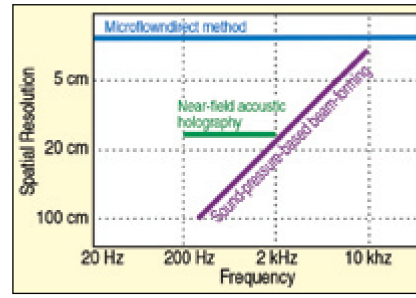
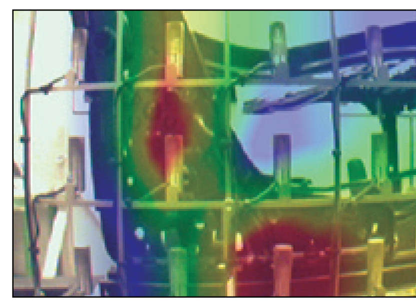
Full Bandwidth Sound Source Localization Solution

Jeroen Verbeek, Microflown Technologies, The Netherlands



Spatial resolution of a Microflown acoustic camera compared to other sound localization methods as a function of frequency.

Noise source localization measurements.



Low-frequency transient noise localization of a car seat frame mounted on a shaker in a normal room.

New problems regularly call for new solutions. For engineers working in the field of noise control, sound source localization is an important part of their activities – from the product development stage to end-of-line quality control. Microflown Technologies has introduced a fast, accurate and intuitive solution for this important issue. Cars, aircraft, and consumer goods can all be tested using Microflown-enabled methods.

Any sound field is described at a single point by two complementary acoustic properties, the scalar value, *sound pressure*, and the vector value, *particle velocity*. In the acoustic near field, acoustic particle velocity is the dominant property. A Microflown sensor is able to directly measure this parameter. The particle velocity is the ideal metric to localize the source of a noise problem. Traditional complex algorithms and assumptions required by sound-pressure-based solutions are unnecessary.

A new system, the Microflown acoustic camera, covers three applications with a single sensor array – near-field acoustic holography, beam-forming and intensity mapping. These three applications are traditionally addressed individually. The same sensors can be used for more advanced techniques, such as panel noise contribution analysis. The sensor array consists of PU sound intensity probes. A PU sound intensity probe can be thought of as an acoustic "multimeter," measuring both sound pressure and acoustic particle velocity at a single point and thus sound intensity by taking the real part of the cross spectrum of sound pressure and particle velocity. Due to this direct measurement of all quantities, no mathematical computations are needed that limit frequency range, dynamic range, or spatial resolution. Furthermore, the system can be used *in-sit*u and does not require an anechoic room or anechoic measurement conditions.

Frequency Range. A Microflown acoustic camera, when used in the near field, yields an accurate particle velocity map in the frequency range of 20 Hz to 20 kHz. At higher frequencies, the sensors do not necessarily remain in the near field so a sound intensity map may be more useful than a particle velocity map. The active part of the sound intensity tends to be much larger than the reactive part so the sound intensity can be measured robustly.

Dynamic Range. Due to the fact that no reconstructions are required, a dynamic range of over 40 dB can be visualized by the acoustic camera. This range is frequency independent, so the same dynamic range can be reached at all frequencies. The visualizations display absolute values for sound pressure, particle velocity and sound intensity.

Spatial Resolution. Since the Microflown acoustic camera directly visualizes measurement data in the frequency domain, the spatial resolution is just the sensor spacing, which is typically a few centimeters, and it can be changed easily. Initially, an area can be covered with a coarse grid. Later the sensor spacing can be decreased to cover a smaller area with higher resolution, like a zoom function of a conventional camera.

In the low-frequency range, the resolution that can be achieved is unparalleled by any microphone-based method. Although new algorithm-based source localization systems are continually being developed, it is better to measure particle velocity and sound intensity than to compute it.

Measurement Environment. Unlike traditional methods, the Microflown acoustic camera can be used in real operating conditions such as reverberant sound fields. Incoming background noise has a negligible impact on the vibration of the source surface. This is called *one-way coupling*. Therefore, the sound field measured very close to the surface is a function of the source, not the background noise. This effect has been shown to lead to an increase in signal-to-noise ratio of more than 10 dB in practical experimental conditions. The particle velocity near a small source (such as a monopole) is high, while the sound pressure is low. This means that the relative impact of background noise is even less for small-size sources. This effect is typically found in practice, and it leads to an even larger increase in signal-to-noise ratio. The particle velocity is directional and the polar sensitivity of the Microflown has a figure eight pattern. the polar sensitivity of a sound pressure microphone is omnidirectional and measures the total sound field.

This large increase in signal-to-noise ratio applies not only to particle velocity mapping but also to sound intensity mapping. Since the background noise is uncorrelated to the vibration of the surface, the cross spectrum between pressure and particle velocity is unaffected by the background noise as well. Therefore, the measured sound intensity is as unaffected by background noise as the particle velocity measurements it is based upon. The PU sound intensity probe can be used in a high sound pressure/intensity environment. In practice, this makes it the only viable way to measure sound intensity in an environment such as a car interior.

Nonstationary Conditions and Transient Noise. It is possible to perform multipoint measurements of nonstationary sound sources using an array of PU sound intensity probes. The results can be recorded as a function of time, and phase information is maintained in full-array measurements. This means that nonstationary problems such as engine run-ups can be evaluated reliably over a wide frequency range. Furthermore, by looking in the time domain, transient noises like squeaks and rattles can easily being detected in all frequency ranges.

Microflown Acoustic Camera Features

- Covers a frequency range of 20 Hz-20 kHz
- Absolute values for sound pressure, particle velocity and sound intensity
- Dynamic range of over 40 dB
- Suitable for nonstationary conditions
- Time domain or RPM measurement results
- Capable of visualizing and localizing transients
- High-frequency resolution independent of frequency
- Suitable for correlated and uncorrelated sources
- Suitable for measurements in reverberant conditions
- Free configuration of measurement grid (fixed, irregular, scattered)
- Very short time required to obtain results

For additional information on Microflown products, please visit: www.microflown.com.