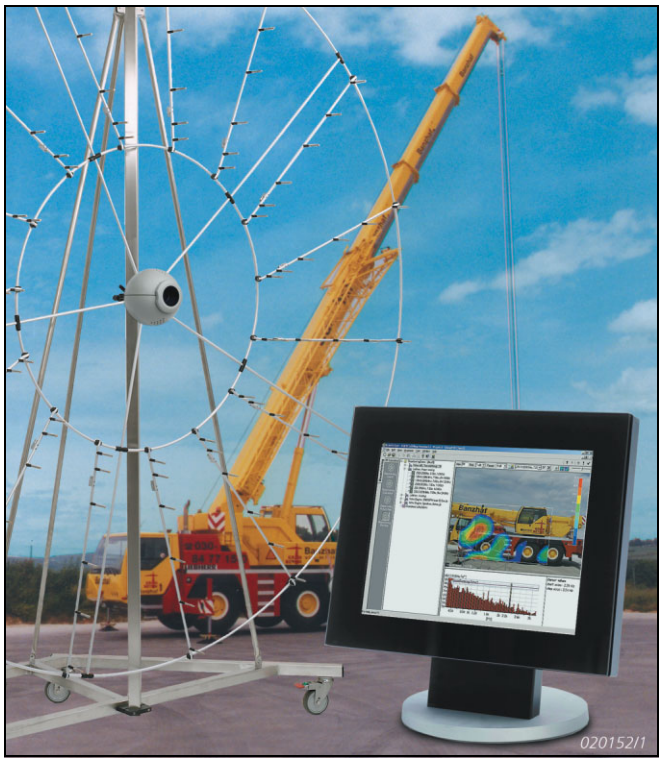
PRODUCT DATA

PULSE Beamforming — Type 7768

Beamforming is a method of mapping noise sources by differentiating sound levels based upon 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.

The innovative Brüel & Kjær wheel arrays can be used with PULSE™ Beamforming to produce acoustically optimal results while maintaining maximum ease of use and handling.

PULSE Beamforming software is centred around an easy-to-understand tree structure where all measurements and calculations are represented. From there, drag-and-drop functionality allows you to plot results in both 2 and 3D. In addition, results can be superimposed on an image of the measured object.



USES AND FEATURES

USES

- Noise-source location
- Mapping of noise radiated from medium- to large-sized objects such as vehicles, components, white goods and construction equipment
- Remote measurement in environments where it is difficult or dangerous to measure close to the source, for example, in wind-tunnels
- Mapping of higher frequencies than standard noise source location methods

FEATURES

- 'Outward-looking' array allows the mapping of targets much larger than the array itself
- Quick, one-shot measurements
- Wheel array design greatly reduces sidelobes and ghost images, allowing easier and more accurate interpretation of data
- Drag-and-drop functionality simplifies data analysis
- Built in database to manage large number of measurements, including user-defined meta data setup
- Stationary, slowly changing (quasi-stationary) and non-stationary sound sources can be used

Introduction

PULSE Beamforming is a versatile and easy to use noise source location system that adapts well even in difficult measurement situations.

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

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.

Beamforming supports three different calculation algorithms:
- Stationary – for sound sources that do not change over time
- Quasi-stationary – for slowly changing sound sources
- Non-stationary – for fast-changing and transient sound sources

PULSE Beamforming software accepts any array geometry, but a series of patented, numerically optimised wheel arrays have been designed to combine optimal acoustic performance with ease of use and handling.

With beamforming, the resolution of the result is proportional to the wavelength. The method is particularly suitable for analysing high-frequency phenomena encountered in, for example, scale model testing.

Additionally, when averaging in quasi-stationary or non-stationary modes, results can be displayed as functions of time, RPM, triggered intervals or crankshaft angle.

How Beamforming Works

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.

The beamforming algorithm works in both a free-field mode and a mirror-ground mode. In the mirror-ground mode, a totally reflective ground plane is assumed to be in a certain position compared to the array.

Apart from the main lobe, any beamforming array will also have a number of undesired sidelobes. If these are not well attenuated compared to the main lobe they can (particularly in narrow-band results) lead to unreal ‘ghost’ images in the final map. The patented Brüel & Kjær wheel arrays suppress ghost images by numerically optimising the microphone positions to give a high sidelobe attenuation over a wide frequency range.

The Beamforming System

The different elements of the PULSE Beamforming system combine to make a fully integrated and easy-to-use solution.

Fig. 1
PULSE Acoustic Test Consultant (ATC)

The measurement process is performed by PULSE Acoustic Test Consultant (ATC). ATC provides fast and easy setup of multichannel array systems, including automatic channel detection, parallel multichannel calibration, real-time channel monitor and on-line determination of channel status. The measured data is stored in the PULSE database from where it can be retrieved for beamforming calculations and display.

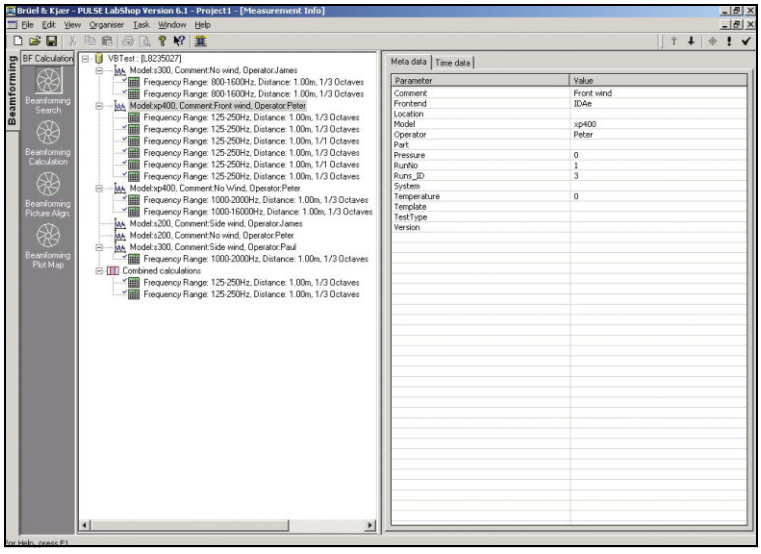
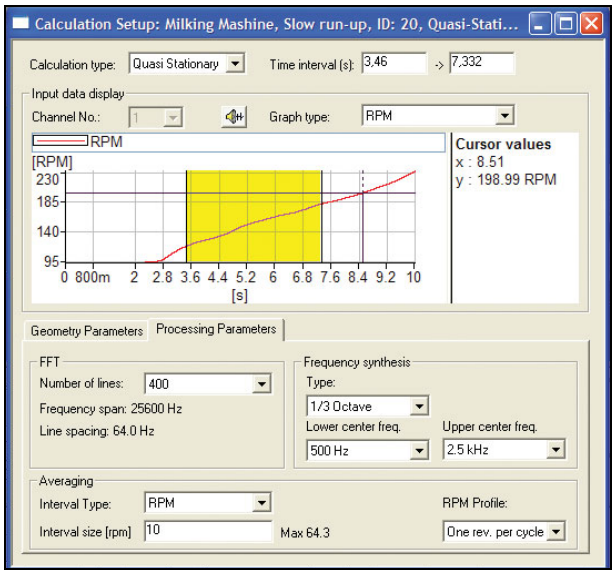


Fig. 2
Beamforming Data Tree

The Beamforming calculation module is controlled from the Data Tree window, a simple tree structure representing all defined measurements and calculations. Each measurement is easily identified from a user-defined set of meta data such as ‘Model’, ‘Speed’, ‘Operator’, etc., which is stored with the data. From each measurement it is possible to perform multiple calculations, for example, by focusing on specific parts of the test object or on specific frequency bands for different types of averaging. For searching in large databases, measurements can be filtered according to user-defined criteria based on the meta data.

Fig. 3
The Calculation Setup window



To display the result of a calculation, simply drag and drop it into a map window. The map window contains both a map and a spectral view of the result. These views are aligned so the map always maps the selected frequency band just as the spectrum always shows the data of the selected point on the map. Additionally, extensive display management tools are available, including zoom, scroll, tilt, rotate, etc.

Calculations can be displayed in separate map windows for comparison, or in the same map for a complete 3D result.

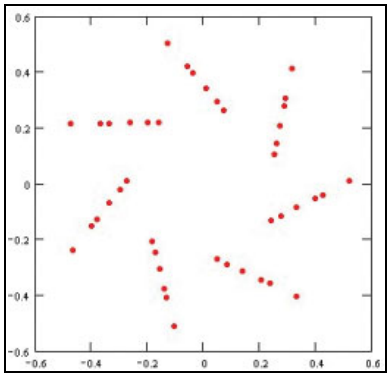
Beamforming Array Design

Brüel & Kjær's wheel arrays are designed for optimal acoustic performance. They are easy to use and handle. Wheel arrays consist of a number of spokes, each holding up to 6 microphones. Each spoke contains fully integrated cabling and is connected to a PULSE input module through a single cable. Array Microphones Type 4935, for example, are simply clicked onto the microphone holders. The use of spokes also makes it easy to identify each individual microphone despite the irregular positioning necessary to ensure the acoustic performance. Assembly and disassembly can be performed in minutes due to the modular construction of the arrays and the 'click-on' mounting of microphones.

Three typical wheel-array designs (see below) cover different applications and have different performance levels. The geometry of each array has been optimised for minimum sidelobe levels over a certain frequency range[1]. Brüel & Kjær also designs custom arrays for customers with special requirements.

Non-wheel arrays, for example the grid arrays used with PULSE STSF, and PULSE Non-stationary STSF, can also be used with the beamforming system, although most only operate in a very limited frequency range without high sidelobes. Optimised random arrays have excellent acoustic performance but are difficult to build physically unless flush-mounted on a plate.

Fig. 4
42-channel beamforming wheel array



WA 0890 V 42-channel Beamforming Wheel Array

- Typical application: general purpose
- Array diameter: ~1 m
- Sidelobe suppression: –10.6 dB up to 6.4 kHz
- Resolution at 1 m: 34 cm at 1 kHz
  17 cm at 2 kHz
  8 cm at 4 kHz
  5 cm at 6.4 kHz

1) The frequency ranges specified are valid under the assumption that the arrays are focused not more than 30° away from the axis. Disruptive sources outside this cone will be suppressed with the array's sidelobe suppression ratio. If disruptive sources are further assumed to be only inside the same cone around the axis, then the specified upper frequencies can be multiplied by a factor of 1.333

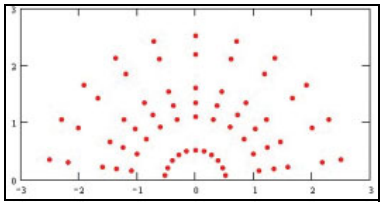


Fig. 5
66-channel beamforming wheel-array

WA 0890 V 66-channel Beamforming Wheel Array

- Typical application: entire vehicles
- Array diameter: ~5 m
- Sidelobe suppression: –15.0 dB up to 1.35 kHz
  –8.5 dB up to 10.7 kHz
- Resolution at 1 m: 137 cm at 250 Hz
  68 cm at 500 Hz
  34 cm at 1 kHz

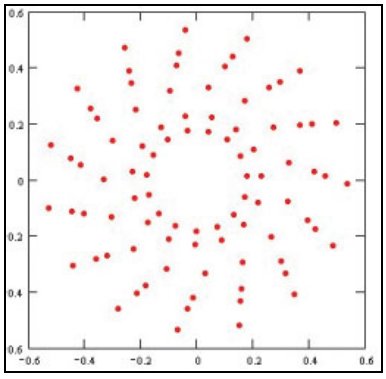


Fig. 6
90-channel beamforming wheel-array

WA 0890 V 90-channel Beamforming Wheel Array

- Typical application: automotive components
- Array diameter: ~1 m
- Sidelobe suppression: –15.7 dB up to 5.0 kHz
  –10.5 dB to 25.6 kHz
- Resolution at 1 m: 34 cm at 1 kHz
  17 cm at 2 kHz
  7 cm at 5 kHz

Picture Alignment

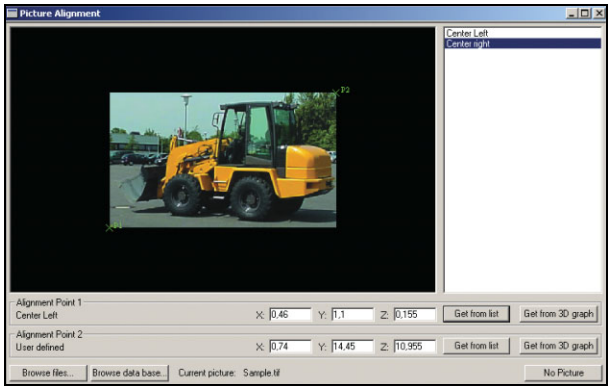


Fig. 7
The Picture Alignment window

Any mapped result can be superimposed on a picture of the measurement object. This makes it easy to document noise problems, especially if you are not an engineer. The background picture can be quickly recorded by digital camera (for field or consultancy use), can be exported from graphical-design tools or by using the Microsoft® Windows® screen-capture function.

Once the picture is imported, it can be easily aligned to the mapped result by simply identifying two characteristic points.

Graphics Display

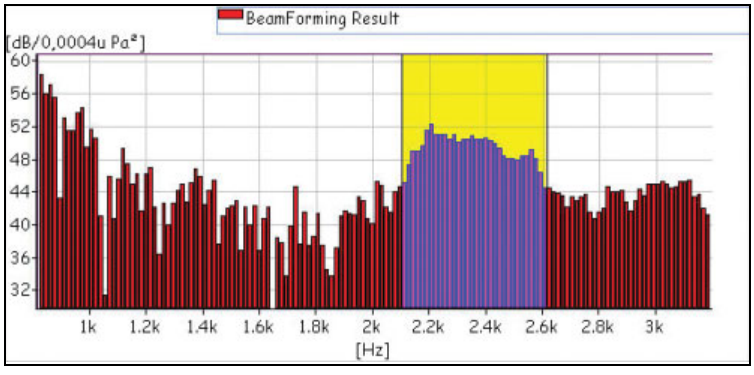


Fig. 8
Spectrum view (from graphics display window) of cursor position over a car-door handle

Data Export

Beamforming results can be exported to UFF ASCII, UFF Binary and PULSE ASCII formats, allowing data exchange with most other data-processing applications. Export to both Microsoft® Windows® and Unix® platform formats are supported.

You can also copy and paste graphs from the program to Microsoft® Word, Excel or any other application capable of handling images from a clipboard.

Snap Shot

Using this feature, a complete measurement, calculation and display of the result, is performed in a simple operation requiring just a few mouse clicks where contours are laid over a picture taken using a camera placed in the centre of the microphone array.

Playback

You can play back and/or listen to calculated data. Using PULSE Time Edit, this allows you to export and further manipulate time signals.

Application Example

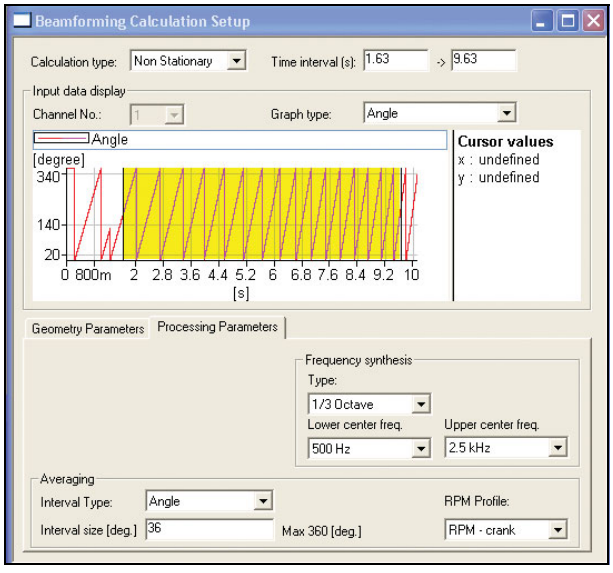


Fig. 9
Calculation setup for a non-stationary calculation with averaging in angle intervals of 36 degrees

A common application example is that of an engine running at constant RPM. In such a state, averaging in angle intervals is logical. In Fig. 9, the graph displays angle data processed from a tacho signal. An interval size of 36 degrees here implies 10 intervals per revolution; therefore particular noise emissions or noise problems can be isolated and focused upon. Alternatively, engines with run-ups can be examined using RPM intervals.

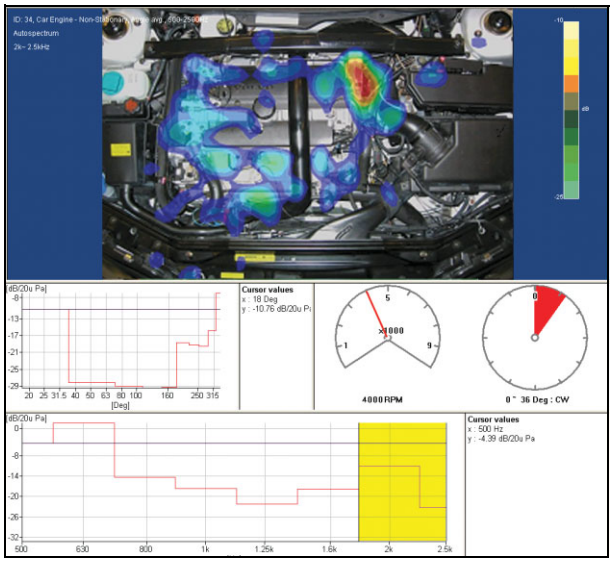


Fig. 10
The result of the calculation setup in Fig. 9. The 2.0 – 2.5 kHz 1/3-octave band averaged for crank angles between 0 and 36 degrees

Specifications – PULSE Beamforming Type 7768

Configuration

OPERATING SYSTEM REQUIREMENTS
Microsoft® Windows® 2000 or Windows® XP

OTHER SOFTWARE REQUIREMENTS
Microsoft® Office 2000 and Microsoft® SQL Server (optional)

PULSE SOFTWARE REQUIREMENTS
FFT & CPB Analysis Type 7700 or FFT Analysis 7770
Data Recorder Type 7701
Analysis Engine Upgrade Type 7707 (according to number of channels and maximum frequency)
Acoustic Test Consultant Type 7761
Noise Source Identification Type 7752
Time File Management Type 7789 (to enable calculated data to be listened to)

COMPUTER CONFIGURATION
As required for similar PULSE

FRONT-END
Any PULSE compatible front-end

COMPUTER CONFIGURATION/DATA ACQUISITION FRONT-ENDS
As for PULSE

TRANSDUCERS
Microphones or hydrophones (free-field or pressure transducers) with ±3° phase match
Array Microphone Type 4935 is recommended for measurements of up to 5 kHz
Array Microphone Type 4944 A is recommended for measurements of up to 20 kHz

Features

MEASUREMENT (WITH ACOUSTIC TEST CONSULTANT TYPE 7761)
- Automatic detection of measurement channels
- Multichannel calibration

CALCULATIONS AND RESULTS
- Sound Pressure Contribution to the array position of stationary sources
- Free-field and mirror-ground condition
- Calculation area user-defined
- Calculation mesh user-defined
- 1/1-oct. 1/3-oct, narrow-band
- Combined calculations to further reduce ghost images
- Stationary, quasi-stationary, non-stationary
- Averaging in time, RPM, angle and triggered intervals
- Listen to calculated data
- Single-click snap-shot measurement
- Scaling to target distance, sound pressure and sound intensity
- Coherent contribution using references

DISPLAYS
- Picture overlay
- 2D and 3D views
- Spectrum view at a point

EXPORT OF DATA
Export of measured and calculated data to:
- UFF (Universal File format)
- BUFF (Binary Universal File Format)
- PULSE ASCII File Format

Ordering Information

WA 0890 V\42 Ch. 1\1 Circle\1.0 m 42-channel Full-wheel System
WA 0890 V\90 Ch. 1\1 Circle\1.0 m 90-channel Full-wheel System
WA 0890 V\66 Ch. 1\2Circle\5.0 m 66-channel Half-wheel System

Recommended PULSE Configurations

CONFIGURATIONS					
Type	**Description**	**Entry-level 42-channel 5 kHz System**	**Typical 66-channel 5 kHz System**	**Typical 66-channel 25.6 kHz System**	**Analysis-only System**
PULSE Analyzer Type 3560					
3560 D-T42	PULSE Noise Source Identification System – Beamforming (42 In / 6.4 kHz)	1			
3560 E-T42	PULSE Noise Source Identification System – Beamforming (66 + 5 In / 20 kHz)		1	1	
7752 B	Noise Source Identification				1
M1-7752	Maintenance				1
7768	PULSE Beamforming				1
Software Options					
7789	Time File Management	1	1	1	1
BZ 5494	PULSE Non-stationary option for Beamforming	1	1	1	1
BZ 5495	PULSE Quasi-stationary option for Beamforming	1	1	1	1
M1-7768	Maintenance				1
Microphones and Array					
	Array and cables	42	66	66	0
4944 A	Array Microphones	0	0	66	0
4935	Array Microphones	42	66	0	0

Prerequisites	
System	Windows® 2000
Database	SQL Server
Applications	Office 2000

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