PRODUCT DATA

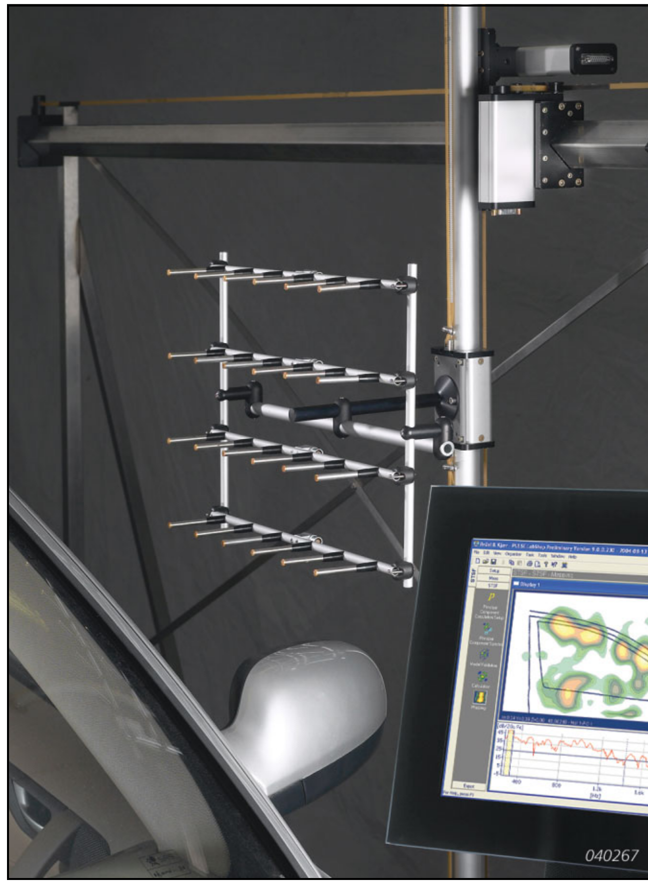
Spatial Transformation of Sound Fields — Type 7780

Spatial Transformation of Sound Fields (STSF) Type 7780 is application software for assessing the sound-field of a test object. The STSF software is designed to run on a PULSE™ System with Acoustic Test Consultant Type 7761.

A set of reference transducers and a scan microphone array system is used to obtain a complete model of the sound field by measuring over a two-dimensional region close to a stationary sound source.

Using this model to back-propagate to a plane close to the surface of the source allows high-resolution source localisation.

The measurement process can be fully automated by adding Robot Option BZ 5370, a traverse system for automatic positioning of the scan array.



USES AND FEATURES

USES

- High-resolution source localisation
- Source contribution analysis
- Tyre/road noise analysis
- Complete vehicle noise analysis
- Wind noise effect on driver
- Leakage detection
- Airborne noise transmission through doors, door seals, etc.

FEATURES

- Inclusion and exclusion of partial fields
- Contour graphics for visualisation of source location
- Complete integrated measurement, data storage and analysis system based on PULSE™
- Validation of measurement data
- Optional microphone scanning robot
- Interpolation of bad measurement points
- Near-field Acoustical Holography with arrays smaller than sound source using SONAH – Statistically Optimal Near-field Acoustical Holography
- Optional use of virtual references

Brüel & Kjær

Introduction

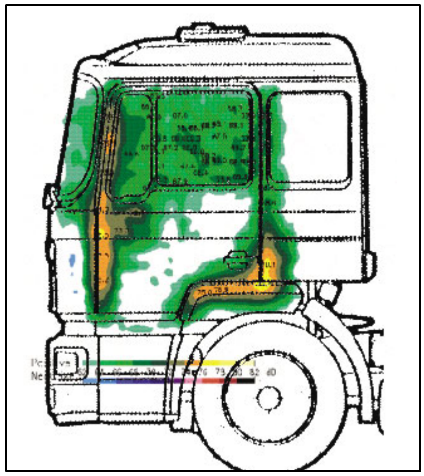


Fig. 1
Sound intensity map used to detect leaks in door seals

The STSF software applies the Near-field Acoustic Holography technique to cross-spectra of the sound pressure over a plane close to the sound source, and calculates a descriptor of the sound field in parallel planes.

Near-field Acoustic Holography calculates the pressure, particle velocity, and active and reactive acoustic intensity in the near-field region.

Sound is recorded using two sets of transducers:
- Scan microphones
- Reference transducers

The reference transducrs must be at fixed locations, while the scan transducers may have to be scanned to cover the required measurement area.

Measurements are made using the PULSE™ multi-analysis system Type 3560 and Acoustic Test Consultant Type 7761. The results are displayed using Noise Source Identification software Type 7752. An optional automatic microphone traversing robot can be applied to the system and controlled via Robot Option BZ 5370.

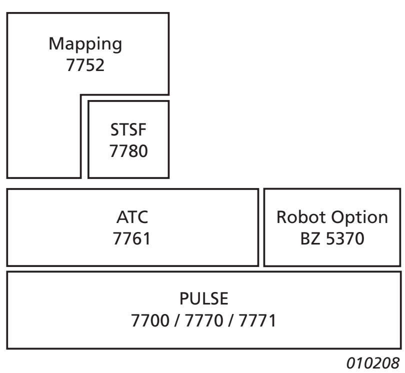


Fig. 2
Spatial Transformation of Sound Fields Type 7780, builds on and expands the possibilities of PULSE™ applications

With Acoustic Test Consultant Type 7761, the STSF software provides an integrated solution for calibration, measurement and processing.

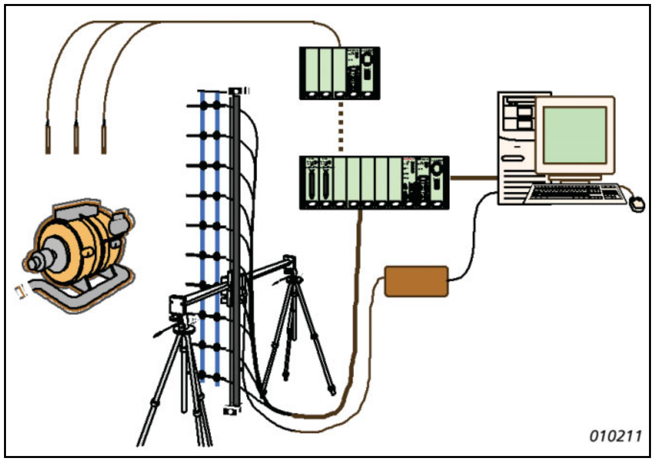
In addition, the STSF software executes a number of functions for inspecting data, including:
- Data validation
- Stationarity analysis
- Coherence and virtual coherence
- Principal component analysis

Measurement Description

A practical STSF measurement is based on a two-dimensional scan over a plane surface close to the test object, during which:
- the cross-spectra are measured from each scan point to each of a set of fixed reference points
- the full cross-spectrum matrix between all pairs of reference points are measured simultaneously
- the autospectra at the reference points are measured
- the sound pressure level *can* be measured at each measurement point in order to validate the data

During the collection of scan spectra, the use of traverse equipment (a robot with controller) for moving the array microphones to various scan locations can reduce the total measurement time significantly. Robot Option BZ 5370, which is available for use with the required Acoustic Test Consultant software, Type 7761, allows you to control a 2-axis microphone positioning system.

Fig. 3
Typical measurement setup. Array Microphones Type 4935 or Type 4951 are recommended for use in a linear or rectangular array



Reference Transducers

The reference signals can be provided by microphones, hydrophones, accelerometers, laser velocity transducers, etc., at fixed positions. They are used both to distinguish between the different, mutually uncorrelated parts of a sound field and to obtain phase information between the scan positions. An STSF measurement provides a complete model of a sound field, if the number of references is at least equal to the number of significant, independent sound sources. In any case, the sound field coherent with the applied references is mapped.

Virtual References

Virtual references provide the possibility of mapping the sound field coherent with a calculated reference signal, that is, a signal which has not been physically measured, but which is chosen and calculated at the time of the data processing. The reference signal can be the calculated pressure or the calculated particle velocity (normal component) at a single position in the source plane. Velocity Virtual Reference or Pressure Virtual Reference based calculations can be chosen.

Scan Transducers

The scan transducers must be free-field or pressure microphones with mutual phase deviations not exceeding ±3° within the frequency range of interest. In addition, their amplitude linearity must be good and they must have a high stability. Array Microphone Type 4935 is recommended as a best-value solution.

Preparing the Noise Source

Before a measurement can begin, the noise source and its surroundings must be checked and, if necessary, modified so that either free-field or mirror-ground conditions exist over the entire measurement region and frequency range of interest. In addition, the noise radiated by the source must be kept stationary throughout the measurement. Imperfect stationarity may lead to both variation in amplitude and shift in spectral components. As a consequence, the narrower the bandwidth used, the steadier the sound source must be.

During a measurement, the software monitors the reference signals for deviations from stationarity of sound source.

Data Post-processing

Type 7780 allows all sound-field descriptors of the radiated sound field, such as active and reactive intensity, particle velocity and sound pressure, to be calculated both in the measurement plane and in all parallel planes closer to, or further away from the source than the measurement plane. An “SPL along a line” calculation allows plots of frequency-weighted SPL along that line or SPL spectra at points on the line to be obtained.

Once a measurement has been completed, the next step is to calculate principal components from the references using principal component decomposition. When this is done, inspection of the principal component spectra allows you to determine whether you have too many reference transducers.

Then calculations can be performed using NAH (Near-field Acoustic Holography) or SONAH (Statistically Optimal Near-field Acoustic Holography)[1]. The calculation extracts a principal-component-based representation of the sound field from the measured cross-spectra. From this sound-field representation, holography can be used to calculate pressure, and the normal component of particle velocity, active and reactive intensity in any plane parallel to the measurement plane. If there are bad measurement points in the data, Type 7780 can interpolate values from adjacent points. The capacity to perform calculations depends on the memory available and on the type of calculations to be made. We therefore recommend that you limit calculations to 4000 measurement points with 4 reference microphones for 400-line FFT spectra (or 8000 points with 2 references, 400 lines, etc.).

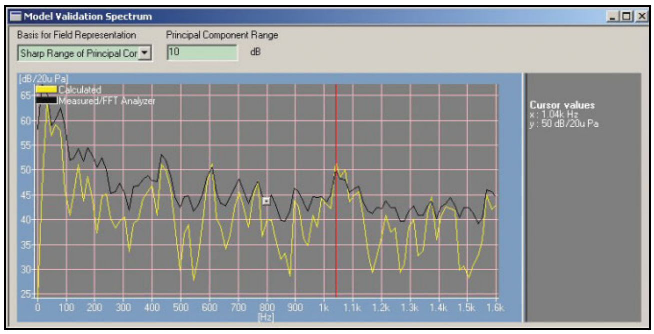


Fig. 4
Comparing spectra for model validation

To determine if the references chosen represent the full sound field, you can then compare the measured autospectra to auto-spectra calculated by STSF at the same (measurement) positions. If the match is poor, more reference transducers may be required or they may need repositioning.

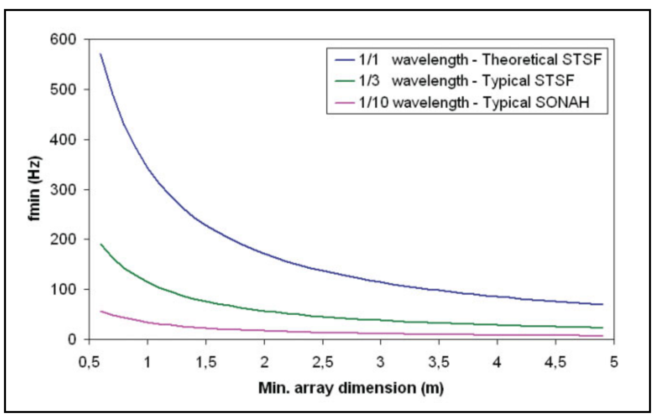


Fig. 5
Minimum analysis frequency as a function of scan area dimension. The minimum analysis frequency is ten times lower when using SONAH instead of NAH

Occasionally, good model validation is not required. Sometimes the references are purposely chosen with the objective of including only part of the sound field measured by the scan transducers in the STSF sound-field model. This will be the case, for example, where the background noise is picked up by scan microphones but not by references.

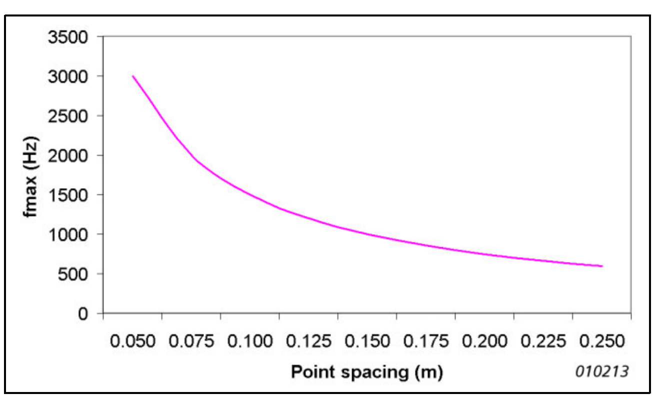


Fig. 6
Maximum analysis frequency as a function of point spacing

The frequency range, resolution and measurement time depend on dimensions of the measurement array, object and surface. Fig. 5 illustrates how the minimum analysis frequency depends on the scan area dimensions when its size is restricted to be at least 1 and 1/3 of the wavelength. NAH conditions typically require at least 1/3 wavelength scan area size, while SONAH works well with only 1/10 wavelength scan area size. Fig. 6 shows how the maximum analysis frequency depends on microphone measuring point spacing. The spacing must be less thanh 1/2 wavelength.

1)The SONAH calculation method avoids the use of spatial FFT processing and therefore avoids the major part of the spatial windowing effects produced by traditional NAH. This allows measurement by an array which does not completely cover the source and which can be significantly smaller than the wavelength. Such conditions would produce serious errors with NAH.

Robot and Microphone-positioning Systems for STSF

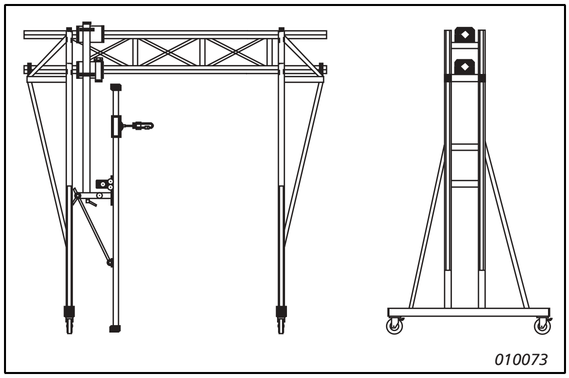
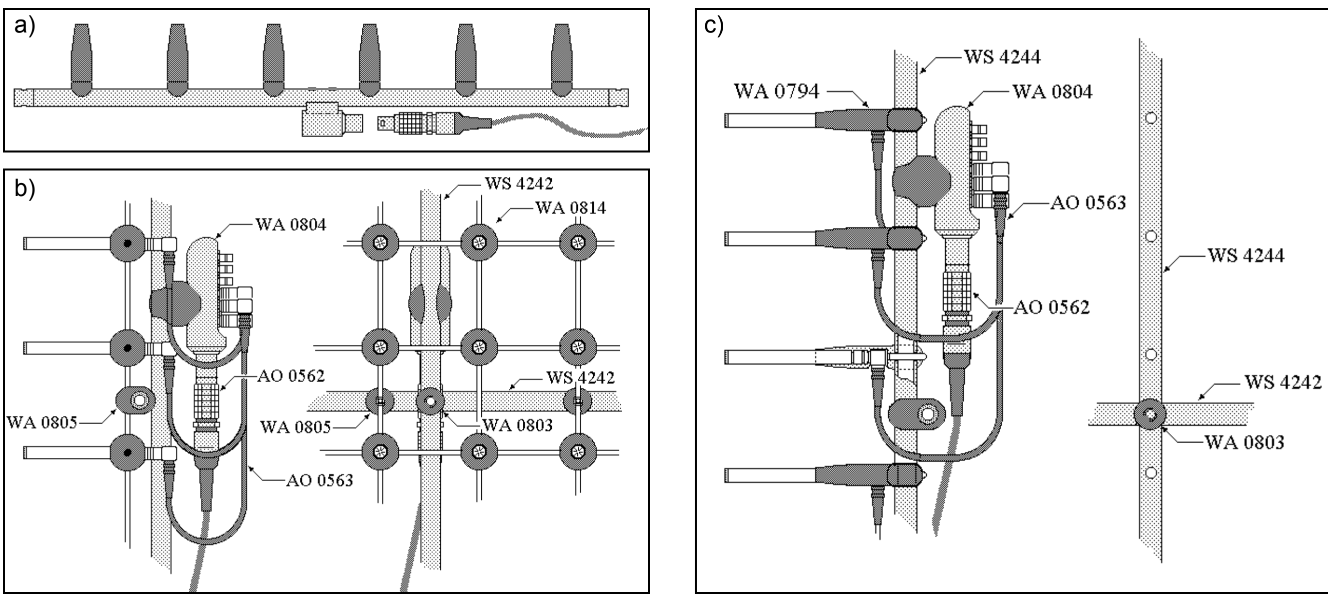


Fig. 7
Biaxial robot microphone-positioning system for intensity measurements

An automated microphone-positioning system is used with Type 7780. Typical microphone system configurations involve a biaxial (X and Y axes) system for measurement on one plane. However, the robot option can control from two to eight motors allowing you to orientate a microphone-positioning system in up to five directions (X, Y, Z, Phi and Theta), thereby making it possible to measure all planar surfaces around an object.

Microphone Arrays

Fig. 8 *a) Integral Connection Array WA 0806, b) Flexible Configuration Array WA 0807, c) Vertical Inline Array WA 0808*



Three types of array can be used for STSF measurements. In Fig. 8a, six microphone holders are permanently mounted on a 10 mm diameter tube with integral wiring and common output connector (LEMO 7-pole). In Fig. 8b, microphones are inserted into the holders, and each group of six microphones is connected to a patch connector using short and flexible SMB cables. Fig. 8c shows the mounting of individual microphone holders on one (or more) vertically mounted tubes, equipped with evenly spaced fixing holes (every 25 mm). Each group of six microphones is connected to a patch connector, using short and flexible SMB cables.

Specifications – STSF Type 7780

Configuration

COMPUTER CONFIGURATION/DATA ACQUISITION FRONT-ENDS
As for PULSE

SOFTWARE
See Ordering Information

SCAN TRANSDUCERS
Microphones or hydrophones (free-field or pressure transducers) with ±3° phase match
Array Microphone Type 4935 or Type 4951 is recommended

REFERENCE TRANSDUCERS
Microphones, hydrophones, accelerometers, laser velocity-transducers, etc.
Optional calculation of virtual references

Features

MEASUREMENT (WITH ACOUSTIC TEST CONSULTANT TYPE 7761)
Linear or rectangular array
Automatic detection of measurement channels
Validation of stationarity of sound source during measurements

CALCULATION/ANALYSIS
Principal component decomposition of references including equalisation of reference signals
Model validation with selectable synthesis bandwidth
Interpolation for bad measurement points
Calculation of Near-field Acoustical Holography (NAH or SONAH) closer to and further away from the measurement plane
- Sound Pressure
- Intensity (Active and Reactive)
- Particle Velocity

Determination of SPL along a line
Selectable inclusion of references
Virtual references

DISPLAYS (USING NOISE SOURCE IDENTIFICATION TYPE 7752)
Display of measured sound pressure levels, calculated sound pressure levels, calculated active and reactive intensity (z-component) and calculated particle velocity (z-component)
- Spectrum
- Colour Contour
- Sound Power using the area cursors

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

RECOMMENDED PULSE CONFIGURATIONS

Type/Part No.	Description	Full Configuration		Software Required For:	
		12-channel Measurement System	30-channel (incl. ref. ch.) Measurement System	Calculation Only System	View Only System
PULSE Analyzer Type 3560 D/3560 E		3560 D-T40[a]	3560 E-T40[a]		
2826	Power Supply	1	1		
7536	LAN Interface	1	1		
3560 D	Portable PULSE Acquisition Front-end	1			
3560 E	PULSE Acquisition Front-end		1		
3038 B	12-channel input module	1	2		
3039	6-channel input module		1		
UA 1365	Blank Module	4	5		
7770-N12	PULSE FFT Analysis, 12-channel license[b]	1			
7770-N16	PULSE FFT Analysis, unlimited channel license[b]		1		
M1-7770-N12	PULSE Annual Software Maintenance and Support Agreement	1			
M1-7770-N16	PULSE Annual Software Maintenance and Support Agreement		1		
STSF Application Software					
7761-N	PULSE Acoustic Test Consultant	1	1		
M1-7761-N	PULSE Annual Software Maintenance and Support Agreement	1	1		
BZ 5370-N	Robot Option	1	1		
M1-BZ 5370-N	PULSE Annual Software Maintenance and Support Agreement				
7780-N	PULSE Spatial Transformation of Sound Fields	1	1	1	
M1-7780-N	PULSE Annual Software Maintenance and Support Agreement	1	1		
7752-N	PULSE Noise Source Identification	1	1	1	1
M1-7752-N	PULSE Annual Software Maintenance and Support Agreement	1	1		
7709-N	PULSE Viewer			1	1
Microphones, Array and Robot					
9665	Positioning system x/y 4 × 2 m[c]	1	1		
	Array & cables	Please contact Brüel & Kjær			
4935	Array Microphones	12	30		

a. System configuration does not include microphones, array or robot
b. For both FFT and 1/nth-octave (CPB) analysis, PULSE FFT & CPB Analysis Type 7700 is available
c. Also available in other sizes – please contact Brüel & Kjær

TRADEMARKS
Windows is a registered trademark of Microsoft Corporation in the United States and/or other countries

HEADQUARTERS: DK-2850 Nærum · Denmark · Telephone: +45 4580 0500 · Fax: +45 4580 1405
www.bksv.com · info@bksv.com

Australia (+61) 2 9889-8888 · Austria (+43) 1 865 74 00 · Brazil (+55) 11 5188-8161 · Canada (+1) 514 695-8225
China (+86) 10 680 29906 · Czech Republic (+420) 2 6702 1100 · Finland (+358) 9-521 300 · France (+33) 1 69 90 71 00
Germany (+49) 421 17 87 0 · Hong Kong (+852) 2548 7486 · Hungary (+36) 1 215 83 05 · Ireland (+353) 1 807 4083
Italy (+39) 0257 68061 · Japan (+81) 3 5715 1612 · Netherlands (+31) 318 55 9290 · Norway (+47) 66 77 11 55
Poland (+48) 22 816 75 56 · Portugal (+351) 21 47 11 4 53 · Republic of Korea (+82) 2 3473 0605
Singapore (+65) 6377 4512 · Slovak Republic (+421) 25 443 0701 · Spain (+34) 91 659 0820 · Sweden (+46) 8 449 8600
Switzerland (+41) 44 880 7035 · Taiwan (+886) 2 2502 7255 · United Kingdom (+44) 14 38 739 000
USA (+1) 800 332 2040

Local representatives and service organisations worldwide

Brüel & Kjær

BP 1939 – 15 05/09 Rosendahls Bogtrykkeri