

PULSE Array-based Noise Source Identification Solutions: Beamforming Type 8608, Acoustic Holography Type 8607 and Spherical Beamforming Type 8606

Noise Source Identification (NSI) is an important method for optimizing the noise emission from a wide range of products from vehicles, white goods, power tools and heavy machinery to components like engines, tyres, gear-boxes, exhausts, etc.

The goal of NSI is to identify the most important sub-sources on an object in terms of position, frequency content and sound power radiation. Ranking of sub-sources can be used to identify where design changes will most effectively improve the overall noise radiation.

Array-based methods provide both the fastest measurement process and the highest quality of the results. The combination of acoustical holography with phased array methods gives accurate, high-resolution maps in the full audible frequency range.

Time-domain methods can be used to study transients like impacts and run-ups or to get detailed understanding of stationary sources, for example, noise radiation versus crank angle on engines. For large, stationary sources, an automated microphone positioning system (robot) can be used to measure automatically.



Hardware and Software

Software

- Spherical Beamforming Type 8606: provides a 360° sound-field map without making assumptions about the sound field
- Acoustic Holography Type 8607: a method for mathematically describing the sound field based on a set of measurements
- Beamforming Type 8608: a method of mapping noise sources by differentiating sound levels based on the direction from which they originate
- All applications can post-process data
- Options that increase the functionality of the applications are available:
 - For all applications: Conformal, Transient, Quasi-stationary and Sound Quality Metrics Calculations
 - For Types 8606 and 8608: Refined Beamforming Calculations for improved spatial resolution
 - For Type 8608: Moving Source Beamforming (for road vehicles, rail vehicles, aeroplanes, and wind turbines)
 - For Type 8607: Panel Contribution (patented method), Intensity Component Analysis and In Situ Absorption

Arrays

- Grid arrays for scanned and general purpose measurements
- Patented arm wheel arrays, numerically optimized for acoustical performance in relation with beamforming
- Sliced wheel arrays, numerically optimized for acoustical performance in relation to Beamforming and Acoustical Holography
- Hand-held array for real-time holography mapping, patch holography and conformal mapping using Statistically Optimized Near-field Acoustical Holography (SONAH, patented technology) and Equivalent Source Method (ESM)
- Spherical array for Beamforming even in confined environments
- Single signal cable system for connecting up to 132 channels via one socket

Selection of Arrays and Robots

Table 1 A selection of Brüel & Kjær's arrays and robots for fixed, path and scanned measurements

<p>Spherical Array</p>  <p>080020</p> <p>Applications: Vehicle and aircraft interior, building and industrial plants</p> <p>NSI Method: Spherical Beamforming</p> <p>No. of Channels: 36 or 50</p> <p>Size: 20 cm diameter</p> <p>Maximum Frequency: 12 kHz</p> <p>Accessories: Tripod WQ-2691</p>	<p>Wheel Array (incl. camera)</p>  <p>080015</p> <p>Applications: General purpose (90-channel array typically used in automotive component applications)</p> <p>NSI Method: Beamforming</p> <p>No. of Channels: ≥42</p> <p>Size: 0.65 m to 4.0 m diameter</p> <p>Maximum Frequency: 20 kHz</p> <p>Accessories: Tripod WQ-2691</p>	<p>Half-wheel Array</p>  <p>080018</p> <p>Applications: Road vehicle and rail vehicle moving source beamforming including wind-tunnel and pass-by testing</p> <p>NSI Method: Beamforming</p> <p>No. of Channels: ≥42</p> <p>Size: 1.5 m to 4.0 m diameter</p> <p>Maximum Frequency: 10 kHz</p> <p>Accessories: Carriage WA-0893</p>	<p>Grid Array</p>  <p>080017</p> <p>Applications: General purpose, non-moving noise sources</p> <p>NSI Method: Acoustic Holography and Transient Calculations</p> <p>No. of Channels: ≥6</p> <p>Size: 0.125 m × 0.125 m and over (various spacing available)</p> <p>Maximum Frequency: 6 kHz</p> <p>Accessories: Support Stand WA-0810 or Array Positioning System</p>
<p>Sliced Wheel Array</p>  <p>080016</p> <p>Applications: General purpose, engines, automotive components/interior, etc.</p> <p>NSI Method: Beamforming and Acoustic Holography</p> <p>No. of Channels: 18, 36, 60 or 84</p> <p>Size: 0.35 m to 2.0 m diameter</p> <p>Maximum Frequency: Beamforming 36-ch.: 6.0 kHz; 60-ch.: 8.0 kHz</p> <p>Acoustic Holography 36-ch.: 1.5 kHz; 60-ch.: 1.2 kHz</p> <p>Accessories: Tripod WQ-2691</p>	<p>Hand-held Array (single or double-layer)</p>  <p>120353</p> <p>Applications: Components, interiors, etc.</p> <p>NSI Method: Real-time Holography, Patch Mapping and Conformal Calculations</p> <p>No. of Channels: min. 6 × 6 × 1, max. 8 × 8 × 2</p> <p>Spacing: 25, 30, 35, 40 and 50 mm (size dependent on channel count and spacing)</p> <p>Maximum Frequency: 6 kHz</p> <p>Accessories: 3D Creator Optical Sensor Positioning System WU-0695-W-001</p>	<p>2D Robot</p>  <p>080014/:</p> <p>Applications: From large, stationary noise sources, such as vehicles and engines, down to hearing aids and dentists' drills</p> <p>NSI Method: Acoustic Holography</p> <p>No. of Channels: 2 to 96</p> <p>Size: 1 m × 1 m up to 10 m × 3 m</p> <p>Maximum Frequency: 12 kHz</p> <p>Accessories: Integral Connection Array WA-0806, Flexible Connection Array WA-0807 and Robot Controller WB-1477</p>	<p>Pentangular Array</p>  <p>100119</p> <p>Applications: Outdoor noise sources, wind turbines, factories</p> <p>NSI Method: Beamforming, extraneous noise suppression</p> <p>No. of Channels: 30</p> <p>Size: 3.5 m diameter</p> <p>Maximum Frequency: 5 kHz</p> <p>Minimum Frequency: 100 Hz</p> <p>Accessories: Tripod WQ-2691</p>

To improve overall noise levels, it is necessary to locate, quantify and rank the individual noise sources coming from a source. This starts by identifying ‘hotspots’ – areas where the local sound radiation is significantly greater than that of the surrounding area. Knowing these hotspots, the dominating frequencies and relative sound power contributions enable the cause of the noise to be identified and its contribution to the overall noise level to be assessed.

Traditionally, this has been done by mapping the sound intensity directly at a number of points across the source measured with an intensity probe. With array-based techniques, this process can be significantly improved as many points are acquired simultaneously, making measurements much faster. Brüel & Kjær provides a wide selection of arrays to cover most practical situations. The measurement types can be classified as:

- Fixed: The array is set-up and not moved during the measurements, for example, a pentangular array used to measure a wind turbine
- Patch: A grid array is moved from one position to another either manually or with a robot, for example, a hand-held array used for conformal mapping of a vehicle dashboard
- Scanned: A single, a row, or a full grid of microphones is scanned over a source by means of a robot, for example, used for measurements on stationary noise sources such as transformers or dentists' drills

PULSE™ Array Acoustics with Post-processing

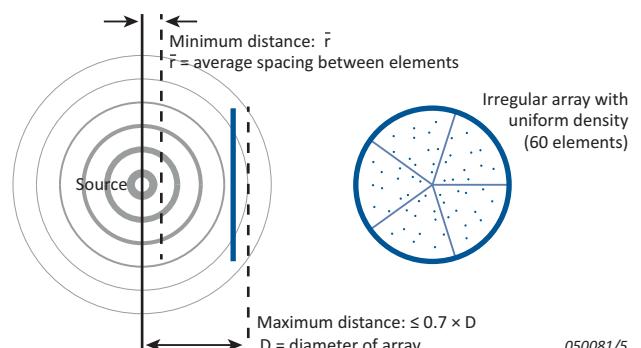
PULSE Array Acoustics is designed to optimize the return on data measured with an array. The calculation, display and reporting of the measurement is done using one of the three main applications: Beamforming Type 8608, Spherical Beamforming Type 8606 or Acoustical Holography Type 8607. In each application, you can select from a range of algorithms to optimize calculations for your measuring method. Statistically Optimized Near-field Acoustic Holography (SONAH) and Equivalent Source Method (ESM) are available for Acoustical Holography, and non-negative least squares (NNLS) is available for Beamforming.

To increase the applicability of PULSE Array Acoustics, add one or more options. Transient, Quasi-stationary, Conformal or Sound Quality Metrics Calculations can be added to each application, but there are also a number of options that are specifically designed for use with particular applications, for example, Moving Source Options for Beamforming, and Panel Contribution for Acoustic Holography. CLEAN based on Source Coherence (CLEAN-SC) is available through the Refined Beamforming Calculations option for both Spherical Beamforming and Beamforming.

Full Frequency Range Calculations

Fig. 1
The patented
Wideband Holography
method used to cover
the combined
frequency ranges of
SONAH and
beamforming, based
on a single
measurement at an
intermediate distance
(thick blue line shows
side view of a typical
irregular array)

Acoustic holography methods such as SONAH and ESM require arrays with an average spacing of less than a half wavelength between elements. For a given array, this restricts the upper limit of the supported frequency range. Irregular ‘Combo Array’ geometries can extend the frequency range, being used for SONAH at low frequencies and for beamforming above the upper limit of the supported frequency range. However, you need to employ two methods in order to cover the full frequency range: a low-frequency measurement at close range for SONAH and a high-frequency measurement at greater distance for beamforming. The patented Wideband Holography method can cover the combined frequency ranges of SONAH and beamforming based on a single measurement at an intermediate distance (Fig. 1).



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Near-field Acoustic Holography

Near-field Acoustic Holography (NAH) builds a mathematical model describing the sound field based on a set of sound pressure measurements typically taken in a plane fairly close to the source. From this description the parameters of the sound field, sound pressure, sound intensity, particle velocity, etc., can be derived in target planes parallel to the measurement plane.

The model can also be used to calculate far-field responses, estimating the sound pressure distribution along a line in the far-field based on the Helmholtz Integral Equation. Further potential noise reduction schemes can be applied to evaluate the impact of various source reduction possibilities. Two algorithms are available: SONAH and ESM.

The SONAH calculation method overcomes the limitations of NAH calculation methods, namely:

- The measurement area must cover the full noise source plus some additional area to avoid spatial window effects
- The measurement grid must be regular rectangular to support spatial FFT calculations

SONAH can operate with irregular arrays and allows for measurements with arrays smaller than the source, without severe spatial windowing effects.

The ESM calculation can be used to deal with very curved surfaces, in that it can remove artefacts which SONAH can produce on non-plane surfaces. ESM is, therefore, implemented in Acoustical Holography when using Conformal calculations for the options Panel Contribution, Intensity Component Analysis and In Situ Absorption.

Measurement and Analysis

Stationary NAH measurements are typically made using a limited size grid array that is scanned over the source using a robot positioning system. To maintain an absolute phase reference between scan positions, a set of reference signals is simultaneously acquired. Transient measurements are typically performed using large fixed arrays, as all measurement positions must be acquired simultaneously.

Performance

- **Resolution, R :** Defined as the shortest distance at which two point sources can be separated

$$R \geq \min(L, \lambda/2)$$

where L is the distance from array to source and λ is the wavelength

- **Frequency Range**, determined by:

$$f_{\max} = c/2dx, \text{ and}$$

$$f_{\min} = c/8D$$

where c is the speed of sound, dx is the average spacing between measurement points and D is the diameter of the array

The use of NAH is, therefore, limited at high frequencies by the spacing between measurement points. Typically NAH can be used from 50 Hz to 3000 Hz.

Features and Benefits

- Easy, high-resolution mapping at low and mid frequencies
- Very low f_{\min} using SONAH or ESM
- Fully automated data acquisition including robot control using BK Connect® Array Analysis Type 8430 (includes PULSE Acoustic Test Consultant Type 7761)

Typical Applications

- Contribution analysis
- Engines and powertrains
- Components
- Door seal leakage
- Office machinery
- White goods
- Heavy machinery

Application Examples

Fig. 2

Averaged particle velocity maps for the 1/12-octave bands 205 – 1454 Hz, A-weighted.

Left: NAH

Right: SONAH. Note how SONAH reduces the edge effects

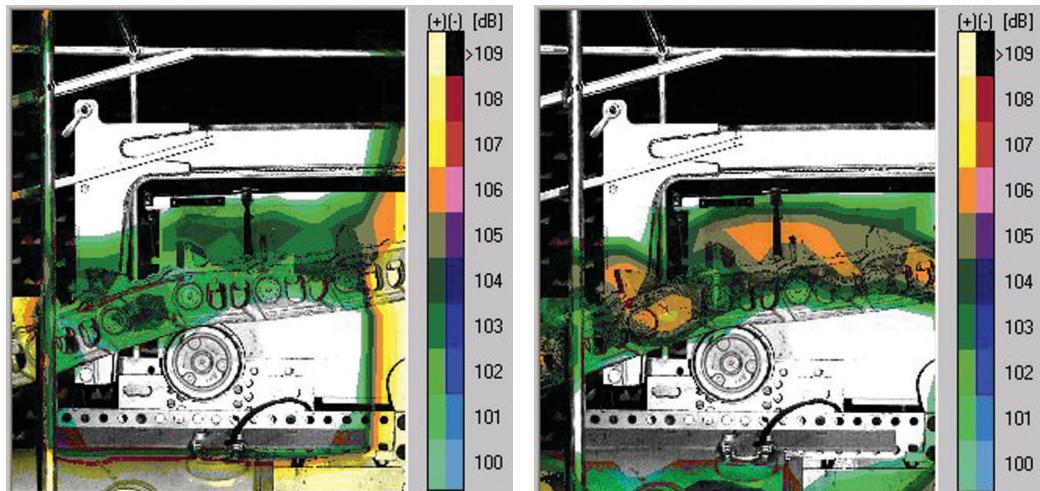
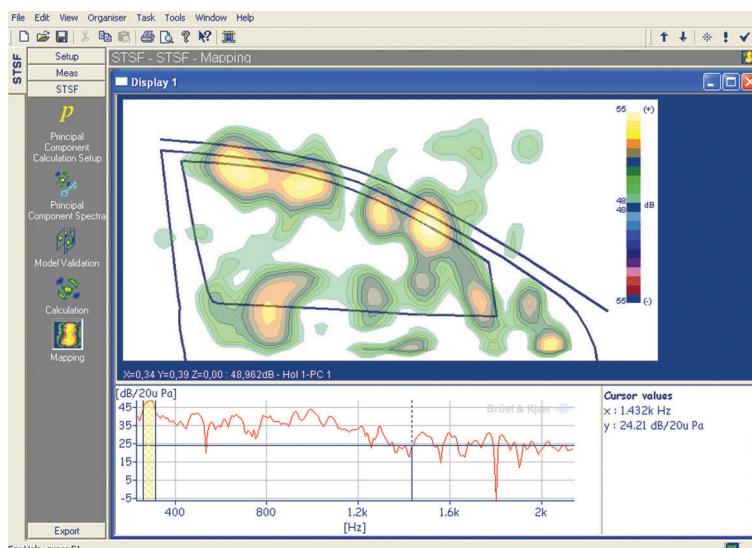


Fig. 3

Map of door seal leakage.

Acoustical Holography calculations provide high-resolution mapping by calculating results in a plane close to the source surface



Planar Beamforming

Beamforming is a method of mapping noise sources by differentiating sound levels based on the direction from which they originate. The method is very quick, allowing a full map to be calculated from a single-shot measurement. It also works at high frequencies. Innovative Brüel & Kjær wheel arrays can be used with PULSE Beamforming to produce acoustically optimal results while maintaining maximum ease of use and handling.

Compared to other source location methods, the beamforming method is quick since all channels are measured simultaneously. This optimizes the use of expensive measuring facilities such as anechoic chambers and wind tunnels, and takes away the tediousness and repetitiveness of many traditional methods.

Where the object under test can be considered to be composed of non-coherent sources, Refined Beamforming algorithms based on deconvolution can be used to improve the spatial resolution of the noise maps by a factor of three or more.

Measurement and Analysis

The sound field radiating from the test object is measured at a number of microphone positions at some distance from the object. The microphones are arranged in a planar array facing towards the centre of the object.

By introducing a specific delay on each microphone signal and adding the result, it is possible to computationally create an acoustical antenna equivalent to a parabolic reflector with a main lobe of high sensitivity along a certain angle of incidence. By repeating the calculation process on the same set of measured data for a large number of angles, a full map of the relative sound pressure contribution at the observation point can be generated. With Beamforming, results can be calculated to within an angle of up to 30° away from the centre axis so that even small arrays can map large objects. It is, for example, possible to map a full vehicle from just one measurement position.

Array Design

The dynamic range (also known as the maximum side lobe (MSL) level) of the maps will typically be between 8 and 15 dB depending on the design of the array. In general, irregular arrays outperform traditional regular array designs, but even irregular arrays with the same number of microphones may have very different performance depending on the exact position of the microphones. Brüel & Kjær uses a patented numerical optimization method to design arrays with optimal performance for the frequency range and number of microphones.

The special sliced wheel array design is optimized to perform with both Beamforming and Acoustical Holography and can, therefore, be used with a combination of the methods to provide mapping of the full audible frequency range.

Performance

Resolution, R : Defined as the shortest distance at which two point sources can be separated

$$R \approx L/D * \lambda$$

where L is the distance from array to source, D is the size of the array, and λ is the wavelength

The use of Delay and Sum calculation methods (Beamforming) is limited at low frequencies by resolution. Typically Beamforming can be used from 500 Hz to 20 kHz. However, spatial resolution can be improved using NNLS and CLEAN-SC methods.

For large sound sources outdoors, such as wind turbines and factories, a pentangular array is recommended. When used in its funnel-shape configuration, the array enables extraneous noise from the rear of the array to be suppressed up to 10 dB (depending on the frequency).

For road and rail vehicles, aeroplanes and wind turbines, dedicated moving source beamforming options have been developed.

Features and Benefits

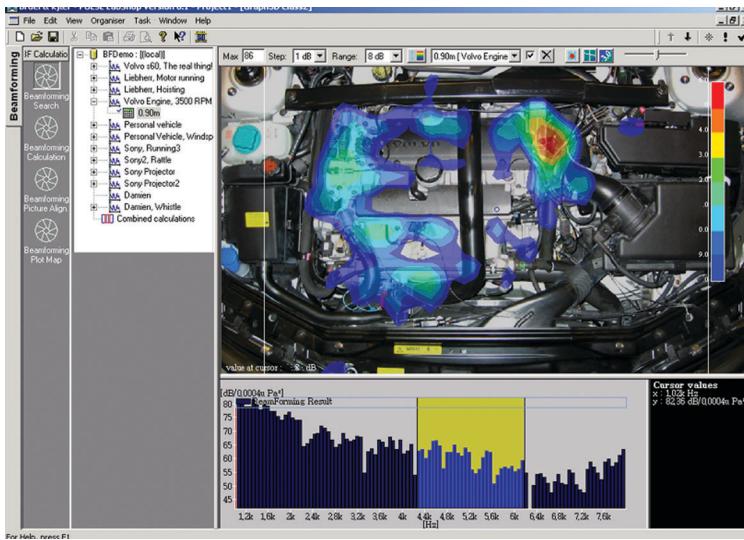
- Quick snapshot measurements
- Ideal for mid and high frequencies
- Covers large objects
- May, in combination with SONAH, cover the full audible frequency range

Typical Applications

- Contribution analysis
- Machinery
- Construction equipment
- Wind tunnels
- Engines and powertrains
- Components
- Seals
- Vehicle interiors

Application Example

Fig. 4
Beamforming result
on a car engine



Conformal Mapping

A completely conformal map can be created based on a set of patch measurements at known positions and object geometry. The object geometry can either be imported from a number of standard formats or detected using the position detection system integrated in the hand-held array.

Object Geometry

Replacing the microphone array with a pointer, the positioning system in the hand-held array's handle registers the 3D coordinates of the most significant points of the geometry. Meshing tools can then be used to refine the object geometry to a suitable granularity depending on the resolution required. Alternatively, the object geometry can be imported from existing CAD or CAE models, in which case a reduction of the model is usually required in order to minimize the number of elements, and thereby the number of measurement points. CAD surface models can be imported via the IGES file format (file extension .igs) or surface mesh models via the Universal File Formats 2411 and 2412 (file extension .unv).

In general, IGES file format types 143 and 144, as well as the 500 series (also called B-Rep) can be imported. STL and UFF files can also be imported.

Measurement and Analysis

Measurements with the hand-held array are made at the most accessible places around the object, with 36 to 128 points typically measured simultaneously. Based on the integrated positioning system, the software keeps track of the positions measured. Typically the number of measurement points should correspond to the maximum frequency.

Features and Benefits

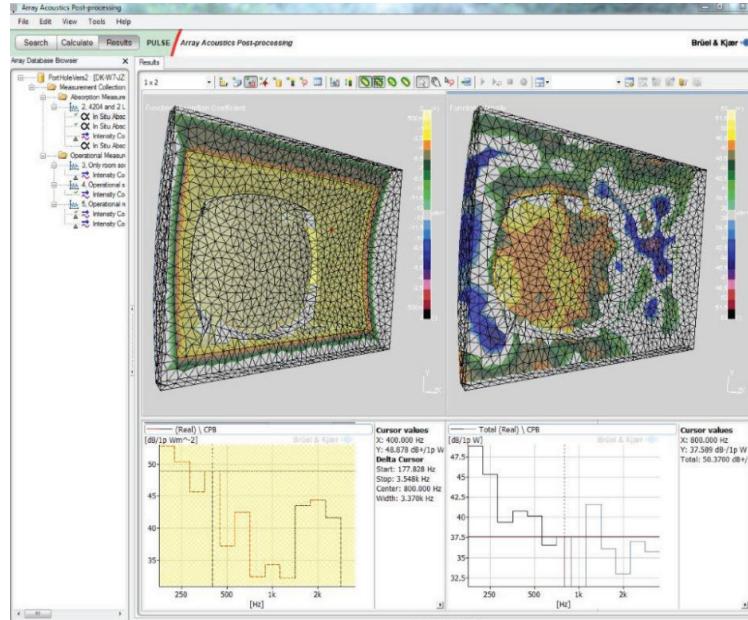
- Accurate mapping of non-planar objects
- High mapping resolution, even at low frequencies
- Measurements can be taken at the most accessible places
- No complicated array support structure needed
- No previous modelling required

Typical Applications

- Contribution analysis
- Components
- Subassemblies
- Seals
- Vehicle interiors

Application Example

Fig. 5
Conformal mapping of an aeroplane porthole: **Left:** The averaged absorption averaged over the various areas. **Right:** The intensity map.
Graph on left: Intensity spectrum for a particular point;
Graph on right: Sound power spectrum for whole porthole



Spherical Beamforming

Spherical Beamforming offers two calculation algorithms: Spherical Harmonics Angularly Represented Pressure (SHARP) and Filter and Sum (FAS, patent pending). Both provide a complete omnidirectional noise map in any acoustic environment based on one simple measurement. Unlike other methods that only map part of the surroundings, Spherical Beamforming uses a spherical array to map noise in all directions while 12 cameras mounted in the sphere automatically take pictures in all directions. At display time, these images are used as the background for the acoustic map.

In addition, Spherical Beamforming does not make any assumptions about the nature of the acoustic environment and can, therefore, be used in both free-field and reverberant surroundings. For these reasons, Spherical Beamforming is commonly used to make overview maps in confined and semi-damped spaces such as vehicle and aircraft cabins.

Measurement and Calculation

The measurement is performed using an array of microphones mounted on the surface of a hard sphere. The microphone positions on the sphere are numerically optimized to maximize the dynamic depth of the map. The sphere is usually placed at a typical impact position, for example, in the driver's seat of a vehicle.

The SHARP calculation decomposes the observed sound field into its spherical harmonic components and then estimates the directional contributions by recombining these spherical harmonics.

The FAS calculation takes the output from each microphone and applies a Finite Impulse Response (FIR) filter which is optimized for each angle of incidence to minimize the side lobes for the sphere. The resultant pressures are then summed to yield an acoustical map.

Performance

The angular resolution of the SHARP and FAS algorithms used for Spherical Beamforming is roughly the same. However, FAS provides considerable improvement in MSL. Low frequency boost (LFB) helps particularly with 50-channel spherical arrays.

Table 2 Resolution (-3 dB), in degrees, for a sphere with a radius of 10 cm

	Spherical Beamforming									
	100 Hz	200 Hz	500 Hz	1 kHz	2 kHz	4 kHz	6 kHz	8 kHz	10 kHz	12 kHz
SHARP	145	105	68	48	32	24	16	13	10	8
FAS	145	105	68	48	32	24	16	13	10	8
FAS + LFB, 36 ch.	110	95	68	48	32	24	16	13	10	8
FAS + LFB, 50 ch.	85	70	52	48	32	24	16	13	10	8

The error-free dynamic range, or MSL level, decreases with frequency. With SHARP, for the 50-channel array, the MSL level is better than 6 dB up to 8 kHz, and for the 36-channel array, better than 6 dB up to 5 kHz. For FAS, the MSL level is greatly improved yielding better than 6 dB up to 12 kHz for the 50-channel array, and better than 7 dB up to 6.4 kHz for the 36-channel array.

The band of use of Spherical Beamforming is set, therefore, at low frequencies by the angular resolution and at the high frequencies by the MSL level, with a range from 250 Hz to 12000 kHz.

For measurements inside vehicles, Spherical Beamforming is typically used to give an overview of the acoustics. For more detailed information, particularly at low frequencies, a hand-held array can be used together with Conformal Acoustical Holography, thus covering a very wide frequency range.

Features and Benefits

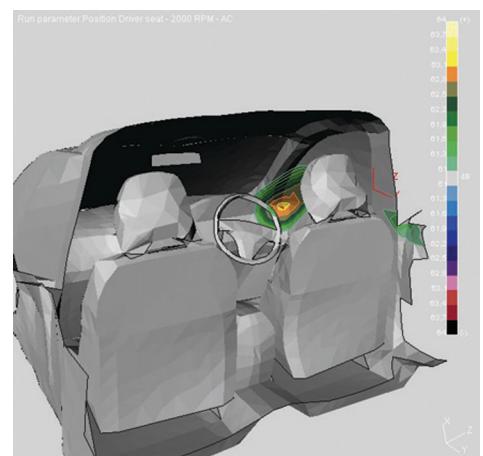
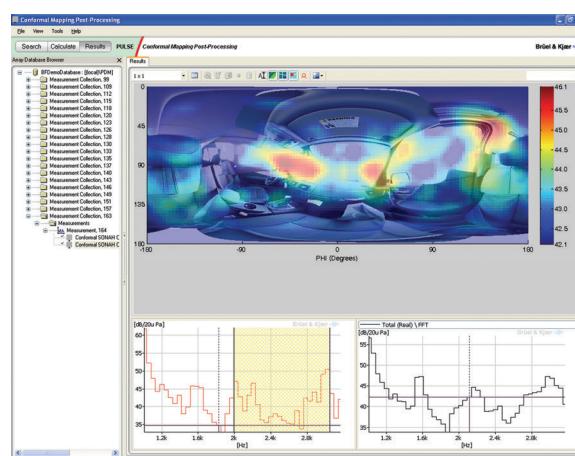
- Quick snapshot measurement
- Ideal for mid to high frequencies
- Omnidirectional coverage
- Independent of acoustic environment

Typical Applications

- Vehicle interior noise
- Aircraft cabin noise
- Rooms
- Industrial plant noise

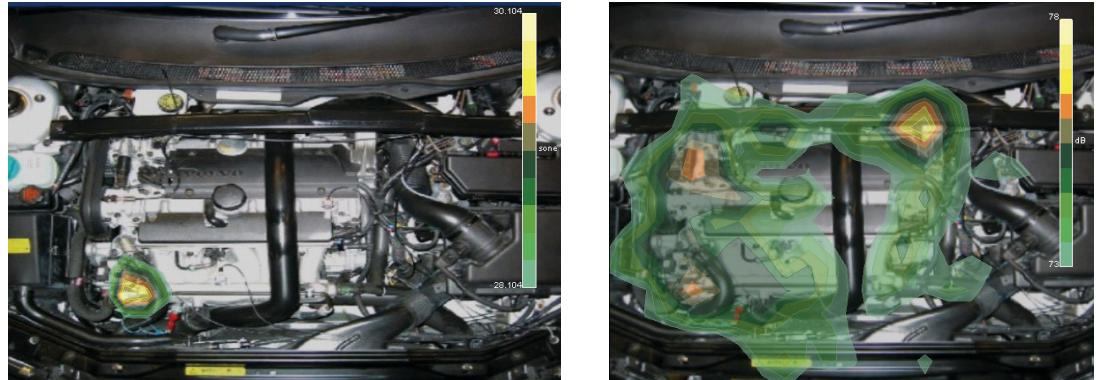
Application Example

Fig. 6
Left: Omnidirectional result from a road test using Spherical Beamforming. The car interior at 80 mph: 2000 – 3000 Hz
Right: Conformal mapping result from a test on a car using a Spherical Array situated in the driver's seat (with air conditioning) running). The result shows the right vent making more noise than other vents, (1/3-octaves, 4 – 5 Hz)



For all the array applications (Beamforming, Acoustic Holography, Spherical Beamforming), sound quality metrics can be mapped, see the examples in Fig. 7.

Fig. 7
Comparison of loudness and SPL maps, 15.5–18 bark
Left: Stationary loudness
Right: Sound pressure



The sound quality metrics that are available depend on the processing type selected in the Array Acoustics Suite, see Table 3. The metric *Impulsiveness* was developed in partnership with Isuzu Motors Limited in Japan.

Table 3
Sound Quality metrics available

	Processing Types in Array Acoustics Suite			
	Stationary	Quasi-stationary	Transient	Sound Quality Metrics
Stationary Loudness	•	•		•
Non-stationary Loudness			•	
Sharpness	•	•		•
Statistical Loudness				•
Roughness				•
Fluctuation Strength				•
Articulation Index	•	•		•
Psychoacoustic Annoyance				•
Loudness Level	•	•	•	•
Combined Metrics				•
Impulsiveness				•

Typical Setups for Array Systems

Fig. 8
Typical 18-channel
Sliced Wheel Array
system

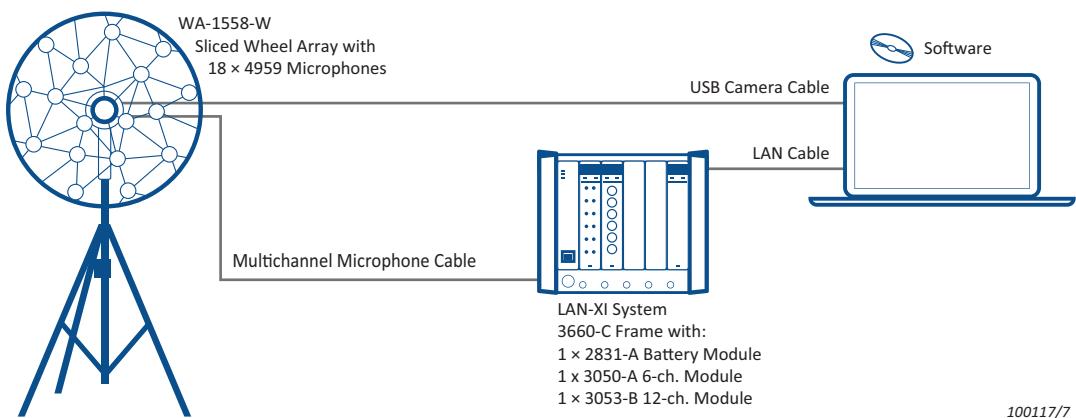


Fig. 9
Typical 36-channel
system for spherical
beamforming.
Spherical
beamforming systems
are supplied as
customer-specified
projects

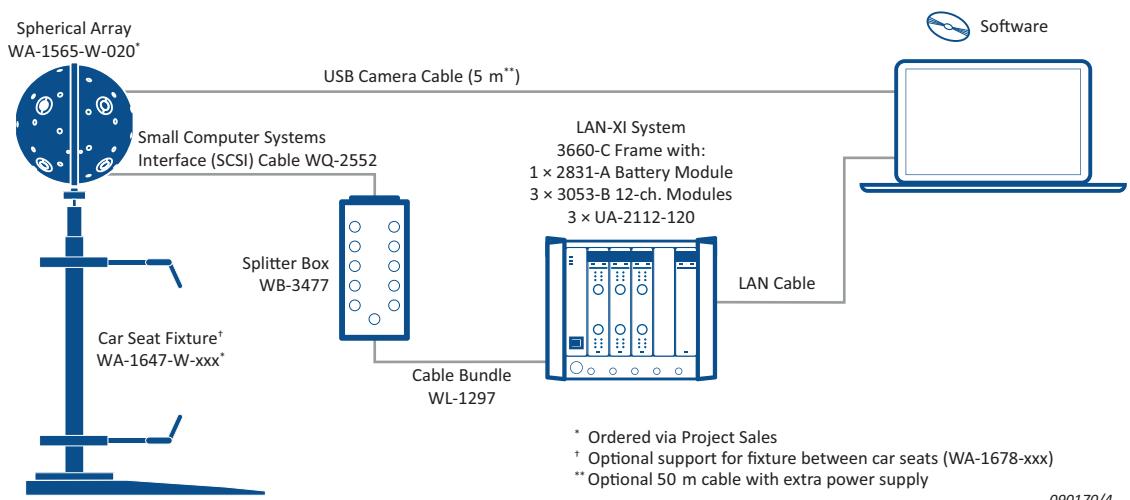


Fig. 10
Typical Pentangular
Array system

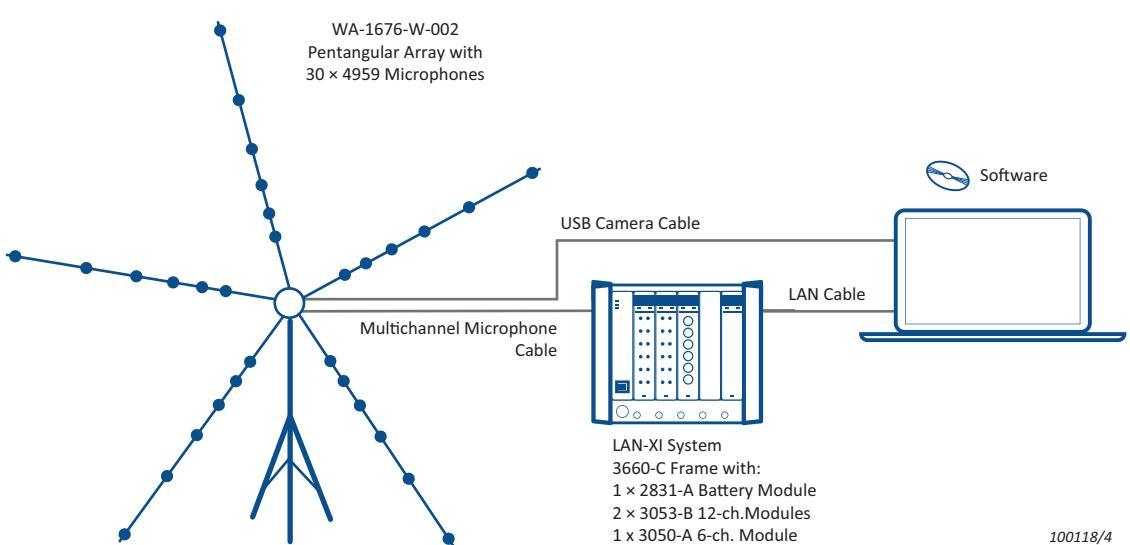
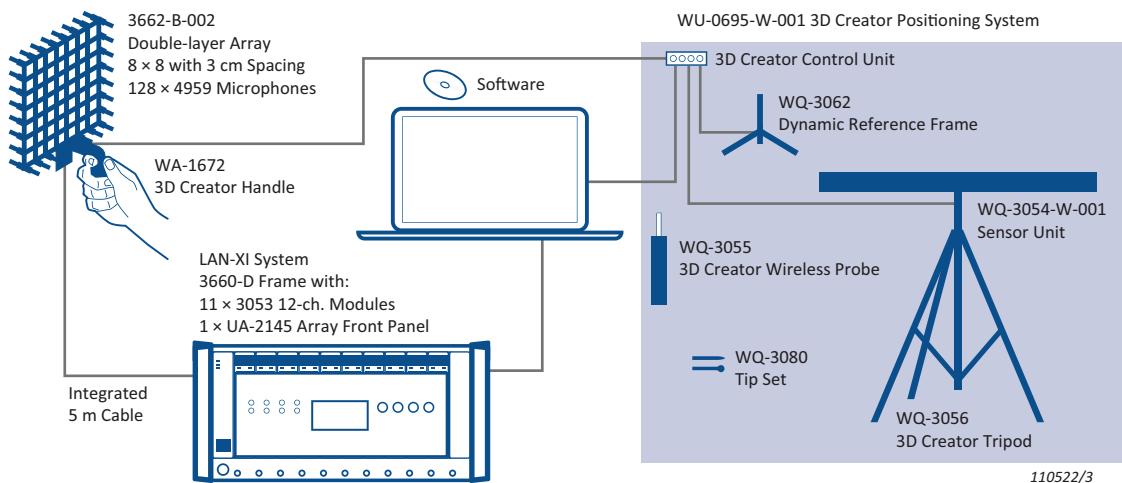


Fig. 11

Typical Hand-held Double-layer Array system with Array Front Panel UA-2145 with single cable for all acoustic signals



Hand-held Arrays – Frequency Ranges

Hand-held Array Type	Layer	Configuration	Grid Spacing (mm)	Mics. Required	Array Length (m)	Typical Min. Frequency (Hz)	Typical Max. Frequency (Hz)
Type 3662-A-001	Single	8 x 8 x 1	25	64	0.175	245	6174
Type 3662-A-002	Double	8 x 8 x 2	25	128	0.175	245	4979
Type 3662-A-003	Single	6 x 6 x 1	25	36	0.125	343	6174
Type 3662-A-004	Double	6 x 6 x 2	25	72	0.125	343	4979
Type 3662-B-001	Single	8 x 8 x 1	30	64	0.210	204	5145
Type 3662-B-002	Double	8 x 8 x 2	30	128	0.210	204	4979
Type 3662-B-003	Single	6 x 6 x 1	30	36	0.150	286	5145
Type 3662-B-004	Double	6 x 6 x 2	30	72	0.150	286	4979
Type 3662-C-001	Single	8 x 8 x 1	35	64	0.245	175	4410
Type 3662-C-002	Double	8 x 8 x 2	35	128	0.245	175	4410
Type 3662-C-003	Single	6 x 6 x 1	35	36	0.175	245	4410
Type 3662-C-004	Double	6 x 6 x 2	35	72	0.175	245	4410
Type 3662-D-001	Single	8 x 8 x 1	40	64	0.280	153	3859
Type 3662-D-002	Double	8 x 8 x 2	40	128	0.280	153	3859
Type 3662-D-003	Single	6 x 6 x 1	40	36	0.200	214	3859
Type 3662-D-004	Double	6 x 6 x 2	40	72	0.200	214	3859

Specifications – Types 8606, 8607 and 8608

Types 8606, 8607 and 8608 are Windows®-based applications for use with PULSE

Software is delivered via installation media (DVD or USB). The licence is either: node-locked to a PC host ID or dongle; or floating, locked to a network server

SYSTEM REQUIREMENTS

- The following BK Connect applications:
 - Data Viewer Type 8400
 - Hardware Setup Type 8401
 - Hardware Setup (advanced) Type 8401-A
 - Array Analysis Type 8430 (includes PULSE Acoustic Test Consultant Type 7761, see Product Data [BP 1908](#))
 - Microsoft® Windows® 10 Pro or Enterprise (x64) with either Current Branch (CB) or Current Branch for Business (CBB) servicing model
 - Microsoft® Office 2016 (x32 or x64) or Office 2019 (x32 or x64)
 - Microsoft® SQL Server® 2017 or SQL Server® 2019
- Note:** Microsoft SQL Server 2017 is included in BK Connect installation

RECOMMENDED SYSTEM CONFIGURATION

- Intel® Core™ i7, 3 GHz processor or better
- 32 GB RAM
- 480 GB Solid State Drive (SSD) with 20 GB free space, or better

- 1 Gbit Ethernet network*
- Microsoft® Windows® 10 Pro or Enterprise (x64) with CB
- Microsoft® Office 2016 (x32)
- Microsoft® SQL Server® 2017
- Screen resolution of 1920 × 1080 pixels (full HD)

HARDWARE REQUIREMENTS

The minimum hardware requirements:

- One multi-channel acoustic array
- LAN-XI Data Acquisition Front End that supports the chosen array

Note: A dedicated network for the front end is recommended as it gives better stability to the system

FRONT END

The software automatically detects the front-end hardware connected and configures the system. If IEEE 1451.4 capable transducers (with standardized TEDS) are being used, these are also detected and attached automatically to the correct channel of the input module

- A dedicated data acquisition network (LAN or WAN) is recommended. A network that only handles data from the front end improves the stability of the data

Acoustic Holography Type 8607		Beamforming Type 8608		Spherical Beamforming Type 8606	
Measurement					
Monitor view	Yes	Yes	Yes	Yes (for single camera)	
Data	Time or Spectral	Time	Time	Time	
Process	Single, Patch or Scanned	Single	Single	Single	
Optical picture	N/A	Take or reuse	Take or reuse	Take or reuse	
Automatic processing	Store automatically, Calculate automatically, Selectable calculation	Store automatically, Calculate automatically, Selectable calculation	Store automatically, Calculate automatically, Selectable calculation	Store automatically, Calculate automatically, Selectable calculation	
Data Management					
Databases	Multiple simultaneous	Multiple simultaneous	Multiple simultaneous	Multiple simultaneous	
Inspect metadata	Yes	Yes	Yes	Yes	
Search on metadata	Yes	Yes	Yes	Yes	
Change metadata	Yes	Yes	Yes	Yes	
Calculation					
Multi core support	Yes	Yes	Yes	Yes	
Target mesh type	Planar, Conformal	Planar, Conformal	Planar, Conformal	Spherical, Conformal	
References	Physical and Virtual	Physical	Physical	Physical	
Methods	NAH, SONAH, ESM	Delay and Sum, NNLS, CLEAN-SC*	Delay and Sum, NNLS, CLEAN-SC*	SHARP, FAS, CLEAN-SC*	
Filtering	Frequency, Order	Frequency, Order	Frequency, Order	Frequency, Order	
Domains	Stationary, Quasi-stationary, Transient	Stationary, Quasi-stationary, Transient	Stationary, Quasi-stationary, Transient	Stationary, Quasi-stationary, Transient	
Function	Pressure, Intensity, Reactive Intensity, Particle Velocity, Front Source Intensity, Rear Source Intensity, Scattered Intensity, Radiated Intensity, Absorption Coefficient	Pressure Contribution, Pressure, Intensity, Reference Contribution	Pressure Contribution, Pressure, Intensity	Pressure Contribution, Pressure, Intensity	
Index dimensions	Time, RPM, Angle	Time, RPM, Angle	Time, RPM, Angle	Time, RPM, Angle	
User Interface					
User levels	Basic and Advanced User defined	Basic and Advanced User defined	Basic and Advanced User defined	Basic and Advanced User defined	
Defaults	User defined	User defined	User defined	User defined	
Contribution Analysis					
Sound Power	Area, Component	Area, Component	Area, Component	Area, Component	
Map Displays					
Number of displays	1 × 1 to 4 × 4	1 × 1 to 4 × 4	1 × 1 to 4 × 4	1 × 1 to 4 × 4	
Alignment of displays	Camera Position, Data, Frequency, Index, Colour scale	Camera Position, Data, Frequency, Index, Colour scale	Camera Position, Data, Frequency, Index, Colour scale	Camera Position, Data, Frequency, Index, Colour scale	

	Acoustic Holography Type 8607	Beamforming Type 8608	Spherical Beamforming Type 8606
Playback	Calculated Points	Calculated Points	Calculated Points
Reporting			
Cut and Paste	One view, All views	One view, All views	One view, All views
Movie file generation	Animation driven Audio driven	Animation driven Audio driven	Animation driven Audio driven
Microsoft® Word report generator	Across frequencies Across indices	Across frequencies Across indices	Across frequencies Across indices
Capacity			
Calculation [†]	<p>Stationary (time based): As Type 8608 Scanned measurements with robot (stationary, frequency based):</p> <ul style="list-style-type: none"> • 5000 measurement points with SONAH • 10000 measurement points with NAH and 2 references, and 400 line FFT (or equivalent) <p>For greater number of measurement points, use PULSE based solution formerly known as Type 7780</p>	<p>Stationary (time based):</p> <ul style="list-style-type: none"> • 300 s at 12.8 kHz • 60 measurement points • 8000 target points • 800 line FFT <p>(or equivalent)</p>	<p>Stationary (time based):</p> <ul style="list-style-type: none"> • 300 s at 6.4 kHz • 800 lines FFT • 2592 target points (spacing 5° in azimuth and elevation)
Calculation [†]	<p>Transient:</p> <ul style="list-style-type: none"> • The maximum signal length for transient calculations is 1/15 of the maximum measured signal length at the chosen sampling frequency[‡] • 60 measurement points • 400 target points • 300 frames • 800 line FFT <p>(or equivalent)^{**}</p>	<p>Transient:</p> <ul style="list-style-type: none"> • The maximum signal length for transient calculations is 1/4 of the maximum measured signal length at the chosen sampling frequency[‡] • 60 measurement points • 400 target points • 300 frames • 800 line FFT <p>(or equivalent)^{**}</p>	<p>Transient:</p> <ul style="list-style-type: none"> • The maximum signal length for transient calculations is 1/15 of the maximum measured signal length at the chosen sampling frequency[‡] • 50 measurement points • 400 target points • 300 frames • 800 line FFT <p>(or equivalent)</p>
Measurement	<p>Frequency Data:</p> <ul style="list-style-type: none"> • Set by PULSE FFT analyzer • 2000 measurement points • 6 references • 400 line FFT <p>Time Data: Requires BK Connect Time Data Recorder Type 8402</p>	<p>Time Data:</p> <ul style="list-style-type: none"> • 300 s at 12.8 kHz • Set by data recorder (Requires BK Connect Time Data Recorder Type 8402) 	<p>Time Data:</p> <ul style="list-style-type: none"> • 300 s at 12.8 kHz • Set by data recorder (Requires BK Connect Time Data Recorder Type 8402)

* Requires the option: Refined Beamforming Calculations BZ-5639

† For one parameter at a time (for example, sound pressure, sound intensity)

‡ Transient calculations for longer signals can be performed in segments. These values are for pressure and for particle velocity. For intensity, the values must be halved

** Full compliance with specification with Windows® 64-bit. With Windows® 32-bit, the specification is halved

Ordering Information

Type 8606 PULSE Array Acoustics, Spherical Beamforming

Type 8607 PULSE Array Acoustics, Acoustic Holography

Type 8608 PULSE Array Acoustics, Beamforming

Software licenses are either node-locked or floating

Types 8606, 8607 and 8608 require the following:

- BK Connect Data Viewer Type 8400
- BK Connect Hardware Setup Type 8401
- BK Connect Hardware Setup (advanced) Type 8401-A
- BK Connect Array Analysis Type 8430 (includes PULSE Acoustic Test Consultant Type 7761)

OPTIONS

Order No.	Name	Product Data	Acoustic Holography Type 8607	Beamforming Type 8608	Spherical Beamforming Type 8606
BZ-5635	PULSE Array Acoustics, Quasi-stationary Calculations	–	•	•	•
BZ-5636	PULSE Array Acoustics, Transient Calculations	–	•	•	•
BZ-5637	PULSE Array Acoustics, Conformal Calculations	–	•	•	•
BZ-5638	PULSE Array Acoustics, Sound Quality Metrics	BP 2144	•	•	•
BZ-5652	PULSE Array Acoustics, External Plug-in Manager	BP 2531	•	•	•
BZ-5644	PULSE Array Acoustics, Wideband Holography	BP 2530	•	•	
BZ-5639	PULSE Array Acoustics, Refined Beamforming Calculations	BP 2543		•	•
BZ-5939	PULSE Array Acoustics, Rail Vehicles Moving Source Beamforming	BP 2454		•	
BZ-5940	PULSE Array Acoustics, Flyover Moving Source Beamforming	BP 2537		•	
BZ-5941	PULSE Array Acoustics, Wind Turbines Moving Source Beamforming	BP 2493		•	
BZ-5943	PULSE Array Acoustics, Road Vehicles Moving Source Beamforming	BP 2453		•	
BZ-5963	PULSE Array Acoustics, Proximal Holography	BP 2538	•		
BZ-5370	PULSE ATC Robot Option	BP 1908	•		
BZ-5640*	PULSE Panel Contribution	BP 2452	•		
BZ-5641*	PULSE Intensity Component Analysis	BP 2452	•		
BZ-5642*	PULSE In Situ Absorption	BP 2452	•		
BZ-5611	PULSE ATC Positioning Option	BP 1908	•		

* Requires BZ-5637

Supported Brüel & Kjær Products

LAN-XI DATA ACQUISITION HARDWARE

UA-2145-D LAN-XI Array Front Panel for 11 modules

ARRAYS

WA-0806	Integral Connection Array
WA-0807	Flexible Connection Array
WA-1565-W-020	Spherical Array, 36 channels
WA-1565-W-021	Spherical Array, 50 channels
WA-0890-F	Full-wheel Beamforming Array
WA-0890-H	Half-wheel Beamforming Array
WA-1558	Sliced Wheel Array
Type 3662-X-yyy*	Hand-held Array (see Table 1)

ARRAY ACCESSORIES

Type 9665 [†]	Array Positioning System (Robot)
WB-1477 [†]	Robot Controller
WU-0695-W-001	3D Creator Optical Sensor Positioning System
WQ-2691	Tripod
WA-0810	Support Stand for Grid Array
WA-1647-W-001	Car Seat Fixture for Spherical Array
WA-0728-W-004	Single-channel Pistonphone Adaptor, stethoscope, for Spherical Array with Microphones Type 4959
WA-0728-W-005	Single Channel Pistonphone Adaptor, stethoscope version for foldable array with Type 4959

MICROPHONES

Type 4957	10 kHz Array Microphone
Type 4958	20 kHz Precision Array Microphone
Type 4959	10 kHz Very Short Array Microphone

Supported Brüel & Kjær Services

SOFTWARE MAINTENANCE AND SUPPORT

Available for all software packages (see Product Data [BP 1800](#))

* X = A, B, C or D, which is standard spacing at 25, 30, 35 or 40 mm
yyy = 001, 002, 003 or 004, which are channel counts at $8 \times 8 \times 1$, $8 \times 8 \times 2$, $6 \times 6 \times 1$ or $6 \times 6 \times 2$

† Robots are customized orders only. Please contact Brüel & Kjær ([bksv.com/contact](#))

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