# 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 centered 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.

**7768**

Brüel & Kjær

*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, e.g., 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 metadata setup

## 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.

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.

## 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 and in 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 side lobes. 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 suppresses ghost images by numerically optimising the microphone positions to give a high sidelobe attenuation over a wide frequency range.

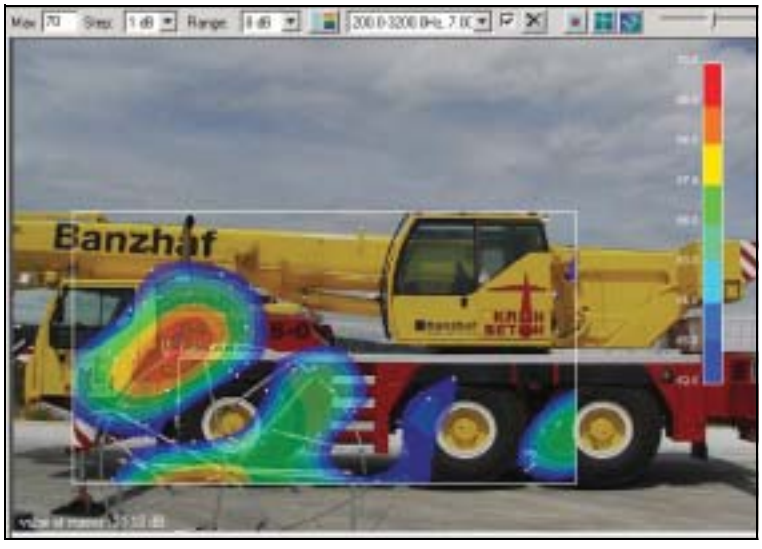
## The Beamforming System

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

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 online determination of channel status. The measured data is stored in the beamforming database from where it can be retrieved for beamforming calculations and display.

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 metadata 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 searching in large databases, measurements can be filtered according to user-defined criteria based on the metadata.

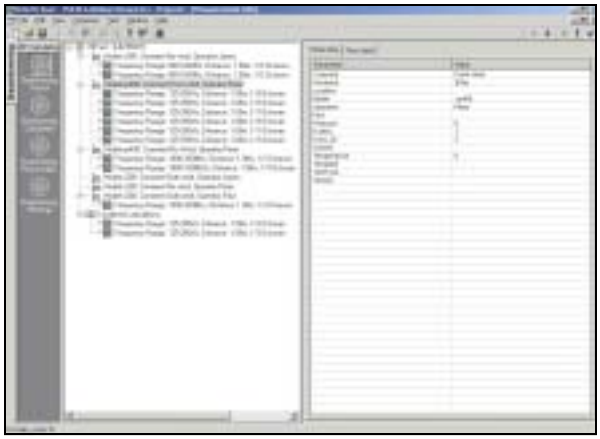
*Fig. 1*

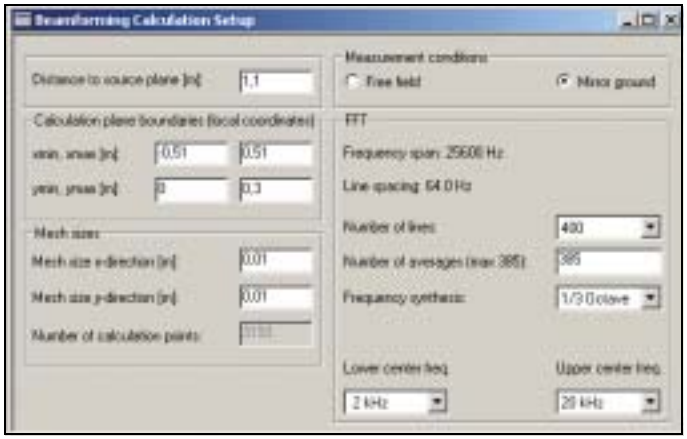



To display the result of a calculation simply drag and drop it into a map window. The map window contains both a map and a spectral view of the result. These views are aligned so the map always maps the selected frequency band just as the spectrum always shows the data of the selected point on the map.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

***Fig. 2*** *Beamforming Data Tree (left) and Calculation Setup window (right)*





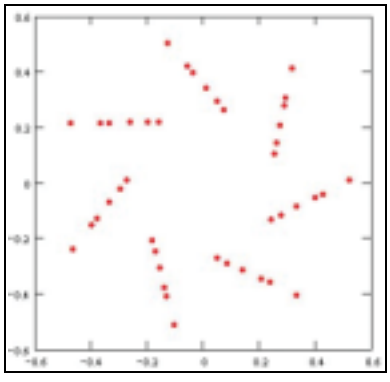

## Beamforming Array Design

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. 3*** *42-channel beamforming wheel array*

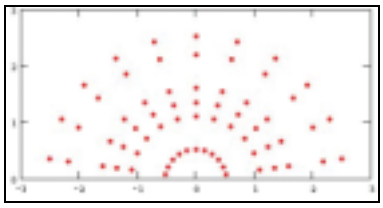


*WA 0890 V 42-channel Beamforming Wheel Array*

- 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

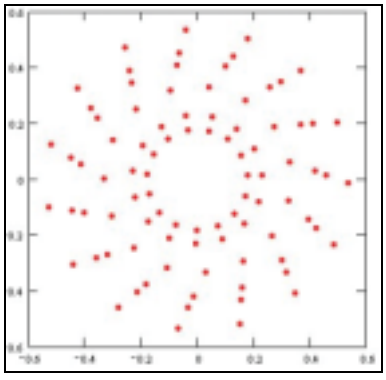
[1] The frequency ranges specified are valid under the assumption that the arrays are focused not more than 30° away from the axis. Disruptive sources outside this cone will be suppressed with the array's sidelobe suppression ratio. If disruptive sources are further assumed to be only inside the same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

***Fig. 4***
*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 5 m: 137 cm at 250 Hz
  68 cm at 500 Hz
  34 cm at 1 kHz

***Fig. 5***
*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

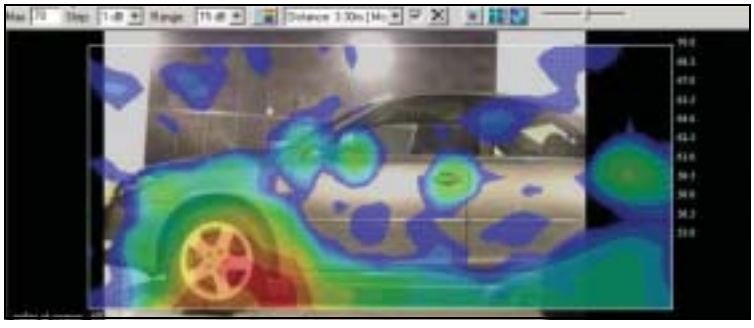
***Fig. 6***
*The Picture Alignment window*

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. 7***
*Map display from a wind-tunnel test*



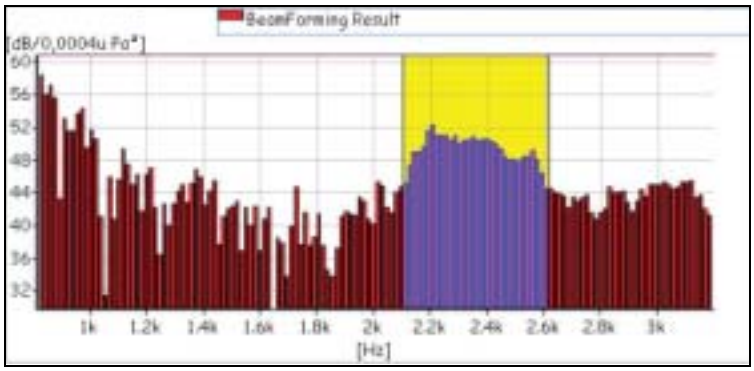



***Fig. 8***
*Spectrum view (from graphics display window) of cursor position over the car-door handle seen in the image displayed in Fig. 7*

## 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.

# Specifications – PULSE Beamforming Type 7768

## Configuration

**OPERATING SYSTEM REQUIREMENTS**
MS® Windows® 2000 or MS® Windows® XP

**OTHER SOFTWARE REQUIREMENTS**
MS® Office 2000 and MS® SQL Server

**PULSE SOFTWARE REQUIREMENTS**
7700 or 7770
7701
7707 (according to number of channels and fmax)
7761
7752

**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, narrowband
- Combined calculations to further reduce ghost images

**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\2 Circle \ 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 E** | | | | | |
| 2826 | Power Supply | 1 | 2 | 6 | 0 |
| 7536 | LAN Interface | 1 | 2 | 6 | 0 |
| KQ 0155 | 10-slot IDA$^{e}$ Frame | 1 | 2 | 3 | 0 |
| UH 1031 | Fan Unit | 1 | 2 | 3 | 0 |
| 3032 B | 6-channel input module | 7 | 11 | 11 | 0 |
| 7770 B | 8-channel FFT analysis | 1 | 0 | 0 | 0 |
| 7770 B – MS1 | Maintenance and Upgrade | 1 | 0 | 0 | 0 |
| 7770 J | 128-channel FFT Analysis | 0 | 1 | 1 | 0 |
| 7770 J – MS1 | Maintenance and Upgrade | 0 | 1 | 1 | 0 |
| 7701 | Data Recorder | 1 | 1 | 1 | 0 |
| 7707 | Analysis Engine | 0 | 1 | 5 | 0 |
| UA 1365 | Blank Module | 1 | 5 | 7 | 0 |
| **Beamforming Application Software** | | | | | |
| 7761 | PULSE Acoustic Test Consultant | 1 | 1 | 1 | 0 |
| 7761 – MS1 | Maintenance | 1 | 1 | 1 | 0 |
| 7752 B | Noise Source Identification | 1 | 1 | 1 | 1 |
| 7752 – MS1 | Maintenance | 1 | 1 | 1 | 1 |
| 7768 | PULSE Beamforming | 1 | 1 | 1 | 1 |
| 7768 – MS1 | Maintenance | 1 | 1 | 1 | 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 |



Brüel & Kjær reserves the right to change specifications and accessories without notice.

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