Automotive Sound Quality Bundle BZ-6047

Sound plays a major role in consumers' perception of a product's quality. Sound quality has been important to the automotive industry for decades and now is also a primary concern for manufacturers of consumer appliances, office equipment, power tools, marine equipment, off-highway construction vehicles, farm equipment and other products.

Achieving desirable sound quality is a much more sophisticated process than simply determining that a measured sound is 'too loud'. It requires tools that can identify key characteristics of the sound that correlate to consumer perceptions of quality. These tools must be able to identify aspects of the design that can be modified to eliminate specific, objectionable sounds and yet retain appropriate, desirable sounds.

Those tools are part of Brüel & Kjær's Automotive Sound Quality software product range.

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The Software Suite – Five Modules

Brüel & Kjær's Automotive Sound Quality (SQ) software gives you tools for recording, analysing, auditioning, dissecting, and synthesising sounds. It enables you to set objective and achievable quality targets for your products, specified in engineering terms.

The Automotive Sound Quality software products complement each other. Simulation models and test data enable you to improve the overall sound quality and design the desired sound characteristics into the product.

Automotive Sound Quality is installed on a Microsoft® Windows®-based laptop. This enables in-vehicle binaural measurement and immediate playback and analysis of recordings, ensuring quality measurements every time.

Automotive Sound Quality Bundle BZ-6047 is for diagnosing sound problems and producing desirable design targets. The bundle comprises four sound quality modules:
• Automotive SQ Core BZ-6048
• Automotive SQ Real-time Filtering BZ-6049
• Automotive SQ Metrics BZ-6050
• Automotive SQ Designer BZ-6051

The fifth module, Automotive SQ Vold-Kalman Filtering BZ-6052, is for high performance tracking of harmonic responses, or orders.

Automotive Sound Quality software enables you to measure and thoroughly analyse the audio 'signatures' of your products.

Brüel & Kjær

Automotive SQ Core BZ-6048

The Automotive SQ Core module provides the basic user interface for recording, playback, display, editing, math operations, and more. Produce CD-quality digital recordings of sound data from analogue inputs, built-in or on a sound card, and digital inputs on supported sound cards. BZ-6048 comprises two components: Performer and Recorder/Editor.

Performer

Performer provides sophisticated capabilities for the rapid comparison of individual or combinations of sounds.

Applications:
- Recombination and synthesis of a total vehicle sound from individual components
- Competitor comparison of sounds under transient conditions
- 'What-if' studies on modified sound components
- Playback of individual contributions from noise path analysis

Features:
- Synchronise sound files by time or rpm
- Group up to 12 sounds into a single preset file
- Play grouped sounds individually or simultaneously, using keyboard function keys F1 – F12
- Synchronise sounds to retain relative phasing
- Play even the shortest sounds glitch-free, with the Performer's advanced looping capabilities

Recorder/Editor

Features:
- Efficient processing, up to 2 GB of multiple sounds
- Record/transfer sound data using analogue, digital, or multichannel acquisition inputs
- Calibrated input and output signals so sounds are replayed at their recorded levels
- Internal digital equalisation of output signals for true reproduction of binaurally recorded signals
- Cut, copy, and paste between multiple open files
- Comprehensive graphical editing, math, and synthesis functions including mix, fade, envelope, create, and draw
- 2D real-time display
- Spectral processing synchronised with audio playback
- 3D waterfall display
- Spectrograms, also known as colour sonograms, for a wealth of information in a single display
- Contour plots: amplitude is presented as colour, with the Y-axis as frequency and the X-axis as rpm or time
- Flexible and comprehensive cursor functions for simultaneous display of amplitude, frequency, order, rpm and time information
- Real-time cursor order and frequency slicing
- Compare two sounds, display types of average spectrum and band, total, multiple orders or metrics
- Create a playlist, sequence a number of files and silences into an audio presentation with correct relative calibration

Automotive SQ Real-time Filtering BZ-6049

The Automotive SQ Real-time Filtering module allows you to apply up to 128 stereo digital filters per sound and to modify the filter parameters while the sound is playing, all in real-time, interactively, using mouse control.

Features:
- Place low, high, and band cut/boost filters in infinite impulse response (IIR) format at any frequency by dragging the appropriate icon onto the display panel
- Define finite impulse response (FIR) filters of arbitrary shape and phase and up to 32,768 taps by using the software's graphical user interface (GUI) or by importing from Test for I-deas ADF, universal, or spreadsheet text files
- Filters can be nominally fixed frequency or locked to a rotational order. The gain of the order-tracked filters can be constant or profiled to simulate the removal of a resonance

Additional features for fixed-frequency applications:
- High-order filters, critical band wide filters, band-pass filters, and off-line filtering for more complex filter shapes
- Use tracked and fixed filters simultaneously
- Profile IIR filters for amplitude control vs rpm or time either by drawing or tabular entry

Automotive SQ Metrics BZ-6050

The Automotive SQ Metrics module contains tools for extracting the numeric characteristics used for ranking sounds in engineering terms according to perception-based criteria.

Features:
- Includes most commonly used metrics
- Open architecture features allow users to develop and include their own metric algorithms in Visual C++
- Display results as 2D graphics
- Write results to both ASCII and Test for I-deas ADF text files

Automotive SQ Designer BZ-6051

The Automotive SQ Designer module has a sophisticated, yet intuitive, sound modification and synthesis capability consisting of many tools used to understand and modify the complex structures in recorded sound.

Features:
- Time domain averaging tools for extracting harmonic components from the total sound and editing individual harmonics
- Separate harmonics into groups such as odd, even, and half order
- Automatically remove harmonics from the source sound for decomposition
- Spectral editing of the averaged waveform by clicking and dragging the harmonics in the spectral display

Vold-Kalman Filtering BZ-6052

The Automotive SQ Vold-Kalman Filtering software is used for high performance tracking of harmonic responses, or orders, of periodic loads in mechanical and acoustical systems.

Closely spaced and crossing orders can be extracted from systems with multiple shafts, and possess a finer frequency and order resolution than more conventional techniques. These tracking capabilities are independent of slew rates. Harmonic amplitude and phase are functions of the load and the transfer characteristics of the system, and are called the complex envelope. The filter tracks the complex envelope as a function of time and is symmetric in time, such that there is no phase bias. Because tachometer information is used for the estimation, the complex envelope may also be expressed as a function of axle speed or rpm. The harmonic waveform may be generated from the complex envelope and the tachometer information for synthesis and editing purposes.

Applications

Creating a Noise – Sound Synthesis

The primary purpose of the Automotive Sound Quality software is sound analysis – dissecting a sound and identifying its key characteristics. But often there is a need to reverse the analysis and create an accurate product sound from an analytical prediction or a noise path analysis. In these cases the results are usually only available as spectral data.

Fig. 1 Spectral data can be imported and applied as high-resolution filters
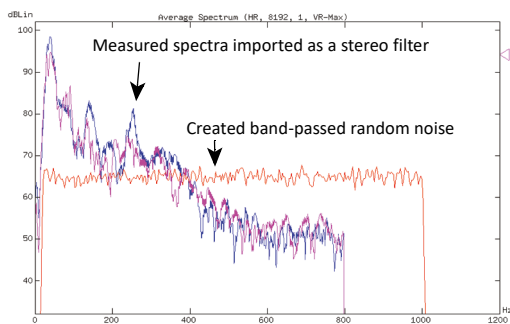
Because of its 32768-tap FIR filter capability, Brüel & Kjær's Automotive Sound Quality software can create sounds from spectral data with a high degree of accuracy. Spectral data can be imported from a wide range of sources and applied as filters to sound data as shown in Fig. 1. The amplitude and phase of the original data is retained and separate functions can be applied to left and right ears allowing true binaural sound creation.

One application of this is in the analysis of road noise contributions. The contributions of each wheel to the total road noise can be calculated using multiple coherent output power (MCOP) analysis. The output from this analysis is the spectral contributions for each of the wheels. These functions can be converted into sounds by simply applying them as filters to random noise.

The resulting sounds can be mixed and compared in real-time in the Core module (Performer) to evaluate the contributions from each wheel, individually. Other applications include synthesis of intake or exhaust orifice noise and simulation of sound deadening materials to attenuate noise transmission.

Keeping Track of the Orders

Stationary, or steady-state, sounds are relatively simple to analyse. However, the majority of product sounds are transient in nature and require more sophisticated tools for accurate analysis. Automotive Sound Quality contains a wealth of tools aimed at making that task easier. Each sound file can contain up to two tachometer signals that can be used throughout the product as integrated references for analysis and display. In the displays the tachometer data can be used to provide real-time speed information and provide rpm scaling for the time axes.

Fig. 2 Sonogram display with a real-time order slice selected for the lower display
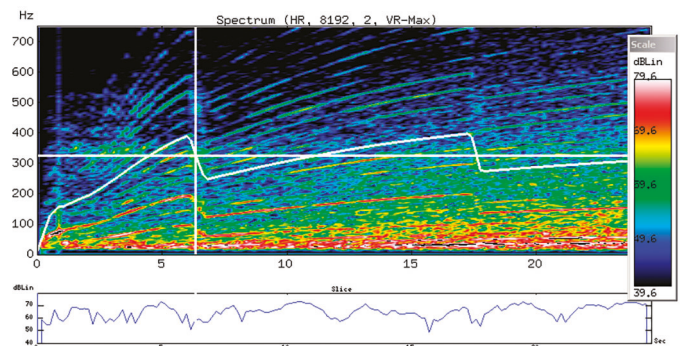
In Fig. 2, the tachometer provides a third axis to the cursor adding a constant order line to the standard time and frequency axes available in other products. Moving the cursor across the display produces a real-time order slice in the lower display.

Fig. 3 *18 × 8-pole tracked band-pass filters applied in real-time to a binaural recording*
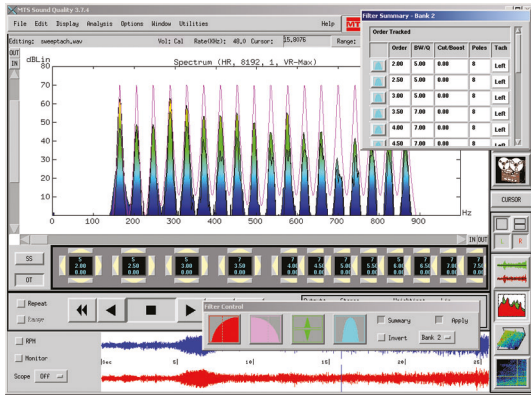
In the Real-time Filtering module, the same tachometer can be used to control the frequency of the filters allowing them to track harmonics (orders) of the tachometer frequency with a filter update rate of around 1000 per second. The tracked filters can be low-pass, high-pass, bandcut, boost or band-pass filters as shown in Fig. 3.

Automotive Sound Quality software is capable of applying more than 100 filter poles to the data in real-time allowing isolation of synchronous harmonic data from other harmonic and random sounds. In the example shown in Fig. 4, the engine sound is isolated from road and wind noise and the filters can be by-passed with a single click of a button while the sound is playing. Another click allows the band-pass filters to be inverted to infinite notch filters, effectively inverting the selection to audition only the road and wind noise with the engine removed. This is true sound decomposition in real-time.

Far more exacting problems, where the rate of speed change is high or the data contains closely spaced or crossing orders, require the application of the ultimate in order analysis: Vold-Kalman filtering. This precise filtering method allows the accurate estimation of the order amplitude and phase by correlation to the tachometer. The implementation built into the Automotive Sound Quality software is a second-generation algorithm that allows first and second order filters and decoupling for crossing or closely spaced orders.

In addition to extracting high quality swept order sounds, the harmonic data can also be removed from the original recording without producing a 'groove' in the background noise. This is because both the amplitude and phase are retained in the order estimate.

Fig. 4 Top: *The original sound with closely spaced crossing orders.* **Bottom:** *The background random with no 'grooves'*
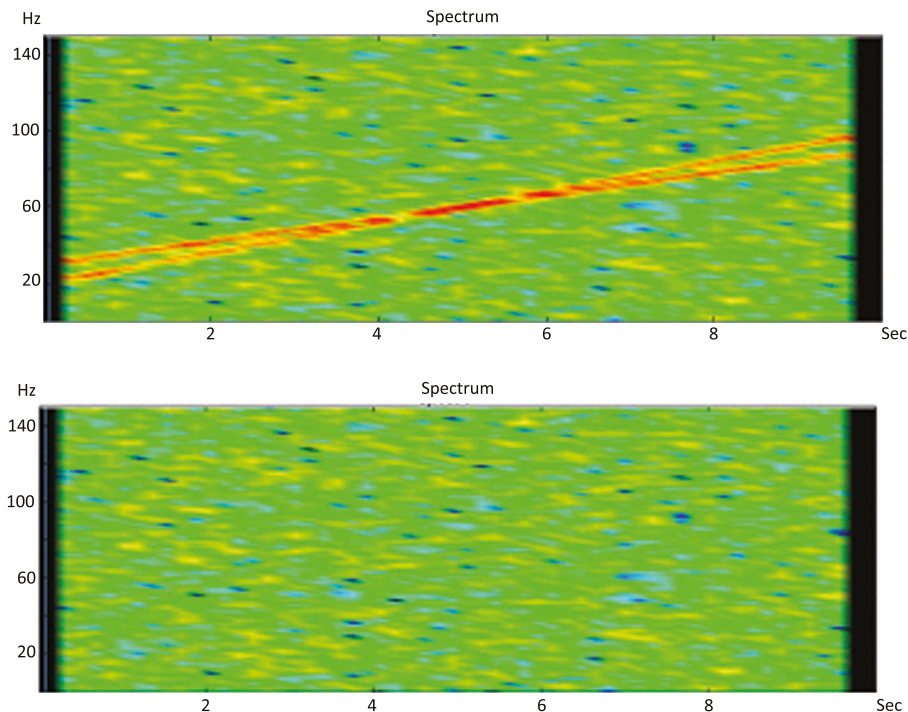
In Fig. 5, sonogram displays show a synthesised example of a decomposition of two crossing harmonic sounds mixed into a random background only 3 dB below the peak of the harmonics.

Fig. 5 *The two crossing harmonics removed with no distortion at the crossing*
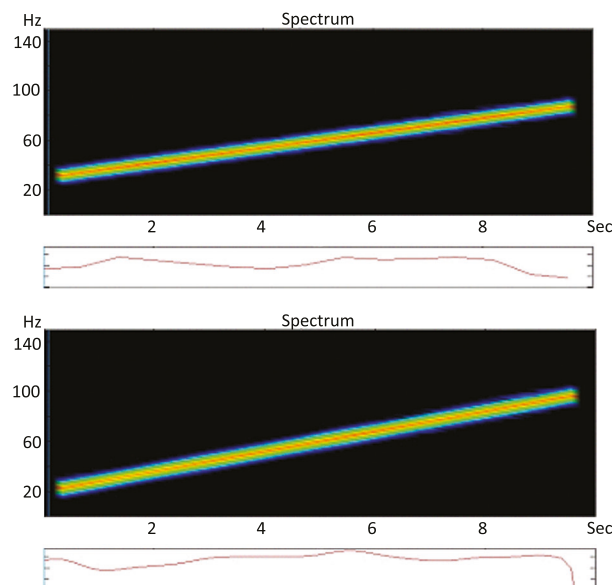
More Information

Contact your local Brüel & Kjær sales representative for more information on the complete Automotive Sound Quality software suite.

System Requirements

PROCESSOR
Intel® Core™
Recommended: Intel® Core™ i7 or greater
Memory (RAM): 4 GB; 8 GB or greater recommended

OPERATING SYSTEM
Use with one of the following:
• Windows®10
• Windows® 7 (x32 or x64)
(Please see the individual software package's release note for specific operating system support information)

GRAPHICS AND VIDEO
Graphics adapter: OpenGL® support (recommended: NVIDIA QUADRO desktop and mobile video cards)

Monitor: SVGA compatible; minimum resolution of 1024 × 768; dual-monitor video card

AUDIO
DirectMedia-compatible audio device
Sound cards:
• **For analog recording and playback**: Any Windows-supported, 2-channel sound card
• **For digital or 4-channel audio support**: RME® HDSP9632, Fireface 400 and Fireface UC
  NOTE: Digigram VXpocket and LynxONE sound cards are not supported from Automotive Sound Quality (ASQ) v 4.2. If you have one of these sound cards, it is recommended to use ASQ v 4.0

Automotive SQ Core BZ-6048

RECORDER/EDITOR
• Multiple sounds of up to two gigabytes in size can be loaded
• Sound data may be recorded/transferred using any of the following workstation facilities:
  – Analogue inputs: Two sound channels plus two tachometer channels
  – Digital inputs: AES/EBU, SP-DIF, ADAT standards
  – Multi-channel acquisition inputs: Recorded using BK Connect or externally
• Read and write support provided for WAV, AIFF, AIFF-C, Test for I-deas ADF, HEAD Acoustic HDF, LMS Skalar TDF and universal files (binary and ASCII)
• Input and output calibrations ensure sounds are replayed at their correctly recorded levels. Internal digital equalisation of the output signals provides true reproduction of binaurally recorded signals
• Multiple files may be open simultaneously in separate windows and data may be cut, copied, and pasted between them
• Comprehensive graphical editing, math, and synthesis functions include mix, fade, envelope, create, and draw

DISPLAY
2D real-time display and spectral processing synchronised with audio playback includes the following features:
Frequency Axis Modes: Linear, log, order
Band Types:
• Narrow band
• 1/n-octave (FFT and digitally filtered)
• Loudness ISO 532 B
• 1/n-octave Gaussian wavelets
Amplitude Weighting: Lin, A,B,C,D

Display Types: Wire, plates, shaded plates, differenced (octave bars)
• 3D waterfall display features include:
• Surface plot
• Duplication of 2D displays in 3D waterfall format. Z-axis units in time, samples, or rpm
• Rectilinear 3D planes
• 3-axis rotation and plane zoom of the display, under mouse control and perspective option
• 2 modes of 3D display are supported:
  – Real-time display: Spectra flow down the plane and disappear at the front
  – Off-line display: Static 3D display of all or part of the sound file data controlled by a Z-axis pan/zoom control. During playback a cursor box moves over the data and the spectra at the current play cursor position changes colour
FFT Block Sizes: 512 to 32 678 in powers of 2
Windows: Hanning and flat top
Real-time display with no missing data optimised to update as fast as possible with variable overlap.
Off-line calculation with unlimited overlap

PERFORMER
• Synchronisation between sound files, based on either time or RPM
• Grouping of up to 12 sounds into a single preset file and played either individually or simultaneously. Calibrated gain adjustments of individual sounds during playback. Playback of sounds using F1 – F12 function keys
• Selected sound can be synchronised to retain relative phasing
• Advanced looping provides for glitch-free playback of even the shortest sounds

Automotive SQ Real-time Filtering BZ-6049

• Low, high, and band cut/boost in infinite impulse response (IIR) format can be placed at any frequency simply by dragging the appropriate icon onto the display panel
• Finite impulse response (FIR) filters of arbitrary shape and phase and up to 32,768 taps can be defined with the mouse or importing from Test for I-deas ADF, universal, or spreadsheet text files
• Filters can be nominally fixed frequency or locked to a rotational order. The gain of the order-tracked filters can be constant or profiled to simulate the removal of a resonance
• Use of high-order filters, critical band wide filters, band-pass filters, and off-line filtering for more complex filter shapes
• Tracked and fixed filters can be used simultaneously. IIR filters can be profiled for amplitude control vs rpm or time either by drawing or tabular entry

Automotive SQ Metrics BZ-6050

The following standard metrics are included:
- Loudness (ISO 532 B) in phons and sones
- Transient loudness
- Sound pressure level
- Speech interference level
- Spectrum balance
- Composite rating of preference
- Intelligibility (articulation index)
- Sharpness
- Tonality
- Kurtosis
- Roughness
- Fluctuation strength
- Time varying loudness (N percentile)
- Specific loudness, roughness, and fluctuation strength
- FSFM
- Speed variation

Results can be displayed as 2D graphics and written to both ASCII and Test for I-deas ADF files

Automotive SQ Designer BZ-6051

- Time domain averaging tools allow the extraction of harmonic components from the total sound and editing of individual harmonics
- Harmonics can be separated into groups such as odd, even, and half order
- Harmonics can be automatically removed from the source sound for decomposition
- Spectral editing of the averaged waveform is accomplished by mouse clicking and dragging the harmonics in the spectral display

Automotive SQ Vold-Kalman Filtering BZ-6052

Order tracking with the filter is a post-processing operation that should be used in conjunction with waterfall and spectrogram visualisation for optimal insight into the data. Because of the resolution of the filter, the tachometer analyses must be precise, such that an inspection of the raw and fitted rpm estimates is recommended. An inspection of waterfalls or spectrograms of the original and masked data to verify choice of bandwidth and decoupling options should accompany the extraction of orders.

The module provides:
- Beat-free decoupling of close and crossing orders
- Advanced tachometer processing including automatic wild point rejection
- No leakage
- Complex envelope
- Waveform
- No slew rate limitation
- Explicit bandwidth specification
- Multiple filters for flat pass-band
- Direct extraction of the complex envelope
- No phase bias unless digital filter is FIR or filtered in both directions

Ordering Information*

BZ-6047   Automotive Sound Quality Bundle
includes the following software:
- BZ-6048-F: Automotive SQ Core
- BZ-6049-F: Automotive SQ Real-time Filtering
- BZ-6050-F: Automotive SQ Metrics
- BZ-6051-F: Automotive SQ Designer

BZ-6052-F   Automotive SQ Vold-Kalman Filtering

SOFTWARE MAINTENANCE AND SUPPORT AGREEMENTS

M1-6047-F	Agreement for BZ-6047
M1-6048-F	Agreement for BZ-6048
M1-6049-F	Agreement for BZ-6049
M1-6050-F	Agreement for BZ-6050
M1-6051-F	Agreement for BZ-6051
M1-6052-F	Agreement for BZ-6052
M2-6047-F	Agreement and Upgrade for BZ-6047
M2-6048-F	Agreement and Upgrade for BZ-6048
M2-6049-F	Agreement and Upgrade for BZ-6049
M2-6050-F	Agreement and Upgrade for BZ-6050
M2-6051-F	Agreement and Upgrade for BZ-6051
M2-6052-F	Agreement and Upgrade for BZ-6052

Optional Accessories

RECORDING

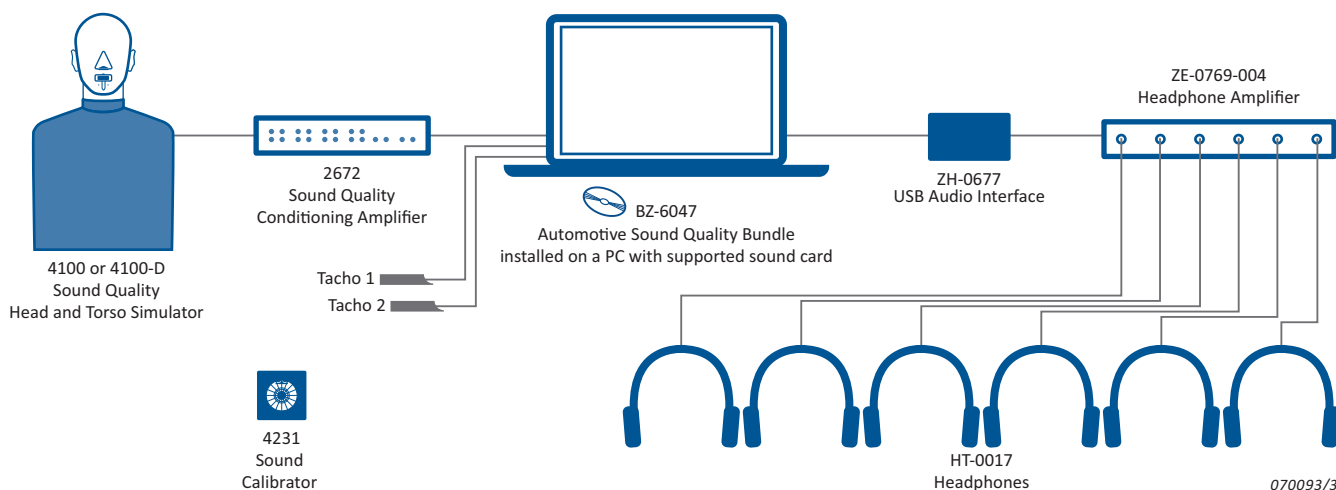|	
Type 4100	Sound Quality Head and Torso Simulator, includes Preamplifier Type 2669-L with charge injection calibration (CIC) facility
Type 4100-D	Sound Quality Head and Torso Simulator, includes CCLD Preamplifier Type 2671
Type 2672	Sound Quality Conditioning Amplifier, for Types 4100 and 4100-D
UA-1324	Positioning Frame, for Types 4100 or 4100-D and Type 2672
Type 4101	Binaural Microphone
Type 4101-A	Binaural Microphone with TEDS

PLAYBACK

HT-0017	Headphones, Sennheiser HD 650, 3.5 mm stereo jack plug
ZE-0769-004	Headphone Amplifier, 6 × independent high-power stereo amplifiers. Includes cable with 3.5 mm stereo jack plug to 2 × 6.35 mm mono jack plug (TRS), 2 m (6.6 ft), for connecting to sound source
ZH-0677	USB Audio Interface, RME Fireface UC

CABLING

AO-0508	Cable, 3.5 mm stereo jack plug to 2 × phono plug, 1.2 m (4 ft)
AO-1458	Cable, stereo jack plug to 2 × BNC plug, 1 m (3.3 ft)
AO-1459	Cable, mono jack plug to BNC plug, 1 m (3.3 ft)
JP-0070	Adaptor, phono socket to BNC plug
JP-0352	Adaptor, phono stereo jack plug to 3.5 mm stereo jack socket

Fig. 6 *Typical instrumentation for sound quality recordings and analysis*

* 'F' stands for floating licence.

Brüel & Kjær

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