PRODUCT INFORMATION

Spherical Beamforming Systems

based on Spherical Beamforming Type 8606

Spherical Beamforming is one of a suite of systems developed for noise source identification. Based on one simple measurement, the system provides a complete, omnidirectional noise map in any acoustic environment.

Unlike other measurement methods that only map part of the surroundings, spherical beamforming uses a spherical array of microphones and cameras to simultaneously measure noise levels and take pictures in all directions. When the results are displayed, the noise measurements are superimposed on the pictures to create an acoustic map.

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 environments. The system is commonly used to make overview maps in confined and semi-damped spaces such as vehicle, train and aircraft cabins.

Uses, Features and Benefits

Uses

- Wide frequency range measurements
- Vehicle interior noise measurements
- Squeak and rattle testing
- End-of-line wind box vehicle testing
- Aircraft and train cabin noise measurements
- Industrial plant noise measurements
- Source location in rooms and factory halls

Features

- Quick snapshot measurement
- Omnidirectional coverage
- Independent of acoustic environment
- Two algorithms implemented:
  - Filter and Sum (FAS), patent pending
  - Spherical Harmonics Angularly Resolved Pressure (SHARP)

Benefits

- Saves time via rapid evaluation of noise problems
- Easy to use
- Easy to mount inside a vehicle
- Robust array with many applications
- Boosts low-frequency resolution with FAS

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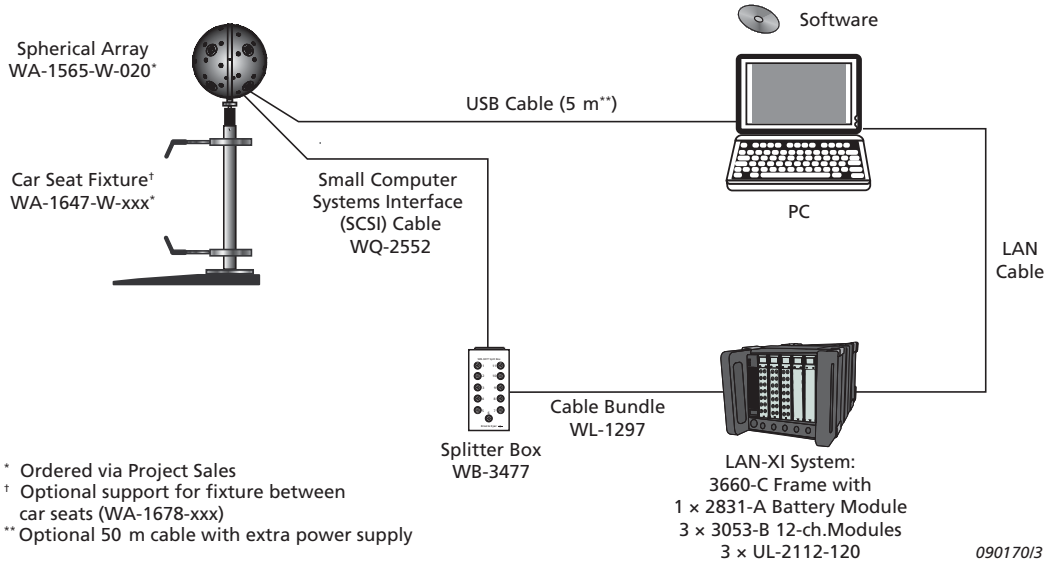
Measurement and Calculation

Fig. 1
Car seat fixture for spherical array

The measurement is performed using an array of 36 or 50 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 (sound) impact position, for example, in the driver's seat of a vehicle using the car seat fixture for spherical array (Fig. 1).

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

Fig. 2
Typical 36-channel system. Spherical beamforming systems are supplied as customer-specified projects



* Ordered via Project Sales
† Optional support for fixture between car seats (WA-1678-xxx)
** Optional 50 m cable with extra power supply

Calibration

Fig. 3
Calibration of the spherical array

The spherical array and complete measurement system are easily calibrated using Pistonphone Type 4228 with a single-channel "stethoscope" adaptor (Fig. 3).

Performance

The angular resolution provided by the spherical beamforming algorithms FAS and SHARP are roughly the same (see Table 1). However, FAS provides considerable improvement in the maximum side lobe (MSL) level and, in conjunction with a low-frequency boost (LFB) algorithm, increases the angular resolution at low frequencies.

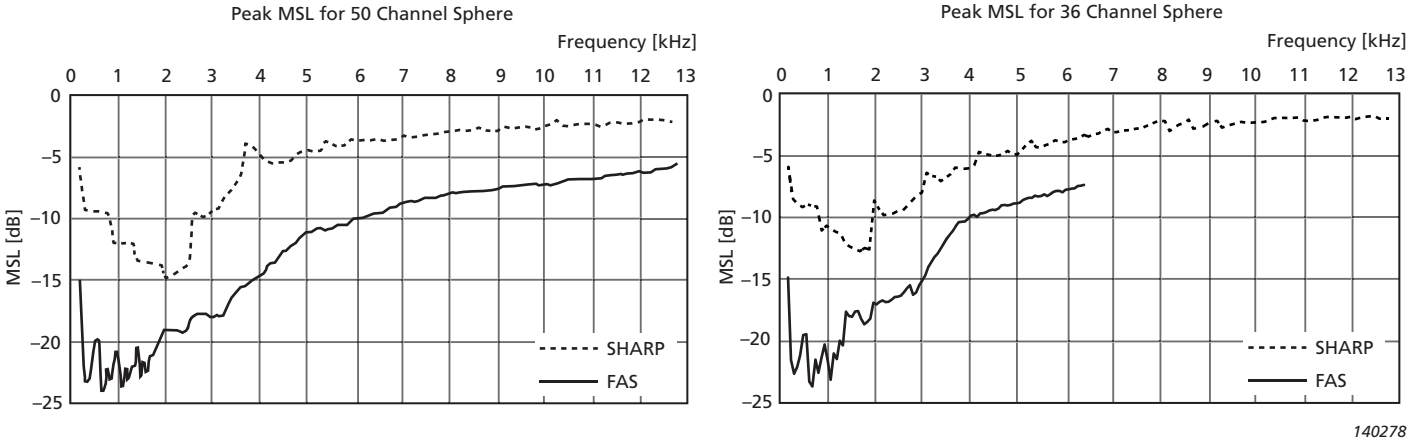
Table 1 *Comparison of resolution (–3 dB), in degrees, between FAS and SHARP beamforming for a sphere with diameter 19.5 cm*

Algorithm	100 Hz	200 Hz	500 Hz	1 kHz	2 kHz	4 kHz	6 kHz	8 kHz	10 kHz	12 kHz
FAS (36 and 50 ch.)	145	105	68	48	32	24	16	13	10	8
FAS with LFB (36 ch.)	110	95	68	48	32	24	16	13	10	8
FAS with LFB (50 ch.)	85	70	52	48	32	24	16	13	10	8
SHARP (36 and 50 ch.)	145	105	68	48	32	24	16	13	10	8

The error-free dynamic depth, or MSL level, decreases with frequency, but for FAS with the 50-channel array, it is greater than 6 dB up to 12 kHz, and for the 36-channel array, greater than 6 dB up to 7 kHz. Therefore, the bands of use of spherical beamforming are set towards low frequencies by resolution and towards high frequencies by dynamic depth, with a range from 100 to 12800 Hz.

The SHARP algorithm has a limited MSL level at higher frequencies, so it is recommended to use FAS above 6.4 kHz.

Fig. 4 *Comparison of the MSL levels for the SHARP and FAS algorithms.* ***Left****: 50-channel array,* ***Right****: 36-channel array*



Application Examples

Typical applications for spherical beamforming include:

- Vehicle interior noise
- Wind tunnel measurements on vehicles
- Aircraft cabin noise
- Rooms
- Industrial plant noise

See Figures 5 through 8 for examples of these applications.

Fig. 5 *Combination of the spherical array (**left**) with the hand-held conformal holography system (**right**) used to investigate noise from a ventilation system*

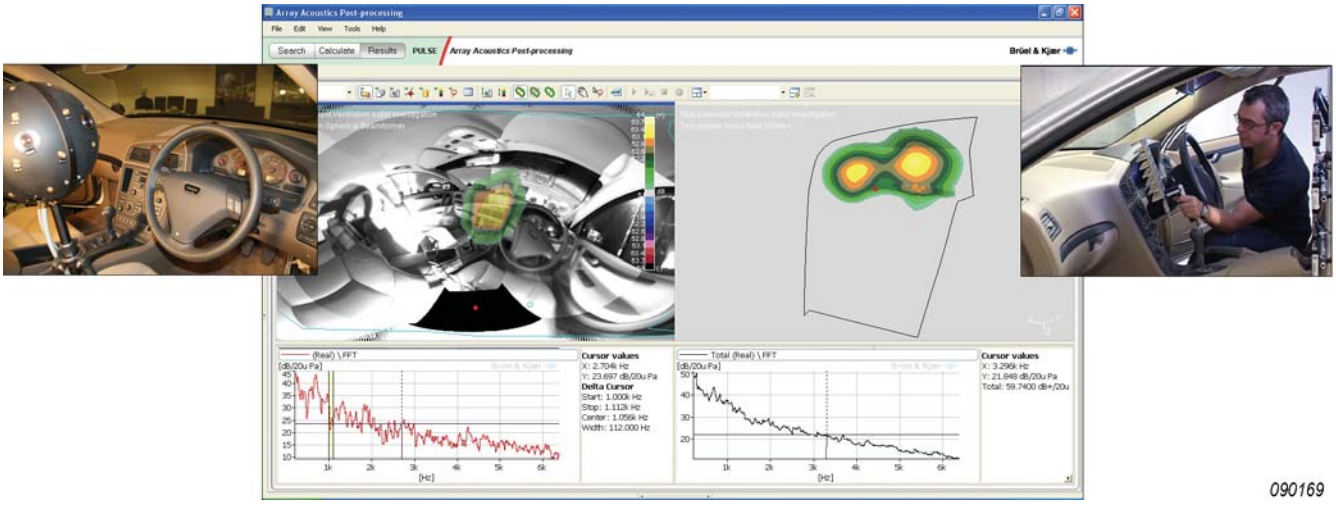


Fig. 6
Spherical beamforming used to investigate noise (2 – 4 kHz) from a locking mechanism during door slam

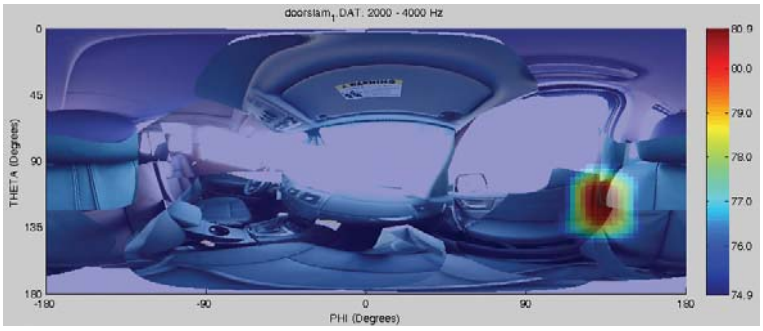
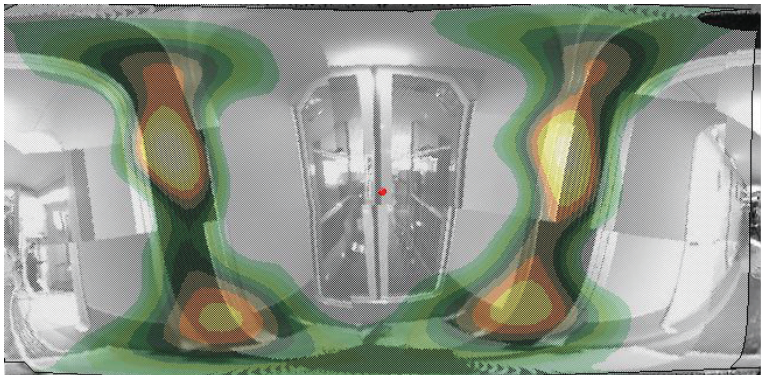


Fig. 7 *Spherical beamforming used to investigate a hole in the upper seal of a passenger door at 80 mph.*
Left*: 600 – 4500 Hz: This broad-frequency-range map does not localize the hole in the seal well*
Right*: 1400 – 1500 Hz: This frequency range accurately pinpoints the hole in the seal*

Fig. 8
Spherical beamforming used to investigate noise in the gangway of a high-speed train. The map shows the 1600 Hz third-octave band



Configuration

OPERATING SYSTEM REQUIREMENTS
Microsoft® Windows® 8.1 Pro or Enterprise (x64), Windows® 7 Pro, Enterprise or Ultimate (x64)

OTHER SOFTWARE REQUIREMENTS
Microsoft® Office 2013
Microsoft® SQL Server® 2012 Express (SP 2) (included with PULSE)

COMPUTER CONFIGURATION/DATA ACQUISITION FRONT ENDS
As for PULSE, see System Data BU 0229

PREREQUISITES
- PULSE 7700/7770/7771
- PULSE Acoustic Test Consultant Type 7761

Software Specifications for PULSE Spherical Beamforming Type 8606

Measurement	
Monitor view	Yes (for single camera)
Data	Time or spectral
Optical picture	Take or reuse
Automatic processing	Store automatically, Calculate automatically, Selectable calculation
Data Management	
Databases	Multiple simultaneous
Inspect metadata	Yes
Search on metadata	Yes
Change metadata	Yes
Calculation	
Multi core support	Yes
Target mesh type	Spherical
References	Physical
Methods	FAS (with low-frequency resolution boost) and SHARP
Filtering	Frequency, Order
Domains	Stationary, Quasi-stationary, Transient
Function	Pressure Contribution, Pressure, Intensity
Index dimensions	Time, RPM, Angle
User Interface	
User levels	Basic and Advanced, User-defined
Defaults	User-defined
Contribution Analysis	
Sound Power	Area, Component
Map Displays	
Number of displays	1 × 1 to 4 × 4
Alignment of displays	Data, Frequency, Index, Colour scale
Playback	Measured and calculated Points
Reporting	
Cut and Paste	One view, All views
Movie file generation	Animation driven, Audio driven
Microsoft® Word report generator	Across frequencies, Across indices

Hardware Specifications for Spherical Array WA-1565

36-CH. SPHERICAL ARRAY
Frequency Range
- 200 – 6400 Hz with SHARP
- 100 – 6400 Hz with FAS

Diameter: 19.5 cm (7.68 in)
Weight: 5 kg (11.02 lb)

50-CH. SPHERICAL ARRAY
Frequency Range
- 200 – 7000 Hz with SHARP
- 100 – 12800 Hz with FAS

Diameter: 19.5 cm (7.68 in)
Weight: 5 kg (11.02 lb)

Typical 36-channel System

PULSE SOFTWARE FOR SPHERICAL BEAMFORMING

1 × Type 8606-X*	PULSE Spherical Beamforming
1 × Type 7770-X16*	PULSE FFT Analysis, Unlimited Channels
1 × Type 7708-X16*	PULSE Time Data Recorder, Unlimited Channels
1 × Type 7761-X*	PULSE Acoustic Test Consultant

SOFTWARE MAINTENANCE AND SUPPORT

1 × M1-8606-X*	Annual Software Maintenance and Support Agreement for PULSE Spherical Beamforming
1 × M1-7770-X16*	Annual Software Maintenance and Support Agreement for PULSE FFT Analysis, Unlimited Channels
1 × M1-7708-X16*	Annual Software Maintenance and Support Agreement for PULSE Time Data Recorder, Unlimited Channel
1 × M1-7761-X*	Annual Software Maintenance and Support Agreement for PULSE Acoustic Test Consultant

DATA ACQUISITION HARDWARE

1 × Type 7201-G	Dell™ High-end Notebook
1 × Type 3660-C-100	LAN-XI Front-end Frame with GPS, 5-module
3 × UA-2112-120	LAN-XI Front Panel with Array Connectors, 2 × LEMO (7-pin) connectors
3 × Type 3053-B-120	12-channel Input Module LAN-XI 25.6 kHz (CCLD, V), including Front Panel UA-2107-120
× Type 2831-A	Battery Module

SPHERICAL BEAMFORMER INCLUDING ACCESSORIES

1 × WA-1565-W-020†	Spherical Array, ∅ 195 mm/36 positions/12 cameras, includes Splitter Box WB-3477
1 × WL-1297-W-005‡	Bundle of 6 cables in braided sleeve with individual numbering, 7-pin LEMO connectors, length 20 m
1 × WA-1647-W-001†	Car Seat Fixture for Spherical Array
1 × WA-0728-W-004†	Single-channel Pistonphone Adaptor
1 × Type 4228	Pistonphone
WQ-2552	Small Computer Systems Interface (SCSI) Cable, 5 m

* X indicates the license module, either N: Node-locked or F: Floating
† Ordered via Project Sales
‡ Available in different lengths, inquire when ordering

Optional Accessories

SOFTWARE

1 × Type 7770-X16*	PULSE FFT & CCB Analysis, Unlimited Channels
1 × Type 7771-X16*	PULSE CCB Analysis, Unlimited Channels
BZ-5635-X*	PULSE Array Acoustics Quasi-stationary Calculations
BZ-5636-X*	PULSE Array Acoustics Transient Calculations
BZ-5637-X*	PULSE Array Acoustics Conformal Calculations
BZ-5638-X*	PULSE Array Acoustics Sound Quality Metrics
BZ-5652-X*	PULSE Array Acoustics External Plug-in Manager

HARDWARE

WA-1565-W-021†	Spherical Array for 50 Channels, includes Splitter Box WB-3477
WL-1297-W-006‡	Bundle of 9 cables in braided sleeve with individual numbering, 7-pin LEMO connectors, length 20 m
WA-0728-W-007†	Single-channel Pistonphone Adaptor, with stethoscope for spherical array Microphones Type 4959
WA-1647-W-001†	Car Seat Fixture for Spherical Array
WA-1678	Optional Support for fixture between car seats
WQ-2691	Tripod, heavy duty, 0.94 m–2.17 m, max. load 12 kg

TRANSDUCERS

Type 4959	Short 20 kHz Array Microphone

SOFTWARE MAINTENANCE AND SUPPORT

Available for all software packages
See the PULSE Software Maintenance and Support Agreement Product Data (BP 1800) for further details

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