in turn, mounted in a rectangular machine enclosure typical of those used for large computer systems.

GENERAL PREDICTION METHODS

When a machine contains a source of airborne sound that radiates from a particular location, such as a power supply, determination of the source level is straightforward. When, however, the sound propagates through gates as it does in a gate having blowers mounted, for example, on the top and bottom, determination of the sound power level radiated from the top and bottom is more difficult. The directional characteristics of the device must be taken into account and the sound attenuation through the gate must be determined. When the sound power radiated from a particular location has been determined, it is necessary to provide transmission factors to account for losses within the machine and sound propagation from the source to the selected microphone position. When all of these factors have been used in the calculations, sound levels at each microphone position are calculated and added on a mean-square basis for each source taking into account the source location.

BLOWER RADIATION, MODULE ATTENUATION AND FRAME TRANSMISSION FACTORS

Blower Radiation

The modules described in the introduction were arranged with a centrifugal blower in a number of geometrical configurations to determine how much sound power is radiated under the following conditions:

a) When both the blower inlet and outlet are ducted (as in a mid-gate blower configuration)
b) when the blower outlet is ducted and the inlet is free
c) when the blower inlet is ducted and the outlet is free.

Fig. 1 shows an estimate of the fraction of sound power radiated toward the outlet of a blower when both the inlet and outlet are ducted using the previously-described modules. The solid line in the figure is the value used in the prediction program. Similar data were obtained when the blower outlet only was ducted and when the blower inlet only was ducted.

Module Attenuation

In addition to the experiments performed to develop the curve of Fig. 1, it was necessary to determine the attenuation of sound as it propagates through a gate populated with cards. The results depend on the number of modules above and below the blower used as a sound source, the way in which the experiments are done (with blowers as sources or with artificial sources) and on the frequency of sound. The experimental data shown in Fig. 2 represent the average values for several different configurations; the straight-line approximation given in the figure was used for the calculations in this paper.

Frame Transmission Factors

As pointed out previously, transmission factors are required to describe the relationship between a) the sound power level of a source located at a certain point in a machine frame and the sound pressure level produced at a defined measurement point, and b) the sound power level of a source located at a given position in a machine and the sound power level of the machine. In these experiments, a typical machine frame was used and a source of known sound power was mounted in various positions within the frame. The sound pressure level around the frame and the sound power level radiated by the frame were determined. From these data, transmission matrices were derived which can be used to correct the sound power level of each device in the frame in each one-third octave band and obtain either the appropriate sound power level or the sound pressure level at a given point around the machine. A typical transmission curve for a noise source near the center of a machine frame and a microphone 1 m from the frame is shown in Fig. 3.

COMPARISON OF MEASURED AND CALCULATED RESULTS

Fig. 4 shows a comparison between measured and predicted one-third octave band sound pressure levels when a blower is mounted at the top of a gate mounted in a typical machine frame. The microphone is placed at the front of the frame. The values just above the caption are the comparisons of A-weighted sound pressure levels.

Several computations were also made using other microphone positions and blower locations as well as for sound power level. The sound power level programs are somewhat simpler because of the absence of any microphone positions; the sound pressure level programs must predict levels at four microphone positions and the average level at the four positions.

CONCLUSIONS

1. In predicting noise from sources such as blowers when there is sound propagated through gates, it is important to determine the fraction of the sound energy radiated from different areas of the machine frame. It is also important to take into account sound attenuation within each module.
2. Both sound pressure level and sound power level measurements can be made with a reasonable degree of accuracy (generally less than about 2-3 dB) provided the machine geometry is reasonably close to that for which transmission data are available.

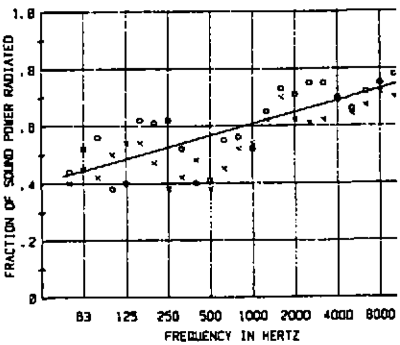

Fig. 1. Fraction of the sound power radiated toward the blower outlet when both inlet and outlet are ducted.

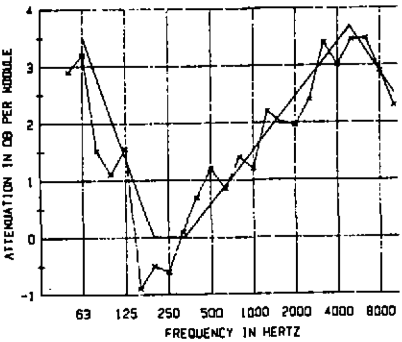

Fig. 2. Best estimate of the attenuation per module in dB. A four-high stack of modules would, for example, have an attenuation four times that shown in the figure.

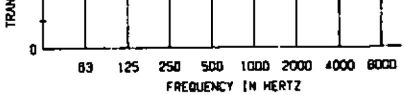

Fig. 3. Typical transmission curve. The ordinate gives the number of decibels to be subtracted from the radiated sound power level of the source to obtain the sound pressure level one meter from the surface of the machine frame.

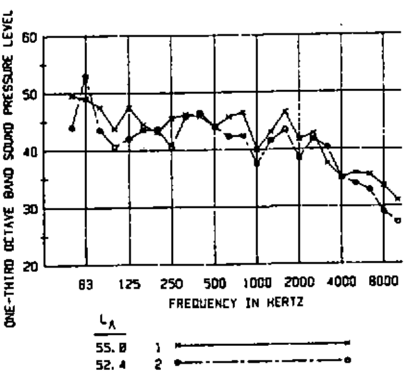

Fig. 4. Comparison of measured (x——x) and calculated (o—·—o) sound pressure levels in dB re 20 micropascals for a blower mounted at the top of a gate. Front microphone position.