PRODUCT DATA

PULSE™ In Situ Absorption BZ-5642
PULSE Intensity Component Analysis BZ-5641
PULSE Panel Contribution BZ-5640

PULSE In Situ Absorption BZ-5642, PULSE Intensity Component Analysis BZ-5641 and PULSE Panel Contribution BZ-5640 are patch holography options for PULSE Acoustic Holography Type 8607, part of the Array Acoustics Post-processing Suite.

They are primarily intended for use inside the cabins of cars, trains and aircraft where they are used to measure stationary noise sources by means of a double-layer hand-held array.

The options require the following PULSE Array Acoustics software:
- *Acoustic Holography Type 8607*
- *PULSE Array Acoustics Conformal Calculations BZ-5637*

Uses and Features

Uses
- Mapping of absorption coefficients
- Determination of the basic intensity component quantities:
  – Total Intensity
  – Front Source Intensity
  – Rear Source Intensity
- Determination of the advanced intensity component quantities:
  – Radiated intensity
  – Scattered Intensity (requires absorption measurement as input)
- Pressure contributions from panels to a target position (patented method)
- Acoustical FRFs between panels and target position

Features
- Measurements controlled by PULSE Acoustic Test Consultant Type 7761
- Calculations and results provided by Array Acoustics Post-processing supplied with PULSE Acoustic Holography Type 8607
- 3D Creator positioning system support allows the rapid creation of conformal surface models
- Support of input from CAD and mesh models to simplify creation of a geometry for a complex structure

Brüel & Kjær

Patch Methods

There are basically four patch methods, all of which employ a hand-held array and are used on stationary noise sources. See the overview in Fig. 1.

The **Patch Holography method** uses a single- or double-layer hand-held array. The output of the measurement is a conformal map of pressure, velocity, intensity or sound quality metrics.

PULSE In Situ Absorption BZ-5642 is an advanced patch holography method requiring the use of a double-layer hand-held array. The output is provided as a mapping of the absorption coefficient at particular points, or as a mapping of the absorption coefficient averaged over a specified surface.

PULSE Intensity Component Analysis BZ-5641 is an advanced patch holography method requiring the use of a double-layer hand-held array. Output is provided in two sets:

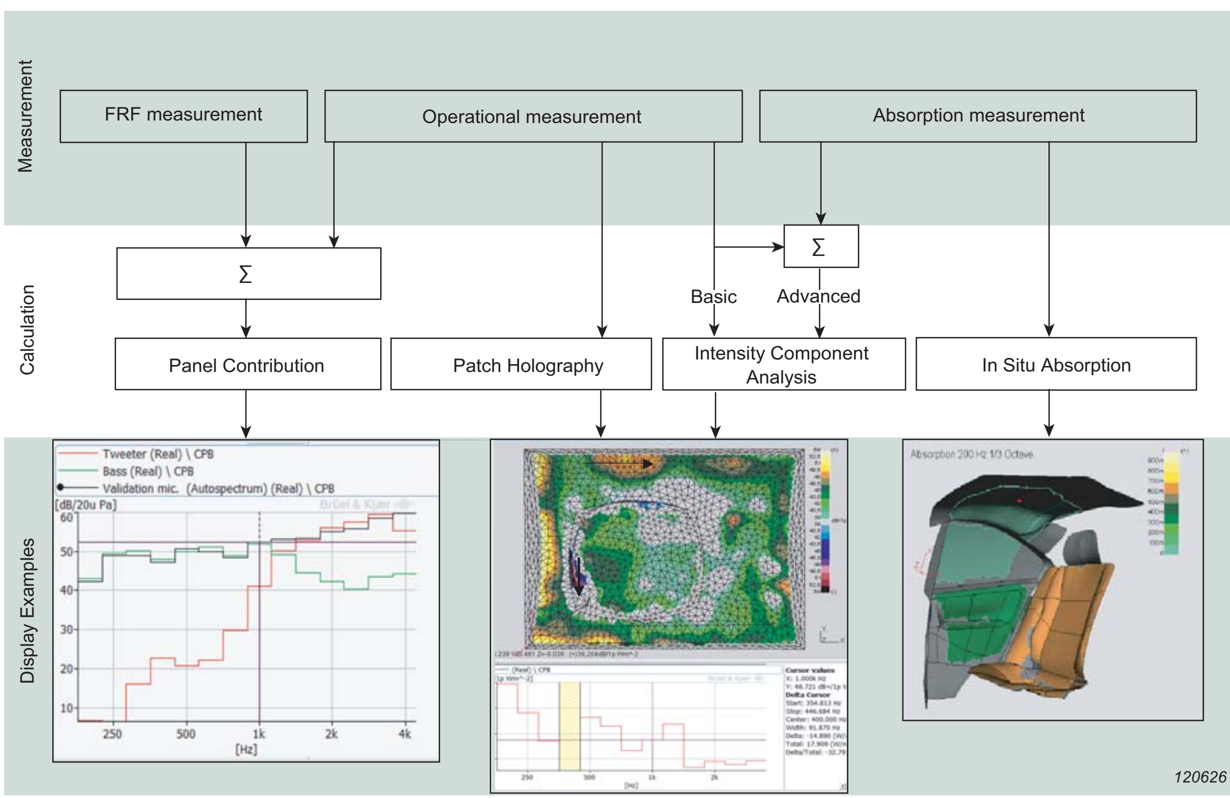
- Three basic intensity quantities: Total Intensity, Front Source Intensity and Rear Source Intensity

or

- Two advanced intensity quantities: Radiated Intensity and Scattered Intensity (these advanced quantities require the measurement of absorption as input)

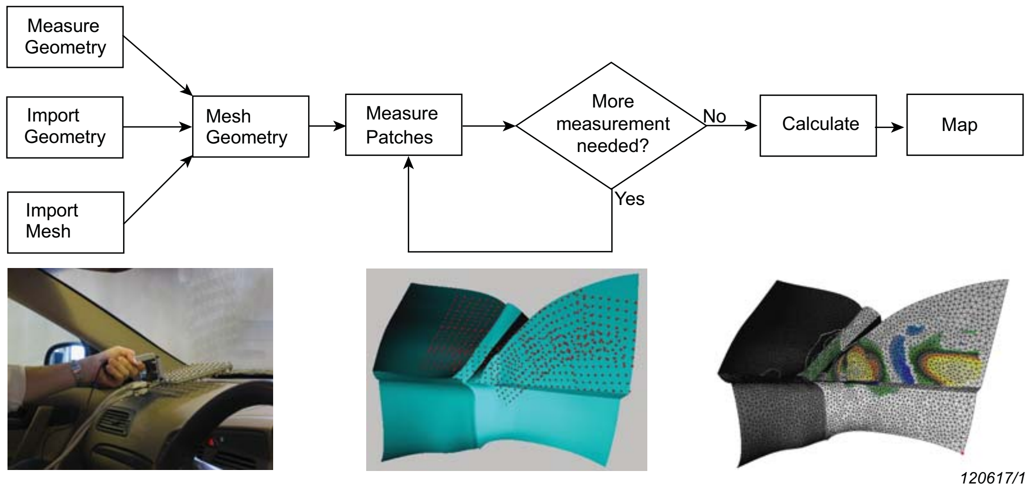
PULSE Panel Contribution BZ-5640 is an advanced patch holography method requiring the use of a double-layer hand-held array. The panel contribution option (patented method) provides, as output, the contributions from the various panels in the cabin under test to the sound pressure level at a defined target position, usually that of the driver's or pilot's ear. The acoustical FRFs between the panels and the target position are also provided. Maps of these quantities indicate how great an influence certain regions have on the sound pressure at the target position.

Fig. 1 *Overview of the various measurement types, the calculation methods and display examples*



Workflow for Patch Methods

Fig. 2
Workflow for patch methods.
Top: *The workflow*
Bottom left: *Making measurements using a double-layer hand-held array consisting of 8×8 microphone pairs;*
Centre: *measured patches;*
Bottom right: *sound intensity map superimposed on a conformal mesh of calculation points*



For all patch holography methods, the workflow is as depicted in Fig. 2. A geometry of the object under test is required; this can either be measured using a positioning system or imported from a CAD program. Based on the geometry, a holographic calculation mesh is defined. This mesh is usually much rougher than the detail supplied by a CAD model. Measurements, with the help of PULSE Acoustic Test Consultant Type 7761, are then made in patches to cover the surfaces of interest. A set of LEDs on the array handle ensures that the exact position of the array is recorded with the measurement. The data are stored in a database, then the calculations and reporting are performed in the Array Acoustics Post-processing environment. The supported format for CAD models is IGES and for mesh models is STL and UFF.

Acquisition System for Patch Holography Measurements

The basic acquisition system is shown in Fig. 3. This instrumentation can be used for measuring the basic intensity components: Total Intensity, Front Source Intensity, Rear Source Intensity. For the advanced intensity components, an absorption measurement is required as input. This means that a sound source has to be used to excite the surface under test. Usually any broadband sound source will do. However, a single sound source would emphasize a particular angle of incidence on the surface (whose absorption is to be determined), so it is common for several sound sources to be employed in an attempt to approximate/simulate the sound field which exists under operational conditions.

Fig. 3
Basic acquisition system: double-layer hand-held array, PULSE LAN-XI front-end, 3D Creator Positioning System

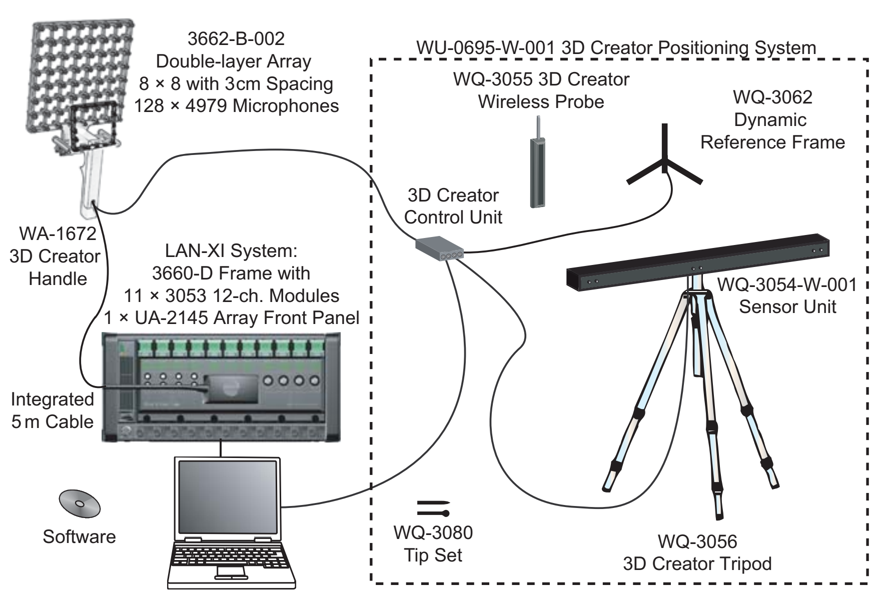
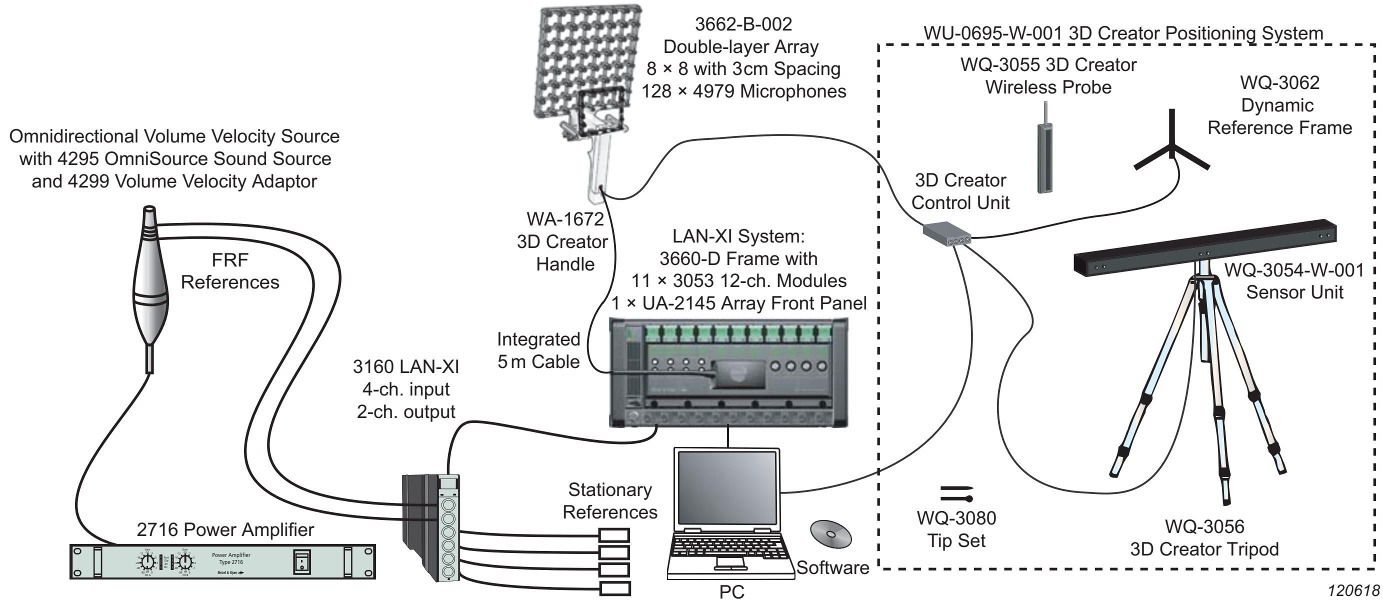


Fig. 4 *Acquisition system for panel contribution: double-layer hand-held array, PULSE LAN-XI front-end, 3D Creator Positioning System, volume velocity source, amplifier, generator and reference microphones*



Panel Contribution: Theory

Contribution from a particular panel within a cabin to the pressure at the driver's or pilot's ear can be determined using a two-step measurement process (patented method). First the FRFs from the panel of interest to the reference point at the driver's/pilot's ear need to be measured (Fig. 5, left). Then an operational measurement needs to be made (Fig. 5, right). In practice, there could be a whole series of FRFs to be measured as you might be interested in the contributions not only to the driver but, also to the passengers. Similarly, if you are interested in more than one operational condition, a series of operational measurements have to be made. During the calculation of the results, the relevant pairs of measurements are then selected. As an example, Fig. 6 shows the results measured on a loudspeaker.

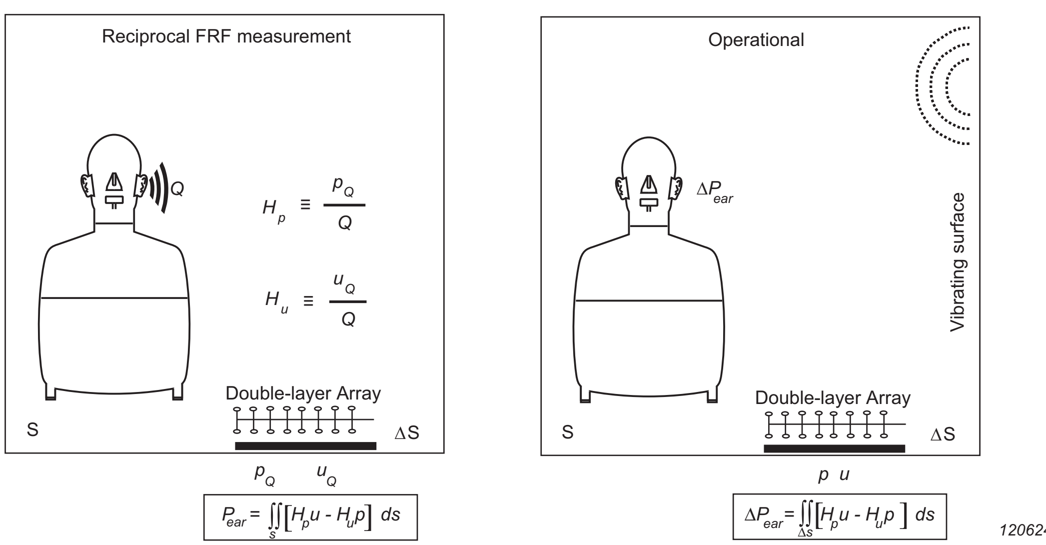
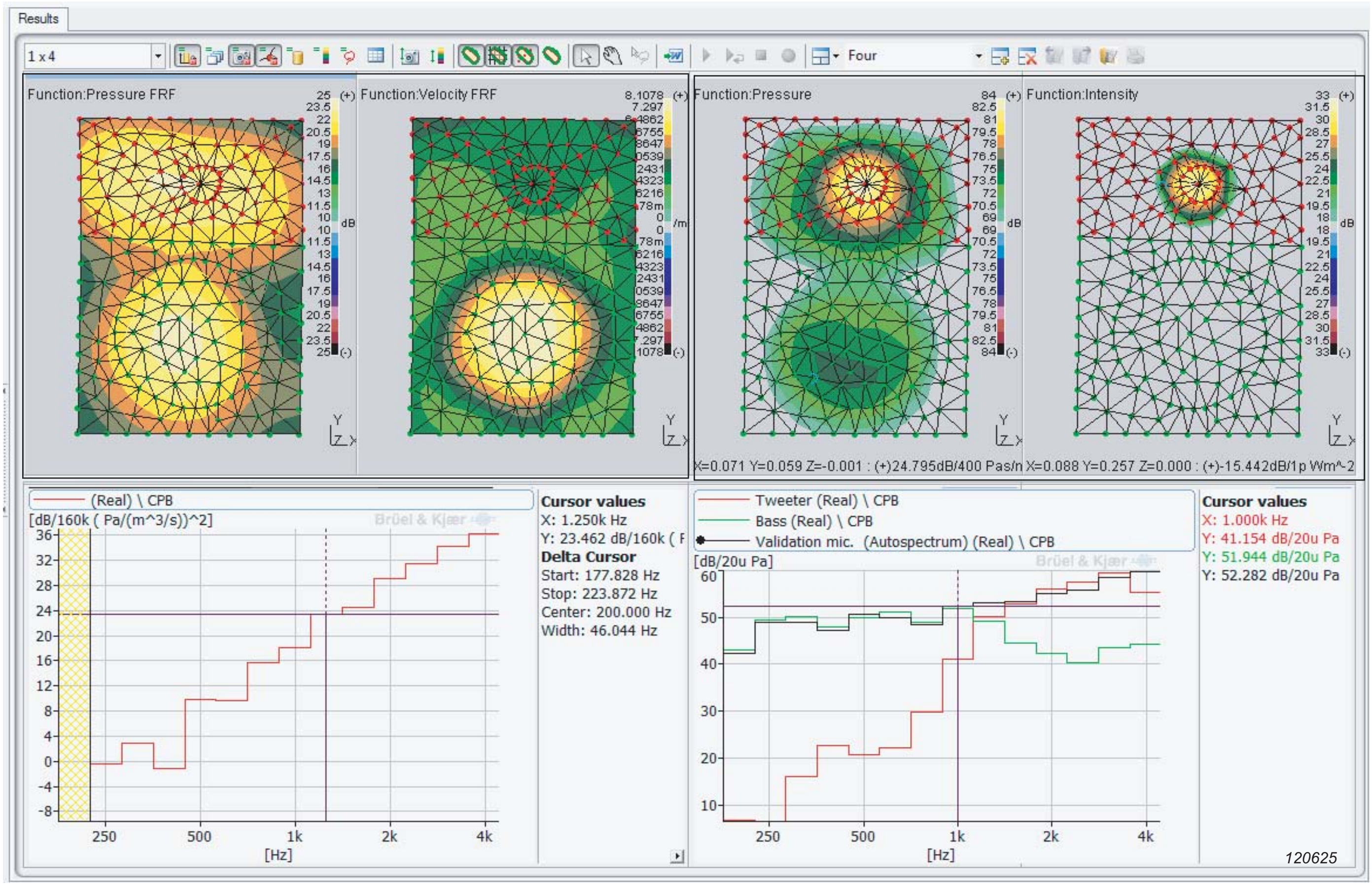


Fig. 5
Measurement of panel contribution is a two-step process:
Left: *Reciprocal FRF measurements.*
Right: *Operational measurements*

Fig. 6 *Results of a panel contribution measurement on a loudspeaker.* ***Upper left****: Pressure FRF and Velocity FRF maps.* ***Upper right****: Pressure Operational and Intensity Operational maps.* ***Lower left****: Pressure FRF.* ***Lower right****: pressure contribution from the tweeter and from the bass unit compared to the directly measured pressure from a validation microphone*



Intensity Component Analysis: Theory

The basic intensity components which can be measured using a double-layer hand-held array close to a vibrating panel in a cabin wall are the Total Intensity (which is the intensity measured with an ordinary intensity probe), the Front Source Intensity and the Rear Source Intensity (Fig. 7). Reflections and sound sources within the cabin can mask the noise coming from the panel of interest. In this situation, Front Source Intensity is useful as it suppresses the background noise. When the cabin is acted upon by external forces, for example turbulence during flight, sound is transmitted through the cabin wall and radiated into the cabin. The sound within the cabin is also scattered by the panel of interest. From knowledge of the absorption, the Scattered Intensity and the Radiated Intensity can be determined (Fig. 8). This means that the determination of advanced intensity components is a two-step process: first the absorption is measured, then the basic intensity components are measured under operating conditions (Fig. 9).

Fig. 7
Basic intensity components that can be measured directly

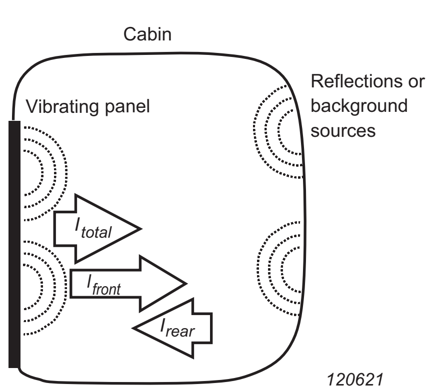


Fig. 8
Advanced intensity components can be calculated provided the absorption coefficient is known

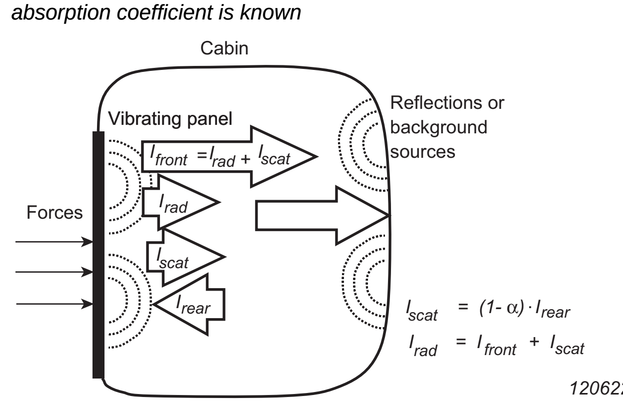
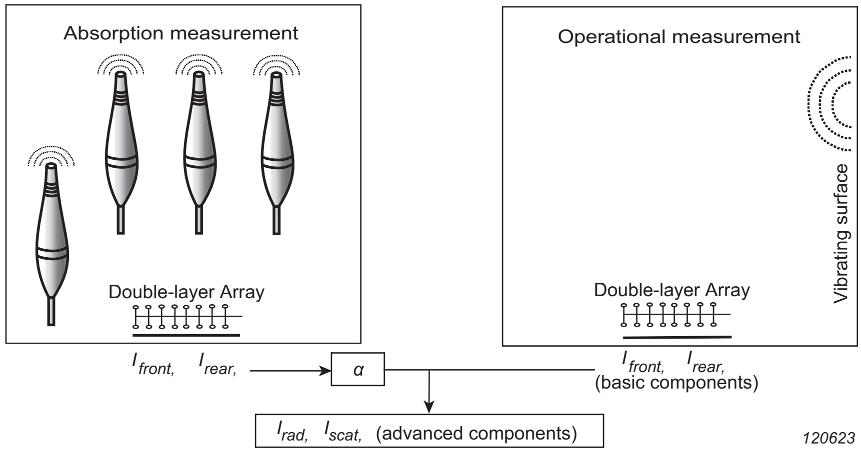


Fig. 9
Measurement of the advanced intensity components is a two-step process requiring first an absorption measurement, then the measurement of the basic intensity components under operational conditions



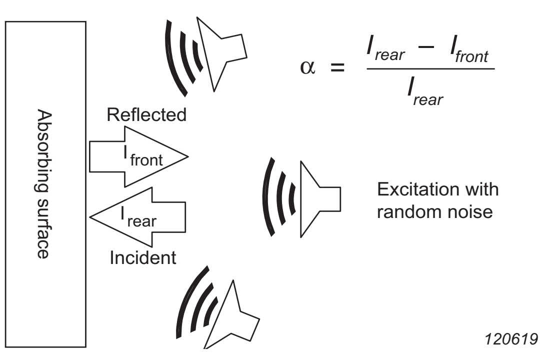
In Situ Absorption: Theory

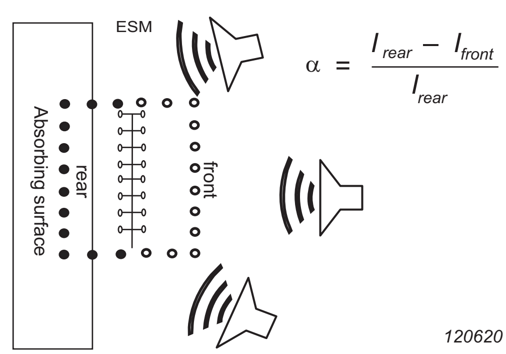
In Situ Absorption is determined from the measurement of the incident and the reflected intensity on the absorbing surface (Fig. 10). The double-layer array is positioned close to the surface under test. Artificial sound sources are switched on behind the array. This option determines the ESM (Equivalent Source Method) source strengths. The surface intensities are then computed for the rear equivalent sources and then for the front equivalent sources. The in situ absorption α is finally determined from the measurement of the incident and the reflected intensity on the absorbing surface using the formula:

$$\alpha = \frac{I_{rear} - I_{front}}{I_{rear}}$$

with or without area averaging to reduce the effects of non-locally reacting surfaces.

***Fig. 10 Left**: Definition of absorption coefficient. **Right**: Measurement of absorption coefficient using a double-layer array. The Equivalent Source Method (ESM) is used to decompose the sound field into I_{rear} and I_{front} from which the absorption coefficient can then be calculated. The rectangular grid with black and white circles represents the position of the equipment sources in the calculations. This can also be done using the SONAH algorithm*





Specifications

PC REQUIREMENTS
See PULSE Software System Data BU 0229

Table 1 *Summary of the outputs from the three in-cabin options, with the extra equipment required, the measurements to be performed and the assumptions for the measurement conditions*

	In Situ Absorption	Intensity Component	Panel Contribution
Output	α, I_{tot}*	Basic: I_{front}, I_{rear}, I_{tot} Advanced: I_{rad}, I_{scat}	Panel contribution spectra, pressure, FRF, Velocity FRF, I, p, v
Extra equipment	Excitation Sources	Excitation Sources (for advanced)	Volume Velocity Source, Fixed references
Measurement type	Absorption†	Operational and absorption† (for advanced only)	FRF and Operational (with fixed references)
Assumptions	Stationary Field	Stationary field Local reaction (for advanced) Front and Rear sources incoherent (for advanced)	Stationary field Panels structurally decoupled

* Also I_{front} and I_{rear} with Intensity component Analysis license
† Excitation with artificial source(s)

Ordering Information

BZ-5640-X*	PULSE Panel Contribution
BZ-5641-X*	PULSE Intensity Component Analysis
BZ-5642-X*	PULSE In Situ Absorption

SOFTWARE PREREQUISITES

One of the following:

Type 7700-Xy*	PULSE FFT & CPB Analysis
Type 7770-Xy*	PULSE FFT Analysis
Type 7771-Xy*	PULSE CPB Analysis

Plus all of the following:

Type 7761-X*	PULSE Acoustic Test Consultant
Type 8608-X*	PULSE Array Acoustics Beamforming
Type 8607-X*	PULSE Array Acoustics Acoustic Holography
BZ-5637	PULSE Array Acoustics Conformal Calculations

Hardware for Absorption and Intensity Component Analysis Measurements

Type 3660-D	LAN-XI 11 module Front-end frame
11 × Type 3053	12-ch. LAN-XI Module
Type 3662-B-002	Double-layer Array†
UA-2145	Array Front Panel for Type 3053
WU-0695-W-001	3D Creator Positioning System

* X = license model either N for node-locked or F for floating
y = optional channel count, from 1 (single) to 7. No number denotes unlimited channels (channel-independent)

† For other double-layer Arrays available see Product Data: BP 2144

Extra Hardware for Panel Contribution Measurements

Type 2716	Power Amplifier
Type 4295	Omnidirectional Volume Velocity Source with OmniSource™ Sound Source
Type 4299	Volume Velocity Adaptor
Type 3160	LAN-XI Generator Input/Output Module, 51.2 kHz
Type 4957	10 kHz Array Microphone 50 Hz – 10 kHz
Type 4958	20 kHz Precision Array Microphone 10 Hz – 20 kHz
Type 4188-A-021	½″ Prepolarized Free-field Microphone and Preamplifier
AO-0587-D-100	Cable, single screen coax., SMB (F) to BNC (M), 10 m (33.3 ft)

Service and Support Products

M1-5640-X*	Software Maintenance and Support Agreement for PULSE Panel Contribution
M1-5641-X*	Software Maintenance and Support Agreement for PULSE Intensity Component Analysis
M1-5642-X*	Software Maintenance and Support Agreement for In Situ Absorption
M1-8607-X*	Software Maintenance and Support Agreement for PULSE Array Acoustics

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