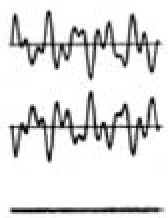
SOUND SOLUTIONS

ACTIVE NOISE CONTROL

No. 9

There has been a tremendous increase in the interest of the concept of active noise control (ANC) over the past several years. So much of what you read these days is literature that has either been prepared by or has been strongly influenced by ANC system manufacturers and other entities with a direct investment in this technology. The purpose of this article is to explain how these systems work, why they work well in some situations, and why they do not work well in other situations - all from the perspective of an independent consultant.

All ANC systems work on the fundamental principal of phase cancellation. Because acoustic energy propagates in wave form, two identical signals with opposite phase will cancel each other leaving theoretically no residual noise. Conversely, if the two acoustic signals combine with the same phase the net result is a noise level *increase* of 6 dB. This is known as the **superposition principle,** and it is illustrated in the figure below. The top curve represents the unwanted noise. It can have any arbitrary waveform - it does not have to be a sinusoidal waveform. The middle curve is the mirror image of the unwanted noise. If these two signals are aligned in time and combine at a given point in space the net acoustic pressure is zero.

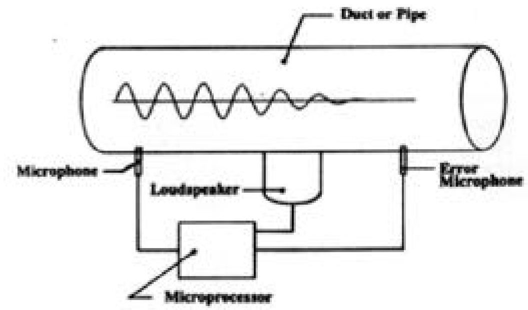


Unwanted Noise

Cancelling Noise

Residual Noise

All active noise control systems contain four fundamental elements: 1) a microphone to sense the unwanted noise, 2) a microprocessor to calculate the required cancelling signal, 3) a loudspeaker to create the cancelling noise, and 4) an error sensing microphone downstream of the loudspeaker to provide feedback to the microprocessor. Because it takes a finite amount of time to compute and generate the noise cancelling signal, the ANC system must be able to accurately **predict** the unwanted noise signal at the loudspeaker location before it gets there. Accurate prediction of future events is difficult in any field, however there are certain acoustical environments where this can be accomplished. The most common and easily understood is the condition of sound propagation down a duct or a pipe. The acoustic signal inside a pipe or a duct at one location is approximately the same as the signal at a point further down the pipe - only at a delayed time (or phase). This is particularly true at low frequencies where the wavelength of sound is much greater than the pipe cross dimension. In this limited situation sound travels in what we call plane waves. There is little or no reduction in sound level with distance, and the sound waves follow the pipe or duct like a wave guide. By placing a microphone inside the duct at a point near the source and a loudspeaker inside the duct at some point downstream, an active noise control system can be effected (see figure below). The loudspeaker must be located far enough downstream of the microphone to allow time for the microprocessor to compute and generate the cancellation signal, but not so far that the signal prediction capabilities of the microprocessor are degraded.



It is important to understand that the signal generated by the loudspeaker must not only have the "mirror image" acoustic waveform of the unwanted noise, but it must also create the same *level* of sound as the unwanted noise inside the pipe or duct. In some cases this requires very high-power audio amplifiers and more than one loudspeaker mounted around the circumference of the pipe.

The most promising application of active noise control is in industrial plants where you can find large, high pressure blowers and compressors that generate high levels of low frequency noise containing tones. Low frequency tones are especially troublesome because they can be audible for miles around the facility. Conventional absorptive duct silencers are much less effective than active silencers at low frequencies.

Another potential application for active noise control is HVAC systems. Excessive low frequency noise in ductwork is a common problem in HVAC systems. However, the reader should be cautioned that sometimes the excessive low frequency noise is turbulence induced noise - not fan noise. Fan noise can be cancelled with ANC systems, but turbulence-induced noise cannot. Turbulence-induced noise is random noise, and therefore cannot be accurately predicted at the loudspeaker location using the signal detected at the microphone position in the duct. Even if the fan is the primary source of noise in the duct system, the presence of excessive turbulence will diminish the acoustical performance of the ANC system. In short, there is no substitute for good duct design in any HVAC system.

Fundamentally, active noise control systems are relatively simple. However, there are many engineering factors (e.g. temperature and humidity at the microphone/loudspeaker locations) that should be considered prior to committing to an ANC system. As with any new technology, it is always wise to consult an independent expert to make sure that ANC will work in your specific application.

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