Sound Source Visualization System

**System example (Full system)**
- Sound Source Visualization
- Probe Microphone*1
- BF Monitor
- BF Offline Analysis
- Data Station (4ch), Signal output (option)
- OS-2000 series (FFT Analysis package)
- OS-2000 series Video playback function (option)*2
- OS-2000 series IIR filter (option)*3

**Product name**
- MI-5420A
- BF-3200
- BF-0310
- DS-3204, DS-0371
- OS-2720
- OS-0281
- OS-0261
- PC

**Model name**

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*1: Two kinds of microphone probe head (120 mm, 60 mm), camera, dedicated cable for camera and microphone (3 m) are included.
*2: Video playback software (option) is required.
*3: Required when performing the function equivalent to BPF function of BF monitor by offline analysis.

Best solution for sound source visualization below 500 Hz

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**MB-2200M10 Ultraminiature Microphone**

By arranging multiple microphones and measuring sound pressure, a sound pressure map of 500 Hz band or less which is not supported by the MI-5420A can be acquired. The MB-2200M10, light and ultra miniature microphone, is effective for such multi-point detection. Very easy to set even when a lot of microphones are necessary to be installed.

**[Application of multi-point simultaneous detection using MB-2200M10]**
The left example shows the measurement of sound pressure distribution using 49 pieces of MB-2200 M10. It is very small and light weighted, you can perform multi-point simultaneous measurement without dropping microphones, even if you open and close the door with those sensors attached. You can see the process of sound attenuation just from the moment the door hits the latch.

Sound pressure maps can be drawn with several microphones.

Recording is performed while moving the microphones.

The number of microphones and input channels for all the measuring points are necessary for simultaneous recording.

**For steady sound**
- DS-3000
- MB-2200M10
- OC-1320

**For transient sound**
- Multichannel Data Station (40 kHz 4ch FFT set)
- Ultraminiature Microphone
- Multi-functioned graph creating software (OC-1300 series standard package)
- Personal computer
Where does this sound come from?
Advanced probe microphone meets the demands you want to see, and you want to know.
Small and lightweight
Use it anytime, anywhere

▶ Achieves wide analysis frequency range
Sound source visualization from 500 Hz to 8 kHz* of frequency range
*Recommended frequency. Refer to [Specification] on page 11.

▶ Visualizing sound source using only 4 microphones
4ch Beam Forming System localizes sound source position with minimum microphones by “Beam Forming” and new calculation method.

▶ Monitors sound source status in the field in real-time (20 times/sec.)
Having good performance of follow-up, you can visualize various sounds including transient sound as well as stationary sound.

▶ Short-distance object can be measured by a camera with a wider viewing angle
The measurement from close to a target produces less reflection waves and less environmental influences including noise, making it easier to detect the sound and vibration signals. You can grasp sound source position with this system, even in an environment where sound source visualization has been difficult up to now.

Sound source visualization method: Beam Forming
Beam Forming is one of the sound visualization techniques that obtains the sound pressure distribution from the phase difference information of the sound source to the microphone, and makes it visualized with the color map. This technique provides easy-to-understand results by superimposing on the image of the camera, so you can intuitively grasp the position of the sound source in real time, which is displayed in red for high sound pressure. This technique often requires a lot of microphones to cover a wide area and generally tends to increase the size of the system. By Beam Forming system, Ono Sokki achieved real-time sound source visualization with just 4 microphones.
MI-5420A 4ch Beam Forming System

Sound Source Visualization Probe Microphone MI-5420A

- 120 mm (500 Hz to 4 kHz)
- 60 mm (1 kHz to 8 kHz)

Wide variety of sensor connection*

- Rotation
  - Optical detector LG-9200
  - Digital Engine Tachometer CT-6700
  - Signal cable MX-7100 series

- Vibration
  - Accelerometer with built-in amplifier NP-3000 series
  - Signal cable NP-0120/0130/0150/0170 series
  - Miniature/RCA conversion adapter NP-0021

- Acoustic
  - Sound Level Meter LA-1411/1441/4441
  - Signal cable AX-501

OS-2000 series

Time-series Data Analysis Software

OS-2000 series

OS-2000 series can flexibly and freely edit and analyze the time-series data which is too long to be used on Microsoft® Excel®. It supports a wide variety of data formats, not only general formats such as CSV and WAV files, but also unique format to each recording device. OS-2000 series has many useful functions including overlay of waveforms in different formats, division, moving, and zooming in and out. Smooth cooperation with Microsoft® Excel® is also available. Various other functions, such as video playback function, FFT analysis function, etc. functions and sound quality evaluation are available.

*For more information on DS-3200 series, OS-2000 series, and other measuring instruments, please refer to each brochure.

BF-3200 BF monitor

This software performs sound source visualization processing of sound being generated from the measurement object in real-time (more than 20 times/sec.), and displays the results. Simultaneous recordings of camera image and time data of microphones are also available. You can replay those data and reanalyze with different frequency band on this software. Even when you do not know the frequency band at which abnormal noise is generated, you can easily check and specify it while listening to the sound applied the band pass filter.

BF-0310 BF Offline analysis

This software which is an option for the BF-3200 plugged in the OS-2000 series Time series data analysis software is effective for further analysis of the recorded sound. You can make more detailed setting for time resolution and frequency resolution to the recorded data than the BF monitor. Making it cooperated with the OS-2000, you can analyze the result of sound source visualization using tracking analysis and sound quality evaluation as well as FFT analysis.

- OS-2000 series (Time series data analysis software), OS-2720 (FFT analysis package) and OS-0281 (video playback option) are required.
- The addition of the OS-0261 (IIR filter) option is recommended.
**Applications**

1. **Operating sound of desktop printers**
   
   Reduction of printer operation sound directly leads to improvement of product value. For taking countermeasures against noise, grasping the timing and the position where the noise is generated is necessary. This system can find the source position of sound generated by parts being hit each other by using decomposing with frequency band filter. Even when various sounds are mixed behind during printing, you can easily find the sound source position.

   [Image: Visualizes various sounds generated from a desktop printer]

2. **Detection of operating sound of power seats**

   As automobiles get quieter, small sounds that have never disturbed have come to be recognized as “noise”. The operating sound of electric power seats, which are often used for sound proofed luxury cars, is required to be quiet. This sound source visualization system helps to find the sound source position inside of cars for making countermeasures for operating sound reduction. Since the microphone probe is compact and lightweight handy type, you can search the sound source from various angles while holding with a hand, even when the sound source position is changing at every moment according to the motion of the power seat. Showing the measured result as a color map in moving picture allows you to confirm the sound generating position intuitively, although that is difficult with a still image such as a sound pressure map.

   [Image: Visualizes the sound generated from a power seat]

3. **Noise detection inside air conditioners**

   Air conditioners installed indoors are indispensable to our daily lives. As they are used in various environments, sometimes it is required to have very small and quiet operation sounds depending on the situation used. Even very small sound will be emphasized as “noise” in a quiet environment such as a bedroom. Typical examples of air conditioner noise are rattling at the beginning of operation and squeak of the frame. Those noises can be visualized by using the threshold setting function of this system. You can grasp the abnormal sounds being generated irregularly with the data which is obtained only when the noise exceeds a certain level of the sound pressure.

   [Image: Searches for sound source position generating from an air conditioner]

4. **Noise detection in head-up displays**

   With the spread of EV and HEV, environment of automobile inside becomes quieter. Along with this, the sounds made by motion of automobile parts are also increasingly required to be quieter. A head up display, installed often near the driver and may bother the driver, is one of the parts that countermeasures against noise such as chatter or squeak may be strictly required. For the countermeasures, this sound source visualization system is effective. You can record all sounds that pass in an instant, and analyze the recorded data afterward. You can visualize the sound changing from moment to moment, and grasp even the position of transient sound which is irregularly generated.

   [Image: Searches where the squeaking of a frame comes from]
5 Noise detection in hydraulic pumps
The following example shows the detection of abnormal rattling sound generated around hydro pressure pump built in large construction equipment outside. To find the reason and position of the sound occurrence, the sound source visualization system is used. This simple system does not take much time for setting, only a PC, DS-3000 series Data Station, and compact and lightweight microphone probe. Furthermore, if you cannot spend much time for on-site measurement, you can deeply analyze the recorded data afterward offline with OS-2000 series secondary processing software.

6 Visualization of wiper rubbing sound
This application shows how to visualize the fricative sound that is generated from operating car wipers. To grasp the position where irregularly the squeaky sound is generated, this sound source visualization system is helpful. You can see the target noise in both a color map and a video. The threshold setting function of this system can visualize sound in color map according to the level. You can check it only when fricative sound is generated.

7 Noise detection of outdoor units
For an outdoor unit, the operation sound is required to be quiet because sometimes it may be the reason of complaints from neighborhood. To achieve quieter operation sound, it is necessary to grasp locations of sound source, generated from various components including compressor, and take countermeasures for noise reduction at each position. This system can visually check where and which amount of sound is generated by the video. Further, you can check the effectiveness of countermeasures by video output of both before and after.

8 Noise detection in power windows
This is an example of detecting abnormal sound (rubbing noise) hidden in an operating sound of power windows. The sound source visualization system helps to find where on the rail the rubbing sound comes from when the power window is operated, that is required to take countermeasures for noise reduction. You can capture how the sound source position moves with color map and video. As it also can record the trajectory of moving sound, you can also check where the sound source position is concentrated and the frequency of noise occurrence.
**Applications - Analysis Example -**

The following examples show how to take countermeasures for noise reduction by using 4ch Beam Forming Sound Source Visualization system. You can easily see the effect by checking before and after countermeasures in color map.

1. **Operating sound of a multifunction photocopier**

   **[Measurement procedure]**
   - Record the sound from the open area of the multifunction photocopier during paper feeding.
   - Decide the place to take noise reduction measures referring to the recorded sound data (finding the place from which the sound is generated)
   - Affix shielding tapes and record the sound again during paper feeding.
   - Analyze the recorded data with offline analysis software, and compare the result before and after the noise reduction measures (with or without the shielding tape)

   **[Analysis result]**
   - Color maps and sound pressure levels measured by a sound level meter tell the change of the sound radiated from open area.
   - Compare the sound source position (red area) on color maps Fig. 1 and Fig. 2. After the shielding tapes are affixed, there is no red area in Fig. 2.
   - The sound pressure level (A-weighting) has been reduced about 10 dB from 72.2 dB to 62.6 dB compared to the noise before measures.

   ![Figure 1: Before measures (without shielding tapes)](image)
   ![Figure 2: After measures (with shielding tapes)](image)

2. **Time Sequence Analysis of Vehicle Door Closing Sound**

   **[Analysis result]**
   - When a door is closed, various noises are generated from various positions in a short period.
   - As shown in the following result of time waveform and frequency analysis, the sound pressure is increased at the timings of A and B, in a frequency band between 1 kHz to 2.5 kHz.

   ![Time waveform](image)

   **Visualization of the sound by focusing upon this band.**
   - It shows that A is the waveform of latching sound, and B is that of door-hitting sound.
   - Beam Forming system can visualize the sound which is heard as a single sound with human ears, but actually generated from multiple places with time series.

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### Specification of 4ch Beam Forming System

**MI-5420A**

- **Frequency**: (315 Hz to 16 kHz) Continuous or (1/3 octave bands from 315 Hz to 16 kHz) Discrete
- **Input range**: ±1 V (0 dB = 1 V/Pa, 1 kHz)
- **Dynamic range**: 39 dB (A weighting)
- **S/N ratio**: 65 dB or more
- **Damping factor**: 25 dB or less
- **Sample frequency**: 20 kHz (fixed)
- **Frame length**: 51.2 kHz
- **Number of pixels used for calculation**: 1024 × 768
- **Horizontal 78° × Vertical 63° (TYP value)**
- **Visualization frequency setting band**: [0.5 kHz to 5 kHz] (custom (specified frequency section))

**BF Offline Analysis (option)**

- **Analog parameter setting**: 20 dB or less
- **Digital parameter setting**: 39 dB (A weighting)
- **FFT monitor**: Measurement frequency setting band
- **Calculation function**: Beam forming analysis (BF), Visualization analysis (VF), FFT analysis (FT)
- **Beam forming analysis (BF)**
  - In the free acoustic field, when the distance between the sound source and the microphone is 1 m, the spatial resolution is obtained by 4 dB from the sound source center is within the wavelength or within 30 cm.
  - Definition 2 The target scope size can secure 1/3 or more of the camera angle of view.
- **Visualization analysis (VF)**
  - Definition 1 In the free acoustic field, when the source center is within the wavelength or within 30 cm.
  - Definition 2 When within the visualization frequency band.
- **Input channel**: 4ch
  - Definition of visualization frequency band
  - Definition 1 In the free acoustic field, when the distance between the sound source and the microphone is 1 m, the spatial resolution is obtained by 4 dB from the sound source center is within the wavelength or within 30 cm.
  - Definition 2 The target scope size can secure 1/3 or more of the camera angle of view.
- **Data output**: Excel, MATLAB, ASCII, and other formats for analysis
- **Operating environment**: Intel® CoreTM i7 or more
- **Software**: DirectX 9.0c or later (when using BF-0310, OS-0281), Microsoft® Windows®7 Professional (64 bit) (Net Framework 3.5 Service Pack 1 must be installed.)
- **Interface**: USB 3.0

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**BF-3200 / BF-3010 Software**

- **BF-3200 Monitor**
  - Measurement procedure
  - Analysis procedure
  - Calibration procedure
  - Operation function
  - Setting function
  - Set-up function
  - Installation CD

- **BF-3010 Offline Analysis (option)**
  - Measurement procedure
  - Analysis procedure
  - Calibration procedure
  - Output function
  - Setting function
  - Set-up function
  - Installation CD
  - Operation accessories
- **BF-3200 Offline Analysis (option)**
  - Measurement procedure
  - Analysis procedure
  - Calibration procedure
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**MI-5420A Outer Dimensions**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>120 mm</th>
<th>60 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>230 mm</td>
<td>140 mm</td>
</tr>
<tr>
<td>Height</td>
<td>300 mm</td>
<td>150 mm</td>
</tr>
<tr>
<td>Depth</td>
<td>190 mm</td>
<td>150 mm</td>
</tr>
</tbody>
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