PRODUCT DATA

Non-stationary STSF Software — Type 7712

Non-stationary STSF Software Type 7712 is a ground-breaking software package for measuring and analysing non-stationary sound fields.

Effective use of non-stationary STSF measurements can help you:

- Comply with noise standards
- Understand the noise radiation mechanism of your product
- Reduce design time by targeting engineering changes
- Save measurement time to free facilities for other purposes
- Optimise sound-related features of your product to an unprecedented degree

Never before has so much information been available from just one simple measurement. You can study any instant or averaged period of a radiated sound field in detail. You can also animate the data to show how the sound field changes over time.

7712

Brüel & Kjær

USES

- ❍ Noise analysis of run-up/coast-down conditions of engines and vehicle components
- ❍ Analysis of sound fields generated by microphenomena such as the effects of individual parts of a tyre tread pattern, the opening and closing of valves and other events during an engine combustion cycle
- ❍ Analysis of transient microphenomena in stationary sources
- ❍ Measurement and analysis of the non-stationary sound fields created by household appliances, photocopiers, printers, air conditioners, etc.
- ❍ High resolution, four dimensional (time and space) source location and determination of non-stationary sound fields
- ❍ Measurement and analysis of the radiated sound field of highly transient noises

FEATURES

- ❍ Integrated measurement, data storage and analysis system
- ❍ One measurement gives a complete four dimensional definition of the radiated sound field using the Time Domain Holography method
- ❍ Calculation of any sound field descriptor (sound power, sound pressure, intensity, particle velocity, displacement) as a function of time and position on any plane parallel to the measurement plane
- ❍ Averaging as a function of time, RPM, shaft angle or engine cycle, or unaveraged
- ❍ Documentation using Microsoft® Office tools or animation (.AVI)
- ❍ Sound source modifications to simulate engineering changes
- ❍ Playback and output for sound evaluation (sound quality)
- ❍ Split or join projects for improved data comparison and management
- ❍ Available for both Windows NT® and HP-UX®

Non-stationary STSF

Applications for non-stationary STSF (Spatial Transformation of Sound Fields) measurements are increasing. From noise-standard compliance to sound quality, governments and consumers are demanding that more and more attention be paid to the sound a product makes. And any time you need to locate and measure the source of a sound problem in a non-stationary sound field, non-stationary STSF could be the solution.

Traditional source location methods typically require stationary conditions for the test, and a time-averaged map of, for example, sound intensity is typically obtained. In many cases, however, this is insufficient for finding the causes of a noise problem. One example is noise problems that only occur, or are much more prevalent, under transient test conditions. For example, an engine may have a noise problem that occurs during fast acceleration, but is nonexistent or far less dominant under stationary operating conditions. Another example is knocking types of engine noise, where it is just as important to localise the knocks in time (engine cycle) as in space. A third example is problems, where the average noise level is acceptable, but the sound is bad. Since non-stationary STSF is a time domain measurement and data-processing tool, it provides basically time domain output data, which can be input to a sound quality evaluation. You can even predict the sound after a simulated modification of the sound source.

Only non-stationary STSF measurements performed in free-field or semi-anechoic conditions can root out the source of the above-mentioned noise problems. They allow you not only to rank the sources, but also to locate the sound generating mechanisms precisely in space and in time. As a result attention can be quickly focused on the real causes of the noise problem, which can save significantly time and development costs.

Applications

The applicability of the Non-stationary STSF is vast, ranging from applications in the automotive industry such as studying transient microphenomena in tyres and valves to measuring of non-stationary sound fields created by households appliances, photocopiers, printers, air conditioners, etc.

The following examples show the applicability of Non-stationary STSF Type 7712 within some automotive applications such as brake squeal testing, engine testing and estimation of surface vibration on tyres.

Brake Squeal

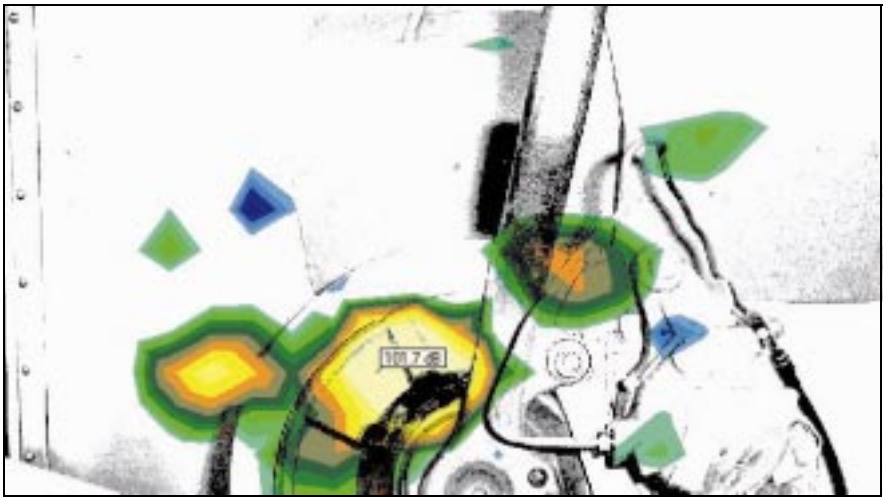


Fig. 1
Inside view of averaged narrow band intensity of a squealing brake. The contour plot is overlaid on a digital photograph of the brake

Brake squeal is often hard to reproduce and maintain for a longer period of time since it depends heavily on operating conditions of the brake such as temperature and force. For this reason analysing squeal sources is difficult.

Localization and quantification of brake squeal
With Type 7712 you only need to capture a fraction of a second of the squeal to be able to accurately locate and quantify the sources.

Tyres

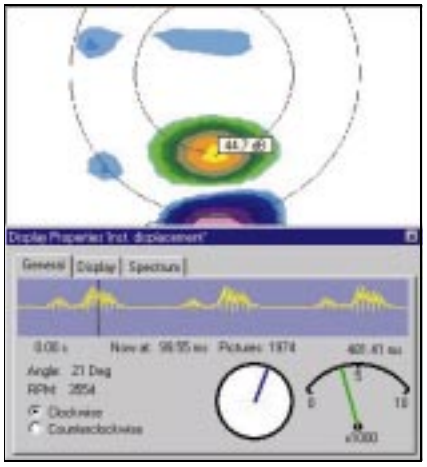


Fig. 2
Animated air particle displacement at the side wall of a tyre running at constant speed. The contour plot is overlaid on a simple drawing made using Microsoft® Paint

Measuring operational surface vibration on a rotating tyre is not possible using traditional techniques. Type 7712 provides a way of deriving this information from a non-contact acoustic measurement.

Estimation of surface vibration
Since the air particles just outside a rigid surface like the side wall of a tyre are bound to follow the movements of the surface itself, air particle velocity may be used to estimate vibrational behaviour of the surface itself. So using the inherent capability of Type 7712 to calculate any sound field property in any plane, the surface may actually be calculated from the same short measurement that may be used to determine the major sound sources of the tyre.

Engine Testing

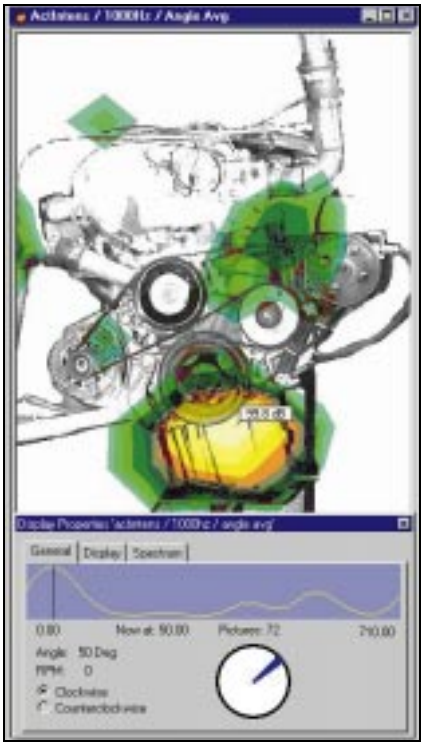


Fig. 3
Contour plot of a radiated sound field during engine run-up. The contour plot is overlaid on a digital photograph of the engine. Note the gauge for crank shaft angle. See also the front cover picture

Engine noise is transient by nature. Most combustion engines are not only subjected to transient operating conditions in terms of rpm, load and other parameters, but are also internally designed with a number of cylinders each passing through a number of distinct stages in their operation (compression, ignition, etc.). As a consequence any stationary approach will give only a limited description of the actual noise levels and source mechanisms involved.

Localization and quantification of noise sources also under transient conditions like fast run-ups
The transient capabilities of Type 7712 may be used to evaluate the noise radiation as a function of engine rpm. Filters may be used to focus the analysis to either specific frequencies or orders.

Evaluation of microphenomena during the engine cycle
Microphenomena may be studied by time domain animation of any sound field descriptor. A new function, Instantaneous Active Intensity, is particularly useful for tracking moving or time varying sources. Engine cycle averaging makes it possible to relate the observed sound sources to specific events during the engine cycle such as the firing of individual cylinders. Engine cycle averaging intervals can be expressed in either 360° or 720° of crankshaft angle depending on engine type.

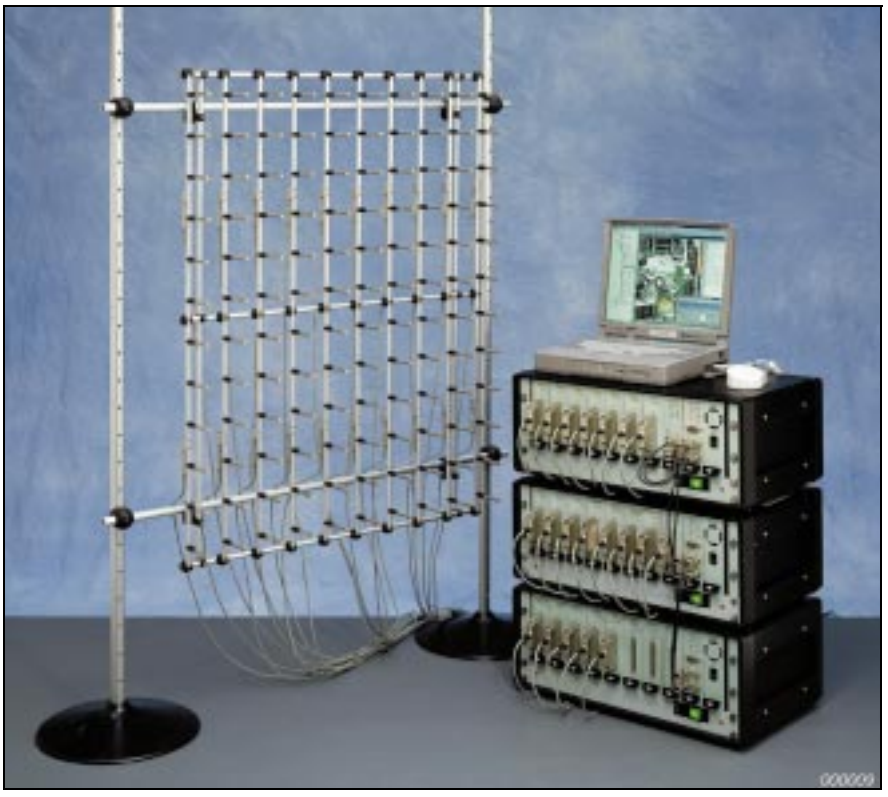
Measurement Made Easy

Non-stationary STSF measurements are made with a fixed microphone array covering the entire sound source. Since you only need to acquire time data corresponding to one transient or a few seconds of a stationary signal, measurement is very fast. In addition to the microphone array, you can configure a number of additional channels to perform simultaneous measurements of auxiliary signals, e.g., RPM tachometers or vibration signals from accelerometers.

System Configuration
Keeping track of the cables involved in a multichannel measurement can be a nightmare. To minimise the potential for cabling problems and save setup time, the software includes a **Detect** function. All you need to do is apply a calibrator signal to each channel. The system then automatically assigns the physical address of the microphone on the array to the detected channel location on the front-end so you don't have to worry about where each microphone is physically plugged into the front-end. The microphone array is easy to set up as the microphones snap easily into and out of place on the scalable microphone grid. And the six-to-one Microphone Cable AO 0432 minimises the number of cables.

Calibration
Calibration is easy, too. Brüel & Kjær has designed an adaptor (WA 0728) for Pistonphone Type 4228 that allows you to calibrate six microphones simultaneously. The software automatically senses which channels you are calibrating.

Fig. 4
Integrated 120-channel non-stationary STSF system including:
– Microphone with integrated cabling
– Multichannel data acquisition system
– PC for control of data acquisition and analysis



On-line Channel Monitoring
To ensure the integrity of the measurement chain and save time, on-line monitoring detects such problems as cable breaks, overloads and CCLD faults even during measurement.

How It Works

Calculation
The basic calculation method used by Type 7712 is Time Domain Holography (TDH). From the measured pressure time signals, TDH calculates the pressure and the particle velocity time signals in any plane parallel to the measurement plane but not touching the measurement object. The main parameter sets defining this holography calculation are:

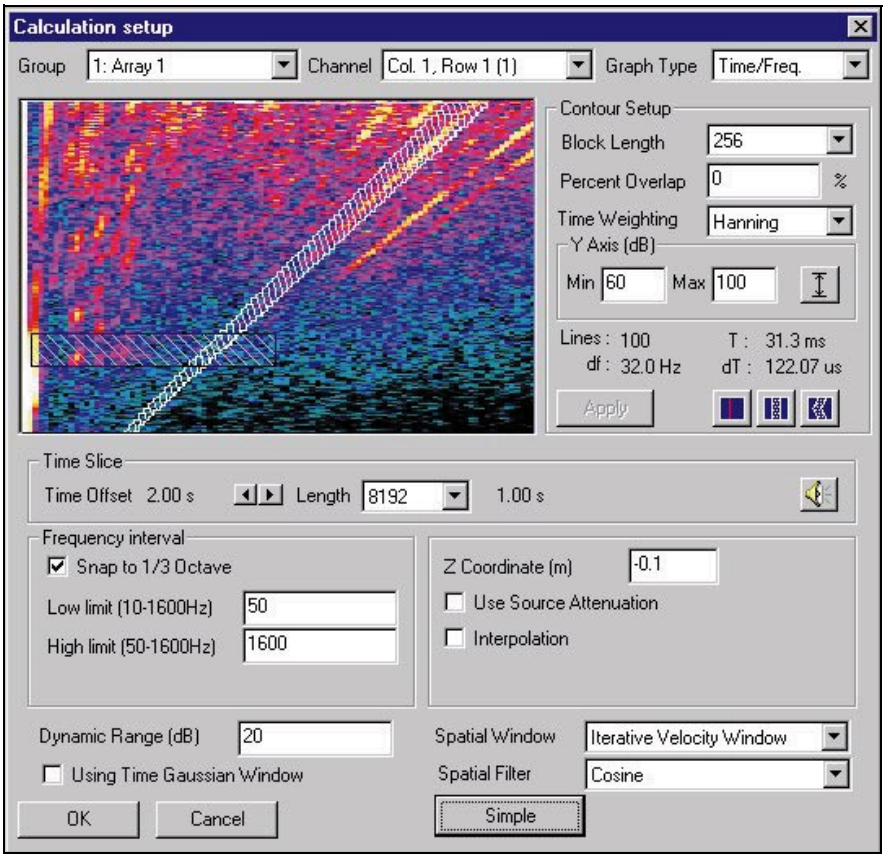
- The position of the calculation plane
- The time and frequency interval to be processed

Display
Various displays can then be defined to view the calculated time data. For each display, you typically have to input the following parameter sets:

- The frequency filters – 1/3-, 1/12-octave, Constant bandwidth, Order band
- The display function – Pressure, Particle Velocity, Intensity, etc.
- The averaging – None, Time, RPM, Engine Cycle Interval, Shaft Angle

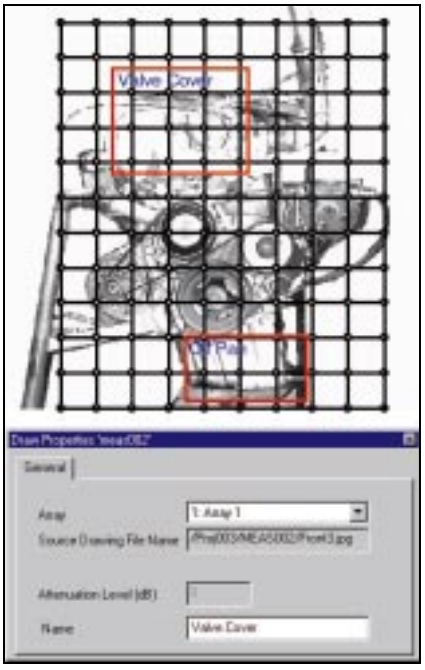
Contour plots of any quantity can be easily aligned and superimposed on a digital photograph of the test object.

Fig. 5
Type 7712's calculation setup showing orders in a time/frequency contour plot



Background Processing
Since the holography calculations and some of the post-processing types needed for the displays are rather time consuming, these calculation jobs are performed as background processes. This allows you to continue working as the calculations are being made.

Fig. 6
Determining the sound power of user-defined sub-areas



Export of data
All time and averaged data, measured and calculated, can be exported in UFF and BUFF format, and pressure time data in WAV format. This allows the system to be used also for general purpose data acquisition. Using Type 7712 in conjunction with sound quality allows subjective studies to be based on 7712 results. If simulation of source modification is used, you can, in effect, listen to the result of a proposed design change.

Sound Power Calculation
Sub-areas for sound power calculation (see Fig. 6) can be freely positioned over the measurement grid. Each sound power area can be named and the overall spectrum or the spectrum for each area viewed. This lets you see which areas contribute most to the total sound power and where it may be most beneficial to make modifications.

Source Modification Simulation
To simulate the result of design changes, you can define a number of sub-areas on the measurement grid and apply an attenuation to each. The attenuation simulation is performed on the particle velocity in the source

plane. Exporting the display data in WAV format, with and without attenuation, will then allow, for example, subjective studies using sound quality.

Viewing and Documenting Your Results

Once Type 7712 has calculated the results, a number of options are available for displaying them. All graphs in the software have a cursor function.

Animated Contour Plots
Any sound field descriptor you wish to investigate can be displayed in a contour plot both for any instant in the time domain or any averaged (time) interval. These plots can be shown as a sequence creating, in effect, an animation of the sound field parameter. Several plot animations can also be displayed in parallel.

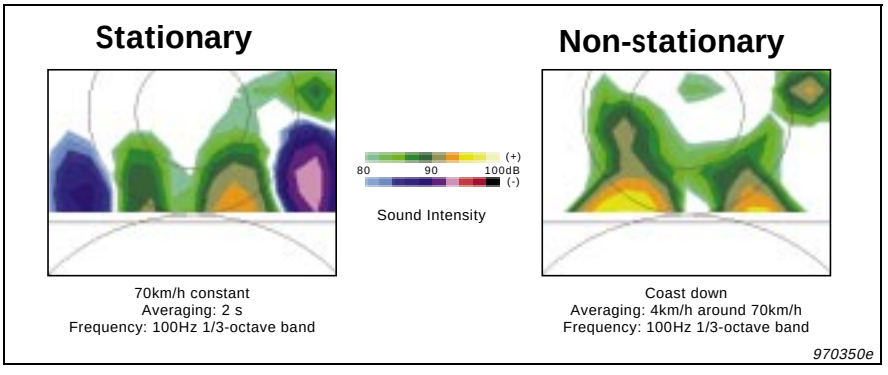
Spectra
The software can display a spectrum plot for any position in a contour plot. If sound power areas are defined, you can also display the sound power spectra.

Source Drawings
To further aid visual interpretation of the event you have measured, you can import source drawings or digital photographs (bitmap or jpeg). These pictures can be scaled and aligned to fit the measurement grid as an overlay.

Documentation
For documentation of your results, you can copy the graphical content of the currently active window to, for example, a Word document, or you can print from the software or save an animation in AVI format.

STSF and Non-stationary STSF

Fig. 7
Identical instantaneous conditions can show very different results when comparing stationary sound fields (a tyre at constant speed) with non-stationary sound fields (a tyre during coast-down). Note the difference in the radiated sound intensity pattern



Over the past decade, Brüel & Kjær's STSF Software using the principles of Near-field Acoustical Holography and the Helmholtz Integral Equation has been used as an efficient tool for the detailed investigation of acoustic radiation phenomena. The limitation of this method is that it requires a sound source that is stationary in time. Now, Brüel & Kjær offers Non-stationary STSF Software, the first commercially available system that uses a recently developed technique known as Time Domain Holography to measure and analyse non-stationary acoustic radiation phenomena.

Both STSF and Non-stationary STSF techniques use acoustical holography calculations, but the measurement method and the types of data being processed are very different.

STSF measures only *coherent* sound field descriptors of a stationary stochastic sound field, that is to say, the part of a sound field coherent with a selected set of reference signals. Data reduction occurs during acquisition because autospectra and cross-spectra are averaged. Scanning is possible because the sound field is stationary. This method has advantages and disadvantages. On the one hand, it excludes incoherent sound field components (uncorrelated background noise, for example) and allows a principal component representation of the sound field. On the other hand, it can be a problem when dealing with a sound field with many independent partial sources, to provide a proper set of reference signals. The use of an incomplete set of references means that any sound field components that are not coherent with any one of the references will not be included.

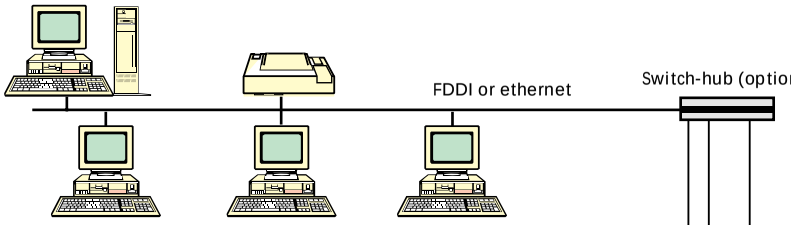
Table1
The differences between the two techniques. Stationary and non-stationary STSF complement each other very well because they use the same or similar equipment to accomplish different tasks

	STSF	Non-stationary STSF
Scanning (large area and high frequency)	✔	
Background noise suppression before holography calculations	✔	
Data reduction before holography	✔	
Non-stationary (transient) sources		✔
Wave animation		✔
Gated averaging at various intervals		✔
Order filtering		✔
Output to sound evaluation (sound quality)		✔
Mapping over 3D region	✔	✔
Correlation with references	✔	

A non-stationary STSF measurement, by its very nature, makes scanning impossible, so the microphone array must cover the entire measurement plane. The measurement gathers time history data and performs no data reduction before holography calculations are made. This means that non-stationary measurements don't lose detailed time information by averaging during measurement, though you can average as a post-processing function. Maintaining full sampling rate time resolution allows you to find the precise moment and location of sound generating mechanisms.

One/System

System Setup

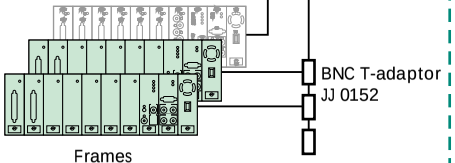


Application Software

Non-stationary STSF 7712

I-DEAS Vendor Library BZ 5231

STSF 7688



Frames

Terminator JJ 0069

System Documentation 3561

One/Frame

Rack Enclosure KQ 0155

Frame

Fan Unit UH 1031: Main cable between fan unit and power supply 2823 included

Assembly Test UA 1366

Assembly Kit UA 1363 Rack Mounting Kit included

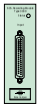
SCSI disk in Cabinet 96–276 V 50/60 Hz UL 0118 (optional)

4 Mbyte Memory option WH 3090 available

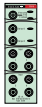
Modules

(max. 10/frame)

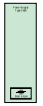
Synchronization Module 7530 (One/system required)



25.6 kHz 6-channel A & V Recording Module with D-sub connector 3030



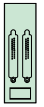
Generator 4/2-ch. Input/Output Module 3109



Blank Module UA 1365

LAN Interface Module 7532 (required)

Power Supply 2823 (required)

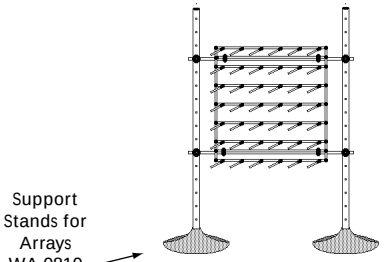


SCSI Module UA 1342 (optional; for use with 7532)

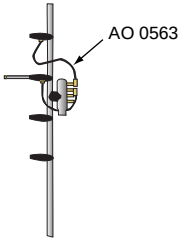
9804571

Array Configurations

WA 0807



WA 0806



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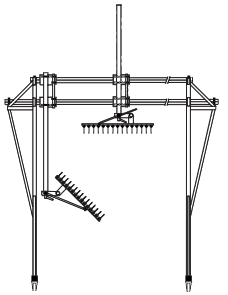
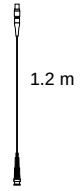
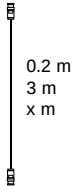


Manual Positioning
System for
Non-stationary STSF
WA 0840

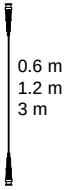
Cables and Accessories



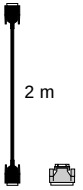
7-pole LEMO
to BNC
1.2 m: AO 0479



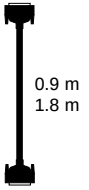
Triaxial to triaxial
0.2 m: AO 0451
3 m: AO 0158
x m: WL 0235



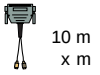
BNC to BNC
1.2 m: AO 0087
3 m: AO 0142



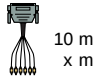
9-pole to 9-pole
D-sub null modem
cable with 9-pole
to 25-pole adaptor
AO 1386



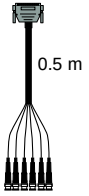
SCSI wide
D-sub 68-pole
connection cable
0.9 m: AO 0516
1.8 m: AO 0517



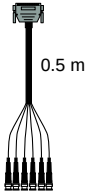
2 channel
triax cable
10 m / x m:
AO 0536



6 channel
microdot cable
10 m / x m:
AO 0535



37-pole male
D-sub to
6 × BNC jack
0.5 m: WL 1271



37-pole female
D-sub to
6 × BNC plug
0.5 m: WL 1291

LEMO to
37-pole D-sub
(Array to IDA
connection)
10m: AO 0562

Triax. Splitter
WB 1001

Array Microphone
4935
with ID

Pistonphone Adaptor
WA 0728
for Calibration
of 6 x 4935

Pistonphone
4228

37-pole D-sub to
37-pole D-sub with
6 sockets WB 1461
Break-out for
Trigger Signals

Microdot
to
BNC adaptor
JP 0145

Photoelectric
Tachometer
Probe MM 0024

Specifications — Non-stationary STSF Software Type 7712

Non-stationary STSF Software Type 7712 is application software for use with Intelligent Data Acquisition System Type 3561

Accessories Required

UNIX Workstation or PC configured as follows:

UNIX WORKSTATION
HP C-Class Workstation with the following configuration:
- HP-UX (version 10.20)
- Minimum 64 MB RAM (128 MB recommended)
- Minimum 2 GB hard disk (6 GB recommended)
- 20″ colour monitor. Minimum resolution: 1024 × 768
- CD ROM drive for installation of software
- DAT recorder optional for backup of measurements
- Ethernet adaptor with coax. (for TCP/IP support)
- Colour printer

PC
- 500 MHz PIII or better recommended
- Windows NT® 4.0, service pack 6
- Minimum 128 MB recommended
- Minimum 10 GB hard disk
- 20″ colour monitor. Minimum resolution: 1024 × 768
- CD ROM drive for installation of software
- Ethernet adaptor with coax. (for TCP/IP support)
- Colour printer

DATA ACQUISITION FRONT-END
Refer to the system diagrams for possible configurations of Intelligent Data Acquisition System Type 3561
For compatibility with existing systems, 6-channel Recording Modules Types 3025 and 3026 and LAN Interface Module Type 7529 can be used in the acquisition front-end along with Microphones Type 4196
Note: Input Module Type 3030 is not phase-matched with Input Modules Types 3025 and 3026, so do not mix input module types for the channels dedicated to the array

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

AUXILIARY TRANSDUCERS
Microphones, hydrophones, accelerometers, laser velocity transducers, tacho-probes, etc.

Features

LICENSE	Measurement	Analysis	Viewer	Full
Measurement				
Up to 3000 channels and 64 IDA frames	✔			✔
Data acquisition: up to 25.6 kHz per channel using Type 3030 6-channel A&V recording module up to 12.8 kHz per channel using type 3025/3026 recording modules	✔			✔
Automatic detection of measurement channels	✔			✔
Automatic calibration of up to 6 channels at a time using WA 0728 and Type 4228 Pistonphone	✔			✔
Throughput-to-disk up to 12.8 kHz per channel	✔			✔
Calculations/Analysis				
Time domain holography		✔		✔
Sound pressure, intensity, active intensity, reactive intensity, velocity, displacement		✔		✔
Spectra in any user-defined position		✔		✔
Averaging in time, RPM, shaft angle or engine cycle intervals		✔		✔
Filtering in 1/3-, 1/12-octave bands, order bands or constant bandwidth frequency bands		✔		✔
Sound power in user-defined areas		✔		✔
Source attenuation simulation		✔		✔
Display				
Time signals	Raw data	✔	✔*	✔
Spectra	Raw data	✔	✔*	✔
Time frequency contour plot	Raw data**	✔**	✔*	✔
Mapping contour plot		✔	✔*	✔
RPM graph		✔	✔*	✔
Shaft angle graph		✔	✔*	✔
Animation				
Mapping contour plots			✔*	✔

* Only for inspection of existing displays ** Not on HP-UX

LICENSE	Measurement	Analysis	Viewer	Full
Documentation				
Copy/Paste	✔	✔	✔	✔
Print	✔	✔	✔	✔
AVI animation		✔	✔	✔
Data storage				
Split and join projects using export and import of projects and measurements	✔	✔	✔	✔
Compare with other results: multiple projects and measurements for comparison between results		✔	✔	✔
Other features				
Access to transducer database	✔			✔
On-line context sensitive help	✔	✔	✔	✔
Exports data in UFF (Universal File Format), BUFF (Binary Universal File Format) and WAV	✔	✔	✔	✔
Imports drawings/photographs in BMP and JPEG formats	✔	✔		✔

Ordering Information

Type 7712 Non-stationary STSF Software
is available with different licenses. Please order Type 7712 x (x = A, B, C, D, E, F, G, H). See "Features" above for details

	Measurement License	Analysis License	Viewer License	Full
NT	C	D	E	A
UNIX	F	G	H	B

Note: Measurement and Analysis licenses each include the Viewer

Training

A training course is recommended in connection with the installation of this system. Order:
WW 5750: Installation and training on site

Software Maintenance and Support

Type 7712 x-MS1: Non-stationary STSF Software Maintenance and Upgrade (x = A, B, C, D, E, F, G, H)

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